IEA HPP Annex 42: Heat Pumps in Smart Grids

Task 1 (i):

Market Overview

United Kingdom

22nd January 2014

Report compiled by:

Delta Energy & Environment

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List of abbreviations

RES-E	Electricity from renewable energy sources
RES-H	Heat from renewable energy sources
RES-T	Transport from renewable energy sources
RHI	Renewable Heat Incentive
HP	Heat Pump

1. Executive Summary

UK energy market context – challenges & opportunities for heat pumps

- **The UK faces an increasing need to reduce peak demand and balance supply & demand – creating an opportunity for heat pumps:** The current UK policy direction means that by 2020, the UK electricity system will most likely see higher peak demand in winter times and higher levels of intermittency on the supply side reflecting increasing electrification of heat and transport, and increased penetration of renewable generation. The need to reduce peak demand through the use of flexible demand side resources such as heat pumps will be critical for the future security of supply in the UK.

- **The UK energy infrastructure will require heavy investment in the upcoming years to support its transition,** particularly to upgrade the electricity transmission and distribution grids to support increasing renewables and distributed generation - some of this investment may be reliant on foreign investors.

- **There are currently very few electricity tariffs which promote demand-side flexibility – but this will change as the requirements for flexible demand-side resources grow.** In the longer-term, we expect to see dynamic tariffs emerge as one mechanism to promote demand side flexibility. The structure of UK electricity prices (with a large proportion of the cost which is market-dependant), should allow for high variability of prices in such flexible tariffs in the UK – potentially creating a high value proposition to the end-customer if they can provide flexibility.

The UK heat pump market development – rapid growth anticipated

- **The UK heat pump market grew from 2005-2010 but has been relatively flat since then.** This dampening of the market is a result of the a combination of factors including the economic downturn, and the fact that many have been awaiting the introduction of the Renewable Heat Incentive (due 2014 but originally planned for 2012).

- **Stronger growth towards 2020 is expected** (the total installed heat pump capacity in the UK is expected to rise from its 2012 level of 9.14-9.24 MW_{th}, to ~5.4-5.6 GW_{th} by 2020). Growth will be driven by, for example, the commencement of the RHI, the tightening of building regulation, the engagement of utilities in the heat pump market, the emergence of new more competitive products on the UK market, and continued stable growth in the social housing and self-build sectors.

Challenges for heat pumps which need to be overcome to realise the potential – and capture the flexibility

- **The characteristics of the UK building stock are not ideal for heat pumps, or for providing heat pump flexibility** – high thermal losses, the

use of high temperature radiators, small rooms, and a trend towards having no hot water storage create specific challenges for heat pumps, and reduce the potential flexibility they can bring.

- **Gas is a formidable challenge in the UK:** The gas network extends to >85% of dwellings. The electricity / gas price ratio (where gas is approximately a third of the price of electricity), combined with the availability of low cost gas boilers, makes it difficult for electric heat pumps to compete against gas economically. This immediately restricts the addressable market to <15% of dwellings unless alternative solutions are found (e.g. hybrids?).

- **Typical operating patterns of UK heating systems differ from those in many other countries in Europe – and are not well suited to heat pumps.** Instead of keeping the home at a relatively stable temperature, customers in the UK tend to use their heating systems in "bursts" (which will lead to demand spikes and poor heat pump efficiency)

- **Customer barriers need to be overcome to realise the UK heat pump market opportunity.** The upfront cost for heat pumps is a critical barrier for heat pumps both on and off-gas – especially given that there is no "culture" of investing in heating systems in the UK. Further, heat pumps are still considered as a new and risky technology by a wide section of the public.

- **Ensuring quality of installation – and the availability of sufficient trained installers - is still a challenge.** There is a need to further develop the extent of the sales, distribution and installation networks for heat pumps in the UK. There is still work to be done to overcome some of the issues of poor performance highlighted in the Energy Saving Trust heat pump field trials, for example.

- **The UK's single phase supply creates challenges with connecting heat pumps to the distribution network.** Heat pumps whose operation can minimise 'spiky' loads (e.g. inverter-driven systems with softer starts), and whose operating times can be influenced / controlled in order to shift demand away from critical times, will be necessary to enable the anticipated growth in the UK heat pump market.

2. Overview of the UK Energy Sector

2.1. Overview of main challenges in the UK

On its way to 2020 the UK faces some significant challenges in the energy sector. **The EU's renewable energy targets for the UK require a share of 15% of renewable energy in the gross final energy consumption in 2020, increasing from 1.3% in 2005.** The target could be met by the following mix: 31% RES-E share, 12% RES-H share, 10% RES-T share. This means that the current share of renewables in the electricity sector has to triple and that the share of renewables in the heating sector will have to be increased by the factor 12 by 2020. At the same time the UK faces challenges in terms of security of the electricity supply, due to the closure of several Gigawatts of conventional generation capacity over the next 3 years and an increased share of intermittent wind generation.

Another **important topic in terms of security of supply in the UK is the increasing dependence of the UK on energy imports.** In 2004 the UK has turned from a net exporter of energy to a net importer of gas and other fossil fuels used in power generation, heating and transport. According to Eurostat the energy dependency of the UK was at a record high of 36% in 2011. The dependency of coal imports was 64.1% and dependency of gas imports was 44.2%. This means that in the same year around 54% of the total electricity production in the UK was dependent on fuel imports.

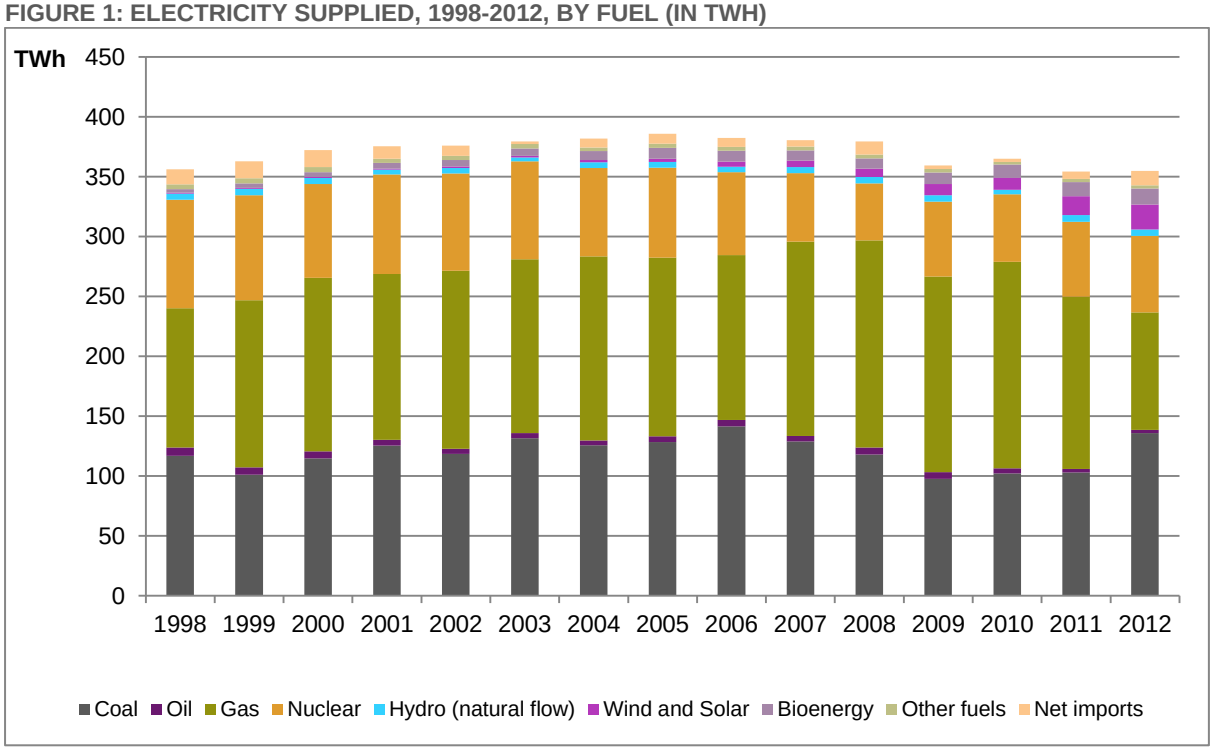
Apart from the EU renewables targets and the question of security of supply **one of the major challenges of the UK energy policy is to meet the country's binding carbon targets.** Apart from its contribution to the EU 2020 targets, the UK has a long term binding target to reduce its carbon emission to 80% compared to the levels of 1990 by 2050. In order to achieve this goal, the UK's energy supply will have to be almost entirely decarbonised by that time, and the heating sector will have to be switched to efficient electric systems like heat pumps and district heating. In order to decarbonise the grid the UK is going to invest heavily into new low carbon infrastructure, like renewables, nuclear power plants and carbon capture and storage technologies (CCS).

Apart from the supply and demand side infrastructure, **the UK is also facing major challenges regarding its transmission and distribution networks.** It is expected that the country will have to invest almost £ 9 billion into its transport networks until 2020, and another £ 12-20 billion into its distribution networks until 2050. For all these investments in the supply, transport and distribution sectors of the energy system the country is going to rely heavily on foreign investments, since large parts of the UK's energy infrastructure are owned by foreign investors.

2.2. UK electricity generation

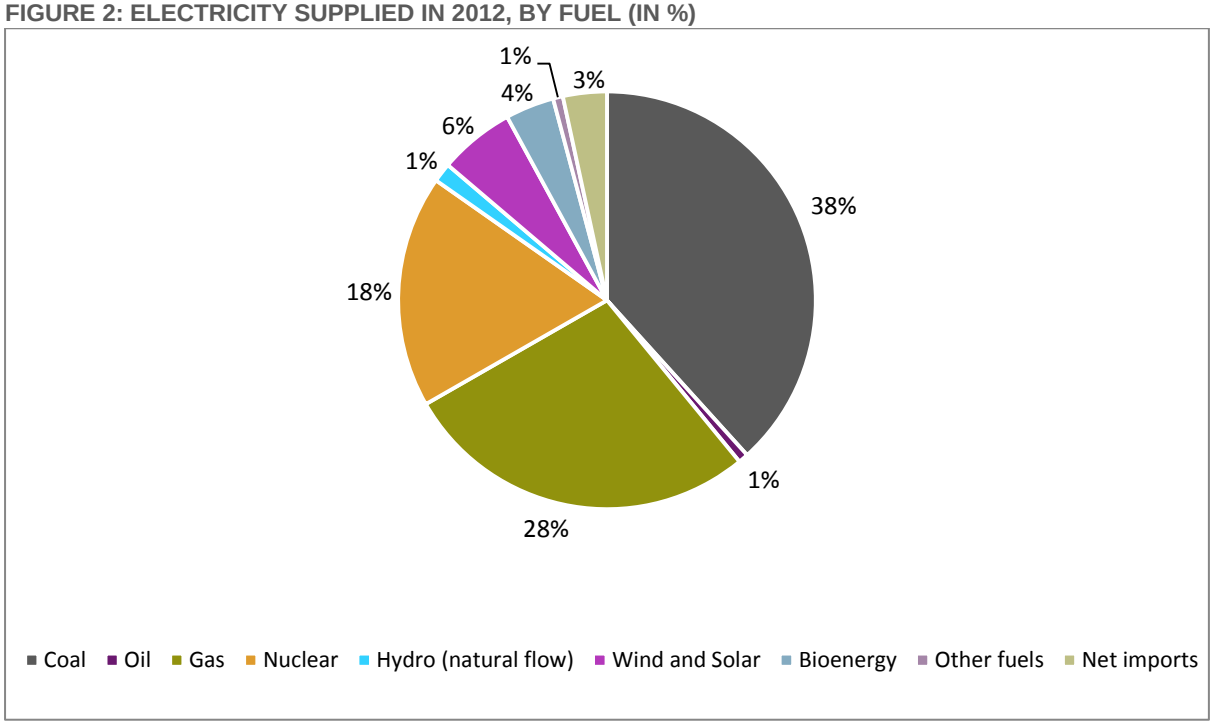
The UK's electricity supply is dominated by coal and gas. Since 2010 the share of gas is declining, whereas the share of coal in the electricity mix is on the rise. This trend could be inverted by the introduction of a carbon price floor in April 2013.

FIGURE 1: ELECTRICITY SUPPLIED, 1998-2012, BY FUEL (IN TWH)



Source(s): ***DECC, Energy Trends 11/2013, Section 5***

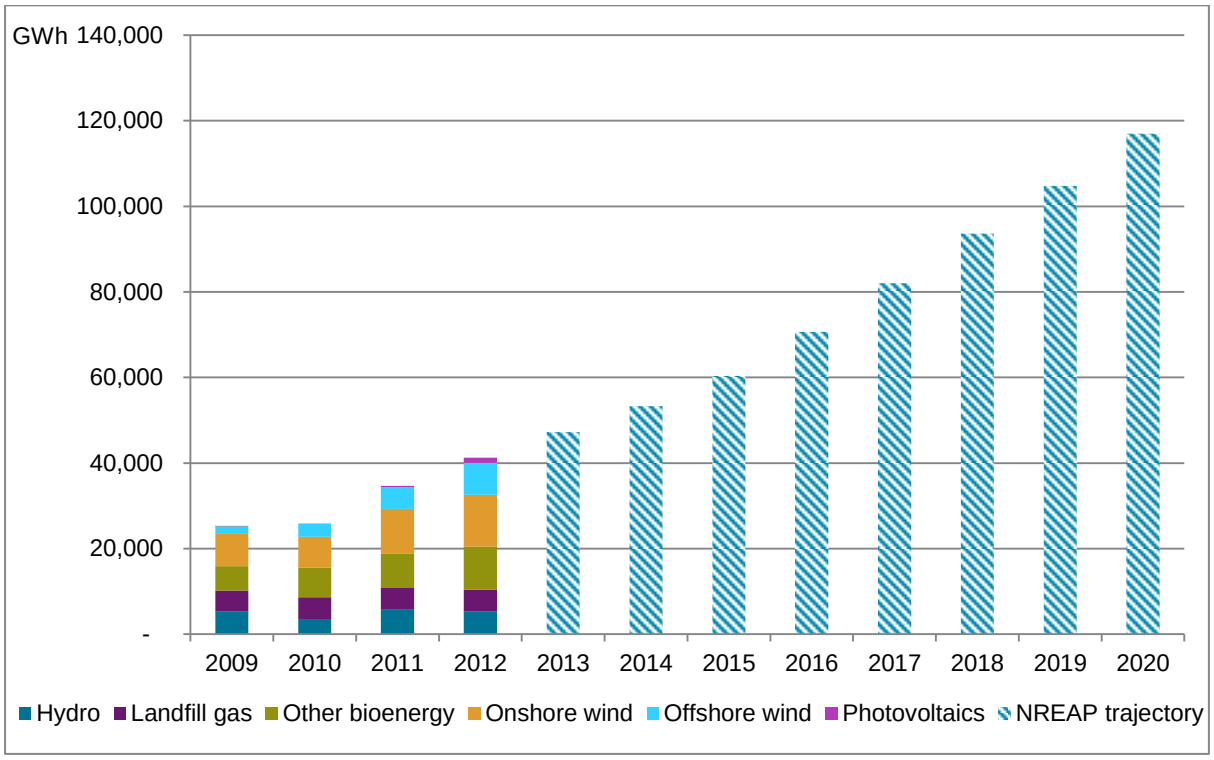
FIGURE 2: ELECTRICITY SUPPLIED IN 2012, BY FUEL (IN %)



Source(s): ***DECC, Energy Trends 11/2013, Section 5***

Over the last three years, the share of renewables in the electricity mix has been rising consistently. In 2012 it reached a share of 11.1% in the electricity supplied. Generation from renewable sources is dominated by wind energy and biomass, reaching a share of 70% in the overall generation of renewable electricity.

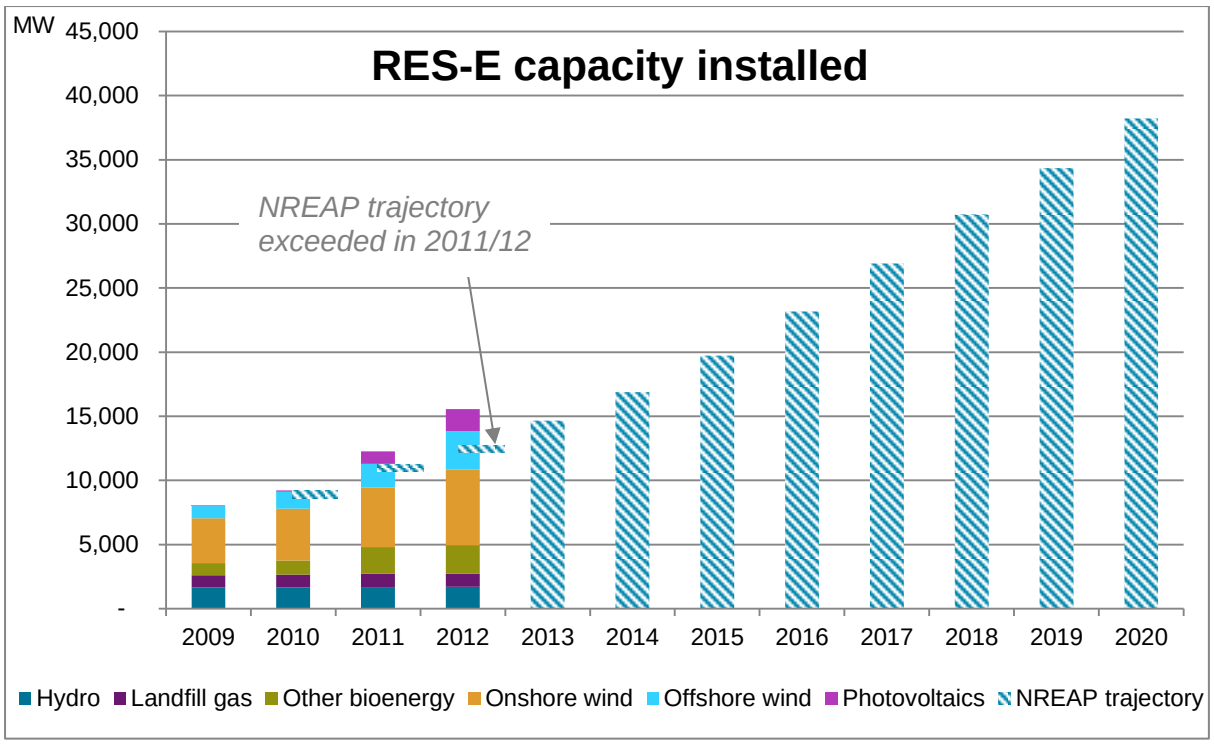
FIGURE 3: ELECTRICITY GENERATION FROM RENEWABLES



Source(s): *DECC, Energy Trends 11/2013, Section 6*
UK National Renewable Energy Action Plan

The UK's renewable energy generation capacity currently reaches 23.83 GW, and is currently above the trajectory outlined in the UK's National Renewable Energy Action Plan (NREAP). It is expected to reach a total installed capacity of approximately 38 GW in 2020, with the bulk of the added capacity coming from on- and offshore wind farms. **This will increase the volatility of supply in the UK electricity grid and therefore require new ways to deal with situations like over- or undersupply through demand side response technologies.**

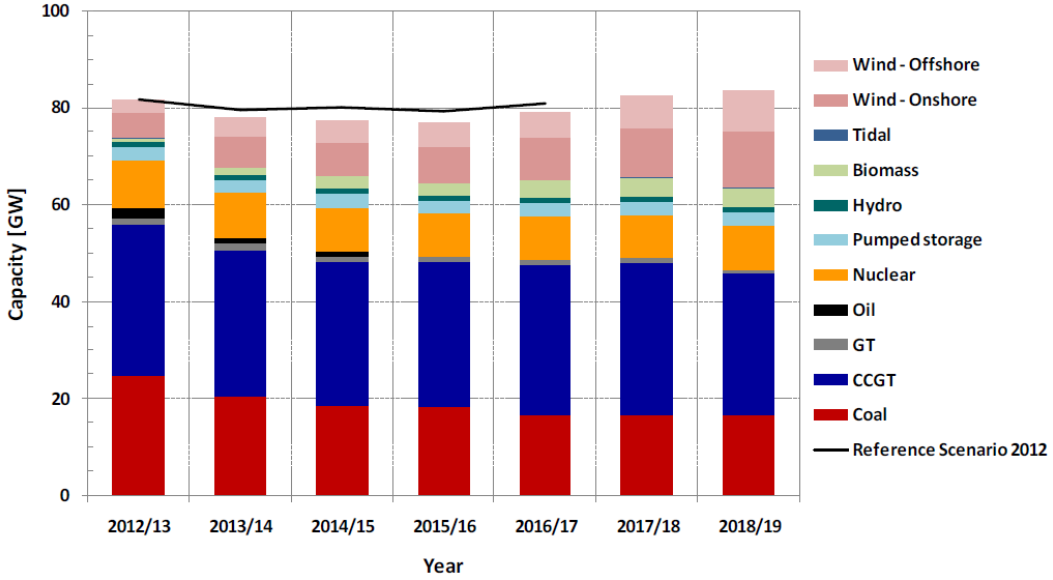
FIGURE 4: RES-E CAPACITY INSTALLED



Source(s): *DECC, Energy Trends 11/2013, Section 6*
UK National Renewable Energy Action Plan

The UK's total generation capacity currently reaches 82 GW. A yearly Electricity Capacity Assessment report by OFGEM expects a decrease in installed capacity to approximately 76 GW by 2015/16, before it starts to rise again, reaching almost 85 GW of installed capacity by the end of the decade.

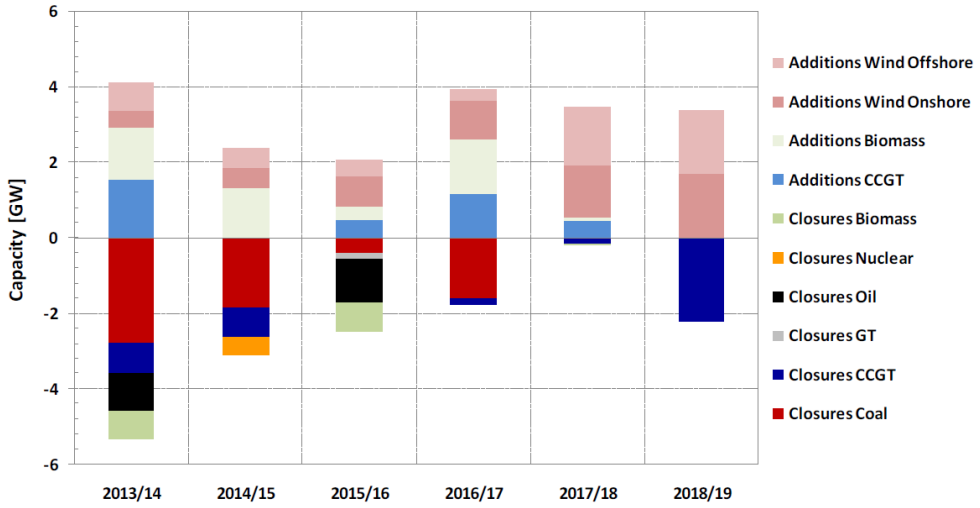
FIGURE 5: PROJECTED INSTALLED CAPACITY BY GENERATION TECHNOLOGY TYPE, 2012-2019



Source(s): *OFGEM, Electricity Capacity Assessment Report 2013 – Reference Scenario*

The major changes in the installed capacity are due to closures in the fossil and nuclear fuel generation park, and therefore in the part of the generation park with a high availability.

FIGURE 6: CHANGES IN INSTALLED CAPACITY BY GENERATION TECHNOLOGY TYPE



Source(s): OFGEM, Electricity Capacity Assessment Report 2013 – Reference Scenario

Matching supply and demand on the coldest day of the year (usually the day of peak demand in the UK) is going to be increasingly challenging over the coming years – despite an expected reduction in peak demand.

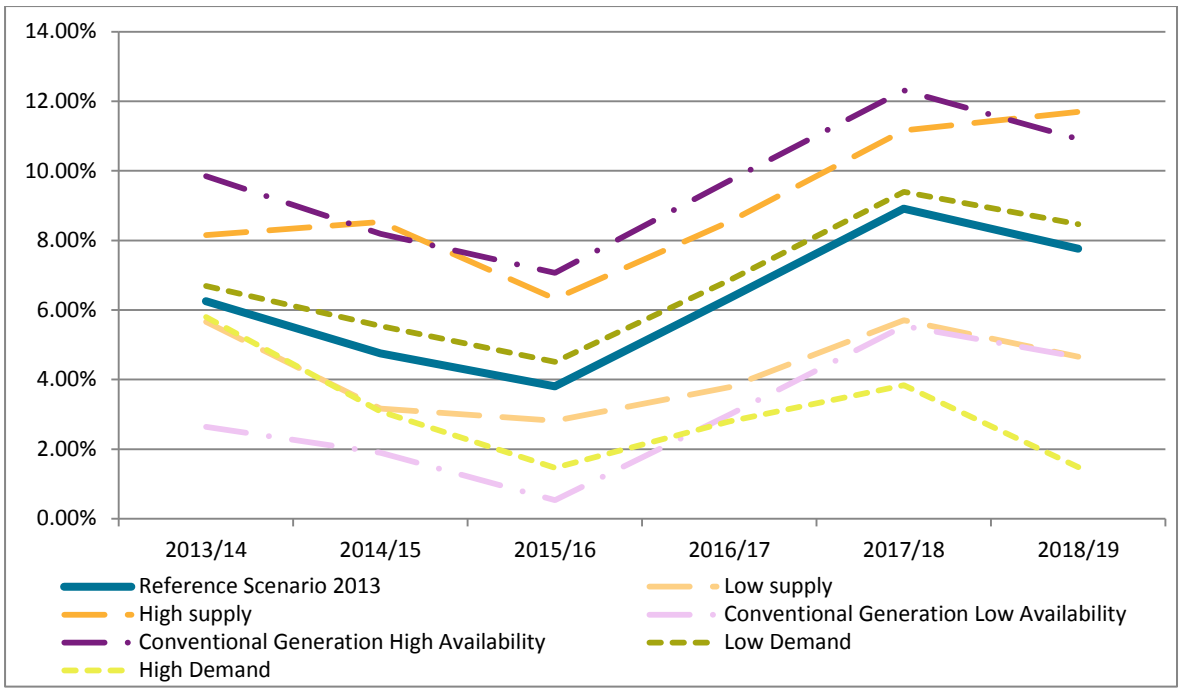
The available surplus of firm generation capacity available to meet the peak demand is diminishing (i.e. due to an expected reduction in conventional plant like nuclear, coal, gas or hydro, as well as biogas plants).

The additional installation of wind capacity will increase the total installed generation capacity from 2016 onwards – but will only be able to partly offset the reduction in firm capacity - only 17% of the installed wind capacity is considered to be 'firm' by 2018/19, meaning that at any given time in the year the UK's fleet of wind turbines will provide at least 17% of its rated full load output.

This reduction in firm generation capacity is the reason why over the coming years, and despite an expected reduction in peak demand, the UK's de-rated capacity margin will decrease to as low as 2-3% over the next 2 years. [1]

[1] **Definition of de-rated capacity margin from the OFGEM report:** "The de-rated capacity margin is defined as the average excess of available generation capacity over peak demand, expressed in percentage terms. Available generation capacity takes into account the contribution of installed capacity at peak demand by adjusting it by the appropriate de-rating (or availability) factors which take into account the fact that plant are sometimes unavailable due to outages."

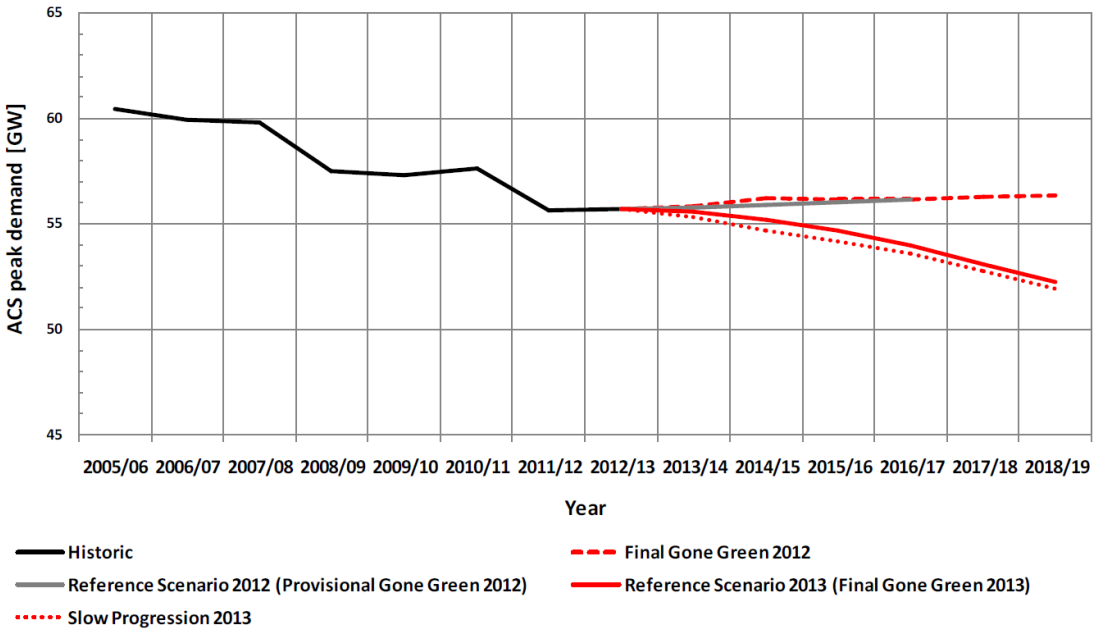
FIGURE 7: UK DE-RATED CAPACITY MARGIN



Source(s): OFGEM, Electricity Capacity Assessment Report 2013
Delta Energy & Environment

The above reference scenario is based on the assumption that **the current trend of a diminishing average cold spell peak demand will continue over the coming years** – as shown below.

FIGURE 8: NATIONAL GRID'S HISTORIC & PROJECTED 'AVERAGE COLD SPELL' PEAK DEMAND



Source(s): OFGEM, Electricity Capacity Assessment Report 2013

The above scenarios of peak demand development by National Grid identify two of the main factors for the decrease in peak demand in the reference scenario as:

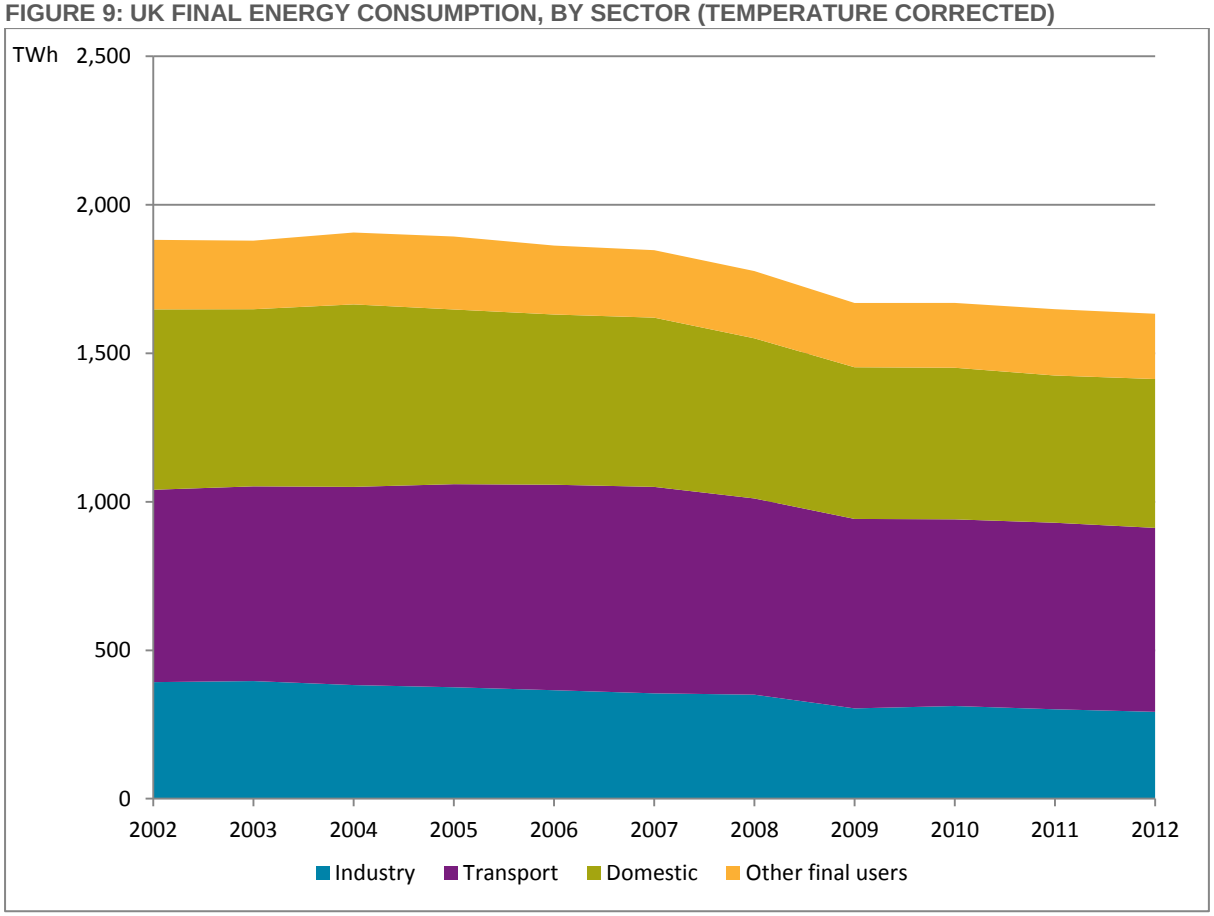
- an increased demand response
- an increase in energy efficiency in the domestic sector

Reducing peak demand through the use of flexible demand side resources such as heat pumps is therefore critical for the future security of supply in the UK.

2.3. UK Energy Demand

The UK's final energy demand is currently around 1,630 TWh per year, 30.7% of which is consumed by the domestic sector:

FIGURE 9: UK FINAL ENERGY CONSUMPTION, BY SECTOR (TEMPERATURE CORRECTED)

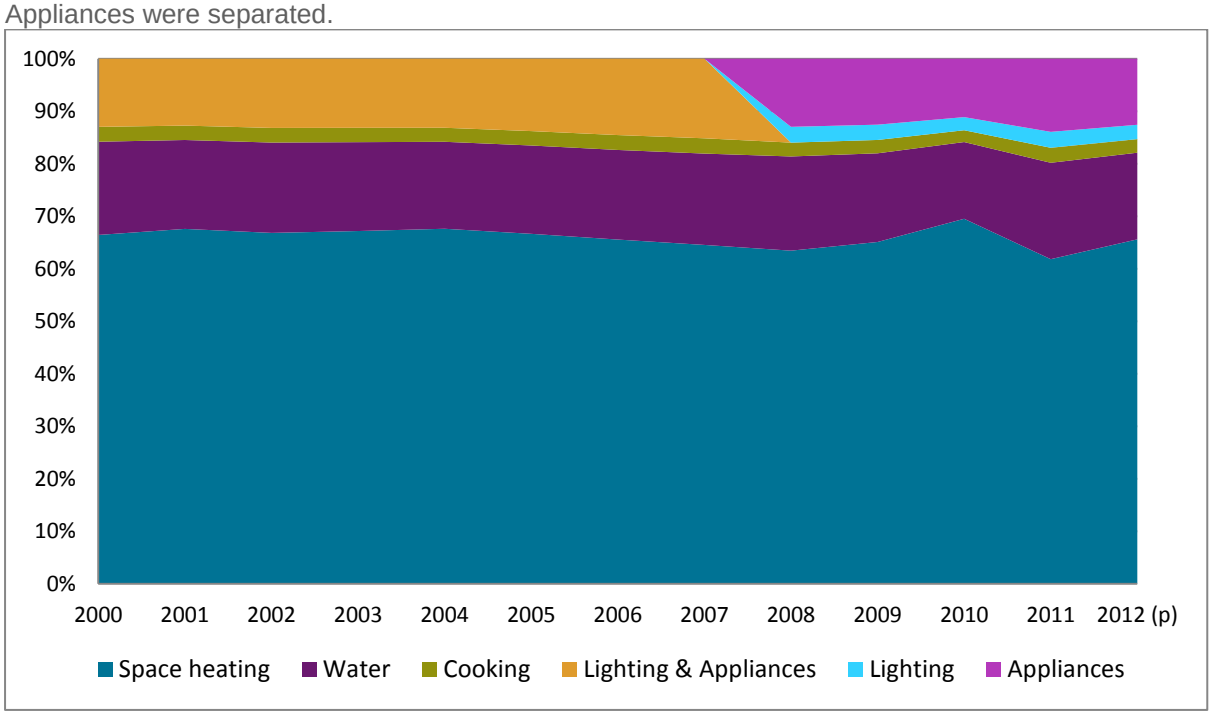


Source(s): DECC, Energy Consumption in the UK, 2013 Update

The most important use of energy in the domestic sector is for space and water heating purposes, representing over 80% of the energy consumed in this sector every year between 2000 and 2012 (see Figure 10). Overall consumption of energy in the domestic sector is decreasing – as seen in Figure 9.

FIGURE 10: ENERGY CONSUMPTION OF UK HOUSEHOLDS, BY END USE

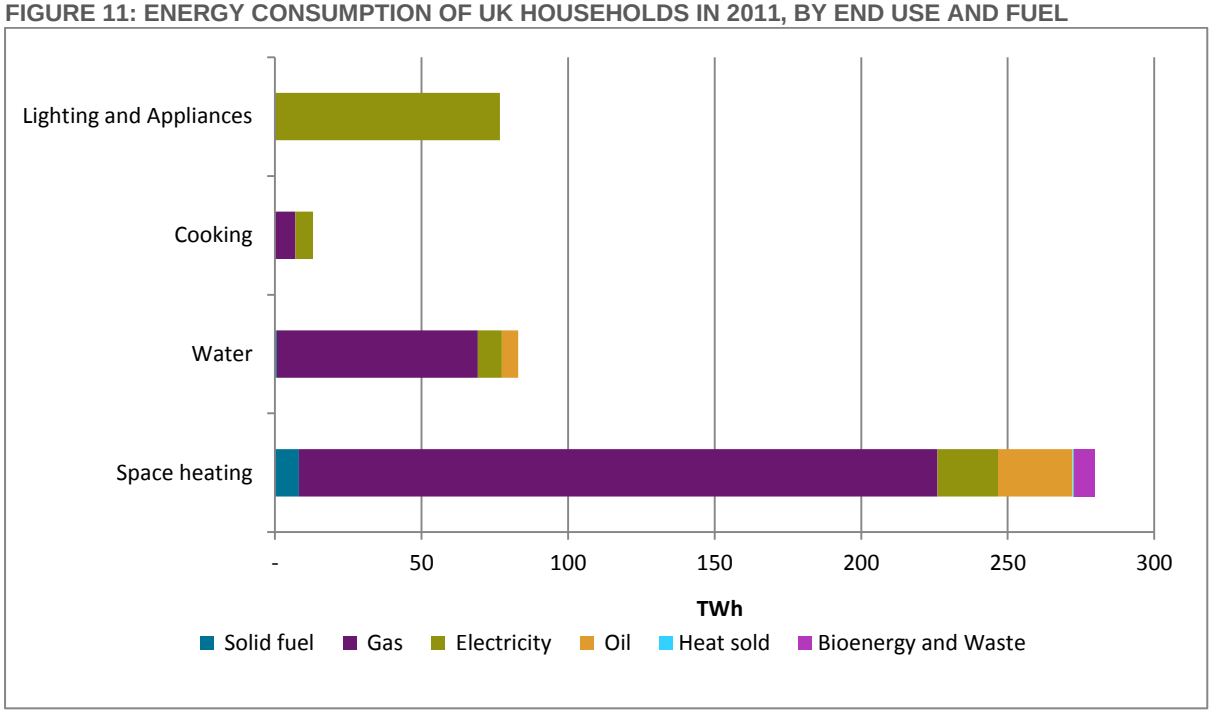
NB: There was a change in data collection method between 2007 and 2008 where Lighting & Appliances were separated.



Source(s): ***DECC, Energy Consumption in the UK, 2013 Update***

Gas is by far the most important energy carrier in the use of energy by UK households, accounting for 64.8% of the total energy demand. This is followed by the use of electricity, which accounts for 24.8% of the energy consumed.

FIGURE 11: ENERGY CONSUMPTION OF UK HOUSEHOLDS IN 2011, BY END USE AND FUEL



Source(s): ***DECC, Energy Consumption in the UK, 2013 Update***

2.4. UK Energy Infrastructure

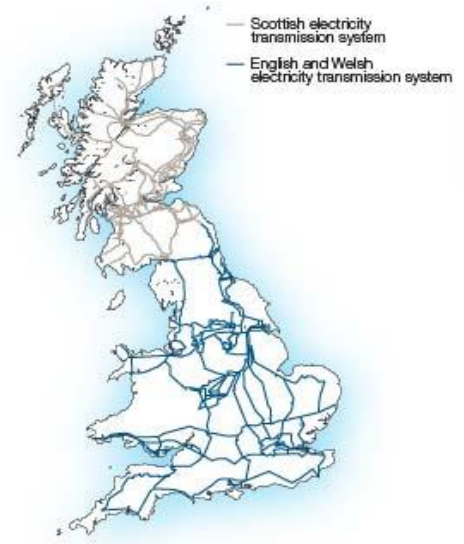
The UK energy infrastructure will require heavy investment in the upcoming years in order to cope with an increased uptake of renewable generation and the widespread deployment of new demand side technologies like heat pumps and electric vehicles. **Due to its ownership structure, the UK may have to rely to some extent on foreign investors to overcome this challenge** (the UK energy infrastructure is largely privatised and large parts are owned by foreign companies[2]).

The UK Electricity Grid

Transmission Grid: The electricity transmission network in England and Wales is owned and managed by National Grid plc., who also operates the transmission network in Scotland (owned by SSE and Scottish Power). **The UK's ability to match supply and demand via the import and export of electricity to neighbouring countries is currently relatively limited.** The electricity transmission network currently has three interconnectors to France, the Netherlands and Ireland, with a total capacity of 3.5 GW. Three additional interconnector projects are being planned, linking the UK to Belgium (1 GW, operational in 2018), Norway (1.4 GW, operational around 2020) and France (1 GW, operational around 2020). Further projects are under investigation, including links to Denmark and Iceland.

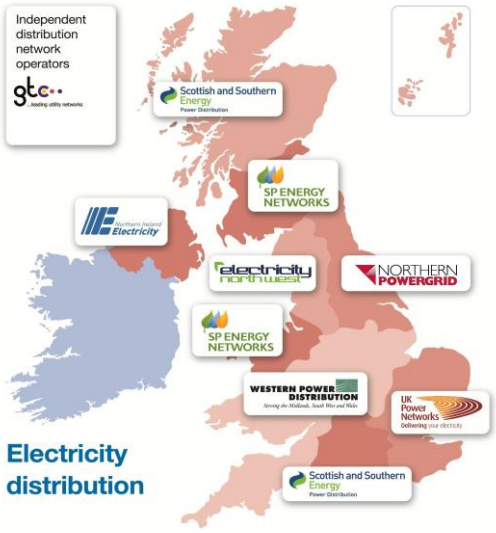
Distribution Grid: The ownership of the distribution network in the UK is more fragmented – there are a total of 8 distribution network operators. This could inhibit the roll-out of smart grid solutions, due to e.g. diverging requirements regarding grid connection.

FIGURE 12: UK ELECTRICITY TRANSMISSION NETWORK



Source: National Grid plc.

FIGURE 13: UK ELECTRICITY DNOS



Source: Energy Networks Association

[2] A study of the generating industry in the UK by Ian Rutledge of the Sheffield Energy Resources Information Services found that in 2011 only one quarter of the total generating capacity in the UK was attributable to British companies.

It is expected that over the coming years strong investments will have to be made into the electricity networks in order to accommodate the increasing share of renewables and distributed generation. Due to the ownership structure of the UK distribution network (UK Power Networks is for example owned by a Chinese holding company), this investment will partly rely on foreign sources.

- **£8.8 billion investment in transmission network:** In its 2012 report, the Energy Networks Strategy Group estimated that £8.8 billion of investment into the transmission networks alone are required until 2020. These investments are necessary in order to accommodate the additional renewable energy generation capacity needed to reach the UK's renewable energy targets.
- **£12-20 billion investment in the distribution network:** A study commissioned by the Energy Networks Association comes to the conclusion that an additional £12 - £20 billion will need to be invested into the distribution network between 2012 and 2050, in order to cope with the increased deployment of heat pumps, PV and electric vehicles foreseen by the Government's energy strategy.

The UK Gas Grid

The gas transmission network is owned and operated by National Grid plc. The network is connected via three interconnectors to Belgium, the Netherlands and Ireland. It further extends to the UK's gas and oil fields in the North Sea.

The UK's gas distribution network is operated by five DNO companies, of which at least two are owned by foreign investors. **About 22 million homes, or 85% of the dwelling stock, are currently connected to the gas network**.

FIGURE 14: THE UK GAS TRANSMISSION NETWORK

Source: National Grid plc.

FIGURE 15: THE UK GAS DNOS

Source: Energy Networks Association

District Heating Networks in the UK

District heating networks are not very common in the UK. A 2013 survey by the Department for Energy and Climate Change counted 1,765 district heating schemes, supplying approximately 190,000 dwellings. 55% of all district heating schemes are situated in London. 72.5% of all district heating schemes in the UK are considered as small, i.e. they deliver heat to less than 100 dwellings.[3]

The largest district heating scheme in the UK is located in Sheffield. The network operates since the late 1980s and today supplies more than 140 buildings with around 120 GWh of heat every year. The main heat source is a 60 MWth / 19 MWe combined heat and power plant fuelled by 225 kt of waste. Other large district heating & cooling schemes include e.g. Southampton (since 1986), where an average of 40 GWh of heat and 7 GWh of chilled water are supplied each year.

2.5. UK Energy Policy

The UK government's energy policy is driven by two major targets:

- A renewables target of 15% in the gross final energy consumption by 2020, the UK's contribution towards the EU's 2020 targets
- An 80% cut in greenhouse gas emissions (compared to 1990) by 2050, governed by the Climate Change Act of 2008 and implemented via binding carbon budgets.

The UK's plan for reaching its medium term 2020 targets foresee a share of 31% of renewable energy in the electricity sector by 2020, a threefold increase over current levels. According to the NREAP trajectory **two thirds of this target will be met by on- and offshore wind farms - adding considerable intermittent generation capacity to the energy mix.**

In addition to this, the Department of Energy and Climate Change is expecting that **by 2020, the Renewable Heat Incentive (RHI)[4] will have added almost 500,000 heat pump installations in the domestic sector**. An increase in the tariff levels for heat pumps in the already existing non-domestic RHI is also going to increase uptake in the commercial and industrial sector.

By 2020, the UK electricity system will therefore most likely see higher peak demand in winter times, as well as higher levels of intermittency on the supply side.

[3] The definition of district heating network applied in the survey is very wide. It comprises all schemes with either "two or more distinct buildings connected to a single heat source or one building in which there are more than ten individual customers connected to a single heat source." The average number of homes connected to small heat networks is 35.
[4] RHI, a support scheme for renewable heating systems to be introduced in Spring 2014

2.6. Energy Prices, Tariffs & Structures

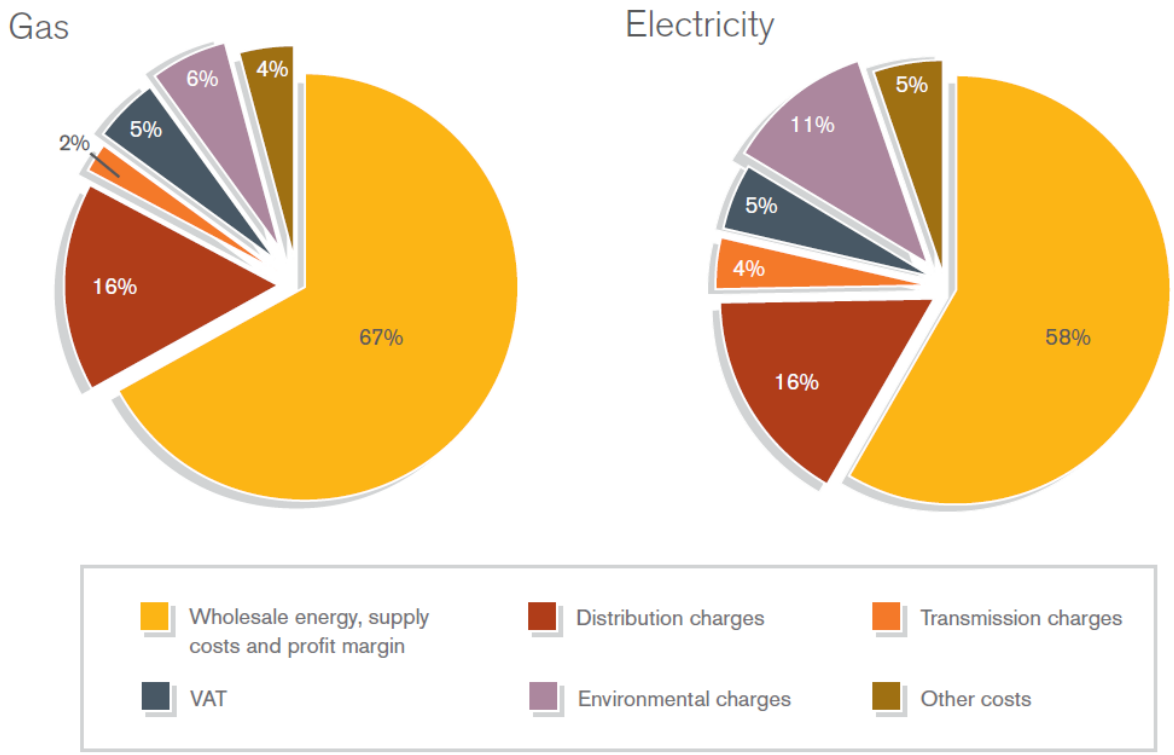
Energy prices in the UK are comparatively low.

Gas	4.44p / kWh
Heating Oil	6.6p / kWh
Wood Pellets	5p / kWh
Electricity (standard tariff)	14.51p / kWh
Electricity (day/night tariff) -peak	15.7p / kWh
Electricity (day/night tariff) -off peak	7.09p / kWh

Source(s): ***Electricity and gas from DECC qep221 and qep231, based on average consumer bill***
Day/night tariff rates from DECC qep224, including standing charges
Heating oil and wood pellet prices from http://www.confusedaboutenergy.co.uk/ index.php/domestic-fuels/fuel-prices#.Up-20OKmWt8, prices as of 19th February 2013.

There are currently very few electricity tariffs which promote flexibility on the demand side. The only two exceptions are the Economy 7 tariff (a day/night tariff providing 7 hours of off peak rates in a single block) and the Economy 10 tariff (providing 10 hours of off peak rates in three blocks). Whereas Economy 7 tariffs are still wide spread for electric storage heaters, the Economy 10 tariff is not offered by many suppliers (possibly only one supplier).

FIGURE 16: INDICATIVE STRUCTURE OF GAS AND ELECTRICITY COSTS TO UK CUSTOMERS
The structure of the gas and electricity costs to UK customers in July 2013, as presented by Ofgem. This gives an indication of the price structures – though of course this structure fluctuates with time.



Source(s): ***OFGEM, Household energy bills explained (Update from July 2013)***

The structure of the UK electricity costs has a larger share of market price dependent elements than many other countries in the EU. This should allow for a greater variability of prices in flexible tariffs in the UK – creating potential for a higher value proposition to the end-customer (if their electricity consuming assets such as heat pumps can be operated more during times of low prices, and less during times of high prices).

3. Analysis of the UK housing stock & heating market

3.1. Overview of main challenges in the UK

The characteristics of the UK building stock create one of the main challenges with regards to the use of heat pumps:

- The high average age of the building stock means there is comparatively low thermal quality of the building envelopes.
- There is an increasing trend towards removing storage tanks from UK homes because of lack of space, and the dominance of combi gas boilers.

The availability of relatively low cost gas and gas boilers creates a strong challenge for heat pumps – limiting the potential heat pump market size. The heating system stock in the UK is dominated by gas, which heats 85% of all dwellings. Even with the introduction of the domestic Renewable Heat Incentive in Spring 2014 it is expected that heat pumps will only pay back in off-gas grid buildings (i.e. replacing oil or electric heating). In 2020 heat pumps will therefore still only reach a very low penetration of the building stock.

The characteristics of UK buildings, combined with the overall small share of heat pumps in the UK heating market, significantly reduce the amount of demand response flexibility that heat pumps could provide in the UK.

3.2. UK Housing Stock Characteristics

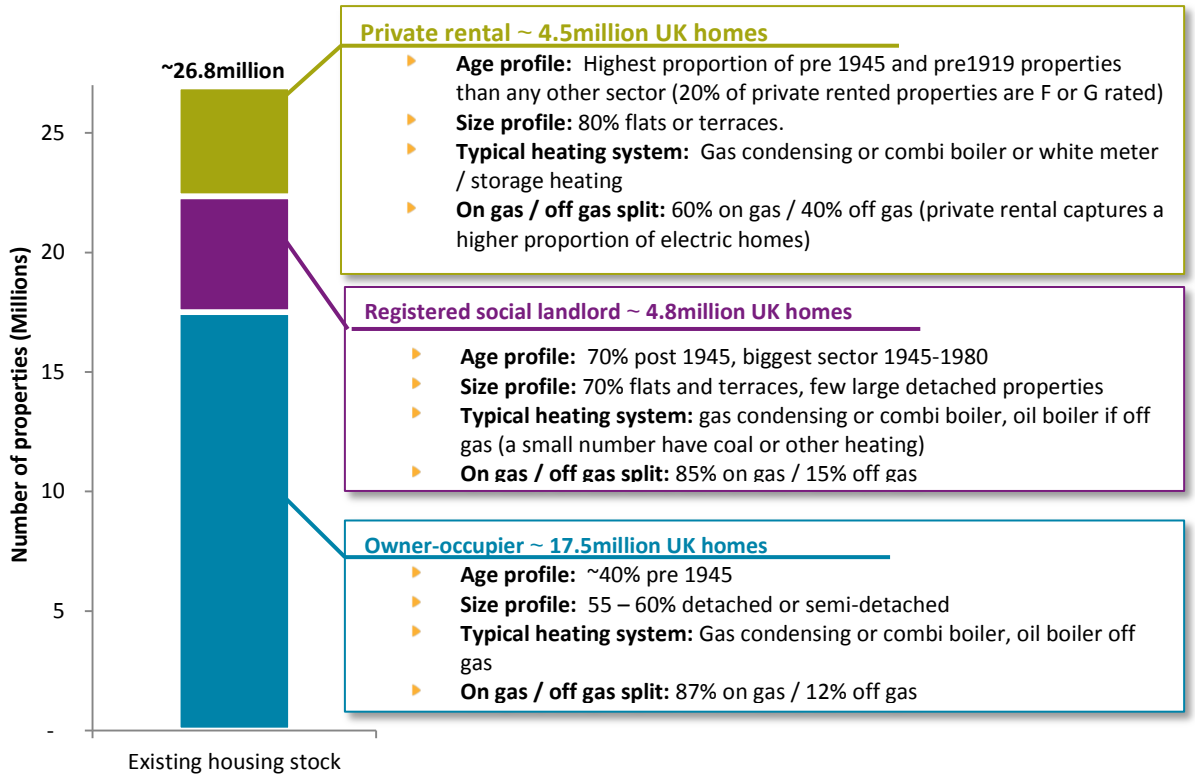
Customer types

In 2011 the dwelling stock in Great Britain comprised ~26.73 million dwellings[5]. **The dwelling stock is dominated by owner-occupied dwellings**, making up 65% of the total housing market. Social housing (18%) and privately rented property (17%) account for the rest of the dwellings.

- **The social housing sector has been the most important sector for heat pumps** - social housing providers are a major customer for heat pumps, driven by a need to overcome fuel poverty issues through reducing monthly energy charges for their tenants.
- **The owner-occupier sector is increasingly important for the heat pump market** (and is expected to see the fastest growth driven by the RHI). Owner-occupiers are able to make their own decisions regarding a heating system (unlike in the rented sector) - however, the upfront cost of a heat pump is still a strong barrier for investment in this sector.
- **The rented sector is not significant for heat pumps** – generally private landlords are not willing to make an investment which will benefit the tenant in running cost savings.

[5] Of these, 86% (22.98 million) were located in England, 8.88% (2.37 million) in Scotland and 5.17% (1.38 million) in Wales

FIGURE 17: BREAK-DOWN OF UK HOUSING STOCK



Source(s): ***Delta-ee***

Age of the building stock

In both the English and the Scottish dwelling stock more than 50% of dwellings have been built before 1965. In both regions approximately 78% of dwellings have been built before or in the early 1980s. This means that **a large share of the UK's building stock is has a relatively low thermal inertia, which requires constant heating and therefore significantly reduces the useability of the thermal mass of a building as energy storage.**

FIGURE 18A: ENGLAND'S DWELLING STOCK 2011 BY AGE

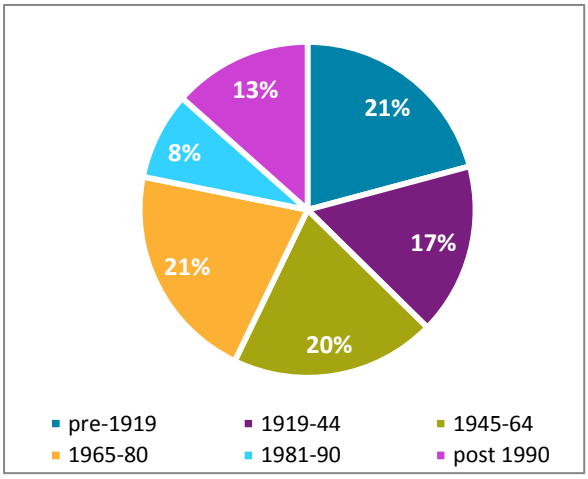
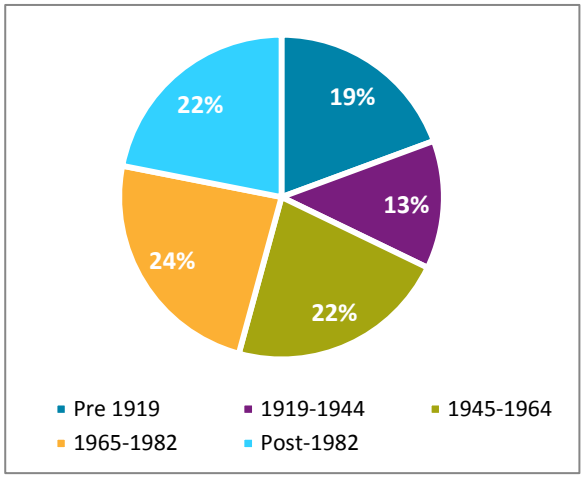


FIGURE 18B: SCOTLAND'S DWELLING STOCK 2011 BY AGE

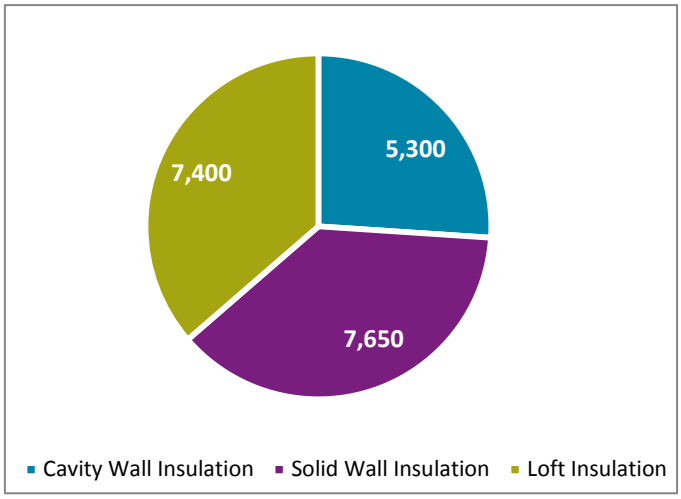


Source(s): ***English Housing Survey 2013, DA1101: stock profile***
Scottish House Condition Survey: Key Findings 2011

Thermal Performance

In terms of thermal performance, the UK building stock still requires some significant investment. As of 2013, a potential of 20.35 million energy efficiency improvement measures remains to be delivered:

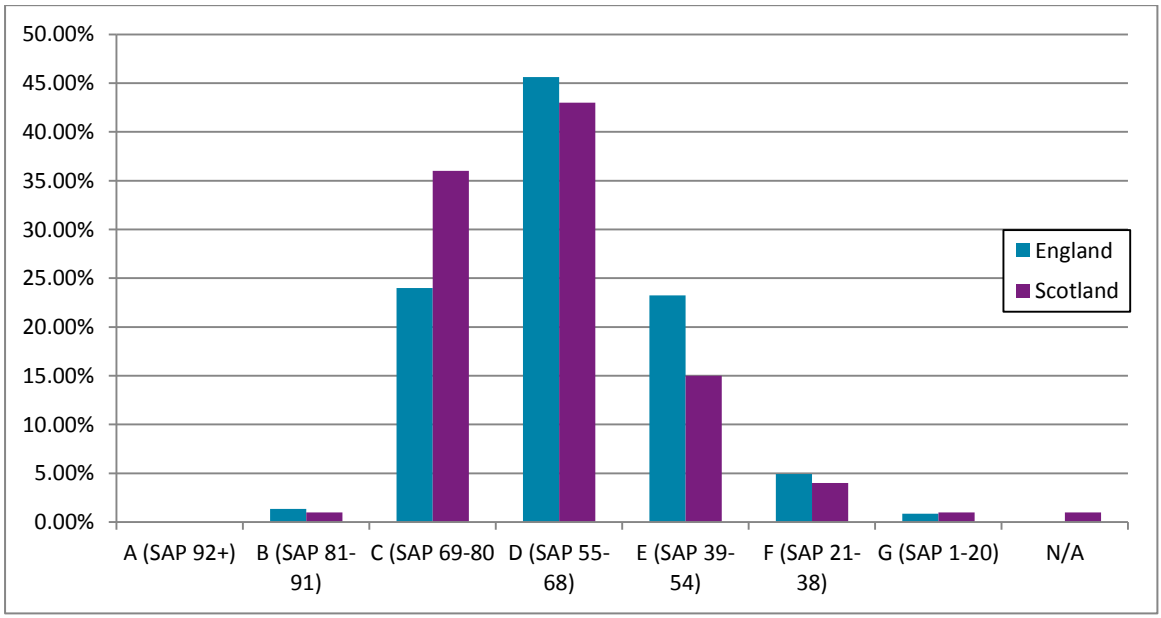
FIGURE 19: REMAINING POTENTIAL FOR THEMAL IMPROVEMENTS IN THE UK BUILDING STOCK (000S)



Source(s): ***DECC, Estimates of Home Insulation Levels in Great Britain: July 2013 (Experimental Statistics)***

The thermal efficiency of buildings in the UK is rated via the Standard Assessment Procedure (SAP). The SAP rating is based on a scale of 1-120, with 1 the worst and a score of 100 representing no net costs for water and heating (ratings >100 indicate a net benefit, e.g. through the feed-in of renewable electricity). The share of buildings in each rating band in England and Scotland can be seen below. **Less than 25% of homes in England achieve a "C" rating or above - underlining the need for improvements to be made in the energy performance of the UK building stock.**

FIGURE 20: ENERGY PERFORMANCE OF BUILDINGS IN ENGLAND AND SCOTLAND BY EPC RATING

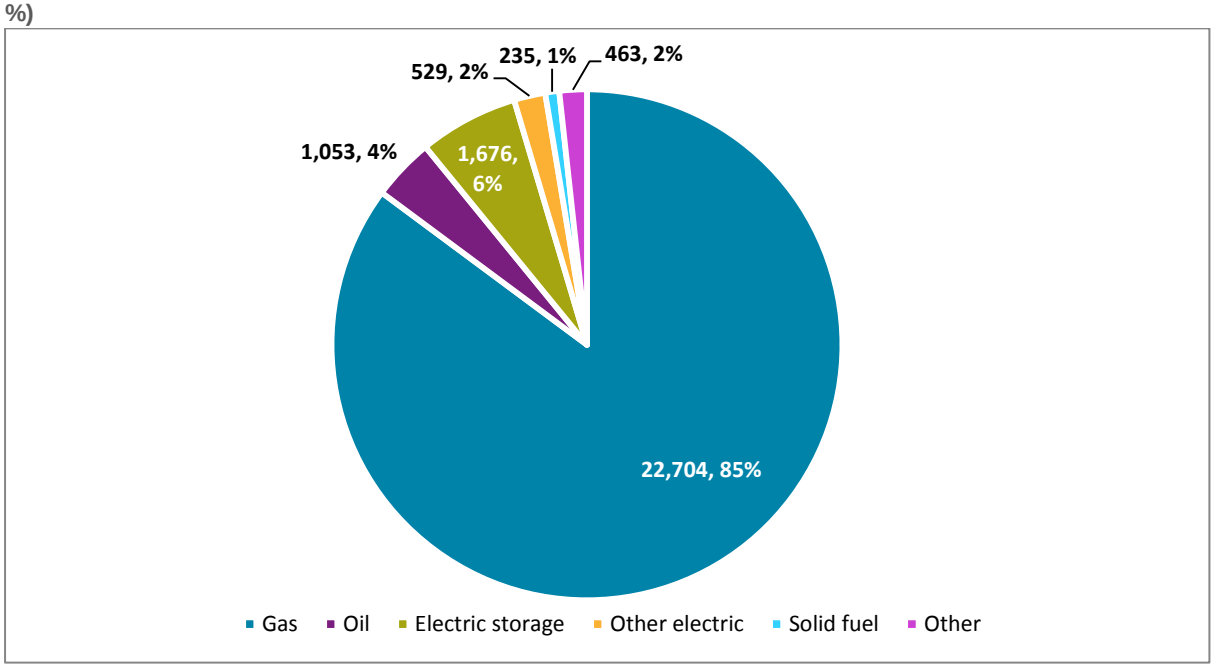


Source(s): ***DECC, Final Project Report, An investigation of the effect of EPC ratings on house prices, June 2013; Scottish House Condition Survey: Key Findings 2011; Delta-ee***

3.3. Trends in the Heating Market

The UK heating system stock is dominated by (relatively low cost) gas boilers, which account for 85% of the installed systems (and >90% of heating systems sold per year). This is currently the greatest barrier to the uptake of heat pumps in the UK – the electricity / gas price ratio (where gas is approximately a third of the price of electricity), combined with the availability of low cost gas boilers, makes it difficult for electric heat pumps to compete against gas economically.

FIGURE 21: INSTALLED CENTRAL HEATING SYSTEMS IN THE UK IN 2011, BY FUEL TYPE (IN '000 AND %)



Source(s): DECC, Energy Consumption in the UK, 2013 Update

The heat distribution in the UK building stock is dominated by high flow temperature radiator systems, running at 70°C and above – creating a challenge for heat pumps. Due to the high flow temperatures they have been sized for, radiators in UK homes are usually small and flow temperatures may not be able to be reduced by much[6]. It is estimated that 90-95% of existing buildings are equipped with such radiator systems, making the existing property market in the UK particularly challenging to penetrate for heat pumps.

The average size of new build UK homes is one of the smallest in Europe (see for example the 2011 study by the Royal Institute of British Architects[7] or the 2001

[6] There is some debate as to whether flow temperatures as high as 70°C are necessary across the whole building stock (e.g. it is thought there is a portion of dwellings with over-sized radiators in the UK whose flow temperatures could potentially be reduced – but it is not clear how many dwellings this refers to)

[7] Royal Institute of British Architects, 2011, *The Case for Space: The Size of England's new homes*, http://www.architecture.com/Files/RIBAHoldings/PolicyAndInternationalRelations/HomeWise/CaseforSpace.pdf

study the French Office of National Statistics, INSEE[8]). Further, unlike homes in e.g. Germany, UK homes rarely have basements and heating systems are typically installed within the living space. **There is therefore an increasing preference to not use hot water storage tanks. This lack of storage space could significantly reduce the flexibility potential from heat pumps in UK homes – especially when combined with the low thermal inertia of the building stock.** With an average of only 85m² per home in the building stock and the average new build home being only 75m² in size, there is a trend towards removing hot water storage tanks in the UK in order to maximise useable space in the property. Only 51% of households in the UK were estimated to have a hot water tank in 2011, a reduction of 7% since 2008 – and a downward trend which is expected to continue. This trend reflects the increasing use of combination boilers (without tanks) which in 2010 made up more than 73% of the total gas boiler market.

Historic heating market trends

Key characteristics of the UK heating market evolution are as follows (see Figure 20 and 21 for graphs):

- About 1.5 million gas boilers are installed per year – making the UK the biggest boiler market in Europe
- A growing dominance of wall-hung gas combi boilers over the last decade
- A growth in condensing boilers since 2005 (by 2020, most boilers in the UK will be condensing.
- Renewables emerging since mid-2000s – but still account for <2% of the annual heating sales (and heat pumps <1%).
- Most renewables replace oil or electric heating – not gas.

What does this mean for heat pumps?

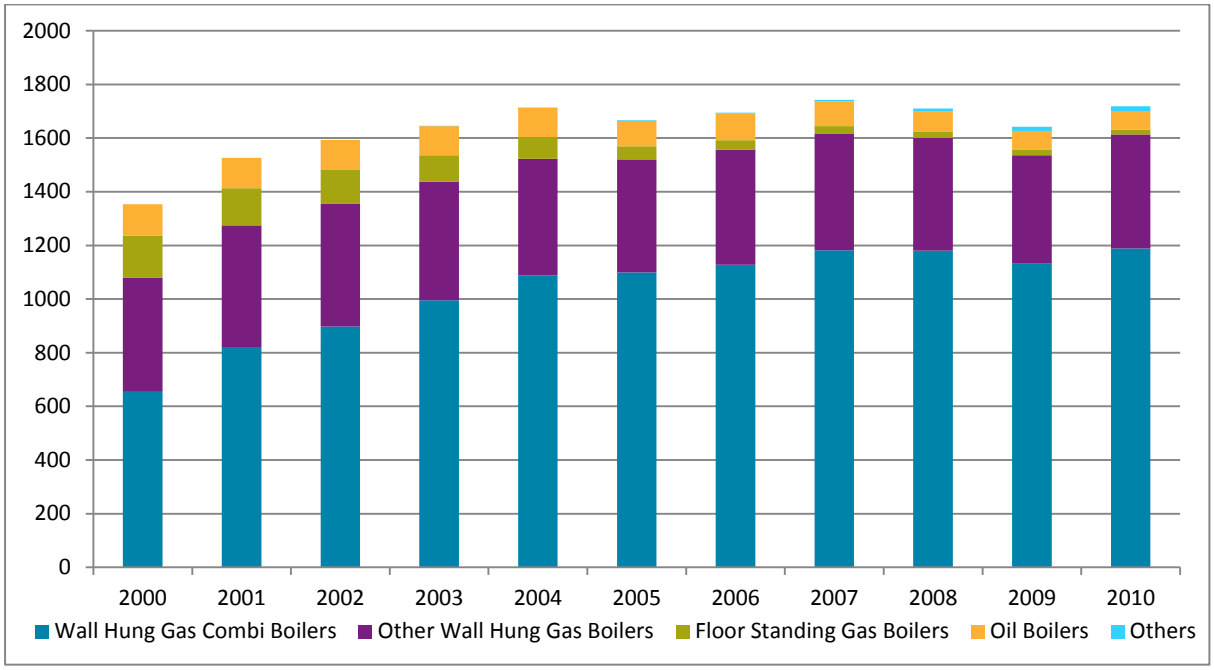
The preference for wall-hung combi boilers means that UK homes have increasingly little space available for renewable heating such as heat pumps, which usually require tanks. The heat pumps which will be able to penetrate this part of the market will have to be very compact and work without storage. This means flexibility from heat pumps will be limited.

The UK has experience of encouraging a switch from one heating system type to another through regulation – but this approach is unlikely to be repeated for heat pumps. The growth of condensing boilers has been in response to the 2005 regulation that all gas boiler replacements in the UK have to be condensing systems. It is unlikely that such a regulation will be placed to encourage the growth of renewables – especially given the significantly higher upfront cost of renewables compared to traditional heating systems.

[8] ÉCONOMIE ET STATISTIQUE N° 343, 2001-3, Page 32

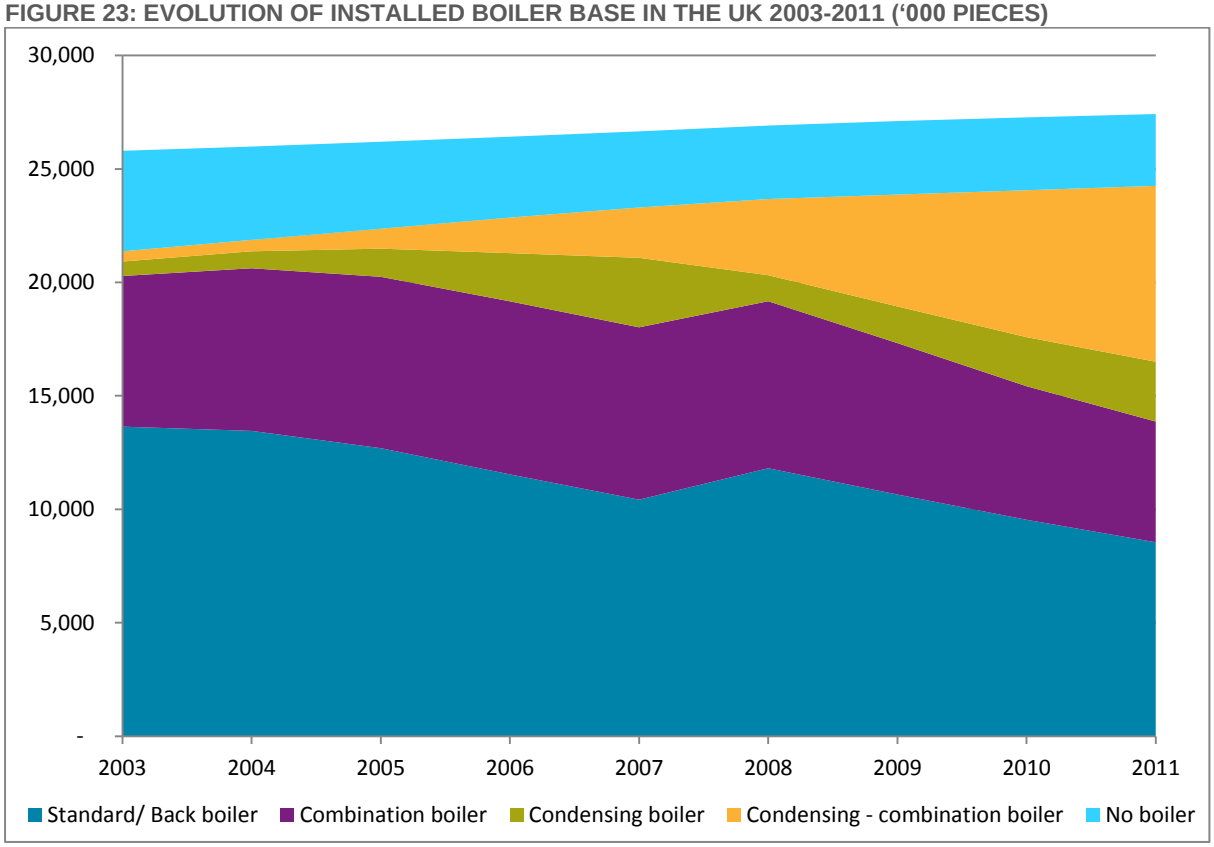
FIGURE 22: HEATING SYSTEM SALES IN THE UK, 2000-2010, EXCLUDING ELECTRIC STORAGE HEATERS (IN '000 PIECES)

Heat pumps and other renewable technologies are within “others” and account for less than 2% of the market.



Source(s): ***BRG; Delta-ee***

FIGURE 23: EVOLUTION OF INSTALLED BOILER BASE IN THE UK 2003-2011 (‘000 PIECES)



Source(s): ***DECC, Energy Consumption in the UK, 2013 Update (there was a change of data source in 2008, responsible for the discontinuity in the dataset)***

3.4. Customer Preferences

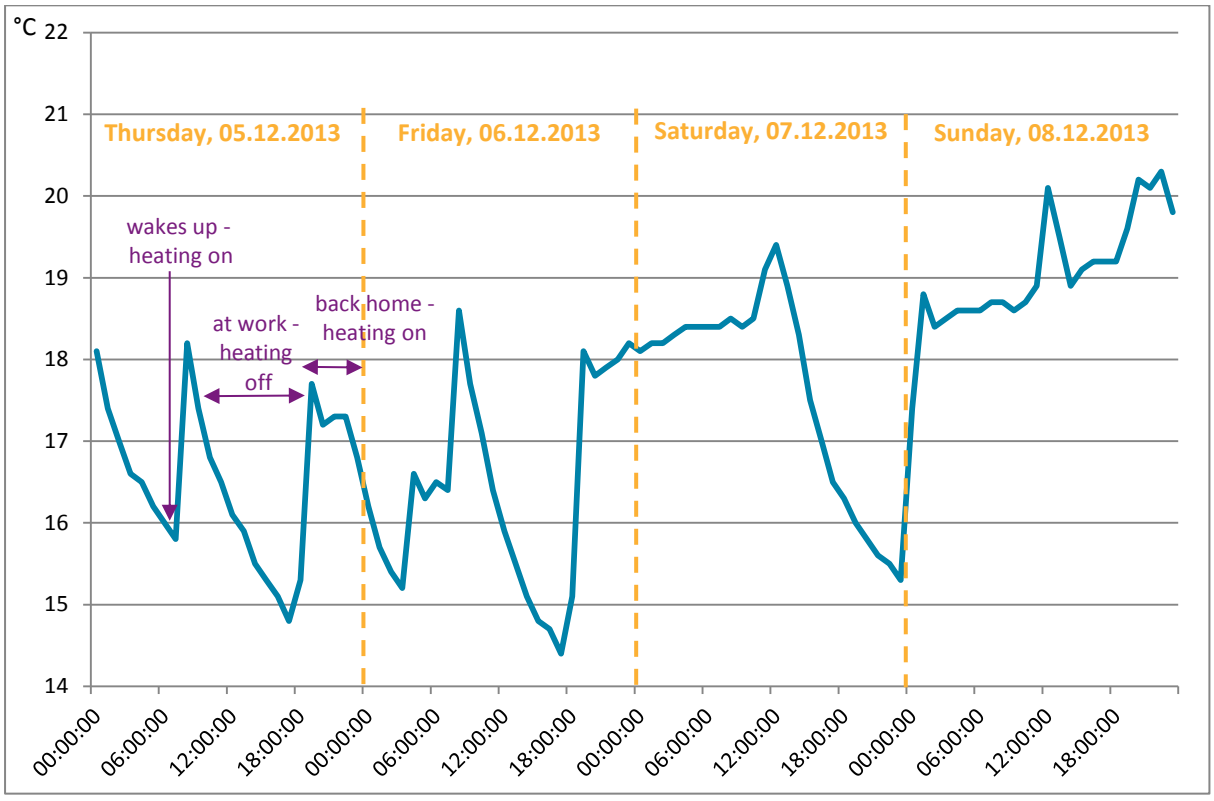
Typical operating patterns of UK heating systems differ from those in many other countries in Europe – instead of keeping the home at a relatively stable temperature, customers in the UK tend to use their heating systems in "bursts". Essentially the heating is only switched on when the customer is at home. This operation mode requires high flow temperatures at the start of the heating period, in order to reduce the time required to increase the temperature in the dwelling to a comfortable level.

Such an operation strategy is not well suited for a heat pump.

- It would lead to significant peaks in electric demand in the mornings and evenings
- It would result in poor heat pump performance – as illustrated by some of the challenges experienced during the UK Energy Saving Trust heat pump field trials.

The graph below shows an actual temperature profile measured in an Edinburgh home, illustrating the occupancy-led control of the heating system.

FIGURE 24: OCCUPANCY LED HEATING SYSTEM OPERATION IN A UK HOME, 05-08.12.2013
The graph shows that the heating system is only run when the occupant is at home. During week-days the heating system is switched on in the morning for a period of 1-2 hours, it is then switched off until the occupant returns in the evening and switched off for the night. On weekends the heating system usually remains switched on as long as the occupant is in the house.



Source(s): ***Temperature measurement in an Edinburgh home, via www.ic-meter.com, live data from the home, as well as the Delta-ee offices can be seen via the website's demo account***

4. Analysis of the UK domestic heat pump market

4.1. Installed Heat Pump Capacity

It is estimated that at the end of 2012 there were approximately 90,000 heat pumps installed in the UK. At an average capacity of 10.5 kW_{th} per heat pump, the **total installed (thermal) heat pump capacity in the UK was around 9 MW_{th}.**

Based on an SPF of 2.5 in the current UK heat pump park during the heating season, the electrical demand of the installed heat pump base during the heating season was ~3.6 MW_{el}.

Using the projected uptake of heat pumps from the impact assessment of the Domestic Renewable Heat Incentive, we assume that the installed base of heat pumps in the UK will reach approximately 515-530,000 units in 2020. Applying the same assumptions as above, this means **an installed UK heat pump capacity in 2020 of ~5.5 GW_{th}** or ~2.2 GW_{el}. Heat pumps (without smart capabilities) could thus account for more than 5% of the average cold spell peak demand in the UK electricity network by 2020 (see chapter 2.2 for more information on peak demand projections).

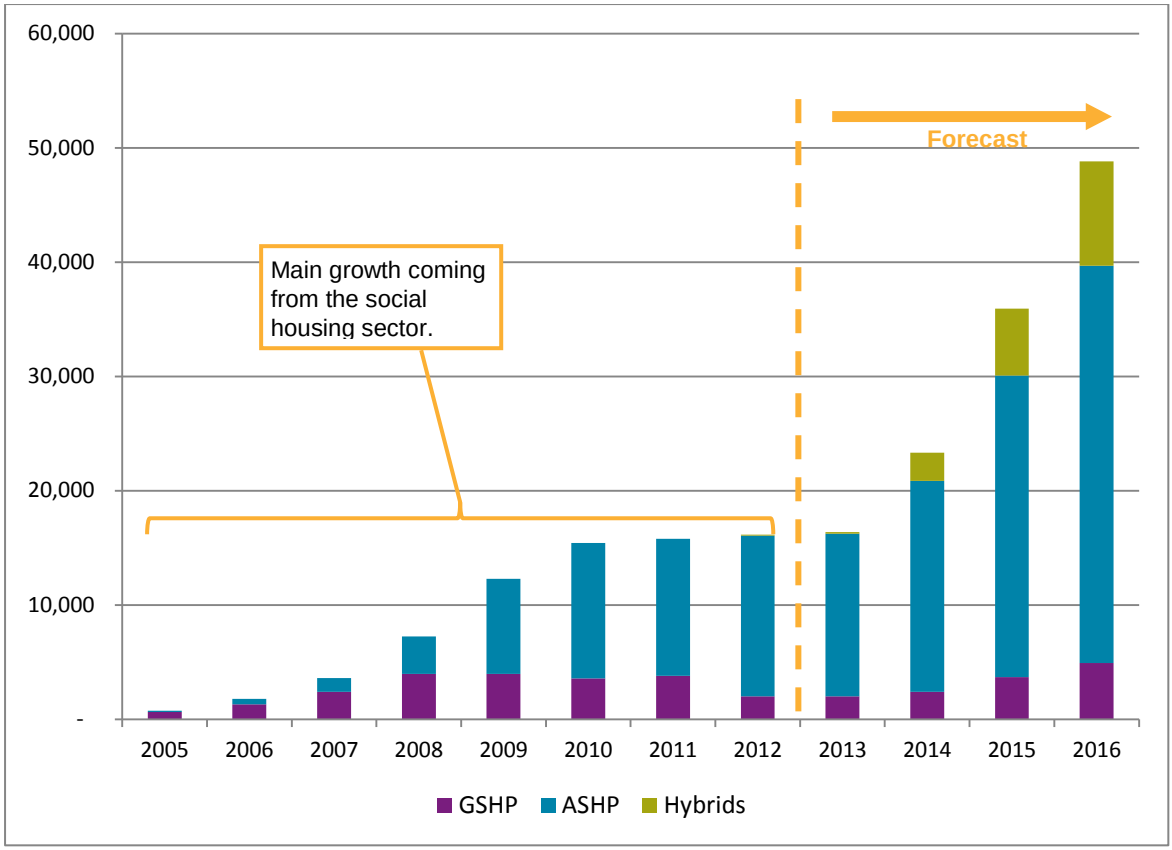
4.2. Trends in the Heat Pump Market

Growth of UK HP market 2005-2010: Induced by rising fossil fuel prices and the availability of grants for installations in the social housing sector.

Slightly negative growth of the UK HP market 2011-2012: Due to the gloomy economic conditions, a removal of grants in the social housing sector, adverse trends in the energy prices, some negative press about heat pumps after the rush in the early years of the market development and the repeated delay of the Renewable Heat Incentive for domestic installations, which has led potential customers to postpone investment decisions or to opt for conventional alternatives.

The heat pump market in the UK is today dominated by air-to-water heat pumps, underpinned by a small base of ground source installations. It is expected that the introduction of the domestic RHI will revive the market from 2014 onwards and fuel a significant growth over the coming years. From 2014 onwards we could also see a stronger uptake of hybrid (and bivalent) solutions in the on-gas sector, mainly driven by the RHI and the introduction of more competitive products from some of the major market players in the UK.

FIGURE 25: HISTORIC AND FUTURE TRENDS IN THE UK HEAT PUMP MARKET



Source(s): *Delta-ee Microgen Insight Service*
Delta-ee Heat Pump Research Service

4.3. Market Drivers

Domestic RHI

The most important market driver for heat pumps in the UK will be the Renewable Heat Incentive for domestic installations, which is expected to be introduced in Spring 2014. The domestic RHI will remunerate the generation of renewable heat via a tariff system: 7.3 pence/kWh will be paid for every kWh of renewable heat produced by air source heat pumps and 18.8 pence/kWh for every kWh of renewable heat generated by ground source heat pumps.

Due to fixed income for heat pump installations from the RHI tariffs, it is expected that the UK market will also see the introduction of new business models, where the heat pump is installed for free or at a reduced cost to the end-user and the capital investment costs are recouped via the RHI payments and the sale of heat to customers.

Building Regulations

Tightening building regulations will only play a minor role in the uptake of heat pumps in the UK new build segment over the coming years. The Government's aim is to tighten building regulations, so that from 2016 onwards all residential new

build will be Zero Carbon Homes. Since this can be reached by varying measures, ranging from the reduction of energy demand over on-site carbon abatement measures like renewable micro-generation (e.g. PV or small wind) to payments for off-site carbon abatement measures, it is expected that this will have a slightly positive, but limited impact on the heat pump market.

Involvement of Utilities

Utilities in the UK are involved further down the value chain of the heating sector than in many other countries – and are taking steps into heat pumps which could drive market growth. Many utilities in the UK have their own installer businesses. The main business here is still the sales and installation of gas boilers, several utilities are now also engaging in the installation of heat pumps. The leading utility in the boiler installation market has bought installation companies for heat pumps and biomass systems and several other suppliers work the market together with contractors. Due to the wide reach of the utilities in the UK (the 'Big 6' supply over 90% of UK customers), this engagement could become a major contributor to the market success of heat pumps in the UK.

Reducing running costs and meeting carbon targets in the social housing sector

Reducing running costs for their tenants and meeting carbon reduction targets are two of the main drivers for the installation of heat pumps in the social housing sector of the UK. It is expected that these aspects of the use of heat pumps will continue to drive the market in the future.

Green engagement in the self-build market

Self-builders in the UK, despite their low share of the new build market, form a steady base in the heat pump market and were critical in the early days of the market. With the introduction of the RHI it is to be expected that the share of heat pumps in the self-build sector is going to increase in the future.

4.4. Market Barriers

Heat pumps give low potential savings against gas in the UK

The extent of the gas networks in the UK is one of the main barriers to an increased uptake of heat pumps between now and 2020. With the costs of standard electricity being 3.27 times as high as the cost per kWh of gas, the running cost savings of heat pumps against a gas boiler are currently low. Another factor is the very low cost level of (condensing) gas boilers in the UK. A gas boiler is usually installed at 20% of the cost of an equivalent heat pump system.

Upfront cost is a major barrier to end-user uptake of heat pumps

The upfront cost for heat pumps is an important barrier for heat pumps both on and off-gas – especially given that there is no "culture" of investing in heating systems in the UK. With an average installed cost of ~£ 10,000 for an air-

source heat pump in a single family home, heat pumps are significantly more expensive than their fossil fuel based competitors (a gas boiler is typically 20% of the cost of an ASHP).

Perception of heat pumps – low level of trust from end-users and installers

Results from the Delta-ee customer research[9] into attitudes towards renewable heating technologies, indicate that **heat pumps are still considered as a new and risky technology by a wide section of the public.** This negative perception of heat pumps has in the last few years been increased by negative publicity surrounding some poor installations (even if these do not represent the status of the industry as a whole).

Installer research by Delta-ee[7] also indicates a lack of trust and awareness amongst many installers of microgeneration technologies including heat pumps. Installers in particular are very influential in determining heating system choice of the end-user – and the majority will encourage end-users to stick with what they know.

Quality does not yet permeate the whole UK heat pump value chain

The results of the first phase of the Energy Saving Trust Heat Pump field trials highlighted a number of issues which needed to be addressed in order to ensure quality of installation – which is a critical platform on which to build trust in heat pumps. Many of the key issues highlighted in the EST trial were addressed during the 2nd phase of the trial. However, there is still work to be done. Issues highlighted in the EST trial were also reflected in recent Delta-ee research[7].

- **Insufficient end-user education about how to operate their heat pump** is a major cause of poorly performing heat pumps and installer call-backs (e.g. end-users operating heat pumps in the way they would operate a boiler – see 2.4.
- **Under (and over)-dimensioning of heat pumps** for the thermal demand is still a problem causing poor performance, which requires further installer education/support.

Challenges arising from the connection of heat pumps to the distribution network

On the residential level most customers in the UK are supplied with single-phase electricity. As a result, the grid has little capacity to connect large loads – an issue which could create challenges with heat pump installation[10]. Balancing demand and supply on the lowest voltage level is important for keeping the supply on a feeder line stable, without excessive costs to the customers due to necessary network upgrades. **Heat pumps whose operation can minimise 'spiky' loads (e.g. inverter-driven systems with softer starts), and whose operating times can be influenced / controlled in order to shift demand away from critical**

[9] Source: Delta-ee Microgeneration Insight Service

[10] There is anecdotal evidence of grid connection challenges for heat pumps as a result of this issue – particularly in remote areas which are off the gas grid (and thus – economically – better suited to heat pumps). As the HP market grows, this challenge will become more critical.

times, will be necessary to enable the anticipated growth in the UK heat pump market.

A need to further develop the sales and distribution networks for heat pumps

Many large European heat pump companies currently do not have very strong / extensive networks of installers and distributors in the UK market. This is a strong barrier to the wider deployment of heat pump technology in the UK. From Delta-ee's recent UK installer research, we have found that installers who have trained as installers of heat pumps have largely been driven by their own personal interest in renewables, rather than in an expectation of immediate profit making – this is a naturally limited number of installers. The mass or conventional heating installers will continue to sell boilers until they see sufficient market pull. This is a challenge for heat pump manufacturers to find willing installer partners.

Increasing the number of qualified heat pump installers – and ensuring that trained installers maintain their experience level with heat pumps - is going to be one of the key challenges to deliver the expected HP uptake due to the introduction of the RHI. Currently there are around 1100 companies listed as heat pump installers (air-, ground- and exhaust-air heat pumps) in the Microgeneration Certification Scheme. It is expected that the total number of individual installers trained to install heat pumps is less than 10,000. With a total of currently ~16,000 heat pump installations a year, it is also expected that many of the listed installers complete little to no installations per year. We therefore expect that there is currently a lack of experience with the technology, even for certified heat pump installers in the UK.

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