Department of Energy & Climate Change

The Future of Heating: Meeting the challenge

March 2013

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1850

Ministerial Foreword

In a world facing the threat of catastrophic climate change, it is the job of my department to lead the UK into a thriving low carbon economy, achieving our ambitious target of an 80% cut in greenhouse gas emissions by 2050.

We are making excellent progress: on track to meet the first three carbon budgets, on track to meet our EU target for renewable energy, in the midst of some fundamental reforms to our electricity markets via the Energy Bill, and having just launched the ground-breaking Green Deal programme to help drive energy efficiency across the country. In the coming years, every home will be supplied with a smart meter, and consumers will be much better placed to make informed choices about their energy needs and where to get their energy from.

But that is not enough. As we stated last year, there has been a historic failure to get to grips with one enormous part of the energy jigsaw; the supply of low carbon heat. Energy efficiency and better informed consumers help to tackle the demand for heat, and market reforms are helping to decarbonise the supply of electricity. We have, however, inherited a big hole where there should be policy for finding alternatives to fossil fuel for the supply of heat.

This document plugs that hole. It deals systematically with all the different heating requirements in the UK; and there are many. In a country like ours, and for obvious reasons, we require a lot of heat: a consequence of our geography, our housing stock and the scale of our industrial activity.

As a country, we spend £32 billion a year on heating. It accounts for around a third of our greenhouse gas emissions. Without changing the way we produce and consume heat, we will not meet our long-term climate change target. To get there, we are going to have to change the way we generate, distribute and use heat in buildings and industry. And we are going to need those changes to take place in an orderly, cost-effective way that ensures a vibrant, low carbon economy and a supply of affordable energy for all consumers.

I am delighted to be able to report on our progress in meeting the challenge.

Edward Davey
Secretary of State for Energy and
Climate Change

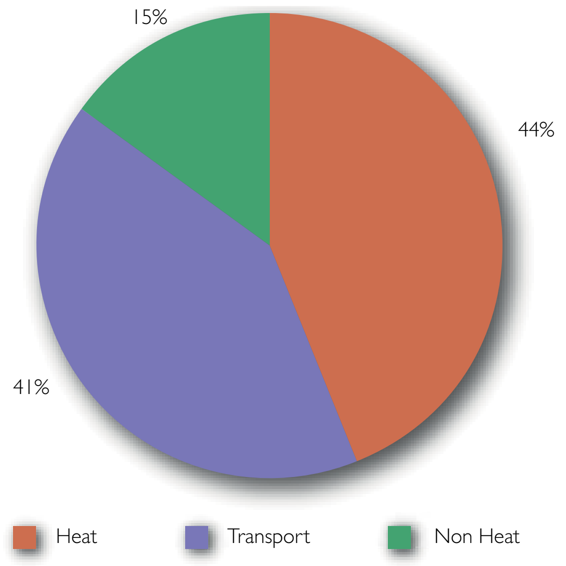
Introduction

1. Nearly half the energy we use in the UK is used for heating of one sort or another. And of the total of 906 TWh of natural gas consumed in the UK in 2011, 52% was used to provide heat for buildings and industry. This compares to the 34% burned in power stations to make electricity.[1]

2. Last year, Government published *The Future of Heating: A Strategic Framework for Low Carbon Heating in the UK*. This set out for the first time a framework for solving the problem of ensuring there is affordable, secure and low carbon heating in a nation where 70% of all heat currently comes from natural gas, a fossil fuel.[2] It set out a vision of our energy future: a future with secure supplies of low carbon and renewable energy at affordable prices, supporting a strong UK economy.

3. Because so much of our energy is used for heating, it is important to understand the particular challenges that heating presents, and some solutions to those challenges.

Chart 1: Energy Usage for Heat, Non Heat and Transport, 2011

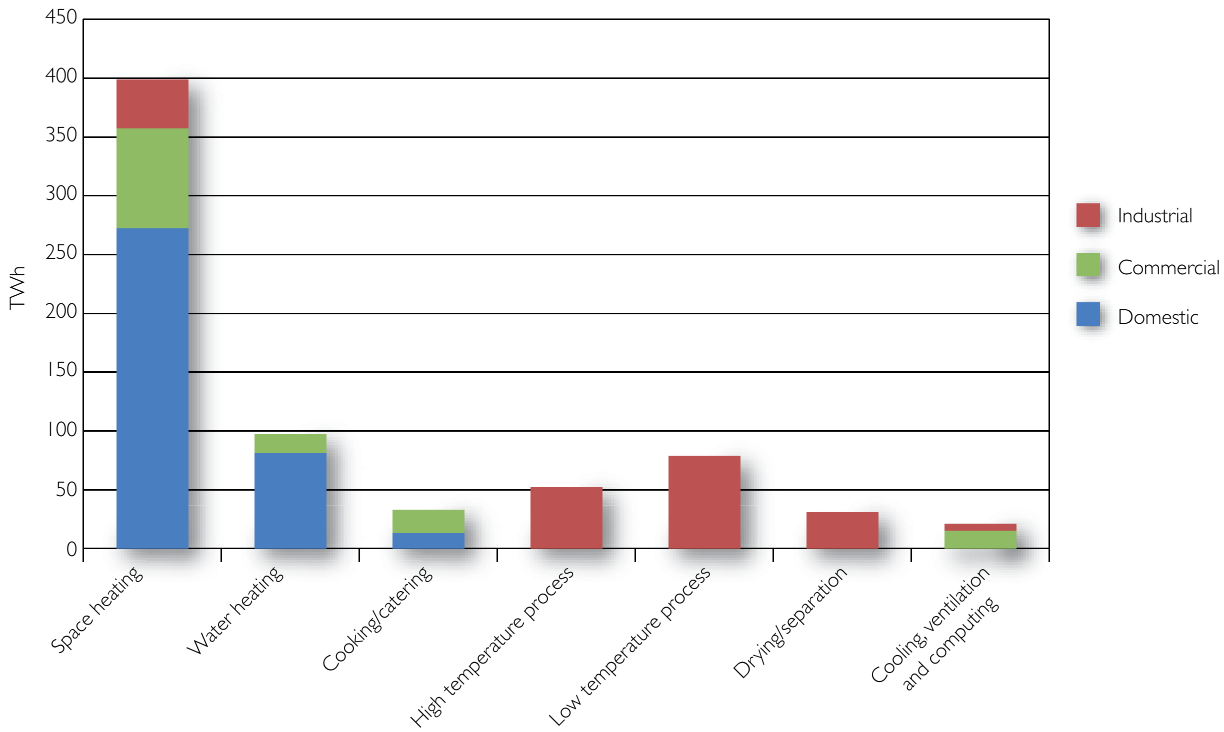


Source: DECC

4. To fully understand the heat challenge it is important to recognise that, unlike electricity, different sorts of heat are required for different purposes. The heat requirement is highly dependent on the circumstances: where is it needed, what is it needed for, when it is needed and how hot it needs to be.

1 DECC, 2012, *Digest of UK Energy Statistics*
2 DECC, 2012, *The Future of Heating: A Strategic Framework for Low Carbon Heating in the UK*, at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48574/4805-future-heating-strategic-framework.pdf, accessed 1 February 2013

Chart 2: Energy consumption for heating by sub-sector and end-use in TWh (2011)

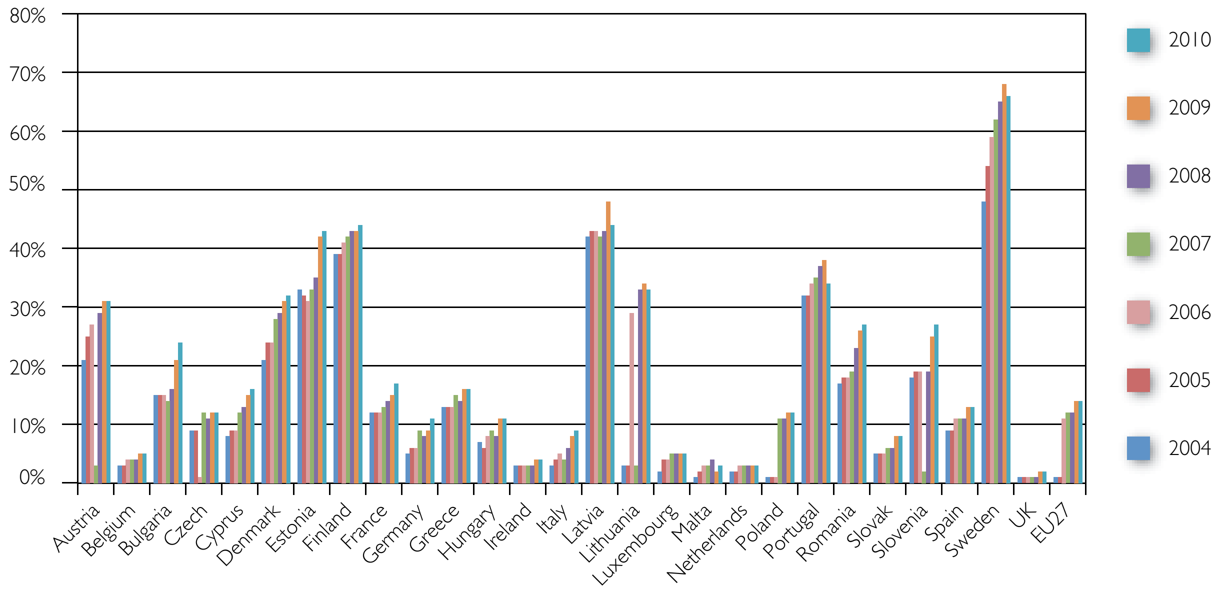


Source: DECC

5. It is instructive to compare the UK's experience with that of other countries. As a consequence of a high heating demand, a low requirement for cooling, and access to North Sea gas in recent decades, the UK has developed into the world's number one market for gas boilers. Natural ventilation rather than air conditioning is the main form of cooling in the domestic sector and parts of the commercial sector. Where some countries have been developing heat networks and renewable heating as responses to concerns about price and security of supply of imported fossil fuels, the UK's very low penetration of these technologies is a direct consequence of ample supplies of low cost natural gas distributed nationally, following the switch from town gas some forty years ago.

6. In the UK we have relatively robust data on heating; a lack of comparative data in other countries can sometimes impede comparison. Data from Eurostat 2010 makes clear the relatively low penetration of renewable heat in the UK.

Chart 3: Percentage of heating and cooling from renewable resources as a percentage of total energy used for that purpose



Source: Eurostat – SHARES 2010

7. In *The Future of Heating: A Strategic framework for low carbon heat in the UK* (henceforth "the Strategic Framework"), the Government set out the challenge for decarbonising heat until 2050. Building on the Government's *The Carbon Plan: delivering our low carbon future*[3] (henceforth "the Carbon Plan") this suggested that the 2050 carbon emissions reduction target is likely to require reducing emissions from buildings to near zero by 2050, and up to a 70% reduction in emissions from industry – the majority of which are heat-related.[4]

8. DECC has reviewed and improved the modelling of heat out to 2050 in light of comments received from stakeholders in response to last year's document. The Department commissioned Redpoint to use the Redpoint Energy System Optimisation Model (RESOM) to look at the implications for heating of the UK meeting its 2050 emissions reduction targets. DECC has complemented this with analysis from the Energy Technology Institute's Energy System Modelling Environment (ESME) model to explore uncertainties and to draw comparisons with RESOM. The implications are explained more fully in the Evidence Annex. In summary, the revised modelling broadly confirms the original picture set out in the Carbon Plan, but suggests there are some scenarios where part of the least-cost mix includes the continuation of some natural gas heating for buildings out to 2050, though this would be delivered by emerging technologies such as hybrid boiler/heat pumps or by gas absorption heat pumps, rather than standard gas boilers.

9. This is because the new modelling is better at taking into account the extreme peaks in heat demand that happen on the coldest days each

3 DECC, 2011, *The Carbon Plan: delivering our low carbon future* at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/47613/3702-the-carbon-plan-delivering-our-low-carbon-future.pdf, accessed on 12 March 2013

4 DECC, 2012, *The Future of Heating: A Strategic Framework for Low Carbon Heating in the UK*, at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48574/4805-future-heating-strategic-framework.pdf, accessed 1 February 2013

year. A model to identify the cheapest way to meet our low carbon ambitions will indicate that – all other things being equal – it is cheaper to meet this very high demand using the existing gas grid than making the additional extra investment in new power stations and electricity infrastructure that would be needed if it were to be primarily met through electric heating (including electric heat pumps). The 80% carbon target for 2050 is an absolute constraint in the models: in other words the model will only choose gas for heating in circumstances where this does not breach the overall carbon target.[5] These additional refinements in the model lead to a greater consideration of the whole energy system, and the relationships between a variety of grid and storage options which is set out in more detail in chapter 4.

10. In November 2011, the Government launched the world's first renewable heat incentive, paying tariffs to non-domestic heating systems that use renewable sources of heating such as biomass boilers, heat pumps, deep geothermal and solar thermal. The scheme has so far had more than 1800 applications for installations producing around 130 GWh of renewable heat. We expect this to represent around £24m of support for the 2012-13 financial year, with much more in the pipeline. However, some technologies have seen lower take up than we were hoping for, and we now have improvements to some of the input assumptions that were used in calculating the original tariffs, which is why the Government announced an early review of tariff levels in February of this year. There will be a consultation on these new tariff levels in the spring. We do not expect to reduce tariffs through this exercise; the expectation is that some tariff levels will go up as a result. We have also previously announced that it is DECC's intention that any installations accredited after the date that a review was first suggested – 21 January 2013 – should benefit from uplifts to the tariff they receive from the date they are implemented.

11. The Government has consulted on Renewable Heat Incentive tariffs for domestic buildings, with a commitment that this will support all eligible installations since July 2009. Details of tariff levels and eligibility are expected to be published this summer. The Government is also extending the Renewable Heat Premium Payment scheme (RHPP). The extended scheme will run until the end of March 2014.

12. This document explains how renewable heating fits into the wider heat strategy. More information on how the RHI is helping the switch away from fossil fuels for industrial heat is covered in chapter 1. One of the actions announced at the end of that chapter is to look at the scope for incentivising the recovery and re-use of waste industrial heat alongside the 2014 non-domestic RHI review. In chapter 2, the role of the RHI in supporting renewable heat in heat networks is covered and an action is announced to consider the use of an 'RHI uplift' to make this a more attractive option for network developers. Chapter 3 describes the extension of the RHPP scheme and the ways in which the existing RHI is driving the take-up of renewable heating in non-domestic buildings, in the commercial and public sectors. More information on the RHI is also available on the website: https://www.gov.uk/government/policies/increasing-the-use-of-low-carbon-technologies/supporting-pages/renewable-heat-incentive-rhi

13. In the Evidence Annex there is a summary of the initial learning from the RHPP scheme following customer surveys and metering of usage.

People

14. The changes needed to our heating systems as a result of the threat of climate

5 RESOM modelling by Redpoint, commissioned by DECC, 2012, see Evidence Annex

change are likely to touch the lives of every person in the UK. We all need to heat our homes and buildings. The impact of a radical shift in the way we heat our homes may be felt most acutely amongst low-income and fuel poor households – for whom heating costs will make up a higher proportion of their total income. For these households, the decarbonising of heating offers both opportunities and risks. It is important that everyone can understand the impacts that government's proposals will have on the fuel poor households and how these impacts vary across different future scenarios. Alongside the work to develop the policy framework, DECC will continue to work to understand more fully the impact of proposals on consumers and to understand the potential for synergies between the areas of low carbon heating and fuel poverty.

15. The Government is designing policies to help consumers by personalising the assessment of their needs (for example through Green Deal Assessments) – and that will include their heating needs too. This is not just about giving people informed choices on heating their homes, but also making sure policies are integrated so the customer journey is joined up and makes sense from the perspective of the individual person or business.

Business

16. British commercial and industrial heat users are already leading the world. Of the 12 largest world economies, the UK is performing best overall on energy efficiency indicators.[6] The move to low carbon heating is an opportunity to build on this success by diversifying our sources of heat and chasing further efficiency gains. It is our chance to integrate heating solutions into smart homes, smart buildings and smart grids that can allow Home or Building Energy Management services which are responsive, cheaper and greener.

17. A significant portion of industrial heat usage is in heat intensive industry (often electricity intensive too). These industries are vital to delivering a greener economy. For example, low carbon housing requires high grade cement, steel and glass for construction, and many other products in fitting out.

18. These energy intensive industries are spread throughout England, Wales and Scotland and are often the largest local employers in high unemployment areas. In 2010, economic output from UK energy intensive industries contributed around £49.6 billion (4%) gross value added to the UK economy and employed over 600,000 people (2% of the total UK workforce).

19. This government is keen to develop innovation: supporting the market to discover solutions and to speed up the deployment of these solutions while recognising there are long lead-in times on new technologies. It is important that solutions are developed by the market in response to customer demand. The role of government is to shape that market where necessary to overcome barriers. In the 'barriers' section of each chapter the document considers evidence of any market failure and the case for some form of intervention. This Government's focus will be on creating the right frameworks to support the market and minimise costs to consumers and industry.

Places

20. This is not just a policy document about products and people, it is about places and infrastructure. The circumstance-specific nature of heat demand is a recurring theme in the document. Some of this is directly dependent on geographical location and varies across the UK. In January 2013, the Scottish Government published an outline for a draft heat vision for Scotland, including a statement of ambition and setting out the process for its development. The Scottish Government will also publish a Heat

6 The ACEEE 2012 International Energy Efficiency Scorecard, http://www.aceee.org/sites/default/files/publications/researchreports/e12a.pdf, accessed on 21 February 2013.

Box 1: Heating infrastructure options for buildings

- Individual heating systems, not linked to a networked fuel supply, for example, standalone biomass boiler, solar thermal, coal, gas heating through bottled gas or electric heating run off a standalone generator.
- Electric heating, including heat pumps, powered through grid electricity.
- Individual heating system (boiler) fuelled through pipework carrying natural gas or biomethane.
- Individual heating system (boiler) fuelled through pipework carrying an alternative gas such as hydrogen.
- Heating that comes into the house via a heat exchanger connected to pipework carrying hot water (heat networks).

Generation policy statement later this year to provide clarity on their views on the generation of heat within Scotland and to set out scenarios for meeting their heat vision.[7]

21. Heat can be a single house-based solution like a woodchip boiler burning locally supplied fuel, or it can be a national infrastructure project as would be involved in creating a whole new hydrogen-based distribution grid. The heat challenge is a 'systems problem' and can be addressed at different levels of the system.

22. Historically, communal and national level infrastructure has been driven by public investment. Most of it took place when the energy utilities were nationalised industries. Such infrastructure is no longer publicly owned but is now regulated by Ofgem. The exception is heat networks – these are not within Ofgem's remit but in many cases are driven by explicit government planning at the local level.

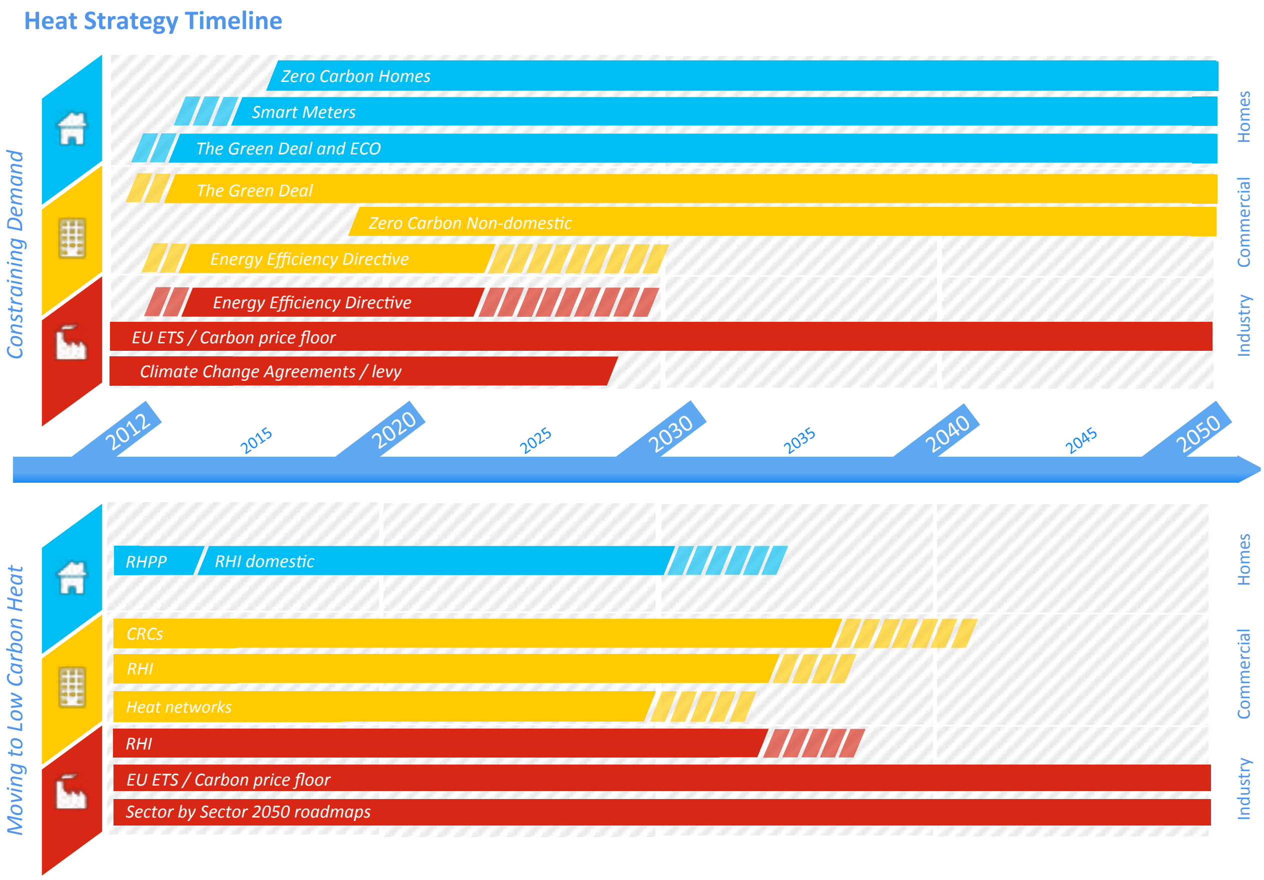
23. So one theme throughout the document is the inter-dependency of heat solutions with the wider energy network. This is a complex whole-system problem and it cannot be fully solved by considering one part of the solution in isolation. The models are showing us that if peak levels of heat demand have to be met by electric heat, then a large number of additional power stations would be needed purely to serve the need for heat on those one or two weeks of the year when demand is highest. But if we could find an effective way of storing energy until it is needed, it would provide us with a better way of tackling the peaking problem than having built-in redundancy (either a gas network only partially used, or power stations only sporadically required). Hence the heat question is also the electricity question, the storage question and the infrastructure question.

Next steps

24. The Strategic Framework was the beginning of a dialogue. DECC received 160 responses to the questions asked in that document, with many offers of help to refine the department's thinking and design the right policies for the decades to come. The last year, therefore, has seen Government working closely with a wide variety of sectors interested in heating and cooling to test elements of that framework, improve understanding of the economics, science and behavioural aspects of heating, and refining the policy options. This document, and its Evidence Annex, report on that work and set out the new actions that Government is proposing.

7 See *Outline for a draft Heat Vision from Scottish Government* at http://www.scotland.gov.uk/Resource/0041/00413386.pdf, accessed on 19 February 2013

Figure 1: Timeline



Source: DECC

Chapter 1: Efficient Low Carbon Heat in Industry

Guide to using this chapter

What is the situation now? describes how important heat is for some of the key industrial sectors in the UK such as steel, cement, glass, oil refining, food and drink, and chemicals. Each of these processes uses heat at a temperature specific to the materials involved and the product being manufactured. Heat can be applied in industry across a spectrum of temperatures from below 100°C to above 1000°C.

Industrial Combined Heat and Power (CHP) describes the opportunities offered by the simultaneous production of heat and generation of electricity at industrial sites.

What might we need for our low carbon future? describes what is known about the potential for making carbon savings from energy efficiency, materials and resource efficiency, fuel switching, industrial Carbon Capture and Storage (CCS) and waste heat recovery.

In **Barriers and challenges,** the commercial, technical and delivery challenges faced by industry are summarised.

Policies in place now lists twelve current policies that are aimed at or are relevant to this area.

The **Next steps** cover proposals on low carbon roadmaps, energy efficiency, industrial CCS, recoverable waste industrial heat, and CHP.

Introduction

1.1 UK Industry consumes very large amounts of energy, over 70% of which is to provide heat, often at very high temperatures. The majority is obtained by burning fossil fuels (predominantly gas, but also some coal and oil). Because of this, industry is responsible for a quarter of UK carbon emissions. 67% of heat demand is in six key industrial sectors: oil refining, basic metals, food and drink, pulp and paper, non-metallic minerals (including ceramics, cement and glass), and chemicals. This chapter focuses on these sectors.

1.2 In the Strategic Framework, DECC concluded that reducing emissions from industrial heat could be done in three ways: more energy efficient processes and equipment; switching to lower carbon fuels; and CCS. Industries that consume large amounts of heat often install CHP, providing them with electricity to use and often a surplus to sell to the grid. Installing CHP does not necessarily decarbonise the site itself, nor increase the site's efficiency, but it does improve energy efficiency and carbon intensity overall when emissions displaced from off-site power generation are considered. Further emissions reductions can be achieved cost-effectively through resource and materials efficiency.

1.3 When designing policies to reduce emissions from industrial heat, it is important to appreciate that the heat required, and decarbonisation options, vary by industry-specific factors. There are some industrial processes which will continue to emit CO_2. Industrial CCS will therefore be required in some scenarios to decarbonise heat supply.

Next steps

- DECC and BIS will develop long-term decarbonisation 'roadmaps' with each industrial sector focusing on the most heat and CO_2 intensive sectors.
- DECC and BIS will by the end of 2013 identify how to support development of industrial CCS.
- New DECC research is assessing the potential for recovered heat as a low carbon energy source. Based on this, DECC will explore the scope for incentivising recovered 'waste' heat, in particular alongside the RHI 2014 review.
- DECC will develop bespoke support for new natural gas CHP, subject to this not displacing low carbon generation. This will cover the full range of gas CHP types.
- BIS and DECC will explore the use of European Regional Development Funding to support CHP and waste heat recovery by Local Enterprise Partnerships.

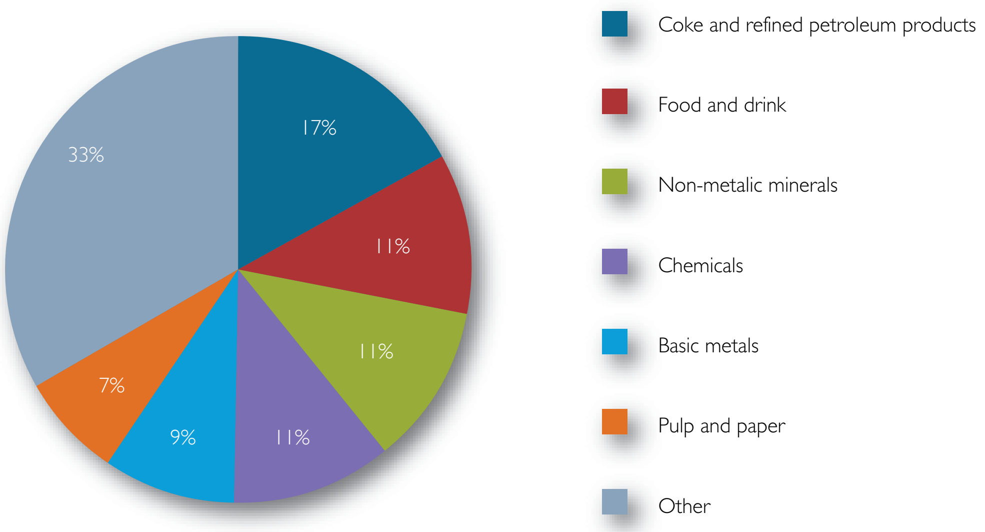
What is the situation now?

Industrial heat – an overview

1.4 Heat is integral to many industrial processes including melting, drying, pasteurising and distilling. Each of these processes uses heat at a temperature specific to the materials involved and the product being manufactured. Heat can be applied in industry across a spectrum of temperatures from below 100°C to 1000°C or higher.

1.5 The majority (73%) of industrial energy demand is for heat. Industrial heat can be divided into four categories: for space heating, high temperature process heat, low temperature process heat and heat for drying and separation. Industrial heat use is a significant component of UK energy use, with industry consuming 20%

Chart 4: Industrial heat demand by sector TWh



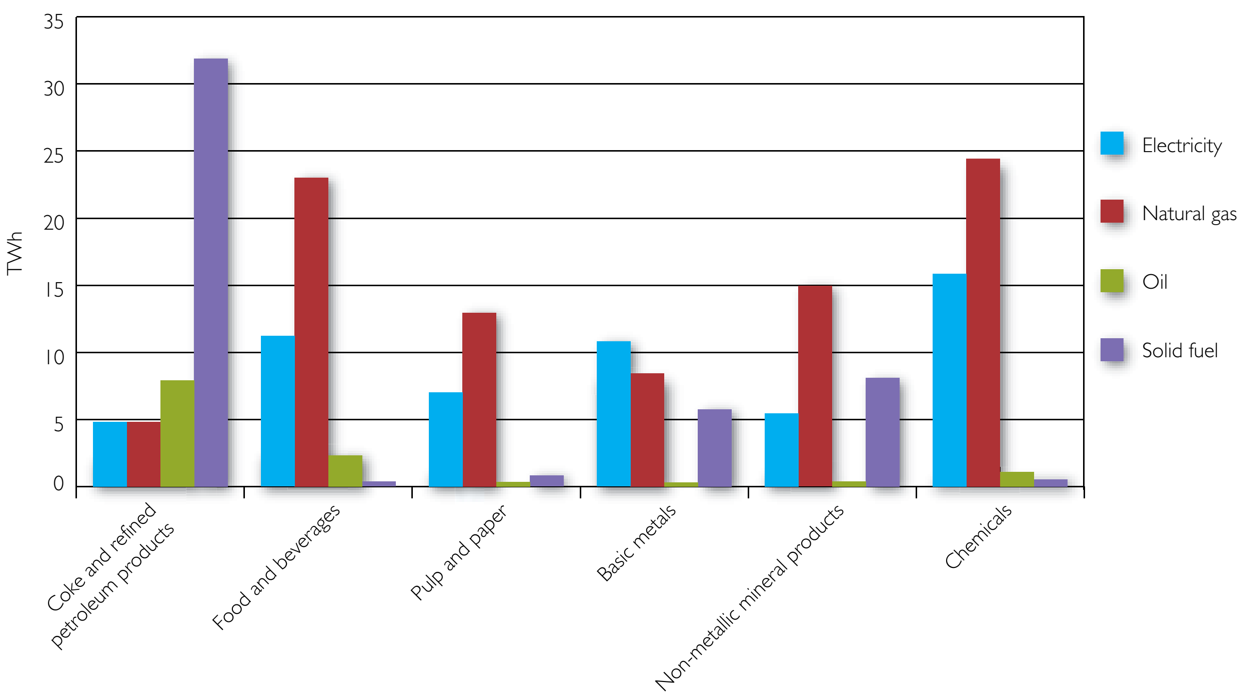
Source: DECC, 2012, *Energy Consumption in the UK 2012* of all UK energy as heat[8] and generating 32% of the UK's heat-related carbon emissions. Industrial heat use is responsible for similar emissions to domestic heat. This heat use is concentrated among six key sectors (see Chart 4).

1.6 The fuels used to generate heat in industry include natural gas, coal/coke, electricity, biofuels and other fuels such as refinery gases (see Chart 5). Energy for space heating and to cool materials through refrigeration is also within the scope of this document, although the energy consumption for these is significantly smaller than process heating which includes low temperature, high temperature and drying and separation (see Chart 6).

1.7 Many companies within the heat intensive sector operate on a huge scale, and have the process heat demand to match. GrowHow is a fertiliser manufacturer and a major supplier to the process chemicals industry which operates over two sites within the UK. GrowHow's gas consumption for a normal year is around 1% of the UK total. One third of this gas is used by GrowHow directly for the purposes of heat, the rest is a process feedstock. To put this in perspective, the GrowHow site at Billingham in County Durham burns an equivalent amount of gas as for all the homes in Southampton.[9]

1.8 This document's analysis of the six key industry sectors considers their heat use, carbon emissions, economic data, market structure and context. The analysis further breaks down the 'non-metallic materials' sector into glass, ceramics and cement as these sub-sectors' differences merit attention. Data on these eight industry sectors and sub-sectors is presented in

Chart 5: Energy Consumption in UK Industry by Sector and Fuel

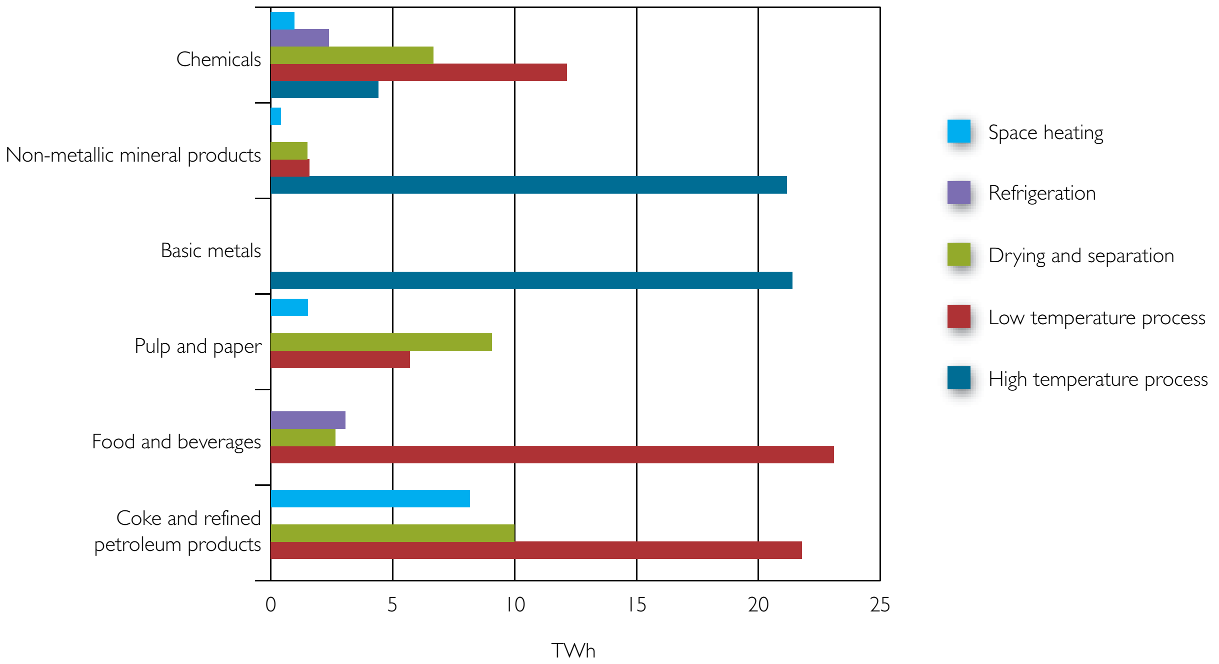


Source: DECC, 2012, *Energy Consumption in the UK 2012*

8 See DECC, *Energy Consumption in the UK*, at https://www.gov.uk/government/publications/energy-consumption-in-the-uk; https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48627/4093-emissions-heat-statistical-summary.pdf, accessed on 19 February 2013

9 Source data from personal communication with GrowHow, as well as https://www.gov.uk/government/statistical-data-sets/mlsoa-electricity-and-gas-2010; https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/65810/3944-energy-trends-section-4-gas.pdf, accessed on 28 February 2013

Chart 6: Heat Demand in UK Industry by Sector and Application (2011)



Source: DECC, 2012, *Energy Consumption in the UK 2012*

Industry Datasheets in the Evidence Annex. The Datasheets suggest that the sectors have particular characteristics relating to the way that heat is used which leads us to take a sector-by-sector approach to exploring their decarbonisation.

1.9 The UK's manufacturing sector is roughly comparable as a proportion of GDP to that of France and the US. Recent analysis[10] ranked the UK as performing best of the 12 largest world economies on industrial energy efficiency.

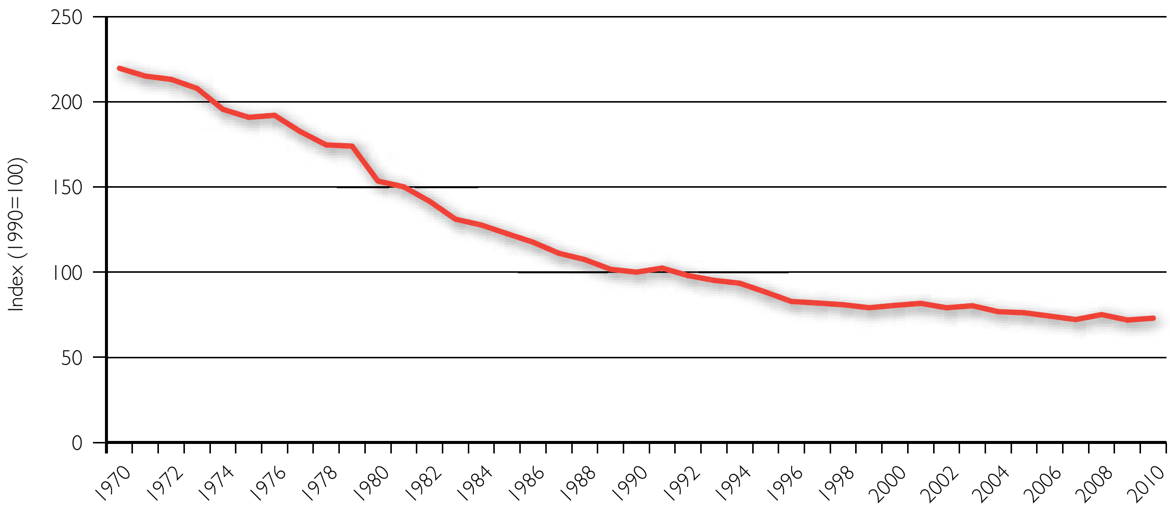
1.10 The UK has one of the lowest rates of manufacturing energy consumption per Gross Valued Added (GVA) in Europe. This implies that the processes in the UK industrial sector are more energy efficient than most other EU countries as the economy share of energy intensive industry has been broadly adjusted for.[11] The UK has made above average progress with energy efficiency since 2000, saving more than the EU27 average.

1.11 Over the past 40 years there has been a strong downward trend in final energy consumption in UK industry (see Chart 7) due to investment in energy efficiency, as well as changes to the UK's industrial sector. Energy intensive industries have improved plant efficiency and operational practices to improve energy management and increase profitability. Opportunities to improve efficiency are typically realised during significant refurbishment or rebuilding of plant, when output increases or decreases in line with wider economic trends, or when ownership changes. These investment cycles will continue to be central to industry's decarbonisation journey.

10 American Council for an Energy-Efficient Economy, 2012, *The ACEEE 2012 International Energy Efficiency Scorecard*, Report Number E12A

11 DECC, 2012, *European Energy Efficiency, Analysis of ODYSSEE indicators* http://www.odyssee-indicators.org/publications/PDF/Analysis-of-odyssee-indicators-2012.pdf, accessed on 20 March 2013

Chart 7: Energy intensity of UK Industry (energy consumption per unit of production)



Source: *DECC, 2012 Energy Consumption in the UK 2012*

Contribution to UK economy from heat-intensive industries

1.12 The six heat intensive industry sectors employ around 2% of the UK's workforce (around 600,000), and contribute an annual £50bn to the economy – around 4% of the UK's GVA.[12] Their continued operations are vital to their local economies. This employment has further importance for the UK in rebalancing its economy away from over-reliance on the service and financial sectors, and strengthening economic activity in regions outside of the South East of England.

1.13 Many heat intensive industries trade in competitive global markets. Their products are subject to significant trade exposure with the rest of the world. Energy input costs are important by definition for heat intensive industries, and they have limited scope to pass on energy costs where they compete with production in other countries. Energy costs represent a significant proportion of overall costs for many heat intensive industries. The Mineral Products Association tells us that, for example, energy costs are around 40% of cement clinker production costs.[13] In 2011, average UK gas prices for industry were the lowest in the EU15, and average UK industrial electricity prices were the seventh lowest in the EU15.[14]

1.14 The Government is committed to ensuring that the transition to a low carbon economy should not damage companies' competitiveness.[15] The UK's transition to a low carbon economy will depend on products produced by energy intensive industry including steel, cement, chemicals, and glass. The global market for low carbon goods and services is worth over £3 trillion, and provides major growth in export potential for UK manufacturing.[16]

12 See the Industry Datasheets in the evidence Annex
13 BCG, 2008, *Assessment of the impact of the 2013-2020 ETS proposal on the European cement industry*
14 DECC, 2012, *Quarterly Energy Prices: September 2012*
15 See http://www.bis.gov.uk/assets/biscore/business-sectors/docs/v/vince-cable-chris-huhne-7-dec-2011.pdf, accessed on 13 March 2013
16 EEF, 2013, *Tech for Growth, Delivering green growth through technology*

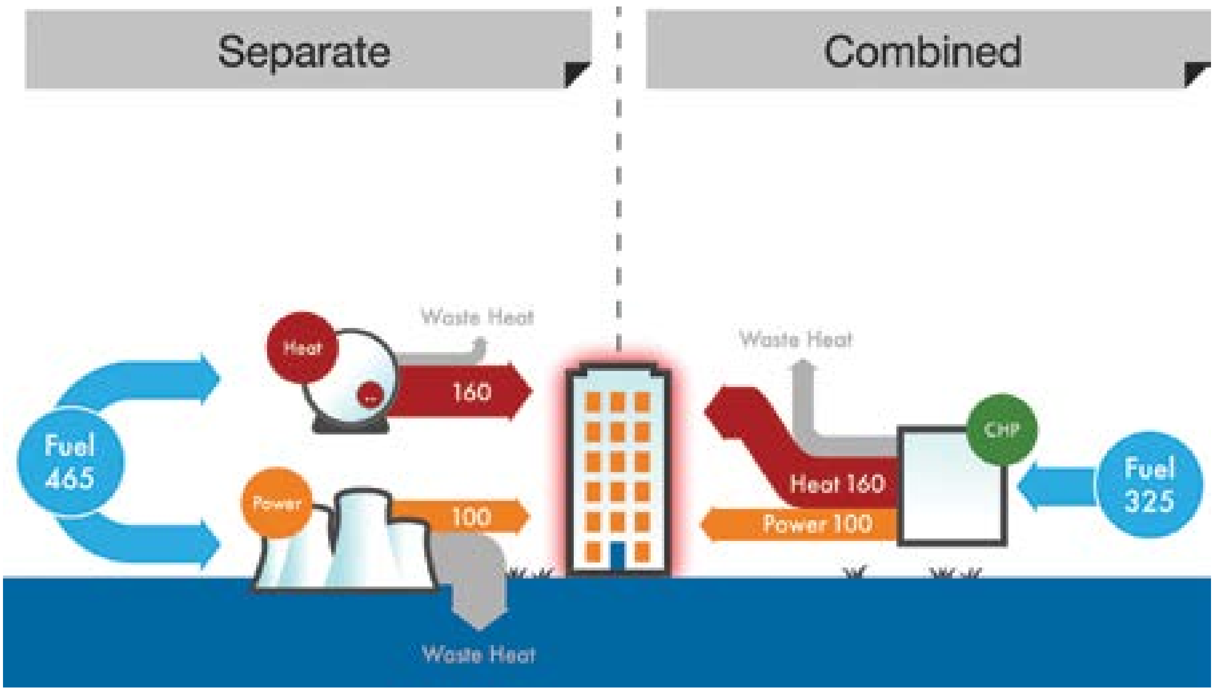
Industrial Combined Heat and Power (CHP)

1.15 As set out in the *The Energy Efficiency Strategy*[17] industrial CHP has delivered substantial energy savings and there is significant potential for additional CHP capacity. The most energy-efficient way to use any fuel is to convert it into power and heat simultaneously. Provided there is a demand for both, CHP can deliver energy and carbon savings of up to 30% by reducing energy lost as waste heat compared to separate power and heat generation from the same fuel (Figure 2). Electrical efficiency generally reduces as more heat is extracted, but this is more than made up for by the useful heat supplied.

1.16 Most UK CHP capacity is industrial, supplying process steam (93.5% of heat from CHP). A smaller, but expanding, proportion of heat supplied by CHP (5.3%) is in the form of 'Low Temperature Hot Water' at 75-95°C for space and water heating. This includes heat provided via heat networks (see chapter 2). Heat recovered from gas turbine exhaust heat, and supplied as hot air at up to 550°C, and hot oil at around 160°C make up the remaining heat supplied by CHP.

1.17 CHP is a well-established technique both in the UK and internationally and makes a substantial contribution to electricity generating capacity. In Denmark, CHP, primarily supplying heat for Heat Networks, contributed 45% of national electricity generation in 2009. In Germany, CHP contributed 13% of electricity generation in 2009 and the German Government has a target to increase CHP to 25% of generating capacity by 2020. In the USA, President Obama's Executive Order in August 2012 called for a 50% increase in CHP capacity by 2020, which would increase capacity to around 12% of US generating capacity. The Order emphasised the energy efficiency and industrial competitiveness benefits of industrial CHP capacity.

Figure 2: Sankey diagram showing energy saving from CHP

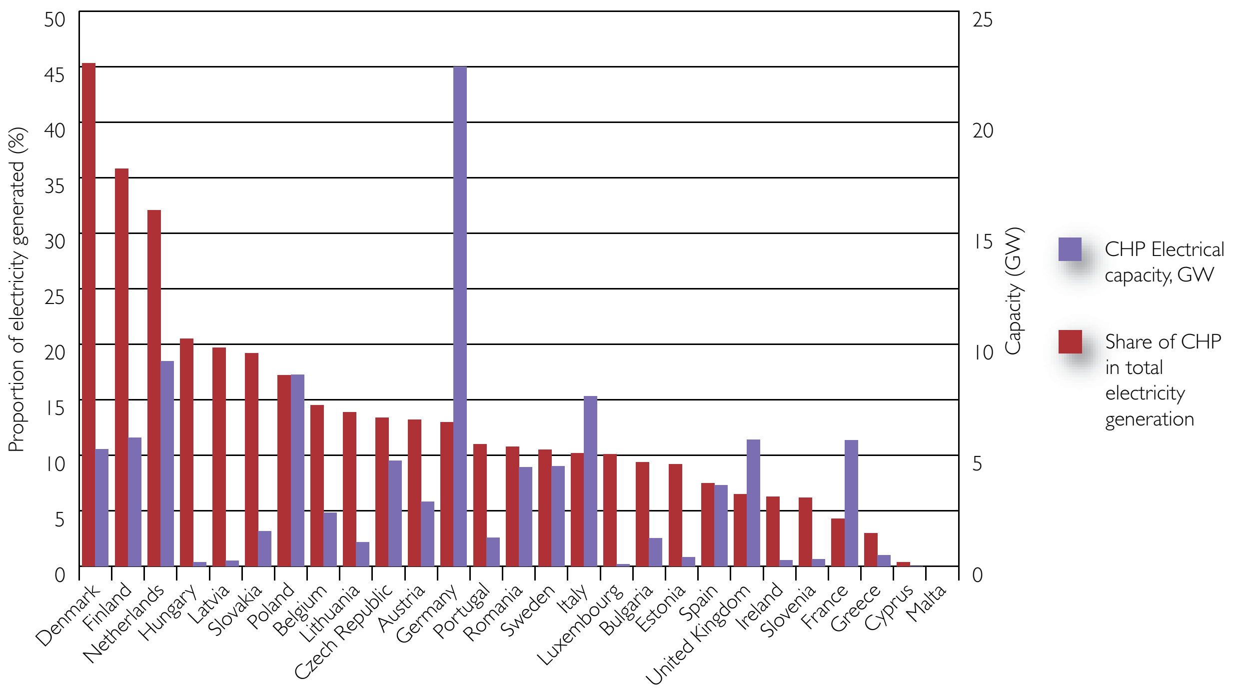


Source: CHP Focus

17 DECC, 2012, *The Energy Efficiency Strategy: The Energy Efficiency Opportunity in the UK*

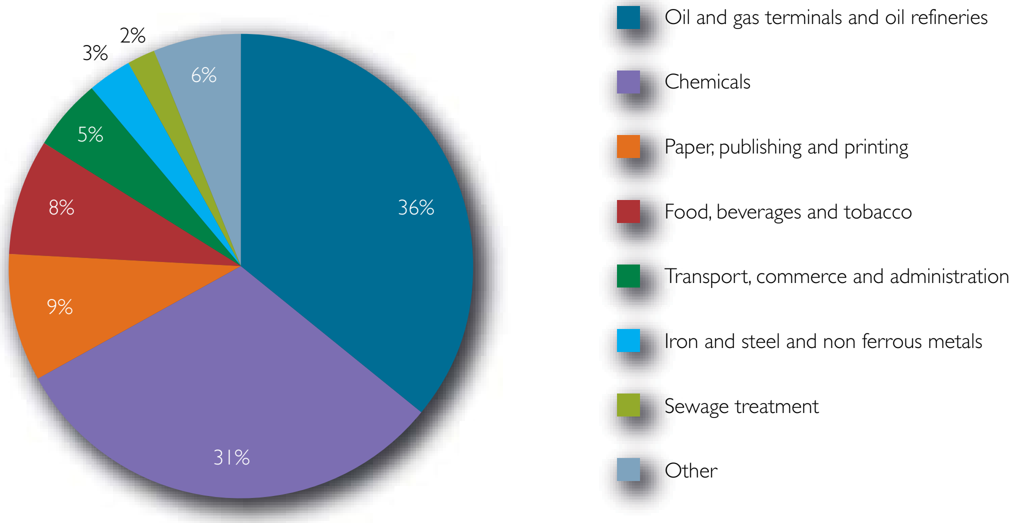
1.18 In the UK, Good Quality CHP capacity contributed 6 GW electrical (GWe), 7% of the UK's electrical generating capacity and 10.4 GW of thermal capacity in 2011. Aside from industrial uses, a large number of small CHP schemes, supply heat and power in the

Chart 8: EU Member States' total electricity generation from CHP



Source: European Environment Agency[18]

Chart 9: UK CHP Capacity by sector



Source: Digest of UK Energy Statistics 2012

18 European Environment Agency, http://www.eea.europa.eu/data-and-maps/figures/share-of-combined-heat-and-3, accessed on 6 February 2013

non-domestic sector, including in commercial premises, local authority buildings, and hospitals.

1.19 Modelling[19] suggests potential for 18 GWe CHP capacity in the UK in 2020. Of this, 10.4 GWe in total is projected to be built by 2020 under existing policy arrangements (8.9 GWe conventional and 1.5 GWe renewable). Excluding CHP known to have come on line in 2012, this represents around 40% growth over current capacity.

1.20 CHP covers a range of sizes from domestic-scale, micro-CHP, generating electricity and space and water heating for a home (see chapter 3), to schemes of over 1 GWe, supplying large industrial heat loads. Although the majority of CHP capacity is fossil fuelled, there is significant growth in renewable CHP capacity. Renewable CHP, fuelled by sustainable biomass, biogas or the biogenic fraction of waste provides a long-term, low carbon source of heat and electricity. Sustainable biomass is biomass which delivers lifecycle greenhouse gas emissions savings and is not sourced from land with high carbon stock or high biodiversity value. Table 1 shows the number and capacity of UK (2011) CHP capacity broken down by size and fuel type, along with typical technologies and heat grade.

What might we need for our low carbon future?

1.21 The Carbon Plan, published in 2011, set out the ambition for industrial heat decarbonisation to achieve an overall reduction in direct and indirect emissions of up to 70% by 2050. Updated modelling of the pathways to 2050 (see the Evidence Annex) confirms this level of ambition. Chart 10 shows the projected path of heat emissions reduction as a result of energy efficiency, fuel switching and industrial Carbon Capture and Storage (CCS) across the industrial sector.

1.22 There are three main ways in which greenhouse gas emissions from industrial heat demand can be reduced: energy efficiency, fuel switching, and industrial CCS. Further reductions in greenhouse gases can be achieved through industrial CHP, material and resource efficiency and waste heat recovery. Industrial clustering is also highlighted below as an approach that can enable delivery of greenhouse gas emissions reductions.

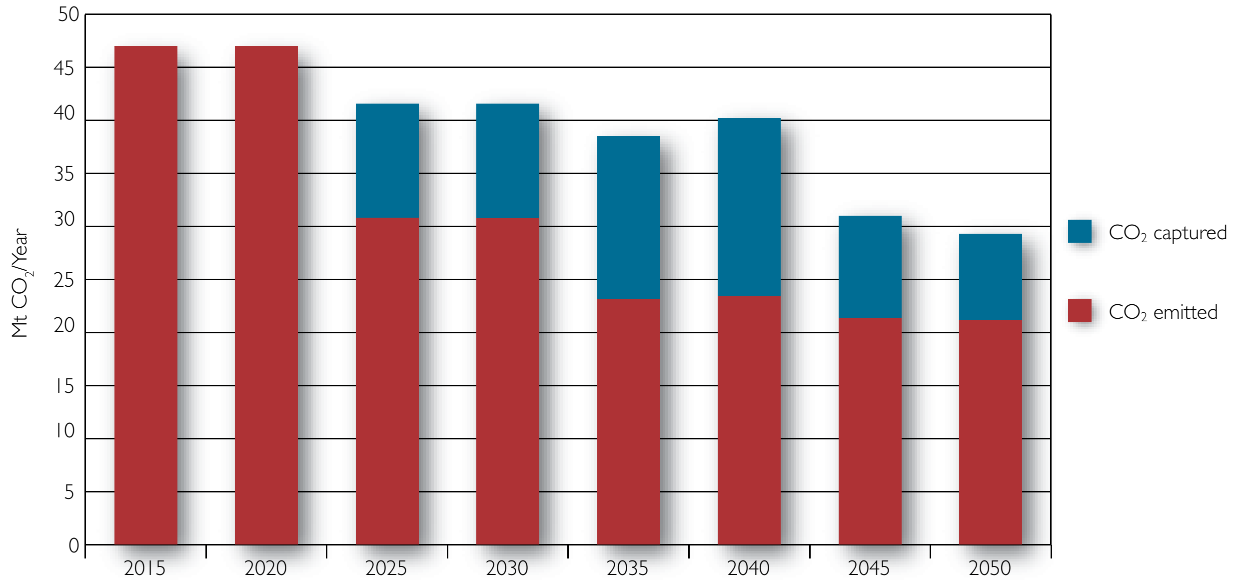
Table 1: UK CHP capacity, typical technologies and grade of heat

Size	No. of schemes	Total capacity	Typical technology	Grade of heat
Fossil fuel CHP				
<10 MWe	1543	852 MWe	Reciprocating engine. Heat, supplied as hot water, recovered from engine cooling system.	75-95°C hot water
10-50 MWe	44	984 MWe	Simple cycle gas turbine. Heat, supplied as steam, recovered from turbine exhaust.	350-450°C steam at up to 60 bar
>50 MWe	25	3947 MWe	Combined cycle gas turbine. Heat, supplied as steam, extracted from steam turbine.	350-450°C steam at up to 60 bar
Renewable CHP				
<10 MWe	220	212 MWe	Bioliquid reciprocating engine. Heat, supplied as hot water, recovered from engine cooling system.	75-95°C hot water
>10 MWe	8	117 MWe	Solid biomass steam turbine. Heat, supplied as steam, extracted from steam turbine.	120-450°C steam at up to 60 bar

Source: Ricardo-AEA

19 Ricardo-AEA, 2013, *Projections of CHP Capacity and Use to 2030*

Chart 10: Projection of industry decarbonisation including contribution of industrial CCS



Source: DECC modelling – ESME core run[20]

Energy efficiency

1.23 Industrial energy efficiency is an important part of the Government's approach for reducing carbon emissions while stimulating growth and competitiveness as set out in the Energy Efficiency Strategy. Since energy represents a significant cost, many heat intensive industries are already close to maximising their energy efficiency. Nevertheless, evidence[21] shows that a range of cost-effective opportunities remain available and Government's existing policies are designed to deliver much of this. The Energy Efficiency Strategy identified potential in 2020 of around 11 TWh saving in the iron and steel, chemicals, food and drink, cement and glass sectors.[22]

1.24 A heat process can be made more energy efficient in a number of ways:

- converting fuel into heat with greater efficiency (e.g. more efficient boilers);
- using that heat more efficiently and cutting out waste e.g. reducing losses by improving insulation of pipes, and using higher efficiency process equipment where available;
- process integration: re-designing manufacturing to use any surplus energy in parallel or adjacent processes within the factory; and
- process optimisation: maximising output and asset use by adjusting controls, production timing, operating procedures and equipment.

20 Note that process emissions are not included in the model and not shown in these results. The results show combustion emissions only

21 The Energy Efficiency Strategy; Carbon Trust, 2012, *Industrial Technology Innovation Needs Assessment*; AEA, 2010, *Analysing the Opportunities for Abatement in Major Emitting Industrial Sectors*; CBI, 2012 *The colour of growth: Maximising the potential of green business*

22 These energy saving measures have negative net present value over the life cycle of the measure.

Box 2: Generating Electricity from Surplus BOS Gas Heat at Port Talbot (2012) – £53m

The integrated steelworks at Port Talbot produces 4.7 million tonnes of steel per year. The site employs 3600 people, supporting a further 14,000 jobs in South Wales through the supply chain. Tata recently replaced the basic oxygen steelmaking (BOS) gas cooling system with a new evaporative cooling system, including upgrades to the existing steam network and the installation of a new steam turbine.

Completed in December 2012, the new cooling system allows the site to recover waste heat to generate 40 tonnes of steam per hour to be used for process heating or electricity generation. The new slightly over-sized steam turbine also ensures that all available steam will be used, whether it is generated from process gases or the surplus heat. As a result, on-site electricity generation will increase by 10 MWe per annum, in turn making a 2.5m investment in a waste heat recovery system economically viable. This will result in a further 1 MWe increase in electricity generation.

Waste Heat Boiler Ducting at Tata Port Talbot (Courtesy of Tata Steel)

Source: Tata Steel

1.25 Many industrial processes have common equipment, and therefore common opportunities for energy efficiency. Other opportunities are specific to one industrial process and can require bespoke solutions to be developed.[23]

1.26 Innovation is a key route to reducing carbon emissions, including through energy efficiency. Carbon Trust research[24] identified iron and steel, cement, chemicals, and food and drink as the industrial sectors with the greatest innovation potential for energy efficiency.

23 Imperial College, 2012, *Reducing CO_2 emissions from heavy industry: a review of technologies and considerations for policy makers*. Grantham Institute for Climate Change Briefing paper No. 7

24 Carbon Trust, 2012, *Industrial Technology Innovation Needs Assessment*

Low carbon innovation in these sectors could also contribute to economic growth.

1.27 This document is concerned specifically with heat use: the Government's Electricity Demand Reduction consultation, published in November 2012,[25] sets out complementary opportunities for reducing electricity consumption.

Materials and resource efficiency

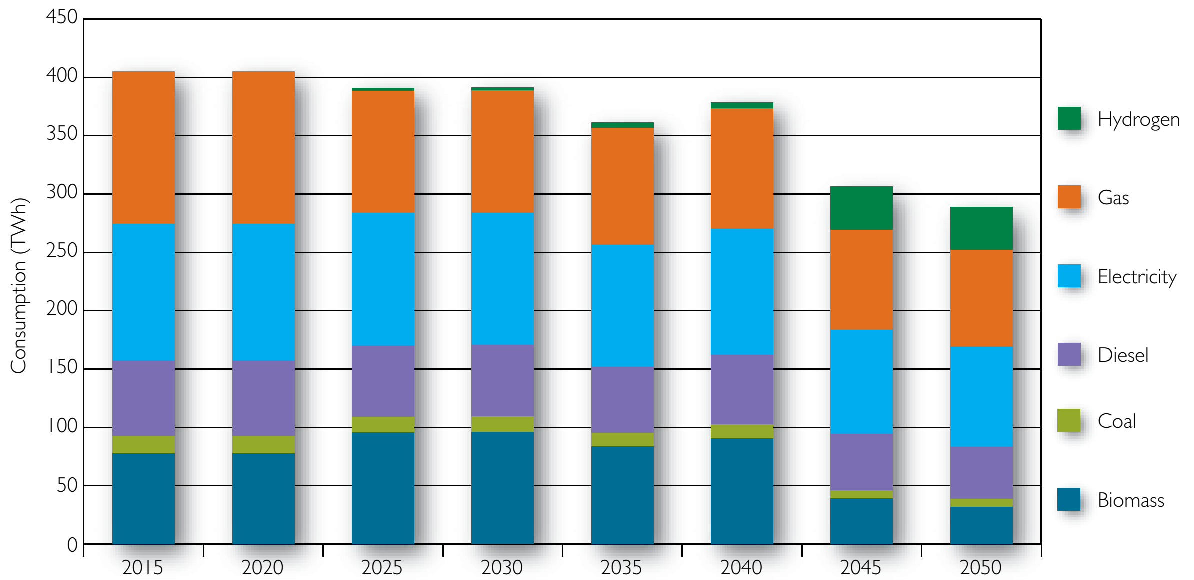
1.28 Global demand for the products of heat intensive industries has quadrupled in the past 50 years and is currently growing at its fastest ever rate.[26] Another approach for reducing emissions from industry is through material efficiency: to reduce primary materials output by increasing product lifespan, reducing material requirements through efficient design, or substitution with a lower carbon alternative.[27] Increasing recycling and re-use of primary materials and components can significantly reduce the emissions associated with their manufacture.

1.29 In March 2012, Defra and BIS published the *Resource Security Action Plan*. The Action Plan sets out actions for Government, businesses and NGOs to 'make the most of valuable resources' through improved resource efficiency, re-use, re-manufacturing, and recycling to help transition to a more circular economy. The actions set out in the Action Plan are currently being taken forward by Government, the Waste and Resources Action Programme (WRAP), the Technology Strategy Board, Environmental Sustainability Knowledge Transfer Network, Green Alliance and business.

Fuel switching

1.30 Industrial activity will always consume energy. It is sensible to explore and maximise energy saving options first, but our climate change targets require us, over time, to move

Chart 11: Industry reduction in heat consumption and fuel switching (TWh)



Source: DECC modelling – ESME core run

25 DECC, 2012, *Electricity Demand Reduction: Consultation on options to encourage permanent reductions in electricity use* http://www.official-documents.gov.uk/document/cm84/8492/8492.pdf, accessed on 19 February 2013
26 Allwood, J. M et al., 2010, *Material efficiency: A white paper*
27 Allwood, J. M. et al., 2013, *Material Efficiency: providing material services with less material production*

away from a reliance on fossil fuels, or find ways of capturing the carbon from them as they burn. As set out in last year's Strategic Framework, fuels such as sustainable biomass, waste, and decarbonised electricity can provide heat for industry with lower overall associated carbon emissions. Recent modelling using ESME and RESOM (presented in the Evidence Annex and Chart 11) projects how industry might most cost effectively switch away from fossil fuels to lower carbon and renewable fuels in the period to 2050.

1.31 The modelling suggests strong potential for use of biomass in industrial heat. Over 20 solid biomass boilers have already been installed in the food and drink sector with support of the Renewable Heat Incentive.

1.32 There may also be a role for fuel switching to hydrogen as a low carbon heat solution for industry. The use of hydrogen could be appropriate for high temperature processes and steam generation, or where CCS is geographically challenging. The modelling suggests that low carbon hydrogen could be used to provide decarbonised industrial heat in the iron and steel and chemicals industries.

1.33 Refuse derived fuels (RDF) can be derived from processing household, commercial and industrial wastes. Nearly 40% of the UK cement industry's thermal energy demand is supplied using RDF. RDF has approximately 50% biogenic energy content, therefore 50% of the energy from RDF is considered to be renewable. The cement industry also burns tyres as a fuel, part of which is natural rubber which is considered to be renewable.

1.34 Switching to electric heat sources will bring carbon benefits as the grid decarbonises. However, the modelling does not suggest that large-scale electrification for industrial heat is a feasible fuel switching option. The additional burden on the power generation and distribution network would be considerable, alongside the demands from electrifying domestic heat and transport.[28]

Industrial Carbon Capture and Storage

1.35 Industrial CCS could be a key technology for the decarbonisation of industry sector, potentially allowing energy intensive industries to continue using fossil fuels while significantly reducing emissions. ESME modelling (see the Evidence Annex) suggests that a significant component of long-term industrial abatement potential lies in CCS technology.

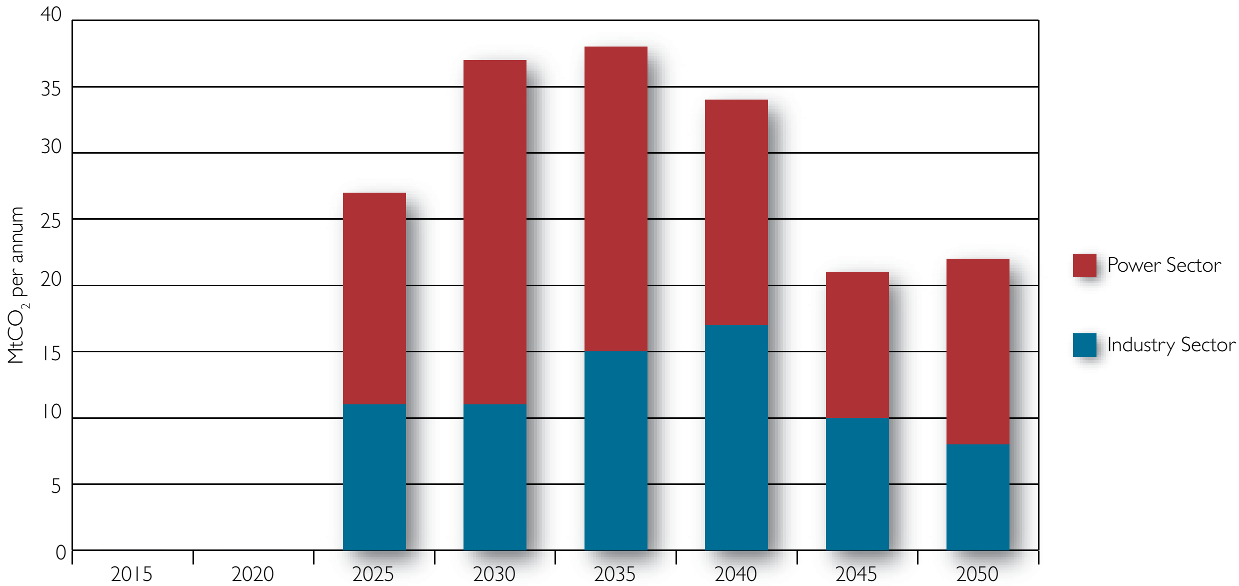
1.36 Industries which emit carbon from their manufacturing process itself (for example CO_2 emitted as a consequence of chemical reactions) are likely to need to implement CCS to decarbonise. Industries which are most likely to be suitable for CCS are iron and steel, cement, oil refining and chemicals.[29] Industrial facilities which are located close to other industries or power stations and storage sites are more likely to be able to implement CCS if they can share transport and storage infrastructure.

1.37 ESME models project that the power sector will capture a larger amount of CO_2 per year than industry up until 2040, from when power and industry are projected to capture similar quantities of CO_2 annually (see Chart 12). However, ESME modelling does not include process emissions which are likely to increase the emissions captured from industry, and there is significant uncertainty regarding the costs of industrial CCS. Some post-combustion capture technologies require large quantities of heat and are therefore particularly sensitive to the price of heat. If a new conventional boiler or CHP

28 PRO-TEM Network, 2012, PRO-TEM Response to *The Future of Heating: A strategic framework for low carbon heat in the UK*

29 Workshops held by UKCCRSC. See http://www.ukccsrc.ac.uk/october-december-2012-ccs-industry-workshops, accessed on 20 March 2013

Chart 12: Share of carbon captured from power and industry through to 2050 ($MtCO_2$)



Source: DECC modelling – ESME core run[30]

plant is to be constructed to provide this heat then annualised costs will be high.[31] These costs could be brought down considerably by using on-site recovered waste process heat.

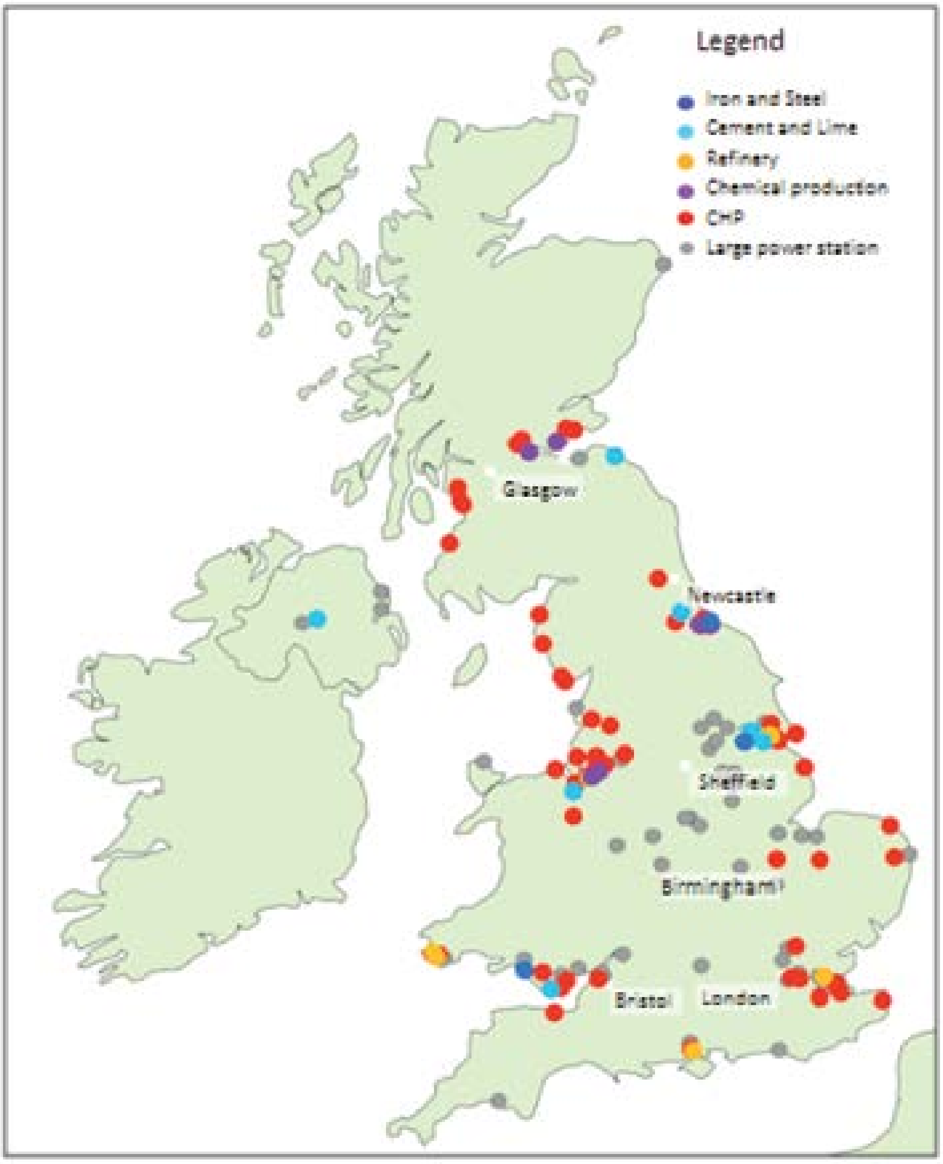
1.38 There are three key methods for CO_2 capture: post-combustion, pre-combustion and oxyfuel. Industrial CCS tends to be process specific, although it shares some common elements with technologies for power sector CCS. Examples of capture technologies applied to specific industries are described below:

- **Iron and Steel:** In top gas recycling blast furnace (TGR-BF) coupled with CCS, iron ore is combined with coke in a blast furnace. CO and CO_2 gases from the top of the furnace are passed through a separator where CO is returned to the furnace and the CO_2 is sent for storage.
- **Cement:** Post-combustion capture technology using amines is considered most suitable for current cement production methods although research into Oxyfuel methods is also under way.
- **Chemicals:** A number of chemical processes are good contenders for post-reaction capture due to large volume, highly concentrated CO_2 streams e.g. ammonia, hydrogen, ethanol and ethylene production.

30 These are the result from the ESME core run, but this is an area where the model shows considerable uncertainty. Take up of CCS and other power sector technologies are outputs from the model rather than inputs, and therefore the amount of CCS and other technologies in the power sector is not necessarily consistent with other recent DECC modelling and analysis, such as that in the Gas Generation Strategy and the Impact Assessment for Electricity Market Reform

31 Element Energy, 2013, *The costs of CCS for UK industry - A high level review* Report for the Department for Business Innovation and Skills

Figure 3: Industrial clusters signal suitability for CCS



Map illustrates locations of selected large industrial and CHP UK CO_2 emitters near shorelines that may be relevant for CCS deployment in the period up to 2030. Locations of selected fossil power stations are also shown as these may provide opportunities for shared CO_2 transport and storage infrastructure.

Source: Element Energy

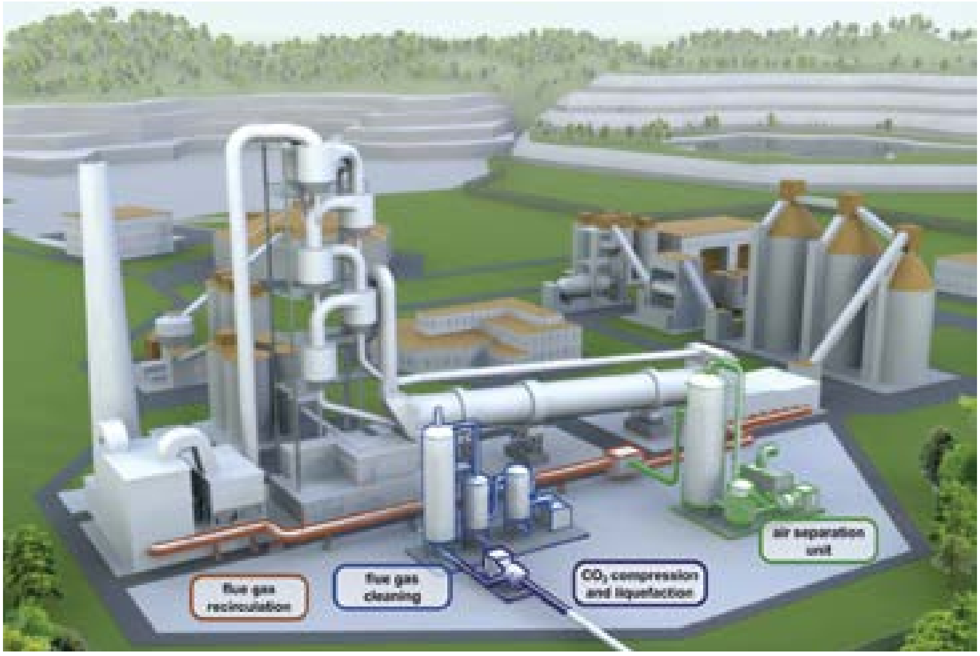
Industrial CHP

1.39 Where direct firing is not required and process temperatures are suitable, CHP will be an important option for improving efficiency and reducing carbon emissions of industrial heat.

In view of the high efficiency with which it uses biomass, the *UK Bioenergy Strategy*[32] identified renewable CHP as a low-risk pathway for use of bioenergy to 2030. Government intends that renewable CHP capacity should meet sustainability standards, revised proposals for

32 See https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48337/5142-bioenergy-strategy-.pdf, accessed on 6 February 2013

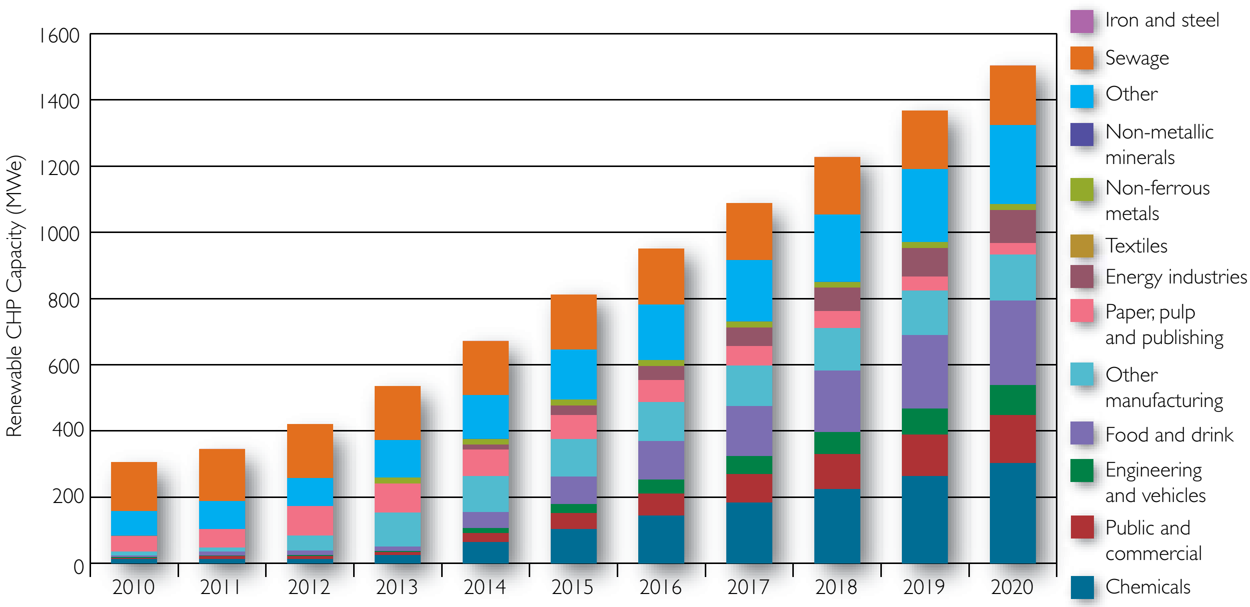
Figure 4: Oxyfuel CCS as applied to a cement plant



Copyright: European Cement Research Academy

which were set out in the Government's recent consultation on amendments to the Renewables Obligation Order.[33] DECC's CHP model predicts strong growth in renewable CHP capacity in particular in the chemicals, public and commercial buildings and food and drink sectors (see Chart 13).

Chart 13: Projected growth in renewable CHP capacity by sector to 2020 (MWe)



Source: DECC CHP modelling

33 See https://www.gov.uk/government/consultations/proposals-to-ensure-sustainability-and-affordability-for-the-use-of-biomass-under-the-renewables-obligation, accessed on 19 February 2013

Box 3: UPM Shotton Paper Mill – Renewable CHP

UPM Shotton Paper Mill Renewable CHP (Courtesy of UPM)

The Shotton Paper Mill, located in Flintshire, Wales, opened in 1984 and is owned by the Finnish group UPM. The Mill recycles around 640,000 tonnes of recovered paper every year, to produce approximately 520,000 tonnes of newsprint. The site employs 300 people.

As large amounts of electricity and heat are required to produce the newsprint, UPM was keen to reduce its energy costs while improving the site's competitiveness. In 2006, a £55m, 20 MWe renewable-fuel CHP scheme began operating at the mill. The scheme burns 100% renewable fuels – a combination of 200,000 tonnes of site-derived waste sludge from the de-inking process, and 200,000 tonnes of biomass in the form of forestry waste. The scheme provides a third of the Mill's electrical and all of its heat demand, operating at an overall efficiency of 74%. The scheme delivers a CO_2 saving of 193,000 tonnes per annum.

1.40 Natural gas CHP can provide modest carbon and energy savings. The *Gas Generation Strategy*[34] indicates that natural gas generation (including CHP) will continue to play a major role in our generation mix as our electricity system decarbonises. Significant investment in new gas generation capacity could be required by 2030, in part to replace older coal, gas and nuclear plant as it retires off the system. RESOM modelling (see the Evidence Annex) suggests that natural gas CHP will have a significant role to play in reducing carbon emissions from heat until 2035, but will decline thereafter. The Government's view is that natural gas CHP is a useful transition technology, but that over time, it will need to be replaced by lower carbon options or retrofitted with CCS technology.

34 See https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/65654/7165-gas-generation-strategy.pdf, accessed on 19 February 2013

Box 4: Heat Network – Dunkirk, France

Dunkirk's heat network, built in 1985, currently delivers nearly 140,000 MWh a year to customers through an approximately 40-km distribution network that covers a large portion of the Dunkirk urban community. The network is supplied primarily by recovered heat from a local steel works.

The steel works specialises in the production of flat carbon steel and is France's largest steel mill. The by-product nature of the recovered heat means that this is an inevitable part of the production process that would be entirely dispersed and lost without the capture system. Recycled heat is distributed via a network of pre-insulated buried pipes. The recovery of industrial heat enables annual savings of 26,000 tonnes of CO_2 compared with a gas-fired solution.[35]

Waste heat recovery

1.41 Another form of energy efficiency which falls both within and outside the boundary of the industrial plant is waste heat recovery. Surplus industrial heat can be recovered and re-used in a variety of ways as a low carbon energy source. Recovered industrial heat can be re-used within the same industrial facility for heat or cooling, used for electricity generation, or piped to nearby industrial plants or heat networks (discussed in chapter 2). Because this heat would otherwise go to waste, it is, in effect, a zero carbon energy source.

1.42 Previous studies have estimated that there is 10-40 TWh of heat currently lost and rejected from industrial sources in the UK.[36] There is scope for more of this heat to be recovered and re-used on-site to enhance energy efficiency (for example in pre-heating of combustion air or feedstock), or it could be converted to electricity using technologies such as an Organic Rankine Cycle. This would contribute to energy efficiency and financial savings.

1.43 Alternatively, recovered heat can be piped to meet other heat demands requiring lower temperatures, for example at other industrial sites, or through municipal heat networks serving homes and other buildings. Industries which are clustered geographically can benefit from symbiotic use of heat by cascading it through a range of industrial processes.

Industrial clustering

1.44 Many heat intensive industrial facilities are co-located in broad clusters. Clustering of industries has happened historically because of a shared need for infrastructure or resources, and this will continue to be relevant in the transition to a low carbon economy, although new infrastructure and resources will be required.

1.45 Clustering provides the opportunity for industries to share low carbon heat infrastructure such as heat networks and CCS transport pipelines, or to trade heat as a resource (see Waste heat recovery above). Large, shared energy plants (for example CHP) have fewer, larger point sources of emissions which is likely to be more cost-effective for carbon capture.

Barriers and challenges

1.46 Evidence suggests that there is further potential for cost-effective investment in energy efficiency, however a number of barriers prevent this potential from being realised. The Energy

35 See http://www.copenhagenenergysummit.org/applications/Dunkerque,%20France-District%20Energy%20Climate%20Award.pdf, accessed on 19 February 2013

36 See: McKenna and Norman, 2010, *Spatial modelling of industrial heat loads and recovery potentials in the UK* Energy Policy 38 (2010) 5878–5891 and other references listed within this source.

Efficiency Strategy identified four overarching barriers in the UK: the existence of only an embryonic energy efficiency market, information (its provision and lack of trust), misaligned financial incentives, and society undervaluing energy efficiency through its behaviour.

1.47 These barriers are a helpful starting point for structuring the approach to decarbonising industry. Research[37] which underpinned the Energy Efficiency Strategy confirmed that the energy intensity of a sector influences the importance it puts on energy efficiency. Energy intensive industries are more likely to have a high awareness of energy consumption and options for efficiency, and to act on energy audit findings.

1.48 In order to better understand these barriers, DECC has commissioned Ricardo-AEA and the Grantham Institute at Imperial College to undertake a literature review including the economic and organisational barriers to decarbonising heat that are faced by industry. DECC will publish the findings in the summer.

1.49 Responses to the Strategic Framework highlighted a range of challenges to decarbonising heat use in industry.

Commercial Barriers

- *Competition:* Many industries in the UK operate in highly competitive markets, which limit their ability to pass through costs of energy or investment to consumers.
- *Investment cycles and capital costs:* Investment in new more efficient plant requires major investment, and is unlikely to be possible outside normal investment cycles, which can sometimes be 40 years or longer. Also returns from energy efficiency investment are low and can be uncertain, and in many companies, bids for investment will compete at a global level against spend on process and products.
- *Short term thinking and risk:* Conversely, many businesses focus decisions on the short to medium term rather than the longer term. Heat intensive industries are also risk-averse, and particularly wary of risks to their product quality or output, and of being locked-in to inflexible infrastructure and technologies.

Delivery barriers

- *Information:* Information on the technical solutions to decarbonise and the costs and technology readiness (for example on industrial CCS) is imperfect among industry players.
- *Skills:* The transition to low carbon industrial heat will require specialised, highly skilled and experienced heat focused engineers. These skills are not readily available in the industry.
- *Clustering:* It is a complex decision for existing industries to move to cluster sites, and any move will be influenced by investment cycles and long-term policy signals.

Technical barriers

- *Energy retrofit limits:* there are limits to the energy efficiency that can be achieved by retrofitting existing industrial sites given the current plant, configuration and infrastructure.
- Fuel switching: For each industrial sector, options are likely to be limited because of process or technological constraints. For example, the steel sector uses coal as both a feedstock and fuel for its manufacturing process, which is not easily replaced. The use of waste-derived fuels to manufacture glass containers for food may be inhibited by controls on contamination and quality.
- Biomass: Industries indicate that they would need a secure supply of competitively priced biomass as well as a clear policy signal before considering the investment required to fuel switch.

37 DECC, 2012, *What are the factors influencing energy behaviours and decision-making in the non-domestic sector?*

- *Recovered waste industrial heat:* Recovered waste industrial heat largely originates from fossil fuel combustion, so does not count as a renewable energy source and there are currently no financial incentives available to promote its use. Little waste heat recovery currently happens in the UK beyond recycling of heat on-site, and examples are not plentiful world-wide. According to case studies and initial analysis, this is probably due to the uncertainty and difficulty of aligning different heat requirements between different organisations, as well as uncertainty regarding future revenues from energy sold off-site.

- *Innovation:* Significant investment will be required in innovation to develop low carbon heat technologies at the scale required for industrial use. Technical areas for innovation include electric glass melting, glass cullet and batch pre-heating, self-cleaning heat exchangers to operate at low temperatures, and ceramic kiln exhaust heat recovery.

1.50 Growth in CHP capacity faces two main barriers: securing finance and access to a good price for electricity exported to the grid. Renewable CHP also faces high fuel costs relative to fossil fuel fired heat and electricity generation.

- *Securing finance:* CHP represents a large capital investment compared to installing boilers and importing electricity from the grid. CHP's energy savings, and revenue from selling surplus electricity, decrease net operating costs. However, these savings may not be sufficient to meet rates of return ('hurdle rates') required to secure finance.

- Evidence from stakeholders indicates that CHP projects face much higher hurdle rates (18-25% post tax) than power-only generation projects. In the case of third party developed projects, this appears to be due to a high premium being attached to the risk of the project losing its heat customer. For on-balance sheet industrial projects, high hurdle rates reflect the opportunity cost of other projects.

- *Accessing the electricity wholesale price:* For CHP schemes which export power to the grid, access to the electricity market and the ability to realise close to the wholesale value for exported electricity are also significant issues.

1.51 Stakeholders often cite current low electricity prices relative to the cost of natural gas (the 'spark-spread') as a barrier to investment in natural gas CHP. This makes investment in both natural gas CHP and power-only plant unattractive at present. The low spark-spread is a response to current over capacity in generation, rather than a market failure. The spark-spread is projected to increase, as electricity demand recovers and older generating capacity is retired.

Policies in place now

1.52 There is a targeted policy framework in place to encourage industrial energy efficiency and carbon reduction and to support CHP. There are four main elements.

- The EU Emissions Trading System (ETS), which places a cap on emissions from electricity generation and the main energy-intensive industries (about half UK CO_2 emissions), and drives abatement. Carbon emissions from power generation are fully exposed to ETS carbon pricing and emissions from heat are increasingly exposed during ETS Phase III (with free allowances for heat declining from 80% in 2013 to 30% in 2020, apart from in sectors exposed to carbon leakage).

- The Climate Change Levy, a tax on the use of fossil-derived energy in industry, commerce and the public sector. CHP is exempt from Climate Change Levy costs on input fuel and output electricity consumed on-site or supplied directly to a known customer.
- Climate Change Agreements (CCAs) which provide eligible energy intensive industries with discounts on the Climate Change Levy in return for meeting energy efficiency targets.
- The CRC Energy Efficiency Scheme requires participating organisations to report on their energy usage and purchase allowances based on their level of consumption.

1.53 The six heat intensive industry sectors that are the focus of this document are all covered under both the EU Emissions Trading System (ETS) and CCAs (except for oil refining which is exempt from the Climate Change Levy and thus CCAs).[38] In addition, there is a series of other policies that encourage and enable decarbonisation in industry and have an impact in this area, as set out in Table 2, below.

Table 2: Policies encouraging and enabling decarbonisation in industry

Policy	Impact on Industrial Heat
Renewable Heat Incentive (RHI)	The RHI is the world's first long-term financial support programme for renewable heat. DECC launched the RHI in November 2011 with a scheme for the non-domestic sector that provides payments to industry, businesses and public sector organisations. The existing scheme will be expanded to cover additional technologies. Details will be announced in summer 2013.
Energy Efficiency Strategy	The Energy Efficiency Strategy, published in November 2012 and developed by the Energy Efficiency Deployment Office (EEDO), sets out the Government's mission to seize the energy efficiency opportunity in the UK over the coming decades. This will underpin future policy development.
Regional Growth Fund	The fund is part of the Government's strategy to stimulate growth and help to rebalance the economy by supporting those areas and communities currently dependent on the public sector. Regional Growth Fund Rounds one and two are expected to create and protect 300,000 jobs. The Regional Growth Fund is leveraging approximately £6 of private sector money for every £1 of public money. Round four has recently been launched.[39]
CHP Quality Assurance	The CHP Quality Assurance programme ensures that only 'Good Quality' schemes, i.e. those delivering genuine energy savings, are eligible for preferential treatment under Climate Change Levy, Carbon Price Floor, Enhanced Capital Allowance, Business Rates and the Renewables Obligation.
CHP Focus	The CHP Focus programme supports potential developers of CHP by provision of information on the benefits of CHP and tools to support assessments of the viability of CHP projects.
Carbon Price Floor (CPF)	The CPF ensures a minimum carbon price for emissions from electricity generation, following a straight-line trajectory to £30/tonne (2009 prices) by 2020. To ensure CHP is on a level playing field with other heat sources, emissions associated with heat from CHP will not be liable to Carbon Price Support (CPS) rates. Use of a boiler substitution method for exempting heat means that carbon savings from CHP are valued at the full CPF. In addition generators up to 2 MWe capacity are not liable to CPS rates, which will exclude approximately 80% of CHP schemes from CPS rates.

38 The Budget 2013 announced a new exemption from CCL for energy used in metallurgical and mineralogical processes from 1 April 2014

39 Details are available at https://www.gov.uk/understanding-the-regional-growth-fund, accessed on 20 March 2013

Policy	Impact on Industrial Heat
Energy Intensive Industries (EII) Compensation package	In 2011, the Government announced a compensation package to those electricity-intensive industries most at risk of carbon leakage to help offset the indirect[40] cost of the CPF and the EU ETS, subject to State Aid approval from the European Commission.
Enhanced Capital Allowance (ECA)	The ECA scheme was introduced in 2001 to increase the take up of energy efficient equipment by industry. It allows businesses to claim 100% tax relief on qualifying energy efficiency expenditure in the tax year. There are approximately 19,000 qualifying products on the Energy Technology List (ETL). This includes Good Quality CHP.
Green Investment Bank (GIB)	The GIB became operational in October 2012 and is capitalised with £3 billion of Government funding to invest in offshore wind, waste, and non-domestic energy efficiency projects. A wide range of industrial heat technologies (including CHP and waste heat recovery) are eligible for consideration for GIB funding under the non-domestic energy efficiency theme.
Preferential business rates for CHP	Good Quality CHP schemes are eligible for preferential business rates.
Environmental Permitting	Developers are required to consider CHP (as a Best Available Technique for energy efficiency) and assess the cost-benefit of CHP opportunities in seeking a permit to operate power plant and industrial installations. Where there are no economic heat supply opportunities at the time of permitting, applicants are required to develop plant as CHP-ready unless they can demonstrate that this is not cost-effective.
Renewable Obligation Certificate banding[41]	Under the Renewables Obligation some types of renewable (including Energy from Waste) CHP are eligible for a higher level of support per MWh electrical output than power-only plant. In general, renewable CHP schemes accredited up until 31 March 2015 are eligible to apply for this support. Biomass CHP is also exempt from the cap on new build biomass power plant capacity.

1.54 While each policy is targeted differently, some conglomerates have been affected by multiple elements, and DECC is in the process of simplifying this framework and removing overlaps. DECC has taken steps in 2012 to simplify the DECC regulatory framework to reduce overlap and reduce administrative burdens on industry, following the principle that no emissions are regulated twice, though businesses operating across diverse sectors will continue to be subject to the separate regulations targeting different sectors.

Next steps

Industrial sector low carbon roadmaps

1.55 The Government believes there is a great opportunity for UK industry to become more efficient, save carbon and prepare itself for a highly competitive low carbon future, provided it looks ahead and prepares now. It is clear that sectors face very different challenges in decarbonising relating to their heat use emissions, and industry economic characteristics. This document's analysis of the barriers suggests that there is a need for a better shared evidence base between government and industry, better information on the technologies which will be required to decarbonise industries and clarity

40 Indirect costs arise when electricity prices increase as a result of fossil fuel based electricity generators passing on policy costs to their customers.

41 See https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/42852/5936-renewables-obligation-consultation-the-government.pdf, accessed on 19 February 2013

about the steps needed to deliver decarbonisation across heat intensive industry.

1.56 A number of heat intensive industries are already taking proactive steps to explore their decarbonisation pathway, often at an EU level. For example, the following industries have published or are developing roadmaps at an EU level: ceramics,[42] iron and steel,[43] pulp and paper,[44] chemicals, flat glass. The cement industry recently published a roadmap for its decarbonisation in the UK.[45]

1.57 The CBI has called for government to 'assist businesses in energy intensive industries most at risk with development of sector decarbonisation roadmaps. Greater visibility and clarity of the future steps required to decarbonise energy intensive industries will help encourage innovation and investment, enabling these sectors to reduce carbon emissions cost effectively'.[46] The EEF has recently called for government to work with industry to produce a roadmap for tackling decarbonisation in 'hard to treat' industrial sectors.[47]

1.58 Therefore, through closer working with the companies themselves and their sector associations, the Government aims to understand more about how heat is used in each of these sectors and how it can be decarbonised. This will allow conclusions to be reached about the technologies and innovations which are likely to play the biggest roles in decarbonisation in each industrial sector, and where government, industry and academia could focus their efforts to achieve the potential for a smooth transition to a long-term low carbon future for heat intensive industries in the UK.

1.59 DECC and BIS therefore propose to work with industry and the Devolved Administrations over the next two years to develop a 'roadmap' for key UK heat intensive industrial sectors, focusing on the sectors that represent the greatest CO_2 emissions and use the greatest amount of heat. The project will build on previous work in this area across government. The process for each sector will have two phases:

- developing a shared evidence base, and on this basis, developing low carbon pathways/ scenarios for each sector to explore and raise awareness about the low carbon technologies and options; and
- agreeing on the steps needed to achieve the emissions reduction, highlighting actions to be taken by industry, Government and others.

1.60 DECC will invite tenders for carrying out phase one of this work during the summer. The aim will be to ensure that academic, industrial, commercial and economic expertise are combined through broad engagement to make the pathways as credible and comprehensive as possible. The project is expected to last around two years.

1.61 To underpin this work, DECC has commissioned a review of the research evidence on decarbonising UK industry, focusing on the heat intensive sectors. Ricardo-AEA and the Grantham Institute at Imperial College will systematically review the technical, economic and social research evidence regarding the potential for decarbonising heat demand, the drivers and barriers. DECC expects to publish the findings this summer.

42 Cerame Unie, 2012, *Paving the way to 2050: The Ceramic Industry Roadmap*
43 Eurofer *European Steel Industry 2050 Roadmap*. (unpublished)
44 CEPI, 2011, *Unfold the future, The Forest Fibre Industry2050 Roadmap to a low-carbon bio-economy*
45 See http://cement.mineralproducts.org/documents/MPA_Cement_2050_Strategy.pdf, accessed 13 March 2013
46 CBI, 2001, *Protecting the UK's foundations; A blueprint for energy-intensive industries*
47 EEF, 2013, *Tech for growth: delivering green growth through technology.*

Energy efficiency

1.62 The Energy Efficiency Strategy announced that DECC will take forward an independent review of the barriers to assessment and accreditation of innovative energy efficiency measures.

1.63 The Department will also support the strengthening of the energy efficiency evidence base, working with Research Councils UK and others, as well as publishing an evidence strategy later this year.

1.64 DECC is leading the implementation of the EU Energy Efficiency Directive (2012/27/EU), working in co-operation with the Devolved Administrations. The Department will consult on introduction of energy audits for large commercial enterprises by the end of the first half of this year.

1.65 The European Commission Common Strategic Framework[48] sets 11 thematic objectives for funding in the 2014-2020 round. One of these objectives is moving to a low carbon economy. Within this theme, European Regional Development Funding (ERDF) can be used to support energy efficiency projects. BIS and DECC will explore opportunities for ERDF to be made available for industrial waste heat recovery projects by Local Enterprise Partnerships in their EU Investment Strategies.

Industrial CCS

1.66 DECC and BIS will work together over the remainder of the year to identify how to further support development of industrial CCS as part of the Government's wider efforts on CCS. This work will involve:

- a techno-economic study to help better understand the necessary technologies and costs;
- exploring options for further supporting industrial CCS innovation, which could include feasibility studies, additional research and development, or pilot demonstrations.

1.67 Since the CCS Roadmap was published in April 2012, DECC and BIS have commissioned a report from Element Energy and worked with the UK CCS Research Centre on industrial CCS; and completed the 2012 Technology Innovation Needs Assessment for industry. The latter highlighted industrial CCS as a priority innovation area within the Iron and Steel sector and Cement sector.

1.68 Budget 2013 announced that DECC would be taking forward two preferred bidders in the £1 billion CCS Commercialisation Programme Competition. They are:

- The Peterhead Project in Aberdeenshire, Scotland; and
- The White Rose Project in Yorkshire, England.

1.69 This competition aims to support practical experience in the design, construction and operation of commercial scale CCS. It is designed to bring forward the first wave of CCS in the UK, including proving offshore CO_2 stores and establishing the first CO_2 infrastructure. The knowledge and experience gained from the Commercialisation Programme will be of benefit to the whole CCS industry, including industrial emitters.

Recoverable waste industrial heat

1.70 DECC is commissioning research to assess the technical and economic potential of recovered waste industrial heat. This study will quantify the contribution towards the 2050 target that could be technically and economically achieved through recovering rejected heat from heat intensive industries and using it to supply low carbon energy within the

48 See http://ec.europa.eu/regional_policy/what/future/index_en.cfm#1, accessed on 13 March 2013

UK energy system. It is expected to report later this year.

1.71 DECC will use the outputs from this project to explore the potential for incentivising the recovery of waste heat from industry, in particular alongside the RHI review during 2014.

1.72 The Government will consult in the autumn on amendments to Environmental Permitting Regulations (see below) in order to implement requirements of the EU Energy Efficiency Directive. This includes a requirement that developers of new or substantially refurbished industrial installations assess the potential for recovering waste heat for supply to other users via heat networks.

Fuel switching

1.73 DECC will explore options to support direct applications of renewable heat in industrial processes including in the Renewable Heat Incentive review during 2014.

Combined Heat and Power

1.74 The Government is taking a range of steps to address the barriers facing growth in renewable and natural gas CHP capacity. These include existing proposals on renewable CHP, revisions to Environmental Permitting, Energy Bill powers on electricity market liquidity, additional CHP Focus activities and next steps on additional support for natural gas CHP.

1.75 *Renewable CHP:* In England and Wales, Good Quality CHP capacity will be exempt from the cap on new build biomass capacity in the Renewables Obligation. In Scotland, it is proposed that Good Quality renewable CHP will be exempt from the 15 MWe limit on dedicated biomass plant. To ensure that renewable CHP delivers the intended energy and carbon savings, DECC has consulted on improvements to the CHP Quality Assurance (CHPQA) programme. Following consideration of the consultation responses the Government plans to implement improvements to CHPQA by 1st January 2014.

1.76 The Government has proposed that Good Quality biomass and bioliquid CHP will in future be eligible for a specific RHI tariff in addition to Renewable Obligation Certificate (ROC) support at the dedicated biomass (power-only) rates. New capacity will be able to choose, at the time of accreditation, either the current ROC uplift or the new RHI tariff until 1st April 2015 when the option of the uplift will cease to be available for new plants. The Government will be publishing its response to the consultation on the extension of the non-domestic RHI in the summer.

1.77 *Environmental Permitting:* The EU Energy Efficiency Directive (2012/27/EU) requires the cost benefit of CHP and industrial waste heat recovery opportunities to be considered when new or refurbished powerplant and heat installations are authorised. The Government intends to amend the Environmental Permitting Regulations to implement these requirements in England and Wales and will consult on this in the autumn. Scotland and Northern Ireland will bring forward their own regulations to implement these requirements.

1.78 *Electricity market access:* The Government has proposed in the Energy Bill[49] powers that would enable the Secretary of State to amend electricity licence conditions to ease participation in the wholesale market and improve electricity market liquidity if required. The Government is also developing a Capacity Market, under Energy Bill powers, in order to ensure adequate reliable generating capacity to cope with peak demand and increased intermittency of electrical generating capacity. Natural gas fired CHP will be eligible to participate within the Capacity Market alongside other forms of electricity generation capacity and non-generation approaches, such as Demand Side Response and storage.

49 See http://services.parliament.uk/bills/2012-13/energy.html, accessed on 19 February 2013

1.79 *Natural Gas CHP:* DECC's CHP modelling suggests that up to a further 3.4 GWe natural gas CHP capacity could be brought forward if hurdle rates could be reduced to levels similar to those for power generation projects. This additional capacity could deliver carbon savings of 28.5 Mtonne CO_2 (over a 2012-2035 assessment period) provided that it displaces natural gas fired generation and boilers, rather than lower carbon generation.

1.80 The Government has not found evidence that Good Quality CHP requires operating support in order to compete with separate natural gas generation and boilers in terms of operating costs. This conclusion will be kept under review in the light of experience following the withdrawal of Levy Exemption Certificates (LEC).

1.81 Furthermore support on CHP electrical output risks causing distortions in the efficient dispatch of electricity. Focusing support on electrical output also discourages operation of CHP at high Heat:Power Ratios, reducing its carbon saving potential. For these reasons the Government does not propose to introduce an alternative form of support analogous to LEC.

1.82 However, our analysis does demonstrate that some form of additional support is required to address the barriers to growth in CHP capacity. Attempting to modify policies intended for other purposes to support CHP does not appear to be an optimal solution. Subject to confirmation that additional natural gas CHP will not displace lower carbon generation, DECC will therefore work on developing a bespoke policy to support new, Good Quality, natural gas CHP capacity.

1.83 While this policy is being developed, DECC will explore interim opportunities for supporting new, Good Quality, natural gas CHP capacity. This will include investigating any opportunities for providing affordable finance for new CHP projects from existing Government funding streams.

1.84 The Government is legislating to introduce a Capacity Market to ensure future security of electricity supplies. The Capacity Market will be delivered using a technology neutral approach, with different types of capacity, including traditional generation, CHP, Demand Side Response and storage, all able to participate. DECC is also examining whether, at a later stage, amendments to the Capacity Market might be required to address the specific characteristics of Electricity Demand Reduction. In view of CHP's contribution to reducing primary energy demand and providing generating capacity, DECC will, in parallel with its work on Electricity Demand Reduction, also examine whether future amendments to the Capacity Market might be warranted for CHP.

1.85 As discussed above for recoverable waste industrial heat, ERDF funding can be used to support energy efficiency projects. BIS and DECC will explore opportunities for ERDF 2014-2020 funding to be made available for CHP projects.

1.86 *CHP Focus:* DECC also proposes to conduct further activities under the existing CHP Focus programme in order to raise understanding amongst potential CHP developers of existing support for available CHP and how to account for this in financial assessments for CHP projects.

Chapter 2: Heat Networks

Guide to using this chapter

The section **What is the situation now?** describes what heat networks are, and their current use in the UK and elsewhere. They are not particularly common in this country: around 2000 networks serve approximately 210,000 dwellings and 1700 commercial and public buildings across the UK. This section contains details of the history and types of heat networks, with market analysis and a consideration of consumer aspects, including metering.

What might we need for our low carbon future? describes what DECC knows from its modelling and stakeholders about the potential for heat networks as part of a low carbon future.

Barriers and challenges outlines work carried out for DECC by BRE on barriers to the development of networks, and considers a range of barriers under the themes of 'Commercial', 'Consumer', 'Local authorities', 'Development', and 'Future low carbon heat sources'.

Policies in place now explains nine current policies that are relevant to this area.

The next section, **Progress report: heat network development in cities across the UK**, gives an update on work that DECC is supporting in Manchester, Newcastle, Leeds, Sheffield and Nottingham this year to develop and expand heat networks, as well as progress reports on developments in London and Scotland.

Next steps introduces a £9m project to establish a Heat Networks Delivery Unit and provide development funding support, as well as outlining proposals on: heat metering; a consumer code of conduct; the Renewable Heat Incentive (RHI); and support for the longer term development of heat networks.

Introduction

2.1 In the UK, we commonly think about heat as something that is generated on-site in individual buildings, with customers burning fuel, predominantly gas, in a boiler. In other parts of the world, it is common for heat to be generated elsewhere at a commercial scale and transported to consumers through a network of pipes. A heat network, sometimes known as district heating, is therefore a distribution technology rather than a heat generation technology.

2.2 Networks can be both lower carbon and cheaper for consumers than a building-level solution: this is highly dependent, however, on the particular circumstances and heat source of the system. Establishing a scheme involves significant upfront investment on a par with other major infrastructure projects. Heat networks are more likely to be cost-effective in urban settings, where there are many buildings like blocks of flats where individual gas boilers may not be an option, and also commercial buildings such as hospitals and leisure centres that provide high and predictable heat demand.

2.3 Heat networks could allow us to benefit from many sources of heat that are currently not being used. They provide a means of transporting waste heat from industrial processes and some commercial buildings (see chapter 1); deep geothermal heat; heat from large-scale heat pumps; and heat recovered from sewerage systems and other infrastructure. Where they displace fossil fuel heating (e.g. gas boilers), they can save considerable quantities of carbon.

2.4 Heat networks can also be used to provide cooling alongside heat. Providing cooling can make the network operate more efficiently where the heat supply is constant through the year, by creating additional demand in the summer months when the demand for heating drops.

Next steps

- DECC will support local authorities in developing heat networks by establishing a Heat Networks Delivery Unit (HNDU) within the Department that will work closely with individual authorities' project teams in England and Wales.
- DECC will provide funding over two financial years to contribute to local authorities' costs in carrying out early stage heat network development. This will enable local authorities to bring forward projects to the stage where they are suitable for investment including loan finance from the Green Investment Bank or commercial lenders.
- DECC will work over the remainder of this year with the Low Carbon Innovation Coordination Group (which includes the Carbon Trust, BIS, the Energy Technology Institute, the Technology Strategy Board and the Scottish Government) to identify the key technological solutions that require innovation support to deliver the Government's ambitions for heat network development out to 2020.
- DECC will explore the scope for extra financial incentives for renewable heat networks within the Renewable Heat Incentive (RHI) in 2014 and also access to a number of streams of capital funding provided by government.
- DECC will seek to endorse an industry-led consumer protection scheme for heat network users later this year, and encourage the heat networks industry to work with consumer groups in developing this practice.
- DECC will consult this year on options for requiring heat meters to be installed in heat network developments.

What is the situation now?

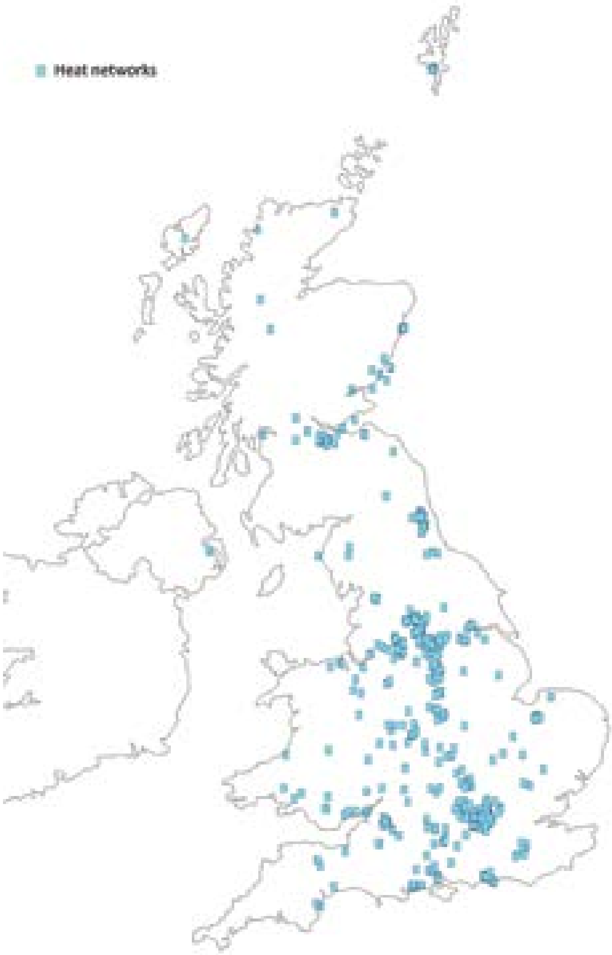
What are heat networks?

2.5 Heat networks supply heat to a number of buildings or dwellings from a central heat production facility (or facilities) through an insulated pipe system, which is generally underground. Most networks distribute heat using hot water that enters buildings at between 90-120°C and exits at 40-70°C, after heat has been extracted. Where higher temperatures are required, for example in industrial applications, heat is transported over shorter distances using steam. Heat networks are best suited to areas with high heat demand density: typically, urban areas. A fairly constant heat demand over time (both over the day and throughout the year) also helps the economics of projects.

Location and scale of heat networks

2.6 The amount of heat supplied to buildings in the UK via heat networks is around 2% of domestic, public sector and commercial heat demand. This amounts to around 2000 networks serving approximately 210,000 dwellings and 1700 commercial and public buildings across the UK.[50] The largest networks are predominantly found in the UK's largest cities and on university campuses.

Figure 5: Map of heat networks across the UK[51]

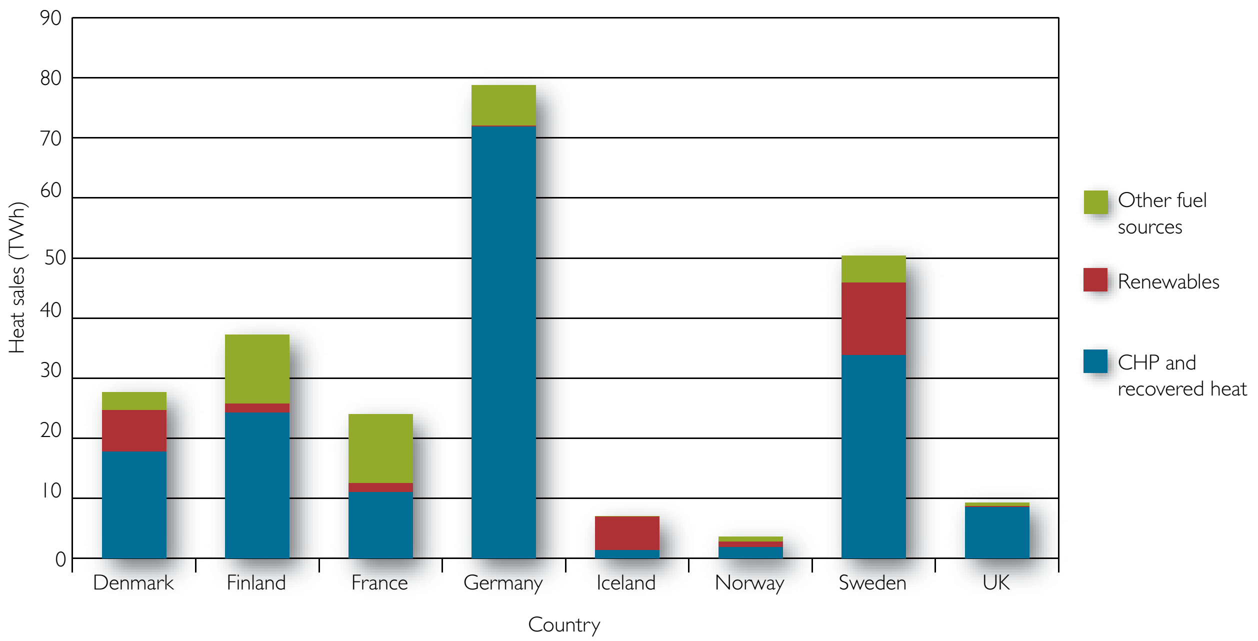


Source: Databuild with DECC additions

2.7 Heat networks are more commonplace in Scandinavia, Eastern Europe, Germany, South Korea and major cities in the USA and Canada. There are also increasing levels of deployment in the growth regions of China. In Denmark, over 61%[52] of customers receive their heat via networks. The emphasis on municipal heat supply has been, in part, driven by climatic conditions. However, some countries' high heat network penetration is a legacy of a collective approach to energy supply, with traditional schemes run on oil, coal or gas supplying large-scale social housing blocks. In Scandinavia, the Netherlands and Austria, new lower carbon, innovative schemes are being developed. Heat networks are used there as a method of transporting renewable and low carbon local heat effectively as part of a wider decentralised energy approach.

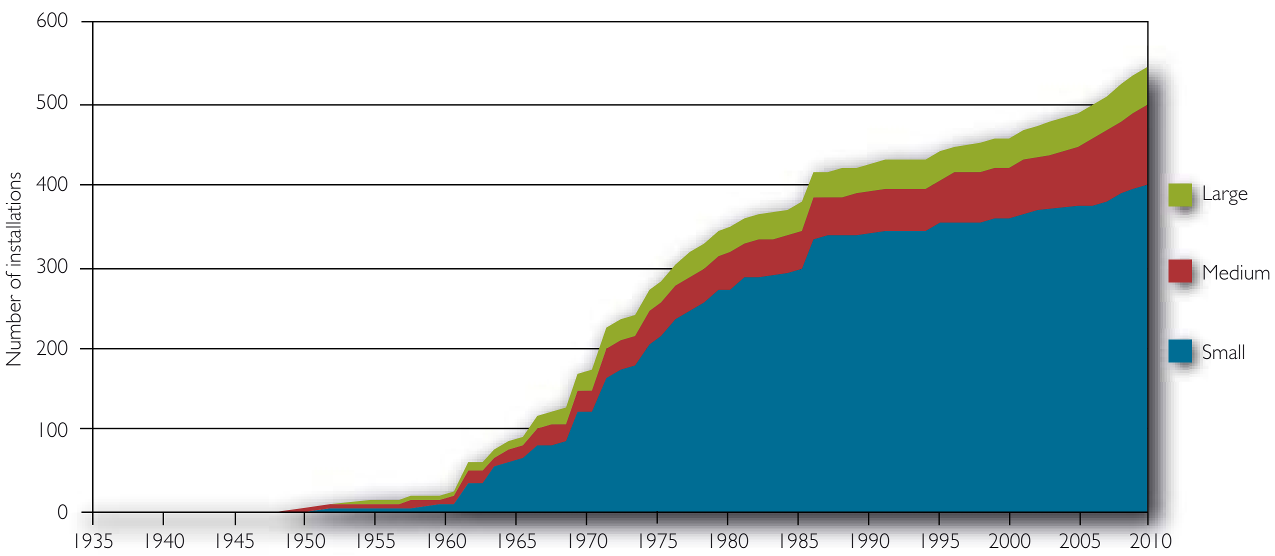
50 Databuild, 2012, *Catalogue of District Heating Schemes,* with DECC additions
51 Map shows all schemes in the Databuild Catalogue of District Heating Schemes, with DECC additions
52 Euroheat, *District Heating and Cooling statistics 2009*

Chart 14: Heat sales to customers via networks across Europe[53]



Source: UK figures from DECC heat network model. Figures from other European countries © Euroheat & Power – District Heating and Cooling Country by Country Survey 2011

Chart 15: Growth in heat networks in the UK[54]



Source: Databuild

53 For the purposes of this chart, 'CHP and recovered heat' includes surplus heat from electricity production (CHP), waste-to-energy plants and industrial processes independently from the fuel used (renewables or fossil) in the primary process

54 Large networks – 500+ residential properties and/or 10+ non-domestic users; Medium networks – 101-499 residential properties and/or 3-10 non-domestic users; Small networks – fewer than 100 residential properties and/or fewer than 3 non-domestic users

History of heat networks in the UK

2.8 In the UK and across Europe, heat networks were first used in urban areas, predominantly in blocks of flats. They became popular in the UK for new developments of this type during the 1960s and 1970s (see Chart 15 below).[55] Many of the schemes in operation today in the UK originate from this period.

2.9 For a number of reasons, including the waning popularity of high-rise housing developments during the 1980s and 1990s, and the poor design, construction and economic performance of some early heat network schemes, heat networks fell out of favour. Over the past decade, as gas prices have risen, and local authorities have looked for ways to cut carbon emissions in projects that can also deliver benefits such as addressing fuel poverty, the case for heat networks has strengthened. Heat networks supplied by CHP plants can provide the most efficient use of gas, and can provide cheaper heating costs compared to individual heating solutions.

Box 5: The Shard, London

Gas CHP-powered heat network

(Courtesy of Sellar)

The Shard, completed in March 2012, is a 306 metre glass spire and the tallest building in Western Europe. A gas CHP plant will provide heat through a network and electricity to each of its 72 storeys. This contributed to the skyscraper being awarded an 'Excellent' rating under the BREEAM green building certification.

This CHP plant, engineered and installed by Clarke Energy, will provide electricity and hot water at high efficiency (85.3% total, 41.4% electrical) to the Shard and the surrounding area. Clarke Energy projects that this will help to reduce carbon emissions and contribute to the low carbon footprint of the building. In parallel, the CHP unit provides significant cost savings versus the separate purchase of electricity and gas from the national grids. The generators are located in the basement of the building, with 1.1 MW of power and 1.1 MW of heat capacity. They are housed in acoustic enclosures in order to minimise the emission of sound from the engines.

55 University of Edinburgh, 2010, *CHP and District Heating to the mid-1990s background paper*

Box 6: University of Warwick

Heat network and CHP

The University of Warwick uses a gas CHP plant and a 16 km network to generate over 50% of its electricity and most of the hot water for space heating and absorption cooling requirements, saving in excess of 5000 tCO_2 per annum.

The network benefits from thermal storage facilities, which help meet heat demand at peak times and reduce the need for additional gas boiler plants. All new buildings are connected to the heat network.

This year, the university will upgrade the original 1960s boiler house with new, high-efficiency boilers with heat recovery. In parallel, a new 4 MWe energy centre will increase the heat network capacity and resilience, doubling the capacity to 8 MWe.

(Courtesy of University of Warwick)

Types of networks

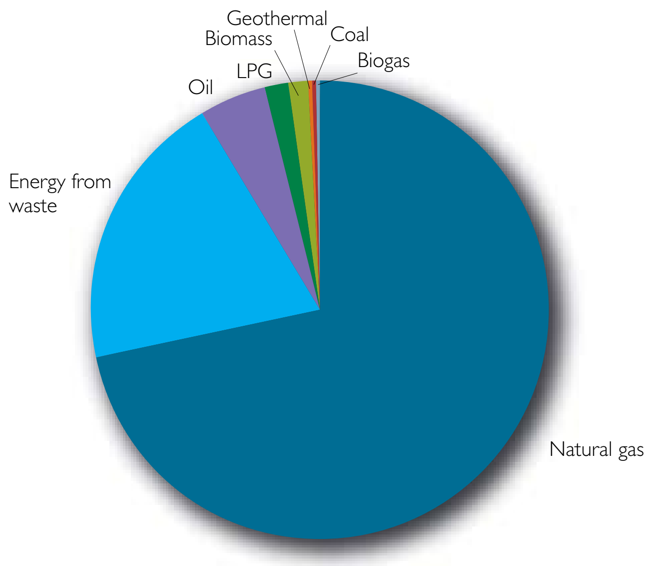
2.10 In the UK, heat networks typically fall into one of four types:

- local authority-led schemes including the connection of schools, leisure centres other public buildings and social housing;
- private sector developments on new housing schemes, which may also include blocks of flats or commercial developments;
- standalone campus networks serving hospital sites or universities; and
- many schemes in individual social housing blocks built in the 1960s and 1970s, which are not generally low carbon, are unmetered and difficult to control. They can be less efficient and more expensive than individual gas boiler systems.

2.11 Heat networks can also be distinguished by fuel type. A key benefit of heat networks is that the heat they supply can come from a wide mix of sources including:

- gas CHP;
- waste heat from nearby industry or heat produced by thermal power stations;

Chart 16: Fuel types supplying heat networks in the UK by TWh



Source: Databuild

- energy from waste plants (refuse incinerators);
- sustainable biomass (as described in the Bioenergy Strategy);
- geothermal energy; and
- large scale heat pumps.

2.12 A recent survey[56] suggests that UK heat networks are predominantly fuelled by gas CHP (72%). The majority of schemes are fuelled by one primary heat source, backed up with gas boilers.

2.13 Experience from elsewhere in Europe demonstrates the potential for combining low carbon heat sources when larger, more strategic schemes are developed.

- In Malmo, 95% of the city's domestic heat demand is met by heat networks. This is provided by a combination of energy from waste, gas CHP, solar and shallow geothermal.
- Vienna's large-scale network is supplied by heat from a combination of energy from waste, biomass boilers, waste industrial heat and thermal power stations.
- In Denmark, the heat network for the five municipalities of Fredericia, Kolding, Middelfart, Borkop and Vejle near Billund is provided by a combination of energy from waste, gas CHP, and waste industrial heat from the Shell refinery and the Carlsberg brewery.
- The Paris heat network is fuelled by geothermal, gas CHP and oil boilers. The average rate of geothermal energy coverage for the group of 29 networks in Paris is approximately 60%.[57]

2.14 Islington Council, Greater London Authority and UK Power Networks are working together on a proposed extension of the existing Bunhill heat network that will capture and use identified sources of waste heat produced within the area, such as from a nearby electricity sub-station. This project will help London and its boroughs to identify, capture and make use of urban sources of waste heat and

56 Databuild, 2012, *Catalogue of District Heating Schemes*
57 IEA, 2009, *40 years of Dogger aquifer management in Ile-de-France, Paris basin, France*

play an important part in developing their lower carbon, lower temperature heat networks of the future.

Market analysis of heat networks sector

2.15 A range of industries in the UK support the deployment of heat networks, including: energy companies, engineering consultants, legal and procurement experts, pipe manufacturers, construction workers and plumbers. The interests of those developing heat networks in the UK are represented by the Combined Heat and Power Association (CHPA) and the UK District Energy Association (UKDEA).

2.16 Accurate data on these supply chain industries are not available in the UK as there is no registration requirement for heat network developers or installers. The number of companies and individuals that specialise specifically in heat networks in the UK is small. However the European heat networks industry has an annual total turnover of €19.5 billion and 556 TWh heat sales,[58] suggesting significant potential for market growth in the UK.

Heat metering and controls

2.17 Central heating and hot water provided from a heat network can be controlled in the same way as with individual gas boilers, with meters and radiator valves.

2.18 New private sector developments and new local authority-led schemes have heat meters installed as standard and charge on the basis of heat usage by individual properties. However, in older schemes, customers are typically billed for a fixed proportion of the total heat generated, taking into account the size of the customer's property. Approximately 25%[59] of existing heat networks serving domestic properties are metered. Anecdotal evidence suggests heat meters are almost universally fitted in commercial properties.

2.19 The lack of individual heat meters in some older schemes leads to limited control over the temperature and amount of heat consumed.

2.20 'Smarter' heat meters have already been developed, which can be read remotely and can provide customers with near real-time information on their heat usage. Smart heat meters can also be switched from pre-pay arrangements to instalment-based payments immediately, providing customers with greater flexibility over billing.

Customer attitudes to heat networks

2.21 The Strategic Framework suggested that the lengths of contracts for heat networks and the difficulty of switching heat suppliers could be barriers to consumers' willingness to obtain their heat via a network, even given the potential advantages of lower heat prices and the absence of boiler maintenance and replacement requirements.

2.22 A recent large-scale survey[60] found that a significant minority of homeowners have heard of heat networks (31%).[61] On receiving basic information about heat networks, a third (34%) of homeowners felt positive about having one, with more (43%) feeling positive amongst those living in high density areas.

2.23 The majority liked the idea that they would not be responsible for the maintenance of the heating system (63%) but the disruption of installing a new system was a potential concern. The majority (55%) would also be more interested in joining a heat network that charged them for the amount of heat used, rather than a set amount each month. Relatively

58 DHC+, 2009, *District heating and cooling: a vision towards 2020-2030-2050*
59 BRE, May 2012, *District heating: heat metering cost benefit analysis*
60 Ipsos MORI and the Energy Saving Trust, 2013, *Homeowners' willingness to take up more efficient heating systems*. London: DECC
61 *83% of homeowners had heard of solar thermal; 47% had heard of ground source heat pumps and biomass boilers; and 32% had heard of air source heat pumps*

few (22%) would be put off buying a new property if it was connected to a heat network but more than twice as many (47%) expressly disagreed with this.

What might we need for our low carbon future?

A role for heat networks

2.24 Several different studies have assessed the future potential for heat networks in the UK. These differ in level of detail, timeframes and underlying assumptions, including what heat densities make heat networks cost-effective and how reducing technology costs change over time.

2.25 By 2050, DECC scenarios indicate that the electricity grid will have decarbonised and diversified. Electricity, especially electric heat pumps, will be used more widely for heating than currently, subject to cost. This greater demand coupled with the use of intermittent generation sources create a significant challenge in balancing the grid.

2.26 In urban areas, there are other challenges with electric heating: for example building density will prevent individual ground source heat pumps being used widely. However, the high heat density that is a feature of urban areas creates the right conditions for heat networks to be deployed cost-effectively. Networks can also make the most of the range of heat sources that individual building solutions cannot harness. As a result of this heat networks could play a strategic role.

2.27 The capacity of networks to store heat helps to tackle system balancing issues, and diverse heat sources will also reduce pressure on peak grid demand. Networks also enable easier transition between fuel types; changing one large heat source to a lower carbon alternative is easier than replacing the equivalent number of individual boilers.

The potential for heat networks

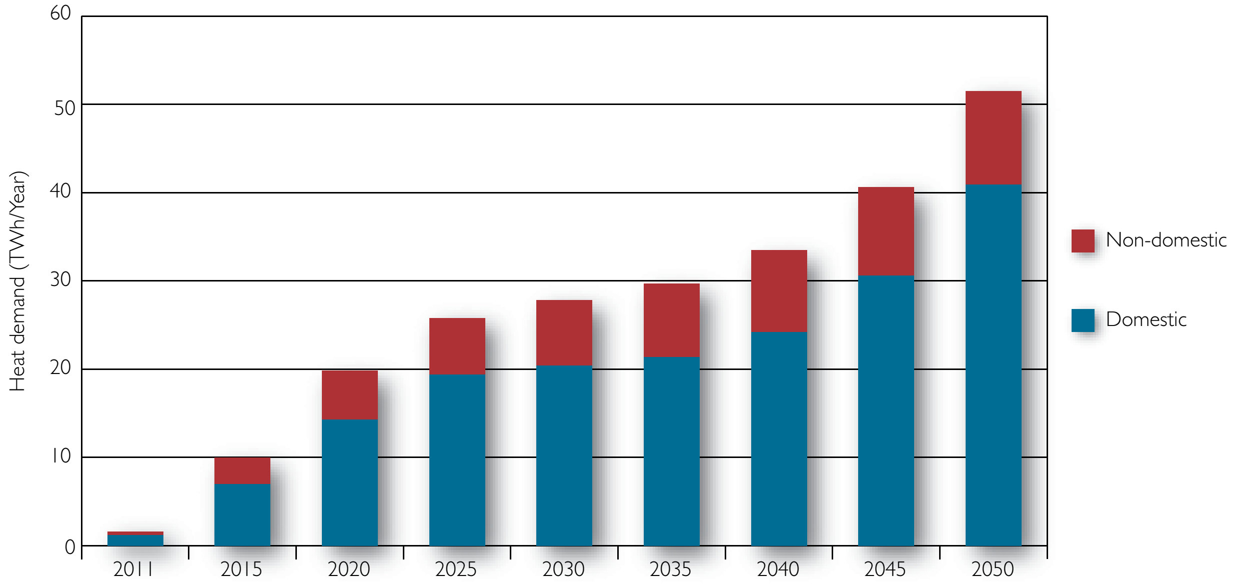
2.28 The 2009 Poyry report[62] suggests that residential heat networks become cost-effective in areas with heat demand at a density greater than 3 MW/km^2. It is estimated that 20% of the UK heat demand has at least this heat density and at the top end of Poyry's projections, where certain barriers[63] are overcome, up to 14% of the national heat demand could be served by heat networks. The report looks mainly at the potential for gas CHP, and suggests that this would lead to a halving of carbon emissions from this heating and cooling, compared with current technologies. There is potential to reduce carbon emissions much further through deployment of renewable heat sources on networks.

2.29 The UKDEA analysed the potential for heat networks in the most populous 200 cities and towns in the UK, and also concluded that networks could supply 14% of the current UK heat demand by 2030.[64] This may underestimate potential as the report does not take into account the potential for smaller networks in other towns.

2.30 DECC is developing a heat networks model to better understand their potential (further details on the approach taken are set out in the Evidence Annex). Initial results from the modelling suggest that up to 20% of UK domestic heat demand might be served by heat networks by 2030. The modelling shows heat networks are an attractive option as they can offer efficiency gains compared with individual heating systems.

62 Poyry, April 2009, *The potential and costs of district heating networks*
63 Poyry. These barriers include economic, institutional barriers and uncertainty around carbon price
64 *UKDEA Policy Paper* July 2012 argues that this would require barriers and disincentives to be reduced and incentives introduced. These incentives include incentivising low carbon heat and more explicitly making district heat available under ECO

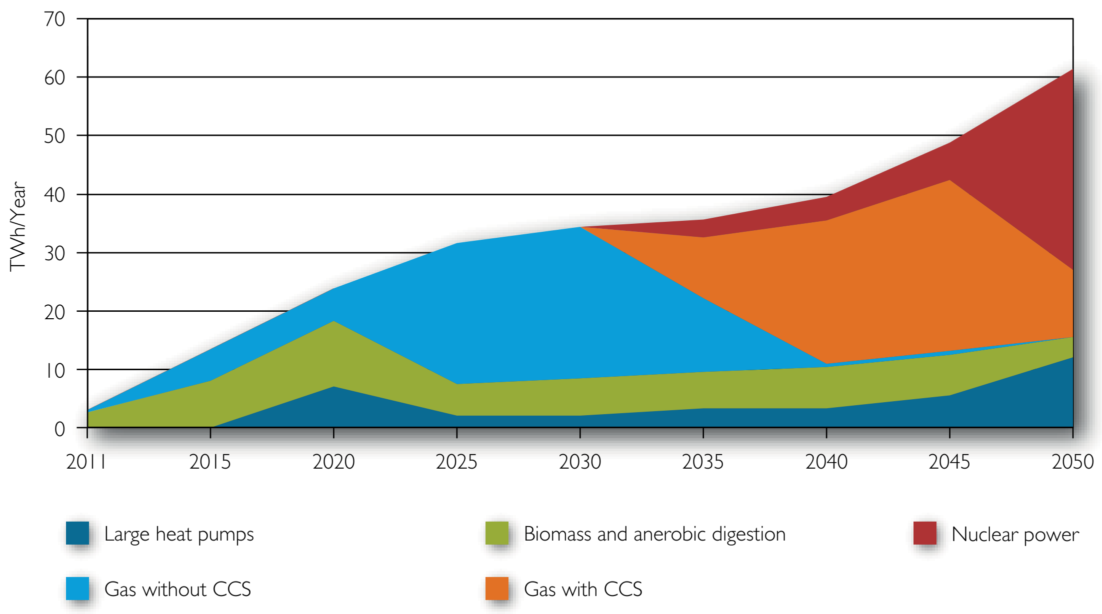
Chart 17: TWh/year of heat demand that could be met by heat networks



Source: RESOM modelling

2.31 Other research considers the potential for heat networks in 2050. Delta EE[65] estimates that 34% of customers would move onto heat networks in a scenario where domestic gas is phased out by 2045. The ETI has modelled that 43% of the current British building heat market can be economically connected to macro district energy schemes.[66]

Chart 18: Sources supplying building level district heat networks (projections)



Source: RESOM modelling

65 Delta-EE, October 2012 *2050 Pathways for Domestic Heat*
66 Energy Technologies Institute, March, 2013, *Macro Distributed Energy Project report*

Box 7: Drammen, Norway

Use of ammonia heat pumps on a heat network

(Courtesy of Star Refrigeration)

A heat network plant was installed in Drammen in 2002 using 8 MW biomass boilers. The heat network was extended in 2011, adding 15 MW of heat pump duty (for base load) and two 30 MW gas-fired boilers (backup for periods of peak demand).

The heat pump draws heat from sea water. The depth of the water close to the coast provides a constant temperature all year. This is ideal for the innovative ammonia heat pump, manufactured by Star Refrigeration in the UK, which supplies the heat to the town. The heat pump efficiency saves the heat network company around €8m per year compared with the cost of using oil fired boilers.

2.32 The pathways to 2050 modelling (RESOM) suggests that heat networks could be an important part of the least cost mix of technologies needed by 2050. Potential is estimated at 7% (20 TWh) of domestic heating and hot water demand by 2030, rising to 14% (41 TWh) by 2050. Heat networks are also an important technology in non-domestic buildings, where they could supply up to 7% (7 TWh) of heating and hot water demand by 2030 and 9% (11 TWh) by 2050. The modelling suggests that heat networks are particularly important for helping to decarbonise heating in older buildings in urban areas.

2.33 The 2050 pathways modelling in RESOM projects that heat networks will decarbonise over time as the UK's carbon budgets tighten to 2050. In the period up to 2030, heat networks will predominantly be fuelled by gas CHP, supplemented with lower carbon fuels such as biomass and biogas. From 2030, the model suggests that heat networks will make the transition to other technologies as the overall emissions target tightens. This might include large scale heat pumps; gas CHP in conjunction with CCS; and heat recycled from nuclear power stations.

Barriers and challenges

2.34 The immediate priority following publication of the Strategic Framework was to identify the barriers and challenges to the development of heat networks. Stakeholders were invited to respond to the document and set out their views. The industry, local authorities and academic institutions have made a significant contribution in this regard.[67]

67 Evidence sources include responses to the Heat Strategic Framework; Poyry, April 2009, *The potential and costs of district heating*; BRE, University of Edinburgh and the Centre for Sustainable Energy, March 2013, *Research into barriers to deployment of district heating networks*

Table 3: Key barriers identified in the BRE barriers report[68]

	Local authority – led schemes	Private sector – led schemes
Objective setting and mobilisation	Identifying internal resources to instigate scheme and overcoming lack of knowledge (**) Customer scepticism of technology (*)	Persuading building occupants to accept communal heat (mandated by the planning authority) (*)
Technical feasibility and financial viability	Obtaining funding for feasibility/viability work (***) Selecting suitably qualified consultants (**) Uncertainty regarding longevity and reliability of heat demand (*) Uncertainty regarding reliability of heat sources (*) Correctly interpreting reports prepared by consultants (*)	Selecting suitably qualified consultants (**) Uncertainty regarding longevity and reliability of heat demand e.g. lack of heat demand in new buildings (*) Uncertainty regarding reliability of heat sources (*)
Implementation and operation	Obtaining capital funding (***) Obtaining funding for independent legal advice (***) Lack of generally accepted contract mechanisms (**) Inconsistent pricing of heat (**) Upskilling local authority procurement team (*)	Concluding agreement with energy services provider, including obtaining capital funding contribution (**) Lack of generally accepted contract mechanisms (**) Inconsistent pricing of heat (**)

2.35 DECC has commissioned research to better understand the full range of barriers at each stage in the development of a heat network project. BRE published its results in their report *Research into barriers to deployment of district heating networks*.[69] This highlighted the most difficult barriers to overcome, and how they differ between schemes commissioned by local authorities and those led by private sector developers. Local authorities and private developers face challenges around the generation and supply of heat, its transmission through networks, and its delivery to final customers. The main barriers identified through research and stakeholder engagement are outlined below.

Commercial considerations

Difficulty in attracting finance and reaching commercialisation

2.36 There are several financial barriers to heat network development: principally that obtaining capital funding is a challenge because projects' payback periods are long in commercial terms, coupled with a high upfront cost[70] and uncertainty of return.[71] This is mainly due to uncertainties with the availability and longevity of the heat loads, the prices obtainable for the heat and electricity produced and the cost of the fuel supply. Market novelty and industry uncertainty about regulation in the area also increase investment risk.

2.37 Development costs such as heat mapping and master planning are also barriers to local

68 Star ratings reflect the difficulty of the challenge posed by the barriers from one star being the least problematic to three stars being the most

69 BRE, University of Edinburgh and the Centre for Sustainable Energy, March 2013, *Research into barriers to deployment of district heating networks*

70 Poyry, 2009, *The potential and costs of district heating,* p7 Laying district heat pipes can cost up to £1.5m per km in urban areas – UKDEA

71 DECC, 2012, *Responses to Strategic Framework for Low Carbon Heat*; feedback from DEPDU; and BRE, 2013, *Research into barriers to the deployment of district heating*

authorities developing schemes. Where local authorities develop city-wide networks, or develop networks retrospectively (not fitted to new build properties), these costs generally fall on local authorities. This is because projects' pre-feasibility risk profiles are unattractive to private sector developers, who rarely meet these costs.[72]

2.38 One key barrier is the high initial investment needed and the level of return (discount rate) required by investors. Analysis by Poyry[73] shows the impact of discount rates and upfront capital costs on investment in heat networks. They conclude that with a discount rate of 10% it is economic for only 0.3% heat demand to be met by heat networks. However, if the discount rate falls to 3.5%, it is economic for 5.8%-13.9% of heat demand to be met through heat networks. The upfront capital cost is a barrier to take up despite the fact that in the long run heat networks may give a return higher than other heat solutions.

2.39 For new developments, project economics often stack up better. A heat network can be installed instead of a gas network, the upheaval costs are small as other utilities such as water and waste are also being installed at the same time, and the heat demand may be higher.

Lack of standardised commercial models

2.40 There is a lack of standardisation of the commercial arrangements that are needed to deliver the construction and operation of heat networks. These include models that would indicate how development and operational risks can best be reduced or shared.[74] Developers and local authorities are therefore required to start from scratch on new projects rather than implementing standard solutions. This is caused by the novelty of projects and increases transaction costs around the commercial aspects of heat network schemes. Local authorities, unfamiliar with new and complex models, have to procure costly specialist advice to guide them through the process.

Consumer challenges

2.41 Recent DECC-commissioned research into consumer attitudes to heat technologies[75] suggests that there would be significant 'barrier costs' associated with persuading homeowners in existing properties to join a heat network (higher than for micro-CHP, but lower than for renewable technologies), but that there may be less resistance to heat networks in new build. Some concerns raised in relation to potential networks attached to existing properties related to the level of disruption needed to build the heat network infrastructure and to install in individual properties, and the potential need for heat generators close to homes. The research also identified the importance of reassuring homeowners that they would still be able to control the temperature in their properties.

2.42 Property developers and heat suppliers have also provided feedback on the challenges they face in selling heat networks to potential customers.[76] The primary concerns raised – relating to security of supply, pricing and customer protection – are rooted in concerns about the current monopoly supply of heat in heat networks. To reassure customers on pricing, they have found that transparency is crucial. A price comparator is provided, usually retail gas prices, and in many cases a price incentive is given so that heat is supplied below the retail

72 DECC, 2012, *Responses to Strategic Framework for Low Carbon Heat*, Low Carbon Pioneer Cities work, feedback from DEPDU and BRE, 2013, *Research into barriers to the deployment of district heating*

73 Poyry, 2009, *The potential and costs of district heating*

74 Poyry, 2009, *The potential and costs of district heating*; responses to DECC strategic framework for low carbon heat, stakeholder meetings, Low Carbon Pioneer Cities

75 Ipsos MORI and the Energy Saving Trust, 2013, *Homeowners' willingness to take up more efficient heating systems*. London: DECC

76 BRE, University of Edinburgh and the Centre for Sustainable Energy, March 2013, *Research into barriers to deployment of district heating networks*

gas price over the lifetime of the contract. Some of the customer concerns have been based on preconceptions about heat networks that have been resolved by explaining how modern systems work and the benefits they can bring.

2.43 The supply of heat to heat network customers is subject to consumer protection law. Unlike with gas and electricity, there is no specific regulation governing the relationship between consumers and suppliers. This is the same situation as for customers who get their heat from oil, solid fuel or any other sources not derived from gas or electricity. This can create consumer reticence and increases the risk and cost of investment in the sector. There is an associated risk that without any consumer protection measures in place for heat networks, there will be difficulties for the heat network industry in promoting the potential of heat networks to investors and developers.

Issues faced by local authorities

2.44 As set out in the Strategic Framework, local authorities are critical players in increasing the deployment of heat networks as they can create a supportive environment for the development of heat networks in their areas and support or sponsor specific projects. They are responsible for many areas of planning, urban regeneration and housing and own the roads under which the networks need to be installed. They are also owners of potential heat loads in social housing and other premises they occupy or control. Local authorities are in the best position to undertake the energy masterplanning of areas suitable for heat networks and the initial assessment of the feasibility of projects. They are well placed to act as 'brokers', for example putting together prospective promoters of projects with prospective providers and customers for heat. The challenge for local authorities is to gain the knowledge and capacity to make the best use of their unique position.

2.45 BRE's report for DECC argues that authorities' most significant challenges include:

- obtaining funding for technical and commercial development work;
- procuring advice on how projects should be structured commercially;
- obtaining capital funding; and
- lack of standard contract mechanisms and legal advice.[77]

2.46 As a result of the difficulty in procuring consultants to undertake development work, local authorities have struggled to navigate through different stages of the process.[78] This means they are unable to drive projects forward, identify potential schemes, and bring together prospective developers. Consequently, they are also unable to attract the necessary capital finance available from commercial lenders. The Green Investment Bank views this sector as a priority area but it will only support projects that it considers to be commercially robust.

Issues around the development of networks

Lack of common technical standards

2.47 The investment risks around developing heat networks mean that some projects may start as small clusters that can be linked together later. Interconnection can be beneficial, including optimising efficiency and reducing risks around the heat load once the initial schemes are built. Although some standards already exist for pipework sizing for heat networks by the Chartered Institution of Building Services

77 BRE, University of Edinburgh and the Centre for Sustainable Energy, March 2013, *Research into barriers to deployment of district heating networks*

78 BRE, University of Edinburgh and the Centre for Sustainable Energy, March 2013, *Research into barriers to deployment of district heating networks*

Engineers, (CIBSE) and for the construction of pipes (EU standards), the design standards are not always compatible with best practice across the EU and do not extend to all aspects of the design.[79] Further, there are no standards for installation and operation and maintenance of schemes. Overall, this leads to three issues:

- costs are increased for those commissioning a scheme, because it is harder to access information on which standards are appropriate for individual schemes;
- there is no incentive for developers to use best practice techniques; and
- the expansion of heat networks is more complex without common minimum standards.[80]

Difficulty selling electricity produced by CHP

2.48 In the case of heat networks delivering heat from CHP plants, the revenue from electricity exported onto the local electricity networks can enhance the economic case. Where CHP plants do not have proper access to the electricity market to gain the optimal price for their electricity production, this creates a barrier to the development of many heat networks.

Lack of statutory access to land

2.49 Some heat network developers feel at a disadvantage as compared with utilities that have a specific legislative status under EU procurement regulations, ensuring access to private land to install networks and rights of connection to other networks. However, while this has not emerged as a key barrier from the BRE study or as part of DECC's consultation on the Strategic Framework, it could become so in the future if demand increases within the private sector to retrofit heat networks into existing buildings.

Difficulties joining up heat networks

2.50 Planning and designing heat networks so that they can be connected to other networks as they develop creates opportunities to introduce additional heat sources and heat loads to networks. If this is not considered from the start, it can increase the development and operational risk and makes it harder to introduce new sources of low and zero carbon heat.

Future low carbon heat sources

2.51 Renewable heat sources for heat networks include solar thermal, deep geothermal, water and large-scale ground source heat pumps, biomass boilers and waste incineration. Other low carbon sources can also displace the use of burning traditional fuels to produce heat. These include using heat discarded from industrial and commercial processes; and buildings and infrastructure such as sewerage systems, mine water and underground railway systems.

Difficulties in planning for future requirements

2.52 However, it is important to consider not only the quantity of heat from low carbon sources, but the temperature at which that heat would be delivered. Hot water services may require higher temperatures than space heating. A heat network may have to consider its operating temperature which may not be optimal for all clients.

2.53 The novelty of some technologies leads to increased commercial risk until satisfactorily proven through demonstration. At an early stage, these technologies carry an additional upfront cost. Some renewable technologies carry additional concerns around security of supply and sustainability.

79 BRE, University of Edinburgh and the Centre for Sustainable Energy, March 2013, *Research into barriers to deployment of district heating networks*

80 Stakeholder meetings, responses to the Strategic Framework

Policies in place now

2.54 There are a number of policies in place that promote the development of heat networks, though none was specifically designed for this purpose. The most significant of these are:

Table 4. Policies encouraging heat networks

Policy	Impact on heat networks
ECO	ECO is a one of DECC's flagship schemes and sits alongside the Green Deal to improve the energy efficiency of hard to treat properties and provides support for vulnerable and low-income households. Providing heat at a low cost for social housing tenants is a key driver for local authorities in deciding to develop heat networks schemes. Connections to heat network schemes will be eligible for ECO financial support in certain circumstances. On 15 March 2013 Ofgem published draft guidance on eligibility for support under the scheme.
RHI	The first phase of the RHI provides funding for renewable heat at the commercial and industrial scale. Renewable heating for heat networks is eligible for support under this scheme, which, provides funding through a tariff paid for each kilowatt hour of heat produced from renewable sources.
Renewables Obligation	If heat in a network comes from a renewable CHP plant, this will claim support via the Renewable Obligation where, in some cases, a 0.5 Renewable Obligation Certificate (ROC) uplift is given for Good Quality CHP. DECC has consulted on introducing a specific RHI tariff for Good Quality CHP to replace the 0.5 ROC uplift from 1 April 2015 (see chapter 1).
CHP Quality Assurance	DECC has consulted on revisions to the certification criteria for Good Quality renewable CHP under the CHPQA programme to ensure the support available for CHP is targeted to schemes delivering genuine energy saving benefits compared to separate generation of heat and power. As part of this consultation, DECC has proposed flexibility for renewable CHP schemes supplying heat networks. This will help support these schemes whilst the network, and hence the heat load of the CHP plant, is evolving.
Zero Carbon Homes policy	The Zero Carbon Homes policy envisages that low carbon heat networks could be employed to help developers meet the zero carbon standard in England as it is neither feasible nor cost-effective to do so in all cases solely through on-site measures like fabric energy efficiency or microgeneration. Similar policies are being developed in Wales and Scotland.
Building regulations	Regulations that set standards for new buildings can encourage heat network development. Housing developers are able to meet their requirements under building regulations for reducing energy demand from housing in the most cost effective way they choose. This can include adopting good fabric energy efficiency standards and connecting housing developments to heat networks.
Licence Lite	Ofgem has proposed licensing arrangements to enable smaller scale electricity generators to gain better access to the electricity supply market and obtain a higher price for their power. DECC has been working with potential applicants for the new kind of licence involved which, under conditions set out in the licence, relieves the electricity supplier from being party to various industry codes which are too costly and complex for small players. Obtaining a good price for the electricity produced in CHP plants which provide heat to networks can be critical to the viability of networks.
Planning policy	Local authorities are encouraged to consider low carbon and renewable heat networks through the National Planning Policy Framework published last year. The framework encourages local planning authorities to identify opportunities for development that can draw their energy supply from decentralised, renewable or low carbon energy supply systems and for co-locating potential heat customers and suppliers.[81]
EU ETS	Combustion over 20 MW is included in the EU ETS. This means any boiler or CHP plant supplying heat to a heat network over this size requires EU ETS permits. This cost is not faced by domestic gas consumers. As the emissions cap is tightened, there will be an increasing disparity between the costs for gas faced by heat networks and for domestic boilers.

81 https://www.gov.uk/government/policies/making-the-planning-system-work-more-efficiently-and-effectively/supporting-pages/national-planning-policy-framework, accessed on 1 February 2013

- the Energy Company Obligation (ECO) and its predecessor Carbon Emission Reduction Target (CERT);
- building regulations and planning policy aimed at setting standards for buildings including the Zero Carbon Homes Initiative;
- the Renewable Heat Incentive (RHI); and
- policies targeted at supporting CHP.

Heat network policy initiatives

Low Carbon Pioneer Cities

2.55 The Low Carbon Pioneer Cities initiative is part of DECC's contribution to the Government-wide City Deals programme. The objective of the programme is to boost economic growth in our largest cities, by decentralising power to those cities and other measures. DECC is supporting Greater Manchester, Leeds City Region, Nottingham, Newcastle and Sheffield City Region by providing over £1m for initial scoping and heat network development work. These projects increase understanding of the practical and financial issues that local authorities face in taking a project from inception to the point where it is viable for commercial investment. Although the projects have only just commenced, early insights from these have fed into the design of further support, set out below.

National heat map

2.56 DECC has developed a heat map for England, which helps to identify areas of high heat demand and potential sources of heat supply. The current heat map shows total heat demand for public, commercial, industrial and residential buildings. It also shows CHP installations (where data are available) and thermal power stations.

2.57 Local authorities will shortly be able to obtain the data for their areas to enable them to understand better local heat supply and demand. This will assist authorities in developing a local heat strategy, enabling them to develop strategic energy plans.

Progress report: heat network development in cities across the UK

Table 5: Low Carbon Pioneer Cities

Leeds City Region	The Leeds project is focused on strategic planning and capacity building with a view to identifying the full potential for heat networks across the City Region. Leeds will undertake a series of energy masterplans in the main urban areas. Local authorities in the region will be able to use the outputs to inform their Local Development Frameworks and to make the case for carrying out feasibility studies for high potential heat networks. DECC has allocated around £230,000 for this project.
Greater Manchester	About £330,000 of DECC funding will enable the development of three heat network projects (Manchester, Oldham and Stockport) to be developed from their current position through to the production of feasibility studies, business cases and development plans. This will lead to estimated CO_2 savings of 4500 tonnes per annum and an expected capital investment of £20m. Undertaking this work as part of a coordinated programme will deliver economies of scale and will establish a replicable, stream-lined approach for the efficient delivery of future planned networks across Greater Manchester and beyond.
Newcastle	Newcastle seeks to procure a private sector partner to deliver two projects in the city centre as a first step toward developing a citywide network. Around £120,000 of DECC funding will support the identification of potential areas for district heating and cooling; scheme selection and design; and developing an outline business case for each project.
Nottingham	Around £290,000 of DECC funding will support the development of district heating opportunities from the city's current heat mapping activities. It will contribute to the costs of feasibility studies and business cases for heat networks across the city. It will also contribute to building a greater understanding of the feasibility of using heat and power from the Nottingham Energy Park to deliver the requirements, in whole or part, of the City hospital.
Sheffield City Region	DECC is supporting Sheffield City Council in the delivery of its goal of joining up existing networks. This requires new governance and financial arrangements that can enable the authority to expand deployment of heat networks in Sheffield; explore the scope for harnessing waste heat from industry and diversify its energy sources. Sheffield will explore a range of commercial structures. DECC has allocated about £250,000 for this project.

Table 6: London

The Mayor of London has committed to generating 25% of London's energy requirements through the use of local, decentralised energy by 2025. The 'London Plan'[82] indicates that this target will be predominantly met through gas-fired CHP and heat networks.

To support the delivery of this target, in September 2011 the GLA established the Decentralised Energy Project Delivery Unit (DEPDU) to support the London boroughs in bringing forward plans for decentralised energy. The unit, which is staffed by technical, financial and commercial specialists, has focused primarily on developing heat network projects.

So far, the unit has supported the majority of boroughs to develop in excess of 25 projects of which seven have been taken to market and five are close to that stage for investment in the capital costs of building the network. Four of the projects, in particular, feature key barriers that need to be overcome to deliver heat networks at scale: linking two existing schemes, creating a strategic network with multiple heat sources, whether local-authority led schemes can be transferred to the private sector or expanded to join a private sector scheme, and connecting existing and future low carbon heat sources.

Box 8: A strategic multi-heat source scheme: Upper Lee Valley

The principle of this proposed heat network in North London is to capture otherwise unused low carbon heat from waste-to-energy facilities in the Edmonton area of the Lee Valley and other sources of heat in later stages of development and supply the heat to existing businesses and residential customers as well as to new developments. This will include connections to existing smaller networks. The GLA's role in sponsoring the early-stage development of the project is to create a 'strategic network': a large pipe that can collect heat from several sources and deliver it to customers across a wide area. While common in other European countries such a strategic heat network has yet to be built in the UK. For the London boroughs of Enfield, Haringey and Waltham Forest, who are taking part in this project, the expectation is that it will deliver significant benefits, including inward investment, new jobs, low carbon heat, and a reduction in fuel poverty.

82 GLA, 2011, *The London Plan: spatial development strategy for Greater London*

Box 9: A scheme using low carbon and fossil fuel heat sources: Olympics Park and Stratford City

The Olympic Park District Heating and District Cooling (DHDC) Network comprises 18 km of distribution pipe work (16 km heating and 2 km cooling) that provided the London 2012 Olympic and Paralympic Games with efficient heating and cooling.

(Courtesy of Inpal Energie)

The DHDC network is connected to two Olympic Park energy centres at Kings Yard and Stratford City. The energy centres use gas and biomass boilers for Combined Cooling, Heating and Power. This amounts to 100 MW of heating and cooling capacity and has the potential to expand to 200 MW in the future. The scheme also provides heating and cooling to the nearby Westfield shopping centre in Stratford. It can be expanded in the future to provide energy to other commercial and residential buildings and additional renewable technologies can easily be introduced.

Cofely District Energy, responsible for the scheme's construction and operation, projects that 11,000 tonnes of CO_2 will be saved each year by 2015, compared to using traditional heating and cooling plant in each building.

Table 7: Scotland

The Scottish Government has provided £2.5m for a District Heating Loans Guarantee Scheme to fund the early stage development costs of nine renewable and low carbon energy heat network schemes. These are low cost loans (3.5%) to be repaid over a ten year period.

The Scottish Government also has a heat mapping programme, working with local authorities to support the development of local Geographic Information System based heat maps. This will help local authorities and others to support investment decisions on strategic heat infrastructure, such as identifying target areas for ECO funding for social housing. The Scottish Government aim is for every local authority in Scotland to have its own heat mapping tool.

In addition, in February 2012, the Scottish Government established an Expert Commission on District Heating, which has put forward a series of recommendations to accelerate the deployment of heat networks in Scotland. Many of these share similarities with the recommendations set out in this chapter.

Next steps

2.58 To harness the potential for heat networks to become a strategically important component in our energy system, the Government needs to work with the industry and others to overcome the barriers outlined in this chapter. In the short term, DECC will take steps to address the more immediate barriers to the deployment of heat networks outlined above as well as considering the longer term challenges. As heat networks are deployed on an increasing scale, further measures may be needed to support their long term development. The next steps outlined below combine actions which can be set in train at this stage with others which will need be considered further in the future.

Support for local authorities

2.59 The Government has developed a number of measures to overcome the local authority capacity and capability barriers and challenges to developing heat network projects. For example, working with local authorities to reduce risk in these early stages should give access to more sources of finance and reduce the cost of capital.

Heat Networks Delivery Unit and development funding support

2.60 DECC is committing funding to two complementary policies that will support local authorities in England and Wales through the process of developing heat networks.

- £3m over two years will be committed to a Heat Networks Delivery Unit (HNDU). This will provide specialist expertise that many local authorities do not have in-house. It will bridge between the local authority and the market, acting as a 'critical friend.'
- A funding stream of £6m over two years will be available to local authorities. It will contribute to the cost of procuring technical reports and advice on the phases of a heat network's development.

2.61 Heat networks projects involve the development stages outlined below. HNDU support will be available to local authorities in the first four stages of the process. The funding stream will be available until the procurement stage.

2.62 In the **mapping**, **pre-feasibility** and **feasibility** stages, local authorities procure technical advice from the market to establish whether they have the conditions for successful heat network development, in increasing levels of detail. HNDU will provide support for local authorities in obtaining advice from the market.

2.63 Once feasibility is established, local authorities will seek to **procure**, or otherwise set up, a delivery structure to govern the construction of the network and its operation. HNDU will support authorities in considering options for procurement that best meet their needs. Contracts are then signed for building and operating the network. This is the **commercial development** stage in the diagram. Projects at this stage will not require further support from HNDU.

2.64 Local authorities will also be able to apply to HNDU for access to DECC's funding stream until the procurement phase.[83] The fund will contribute towards the costs of obtaining technical and commercial advice from the market.

Heat network development stages

83 Setting up a funding stream is supported in the Combined Heat and Power Association's Big Offer

2.65 HNDU will work with a wide variety of stakeholders to develop a set of commercial structures and standard template documents to provide to authorities and others. It will also encourage knowledge sharing between local authorities who are developing heat networks.

2.66 HNDU is designed to ensure that the projects it supports achieve a commercially viable threshold. The Green Investment Bank (GIB) and others will provide guidance to HNDU on the criteria that it and other commercial lenders and equity providers would require to invest in projects. This will help to provide a benchmark by which to judge the commercial attractiveness of projects.

Improving availability of information on heat demand and supply sources

2.67 The national heat map was developed to help local authorities reduce the transaction costs of mapping their heat demand. It is important that DECC reviews whether it is fulfilling this function and whether there are additional data requirements that would substantially improve the usability and usefulness of the heat map.

2.68 DECC will consult and then bring forward proposals on improving the availability of data sources and tools, building on the national heat map, for supporting local authorities and other public sector bodies to assess the potential for new heat networks. DECC will take this work forward over the next year as part of its plans to develop the heat map to host a wider range of relevant information for stakeholders and local authorities.

Support for consumers

2.69 There is no standardisation in the quality and level of protection for household customers who receive heat from heat networks. Consumer groups have been concerned about this issue and potential investors also regard this as a barrier to investment. The Government is taking steps to ensure that heat network customers are treated fairly, to ensure that the consumer challenges, outlined above, do not arise in the future.

Customer code of conduct

2.70 The heat networks industry will establish a consumer protection scheme for heat network users, with a view to this being endorsed by Government later this year. Ideally, a customer charter would be suitable for all heat network operators and ensure that protection for consumers connected to a heat network, is at least as good as that offered by the alternatives. Terms covering disconnection policy, transparency of billing, and protection of vulnerable customers, similar to the terms used in the utility sector, would be necessary to ensure this.

2.71 The heat networks sector is a small, but growing, industry. The Government does not want to stop the growth of the sector through introducing unnecessary regulation. DECC is therefore initially seeking an industry-led scheme, in consultation with consumer groups, that Government can endorse and welcomes proposals that have the support of the whole industry.

Requirements for heat metering

2.72 Providing meters for heat is another important area that will ensure fairness and transparency in billing customers on heat networks. The Government will consult this year on options for installing heat meters in line with the requirements of Article 9 of the recent Energy Efficiency Directive. The Directive requires installation of heat meters in a number of situations, and it must be transposed by June 2014. In developing a policy response, DECC will take into account a number of factors including the cost of manufacturing and installing heat meters, the effectiveness of meters in enabling consumers to change their behaviour and different types of meters that could be installed.

Capital funding and financial incentives

2.73 As described above, access to capital funding represents a significant barrier to local authorities realising heat network projects that appear commercially viable. Government provides a number of streams of capital funding that will help authorities and developers realise more schemes.

Capital financing for heat networks

2.74 Heat Networks are a sub-sector of the GIB Non Domestic Energy Efficiency Strategy and the bank is keen to support DECC by providing advice on policies and programmes to help bring forward commercially developed schemes. GIB may have a role to play in supporting commercial banks in the funding of these schemes.

2.75 Infrastructure UK (IUK) has a remit to provide a stronger focus on the UK's long-term infrastructure priorities and meet the challenge of facilitating significant private sector investment over the longer term. The UK Guarantees scheme aims to kick start critical infrastructure projects that may have stalled because of adverse credit conditions. Around £40 billion of projects could qualify for the provision of guarantees. from one or both programmes outlined above. IUK welcomes enquiries from heat network projects that meet the headline eligibility criteria.

2.76 As part of the Government's policy on Zero Carbon Homes, the Government is continuing to work on options for a cost-effective allowable solutions scheme. Allowable solutions are potential options for delivering Zero Carbon Homes energy savings through other means than improving the fabric of the building. Budget 2013 announced that the Government would consult on allowable solutions by the summer recess.

2.77 DECC will also work with BIS to explore the potential for allowing the use of low carbon funding under the European Regional Development Fund (see chapter 1 next steps for further details) to be made available for heat networks during the period 2014-2020 by Local Enterprise Partnerships (LEPs) in their EU Investment Strategies.

Renewable Heat Incentive for heat networks

2.78 DECC will consider options for providing additional support to renewable heat suppliers that connect their heat supply to a heat network. At present there is little incentive under the RHI for producers of renewable heat to use the heat for heat networks. Indeed, because of the heat losses that are incurred when transmitting heat along networks, renewable heat that is used for heat networks currently receives a reduced payment to account for the heat losses. The Government wants to encourage the connection of renewable sources of heat to heat networks and believes that this will help to encourage renewable heat suppliers to consider this option more favourably. As DECC continues to work on developing the RHI, it will consider further how heat networks can be better supported as part of the next RHI policy review in 2014.

Electricity sales by heat suppliers

2.79 There is a need for better access to the electricity market for smaller electricity generators and suppliers whose electricity sales are an important part of the economics of the competitive supply of energy by heat networks. DECC will continue to support the implementation of Ofgem's Licence Lite proposals (referred to in the section on policies in place now) which, if successfully implemented, have the potential to offer significantly improved margins on the sale of electricity from small scale CHP systems of the type connected to heat networks. The Mayor of London has applied for a Licence Lite licence and DECC will monitor the progress the Mayor makes and any barriers he encounters closely.

Supporting the longer-term development of the heat network sector

2.80 In the barriers section above, a number of longer term institutional challenges to the wider deployment of heat networks are outlined. DECC is taking forward a number of areas of work to overcome these barriers.

Innovative low carbon heat networks

2.81 DECC will work over the remainder of this year with the Low Carbon Innovation Coordination Group (including the Carbon Trust, BIS, the ETI, the Technology Strategy Board and the Scottish Government) to identify the key technological solutions that require innovation support to deliver the Government's ambitions for heat network development out to 2050. The findings from the 2012 Technology Innovation Needs Assessment (TINA)[84] for heat will be used as a starting point for this work.

2.82 The TINA stated that some heat network technologies are areas of high to medium priority for Government innovation support and that this is unlikely to come from other sources. The report highlighted three main areas for investigation: some core components and processes required for heat network development, for example smart controls; low carbon heat sources for use with networks, such as large-scale heat pumps; and storage solutions that can help networks manage supply and demand intermittency.

2.83 DECC will also ensure that learning from the research on recoverable heat from heat intensive industrial sectors (see chapter 1 for further details) includes its use in heat networks.

2.84 DECC will continue to support UK participation in the International Energy Agency Implementing Agreement on District Heating and Cooling[85] during 2013-2014. The group conducts research into the design, installation and operation of heat networks. Current topics include the potential for, and experience of, low temperature heat networks.

Access and connection rights

2.85 DECC will investigate what access rights heat network providers have in other EU member states, including whether they have statutory undertaker powers, to assess whether there are any lessons that could be applicable to England and Wales in the future.

2.86 Statutory powers similar to those available to electricity and gas utilities could make it easier for developers and operators to gain access to land to build and maintain their networks, and gain access to premises of consumers in connection with their supply of heat. It would not be appropriate to pursue this unless there is demand from the industry itself and the Government would want to take views from a wide range of stakeholders.

2.87 Similarly, the growth of heat networks at the scale described earlier in this chapter will involve growth through interconnection between networks and the introduction of new heat sources to expanding heat networks as well as new heat loads. As utility infrastructure in the form of physical networks is a monopoly asset, it is subject to regulation to enable connections to take place where the capacity is available.

2.88 The Government does not see the need for the introduction of such regulation for heat networks at this stage, but it will assess these issues to establish whether they emerge as significant barriers as heat networks grow.

84 A copy of the heat TINA is available at: www.lowcarboninnovation.co.uk/working_together/technology_focus_areas/heat/, accessed on 22 March 2013

85 More information about the IEA implementing agreement on district heating and cooling and the current areas of research can be found on their website at: http://www.iea-dhc.org/home.html, accessed on 22 March 2013

Use of planning powers to support heat network development

2.89 In DECC's initial consultation with local authorities (and from the results of the BRE study into barriers to heat networks), local authorities have not highlighted planning powers as a key barrier to the development of heat networks. There does however appear to be a wide difference in the application of existing powers. DECC will consult with local authorities to understand better if and how they have incorporated heat network feasibility studies into their local area plans. Once the picture is clearer, DECC can establish whether there is a need to help local authorities share good practice.

2.90 The Government will respond to the Review of Planning Practice Guidance led by Lord Taylor shortly.[86] In streamlining planning practice guidance to help make the planning system swifter and more accessible, the Government will consider the need for practice guidance to support the implementation of national planning policy on low carbon and renewable heat networks.

Development of technical standards

2.91 DECC will work with stakeholders across the heat networks industry to establish a process for agreeing industry-led standards. There is a case for producing technical standards on the design, installation and maintenance of heat networks. However, the scope of any standards would need to be agreed by the heat networks industry.

2.92 Many good quality sets of guidance on technical issues have been produced, including materials by the UKDEA, Carbon Trust and CHPA. In February 2013 the GLA's DEPDU published the District Heating Manual for London which contains (inter alia) principles of heat network design, heating standards and construction. However, the proliferation of advice can confuse installers, engineers and those involved in commissioning new schemes where advice differs. DECC will work with industry and local authorities to consider how to publicise and embed new harmonised standards. Anything new must draw upon the wealth of existing guidance in the UK and elsewhere in the EU. It will also be important for any technical standards to be used by the whole heat networks industry.

86 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/39821/taylor_review.pdf, accessed on 1 February 2013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Chapter 3: Heat and Cooling for Buildings

Guide to using this chapter

What is the situation now? covers domestic and non-domestic buildings, what determines their heat usage and the varying types of heating and cooling systems. Heat is used predominantly for space heating but also for hot water and for cooking. Cooling is mainly used in non-domestic buildings, such as offices.

What might we need for our low carbon future? explains what various models are telling us about cost-optimal solutions for heating buildings in the decades to come. The models come to various conclusions about the potential for natural gas to be providing some of our heating needs by 2050, but all agree that there needs to be a fundamental shift away from gas boilers to alternative heating technologies.

The section on **Barriers and challenges** describes barriers to reducing demand for heat and what research tells us about consumer attitudes and behaviour. The majority of the section then considers barriers to the adoption of new heating technologies in homes and non-domestic buildings.

Policies in place now describes current policies that are aimed at or are relevant to heating and cooling in buildings.

The **Next steps** section covers new initiatives on low carbon and renewable heating, support for supply chains, improvements to guidance and standards, and options for the long term.

Introduction

3.1 This chapter primarily covers the heat used in both domestic and non-domestic buildings for space heating, hot water and the ways in which buildings are cooled. It considers how people use heat in buildings (the demand side) and where people get the heat from (the supply side).

3.2 Reducing demand for heat through, for example, better insulation and using less energy through changes in behaviour, are vital first steps. It is one of the most cost-effective ways of reducing emissions, as well as saving consumers money, and is central to efforts to tackle fuel poverty. That is why the Government has introduced its flagship energy efficiency programme, Green Deal, and is rolling out smart meters into every home and smaller businesses (SMEs) by 2019.

3.3 If these policies achieve everything expected from them, there will still be significant demand for heating, hot water and cooking, estimated to be around 500 TWh per year. If no change occurs at all and historic trends continue, demand could rise by up to 50% by 2050, driven by increased internal temperatures and building numbers.[87] In any scenario therefore, we must also deal with the supply side of the equation.

87 Based on worst case scenario in the 2050 Pathways Calculator, demand for space heating and hot water in buildings could reach over 650 TWh/y by 2050 if no action is taken to constrain demand

3.4 The Carbon Plan, published in 2011, explained that we will need to reduce carbon emissions from heating buildings to near zero in order to meet the overall target of cutting greenhouse gas emissions by 80% by 2050. Since natural gas is a fossil fuel, this means finding alternative ways over the coming decades to heat those buildings which currently use gas – the vast majority of our homes, our public and commercial buildings – as well as those off the gas grid which rely on oil and other high-carbon fuels.

3.5 But such radical change does not all need to happen at once. The Strategic Framework described a high-level pathway for how this could be achieved gradually and effectively in areas where change makes the most financial sense and delivers the biggest benefits. The Framework suggested a combination of expanding use of heat networks in urban areas and promoting the uptake of renewable heat in rural off-gas grid areas in the short to medium term, alongside driving heating efficiency in all buildings.

3.6 This document suggests how the UK can be put on that pathway. It reports on the consumer research and modelling, including updated costs, that have been carried out since last year's document was published. It describes the barriers DECC has identified to a low carbon heating future, the policies government already has in place, and further actions and policy options.

Next steps

- DECC will extend the Renewable Heat Premium Payment scheme (RHPP). The extended scheme will run until the end of March 2014.
- DECC intends to use the RHI review in 2014 to examine the case for other renewable fuels such as sustainable, heating-only bioliquids and active air solar heating.
- DECC will introduce a range of measures to improve capability and competency within the low carbon heat sector, including:
  - introducing a voucher scheme for installer training to build up the installer base in preparation for the domestic RHI; and
  - piloting a green apprenticeship scheme over the coming year, with the aim of offering 100 places.
- DECC will support development of a new consumer guide produced by industry and consumer organisations, improving the way low carbon heating is communicated to consumers and providing advice to installers and intermediaries such as local authorities.
- DECC will explore what role tighter standards on building emissions and heating systems could play in achieving the goal of decarbonising heat in buildings by 2050.

What is the situation now?

Types of buildings

Domestic buildings

3.7 There are now 27 million households in the UK[88] across a wide range of housing stock, a lot of which date back to the Victorian era. Despite national Building Regulations being introduced in 1965, with local standards in existence since the 1930s, we still have a legacy of some of the least thermally efficient housing in Europe.

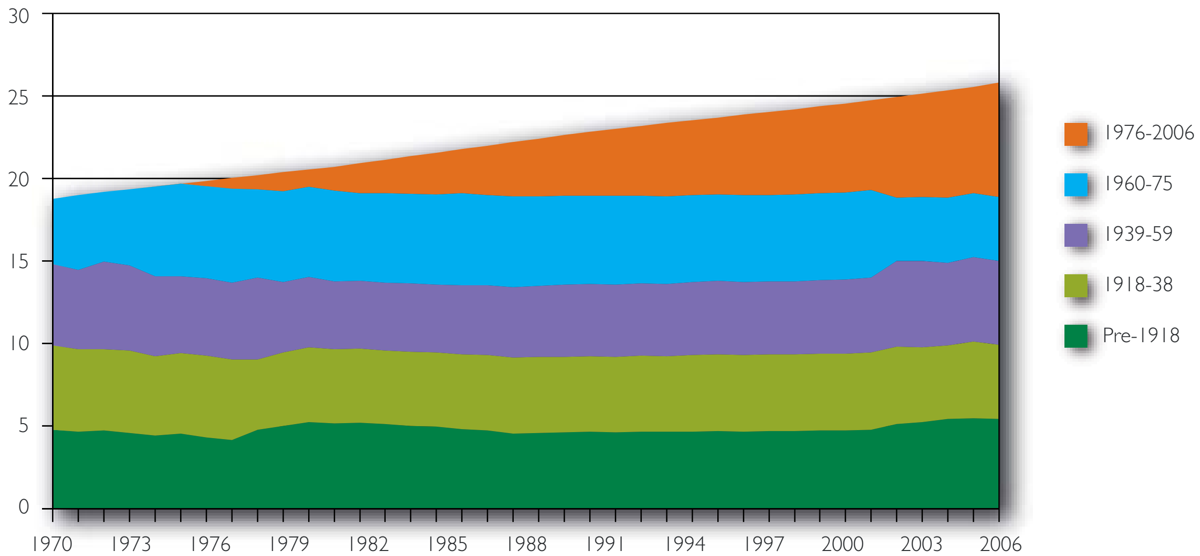
3.8 Over the last 40 years the change in our housing has been quite pronounced. While semi-detached and terraced houses have always been the most common house types, flats and detached houses have now become more common. The stock of older housing has increased since 2000 due to the subdivision of single dwellings into flats.

88 DECC, 2012, *Housing Energy Fact File*

Non-domestic buildings

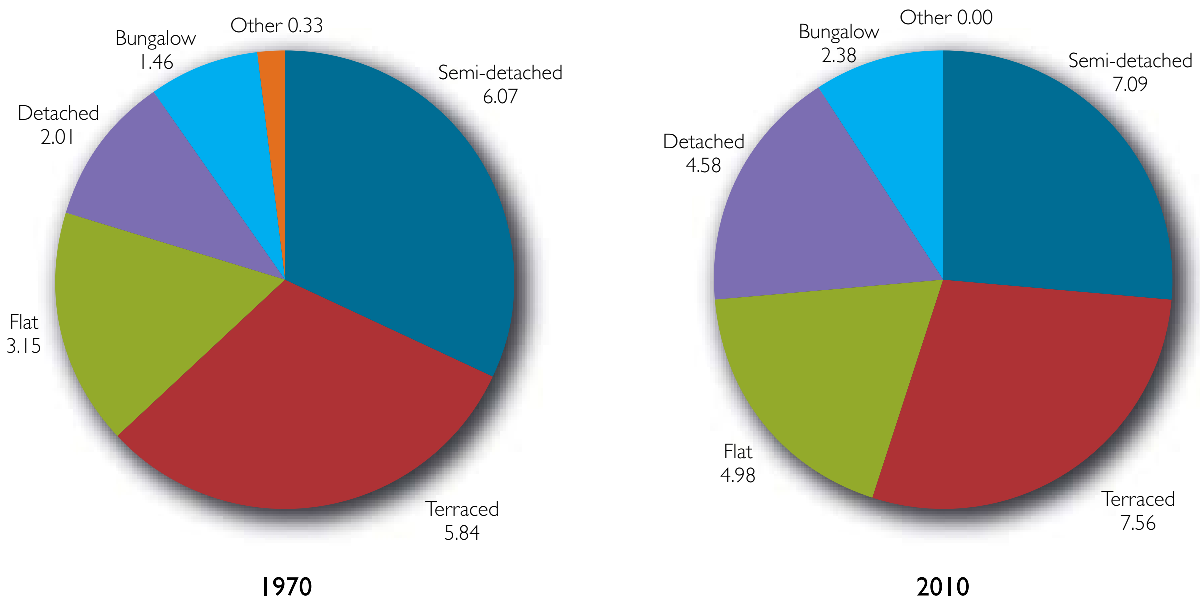
3.9 There are 1.8 million non-domestic buildings in the UK. The stock of buildings in the commercial, public and industry sectors is extremely diverse, ranging from those that have the simplicity and scale of houses, dentists, small shops and libraries through to the largest and most complex buildings in the UK such as airport terminals and hospitals.

Chart 19: Age profile of UK housing[89] (millions)



Source: DECC

Chart 20: UK Housing by type (millions)



Source: DECC

89 Data was collected on a different basis post-2006, but the trends are similar

3.10 The stock of non-domestic buildings also spans a wide age range. More than three-quarters of non-domestic buildings were built before 1985, with nearly a third of these built before the Second World War. By 2050, half of these buildings will still be in use.

Current levels of heating in homes

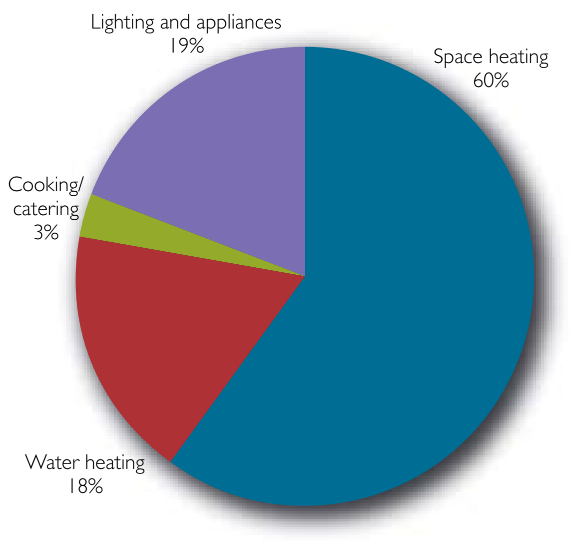
Domestic buildings

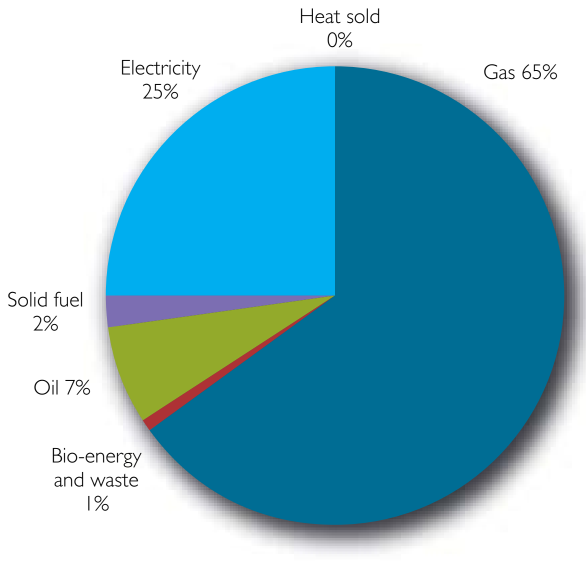
3.11 Heating within the domestic sector currently accounts for 23% of UK energy demand. Modelling undertaken on behalf of DECC for the Housing Energy Fact File 2012 illustrates the changing levels of energy used for space heating, hot water and cooking in our homes since 1970 (see Chart 22).

3.12 The modelling suggests that space heating energy has increased by nearly a quarter over that period, though it shows a downward trend from 2004. Overall, improvements in insulation and heating system efficiency were effectively offset by housing growth and the desire for warmer homes. Heating's share of total energy use in homes has also risen slightly. This may indicate that the growth of central heating has made more difference to energy use than higher levels of energy efficiency, by allowing people to heat the whole of their homes rather than just individual rooms. It may also be the result of the growth in the space in houses that needs heating, as for example conservatories, which can significantly raise the amount of energy used for heating, become more commonplace.[90]

3.13 The situation in regard to hot water is very different. The modelling suggests there has been a cut in energy used for hot water, despite the increase in the number of households. The proportion of household energy used for water heating reduced from nearly 30% in 1970 to just 18% in 2011. This improvement is consistent with reduced heat loss from stored hot water, for example better lagging of tanks and pipes alongside the adoption of more energy efficient boilers.

Chart 21: Final energy consumption and fuel use in domestic buildings, 2011

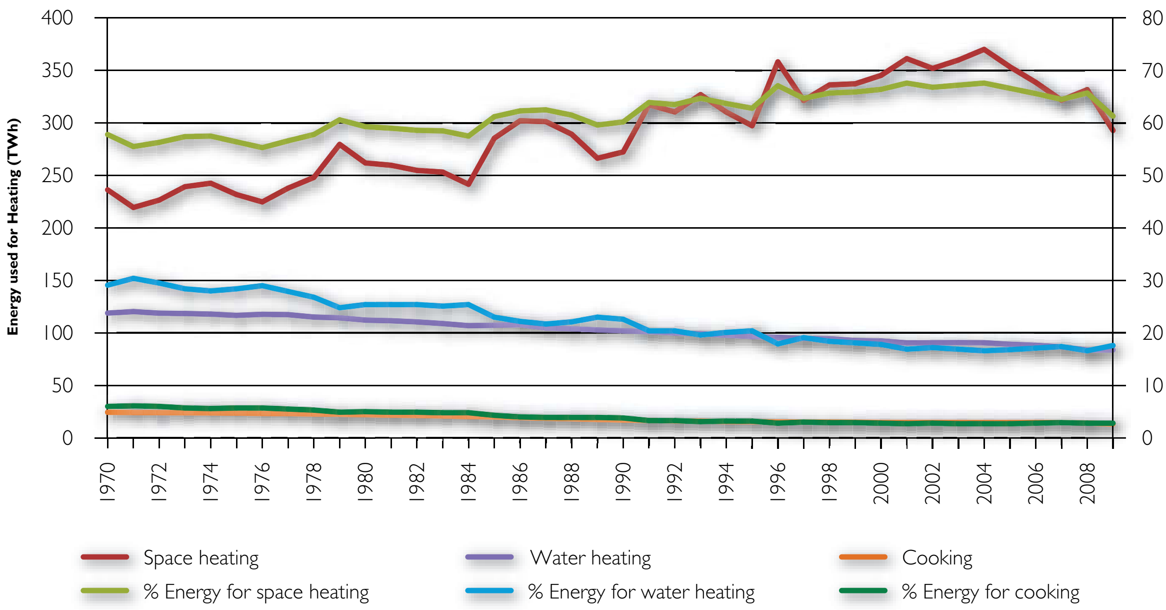




Source: DECC

90 Babcock, Q and Irving, S, (undated), *Energy Performance of Modern Conservatories*. London: CIBSE.

Chart 22: Final energy consumption for heating in domestic buildings



Source: DECC

3.14 Energy use for cooking is nearly half of what it was in 1970. This is in part due to more efficient cooking devices such as microwaves and fan-assisted ovens. The expansion in 'ready meals' and takeaways is also likely to be a large factor in the decline in cooking energy, so it is unclear whether these lifestyle changes have saved energy overall.

3.15 The Strategic Framework sets out the existing technologies for cooking. The relative energy demand for cooking is low and the issues around electrification are similar to those affecting heat more generally. Therefore, cooking will not be dealt with separately within the rest of this chapter. Cooking tends to face the same issues as the electrification of heat more generally.

Non-domestic buildings

3.16 Non-domestic buildings account for 17% of total UK energy consumption with over 60% of energy in our non-domestic buildings being used for delivery of heating and cooling.

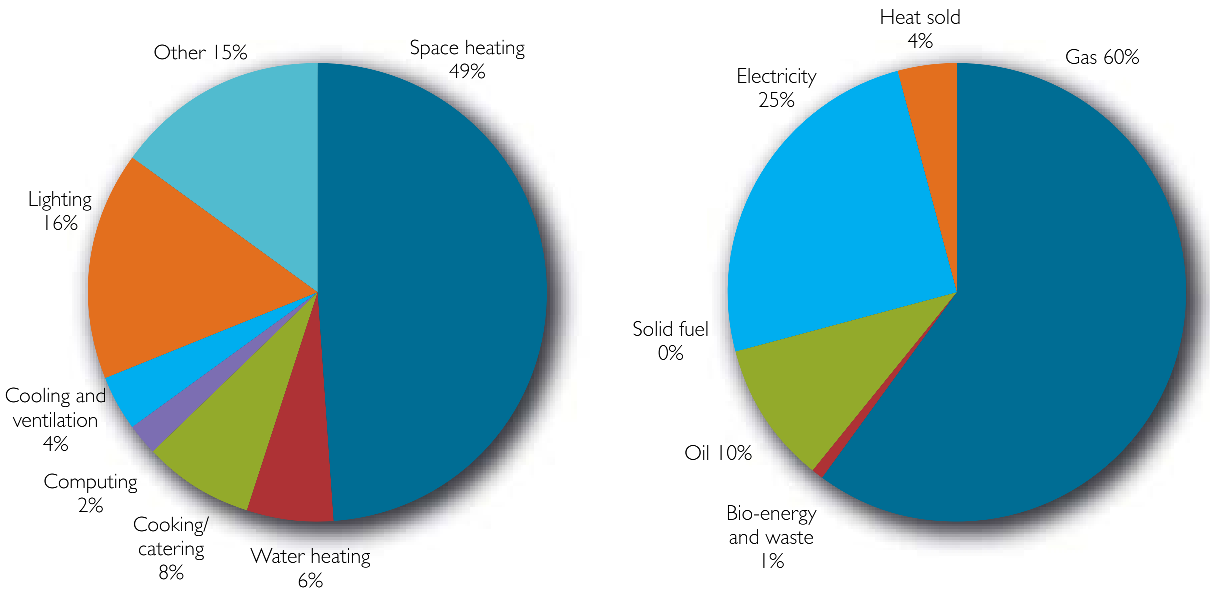
3.17 Unlike in homes, the diversity of building use has a profound effect on the levels of energy used for heating and cooling across the various sectors. Non-domestic buildings may have to deal with high levels of internal heat gains from lighting and other electrical processes such as IT, as well as the conditioning of 'deep spaces,' i.e. those far from natural ventilation.

Box 10: Aspire Housing – Kent Grove, Chesterton, Staffordshire

Aspire Housing set out to provide cheaper alternative heating for off-gas grid customers. The organisation successfully bid for £136,000 from the £4m Renewable Heat Premium Payments Social Landlords Competition to deliver a £300,000 project to install air source heat pumps at 56 properties. This included 29 homes at the sheltered housing scheme at Kent Grove, Chesterton, along with 27 flats and houses within rural areas in Newcastle-under-Lyme.

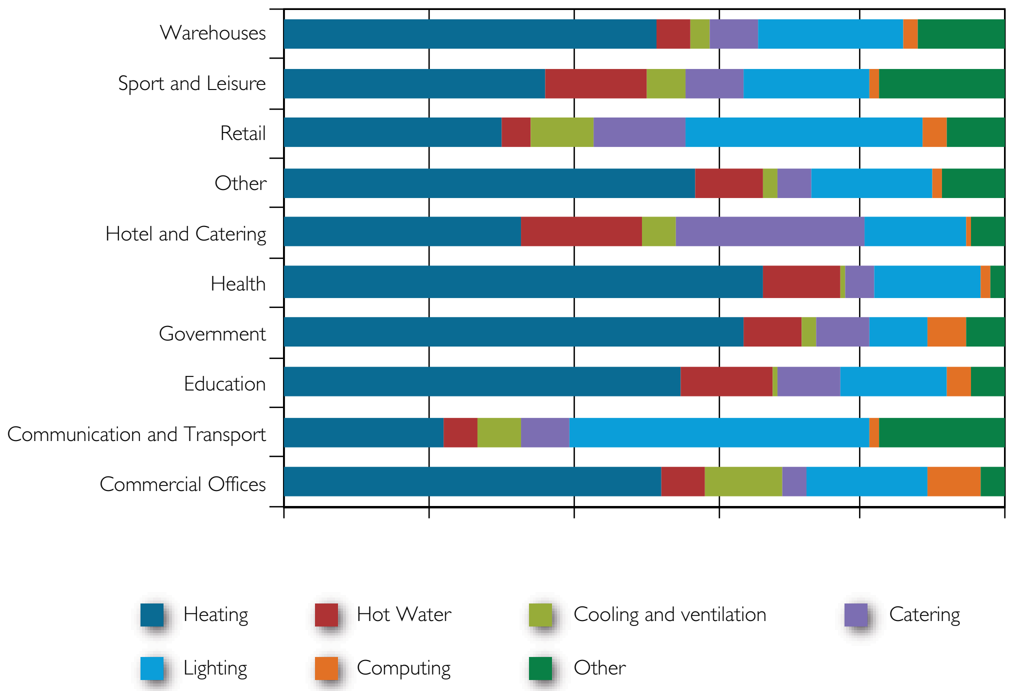
The air source heat pumps are replacing heating systems running on electric, oil and solid fuel. Kent Grove has already benefited from the installation of solar panels this year, meaning that the bungalows will now be powered by two renewable energy technologies. All customers received advice and support in order to properly use their new systems and so be able to benefit from lower energy bills.

Chart 23: Final energy consumption and fuel use in non-domestic buildings, 2011



Source: DECC

Chart 24: Breakdown of CO_2 emissions by end use in each sector



Source: DECC

Types of heating and cooling systems

Domestic buildings

Central heating and controls

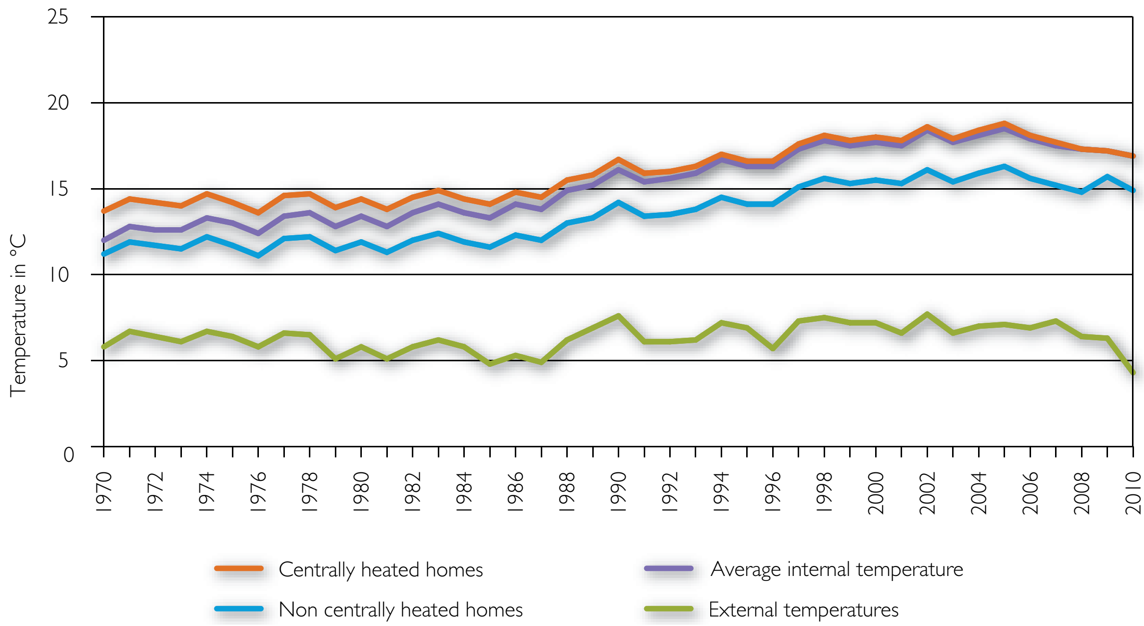
3.18 Since 1970, central heating systems have become the predominant means of heating our homes. In 1970, less than a quarter of homes in the UK had central heating. By 2010, 90% of the housing stock had installed a central heating system.[91] This has contributed to the rise in internal temperatures in our homes (see Chart 25).

3.19 The advent of central heating has seen the development of control systems to help regulate the supply of heat at the required temperature when needed. The statutory guidance accompanying the 2010 Building Regulations set the minimum level of controls in domestic new build as a timer, a room thermostat and thermostatic radiator valves (TRVs), that allow the setting of temperatures for individual rooms. 70% of households lack this minimum level. Furthermore, around 30% have no room thermostat, and 3% have no heating controls at all.[92]

3.20 Over 95% of UK homes are heated by a boiler,[93] with the fuel type dependent on location. Some 23 million homes (80%) are connected to the gas grid. The four million households that are not on the gas grid use other fuels that can vary depending on whether the household is in a rural or urban setting. In dense urban environments, the predominant fuel for heating off-grid homes is electricity, particularly in housing blocks where there may be limitations on the use of gas for safety reasons. In rural settings, the fuels used for heating are mainly electricity and heating oil, with solid fuels and liquefied petroleum gas (LPG) being used to a lesser extent.

91 Excluding homes with electric storage heaters, which are sometimes counted as 'centrally heated'
92 DCLG, 2010, *English Housing Survey*
93 DCLG, 2010, *English Housing Survey*

Chart 25: Average internal and external temperatures of homes



Source: DECC

3.21 The UK average cost of heating a typical three bedroom house is around 50% higher with heating oil and 100% higher with LPG than with mains gas. This has been a contributing factor in causing a higher proportion of off-grid households to be in fuel poverty (32% compared to 15% of on-grid households).[94]

Heating systems

3.22 Since 2005, gas central heating boilers fitted in England and Wales should be high-efficiency condensing boilers, unless there are exceptional circumstances. The same requirement has applied to oil-fired boilers since 2007. Similar regulations are in force in Scotland and Northern Ireland. A condensing boiler extracts additional heat from its waste gases by condensing the water vapour to liquid. A typical increase of efficiency can be as much as 10-12% over non-condensing boilers. Laboratory tests have shown that modern condensing boilers can attain efficiencies around 90%, though field trials show slightly lower efficiencies are achieved in practice.[95]

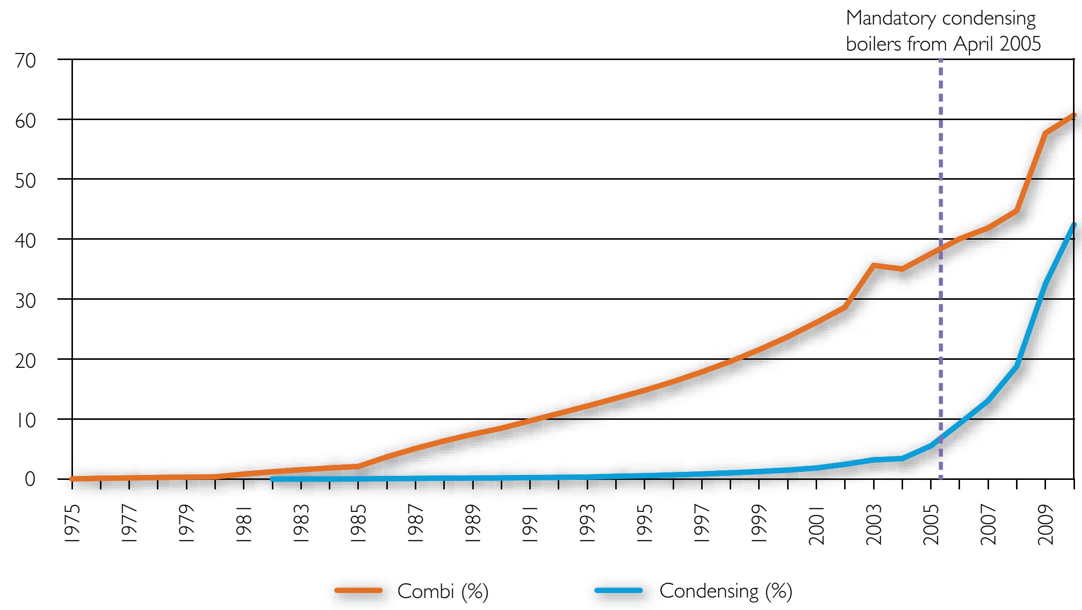
3.23 The share of the market for combination (or 'combi') boilers is now approaching two-thirds of all boilers in the UK with condensing combi boilers making up a third of all gas and oil boilers. These boilers instantly heat water as it flows through the unit, effectively removing the need for the hot water tank required for most other forms of heat supply.

3.24 As set out in the Strategic Framework, there are a range of alternative heating technologies to boilers that are commercially available, with a number of others that are close to market. A full list of technologies is provided in the Evidence Annex published alongside this document, including:

- electrically-driven heat pumps, which harness the ambient heat from the environment (i.e. the ground, air or water) and use a compression and evaporation cycle to increase the source temperature and deliver it via heat emitters (radiators or under floor heating), or directly into the room;

94 Office of Fair Trading market study, 2011, *Off-grid Energy*, accessed at http://www.oft.gov.uk/shared_oft/market-studies/off-grid/OFT1380.pdf, on 21 March 2013
95 Gastec, 2009, *In situ monitoring of efficiencies of condensing boilers and use of secondary heating*

Chart 26: Ownership of condensing and combi boilers (%)



Source: DECC

- biomass systems, from boilers running on pellets or wood chips, through to wood stoves that are a popular secondary heating system in homes;
- solar thermal devices which harness energy from the sun to provide hot water;
- micro-CHP units based on Stirling engines or fuel cells, with systems based on the organic rankine cycle also close to market;
- electric storage heaters that are able to use cheaper off-peak electricity to heat hot water cylinders overnight, releasing the heat over the day; and
- technologies such as flue gas heat recovery systems (FGHRS) that can improve the efficiency of existing boiler systems by recycling waste heat before it goes through the flue and is lost.

3.25 Domestic gas absorption heat pumps (GAHPs) are also expected to come to market in the near future, with the potential to play a significant role as a highly efficient alternative to the gas boiler. There are a small number of commercial applications in the UK already. These systems use the same operating principles as the electric heat pumps described above, with the compressor replaced by a separate device powered by heat from a gas burner. Hybrid systems that integrate a boiler and an electric heat pump are also being developed.

Cooling

3.26 Mechanical cooling in buildings is currently responsible for 4% of total UK energy demand. However, the domestic demand for cooling is much less significant and accounts for less than 1% of household energy use, in the main provided by electric air conditioning. Reports commissioned into the possible effect of climate change on domestic uptake[96] predict this demand will rise, although with varying conclusions regarding likely prevalence. The type of technology employed for domestic cooling also greatly influences predictions for future energy demand. The most comprehensive study

96 Defra, 2012, *The Economics of Climate Resilience Buildings and Infrastructure Theme: Overheating in Residential Housing*

estimates UK domestic energy consumption from cooling systems at 4.2 TWh a year by 2050.[97]

Non-domestic heating systems

3.27 Gas boilers are also the predominant means of heating in the non-domestic sector. However, with the greater volume of heat required and more specialised environments, more complex heating systems are required. This can mean multiple boilers being deployed in a modular array, or different technologies deployed to maximise the efficiency of the system. This can include the practice of separating the space heating and hot water plant into separate lines. CHP is also an option for heating in this sector, where there is a suitably large heat demand for space heating and hot water. When CHP also includes a cooling element, this is also known as 'trigeneration'. At present there are around 1200 CHP schemes supplying over 2.5 TWh of heat per year heat to non-domestic buildings, (see chapter 1 for more on CHP).

3.28 The uptake of renewable heat technologies has been relatively low in the non-domestic sector, though the numbers are increasing now that RHI support is avaiable. The value of waste heat is also becoming more pronounced, with innovative ways of recycling it back into buildings. The supermarket retail sector is an example of a sector in which there is significant focus on reclaiming waste heat from refrigeration processes.

3.29 There are a number of factors that affect the energy performance of non-domestic buildings. The significant internal heat gains from equipment and its inhabitants can greatly affect the internal temperature, and therefore both the design and control of heating and cooling systems. Due to their size, there are more complex systems available for regulating the temperature in non-domestic buildings.

3.30 A Building Energy Management System (BMS or BEMS) provides closer control and monitoring of building services, including heating, ventilation and air conditioning. This is shown on a computer screen in real time and allows settings to be changed quickly and easily. BEMS can reduce total energy costs by 10% or more.[98] An 'optimum start controller' learns how quickly the building reaches the desired temperature, and brings the heating on at the optimum time prior to building occupancy, depending on the weather.

Non-domestic cooling

3.31 Cooling is mainly required in the UK to remove excessive heat gains in deep-plan buildings like modern offices, department stores and IT centres. As many modern offices only require pre-occupancy heating, cooling is the predominant energy requirement throughout the day. Estimates suggest that 40% of commercial floor space will be air-conditioned by 2020, in comparison to only 10% in 1994.[99] Understanding the way non-domestic buildings work and the way they are to be used is therefore essential in designing the heating, ventilation and air conditioning (HVAC) systems in new buildings.

3.32 Currently the cooling of buildings is usually done through some form of electric air conditioning. There are a wide variety of other systems that can be employed, whether at initial build phase or via retrofit. For example, reversible heat pumps can be deployed to provide both heating and cooling, or absorption chillers that run on waste heat, often as part of a CHP system.

97 Collins, L., Natarajan, S and Levermore, G, 2010. *Climate change and future energy consumption in UK housing stock*
98 http://www.carbontrust.com/media/13151/ctv007_office_based_companies.pdf accessed on 8 March 2013
99 Carbon Trust, 2012, *Air Conditioning*

Box 11: The Open University, Milton Keynes

In November 2010, the Open University opened Building 12 on its Walton Hall campus in Milton Keynes. The project was completed in 18 months at an overall cost of £8.8m, providing 2000 square metres of modern office space. Active heating is provided through four ground source gas absorption heat pumps providing 140 kW of the building's heating needs and reducing its emissions by 125 tCO_2 per year. This is 45% less carbon than would be emitted by a conventional gas boiler.

Solar thermal panels supply hot water. Other design features include the high thermal mass construction of the building that moderates temperature changes, thus removing peaks in demand. The building passively moderates its environment in a number of ways, such as by control of solar gains through 'brise soleil' (sun shading), natural ventilation and night-time cooling. The passive and active systems are mutually compatible, with a high degree of local user control. The project has been assessed by BREEAM and achieved the highest 'Outstanding' rating.

3.33 Whilst the number of very warm days in the UK (over 28°C) is fairly low, using comfort cooling for just this short time can be as expensive as a whole year's heating, due to the greater reliance on electricity. However an increased demand for summer-time cooling ought to coincide with the best time for photovoltaic (solar panel) generation, partially offsetting the summer peaks in demand.

3.34 There has been a move towards more passive forms of cooling, where warm air is drawn up and out of buildings. Measures such as reducing unnecessary heat gains, utilising night cooling and better integrated natural ventilation can help to bring down both energy usage and maintenance costs. As with any system, one of the key drivers for reducing energy demand for cooling is behavioural change.

Market analysis for building level heating technologies

3.35 Boilers are by far the most dominant heat technology in the UK market. Sales of new domestic condensing boilers are around 1.5m per year. Although boiler replacements in the UK are generally characterised as 'distress purchases', industry reports that in only 30% of cases the boiler cannot be serviced, with boilers often replaced because it is more economic to do so. Recent research with homeowners found that 'anticipated breakdown' was the main reason for 31% of respondents to purchase a new boiler and wider property renovation accounted for a further 13%.

3.36 There are over 20 manufacturers that supply gas boilers to the UK market. A large proportion of these sales are made by four companies: Baxi, Worcester Bosch, Vaillant and Ideal. Many of the other companies supplying this market may be small in UK terms, but are part of large European companies with some based in Germany, Italy and the Netherlands. It is estimated that at least 70% of UK gas boilers sold were manufactured in the UK.

3.37 Around 10.5 million households have installed condensing boilers since 2005.[100] It is therefore estimated that the number of non-condensing gas boilers remaining in the UK market is between 10.3 and 11.5 million. Of these about five million are believed to be highly inefficient i.e. with an efficiency of less than 70%. Whilst the replacement of non-condensing boilers will continue, they increasingly will be replacing existing condensing boilers, not just older less efficient units. It has been estimated that there will still be around one million non-condensing boilers in use in 2030.

3.38 The number of companies qualified to deal with low carbon heating technologies is relatively small compared to those dealing with traditional gas and oil technologies. As of 2013, there were around 1,650 heating installation companies registered under the Microgeneration Certification Scheme (MCS), representing around 16,500 installers, compared to over 100,000 registered Gas Safe engineers. Growth in the low carbon heat sector will lead to new installer jobs, and upskilling of existing jobs as existing gas installers cross-train.

What affects energy demand for heat and cooling in buildings?

3.39 In addition to building type and heating system efficiency, two key factors affect the energy required to heat, cool and provide hot water to a building:

- the energy performance of the construction elements, including insulation, air-tightness and approach to ventilation; and
- factors relating to actual use of the building, such as number of occupants, their behaviour and preferences.

3.40 The biggest influence on energy demand for heat is the difference between the outside temperature and the desired one within a building, meaning that peak demand in the coldest days in winter will place the greatest strain on our supply networks (see chapter 4).

3.41 From 1987 until 2010, the number of households with some insulation rose from around 80% to over 99%. Over the same period, the number of households with what was described as 'full insulation' rose from 3% to 25%.[101]

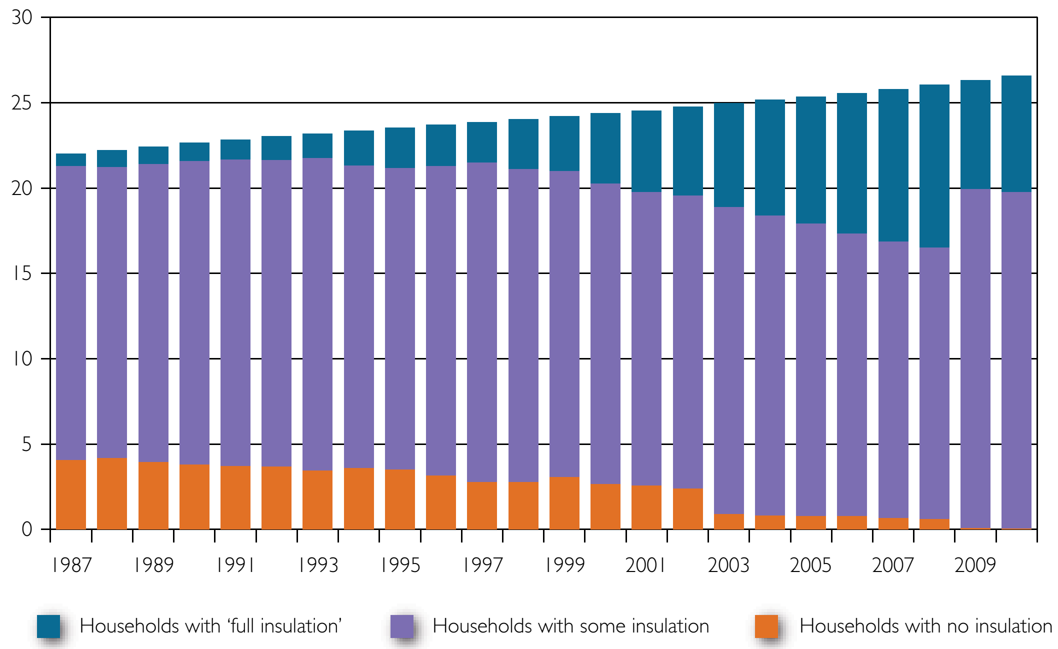
Heat Loss and internal temperatures

3.42 Since 1970, the overall rate of 'heat loss' from homes has fallen by almost a quarter. 'Heat loss' is a function of the difference

100 Heating and Hotwater Industry Council market analysis

101 There is a discontinuity in the data because of a change in how the figures were compiled in 2008 – around 3.5 million households were re-categorised from 'full' to 'some' insulation

Chart 27: Households with no, some and 'full' insulation measures (millions)

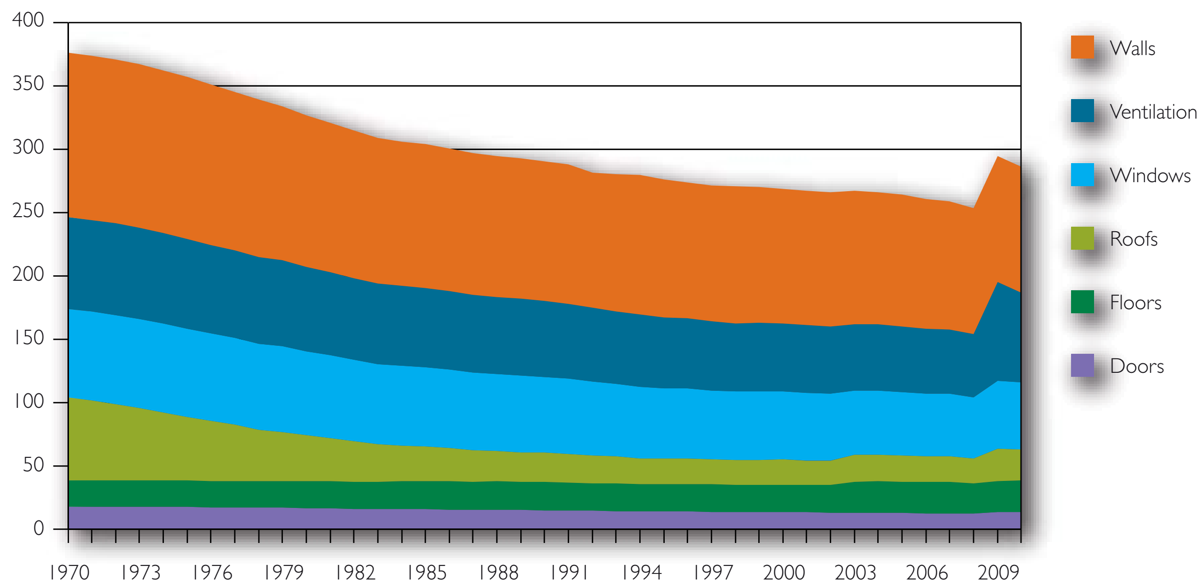


Source: DECC

between internal and external temperature. For an average home in 2010, if it is 1°C cooler outside than inside, it will take 287 watts of heating to maintain a stable temperature. Heat loss is reduced by insulation measures.

3.43 The air permeability of a building is effectively a reflection of the build quality of the envelope. Air permeability is a measure of the uncontrolled leakage of air through cracks and fissures (even if microscopic) in the walls and

Chart 28: Average heat loss per dwelling (W/°C)[102]



Source: DECC

102 DECC, 2012, *UK Housing Energy Fact File*

the roof. This means that cooler air will need to be heated to replace the warmer air that has been lost.

3.44 Making a home more airtight helps to reduce such losses, but at higher levels there will be a greater need for ventilation to improve air quality for safety reasons. A better option is to use mechanical ventilation. Mechanical extraction of air also provides the option to recover the heat from the stale air leaving the building and transfer it to the incoming air via a heat exchanger. This heat can be used as pre-heating for boiler circuits or to supplement the heat source for a heat pump.

Building use, including behaviours and preferences

3.45 Recent research[103] commissioned by DECC has helped to improve understanding of how property characteristics and behaviours affect the demand for heat in households. Evidence suggests that the highest 10% of gas users consume four times as much as the lowest 10%, but that they are not aware they do so. About 40% of this variation can be explained by the property itself – its size, age, etc – as well as other influences such as tenure and household income. Of the remaining 60%, a large part is caused by the occupants and how they behave. Variations in behaviour which affect demand include one-off decisions such as converting a garage to living space, along with routine behaviours such as time spent at home, preferred temperature, use of windows, and a host of other factors. A related qualitative study indicated that extremely high household energy consumption tends to stem from a range of quite commonplace habits and routines. It also suggested that even the lowest 10% had the potential to reduce their energy use without reducing their level of comfort.

3.46 In the non-domestic sector, a key difference is that larger commercial buildings generally have a facilities manager or site engineers responsible for maintaining the plant room and delivering services. However, the commercial imperative is often minimising costs, rather than energy demand management. An alternative model involves the contracting of energy management to an energy services company (ESCO) where both capital and operating costs are outsourced against a service level agreement. Smaller premises are unlikely to have the skills needed in-house, so energy management will operate on a callout basis only.

What might we need for our low carbon future?

3.47 The Carbon Plan and the Strategic Framework stated that it is likely that meeting the 80% carbon reduction targets across all sectors will necessitate emissions from buildings falling to near zero by 2050.

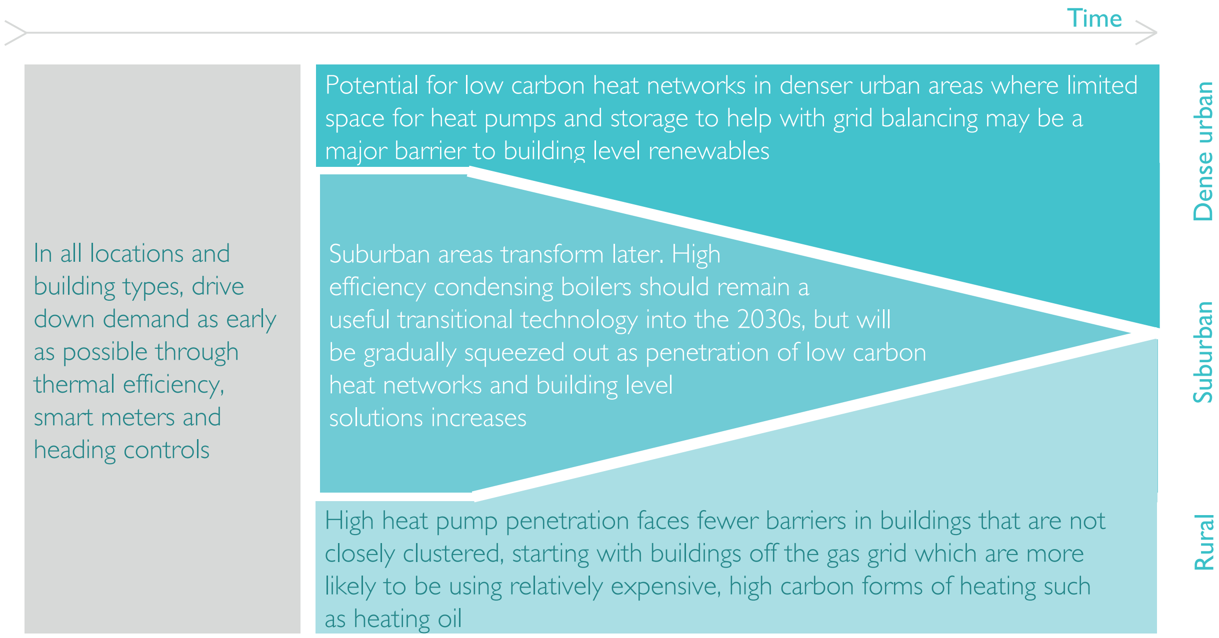
3.48 The Strategic Framework set out a high-level view of how this long-term transformation can be achieved. This involved early action to drive down heat demand in buildings, and three strands of activity on heat supply:

- expanding use of low carbon heat networks in our towns and cities;
- supporting the uptake of renewable heating systems in rural off-gas grid areas; and
- promoting a more efficient use of gas heating in the short to medium term, with gas use reduced to close to zero by 2050.

3.49 DECC subsequently commissioned further modelling to look at possible scenarios for the mix of technologies required to achieve our climate change objectives at least cost. Consumer willingness to change heating systems is not included in the modelling, but is considered in the following section on barriers and challenges. The latest modelling incorporates a number of changes since the Carbon Plan,

103 Fell D, King G, 2012, *Domestic energy use study: to understand why comparable households use different amounts of energy – A report to the Department for Energy and Climate Change*. Brook Lyndhurst. DECC, London

Figure 6: Original strategic framework for low carbon heat in buildings over time



Source: DECC

including greater detail in the profile of heat demand to reflect the peaks that occur within a day and between seasons, with updated assumptions on the cost and range of technologies available.

3.50 The results (see Evidence Annex) confirm the overall picture presented in the Strategic Framework, with large scale deployment of both air and ground source heat pumps, a greater role for heat networks by 2050 and gas playing a major role into the 2030s but diminishing thereafter.

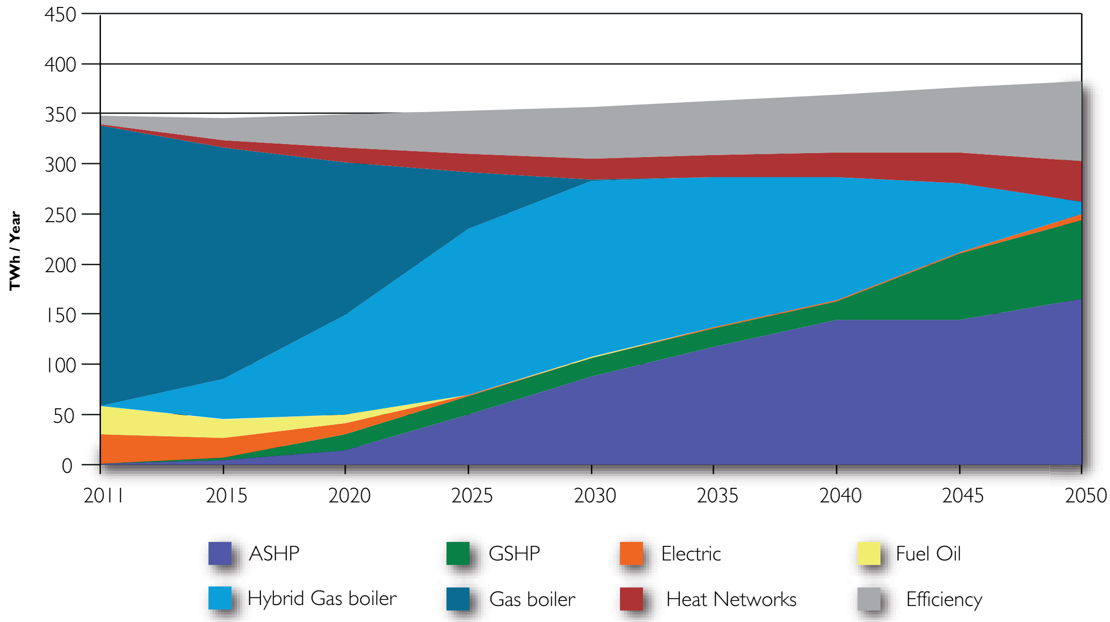
3.51 The main new element of these modelling results is the extent to which gas-based alternatives to standard gas boilers were offered as technology options to the model, and were then taken up. The RESOM model suggests that hybrid systems which combine an air source heat pump with a gas boiler might be a cost-effective option. The model shows these systems being taken up from the 2020s.

3.52 As further emissions reductions are needed to achieve the 2050 target, the model predicts the majority of heat will then be delivered by heat pumps, with gas only used to provide heating in winter. The results suggest that full decarbonisation of heat through electrification might be more costly, as this would require additional generation capacity and further reinforcement of the electricity grid. As both solutions involve redundancy somewhere within the system, a more cost-effective solution might be to develop much more sophisticated means of balancing and storing energy, though it is much harder to model this option (see chapter 4).

3.53 DECC has modelled the same scenarios with the ESME model. This shows a similar overall picture for the role of gas boilers, with the model predicting that there will be no role for gas boilers in 2050. The ESME results suggest that gas absorption heat pumps (GAHPs) may be taken up as a more efficient solution.

3.54 The modelling is highly sensitive to the assumptions made on the costs and performance of technologies, including technologies which are yet to reach commercial scale deployment such as hybrid systems and domestic GAHPs. However, the analysis does suggest that there is still no role for standalone gas boilers in 2050, with the least-cost path requiring us to begin to deploy more efficient

Chart 29: Domestic space heat and hot water output by technology[104]

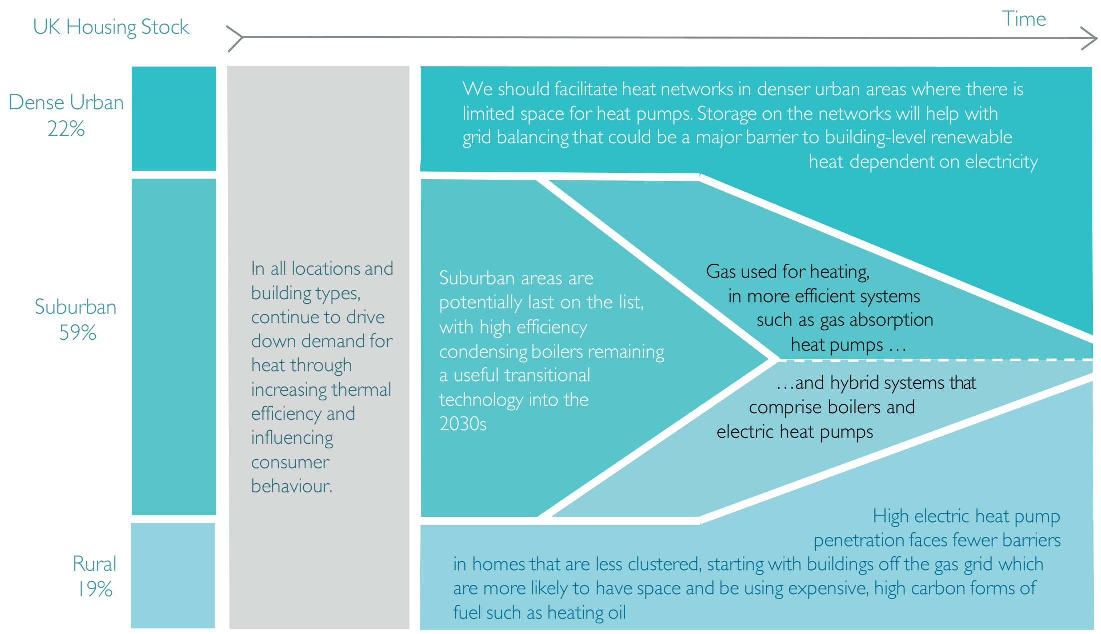


Source: RESOM core run

gas technologies in the 2020s. This change in the expected role for gas can be seen in the updated diagram below.

3.55 These results project only one possible pathway to cost-effective decarbonisation. Existing technologies, such as solar thermal and biomass, and others under development, can play a full role in delivering against long-term

Figure 7: Updated strategic framework for low carbon heat in buildings over time



Source: DECC

104 Note that the heat generated by ASHP and GSHP used as part of a hybrid systems is not identified separately in the chart

objectives. Across all the different heating strands, the Government wants to make progress without prescribing the use of specific technologies. Instead, information for market players, including households and businesses, should be improved to enable effective decision-making.

3.56 To that end, at the beginning of 2012, DECC began a heat pump metering programme under the Renewable Heat Premium Payments scheme to take a snapshot of performance. The preliminary data from this programme indicates that, on average, there has been a measurable but modest improvement in the Seasonal Performance Factor compared to the results from an initial field trial carried out by the Energy Savings Trust (EST) in 2008.[105] Final results are due in the summer of 2013.

3.57 A second year of the EST heat pump field trials is measuring the impact of modifications to the systems that previously reported poor performance. The final report is due to be published shortly. Other studies include laboratory tests to determine the effect of on/off cycles on heat pump performance, performance tests on heat pumps with buffer tanks and a comparison of underfloor heating and oversized radiators. All these studies are due to report later this year.

3.58 More details about research, modelling, assumptions, conclusions and sensitivities can be found in the Evidence Annex to this document.

Barriers and challenges

3.59 There are significant barriers and challenges to realising our 2050 goals, both in terms of driving down demand for energy in buildings and replacing heating systems with renewable and low carbon alternatives. It is also important for the Government to understand how the transition to a low carbon future will impact on consumers and, in particular, on low income and fuel poor households.

Barriers to driving down demand

Balancing standards with the need for affordable housing

3.60 The Government has an ambitious programme of decarbonisation in place driven by building regulations. Whilst work will continue towards delivering targets on zero carbon buildings, it is important that the construction industry remains competitive to act as a driver for economic growth. Any strengthening of standards for new buildings, including those for energy efficiency, needs to be assessed in value-for-money terms, by comparing the cost of compliance for developers against the savings to the householder over the lifetime of the house.

Undervaluing energy efficiency

3.61 The lack of saliency of energy efficiency is one of the key barriers to the wider take up of energy efficiency identified in the Energy Efficiency Strategy. Energy efficiency is often not prioritised due to hassle factors and behavioural barriers. For example, outside the energy intensive industry sectors, energy bills are only a small proportion of business costs. If the relative gain is small, then the additional effort or hassle required to act is a significant barrier, especially if there is uncertainty around the benefits of the investment.

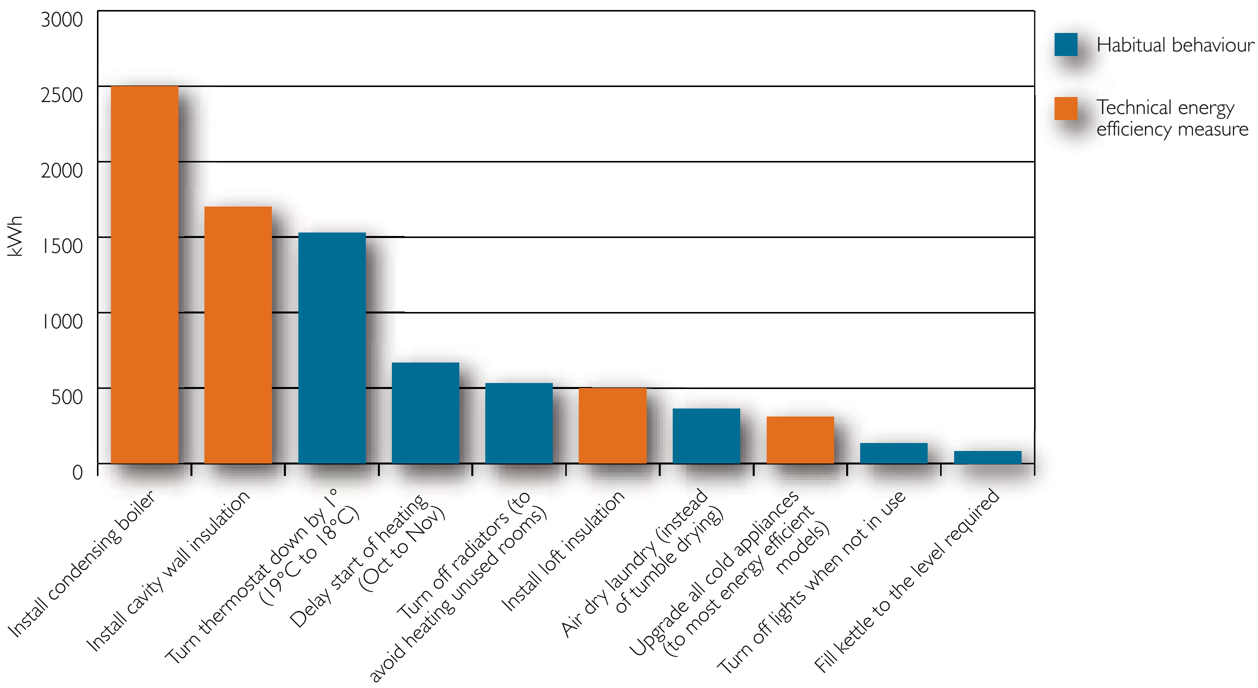
Consumer understanding of energy saving

3.62 While many people are concerned about how much energy they use in the home, evidence suggests that people may misunderstand what they could do to reduce their energy use.[106] The chart below compares estimates of how much energy specific measures can save. It is worth noting that certain actions, like installing insulation and

105 Energy Saving Trust, 2010, *Getting warmer: a field trial of heat pumps at* www.energysavingtrust.org.uk/Media/node_1422/Getting-warmer-a-field-trial-of-heat-pumps-PDF, accessed on 15th March 2013

106 DECC, 2012, *How much energy could be saved by making small changes to everyday household behaviours?*

Chart 30: Changing habits can save as much as some technical measures



Source: DECC

reducing heat use, save far more energy than certain measures to reduce electricity use.

A study in 2012 commissioned by DECC found that very few participants fully understood their heating systems; they controlled their heating systems in varied ways to make their homes feel comfortable. Participants were generally not aware of how much gas they used, in absolute or relative terms. Most estimated their use was 'about average'.[107]

Barriers to replacing heating systems

Lack of awareness and appropriate advice

3.63 Lack of awareness is a significant barrier for many technologies. Research found that over 80% of homeowners had heard of condensing gas boilers and solar thermal, just under a half had heard of ground source heat pumps and biomass boilers and less than a third had heard of air source heat pumps, heat networks, or micro-CHP.[108]

3.64 Related to awareness are the potential sources and availability of trusted advice on appropriate technologies or the availability of suitably qualified installers, another key barrier identified in the Energy Efficiency Strategy. Where information is available it may be generic, rather than tailored to the particular circumstances of the consumer. In the absence of reliable and trusted information, decisions may be taken without knowledge of the full range of appropriate options.

3.65 For example, community groups are known to face challenges at the feasibility stage of a project and therefore would benefit from independent advice to help make them the right decisions about their low carbon heat projects. Choosing the right technology, sourcing project funding and obtaining the necessary permits,

107 DECC, 2012, *Why do comparable homes use different amounts of energy?*
108 Ipsos MORI and the Energy Saving Trust, 2013, *Homeowners' willingness to take up more efficient heating systems*. London: DECC. DECC's Public Attitude Tracker found a similar ranking of awareness amongst households, including homeowners and tenants. See https://www.gov.uk/government/organisations/department-of-energy-climate-change/series/public-attitudes-tracking-survey

licenses and planning consents are areas where they might need support.

Cost of low carbon heat technologies and financing

3.66 Boiler technology is mature, and manufacturing costs benefits are achieved through mass production. Heating engineers are naturally familiar with the technology, meaning that a domestic boiler can be bought and installed in under a day. Low carbon heating technologies do not have these advantages, being relatively new to market. With greater complexity and longer installation time, such technologies tend to be far more expensive.

3.67 The high price of alternative heating systems is a clear barrier to uptake. While 47% of householders recently surveyed said they would pay for a new heating system through their savings, 14% said they could not and so would need to rely on alternative sources of finance.[109] The embryonic nature of the financing market was another overarching barrier identified in the Energy Efficiency Strategy. While there are examples of

Box 12: The Woolhope Woodheat cooperative, Herefordshire

The Woolhope Woodheat cooperative is a renewable energy scheme that aims to provide local people and organisations with biomass boilers and locally sourced woodchip. The consumer pays Woolhope Woodheat for the energy they use, and upfront costs are paid for by the cooperative through the sale of shares, which provide a return on investments through the sale of energy. The cooperative's first scheme will be at Canon Frome Court, a community of 19 flats in a large mansion building. Each flat is currently heated individually, with systems running on LPG, oil or coal.

Woolhope Woodheat is in the process of installing a 200 kW biomass boiler in a separate building on the site to provide heating to the whole community. Over the projected twenty year lifetime of the project, an estimated 1400 tonnes of local wood will be used, saving over 900 tonnes of CO_2. David Straker, a member of the Woolhope Woodheat board, said "…we hope that we can pave the way for other schemes like this across country and inspire other communities to want to make a difference."

109 Ipsos MORI and the Energy Saving Trust, 2013, *Homeowners' willingness to take up more efficient heating systems.* London: DECC

companies focusing on this area, there is the potential for more innovative mechanisms to develop.

3.68 The higher costs associated with low carbon heat technologies may be felt most acutely by lower-income and fuel poor households who tend to spend a greater proportion of their income on energy. The move to a low carbon future offers both opportunities and risks for these households. Renewable technologies may offer lower-cost heating solutions to some consumers – especially for some that are not connected to the gas grid. However, there is a risk that some households could find themselves 'locked-in' to more expensive heating technologies during the transition period.

Lack of appeal or confidence in low carbon heat technologies

3.69 Research indicated[110] that technology type was the most important driver of customer choice for new heating systems, ahead of upfront and ongoing costs or the availability of financial incentives. Even where high levels of incentive are offered for low carbon alternatives, homeowners retain a strong preference for gas heating. Consumers also voiced concerns on performance, aesthetics, and disruption during installation. These result in significant 'barrier costs'. Homeowners might need to be compensated for such costs to address their concerns about the new technology. Options such as longer warranties may help to address this.[111]

Changes to other elements of the heating system

3.70 Heat emitters, for example either radiators or underfloor heating, operating at a lower temperature would allow for an increase in the performance of most heating technologies. Research found that the disruption caused by changing radiators or pipe work is not a key issue affecting a homeowner's choice for heat pumps. However, only 43% said they would be willing to replace their radiators before their heating system.[112]

3.71 In addition, willingness to install a hot water tank could be a further barrier to the uptake of technologies that utilise a heat store to operate efficiently, for example heat pumps or solar thermal. The advent of combi boilers has meant that many householders have removed their hot water tanks and found other uses for the space. In new build, it may be the case that a hot water tank was never installed at all. Of those homeowners without a hot water tank, similar numbers said it would be difficult to find space, as those who said it would be quite easy to find space to install one.[113]

Limited opportunities for replacing heating systems

3.72 Another significant barrier is the limited number of occasions on which an individual heating system will be replaced before 2050. For instance, a domestic condensing boiler installed today might only be due for replacement in 2025, whilst a non-domestic gas boiler might last for 25 years or more.

3.73 Research found that the majority of homeowners would only consider replacing their heating system if it needed significant repairs or servicing.

110 Ipsos MORI and the Energy Saving Trust, 2013, *Homeowners' willingness to take up more efficient heating systems.* London: DECC
111 Delta-ee, 2012, Microgen Insight Service
112 Ipsos MORI and the Energy Saving Trust, 2013, *Homeowners' willingness to take up more efficient heating systems.* London: DECC
113 Delta-ee, 2012, Microgen Insight Service

Lack of capacity and capability in the supply chain

3.74 The ESME and RESOM analysis show that a wide range of technologies will be needed to meet the various 2050 scenarios. In order to meet demand, the current installer base needs to be ready to meet the extra demand for specialist skills.

3.75 The range of training courses available to installers is large with varying degrees of quality. Anecdotal evidence suggests that new companies wishing to install low carbon heating systems cannot easily identify the most suitable training courses for their business. It is therefore important for ensuring the performance and reliability of heating systems, along with raising consumer awareness and trust, to raise the competence of installers.

Infrastructure issues

3.76 As we move towards a greater electrification of heating supply, this will naturally cause a greater strain on the UK's capability not only to generate the extra electricity required, but also to establish the network to deliver it to homes. Localised generation can help offset this, particularly non-intermittent generation such as that from micro-CHP, which is likely to be available during peak heat demand. However there will still be a need for investment in the grid infrastructure, with storage playing a key role (see chapter 4).

Cross-cutting barriers

Split incentives – the landlord-tenant divide

3.77 Misaligned financial incentives were another overarching barrier identified in the Energy Efficiency Strategy. For some landlords and tenants, there may be a lack of incentive to

Box 13: Meadow Well Connected programme: 'Terra Nostra', North Tyneside

'Meadow Well Connected' was established as a community centre in 1994, in the heart of the Meadow Hill estate in North Tyneside. The community centre supports people dealing with issues ranging from drug and alcohol problems to debt and fuel poverty issues. As part of the programme to develop education and skills in the area, the centre has fully qualified staff to offer sustainable and renewable energy training up to BPEC level 1.

The 'Terra Nostra' (Our Earth) project at the centre uses heat from a ground source heat pump and solar thermal heating, with the electricity needed to drive the pump partly supplied by solar photovoltaic panels. The total cost of installing these measures was £106,000. Despite a 25% increase in electricity prices, projected savings of £7000 in their energy bill this year could mean that the whole system will have paid for itself within 15 years.

invest in such measures, as the other party receives the financial benefit. For a landlord, there is no clear incentive to invest in a heating system upgrade or more complex building management control systems if the tenant pays the energy bill and therefore receives the benefit. This is a particular issue in the non-domestic sector, where it is estimated that 90% of offices have a landlord-tenant relationship in place.

Lack of reliable evidence

3.78 A barrier to reducing carbon emissions from heating in the non-domestic sector is the lack of evidence to underpin policy analysis. Existing sources such as the Non-Domestic Buildings Energy and Emissions Model (N-DEEM) are out of date, and do not distinguish energy used for cooling from other electricity use within the building. In order to target policies such as Green Deal and RHI better, a firmer evidence base will help Government to understand the complex use of energy in the non-domestic sector.

Lack of certainty on standards for households and businesses

3.79 A further issue is whether existing methodologies for calculating energy performance give enough clarity to consumers and business on the energy efficiency benefits that heat technologies can deliver. There is, however, a need to balance the complexity of any calculation methodologies with the ease of use. Getting the balance right is important, to ensure that consumers are properly informed about the most appropriate measures and the in-use performance of systems in a particular building.

Policies in place now

3.80 There are policies, both existing and under development, that are already acting to mitigate a number of the barriers identified. These include policies to help households and businesses to drive down demand for energy used to heat buildings and to decarbonise the heating supply. In terms of the consumer barriers, there are important policies to support better advice provision and to provide consumer protection.

Table 8: Policies to drive down demand and improve efficiency

Policy	Impact on buildings
Climate Change Levy (CCL)	CCL on gas is currently levied at 0.177 p/kWh, although that is rising to 0.182 p/kWh from 1st April 2013, encouraging sites to switch to lower carbon forms of heating.
CRC Energy Efficiency Scheme (CRC)	The CRC was introduced in 2010 to encourage energy efficiency in large, non-energy intensive organisations, such as central government departments, retailers, banks, water companies and local authorities. Participation is mandatory for all organisations that consume more than 6000 MWh in electricity per qualifying year. Analysis by the Carbon Trust found significant potential for cost-effective emissions reductions in non-domestic buildings through energy efficiency. However, energy efficiency measures were hampered by at least four barriers – insufficient financial incentives, the landlord/tenant divide, uncertain reputational benefits and organisational inertia. The CRC has been designed specifically to address these barriers.
Energy Companies Obligation (ECO) and Fuel Poverty	ECO provides insulation and heating measures to low-income and vulnerable households. It is estimated to deliver 700–800,000 new condensing boilers to vulnerable households by 2020. DECC will examine the implications of low carbon heating for fuel poor households to inform a new fuel poverty strategy which will be published later this year.

Policy	Impact on buildings
Energy Saving Advice Service	Telephone-based service offered by the Energy Saving Trust (EST) on behalf of DECC offering impartial energy saving advice to homes and businesses in England and Wales, with Energy Saving Scotland advice centres run by the EST in Scotland. The Service will be supporting the Green Deal and ECO as those schemes develop.
Green Deal and Green Deal cashback	The Green Deal is the Government's flagship programme to help improve the energy efficiency of British homes and businesses. Green Deal allows households and businesses to make energy efficiency improvements with some or all of the cost paid for from the savings on their energy bills. Energy-saving improvements for heating include insulation (for example, loft, cavity or solid wall insulation), draught-proofing, double glazing and heat technologies such as condensing boilers and micro-CHP. For a limited period, cashback from Government will be available to householders making energy saving improvements like insulation, double glazing and secondary glazing and boilers. The scheme is available in England and Wales.

Table 9: Policies to support uptake of low carbon heating systems

Policy	Impact on buildings
Energy Labelling Directive (ELD)	The ELD introduced a labelling system for energy using products based on their efficiency. In February 2013 the Commission published its regulations for the mandatory labelling of heating and hot water systems. The regulations set the thermal efficiency levels that must be met in order for a product to be granted a rating from G (lowest) to A+++ (highest, depending on the technology). The labelling scheme will give consumers information on the best performing products so they can make more informed choices about their heating systems. Suppliers and dealers must comply with the labelling requirements by February 2015.
Energy-Related Products Directive (ERPD)	The ERPD will set minimum performance requirements for heating and hot water products, helping to remove less efficient products from the market place. The EU Regulations are due to come into force in late 2013, with the minimum performance standards taking effect in 2015 and 2017.
Enhanced Capital Allowance (ECA)	There are a large number of energy efficient heating technologies on the Energy Technology List (ETL) that qualify for an ECA, including boiler equipment (for example, biomass boilers, gas condensing water heaters), gas CHP, a range of heat pumps and HVAC equipment and controls which could be installed in a commercial property.
Feed-in Tariffs (FITs)	Although primarily a mechanism to support renewable electricity from microgeneration, FITs are also used to support domestic micro-CHP (under 2 kWe) installations that are certified under the Microgeneration Certification Scheme. Micro-CHP units are eligible for a generation tariff of 12.5 p/kWh of electricity, with a further 4.5p/kWh export tariff for selling unwanted electricity back to their supplier (3.2p/kWh if the application was made before December 2012).
Rural Communities Renewable Energy Fund	A £15m renewable energy fund for rural communities, to be launched by June 2013, will offer funding to community groups in rural areas (England) for feasibility studies and planning applications for renewable energy projects. A range of heat technologies, including biomass, anaerobic digestion, ground and air source heat pumps will be eligible. A key objective of the fund is that local heat technologies deliver benefits for local communities.[114]

114 http://www.defra.gov.uk/rural/economy/services-transport/renewable-energy, accessed on 20 March 2013

Policy	Impact on buildings
Renewable Heat Incentive (RHI)	The non-domestic RHI was launched in November 2011 to provide tariff-based financial support for renewable heating in commercial, public, not-for-profit and community buildings over a 20 year period. The domestic RHI proposals are being designed to support householders in moving away from using fossil fuels and therefore contribute to the UK's target on renewable energy deployment by 2020. The scheme will also help prepare the UK for the mass deployment of renewable technologies in the next decade to help meet the Government's ambitious carbon reduction targets.
Renewable Heat Premium Payments (RHPP)	RHPP is currently a £40m two-phased scheme to incentivise the take up of renewable heat technologies ahead of the domestic RHI. A crucial output of the scheme is learning from metered data, as well as customer research. Interim findings from the analysis of customer data from RHPP1 are included in the Evidence Annex.

Table 10: Policies to address cross cutting issues

Policy	Impact on buildings
Building Regulations	Building regulations implement the Energy Performance of Buildings Directive. They ensure that buildings are constructed to a high standard. The long-term aim is to decarbonise new buildings in England via the Government's policy for zero carbon new homes and buildings, with energy efficiency standards forming a key part of the approach to carbon savings. The Government consulted last year on an uplift in the standards in building regulations in 2013 and will announce its response to that consultation in May 2013. In Wales, building on the significant improvements proposed for 2014-2015, a further review of standards is proposed for 2016.
Energy Performance of Buildings Directive (EPBD)	A recast of the EPBD took effect on 9 January 2013. The new Directive aims to drive the reduction of energy use by requiring all buildings developed after 2020 to be nearly zero energy, or after 2018 where the building will be owned and occupied by a public authority. The key measures required from the EPBD in 2007 were: • the provision of advice to consumers when boilers are checked or serviced; • Display Energy Certificates (DECs) for larger public sector buildings to show actual energy use; and • Energy Performance Certificates (EPCs) that display the energy efficiency ratings of all buildings. They are also used to underpin the Green Deal, ECO and Feed-in Tariffs.
Microgeneration Certification Scheme (MCS)	MCS certifies small scale renewable energy generating technologies. It is primarily aimed at consumer protection and acts to drive industry standards. MCS certifies heating installation companies and products with a thermal capacity of up to 45 kW and electricity capacity up to 50 kW. MCS certification is currently required by a number of government policies, including the Feed-in Tariffs up to 50 kW, Green Deal and RHPP.

Policy	Impact on buildings
Current Research	Technology Innovation Needs Assessments (TINAs) (see also chapter 4) are a collaborative effort of the Low Carbon Innovation Co-ordination Group (LCICG), the co-ordination vehicle for the UK's major public sector backed funding, and delivery bodies in the area of 'low carbon innovation'. The TINA on heat published in 2012 focuses on heat pumps, heat networks and heat storage as three key heat technologies that could play a key role in a low carbon future. Innovation in these technologies could reduce UK energy system costs by £14-66bn to 2050 (heat storage could offer additional value). Innovation can also help create a UK industry with the potential to contribute further economic value of £2-12bn to 2050. DECC are also working in partnership with industry to deliver a programme of research and development, led by the Energy Technology Institute. The £100m Smart Systems and Heat programme was launched in April 2012. The aim is to design and demonstrate the first wide-scale smart energy system of its kind in the UK. It begins with a two-year, £3m social research project to better understand how people use heat energy in their homes.
The Standard Assessment Procedure (SAP)	SAP and the Simplified Building Energy Model (SBEM) are methodologies for assessing the likely energy demand of homes and non-domestic buildings. They are used to assess compliance of a new home or building with the requirements of building regulations, respectively. As part of this, they set out methodologies for calculating the energy efficiency of products and materials and consider the carbon intensity of their use. A variant of the SAP methodology (RdSAP) is used to produce EPCs for existing homes.
Smart Meters	The Government's vision is for every home and smaller business in Great Britain to have smart electricity and gas meters. Smart meters give suppliers access to accurate data for billing, removing the need to manually read meters. Domestic customers will be offered an In-Home Display (IHD) enabling them to see what energy they are using and how much it is costing to put them in control and avoid wasting energy and money. Mass roll-out is expected to start in 2014 and smart meters will be rolled out as standard across the country by the end of 2019.

Box 14: How Hill holiday cottages, North Yorkshire – Heat Pump Installation

In late 2007, the Fountain Abbey Trust converted the dilapidated farm buildings at How Hill, North Yorkshire, into holiday cottages to provide income for the maintenance of the estate. A Low Carbon Buildings Programme grant of £27,000 provided half the capital cost towards the installation of two 14 kW ground source heat pumps. In comparison to the oil boilers typically found in rural properties, the system is expected to save around 153 tonnes of CO_2 over its lifetime.

A 200 litre buffer tank helps to reduce the heat pump cycle and boost efficiency. The heat is delivered to under-floor heating systems in the cottages via a well-insulated heating main. The upstairs rooms of each cottage are also fitted with low temperature radiator systems. The occupants have an option to alter the temperature by 2°C either way, providing a small element of control.

Next steps

Driving down demand

The Green Deal

3.81 In support of the Green Deal, DECC is also funding the development of an 'Open Homes' network, where people who have made energy saving improvements to their home allow others to visit to learn about the benefits. Visiting real-life examples can help to address some of the barriers preventing the take up of low carbon heat, such as lack of awareness, uncertainty about the best source of advice, and concerns about the performance of new technologies. The network will include the formation of a national digital 'hub' that will promote access to existing and emerging open homes projects. The network will seek to build on the success of existing schemes including SuperHomes, Bristol Green Doors and Brighton Eco Open Houses.

Advanced Heating Controls

3.82 As part of taking forward the Energy Efficiency Strategy, DECC has started work on a programme to assess the potential of advanced heating controls to reduce domestic energy demand. The initial stage will include a review of existing evidence and research into consumer preferences in order to inform the design of a potential trial to evaluate actual energy savings from such controls.

Replacing heating systems

Renewable Heat Incentive

3.83 In November 2011, the Government launched the world's first renewable heat incentive, paying tariffs to non-domestic heating systems that use renewable sources of heating such as biomass boilers, heat pumps, deep geothermal and solar thermal. The scheme has so far had more than 1800 applications for installations producing around 130 GWh of renewable heat. However, some technologies have seen lower take up than expected, and DECC now has improvements to some of the input assumptions that were used in calculating the original tariffs, which is why the Government announced an early review of tariff levels in February of this year. There will be a consultation on these new tariff levels in the spring. The Government does not expect to reduce tariffs through this exercise; the expectation is that some tariff levels will go up as a result. It has previously been announced that it is DECC's intention that any installations accredited after the date that a review was first suggested – 21 January 2013 – should benefit from uplifts to the tariff they receive from the date they are implemented.

3.84 In the February 2013 RHI policy document, the Government committed to a transparent and inclusive review of the RHI to provide certainty for investment. The next scheduled review for the non-domestic RHI scheme is due to start in 2014. Pending the outcome of an early review of existing tariffs this spring, discussions will then take place with stakeholders on the timing, scope and process for the 2014 review before the summer. These will identify and resolve key evidence gaps to enable a successful review process. In particular, DECC intends to use these review processes to examine the case for other renewable heat solutions and technologies such as sustainable heat-only bioliquids and active air solar heating.

3.85 The Government has also consulted on Renewable Heat Incentive tariffs for domestic buildings, with a commitment that this will support all eligible installations since July 2009. The Government expects to publish details of tariff levels and eligibility this summer.

Competencies and training

3.86 Whilst the RHI will increase demand for renewable heating systems, the current qualified installer base is relatively small. The Microgeneration Government Industry Contact Group (MGICG) has been taking forward work on the 2011 *Microgeneration Strategy*,[115] which includes a work stream on skills, led by Summit Skills and MCS. The Government has worked with MGICG and the wider industry to design measures to boost the training of installers and to put in place the structure to assess experienced workers.

- **Voucher scheme for installer training**
  DECC will launch a voucher scheme to support installer training. The scheme will provide financial support towards training courses that are accredited or mapped against the relevant national competence criteria. DECC will also hold a series of installer workshops to help promote the scheme.

115 See https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48114/2015-microgeneration-strategy.pdf, accessed on 28 March 2013

Box 15: Castle Drogo, Devon

Castle Drogo and its 600 acre estate, situated on the northern edge of Dartmoor national park, welcomes around 150,000 visitors a year. The Castle used oil-based heating for over 20 years, with annual running costs of up to £40,000, and annual emissions of 180 tonnes of CO_2. A National Trust initiative to improve the carbon footprint and sustainability of its properties led to the installation of a 400kW biomass boiler supplying all of the heat and hot water for the castle and its visitor centre. The biomass boiler was particularly suitable as it was easily integrated into the existing heating system, reducing retrofitting costs.

The boiler consumes around 400 tonnes of woodchip per year which is sourced from the Castle estate. The new system has reduced the CO_2 emissions from the Castle's heating by over 80%. The £500,000 project was initially assisted by a £150,000 grant from the Big Lottery Fund. Taking into account the cost of replacing the oil boilers, it is estimated that the project will break even in 10 years.

- **Piloting a green apprenticeship scheme –** The Department for Business, Innovation and Skills is carrying out work with industry to develop the Government's programme of apprenticeships. DECC will build on this to develop a pilot scheme to support at least 100 apprentices in the microgeneration sector.
- **Building Services Engineering Competency Advisory Group (BSECAG)** The national competency framework for environmental technologies has a key role in supporting MCS and other schemes but it will need ongoing development. DECC and DCLG will re-establish the BSECAG to oversee this development, working with industry and the training and development community.

Box 16: 4Life Academy, Birmingham

The new Willmott Dixon 4Life Academy opened its doors in Birmingham recently. This academy will be a centre of excellence to help apprentices of the future gain qualifications via BPEC and City & Guilds in renewable energy.

3.87 DECC will work with MCS, Summit Skills and training bodies to consider developing a database to allow installers to analyse their training needs and identify suitable courses that meet the National Occupational Standards. DECC will also consider the possibilities for reskilling experienced installers who are retiring, as assessors, therefore retaining their expertise within industry.

3.88 It is also vital that standards are raised in order to increase consumer confidence. DECC will therefore work with industry to introduce other measures to ensure consumers have access to better advice and to improve installation standards.

- **Consumer guide on heat technologies**
  The MGICG is producing an information and advice guide for consumers, installers and intermediaries such as local authorities. DECC will work with the MGICG to publish and promote that guide in an electronic form.

- **Improving standards and compliance**
  The *Microgeneration Strategy* included a commitment to establish MCS as a not-for-profit company in order to streamline governance and provide better cover for liabilities. A new licence and contract has been put in place for the next three years with Gemserv Ltd.

- MCS will be increasing the number of inspections to further strengthen the compliance regime and provide greater confidence to consumers. In addition, MCS is considering how it can bring forward an insurance-backed warranty scheme.

Options for the long-term transformation of the heat market

3.89 The Government's aim is to drive the move to low carbon heating in the most cost-effective way, providing the best deal for consumers and supporting the growth of a vibrant UK industry in low carbon heating goods and services. The Government is using a mix of financial incentives, statutory standards and non-traditional/alternative approaches to change behaviour. However, the size of the challenge means further reviews of potential interventions will be required over coming decades.

3.90 The Government's approach will always be to identify barriers in the market before seeking the most cost-effective means of intervention. There are four general types of intervention that can be used.

3.91 **Financial incentives,** such as the RHI, can help to build supply chains for new technologies that are more costly than their fossil-fuel equivalents, but are necessary for meeting our climate change objectives and legal targets. However, the long term goal is for such measures to lead to economies of scale and product innovation to reduce costs and the need for subsidy.

3.92 **Statutory product and performance standards**, such as building regulations, can quickly turn niche markets into mass markets, as in the case of condensing boilers. By signalling new regulatory requirements well in advance and giving market certainty, the Government can stimulate investment in products at a lower risk premium. Where the policy challenge is to drive the installation of more expensive technologies, this approach could impose costs on consumers and businesses. Moreover, given the universal application of standards, they are a blunt policy instrument and associated costs can have impacts across the board, including on vulnerable households.

3.93 **Alternative approaches to influencing behaviour** (based on behavioural economics and psychological research) can encourage behavioural changes that lead to savings for consumers. As these do not necessarily involve subsidy or mandatory standards they do not impose the same level of costs. They are often used as a complementary measure, lowering the costs of incentives or making new standards more acceptable to consumers. However, there is less certainty about the pace at which such measures can drive change.

3.94 **Economic and fiscal instruments** to internalise the damage cost of carbon. The EU ETS does this in respect of electricity generation and heavy industry.

3.95 Certain stakeholders are putting forward the case that it will be very difficult, and potentially very costly, to rely on public subsidy to drive the transformation in heating. Their conclusion is that the existing regime of standards for boilers and building energy performance should be strengthened. This would create a progressive heating performance standard requiring the introduction of more efficient, and eventually lower carbon, heating systems – triggered, as now, when existing systems need to be replaced. Two separate Private Members' Bills were recently introduced into Parliament to this effect.

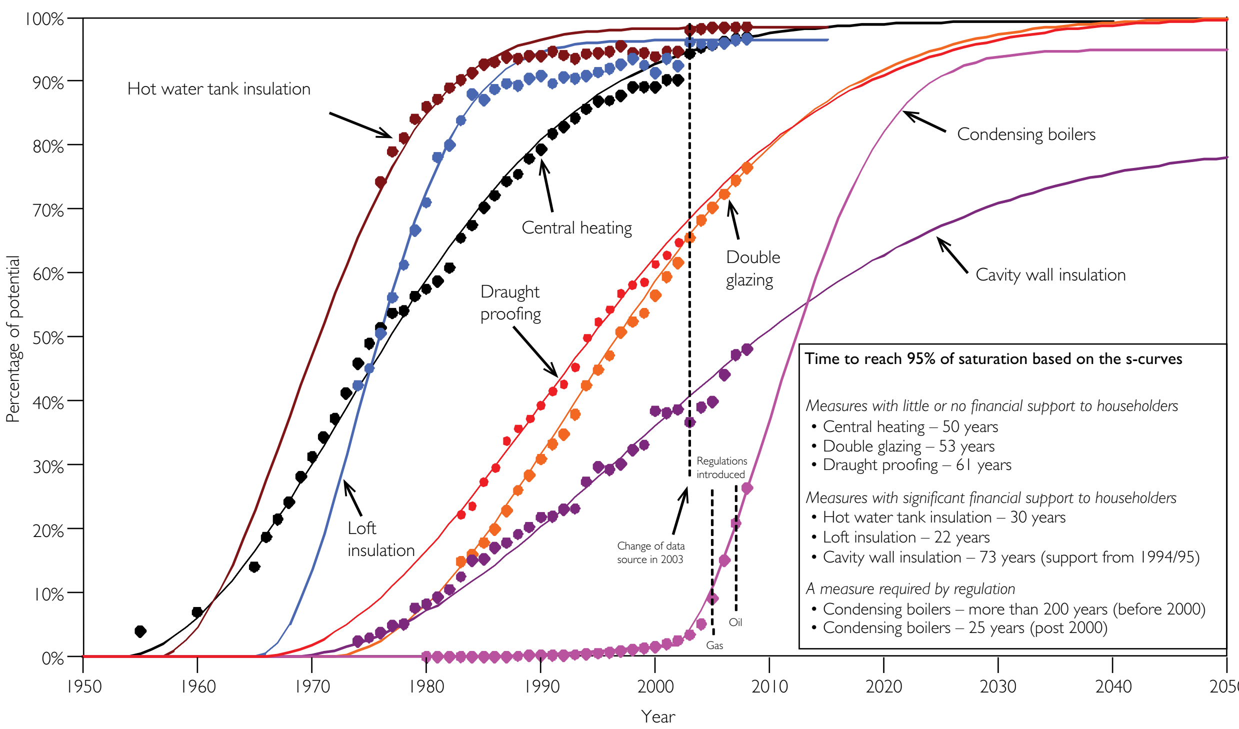
3.96 The introduction of such a standard would impose a cost but if signalled many years in advance, suppliers and consumers would have time to prepare. This would provide more confidence to the market and hence bring down costs over the long term, whilst being more acceptable to consumers. Such a standard could be designed so as to be technology neutral, allowing consumers to choose the most appropriate solution.

3.97 The Government is satisfied that current policies, such as the Green Deal and RHI, will achieve desired results in the short term. This includes work to determine how best to engage consumers through the provision of tailored advice and raise awareness of these technologies, informed by the consumer research reported in the Evidence Annex. However, the Government recognises the need to keep a number of options open and is keen to engage with a wide range of stakeholders on these important questions.

3.98 An important consideration will be the pace of change that can be achieved, given that this could involve quite fundamental changes to the fabric of buildings and heating systems across the UK. The diagram below shows the time periods required to achieve analogous technological changes in our homes, and suggests that it is unlikely that any single form of intervention will deliver progress at the required pace. This means that a mix of actions will be required, which may include tightening standards over coming decades. It is clear that more work needs to be done in this area, not only on the potential costs and benefits, but also on legal aspects, such as EU rules on building performance, product standards and labelling.

3.99 To support further work on all future options for housing, DECC is currently developing a National Household Model to enable analysis of the potential impacts of various regulatory options, as well as the full range of other possible policy interventions. DECC is also continuing its work looking at consumer behaviour and is particularly interested in the scope for labelling to deliver similar impacts to regulation at lower cost.

Chart 33: Market penetration data and s-curves for home energy efficiency related measures (in the United Kingdom)



Source: Les Shorrock, 2011, *Time for Change*, Proceedings of the European Council for an Energy Efficient Economy (ECEEE) 2011 Summer Study, Belambra Presqu'île de Giens, France, 6–11 June 2011. Stockholm, ECEEE, 2011, pp 1043–1048

Cross-cutting measures

Developing calculation methodologies – SAP and SBEM

3.100 The role of SAP and RdSAP is expanding as more policies require a detailed calculation of energy efficiency interventions. It is therefore likely that the Government will continue to develop the National Calculation Methodology, as this provides an established model against which many technologies and products have already been tested. This minimises costs on manufacturers for additional testing to meet the requirements of new policies. DECC will therefore seek to make it easier to introduce new heating and cooling products and technologies in the National Calculation Models.

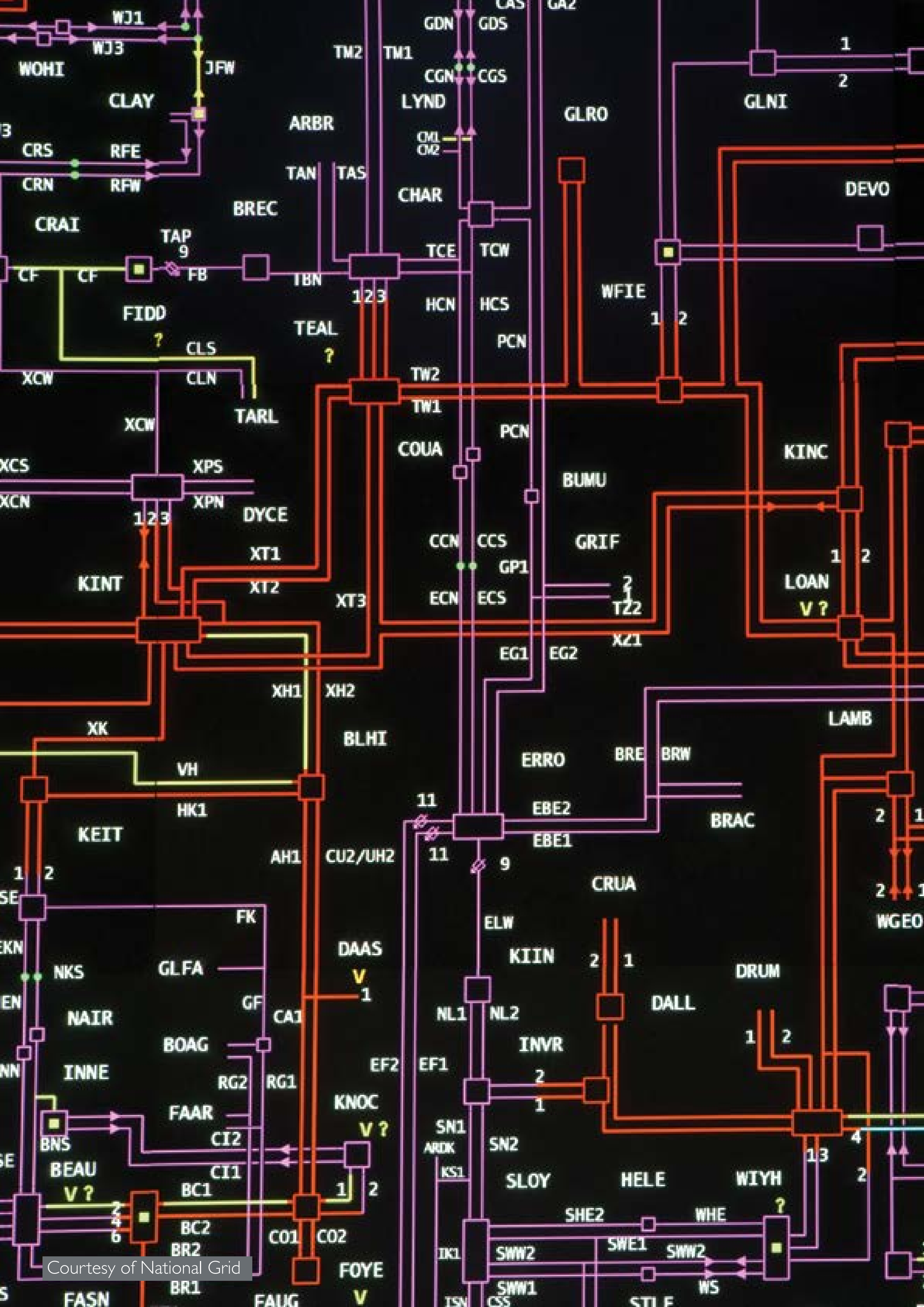
3.101 The Government will also review the operation of both SAP and SBEM to see if they may be better delivered through a different delivery structure. This could include taking powers to allow the Government to charge for the provision of statutory services relating to the provision of National Calculation Methodologies, to make the service as close to self-financing as possible.

Improving the evidence base

3.102 DECC will undertake a full review of the Non-Domestic Buildings Energy and Emissions Model (N-DEEM). This will update the understanding of energy-using equipment in non-domestic buildings and the options available to reduce energy use, including behavioural and organisational considerations. DECC also plans to use its National Energy Efficiency Data framework (NEED)[116] to provide information about the building stock and how it relates to energy use.

3.103 The Government is also planning to conduct a trial to assess the impact of providing advice to householders on heating controls when boiler checks are carried out. This responds to the evidence that many people do not understand how to use their heating controls effectively. This may also have significant policy implications if this advice is shown to have an impact on energy use.

116 A set of linked databases currently covering England and Wales' buildings' characteristics, their energy use, and information on the organisations occupying those premises



Courtesy of National Grid

Chapter 4: Grids and Infrastructure

Guide to using this chapter

In **What is the situation now?**, the chapter sets out the scale, market arrangements, costs, investment and regulation of the gas and electricity networks, that supply the UK's heat.

In **What might we need for our low carbon future?**, the chapter focuses on the challenge of meeting the huge variation in demand for heat both during the day and across the year. This section draws heavily on the modelling commissioned for this document to consider how the 'peak demand' for heat might be met.

With a reduction in the role of gas for heating by 2050, the chapter considers some long-term options for the gas grid, including the injection of biomethane and the potential of hydrogen – as a gas for direct heating use, but also in the wider energy system. The investment in the electricity grid to meet the greater electrification of heat in the future is also covered. There is also a section that considers the role that heat storage could play in helping to balance supply with demand.

The challenges to infrastructure change are summarised and there is a table capturing actions and policies on gas, electricity, biomethane, and hydrogen.

A range of case studies highlight the research and innovation projects that are seeking to gain a better understanding of the potential of new heating technologies and their impact and interaction within the energy system.

The **Next steps** cover proposals on gaining a better understanding of the strategic interaction between lower carbon electricity and heat; on taking forward further research on the potential of hydrogen; demonstration projects on advanced heat storage; and engaging with the industry to address the strategic challenges facing the gas network.

Introduction

4.1 Following a pathway to low carbon heat will, over time, mean significant change for the UK's energy infrastructure. It will have impacts on the existing gas and electricity networks; see the emergence of new infrastructure like heat networks and heat storage, and potentially also new infrastructure to support the use of hydrogen and to take carbon dioxide away. The most recent economic modelling on the future scenarios for heat supply, consistent with the UK's emissions reduction goals, suggests a much more diversified range of heat technologies in the future – with roles for electric heating, and gas and hybrid heat pumps and heat networks (with a range of heat sources) for buildings, and fuel switching and innovation in new technologies for industrial heat, including Carbon Capture and Storage (CCS).

4.2 Decisions on the different elements of the UK's energy infrastructure cannot be taken in isolation. There will be a number of economic and technical trade-offs and constraints that will impact on the respective scale and pace of infrastructure development, both for 2050 and for solutions in the interim.

Next steps

- DECC will take forward work to examine the strategic interaction between lower carbon electricity generation and heat production.
- DECC will this year be commissioning further research to investigate the role hydrogen might play across the UK's energy system.
- DECC plans to announce the successful Phase 2 demonstration projects for its Advanced Heat Storage competition.
- This year DECC will be exploring with the industry how best to address the strategic questions facing the gas network.

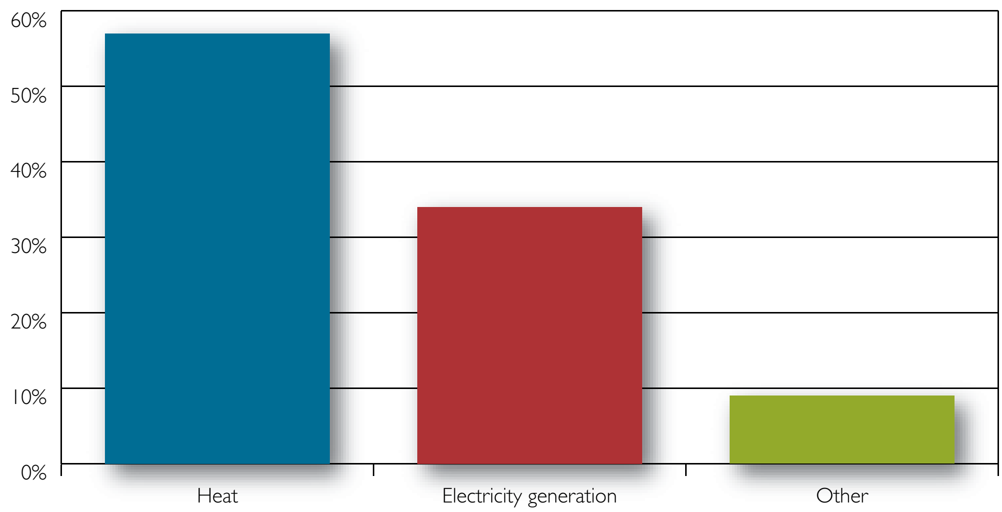
What is the situation now?

4.3 This section provides an overview of the existing energy infrastructure that ultimately supplies the UK's heat. It attempts to bring out the complexity and scale of the challenge of moving to a more diversified supply of heat in the decades ahead.

Heat supply: gas

4.4 Around 70%[117] of all the heat used in the UK – in homes, in commercial buildings and in industrial processes – comes from natural gas.[118] Of the total 906 TWh units of gas used in the UK in 2011, 52% was used to provide heating in buildings and industrial processes, and 34% was used to generate electricity.[119] The remainder was used in activities such as a feedstock in industrial processes.

Chart 32: Total UK Gas Use (2011)



Source: DECC

117 DECC, 2011, *Energy Consumption in the UK*: overall gas use for heat is 68.3%
118 Natural gas is a mixture of several hydrocarbon gases, including methane (between 70% and 90%), ethane, propane, butane and pentane, as well as carbon dioxide, nitrogen and hydrogen sulphide. The composition of natural gas can vary widely, depending on the gas field
119 DECC, 2011, *Energy Consumption in the UK* https://www.gov.uk/government/publications/energy-consumption-in-the-uk, accessed on 15 March 2013

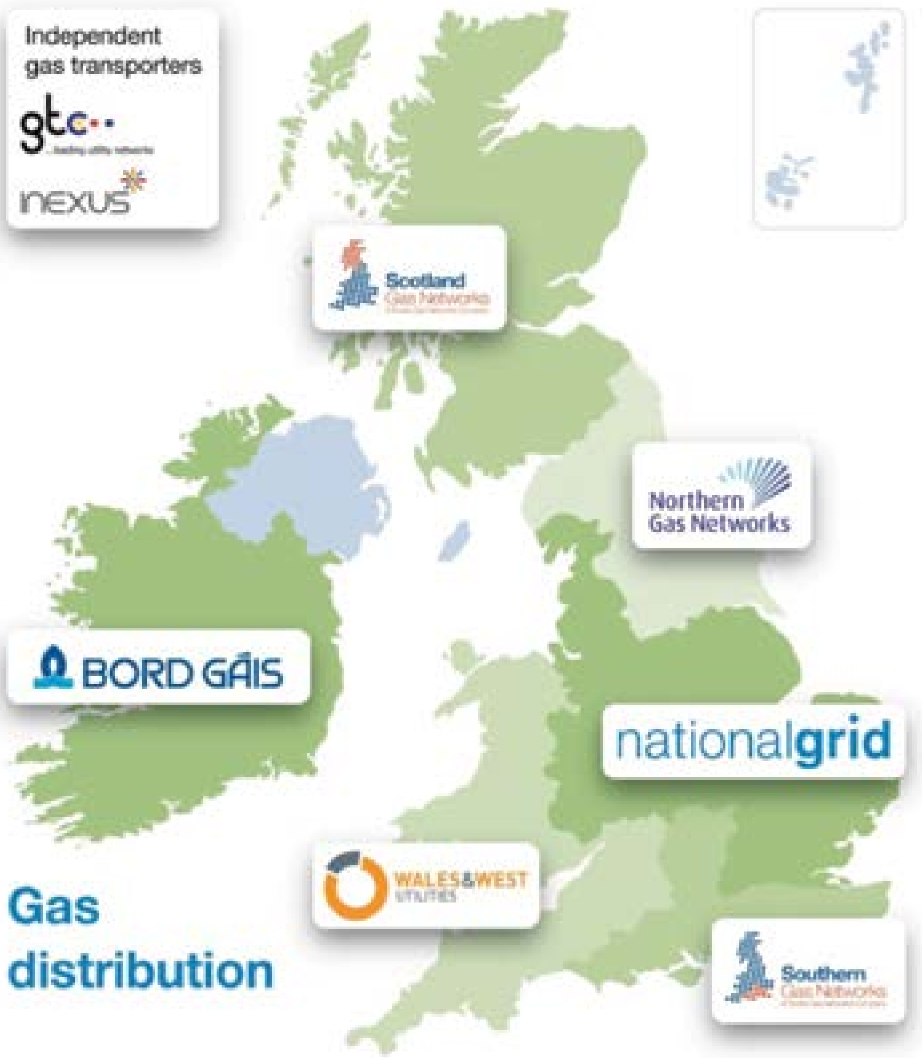
4.5 Gas enters the high pressure National Transmission System (NTS) from nine terminals from where it is transported to power stations for electricity generation, large industrial users, and storage facilities. The NTS is also connected to the eight, regional, low pressure Gas Distribution Networks (GDNs), which transport gas to homes, buildings, and small industry for use as heat.

4.6 Pipelines have delivered gas directly to our homes and buildings since the mid-nineteenth century and the UK has one of the most extensive and dynamic gas systems in Europe.

4.7 Today around 23 million homes (around 80% of all homes) and 80% of UK industry are connected to the UK gas distribution networks.

4.8 The eight GDNs in Great Britain set out in Figure 8 are owned by four companies. There are also eleven Independent Gas Transporters who mostly supply residential developments. The Northern Ireland distribution system is generally much smaller than the local networks in the rest of the UK, and is operated by Phoenix Natural Gas.

Figure 8: Gas distribution companies across the UK



Source: Energy Networks Association

Box 18: Gas Distribution: Iron Mains Replacement Programme.

A significant proportion of current annual investment in the gas networks is spent on the Iron Mains Replacement Programme. This was established in 2002 by the Health and Safety Executive, Ofgem and the gas industry in response to serious failures of iron mains which had resulted in fatalities and disruption to customer supplies as well as costly losses of methane (also a powerful greenhouse gas). Iron mains are generally replaced with polyethylene 'PE' pipes, which do not corrode and are highly resistant to fracture. The life of a PE main is currently expected to be at least 80 years.

Initially the programme required the GDNs to decommission all 'at risk' iron mains within 30 metres of a property over a 30 year period. However, following a ten-year joint review of the programme with Ofgem, HSE announced a new, more flexible policy which places greater emphasis on targeted risk management. As a result, the GDNs are expected to develop more innovative ways to reduce risk for iron mains greater than 8" in diameter in addition to decommissioning, for example, through pipe insertion or spray-lining and asset condition monitoring. However, all 'at risk' iron mains at 8" diameter and below must still be decommissioned by 2032.

Source: HSE

The cost of the gas network

4.9 The level of allowed investment in the gas networks is set by Ofgem[120] through a price control process. The gas distribution and transmission allowances are set for the next price control period for 2013-2021. For gas distribution, the total allowed investment across all 8 networks is £14.4 billion.[121] For gas transmission, the total allowed investment is £5.5 billion.[122]

4.10 The average annual household gas bill is £811. Of that amount, the average cost to the consumer of building, maintaining and operating the local gas pipes is £130 (16%).

Heat supply: electricity

4.11 Of the total 314 TWh of electricity consumed in the UK in 2011 (not including transport), 33%[123] was consumed as heating – this includes all forms of heat, including process heat in industry and cooling.

4.12 Electricity networks transfer electricity from where it is generated to where it is required. With upwards of £35 billion[124] of investment expected over this decade, networks will also play a significant role in supporting economic growth.

4.13 There are two distinct parts to the onshore electricity network: the transmission network and a number of regional distribution networks. In general, the transmission network

120 Ofgem is the regulatory body for the gas and electricity networks

121 Total allowed investment includes capital, operational, and expenditure for pipe replacement and repairs. Source: Ofgem, RII-GD1 Final Proposals overview 17 December 2012 http://www.ofgem.gov.uk/Pages/MoreInformation.aspx?file=1_RIIOGD1_FP_overview_dec12.pdf&refer=Networks/GasDistr/RIIO-GD1/ConRes, accessed on 22 March 2013

122 Total allowed investment includes capital and operational expenditure for National Grid Gas Transmission as both the Transmission Owner (£4.9bn) and the System Operator (£0.6bn). Source: Ofgem, RIIOT1 Final Proposals 17 December 2012 http://www.ofgem.gov.uk/Pages/MoreInformation.aspx?file=1_RIIOT1_FP_overview_dec12.pdf&refer=Networks/Trans/PriceControls/RIIO-T1/ConRes, accessed on 22 March 2013

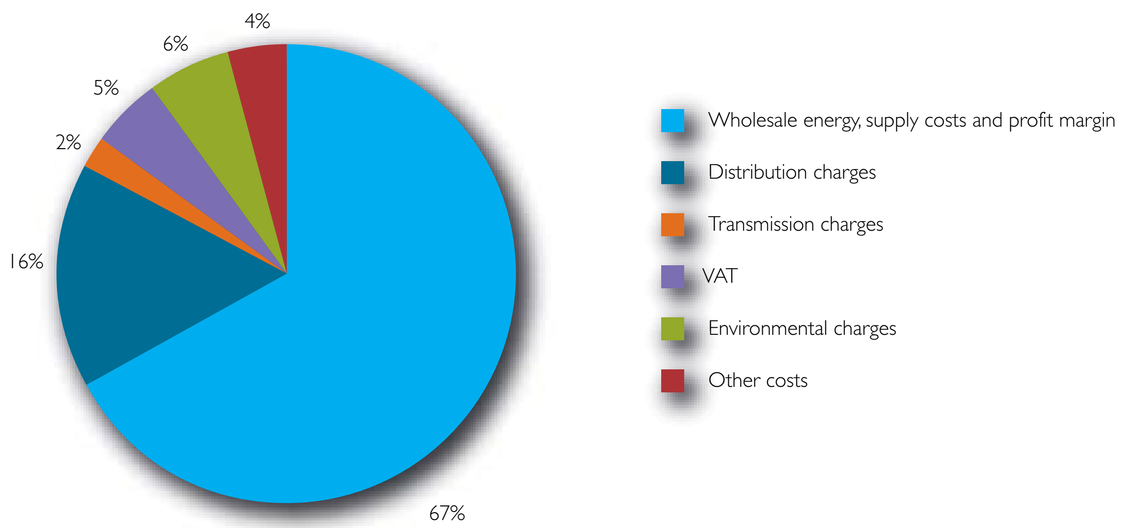
123 DECC, 2011, *Energy Consumption in the UK*

124 Ofgem 2009 *Project Discovery* Energy Market Scenarios http://www.ofgem.gov.uk/marketswhlmkts/monitoring-energy-security/discovery_scenarios_condoc_final.pdf, accessed on 19 March 2013

takes electricity at high voltage[125] from where it is generated to the lower voltage distribution networks which supply individual commercial and domestic premises. However, some large industrial customers draw their electricity directly from the transmission network and some, mostly small-scale, generators connect to the distribution network.

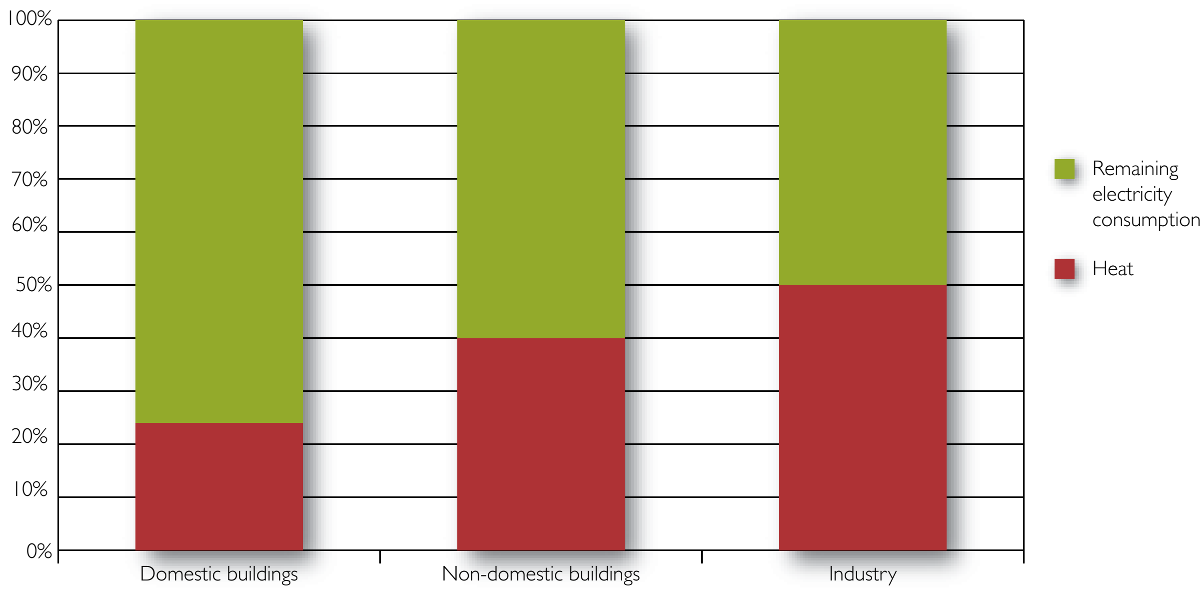
4.14 The 14 regional electricity distribution networks are currently owned by six companies, Distribution Network Operators (DNOs),

Chart 33: Breakdown of household gas bill



Source: Ofgem: Household energy bills explained: Factsheet 98

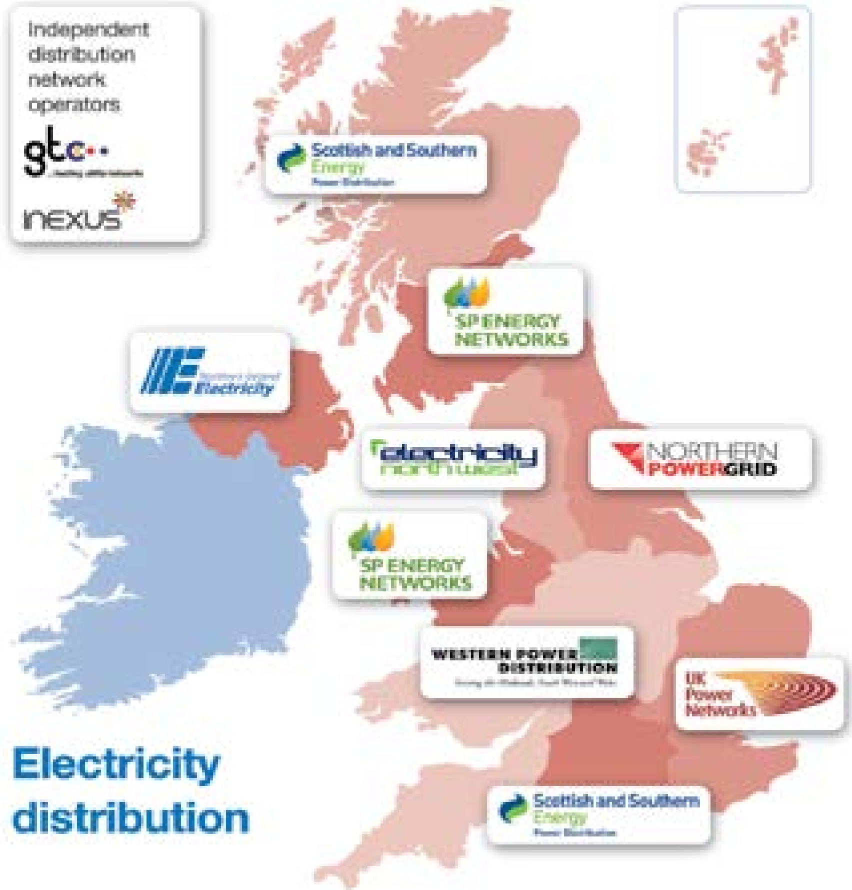
Chart 34: Heat and cooling as a proportion of total electricity consumption by sector (excluding transport) 2011



Source: DECC

125 The offshore transmission assets are owned by three companies: National Grid Electricity Transmission (England and Wales), Scottish Power Transmission (Central and Southern Scotland) and Scottish Hydro Electric Transmission Ltd (Northern Scotland). Offshore companies are granted Offshore Transmission Owner licences through competitive tenders run by Ofgem.

Figure 9: Map of the 14 electricity distribution networks and their owners



Source: Energy Networks Association

as set out in Figure 9. There are also six Independent Distribution Network Operators who own and run smaller networks embedded in the DNOs networks (predominantly network extensions connected to the existing distribution network, e.g. to serve new housing developments).

The cost of the electricity network

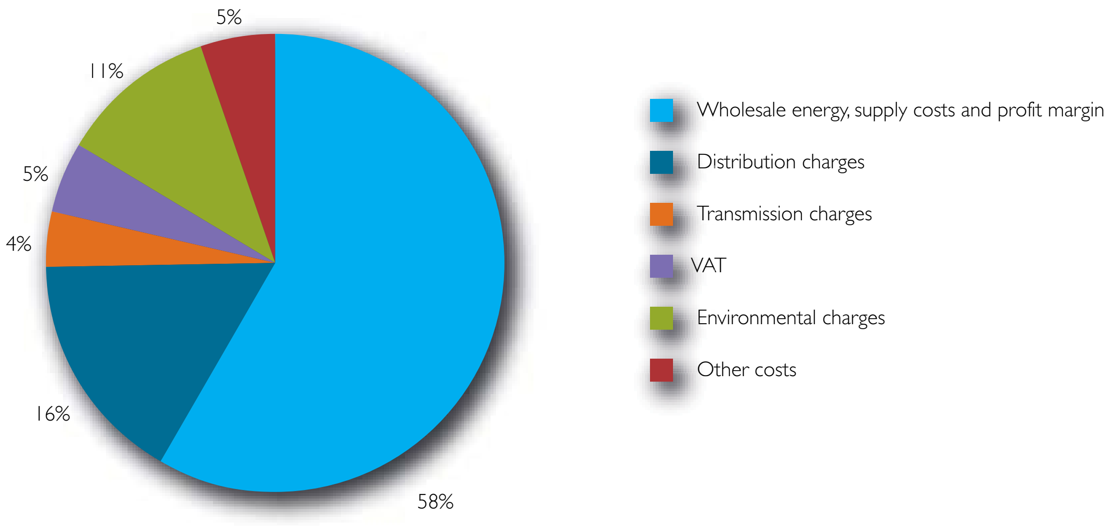
4.15 As with gas network companies, electricity network company activities are funded by the electricity consumer (commercial and domestic) through electricity bills. Onshore transmission and distribution companies are regulated by Ofgem. It does this primarily through price controls which set an expenditure allowance as well as incentives to drive performance. Ofgem's latest figures show that about 16% of the average electricity bill covers the costs of the distribution network and 4% for the transmission network.

What might we need for our low carbon future?

4.16 Modelling undertaken for the Carbon Plan showed virtually no role for domestic natural gas in 2050. A number of responses to the Strategic Framework argued that it could be more cost-effective to retain the gas grid as a back-up option for heating on the coldest days than adding the additional storage and peak generating capacity needed to meet the demand if heat has been electrified.

4.17 Furthermore, the timing and scale of the rollout of electric heating technologies raises implications for electricity capacity and balancing requirements.

Chart 35: Breakdown of household electricity bill

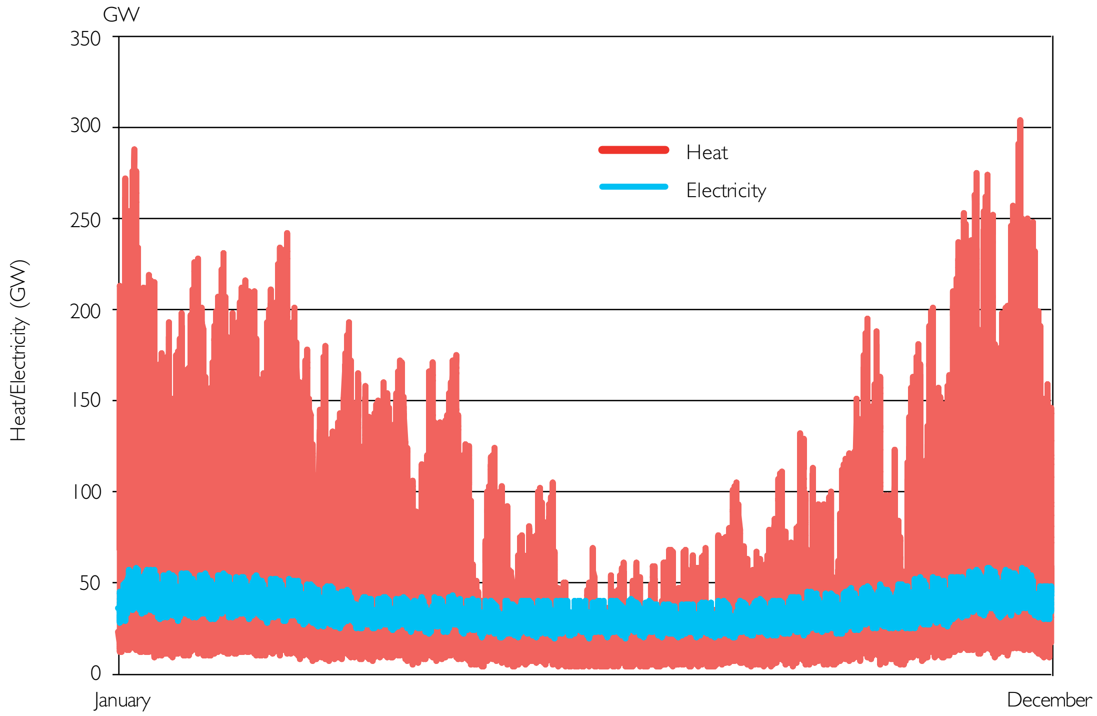


Source: Ofgem: Household energy bills explained: Factsheet 98

Box 19: Meeting the peak demand for heat

Heat demand varies significantly over the course of the day, and, with space heating, over the course of the year, particularly pronounced during winter months, when space heating demand is greatest and total demand can reach 300 GW.[126]

Chart 36: Comparison of heat and electricity demand variability across a year (domestic and commercial) – 2010



Source: Courtesy of Imperial College. For illustrative purposes only and based on actual half-hourly electricity demand from National Grid and an estimate of half hourly heat demand.

126 Page 45, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48574/4805-future-heating-strategic-framework.pdf, accessed on 15 March 2013

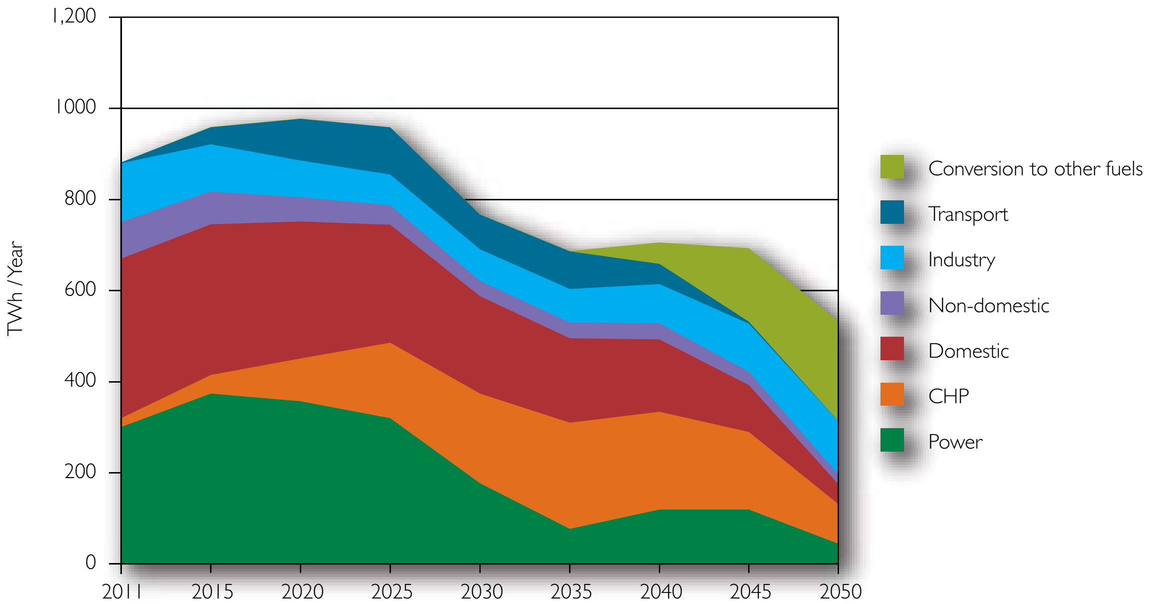
Findings from recent modelling

4.18 In 2012, DECC commissioned additional 2050 pathways modelling (RESOM) with improved representation of seasonal and in-day heat demand to properly reflect wide variations in demand for heating (shown in Chart 36). In addition, the modelling includes additional technologies which were not included in the modelling for the Carbon Plan. These include heat networks with storage and the new building-level technologies including gas absorption heat pumps, hybrid systems (which incorporate a gas boiler with an electric heat pump), micro-CHP, and domestic hydrogen boilers. Further details are set out in Section 2 of the Evidence Annex.

4.19 The high-level conclusions of the modelling commissioned for this document are broadly consistent with the conclusions of the Strategic Framework. However, the modelling suggests there could still be a limited role for natural gas in 2050 to help meet peaks in heat demand on the coldest days of the year. The modelling suggests this could be more cost effective than the alternative of full electrification of the peak seasonal heat demand, with the consequent need for large amounts of additional generation capacity to meet only occasional use. The modelling suggests a more cost-effective solution could be to maintain some gas in buildings for use by gas absorption heat pumps, or in hybrid systems where gas appliances operate alongside an electric heat pump, for example. This was confirmed by the results from the modelling run which removed the option of using gas in domestic buildings. This run showed higher overall system costs, in part because the increase in domestic electricity use required additional reinforcement of the distribution grid as well as additional generation.

4.20 However, the model currently only includes a simplified representation of the gas and electricity grids and their costs. Therefore, the model does not necessarily factor in all the implications of keeping a system of gas boilers and associated infrastructure that are used only occasionally. Further work is required to understand the practical implications of a partially-used gas grid, including the technical

Chart 37: The breakdown of natural gas by end use to 2050[127]



Source: RESOM modelling

127 The predicted use of gas by end use is an output from the RESOM model rather than an input, and is therefore not necessarily consistent with other recent DECC modelling and analysis such as that in the Gas Generation Strategy and the Impact Assessment for Electricity Market Reform

feasibility and the implications for network costs. It follows that whether gas or electricity is used to meet occasional peaks in heat demand, some expensive redundancy in the systems is involved. For this reason, new approaches to storage and balancing could be crucial to the overall system.

4.21 A consistent conclusion from the model is the greater role for heat networks (see chapter 2), in part because of their storage potential. The modelling also suggests a potential role for hydrogen both to provide heat for buildings and, more significantly, heat for industry. However, this finding needs to be treated with some caution as further work will be required to fully understand hydrogen's potential across the energy system and more accurate infrastructure costs.

4.22 The core scenario of the modelling shows overall gas demand falling by 40% by 2050 (compared with 2011). There is a reduction of around 90% in the use of gas for buildings heat. This reduction in demand may enable parts of the National Transmission System to be converted for other uses such as the transport of carbon dioxide for CCS, but the modelling does not currently include this option.

Reducing use of natural gas for heat over time and the future of the gas grid

4.23 Although natural gas use for heat will have to reduce significantly over time if the UK's carbon targets are to be reached, it will play an essential part in the transition to a low carbon future. There are a range of potential outcomes for the gas distribution networks. For example, there may be opportunities to decarbonise parts of the networks with renewable gas or to transport carbon dioxide for CCS where branches or parts of the distribution network are maintained to meet specific circumstances as part of an integrated local solution.

The potential of biomethane injection into the gas grid

4.24 It is possible to convert biomass into biomethane as a substitute for natural gas. This may have significant carbon benefits over fossil fuel alternatives, particularly when derived from wastes, and has the additional benefit of displacing nitrogenous fertiliser in the farming sector and contributing to the reduction of landfill.

4.25 The Government's Bioenergy Strategy suggested that there will be a role for biomethane in space heating in the short to medium term as well as in high-temperature process heating in the longer-term. From the analysis undertaken in the strategy it is unlikely there will be enough feedstock available to replace all the natural gas in the gas grid. Some of the recent modelling runs predict around 20 TWh of biogas from total gas demand of around 550 TWh could be blended into the gas network in 2050 from the gasification of biomass, anaerobic digestion and landfill gas.

4.26 Whilst there are significant benefits in injecting biomethane into the grid, there may be other uses for biomass in other parts of the economy where low carbon alternatives are absent or less cost-effective.

The potential of hydrogen injection into the gas grid

4.27 Hydrogen can be used as an energy carrier to link primary energy sources to end uses. Hydrogen is a common industrial chemical used in the manufacture of fertilisers and in the petrochemical industry. It can be produced from hydrocarbons, such as natural gas, biomass and coal, and from the electrolysis of water, including using electricity from low carbon sources. Hydrogen can be converted by an electrochemical process into electricity and heat in a fuel cell or can be combusted.

4.28 Commercial hydrogen pipeline networks already exist in Europe and the US, other large hydrogen pipeline networks also exist in Canada,

Box 19: Case study on anaerobic digestion and biomethane injection (Poundbury, Dorset)

In December 2012, the Renewable Heat Incentive (RHI) scheme accredited its first biomethane installation located near the Duchy of Cornwall development of Poundbury in Dorset. It is the country's first full-scale Anaerobic Digester and Biomethane-to-Grid Plant, and was opened by the Prince of Wales. The plant provides renewable gas direct to the local community. At maximum capacity the plant will provide enough renewable gas for 56,000 homes in the summer and 4000 in the winter.

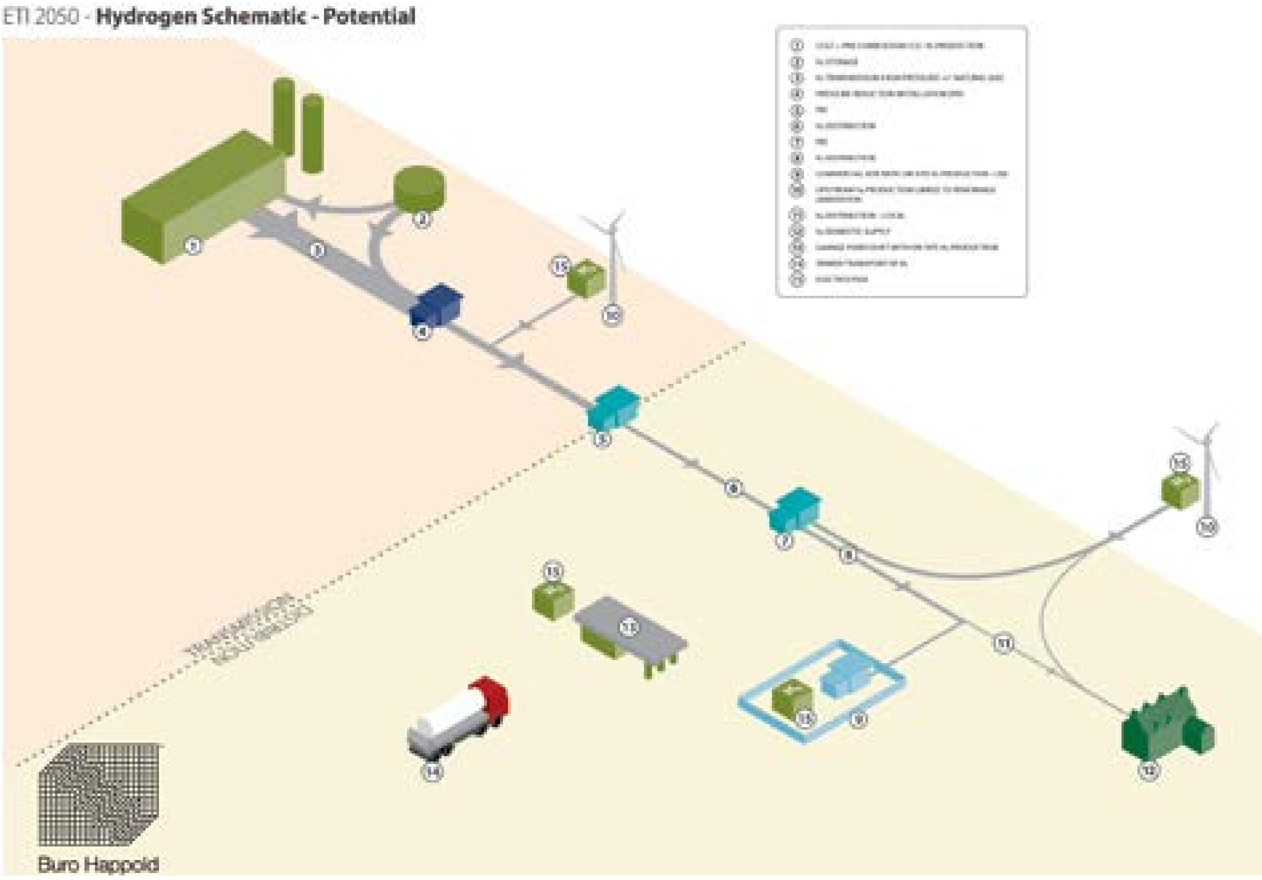
Anaerobic Digestion is a natural process where, in the absence of oxygen, organic material is broken down by micro-organisms to produce biogas which is rich in methane. The Anaerobic Digester will produce this biogas from approximately 41,000 tonnes of maize, grass silage and food waste each year. Anaerobic Digestion produces a bi-product known as digestate which can be used as organic fertiliser on arable crops.

Source: Scotia Gas Networks

Singapore, Hong Kong, China and Thailand. The UK's current hydrogen infrastructure is extremely limited compared to electricity and gas networks: there is an industrial pipeline in Teesside, hydrogen is delivered by road trailer in the UK, and London's Olympic village houses Europe's largest hydrogen refuelling facility serving 8 fuel cell buses. Hydrogen is well suited to large-scale storage with hydrogen caverns operated in a number of countries, including in the UK (in Teesside).

4.29 It may be possible to transport hydrogen in the gas distribution networks. There are three possible options: in very low concentrations where hydrogen is mixed with natural gas; as a complete substitute for natural gas as 100% hydrogen networks; or by combining hydrogen with carbon dioxide to produce methane (methanation) before introducing it into the distribution network. There would be a range of conversion costs involved in any of these scenarios. There would also be technical and safety issues to address. However, such a

Figure 10: Schematic to show potential role of hydrogen



Source: Buro Happold for the Energy Technologies Institute

conversion programme is not unprecedented as the network was previously converted from town gas (50-60% hydrogen by volume) to natural gas over a 10-year period (1967 to 1977).

4.30 Electrolysis to produce hydrogen could provide an opportunity to store for future use low cost electricity from times of surplus generation. There are already a number of research initiatives under way looking at the technical challenges and opportunities of using hydrogen in this way.

Investment in the electricity grid

4.31 The increasing use of electricity to provide heat will impact on the amount of electricity generation required. This will include a continued need for gas as a fuel for power generation, including for balancing out increasing levels of intermittent and inflexible low carbon energy on the system.

4.32 The electricity networks face a number of important challenges in the transition to a low carbon economy. It will be essential that electricity networks can accommodate the new low carbon technologies and generation required to meet carbon targets, whilst maintaining reliability of supply and minimising their impact on consumer bills.

4.33 Ofgem's electricity distribution price control known as RIIO-ED1[128] aims to ensure that network companies play a full role in the move towards a low carbon and secure electricity system which provides long-term value for money for customers. The price

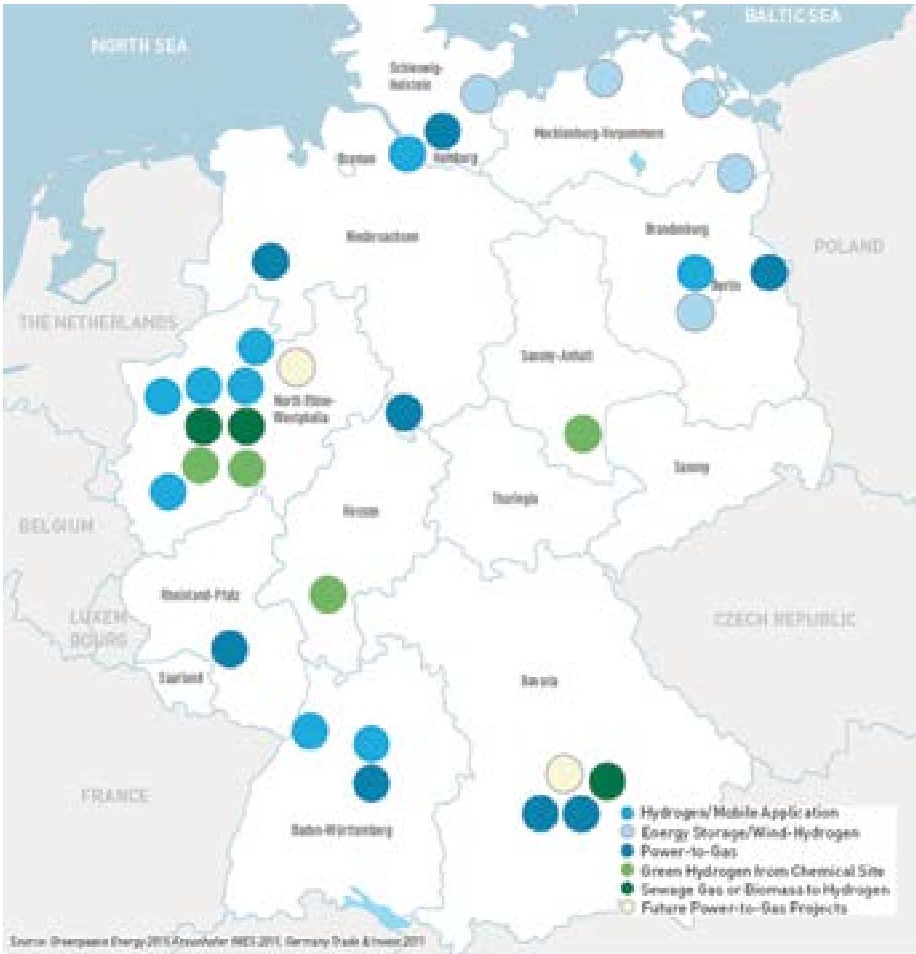
128 'RIIO' is Ofgem's new price control framework (Revenue = Incentives + Innovation + Outputs) designed to encourage investment and innovation.

Box 20: Technology Strategy Board's Smart Power Distribution and Demand competition

An ITM Power-led project aims to investigate the technical, financial and operational feasibility of injecting hydrogen gas, generated from electrolysis fed from excess renewables, into the UK gas networks. Such power-to-gas systems can provide balancing services for the power industry. The project will identify the possible options for implementing power-to-gas in the UK. The 12-month project began in August 2012.

Such schemes are already being developed in other countries. For example, the German government is supporting green hydrogen and power-to-gas projects through a number of funding instruments, initiatives and programs.

Green Hydrogen and Power-to-Gas Demonstration and Pre-Commercialisation Projects in Germany



Source: ITM Power

control will set the outputs that the six electricity distribution companies need to deliver for their customers and the associated revenues that they are allowed to collect for the eight-year period from 2015 to 2023. DNOs' plans will not only need to show how they will reinforce the networks to accommodate changes to generation and demand, but also how they will become 'smarter'. Smart technologies will enable DNOs to make best use of their assets and operate in a more complex energy system.

4.34 The Smart Grid Forum,[129] which DECC co-chairs with Ofgem, is working to help ensure DNOs make the right network investments to help meet the increased electricity demand and distributed generation envisaged in the Carbon Plan. An important element of this work has been the development of a smart grid cost-benefit model ('Model Transform') to help DNOs with their business planning. This uses shared assumptions and scenarios of future demands on electricity distribution networks, consistent with the Government's Carbon Plan. The model seeks to quantify the costs of grid reinforcement and to assess the potential of smart grid technologies to reduce those costs. This model is currently being used to inform Ofgem's RIIO-ED1 price control including DNOs' business plans.

Electricity networks and impacts of heat networks

4.35 It is not clear what impact heat networks will have on electricity networks but it is clear that they could reduce peak electricity demand and network reinforcement costs, particularly when combined with the use of heat storage. The distribution network company Scottish and Southern Electricity Power (SSEPD) is currently undertaking an innovation trial exploring the benefits to the electricity network from working collaboratively with a heat network. This is part of the wider Northern Isles New Energy Solutions (NINES) project which aims to make better use of the renewable generation available on the Shetland Isles. It is expected that the learning from this project will be shared with other DNOs. Work in these areas will need to continue as DNOs give further consideration to the impact on electricity networks as the electrification of heat increases and as heat networks develop.

Storage Infrastructure

4.36 Storage could provide a number of benefits to the UK's future heat and energy systems. For example, smoothing supply profiles from intermittent generation, and providing balancing services. Storage could also potentially save or defer network upgrade costs that may be required in the future to meet peak demand.

4.37 Chart 40 below demonstrates the potential role of heat storage in matching supply with demand in building-level technologies in the domestic sector. Dynamic systems modelling being developed by UCL is trying to understand how different heat and storage technologies integrate into national energy systems.

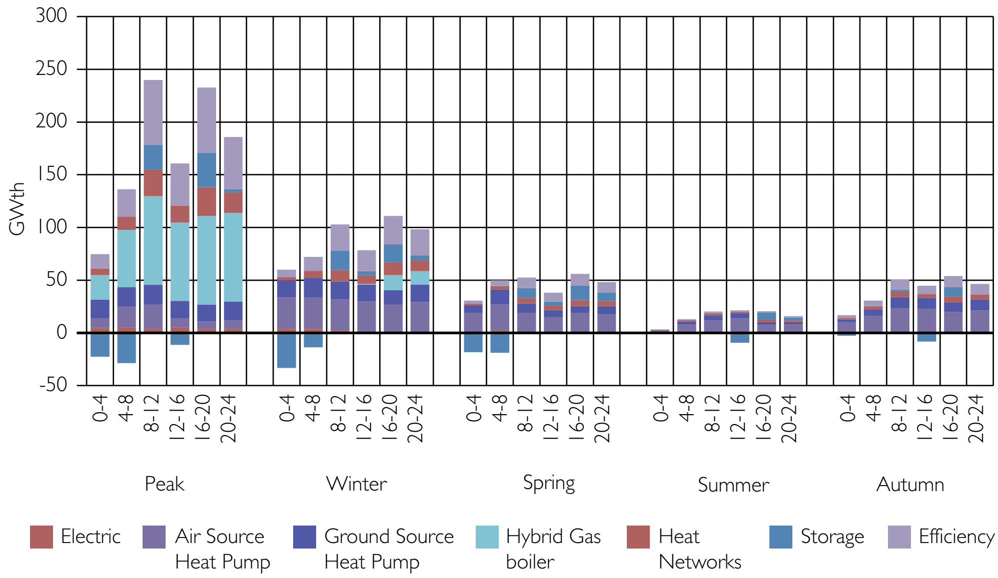
4.38 The gas grid is able to handle very short term spikes in demand as large quantities of natural gas are stored in the grid itself. This storage acts as a buffer between supply and demand, meaning overall supply only needs to match average demand. National Grid ensures a balanced system by buying and selling gas and using stored gas to ensure that, in most normal circumstances, demand can be met.

4.39 The electricity grid is less able to accommodate spikes in demand without significant storage capacity or demand management being deployed to help 'balance' the grid by smoothing out demand, or by increasing generating capacity to meet peaks.

4.40 Given the significant expansion in electricity generation needed to meet the UK's 2050 carbon targets, electrical heating will need to be highly efficient and supported by storage and demand side response from customers (shifting demand to another time when demand is lower).

129 DECC and Ofgem set up Smart Grid Forum in 2011 to identify and overcome barriers to smart network deployment and includes representation from network companies, suppliers, academics and consumer groups.

Chart 38: The profile of domestic heat demand across a range of time periods in 2050



Source: RESOM modelling

4.41 The Energy Research Partnership (ERP) produced a report in 2011 on the future role of energy storage in the UK.[130] Their report provided a comparison of the electrical and thermal rechargeable energy storage that already exists in the UK.

- Grid-scale pumped hydro storage for electricity production in the UK has a volume of 27.6 GWh. There are four major schemes in the UK.
- Hot water storage cylinders are present in 13.7 million UK households. When this heat store is aggregated across the UK it would total around 65 GWh of heat per day.
- Heated brick-type storage heaters are the primary heating system in 7% of the UK housing stock. There are approximately 1.55 million storage heaters installed in the UK.
- The energy storage volume of fossil fuels in the UK is estimated to be 47 TWh of gas and 30 TWh for coal in terms of electrical power generation.

Challenges of infrastructure change

4.42 Making significant changes to the way heat is generated and delivered to homes, businesses and industries will mean changes to the UK's existing infrastructure. Achieving this transition will mean tackling a range of challenges:

- **Investment:** There are a number of investment challenges required to unlock the funding needed to achieve the scale of change required. Network investments have a long lifespan and require detailed forward planning to ensure they are cost-effective. Good planning is required to avoid the risk of investing in potentially sub-optimal solutions, or where this may result in stranded assets.
- **Customers:** Addressing consumers' and businesses' attitude to the supply of heat and new heat technologies will be central to the low carbon transition. Domestic consumers cannot be considered separately to industrial consumers as 80% of industry (by number) is connected to the low pressure tiers of the

130 The Energy Research Partnership produced a report in 2011 on the future role of energy storage in the UK, see www.energyresearchpartnership.org.uk/energystorage accessed on 20 March 2013

gas network which serves domestic consumers. The Government will also need to protect the most vulnerable consumers through the low carbon transition.

- **Timing:** The timing and scale of the transition to electric heating technologies raises implications for electricity capacity and balancing requirements, such as the impact on the electricity network of large numbers of electric heat pumps, particularly during the coldest winter months.
- **Regulatory:** There will be regulatory challenges as new technologies are deployed. There will be challenges of infrastructure development, re-purposing or decommissioning. For example, this will include the practicalities of building new heat networks and migrating customers to these new networks.

4.43 It will be difficult for the private sector alone to manage the change given the potential consequences and impacts across the energy system.

Actions under way now

Action under way	Relevance
In December 2012 DECC published the *Gas Generation Strategy*	The Strategy provides certainty to investors about the Government's view of gas generation to ensure sufficient investment comes forward within the context of the Government's wider energy policy.
The Energy Bill includes provisions for the Secretary of State to designate a Strategy and Policy Statement (SPS)	The SPS replaces existing social and environmental guidance with new duties for Ofgem. The SPS may go wider and will set out the Government's strategic priorities and intended outcomes with respect to energy policy that Ofgem has an important part in delivering.
In December 2012, Ofgem set out their final proposals for the next price control for GDNs (which will run from 1 April 2013 to 31 March 2021)	Ofgem have taken into account the uncertainty over the future role of gas network. Ofgem's proposed approach is to defer capital investment decisions where this is in the consumer interest, ie where there is uncertainty over the future payoff and there is no detrimental effect on consumers in the meantime.
Electricity Market Reform (EMR)	EMR will put in place two key mechanisms – Contracts for Difference (CfDs) and the Capacity Market. These mechanisms will ensure that low carbon electricity generation remains an attractive investment opportunity; and that the UK electricity sector can deliver a secure affordable supply to consumers. Underpinning these arrangements are other key elements that will drive investment in low-carbon power generation: the Carbon Price Floor; and the Emissions Performance Standard.[131]
Demand side response (DSR)	DSR is an active, short-term reduction/shifting in consumption of energy demand at a particular time. DSR can reduce the need for peaking plants and network reinforcement. Currently there is limited demand side responsiveness in the electricity system, making up about 1% of National Grid's balancing services. The 'Electricity System: Assessment of Future Challenges' report,[132] published in July 2012 set out the Government's work to ensure that non-generation balancing technologies, including electricity storage and DSR, can contribute to the responsiveness challenges.

131 Further details on EMR can be found at https://www.gov.uk/government/publications/electricity-market-reform-policy-overview--2, accessed on 15 March 2013

132 https://www.gov.uk/government/publications/electricity-system-assessment-of-future-challenges, accessed on 15 March 2013

Action under way	Relevance
Future investment in electricity distribution networks	The current price control for DNOs started in 2010 and will run until April 2015. Business plans for the next price control (RIIO ED1) are due to be submitted in July 2013, and it will run from April 2015 for 8 years. To inform these, DECC has worked through the Smart Grid Forum to share assumptions and scenarios of the take up of key drivers of network capacity, including heat pumps.
Renewables Roadmap	The Government continues to tackle the barriers to further deployment of biomethane through the actions set out in the Renewables Roadmap,[133] the Waste Review[134] and the Anaerobic Digestion Strategy.[135] The Government is consulting on a transporter licence exemption which will remove the need for biomethane producers to hold a transporter licence to connect their facility to the grid.
Renewable Heat Incentive (RHI)	The RHI is supporting the deployment of biomethane to the gas grid at all scales.
Hydrogen TINA (Technology Innovation Needs Assessment)	This assessment will look at what innovation is needed to secure commercial deployment, and the capacity of the UK to deliver and benefit from this. The initial focus will be on transport, but further work is planned which will look at opportunities in other sectors – including heat and grid balancing – from an energy systems viewpoint.

Research and innovation

4.44 Research and innovation will play an important part in developing a better understanding of the potential of new technologies and their interaction across the energy system. There are a number of relevant research projects already underway.

Box 21: Smart Systems and Heat Programme by the Energy Technologies Institute (ETI)

The programme's aim is to design a first of its kind commercially viable Smart Energy System in the UK. It will run in two phases:

Phase One (2012-2015): The creation of a design methodology and the detailed design of a smart energy system which can be demonstrated at scale

Phase Two (2015-2017): The demonstration of the designed smart energy system to prove that the concept and methodology is viable for commercialisation by running a trial involving up to several thousand dwellings.

One of the objectives of the programme will be to understand the role smart energy systems could play in the evolution of the whole energy system out to 2050, including building retrofits and energy distribution system choices.

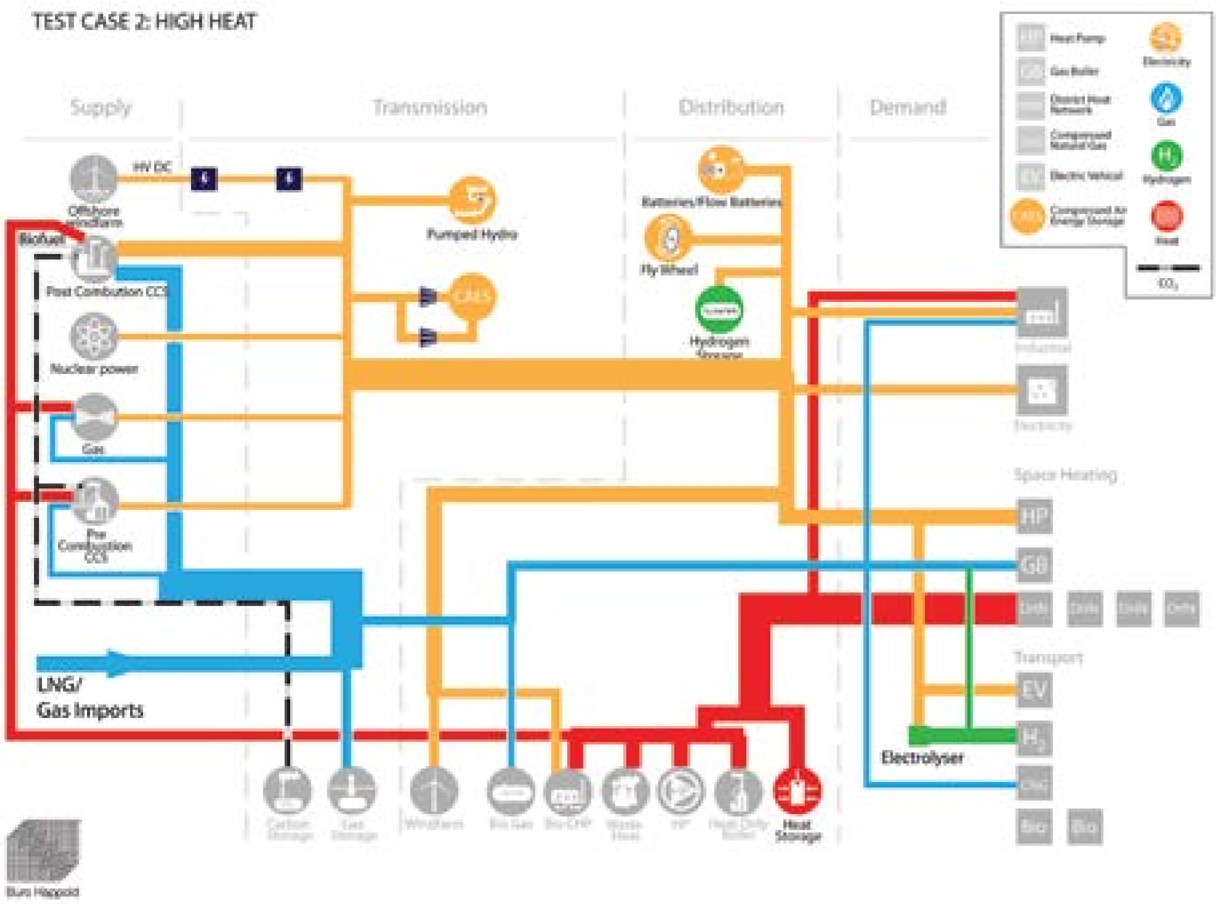
Source: Energy Technologies Institute

133 https://www.gov.uk/government/publications/uk-renewable-energy-roadmap-update, accessed on 15 March 2013
134 http://www.defra.gov.uk/environment/waste/review/, accessed on 15 March 2013
135 http://www.defra.gov.uk/publications/2011/06/14/pb13541-anaerobic-digestion-strategy/, accessed on 15 March 2013

Box 22: 2050 Energy Infrastructure Outlook Project by the Energy Technologies Institute (ETI)

This ETI project will produce a cost data tool capable of supporting cost optimisation analysis for key types of fixed energy infrastructure. The overall aim of the tool will be to assess the relative merits of different infrastructure options, given different energy generation and demand scenarios. It will support this by allowing the calculation of costs for new infrastructure or the abandonment, refurbishment or repurposing of existing infrastructure. The project will also identify possible 'grey areas' where future technology development could significantly influence future cost and performance. This will in turn point to possible research and development opportunities.

The energy vectors being considered are: electricity, gas, hydrogen, and heat. The infrastructure types under consideration are: transmission, distribution, storage, conversions and connections. The following example is the type of infrastructure representation that will be used to guide the data collection for the project.



The project is due to conclude in November 2013.

Source: Buro Happold for the Energy Technologies Institute

Box 23: Customer Led Network Revolution programme on heat pumps and advanced storage project in domestic buildings.



Over a three-year period from 2012, Northern Powergrid, British Gas, Durham University and EA technology Ltd will be trialling smart grid solutions on the distribution network within the electricity grid. The results will help to ensure the electricity networks can handle the mass introduction of low carbon technologies, such as solar PV, electric cars and heat pumps.

DECC is supporting analysis on the impact of an increased uptake of heat pumps in the domestic sector. DECC innovation funding will enhance the programme's learning by introducing a trial of thermal stores integrated with heat pumps to gather evidence of the potential benefits of storage in heating systems to balance peak electricity loads to the grid.

Source: DECC

Next steps

4.45 It is likely that action on a range of options for low carbon heat will provide a more robust energy system in the long run. But the transition to the decarbonisation of heat and the impacts on the UK's energy infrastructure will need to be carefully managed. For example, electricity network and gas grid changes will need to be consistent with new building-level solutions or with heat networks deployment and storage where these would be a more cost effective solution. Furthermore, the Government will need to ensure that decisions are not taken prematurely which might risk closing off long-term alternative solutions.

4.46 Both the Government and a number of other organisations have produced evidence using analytical models that explore potential scenarios and pathways to decarbonising heat. It will be important to continue to work with the industry to continue to deepen the Government's understanding of these complex whole-system trade-offs. This will enable DECC to understand all the costs and opportunities of change and guide future decision-making.

4.47 The Government will need to ensure that research and development programmes reflect the weighting on specific technologies in the latest heat pathways. This will help to develop the analytical base to guide future decisions. Two key areas where DECC will need to focus particular effort will be on heat storage and on hydrogen. This work will also need to feed into and complement work on the future of the electricity system.

4.48 The Strategic Framework and the Department's subsequent engagement with stakeholders has pointed to the need to better identify, understand and manage the future issues around gas for heat and the future of the gas grid, in particular.

4.49 DECC is therefore proposing the following specific actions:

- DECC will take forward work to develop a whole energy systems approach. This would explore the whole energy systems policy questions that flow from the important strategic interactions between the dual challenge of moving towards lower carbon electricity generation and heat production.
- DECC will this year be commissioning further research to improve the Department's understanding of the role hydrogen might play across the energy system to meet the UK's low carbon and security of supply objectives.
- DECC plans to announce the successful Phase 2 demonstration projects for its Advanced Heat Storage competition. Projects will commence in spring 2013 for a 12-month period. The projects will trial prototypes of novel compact heat stores for the domestic sector which can be integrated with low carbon heating technologies (such as heat pumps) to help balance peak loads on the electricity grid.
- This year DECC will be exploring with the industry how best to address the strategic questions facing the gas network.

How to respond

The Department of Energy and Climate Change is seeking comments and further evidence in response to this document. Responses should be sent to: heatstrategy@decc. gsi.gov.uk. Responses should be clearly marked "The Future of Heating – Meeting the Challenge"

Documents sent by post should be addressed to:

Heat Strategy and Policy Team
Department of Energy & Climate Change,
3 Whitehall Place,
London SW1A 2AW

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