DEPARTMENT OF ENERGY & CLIMATE CHANGE

The Future of Heating:
A strategic framework for low carbon heat in the UK

March 2012

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What happens next

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Ministerial Foreword

The need for heat is fundamental to human society, and always has been. It is no coincidence that the harnessing of fire by prehistoric man is seen as one of the most significant moments in the development of Homo Sapiens.

The reasons are obvious, but important. Controllable heat provides warmth in colder climes, hot water, and cooked food. Fire also allowed humanity to start down the road of manufacturing – heat is needed for almost all manufacturing processes from the simplest production of metals from ores, to the most complex chemical, refining and distillation processes that we take for granted now.

Of course it's a long way from prehistoric man to our modern complex and integrated economy. For many centuries heat came from burning wood. Then came coal, the driving force behind the industrial revolution. Gradually oil and gas have become the dominant fuels. And now, whether you are heating water at 40°C for a bath at home, or producing ceramic products at 900°C in a giant kiln, the chances are that you are burning natural gas to do it. Around 80% of all the heat used in the UK – in homes, in commercial buildings and in industrial processes – comes from gas.

This position is not sustainable. If we are to set the UK on a path consistent with avoiding the damage to our economy, society and public health that would be caused by a global temperature rise above 2°C, we need to virtually eliminate greenhouse gas emissions from our buildings by 2050, and to see deep reductions in emissions from industrial processes. And, while natural gas will supply the majority of our heat demand well into the 2020s, cutting emissions from buildings and industry means taking the carbon out of heat in the longer term, managing demand through energy and resource efficiency, and replacing fossil fuels with low carbon alternatives.

This does not need to be a threat. We can see this as a great opportunity for the UK; an opportunity to diversify our sources of heat, make our processes more efficient and our companies more competitive, to develop our cities and towns in sustainable ways that prepare us for a low carbon future, and to bring renewable heat into the mainstream alongside gas boilers, a market which currently sees around 1.6 million new boilers put into homes every year.

In many places, the process of change has already started. In this document you will find examples of cities like Sheffield and Nottingham that have district heating systems providing warmth to the homes and commercial centres of the city, and offering the potential to connect to large scale low carbon heat sources. Heat pumps and biomass boilers have already been installed in homes under the Government's Renewable Heat Premium Payment scheme.

And at a commercial and industrial level, businesses can benefit from the Renewable Heat Incentive, being awarded tariff payments for the low carbon heat they generate.

But we cannot be complacent. The document also contains lessons that we can learn from other countries, and an assessment of some of the physical, financial and behavioural barriers faced by different options for low carbon heat that Government, industry, businesses and consumers will need to work together to overcome.

This document does not contain all the answers. In fact it contains questions – questions that we want you to help us answer. What it does offer is the Government's view, based on the best information available, of the likely pathways open to the UK if we are to deliver the decarbonisation of our heat needed to respond to the threat of climate change and protect the security and affordability of our energy supplies.

Edward Davey
Secretary of State for Energy and Climate Change

Executive Summary: The Heat Challenge

- *Heat is the single biggest reason we use energy in our society. We use more energy for heating than for transport or the generation of electricity. This year the UK will spend around £33 billion on heat across our economy.*
- *We use heat to keep our homes and offices warm, and we use energy to cool them in hot weather. We also use heat to provide us with hot water, cook our food, and manufacture the goods such as steel, iron, cement and chemicals, upon which our economy depends.*
- *Today the vast majority of our heat is produced by burning fossil fuels (around 80% from gas alone), and as a result heat is responsible for around a third of the UK's greenhouse gas emissions.*
- *This is unsustainable. The 2011 Carbon Plan*[1] *set out that if the UK is to play its part in the global effort to combat climate change, we will need our buildings to be virtually zero carbon by 2050. Achieving this can help reduce our exposure to the kind of volatile fossil fuel prices which led to a 9.4% rise in average gas prices last year, driven overwhelmingly by the wholesale gas price on global markets.*
- *The transformation of heat-generation and heat-use will create new markets and new opportunities. The EU market for heat pumps alone was responsible for three-quarters of million units sold last year,*[2] *and there is a chance for the UK to capture more of this market as we make the change to low carbon heat. This will be a national transformation, and also a local one, with different solutions for different localities and geographies as households, businesses and local authorities choose the approach that will work best for them.*
- *This document sets out how we supply and use heat today and describes how the heat system will need to evolve over time, identifying the substantial changes required across our economy and the role for government.*

1 Available at: http://www.decc.gov.uk/en/content/cms/tackling/carbon_plan/carbon_plan.aspx
2 European Heat Pump Association Outlook, European heat pump statistics

Introduction – what we mean by heat and how it is used

1. In this document we talk about heat in a broad sense, thinking about how we use energy to both raise and lower temperatures. Heat is used in our homes and workplaces to provide warmth and hot water, and to cook our food. Increasingly, we are using energy to cool buildings too, relying on air conditioning and mechanical ventilation to maintain comfortable temperatures. Industry requires heat in processes such as the production of iron and steel, ceramics, chemicals, food and drink, and cement.

2. The way we use heat is very different from the way we use electricity, which is delivered in its final form, ready for use. Heat is not bought and sold as a commodity in the UK. It is not common for households or businesses to buy warmed air, hot water, or steam directly. Instead we buy fuels (predominantly gas, oil or solid fuels) or electricity and convert these into heat on-site in boilers, kilns, furnaces and electric heaters.

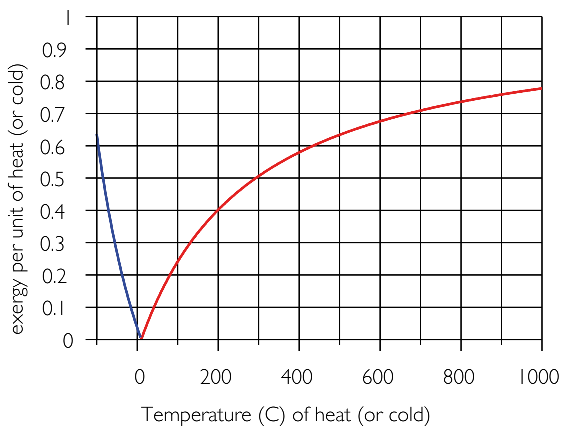
3. There are however a small number of buildings and industrial installations supplied by heating networks, which buy heat in the form of piped hot water or steam, although they are estimated to comprise less than 2% of UK's total heat supply.[3]

Box 1: Energy, heat, and temperature

When thinking strategically about heat, it is important to avoid some common misconceptions.

Misconception 1: One unit of heat is as useful as one unit of electricity or chemical energy.

False. While electrical energy and chemical energy can easily be turned into heat, the laws of thermodynamics don't allow heat to be one-hundred percent turned back into electrical energy or chemical energy. As energy is converted between different forms, there is an irreversible tendency for its capacity to do useful things to decrease. One unit of heat energy is intrinsically less useful and less valuable than one unit of electrical or chemical energy.



The intrinsic value, or exergy, of one unit of heat (red) or cold (blue) as a function of the temperature of that heat (or cold), for an ambient temperature of 10°C.

3 Poyry (2009): *The Potential & Costs of District Heating Networks*, April 2009

Misconception 2: A good way to measure the value of some heat is by the quantity of energy in that heat.

False. Quantity matters, but so does quality; the quality of heat depends on how different the temperature of that heat is from the temperature of the surroundings. If the ambient temperature is 10°C then 1 cup of boiling water at 100°C and 3 cups of water at 40°C contain exactly the same amount of heat-energy, but the energy in boiling water is more useful: you can easily mix the boiling water with ambient-temperature water to make 40°C water, but you can't un-mix tepid water back into cold water and boiling water. Engineers measure the "usefulness" of a quantity of heat by its "exergy", which is the maximum amount of electrical energy that could conceivably be obtained from that heat. The chart above shows, for temperatures above (or below) an ambient temperature of 10°C, the amount of exergy in each unit of heat (or cold). Heat at 20°C has much smaller intrinsic value than heat at 100°C or 600°C.

Misconception 3: Power stations are "wasting energy" if they turn only 50% of the heat in their boilers into electricity and send the other 50% into the air in cooling towers. This "waste heat" could be put to use, for free.

False. The power stations that are the most efficient at generating electricity work by taking very high temperature heat, and turning part of it into electricity and part of it into near-ambient-temperature heat. This "waste heat" is an essential feature of a highly-efficient thermal power station: for the power station to work, this near-ambient-temperature heat must be delivered to a near-ambient temperature place. The near-ambient temperature place does not have to be a cooling tower – radiators in a greenhouse or building would work fine too, for example – but there is a widespread misconception that this "waste heat" should be put to other uses. The truth is that the "waste heat" has very little value, because its temperature is very close to ambient (35°C, say). If we want to make use of a power station's "waste heat", typically a higher temperature is required; many district heating systems, for example, send piped heat at a temperature close to 100°C. Power stations can produce waste heat at these higher temperatures, but if they do so, then they inevitably produce less electricity (compared to an optimized electricity-only power station). So the "waste heat" isn't free; there is a trade-off between the amount of high-value electricity produced and the quantity and temperature of heat delivered. If heat is delivered at temperatures useful to industrial processes (e.g. 300°C), typically at least three units of heat can be delivered for each unit of electricity foregone. At lower temperatures (e.g. 100°C), perhaps seven units of heat can be delivered for each unit of electricity foregone. Combined heat and power tends to be the most efficient use of a fuel in situations where there is a demand for heat that is steady in time.

Misconception 4: Boilers that turn gas into heat with an efficiency of 90% and electric heaters that turn electrical energy into heat with an efficiency of 100% are unbeatably efficient ways of delivering heat.

False. While a 90%-efficient boiler is of course better than a 70%-efficient boiler, it is possible to deliver low-temperature heat with much higher efficiency than 100%! Heat pumps use a small amount of electrical energy or chemical energy to move a larger amount of heat from one place to another (for example, from your garden to your house), boosting the heat's temperature from the ambient temperature to a higher temperature. A well-designed heat pump system can deliver at least three times as much heat (at domestic temperatures) as the electricity it uses. Power stations providing heat and power can be viewed as virtual heat pumps, able to deliver between three and seven units of heat for each unit of electricity forgone, depending on the temperature of the delivered heat. Both heat pumps and power stations can deliver more heat, the closer the heat's temperature is to ambient. So for domestic heating, there is a common message: both heat pumps and CHP-driven district heating work more efficiently with low-temperature heat emitters; the key steps that enable central heating systems to be run at lower temperatures are to improve building insulation, and to ensure that the radiators are large enough.

David MacKay FRS, Chief Scientific Advisor, DECC

Analytical approach

4. This document is an assessment of what decarbonisation of heat supply means in practice, the key priorities in each sub-sector, and the main barriers and opportunities.

5. In order to develop this work, the Government has drawn on evidence from a range of sources, including:

- the best available empirical research and statistical analysis, including work developed and commissioned by the Committee on Climate Change (CCC);
- energy system modelling and the Government's 2050 pathways calculator (see Box 2);
- a series of workshops with trade associations, industry stakeholders, academic institutions and others, to inform this work and test out emerging conclusions; and
- regular discussions with the CCC and the Energy Technologies Institute.

Box 2: The analytical models used and "common messages"

Both the Government and a number of other organisations have produced evidence using analytical models that explore potential scenarios and pathways for decarbonising heat. These models use different approaches and underlying assumptions, and none of them individually offer a perfect prediction of the future. In formulating its strategic approach to heat, the Government has investigated the assumptions underlying a range of models and tested these by examining statistical data, evidence from field trials and academic literature, and through discussion with stakeholders. The models that the Government has considered in the production of this report include:

- **Markal** – a cost-optimising model used to carry out economic analysis of different energy-related systems at the country level. This has been used by DECC, the CCC and others for around 10 years, recently for the fourth carbon budget analysis;
- **Energy System Modelling Environment** (ESME) – also a cost-optimising full energy system model that is now on its second iteration by the Energy Technologies Institute;
- **NERA/AEA heat model** – a tailored heat model for the whole economy, used by DECC and the CCC to inform work on the fourth carbon budget and the development of the Government's Renewable Heat Incentive;
- **2050 Calculator** – an analytical tool developed by the Government that explores possible scenarios for meeting the 2050 emissions reduction target and maintaining security of supply; and
- **Redpoint bioenergy model** – a model developed for the Government and the CCC to use in developing the CCC Bioenergy Review and the forthcoming Government Bioenergy Strategy. Although its focus is use of bioenergy within the energy system, it includes non-bioenergy technologies such as heat pumps.

Taken together, the outputs of these models point to a number of "common messages" which can give a starting point for further inquiry:

- for individual buildings, heat pumps are favoured strongly by all models;
- natural gas combustion at individual building level is completely phased out by 2050 in all cases;
- oil, coal and resistive electric heating are phased out (although some electric resistive heating comes back as the grid is decarbonised in some model scenarios);
- bioenergy plays a minor role in supplying heat at a building-level, but is much more significant in the industrial sector for various manufacturing processes; and
- most models do not address network solutions such as injection of biomethane or heat networks in the same way as building-level technologies. This made it difficult to draw conclusions about their potential role. We have therefore used a broader evidence base to explore these options in this document.

Where we need to be

6. As the Government set out in the *Carbon Plan* published in December 2011, meeting the UK's goal of reducing emissions by 80% by 2050 relative to a 1990 baseline 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 (see Diagrams 1a and 1b).

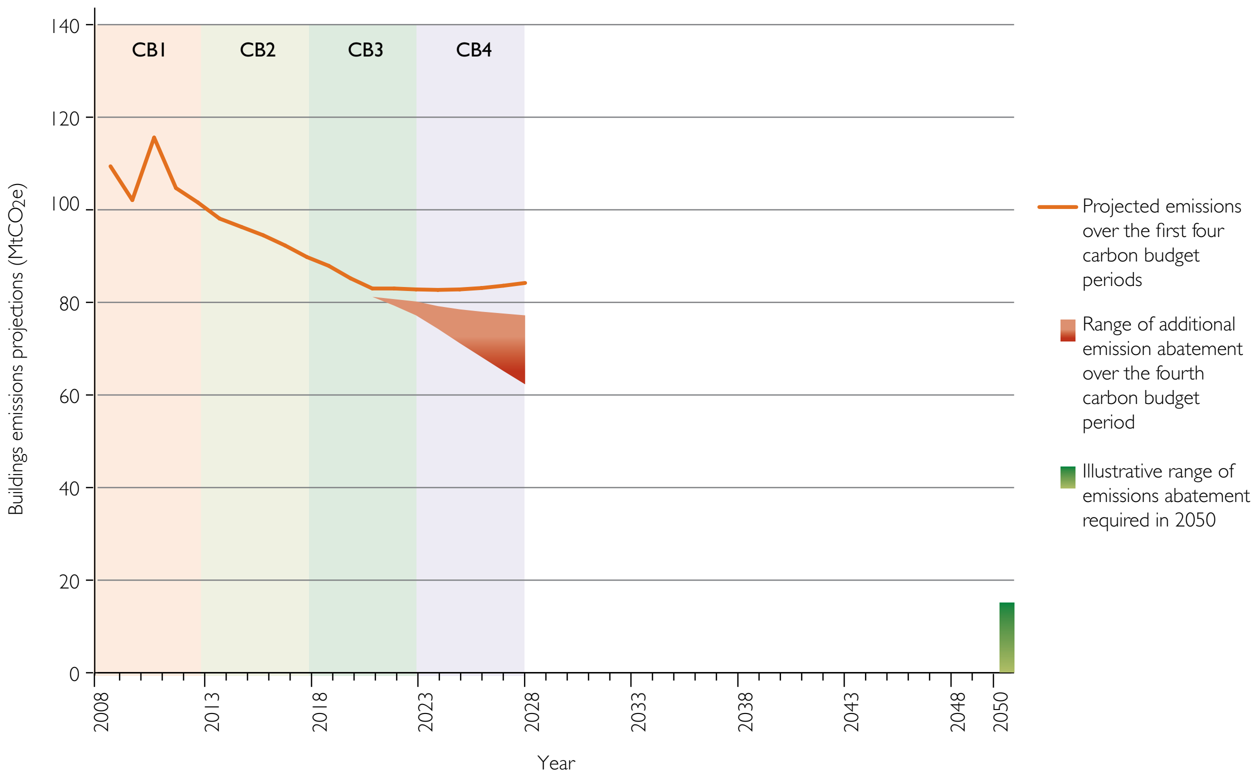
7. This is a significant challenge, and will need substantial changes in the UK's buildings and energy infrastructure, as well as in the choices made by consumers and businesses. If we get it right, we will have improved long-term economic health, supported new business opportunities in a growing low carbon global sector and, by reducing our reliance on fossil fuels for heat, enhanced the security of our energy supplies.

8. This chapter looks at options for addressing each element of this challenge, what it might mean in practice, and the potential implications for Government, consumers and business.

Where we are now – UK's demand for heat

9. Almost half (46%) of the final energy consumed in the UK is used to provide heat. The main other uses of energy are split between energy for transport (41%), energy to provide electricity for our lighting and appliances (8%), and a variety of other uses including agriculture and waste. Of this heat, around three quarters is used by households and in commercial and public buildings. The remainder is used for manufacturing materials, chemicals and goods in the industrial sector (see Chart 1). In total close to 712 TWh of heat was

Diagram 1a: Emissions projections in the buildings sector for the first three carbon budgets and illustrative ranges of emissions abatement potential in the fourth carbon budget period and in 2050



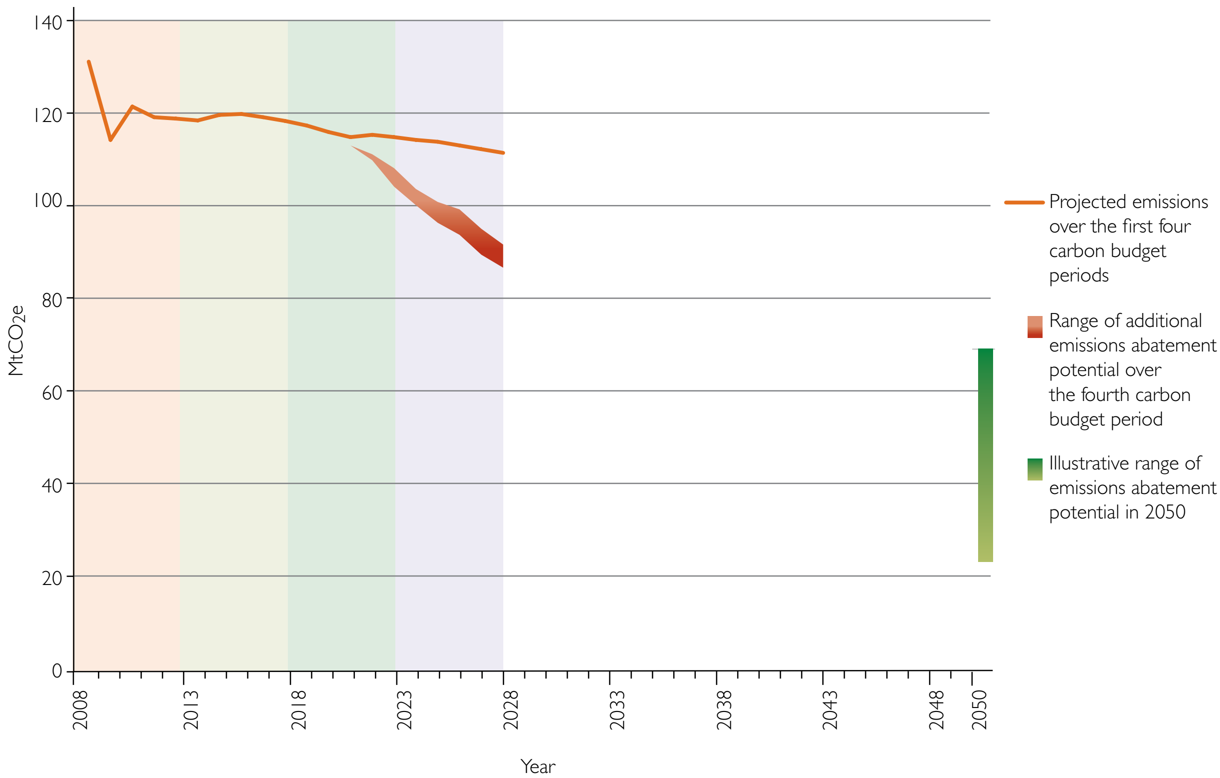
consumed in the UK in 2009, in the context of total UK energy consumption of 1668 TWh.[4] Cooling accounts for around 0.5% of overall energy demand, but in time this may increase as the UK grows warmer as a result of climate change.

10. Over three quarters (79%) of the energy we use in our homes is for space and hot water heating, most of which is met using gas-fired boilers (81%). Electricity (7%) and heating oil (9%) make up a much smaller proportion of the mix, and are used primarily in areas and in buildings not supplied by mains gas. The remainder is from solid fuels such as wood and coal (2%). Renewable heat currently represents 1% of heat generation in the UK, which is expected to grow significantly in the coming decades. Heat pumps are renewable but are classified as a type of electrical heating (see Chapter 2).

11. The demand for heat in buildings varies considerably compared to demand for electricity in buildings, across the year (see Chart 2).

12. Household heat demand has risen somewhat over the past 40 years from 400 TWh/y to 450 TWh/y, despite a marked improvement in the energy efficiency of homes and a slight reduction in the severity of winters. The average internal temperature of homes has risen by 6°C since the 1970s, and this combined with growth in housing – the number of households has risen by around 40% since the 1970s – has offset energy efficiency gains in terms of total energy used to heat homes

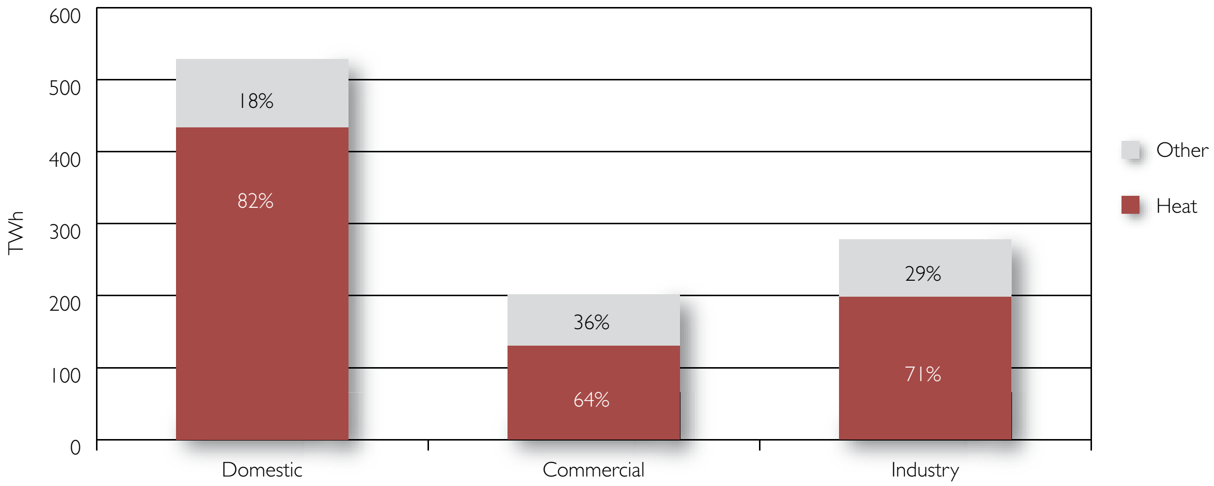
Diagram 1b: Emissions projections in industry for the first three carbon budgets and illustrative ranges of emissions abatement potential in the fourth carbon budget period and in 2050



4 DECC (2011) *Energy Consumption in the UK*

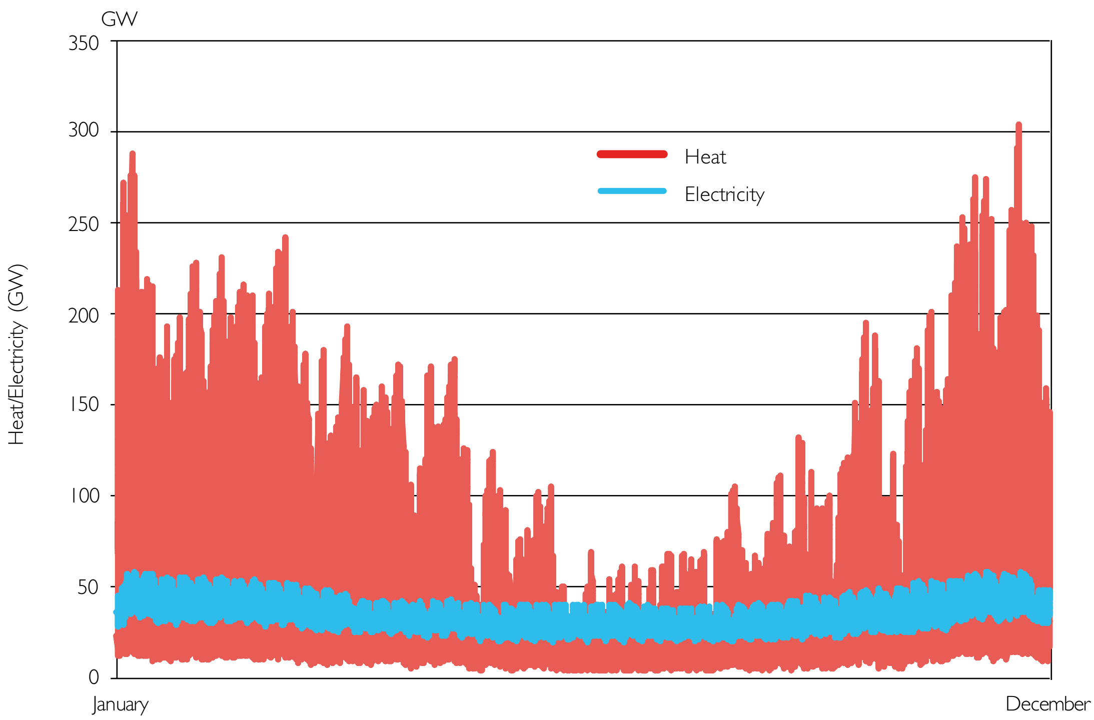
(see Chart 3). Some studies suggest these temperature increases are due to factors including the move to central heating, rather than householders actively turning up their thermostats.[5]

Chart 1: Energy consumption for heat by sector (2009)[6]



Source: Department of Energy and Climate Change

Chart 2: Comparison of heat and electricity demand variability across a year (domestic and commercial) – 2010[7]

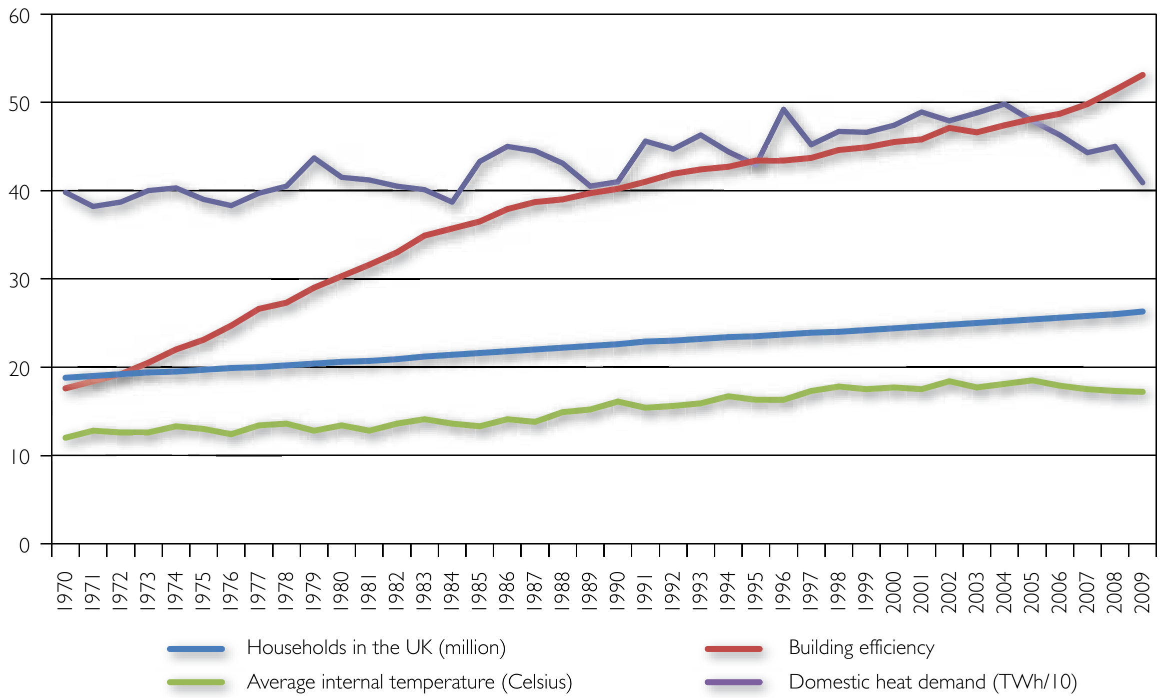


5 Shipworth, M. (2011) *Thermostat Settings In English Houses: No Evidence Of Change Between 1984 and 2007, Building and Environment*, 46 (3), pp. 635-642

6 DECC (2011) *Energy Consumption in the UK*, domestic data tables. Available at: http://www.decc.gov.uk/en/content/cms/statistics/publications/ecuk/ecuk.aspx

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

Chart 3: Growth in domestic heat demand and contributing factors: UK, 1970 to 2008[8]



Source: Department of Energy and Climate Change

13. Household heat demand is also greatly affected by other factors such as the fabric of the dwelling, the dwelling type, its location and the behaviour of its occupants and patterns of use (see Chapter 1).

14. Commercial and public sector buildings, like residential buildings, use heat energy mainly for space and hot water heating, with a smaller proportion used for cooking. Compared to the residential sector, a greater amount of energy is used for cooling.

15. Heat is also a significant component of energy demand in industry (representing around 80% of total energy demand in industry), equal to 185 TWh.[9] Heat is used to drive a diverse range of manufacturing processes either through the application of steam or direct high-temperature heat in furnaces (see Chart 4). For example, relatively low-grade heat at less than 100°C is used for purposes such as drying, while high-grade heat at greater than 400°C is used for glass and steel manufacture, with some processes demanding heat in excess of 1500°C. Heat use is concentrated in six major sectors, with much of this demand located at a relatively small number of large industrial sites.

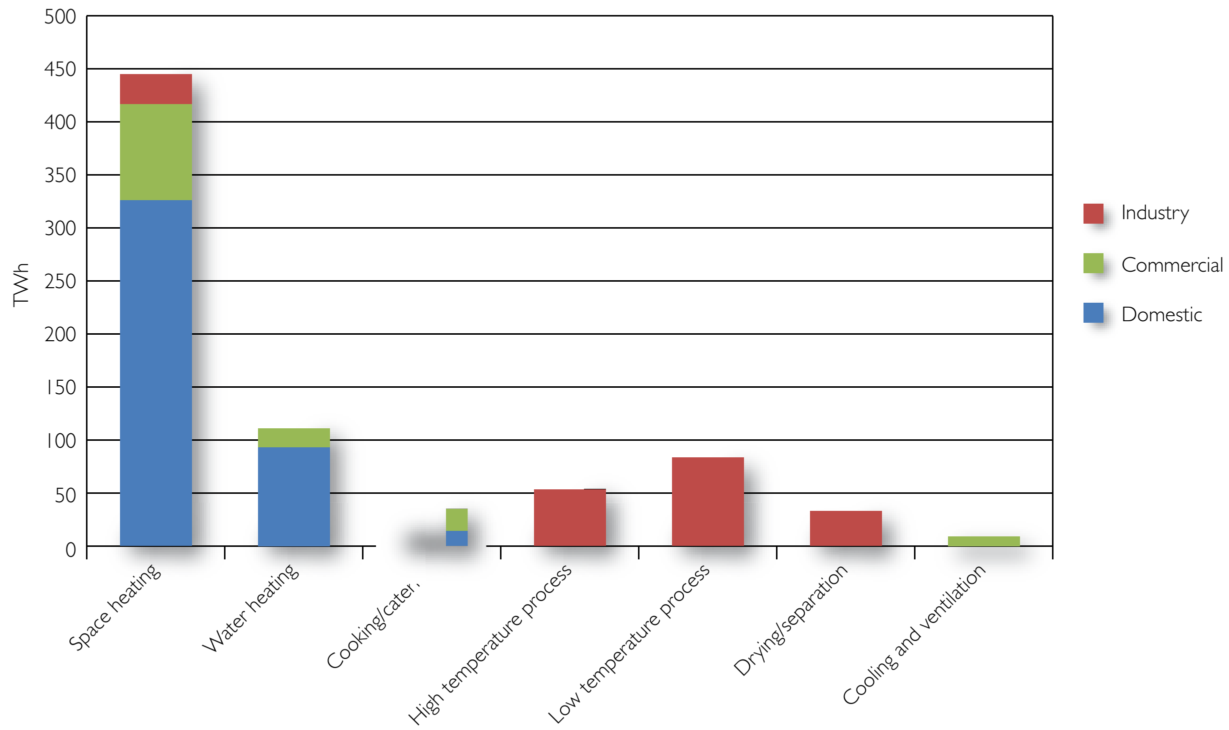
16. A difference between building heating demand and industrial heating demand is that the latter varies less through the year.

17. Currently, close to 80% of heat use in industry comes from fossil fuel combustion. Natural gas, electricity and oil/petroleum are the main energy sources, together with other fuels such as refinery flue gases and some solid fuels such as coal and coke.

8 DECC (2011) *Energy Consumption in the UK*, domestic data tables. Available at: http://www.decc.gov.uk/en/content/cms/statistics/publications/ecuk/ecuk.aspx. Domestic heat demand covers space heating, water, and cooking. Domestic heat series shown as TWh divided by 10 to fit scale of chart

9 DECC (2011) *Energy Consumption in the UK*, derived from table 1.14

Chart 4: Energy consumption for heating by sub sector and end-use (2009)[10]

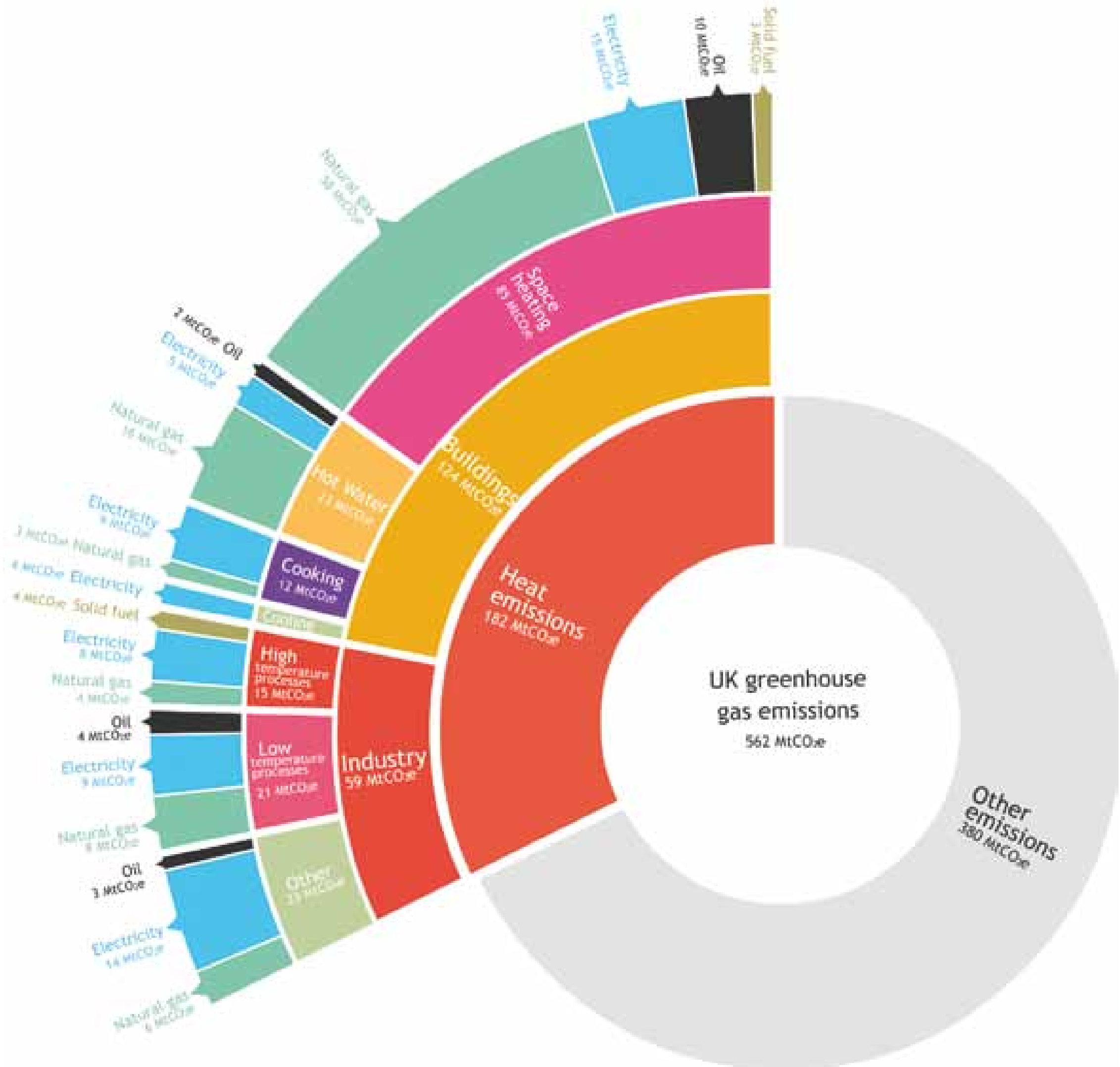


UK greenhouse gas emissions from heat

18. Generating heat causes around a third of UK greenhouse gas emissions. The domestic and industrial sectors are responsible for roughly equal emissions, even though domestic heat demand accounts for a larger proportion of final energy use. This is due to industry using a higher proportion of more carbon-intensive fuels to achieve the high temperatures needed (see Chart 5).

10 DECC (2011) *Energy Consumption in the UK*, domestic data tables. Available at: http://www.decc.gov.uk/en/content/cms/statistics/publications/ecuk/ecuk.aspx. Domestic heat demand covers space heating, water, and cooking. Domestic heat series shown as TWh divided by 10 to fit scale of chart

Chart 5: UK heat emissions by sector (2008)



The UK heat market

19. The energy system in the UK has undergone some radical changes in recent decades. Most energy infrastructure – the coal industry, power stations, gas storage – was previously in public ownership. The gas and electricity markets were privatised in the 1980s and are now operating as regulated utilities, with Ofgem having a statutory role as the independent regulator. Ofgem is sometimes referred to as the "energy regulator" but there are important elements of the energy market which are not regulated, including heat delivered through networks, renewable heat systems, and fuels such as oil, coal and bottled gas. The installation of gas heating systems is regulated through Gas Safe, which is primarily a health and safety regulatory regime.[11]

20. The UK domestic heating market is still growing steadily though this has slowed in line with the overall economy. The market is estimated to have grown by 1% a year between 2008 and 2010, reaching a projected £1.6 billion by the end of 2010. Prior to that, stronger growth of 8% was recorded in 2006. But even allowing for the current economic climate the

11 Similarly, the Heating Equipment Testing and Approvals Scheme (HETAS) is the Government recognised scheme that approves domestic biomass and solid fuel heating appliances, fuels and services

UK market is projected to grow to over £2 billion by 2015.[12]

21. The market for lower carbon heat in the UK is currently small, but growing rapidly. Heat from renewable sources increased by 17% during 2010. Recent growth has mostly been in biomass, but there are early signs of considerable growth in the heat pump market especially for new build housing and commercial developments. It will be important to support the innovation and investment which will help to grow the supply chain, deliver the reduction in costs needed for low carbon heat technologies to reach mass market level, and increase consumer awareness and interest in these technologies.

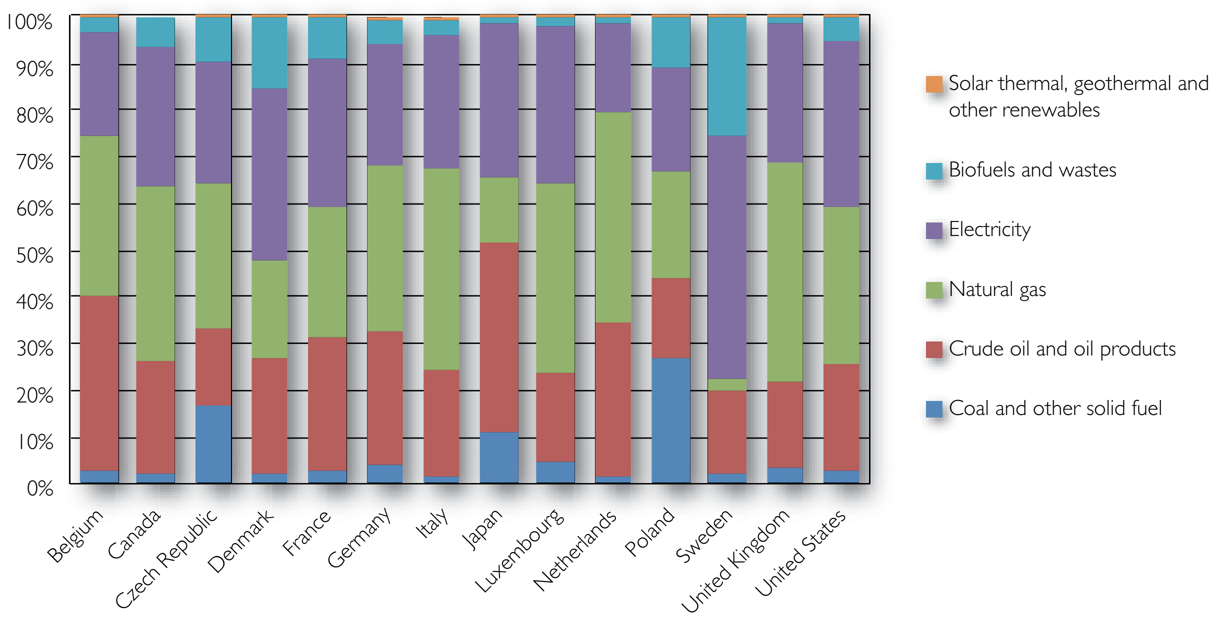
22. Relative to renewables, the market for 'direct' heat purchases through networks is still small, with only about 172, 000 homes currently on heat networks.[13] Payments are often rolled into the residents' rents; a number of industrial parks supply steam or hot water to their tenants. Looking ahead, we will need to seize the opportunities to increase the trade in heat, particularly heat that is currently discarded into the environment (e.g. recoverable heat from heavy industry).

Heat in other countries

23. Elsewhere in the world, fuel use for heat varies significantly according to climate – particularly the severity of winters – and the structure of industries. In most countries, as in the UK, the dominant fuel for heat is natural gas, which fuels on average 57% of heat globally. Other fossil fuels are also a significant contributor, collectively fuelling 29% of non-electric heat consumption. There are however a few notable exceptions including Sweden which sources 67% of its heat renewably from electricity, biomass and waste material (see Chart 6).

24. The way in which heat is delivered varies more significantly in other countries. Unlike the UK, other countries such as Denmark, Sweden and Finland do not have a large scale natural gas

Chart 6: Global heat consumption by fuel



Source: Energy Balances of OECD countries, 2011 edition; International Energy Agency

12 MBD (2010) *UK Domestic Central Heating Market Research Report*
13 BRE (2008) *Heat Metering Cost Benefit Analysis*

grid, and make more use of municipal level solutions such as heating and cooling networks drawing on a range of different fuel and generation types. In countries such as the Netherlands, Germany and Austria, natural gas consumption for heat is at similar levels per capita to the UK but more of it is used in Combined Heat and Power (CHP) plants.

Our options – transforming building-level and industrial heat

25. To achieve the levels of decarbonisation set out in the *Carbon Plan*, we will need to address every aspect of our heat and cooling consumption. The Government is determined to address these challenges in a way that minimises costs and maximises benefits to the economy and for consumers.

26. This will require a transformation in our buildings and across our industry:

- in buildings, this means looking at ways of reducing heat demand and promoting energy efficiency alongside decarbonising heating and cooling supply; and
- in industry, this means looking at a mix of options around energy, process and material efficiency, switching to less carbon intensive fuels to provide heat and the potential for deployment of Carbon Capture and Storage technology.

Reducing demand for energy in buildings

27. Reducing our demand for heat is a highly cost-effective way of cutting emissions from buildings. We can achieve this in three ways:

- by increasing thermal efficiency through better insulation;
- by increasing the efficiency of heating delivery systems; and
- by improving how we manage our heat use (for example by avoiding heating unoccupied spaces through use of heating controls, or using meters to better understand our use), we can reduce our consumption of energy for heat while bringing down bill costs – without necessarily sacrificing comfort levels.

28. Insulation will not only reduce average demand, it will also reduce the peaks of heating demand during short periods in the winter.

29. But the challenges and barriers are well known and need to be tackled effectively – including upfront costs, consumers feeling that they are already doing enough, perceived hassle/disruption, lack of awareness of the benefits or how to access information on the options available.[14]

30. Together the Green Deal, Energy Company Obligation and Smart Meters will address many of these barriers by removing upfront costs, helping vulnerable consumers and enabling people to make the best use of their energy (see Chapter 1).

14 DECC (2011) *Green Deal customer insight research*. Available at: http://www.decc.gov.uk/en/content/cms/consultations/green_deal/green_deal.aspx
Available at: http://www.decc.gov.uk/en/content/cms/consultations/green_deal/green_deal.aspx

Decarbonising heating and cooling supply in buildings

31. Even with substantial improvements in energy efficiency, demand will never reduce to zero. We will therefore not be able fully to decarbonise our buildings without tackling our heat supply – for example, even a building built to the Passivhaus standard used in some parts of Europe[15] will require energy for hot water and cooking.

32. As things stand, we are increasingly dependent on other countries for fossil fuels, particularly gas supplies, to provide heat. Over the coming decades we will need to reduce our dependence on gas and other carbon-intensive fuels for heating and replace them with low carbon technologies which will both strengthen our energy security and aid the delivery of our carbon targets. But this is expected to be a gradual process.

33. There are three ways we could supply low carbon heat:

- by replacing existing building-level heating systems with low carbon alternatives;
- by changing the content of the gas in the existing gas grid; and
- by constructing heat networks connected to low carbon sources.

Building-level technologies

34. Decarbonising our heat supply at the level of individual buildings will require current heating systems (such as gas boilers) to be substituted for a range of low carbon alternatives such as biomass boilers, solar thermal, and heat pumps which provide more energy and warmth than the electricity they consume. There may also be transitional technologies, such as natural gas-powered building-level CHP, along with domestic scale units (known as micro-CHP) which can reduce the carbon emissions of heating in the short term.

35. As the electricity system decarbonises, technologies such as heat pumps and even electric resistive heating in buildings will be an increasingly effective way to decarbonise heat supply. However, increased demand for electricity for heating will require careful planning to ensure that we have both the electricity generating capacity and electricity grid infrastructure to cope with this demand.

36. The temporary peaks of heating demand that occur when temperatures drop below zero are a particular concern.

37. Behavioural barriers and the impacts on air quality and noise may affect deployment of building-level low carbon heating systems in homes and the commercial sector. For example, low awareness and knowledge of the technologies and benefits, inability or unwillingness to pay up-front costs, and concerns over installer skills.[16] While the Government does not expect mass market deployment of low carbon supply technologies this decade, there are opportunities now to build the market and supply chains, improve environmental performance and bring down capital costs. This can be achieved by targeting commercial and public sector buildings, and off-gas grid homes, as well as increasing consumer awareness and understanding of the technologies. In doing so, we can learn from the first wave of installations and enhance our institutional capacity (see Chapter 2).

38. Renewable heat installations which are deployed by 2020, will contribute to meeting the Government's 2020 Renewables Target.[17]

15 "Passivhaus" refers to an ultra-low standard for energy efficiency in a building

16 Consumer Focus (2011), '*Keeping FiT:* Consumers' attitudes and experiences of microgeneration'. http://www.consumerfocus.org.uk/publications/keeping-fit-consumers-attitudes-and-experiences-of-microgeneration

17 The 2009 Renewable Energy Directive sets a target for the UK to achieve 15% of its energy consumption from renewable sources by 2020. See: *DECC Renewable Energy Roadmap*, available at: http://www.decc.gov.uk/en/content/cms/meeting_energy/renewable_ener/re_roadmap/re_roadmap.aspx

Changing content of the gas grid

39. Two low carbon fuels could be deployed through a national grid network, similar to how natural gas is delivered today: biomethane and hydrogen.

40. Sustainable biomass and wastes can be converted to gas and upgraded to biomethane, a gas that can be directly substituted for or blended with natural gas in the grid. Its compatibility with existing boilers and CHP systems would also mean we would decarbonise our heating and hot water supply without having to modify our heating systems. However, the scale of biomethane injection is dependent on technological advances and the availability of affordable and sustainable biomass resources.

41. Gas consumption in buildings currently runs at close to 500 TWh per year. Some biomethane produced from anaerobic digestion is currently injected into the gas grid. In the future, biomethane (in the form of bio synthetic natural gas or BioSNG) could also come from the gasification of waste(s) or biomass. But to meet anything like current levels of demand would require more biomass than is reasonably available to the UK at affordable levels.[18]

42. The Government's forthcoming bioenergy strategy shows that some biomethane injection into the gas grid is a viable long-term option for heat decarbonisation, particularly for industrial processes. However, given competing demand for biomass resources across energy and non-energy sectors biomethane injection cannot be a full-scale replacement for natural gas for building-level heat.

43. It may be possible to replace natural gas with hydrogen, created by electrolysis of water powered by low carbon electricity generation or hydrogen created by reforming natural gas (with the generated carbon dioxide captured and stored, for it to qualify as low carbon) or hydrogen from power stations fitted with Carbon Capture and Storage. Fossil fuel derived hydrogen will not suffer from the limited feedstock problem faced by biomethane. However, at present hydrogen is expensive and would require new boilers and gas appliances. The Government is nevertheless looking into this further as it could offer a way of storing electricity which can then be used for either heating or transport (see Chapter 2).

Developing heat networks

44. In the right areas, it can be less costly and more efficient to connect buildings, communities or industrial sites to a low carbon source through heat networks than to install individual building-level systems. Heat networks may also be more convenient for consumers than gas boilers, due to a lower requirement for maintenance and repair. With appropriate forethought, heat networks can be designed so the heat source can be replaced with less inconvenience to consumers than replacing individual boilers. For instance, they could be designed to make use of transitional heat sources this decade like combined heat and power using natural gas, which can be upgraded later to low carbon heat sources, like large scale heat pumps, geothermal energy, or heat recovered from industrial sites or thermal power stations.

45. Heat networks can be integrated with local authority plans for urban regeneration, for reducing fuel poverty, and addressing environmental issues. They can also be part of an integrated low carbon system, as seen in some European cities.

46. Up to half of the heat load in England is in areas that have sufficiently dense heat loads to

18 The Committee on Climate Change's Bioenergy Review and analysis supporting the Government's forthcoming bioenergy strategy indicates that based on current feedstock availability scenarios, technological costs and alternative abatement opportunities from the use of biomass resources, biomethane injection into the grid should only be one part of a cost effective decarbonisation strategy

make heat networks economically viable.[19] However, installing them can be both expensive and complicated, and presents a strategic challenge for local authorities in developing them.

47. Heat networks also have an impact on the development of the heat market at larger scales. In particular, there are opportunities for commercial and industrial biomass boilers and CHP plants, for energy from waste plants, and for recoverable heat from power generation and industrial process to feed into heat networks (see Chapter 3).

Decarbonising heat in industrial processes

48. At an industrial level, achieving the desired emissions reductions while maintaining competitive growth presents a challenge.

49. Across industry we will need to address the demand for heat:

- by using more energy efficient means of generating heat such as CHP;
- by taking up cost-effective measures including process and thermal efficiency (e.g. recovering and re-using heat), and seizing opportunities that arise as new technologies and materials are developed; and
- by looking at ways to increase the useful lifetime of manufactured products through greater material efficiency.

50. As in buildings, we will need to tackle our heat supply if we are to reduce emissions in this sector to the desired level:

- by fuel switching to low carbon alternatives like sustainable biomass (either directly or through the existing gas grid), and increased electrification; and
- by innovating where more challenging options are required. For some processes where emissions are an inherent part of the chemistry (like steel and refineries) these can only be mitigated with advanced technologies which require innovation, such as Carbon Capture and Storage.

51. But there is a risk that as the result of the increase in energy prices and if pushed too hard to move to low carbon, it may be more profitable for firms to relocate overseas. It is therefore critical that we support the transition and offset the costs of the changes required in this sector, and push for concerted global action to reduce emissions (see Chapter 4).

How we get there – the challenge for Government, industry, business and consumers

52. In order to achieve this level of change, the heat challenge for the UK is threefold:

- the Government will need to understand the physical, technical, sustainable and practical means by which we can decarbonise heat across the UK, and work with industry, business and consumers to explore which options are most appropriate in which circumstances, and what barriers need to be overcome;

19 Poyry (2009) *The Potential & Costs of District Heating Networks*

- the Government will need to provide the long-term policy framework and support required for businesses, investors and consumers to make this change possible and cost-effective for society; and

- consumers will need to make choices around the way in which they use heat, and the Government will need to remove any barriers that prevent them from doing so in the most energy-efficient and affordable way.

53. If these challenges can be successfully tackled, the transformation of heat-generation and heat-use will not only meet the objectives of reducing emissions from heat, contributing to the UK's effort on tackling climate change, but will also:

- help ensure more physical security and a diverse energy supply;

- improve productivity through greater energy efficiency and support growth in low carbon heat generation and its supply chain; and

- ensure the most vulnerable are supported during the transition to a low carbon economy.

54. Figure 1 illustrates the Government's strategic framework for decarbonising heat supply in the UK. Chapter 5 sets out the Government's framework for action in more detail.

Questions

- Do you agree with the nature of the challenge described for reducing emissions from heating and cooling across the UK?

- Do you have evidence that we should be taking account of as we develop our view of this challenge?

- Are there other dimensions that we should be factoring in as we pursue our responses to this challenge?

- Do you have evidence about the role that different technologies or approaches might play in our response to the challenge, or the key barriers that we will have to address?

Figure 1: The Government's strategic framework for decarbonising heat supply – an overview


w Carbon Solutions
Heat Strategy
Electrification
o CHP
CCS
25% fossil fuels in 2050
Next steps
Energy Intensive Industry Package to support intensive industries in the short term.
Begin now to encourage UK and international innovation, such as industrial CCS and advanced bioenergy.
Target ongoing support through the RHI at bio-CHP and biomass boilers for industrial heat between now and 2030, and support electrification in the long term.
District Heating
0% fossil fuels in 2050
Build evidence base to identify issues and barriers for low carbon heat networks, and within 12 months set out policy options to address these.
As appropriate, support expansion and development of low carbon heat networks this decade through new measures.
Target support for renewable heat on commercial buildings and off-gas-grid homes. This will maximise cost effectiveness, develop the supply chain and allow energy efficiency to bed in.
Develop a package of measures to secure large scale deployment of heat pumps from 2015.
5M
uildings
Heat Pumps
Suburban buildings
15M buildings

Chapter 1: Managing Heat Demand in Buildings

- *Much of the heat generated in the UK is wasted – it escapes from poorly insulated buildings, is used to heat unoccupied spaces or to achieve temperatures beyond what people consider comfortable.*
- *Wasting heat costs money and resources. Last year alone avoidable heat loss from poorly-insulated buildings cost UK consumers over well over £1 billion, reducing badly needed spending power.*
- *Dramatic reductions in heat demand are possible by improving our buildings and changing our behaviour. But if no action is taken to manage heat demand and historic trends continue, demand could rise by up to 50% by 2050, driven by increased internal temperatures and building numbers.*[20] *If this happened, it could mean higher average heat costs per household, and could exacerbate the challenge of moving to low carbon heating.*
- *But reducing our demand for heat will save money and cut emissions. It will also reduce the cost of converting to low carbon heating.*
- *The earlier we take action, the sooner we will benefit from more comfortable houses, reduced heating costs, lower emissions and greater economic productivity.*

20 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

Where we need to be

1.1 Reducing wasted heat is a highly cost effective way of cutting emissions from buildings. Acting now, so that by 2020 our building stock is substantially more efficient than today, will save consumers money, reduce UK emissions and pave the way for low carbon heating in the decades to come.

1.2 Minimising avoidable heat loss and unnecessary heating is also key to safeguarding affordable warmth and tackling fuel poverty long term.

1.3 And reducing overall demand will also curtail short-term peaks in heating demand, making it easier and cheaper to supply heating from low carbon sources.

The Carbon Plan Trajectory

1.4 As set out in the Carbon Plan, this decade we need to complete all remaining, practical loft and cavity wall insulations. This could save consumers a further £270 million a year and reduce our annual carbon emissions.

1.5 Alongside this, the Government will support the initial roll out of solid wall insulation, deploying up to 1.5 million measures by 2020, on the way to over 2.5 million by 2030 (see Chart 7).

1.6 Other measures to reduce heat loss, such as double and triple glazing, will also continue to be deployed at scale, supported by the Green Deal – the Government's new platform for ongoing investment in energy efficiency.

Where we are now

1.7 The UK has around 26.7 million domestic houses and flats, and around 3 million, typically larger, commercial and public buildings.

1.8 In total, our buildings demand over 500 TWh for heating per year, around 75% of total UK heat demand and a third of all UK energy demand. Three quarters of this is for our homes, which have an average annual demand of

Chart 7: Projected deployment of Solid Wall Insulation over the first three carbon budgets and illustrative range of deployment over the fourth carbon budget period and in 2050

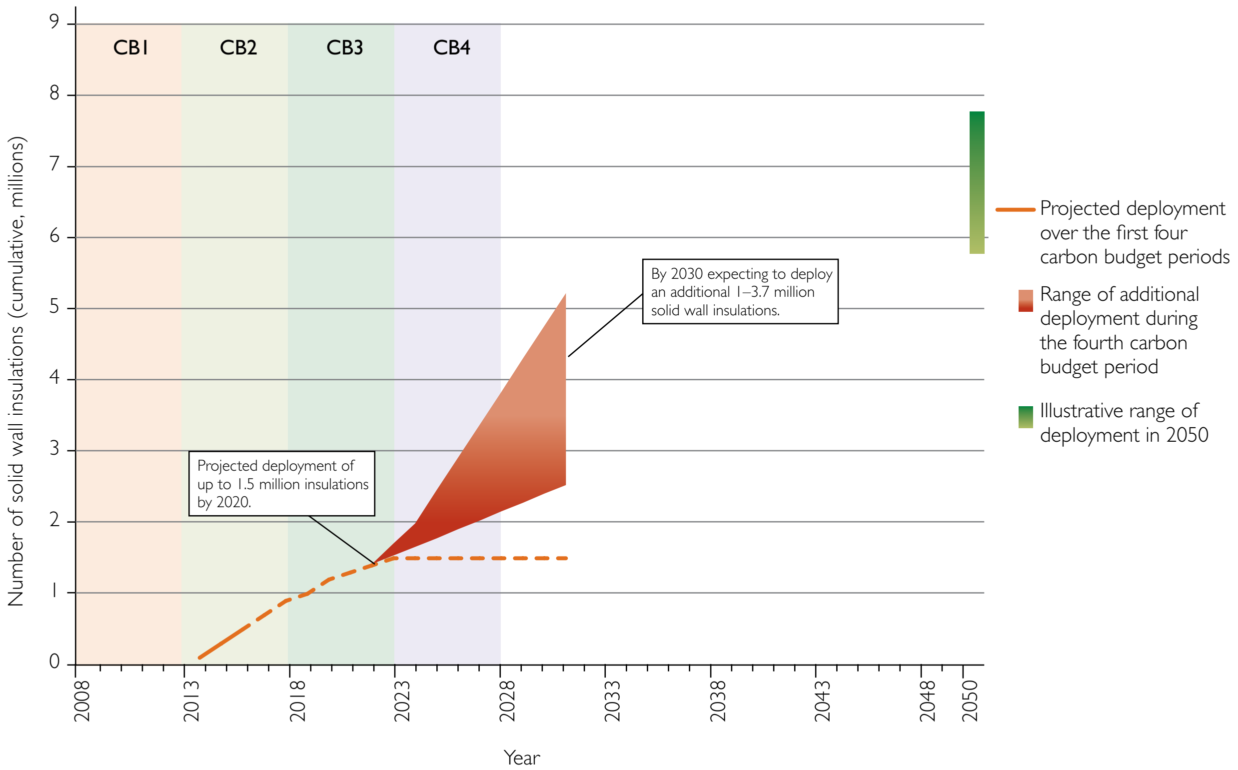


Chart 8: Heat demand from buildings (2009)

Source: Department of Energy and Climate Change

* Only sources of supply greater than 1 TWh shown

around 15 MWh each. Larger commercial and public buildings are fewer in number, but have far higher heating and cooling demand per building, reflecting their increased size and occupancy (see Chart 8).

1.9 However, the demand for heat varies substantially between even similar buildings, with occupant behaviour, heating system and how well the building's fabric retains heat all impacting on a building's heat demand.

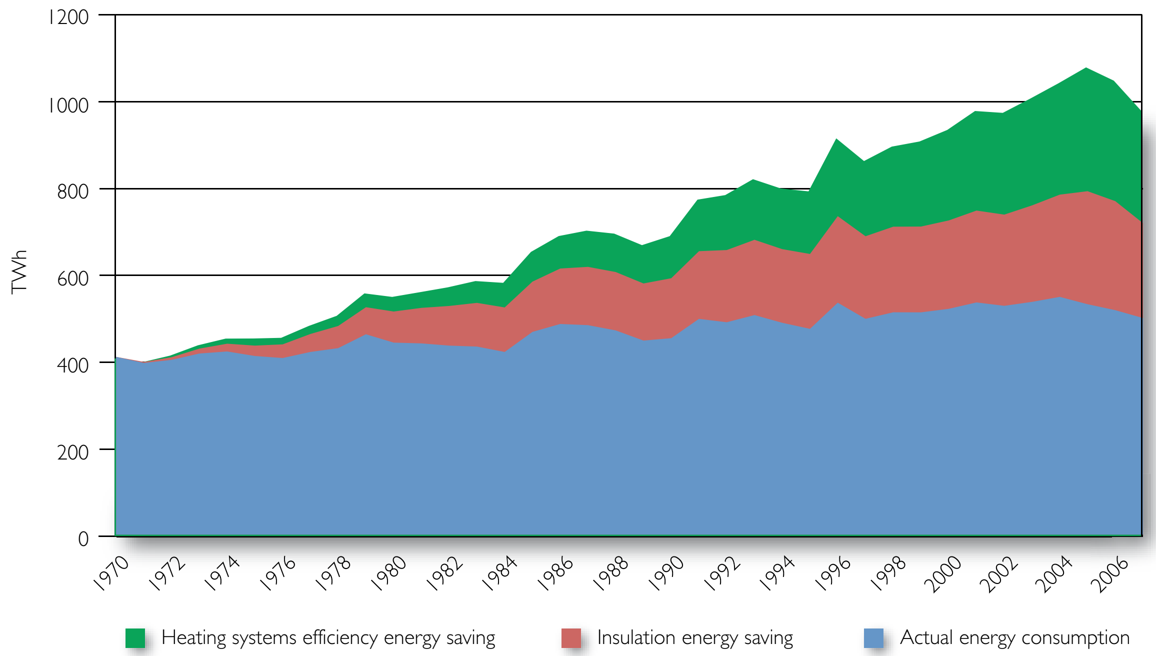
1.10 Over the last four decades, technologies such as cavity wall, loft insulation and condensing boilers have substantially improved the efficiency of our buildings and have reduced UK demand for heating fuels by around 49% (see Chart 9).[21]

1.11 But trends towards more efficient buildings have been offset by an increase in the number of buildings themselves, with 4 million new buildings having been built in the last 20 years. In parallel, there has been a marked increase in the average internal temperatures of buildings from 12°C in 1970 to nearly 18°C today – partly driven by the mass uptake of central heating.[22]

21 DECC (2011) *Energy Consumption in the UK.* Available at: http://www.decc.gov.uk/en/content/cms/statistics/publications/ecuk/ecuk.aspx

22 DECC (2011) *Domestic Energy Fact File and Housing Surveys.* Available at: http://www.decc.gov.uk/en/content/cms/statistics/energy_stats/en_effic_stats/dom_fact/dom_fact.aspx

Chart 9: Energy savings from insulation measures and condensing boilers 1970–2007



Source: Department of Energy and Climate Change

Our Options

1.12 Heat demand can be constrained, either by reducing the heat lost from our buildings or by reducing the average internal temperature of buildings, including through behaviour change or optimised heating systems and controls.

1.13 The scale of energy used for heating means that even small improvements in buildings and changes in behaviour can amount to big savings across the UK. For example, if every household reduced their average internal temperature by 1°C the energy saved would be around 10%.

1.14 By continuing to deploy established measures like cavity wall insulation at scale, and supporting newer fabric technologies like solid wall insulation, we could reduce heat demand by up to 27 TWh by 2020 and may also constrain demand for cooling in summer months. However, rebound effects such as comfort taking are likely to see some efficiency improvements used to achieve higher temperatures in winter rather than a reduction in bills and demand.

1.15 Similarly, by setting in place building standards for new buildings that minimise heat loss, the Government can help secure long-term savings in energy and carbon, and limit increases in heat demand from a rising population.

1.16 And, by changing behaviours, alongside deploying advanced and intuitive heating controls, we could realise further substantial savings. For example, by encouraging reductions in temperature and avoiding the heating of unoccupied buildings and spaces.

How we get there

Reducing Heat Loss from Our Buildings

1.17 The UK has some of the oldest and least thermally-efficient building stock in Europe. Taking action now to improve our buildings will reduce bills and cut emissions this decade, and help the mass roll out of low carbon heating technologies in the next.

1.18 The fabric quality of our existing buildings can be improved through retrofit measures or installed during the construction of buildings, as specified in building regulations. Retrofit measures can significantly reduce heating and cooling demand from existing buildings. And ensuring new-build regulations maximise the efficiency of new buildings will limit increases in heating and cooling demand caused by building more homes and offices, and prevent wasteful heating and cooling for decades to come.

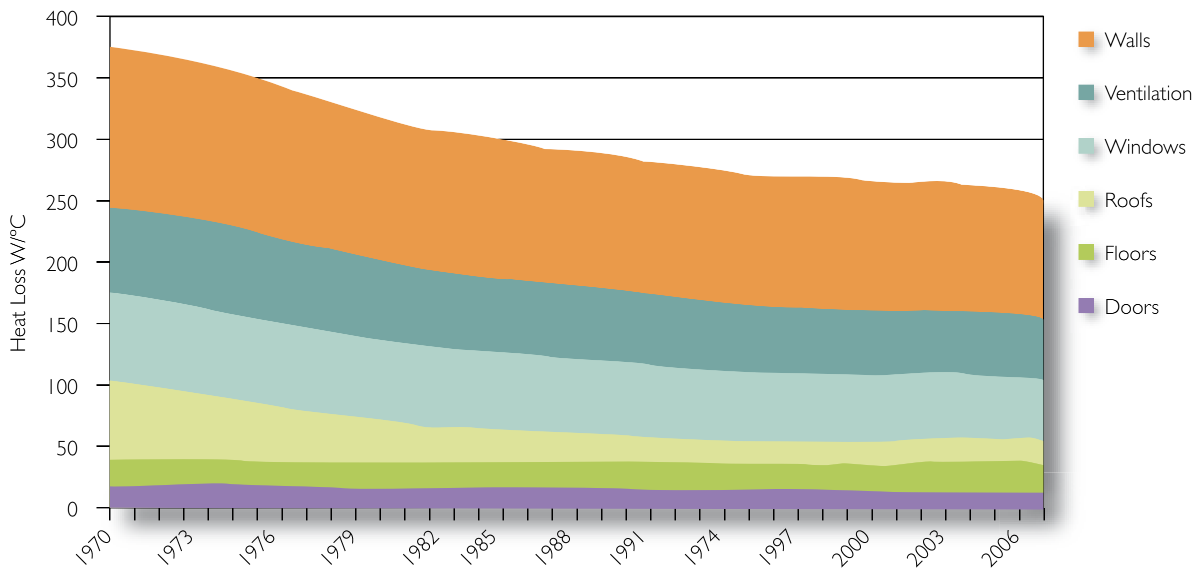
1.19 In the last 40 years there has been significant progress in both retrofit measures and new build standards. This has reduced heat loss from properties, especially heat lost from roofs, windows and cavity walls. In parallel, tightened standards on new buildings have reduced the heat demanded by new homes (see Chart 10).

1.20 Altogether, the improvements in the efficiency of UK houses since 1970 add up to substantial savings in money and carbon every year – and when savings from heating system efficiencies are also added to this, the scale of saving becomes clear – with around £13 billion saved in 2007 alone (see Chart 11).

1.21 Nevertheless, there is still much room for improvement, and avoidable heat loss could be costing the UK well over £1 billion a year. Therefore, it is the Government's ambition that all remaining practical loft and cavity walls be insulated within this decade, through the Green Deal.

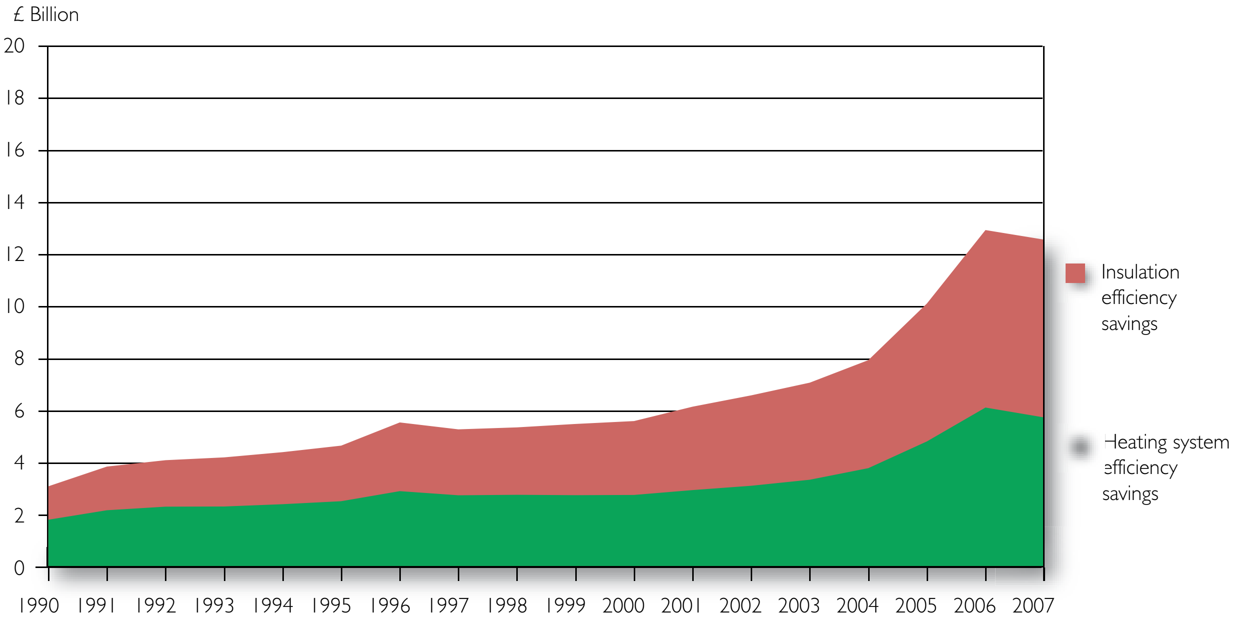
1.22 In addition, new Zero Carbon Homes standards will improve fabric standards in new buildings so that less energy is required for space heating – applying to domestic buildings from 2016 and non-domestic buildings from 2019.

Chart 10: Heat Loss of the Average Dwelling and the Whole Building Stock



Source: Department of Energy and Climate Change

Chart 11: Annual domestic bill savings from increased efficiency of buildings and gas boilers (1970 baseline)[23]



Source: Department of Energy and Climate Change

Retrofit

1.23 Based on current construction and demolition rates, around two thirds of the buildings that will be in the UK in 2050 have already been built.[24] This makes retrofit[25] technologies that can reduce an existing building's energy demand particularly important.

1.24 While more modern houses built under recent building standards have relatively high thermal efficiencies, older houses have far higher heat demands, with a typical Victorian house potentially demanding more than twice as much energy for space heating than a house built today.[26]

1.25 Measures to insulate existing buildings can reduce the energy required for space heating by limiting heat loss and enabling heating systems to work more efficiently. In a typical domestic property this improvement in efficiency can mean substantial annual savings. For example, adding cavity wall and loft insulation can save between 2500-5000 kWh, or around £100-200 a year on heating bills – with both measures expected to pay for themselves within 8 years, and many times over before needing to be replaced.

1.26 Other measures such as double glazing and solid wall insulation have longer payback periods, but may provide additional enhancements, for example in security and aesthetics. Glazing can also be adapted to help reflect solar heating during summer.

23 Savings calculated based on modeled energy savings and historic average gas prices. For modeled energy savings see: DECC (2011) *Energy Consumption in the UK*. Available at: http://www.decc.gov.uk/en/content/cms/statistics/publications/ecuk/ecuk.aspx
24 The Carbon Trust (2009) *Building the Future Today – Transforming the economic and carbon performance of the buildings we work in* http://www.carbontrust.co.uk/Publications/pages/publicationdetail.aspx?id=CTC765
25 Energy savings in this section are based on SAP data, adjusted for observed performance
26 Space heating demand modelled using the Cambridge Housing Model v2.6

1.27 In addition, insulation can act to shield buildings from high temperatures during summer months, constraining the demand for cooling. However, it will be important to ensure retrofit measures, in particular internal solid wall insulation, do not lead to summer overheating in buildings that will increase demand for cooling and impact the comfort of occupants. The Government is working with the building industry and others to understand more about the impact of better-insulated houses on summer cooling demand.

Loft insulation

1.28 Loft insulation reduces heat loss from a building by up to 27% and is usually straightforward to install. A DIY installation can cost as little as £25, and professional installers typically charge around £300.

1.29 On average, loft insulation applied to an uninsulated loft saves well over £100 a year, meaning it can be expected to pay for itself within a few years.[27]

1.30 And while the vast majority of houses with lofts already have some level of loft insulation, many buildings would benefit from an inexpensive top up, especially where there is less than 100mm of insulation – around 3 million buildings.

Cavity wall insulation

1.31 Houses built since 1900 usually have a cavity wall, this can be filled with insulating foam that effectively traps heat inside the building. Modern houses are built with pre-filled cavities so no retrofit is necessary, but in older houses insulating a cavity can reduce heat loss by around 20%.

1.32 A typical cavity wall insulation costs less than £1,000 and saves around £128 a year, meaning in most cases it pays for itself within 8 years.

1.33 Installation rates of cavity walls have been dramatically accelerated in recent years, reaching 600,000 a year in 2009, and it is estimated that over 11 million homes now have cavity wall insulation. The Government expects that of the remaining 7.5 million uninsulated cavities, up to 2.7 million could be insulated through conventional techniques, and will be completed this decade. Harder to treat cavities, for example, unusually narrow cavities, require more specialised approaches, and in some cases solid wall insulation will be more appropriate.

27 Most houses already have some level of loft insulation, and savings for loft top-ups will be substantially less

Solid wall insulation

1.34 In a solid-walled building, solid wall insulation has a comparatively larger effect on reducing heat loss than cavity wall insulation in a cavity-walled building – substantially reducing heat lost through solid walls.[28]

1.35 About 7 million houses in the UK have solid walls, particularly houses built before 1900.

Before SWI

After SWI

For these houses without a cavity wall, or where cavities are considered too hard to treat, solid wall insulation may be a good option.

1.36 Solid wall insulation adds a layer of insulating cladding to the outside or inside of a building's external walls. External cladding may therefore also improve the appearance of some buildings and act to protect external walls.

1.37 Solid wall insulation generally costs between £6,000 and £11,000 and can save around £334 a year. Payback periods are longer than for cavity wall insulation, but in many cases there are additional benefits to the aesthetics and upkeep of buildings.

28 Solid wall insulation can reduce heat transfer through a solid wall by up to 80%, although the realised reduction will depend on the particular composition and thickness of the wall

Glazing

1.38 Double glazed windows and doors can enhance the appearance and security of a building while cutting down on the energy needed for maintaining comfortable temperatures. Moving from single to double glazing, for example, can reduce a building's heat demand by over 10%, and will more than half the heat lost through windows.

1.39 Modern A-rated double glazing is substantially more efficient than earlier models. Ultra-modern triple-glazed windows can reduce heat loss even further, and as costs decrease this may become a key fabric technology.

Other Measures

1.40 There are a range of other measures that can be applied to prevent heat loss from buildings, including floor insulation, to prevent heat escaping from under a building, and insulated doors. Even basic measures to reduce draughts can have a material effect, reducing heat loss by up to 5% while increasing comfort.

The Green Deal

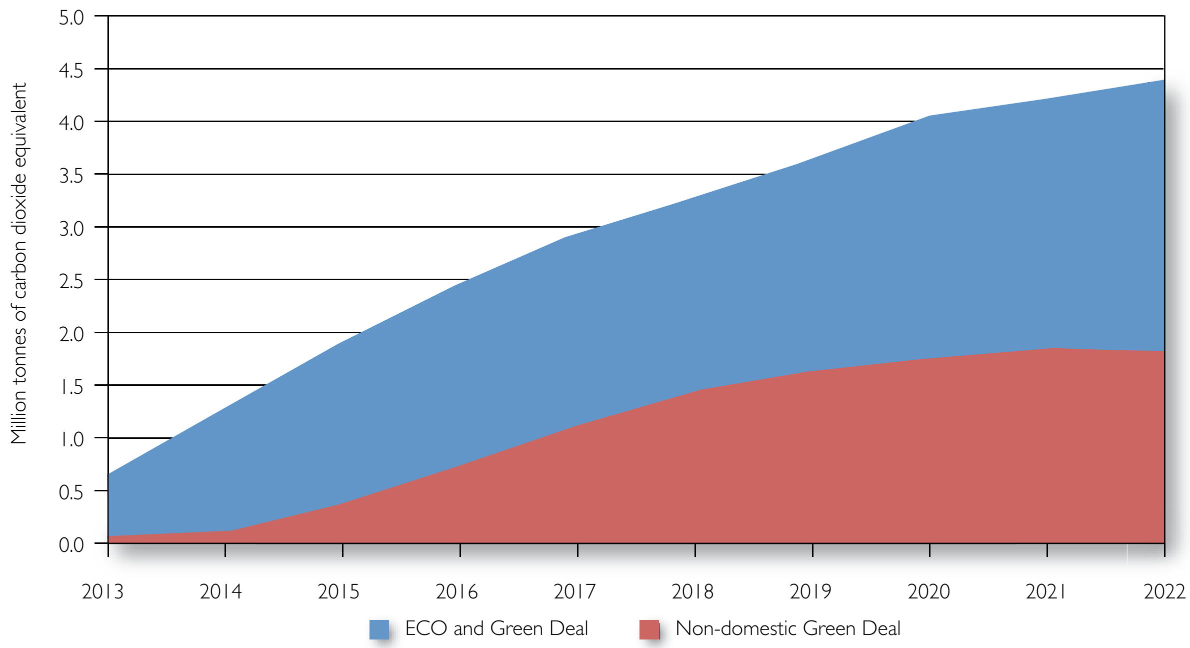
The Green Deal

1.41 This year, the Government will launch the Green Deal – a radical programme to transform the energy efficiency of UK buildings and support growth in low carbon businesses.

1.42 At its heart, the Green Deal will provide a finance mechanism that removes the upfront cost of retrofit measures and enables homeowners, tenants, landlords and businesses to spread the cost of key retrofit technologies over time.

1.43 By removing upfront costs, the Green Deal will transform access to cost-effective energy efficiency measures, meaning that occupants can benefit from warmer, more efficient homes right away, with the improvements being paid for over time from expected savings on energy bills. And, as many energy efficiency measures will pay for themselves relatively quickly, occupants will continue to benefit from efficiency measures long after the initial payback period is completed.

Chart 12: Projected Carbon Savings from ECO and Green Deal



Source: DECC

1.44 The Green Deal will start with an assessment of the measures most suitable to individual properties to help occupants make the most of the opportunity it offers. And, as Green Deals will be attached to building and not occupants, long term improvements can be carried out without the need to commit to long tenancies.

Building Standards

1.45 The first thermal regulations for new buildings were introduced in 1975. Since then, subsequent standards have dramatically improved the level and quality of thermal insulation in new buildings, such that a house built today demands significantly less energy for space heating than an equivalent house built 35 years ago. The Government is currently consulting on options for tightening requirements in 2013, further incentivising the construction industry to take advantage of new materials and technologies that can lock in long-term energy efficiency.

1.46 Zero Carbon Homes standards, being introduced in 2016, and Zero Carbon Non-domestic Buildings standards from 2019, will further raise carbon reduction standards in new build, reducing heat lost from new buildings and providing opportunities for on-site renewable heat technologies, such as heat pumps, along with further demand and funding for low carbon heat through off-site allowable solutions.

1.47 To encourage and accelerate retrofit activity, the current Building Regulations consultation also includes proposals to require additional energy efficiency improvements – known as 'consequential improvements' – where work, such as an extension, takes place to an existing building and the Green Deal is available to meet the up-front cost.

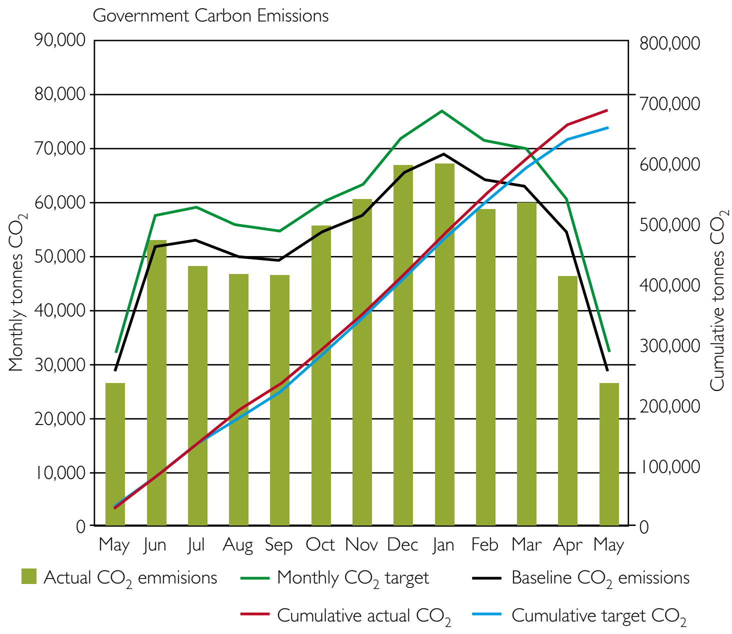
Reducing Average Internal Temperatures

1.48 In addition to improving the fabric efficiency of our buildings, the Government is also keen that other measures, technologies and behaviours that affect heat demand in buildings also support overall efficiency. This includes how heat is used and distributed in properties, and the interactions between occupants, heating systems and the building itself.

Box 3: Case Study: Heating Management Strategy in UK Government Departments, London

Government has been leading the way on action to reduce emissions.

Between May 2010 and May 2011 the Government exceeded its target of reducing carbon emissions by 10% in 12 months. The Government achieved this, in part, by drawing on the following behaviour change techniques:



- changing the defaults around when heating and cooling systems were turned on and off; aligning operating temperatures with best practice; and ensuring that buildings were shut down effectively during relatively quiet periods; and
- using social norms to encourage behaviour change by publishing monthly performance league tables to introduce a competitive element to departmental performance; and installing real-time displays and making these available online.

Smart Meters

1.49 The choices consumers and businesses make on how they use their energy can have a major impact on overall energy demand and the costs they face.

1.50 The Government's vision is for every home and small business to have smart electricity and gas meters by 2019, delivering benefits to consumers, suppliers and networks. This will involve the replacement of 53 million gas and electricity meters through 30 million visits to homes and smaller businesses.

1.51 Smart meters will give consumers a greater understanding of their electricity and gas use, helping them control energy use, save money and reduce emissions.

1.52 In addition, suppliers will have access to accurate data for billing, and energy networks will have better information upon which to manage and plan their activities.

1.53 Smart Meters will also support the development of a smart grid, facilitating demand-side response and supporting the uptake of electric vehicles and microgeneration.

1.54 The Foundation Stage began in April 2011. During this stage the energy industry and Government is making all the preparations needed for the start of the mass rollout in 2014.

Heating Controls and Behaviour Change

1.55 Heating controls may play an important part in helping consumers manage their heat use, in particular, by ensuring heat is delivered effectively, and that interactions between heat supply and storage technologies and occupant's heating preferences are optimised.

1.56 Working with Smart Meters, more advanced heating controls may support behaviour change and highlight opportunities to use energy more efficiently and prevent waste.

1.57 However, to have a positive impact, controls will need to be ergonomic and intuitive, and will need to reflect a good understanding of how people heat their homes.

1.58 Alongside the technical measures, changes to heating behaviours could make very substantial reductions in overall heat demand. For example, heating to 1°C lower would reduce our heating demand by 10%. Similarly, wearing more clothes indoors, only heating rooms we are using, and taking shorter showers could all curtail heat demand.

1.59 More evidence is needed to understand how to effect and sustain heating behaviour change, while maintaining and enhancing comfort levels. In particular, there are likely to be important synergies with new heating technologies and controls which may provide opportunities for behaviour change. Government is supporting a range of research to better understand how to encourage consumers and businesses to adopt energy efficient behaviours, including heating behaviours, and to support the uptake of, currently unfamiliar, low carbon heating technologies.

The Hot Water Challenge

1.60 Heating water for showers, baths and sinks demands around 87 TWh a year – over 20% of all heat demand from buildings.

1.61 Reducing hot water demand is particular challenging as demand is largely unaffected by improvement to buildings' fabric, and is relatively consistent across the age of buildings, and between seasons.

1.62 Given this, behaviour change approaches that can reduce hot water demand and technologies that can recycle heat from waste hot water will be important.

1.63 However, ultimately, it will be necessary to move to supplying hot water from low carbon technologies, in particular solar and electric systems (see Chapter 2).

Questions

- Do you agree with the barriers and opportunities set out in relation to managing demand for heat in buildings?
- Do you have evidence from existing projects to demonstrate the costs and benefits of demand management solutions in reducing emissions?
- If you have been practically involved in managing heat demand in buildings, what lessons can you share?
- What policies should the Government pursue to promote or facilitate improvements in the management of heat use in buildings, both domestic and commercial?

Chapter 2: Transforming Building-Level Heating

- *In the majority of UK homes and businesses, heating spaces and water means burning gas in a boiler. For some, it means burning oil, or using electric heaters. Low carbon heating offers cleaner and often more efficient alternatives which will prepare our homes and businesses for the future with sustainable and secure supplies of heat.*

- *While gas will supply the majority of our heat for many years to come, the change to low carbon is already beginning. Many new homes is now fitted with a heat pump, able to operate three to four times more efficiently than a gas boiler, and businesses are increasingly using heat pumps as a convenient way to both heat and cool their buildings.*

- *We need to start building the market for low carbon and renewable heat now, both to achieve our goal of supplying 15% of UK energy from renewables by 2020 and to deliver affordable, efficient low carbon heat in the future.*

- *The EU market for renewable heat is growing. In 2010, the UK heat pump market alone was worth nearly £50m, and the solar thermal market grew 24% to £25m. The UK has an opportunity to attract the investment and supply chain jobs offered by this growing market as we prepare the way for a low carbon future for our homes and businesses.*

- *The Government is already supporting the deployment of low carbon heat in buildings, beginning this decade with a focus on the commercial sector, and on residential properties situated off the gas grid where renewable heat is often more cost effective. Through action now we can build the supply chain, attract investment, and bring down costs ahead of mass deployment in coming decades.*

Where we need to be

2.1 By 2050, we need to remove all direct greenhouse gas emissions from heating our buildings. This is exceedingly challenging, and means that any heat generated at building level must be set on a low carbon footing by replacing fossil fuel-based heating technologies within individual buildings, such as natural gas or oil fired boilers, with low carbon alternatives.

2.2 Before we do this, maximising the efficiency of our gas boilers will help realise cost and carbon savings in the short and medium term.

Carbon Plan Trajectory

2.3 By 2020, condensing boilers are expected to have reached around 75% market penetration. Condensing boilers already save consumers over £1 billion a year; further deployment by 2020 could save an additional £1.3 billion.[29]

2.4 Alongside this, the Government is supporting the initial deployment of renewable heating technologies, especially in areas not served by mains gas. This will contribute to our 2020 renewables target and develop the skills and supply chains needed for larger scale deployment beyond 2020.

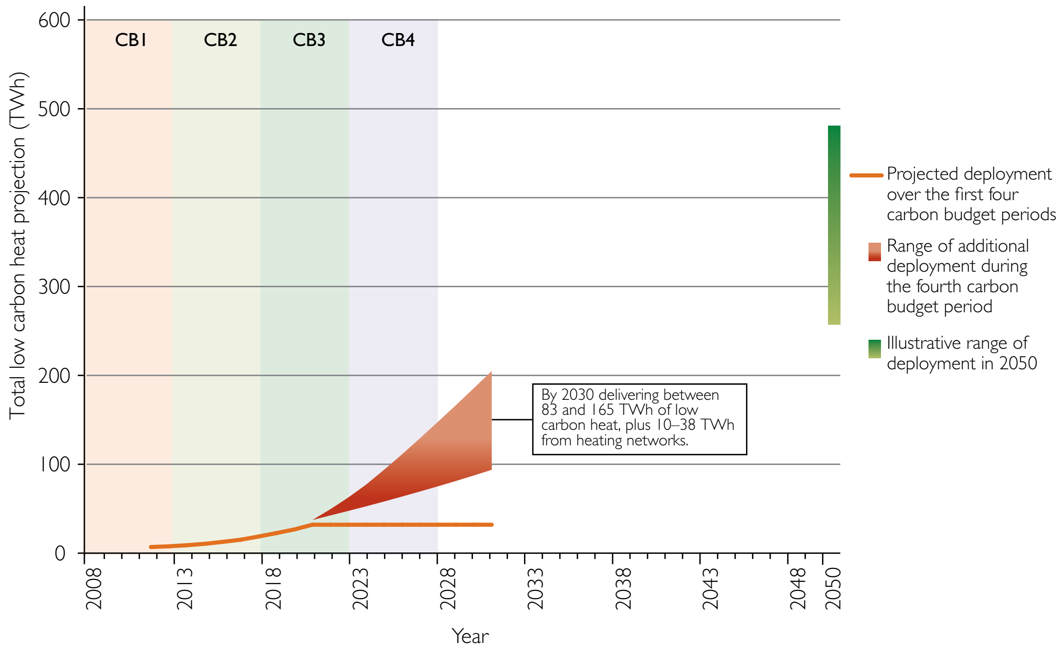
2.5 By 2030, the trajectory set out in the Carbon Plan means that between 83-165 TWh of heat supplied at building level will need to be low carbon.

Natural Gas

2.6 Natural gas will continue to play a leading role in supplying cost-effective heating well into the 2020s. However, by 2050, natural gas will only be used to provide heat to buildings via heat networks. This will draw on heat from natural gas used in industry, and in power generation where natural gas could play a major role with Carbon Capture and Storage and in providing back-up generation.

2.7 While gas burned at industrial scale could be captured and stored, it is not practical to capture emissions at the level of individual

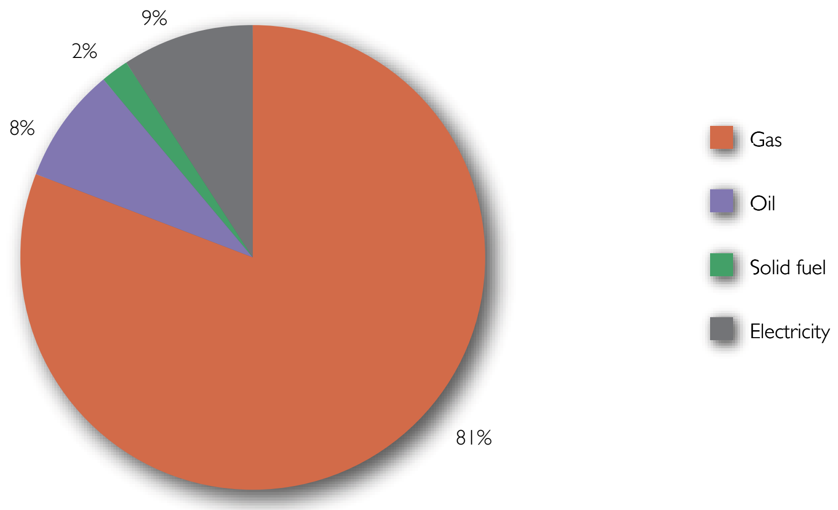
Figure 2: Projected deployment of low carbon heat to buildings



Source: Department of Energy and Climate Change

29 Savings calculated using current gas price and modelled increase in average boiler efficiency. Assumes 18,000 kWh annual gas consumption

Chart 13: Breakdown of current heating systems across all UK buildings



Source: DECC

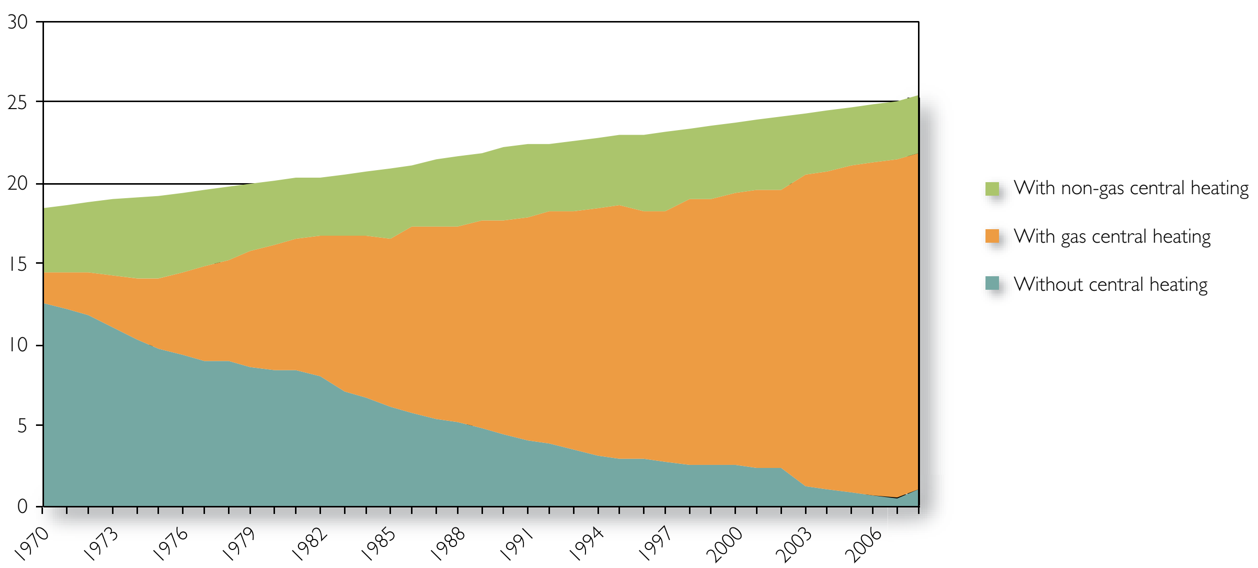
buildings. Therefore, technologies that produce heat in buildings need to be low carbon by 2050 – supplied by low carbon sources such as bioenergy and decarbonised electricity. These technologies will need to satisfy several criteria, in particular, ensuring that heat is as affordable, reliable and efficient as possible.

Where we are now

2.8 Most buildings in the UK burn natural gas in boilers for space and water heating. This is supplied by the gas grid which covers around 80% of UK buildings and on a winter day can delivers up 6TWh – 5 times more energy than the electricity grid. In areas not served by mains gas, oil-fired and electrical heating systems, which are more expensive to operate, are the most common alternatives.

2.9 The gas boiler replaced traditional coal and wood fires from the mid twentieth century, becoming the dominant form of heating in the UK by around 1976. Its introduction enabled the

Chart 14: Uptake of central heating 1970–2007



Source: DECC

mass take up of central heating systems and has brought about a step change in the comfort of buildings, as well as improvements in urban air quality and health (see Chart 14).

2.10 Until the late 1960s, most UK gas boilers were supplied with 'town gas', a variable and often noxious form of methane and other gases extracted from coal. This was phased out in favour of natural gas to exploit the newly discovered resources in the North Sea. This national transition ran from 1965 to 1974 and required the conversion of all gas appliances, carried out by publicly-owned regional gas boards.

2.11 The adoption of natural gas for heating and cooking also facilitated the establishment of the *national* gas grid. While town gas had been produced and distributed locally, natural gas could be transported long distances by pipeline or by purpose-built ships. The discovery of substantial quantities in the North Sea and the arrival of gas in ports therefore gave impetus to a national distribution system, established by connecting existing local grids.

2.12 The transition to clean and affordable natural gas secured gas' share of the heating market and broke our dependence on coal, that had been affected by repeated industrial disputes.

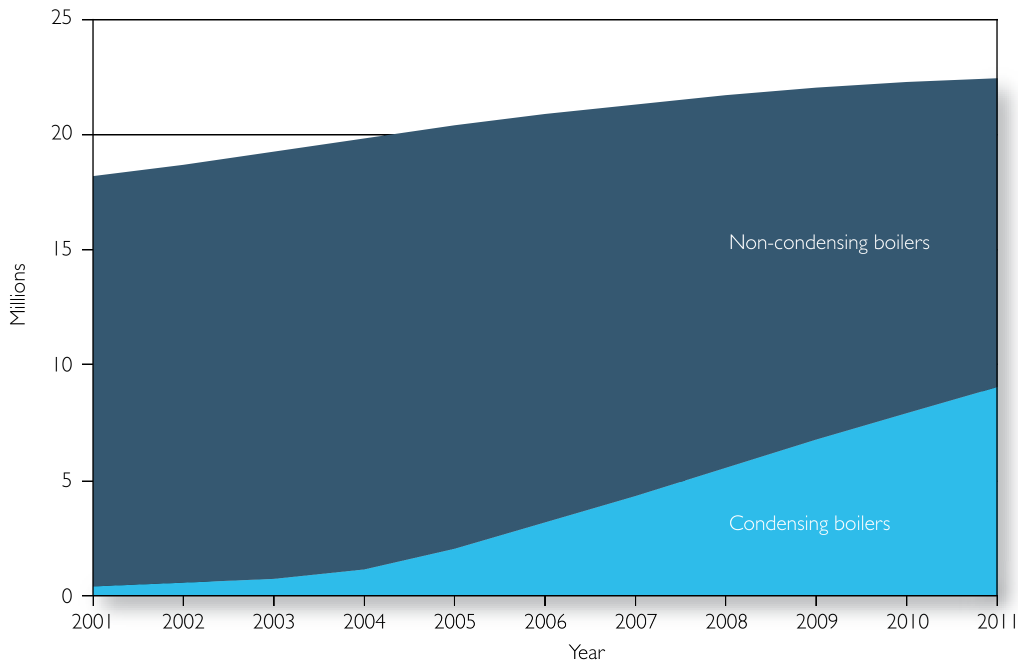
2.13 Since then, gas boilers have improved substantially, with regulation and technical innovation driving improvements in safety and efficiency.

Condensing Boilers

2.14 One of the biggest improvements in heating efficiency has been achieved by the introduction of condensing gas boilers. By capturing some of the heat contained in flue gases, new condensing boilers are around 10% more efficient than the average non-condensing boiler in the current stock. Condensing boilers can reach overall efficiencies of just over 90% for space heating if radiators are heated at an appropriate low temperature.[30]

2.15 This efficiency boost adds up to a major cost and carbon saving – reducing the average household bill by around £95 a year, and by up to £1,000 over the life of the boiler.

Chart 15: UK boiler mix since 2001



Source: DECC

30 90% efficiency on a gross calorific basis

2.16 In 2005, the Government mandated that, with very few exceptions, all new boilers would need to be condensing boilers. Since then, over 9 million have been installed, with around 1.6 million boilers replaced, on average, every year. In 2009 alone, condensing boilers are estimated to have saved £800 million in fuel costs across the UK.

Our options

2.17 While in the near term we can achieve significant emissions reductions by increasing the efficiency of our fossil fuel systems, in the longer term it is necessary to move to low carbon heating technologies wherever heat is generated in buildings.

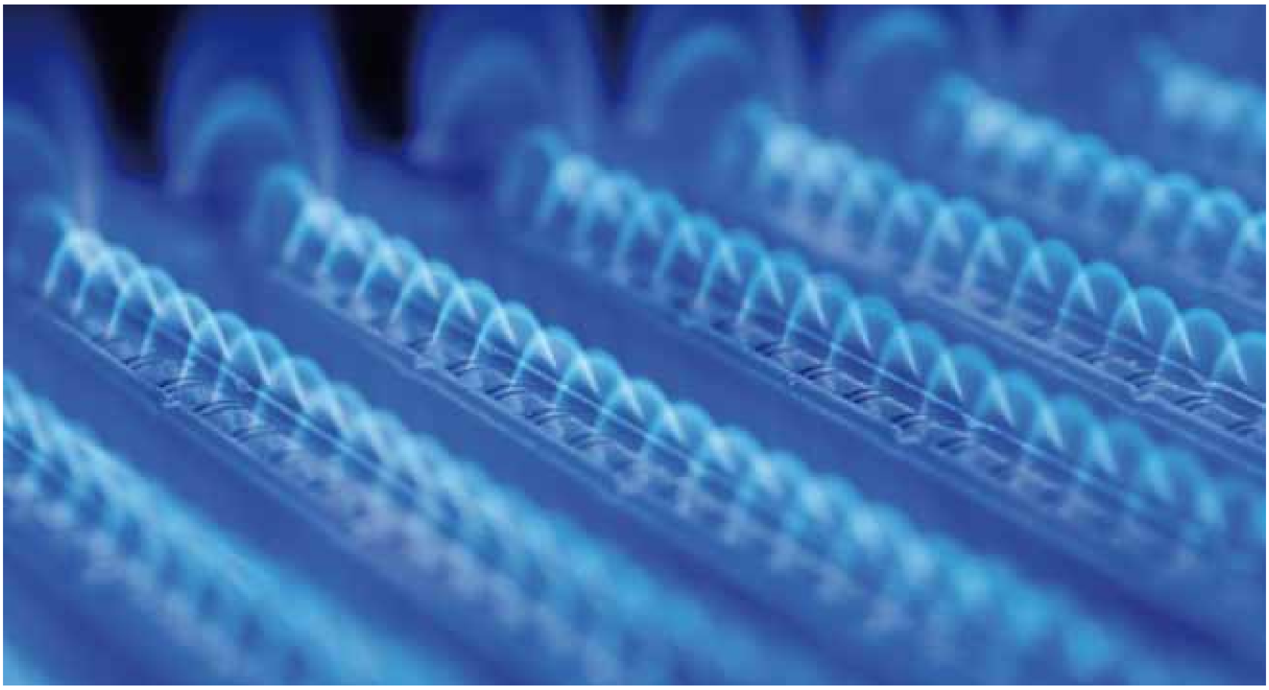
Maximising Fossil Fuel Heating Efficiency

2.18 This decade, the Government will work to improve our current fossil fuel systems by maximising their efficiency – reducing emissions during the transition to low carbon energy and helping limit costs and fuel poverty.

2.19 As part of this, by 2020, most of the 13 million remaining non-condensing boilers will be replaced.

Micro CHP

2.20 Alongside condensing boilers, existing micro CHP units have the potential to slightly reduce the climate change impact of producing electricity and heat by producing both



simultaneously. By generating electricity whilst producing heat, micro CHP units (essentially Combined Heat and Power systems of a similar size to a typical household boiler) enable occupants to also benefit from the additional electricity, for which they receive a feed-in tariff.

2.21 Some more efficient CHP units which use fuel cells rather than sterling engines are now being developed. And gas powered CHP is an effective transition technology until the electricity grid decarbonises, at which point it will need to be replaced by an alternative low carbon heat source or powered by an alternative low carbon fuel.

Low Carbon Technologies

2.22 Low carbon heating technologies can be grouped by the energy source they use to make heat, giving three technology groups:

- technologies that use electricity to generate heat, either resistive heating (that will become low carbon as electricity is decarbonised) or heat pumps;[31]
- boilers that combust biomass fuels – such as wood pellets or biomethane; and
- systems that capture solar heat for use in water or space heating.

2.23 Of these, heating technologies that use low carbon electricity hold particular promise, especially as electricity is universally available and technologies here are relatively established. In addition, the high efficiencies of heat pumps, combined with improved building and storage technologies, could counteract the relatively high costs of electricity, making electrical heating an affordable option, particularly if the manufacturing and installation costs of heat pumps come down as volumes increase.

2.24 In contrast, while biomass sources hold significant promise across the UK energy system, their supply will be constrained and contested, with feedstocks likely directed to transport fuels and industrial heat, where higher energy densities are required. Heating in industry, in particular, is a good use of biomass, and where bio sources are used at scale for heating buildings, it will often be in concert with industrial applications supplying heat networks. More localised solutions such as biomass boilers supplying individual or clusters of buildings, especially in more rural areas, can be a practical solution and is already supported by Government policy, but this approach is unlikely to supply a major proportion of UK heat out to 2050.[32]

2.25 Finally, heating systems that harness heat from the sun to provide space and water heating can provide a substantial portion of a building's heat demand, especially in summer months and in highly efficient houses where space heating demand is minimised. Solar heating systems could be particularly effective in reducing demand and bills if combined with inter-seasonal heat storage to reduce heating peaks in winter months. However, in most cases, solar heating systems need to work alongside a complementary space heating system in order to satisfy winter heat demand.

The Case for Electrification

2.26 As the electricity grid moves to low carbon sources of generation, with significant drops in emission intensity expected by 2030 (see Carbon Plan page 69), electricity will become a universal and versatile source of low carbon energy. Technologies that use electricity to generate heat, including heat pumps and more conventional resistive heating, are well placed to become major low carbon heating technologies in the coming decades.

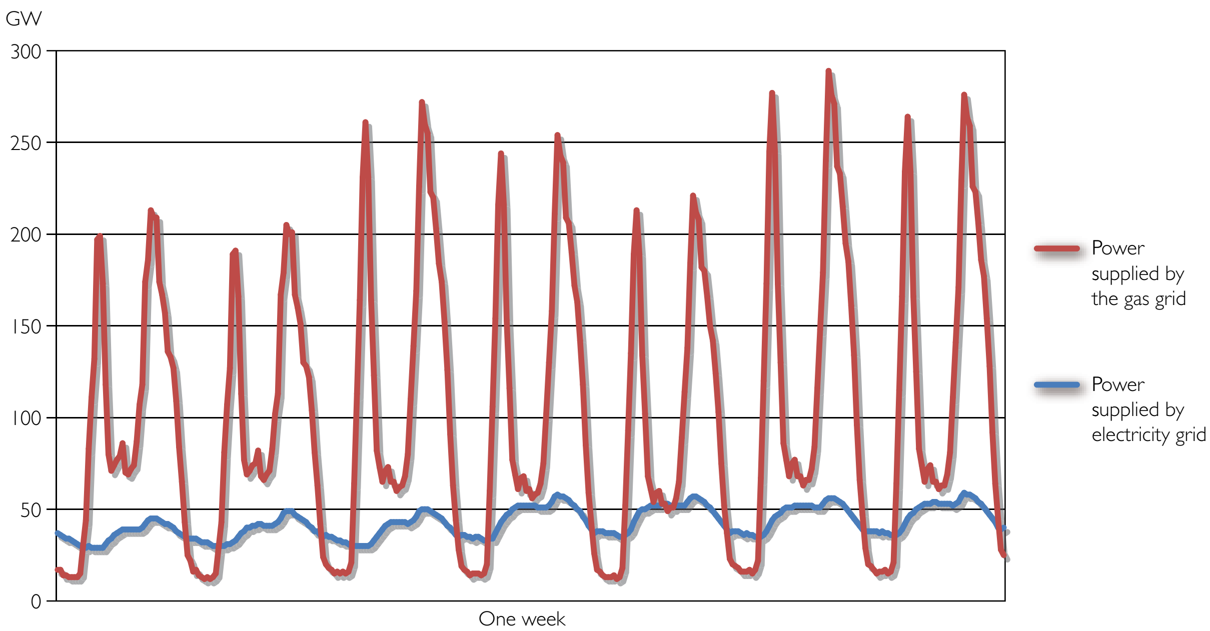
2.27 A common challenge for electric heating technologies is overcoming the relatively high costs of electricity in order to secure affordable operating costs. This will require high efficiencies, both within the heating system itself and the

31 As heat pumps leverage heat from the environment they are considered renewable
32 The Renewable Heat Premium Payment supports biomass boilers for homes not served by the gas grid

Box 4: The Energy System Challenge

Demand for heat varies significantly depending on the time of day and external temperatures, with overall heat demand characterised by peaks during mornings and evenings, which are particularly pronounced during winter months, when space heating demand is greatest and total demand can reach 300 GW.

Power supplied by gas and electicity grid over 1 week in January



Source: DECC

The gas grid is able handle these 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.

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.

Therefore, as more heat is electrified, more balancing options, including storage and demand side response from customers (shifting demand to another time when demand is lower) will be needed. We will also need to increase our overall generation capacity, potentially almost doubling current capacity by 2050 to support increased electrification in heating, transport and industry, as well as population and economic growth. And at a local level, the electricity distribution system will need to be upgraded to cope with greater electricity demand in buildings.

Given this, electrical heating will need to be highly efficient and supported by storage and demand management technologies.

The Carbon Plan sets out how this increase in low carbon electricity will be delivered in the coming decades (see Carbon Plan page 69).

Box 5: Case Study: Efficient Low Carbon Heating, Shetland

On Shetland, a Scottish and Southern Energy Power Distribution project is seeking to demonstrate that smart electric heating can be a low carbon solution to a range of energy challenges, including balancing the supply of electricity.

Working with Glen Dimplex, the project will see the installation of a range of new energy storage solutions, including the new Quantum thermal storage space heaters and water heaters in 750 homes, supported by an active network management system.

This will allow energy generated from renewable sources to be stored at times of peak production, and released later when households require heat, making better use of the distribution network and facilitating the connection of more small and medium scale renewable electricity generation, while maintaining security of supply.

The highly efficient Quantum energy storage devices have been shown to deliver a 20%+ reduction in energy consumption for heating, compared to conventional electric heating systems. This is achieved by matching the output of the heaters precisely with the user's comfort requirement at all times of the day and night. The system also allows consumers to benefit from low cost electricity which is available at off-peak times and when there is a lot of renewable generation on the grid.

Source: Scottish and Southern Energy

building being heated, and could be assisted by the intelligent control and application of heat throughout the building.

2.28 Another challenge is the increased load that will be placed on the electricity system during winter if much of our heating is electrified. The efficient use of electric heating will therefore also be important in limiting the challenges faced by the electricity grid as an increasing proportion of heat demand is supplied electrically. This observation also gives impetus to the development of heat storage systems to smooth peaks of heat demand, and increases the value of building insulation enhancements which will also attenuate peaks in demand.

Heat Pumps

2.29 Sometimes likened to a fridge working in reverse, heat pumps use a compression and evaporation cycle to transfer outdoor heat into buildings. By leveraging ambient temperatures, heat pumps are able to deliver very efficient electrical heating – typically three times more efficient than conventional electric resistive heaters or gas boilers. This increased efficiency is important in limiting bills and in reducing the burden heating at peak times places on the electricity grid, where short spikes in demand can pose a disproportionate challenge. And because heat pumps working at high efficiencies harness heat from the environment, they are classified as renewable heat sources, and contribute to the UK's goal of sourcing 15% of its energy from renewables by 2020.

2.30 As heat pumps move and concentrate heat from one location to another a heat source or store is required. The two most common heat sources used by domestic heat pumps are the air and ground.

2.31 Air source heat pumps extract heat from the air outside buildings, using fans to draw large quantities of air through the system. Air source heat pumps are quick to install, and because they use air as a heat source there is no risk of heat depletion. However, the fans create some background noise (as with a fridge), and as the temperature of air is more variable than the ground, performance can be affected by weather. In particularly cold spells, some air source heat pumps need to use backup resistive elements to provide heat. This can prove costly and reduces overall efficiency.

Ground source heat pumps pass fluid through coils in the ground to extract heat and return it to the surface. Ground source heat pumps make use of the ground as a store of the sun's heat, which makes them less susceptible to daily weather changes. However, as the ground takes time to warm up, care must be taken to ensure ground loops cover an adequate area to avoid heat depletion during winter months.

2.32 Both air and ground source heat pumps can be readily integrated with existing radiators in buildings, although to provide space heating at optimum efficiency, larger radiators or under-floor systems, which can run at lower temperatures, may need to be installed. Alternatively, vented air-based systems can be installed to convey heat throughout buildings. If a heat pump is to supply hot water, a hot water tank will be required; heat pumps cannot replicate the instant hot water function of combination boilers.

2.33 Some heat pumps can also be configured to provide air conditioning during summer months. Such a function is not considered to be renewable energy, however, and until such time as the electricity grid is decarbonised will add to greenhouse gas emissions.

2.34 However, as with other heating technologies, there are some practical barriers to the deployment of heat pumps. In particular, high capital and installation costs need to be reduced as the market and supply chain expands.

Box 6: Case Study: Heat Pumps in a Commercial Building: One New Change, London

Europe's largest heat pump system was installed in a shopping centre, One New Change, in 2010. It is the product of three years' work between British developers Geothermal International and building owner Land Securities.

About 60 km of pipes transfer heat to 65 shops and offices for 4,000 people, providing a source of natural heating and cooling.

An intelligent control device enables the system to redirect heat from warmer to colder areas, improving the eight-floor building's energy efficiency. The system can manage heating peaks of up to 2.4MW and, over one year, provide over 450,000kWh of thermal comfort.

The building's green credentials are enhanced by solar-controlled glass, limiting heat gain to reduce the need for air conditioning.

The building is expected to reduce CO_2 emissions by 10%, and reduce annual energy bills by around £300,000.

Land Securities has been pioneering the use of ground temperatures and ground water on some of its buildings over the last seven years.

Source: Land Securities

Box 7: Case Study: Heat Pumps in a Domestic Building: Southern Housing Group, Isle of Wight

In August 2011 the Southern Housing Group were awarded a Renewable Heat Premium Payment grant of £175,000 through the scheme's Social Landlords competition. In an area off the gas grid, the Group replaced 40 night storage heaters in social housing properties with a combination of air source heat pumps and solar thermal hot water systems. The work was completed in under 3 weeks, with an average of 3 days per installation.

Tenants have seen cost savings with over 50% reductions in their heating bills despite having their heating on for longer periods in the depths of winter. Tenants were also impressed with the ease of use of their heat pumps and the versatility of the systems compared with the night storage heaters.

In six of the properties monitoring systems have been installed to provide detailed information on system performance. In addition to consumer surveys, home energy surveys will be completed by mid-April to calculate the Energy Performance Certificate of each property.

Source: Southern Housing Group

2.35 Installing heat pumps, especially ground source systems, can also be time-consuming and disruptive, and can require significant space outdoors to site equipment, as well as indoors for thermal storage.

2.36 This suggests ground source heat pumps will be best suited to rural and suburban areas where there is greater access to land, fewer underground obstructions, and where any noise will have a less cumulative effect. Air source heat pumps can work in urban areas, although there are concerns around the cumulative noise impact and space requirements.

2.37 In future, installation time will also need to be minimised so that consumers can replace broken heating systems with heat pumps without a prolonged interruption of heat supply.

Resistive heating

2.38 Resistive heating uses electrical resistance in wires to generate heat. It is already used widely in the UK, either to supplement central heating systems – in the case of fan heaters – or as the primary source of heat, especially in properties not supplied by mains gas. Resistive heating is responsive, very cheap to install and unobtrusive, but is far less efficient than heat pumps, making it more expensive to run and more demanding of our electricity system. Where resistive heating is used, high levels of building insulation will be necessary to constrain heating costs, and good energy management, potentially through use of advanced heating controls, may also be necessary to maximise efficiency.

The need for storage

2.39 To limit the grid and generation-based challenges of supplying heat via electricity, and to limit bills, the use of storage in tandem with electrical heating will be important. At present, storage using hot water tanks is common in buildings with electric heating, and enables occupants to take advantage of off-peak tariffs.

2.40 This type of thermal storage, together with other flexible solutions, such as demand side response, will play an important role in helping balance the future electricity system, and in doing so will contribute to our energy security.

2.41 However, hot water tanks can require significant space, and can therefore be difficult to accommodate in smaller urban dwellings. Innovation in this area will be important. For example, phase change thermal stores could allow more compact storage of heat. In addition, home energy stores that store energy in a form that can be converted to heat or electricity, i.e. a home battery or hydrogen store, could provide a more versatile storage solution to complement heating systems.

Hydrogen

2.42 Hydrogen is an energy carrier with significant potential to complement electrification in heating, transport and industry.

2.43 The continued development of electrolyser, fuel cell and storage technologies makes hydrogen a credible solution for many energy applications, especially where storage eases the challenges of supplying peaks in demand, or where supply is intermittent.

2.44 While the majority of hydrogen used today is produced by reforming natural gas, in the longer term, for hydrogen to be considered low carbon it will need to be produced from low carbon electricity or by reforming natural gas in conjunction with CCS.

Hydrogen Storage

2.45 As hydrogen can be generated at the point of use via the electrolysis of water, hydrogen could be produced at building level, and stored until needed during peaks in demand. Stored hydrogen could then be combusted in a modified gas boiler, or converted back into electricity using a fuel cell to run electric heating systems and electrical appliances.

2.46 In this way hydrogen offers a potential alternative to batteries or thermal storage. The extent to which it features in future will depend on the continued development of affordable and efficient technologies suitable for use in buildings. In particular, the efficiency and durability of fuel cells and electrolysers, and the safety and size-implications of storage.

A Hydrogen Grid?

2.47 It may also be possible to repurpose the existing low-pressure gas distribution grid to transport hydrogen at low pressures, which could be used in modified gas boilers and hobs, and in building-level fuel cells.

2.48 However, it is not possible to also convert the high pressure gas transmission network to carry hydrogen without substantial modification. Constructing a national grid for delivering hydrogen to households could therefore be very costly, as intercity pipes would need to resist high-pressure hydrogen and corrosion. Given this, distribution grids that produce low pressure hydrogen locally may be a more viable solution.

2.49 In the near term, relatively small quantities of hydrogen could also be injected into the gas grid to enrich natural gas and reduce carbon emissions from conventional gas-fired boilers.

2.50 More speculatively, chemical processes that convert hydrogen to more easily stored and transported natural gas, by using carbon captured from the atmosphere in a carbon neutral cycle, could provide large-scale and localised solutions.

2.51 More evidence is needed on whether hydrogen-based approaches hold practical promise for the UK (see questions at the end of the chapter).

Making the Most of Solar

2.52 Solar energy can be a major source of heating in buildings, especially where the architecture and glazing has also been designed to make use of solar gain to provide warmth.

2.53 Solar thermal systems harness solar gain by focusing heat from the sun to warm water, which can be used in supplying hot water and space heating demand. In summer months, a solar thermal system can meet a household's entire hot water demand, with a 4m^2 collector able to provide up to 50-60% of a typical household's annual hot water demand, or contribute towards space heating demand. But to achieve high solar fraction (the proportion of heat demand met by solar heating systems) in winter, additional collectors would be needed.

2.54 In a larger, commercial building context, a well designed solar system may be able to satisfy 30-40% of the annual hot water load.

2.55 However, as solar thermal systems would in most cases not supply the full heating needs in a building, they must work in tandem with another heating technology, e.g. a gas boiler or heat pump.

Solar accumulators

2.56 Larger buildings can make use of extensive surface areas as solar collectors. In particular, sites with car parks, or school playgrounds, can effectively accumulate heat that can be used short term, or stored between seasons for when heat demand is greatest (see heat storage below). In many cases such systems benefit from being integrated with heat pumps that can store heat whilst providing air conditioning in summer months, and extract this heat during winter months.

2.57 Large areas mean less-expensive materials can be employed, enabling the overall system to be highly cost effective, especially where integration is planned as part of construction.

Making Sensible Use of Bioenergy

2.58 Bioenergy will play an important part in the future UK energy mix, with potential applications in power generation and transport, as well as a heating fuel. However, the overall amount of bioenergy available will depend on global and national supplies, and on how the bio energy market develops.

2.59 Biomass can be used for on-site space heating, or, to a limited extent, to displace natural gas in the gas grid with biomethane. But in the longer term, a premium on energy density in the transport and industrial sectors suggests bioenergy will be best used as transport biofuels or for industrial heating – reducing the availability and increasing the cost of bioenergy for space and water heating.

2.60 Therefore, while the scale of space and water heating demand in the UK means bioenergy will not be able to supply a commanding portion of demand, it will make an important contribution.

2.61 In rural areas this is likely to be in the form of biomass boilers. In England, it is estimated that two million tonnes of wood could be mobilised by the creation of local energy markets, with supply chains also increasing levels of sustainable woodland management and enhancing woodland biodiversity. And in urban areas, bio-powered industrial facilities are one of the potential sources for supplying low carbon heat to local heat networks (see Chapter 3).

2.62 The Government will shortly publish its bioenergy strategy to outline the role of bioenergy in meeting its objectives.

Box 8: What is biomass and how can it be used to produce heat?

Biomass is biological material derived from living, or recently living organisms. In the context of biomass for energy this is often used to mean plant based material, but biomass can equally apply to both animal and vegetable derived material.

Different forms of biomass can be converted to useful energy by different technologies. For example, food waste and animals slurries can be used to generate methane in anaerobic digesters. This methane can be burned to generate electricity and heat or, after suitable treatment, could be injected into the national gas grid and used in conventional gas appliances.

Solid biomass like wood and straw can be burned in power stations to generate electricity which in turn could be used to drive heat pumps or resistive heaters in buildings. Alternatively, these materials could be burned to generate heat in buildings and for heat networks directly.

Other forms of biomass like recovered cooking oil or liquids produced from oil seed, starch or sugar crops can be used to displace fossil fuels in several applications including heating and transport.

Biomass boilers

2.63 Biomass boilers use lower-energy, physical feedstocks, like wood pellets, to provide heating on site or for distribution through a heat network. As the physical fuels are relatively large and require handling equipment, biomass boilers are larger than conventional natural gas or oil boilers. The additional equipment also means biomass boilers currently need between two and five times more capital investment than conventional alternatives.

2.64 Despite the higher capital investment, fuel costs compare favourably to electricity, and over the longer term, biomass boilers can provide cost-effective heating, especially where a business produces a combustible by-product that can be used as fuel or where there is a local source of biomass that has no other market.

Switching to Biomethane

2.65 Biomethane (biomass and wastes converted to gas), has several advantages over combusting biomass for heat. In particular, as a gas with similar properties to natural gas, biomethane can readily integrate with the existing gas grid and heating infrastructure, with gas boilers requiring no modification. This makes biomethane an attractive option, but the likely availability of feedstocks suggests biomethane will only best used at a sub-national scale, possibly in localised gas grids.

A Biomethane Grid?

2.66 Decarbonising our heat supply without having to change our heating systems, and while using a gas grid that is already built, initially appears attractive.

2.67 However, injecting biomethane into the gas grid presents a number of challenges. Even globally, supplies of sustainably-sourced biomass feedstocks are necessarily limited and are unlikely to be available to the UK in volumes that could replace the 500 TWh of natural gas in the gas grid either wholly or largely. With biomass also needed to decarbonise other sectors – both energy and non-energy, including sectors that are hard to electrify, such as parts of transport and some industrial processes (see Chapter 4), large-scale biomethane injection into the grid at a national level, is not a realistic option, especially when efficiency losses are taken into account.

2.68 Biomethane may however be used in certain ring-fenced areas. Heat networks (set out in Chapter 3), where heat is generated remotely and supplied to buildings, offer a more promising option.

Other Technologies

Heat Storage

2.69 Energy for heating can be stored within buildings as heat itself, with the advantage that no conversion is needed when heat is required during peaks.

2.70 The most common example of this is hot water tanks, where hot water is heated during periods of low demand and stored as high-temperature water. This type of storage is common in the UK, relatively inexpensive and is effective at shifting grid demand within one-day cycles. However, hot water tanks are often large, making them undesirable in smaller premises, and as heat is gradually lost from tanks it is not possible to store heat for extended periods.

2.71 New approaches to storing heat are focussed on addressing these issues, by providing smaller storage systems or by enabling longer-term heat storage, in particular inter-seasonal storage, so that excess solar heat collected during summer can be used in winter months.

Low Carbon Cooking

2.72 The majority of buildings in the UK use some gas for cooking, whether in a gas oven or using gas-fired hobs. Overall emissions from gas cooking are small and could be sustained longer-term. However, as more buildings move to electric heating, the small-quantities of gas needed for cooking may not be sufficient to cost-effectively maintain the local distribution gas grid, and more electric cooking appliances will be required. An increase in biomass-burning cookers is also anticipated.

Conventional Electric Ovens and Hobs

2.73 Electric cookers are common in the UK, and, like conventional electric heating, use electrical resistance to generate heat.

Induction hobs

2.74 Induction cookers are a more advanced form of electric hob that use electricity to produce magnetic fields and induce electrical currents in pans. These currents within the pan generate heat, meaning the hobs themselves remain cool and can be used as additional work surfaces.

How we get there

2.75 As set out above, there are a range of renewable technologies that can provide heat, hot water and cooling to individual buildings, but all face significant barriers. Factors such as the upfront cost of installation, an underdeveloped UK supply chain, unfamiliarity to consumers and space requiremenets mean that these technologies are unlikely to reach their full mass market potential yet. But many are sufficiently established that they can already be a practical solution for many homes and businesses. To help this happen, the Government needs to create the right climate for deployment and to build the market, working with the industry to improve the affordability, efficiency and reliability of key technologies.

Affordable

2.76 The lifetime costs of building-level heating technologies must be competitive. However, as the UK market for many low carbon heating technologies is relatively immature, current purchase and installation costs are generally higher than conventional alternatives, especially in the case of heat pumps.[33] Running costs can also be higher, as electricity (for heat pumps) and biofuels (for biomass boilers) generally cost considerably more than natural gas.

2.77 Reducing the costs of low carbon heating technologies is critical to achieving the mass deployment needed in the next 20 years.

2.78 Substantial cost reductions can be expected as the low carbon heating market grows, the supply chain matures and the range of technical solutions expands. To ensure this happens, the Government needs to take action now to support consumers and the low carbon heating industry in establishing a full and effective market, bringing down costs and building an installer skills base and supply chain. Once established, as with other low carbon technologies, Government support can be phased out as market forces drive innovations and efficiencies.

2.79 In 2011, to catalyse the low carbon heating market, the Government introduced the Renewable Heat Incentive (RHI) and Renewable Heat Premium Payment (RHPP). By bridging the gap in upfront and ongoing costs between low and high carbon heating, these policies are accelerating the uptake of low carbon technologies, especially in off-gas-grid areas where low carbon technologies are pitched against oil-fired boilers, which are more expensive and higher carbon than gas boilers.

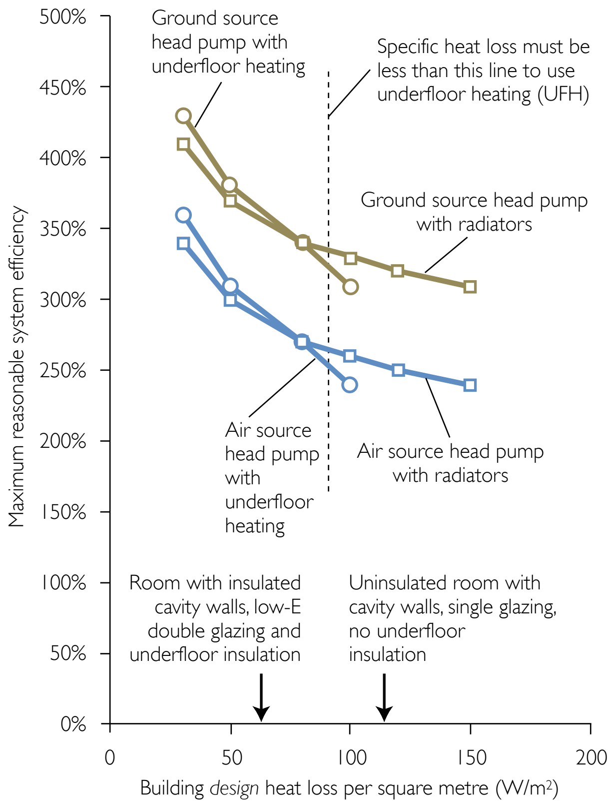
2.80 In 2011, the Government also published its Microgeneration Strategy to address non-financial barriers to on-site renewables, in particular by working with the industry to improve skills, information and standards.

Efficient

2.81 Because on-going heating bills are usually the largest part of the cost of heating a building, the efficiency of a heating system plays a major role in determining overall heating costs, and a small improvement in efficiency can mean a big saving over the life of the system.

2.82 The efficiency of heating systems can be affected by improvements in the technologies themselves and through interactions with energy efficiency measures in buildings. This includes, improving levels of thermal insulation and using heat emitters that can operate at lower temperatures (radiators with larger surface areas or under-floor heating for example) to improve the efficiency at which heating systems operate (see Chart 16). It will also be important to understand how consumers use low-carbon heating technologies, especially where different patterns of use are needed to achieve optimum performance.

Chart 16: Graph showing interaction between thermal efficiency and heat system efficiency



Source: DECC

2.83 Continuing to improve the efficiency of heating systems will constrain costs and carbon. And by ensuring the heat supplied to our homes is used as efficiently as possible we can limit the impact and extent of fuel poverty, especially when combined with efficient buildings and controls. Alongside this, reducing the energy we supply using fossil fuel sources – including electricity during the transition to low carbon supply – means we minimise our exposure to international energy markets where price volatility and spikes impact consumers and businesses.

2.84 Maximising heating system and building efficiency will also serve to reduce the burden placed on our supply networks, particularly important in the case of electric resistive heating and heat pumps, where peaks in demand pose significant challenges and will need to be addressed as the proportion of electric heating grows.

2.85 To build our understanding of how low carbon heating performs in the UK, including how systems interact with efficiency measures in buildings, the Government is undertaking a series of studies and demonstration schemes. These studies will identify challenges and direct innovation, helping to optimise the performance of low carbon heating technologies.[33]

Reliable

2.86 To be commercially successful, low carbon heating systems will need to supply heat reliably, on demand and meet consumers' expectations for comfort. While many low carbon heating technologies are relatively mature with proven reliability (for example, heat pumps have been an established technology for several decades – with on-going field trials focused on optimising rather than proving performance) less-established technologies such as advanced biomass conversion, and more speculative technologies like hydrogen will need to demonstrate the same standards of comfort and safety, while also proving their affordability in a commercial environment.

The Government's strategy for building-level renewable heat

This decade:

- This decade will see the initial deployment of building-level renewable heating technologies in step with energy efficiency improvement to our buildings.
- This early deployment will contribute to our renewable energy target and provide the foundations for a full and effective market able to drive down costs and direct innovation. Initial uptake will also be important in increasing consumer awareness and confidence in low carbon heating technologies.
- The Renewable Heat Premium Payment and the Renewable Heat Incentive have been designed to kick start this early uptake of low carbon heating, especially where these technologies are displacing more expensive and higher carbon heating fuels like oil.
- In parallel, the continued roll out of condensing boilers will substantially increase the efficiency of our fossil fuel heating systems

In the 2020s and beyond:

- In the 2020s and beyond, the Government anticipates a substantial increase in low carbon heating as key technologies reach the mass market.
- In suburban and rural areas, in particular, low carbon heating technologies at the level of individual buildings will be necessary. Here, heat pumps are expected to provide substantial quantities of heat where heat networks (discussed in the next chapter) are not technically or economically viable.

33 DECC has participated in the EST's heat pump and solar thermal field trials and will shortly publish a detailed report, with site by site case studies. The Government is also undertaking two laboratory projects to investigate the most energy efficient ways of heating domestic hot water with a heat pump, the best approaches to integrating buffer tanks in heat pump circuits, and the effect of cycling on heat pump efficiency. These projects will report by October 2012

The Government's strategy for building level renewable heat

2.87 Renewable heat technologies offer an effective and efficient way of decarbonising individual buildings, but face barriers, including consumer acceptability, upfront cost and supply chain constraints.

2.88 Over the coming decades, it is necessary to realise a step change in the deployment of low carbon heating technologies to buildings.

2.89 To achieve this, the Government is taking action now to deepen understanding of low carbon technologies in the UK, and to develop a low carbon heating industry that can sustain growth long term.

Questions

- Do you agree with the barriers and opportunities set out in relation to heating and cooling solutions in homes and other buildings?
- Do you have evidence from existing projects to demonstrate the costs and benefits of heating and cooling solutions in reducing emissions in homes and other buildings?
- If you have been practically involved in installing heating and cooling solutions, what lessons can you share?
- What policies should the government pursue to promote or facilitate low carbon heating and cooling solutions in homes and other buildings?
- What are the challenges to skills development and capacity building that need to be overcome to significantly increase the number of domestic renewable heating installations?
- Do you have evidence on the viability, economics and performance of hydrogen in building heating applications, including distribution through existing gas pipes?

Chapter 3: Developing Heat Networks in the UK

- *Heat networks offer a way to supply heat directly to homes and businesses through a network of pipes, rather than supplying the fuel for people to generate heat on-site. Under some circumstances, heat networks can be the most effective way of supplying low carbon heat to buildings, and can offer greater convenience and reliability to consumers. Heat networks also offer flexibility over time, as a number of different heat sources can supply the same network.*

- *Heat networks are best suited to areas with high heat demand density. They can be an excellent choice in urban areas, providing individually controlled and metered heat as reliably as gas boilers. Heat networks can also serve buildings like blocks of flats where individual gas boilers may not be an option.*

- *Heat networks are compatible with a wide range of heat supply options and provide a way to distribute low carbon heat, which makes them easily upgradeable, creating flexibility to make the transition to low carbon heat over time with less disruption for consumers and businesses. Most of the cost and disruption occurs at the point of initial construction and installation.*

- *Heat networks can be integrated with local authority plans for urban growth and regeneration aimed at tackling social deprivation and environmental issues such as air quality. They can also be part of an integrated low carbon system as already seen in some European cities.*

- *Heat networks already exist in cities such as Sheffield, Birmingham and Aberdeen, helping to regenerate communities, tackle fuel poverty and provide reliable and affordable heating, often through a partnership between local authorities and the private sector.*

- *This chapter details the UK's potential for low-carbon heat networks and the changes that would be required to support any major expansion.*

Where we need to be – low carbon heat networks in our communities and cities

3.1 Traditionally, in the UK we think about heat as something that is generated on-site in individual buildings, with customers buying fuel rather than heat. In other parts of the world, heat networks that transport heat to consumers through a network of insulated pipes are more common. The heat is generated elsewhere, at a commercial rather than domestic scale. A heat network – sometimes known as District Heating – is therefore a distribution technology rather than a heat technology, and its associated carbon emissions depend on the mix of sources for the heat in the pipes.

3.2 Over the coming decades, the use of networks of pipes to deliver low carbon heat in the form of hot water (or even steam) from a central source may be an effective means of providing low carbon heat to buildings without the need for major disruption to buildings themselves. This is likely to be important at the community or district level, particularly in urban environments where demand for heat is more concentrated and more consistent within a given geographical area. But heat networks should only be deployed providing the following conditions are satisfied:

- long term low/zero carbon heat sources (or stores) are available; and
- heat networks are capable of meeting average and peak heat demand without depending on fossil fuels in the future.

3.3 Under these circumstances, heat networks can be core to the UK's heat strategy and have the potential to play a critical role in helping buildings and industry decarbonise their heat supply out to 2050. Some pioneering local authorities and businesses have already established heat networks in their city centres and are realising the benefits; better resource efficiency, new jobs and contracts, lower energy bills, and reducing fuel poverty.[34]

3.4 Heat networks built today will already be future proofed to some extent, because their supply of heat is easily upgradable, provided low/zero carbon sources are available. So in the near term, we can expand existing fossil fuel based heat networks and upgrade them to low carbon fuel supplies to deliver more substantial carbon savings and help to meet the UK's emissions and renewable energy targets.

3.5 In order to do this, we will need to address a number of key challenges:

- risk of no low carbon heat source being available in the long term and being locked in to natural gas, which could lead to a stranded asset;
- infrastructure and disruption caused by construction;
- price, contract issues and public attitudes;
- heat networks that can serve the peaks of winter demand and remain low carbon. (Peaks are usually served by top-up gas boilers so we may need to rely on heat stores, which are technically possible but not commercially practiced in the UK); and
- risk that a heat network builds in inefficiencies, e.g. heat losses from pipes, and places being heated unnecessarily.

Where we are now – how heat networks are deployed

3.6 Heat networks supply heat to a number of buildings or dwellings from a central heat production facility or facilities through an insulated pipe network. Most networks distribute heat using hot water at around 80-120°C. Where higher temperatures are required, such as for industrial applications,

34 Vital Energi: Case Study – *Biomass: Woodbrook Biomass Community Heating Scheme*, Belfast

heat energy is transported over shorter distances using steam at a few hundred degrees at a range of pressures depending on usage. Heat networks are best suited to areas with high heat demand density[35] which influences how much pipework is needed to supply a given heat demand. They are most likely to be economic in areas that not only have concentrated demand but have fairly consistent demand over time (potentially for twelve months a year). Tower blocks represent a high heat density, as do dense urban communities bordering commercial or public sector buildings such as hospitals, schools or universities.

3.7 Because heat networks are able to deliver heat at scale and for a mix of uses, locating heat networks in areas with a mix of sources of demand also allows for the balancing of loads e.g. housing with night-time peaks and swimming pools with day-time peaks.

3.8 Usually, heat networks start small and expand over time, potentially connecting to each other as they grow, creating larger networks that span city centres and a variety of building types. When networks are sufficiently developed, additional heat sources can be connected. As networks become more sophisticated, it may be that customers could have the choice of more than one supplier, making competitive local markets possible.

Heat networks in the UK

3.9 Heat networks in the UK use a range of heat sources including biomass and gas boilers, combined heat and power (CHP) plants and heat from energy-from-waste plants and, in the case of Southampton, a small amount of geothermal heat. Networks are currently estimated to provide less than 2% of the UK's heat demand[36] supplying 172,000 domestic buildings (predominantly social housing, tower blocks and public buildings) and a range of commercial and industrial applications (particularly where high temperature heat in the form of steam is required).

3.10 Networks range from small community units with just two or three premises, to district wide systems. Current UK systems are largely based on fossil fuel CHP, topped up with boilers, because of the more favourable economics, though there is increasing appetite for low carbon sources of supply.

Heat networks in other countries

3.11 By comparison, district heating is widespread in many other parts of Europe, in China, Korea, Japan, Russia, and the USA, although the level of sophistication and reliability is very diverse. While having an average market share of 10% in Europe, district heat is particularly widespread in Scandinavia (Denmark nearly 70%, Finland 49%, and Sweden around 50%). It also has a substantial share elsewhere in Europe. For instance, district heat provides around 18% of heat in Austria (and 40% of heat in Vienna). European networks are currently growing at around 2,800 km per year, about 3% of current installed length.

3.12 Key drivers for the expansion of heat networks in Scandinavian countries were concerns about cost and security of supply following the oil price shocks of the 1970s. With no ready source of natural gas, these countries switched from oil boilers to heat networks in cities (and often to biomass and heat pumps in rural areas). The lower level of heat network deployment in the UK reflects the choices made in the past – most significantly the UK's decision to access affordable natural gas from the North Sea, which provides a cost-effective and reliable source of heating.

35 Poyry (2009) *The Potential & Costs of District Heating Networks*
36 Ibid

Box 9: Case Study: City district heating scheme covering residential centres and businesses; Nottingham

Nottingham City is home to one of the largest district heating networks in the UK.

The network is supplied with heat from a local energy from waste plant. The plant has been running since 1972. The 65km network now serves more than 4,600 homes and over 100 businesses and public sector properties – roughly 3.5% of the city's entire heat consumption.

The district heating system is at the heart of Nottingham City Council's plans to reduce carbon emissions and supply an increasing amount of energy from a renewable source to homeowners and businesses. Nottingham City's goals for the heating network include:

- reducing carbon emissions
- addressing fuel poverty
- providing energy security
- reducing dependency on fossil fuels
- developing the local economy

The network has already reduced residents' bills, contributing to the aim of tackling fuel poverty. The 27,000 tonnes of CO_2 offset by the network contribute significantly to local and national emissions reduction objectives. The high-profile heat network has increased the city's status as a place to invest for new green industries, creating jobs and boosting the economy.

Our options – towards low carbon heat networks

3.13 Fuel sources for heat networks will need to change over time. Gas CHP may represent a cost-effective and resource-efficient option to develop and supply district heating networks now, but is unlikely to be acceptable in the long term if we are to reach the levels of decarbonisation envisaged in the Carbon Plan. Government needs to set a framework that encourages the replacement over time of generating plant with increasingly low carbon alternatives. In the right conditions, changing a central heat source for individual buildings is likely to involve less hassle and cost overall for customers than changing stand-alone technologies. Pipes also last significantly longer than individual heat-generating technologies.

3.14 Because pipe infrastructure is not fuel specific, a range of technology options can be used to generate the heat which is transported through the network, and each network can have generation plants in multiple locations. For example the district heating scheme in Southampton draws heat from a geothermal well a mile deep and CHP generators around the city. This allows it to provide a relatively low carbon[37] and renewable heat supply for the 14km network running through the city centre; Generating plant costs are also comparatively minor in relation to the overall costs of the network. This means:

- networks offer a solution to the problem of limited space in homes and buildings for low carbon technologies like heat pumps or biomass boilers and their accompanying hot water tanks. In urban areas in particular, where space is at a premium, this can be a big advantage;
- they can be upgraded over time according to local and national priorities, without impacting on consumers. For example, it may be economic in the short term to power a network with gas CHP, and to replace this with a lower carbon alternative such as biomass CHP in the medium to long term. In-building heat sources can also be replaced over time, but in many cases it may be easier to replace in-building heat sources once, to switch to district heating, and then replace the central heat source when appropriate, than to frequently replace the in-building heat source;
- they can take advantage of economies of scale to realise greater efficiencies and keep costs down for consumers;
- heat networks themselves can provide seasonal as well as daily storage using large water tanks, offering a simple and practical option which takes up less space than a water tank in every home. This could be important in city centres where land values are very high; and
- they can be integrated with Local Authority plans on waste management, air quality, urban regeneration, regional growth, fuel poverty and other social and environmental issues. This is why so many cities already have plans involving the construction of heat networks.

3.15 Heat can also be recovered from industrial sites that generate a lot of excess heat that is usually lost to the atmosphere,[38] or from locations where excess heat is a problem, such as underground tunnels. This heat may be able to be redirected to where it is useful, eliminating the need for further fuel combustion.

3.16 In the same way, heat networks can be used to provide cooling which is likely to be required more in the future (see Box 13).

37 Good Quality CHP denotes schemes that have been certified as highly efficient under the CHP Quality Assurance programme in line with EU legislation. CHPQA ensures that the CHP plant achieves at least 10% primary energy savings compared to the separate generation of heat and electricity, via a boiler and power station, using the same fuel. This fuel efficiency means that gas CHP is a lower carbon technology compared to conventional means of fossil fuel energy generation

38 For example from ceramics industry and refineries

Box 10: Case Study: Large scale city scheme, with waste management and potentially new connection of different networks, Sheffield

The heat network in Sheffield's city centre is one of the largest in the country with a pipeline of 50km. Over 140 buildings are provided with heating and hot water which is generated from local municipal waste.

The network was first developed in the 1970s to heat 995 council dwellings, as a response to the oil crisis. As part of the city's vision to provide a city-wide district heating network, Sheffield Heat and Power was established in 1988 and began to develop the wider city centre networks.

The network is now operated by Veolia Environmental Services as part of a 35 year integrated waste management contract with the city. The network delivers 110,000mWh of heat per year at 120˚C to a variety of customers, including the university, the local authority, hospitals, private and public sector offices, and housing.

A new Energy Recovery Facility was built in 2005,operating 24 hours a day and processing 225,000 tonnes of waste per annum. This produces up to 60MW of heat and 19 MW of electricity, saving 21,000 tonnes of CO_2 every year.

Box 11: Case Study: Community scale scheme, including natural gas and biomass Barrier Park, London Borough of Newham

The Barrier Park heat network is driven by a central Energy Centre comprising:

1. A gas CHP unit to provide the base thermal load, serving the scheme's domestic hot water demands as well as part of the space heating demand;
2. Gas-fired condensing boilers to meet peak loads and provide standby;
3. A thermal store to maximise the output of the CHP unit; and
4. A biomass boiler.

The use of CHP reduces the carbon dioxide emissions of the site compared to the use of individual gas boilers. With the CHP supplying 65% of the site's energy demands the Barrier Park development has modelled a CO_2 saving of 398 tonnes per annum.

Each dwelling has a Heat Interface Unit (HIU)[39] and is equipped with wall-mounted temperature sensors and thermostatic radiators valves, to control internal temperatures. Residents can also programme their heating for the week ahead to maximise efficiency. Non-residential areas are also served by the heat network, including retail premises and a crèche.

The CHP unit is sized to meet the base load hot water demand for the site, while the biomass boiler is mainly used in the winter months. The biomass boiler is sized and operated to provide further carbon savings.

39 This is smaller than a conventional boiler

Box 12: Types of heat sources compatible with heat networks

- **Fossil fuel Combined Heat and Power (CHP):** Gas CHP is currently the most cost-effective means of developing a heat network. There are strong synergies between district heating and gas CHP; gas-CHP engines can be employed quickly to serve existing or new district heating networks, delivering relatively low carbon heat as well as electricity as a revenue stream.
- **Biomass boiler:** Boilers running on woodchips and wood pellets are being used in heat networks in the UK at present.
- **Conventional gas boilers**: Boilers fired by natural gas.
- **Bio-CHP:** CHP that utilises renewable fuels such as biomass, biogas, bioliquids and the bio-element of waste. Bio-CHP allows for low carbon generation of heat and electricity, however it is currently more expensive to develop than conventional gas CHP
- **Biomass co-firing:** this involves supplementing existing fossil fuel based CHP plants with biomass feedstock.
- **Deep geothermal:** Geothermal energy originates from heat retained within the earth from radioactive decay of minerals. Heat is extracted via wells roughly 1500 meters deep.
- **Large heat pumps:** Heat pumps used as either a centralised system utilising one larger heat pump or a de-centralised system using multiples of smaller controlled heat pumps.
- **Heat recovered from industrial processes:** heat which has been used once and is no longer useful to a business (because it is no longer hot enough for the industrial process) is generally expelled through a chimney or cooling tower. This is especially the case for high temperature industry, whose discarded heat can provide a low-carbon alternative to the direct use of heating fuels for low temperature users. In Gothenburg and Rotterdam for example, recoverable heat from industrial processes (rather than from electricity generation) provides the main source for the local district heat networks.
- **Heat recovered from thermal power generation:** these can include thermal power stations which use coal, gas (i.e. fossil fuel CHP), nuclear, energy from waste and biomass. In the future this could include power stations fitted with carbon capture and storage.
- **Heat from incinerating non-recyclable waste:** waste management systems separate out the recyclable waste and generate heat by incinerating non-recyclable waste.
- **Conversion of electricity to heat when electricity is in plentiful supply:** the future electricity generation mix is expected to result in more occasions when the electricity price is low, such as when the wind is blowing and demand is also at a low level. At these times of high supply, electricity can be stored as heat in a tank or in the system and used when needed, taking advantage of the lower electricity price.

Box 13: Cooling Networks

Cooling is playing an increasing part in satisfying thermal comfort needs in buildings, particularly in offices and other commercial buildings and is projected to grow further. Cooling can also be provided to multiple buildings via a pipe network laid in parallel with the heat network. A range of technologies can be used to generate (and store) this cooling, including conventional refrigeration. The most prevalent is the absorption chiller, which can make use of the heat output of CHP plants (also known as combined cooling, heat and power (CCHP) or 'trigeneration' plants). This can provide more optimal use of plants both technically and economically. Other networks draw cold water from a central source and circulate this directly through buildings, providing natural cooling. The combination of heat and cooling can make district or local energy economically attractive in areas where demand for heat alone may not be sufficient.

How we get there – developing the market

3.17 Heat networks represent a departure from the traditional approach to generating and transporting energy in the UK, and we need to understand their place in the new energy infrastructure of the future. Facilitating the deployment of heat networks means being aware of the implications of installing new energy infrastructure in the context of local planning, mitigating the risk of stranded assets and fuel availability.

Understanding the barriers

3.18 Installing heat networks is complicated and requires significant planning and capital investment. Government is keen to first identify and address the barriers to deployment, which can be significant, notably the cost of installing the pipes, as well as questions of regulation, ownership and charging structures:

- upfront capital cost is clearly a major hurdle. It is estimated that the cost of installing heat network pipes in the UK is up to £1000 per metre. Heat pipes are costly because they require substantial insulation to avoid heat losses in transporting the hot water or steam. Heat pipes are cheaper where district heating is more established.[40] This cost can restrict the range of buildings and areas for which district heat is economic, which is why heat density is so important, as set out above;
- the upfront capital cost of installing heat networks and the competitive retail value of heat result in quite lengthy pay back periods, potentially 20 years. Set against that, with dense heat loads and a few anchor loads, district heat can offer a long term source of predictable income and provide greater certainty to consumers about the price they will pay for their heat supply;
- developers therefore need a high degree of certainty that they will continue to have a sufficient customer base for the long term to assure a return on the investment. One way of ensuring this customer base is for heat suppliers to seek long-term contracts with their customers. Consequently, networks are often best developed by starting with low risk customers who can commit to long term contracts, such as public sector buildings, social housing and some commercial and industrial buildings. This usually means networks start small, and over time they can expand and potentially connect to each other, creating larger networks that span city centres and a variety of building types. Often the biggest barrier and risk in building a heat network is at the outset, when there may be

40 Trade Associations comparative price data

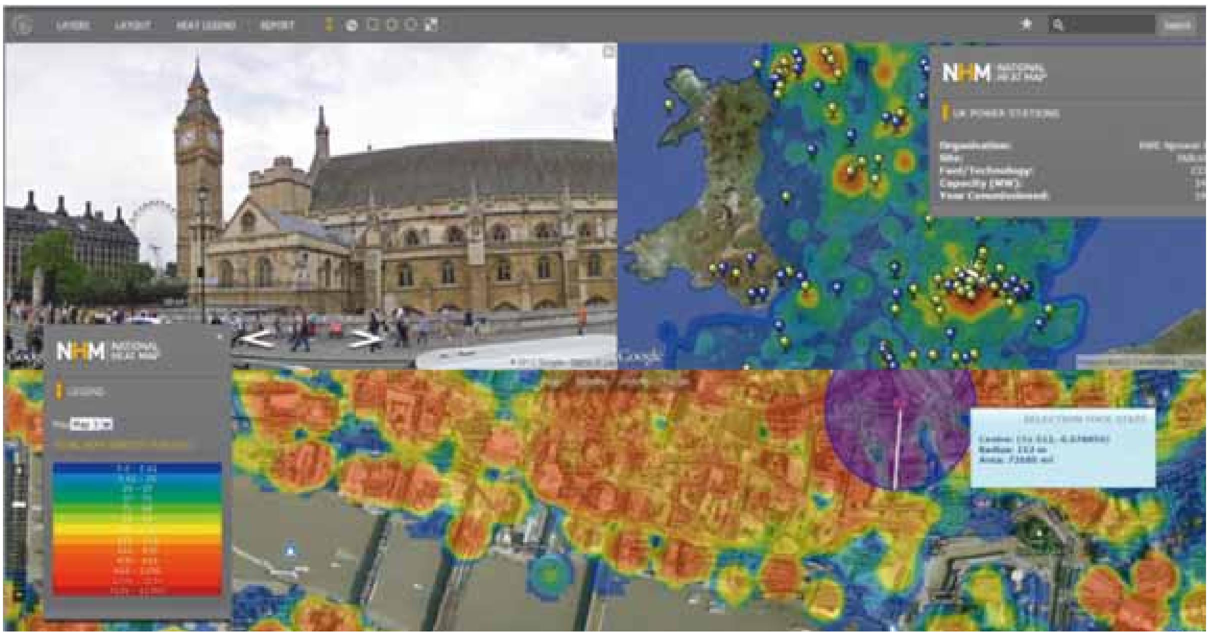
a limited number of heat users and a single source of heat production, but secure heat demand and supply is fundamental to financing the substantial costs of installing the pipes to carry the heat and the source of heat supply; and

- the relationship between the consumer (business or householder) and the supplier can be very different when they are purchasing heat rather than gas. Often, an energy services company (or 'ESCO') can be involved. Contracts are longer and switching between suppliers is unlikely, at least initially as networks are established, in order to provide certainty of returns on large capital investments. From both a competition and a consumer protection perspective this could

Figure 3: National Heat Map (NHM)

The National Heat Map is a unique interactive tool that provides local authorities, communities, private sector developers and heat suppliers with a reliable source of information about where heat networks are technically possible. It is the only map covering the whole of England that allows planners to zoom down to the level of individual buildings and view their heat demand, and shows the demand of wider areas with the same accuracy. This will underpin feasibility studies by enhancing precision whilst reducing costs. As this document highlights, we are likely to see heat networks playing a greater role in the supply of heat in the UK in the coming decade.

The methodology used to develop the map on a national scale was a substantial achievement, in particular the ability to use building-specific real-world data. Many other heat maps, including other nation-wide maps, use benchmarked data rather than actual readings. This data feeds into a sophisticated model based on energy consumption statistics to provide greater accuracy and greater precision than any other heat map of its type, which can be easily updated year after year. The Heat Map is being published alongside this document and can be viewed at http://ceo.decc.gov.uk/nationalheatmap



be a significant barrier and more work needs to be done to understand consumer attitudes to long term contracts.

- Increasing scale may diminish the risks, by spreading them over more sources of heat demand and heat supply, in addition to introducing economies of scale, all of which can increase the value of the network to investors and lower the barriers to its future extension, making it more viable for smaller consumers to connect with shorter term contracts, facilitating competition.

3.19 Other potential barriers include planning difficulties, commercial and contractual complications, consumer reaction, and an unregulated market.

3.20 It will be critical to bring down infrastructure costs as well as increasing credibility in the market to drive investment, capacity in skills and the supply chain.

Technical potential in the UK

3.21 The Government believes that heat networks have the potential to play a significant role in the UK energy mix, subject to the caveats and conditions listed above. The National Heat Map (see Figure 3) for England reveals that nearly 50% of the heat demand in England is concentrated with enough density to make heat networks worth investigating.[41] However, there are a number of economic and other barriers that would need to be addressed before schemes could become viable.

3.22 Across the UK many city authorities are already developing ambitious plans – including London, Manchester and Newcastle.

3.23 From large single site schemes such as the Olympic Park, to multi-site, mixed-use schemes involving a range of public and private sector buildings, and finally to area-wide heat transmission and integrated urban projects, evidence in the UK and on the Continent demonstrates the effectiveness of adopting a phased approach, starting small and linking projects together over time. But against this, the commercial attractiveness of a project often requires a large critical mass.

Opportunities in the short and medium term

3.24 **Where heat networks are suitable, we need to begin removing barriers from now to 2020.** New schemes are likely to develop city by city as local authorities work in partnership with energy companies, waste companies and local industry to develop networks (e.g. Sheffield and Southampton models). They are likely to use a mix of gas CHP or renewable options. This in turn will increase credibility in the market to drive investment and deliver increased capacity in skills and the supply chain, consistent with our long term objectives for decarbonising heat in the UK.

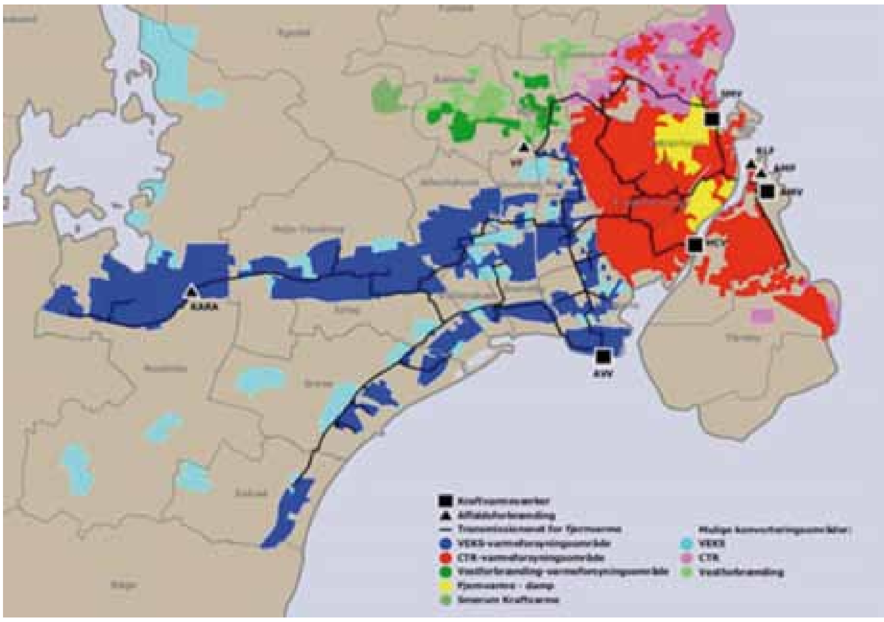
3.25 **It therefore makes sense to prioritise schemes which can deliver environmental and social benefits in the relatively short term** and can be expanded and upgraded in the future, subject to removing the necessary barriers to deploying heat networks. Opportunities for local authorities and investors include:

- **urban/city areas:** establishing (and extending existing) schemes in the cores of major urban centres, focused on public sector, commercial developments, high density housing, and any other site where heat networks are economical;

41 According to Poyry, district heating becomes economically viable at 3,000kWh/km^2

Box 14: Case Study: City-wide scheme with multiple heat sources, and move to renewables over time; Copenhagen

The district heating system in Copenhagen is one of the largest in the world, meeting more than 98% of heat demand in the city and surrounding municipalities. The network serves more than 33,000 premises, providing space and water heating for roughly half a million people.



The main part of the network is driven by 10 CHP plants with the total capacity of around 2,000 MW heat. The rest of the heat demand is supplied by a number of heat-only boilers for peak load production. Additionally, some heat is supplied from a geothermal demonstration plant established in 2005, and surplus heat is also exploited from a large waste water treatment plant. The network is partially fuelled by biomass and waste incineration, and there are plans to increase the biomass proportion over time, gradually reducing gas dependency.

Because the network receives its heat supply from numerous sources the system is very flexible, and is therefore less vulnerable to fluctuating energy prices. To maximise economic performance, CHP stations are put into or taken out of operation based on daily forecasts of estimated heat demand, fuel prices and electricity prices.

The network also includes a steam-based system which supplies steam for industrial processes.

- **new build:** using heat networks to provide low carbon heat for new build in medium and high density areas. Although new build properties tend to have lower heat demand densities than existing building stock, heat networks can still be an efficient way of providing heat, particularly with a low carbon heat source. For example, in St Neots there are plans to extend an existing heat network to include 3,250 new homes.

- **electrically heated high-rise:** generally high rise flats use electrical heating where gas heating is not possible for safety reasons. Installation of heat networks in these areas can save residents' money as well as carbon, and could be an effective tool to address both fuel poverty and climate change. A scheme in Aberdeen cut heating bills in half for 288 flats, where 70% of bill-payers had previously been 'fuel poor';[42]

- **extending existing heat networks:** existing heat networks may be extendable to include currently outlying buildings and to connect with other existing networks. Contractual relationships between private customers and heat suppliers can be hard to broker when a scheme is in the design phase, but once a scheme is operational it can be much easier to extend networks to capture customers from the private sector, with reduced risk to the supplier if the customer changes, and a reduced need for the customer to commit to a long term contract; and

- **making use of existing CHP plants and heat recovered from industrial processes:** there are many examples of existing CHP plant which use only some of their heat output. They may, for example, use their heat on-site, or export it to a single customer. As with the extension of existing heat networks, new infrastructure will allow heat to be exported from hospitals, universities, industrial sites and others, to surrounding customers. In Southwark the Veolia-owned energy-from-waste plant will soon export heat to around 3,000 council-owned homes, saving up to 10,000 tonnes of carbon dioxide per year.[43] We will also need to take advantage of recoverable heat from industrial and thermal power plants this decade.

Longer term deployment

3.26 From the early 2020s we should aim for further expansion of heat networks to larger areas and upgrade them to more sustainable and low carbon sources of heat, including:

- **upgrading gas CHP networks** to low carbon alternatives like energy from waste and large heat pumps;

- **establishing and expanding networks which use recoverable heat** from low carbon power generation (e.g. power stations fitted with Carbon Capture and Storage);

- **joining stand-alone renewable capacity** to existing networks, and larger new build housing developments will change the face of our communities and help decarbonise our heat supply for the long term; and

- **carefully planning heat storage** into future heat networks to ensure that peaks of winter demand can be met from low carbon sources.

42 Energy Saving Trust: *Aberdeen City Council; a case study of community heating*
43 Evidence from Southwark Council

Setting the conditions for more deployment in the UK

3.27 Much more is needed for heat networks to reach their full potential in this country. Responding to the challenges set out above is likely to require a mix of actions at different scales, in particular at a local level.

The role of local authorities

3.28 Evidence from existing heat networks in the UK show that local authorities have a pivotal role in enabling the development, deployment and expansion of heat networks. Their vision and engagement has been vital both in providing anchor loads through public buildings and social housing which give a steady source of heat demand and long term confidence in demand for investors, and in providing co-ordination and local knowledge to what can be complex arrangements. The role of local authorities is both strategic and specific to projects within their area. Through heat mapping and energy planning and in line with emerging planning policies, local authorities should identify opportunities where energy can be supplied from decentralised, renewable, or low carbon energy supply systems and for co-locating potential heat customers and suppliers. They can publicise community energy opportunities, the availability of suitable sources of heat demand and help bring together the owners of local heat demands, energy suppliers and infrastructure providers and communities to develop the potential for low and zero carbon heat infrastructure in their areas.

3.29 At a specific project level, local authorities have an important role, combined with private sector participation and investment. Local authorities can provide a broker role and help secure local sources of heat demand for a project. They can also provide planning support and guidance for projects and in their capacity as highways authorities, facilitate access to install necessary infrastructure and assist in the coordination with other utilities. Government is committed, to putting in place the right framework to support local authorities in continuing the excellent work that many have already begun to facilitate heat networks.

3.30 The National Heat Map and Community Energy Online[44] are tools that the Government has recently created to help local authorities and communities. However, much more work is needed to complete the evidence base and ensure investments deliver the claimed savings, within both central government and locally.

Bringing down costs and increasing certainty of return

3.31 Long term contracts can mitigate investment uncertainty, but not always reduce the upfront costs or the length of the payback period.

3.32 Bringing down the cost of pipe infrastructure would reduce capital costs substantially, and increase the economic viability of areas that might otherwise be considered marginal. The emergence of pipe manufacturers in the UK is a welcome development in the supply chain, and the Government will ensure the market is nurtured, if evidence shows that heat networks are a viable option.

Understanding and awareness

3.33 In the UK heat networks suffer from a poor reputation arising from historic schemes where customers have been unable to control their heat supply and their bills, or where the efficiency of such networks has been extremely poor. Modern district heating schemes give customers just as much control as individual gas boilers and could be efficient, but consumer awareness of this can be low, and district heat is as yet relatively unknown in the UK. Until heat networks are more widespread in the UK and understood, customers may be reluctant to connect to networks.

44 Available at: http://ceo.decc.gov.uk/nationalheatmap; and, http://ceo.decc.gov.uk/

Quality assurance and consumer interests

3.34 In the UK, heat is not regulated in the same way as gas and electricity. Therefore, heat network consumers' rights are only supported by general trading standards. The lack of specific protections may therefore affect overall market growth as new build developers opt for alternatives that have greater consumer confidence, and which may be more attractive to investors. It will be important to consider these issues carefully, and balance the need for appropriate reassurance for consumers with the need to create a flexible regulatory environment in which a newly emerging market can grow.

Questions

- Do you agree with the barriers and opportunities set out in relation to heat networks?
- Do you have evidence from existing projects to demonstrate the costs and benefits of heat networks in reducing emissions, alleviating fuel poverty or reducing fuel consumption?
- If you have been practically involved in setting up heat networks, what lessons can you share?
- What policies should the Government pursue to promote or facilitate heat networks?
- Do you see the need to regulate the supply of heat through heat networks and, if so, how?

Chapter 4: Transforming Industrial Heat

- *UK industry employs over 4 million people, accounting for 15% of the UK workforce and a third of the national GDP.*[45]
- *Heat is a key input to almost any industrial process from baking bread to the production of complex chemicals. For many companies, heating fuel is one of the main raw materials for their production process. In all, around 80% of the energy demand of UK industry is for heat, and the majority of that energy currently comes from carbon-intensive fossil fuels.*
- *Considerable progress has already been made in reducing the carbon intensity of UK industry, which has demonstrated that it is possible to decouple carbon reduction and economic growth, reducing emissions by 46% since 1990 at the same time as growing by around 1% a year.*
- *The challenge now is to build on this achievement by putting energy and resource efficiency at the top of the agenda and looking to further displace fossil fuel combustion through switching to low carbon sources.*
- *This will not only help tackle emissions but increase diversification of our heat supply, while developing new skills and engineering knowledge through maximising the business opportunities from low carbon goods, services and forms of production.*
- *A clear heat strategy across our industrial sector is vital if we are to preserve and enhance our competitive position internationally. By focusing on biomass, biogas and electrification, as well as innovative technologies like Carbon Capture and Storage, we have the opportunity to achieve a competitive advantage, winning contracts abroad in a new and thriving global market.*
- *This chapter sets out the substantial changes that can build a prosperous, low carbon UK industrial sector over the coming decades.*

45 Office of National Statistics (2009) *Annual Business Survey*, Production and Consumption Sectors (B-E)

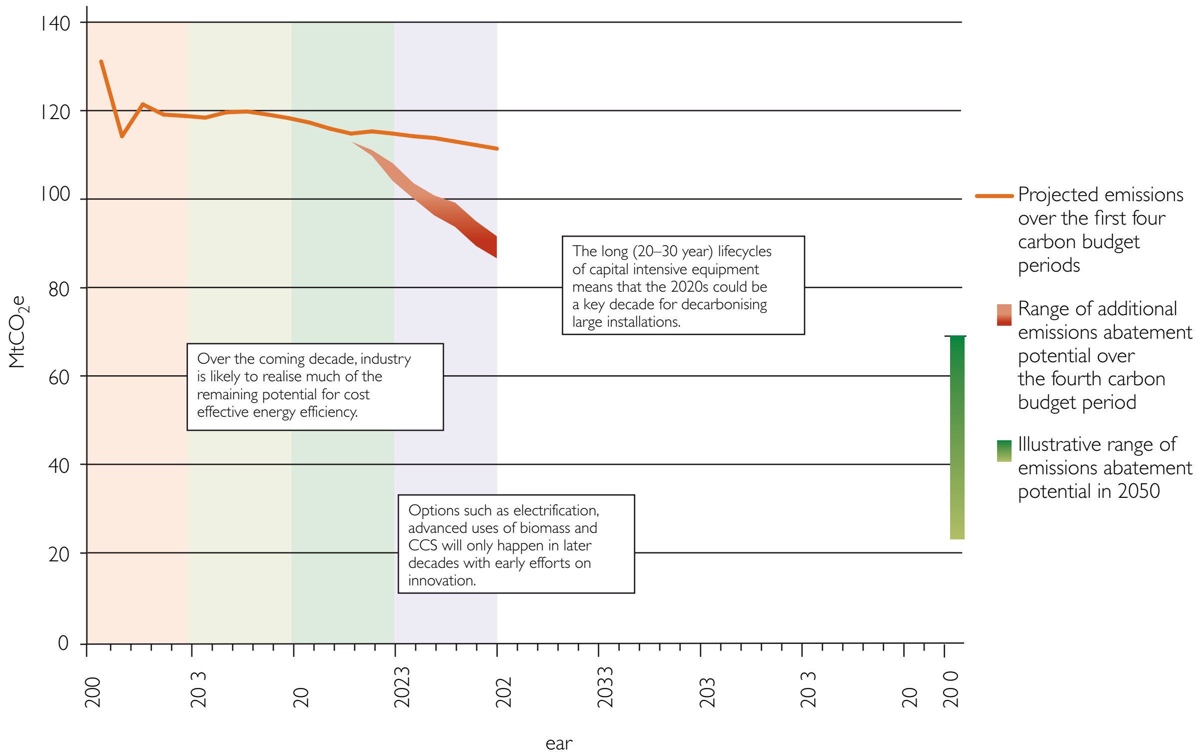
Where we need to be – a low carbon, prosperous and competitive industry

4.1 The industrial sector encompasses a diverse range of manufacturing processes and end-products, involving highly-integrated processes driven by heat, often with associated emissions as an inherent result of the chemistry of the process. From a heat perspective, the temperature required to drive a particular process often dictates what heat supply options are suitable. Currently, heat for industrial processes comes mainly from natural gas, electricity and oil/petroleum, which are currently very carbon intensive (though electricity generation is expected to decarbonise over time).

4.2 As set out in the Carbon Plan, if industrial emissions were to remain steady over coming decades, their share of total UK emissions would grow from 23% now to over half of the emissions allowed by the 2050 target, which would require an unachievable level of effort in other sectors of the economy. UK industry will therefore need to reduce its emissions by up to 70% by 2050 (compared to 1990 levels) if we are to deliver our national target and contribute to the global effort on climate change (see Chart 17).

4.3 Industry will need to continue to reduce the energy intensity of manufacturing through a range of measures. These include improving the efficiency of different processes and, where possible, reducing carbon intensity – further displacing fossil fuel combustion – through switching to low carbon sources like sustainable biomass and decarbonised electricity. In the near term, low carbon heat options are already available for lower temperature processes to create steam and hot water, and there will be a role for biomass in decarbonising higher temperature processes. However, some processes such as iron and steel production and oil refining are likely to require greater

Chart 17: The Carbon Plan – industry carbon abatement to 2030 and 2050



Source: Department of Energy and Climate Change

innovation now, ahead of deployment at scale in the long term.

4.4 Some of the industrial sector operates in highly competitive international markets, meaning that there are limits on how much of the cost of moving to low carbon can be passed through to customers. There is an important role for Government to work with industry to ensure a framework which supports decarbonisation without reducing competitiveness and forcing some industry emissions offshore (known as carbon leakage). It is crucial that we achieve this transformation while maintaining growth in a sector that employs over 4 million people, accounting for around 15% of the UK workforce and a third of the national GDP.

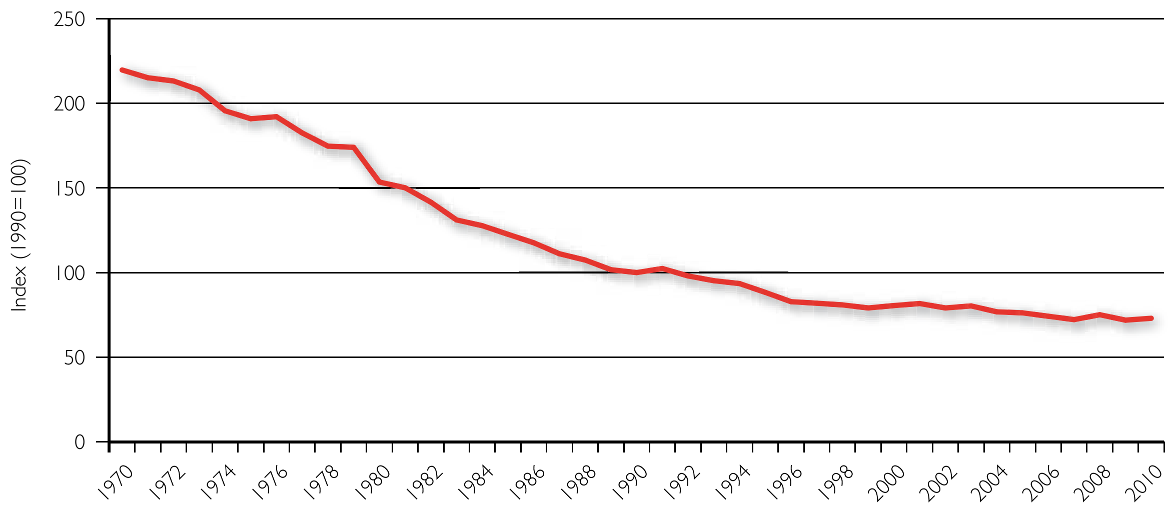
4.5 By taking up opportunities now, industry can further reduce manufacturing costs and gain a competitive advantage through the early adoption of low carbon manufacturing techniques.

Where we are now – industrial demand for heat

4.6 Heat forms 80% of industrial energy use[46] and can represent 20-40% of final product costs, which has acted as a strong driver for industry to maximise energy efficiency. Total heat demand for the industrial sector represented 26% of UK total heat demand (equivalent to 185 TWh) in 2008.[47] This is less than domestic heat demand but greater than in the commercial sector (see Chapters 1 and 2).

4.7 UK industry has made significant progress in reducing the energy intensity of manufacturing over the last 40 years (see Chart 18). The sector has grown by an average of 1% a year in Gross Value Added (GVA) terms over the last 40 years, whilst reducing total energy consumption by 44% since 1970 and by 9% since 1990. This has been coupled with a reduction in emissions which have reduced by 111 $MtCO_2e$ since 1990 – a reduction of around 46% over 20 years.

Chart 18: Energy Intensity since 1970



Source: Department of Energy and Climate Change

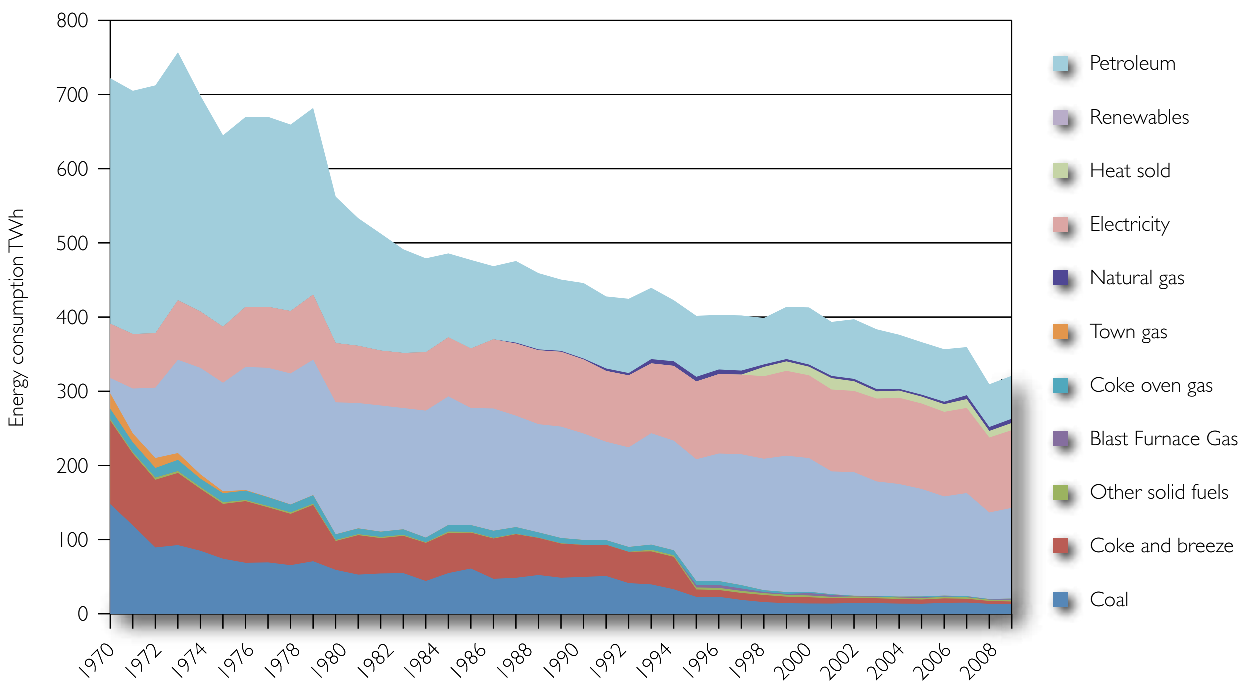
46 DECC (2011) *Energy Consumption in the United Kingdom*, derived from table 1.14
47 DECC (2011) *Energy Consumption in the United Kingdom*

4.8 These achievements are largely due to the decrease in the level of energy use by UK industry over this period (particularly in the 1980s), driven by significant improvements in energy efficiency alongside sectoral readjustments towards higher-value products.

4.9 Within this downward trend there have also been changes to the fuel types used by industry, driven by changing fuel prices and restructuring within the sector, which have served to reduce resulting emissions. The move from solid fuels (coal and coke) to natural gas and electricity, along with a large reduction in the amount of petroleum used, has been a key driver. Whilst gas is now the majority fuel type used for heat in industry, the proportion of other fuels (such as solid fuel) is higher in comparison with other sectors, driven for instance by the need to achieve very high temperatures for some processes (see Chart 19).

4.10 It is important to determine how the industrial sector can continue to maintain progress in increasing GVA output whilst continuing to reduce emissions. We also need to understand if there are practical limits to the further restructuring within specific sub-sectors, or whether we are reaching limits on efficiency improvements for specific processes. If this is the case it will be important to focus greater attention on reducing emissions from heat supply by focusing on alternatives (such as changing to lower carbon fuel types), by fundamentally altering the chemical process or by replacing the final product of the industrial process with an alternative that can be produced without causing the same level of emissions.

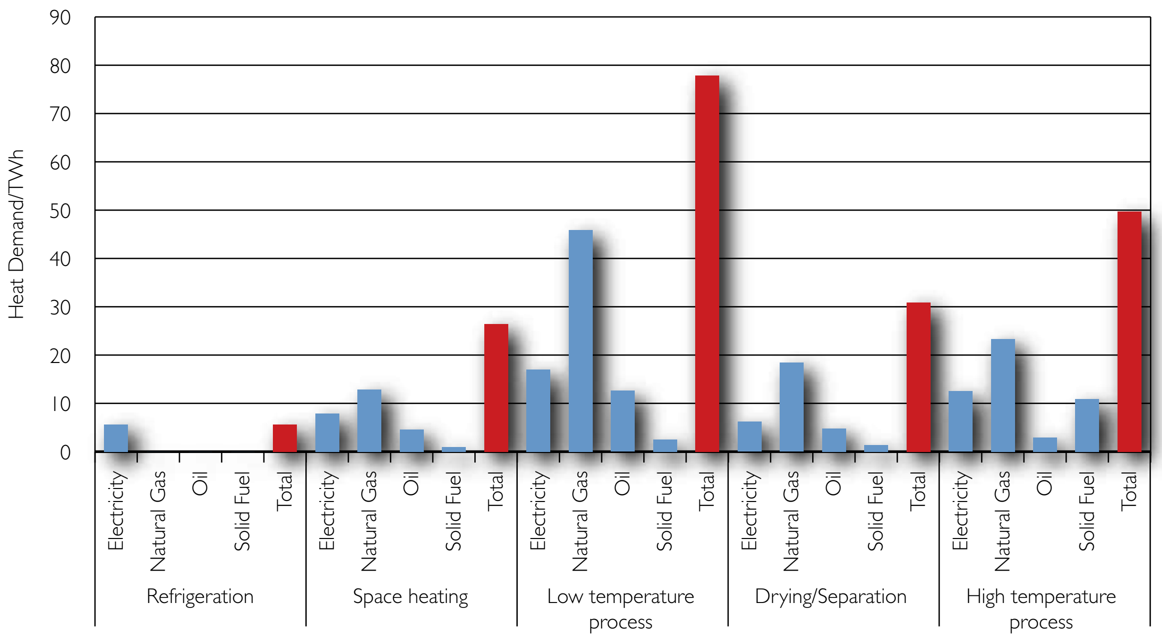
Chart 19: Trend in energy consumption in UK industry since 1970[48]



Source: Department of Energy and Climate Change

48 Data sourced from *Energy Consumption in the UK 2011* industrial data tables: http://www.decc.gov.uk/en/content/cms/statistics/publications/ecuk/ecuk.aspx

Chart 20: Heat demand by process temperature and fuel[49]



Source: Department of Energy and Climate Change

Demand by process temperature and fuel type

4.11 Heat is used in a diverse range of industrial processes over a wide range of temperatures. These include drying and separation processes, heat treatment of glass and plastics, steam generation for use in processes and generating hot blast air for iron and steel production.

4.12 Heat demand in different industrial sectors can be presented as a function of temperature. Energy intensive industry sectors (e.g. the use of kilns or furnaces to produce glass, cement, iron and steel) often require **high temperatures**, i.e. above 1000°C. Sectors such as food and drink, chemicals and pulp and paper often require **low temperature** process heat around 300-500°C (though still high relative to the temperatures needed for space and water heating in buildings) to produce high-value products (see Chart 20).

4.13 For some high temperature processes, the burn characteristics of the fuel (namely calorific value, flame stability and cleanliness) are more critical which makes the choice of fuel and the cost of infrastructure such as kilns and furnaces more significant. This infrastructure typically has long operating lifetimes, stretching to 30-40 years in some cases, meaning that there are fewer opportunities between now and 2050 to change or upgrade this equipment to accommodate low carbon heat supply options.

The big six sub-sectors and what the heat is used for

4.14 Within UK industry, six large industrial sub-sectors constitute two thirds of the total demand for heat and account for around 70% of greenhouse gas emissions from the sector, making these a natural focus for efforts to decarbonise industrial heat use (see Box 15).

49 DECC (2011) *Energy Consumption in the UK*, industrial data tables. Available at: http://www.decc.gov.uk/en/content/cms/statistics/publications/ecuk/ecuk.aspx

4.15 Looking ahead it is possible to project an average trend in energy efficiency improvement, but this will mask the fact that the availability of further efficiency improvements will differ between sectors. For energy intensive sectors, energy costs represent such a high proportion of final product costs that is has been a major driver for improvement. It is likely that this sector has limited remaining potential. There may be greater potential in less energy intensive sectors.

4.16 The Government has analysed the fuel type and thermal breakdown for heat demand in these large sub-sectors and used this to estimate the potential size and type of low carbon heat source that might be deployed in the future. This analysis underpins the options around efficiency and fuel switching, set out in the sections below.

Geographical distribution of heat demand

4.17 When considering heat demand in these sectors, it is worth noting that much of this demand is located at a relatively small number of large complex sites, performing different processes that utilise large plant and machinery (see Figure 4). This is potentially helpful as heat needs to be used relatively locally. This spatial co-location may provide opportunities for the more efficient heat recovery and transfer of heat between sites using high and low temperature heat, and even further to building heat demand served by district heating if applicable (see Chapter 3). Use of high grade heat at these sites needs to be reconciled with local low grade heat demand to increase overall efficiency and heat use.

Box 15: Heat demand for the "Big Six" industrial sectors

Coke and Refined Petroleum Products: primarily energy use for coke production from coal in coke ovens. 1000°C (high temperature) ovens are fired by a mixture of natural gas and also the gases produced by the ovens themselves and blast furnaces. Refineries use natural gas, refinery gas, fuel oil and petroleum coke residues from the refining process. CHP is used extensively.

Food and Drink: use of hot water and steam for the production, processing, drying and separation of food and drink products, also refrigeration (e.g. for frozen foods). Gas-fired CHP is also a feature in this sector.

Pulp and Paper: large amounts of hot water and steam used for the production and evaporation of pulp and drying of paper product.

Basic Metals: the production of iron and steel, through blast furnaces (which are generally very efficient) and electric arc furnaces, electrolytic production of aluminium and copper. Solid fuels and gas are used for high temperature primary production and electricity for electric arc furnace steel, plus aluminium.

Non-Metallics: includes production of glass, ceramics, bricks, lime and concrete, using a high proportion of gas use but also solid fuels (including waste) within high temperature kilns and furnaces.

Chemicals: highly diverse range of products from industrial gases, fertilisers, plastics, paints, pharmaceuticals and detergents. Majority of processes between 100-500°C for hot water and steam using a large proportion of gas (for which this sector is biggest consumer across industry) but also electricity (e.g. for chilling). There is some CHP in this sector.

Figure 4: Approximate locations and clustering of some major industrial facilities

Source: Department of Energy and Climate Change

Our options – towards low carbon heat in industry

4.18 There are three main ways in which we can reduce greenhouse gas emissions as a result of industrial heat demand:

- **by reducing demand for heat** – focusing first on cost-effective measures such as increasing the energy efficiency of manufacturing energy processes or by using more efficient means of generating heat such as CHP. In the longer term, there is a need to increase the useful lifetime of manufactured products through greater material efficiency which seeks to avoid the amount of energy intense primary production of materials. Seizing opportunities as low carbon technologies mature and new low carbon materials are developed (e.g. low carbon cements) will act to reduce the need for energy, thereby lowering manufacturing costs and boosting the competitiveness of UK companies;
- **by fuel switching** – in the medium and long term we will need to decarbonise the supply of energy for heat by switching to low carbon alternatives such as biomass and decarbonised electricity. However for some high temperature sectors there are more limited options due to technological constraints; and
- **by innovating**: for industries like iron, steel and refining, emissions reductions will be challenging. Advanced technologies will be required which need innovation, such as alternative chemistries and materials or Carbon Capture and Storage (CCS).

4.19 However, very high capital costs and disruption to production mean that changes such as fuel switching and CCS will often not make economic sense other than at natural life-cycle end points.

How we get there – decarbonising industrial heat

4.20 Industry will require sufficient certainty on the availability of technologies and the sustainability of fuels when making investment decisions years in advance, due to high cost of infrastructure and time taken to get a return on investment, where international industry standards will drive what investments can be made without reducing competitiveness. This is especially the case for technologies that require innovation, research and development, which must take place before deployment.

4.21 The Government will therefore need to provide the right policy environment to ensure this transformation is possible. In particular, it will need to ensure that a switch to low carbon sources of heat does not increase manufacturing costs and affect the competitiveness of the sector. The practical impact will depend on how much of the additional cost of policies can be passed through to consumers and upon energy and carbon prices in competitor countries.

4.22 A key risk is that industry will respond to rising energy and carbon prices by reducing production in the UK and increasing output elsewhere – essentially off-shoring part of industry at a detriment to the UK economy without any reduction in global greenhouse gas emissions. Indeed, this might actually cause an increase in emissions when looked at from a global perspective, if manufacture relocates to countries with less stringent carbon emission regulations.

4.23 The Government therefore wants to provide the right framework and support. These pressures will be taken into account, particularly when considering more complex and costly efficiency and fuel switching options.

Reducing demand for energy within industry

4.24 Many cost-effective measures have already been adopted. In some sub-sectors, there are still opportunities which are cost-effective, but which may need some initial capital investment upfront to unlock potential. Payback periods for large pieces of equipment such as a more efficient glass kiln can be ten years or longer, making it hard for such projects to win support in the boardroom where much quicker returns on investment are often sought.

4.25 Recent Government Updated Energy and Emissions projections[50] suggest that industrial energy consumption will fall by 12% over the next two decades (see Chart 21 below). The main drivers of this drop in energy consumption are due to opportunities such as CHP and process, energy and material efficiency.

Combined Heat and Power

4.26 CHP refers to generating electricity and heat as part of the same process, and is therefore a highly efficient means of turning a given input fuel into useful energy. CHP can offer reductions in primary energy demand of up to 30% when compared against the separate generation of heat and power i.e. via a boiler and a power station, regardless of fuel source.

4.27 74% of current CHP capacity in the industrial sector is fuelled by gas, with the take-up of fuels such as biomass and waste beginning to increase. There is currently 5.9GWe of Good Quality CHP capacity in the UK, with 89% of this in the industrial sector, representing 6.9% of UK electricity generation. There is a further established technical potential to increase this to 24 GWe by 2020, meaning that CHP fuelled by both gas and renewable sources could effectively generate about 150TWh of

Box 16: Case Study: Heat-led CHP at British Sugar in Norfolk

Source British Sugar

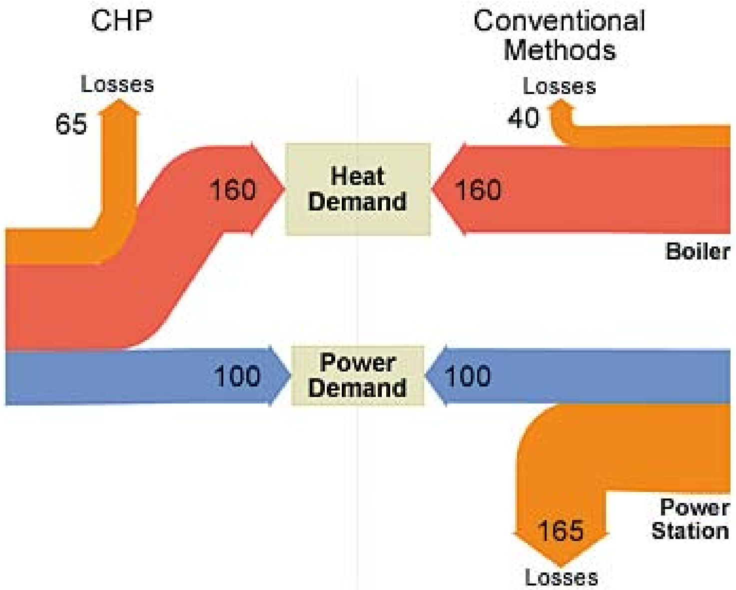
British Sugar's Wissington site is the largest sugar beet factory in the world. The factory can best be described as a biorefinery because on the same site it produces annually 420,000 tonnes of sugar products, up to 55,000 tonnes of bioethanol, 140,000 tonnes of animal feed plus many other products. Heat recovery greatly reduces the carbon footprint of the refinery. The factory is adjacent to the UK's largest single tomato glasshouse which uses considerable volumes of low-grade heat and CO_2 from the factory's CHP plant to help grow around 140 million tomatoes each year.

At the heart of this truly sustainable approach to manufacturing is a highly efficient, 70 MWe capacity, CHP plant. This meets all the steam and electricity needs of the site's operations and is able to export 50 MWe of additional, low-carbon electricity back to the local network; enough power to meet the energy needs of 120,000 people. Performance of the CHP plant itself is augmented by the addition of a multimillion-pound water injection system which can boost output from the gas turbine particularly during warm weather.

Source: British Sugar

50 See: DECC(2011) *Energy and Emissions Projections*, Annex C. Available at: http://www.decc.gov.uk/en/content/cms/about/ec_social_res/analytic_projs/en_emis_projs/en_emis_projs.aspx

Figure 5: How CHP works



electricity, about 39% of UK electricity generation based on 2010 data. Not all of this potential may be cost effective, nor perhaps the most optimal path to decarbonisation.

4.28 Whilst gas CHP is not considered as a long-term low carbon heat option, it can continue to provide cost-effective carbon abatement until 2030. This makes CHP the most efficient way of using fossil fuels in industrial processes during the transition to lower carbon alternatives. There is also the potential for gas CHP to play a role beyond 2030 as a more efficient alternative to gas peaking plant, by providing the steam for industrial processes instead of electric boilers when a demand for electricity generation needs to be met.

4.29 In addition there is the potential for further fuel-switching to low carbon fuels such as waste, biomass and biogas CHP, particularly within sectors such as pulp and paper where waste products can be used to generate this heat and there is an avoided disposal cost. However certain sub-sectors may find it difficult to adapt for a number of reasons, due to the size of heat demand and certainty of fuel supply and there will be a need to take these issues into consideration.

Process, energy and material efficiency

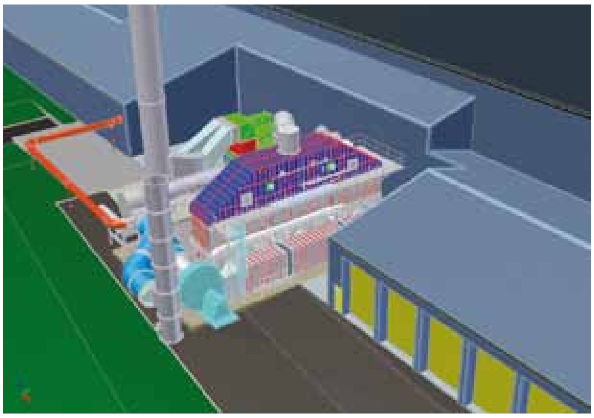
4.30 Further opportunities for energy efficiency in industry include:

- **conventional energy efficiency**: improved energy efficiency of processes will help reduce overall energy demand. There remain opportunities in some areas for instance through process optimisation and control or use of continuous processes rather than having to start and stop equipment. Many measures can be retrofitted with little capital investment and rapid payback periods, in most cases less than a year;

- **process and thermal efficiency:** there are additional opportunities to reduce energy consumption and emissions through changing processes as well as increasing their efficiency. We will need to look for opportunities for further integration of manufacturing and production processes and greater thermal efficiency – for example, greater insulation of kilns or furnaces and increased heat re-use both on site and through export. Other opportunities include, greater pre-heating of glass cullet (recycled container glass) before going into furnaces, and use of low temperature membranes for separation rather than thermally driven distillation in chemicals or food or drink. Options such as these have greater capital costs but a reasonably short payback period which means they are likely to be considered cost-effective by much of UK industry. Greater heat recovery, using useful heat high temperature processes to drive low temperature processes, will also be key.

- **material efficiency**: material efficiency refers to saving energy through re-use of manufactured materials rather than producing new components for every product. This is important as a large proportion of the energy required to create finished goods is consumed by energy intensive industries which generally convert minerals/scrap to some liquid form (e.g. molten metal, pulp, molten plastics, wet cement). Making greater use of these finished products would reduce the level of primary and secondary production and associated

Box 17: Case Study: Industrial Energy Efficiency: Tata Steel, Shotton Works, North Wales



Tata Steel Colors produces organic paint coated pre-finished steel products, principally for cladding, composite walling and roofing applications within the building and construction sector both in the UK and overseas. The manufacturing process requires large amounts of natural gas and generates substantial quantities of volatile organic compounds (VOCs). These VOC emissions need to be treated by an air pollution device to substantially reduce the amount released into the atmosphere.

In order to reduce natural gas consumption on Colorcoat line No.2 and to meet strict VOC emission limits, a Regenerative Thermal Oxidiser has been installed which is capable of processing 83,000 Nm^3/hr of air, achieving the site's environmental permit emission targets and providing energy efficiency benefits.

Source Tata Steel

Once the Oxidiser is at operating temperature it requires no additional fuel. A secondary heat exchanger routes waste heat back to the process ovens, reducing the amount of natural gas required. In addition, supplementary fuel injection has been installed, for greater efficiency.

The system was installed in January 2012, and the site has already seen energy savings of 50% on the line. This equates to a conservative annual energy cost saving of £850,000 and an estimated annual CO_2 saving of approximately 6,750 tonnes.

energy usage. Various measures can reduce the economy's demand for the manufacture of energy-intensive goods and therefore reduce associated emissions. Opportunities include extending the lifecycle of energy intensive primary materials by reusing without re-melting (e.g. engine manufacture) and greater recycling and system commoditisation to extend life of overall products. Also, use of less energy intensive raw materials to manufacture products e.g. more composites rather than metals.

The Government's policy framework to provide certainty

4.31 There are already incentives for Energy Intensive Industry to maximise energy efficiency. A number of policy instruments currently work in tandem to reduce industrial energy consumption by promoting energy efficiency measures and to reduce carbon emissions by the purchase of allowances.

- **European Union Emissions Trading System (EU ETS)** – This is one of the key policies introduced by the European Union in 2005 to help meet its greenhouse gas emissions targets of 8 percent below 1990 levels under the Kyoto Protocol. As a cap-and-trade system, the EU ETS sets an emissions target (cap) for installations covered by the system[55] but allows trading and the carbon market to determine the carbon price and therefore where emissions can be reduced most cheaply. The EU ETS will remain a critical driver for the UK's industrial low carbon transition for this decade and beyond;

- **Climate Change Levy (CCL) and Climate Change Agreements (CCAs)** – Cost-effective energy efficiency measures are also being supported by government policy instruments through the CCL. This is a tax charged on high carbon energy supplied to businesses and the public sector. The Government introduced the CCAs to reduce the impact of the CCL on the competiveness of energy-intensive industry, while still incentivising industry to take action to reduce emissions. These voluntary agreements provide a discount on the CCL for eligible industries in return for meeting challenging energy efficiency or emissions reduction targets.[56]

- **European Union Emissions Directives** – Larger industrial installations are currently subject to the Integrated Pollution Prevention and Control Directive which is being replaced from January 2013 by the Industrial Emissions Directive. Both these Directives require energy to be used efficiently in the installations they cover.

4.32 The Government will continue to deploy policies and beyond to incentivise further energy efficiency and ensure regulatory certainty in this sector.

4.33 The potential to help unlock remaining efficiency potential such as greater heat recovery from waste high temperature heat requires investment in infrastructure to transfer high temperature heat to where it can be re-used.

4.34 Support to bring down investment costs and payback down on efficiency projects will be supported by the **Green Investment Bank** which has identified industrial energy efficiency as one of its priority areas.

4.35 To help those areas of industry particularly exposed in the short term to both electricity price rises and international competition, the Government has announced support measures to support electricity intensive industries in the near term.

51 The EU ETS covers electricity generation and energy intensive industries

52 Current CCAs entitle participants to claim CCL discount until the end of March 2013. The Government announced in the 2011 Budget that the scheme will be extended to 2023, and is currently developing proposals that will simplify the scheme. These proposals will provide targeted financial benefits to business in the range of £2.4–£3.4 million from 2012 to 2020

Box 17: Support for Energy Intensive Industries

In late 2011, the Government announced a package of support for energy intensive industries that aims to ensure that manufacturing is able to remain competitive during the shift to a low carbon economy and to minimise 'carbon leakage' which might happen if investment relocates abroad. It will reduce the impact of policy on the costs of electricity for the most electricity intensive industries, beginning in 2013 and worth around £250 million over the Spending Review period. As part of this, the Government will:

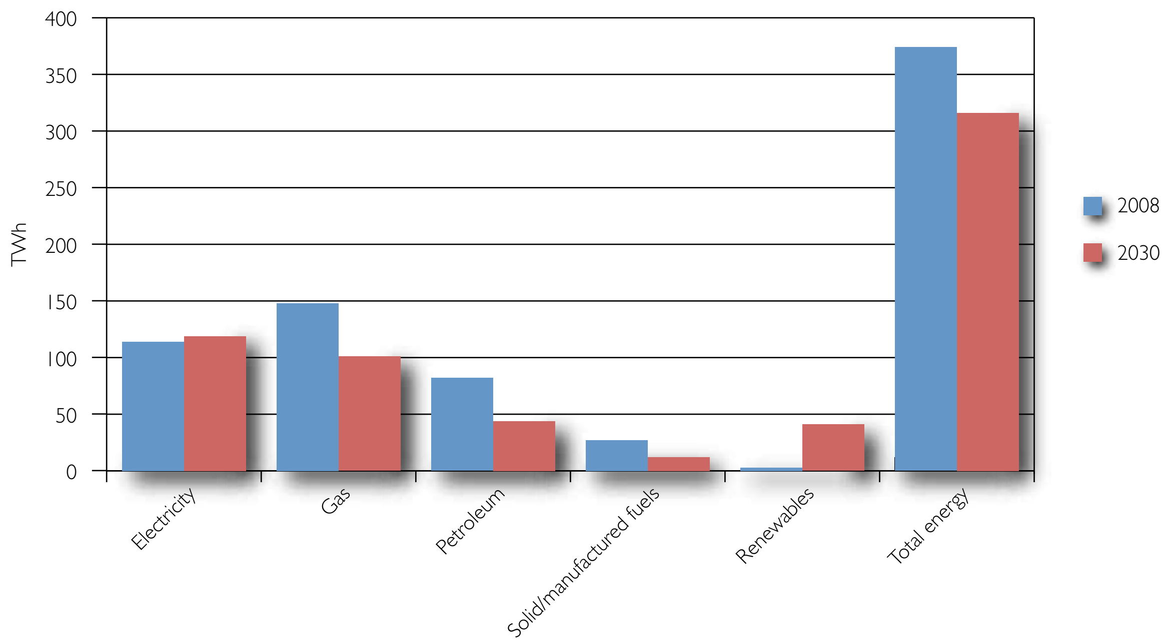
- compensate key electricity-intensive businesses to help offset the indirect costs of the Carbon Price Floor (CPF) and the EU Emissions Trading System (EU ETS) for key electricity-intensive businesses, subject to EU State Aid rules, and
- increase the level of relief for electricity from the Climate Change Levy for Climate Change Agreement participants from the current level of 65 per cent to 90 per cent.

The Government will also explore options for reducing the impacts of electricity costs arising as a result of Electricity Market Reform policies on electricity-intensive industries where this has a significant impact on their competitiveness and will be subject to value for money and state aid considerations.

Fuel switching to low carbon alternatives

4.36 Together with reductions in demand from energy efficiency measures, industry will need to decarbonise its heat supply – most of which is currently from gas. Given the uncertainty about how much potential for further efficiency savings there are in the sector, we will need to decarbonise heat supply where possible and

Chart 21: Energy use in 2008 and 2030 by fuel type[53]



Source: Department of Energy and Climate Change

53 See: DECC (2011) *Energy and Emissions Projections*, Annex C. Available at: http://www.decc.gov.uk/en/content/cms/about/ec_social_res/analytic_projs/en_emis_projs/en_emis_projs.aspx. Note: offshore refinery processes are excluded from this chart

move to low carbon energy sources. In the very short term, there may be opportunities for emissions reduction through switching remaining solid fuel use to gas but in the long run we need to set industry on a low carbon heat path through switching to bioenergy or decarbonised electricity.

Sustainable biomass and biogas

4.37 There is a large potential for deployment of sustainable **biomass** within the industrial sector. While the major cost-effective opportunity over the next decade is in replacing old industrial gas boilers with gas CHP, estimates suggest that around half of industrial heat demand could be met by biomass (mainly in boilers and possibly with use of CHP) in the 2020s.[58] For example, the chemicals sector has already achieved a 36% penetration of gas-fired CHP, so a move to renewable CHP using biomass may be a means to deliver further emission reductions.

4.38 The largest potential in the short term is to be found in processes which require low temperature steam (up to around 300 degrees), but there are also suitable high temperature applications such as cement kilns which should be relatively easy to adapt to biomass use or waste combustion.

4.39 Decarbonising higher temperature processes presents a challenge. **Biogas** (in the form of biomethane) can be particularly appropriate for those industries such as ceramics and glass where fuel cleanliness is paramount, and mechanical engineering e.g. steel casting, where high calorific values are required. Sectors such as plastics which use natural gas as a feedstock may also have an interest in the provision of biogas.

4.40 A consideration of the geographical clustering of major chemical manufacturing sites and the current high level of natural gas demand in this sector raises the question as to whether a number of discrete industrial bio-gasification sites could be developed. These would have the ability to utilise a wide range of biomass feed stocks and produce a range of products, from the production of syngas[59] which could be used to produce a number of chemicals, to hydrogen, which could be used to generate electricity, or biomethane for use in the chemicals sector. Such units could be an effective way of serving local industrial demand.

4.41 However, for biomass and biogas to be used at a meaningful scale, some key security of supply issues over the sustainability of feedstocks will have to be addressed.

4.42 The **Renewable Heat Incentive (RHI)** will support substantial deployment of biomass and biogas combustion, including CHP, and biomethane injection into the gas grid. The support for biogas includes anaerobic digestion, sewage gas and syngas. We are already seeing large installations being deployed as a result of this financial incentive.

4.43 Due to a lack of evidence during the initial policy design, the limit for biogas combustion was set at heating equipment with a capacity of less than 200kWh. However, as part of the future expansion of the scheme, on which the Government will consult this September, it is considering removing or setting a higher limit, based on the latest evidence. Such a change would help support larger industrial biogas heat applications and encourage companies to switch fuels. However, such a switch will require secure and sufficient feedstock supply and long-term incentives providing policy certainty.

54 NERA (2010) Decarbonising Heat: Low-Carbon Heat Scenarios for the 2020s, Report for the Committee on Climate Change

55 A gas mixture that comprises of carbon monoxide, carbon dioxide and hydrogen. The syngas is produced due to the gasification of a carbon containing fuel to a gaseous product that has some heating value

4.44 The RHI is currently limited to supporting installations which generate hot water or steam through a boiler or engine, as these can be metered relatively easily. Government is also considering the inclusion of equipment which can heat air directly, thereby potentially expanding the type and number of industrial uses of bioenergy which the RHI supports.

Decarbonised electricity

4.45 As set out above, electricity equates to approximately a quarter[56] of total energy demand for heat within industry and will increasingly become an important source of low carbon heat energy as the grid decarbonises. Electricity is mainly used for space or liquid heating where volatile or flammable products are used or where controllable low temperature heat is required. It is also used to produce high temperatures for melting (in an arc furnaces) and to directly drive a reduction process e.g. in aluminium production.

4.46 The latest projections project that the proportion of electricity used in this sector is likely to increase and replace gas as the largest supplier of energy demand by 2030 (see Chart 21). Assuming that a similar proportion of heat is required for driving manufacturing processes in the future, then more heat applications will need to be electrified, for example, greater use of electric arc steel making or electrolysis to replace blast furnaces, or more direct electric heating in ovens. There is also the potential to use relatively high temperature heat pumps in the future for relatively low temperature applications.

4.47 The Electricity Market Reform project has been designed to deliver a largely decarbonised electricity sector by 2030 in line with the Fourth Carbon Budget.[57] This is in the context of an increase in demand for electricity as expected electrification of heat and transport offset increased efficiency in electricity use.

4.48 Further support and innovation may be required to allow industry to utilise greater availability of low carbon electricity in the future. There may be methods of supporting electro-intensive industry through the transition through Electricity Market Reform, including facilitating closer interaction between electricity generators and industrial users, and potentially offering incentives for more flexible interruptible contracts to assist demand-side response under the Capacity Mechanism.

Industrial Carbon Capture and Storage (CCS)

4.49 CCS is at present an unproven technology at large-scale, but so far the evidence suggests that there is a real potential for commercialisation. For a small number of industries, CCS provides a further option alongside fuel-switching for tackling combustion emissions of remaining fossil fuels for high temperature processes. This includes coke-fired blast furnaces for iron and steel production, or where emissions are implicit in the chemical process such as the manufacture of cement, lime and bricks. CCS could therefore be important for emissions-intensive processes where it is not cost-effective to decarbonise by any other route, for example, if the UK cannot produce all iron and steel with electrolysis or biomass.

4.50 For the 15% remaining process emissions,[58] it may be that commercialisation of CCS will be critical, but this will be long term as most of these sources are very small and will be very expensive to link to transport and infrastructure. However, they may be able to migrate over time if there is certainty over the provision of transport and storage infrastructure, for example where larger sources

56 DECC (2008) *Energy Consumption in the UK*
57 See: The Carbon Plan (2011) *Delivering our low carbon future*. Available at: http://www.decc.gov.uk/en/content/cms/tackling/carbon_plan/carbon_plan.aspx
58 AEA (2010) *Analysing the Opportunities for Abatement in Major Emitting Industrial Sectors*

of emissions such as power stations are already utilising CCS. Clusters of industrial emitters may be large enough to support dedicated pipelines but it is more likely they will connect to infrastructure built for (or in collaboration with) the power sector.

4.51 CCS may also have a role to play in offering the potential for bio-negative emissions reduction through sequestering emissions from biomass, which is already low carbon e.g. if linked to a biomass fired blast furnace or to a large scale gasification facility.

4.52 There are currently CCS research projects underway in the UK and Europe supported by various funding sources, with the aim of accelerating commercial viability. In the industrial sector, assets are typically of high capital value with lifetimes of up to 40 years. CCS would therefore need to be planned sufficiently in advance.

4.53 Initially, CCS deployment in the industrial sector will be dependent on the development of infrastructure for transport and storage within the power sector, combined with the location of existing chemical plant (with limited propensity to move). Once the technology has been proven and infrastructure is in place, it may then be rolled out, but again only to sites with large emissions and a location near to storage sites and infrastructure. There is a question as to whether all process emissions would ever be captured by CCS where they originate from small sources. Development of CCS infrastructure may prove uneconomic, for example at small sites for glass and ceramics manufacturing, meaning CCS is unlikely without considerable consolidation and relocation. It may not be efficient to deploy CCS for emission sources below 500kt,[63] meaning that consolidation of cement and lime manufacturing and relocation to CCS clusters may be an option.

4.54 The Government will shortly be publishing a CCS Roadmap which sets out the Government's interventions and the rationale behind them.

Questions

- What technical and financial barriers could prevent the switch to low carbon heating technologies on industrial sites?
- What scope is there for further reductions in emissions through energy efficiency in industrial processes?
- Do you have evidence from existing projects to demonstrate the cost-effectiveness or otherwise of approaches to reducing emissions from industrial heat, including combined heat and power?
- If you have been practically involved in projects that sought to reduce emissions from industrial heat, what lessons can you share?
- What policies should the Government pursue to promote or facilitate reduction in emissions from industrial heat?
- What policies should the Government pursue to promote or facilitate recovery of waste heat from industrial processes?

59 Element Energy. (2010) *Potential for the application of CCS to UK industry and natural gas power generation*

The Government's strategy for transforming industry

Box 19: Strategy for the coming decades for decarbonising industry

In this decade, the focus for Government is on:

- energy efficiency, both in terms of how processes are run and also adopting more thermally efficient practises e.g. heat recovery within processes, encouraged by energy efficiency incentives such as Climate Change Agreements;
- some switching in low temperature processes to sustainable biomass (where there is little need for innovation), encouraged by the Renewable Heat Incentive;
- more efficiency through CHP both on gas and also where effective using biomass and energy from waste supported through the Renewables Obligation and RHI;
- some fuel switching to waste and biomass combustion, and more gas and biogas use in high temperature processes to reduce remaining use of solid and liquid fossil fuels; and
- at the same time, support innovation in electrification, bioenergy, CCS and material efficiency.

In the medium term (2020–2030), we expect:

- greater efficiency of thermal processes by heat recovery and re-use between high and low temperature processes;
- greater use of biogas (in the form of biomethane) for high temperature processes where clean burning fuels are needed;
- further deployment of sustainable biomass for low temperature processes to reduce natural gas use;
- greater electrification of lower temperature processes e.g. direct electric steam generation, as electricity supply is decarbonised, greater use of electric arc furnaces and electric kilns for glass production; and
- initial deployment of CCS to capture combustion emissions from remaining fossil fuel use in high temperature processes.

In the longer term (2030 beyond) we expect:

- greater material efficiency or material switching to reduce the amount of primary production required;
- wider deployment of CCS to capture remaining inherent process emissions. A relatively small number of interventions at a few sites have the potential to yield large savings; and
- further fuel switching to electricity and biomass as more innovative solutions are developed for remaining high temperature processes.

Chapter 5: Framework for Action

- *Achieving the ambition described in this document will require a transformation which will mean changes across the country, with different solutions for different sectors.*
- *The Government's vision is of buildings benefitting from a combination of renewable heat in individual buildings, particularly heat pumps, and heat networks distributing low carbon heat to whole communities. We will build this future by focusing first on the energy efficiency of our buildings and preparing the market for a transformation in our heating in the 2020s and 2030s. Achieving our goals will be far from easy. We need first to fully understand all the barriers – commercial, technical and behavioural – to achieving this vision. More action will then be needed from central and local government, business and consumers to make the transformation happen.*
- *For industry, we want to continue the transformation already begun, and continue to see decarbonisation complemented by economic growth. Government's vision is of a thriving, competitive industry which takes up the opportunities of greater efficiency, and moves over the medium and long term to low carbon fuel types such as bioenergy and electrification of processes, with Carbon Capture and Storage addressing those processes which cannot be decarbonised because of the chemistry involved.*
- *Government is acting now to set the UK on course for this vision. Policies such as the Green Deal will support greater energy efficiency now, while the Renewable Heat Premium Payment and Renewable Heat Incentive will help encourage innovation and build the market for renewable heat. These actions will pave the way for the major changes that will need to happen in the 2020s and beyond.*
- *This document asks a series of questions which will drive engagement with the heat industry, its consumers and other stakeholders over the coming months. Once the deadline for responses has passed, DECC will then publish a summary of the comments received on the DECC Website, and continue to work through the issues set out in this document for the remainder of the year, following up specific points expanding the evidence base in the ways set out here. This should then enable the Department of Energy and Climate Change to publish a document containing a range of policy proposals for decarbonising heat within 12 months.*

How we get there – transforming the way we use and supply heat

5.1 The Government's vision and strategy for decarbonising heat is set within a three stage strategy, outlined for the whole economy in the Carbon Plan published in 2011:

- **This decade – complete and prepare:** The Government's focus for both buildings and industry will be on energy efficiency, saving emissions and preparing the way to achieve the maximum efficiency from low carbon heat sources. At the same time, the Government will work with business to prepare the market, drive early deployment, innovation and build supply chains for low carbon heat technologies, helping to bring down costs ahead of large scale roll-out.

- **The 2020s and 2030s – mass deployment:** We anticipate that the next two decades will see the growth of low carbon heat to mass market levels in buildings, and greater fuel switching to low carbon heat sources such as biomass in industry. Government's focus will be on creating the right frameworks to support that market and minimise costs to consumers and industry.

- **The long term – finalising:** From the 2030s, the Government's focus will increasingly shift to helping business and consumers tackle the more challenging areas. This includes supporting the roll-out of low carbon heating in more difficult to reach buildings, and supporting industry in the roll-out of technologies that require more innovation, such as biomass for high temperature processes and industrial CCS.

This decade

Buildings

5.2 To safeguard affordable heat and secure ongoing energy and carbon savings, we are already acting to maximise the energy efficiency of our buildings. The Government's polices are aimed at ensuring that all practical cavity wall and loft insulations will be completed, and solid wall insulation deployed to up to 1.5 million buildings, by the end of this decade.

5.3 Through the Green Deal, the Government will transform access to cost-effective efficiency measures by enabling building owners and tenants to harness the savings from these measures to cover their upfront costs. The Green Deal will provide the platform for investments in efficiency that are based on the true merit of measures and not on their short-term costs. In this way, the Green Deal will unlock the deep improvements in UK buildings needed to protect consumers and pave the way for cost-effective low carbon heat.

5.4 Alongside the Green Deal, the Energy Company Obligation (ECO) will ensure energy companies protect the most vulnerable consumers, and will support deployment of energy efficiency measures which face high costs and barriers.

5.5 The energy efficiency of new buildings will also be dramatically improved, with Zero Carbon Homes and non-domestic standards maximising fabric quality and locking in long-term savings at the point of construction.

5.6 Also this decade, the replacement of most of the remaining 13 million non-condensing gas boilers with high-efficiency condensing boilers will improve energy efficiency and reduce emissions.

5.7 To prepare for the large-scale deployment of low carbon heating technologies needed from 2020, the Government will support the development of the low carbon heating industry and market. The Renewable Heat Premium

Payment and the Renewable Heat Incentive are already catalysing early uptake of low carbon heating, especially where these technologies are displacing more-expensive and higher-carbon heating fuels like oil. These initiatives will contribute to meeting the Government's renewable energy target in 2020.

5.8 In the next year, Government will also bring forward further measures to accelerate the deployment of low carbon heat to buildings, with a view to stimulating a full and effective market that will focus innovation, drive down costs and strengthen supply chains and skills.

5.9 The Department of Energy and Climate Change will publish a document containing a range of policy proposals for decarbonising heat within 12 months. The Department will also be consulting on future phases of the Renewable Heat Incentive in line with the timetable published on 26 March 2012.

5.10 Although the Government does not expect large scale roll out of low carbon heat technologies in buildings by 2020 beyond the level needed to contribute to our renewables target, during this decade we will need to develop the supply chain for our skills and institutional capacity, including through targeting particular sectors such as the commercial sector and homes not supplied by mains gas.

5.11 Alongside this, the Government will continue to explore the risks of overheating in buildings which could be exacerbated by climate change in the UK, and the potential impacts of cooling demand on energy efficiency and carbon emissions.

Heating networks

5.12 Heating networks are currently estimated to provide less than 2% of total heat in the UK. The Government believes that heat networks have an increasingly key role to play in the UK energy system and this decade will be crucial in removing the barriers and beginning deployment. New schemes are likely to be localised, and are expected to use gas CHP (which can be upgraded in the future), biomass and other low carbon options where possible. This will increase credibility in the market, driving investment and building capacity in skills and the supply chain. Opportunities this decade include:

- establishing schemes in the cores of major urban centres where high-density housing (especially new builds) provide sufficient heat loads to make heating networks economical, and where building-level technologies are less suitable due to lack of space. This will include targeting electrically-heated high-rise buildings and social housing;
- extending existing heat networks where schemes are operational to capture customers from the private sector and increase supplier confidence; and
- making use of existing CHP plants and heat recovered from industrial sites and thermal power plants.

Industry

5.13 Over 80% of emissions from industry originate from generating heat to drive a diverse range of manufacturing processes, many of which are highly energy intensive and rely on fossil fuels combusted on-site. This decade the emissions reductions from industry will come from remaining opportunities for energy efficiency and from beginning to move to low carbon fuels, further displacing fossil fuel combustion in manufacturing, including:

- exploiting remaining potential for conventional energy efficiency for instance through process optimisation and use of continuous production processes (rather than starting and stopping industrial equipment);
- driving further efficiencies in the use of energy and materials, adopting more thermally efficient practises e.g. heat recovery within processes;
- through the EU ETS and UK policies such as Climate Change Agreements and the CRC Energy Efficiency Scheme, the Government

will help to ensure that these cost effective energy efficiency measures are being taken up;

- we will also need to exploit opportunities to increase Combined Heat and Power deployment. This is primarily an energy efficiency measure; regardless of the fuel type, it is more efficient to produce heat and electricity together provided there is demand for both. Initially, much of this CHP will continue to be gas-fired but there is potential for a large expansion in biomass CHP use, particularly within sectors that use low temperature processes such as pulp and paper where waste can be used to generate this heat;
- as with buildings, the Government expects industry to take advantage of the Renewable Heat Incentive, so where it is cost-effective we should begin fuel switching to sustainable biomass and other renewable energy sources which are deployable now. As we begin the transition to low carbon forms of heat supply, the Government will work closely with industry to address the key risks, including the impact of increases in energy costs to ensure that the UK remains competitive; and
- innovation in this decade will be crucial in delivering the necessary emissions reductions in the long term. This will help bring down the costs of decarbonising industry in a number of key sectors, moving technology options such as greater electrification of processes and CCS closer to the commercial stage of deployment. CCS will be demonstrated this decade, supported by UK and international sources of funding, the success of which, will allow practical application next decade and beyond. Furthermore, advanced forms of sustainable bioenergy use and electrolysis are also not yet at commercial stage, and public and private support to address innovation gaps both in the UK and internationally will be important this decade, in making them possible for the future.

Next decade and beyond

Buildings

5.14 By the 2020s the efficiency of UK building stock will have substantially improved, with the most cost-effective efficiency measures having been completed. Solid wall insulation will continue to be rolled out alongside more-incremental improvements such as under floor insulation and double and triple glazing.

5.15 During the 2020s and 2030s the Government anticipates a substantial increase in low carbon heat deployment as key technologies begin to reach the mass market.

5.16 In urban areas, Government will look to local authorities to help roll out low carbon heat networks that make the best use of local heat sources and stores.

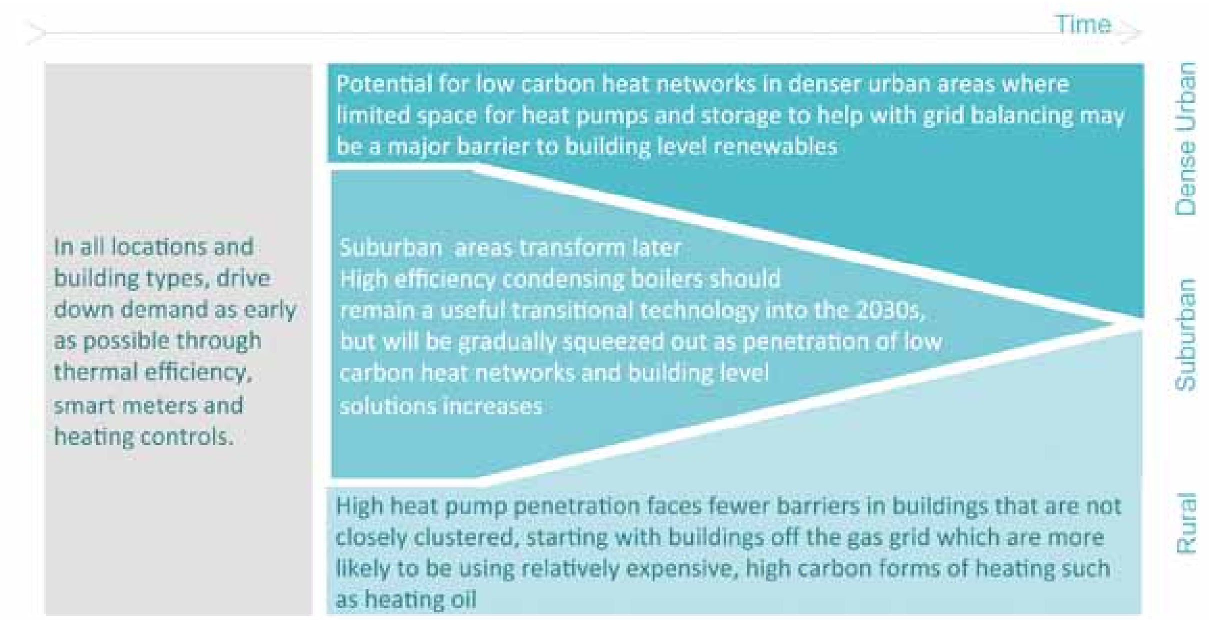
5.17 In suburban and rural areas, low carbon heating technologies at the level of individual buildings will be necessary. In particular, heat pumps are expected to provide substantial quantities of heat.

Heating networks

5.18 From the early 2020s, the Government also anticipates the further expansion of heat networks to larger areas, though this is still likely to be predominantly in urban areas with denser heat loads, and upgrade them to more sustainable and low carbon sources of heat. Further into the future, these networks could expand to capture larger commercial and industrial sites, and entire city centres, including:

- upgrading gas CHP networks to low carbon alternatives like large heat pumps and biomass;
- establishing and expanding networks which use recoverable heat from low carbon power generation (potentially including new nuclear and Carbon Capture and Storage); and

Figure 6: Government's strategic framework for low carbon heat in buildings



- joining stand-alone renewable capacity to existing networks, and larger new build housing developments which will change the face of our communities and help decarbonise our heat supply for the long term.

Industry

5.19 The 2020s and beyond will see the continued take-up of remaining efficiency measures, including greater efficiency of thermal processes through heat recovery and re-use between high and low temperature processes. We can also increase the useful lifetime of manufactured products through greater material efficiency, which seeks to avoid the amount of energy used for primary production of materials.

5.20 The focus in the medium to long term will be greater deployment of more advanced decarbonisation measures:

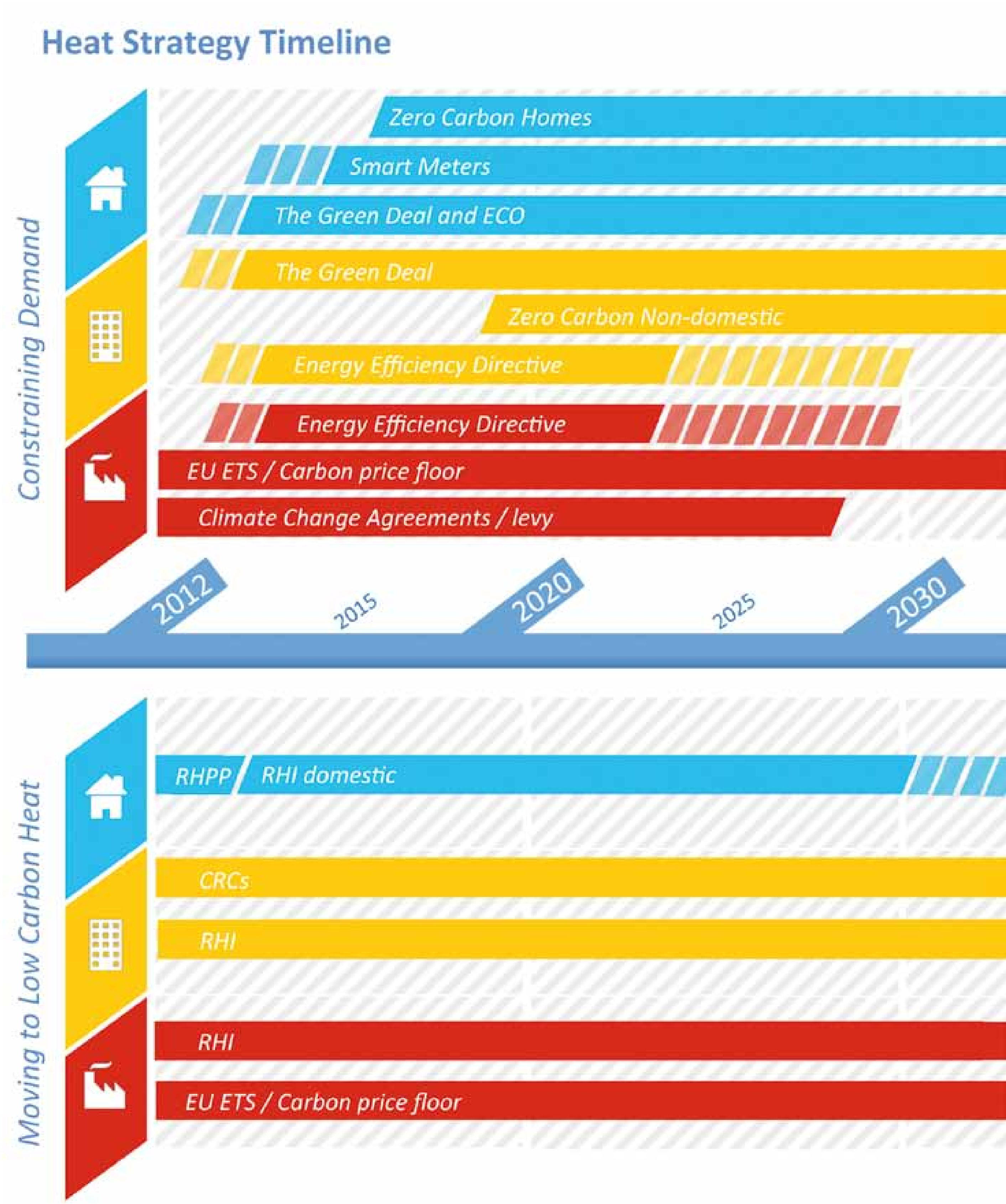
- For lower temperature processes there is potential for greater electrification, for example increased use of electric arc furnaces and electric kilns for glass production, and potentially direct electric heating of water as the electricity supply is decarbonised. Further deployment of sustainable biomass and renewable CHP to reduce natural gas use, will also be required in sectors.

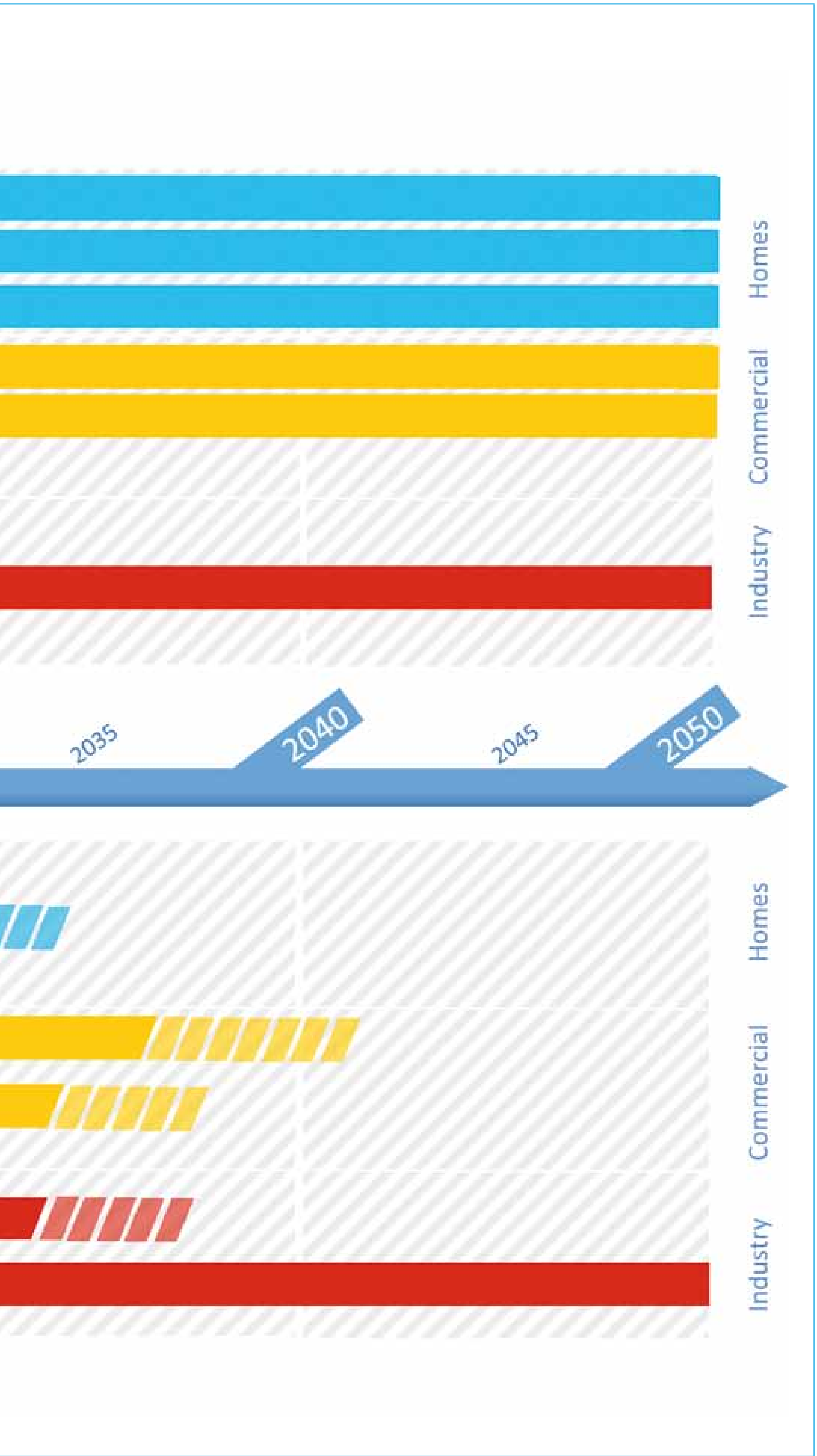
- For high-temperature processes, biogas could be used during the 2020s in a small number of industries, such as ceramics and glass where fuel cleanliness is paramount, and mechanical engineering such as steel casting where high calorific values are required. Sectors such as plastics which use natural gas as a feedstock may also have an interest in the provision of biogas. Beyond 2030, the Government expects to see take up of electrification as it becomes increasingly decarbonised and commercially viable for high temperature processes.

Figure 7: Government's strategic framework for low carbon heat in industry

- During the 2020s and beyond, we may also begin to see industrial deployment of CCS. This will play a key role in capturing remaining combustion emissions from remaining fossil fuels use in high temperature processes, for example from the continued use of coke-fired blast furnaces for steel production, and where process emissions result directly from processes themselves such as the manufacture of cement. It makes sense for CCS to be deployed where it is economic, in particular where industrial plants with high emissions are located near storage sites. Industrial sectors with low capture costs but relatively small emissions may choose over the longer term to locate close to future CCS infrastructure as it is developed. Beyond 2020, relatively small number of interventions at a few sites e.g. iron and steel have the potential to yield large savings through the use of CCS.

Figure 8: Illustrative timeline for decarbonising UK heat supply




Homes
Commercial
Industry
2035
2040
2045
2050
Homes
Commercial
Industry

Glossary

Anaerobic Digestion (AD): A treatment process breaking down biodegradable material, particularly waste, in the absence of oxygen. Produces a methane-rich biogas that can substitute for fossil fuels.

Air source heat pump (ASHP): An air-source heat pump uses electricity to draw air across the evaporator of the heat pump extracting heat from the outside air, in the same way that a fridge extracts heat.

Biomass: Biological material that can be used as fuel. Includes solid biomass such as wood, plant and animal products, gases and liquids derived from biomass, industrial waste and municipal waste.

Biomethane: Pipeline quality methane of biological origin (effectively renewable natural gas), generally produced either by cleaning up the biogas that results from anaerobic digestion or via a 'methanation' process to produce methane from the synthesis gas resulting from biomass gasification.

Biosynthetic gas: Biosynthetic gas can be produced by gasification of biomass feedstocks into syngas. The syngas can then be processed into high quality biomethane.

Calorific Value: The calorific value of a fuel is the heat available from that fuel when it is completely burned, expressed as heat units per unit of fuel weight or volume.

Carbon Capture and Storage (CCS): Technology which involves capturing carbon dioxide, transporting it and storing it in secure spaces such as geological formations, including old oil and gas fields and aquifers under the seabed.

Carbon Plan: Published in December 2011, the Carbon Plan sets out the Government's plans for achieving the emissions reductions committed to in the first four carbon budgets, on a pathway consistent with meeting the 2050 target.

Carbon Emissions Reduction Target (CERT): Requires all domestic energy suppliers with a customer base in excess of 50,000 customers to make savings in the amount of CO_2 emitted by householders.

Climate Change Agreement (CCA): Energy intensive industries may receive a discount from the Climate Change Levy against agreed targets for improving their energy efficiency or reducing carbon emissions. CCAs set the terms under which eligible companies may claim the levy reduction.

Committee on Climate Change (CCC): The CCC is an independent body established under the Climate Change Act (2008). The CCC advises the UK Government on setting and meeting carbon budgets and on preparing for the impacts of climate change.

Climate Change Levy (CCL): One of a range of measures designed to help the UK meet its legally-binding commitment to reduce greenhouse gas emissions. It is chargeable on the industrial and commercial supply of taxable commodities for lighting, heating and power by consumers in the following sectors of business: industry, commerce, agriculture, public administration, and other services.

Combined Heat and Power (CHP): The simultaneous generation of useable heat and power (usually electricity) in a single process.

Community Energy Online (CEO): The Community Energy Portal of the Department of Energy and Climate Change aimed at Local Authorities and community groups.

Condensing Boilers: A condensing boiler extracts additional heat from the waste gases by condensing water vapour to liquid water, thus recovering its latent heat.

Carbon Reduction Commitment Energy Efficiency Scheme (CRC): The CRC is a mandatory scheme aimed at improving energy efficiency and cutting emissions in large non-energy intensive public and private sector organisations.

District Heating (DH): The supply of heat to a number of buildings or dwellings from a centralised heat production facility by means of a pipe network carrying hot water or steam.

Electricity Market Reform (EMR): In July 2011 the Government published 'Planning our electric future: a White Paper for secure, affordable and low-carbon electricity.' The White Paper sets out key measures to attract investment, reduce the impact on customer bills, and create a secure mix of electricity sources including gas, new nuclear, renewables, and carbon capture and storage.

Energy Company Obligation (ECO): A new obligation on energy companies which draws on the strengths of the existing energy company obligations. Vulnerable households on low incomes, as well as those in properties that are more difficult to treat, will be a key focus of the scheme. The ECO will ensure that households unable to take advantage of Green Deal finance can still be supported and can improve the energy efficiency of their homes.

Energy intensity: A measure of total primary energy use per unit of gross domestic product.

Energy Service Company (ESCo): An ESCo is a commercial structure created to produce, supply and manage the local delivery of decentralised energy. An ESCo might cover a single energy user such as a hospital or a number of smaller users, such as households or commercial premises, or both. ESCOs help to overcome financial constraints to investments and pay off initial costs through energy cost savings.

European Emissions Trading Scheme (EU ETS): A Europe-wide cap and trade scheme that sets an overall cap on the total emissions allowed from all the installations covered by the System. This is converted into allowances (one allowance equals 1 tonne of CO_2) which are then distributed by EU member states to installations covered by the scheme. From 2013, there will be full auctioning for the power sector in GB.

Fossil Fuels: Coal, oil and gas are called "fossil fuels" because they have been formed from the organic remains of plants and animals laid down many millions of years ago. As fuels they offer high energy density, but making use of that energy involves burning the fuel, with the oxidation of the carbon to carbon dioxide and the hydrogen to water (vapour).

Green Deal: The Energy Act 2011 includes provisions for the 'Green Deal', which intends to reduce carbon emissions cost effectively by revolutionising the energy efficiency of British properties. The Green Deal financial mechanism eliminates the need to pay upfront for energy efficiency measures and instead provides reassurances that the cost of the measures should be covered by savings on the electricity bill.

Ground Source Heat Pumps (GSHP): Ground source heat pumps pass fluid through coils in the ground to extract low level heat and upgrades the temperature so that it is warm enough to heat space and water inside the building.

Heat networks: The pipe network used in district heating.

Heat emitters: Ways of emitting heat from a heating system such as radiators, and under-floor heating.

Local Authority (LA): An administrative unit of local government.

Liquefied Natural Gas (LNG): When natural gas is cooled to a temperature of approximately -160°C at atmospheric pressure it condenses to a liquid called Liquefied Natural Gas.

Liquefied Petroleum Gas (LPG): Gas usually propane or butane, derived from oil and put under pressure so that it is in liquid form. Often used to power portable cooking stoves or heaters and to fuel some types of vehicle.

Micro-CHP: This technology generates heat and electricity simultaneously, from the same energy source, in individual homes or buildings. The main output of a micro-CHP system is heat, with some electricity generation.

Microgeneration: Microgeneration is defined under the Energy Act 2004 as less than 45kW (micro-heat) and less than 50kW (micro-electricity). Microgeneration can refer to community scale energy which may fall within these capacities.

Microgeneration Strategy: Published in June 2011 alongside the Microgeneration Industry Contact Group Action Plan. The Strategy focuses on non-financial barriers to microgeneration which must be tackled to maximise the effectiveness of the financial incentives that have been put in place.

Renewable Heat Incentive (RHI): Provides long-term financial support to renewable heat installations to encourage the uptake of renewable heat.

Renewable Heat Premium Payments: A second phase of the RHPP scheme launched on 2 April 2012 makes available £25m for renewable heat installations in homes and communities.

Resistive heating: Uses electrical resistance in wires to generate heat.

Renewables Obligation: The UK's current scheme to incentivise investment in renewable generation. It places an obligation on licensed electricity suppliers to provide a set number of Renewables Obligation Certificates per MWh of electricity supplied in the UK or to pay a buy-out price.

The Standard Assessment Procedure (SAP): SAP is the UK Government's national calculation methodology for assessing and comparing the energy and environmental performance of dwellings. Its purpose is to provide accurate and reliable assessments of dwelling energy performance that are needed to underpin energy and environmental policy initiatives.

Smart Meters: The rollout of smart meters will be a major national project. It will replace around 53 million gas and electricity meters. They will provide consumers with near real-time information about energy use, and more accurate bills.

Syngas: Syngas is the abbreviation for synthesis gas. This is a gas mixture of carbon monoxide, carbon dioxide and hydrogen. The syngas is produced due to the gasification of a carbon containing fuel to a gaseous product that has some heating value.

Trigeneration: The simultaneous generation of electricity, useful heating and useful cooling from the same original heat source.

Waste: Includes food waste, wood waste, sewage and other biological waste from homes or industry, which tend to otherwise be discarded, as well as livestock manures.

Annex 1 – Response Template

1. The Department is seeking comments by Thursday 24 May 2012.

2. DECC will then publish a summary of the comments received on the DECC Website, and continue to work through the issues set out in this document for the remainder of the year, following up specific points with stakeholders and expanding the evidence base. This should then enable the Department to publish a document containing a range of policy proposals for decarbonising heat within 12 months.

3. Please use the table below as a template to respond to the published questions. It will help us to record and take account of your views. Responses should be sent to heatstrategy@decc.gsi.gov.uk by Thursday **24 May 2012**.

4. Also, please provide evidence for your answers and comments where possible.

PERSONAL DETAILS
Respondent Name:
Email Address:
Contact Address:
Contact Telephone:
Are you responding as an individual or on behalf of an organisation?
Organisation Name:
How were members' views assembled:
Would you like this response to remain confidential? Yes/No (Delete as appropriate)
If yes, please state your reasons:

EXECUTIVE SUMMARY: THE HEAT CHALLENGE
Q1: Do you agree with the nature of the challenge described for reducing emissions from heating and cooling across the UK? Agree/Disagree/I don't know (Please delete as appropriate) Please explain:
Q2: Do you have evidence that we should be taking account of as we develop our view of this challenge? Your answer:
Q3: Are there other dimensions that we should be factoring in as we pursue our responses to this challenge? Your answer:
Q4: Do you have evidence about the role that different technologies or approaches might play in our response to the challenge, or the key barriers that we will have to address? Your answer:

CHAPTER 1: MANAGING HEAT DEMAND IN BUILDINGS
Q5: Do you agree with the barriers and opportunities set out in relation to managing demand for heat in buildings? Agree/Disagree/I don't know (Please delete as appropriate) Please explain:
Q6: Do you have evidence from existing projects to demonstrate the costs and benefits of demand management solutions in reducing emissions? Your answer:
Q7: If you have been practically involved in managing heat demand in buildings, what lessons can you share? Your answer:
Q8: What policies should the Government pursue to promote or facilitate improvements in the management of heat use in buildings, both domestic and commercial? Your answer:

CHAPTER 2: TRANSFORMING BUILDING-LEVEL HEATING
Q9: Do you agree with the barriers and opportunities set out in relation to heating and cooling solutions in homes and other buildings? Agree/Disagree/I don't know (Please delete as appropriate) Please explain:
Q10: Do you have evidence from existing projects to demonstrate the costs and benefits of heating and cooling solutions in reducing emissions in homes and other buildings? Your answer:
Q11: If you have been practically involved in installing heating and cooling solutions, what lessons can you share? Your answer:
Q12: What policies should the Government pursue to promote or facilitate low carbon heating and cooling solutions in homes and other buildings? Your answer:

Q13: What are challenges to skills development and capacity building to significantly increase the number of domestic renewable heating installations? Your answer:
Q14: Do you have evidence on the viability, economics and performance of hydrogen in building heating applications, including distribution through existing gas pipes? Your answer:
CHAPTER 3: DEVELOPING HEAT NETWORKS IN THE UK
Q15: Do you agree with the barriers and opportunities set out in relation to heat networks? Agree/Disagree/I don't know (Please delete as appropriate) Please explain:
Q16: Do you have evidence from existing projects to demonstrate the costs and benefits of heat networks in reducing emissions, alleviating fuel poverty or reducing fuel consumption? Your answer:

Q17: If you have been practically involved in setting up heat networks, what lessons can you share?

Your answer:

Q18: What policies should the Government pursue to promote or facilitate heat networks?

Your answer:

Q19: Do you see the need to regulate the supply of heat through heat networks and, if so, how?

Yes/No/I don't know (please delete as appropriate)

Please explain:

CHAPTER 4: TRANSFORMING INDUSTRIAL HEAT

Q20: What technical and financial barriers could prevent the switch to low carbon heating technologies on industrial sites?

Your answer:

Q21: What scope is there for further reductions in emissions through energy efficiency in industrial processes? Your answer:
Q22: Do you have evidence from existing projects to demonstrate the costs and benefits of approaches to reducing emissions from industrial heat, including combined heat and power? Your answer:
Q23: If you have been practically involved in projects that sought to reduce emissions from industrial heat, what lessons can you share? Your answer:
Q24: What policies should the Government pursue to promote or facilitate reduction in emissions from industrial heat? Your answer:

Q25: What policies should the Government pursue to promote or facilitate recovery of waste heat from industrial processes?

Your answer:

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