ANALYSIS OF CARBON REDUCTION POLICIES
FOR PLYMOUTH

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Total carbon dioxide emissions in Plymouth in 2007 were estimated at 1,457 kt, of which 33% are associated with homes, 43% with commercial and industrial activity, and 24% with transport.

The emissions from dwellings in Plymouth are lower than the national average and many other areas of the country primarily due to the mild south west climate and the dominance of gas as the city’s heating fuel. The city’s housing stock is characterised by a significant proportion of old, solid wall and large terraced buildings. Some 30% of the homes are pre 1919 and similarly some 30% are of the large terraced form. It is also notable that many of these older terraced dwellings are in the private rented sector, with some 50% of this sector being pre 1919 dwellings. 15-30% of dwellings have no cavity wall insulation and some 10% have no loft insulation. The average SAP rating for all house types is 52 – similar to the national average. This suggests that there is a significant challenge in the city to reach the kind of dwelling performance levels that the Government wants to achieve with its Green Deal programme of an A or B rating (a SAP rating of greater than 80). A potential key target area would be the ‘hard to treat’, older terraced houses, particularly in the private rented sector.

Non-domestic emissions comprise the largest element of Plymouth’s CO₂ footprint. These emissions are split roughly equally between the manufacturing and services sectors. Within manufacturing ship building related industries dominate, followed by food processing. The services sector is dominated by retail, hotels and catering and the public sector (including education). Ship building and the public sector are two sectors which are significantly higher in the mix of emissions than compared with the national average. There would appear to be significant scope to improve the performance of public sector buildings. End use of energy in these sectors is dominated by space heating, low temperature heating and lighting. In the manufacturing sector process and space heating are the key elements, in retail lighting is the major component and in the rest of the services sector heating is the key element. Emissions from the manufacturing sector are concentrated within only about 50 key sites which could account for 30% of non-domestic emissions, whereas the service sector is spread over some 6,000 sites. The main areas for non-domestic emissions in the city are concentrated around the city centre, the East End, Plympton, Devonport and Roborough industrial area. With the dominance of heat requirements in the energy mix and a number of key sites in the city for industrial activity, there is a clear potential for heat sharing initiatives through CHP and district heating initiatives.

Transport emissions are some 24% of the total and are lower than the national and South West per capita emission figures. Car traffic is the dominant source of emissions accounting for 68% of emissions, followed by vans at 14% and HGV’s at 11%. Being a city the average travel distances are lower than the South West average, with some 30% of emissions being generated by trips under 5 miles. These short trips provide the potential for non-car travel through walking, cycling and public transport. Some 38% of emissions are generated by commuting and business related car trips, with a further 27% being generated from personal trips and 13% related specifically to retail trips.

National policy measures are expected to reduce Plymouth’s emissions over the period to 2022. By 2013 emissions are estimated to be 14% lower and by 2020 28% lower. These are based on projections from the Low Carbon Transition Plan, which is the largest and most consistent forecast available, though elements may now be out of date following the formation of the Coalition Government. Plymouth’s carbon reduction aspirations are for a 20% reduction by 2013 and a 60% reduction by 2020. These are significantly higher than national policy is expected to achieve and so extensive local activity will be needed if Plymouth is to achieve these aspirations.

The national policy measures that will have the most impact in Plymouth are renewable energy in the national generating mix and home energy efficiency improvement measures. The improvements in the generating mix will affect emissions from all sectors and there will be a limited role for Plymouth to play, apart from supporting planning application for any large scale renewable energy projects in its area. Home energy efficiency improvements will clearly be a major element of reducing emissions in the domestic sector and one where the local authority can have a significant influence. Other important areas are the products policy, vehicle emission standards, renewable transport fuels and the RHI. The products policy on improving the efficiency of appliances will have a particular impact in the commercial sector in terms of lighting and appliances. This will also be the case for the RHI since heat production is a major source of emissions in the commercial sector. Vehicle efficiency standards and renewable transport fuels will be the driving factors in transport emissions. Plymouth can support the development of these lower emission vehicles by working with their own and local business fleets.

The wider Plymouth economy will be expected to grow going forward to 2020. However, with carbon emissions potentially falling this means that the carbon intensity of production will drop. This will be more marked in the service
sector, where improvements in emissions are greater, than in the industrial sector. However, energy prices are likely to rise faster that efficiency improvements and so energy cost and security will still be a major business concern, especially in the industrial sector.

Each sector has been assessed in terms of the local “bottom-up” potential to reduce carbon emissions. The key messages from this analysis can be summarised as follows:

**Residential**
- Insulation measures could save some 44kt CO\(_2\) annually by 2020.
- A focus should be older and ‘hard to treat’ properties in the private rented sector.
- Updating boilers and fuel switching could generate a further 32kt CO\(_2\) annual saving.
- Working with the Green Deal and the Energy Company Obligations will be an important route to leveraging funds for this area. This needs to be explored as the Green Deal is developed through to 2012.
- Micro-generation options seem to have less potential than efficiency improvements, but working to maximise the benefits from FITs and the recently announce RHI could generate some 11kt CO\(_2\) annual savings.

**Non-domestic**
- The CRC and CCA will be a strong driver of efficiency improvements in larger non-domestic users.
- Smaller businesses will not be affected by these measures and so should be a target area for local activity.
- The Green Deal will be available to these smaller businesses and so leveraging funds for this sector should be explored along with its use for the residential sector.
- As heat is a major component of non-domestic emissions the development of shared heat schemes through district heating and CHP can generate significant savings. Potential key schemes to develop include:
  - The Devonport EFW facility
  - A Derriford CHP and district heating scheme
  - A Plymouth City Centre CHP and district heating scheme

**Transport**
- National policy through key measures such as car CO\(_2\) emission standards and the renewable transport fuels obligation are expected to generate some 56kt CO\(_2\) savings by 2020
- Key additional measures that could generate carbon savings are:
  - An electric vehicle programme generating 13kt CO\(_2\) savings;
  - Increased behavioural change activities (Smarter Choices) generating a further 13kt CO\(_2\) savings;
  - A package of work place parking levy and public transport investment potentially saving 14kt CO\(_2\).

In conclusion, this study provides a significant amount of evidence with regards carbon emissions in Plymouth and how these may be reduced. This evidence will need to be assessed in detail along with Plymouth’s ongoing activity in this area and their wider priorities in order to develop a set of detailed carbon reduction activities. The analysis points to the following key messages which need to be considered in taking activity forward:

- The current target of a 60% reduction in CO\(_2\) emissions by 2020 is unrealistic. A more practical, yet still challenging, target would be a 30% reduction by 2020 on a 2005 baseline.
- The council should be looking to build on their existing activity on energy efficiency support by aiming to leverage significant funding from the forthcoming Green Deal programme and related Energy Company Obligation. Key areas of focus would appear to be:
  - The private rented sector (perhaps through HMO licensing or sector links such as landlords serving the student population), especially the significant number of older properties
  - Small businesses, especially those in rented property
- Explore schemes that maximise the use of FIT and the newly announced RHI scheme to generate renewable energy installations in the city. Key target areas could be:
  - PV schemes through housing associations and community groups
  - RHI supporting biomass and other renewable heat schemes in business and public sector buildings
Facilitate the development of district heating schemes in the city and where possible with a biomass/waste fuel sources. Key schemes to explore include the ongoing Devonport EfW facility and the Derriford CHP schemes, plus the development of a city centre district heating scheme.

Look to use LTP and Local Sustainable Transport Funding resources to develop:

- Measures to support electric and low emission vehicles
- Greater activity on behaviour change activities with a potential focus on business and commuter travel
- A work place parking levy for the city supporting increased investment in public transport.

Each of these areas needs to be explored in more detail to develop a detailed action plan and set of schemes to take forward. It will also be important to establish a monitoring process building on the DECC’s regional CO₂ and the development of proxy indicators relevant to the schemes being developed.
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1. INTRODUCTION

The South West Energy and Environment Group (SWEEG), a partnership between the south west local authorities, public and third sector organisations and the University, was founded in 1976. The partnership funds scientists in the University’s Centre for Energy and the Environment (CEE) to perform applied research into energy and environmental topics of concern to its members. The CEE has carried out a wide range of studies analysing carbon emissions and assessing carbon reduction measures over the last few years. Energy Action Devon has been providing free and impartial advice to help householders and organisations reduce their energy consumption for nearly 20 years. This study applies this expertise to Plymouth to provide a comprehensive evidence base for low carbon policy formulation in the City.

The key objectives of the study are to:

1. Assess where emissions arise from within Plymouth.
2. Identify and assess actions that the local authority and other agencies in Plymouth can take to complement and add value to national policy.
3. Identify and assess additional local actions in Plymouth to further reduce carbon emissions.
4. Propose a set of carbon reduction targets or budgets for the City and mechanisms for monitoring them.
5. Set out key success factors for meeting these targets.

For an analysis of where emissions arise from across the domestic, non-domestic and transport sectors

For an estimate of the impact of national carbon reduction policy measures on emissions future in Plymouth

For an analysis of additional local measures in Plymouth that further reduce carbon emissions in the City

For potential carbon reduction targets including proxy indicators, and how they might be monitored

For overall conclusions and key recommendations for taking forward carbon reduction policy in the City
2. ANALYSIS OF CURRENT EMISSIONS

2.1. OVERVIEW

Regional data on carbon dioxide (CO$_2$) emissions is produced by DECC and gives a top-level view of emissions in Plymouth. These data are broken down into three main sectors of activity (industrial and commercial, domestic, and transport). DECC has now provided data for a 4 year period from 2005 to 2008 (note: data is reported with a 21 month time-lag$^1$) as shown in Figure 1 below. Emissions have dropped by about 5.2% over this period in Plymouth, with the rate of reduction accelerating. The result is strongly influenced by the reduction in emissions of 5.9% in the industrial and commercial sector from 2007-08, which is likely to be related to the economic downturn. The industrial and commercial sector is responsible for over 40% of emissions, with domestic emissions being about a third and transport one quarter of emissions in Plymouth.

![Figure 1: Regional CO$_2$ data for Plymouth 2005-2008 (Source: DECC, 2010).](image)

The DECC data provide a fairly simple picture with little detail on where – either sectorally or spatially – emissions are being generated. Through the work carried out by the Centre on the impact of national policy measures and the low carbon economy, a much more detailed breakdown of carbon dioxide emissions can be provided for a 2007 baseline year$^2$. The basic split between sectors is shown in Figure 2. Almost all emissions from the industry and commercial sector can be attributed to the manufacturing and services sectors, with the split between them being broadly equal. It is interesting to note that shipbuilding is responsible for a third of all manufacturing emissions. Carbon dioxide

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1. Note: This analysis was undertaken using an older version of the NI186 dataset from DECC. The total emissions in Plymouth were 1,477 ktCO$_2$ in 2005 and 1,432 ktCO$_2$ in 2008. The most recent release of data covering the same period states emissions in 2005 are 1,489 and 1,414 in 2008. Whilst the earlier release of the data has been presented in this report, this should not affect the overall results or conclusions as the error introduced is very small, and well within the error boundaries of the calculations used.

2. 2007 was chosen as the baseline year as it coincides with the availability of several relevant datasets.
emissions from primary industries (agriculture), secondary industries (extraction), utilities\(^3\), construction, land use change and waste management are negligible. The domestic, non-domestic and transport sectors are explored in a little more detail in the following sections.

\(^3\) Emissions for utilities taken for water supply only. Emissions associated with electricity generation and distribution were allocated to sectors through end-use.
2.2. **DOMESTIC**

2.2.1. **DATA RELIABILITY AND ASSUMPTIONS**

The data used to analyse the domestic sector has come from a variety of sources. It is important to note that data reliability varies significantly and in many cases there are large gaps in the information available. Several of the data sources cover different geographical areas which often do not overlap. The report authors have not been in a position to verify any of the data sources. As a result, many assumptions have been used to try and draw meaningful conclusions. Each section highlights where assumptions have been made and a comment has been made about the reliability of the conclusions.

2.2.2. **AVERAGE CO₂ PER CAPITA IN PLYMOUTH**

For the National Indicator 186 data set, the Department of Energy and Climate Change (DECC) produces annual figures for per capita CO₂ emissions. Taking a baseline year of 2007, Plymouth produced an estimated 488 kt CO₂ from domestic gas, electricity and solid fuel consumption. This gives an average domestic CO₂ consumption of **1.9 tonnes per person**. This is 21.3% less than the UK average in 2007 which was 2.4 tonnes per person. There are two main reasons for relatively low emissions per person. The first is the relatively warm climate in the South West, resulting in less need for heating. This can be seen in Figure 3 when Plymouth emissions are compared to cities in the north of the country such as Newcastle and Manchester. The second, and perhaps more significant reason, is the fact that the majority of Plymouth is connected to the gas-grid and so uses less carbon-intensive fuel than nearby rural authorities. As shown in Figure 3 emissions per capita in neighbouring North-Devon and Mid-Devon are considerably higher, and rural authorities in the north of the country even higher still.

![Figure 3: Domestic CO₂ emissions per capita for Plymouth and a selection of regions (Source: DECC, NI186 data 2007)](image)

2.2.3. **GAS CONSUMPTION BY MIDDLE LAYER SUPER OUTPUT AREA**

Some NI186 data is also available at Middle Layer Super Output Area level. Figure 4 shows how estimated gas consumption varies across Plymouth. Although it is not possible to directly compare the MSOA level data with the ward or neighbourhood data available from Plymouth City Council (because of different geographical coverage), there is enough overlap to make some meaningful conclusions.

The MSOA area with the highest estimated domestic gas consumption roughly corresponds with the neighbourhood of Hartley and Mannamead. This is one of the wealthiest areas of Plymouth and according to the 2010 House
Condition Report is the neighbourhood with the smallest percentage of vulnerable families. Hartley and Mannnamead also have one of the highest percentages of properties with solid walls. It is therefore possible to conclude that householders in this area have some of the least thermally efficient properties in the city, but are able to afford to keep them heated, thus using a relatively large amount of gas.

In contrast, the MSOA with the lowest estimated domestic gas consumption roughly corresponds with Devonport, one of the poorest areas of Plymouth with the 4th highest percentage of vulnerable families. However, the emissions in Devonport are likely to have changed since the 2007 baseline NI186 data, because there have been large scale changes to the housing stock in the last few years, including demolitions and relatively low emission new housing developments.

Figure 4: Estimated domestic gas use by Middle Layer Super Output Area (Source: DECC NI186 data 2007, base map from the Office of National Statistics)

2.2.4. ELECTRICITY CONSUMPTION BY MIDDLE LAYER SUPER OUTPUT AREA

Figure 5 illustrates the estimated domestic electricity use across Plymouth. This is for ordinary electricity meters (not Economy 7). This map shows a similar pattern to the gas use, with higher electricity consumption in the wealthier areas of the city and lower consumption in the poorer areas.

Figure 5: Estimated domestic electricity use by Middle Layer Super Output Area (Source: DECC NI186 data 2007, base map from the Office of National Statistics)

Figure 6 uses estimates of average weekly income at MSOA level from the Office of National Statistics, plotted against estimated annual electricity consumption. A linear regression analysis found an $r^2$ value of 0.65, indicating a moderate to strong relationship between these two factors. This is not a surprising finding and suggests that higher income households have a greater number of electrical appliances and are perhaps more profligate electricity consumers.
Figure 6: Domestic electricity consumption vs gross weekly income within each MSOA (Source: DECC NI186 data 2007 and Office of National Statistics income data 2010)

2.2.5. PROPERTY AGE

It is difficult to accurately compare the age of houses in Plymouth because the three most recent datasets are from different years. As illustrated in Figure 7, in 2010 Plymouth had a greater proportion (27%) of pre-1919 housing than the national average in 2008 (25%). Figures from the Energy Saving Trust suggest that a typical Victorian property will be responsible for producing 8 tonnes of CO₂ per annum, compared with only 4 tonnes for a modern house. Although there is only a 2% difference between Plymouth and national average figures for pre-1919 houses, this makes a big difference to the cost of insulating Plymouth when multiplied by the number of houses. Solid wall insulation costs an average of £12,000 for a typical 3 bed semi, compared to £150 for a house with cavity walls.

Plymouth also has a greater percentage (19%) of 1945-1964 housing than the rest of England (17%). Many of these houses built after the war were of non-traditional construction and are often “hard-to-treat” (i.e. are of a construction type that cannot be insulated with standard materials e.g. cavity wall insulation). In 2010 Plymouth had 1% less post-1990 housing than the national average in 2008. Given the national increase in housing between 2008 and 2010, this discrepancy is likely to be 2% or more. In conclusion, Plymouth’s housing stock is older than the national average, and is therefore less thermally efficient and more expensive to treat.

Figure 7: Plymouth housing by date of construction (Source: Plymouth House Condition Study 2010)
2.2.6. HOUSING STOCK TYPES

Plymouth has a significantly larger than average proportion of medium to large terraced houses compared to the national average, and a significantly smaller proportion of detached houses (as illustrated in Figure 8). It also has a relatively large proportion of buildings which have been converted into flats.

The make-up of housing types has implications for the carbon emissions of Plymouth. There are many long terraced streets, so the vast majority of terraced houses are mid-terraced. This means they have a smaller heat loss perimeter and are more thermally efficient than a comparably sized detached, semi-detached or end-terrace property. The smaller than average heat-loss perimeter of Plymouth homes may to a certain extent counter the greater than average number of solid wall homes, although modelling this accurately would be very difficult.

![Figure 8: Plymouth Housing by dwelling type (Source: Graph from Plymouth House Condition Study 2010)](image)

2.2.7. CARBON EMISSIONS BY TENURE

Table 1 shows the breakdown of households in Plymouth by tenure. The table illustrates that Plymouth has a greater percentage (19.6%) in 2010 of privately rented properties than the UK as a whole (14.2%). The number of private-rented homes in Plymouth has increased from 14.1% in 2005, which at that time was nearer the national average figure (2008). It would be interesting to understand the cause of this shift; for example, if it is connected to a growth in Plymouth’s student population the education institutions may give a channel to reach landlords.

![Table 1: Tenure of Plymouth’s Housing Stock (Source: 2010 House Stock Condition Study & EHCS 2008)](table)

* Includes ‘other public’ dwellings and all former council housing stock which was transferred in 2009 to Plymouth Community Homes
Figure 9 shows the age of houses in Plymouth depending on whether they are owner occupied or privately rented. 49% of the privately rented properties in Plymouth were built before 1919, compared to only 22% of owner occupied properties. This clearly demonstrated the importance of targeting the private rented sector in order to reduce carbon emissions.

![Figure 9: Age of housing stock by tenure (Source: 2010 House Stock Condition Study & EHCS 2008)](image)

### 2.2.8. SOLID WALL

Data compiled by the Centre for Sustainable Energy (CSE) using the 2001 Census, found that there are a total of 23,443 solid wall houses in Plymouth or 22.4% of the total. This percentage will be closer to 21% for the baseline year of 2007, given the growth in housing since 2001. Figure 10 shows where these solid wall properties are located in the city. As would be expected the majority are found in the older core of the city, the City Centre and the surrounding neighbourhoods of Mutley and Greenbank, Sutton and Mount Gould, Peverell, Keyham, Hartely and Mannnamead, Ford, Stoke and Stonehouse. There are also pockets of solid wall properties in some of the communities which presumably used to be outlying villages or hamlets in the early 20th century, but that have now merged into the city. The table in Appendix 1 shows the percentage of solid wall houses by ward.

![Solid Wall Properties in Plymouth](image)

*Figure 10: Percentage of solid wall homes in Plymouth by Output Area*
2.2.9. Fuel Type

The vast majority of houses in Plymouth are connected to the gas network. According to data from CSE there were a total of 3,095 houses without a gas connection in 2001, representing 3.8% of the households in Plymouth (with housing growth this will be more like 2.8% in 2007). As shown in Figure 11 these are clustered in small areas in Estover, Barne Barton, Manadon, Egguckland and the City Centre. The table in Appendix 1 shows the percentage of off-gas houses by ward.

![Gas Connections Plymouth](image)

Figure 11: Percentage of off-gas homes in Plymouth by Output Area

Comparing the map of gas connections and solid wall properties shows that many of the areas where there are less gas connections also have a higher incidence of solid wall properties. It is these houses that would benefit from specific targeting in order to reduce carbon emissions. In CSE’s report they combined the solid wall and off gas data to give each output area a “Hard to Treat Index” which gives the incidence of these two factors together for each Output Area.

2.2.10. Estimate of Unfilled Cavity Walls and Lofts

Of all the physical measures that can be taken to reduce carbon dioxide emissions, installing cavity wall insulation (where it is possible to install it), and topping up loft insulation to the recommended level, nearly always provide the greatest reduction in carbon emissions per pound spent. The Energy Saving Trust estimate that a typical 3-bed semi detached house can save approximately 0.6 tonnes of CO₂ a year by installing cavity wall insulation, 0.7 tonnes by installing loft insulation (if none already present) and 0.2 tonnes for houses with some already present. It would therefore be useful to know the number of unfilled cavities and lofts in Plymouth and their location.

In 2005 Plymouth City Council’s Home Energy Team carried out a random survey of 10,000 homes in Plymouth, and received 3,209 responses, representing approximately 3% of the housing stock. By extrapolating the responses of the survey, the resulting report estimated that in 2005 there were approximately 36,000 homes with unfilled cavities and 14,000 homes with unfilled virgin lofts. There are no figures available for partially filled lofts.

Table 2 shows the number of houses with cavity wall insulation installed from April 2002 until March 2010 in Plymouth. No Plymouth City Council data is available after this date. The table demonstrates a steady rate of installations increasing to a peak in 2008/9 and data available for the financial year 2010/11 so far seems to suggest that the number of installations will have fallen slightly from the last two years.
If we subtract the cavity wall installs completed between 2005 and the end of 2007 (the baseline year for this report) it gives a baseline figure of approximately 30,000 empty cavity walls in 2007. No exact figures are available for virgin loft insulation installs between 2005 and 2007, nor are estimates for the number of partially filled lofts.

In terms of insulation by tenure, The Home Energy Survey 2005 suggested that only 23% of private tenants have loft insulation, compared to 75% of owner-occupied properties. Data from the Cosy Devon scheme in Plymouth, which offers free and discounted insulation to owner-occupiers and private rented houses, supports this finding. Cosy Devon which over the last year has accounted for half of the CWI installs in Plymouth, found that of the 1,329 CWI measures installed since the programme began in 2009, only 22 of these (or 1.7%) were in the private rented sector. Similarly only 1.9% of loft installations were in private rented properties. These percentages can presumably be extrapolated to all of the recent insulation installations in Plymouth, suggesting that private-rented properties are rich source of un-insulated lofts and cavities.

### 2.2.11. **Estimate of old boilers**

Improving the efficiency of heating and hot water systems will play a significant role in reducing domestic CO$_2$ emissions. The Heating and Hot Water Industry Council (HHIC) has published figures on estimated proportion of households with different boiler ratings. Although it is a crude method, these national figures can be applied to Plymouth to estimate the make-up of boilers in the city. The total number of gas connections is available from the NI186 data, so the numbers in Table 3 have been estimated by multiplying the estimated percentage of each boiler type by the total number of boilers.

#### Table 3: Estimated number of gas boilers in Plymouth by SEDBUK boiler band rating

(Source: HHIC and DECC NI186 data)

<table>
<thead>
<tr>
<th>Boiler Band</th>
<th>% of boilers with this rating in the UK</th>
<th>Estimated number of boilers in Plymouth 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>30.3</td>
<td>30,762</td>
</tr>
<tr>
<td>B</td>
<td>8.8</td>
<td>8,908</td>
</tr>
<tr>
<td>C</td>
<td>0.3</td>
<td>304</td>
</tr>
<tr>
<td>D</td>
<td>22.2</td>
<td>22,472</td>
</tr>
<tr>
<td>E</td>
<td>12.9</td>
<td>13,058</td>
</tr>
<tr>
<td>F</td>
<td>8.5</td>
<td>8,604</td>
</tr>
<tr>
<td>G</td>
<td>17.0</td>
<td>17,209</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>101,228</td>
</tr>
</tbody>
</table>

Whilst the greatest proportion of boilers in Plymouth are most probably A-rated, based on national figures, there are probably still in the region of 17,209 G-rated boilers. Upgrading a G-rated boiler to an A-rated boiler saves approximately 1.1 tonnes of CO$_2$ a year.

### 2.2.12. **SAP ratings**

The House Condition Study 2010 estimates the SAP ratings for houses according to tenure, as illustrated in Figure 12. The average SAP across all properties is 51.8, with the private rented sector having the lowest average SAP of 50 SAP.
and RSL’s the highest of 53, with owner-occupied houses at an average of 52. These figures reflect the fact that the private rented sector has a disproportionately large number of solid-wall properties, and a low take-up of loft and cavity wall insulation as discussed above. The SAP ratings for social housing appear to be low compared to the national average, which was 58 for the social sector in 2005. By comparison, the council’s social housing stock in Oxford has an average SAP rating of 71 (compared to a city wide average of 53). A conversation with the Asset Manager from Plymouth Community Homes (15,000 houses) in June 2011 found that the 2011 average SAP for their homes is 68. However, this relatively high average SAP is largely due to thermal efficiency improvements that have been made in recent years since the 2007 baseline.

![Figure 12: Estimate of average SAP ratings by tenure (Source: Plymouth Housing Condition Study 2010)](image)

In contrast, a report downloaded from the UNO database reported an average SAP of 57.2 amongst private sector housing. This information was taken from the 9,658 homes with data stored on the system (but excluding all the council houses which were transferred to Plymouth Community Homes). Figure 13 shows the breakdown of housing stock by SAP band.

![Figure 13: Private-sector houses by SAP band using UNO data (Source: Plymouth City Council UNO database 2011)](image)

The UNO data has a much greater sample size than the Plymouth House Condition Study 2010, therefore the results may be more accurate, however this would require further research.

One clear conclusion from the above graph is the scale of the challenge in bringing the housing stock up to the required efficiency standard. According to the information published by the Government in relation to the Green Deal, it is aiming for all homes to be a SAP Band A or B by 2050. Of the 9,658 existing private sector houses with data...
entered in UNO, only four of these are currently Band B, with none in Band A.

2.3. **NON-DOMESTIC**

Carbon dioxide emissions from the non-domestic sector have been examined in greater detail by looking at sub-sectors within the economy, end use and spatial distribution across Plymouth.

2.3.1. **SUB-SECTOR ANALYSIS**

The emissions from the non-domestic sector were broadly allocated to more specific sub-sectors\(^4\) within manufacturing (Figure 14) and services (Figure 15). The manufacturing sector emits 296 ktCO\(_2\) and is dominated by the shipbuilding activity at Devonport, which is responsible for a third of all manufacturing emissions in Plymouth. It is possible that this result may not be entirely reliable, as the emissions have been apportioned to the shipbuilding sector based on national assumptions on emissions from shipbuilding, whereas significant activity within this sector in Plymouth may be in connection with nuclear submarines, which may result in different emissions. The food and drink sector is also a significant emitter (15% of all manufacturing), mostly from manufacture of bread and “other food products” (could include sugar, cocoa, tea, coffee, condiments, prepared meals, homogenised food, and “other”). Other significant sources of emissions are from the manufacture and initial process of iron and steel (33 ktCO\(_2\)), medical equipment (17 ktCO\(_2\)), plastic products (16 ktCO\(_2\)) and mechanical power equipment i.e. engines, pumps, compressors, taps, gears, bearings etc. (10 ktCO\(_2\)). Together they make up for over 70% of manufacturing emissions with Plymouth. Shipbuilding, food, and iron and steel alone make up almost 60%.

![Figure 14: Carbon emissions from the twenty largest manufacturing emitters in Plymouth, 2007](image)

The services sector emits 308 ktCO\(_2\) of carbon dioxide. A third of these emissions are from the retail sector. A

---

\(^4\) Allocation of CO\(_2\) was based on calculating a national carbon intensity value for each sub-sector based on energy consumption data from DECC and economic output data (GVA) taken from the SW Regional Observatory. These intensities were then applied to GVA data for Plymouth. Through this method, estimated emissions from the manufacturing and services sectors in total were 18% lower than observed/measured by DECC indicating that Plymouth has a higher carbon intensity within its economy through a combination of reduced energy efficiency, or more likely lower economic output/productivity compared to the national average. Emissions were adjusted to correspond to the observed DECC emissions for Plymouth. The values produced by this allocation method should be viewed as an approximate “snapshot” of emissions across Plymouth’s economy in 2007.
further 29% comes from the public sector (12% education, 11% public administration and defence and 6% health). The hotel and catering sector is responsible for 14.4% of emissions. Together, these sectors emit 75% of all carbon dioxide from the services sector. The remaining emissions are roughly equally split between recreational services, wholesale distribution, communications and transport buildings, car showrooms and garages, and office based commercial activity.

Compared to the national average, emissions from the non-domestic\(^5\) sector per person are significantly lower in Plymouth (Figure 16). The main reason for this is the general lack of the most carbon emitting industries in Plymouth. For example, there is no significant coke refinement or chemical manufacture, which are the two greatest carbon emitting sub-sectors within manufacturing, as well as relatively little manufacture of wood and wood products, paper and printing and non-metal products.

The sub-sectors where Plymouth emits significantly more than the national average are in transport equipment and the public sector. The manufacture of transport equipment in Plymouth almost entirely consists of shipbuilding and repair, whereas nationally shipbuilding and repair accounts for only about 7% of emissions from manufacture of transport emissions – the majority coming from motor vehicles and aerospace. Based on this methodology, emissions in Plymouth account for about a quarter of national emissions in the shipbuilding and repair sub-sector. The larger emissions in the public sector are due to a higher concentration of public service activity in Plymouth compared to the national average, for example Derriford Hospital in the health sector, Plymouth University in the education sector and greater public administration and MOD presence than the UK average. The methodology used assumes the same carbon intensity (carbon emissions per unit of GVA) locally as nationally, and so the differences observed are due to the relative compositions of the Plymouth and UK economies rather than any inherent difference in energy or carbon efficiencies.

\(^5\) Excluding primary and secondary industries, and waste, of which there are very low emissions in Plymouth
2.3.2. END USE ANALYSIS

A detailed breakdown of emissions by end use by manufacturing sub-sector (Figure 17) enables the most significant end uses to be identified. For example, space heating is the highest source of emissions in the shipbuilding sub-sector (the largest overall manufacturing sub-sector). Low temperature processes are the largest emitters overall with significant emissions in shipbuilding and food and drink sub sectors. Unsurprisingly, high temperature processes are responsible for 85% of emissions within the metals sub-sector. Motors (37%) are the most significant emitter from the rubber and plastic products sub-sector; whilst the medical sector has a more even spread of emissions across low temperature, lighting and space heating.
A similar breakdown for the services sector (Figure 18) reveals that lighting (38%) is the most significant single emitter within the retail sub-sector and that emissions from catering are 29% of the total emissions from the hotels and catering sector. Space heating is the largest emitter from eight of the eleven sub-sectors, and accounts for between 18% (transport and communications) and 49% (public administration and health) of total emissions within a sub-sector.

Aggregated end use emissions (Figure 19) show that service sector space heating is the highest emitting end use followed by industrial low temperature processes, service lighting (mostly retail) and industrial space heating (mostly Devonport).
2.3.3. EMISSIONS PER SITE

The estimates of emissions per sub-sector can be combined with the number of business sites within Plymouth to estimate the average emissions per site. These results are shown in Figure 20. There are over 7,000 business sites in Plymouth, and about 6,000 (or 84%) of them are in the service sector. However, the average emissions from each of these sites are 50 tCO$_2$ meaning that in total these sites account for only half of the non-domestic emissions in Plymouth. By contrast, there are about 50 sites (well under 1%) which manufacture metals (iron and steel), transport equipment (mainly shipbuilding) and food and drink (half of which are “baking confectionary and other goods”). These account for about 30% of emissions from the non-domestic sector. The top down analysis has identified one iron and steel manufacturing site in the whole of the city, which is responsible for huge emissions (30 ktCO$_2$). It is possible that this is an erroneous result due to the limitations of the methodology, or perhaps due to the “headquarter effect” where a business that is registered in Plymouth (and therefore the company GVA would be attributed to the city) actually undertakes activities – and therefore produces emissions – across a wider geographical area.

Table 4 shows a selected list of manufacturing sub-sectors where the top-down analysis has identified potential concentrations over relatively small numbers of sites. The most significant of these is in shipbuilding where there are 24 sites emitting on average over 4 ktCO$_2$ (4000 tCO2) a year. These account for about 16% of all non-domestic emissions in Plymouth. There are other significant clusters, for example in the manufacture of “mechanical power equipment” and the production of “baking confectionary and other foods”. Reducing emissions from any of these sectors will require bespoke interventions due to the inherent diversity across the manufacturing sector.
Figure 20: Average emissions per business sites by sub-sector (blue columns, left hand axis) compared to number of sites and total emissions for the sub-sector (numbered red and green columns, right hand axis). Note the logarithmic axis scales.

Table 4: Selected manufacturing sub-sectors which indicate a concentration of emissions in relatively small numbers of sites

<table>
<thead>
<tr>
<th>Sector Name</th>
<th>Number of Sites</th>
<th>Average Emissions/site (tCO2)</th>
<th>Total emissions (ktCO2)</th>
<th>% of Non-Domestic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron and steel</td>
<td>1</td>
<td>33,059</td>
<td>33</td>
<td>5.4%</td>
</tr>
<tr>
<td>Textile finishing</td>
<td>1</td>
<td>4,441</td>
<td>4</td>
<td>0.7%</td>
</tr>
<tr>
<td>Shipbuilding and repair</td>
<td>24</td>
<td>4,058</td>
<td>97</td>
<td>15.8%</td>
</tr>
<tr>
<td>Baking confectionery and other foods</td>
<td>10</td>
<td>3,860</td>
<td>39</td>
<td>6.3%</td>
</tr>
<tr>
<td>Rubber products</td>
<td>1</td>
<td>2,861</td>
<td>3</td>
<td>0.5%</td>
</tr>
<tr>
<td>Receivers for TV and radio</td>
<td>3</td>
<td>2,402</td>
<td>7</td>
<td>1.2%</td>
</tr>
<tr>
<td>Mechanical power equipment</td>
<td>6</td>
<td>1,709</td>
<td>10</td>
<td>1.7%</td>
</tr>
<tr>
<td>Paper and paperboard products</td>
<td>1</td>
<td>1,583</td>
<td>2</td>
<td>0.3%</td>
</tr>
<tr>
<td>Glass and glass products</td>
<td>5</td>
<td>1,308</td>
<td>7</td>
<td>1.1%</td>
</tr>
<tr>
<td>Fish and fruit processing</td>
<td>4</td>
<td>1,112</td>
<td>4</td>
<td>0.7%</td>
</tr>
<tr>
<td>Furniture</td>
<td>10</td>
<td>972</td>
<td>10</td>
<td>1.6%</td>
</tr>
<tr>
<td>Plastic products</td>
<td>16</td>
<td>972</td>
<td>16</td>
<td>2.5%</td>
</tr>
<tr>
<td>Medical and precision instruments</td>
<td>24</td>
<td>720</td>
<td>17</td>
<td>2.8%</td>
</tr>
<tr>
<td>Miscellaneous manufacturing and recycling</td>
<td>22</td>
<td>418</td>
<td>9</td>
<td>1.5%</td>
</tr>
<tr>
<td>TOTAL (Note: Plymouth total of 7,182 business sites)</td>
<td>128</td>
<td>258</td>
<td>42.0%</td>
<td></td>
</tr>
</tbody>
</table>
2.3.4. EMISSIONS FROM LARGE PUBLIC SECTOR BUILDINGS

Data has recently been published for all Display Energy Certificates (DEC) produced nationally. A DEC is required for any building above 1,000m² that is regularly visited by the public, and could therefore be considered a reasonable proxy for the public sector. The 2010 (latest) DEC results for buildings in Plymouth were extracted and analysed. In total, there are about 100 buildings which between them emit approximately 50 ktCO₂ which is about a sixth of all emissions from the services sector. These emissions capture around half of emissions for the public sector estimated from the top-down allocation of carbon in the previous sections, although there are likely to be many smaller buildings which do not require a DEC, and perhaps some that do that haven’t undertaken one. For example, there are 91 listed schools on the council’s website (which excludes private schools), and only 23 DECs from schools (and 17 from Colleges – including Marjon) in Plymouth from the data.

The Derriford hospital has a single DEC certificate with a rating of 114 (E) and total emissions of 19,400 tonnes of carbon dioxide, which make it easily the largest single emitter. The University of Plymouth has DECs for 20 buildings which total over 9,000 tonnes of carbon dioxide. A full breakdown is shown in Figure 21.

![Figure 21: Total emissions (tCO₂) from different building types from DECs produced in Plymouth 2010 (Source: adapted from published CSE data)](image)

Table 5 shows a summary of DEC ratings for buildings in Plymouth. The mean DEC rating for all buildings is 103, which compares to a rating of 101 nationally (i.e. buildings in Plymouth perform slightly worse). In particular, as the largest single emitter, the E rating (114) at Derriford could indicate potential for significant savings if performance were improved. In addition, the University, Royal Mail, Colleges, Defence and Court buildings perform much worse than average. Additional savings could be made if measures and interventions were introduced to improve performance of those buildings.

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Table 5: Summary of emissions and DEC ratings for different buildings types from 2010 (Source: adapted from published CSE data)

<table>
<thead>
<tr>
<th>Summary</th>
<th>Sites</th>
<th>Total CO2 (tonnes)</th>
<th>Proportion of buildings...</th>
<th>Mean Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>A-D</td>
<td>E-G</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hospital</td>
<td>4</td>
<td>20,339</td>
<td>25%</td>
<td>75%</td>
</tr>
<tr>
<td>University</td>
<td>20</td>
<td>9,028</td>
<td>40%</td>
<td>60%</td>
</tr>
<tr>
<td>Other public buildings</td>
<td>24</td>
<td>4,838</td>
<td>63%</td>
<td>38%</td>
</tr>
<tr>
<td>Council Buildings</td>
<td>7</td>
<td>3,055</td>
<td>86%</td>
<td>14%</td>
</tr>
<tr>
<td>Royal Mail</td>
<td>3</td>
<td>2,591</td>
<td>33%</td>
<td>67%</td>
</tr>
<tr>
<td>Schools</td>
<td>23</td>
<td>2,366</td>
<td>65%</td>
<td>35%</td>
</tr>
<tr>
<td>Colleges</td>
<td>17</td>
<td>2,143</td>
<td>29%</td>
<td>71%</td>
</tr>
<tr>
<td>Swimming Pools</td>
<td>2</td>
<td>1,612</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>H M Land Registry</td>
<td>2</td>
<td>1,277</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>Defence</td>
<td>2</td>
<td>682</td>
<td>0%</td>
<td>100%</td>
</tr>
<tr>
<td>Courts</td>
<td>1</td>
<td>302</td>
<td>0%</td>
<td>100%</td>
</tr>
<tr>
<td>H M R C</td>
<td>1</td>
<td>214</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>Total</td>
<td>106</td>
<td>48,447</td>
<td>49%</td>
<td>51%</td>
</tr>
</tbody>
</table>

2.3.5. Spatial Analysis of Non-Domestic Emissions

An analysis of non-domestic CO₂ emissions in Plymouth highlights the highest emitting MSOAs (see Figure 22).

7 Conversion factors used for gas and grid electricity were 0.185 and 0.541 kgCO₂/kWh respectively
The top ten MSOAs account for 75% of the total CO$_2$ emissions from non-domestic electricity and gas use. Figure 23 illustrates the variation of CO$_2$ emissions for each of the top ten MSOAs.

Figure 23: CO$_2$ emissions from the ten highest emitting MSOAs. The top ten MSOAs represent 75% of CO$_2$ emissions.

Figure 24 shows the Regen SW heat map for Plymouth. The methodology includes all buildings (domestic and non-domestic) and is based on building floor area and standard beat benchmarks so does not account for process energy use.

Figure 24: Approximate spatial heat demand (kWh/m$^2$) (source: Regen SW)

8 Source: NAEI 2007 Local Authority consumption statistics. CO$_2$ data for the MSOA regions E02003136 and E02003140 has been added together since there was insufficient information for gas and electricity consumption to separate the regions.
Areas of high heat demand detailed in Figure 24 correlate strongly with the areas with high CO₂ emissions for gas and electricity illustrated in Figure 22. Notable areas of high energy demand and CO₂ emissions are situated in the area enclosed by The Hoe, Mutley and the area surrounding Plymouth City Airport.

Figure 25: Anchor heat loads in the City of Plymouth (source: Regen SW)

Figure 25 shows individual anchor loads within the City of Plymouth. The data shows that there is a large concentration of heat use around the city centre. Other notable areas include East End (principally in the vicinity of Plymstock), and Plympton. There are also a significant number of sites that are situated in the Central and North East areas, however these locations appear to be significantly more spread out than those in the more developed areas of the city. The CO₂ emissions map in Figure 26 shows emissions for Plymouth and the surrounding area.
The data from the NAEI shown in Figure 26 shows similar patterns for electricity and gas use, though the ratio actual emissions is greater for electricity. The emissions patterns for gas are similar to those revealed by the heat map and anchor load data in Figure 24 and Figure 25 respectively, which is to be expected because gas is fuel that is most used for space heating. However, this data does not include some of the larger non-domestic sites (i.e. point sources). The larger scale non-domestic sites are covered in detail in the following section (section 2.3.5.1).

Figure 27 shows the total heat load for small scale industrial sites in the Plymouth area. The areas with the largest heat load include central Plymouth, Roborough, Lee Mill Industrial Estate and the area surrounding Plympton. There are also small-scale energy intensive sites near Ivybridge and south of Lee Moor, but these out outside the boundary of the City of Plymouth.

\[^9\] km x 1 km emission of CO2 data for 2008 was based on data reported by the End User and compiled by the NAEI. It is important to note that this emissions data does not include emission from larger sites (i.e. point sources).
2.3.5.1. NAEI POINT SOURCES IN PLYMOUTH

There are two point sources identified by the National Atmospheric Emissions Inventory (NAEI) in the City of Plymouth; Derriford hospital and that naval base at Devonport (HMNB Devonport). The NAEI have identified CO$_2$ emissions for Derriford hospital and HMNB Devonport as 1,782 and 5,765 tonnes of CO$_2$ respectively. However, these emissions do not appear to account for all of the activities at each of these sites.

The CSE and Cofely studies reported combined heat and electricity load for Derriford Hospital and HMNB Devonport of 8.7 GWh$^{10}$ and 176.8 GWh$^{11}$ per annum respectively. Assuming a conversion factor for gas of 0.185 kgCO$_2$/kWh and a factor for electricity of 0.541 kgCO$_2$/kWh, the total CO$_2$ emissions for each of these two sites would be as follows.

- HMNB Devonport: 72,137 tCO$_2$ per annum
- Derriford Hospital: 4,801 tCO$_2$ per annum

The calculated emissions above are well in excess of those detailed by the NAEI, which would suggest that the data held by the NAEI does not cover all emissions from each of these sites. However, they may still be low, for example we have seen that the recent DEC for Derriford showed emissions nearer 20 kt.

2.3.5.2. EU-ETS SITES

The European Union Emissions Trading Schemes (EU-ETS) has not identified any site that has an EU-ETS allocation for CO$_2$ emissions. However, there are three significant sites identified by the schemes that are situated in South Hams, close to the border with the City of Plymouth;

- Wienerberger Ltd (Steer Point Brickworks, PL8 2DG) - 19,804 tCO$_2$ per annum
- Imerys (Herreschoff Kilns, Lee Moor, PL7 5JP) - 12,538 tCO$_2$ per annum
- Arjo Wiggins (Stowford Mill, Ivybridge, PL21 0AA) - 6,005 tCO$_2$ per annum

$^{10}$ Source: Plymouth City Centre and Derriford Sustainable Energy Study (Page 62, Appendix A), Centre for Sustainable Energy / Wardell Arstrong. This figure includes both healthcare buildings and administration offices (Healthcare; 593 MWh/y for gas and 664 MWh/y for electricity, Administration Offices; 2,680 MWh/y for gas and 4,787 MWh/y for electricity).

$^{11}$ Source: Business Feasibility Study for an Energy Services Company in Plymouth (Page 2), Plymouth City Council / ICE UK Ltd (110.7 GWh for electricity and 66.1 GWh for heat, which is assumed to be primarily from gas).
2.3.5.3. Carbon Reduction Commitment

The CRC applies to all organisations that require electricity use to be measured on a half-hourly basis (i.e. those businesses that consume more than 6 GWh of electricity per year), but are below the EU ETS threshold for energy use. According to the DECC data for 2007, there are 317 half-hourly meters in the Plymouth area which account for only 4% of all non-domestic electricity meters. The half-hourly meters consume 0.56 TWh per annum, which is 76% of all non-domestic electricity consumption.

2.3.5.4. Areas with Potential for CHP and District Heating Solutions

The CSE and Cofely studies identify areas in the City of Plymouth that have potential for district heating / CHP solutions. In addition to the possible schemes discussed for Derriford, Plymouth City Centre and Devonport, it may also be useful to consider the options for Roborough Industrial Estate.

X-FAB (formerly Plessey Semiconductors) is a factory situated just outside the City of Plymouth. X-FAB is located several hundred yards from other businesses within Roborough Industrial Estate and as such may provide an additional opportunity for a district energy solution. The cluster of anchor loads in Plymstock should also be investigated.

2.3.5.5. A Spatial Analysis of the Non-Domestic Building Stock in Plymouth

Data on the distribution of non-domestic building stock in Plymouth\(^\text{12}\) shows the relative ages of Plymouth’s non-domestic building stock compared to the South West. Figure 28 shows that only a relatively small proportion of Plymouth’s non-domestic buildings were built between 1980 and 2000, but that the proportion buildings built in the post-war period (between 1940 and 1970) is significantly larger. It is also interesting to note that some 19% of Plymouth’s non-domestic buildings are of unknown age compared to only 6% across the South West.

![Figure 28: Distribution of ages of non-domestic buildings in Plymouth and the South West Region by floor area](http://www.communities.gov.uk/archived/publications/planningandbuilding/ageindustrialstock)

Buildings that were built between 1940 and 1970 make up the majority of the building stock (by floor area) in Plymouth and the greater proportion of these are factory and retail operations. The distribution of ages of offices and warehouse spaces are relatively even (Figure 29).

\(^{12}\) http://www.communities.gov.uk/archived/publications/planningandbuilding/ageindustrialstock
2.3.6. NEW DEVELOPMENT AND CARBON EMISSIONS

New development will play an important role in the reduction of carbon emissions. In 2009 the Government announced that non-domestic buildings should be zero carbon by 2019 with public sector buildings zero carbon in 2018. It is anticipated that this policy will be implemented through the sequential tightening of building regulations. Since October 2010 new non-domestic buildings have been required to reduce CO₂ emissions by 25% from 2006 levels.

While the detail surrounding zero carbon has not been finalised – critically the measures that will count towards “allowable solutions” – it is anticipated that zero carbon will generally be achieved through a reasonable combination of on-site measures and connected heat with the remainder being met through allowable solutions (mostly) in the locality. The cost of achieving low carbon development will not therefore only be a function of the new building but the locality in which it is built. Energy enabled sites have the potential to bring a competitive advantage to a locality.

A spatial understanding of existing energy use and heat use in particular enables combined with the potential for new development sites provides an opportunity to consider the optimisation of heat generation and use. Significant carbon savings can be achieved by co-locating complimentary heat loads and considering the co-generation of electricity and heat (CHP). The relatively high cost of heat distribution makes it important to consider energy at an early stage during the spatial planning of new developments. Heat distribution strategies should be included when considering the layout, mix of use and densities of new building projects. The relationship between new and existing buildings should also be considered as existing buildings may provide a demand for or source of low carbon heat. Plymouth is already well advanced in incorporating energy planning into its local development framework.

Figure 29: Distribution of ages of non-domestic buildings in Plymouth by age and by class (normalised by floor area)
2.4. TRANSPORT

The CEE carried out an initial assessment of baseline carbon emissions as part of the ‘Exeter and the far South West DaSTS carbon study’. Within this study a transport and carbon emissions model was developed that used regional traffic and fleet data to provide a detailed emissions breakdown for the transport sector. The model was also capable of taking input for network based transport models to provide a much more spatial analysis of emissions. However, the use of data from these network models has not yet been carried out.

In this current study we have developed this work further by using local traffic, fleet and speed data for Plymouth, where this exists, to provide an analysis that is more relevant to the local conditions in Plymouth. Baseline emissions have been generated using the model for a baseline year of 2007. The carbon model gives total emissions of CO\textsubscript{2} from road transport as 282 kt/yr, this compares to a figure of 351 kt/yr from the NI186 regional CO\textsubscript{2} data and 312 kt/yr from the carbon model using regional defaults. In all of these cases, the scope of emissions excludes motorway traffic and diesel railways.

The differences between these data sets can be seen from the breakdowns in Figure 30 and Figure 31. With regards road type the NI186 data gives a significantly higher proportion of emissions being generated from traffic on trunk roads than the carbon model, using either local or regional data. The NI186 data was created by AEA Technologies and is likely to be based on national assumptions. Comparing the regional and local data in the carbon model there is slightly higher emissions from trunk roads using the regional data. In additional the regional data assumes a mix of urban and non-urban road types, where as the local data assumes all roads are urban with consequently lower vehicle speeds.

![Figure 30: Total carbon dioxide emissions by road type.](image)

Vehicle type disaggregate is not available in the NI186 CO\textsubscript{2} data, but can be generated from the carbon model. Comparing the use of local and regional data clearly shows that the regional data estimates more emissions from heavy goods vehicles than the local data. These additional HGV emissions in the regional data are largely a result of traffic on non-urban trunk roads that are not present in the Plymouth urban area.

To summarise, it may be that the NI186 transport data may overstate emissions in Plymouth as the composition of the fleet in Plymouth is likely to be different to the national average (i.e. fewer HGVs). As the NI186 data is likely to be available annually, then it is likely that it will be used for monitoring and targeting; however it should be borne in mind that it may overstate transport emissions.
Using local data also gives a different picture in relation to car emissions generated in the different trip length categories. These results are shown in Figure 32 and indicate that the local data generates more emissions from the short trip categories, under 5 miles, which are more amenable to mode shift to walking, cycling and public transport use. The local data also does not have the significant peak for trips between 10 and 25 miles.

The carbon model also produces car emissions by trip purpose. In this case only the regional split was available for this and gives the results shown in Figure 33. This shows that although emissions from commuting and business travel are significant at some 41%, personal trips for shopping, leisure and visiting friends generate more emissions. This suggests that alongside the traditional activity of travel plans with businesses, consideration needs to be given to measures focused at influencing private trip patterns.
Figure 33: Carbon dioxide emissions for cars by trip type.
2.5. **KEY FEATURES OF CURRENT CARBON EMISSIONS**

The total CO\(_2\) emissions in Plymouth in 2007 were estimated at 1,457 kt, of which 43% are associated with commercial and industrial activity, 33% with residential homes and 24% with transport. The key features of each of these sectors that affect their emissions can be summarised as follows:

### 2.5.1. DOMESTIC EMISSIONS

The emissions from domestic dwellings in Plymouth are lower than the national average and many other areas of the country. This is primarily due to two reasons: the mild south west climate and the dominance of gas as the heating fuel. In terms of the housing stock in the city it can be characterised by having a significant proportion of old, solid wall and large terraced buildings. Some 30% of the homes are pre 1919 and similarly some 30% are of the large terraced form. It is also notable that many of these older terraced dwellings are in the private rented sector, with some 50% of this sector being pre 1919 dwellings.

In terms of the levels of insulation we estimate that some 15-30% of dwellings have no cavity wall insulation and some 10% have no loft insulation. The average SAP rating for all tenures was 52. This suggests that there is a significant challenge in the city to reach the kind of dwelling performance levels that the Government wants to achieve with its Green Deal programme of an A or B rating (a SAP rating of greater than 80). A potential key target area would be the ‘hard to treat’, older terraced houses, particularly in the private rented sector.

### 2.5.2. NON-DOMESTIC EMISSIONS

Non-domestic emissions comprise the largest element of Plymouth’s CO\(_2\) footprint. These emissions are split roughly equally between manufacturing and services. Within manufacturing ship building related industries dominate, followed by food processing. The services sector is dominated by retail, hotels and catering and the public sector (including education). Ship building and the public sector are two sectors which are significantly higher in the mix of emissions than compared with the national average. There would appear to be significant scope to improve the performance of public sector buildings.

In terms of the end use of energy in these sectors it is dominated by space heating, low temperature heating and lighting. In the manufacturing sector process and space heating are the key elements, in retail lighting is the major component and in the rest of the services sector heating is the key element.

In terms of special distribution of emissions from the manufacturing sector these are concentrated within only perhaps 50 key sites, whereas the service sector is spread over some 6,000 sites. The main areas for non-domestic emissions in the city are concentrated around the city centre, the East End, Plymton, Devonport and Roborough industrial area.

With the dominance of heat requirements in the energy mix and a number of key sites in the city for industrial activity, there is a clear potential for heat sharing initiatives through district heating and CHP initiatives.

### 2.5.3. TRANSPORT

Transport emissions are some 24% of the total and are lower than the national and South West per capita emission figures. Car traffic is the dominant source of emissions accounting for 68% of emissions, followed by vans at 14% and HGV’s at 11%. Being a city the average travel distances are lower than the South West average, with some 30% of emissions being generated by trips under 5 miles. These short trips provide the potential for non-car travel through walking, cycling and public transport.

In terms of trip purpose some 38% of emissions are generated by commuting and business related car trips, with a further 27% be generated from personal trips and 13% related specifically to retail trips.
3. IMPACTS OF NATIONAL POLICY

3.1. OVERVIEW

National policy on carbon reduction has been taken from the UK Low Carbon Transition Plan\(^{13}\) (LCTP) 2009. Although there has been a change in government since the plan was produced and some of the policy has changed, or is changing\(^{14}\) – for example the Carbon Reduction Commitment is now a tax and not a trading scheme, and the Renewable Heat Incentive will be funded by central government rather than through consumers’ heating bills – the LCTP and its supporting documents still represents the most complete picture of the national policy measures in place to reduce carbon emissions. The UK national target is an 80% reduction in greenhouse gas emissions by 2050 and 34% by 2020, relative to 1990 levels. The aim is to meet the 2020 target over three budget periods: 2008-2012, 2013-2017, and 2018-2022. This section uses an apportioning exercise developed by the CEE to estimate the impact of national carbon reduction policy on emissions in Plymouth.

Figure 34 shows the impact of national policy on the residential, transport and non-domestic sectors, with the last of these three sectors split into industry, business and public sector. Measured data are available up to 2008, with an estimated projection shown for the period 2008-22 (this change from measured to projected emissions explains the kink in the graph at 2009 i.e. already the trajectory of emission reductions is too slow). The Plymouth corporate goal of a 20% reduction in carbon dioxide emissions by 2013, 60% by 2020 and 80% by 2080 (relative to 2005 levels) is shown in yellow. To meet any of these targets will require both the national policy to deliver expected carbon reductions, together with additional local action to reduce emissions further. The 60% target by 2020 would seem to be particularly challenging.

The projections in the LCTP are based on assumptions on level of economic growth, international fuel prices, population, and other factors. These assumptions are “agreed across government departments or based on official UK statistics”. The method employed in this report involves apportioning national carbon projections and savings to a local level, with the central assumption being that national growth and local growth (including areas adjacent to Plymouth such as Sherford) projections are similar. It can be seen that economic projections (employees and GVA) for Plymouth are similar to those nationally (Table 6). The population in Plymouth is projected to grow at a faster rate than nationally\(^{15}\). This is likely to mean that emissions from the residential sector and potentially other sectors such as transport and waste will be higher than estimated here, though it is not possible to quantify this.

| Table 6: Projected range of growth in population, employees and GVA from 2008-2022 for weak and central growth scenarios (Source: Oxford Economics\(^{16}\)) |
|---------------------------------|-----------------|-----------------|
| Plymouth                        | UK              |
| Population                      | 8-10%           | 5-7%            |
| Employees                       | 3-4%            | 2-5%            |
| GVA                             | 26-29%          | 27-31%          |

\(^{13}\) DECC 2009, The UK Low Carbon Transition Plan: National Strategy for Climate and Energy

\(^{14}\) The Governments recently published “Carbon Plan” describes the evolution of policy but neither it nor the quarterly updates give any new quantitative assessment of the carbon emission impact of policy.

\(^{15}\) Based on the projections from Table 6. The Plymouth LDF plans for 9,465 additional homes from 2006-16 and 7,674 from 2016-21 – a 16% increase compared to the 109,500 existing dwellings stated in the LDF. This compares to a projected 11% increase in population nationally based on data from the ONS (http://www.statistics.gov.uk/cci/nugget.asp?id=1352) which has been interpolated to obtain the projected increase from 2006-2021. Based on data from neighbourhood statistics (2009 data) there are 2.26 people/household in Plymouth and 2.28 in England i.e. very similar. The implication of this is that these estimates (LDF and ONS) predict more rapid population and household growth than the Oxford Economics projections, though in both cases growth in Plymouth are projected to be greater than nationally. The result of this is that both the BAU growth AND carbon savings for Plymouth would be greater than stated in this report, with the net effect being that emissions from the domestic (and other) sectors may be higher going forward. It is not possible to quantify this effect due to the way in which the LCTP projections have been modelled.

The policies within the LCTP document are divided into “baseline” (i.e. those that were in existence prior to the LCPT) and “LCTP” (i.e. those that were launched at around the time of the LCTP). Figure 35 shows a graph that aggregates all the policies in the LCTP by broad policy type. By far the largest two measures are due to a “greening” of the national electricity grid, and measures targeted at improving the energy efficiency of the existing dwelling stock. Together, these will account for almost half of all emission reduction in Plymouth. A further third of all reduction will come from the tightening of the Building Regulations, improved efficiency of new cars, improved efficiency of products (e.g. lights or white goods) and the reduction of carbon intensity of transport fuel through the use of biofuels.

Figure 35: Carbon reduction for the LCTP and baseline policies aggregated into broad categories
3.2. **DOMESTIC**

The list of measures within the LCTP aimed at the domestic sector together with the role Plymouth City council will be required to play is shown in Table 7 and Figure 36. The focus of these national initiatives aims to reduce emissions by:-

- Improving the energy efficiency of existing dwellings through improvements in insulation and heating systems, with additional focus on homes at risk of fuel poverty. It should be stated that the estimated savings that are emerging for the Green Deal are significantly lower than the savings from improvement to existing buildings used in the LCTP analysis, and therefore savings from national policy might be over-predicted here.
- National level policy aimed at the electricity sector
- Setting standards for the energy performance of newly constructed and refurbished dwellings
- Uptake of local renewable energy through energy cashback schemes
- Energy labelling of products and buildings

Plymouth City Council will need to play a strong role in the delivery of these national policies, particularly regarding efficiency improvements to existing dwellings, energy standards in new build (through enforcement of building regulations) and by coordinating the provision of district heating solutions to new build and adjacent existing buildings.

### Table 7: Overview of non-domestic policy measures in the LCTP

<table>
<thead>
<tr>
<th>National Policy Measure</th>
<th>Carbon Dioxide Reduction 2008-22 (ktCO2)</th>
<th>% of emission reduction within domestic sector</th>
<th>Potential local support/implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improving efficiency of existing homes (covers schemes such as CERT and CESP as well as developing policy from the Household Energy Management Strategy and the Green Deal which includes whole house packages and hard to treat properties)</td>
<td>658</td>
<td>36%</td>
<td>The LA will have a very strong role to play in delivering the rate of interventions required. There will be planning and promotion roles, as well as continued improvement to the social housing stock.</td>
</tr>
<tr>
<td>Large scale energy generation (The reduction in carbon intensity of UK electricity through increased large scale renewable energy, carbon capture and storage, and additional emissions directives for power stations)</td>
<td>475</td>
<td>26%</td>
<td>This policy is outside the influence of the LA</td>
</tr>
<tr>
<td>Building Regulations inc. Zero Carbon Homes (the incremental tightening of the Building Regulations in 2010, 2013 and 2016)</td>
<td>300</td>
<td>16%</td>
<td>The LA as both the planning authority has the potential to set requirements that go beyond the building regulations. In addition, in its role as Building Control Body the LA has an important role to play in enforcing the regulations to ensure that carbon reduction is realised. There will also likely be a strong coordinating role needed for district heating and energy solutions.</td>
</tr>
<tr>
<td>Products policy (European legislation to Ecolabel products and set minimum standards for the energy efficiency of products. UK government is supporting the development of these schemes, and in some cases pre-empting them (e.g. early phasing out of incandescent light bulbs)</td>
<td>203</td>
<td>11%</td>
<td>This measure will be delivered by market regulation and is outside the influence of the LA, though increasing the uptake of more efficient products could be promoted.</td>
</tr>
<tr>
<td>Policy</td>
<td>LA Influence</td>
<td>LA Support</td>
<td></td>
</tr>
<tr>
<td>---------------------------------------------</td>
<td>--------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>Warm front &amp; fuel poverty</strong> (improving the energy efficiency of building fabric and services for vulnerable households)</td>
<td>121</td>
<td>Very strong LA influence in delivering this measure both for social housing and housing in the private sector.</td>
<td></td>
</tr>
<tr>
<td><strong>Renewable Heat Incentive</strong> (the uptake of on-site renewable heat through the RHI scheme. As this will now be funded by Government rather than through heating bills, it is likely that the estimate here has over-stated the likely savings)</td>
<td>65</td>
<td>The LA could support the policy by installing renewable heating systems through its own estate, and promoting the policy more widely. The RHI can also support biomass district heating solutions.</td>
<td></td>
</tr>
<tr>
<td><strong>Feed-in tariff</strong> (energy cashback scheme aimed at the accredited installation of electricity generation on-site renewable technologies)</td>
<td>9</td>
<td>The LA could support the policy by installing renewable electricity systems through its own estate, and promoting the policy more widely.</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 36: Reduction of carbon dioxide emissions in the domestic sector due to national level policy from the LCTP**
3.3. NON-DOMESTIC

The list of measures within the LCTP aimed at the non-domestic sector together with the role Plymouth City council will be required to play is shown in Table 8 and Figure 37. The focus of these national initiatives aim to reduce emissions by:-

- National level policy aimed at the electricity sector
- Uptake of local renewable energy through energy cashback schemes
- Energy labelling of products and buildings
- Legislating emissions from the construction and refurbishment of buildings
- Carbon reduction agreements for energy intensive industry and carbon taxation for medium sized businesses
- Business advice and engagement

These measures are largely set at the national scale, for example almost half of emissions reduction in the non-domestic sector will be as a result of the “greening” of the electricity supply, which is something that will occur outside of Plymouth and beyond the influence of the LA. However, the authority could support some of the other measures through enforcement of building regulations, and increasing business engagement.

Table 8: Overview of non-domestic policy measures in the LCTP

<table>
<thead>
<tr>
<th>National Policy Measure</th>
<th>Carbon Dioxide Reduction 2008-22 (ktCO2)</th>
<th>% of emission reduction within non-domestic sector</th>
<th>Potential local support/implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Large scale energy generation</strong></td>
<td>705</td>
<td>46%</td>
<td>This policy is outside the influence of the LA</td>
</tr>
<tr>
<td>(The reduction in carbon intensity of UK electricity through increased large scale renewable energy, carbon capture and storage, and additional emissions directives for power stations)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Renewable Heat Incentive</strong></td>
<td>158</td>
<td>10%</td>
<td>The LA could support the policy by installing renewable heating systems through its own estate, and promoting the policy more widely. The RHI can also support biomass DH solutions.</td>
</tr>
<tr>
<td>(the uptake of on-site renewable heat through the RHI scheme. As this will now be funded by Government rather than through heating bills, it is likely that the estimate here has over-stated the likely savings)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Products policy</strong></td>
<td>145</td>
<td>10%</td>
<td>This measure will be delivered by market regulation and is outside the influence of the LA, though increasing the uptake of more efficient products could be promoted.</td>
</tr>
<tr>
<td>(European legislation to Ecolabel products and set minimum standards for the energy efficiency of products. UK government is supporting the development of these schemes, and in some cases pre-empting them (e.g. early phasing out of incandescent light bulbs)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Energy Intensive Energy (CCA)</strong></td>
<td>110</td>
<td>7%</td>
<td>Agreement with industry and Government, and therefore beyond the influence of LA</td>
</tr>
<tr>
<td>(Climate Change Agreements were established to mitigate the impact of the Climate Change Levy on the competitiveness of energy intensive industry, whilst also securing uptake of energy efficiency opportunities. CCAs are voluntary agreements between Government and industry that enable eligible energy intensive businesses to obtain an 80% discount from the CCL in return for meeting challenging, but cost effective, energy efficiency or carbon saving targets)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Policy Area</td>
<td>Percentage</td>
<td>LA Influence</td>
<td></td>
</tr>
<tr>
<td>------------------------------------------------------</td>
<td>------------</td>
<td>-----------------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>Building regulations</strong> (the incremental tightening of the Building Regulations in 2010, 2013, 2016 and 2019)</td>
<td>109 7%</td>
<td>The LA as both the planning authority has the potential to set requirements that go beyond the building regulations. In addition, in its role as Building Control Body the LA has an important role to play in enforcing the regulations to ensure that carbon reduction is realised. There will also likely be a strong coordinating role needed for district heating and energy solutions.</td>
<td></td>
</tr>
<tr>
<td><strong>Carbon reduction commitment</strong> (Mandatory scheme for half-hour metered organisations using over 6 MWh electricity to pay for their carbon emissions)</td>
<td>78 5%</td>
<td>Plymouth will be required to participate in the CRC and so this will likely drive additional carbon reduction measures that would now become viable. In addition, the LA could take a local coordinating/leadership/knowledge transfer coordination role with other participating businesses in Plymouth</td>
<td></td>
</tr>
<tr>
<td><strong>Public sector loans</strong> (The Salix revolving loan administered by the Carbon Trust is used to provide the capital to implement carbon reduction measures, with the savings due to lower bills being recycled into the scheme)</td>
<td>52 3%</td>
<td>Plymouth participates in the Salix scheme and can provide a local leadership and coordinating role with other public sector organisations in the city.</td>
<td></td>
</tr>
<tr>
<td><strong>Industrial emissions directive</strong> (EU’s Industrial Emissions (Integrated Pollution Prevention and Control) Directive, which will replace the regulatory framework established by the EU’s Large Combustion Plants Directive and sets stricter limits on the emissions of sulphur and nitrogen oxide)</td>
<td>47 3%</td>
<td>This is an international policy and is beyond the influence of the LA</td>
<td></td>
</tr>
<tr>
<td><strong>Carbon Trust measures</strong> (business advice and loans from the Carbon Trust to business and industry)</td>
<td>34 2%</td>
<td>The LA could play a signposting role to the services the Carbon Trust offers. In addition, there may well be greater potential for emission reduction through business engagement than has been assumed in the LCTP</td>
<td></td>
</tr>
<tr>
<td><strong>Smart meters</strong> (rolling out of smart meters)</td>
<td>34 2%</td>
<td>National measure, will happen through utility providers without need to LA support</td>
<td></td>
</tr>
<tr>
<td><strong>Climate Change Levy</strong> (tax on energy consumption, which is recycled back to businesses through reductions in national insurance and support for energy efficiency)</td>
<td>18 1%</td>
<td>No LA influence</td>
<td></td>
</tr>
<tr>
<td><strong>Feed-in tariff</strong> (energy cashback scheme aimed at the accredited installation of electricity generation on-site renewable technologies)</td>
<td>15 1%</td>
<td>The LA could support the policy by installing renewable electricity systems through its own estate, and promoting the policy more widely.</td>
<td></td>
</tr>
<tr>
<td><strong>Energy performance of buildings directive</strong> (the energy labelling of buildings, including expansion of the scheme to cover non-public sector buildings for DECs)</td>
<td>14 1%</td>
<td>Will happen without LA support. Policing of DECs is by Trading Standards, though at present there are concerns that the scheme is not being effectively enforced</td>
<td></td>
</tr>
</tbody>
</table>
Figure 37: Reduction of carbon dioxide emissions in the non-domestic sector due to national level policy from the LCTP
3.4. TRANSPORT

The key transport measures included in the baseline policy set and the full LCTP policy set used for predicting future transport emissions are shown in Table 9 below. The focus of these national initiatives aim to reduce emissions by:-

- technological improvements to road vehicles;
- use of biofuels in road and rail vehicles, and
- promoting more fuel-efficient driving techniques.

These measures are technology-focused, and therefore local authorities have little influence over them, being largely driven by fuel suppliers and vehicle manufacturers. However, the authority could support these measures through the introduction of new vehicles into their own fleets and working with other fleet operators to do the same. The potential influence over each measure is summarised in Table 10.

Local authorities do have considerable influence, as transport authorities, over encouraging modal shift and sustainable development. Such measures are captured to some degree within underlying policy affect on the traffic forecasts used for modelling the impact of the LCTP.

Table 10: Overview of transport measure in the LCTP

<table>
<thead>
<tr>
<th>National Policy Measure</th>
<th>Carbon Dioxide Reduction 2008-22 (ktCO2)</th>
<th>% of emission reduction within the transport sector</th>
<th>Potential local support/implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>The effect of the EU Voluntary Agreement target to reduce new car CO₂ emissions to 2009</td>
<td>243</td>
<td>35%</td>
<td>Policy operated through motor manufacturers. LA could support through increase proportion of new vehicles in own fleet and working with other business fleets.</td>
</tr>
<tr>
<td>Road Transport Fuel Obligation to introduce 5% biofuels by volume</td>
<td>162</td>
<td>23%</td>
<td>Policy operated through fuel suppliers. LA could support by promoting and supporting local fuel availability (e.g. Somerset bioethanol project)</td>
</tr>
<tr>
<td>Increase transport biofuel target from 5% by volume to 10% by energy</td>
<td>94</td>
<td>13%</td>
<td>Policy operated through fuel suppliers. LA could support by promoting and supporting local fuel availability (e.g. Somerset bioethanol project)</td>
</tr>
<tr>
<td>Interim EU Voluntary Agreement target to reduce new car CO₂ emissions to 130 g/km by 2015</td>
<td>61</td>
<td>9%</td>
<td>Policy operated through motor manufacturers. LA could support through increase proportion of new vehicles in own fleet and working with other business fleets.</td>
</tr>
<tr>
<td>EU regulation to reduce average new car CO₂ emissions to 95 g/km by 2020</td>
<td>47</td>
<td>8%</td>
<td>Policy operated through motor manufacturers. LA could support through increase proportion of new vehicles in own fleet and working with other business fleets.</td>
</tr>
<tr>
<td>A possible EU regulation to limit average CO₂ emissions from new vans</td>
<td>37</td>
<td>5%</td>
<td>Policy operated through motor manufacturers. LA could support through increase proportion of new vehicles in own fleet and working with other business fleets.</td>
</tr>
<tr>
<td>Complementary measures for cars (gear shift indicators, tyre pressure</td>
<td>15</td>
<td>2%</td>
<td>Policy operated through motor manufacturers. LA could support through</td>
</tr>
</tbody>
</table>
monitoring systems low viscosity lubricants, low rolling resistance tyres and more efficient air conditioning) increase proportion of new vehicles in own fleet and working with other business fleets.

<table>
<thead>
<tr>
<th>Policy</th>
<th>Result</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel duty escalator</td>
<td>7 1%</td>
<td>No influence by LA</td>
</tr>
<tr>
<td>Introduce bus driver training</td>
<td>6 1%</td>
<td>Policy aimed at bus operators, but strong role for LA’s to work with bus operators to ensure this happens.</td>
</tr>
<tr>
<td>Introduce low rolling resistance tyres for HGVs</td>
<td>3 0.5%</td>
<td>Aimed direct at HGV operators, maybe influence by LA’s through freight quality partnerships.</td>
</tr>
<tr>
<td>Introduce low carbon buses</td>
<td>3 0.5%</td>
<td>Policy aimed at bus operators, but strong role for LA’s to work with bus operators to ensure this happens.</td>
</tr>
</tbody>
</table>

The impact of the LCTP has been estimated in 2 ways: firstly using a top down approach where the national impact is scaled to the local level, and secondly by modelling the LCTP measures in our carbon model. When using the top down approach the 2007 base year is taken from national NI186 data. The results are shown in Figure 38 below and show two projections. The first is a projection with all national policy measures prior to the LCTP, the second projection includes the influence of the LCTP. The baseline projection suggests transport emissions in Plymouth will drop by 8% between 2007 and 2022 (the end of the current LCTP period). When the LCTP measures are included, this reduction increases to 24%.

![Figure 38: Top down project of transport CO₂ emissions with and without the LCTP](image)

The carbon model produces results for 4 target years: 2010, 2015, 2020 and 2025. The results of the model for these target years including the impact of the LCTP measures are shown in Figure 39 below. The carbon model, using local Plymouth data, has a lower 2007 baseline data point than the top-down approach as discussed above in Section 2. It shows a slightly lower impact from the LCTP, some 21.5% by 2025. However, both are showing a similar reduction trajectory, which gives us confidence in the modelled results.
The top down analysis using the LLAMA provides an estimate of the potential impact of each of the individual policy measures over the period 2008-2022, as has been shown above in the overview section covering all sectors. Figure 40 below provides a summary of the impact of just the transport measures. Some 60% of the expected savings are related to existing policies on vehicle CO₂ standards and biofuels, with a further 20% from tightening these policies.

---

39 "LCTP Local Authority Measures Analysis" CEE, 2010
3.5. **CARBON AND THE ECONOMY**

This section combines forecasts for Plymouth’s economy with projections for carbon emissions, with assumptions and definitions stated in Appendix 4. The overall trends for the Plymouth economy (Figure 41) suggest a steady rise in output (expressed as Gross Value Added – GVA) from the recessionary low in 2009. GVA recovers to 2008 levels in 2012 and by 2020 has grown by 31%. Employment grows much more slowly recovering to 2008 levels by 2014 and rising less than 3% by 2022. Labour productivity (GVA per employee) closely follows the pattern of GVA growth rising 27%. Carbon productivity (output in GVA per unit of carbon emission) rises strongly as LCTP measures reduce emissions across the City leading to a 73% increase by 2022. Labour carbon intensity (carbon emissions per employee) falls correspondingly to 73% of 2008 levels by 2022. Of possible concern is that the price of industrial energy is projected to increase by far more than either GVA or carbon productivity. This could indicate that the economy in Plymouth will become more vulnerable to the cost of energy, in spite of reducing energy consumption.

![Figure 41: Observed and projected trends for the Plymouth economy based on economic modelling by Oxford Economics, and the impact of national carbon policy from the LCTP, indexed against 2008](image)

The general trend of a steady rise in GVA hides a more diverse picture across sectors. Several sectors show a bounce back from the recession including shipbuilding, finance intermediation, business services and transport and communications. Shipbuilding exhibits strong growth from £279m in 2009 to £462m in 2022 a rise of 65%. Growth in finance intermediation, business services, and transport & communications are 60%, 53% and 49% over the same period. Other personal services (2%), public administration & defence (8%), non service sector excluding shipbuilding (16%) and education (16%) are the worst performing sectors.
Employment growth is mixed with rises in some sectors offset by falls in others. Employment in hotels and restaurants and business services grow by 15% from 2009 to 2022 (although the rise in business services only achieves a return to pre-recessionary levels). Transport & communications is the other sector to exhibit double digit growth (12%). Significant falls in employment are suggested in the non-service sector excluding shipbuilding (-29%) and shipbuilding (-19%).

Labour productivity increases across all sectors from 2009 to 2022 with an overall growth of 27%. Rises are particularly marked in shipbuilding (104%) the non-service sector excluding shipbuilding (62%) and financial intermediation (54%) as these sectors grow without a proportionate increase in employment. Low growth in labour
productivity is observed in other personal services (5%) and public administration and defence (5%).

Overall there is a 73% gain in carbon productivity from 2009 to 2022. Rises of over 100% occur in financial intermediation (145%), business services (133%), Transport & communications (127%), hotels & restaurants (117%) and distribution & retail (105%). The smallest gains are in the non-service sector excluding shipbuilding (35%), construction (50%) and public administration & defence (53%). For all but the financial intermediation and business services sectors the increase in carbon productivity is significantly lower than the projected increase in the cost of energy, indicating that most non-domestic sectors could become increasingly vulnerable to increases in the cost of energy. The manufacturing sector in particular would seem to be the most vulnerable, indicating that in spite of energy reduction due to national carbon reduction policies, the manufacturing sector may need to reduce energy consumption further in order to maintain competitiveness.
Labour carbon intensity from 2009 to 2022 changes most in hotels & restaurants and business services (both -43%). Intensity is also significantly reduced in transport & communications (-42%), distribution & retail (-39%). Intensity increases in the non service sector excluding shipbuilding (20%) and shipbuilding (5%). All other sectors show declines of between -17% (construction) and – 37% (financial intermediation).
3.6. **KEY IMPACTS OF NATIONAL POLICY**

In 2005 Plymouths CO$_2$ footprint is estimated at 1,477 kt CO$_2$. National policy measures are expected to reduce these emissions over the period to 2022. By 2013 emissions are estimated to be 14% lower and by 2020 28% lower. Plymouth’s carbon reduction aspirations are for a 20% reduction by 2013 and a 60% reduction by 2020. These are significantly higher than national policy is expected to achieve and so extensive local activity will be needed if Plymouth is to achieve these aspirations.

The national policy measures that will have the most impact in Plymouth are renewable energy in the national generating mix and home energy efficiency improvement measures. The improvements in the generating mix will affect emissions from all sectors and there will be a limited role for Plymouth to play, apart from supporting planning application for any large scale renewable energy projects in its area. Home energy efficiency improvements will clearly be a major element of reducing emissions in the domestic sector and one where the local authority can have a significant influence, although savings from the Green Deal may not be as high as savings originally forecast at the time of the LCTP.

Other important areas are the products policy, vehicle emission standards, renewable transport fuels and the RHI. The products policy on improving the efficiency of appliances will have a particular impact in the commercial sector in terms of lighting and appliances. This will also be the case for the RHI since heat production is a major source of emissions in the commercial sector. Vehicle efficiency standards and renewable transport fuels will be the driving factors in transport emissions. Plymouth can support the development of these lower emission vehicles by working with their own and local business fleets.

In terms of the wider Plymouth economy this will be expected to grow going forward to 2020. However, with carbon emissions potentially falling this means that the carbon intensity of production will drop. This will be more marked in the service sector, where improvements in emissions are greater, than in the industrial sector. However, energy prices are likely to rise faster than efficiency improvements and so energy cost and security will still be a major business concern, especially in the industrial sector.
4. **Assessment of Local Action**

This section provides an assessment of local action both in terms of supporting national measures, and identifying local actions that could result in additional carbon benefits. Each of the three sectors is discussed below to examine the potential for local action and where best to potentially focus effort.

4.1. **Domestic**

As outlined in Section 3 the savings made as a result of the policies outlined in the LCTP estimate that the domestic sector in Plymouth can make savings of 1,831 ktCO₂ between 2008 and 2022. To re-cap, these savings are predicted to come from the following policy areas shown in Table 11.

| Table 11: Overview of domestic policy measures in LCTP |
|------------|-----------------|----------|------------------|
| Policy measure | CO₂ reduction 2008-22 (ktCO₂) | % of emission reduction | Potential for local authority intervention |
| 1            | Improving efficiency of existing homes | 658 | 36% | Strong |
| 2            | Large scale energy generation | 475 | 26% | None |
| 3            | Building Regulations inc. Zero Carbon Homes | 300 | 16% | Moderate |
| 4            | Products Policy | 203 | 11% | Weak |
| 5            | Warm Front and Fuel Poverty | 121 | 7% | Strong |
| 6            | Renewable Heat Incentive | 65 | 4% | Moderate |
| 7            | Feed-in-tariff | 9 | 1% | Moderate |

This section examines the feasibility of these savings and where local policy could support and enhance national measures. Policy Measure 1, improving efficiency of existing homes, is discussed in detail as this is the area likely to bring about the greatest CO₂ savings and is an area where the council could have a significant influence. Measure 2 is not considered within the scope of this section, and there is some brief discussion of the remaining five policy areas.

4.1.1. **Improving the Energy Efficiency of Existing Homes**

The largest CO₂ reductions are predicted to come from improving the energy efficiency of existing housing stock, with savings amounting to 658 ktCO₂. A range of calculations have been carried out using the Energy Saving Trust’s Carbon Calculator Tool to assess potential savings from a range of energy efficiency measures. The calculator allows the user to enter information about their house (e.g. fuel type, number of bedrooms, house type) and then presents the possible savings against each measure. These savings are based on typical patterns of energy consumption.

4.1.1.1. **Unfilled Cavity Walls and Lofts**

The easiest win in terms of cutting carbon emissions in the short term, at the least expense, is almost certainly continuing to target homes with unfilled cavities and unfilled or partially filled lofts.

A range of potential domestic energy efficiency scenarios are shown in Appendix 2 based on the Energy Saving Trust Carbon Calculator Tool that could be achieved from insulating different percentages of suitable remaining houses. In the Green Deal information published by the Government it predicts that all suitable properties with empty lofts and cavities will be insulated by 2015. As discussed in further detail below, insulating 100% of all potential properties is extremely unlikely, therefore each of the three Scenarios in the table is broken down into 100%, 75% or 50% of suitable properties being insulated.

In order to calculate the potential savings, data from the House Condition Study 2010 on the proportion of different housing types, was used to put into the Energy Saving Trust model to give a more accurate idea of the savings (e.g. 29.8% of houses were entered as being semi-detached, 35.7% mid-terrace, 2% end-terrace etc.). In order to calculate the cumulative savings between 2008 and 2022 it was necessary to assume the rate at which insulation is installed. It was assumed that the rate of installations would tail off gradually as illustrated directly below the table in Figure 47.
Table 13: Estimate of insulation installs in Plymouth 2007-2022 (Source: Data from Plymouth Home Energy Team Survey 2005, Energy Saving Trust and Cosy Devon)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>% of remaining suitable properties insulated</th>
<th>Cavity Wall Insulation</th>
<th>Virgin Loft Insulation</th>
<th>Top-up loft insulation</th>
<th>TOTAL CO\textsubscript{2} savings (kt) per annum in 2022</th>
<th>Cumulative savings 2008-2022 ktCO\textsubscript{2}</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>100%</td>
<td>30000</td>
<td>18.8</td>
<td>12000</td>
<td>13.5</td>
<td>25800</td>
</tr>
<tr>
<td>b</td>
<td>75%</td>
<td>22500</td>
<td>11.8</td>
<td>9000</td>
<td>8.5</td>
<td>19350</td>
</tr>
<tr>
<td>c</td>
<td>50%</td>
<td>15000</td>
<td>9.4</td>
<td>6000</td>
<td>6.8</td>
<td>12900</td>
</tr>
</tbody>
</table>

\(\textit{a}) \) These figures were estimated using data from the Cosy Devon scheme, which suggests that for every virgin loft that is insulated 2.15 partially filled lofts are insulated. This allows a crude estimate of the number of partially filled lofts remaining.

As shown in Table 13, insulating 100\% of remaining lofts and cavities could save approximately 459 ktCO\textsubscript{2} in the period 2008-2022, based on the rate of installs shown in Figure 47. This results in annual savings of 40.6 ktCO\textsubscript{2} in 2022 from the baseline year of 2007.

Insulating 100\% of suitable properties is highly unlikely however, even when an area of housing is intensely targeted with a door-to-door campaign. Possibly the most cited example of a campaign like this is Kirklees in North-East England, where the local authority spent £20 million pounds on a campaign offering free loft and cavity wall insulation to all private-sector residents. The council estimated that of 125,000 private-sector properties in the area, approximately 90,000 would be suitable for loft and cavity measures. All houses in the area were visited up to three times and a total of just over 50,000 households took up the free offer. Whilst this campaign was one of the most successful of its kind in the country, it demonstrates that even with a highly intensive door-to-door approach, and multi-million pound budget it is simply not possible to reach everyone.

Based on these findings it would be unrealistic to assume that all of Plymouth’s lofts and cavities could be insulated by 2022. Therefore a more realistic estimate of potential savings is likely to be based on insulating 50-75\% of remaining properties. This would suggest possible annual savings of 20.4 ktCO\textsubscript{2} to 26.5 ktCO\textsubscript{2} and cumulative carbon savings of between 231 and 300 ktCO\textsubscript{2} by 2022. This would still require a significant amount of intervention from Plymouth City Council to ensure uptake of measures and probably millions of pounds worth of support.

If we assume the current Cosy Devon scheme offer prices of £149 per insulation measure then to achieve the above savings of between 50\% and 75\% of remaining properties would cost between 5.1 and 7.6 million pounds (this is for the measures alone and does not include the costs of managing and marketing the scheme, which become more and more costly as the number of empty cavities diminishes). This would result in annual costs of between £248 and £286 per tonne of CO\textsubscript{2}.

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Insulating 100\% of suitable properties is highly unlikely however, even when an area of housing is intensely targeted with a door-to-door campaign. Possibly the most cited example of a campaign like this is Kirklees in North-East England, where the local authority spent £20 million pounds on a campaign offering free loft and cavity wall insulation to all private-sector residents. The council estimated that of 125,000 private-sector properties in the area, approximately 90,000 would be suitable for loft and cavity measures. All houses in the area were visited up to three times and a total of just over 50,000 households took up the free offer. Whilst this campaign was one of the most successful of its kind in the country, it demonstrates that even with a highly intensive door-to-door approach, and multi-million pound budget it is simply not possible to reach everyone.

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As discussed in Section 2 it is likely that the vast majority of homes in the private rented sector would benefit from cavity wall insulation or loft insulation. Therefore targeting landlords and tenants with specific marketing and (if finances were available) a grant offer, would be of benefit. Using HMO licensing could provide a mechanism for effecting change in the private rented housing stock. The information published by the Government to date on the Green Deal strongly suggests that landlords will be legally required to ensure that their properties are insulated. However, it is not yet clear how this requirement will be enforced.

“We intend to enable local authorities to insist landlords of the worst performing properties make all energy efficiency improvements for which there is financial support available, such as Green Deal or ECO. Our intention is that this local authority action would be focussed on landlords owning properties with an EPC rating of F or G.”\(^{18}\)

### 4.1.1.2. Upgrading Boilers

Table 12 shows the possible savings made from upgrading boilers in Plymouth between 2011 and 2022. The estimated proportions of different boiler types in 2010 and 2020 were provided by the Heating and Hot Water Industry Council. The assumptions used to calculate the figures are added as footnotes below the table.

**Table 12: Estimate in boiler upgrades in Plymouth 2010-2020 (Source: Data from HHIC and DECC and Energy Saving Trust)**

<table>
<thead>
<tr>
<th>Boiler Band</th>
<th>% of gas boilers with this rating 2010</th>
<th>Estimated no. of gas boilers in Plymouth 2010</th>
<th>% of gas boilers with this rating 2020</th>
<th>Estimated no. gas boilers in Plymouth 2020</th>
<th>Change in no. of boilers 2011-2020</th>
<th>No. of boilers changed A-rated annually</th>
<th>No. of boilers changed B-rated annually</th>
<th>Annual savings (ktCO(_2) per annum)</th>
<th>Total annual savings by 2022 (ktCO(_2))</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>30.3</td>
<td>30,672</td>
<td>64</td>
<td>71,885</td>
<td>41,213</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>8.8</td>
<td>8,908</td>
<td>19</td>
<td>21,341</td>
<td>12,433</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>0.3</td>
<td>304</td>
<td>0</td>
<td>0</td>
<td>-304</td>
<td>21</td>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>22.2</td>
<td>22,472</td>
<td>7</td>
<td>7,862</td>
<td>-</td>
<td>1023</td>
<td>438</td>
<td>0.72</td>
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</tr>
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<td></td>
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<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>12.9</td>
<td>13,058</td>
<td>3</td>
<td>3,370</td>
<td>-9688</td>
<td>678</td>
<td>291</td>
<td>0.47</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>8.5</td>
<td>8,604</td>
<td>3</td>
<td>3,370</td>
<td>-5,234</td>
<td>366</td>
<td>157</td>
<td>0.36</td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>17.0</td>
<td>17,209</td>
<td>5</td>
<td>5,616</td>
<td>-</td>
<td>812</td>
<td>348</td>
<td>1.26</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>101,228</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.81</td>
</tr>
<tr>
<td></td>
<td></td>
<td>112,321</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>28.1</td>
</tr>
</tbody>
</table>

* a) This total figure comes from the DECC NI186 figures for the number of domestic gas connections
* b) This figure includes the extra 11,093 homes estimated to be built in the Plymouth Delivery database between 2008 and 2022. It is assumed that all of the 11,093 will have an A-rated boiler installed. However no savings are assumed from these new houses, only from the old boilers in existing houses that are upgraded.
* c and d) Data from HHIC on estimated percentages of different boiler grades in 2020 suggest that approximately 77% of boiler replacements will be for A-rated boilers and 23% will be for B-rated boilers. It has been assumed that an equal number of boiler upgrades have taken place in each of the years between 2011 and 2020 (i.e. 10% a year at a 70:30, A:B ratio).
* e) The carbon savings are based on figures from the Energy Saving Trust for upgrading a boiler to an A-rated boiler from G (1.1 tonnes), F (0.7 tonnes), E (0.5 tonnes), D (0.3 tonnes). 5% was reduced from these figures to give an approximate saving for upgrading to a B-rated boiler.
* f) Figures on the carbon savings made from upgrading a C-rated boiler were not available, but given the small number and the small improvement in efficiency of this measure, the savings were assumed to be negligible.

Assuming that of all the boiler replacements between 2011 and 2020, 10% take place each year, then the estimated annual carbon savings are 2.81kt CO\(_2\) a year and a total of 28.1kt CO\(_2\) by 2022. This calculation assumes that an equal number of boilers are upgraded every year, and the total annual savings have been added together for every year to give a cumulative saving. This gives a cumulative saving of 138.9 ktCO\(_2\) between 2011 and 2020. If similar annual carbon savings of approximately 2.81 ktCO\(_2\) are assumed for the four years between 2007-2010 before the HHIC data begins, (but no extra upgrades after 2020 when the upgrades will be tailing off) then total cumulative carbon savings from replacing gas boilers can be estimated at 320 ktCO\(_2\) and the annual carbon savings as 39.3.

\(^{18}\) The Green Deal: A Summary of the Government’s Proposals, DECC.
What the above figures highlight very clearly is that carbon savings made earlier will create much greater total cumulative carbon savings by 2020. With only four extra years of carbon savings of 2.5 ktCO$_2$, the cumulative total more than doubles. This demonstrates the importance of saving carbon as early as possible in order to benefit from the lifetime savings of the measure. It is worth stressing that these calculations are fairly crude as they do not take into account the efficiency of the building and they assume a standard pattern of use, and they also apply national figures to Plymouth. Also, as the insulation levels of Plymouth homes improve, the savings made from upgrading a boiler are reduced; therefore the total potential savings above will be less. The figures also only include the upgrade of gas boilers, and do not take into account other heating systems. The potential savings from fuel switching from off-gas properties are discussed in Section 4.1.1.5.

4.1.1.3. SOLID WALL INSULATION

Combining the potential savings from CWI and loft insulation and boiler upgrades gives a total saving of between 551 and 620 kt CO$_2$ between 2008 and 2022, depending on the loft and cavity scenario taken. This leaves a shortfall of between 38 and 107 ktCO$_2$ to be found from other measures. Energy efficient lighting and appliances, replacing electric heating with gas or lower carbon fuels, and behaviour change will provide some savings, as discussed in the following sub-sections, but further savings will probably need to be found from solid wall insulation. Table 13 illustrates the savings made from adding external solid wall insulation to a range of housing types.

The solid wall insulation industry is very much in its infancy (apart from social housing which has seen a large number of installations nationwide in recent years, including whole estates and tower blocks). For individual private-sector homes there have only been a handful of known installations in Plymouth, most of which took place through the Plymouth Solid Wall Insulation pilot scheme managed by Plymouth City Council, which treated 15 homes in the city in 2010-11.

Table 13: Estimated CO$_2$ savings from different house types

<table>
<thead>
<tr>
<th>House type</th>
<th>Savings from adding solid wall insulation (kgCO$_2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 bed semi-detached</td>
<td>2,525</td>
</tr>
<tr>
<td>3 bed mid-terrace</td>
<td>1,325</td>
</tr>
<tr>
<td>3 bed end-terrace</td>
<td>2,410</td>
</tr>
<tr>
<td>3 bed detached</td>
<td>4,007</td>
</tr>
<tr>
<td>3 bed detached bungalow</td>
<td>2,147</td>
</tr>
<tr>
<td>3 bed semi-detached bungalow</td>
<td>1,761</td>
</tr>
<tr>
<td>2 bed flat – 2 walls exposed</td>
<td>8,82</td>
</tr>
<tr>
<td>2 bed flat – 3 walls exposed</td>
<td>1,447</td>
</tr>
</tbody>
</table>

Using the same method of calculating potential carbon savings and cumulative carbon savings as for cavity wall insulation, Table 14 shows possible savings from solid wall insulation for different numbers of housing, including savings for if all 23,443 houses were insulated. The savings follow 3 different trajectories. All assume that solid wall insulation installations begin in 2013 following the start of the Green Deal finance packages. Scenario 1 assumes as slow build up of solid wall installations (Figure 48), Scenario 2 assumes a moderate increase in installs per year (Figure 49) and Scenario 3 is the most rapid of the three (Figure 50).
Figure 48: Solid wall insulation Scenario 1 – slow growth

Figure 49: Solid wall insulation Scenario 2 – moderate growth
Table 14 illustrates how depending on the number of houses to be insulated, rapid adoption of solid wall insulation could lead to up to around 50% more cumulative CO\textsubscript{2} savings than slow growth. If all 23,443 homes with solid walls in Plymouth were insulated it would create significant carbon savings of 45.3 tonnes a year by 2022 and between 148.7 and 225.1 ktCO\textsubscript{2} in total over the period 2008 and 2022 depending on the rate at which the measures are installed. Even insulating 10,000 would be very ambitious considering the complexity of the technology compared to cavity wall insulation, the fact that it is unknown, expensive and disruptive (particularly internal insulation). Plymouth Community Homes plan to externally clad approximately 4,500 of their properties over the next 30 years, therefore 10,000 homes across all housing providers and tenures may be attainable – though highly challenging.

Based on current prices solid wall insulation costs approximately £6000 per tonne of carbon saved (compared to around £250 for loft or cavity wall measures), and is therefore a very expensive method of reducing emissions. However, due to the decline in available cavities and the high percentage of solid wall properties in Plymouth and rising fuel prices, solid wall insulation will need to be part of the mix of measures included up to 2022. To maximise CO\textsubscript{2} savings Plymouth City Council could use the available data and information on hard to treat index data to prioritise off-gas and solid wall properties.

### 4.1.1.4. Energy Efficient Lighting and Appliances

The carbon savings made through more efficient lighting and appliances could be considered as partly contributing towards the “improving efficiency of existing homes” policy area. This measure has been considered included in Section 4.1.3 “Product Policy”.

### 4.1.1.5. Fuel Availability and Fuel Switching

The relative supply of grid energy to a home will have a very significant impact on its relative emissions. The most
emissions intensive heating is electric heating emitting 0.541kgCO₂/kWh. Mains gas emits 0.190kgCO₂/kWh, fuel oil emits 0.266kgCO₂/kWh, Liquid Petroleum gas 0.214kgCO₂/kWh and wood pellets 0.0026 kgCO₂/kWh.

Table 15: Fuels use for space heating

<table>
<thead>
<tr>
<th>Fuel source</th>
<th>Consumption for heating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric</td>
<td></td>
</tr>
<tr>
<td>Standard</td>
<td>14,000</td>
</tr>
<tr>
<td>Economy 7</td>
<td>92,400</td>
</tr>
<tr>
<td>Gas</td>
<td>1,650</td>
</tr>
<tr>
<td>Other fuel</td>
<td></td>
</tr>
</tbody>
</table>

Table 16: Fuel source for hot water heating.

<table>
<thead>
<tr>
<th>Electric</th>
<th>Gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central heating connected to hot water cylinder</td>
<td>Combi Boiler</td>
</tr>
<tr>
<td>Number of homes</td>
<td></td>
</tr>
<tr>
<td>18,700 (17%)</td>
<td>46,200 (42%)</td>
</tr>
<tr>
<td></td>
<td>45,100 (42%)</td>
</tr>
</tbody>
</table>

Typical consumption in the home for hot water accounts for approximately 20% of energy use or 4,316kWh based on average domestic consumption. This equates to 474.8 GWh per annum. The electrically heated element of this consumption would be almost half of the total emissions attributable to water heating. The number of potential solar water systems was estimated to be 48,700 in the 2005 survey. This and fuel switching for water heating are discussed elsewhere in this report.
### 4.1.1.6. BEHAVIOURAL CHANGE, ENERGY ADVICE AND MARKETING

Often referred to as the “low-cost, no-cost” measures, even subtle changes in behaviour can have highly significant effects on consumption. It is fair to postulate that behavioural differences and different patterns of building occupancy even within identical buildings, with the same heating system and appliances, can exhibit significant differences in consumption patterns and therefore emissions.

**Table 17: Some illustrative savings through behaviour change**

<table>
<thead>
<tr>
<th>Measure</th>
<th>Energy Saving Net of comfort (kWh)</th>
<th>Financial Saving (£/yr)</th>
<th>Carbon Saving (kgCO₂/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turning Heating Down 1DegC</td>
<td>1,378</td>
<td>£57</td>
<td>268</td>
</tr>
<tr>
<td>Switching off un-needed lights</td>
<td>15</td>
<td>£8</td>
<td>20</td>
</tr>
<tr>
<td>Only put in as much water as you need when boiling the kettle</td>
<td>51</td>
<td>£7</td>
<td>22</td>
</tr>
</tbody>
</table>

Using the 2009 Defra survey as a guide the shifting changes to more energy awareness in the home suggest that most people are aware of the impact of their behaviour on energy consumption and are taking positive steps to reduce usage. However, there is still some mileage in the possible contribution of behaviour change to emissions reduction. If every resident in Plymouth was to adopt two of the three measures in Table 17 they would contribute:

- Turning Heating Down 1°C: 2.94 kt CO₂
- Only boiling as much water as you need: 0.7 kt CO₂

This illustrates such low-cost measures can be effective in tackling the overall sum of emissions from the domestic sector.

**Table 18: Cutting down on energy use – stages of change response scale**

<table>
<thead>
<tr>
<th>Stage</th>
<th>Pre-contemplation</th>
<th>Rejection</th>
<th>Contemplation</th>
<th>Maintenance</th>
<th>Relapse</th>
<th>Unclassified*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Only boiling the kettle with as much water as you need</td>
<td>6</td>
<td>4</td>
<td>2</td>
<td>84</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Washing clothes at 40 degrees or less</td>
<td>6</td>
<td>3</td>
<td>4</td>
<td>77</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>Cutting down on the use of gas and electricity at home</td>
<td>6</td>
<td>4</td>
<td>7</td>
<td>76</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Turning down thermostats (by 1 degree or more)</td>
<td>10</td>
<td>8</td>
<td>8</td>
<td>66</td>
<td>-</td>
<td>8</td>
</tr>
<tr>
<td>Cutting down on the use of hot water at home</td>
<td>16</td>
<td>9</td>
<td>6</td>
<td>64</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>

*Base: All respondents (2,009)

According to Ofgem\(^{19}\), despite the increase in energy efficient appliances and lighting in recent years, household electricity consumption has remained static. The main reason for this is most probably the increase in the number and usage of electrical appliances owned by households.

Given this finding, estimating what potential carbon savings may result from behaviour change up to 2022 would be extremely difficult to do with any degree of accuracy.

### 4.1.2. BUILDING REGULATIONS INCLUDING ZERO CARBON HOMES

In 2007 the Government announced that all homes should be zero carbon by 2016. The policy is being implemented through the sequential tightening of building regulations. In October 2010 new homes are required to reduce CO₂

\(^{19}\) Ofgem Factsheet 96, www.ofgem.gov.uk
emissions by 25% from 2006 levels with further tightening to a 44% reduction in 2013 and “zero carbon” homes in 2016.

While the definition of “zero carbon” has not been finalised it is anticipated that “zero carbon” will not be net zero carbon on site but will reduced emissions through a combination of on-site measures, connected heat and allowable solutions.

Overall, while low and “zero carbon” new homes will reduce emissions from a baseline forecast (as in the LCTP projections), new homes built to national policy requirements between 2011 and 2022 will add to Plymouth’s carbon emissions rather than contribute to a reduction against a 2005 baseline.

Housing provision figure in the city’s Core Strategy\(^\text{20}\) suggest that 13,300 homes will be build in the period 2006 to 2016 (1,330 per year) and 7,700 homes (1,540 per year) in the period 2016 to 2021. If it is assumed that a typical new 2006 home emits regulated and unregulated emissions of 1.4 tonnes per annum each (total emission 2.8 tonnes), the following incremental CO\(_2\) emissions can be anticipated:

\[
\text{Table 19: Estimated incremental CO}_2\text{ emissions from new homes in Plymouth from 2008 to 2020}
\]

<table>
<thead>
<tr>
<th>Period</th>
<th>2008 - 2010</th>
<th>2010 - 2013</th>
<th>2013 - 2016</th>
<th>2016 to 2020</th>
<th>Total over period</th>
<th>Annual Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of homes in period</td>
<td>2,660</td>
<td>3,990</td>
<td>3,990</td>
<td>6,160</td>
<td>16,800</td>
<td>1,400</td>
</tr>
<tr>
<td>Regulated emissions reduction*</td>
<td>none</td>
<td>25%</td>
<td>40%</td>
<td>100%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regulated emissions t CO(_2)pa</td>
<td>3,742</td>
<td>4,190</td>
<td>3,128</td>
<td>0</td>
<td>11,042</td>
<td>920</td>
</tr>
<tr>
<td>Appliance emissions t CO(_2)pa</td>
<td>3,742</td>
<td>5,586</td>
<td>5,586</td>
<td>8,624</td>
<td>23,520</td>
<td>1,960</td>
</tr>
<tr>
<td>Total emissions t CO(_2)pa</td>
<td>7,448</td>
<td>9,776</td>
<td>8,714</td>
<td>8,624</td>
<td>34,562</td>
<td>2,880</td>
</tr>
</tbody>
</table>

* assumes that the definition of zero carbon does not require any reduction in appliance emissions

Average estimated annual incremental emissions from new homes over the period 2008 – 2020 of some 2.9kt CO\(_2\) per annum represents 0.6% of current domestic emissions.

However, local policies which accelerate the delivery of low and zero carbon homes deliver additional carbon savings although the short term carbon impact of these policies would be relatively small. Government has generally discouraged local policies which accelerate the national timetable unless this can be supported by strong local evidence (for example unique local circumstances that give access to low carbon energy).

Plymouth has developed substantial evidence for establishing district heating networks in the Derriford and City Centre areas (see Section 4.2.2). However, the timetable for these systems is unlikely to achieve significant additional CO\(_2\) reductions beyond the national tightening of building regulations. The impact of district heating networks is more likely to be economic; areas which provide low carbon energy infrastructure (such as district heating) that make the delivery of low and zero carbon homes more affordable for developers will attract more new development than those without. District heating systems provided for new development can also be connected to local existing buildings in order to cut existing emissions.

A holistic approach to the planning areas of new housing is being adopted in Plymouth as part of its Area Action plans. The inclusion of sustainable transport considerations in these plans is an important part of enabling new development in Plymouth to limit its incremental contribution to carbon emissions.

\(\text{Page 90 of “Adopted Core Strategy” PCC, 2007}\)
4.1.3. PRODUCTS POLICY

4.1.3.1. ENERGY EFFICIENT LIGHTING

Lighting is calculated as contributing approximately 20%\(^\text{21}\) of the overall electricity consumption of homes. Using the 2007 domestic electricity consumption value of 446.5 GWh it can be estimated that lighting from domestic properties in Plymouth contributes 89.3 GWh consumption and 48.31 kt of CO\(_2\) per annum.

The latest survey data carried out by Defra on energy efficient lighting indicates a mean average for the total number of light bulbs per home was estimated to be 20 per home which is consistent with research carried out by the Energy Saving Trust in February 2008 (which indicated a mean number of 19 light bulbs per home). In 2007 the equivalent figure was reported as 4 energy saving light bulbs per home, increasing to a reported 7 per home in February 2008 (and 39% of all bulbs).

Comparisons with research carried out by the Energy Saving Trust in February 2008 and the 2007 Defra survey data indicate that the average proportion of energy saving light bulbs in people’s homes is increasing. The mean number of energy saving light bulbs per home was just over half this number (12) indicating that in an average home around 60% of the light bulbs were energy saving light bulbs.

<table>
<thead>
<tr>
<th>Table 20: Energy saving light bulbs in the home – trend series</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Defra 2009</strong></td>
</tr>
<tr>
<td>Mean number of energy saving light bulbs in the home</td>
</tr>
<tr>
<td>Proportion of light bulbs in the home which are energy saving</td>
</tr>
</tbody>
</table>

On the basis of that the electricity consumption of Plymouth was 446.5 GWh in 2007 low energy light bulbs can be assumed to be making a saving over the relative proportion of contribution to 2005 electricity consumption figures. The Energy Saving Trust quotes a CFL as saving\(^\text{22}\) 8 kg CO\(_2\) and 8 kWh per annum, giving a total of 4.3 kg CO\(_2\) per bulb.

On that basis in 2007 low energy lighting can be estimated as already saving 32 kWh and 17.31 kg CO\(_2\) per dwelling and 1.9 GWh total across the city. With savings rising to 56 kWh and 30.3 kg CO\(_2\) per home in 2008 this would have added an additional net saving of 13.0 kg CO\(_2\) per dwelling to the 2007 total. This would result in a saving of 6.2 GWh off the gross domestic electricity consumption in the city and a further reduction in emissions from domestic lighting off the 2007 consumption figure of 3.3 kt CO\(_2\).

With the national data suggesting the proportion of domestic lighting had risen again in 2009 to 60% low energy lighting the total savings (from 66,000 homes, 96 kWh and 51.9 kg CO\(_2\) per home) can be calculated at 10.8 GWh and 5.7 kt CO\(_2\) representing a total reduction in the contribution of the proportion of electricity demand from lighting (using the 2007) baseline as 8.7 GWh and a reduction in emissions from 2.3 kt CO\(_2\).

If the national survey findings on the distribution of lighting are taken as an authoritative guide then a possible 100% of all lighting fittings could be achieved. Given that even with a range of regulatory manufacturing and consumer legislation 95% is still very challenging, the potential savings per household based on the current carbon intensity of the grid are estimated as 152 kWh (19 out of 20 bulbs) and 82.2 kg CO\(_2\) per annum per household. This suggests that low energy lighting could contribute an additional contribution to savings above the savings already calculated to 2009 of 56 kWh and 30.3 kg CO\(_2\) per home. The total available savings on the basis of these assumptions is 6.16 GWh and 3.33 kt CO\(_2\). Over the period considered, it is also likely that LED lighting will begin to make significant savings in the domestic sector.


\(^{22}\) ‘CFL’s’ - saving per bulb. Average across all brightnesses and fittings in the home.
4.1.3.2. ENERGY EFFICIENT APPLIANCES

Energy Saving Trust estimates for appliance savings are reflected in Table 21.

Table 21: Annual savings from appliances

<table>
<thead>
<tr>
<th>Annual Savings*</th>
<th>Energy Saving</th>
<th>Financial</th>
<th>Carbon Saving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net of comfort (kWh)</td>
<td>Saving (£/yr)</td>
<td>kgC/yr</td>
<td>kgCO₂/yr</td>
</tr>
<tr>
<td>Refrigerator/fridge</td>
<td>45</td>
<td>£13</td>
<td>10</td>
</tr>
<tr>
<td>Fridge Freezer</td>
<td>132</td>
<td>£39</td>
<td>30</td>
</tr>
<tr>
<td>Freezer</td>
<td>79</td>
<td>£23</td>
<td>18</td>
</tr>
<tr>
<td>Washing Machine</td>
<td>78</td>
<td>£11</td>
<td>9</td>
</tr>
<tr>
<td>Dishwasher</td>
<td>158</td>
<td>£23</td>
<td>19</td>
</tr>
<tr>
<td>CFLs</td>
<td>8.0</td>
<td>£3</td>
<td>2</td>
</tr>
</tbody>
</table>

*The appliance savings based on replacing a 10 year old model with an equivalent Energy Saving Recommended model.

Estimates of the current distribution of A-rated appliances in homes are extremely difficult to arrive at. Previous estimates in similar studies (University of Exeter, 2007) correlated average appliance efficiency with the distribution of energy efficient lighting. However, given the large scale distribution of CFLs under CERT and the relatively high expenditure related to appliances the rate of conversion is likely to be significantly lower. If it is assumed that at least 70% of homes (77,000) are yet to convert to energy efficient appliances then the saving per household can be estimated as 368 kWh per annum. This suggests that there is scope for 199 kgCO₂ per annum savings per household and a total energy saving of 28.3 GWh and 15.3 ktCO₂ through energy efficient appliances.

4.1.4. WARM FRONT AND FUEL POVERTY

If a household needs to spend more than 10% of its income on home energy it is assessed to be ‘fuel poor’. The latest evidence available suggests that whilst many measures have been taken to address fuel poverty numbers of households in this situation are rising in the face of increased burden from energy costs.

Fuel poverty is also often linked to housing type with solid walls, no or poor levels of insulation and expensive and relatively inefficient forms of heating. Some findings from Plymouth City Councils 2005 energy survey suggest that:

- 33,400 (33%) of households are in receipt of benefit (23% of homeowners; 63% of council tenants; 82% of RSL tenants; 22% of private tenants)
- 6,270 (19%) of households on benefit have electric or coal heating
- 5,180 (16%) of households on benefit pay for fuel by prepayment meter; 11,540 (35%) pay by cash, cheque or budget plan; 14,670 (44%) pay by direct debit (compared to 57% of all households)
- 2,652 (8%) households on benefits pay for fuel by prepayment meter and do not have a dual-fuel tariff
- 4,760 homes on benefit have a loft but not loft insulation

Fuel poverty can adversely affect the health, opportunity and well-being of people living in fuel poor households if they are unable to maintain an adequate heating regime. It can also caused issues with building fabric related to damp, condensation and mould growth.

One of the principle issues with those experiencing fuel poverty can is linked to payment types. For example

- 16% of all householders are in receipt of benefit and pay for fuel by cash or prepayment meter
- 13% of householders on benefits do not have a dual-fuel tariff
- 8% of householders pay by cash or prepayment meter and do not have a dual fuel tariff

Using the 2007 DECC consumption data and making assumptions on the proportion of energy consumed in gas connected properties, the average heating component of homes heated with gas is approximately 9,000kWh. Examination of the Economy 7 data would suggest that just 5,858kWh is being used for heating in homes without a gas connection. This would suggest (and is consistent with other studies) that not only is that energy costing the occupier more but it is very likely the home is under-heated and the relative production of emissions for the same heating value is three-times more carbon intense.
4.1.5. MICROGENERATION AND DISTRICT HEATING

Significant analysis of the renewable energy generation potential within Plymouth and its environs has already been commissioned and reported (Plymouth's Renewable Energy Strategic Viability Study, 2007). This study focussed primarily on the potential of large scale renewable generation, renewable energy as an integral part of new developments and opportunities for combined heat and power within clusters of existing high energy users.

The study concluded that there is an electricity resource of 286 MW and a heat resource of 472 MW though these estimates are of course across domestic and non-domestic users. Biomass and wind are relatively constrained within the city as is electricity from hydro-electric (though no specific study is available on the generation and supply potential) with heat pumps (ground source and air-source) and solar resources considered the most deployable and beneficial. One significant issue with recent developments is the introduction of the Feed in Tariff (FiT) and later in 2011 the Renewable Heat Incentive (RHI). Calculations for the FiT has been taken into account in the national measures though the details for the RHI are insufficiently clear at the current time for any reliable contributions to be calculated on uptake rates. The annual savings for a range of renewable technologies as calculated by the Energy Saving Trust (2008) are illustrated in Table 22. The 2007 study for Plymouth suggested the available renewable resource to the existing and future housing stock as illustrated in Table 23.

Table 22: Annual energy, cost and emissions savings from micro-generation technologies (Source: Energy Saving Trust 2008)

<table>
<thead>
<tr>
<th>Technology</th>
<th>Energy Saving Net of comfort (kWh)</th>
<th>Financial Saving (£/yr)</th>
<th>Carbon Saving kgC/yr kgCO₂/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar Water Heating</td>
<td>1,282</td>
<td>£50</td>
<td>71</td>
</tr>
<tr>
<td>Ground Source Heat Pumps</td>
<td>7,709</td>
<td>£247</td>
<td>305</td>
</tr>
<tr>
<td>Air Source Heat Pumps</td>
<td>7,878</td>
<td>£225</td>
<td>270</td>
</tr>
<tr>
<td>PV (2.5kWp)</td>
<td>2,125</td>
<td>£248</td>
<td>250</td>
</tr>
<tr>
<td>Biomass</td>
<td>-1257</td>
<td>£200</td>
<td>1,211</td>
</tr>
</tbody>
</table>

Table 23: Potential for renewable electricity and heat (Source: Plymouth's Renewable Energy Strategic Viability Study, 2007)

<table>
<thead>
<tr>
<th>Technology source or fuel</th>
<th>Equivalent installed capacity (based on accessible resource) (MW)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar photovoltaic</td>
<td>16.8 MW</td>
<td>Comprises 13.5 MW from existing housing only and 3.2 MW from future new build</td>
</tr>
<tr>
<td>Micro-wind</td>
<td>13.6</td>
<td>Technology not taken forward</td>
</tr>
<tr>
<td>Total Electricity</td>
<td>30.4 MW</td>
<td></td>
</tr>
<tr>
<td>Woodland (sawmills)</td>
<td>0.2</td>
<td>Assumes that product will go into pellet and biomass heating options</td>
</tr>
<tr>
<td>Solar water heating</td>
<td>23.5</td>
<td>Based on housing only. Comprises 18.9 MW from existing housing and 4.5 MW from future new build</td>
</tr>
<tr>
<td>Total heat</td>
<td>23.7 MW</td>
<td></td>
</tr>
</tbody>
</table>

Other estimations in the study on the potential for heat pumps have not been entered into calculations at this stage as without significant refurbishment of older housing stock (i.e. suspended floors and solid wall) they are relevant to

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23 Biomass saving for switching from oil, electric, LPG or coal (not gas) to a biomass pellet boiler (not a biomass stove).
new build in the vast majority of applications given the profile of Plymouths housing stock.

The most recent estimate of the solar photovoltaic resource (David Fletcher pers. comm.) uses a very significant proportion of the city’s social housing stock as a guide (given its wide distribution across various geographies across the city). In this estimate 15,000 homes have been examined under a solar sundial with 3,700 found in the optimum position in terms of roof orientation and pitch. A total of 5,400 were identified as viable and up to 7,500 if flat roofs are adapted to take panels on frames. Taking the mean of the potential properties where planning and other structural constraints are not likely to be barriers (4,550) and applying an average system size of 2 kWp each system would generate approximately 1,500 kWh per year (slightly lower than the value expressed in Table 22).

If this number of homes is assumed to be representative of the Plymouth housing stock then the potential solar photovoltaic resource can be calculated as 30% of the stock or 33,000 homes. The generation potential can be estimated as 49.5 GWh, a figure considerably larger than the 2007 study suggested. The emissions savings from this generation (using the 2008 EST data) would amount to 30.2 ktCO₂ per annum.

However, this rate of implementation is a best estimate of the technical potential only. The most recent survey of public attitudes (though admittedly pre-Feed in Tariff) suggests a “pre-contemplation” rate of 12% which would reduce the realisable savings to a much lower 3.6 ktCO₂ per annum. This lower rate of implementation is significantly lower than the estimates as modelled for the impact of the Feed-in-Tariff as a national measure.

The application of ground and air source heat pumps and biomass (in the form of small wood pellet boilers) to the estimated 3,900 off-gas grid properties in Plymouth has some potential for renewable energy generation though again the relatively higher capital costs coupled with consumer confidence would suggest that conversion rates will be in the order of 5-10%.

The other issue will be the appropriateness of the technologies to the specific housing involved. Heat pumps require high levels of thermal efficiency and air-tightness to be of any cost and emission saving benefit. Using the overall profile of Plymouths post 1990’s housing stock at 11% of the total stock it can be estimated that 420 homes are likely to fall into probable profile to be suitable for heat pump technologies. On the basis that the technologies will reduce emissions by an estimated 1,000kg/CO₂ per property a potential saving of 0.4 ktCO₂ per annum could be realistically achieved.

Of course the entire position for renewable energy generation will alter if the carbon intensity of the grid reduces or increases; if the relative cost of fossil fuel based sources rises or falls; and if there are issues around security of supply. On this basis it is very much more hazardous to make accurate assessments on the uptake of biomass heating especially in areas with mains gas availability. The Renewable Heat Incentive is calculated to make a significant impact as a national measure on domestic emissions in particular. Current national data suggests that around 1% or properties are using biomass as opposed to mains supply for heating which if transposed into Plymouth would suggest approximately 1,100 properties.

Solar water heating is a more publicly recognised and accepted technology. Using national survey data it could be estimated that 1% of properties have solar water systems installed equating to 1,100 properties in Plymouth. This level of installs (perhaps based on local knowledge a slightly high estimate) would yield 0.3 tCO₂ per annum. Again using the national survey data it can be estimated that 10% of owner occupiers could be willing to convert to solar water systems. Assuming this level of conversion a potential 11,000 properties would generate a saving of 2.9 ktCO₂ per annum. As referred to earlier in this report the conversion of the 18,700 electrically heated systems alone to solar water heating is of particular worth and would save an estimated 4.8 GWh and 2.6 ktCO₂.

This very low estimate when compared to the 65 ktCO₂ estimated for impact of the Renewable Heat Incentive can be related to the potential contribution of heat pumps, estimated in the 2007 study to achieve an installed capacity of 79.4MW. As above this latter installed capacity estimate relates to new build and not the existing stock.

It is worth reflecting on the potential for solar water systems as estimated to be 48,700 in the 2005 Plymouth City Council survey. If the remainder (30,000) are assumed to be mains gas fed properties then potential savings from domestic solar water heating can be estimated as 7.8 ktCO₂.

24 Defra - Public attitudes and behaviours towards the environment - tracker survey 2009
4.1.6. **SUMMARY OF POTENTIAL SAVINGS FROM DOMESTIC SECTOR**

This section has looked at the likely potential for emissions savings from the domestic sector using a bottom up approach. It combines both technical potential and likely levels of uptake. The analysis suggests the levels of savings shown in Table 24 may be possible:

*Table 24: Potential carbon dioxide savings by 2022 for domestic improvements*

<table>
<thead>
<tr>
<th>Measure</th>
<th>Estimated CO₂ savings by 2022 (baseline 2007) ktCO₂ per annum</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loft and cavity wall insulation</td>
<td>20.4 – 26.5</td>
<td>Assuming 50 – 75% of remaining properties treated</td>
</tr>
<tr>
<td>Boiler upgrades</td>
<td>39.3</td>
<td>Based on HHIC predictions</td>
</tr>
<tr>
<td>Fuel switching</td>
<td>5.8 – 22.1</td>
<td>Lower figure = 20% of properties switch to gas and higher figure = 50% switch to biomass</td>
</tr>
<tr>
<td>Solid wall insulation</td>
<td>9.7 – 19.3</td>
<td>Assuming 5,000 – 10,000 installs</td>
</tr>
<tr>
<td>Efficient lighting and appliances</td>
<td>19</td>
<td>Approximate estimation using EST figures</td>
</tr>
<tr>
<td>Behaviour change</td>
<td>-</td>
<td>Too difficult to estimate</td>
</tr>
<tr>
<td>Microgeneration</td>
<td>11.8</td>
<td>Very approximate estimation</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>106 – 141.2</strong></td>
<td></td>
</tr>
</tbody>
</table>

These measures give a total of between 106 – 141.2 kt CO₂ savings by 2020. Adding the likely savings from renewable energy in the national grid of some 31 ktCO₂ per year gives a total potential by 2020 of between 140 and 172.2 ktCO₂ savings per year by 2020. This compares with the top down estimate of the impact of national policy measures that cover domestic housing of 175 ktCO₂ per year. These figures suggest that the national target is achievable, but still very ambitious and requiring significant local authority funds and support.

The key areas of activity would seem to be:

- Initially continuing to target those homes without the basic measures of cavity wall and loft insulation, particularly in the private rented sector
- Fuel switching in electrically heated area;
- Solid wall insulation, particularly targeted at areas with a greater incidence of hard-to-treat properties
- Promoting the updating of older boilers
- Promoting efficient lighting and appliances.

Micro generation would appear to have less potential, but this does depend on uptake rates. Currently with the FIT in place PV offers the greatest potential and initiatives to encourage and support uptake would be worthwhile.

There will be great scope for Plymouth City Council to play an active role in encouraging more energy efficient technologies either indirectly through promotion of the Green Deal, or by providing direct financial incentives.
4.2. NON-DOMESTIC

Most businesses are not energy intensive and it is telling that Plymouth has no organisations large enough to register for the EU ETS. For the majority of businesses energy is a relatively small proportion of their costs and most management do not therefore make energy reduction a priority. In general business will be affected by national measures in different ways depending on the size of the business and they can be split into two main groups:

- Larger businesses that are covered by CCA and CRC (traded sector) – which will cover most of the industrial sector and the bigger services sector businesses
- Small to medium size enterprises (SMEs) that are not covered by the CCA and the CRC (non-traded sector) – covering small manufacturing and the bulk of the services sector such as retail.

With the traded sector the CCA and CRC are expected to drive the majority of energy efficiency measures and it is not anticipated that there will be much work for local authorities to do here. Local authorities can however have an influence on the take up of district schemes such as biomass heat and CHP. Details of potential sites that may be suitable for CHP have been detailed in Section 4.2.2 below.

In the non-traded sector the carbon emissions of small to medium enterprises will tend to be less influenced by national policy. Therefore there is a greater need and potentially more scope for Plymouth to work with these smaller businesses. Energy efficiency schemes that are likely to affect smaller businesses are common to those of the domestic sector.

The sections below discuss the potential for improved energy efficiency, renewable energy sources and CHP and district heating in the non-domestic sector, as the key areas where local action could be taken.

4.2.1. ENERGY EFFICIENCY

Energy efficiency measures are usually the most cost effective way of reducing CO\(_2\) emissions. In section 2 it was shown that heating and lighting are the main sources of CO\(_2\) emissions in Plymouth and improved measurement of energy use will be key to tackling them.

Reductions in the demand for energy for heating are essential if non-domestic CO\(_2\) reduction is to be achieved. The main problem with trying to identify the scope for improvements in heating efficiency and with setting priorities for action is the lack of knowledge about the non-domestic building stock nationally and locally. However, measures to reduce carbon emissions from heating in Plymouth’s non-domestic buildings should include, in order of decreasing cost effectiveness:

- Improving controls and system management (e.g. altering timing and reducing the set point)
- Replacing old boiler plant
- Improving roof insulation
- Filling any unfilled cavity walls with insulation
- Replacing single glazing with double glazing.

Lighting is the most important energy end use in Plymouth’s service sector. High priority measures to reduce consumption by lighting should include:

- Checking whether the installed capacity of lighting is excessive, and removing fittings if necessary.
- Putting in place automatic controls or procedures to ensure all lighting is off outside working hours.
- Occupancy switching of lights in circulation areas.
- Replacement of inefficient fittings (e.g. those with magnetic starters and those which direct light ineffectively) with new, more efficient fittings.
- Daylight controlled dimming of lamps where possible.

Improved energy measurement using advanced metering automatically to collect accurate data (typically every half hour) from energy meters enables more accurate billing, and a full understanding of energy consumption of a site or building. This allows energy savings by:
- Quantifying the baseload, which can guide the reduction of unnecessary constant energy consumption.
- Enabling comparison of the (typically daily) energy consumption profile with the operational profile of a site to allow optimisation of energy use, e.g. by showing that electricity consumption in a school does not reduce when lessons end for the day.
- Identifying the scale and time of peak consumption so that the activities or equipment causing the peak can be identified.

Projects in the region (such as the now defunct EnVision project) have demonstrated that with sufficient advice and support businesses recognise the savings from energy reduction and efficiency and make the necessary investment. The challenge is to access enough businesses. Local authorities are arguably well-placed to work with local business to facilitate behaviour change.

The Carbon Trust provides support to businesses nationally, generally to larger businesses whereas EnVision’s support was directed to local SMEs. EnVision’s resources and funding enabled support to only a limited number of businesses. For real change a step change in the quantity of advice and support offered is needed.

In addition the forthcoming Green Deal funding scheme (which help private companies to offer retrofit energy measures at no upfront cost to the customer) is expected to affect both domestic and small non-domestic buildings. Local authorities have the potential to augment the positive effects of the Green Deal by encouraging cooperation between businesses (e.g. examining possibilities of neighbourhood schemes such as a street of shops).

Since the detail of the non-domestic buildings stock is limited and the activity very varied it is hard to estimate the potential for carbon reduction from efficiency measures in this sector. A very basic approach is to use energy benchmark data from CIBSE and the Carbon Trust (ECON 19). The best data is for office buildings and suggests that an improvement from a current ‘typical’ building to ‘best practice’ will reduce emissions by about 40%. This could potentially be applicable to the services sector in general. A similar aggregate figure is not easily obtainable for the industrial sector with the wide range of processes and buildings types in this sector. However, it can be assumed that improvements are harder to make and moving from ‘typical’ to ‘best practice’ may only achieve savings of some 30%. It is also unrealistic to think all business could make or would make such improvements. If we assume that only 50% are likely to improve by 2020 this would give an estimated CO$_2$ saving against the 2005 baseline of 105 kt CO$_2$.

4.2.2. RENEWABLE AND LOW CARBON ENERGY SOURCES

Low carbon energy solutions also have an important role to play in reducing carbon emissions. Plymouth has undertaken a substantial amount of work on renewable and low carbon energy in the City and is making steady progress towards delivering the benefits of low carbon energy which include

- Lower fuel prices and a reduction in fuel poverty in the City
- A resulting improvement in the City’s competitiveness
- Retention of energy spend in the City which helps the economy
- Jobs and economic opportunities for City businesses provided by the development and operation of projects
- Local energy supply which can provide additional energy security for the City

The three key pieces of evidence are summarised below.

4.2.2.1. RENEWABLE ENERGY STRATEGIC VIABILITY STUDY

The 2007 renewable energy study\(^\text{25}\) concluded that:

- Plymouth is in a similar situation to other city unitaries in that its mainly urban landscape will tend to limit the availability of certain types of renewable resource within its boundaries – principally biomass and wind.
- In the short term, micro-renewables, such as solar PV, solar water heating, heat pumps, small-scale wood heating and small-scale/rooftop wind are more likely to be employed in relation to on-site renewables policy compliance within residential developments.
- Plymouth’s urban waste stream is a significant resource and is sufficient to support Energy from Waste technologies, providing a suitable heat load can be identified to justify a CHP plant.
- In planning the specific characteristics of Area Action Plans the site characteristics should be matched to appropriate renewable technologies, e.g. mixed-use development with renewable combined heat and power.

\(^\text{25}\) “Plymouth renewable energy strategic viability study”, CSE, March 2007
• The strategic position within the community held by Plymouth City Council provides an opportunity to facilitate multi-sector partnerships – especially for large scale mixed-use developments, where renewable energy infrastructure may be shared, or where Energy Service Companies (ESCOs) may be involved to potentially reduce the additional capital cost burden.

Energy collaboration between adjacent organisations is not methodologically promoted in the UK. The local nature of these projects, the timescales involved and the multiple agency involvement needed to deliver shared infrastructure between industrial sites suggest that the City Council will have an important long term role in promoting and facilitating such projects. As part of the development of area action plans the City Council commissioned two pieces of work on the use of sustainable energy three areas of the City, the City Centre, Derriford and Devonport.

4.2.2.2. Plymouth City Centre and Derriford sustainable energy study

The 2009 study found that, in the medium to long term, macro-scale solutions are the most appropriate way to deliver the required carbon reduction targets. Furthermore, the work concluded, by taking a phased approach, there is an opportunity for macro-scale solutions to be implemented at an earlier stage particularly in the City Centre, where existing heat loads such as Council or University buildings could potentially be served by the network early in the process. Linking in such heat loads will make any CHP plant more efficient and will generate more revenue with little if any increase in the plant’s capital or operating cost. As these loads currently exist, they will also provide an important stimulus for early implementation of a CHP/district heating scheme.

The analysis suggests that certain macro-scale combined heat and power (CHP) technologies with district heating networks are capable of achieving the substantial carbon reductions required for the 2016 targets. Natural gas CHP systems would normally be the favoured choice of developers for both sites due to the technology’s track record, low capital cost and small footprint, and could achieve over 70% CO2 reduction on regulated emissions. However, biomass CHP technology with district heating provides the opportunity to exceed this target and achieve 100% CO2 reduction on total emissions i.e. zero carbon. As constraints associated with the City Centre would make biomass a difficult option to implement, and as the biomass wood fuel resource in the Plymouth area would be insufficient to supply both sites, the preferred option would therefore be to encourage biomass implementation in Derriford only. Economic viability is generally encouraging for the modelled macro-scale biomass solutions.

There is a strong argument for bringing forward and implementing macro-scale solutions as soon as possible to minimise the implementation of less-cost effective micro-renewables and to potentially exceed Building Regulation carbon reduction targets. Planning policy will therefore need to prioritise the development of CHP and district heating networks over micro-renewables from the earliest opportunity. Examples of this approach could be to actively discourage the use of micro-scale heat generation where district heat networks are available and by ensuring that buildings are compatible with, and able to connect to the network in the future.

In order to deliver the area wide energy supply solutions, early intervention is needed to develop the necessary commercial and physical infrastructure. This is unlikely to occur without significant involvement from the Council and the public sector, particularly in accessing the Regional Infrastructure Fund to provide up-front finance and in facilitating an ESCo partnership. This coordinating role will help to ensure a unified area-wide approach rather than piecemeal, and should serve to maximise CO2 savings and benefit overall viability through economy of scale.

4.2.2.3. City of Plymouth district energy study

The feasibility for an energy services company in Plymouth was evaluated by Cofely in 2010. The study divided the potential for the development of district energy with CHP in Plymouth into three areas (the City Centre, Derriford and Devonport) to focus on catalyst schemes that have a sufficient density of energy and which could subsequently enable further connections.

In the City Centre it was estimated that connecting the Council owned buildings around the Civic Centre to the University of Plymouth’s city campus was not initially feasible because of the distance and elevation between the two. However, as redevelopment of the shopping district which separates these two core consumers takes shape, then further 3rd party consumer connections can be made. The same can be said for the other two areas where expansion

26 “Plymouth City Centre and Derriford sustainable energy study” CSE & Wardell Armstrong, August 2009
27 City of Plymouth District Energy Study, Feasibility study for an energy services company in Plymouth, Cofely, January 2010
of the core schemes suggested in the report is not only viable but strongly recommended as it adds profitability and ability for increased carbon reductions to all consumers.

In Derriford, the hospital was identified as a core consumer and the location for the Energy Centre as it has significant energy demand and a key geographical location in the centre of existing and future developments. Due to the nature of the healthcare industry as a high energy user, this area could realise some large energy cost savings and a strong scheme being developed. The study also identified the opportunity to benefit new development plans by laying down a foundation network of heating mains that can be utilised by new developments as and when they are built.

Whilst the individual energy loads (individual domestic properties) in Devonport area are not as significant as to provide a catalyst district energy scheme, the inclusion of HMNB Devonport would enable a network to be installed and funded by an ESCo. Other options for this area could include locating the Energy Centre at City College or future developments in the South Yard such as Princess Yachts and using some government funding such as the 2009 Homes and Communities.

The study concluded that Plymouth City Council needs to take a proactive role in the development of an ESCo because the market will not simply respond and establish an ESCo, unless there is a clear and secure mechanism for funding infrastructure (committed energy loads) and recommended that it lead the procurement process.

### 4.2.3. DISTRICT HEATING AND CHP

The City Council’s work on CHP in Plymouth played a role in Devonport becoming a potential site for a CHP energy from waste scheme in the dockyard. In January 2011, following a procurement process by the Devon Waste Partnership, MVV Umwelt was awarded the contract to build an energy from waste plant at the North Yard of HMNB Devonport (Figure 51), and, subject to obtaining the necessary consents, the plant will be commissioned during 2014. When operational the site will function as a combined heat and power generator (CHP) with a maximum output capacity of 22.5 MW. The plant will also provide usable heat for the naval base (with a peak output of around 23.3 MW). Around 245,000 tonnes of waste per annum will be processed, 30% of which will be from commercial waste. The proportion of commercial waste used at the plant is expected to drop as the amount of household waste processed at the plant increases.

The heat load of HMNB Devonport, estimated to be 66.1 GWh per annum, will be fully supplied by the energy from waste plant. This implies a capacity factor of 32% for heat generation. To generate enough electricity for 37,000 homes, the electricity generation is estimated to operating at an average of 90% of full capacity.

Further potential for CHP and district heating has been explored in the Cofley study (2010) which divided the City of Plymouth into three areas that had sufficient energy demand for large scale CHP. These areas included Devonport, Derriford and the City Centre.

The estimated electricity and gas use of HMNB Devonport in 2008 was:

- 111 GWh per annum for Electricity
- 66 GWh per annum for Gas

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28 “City of Plymouth District Energy Study: Feasibility Study for an Energy Services Company in Plymouth”, Plymouth City Council, January 2010
29 This assumes an average electricity consumption of 4,800 kWh per annum for each home and that the true peak capacity of the energy from waste plant is 22.5 MWp.
30 Data derived from MVV press release (January 2011)
MVV have not supplied details of the CO₂ conversion factors for the proposed energy from waste plant, so the emissions from this plant can only be estimated. Data from the “The City of Plymouth District Energy Study” was used to estimate a CO₂ conversion factors of 0.298 kgCO₂/kWh (based on an energy split of 44% gas and 56% electricity). This factor for a 244 GWh plant gives emissions of 35,781 tCO₂pa. However, it is important to note that this estimate assumes that the larger CHP plant would output the same relative proportion of heat and electricity and that there are no efficiency gains accrued by installing plant which has a large capacity.

The City of Plymouth District Energy Study identifies potential CHP and district heating in Derriford and the City Centre which deliver electricity and heat to existing buildings and new development. CO₂ savings identified from these gas base schemes are up to 6,336 and 1,217 tCO₂pa respectively. The earlier CSE study consider biomass based schemes which deliver order of magnitude increases in CO₂ savings to 52 ktCO₂pa and 30 ktCO₂pa respectively.

4.2.4. SUMMARY OF CO₂ EMISSIONS SAVINGS

The key areas of local carbon savings centre on driving forward energy efficiency improvements and supporting the development of district heating schemes. The estimated CO₂ emissions savings that could be achieved by these local policies for non-domestic buildings are summarised in Table 25 below.

Table 25: Estimated CO₂ savings by 2020 for local policy measures

<table>
<thead>
<tr>
<th>Policy Measure</th>
<th>Estimated CO₂ Savings by 2020 (baseline 2005)</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Typical” to “Good practice” for all businesses</td>
<td>105 kt CO₂ per annum</td>
</tr>
<tr>
<td>Devonport EfW facility</td>
<td>36</td>
</tr>
<tr>
<td>Derriford CHP Scheme (gas - biomass)</td>
<td>6 - 52</td>
</tr>
<tr>
<td>Plymouth City Centre District Heating Scheme (gas - biomass)</td>
<td>1 - 30</td>
</tr>
<tr>
<td>Total:</td>
<td>148 - 223</td>
</tr>
</tbody>
</table>

This bottom up assessment gives a range of technical potential from 148 to 223 kt CO₂ savings per year by 2020. At the lower end this is similar to the estimated impact of national policy at some 157 kt CO₂ savings per year (a 26% reduction by 2020). At the high end 223 kt CO₂ represents a potential reduction of up to 37% by 2020. One of the key differences is that national policy is not expecting to deliver such significant energy efficiency savings as has been estimated here. The combined effect of the CRC, CAA, carbon trust advice, products policy and public sector loans is expected to be only some 58 kt CO₂ per year, about 50% of the estimated potential. The biggest impacts of national

31 The City of Plymouth District Energy Study examined the CO₂ emissions savings from a considerably smaller 4 kW energy from waste plant. The CHP plant that was modelled in the study produced estimated savings of 4561 tonnes of CO₂ per annum for a total of 52.1 GWh of energy (22.8 GWh for heat and 29.3 GWh for electricity). Using typical conversion factors of 0.185 and 0.541 kgCO₂/kWh for standard gas and electricity respectively, the total CO₂ emissions replaced by those of the CHP plant are 20,069 tonnes. If the CHP plant saves 4,561 tonnes, then its emissions will be approximately 15,508 tonnes of CO₂ per annum giving a combined conversion factor of 0.298.
policy measures are from renewables in the grid and the RHI.

4.3. TRANSPORT

A set of additional transport measures have been assessed using the transport carbon model. This work builds on a similar study carried out for Devon County Council. The initial list of transport measures from the DaSTS study was reviewed with Devon County Council and a more focused list was identified in consultation with the council. The same list of measures has been assessed for Plymouth.

These measures fall into three broad categories: demand reduction, vehicle technology measures and driver behaviour measures. For each measure, assumptions have been set out for the mechanisms that could be used to deliver them and the effect on physical parameters (such as traffic volume and vehicle CO$_2$ emission factors) for the years 2015, 2020 and 2025.

The carbon savings from each measure has been modelled using the Centre’s transport and carbon model. In all cases the baseline against which the savings have been estimated is the Low Carbon Transition Plan central scenario. Simple cost information has been collected for the implementation of each of the measures, focusing on public costs. This has been used to assess the cost effectiveness of each measure in terms of cost per tonne of carbon saved.

Further details on the assumptions and modelling approach used are provided in CEE Internal Document 769. The measures that have been modelled in this study fall into three categories: demand management, vehicle technology and driver behaviour. A description of each of these measures and the assumptions used for modelling carbon emissions is set out in the sections below. The final section provides a simple summary of what policy levers the Council could use to implement each of the measures.

4.3.1. DEMAND MANAGEMENT MEASURES

4.3.1.1. SMARTER CHOICES

Smarter Choices is a package of measures covering the provision of information, for example travel planning activities, the promoting of walking and cycling and public transport trip information. Assessment of Smarter Choices uses the evidence from the sustainable travel towns study to estimate the possible impact of a significant programme of measures in Plymouth.

4.3.1.2. IT MEASURES

This measure considers the impact of tele-working and IT on commuter trips and business travel. The impact is estimated in terms of a reduction in rural commuting trips (affecting traffic on rural and trunk roads) and business trips (affecting all roads). The overall data available for such measures is poor. The two main sources are the DfT Smarter Choices study and a UKERC study on policies that affect passenger transport carbon emissions. These studies suggest that impacts can be variable.

4.3.1.3. ACCESS MANAGEMENT

The access management measure assumes vehicle restrictions in key urban centres, for example low emission zones or restricting through traffic. The impact of this measure has been estimated as a reduction in traffic on a proportion of urban roads (20%, to reflect only urban centres) and was applied to cars, light goods vehicles and heavy goods vehicles. An increase on the other 80% of urban roads has been assumed to account for traffic that has been displaced rather than removed completely.

4.3.1.4. WORKPLACE PARKING LEVY

This demand management measure is assumed to be an area-wide parking initiative across all of Plymouth. It is assumed to reduce urban car commuting traffic. Currently the only scheme being developed is in Nottingham, and no direct information on traffic impact could be found. An alternative source of information is the impact of road pricing on traffic. The London scheme is estimated to have reduced traffic levels by 15%. A similar impact has been assumed for Plymouth.

4.3.1.5. PUBLIC TRANSPORT INVESTMENT PACKAGE

This is an estimate of the effect of increased investment in bus-based public transport. It was modelled as an increase
in bus traffic and a reduction in car traffic in urban areas. Commensurate with a previous air quality assessment scenario, a 10% reduction in car use and a 50% increase in bus traffic has been assumed.

4.3.2. VEHICLE TECHNOLOGY MEASURES

4.3.2.1. URBAN ELECTRIC VEHICLES
This scenario assumes a given penetration of electric vehicles in the urban traffic mix. Information from the King review and the Committee on Climate Change suggests mass market electric vehicles will not be available until 2015 and could grow to as much as 20% of the urban market by 2020. Such measures would be supported by a local authority through investment in recharging infrastructure and information and support for buyers. For this project, a more conservative scenario has been assumed, where electric vehicles account for the following percentage of car and light goods vehicle kilometres: 5% by 2015, 10% by 2020 and 15% by 2025.

4.3.2.2. LOW CARBON BUSES
This is based on the DfT definition of a low carbon bus (30% lower CO\(_2\) emissions than a Euro 3 bus) and assumes a penetration of 50% by 2025. The current LTCP penetration for low carbon buses assumes a 34% penetration by 2022, so this is just a more rapid growth.

4.3.3. DRIVER BEHAVIOUR MEASURES

4.3.3.1. ECO-DRIVING
This represents a major Plymouth-wide programme to encourage eco-driving. This is assumed to improve the average fuel efficiency of cars operated in the area. The DfT’s Low Carbon Transport Strategy assumes that the long term effect of eco-driving training programmes is a 3% improvement in fuel economy. If an area-wide information and training campaign is carried out by the county council, a simple assumption is that this achieves a 3% improvement in fuel economy when fully implemented. Staged implementation has been assumed.

4.3.3.2. AREA-WIDE 20MPH LIMITS
This assumes that area-wide 20 mph (32.2 km/h) limits are applied to all non-trunk roads in urban areas. This would involve changing speed limits and could be complemented by ‘Home Zone’ type developments.

4.3.4. POLICY IMPLEMENTATION
Each of the measures above can be implemented and supported through a range of policy measures. The key policy levers that could be used are set out in Table 26.

Table 26: Policies that could be used to implement the additional measures.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Possible Policies</th>
</tr>
</thead>
</table>
| Smarter Choices     | • An authority’s own travel plan activities and promotion through travel plan officers.  
|                     | • Planning policy, particularly for new settlements (e.g. Cranbrook), requiring travel plans and information activities.  
|                     | Supporting measures  
|                     | • Investment supporting public transport provision.  
|                     | • Infrastructure improvements for buses (bus lanes, park-and-ride facilities, real-time information systems), and measures to discourage car use in urban areas (preferential parking charges for park and ride compared to city centre parking).  
| IT Measures         | • Investment and lobbying for universal broadband coverage (including rural areas).  
|                     | • Promotion through travel plan and Smarter Choices campaigns.  
| Access Management   | • Restrictions on vehicles in urban areas, e.g. Low Emission Zones  
|                     | • Congestion charging in urban areas  
|                     | • Routing through traffic away from urban areas  
|                     | • Pass systems to restrict access to key urban areas to local deliveries and residents.  
| Workplace Parking Levy | • Use of road pricing powers to levy a charge per parking space provided by employers in urban areas.  
| Public Transport    | • Investment supporting public transport provision.  

65
**Investment Package**
- Infrastructure improvements for buses (bus lanes, park-and-ride facilities, real-time information systems), and measures to discourage car use in urban areas (preferential parking charges for park and ride compared to city centre parking).

**Urban Electric Vehicles**
- Investment in recharging infrastructure
- Promotion of electric vehicles
- Could be linked to low emission zone or workplace parking policies

**Low Carbon Buses**
- Demanding such vehicles on contracts supported by the local authority.
- Low emission zone restrictions on the types of bus operating in urban areas.

**Eco-Driving**
- Provision and promotion of eco-driving courses
- Incentivising such courses (e.g. public transport vouchers).

**Area Wide 20 mph Limits**
- An extension of current 20 mph limits to cover whole urban areas.
- Homezone improvements to streets to discourage speeding and give priority to pedestrians and cyclists.

### 4.3.5. Modeled Carbon Results for Additional Measures

In modelling the carbon savings from each measure it was also necessary to consider the interaction between the measures, e.g. an improvement in car technology will have a different effect if other measures are introduced to reduce car usage. Packages of measures therefore had to be identified and modelled in a logical way to represent the effect of different approaches to tackle future challenges in the transport sector. The measures were divided into three groups, namely demand management, vehicle technology and driver behaviour. Each measure within a group was modelled individually, and then the combined effect of all measures in a group was modelled. The next group of measures was then modelled with the previous group of measures in place. Hence vehicle technology measures were only modelled with demand management measures in place, and driver behaviour measures were only modelled with both demand management and vehicle technology measures in place.

Using this approach the predicted absolute CO₂ emissions for each additional measure scenario are shown in Figure 52:
- The first set of bars show the emissions predicted under the LCTP.
- The next five sets of bars show the effect of each of the demand management measures (in combination with the LCTP), and the seventh set of bars the combined effect of these measures.
- The next two bars show the effect of each of the vehicle technology measures (in combination with the LCTP and all of the demand management measures), and the tenth set of bars the combined effect of the LCTP, demand management and technological measures.
- The next two bars show the effect of each of the driver behaviour measures (in combination with the LCTP and all of the demand management and technological measures), and the final set of bars the combined effect of the LCTP, demand management, technological and behavioural measures.

The results show that the baseline (LCTP) scenarios return modest reductions in CO₂ emissions from 2007 to 2010 and a steady reduction thereafter through to 2025. Overall the LCTP is expected to reduce emissions between 2007 and 2025 by 21.5%.
The additional measures are shown to have a smaller but significant overall effect on total CO₂ emissions compared to the package of LCTP measures. To reveal the impact of these measures more clearly, the carbon saving of each measure relative to the LCTP baseline is shown in Figure 53 (as absolute reductions) and Figure 54 (as the percentage reduction). The incremental effect of the behavioural and technological measures is shown relative to the results with the previous packages of measures in place.

The package of demand management measures returns a significant saving of 34 kt CO₂ in 2025, a 14.9% improvement on the LCTP scenario. Adding the technological measures yields a further 14 kt CO₂ in 2025 an additional 6.5% reduction in emissions. These measures together reduce emissions by a total of some 21% over and above the LCTP measures. Ecodriving returns a further 1.1% saving; however, urban 20 mph limits are predicted to significantly increase CO₂ emissions (emission factors increase at low vehicle speeds but this may be countered by non-modelled effects such as the smoothing of vehicle flows and through encouraging walking and cycling). The most significant individual measures are seen to be Smarter Choices, urban electric vehicles and public transport investment each effecting an additional reduction in CO₂ emissions of 5% to 6% in 2025 compared to the LCTP projection.

Figure 52: Carbon dioxide emissions for each scenario modelled.

Figure 53: Carbon dioxide emissions reductions for each scenario modelled, relative to the LCTP.
Figure 54: Percent reduction in carbon dioxide emissions for each scenario modelled, relative to the LCTP.

Figure 55 shows the combined effect of the different packages of measures in terms of emissions reductions compared to 2007. In 2015 the additional measures could generate similar savings to the national policy measures. By 2025 national policy is generating double what the local measures will produce as technology standards work their way into the fleet. Over all, if 20 mph limits are excluded the combined package of LCTP and additional measures could reduce transport CO₂ emissions in Plymouth relative to 2007 by 10.8% in 2015, 32.5% in 2020 and 39.2% in 2025.

4.3.6. COST EFFECTIVENESS OF ADDITIONAL MEASURES

A full cost assessment of the measures is beyond the scope of this study. However, some indicative cost information on the measures has been collated and a very simple cost effectiveness metric has been applied to these data.

The cost information collected has focused on the potential public costs borne by the local authority in order to
implement or promote the measure. Examples include publicising schemes, subsidising public transport and improving transport infrastructure. In addition there will be private costs and benefits to residents and employers of the measures: for example provision of IT infrastructure by employers to facilitate home working, paying public transport fares and fuel savings from reduced car use and more fuel-efficient vehicles. Lastly there is what are considered indirect cost and benefits such as improvements in air quality and a reduction in congestion. Private and indirect costs have not been considered here.

The public cost of each measure has been estimated and is discussed below, with further details and references being given in CEE Internal Document 769. These costs have then been used to calculate an indicator of cost effectiveness per unit reduction in CO\textsubscript{2} emissions. This indicator has been formulated as the total investment over the period to 2025 divided by the total carbon savings to 2025, giving an average public cost per kilogramme of CO\textsubscript{2} saved by 2025.

### 4.3.7. Cost Assumptions

#### 4.3.7.1. Demand Management Measures

**Smarter choices** – the evaluation of the sustainable travel towns project estimated that the cost of the programme of smarter choices measures averaged 4p/km of traffic removed over all of the demonstration sites. It is not clear whether this is an ongoing cost required to maintain that reduction or a one off cost that assumes once a reduction is generated it remains to some degree. The truth is probably somewhere between the two. The analysis has assumed that this is a one-off cost. Therefore, the traffic reduction achieved in 2015 is not assumed to have any further cost associated with maintaining it to 2025. Based on the vehicle-kilometres saved (as estimated by the carbon model) £5.9m will have been invested between 2010 and 2025.

**IT Measures** - The principal public cost is likely to be publicity, unless there is direct contribution to the infrastructure costs of upgrading broadband and data connections. The actual costs of providing computers, broadband connections and other equipment are likely to be met by the individual or employer. These private costs are likely to be offset by savings on transport costs and servicing office space. In fact most of the literature suggests that these measures are implemented by businesses and individuals to save travel cost and time. Therefore the only public cost assumed here is the promotion of such activity through awareness campaigns and potentially through travel plans. The cost of this is assumed to be the same per vehicle-kilometre averted as for smarter choices, and again is assumed to be a one-off cost. This gives an estimated total cost of £1m by 2025 to generate the vehicle-kilometre savings estimated in the model.

**Access Management** – This is rather generic measure as described above. Cost data from the London LEZ has been used as an indication of the cost of an access management scheme in Plymouth. The costs of setting up and running a low emission zone vary with the exact scheme and the types of vehicles included. A manually enforced scheme for lorries would have the lowest cost to set-up (an estimated £2.8 million to set-up, with running costs of around £4 million each year). There are a number of ways that an automatically enforced scheme (based on vehicle recognition through cameras, ANPR) could be introduced. The costs of introducing a network of fixed cameras across London were prohibitively high. Therefore, the approach taken was to use the existing Central London Congestion Charging Scheme (CCS) infrastructure, combined with the use of mobile ANPR cameras, and possibly a small number of additional fixed cameras outside this area. This type of scheme is estimated to cost £6 to £10 million to set-up, with running costs of around £5 million to £7 million each year, but might generate revenues of £1 million to £4 million per year. It is stressed that none of the LEZ schemes considered would be likely to be self-financing.

The above figures for a manually enforced scheme have been taken and halved to take into account the likely smaller area and fewer entry points into a LEZ in Plymouth. This gives a total implementation and operational cost from 2015 to 2025 of £13.4m. However, simpler schemes may be less costly and more appropriate to Plymouth, an example being the Bath Clear Zone scheme and bus gate which cut off through traffic across the centre of the city.

**Workplace Parking Levy** – The most advanced scheme in relation to this is in Nottingham. This scheme has an estimated set-up cost of £1.9m and a running cost of £0.6m in 2010. Income in 2010 is expected to be £5.6m. Therefore, this scheme has the potential to generate a surplus, which could be used to fund public transport improvements. For this measure, it has been assumed that there will be no net public cost, and potentially a net income.
Public Transport Investment Package – This measure assumes a 50% increase in bus vehicle-kilometres to produce a 10% reduction in car vehicle-kilometres. A 50% increase in bus vehicle-kilometres will bring a commensurate increase in operating costs, and will also require investment in new vehicles. Operating costs for a 50% increase in bus vehicle-kilometres have been based on Webtag guidance as follows - vehicle operating costs (pence per km) for buses are \( 24.959 + (569.094 / v) \) for non fuel costs (oil, tyres, maintenance, and depreciation) and \( 11.67790353 - 0.34941048v_2 + 0.00504730v_3 - 0.00002238v_3^3 \) for fuel costs (\( v \) in km/h), at 2002 prices. These have been factored to 2008 prices using the Webtag discount factor. Staff costs have been estimated based on a salary of £17,000 per annum, 240 days worked, 7 hours per day, per annum, a 100% overhead for time spent at bus stops and on breaks and a 50% overhead for administrative staff. This gives a total operating and capital cost of £12.7m per year by 2025.

It can be assumed that the local authority would only meet a proportion of the above costs, with the operator meeting the rest and taking the fare revenue. If the authority support amounted to 30%, the public cost would be around £3.8m per year in 2025. Interpolating this over the period 2010 to 2025 would give a total cost of £19.4m.

### 4.3.7.2. Technology and Behavioural Measures

#### Urban Electric Vehicles

This scenario assumes that the local authority would support electric vehicles through the installation of a network of recharging points. The electric vehicle scenario in the model produces some 160 million electric car vehicle-kilometres per annum in 2025. Assuming the average electric car travels 10,000 km per year this would amount to 16,000 cars across Plymouth. If one point is provided for every 50 cars, this would require a network of 325 charging points across the city (it has been assumed that electric vans are charged at the operator’s premises). Newcastle is installing 1300 electric vehicle charging points at a total cost of £5000 each. The electrical connection fee and electricity costs would be extra but could be meet by charges to the user. Based on the above cost and 325 points in place by 2025 the public cost would be £1.6m.

#### Low Carbon Buses

The current purchase cost of a low carbon bus is assumed to be £230,000 (£100,000 more than a standard diesel bus) but is assumed to fall to £185,000 in 2012, given that higher demand is likely to result in some reduction in purchase cost. The £230,000 assumption has been cited by a bus manufacturer as a current cost, while the £185,000 assumption is a mid-estimate taken from the Low Carbon Vehicle Partnership cost estimate of low carbon buses, once a small amount of mass production is achieved. In 2019, the purchase cost of a low carbon bus is assumed to fall to £150,000 as further economies of scale in production are achieved. This is also an estimate from the Low Carbon Vehicle Partnership and 2019 represents a reasonable estimate of when this is likely to be achieved. Interpolating between these data gives a marginal cost of a low carbon bus of £50,000 in the period 2011 to 2015, and £25,000 in the period 2016 to 2020. A marginal cost of £20,000 has been assumed from 2021 to 2025.

The number of buses operating in Plymouth has been estimated as 200 based on the number of bus km in the model and assuming an annual bus mileage of 100,000 km. The low carbon bus scenario assumes 50% of vehicles will be low carbon by 2025. This gives a total investment of £2.8m.

#### Eco-Driving

The smarter driving course offered by EST for company drivers is a one-hour lesson costing about £25 per head. This is kind of training that could be offered to drivers in Plymouth. If the authority offered this at half price, this would amount to £12.50 per head. Naturally, if training could be delivered at lower cost the cost effectiveness of eco-driving would be improved. There are about 170,000 people aged 20 to 80 in Plymouth, assuming that 80% of these drive that would be some 135,000 people to train by 2025. In addition it is assumed retraining is required on a five-year cycle, an assumption that has been made in the LCTP for the SAFED scheme. This gives a total cost to 2025 of some £3.4m.

#### Area Wide 20 mph Limits

An indication of costs has been taken from a proposed scheme in Newcastle costing £1.4m, including £1.1m for signs, £200,000 for legal orders, £95,000 for design and £5,000 for publicity. These figures could be applied directly to Plymouth. However, since no carbon benefit is predicted from this measure (as modelled), it has not been included in the analysis of cost effectiveness.

### 4.3.7.3. Cost Effectiveness Results

The cost effectiveness metric has been calculated by dividing the total public cost by the total carbon savings to 2025, giving an average public cost per kilogramme of CO\(_2\) saved by 2025. The results of this are shown in Figure 56 below.

When looking at these results it must be borne in mind that the cost data is very approximate with a lot of assumptions and ‘guesstimates’. Nevertheless, the results show some interesting and potentially useful trends.
Behavioural measures such as smarter choices and IT measures show good cost effectiveness, as to some degree does eco-driving. Of these the smarter choices programme also provides a significant level of carbon savings. The electric vehicle scenario proves to be the most cost effective measure and delivers significant carbon savings.

Potential revenue-generating measures such as the workplace parking levy also look attractive as they will be cost neutral or even provide a net income. They also have the potential to deliver reasonable levels of carbon savings. The most costly measures are the low carbon buses, access management schemes and public transport investment. The capital and running costs for these schemes are significant, although in the case of public transport invest there is also significant carbon savings.

![Figure 56: Indicative cost effectiveness for carbon reduction measures.](image)

In reality the picture is likely to be much more complex both in terms of costs and interaction between measures. For example for the Smarter Choices measures to be really effective, some level of public transport investment is likely to be necessary so the costs will overlap.

### 4.3.8. SUMMARY OF KEY LOCAL TRANSPORT MEASURES

Three groups of measures have been assessed: demand management, vehicle technology and driving behaviour. The measures are generic in nature and so have been modelled using fairly simple assumptions about their likely impact. Similarly the cost information has only been provided to give some indication of potential implementation costs. Bearing these limitation in mind, the key findings of the study are as follows:

- The combined set of additional measures assessed could potentially reduce carbon emissions in Plymouth by a further 22% compared to the expected impact of national policies by 2025.
- In total the demand management measures generate a 14.5% saving, the technology measures a further 6.5% saving and eco-driving another 1.1% saving.
- The most significant individual measures are seen to be eco-driving Smarter Choices, urban electric vehicles and public transport investment, each effecting a reduction in CO₂ emissions of 4% to 6% in 2025.
- Area-wide 20mph limits, as modelled, increase CO₂ emissions. However, this may be countered by the smoothing of vehicle flows and through encouraging walking and cycling.
- The potential cost effectiveness of the measures varies widely from the workplace parking levy which could potentially be cost negative (i.e. provide a net profit) through to low carbon buses which would seem quite costly (£600/tonne) for the likely carbon savings.
• After the workplace parking levy, the most cost effective measures are urban electric vehicles at £13/tonne CO₂ and Smarter Choices and IT measures at around £30-40/tonne of CO₂ saved.

• The least cost-effective measure is low carbon buses, followed by access management and public transport investment.

The picture is likely to be more complicated than these results suggest as there will be an interaction between the investment required to effectively implement the measures. For example, some level of public transport invest will be required to support a Smarter Choices programme. There are also other benefits generated by some of these measures that have not been quantified such as improvements in air quality and a reduction in congestion.

Despite the limitations of the analysis, it does suggest that there are three potential packages of measures that Plymouth could consider for inclusion in their LTP to reduce carbon emissions:

1. **An electric vehicle infrastructure programme** - which may be able to deliver 13 kt of CO₂ savings per annum by 2025 for potentially less than £15 per tonne.

2. **A significant Smarter Choices programme**. This could generate another 13 kt of CO₂ emissions per year by 2025 at a public cost of £45 per tonne or less. This programme could be complemented by eco-driving, although this appears less cost effective in urban conditions.

3. **A workplace parking levy and public transport investment scheme** – this package could generate carbon savings of some 14 kt of CO₂ per year, with the fairly high cost of public transport investment being offset by income from the parking levy.

The electric vehicle infrastructure programme would appear to be very cost effective and provide additional air quality benefits, but may take time to implement and generate the number of vehicles needed to deliver real carbon savings. The package Smarter Choices of measures is potentially a quick win, with minimal cost and short lead times. The parking levy and public transport investment package of measures would provide a significant complement to the Smarter Choices programme ensuring that the full range of benefits are delivered in the longer term. The following three potential targets are presented based on level of additional local measures:

1. Baseline: A 16% reduction in carbon dioxide emissions from 2005 to 2020 based only on the impact of national policy

2. Best Value: A 26.5% reduction in carbon dioxide emissions from 2005 to 2020 based on implementing smarter choices, IT measures, workplace parking levy and electriv vehicle infrastructure as well as the impact of national policy

3. All measures: A 32.5% reduction in carbon dioxide emissions from 2005 to 2020 based on all of the local measures discussed in this section with the exception of 20 mph zones, on top of the impact of national policy
5. TARGETS AND MONITORING

5.1. FORECASTS AND TARGETS

Within the analysis above we have looked at the current baseline emissions, what national policy might do to these emissions and an assessment of local activity to reduce emissions. The potential carbon dioxide emission reduction percentage estimated against a baseline of 2005 from this analysis is shown in Table 27 below compared to Plymouth’s carbon reduction aspirations (note: these reductions should not be confused with national level greenhouse gas reduction targets which are relative to a 1990 baseline).

Table 27: Estimated carbon dioxide reduction from 2005 to 2020 compared to Plymouth’s climate change target.

<table>
<thead>
<tr>
<th>Sector</th>
<th>LCTP reduction</th>
<th>Local potential</th>
<th>Plymouth target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic</td>
<td>34%</td>
<td>28%</td>
<td>Na</td>
</tr>
<tr>
<td>Non-domestic</td>
<td>26%</td>
<td>37%</td>
<td>Na</td>
</tr>
<tr>
<td>Transport</td>
<td>23%</td>
<td>32%</td>
<td>Na</td>
</tr>
<tr>
<td>Total</td>
<td>28%</td>
<td>32%</td>
<td>60%</td>
</tr>
</tbody>
</table>

This analysis suggests that Plymouth’s current aspiration for a 60% cut in emissions by 2020 would seem to be unrealistic. National policy measures are likely to deliver only a 28% cut emissions, with a total estimated potential including local measures of a 33%. Based on the estimates in Table 27 we would propose an alternative carbon reduction target for Plymouth as follows:

- a 15% cut across all sectors by 2013
- a 30% cut across all sectors by 2020

These targets will still be challenging, but should be more achievable. They are also better in line with Governments commitment to meeting an 80% reduction in greenhouse gas emissions by 2050 and 34% by 2020.

5.2. MONITORING

In terms of monitoring progress against targets there are two basic complementary approaches that can be used:

1. Monitoring of targets against regional CO₂ data published by DECC – this data has previously been published in relation to NI 186. We are assuming that the full regional data set, will continue to be published, now that it has been established.
2. Use of proxy indicators – this is supporting data trends that reflect local activity that underlies carbon reduction for example reduction in vehicle traffic. These indicators should be selected to reflect the key local activity that you are undertaking.

The monitoring data should be used to track progress, assess success of the measures being implemented and feedback in to developing carbon reduction activities.
5.3. **Proxy Indicators**

Suggested proxy indicators for key activity areas set out in Table 28

*Table 28: Potential proxy indicators to chart Plymouth’s progress against carbon targets*

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Data source</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Domestic</strong></td>
<td></td>
</tr>
<tr>
<td>Levels of household insulation – cavity, loft and solid wall</td>
<td>Plymouth City Council Home Energy Team survey 2005, national and local house condition survey data</td>
</tr>
<tr>
<td>No Households targeted with advice</td>
<td>Data from EAD energy efficiency advice line, data from Plymouth housing officers</td>
</tr>
<tr>
<td>Number of FIT/RHI installations</td>
<td>National data from FIT/RHI registers may be available.</td>
</tr>
<tr>
<td><strong>Non-domestic</strong></td>
<td></td>
</tr>
<tr>
<td>No of businesses targeted with advice</td>
<td>Data from local initiatives or from carbon trust and business advised in Plymouth</td>
</tr>
<tr>
<td>Aggregated CRC data on non-domestic carbon emissions</td>
<td>Potentially available from Environment Agency.</td>
</tr>
<tr>
<td>Install capacity of district heating and CHP plant, MW</td>
<td>Data from local planning applications.</td>
</tr>
<tr>
<td><strong>Transport</strong></td>
<td></td>
</tr>
<tr>
<td>Changes in traffic levels, VKM</td>
<td>DFT regional traffic data, local traffic counts</td>
</tr>
<tr>
<td>Bus patronage</td>
<td>Local data with PT operators</td>
</tr>
<tr>
<td>Proportion of electric and low emission vehicles in Plymouth</td>
<td>DVLA data for Plymouth post code area</td>
</tr>
</tbody>
</table>
6. CONCLUSIONS AND RECOMMENDATIONS

6.1. CURRENT EMISSIONS
Carbon dioxide emissions in Plymouth in 2008 are estimated at 1,432 kt per year having dropped slightly from a base year in 2005 of 1477 kt. The largest source of emissions is from the non-domestic sector, some 42%, followed by the residential sector, 35%, and lastly transport at 23%. Within the non-domestic sector industrial and service sector emissions are roughly equal. The key characteristics of current emissions from each sector can be summarised as follows:

**Residential**
- 30% of properties are pre-1919, solid wall and 'hard to treat' in terms of insulation, with thousands of unfilled lofts and cavities remaining
- A significant proportion of these older properties are in the private rented sector (50% of this sector is pre-1919).
- Some 15-30% of properties have no cavity wall insulation and 10% no loft insulation.
- Average SAP rating is 52
- Most properties are on the gas grid, some 96%, but only 84% are connected

**Non-domestic**
- Ship building and food production are the largest industrial emissions sources.
- Retail, hotels and catering, and the public sector are the largest sources of emissions in the service sector.
- Manufacturing emissions are dominated by process and space heating needs.
- In the service sector space heating and lighting are the key generators of emissions.
- The manufacturing sector is more focused in about 50 key sites, whereas the service sector is more dispersed across the city in some 6,000 sites.

**Transport**
- Emissions are dominated by car traffic, accounting for some 68% of emissions. Vans account for 14% of emissions and HGV’s 11%.
- 30% of car trips are less than 5 miles and so have the potential for mode shift to walking, cycling and local public transport.
- 38% of car emissions are generated by commuting and business trips, 27% from personal trips and 13% from retail trips

6.2. IMPACT OF NATIONAL POLICY
National policy measures are expected to reduce emissions in Plymouth by 14% by 2013 and 28% by 2020 compared to a 2005 baseline. The key policies that are expected to reduce emissions in Plymouth are:
- Renewable energy sources in the national electricity grid which will affect all sectors.
- The home energy efficiency strategy dominating the residential sector.
- Products policy which will improve the efficiency of appliances and lighting and will be important to both the services and residential sector.
- Car CO₂ emissions standards which will be a key driver in the transport sector.
- Renewable transport fuels the second key policy in the transport sector.
- The renewable heat incentive (RHI) which will be important in the heat dominated industrial sector.

6.3. KEY AREAS OF LOCAL ACTIVITY
Each of the key sectors has been assessed in terms of the local potential to reduce carbon emissions. The key messages from this analysis can be summarised as follows:

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Note: These predictions are based on apportioning national carbon savings to a local level based on indicators such as population or GVA, as has been discussed in Section 3. These projections should not be compared directly to national level targets, which are expressed as GHG reductions compared to a 1990 base.
Residential

- Traditional insulation measures could save some 20-27 kt CO₂ by 2020.
- A focus area would be older and ‘hard to treat’ properties in the private rented sector.
- Updating boilers and fuel switching could generate a further 39 kt CO₂ savings.
- Working with the Green Deal and the Energy Company Obligations will be an important route to leveraging funds for this area. This needs to be explored as the Green Deal is developed through to 2012.
- Micro-generation options seem to have less potential than efficiency improvements, but working to maximise the benefits from FITs and the recently announce RHI could generate some 12kt CO₂ savings.

Non-domestic

- The CRC and CCA will be a strong driver of efficiency improvements in larger non-domestic users.
- Smaller businesses will not be affected by these measures and so should be a target area for local activity.
- The Green Deal will be available to these smaller businesses and so leveraging funds for this sector should be explored along with its use for the residential sector.
- As heat is a major component of non-domestic emissions the development of shared heat schemes through district heating and CHP can generate significant savings. Potential key schemes to develop include:
  - The Devonport EfW facility
  - A Derriford CHP and district heating scheme
  - A Plymouth City Centre CHP and district heating scheme

Transport

- National policy through key measures such as car CO₂ emission standards and the renewable transport fuels obligation are expected to generate some 56 kt CO₂ savings by 2020
- Key additional measures that could generate carbon savings are:
  - An electric vehicle programme generating 13kt CO₂ savings;
  - Increased behavioural change activities (Smarter Choices) generating a further 13kt CO₂ savings;
  - A package of work place parking levy and public transport investment potentially saving 14kt CO₂.

6.4. RECOMMENDATIONS

This study has provided a significant amount of evidence with regards carbon emissions in Plymouth and how these may be reduced. This evidence will need to be assessed in detail along with Plymouth’s ongoing activity in this area and their wider priorities in order to develop a set of detailed carbon reduction activities. The analysis points to the following key messages which need to be considered in taking activity forward:

- The current target of a 60% reduction in CO₂ emissions by 2020 is unrealistic. A more practical, yet still challenging, target would be a 30% reduction by 2020 on a 2005 baseline.
- The council should be looking to build on their existing activity on energy efficiency support by aiming to leverage significant funding from the forthcoming Green Deal programme and related Energy Company Obligation. Key areas of focus would appear to be:
  - The private rented sector (perhaps through HMO licensing or sector links such as landlords serving the student population), especially the significant number of older properties
  - Small businesses, especially those in rented property
- Explore schemes that maximise the use of FIT and the newly announced RHI scheme to generate renewable energy installations in the city. Key target areas could be:
  - PV schemes through housing associations and community groups
  - RHI supporting biomass and other renewable heat schemes in business and public sector buildings
- Facilitate the development of district heating schemes in the city and where possible with a biomass/waste fuel sources. Key schemes to explore include the ongoing Devonport EfW facility and the Derriford CHP schemes, plus the development of a city centre district heating scheme.
- Look to use LTP and Local Sustainable Transport Funding resources to developed:
  - Measures to support electric and low emission vehicles
  - Greater activity on behaviour change activities with a potential focus on business and commuter travel;
  - A work place parking levy for the city supporting increased investment in public transport.

Each of these areas needs to be explored in more detail to develop a detailed action plan and set of schemes to take forward. It will also be important to establish a monitoring process building on the DECC’s regional CO₂ and the development of proxy indicators relevant to the schemes being developed.
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F. ‘Carbon modelling of potential round 3 local transport plan measures for Devon County Council, Internal document 755, September 2010
G. ‘Low carbon economy in the context of the Devon economy’, Scientist report 129, September 2010
## APPENDIX 1

### Number and percentage of solid wall and off gas properties in Plymouth by ward

<table>
<thead>
<tr>
<th>Ward Name</th>
<th>Total households</th>
<th>No Solid Walled</th>
<th>No Off Gas</th>
<th>Solid wall %</th>
<th>Off gas %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Budshead</td>
<td>5,617</td>
<td>142</td>
<td>0.00</td>
<td>2.5%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Compton</td>
<td>4,801</td>
<td>1,678</td>
<td>80.72</td>
<td>35.0%</td>
<td>1.7%</td>
</tr>
<tr>
<td>Devonport</td>
<td>6,118</td>
<td>1,999</td>
<td>207.85</td>
<td>32.7%</td>
<td>3.4%</td>
</tr>
<tr>
<td>Drake</td>
<td>3,082</td>
<td>2,050</td>
<td>91.85</td>
<td>66.5%</td>
<td>3.0%</td>
</tr>
<tr>
<td>Efford and Lipson</td>
<td>5,848</td>
<td>1,543</td>
<td>138.19</td>
<td>26.4%</td>
<td>2.4%</td>
</tr>
<tr>
<td>Egguckland</td>
<td>5,579</td>
<td>103</td>
<td>498.82</td>
<td>1.8%</td>
<td>8.9%</td>
</tr>
<tr>
<td>Ham</td>
<td>5,820</td>
<td>729</td>
<td>42.02</td>
<td>12.5%</td>
<td>0.7%</td>
</tr>
<tr>
<td>Honicknowle</td>
<td>6,019</td>
<td>84</td>
<td>282.87</td>
<td>1.4%</td>
<td>4.7%</td>
</tr>
<tr>
<td>Moor View</td>
<td>4,974</td>
<td>27</td>
<td>395.98</td>
<td>0.5%</td>
<td>8.0%</td>
</tr>
<tr>
<td>Peverell</td>
<td>5,485</td>
<td>2,659</td>
<td>59.96</td>
<td>48.5%</td>
<td>1.1%</td>
</tr>
<tr>
<td>Plympton Chaddlewood</td>
<td>3,356</td>
<td>0</td>
<td>166.40</td>
<td>0.0%</td>
<td>5.0%</td>
</tr>
<tr>
<td>Plympton Erle</td>
<td>3,718</td>
<td>782</td>
<td>327.92</td>
<td>21.0%</td>
<td>8.8%</td>
</tr>
<tr>
<td>Plympton St Mary</td>
<td>4,963</td>
<td>245</td>
<td>240.94</td>
<td>4.9%</td>
<td>4.9%</td>
</tr>
<tr>
<td>Plymstock Dunstone</td>
<td>5,331</td>
<td>201</td>
<td>106.16</td>
<td>3.8%</td>
<td>2.0%</td>
</tr>
<tr>
<td>Plymstock Radford</td>
<td>5,401</td>
<td>445</td>
<td>184.80</td>
<td>8.2%</td>
<td>3.4%</td>
</tr>
<tr>
<td>Southway</td>
<td>5,256</td>
<td>178</td>
<td>43.88</td>
<td>3.4%</td>
<td>0.8%</td>
</tr>
<tr>
<td>St Budeaux</td>
<td>5,704</td>
<td>747</td>
<td>180.09</td>
<td>13.1%</td>
<td>3.2%</td>
</tr>
<tr>
<td>St Peter and the Waterfront</td>
<td>6,489</td>
<td>2,369</td>
<td>654.30</td>
<td>36.5%</td>
<td>10.1%</td>
</tr>
<tr>
<td>Stoke</td>
<td>5,585</td>
<td>3,445</td>
<td>96.92</td>
<td>61.7%</td>
<td>1.7%</td>
</tr>
<tr>
<td>Sutton and Mount Gould</td>
<td>5,447</td>
<td>4,017</td>
<td>104.87</td>
<td>73.7%</td>
<td>1.9%</td>
</tr>
</tbody>
</table>
APPENDIX 2

The tables below show three scenarios for energy CWI and loft insulation measures to Plymouth’s dwelling stock, depending on the number of dwellings to be addressed which varies depending on data source used.

<table>
<thead>
<tr>
<th>Scenario 1 – HEED data Oct 2009</th>
<th>remaining suitable properties insulated</th>
<th>Cavity Wall Insulation</th>
<th>Virgin Insulation</th>
<th>Loft Top-up insulation</th>
<th>loft TOTAL savings KtCO₂ pa 2022</th>
<th>Cumulative savings 2008-2022 KtCO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. houses Carbon savings (Kt CO₂) No. houses Carbon savings (Kt CO₂) No. houses Carbon savings (Kt CO₂)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a</td>
<td>100% 15,093 9.4 6137 6.9 34242 11</td>
<td>27.4 309.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b</td>
<td>75% 11,319 7.1 4603 4.3 25682 8.3</td>
<td>20.6 233.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c</td>
<td>50% 7520 4.7 3069 3.5 17121 5.5</td>
<td>13.7 155.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scenario 2 – HEED data Feb 2011</th>
<th>remaining suitable properties insulated</th>
<th>Cavity Wall Insulation</th>
<th>Virgin Insulation</th>
<th>Loft Top-up insulation</th>
<th>loft TOTAL savings KtCO₂ pa 2022</th>
<th>Cumulative savings 2008-2022 KtCO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. houses Carbon savings (Kt CO₂) No. houses Carbon savings (Kt CO₂) No. houses Carbon savings (Kt CO₂)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a</td>
<td>100% 4267 2.67 1401 1.6 7820 2.5</td>
<td>6.8 76.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b</td>
<td>75% 3200 2 1051 1.2 5865 1.9</td>
<td>5.1 57.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c</td>
<td>50% 2134 1.3 701 0.8 3910 1.3</td>
<td>3.4 38.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scenario 3 - remaining suitable properties insulated</th>
<th>Cavity Wall Insulation</th>
<th>Virgin Insulation</th>
<th>Loft Top-up insulation</th>
<th>loft TOTAL savings KtCO₂ pa 2022</th>
<th>Cumulative savings 2008-2022 KtCO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. houses Carbon savings (Kt CO₂) No. houses Carbon savings (Kt CO₂) No. houses Carbon savings (Kt CO₂)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a</td>
<td>100% 10000 6.25 3800 4.3 21200 6.8</td>
<td>17.4 196.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b</td>
<td>75% 7500 4.7 2859 3.2 15900 5.1</td>
<td>13.1 148.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c</td>
<td>50% 5000 3.1 1900 2.1 10600 3.4</td>
<td>8.7 98.5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX 3 – SECTOR DEFINITIONS

There are a range of different sectoral breakdowns used in the various data sources and reports on which this work is based. The three main breakdowns and shown below, indicating how they relate to each other:

- **Level 1** – is the least disaggregated and comprises the broad sectors used for the regional CO$_2$ data, of which NI186 is a subset.
- **Level 2** – is the next level of disaggregation as used in the ‘Low Carbon Transition Plan’, the 5$^{th}$ National Communication (on climate change) and in the CEE report on ‘The impact of national policy on local carbon emissions’.
- **Level 3** – is the more detailed disaggregation used in the CEE study on ‘A low Carbon Economy in the context of the Devon Economy’.

Renewable energy is 4$^{th}$ sector used in this report although it is not a economic sector as such, rather a resource and set of technologies that we are seeking to utilise as part of the low carbon economy.

<table>
<thead>
<tr>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic</td>
<td>Domestic</td>
<td>Domestic</td>
<td>Household energy use, including allocated emissions from electricity use.</td>
</tr>
<tr>
<td>Non-domestic</td>
<td>Agriculture, Industry</td>
<td>Primary industry</td>
<td>Agriculture, fisheries and forestry</td>
</tr>
<tr>
<td>(commercial and</td>
<td>Secondary Industry</td>
<td>Quarrying and materials extractions</td>
<td></td>
</tr>
<tr>
<td>industrial)</td>
<td>Manufacturing</td>
<td></td>
<td>Wide range of manufacturing sectors</td>
</tr>
<tr>
<td></td>
<td>Energy and Water</td>
<td></td>
<td>Energy use in water sector, and energy distribution</td>
</tr>
<tr>
<td></td>
<td>Construction</td>
<td></td>
<td>Building and construction activity</td>
</tr>
<tr>
<td>Business Services</td>
<td>Public Services</td>
<td></td>
<td>Retail and commercial services</td>
</tr>
<tr>
<td>Waste management</td>
<td>Waste management</td>
<td></td>
<td>Energy use and emissions from waste treatment and management activities (not collection).</td>
</tr>
<tr>
<td>Transport</td>
<td>Transport</td>
<td>Transport</td>
<td>All transport activity in county including all that associated with sectors above.</td>
</tr>
<tr>
<td>LULUFC</td>
<td>LULUFC</td>
<td>LULUFC</td>
<td>Land use and land use change effects.</td>
</tr>
</tbody>
</table>
APPENDIX 4 – DEFINITIONS AND PROJECTIONS FOR PLYMOUTH’S ECONOMY

The analysis of projections to Plymouth’s economy and carbon emissions together with associated economic indicators was based on two sources. The projections for carbon emissions were based on the apportioned savings from national policy (LCTP) as has been used as the basis of the projections for emissions reductions due to national policy elsewhere in this report. Projections from the LCTP divided the non-domestic sector into four sub-sectors; industry, business, public and agriculture. Agricultural emissions in Plymouth are negligible and so are not reported. For the purposes of the economic analysis, sub-sector carbon emissions within each of those divisions within the non-domestic sector were further sub-divided based on the split of emissions per sub-sector in the baseline year (2007). For example, “hotels and restaurants” were responsible for 20% of business emissions in 2007, and were assumed to be responsible for 20% of business emissions each year until 2022. Although this is unlikely to be true, there was no further detailed information available. The projected cost of fuel and petrol was taken from Annex F of the LCTP High scenario, which is not a dissimilar projection to prices experienced at present.

The projections for Plymouth’s economy were taken from projections made by Oxford Economics (expressed as GVA and employment), which were taken from the SW Regional Observatory website. The “weak” economic projection was chosen to attempt to reflect the slow economic growth experienced at present, which were not foreseen at the original time of these projections.

The economic projections included employment and economic output (GVA). Definitions for these, as well as some additional indicators derived from these and the carbon projections are detailed below.

The definitions for the indicators adopted are as follows:

Employment
Definition
Employment captures any formal contract between two parties: an employer and an employee. Employees may work under full-time or part-time contracts. Employment is measured in thousands of workers.

Interpretation/Caveats
Employment as such is a common indicator of the importance of a particular sector or sub-sector for the labour market. Ideally, employment should be expressed in working hours or, alternatively, the full-time equivalent if a particular number of hours per month or year are set as a standard. Unfortunately, Oxford Economics (2010) data does not provide this detail. Hence, comparison across sectors is problematic if the ratio between full-time and part-time is different. For a particular sector, a sensible comparison between Plymouth and the UK must assume that the ratio between full-time and part-time is more or less the same for both regions. Interpretation of time trends for sectors must also assume that this ratio stays more or less the same over time.

GVA
Definition
Gross value added (GVA) is the value of goods and services produced in an area, industry or sector of an economy. It is the difference between output and intermediate consumption for any given sector/industry. That is, the difference between the value of goods and services produced and the cost of raw materials and other inputs which are used up in production. GVA is measured in millions of pounds (£m) and in the Oxford Economics (2010) data expressed in 2005 prices.

Interpretation/Caveats
GVA is commonly seen as a good proxy to measure the output of a sector or region. GVA has a close relationship with what is known as gross domestic product (GDP): GVA + taxes on products – subsidies on products = GDP

The advantage of GVA compared to GDP is that it excludes the effects of fiscal policies on output. GVA (like GDP) is usually measured in prices of a particular year (e.g. we use 2005) in order to exclude inflation. For instance, if economic output remains the same but inflation is 5%, GVA growth would otherwise be 5%. With our measure, GVA growth would be 0%, which is better reflecting the realities. Finally, it should be said that GVA measures output in

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monetary terms and hence uses current prices. This means that prices must reflect the “valuation of society for particular goods” and assumes that there are no externalities that are not reflected in prices or distort prices. This is obviously a problematic and simplifying assumption, which we will (at least partially) correct below by putting GVA in relation to carbon emissions.

**Labour Productivity**

**Definition**

Labour productivity is the amount of goods and services that a worker/employee produces in a given amount of time\(^{bb}\). We define it as the ratio of output, measured as GVA, to input, measured as employment, i.e. GVA/Employment. Since GVA is measured in millions of pounds and employment in thousands of workers, our productivity numbers are thousands of pounds per worker.

**Interpretation/Caveats**

Labour productivity can be regarded as a good proxy of the economic competitiveness of a sector or region. In a market-economy in which growth is driven (among other factors) by competition, a sector or an industry will only be successful in the long-run if labour productivity is not below that of competitors. As a tendency, growth sectors will be those sectors with a high labour productivity. Labour productivity in a sector can go up because GVA rises and/or because employees leave a sector. The last possibility is not problematic in a growing economy in which these employees are taken up by other sectors. A labour productivity growth due to GVA and employment growth where the former is faster than the latter is therefore a development that does not need much qualification. In all other cases, the development has to be interpreted in the specific context, and conclusions have to be drawn with caution. Most economists would agree that, roughly speaking, wage increases should, at least loosely, be tied to increases in labour productivity.

Given the caveats we mentioned under Employment above, it is evident that our measure of productivity suffers from the same shortcomings. That is, cross-sectoral as well as cross-regional comparisons are problematic as the following simple and stylized example will illustrate. Suppose industry A employs 100 part time workers, working 20 hours per week, and industry B employs 50 full-time workers, working 40 hours per week. Both produce £100 of GVA. As a result of this, industry A has a labour productivity of £1 per worker and industry B of £2 per worker using our crude measure from above. In terms of hours, and “in reality”, the labour productivity of industry A and B would be the same, namely £0.5 per hour, which more accurately reflects their relative labour productivity.

**Carbon Productivity**

**Definition**

Carbon productivity is the amount of goods and services that can be produced with one unit of CO\(_2\) released in the production process. We define it as the ratio of output, measured as GVA, to input, measured as CO\(_2\)e, i.e. GVA/CO\(_2\)e. Since GVA is measured in millions of pounds in 2005 prices and CO\(_2\)e is measured in ktCO\(_2\), carbon productivity is measured in thousands of pounds per tonne CO\(_2\) (t CO\(_2\)).

**Interpretation/Caveats**

Carbon productivity puts economic output in relation to carbon emissions and is therefore a measure of the “greenness of production”. High emissions in a sector are not bad per se, though certainly damaging overall, as long as they produce high output. Similarly, low emissions in a sector are not necessarily good, if they produce little output. Carbon productivity is therefore one possibility to capture the notion of a “balanced green economy”. On the one hand, there has to be economic production and consumption. On the other hand, this should not impact too severely on the environment. Hence, in a balanced green economy, economic growth should go along with an increasing carbon productivity. In fact, ideally, an increasing carbon productivity should come simultaneously from a higher GVA and lower total emissions and not from only one of these sources.

Since CO\(_2\) emissions is an input in the computations of carbon productivity, and as has been pointed out above, due to data limitations, the percentage decline of emissions resulting from the LCTP are assumed to be more or less the same for the UK and Plymouth across sectors. Differences in carbon productivity between the UK and Plymouth mainly stem from differences in the development of GVA (and not from the development of CO\(_2\) emissions) in the UK and Plymouth and initial differences in carbon productivity between the UK and Plymouth in the starting year of our

analysis in 2007. In other words, initial carbon productivity differences in the UK and Plymouth are more or less preserved over time, as long as there are no dramatic differences in GVA development in a particular sector. This is a shortcoming of the methodology that has been adopted in this analysis, which has been necessary due to a lack of robust data sources.

**Labour Carbon Intensity**
- **Definition**
  
  Labour carbon intensity is the amount of CO$_2$ emissions released per unit of employment. We define it as the ratio of CO$_2$ emissions to employment, i.e. CO$_2$/Employment. Since we measure CO$_2$ in kilo tonnes and Employment in thousands of workers, labour carbon intensity is measured in tonnes CO$_2$ per worker.

- **Interpretation/Caveats**
  
  Labour carbon intensity is an alternative indicator to carbon productivity in order to capture the notion of a “balanced green economy”. Ideally, we are looking for a low labour carbon intensity of a sector or an economy. However, we have to be cautious with any conclusions drawn because of the caveats mentioned under Employment, which does not distinguish between full and part-time.
  
  Again since CO$_2$ emissions is an input in the computations of labour carbon productivity, similar caveats apply as has been mentioned for carbon productivity.