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Exploring transition pathways to sustainable, low carbon societies
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Deliverable D2.2: ‘Analysis of stability and tensions in incumbent socio-technical regimes’

Country report 5: Regime analysis of the UK heating system

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Executive summary

The purpose of this document is to provide an analysis of stability and tensions in the incumbent socio-technical regime(s) within the heating domain in the United Kingdom, as part of PATHWAYS D2.2.

We first give an overview of the prevailing heating domain in the UK and a rationale for our specific focus on domestic heating. We also discuss the existence of subaltern regimes and their relationship to the prevailing regime.

The bulk of the document then describes the prevailing regime(s), focussing on main developments and tangible system elements as well as on active social groups and intangible regime elements.

In the concluding section, we analyse the inertia of the prevailing regime in the UK’s heating domain, and relate it to the PATHWAYS typology. The assessment of stability and tension within the regime is presented in a summary table.

The UK offers an interesting context for analysing the heat domain within a comparative setting as it clearly lags behind other Western European countries in terms of efficiency and innovation. However, having only recently ‘discovered’ heat as an important issue—at a critical point in time where multiple pressures seem to be aligning—the UK is setting a number of ambitious commitments in the frame of its first Heat Strategy. If it manages to develop the necessary skills and markets, it may hence well pick up on technological innovations developed elsewhere. Projecting or assessing the feasibility of future developments, however, is difficult given the high uncertainties related to technical aspects and the credibility of long-term policy commitments.

We here provide conclusions by reviewing the extent of lock-in and tensions of the current regime. These are summarised in two tables for the heating and the housing regime, respectively, although many overlaps exist.

The heating regime is fairly stable in particular due to strong infrastructural lock-in (gas grid / housing stock), the concentration of powerful actors on the supply side, the captivity and relative lack of awareness on the demand side (consumers), and a tendency for business as usual in the equipment installation and maintenance trade. However, this stability does not seem to be strongly related to active resistance strategies, which is hopeful for future change.

There are major tensions ahead for the heating regime, potentially developing towards a high degree of alignment (energy security and price stability, climate concerns, emergence of credible alternatives elsewhere). The current heating arrangement, relying on an increasing proportion of imported gas is seen as unsustainable in the long run. There are some signs of willingness to make strategic decisions and commitments on the policy side (although the credibility and durability of such discourse remains questionable). There are however substantial sources of uncertainty regarding current ambitions to stimulate a transformation in this domain.
### Stability and tensions in UK heat regime

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<th><strong>Lock-in, stabilising forces</strong></th>
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| **External landscape pressures** | Low cultural significance of ‘heat’  
Low policy salience of ‘heat’  
Financial crisis  
Neoliberal ideology and policy | Climate change and awareness of sustainability matters  
Gas and energy prices (related to resource availability and geopolitical change)  
Self-sufficiency and energy independence agenda  
Fuel poverty |
| **Heating equipment supply** | **STRONG/MODERATE**  
Gas boiler efficiency improvements over the years (incremental change)  
Gas assumes dominant market position  
No strong alternative in UK context  
Industry characterised by slow rate of change in skills and practice bases with preference for established solutions | **WEAK/MODERATE**  
Plans to rapidly phase out of existing gas boiler by 2030 (Heat strategy) (are these credible?)  
Many leadership and best practice examples in different European countries. Awareness of UK as laggard in comparative perspective |
| **Gas supply and distribution infrastructure** | **STRONG**  
Strong infrastructural lock-in (sunk costs, etc.), well functioning network. Competitive advantage from past network investments.  
Organisational linkages with electricity supply  
‘Unconventional’ gas may attenuate supply squeeze.  
Gas grid could in a distant future be adjusted to distribute other energy carriers. | **MODERATE**  
Rising price of gas is major concern  
Opening to competition beyond Big Six (though weak)  
Gas supply under increasing criticism and dissatisfaction |
| **Users /consumers** | **STRONG/MODERATE**  
Consumers do not actively pursue heat-related choices. Individual users do not interact much with this kind of technology.  
Heating equipment purchases are often not planned but follow from breakdown.  
Awareness and interest about different heating and energy efficiency options are relatively low. | **WEAK**  
Gas prices lead to greater interest in more efficient options  
Low levels of engagement, trust and consumer satisfaction with gas suppliers  
Increasing sources of information about heating alternatives for interested consumers (e.g Energy Saving Trust) |
| **Policy-makers** | **MODERATE**  
‘Unknown territory’ for policy, as low-carbon heat has only recently been put on the agenda.  
History of support for micro-generation measures, but highly criticised in their effectiveness and scope  
Historic instability of energy policy in the UK not conducive to long-term financial commitments (of Renewal Heat Incentive) | **POTENTIALLY STRONG (but uncertain)**  
New phase of low-carbon heat policy programme (Heat Strategy):  
- ambitious technological rollout vision (mainly energy efficiency and electrification via heat pumps)  
- specific instruments that follow from that (Renewal Heat Incentive) |
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The building regime in the UK is characterised by strong inertia, which is predominantly related to infrastructural elements such as the housing stock, but is also translated in low consumer interest, and unpreparedness of the construction sector. The sources of inertia are mainly structural, rather than the fruit of active resistance strategies.

The scope for change in terms of crack and tensions is currently relatively low, and unlikely to counterbalance the current stability. A number of early changes in social mobilisation, awareness raising with respect to energy efficiency, and the development of the Heat Strategy are however signs that the current situation could be changing.

The importance of implementing large-scale changes in the heat regime is progressively being recognised. The UK has recently shown ambitious commitments for a transition to a low-carbon heat regime, including an anticipated full decarbonisation of residential heat by 2050. There are however a number of challenges and barriers for reaching its goals. An inefficient and slow moving building stock and a generally poor track record with low carbon heat are two challenges to be named. Nevertheless, if these commitments are taken seriously and hence the necessary steps implemented sincerely (e.g. effective roll-out of efficiency measures, a virtual replacement of all gas boilers with heat pumps, and support for District Heating (DH)), vast opportunities can open up for the development of a sustainable heat industry. However, a history of ‘changing moods’ in UK energy policy and the failure to guarantee long-term stable conditions for low carbon solutions raises further doubts as to the feasibility of the current ambitious strategic objectives for heat.
<table>
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<tr>
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<td>Fuel poverty</td>
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<td><strong>Construction sector</strong></td>
<td>STRONG/MODERATE</td>
<td>WEAK</td>
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<td></td>
<td>Diffusion of basic insulation options and techniques (loft insulation, wall insulation, etc.) but not always integrated, leading to only minor improvements on average</td>
<td>Development of specialised companies catering for a niche market of high efficiency retrofits.</td>
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<td>Low awareness and proficiency of advanced energy efficiency refurbishment skills and techniques</td>
<td>Emerging markets elsewhere in Europe, developing supply chains, skills, markets.</td>
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<td></td>
<td>There is a need for skills and supply chain improvements in the building industry, e.g. improved training, professionalisation, and greater standard requirements.</td>
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<td><strong>Housing stock</strong></td>
<td>STRONG</td>
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<td></td>
<td>Strong infrastructural lock-in in exiting housing stock, which is on average old and energy inefficient. Replacement rates are very low.</td>
<td>The energy performance of newly built houses has much improved, but replacement rates are low.</td>
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<td><strong>Users/consumers</strong></td>
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<td>Retrofitting remains a voluntary measure and can lead to partial solutions (caused by structure of financial incentives)</td>
<td>Rising gas prices lead to greater interest in efficiency matters</td>
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<td>Spontaneous customer demand for retrofitting is low due to high upfront costs, uncertainty about economic gains, and technical difficulties</td>
<td>Increasing interest among house owners to retrofit but not in private tenancies due to principal-agent problem</td>
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<td>Insulation and energy efficiency improvements are disruptive and often coincide with major refurbishments</td>
<td>Emergence of ‘greener’ homeowners</td>
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<td>A number of organisations promote the development of low-energy skills in the building sector (e.g. UK Green Buildings Council lobbies for energy efficiency in buildings to become an infrastructure priority)</td>
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1 Introduction

The purpose of this document is to provide an analysis of the stability and tensions in the incumbent socio-technical regime(s) within the heating domain in the UK, as part of PATHWAYS D2.2, in accordance with the protocol agreed by all partners.

We first provide an overview of the prevailing heating domain in the UK, and a rationale for our specific focus on domestic heating. We also discuss the presence of subaltern regimes and their relationship with the prevailing regime. The bulk of the document then describes the prevailing regime(s), focussing on main developments and tangible system elements as well as on active social groups and intangible regime elements.

The analysis presented in this report is structured around two main research questions:

1) What are the main external landscape developments that affect the UK heating regime?

2) Do external pressures and internal problems lead to tensions and destabilisation of the UK heating regime? Or is the regime still fairly stable, with (most) actors focussing on incremental change?

1.1 Heating domain – some general remarks

Heating, unlike more concentrated energy forms such as electricity or fuels, tends to be diffuse. Because heat transfer is a dissipative process, heat is difficult to store or transport over long distances. Consequently, most current heating applications focus on point source conversion of stored energy to heat (appliances fuelled by energy carriers such as gas or electricity), heat distribution in networks (e.g. district heating), or heat transfer (e.g. heat pumps, solar thermal). Heat supply in the UK has tended to be highly decentralised, and to a lesser extent concentrated in localised networks (this aspect is quite underdeveloped in the UK as compared to other national settings - with around 2% of heat supplied to buildings (DECC 2013:39)). This makes heating in its present configuration in the UK a complicated process to monitor and influence.\(^1\) The potential agents of change – individual homeowners or tenants – are widely dispersed, inexpert, and poorly informed rather than concentrated point sources run by technically skilled personnel as is the case in electricity supply and distribution, for instance.

Heating demand follows seasonal patterns, with peak demand concentrated around a few weeks in winter, and a much lower demand during summer. Compared to other European countries, the UK has a relatively high demand for heating but a very low demand for cooling (with natural ventilation being the main form of cooling). There are, however, indications that this may be changing with warmer weather conditions and altering preferences. As with electricity, heat demand varies considerably also throughout the day, which means that the technical issue of balancing loads is a major consideration for overall system choices.

Unlike other forms of energy, heat (currently) has relatively low policy salience. Only in recent years has heating become a policy focus in the UK, specifically in the frame of climate and housing policies, with a dedicated low-carbon heat policy since 2011. Overall, heating also has a relatively low socio-cultural visibility, which may be explained by the relative technical complexity and low experiential commensurability of technical choice related to

\(^1\) Heating is also difficult to trace from a statistical point of view. Household energy consumption by use is usually determined through modelling and estimation. Heat networks provide further opportunities for metering and related control.
heating. Heating practices vary, of course, according to individual and collective preferences (e.g. comfort) that change over time and may present additional technological challenges (Chappells and Shove 2005). In the UK, because of the predominance of gas heating and rising fuel prices, heating has made its way into public debates mainly via issues of fuel poverty, energy security, and choice of supplier (following liberalisation).

1.2 The domestic heat regime in the UK

In this section, we give an overview of the heating domain in the UK, its main characteristics, and its interaction with other domains. Based on this, we provide a justification for narrowing down the analytical focus on the domestic heat regime.

Heating is one of the main energy uses in the UK. In 2012, heat represented 47.1% of total energy end use—a figure that rises to 77.5% when considering only static energy use and excluding transport (DUKES 2013: 1.07). This demand for heat is dominated by the residential sector (57%). Industry and services account for 24% and 19% of total heat use, respectively (Figure 1). The substantial contribution of the residential (or domestic) sector to total energy use in the UK justifies an explicit focus on this sector.²

Two main fuel sources dominate the heating domain in the UK: 71% of heat derives from gas-fired systems and 15% from electric systems. For household heat use, this picture differs slightly with 80% being gas-fired, 9% electric and 7% oil-fired. Figure 2 represents the various contributions of fuels to space heating, in terms of primary energy input. The heating market represents an annual £32 billion yearly in the UK (DECC 2013), which can make up a

² Industrial heat systems and trajectories are fundamentally different from domestic heat systems as they operate at much larger scales and concentrations, and, for the most part, at much higher temperatures. They involve different processes, actors, supply chains, and policies (although they share the ‘heat strategy’ policy heading). In terms of decarbonisation strategies, they are comparable to the electricity sector, with the main options that are currently considered being: relying on biomass, combined heat and power (CHP), and carbon capture and storage (CCS) – which is compatible with a view of the industrial heat system as fairly concentrated point sources with substantial potential for control.
substantial proportion of household costs, especially for poorer households. Heating is responsible for roughly a third of UK GHG emissions (DECC 2013), which further highlights the relevance of this domain in national decarbonisation strategies.

Figure 2: Space heating in UK households by fuel source, in primary energy equivalents (1990-2012). (Source: DUKES 2013)

1.2.1 Configurations, multiple systems and interactions

Delineating the UK domestic heating system and its relationship to other domains and regimes is not straightforward. Socio-technical considerations of heating can be seen to revolve around 1) a **heating regime** (heating appliance, fuel and related infrastructure, energy system installation and maintenance, their use, etc.), and 2) a closely related **housing regime** (housing unit, insulation, heating requirements, indoor temperature and comfort, living practices, infrastructure, ownership structures, construction, etc.). These regimes are further linked to different energy regimes for primary supply (electricity, various fuels, etc.) labelled ‘*energy supply industry*’ as well as a building construction and renovation regime labelled ‘*construction industry*’ (Figure 3).

Figure 3: Interactions within and at the margin of the domestic heat regime.
**Heating regime.** The main purpose of this regime is to heat homes by transferring energy from the external environment. The main technical components involved in domestic space heating in the UK are further detailed in Figure 4.

![Figure 4: Schematic overview of technical components and options in domestic heating in the UK (bold lines represent current dominant configuration).](image)

With respect to the heating regime, this suggests that a number of system configurations co-exist in the UK, determined largely by the type of heating appliance or system:

1. **Grid-connected individual space heating with point-source heat production**
   a. a **dominant heating configuration** linking an energy system (fuel supply) to heating systems by means of a national infrastructure (gas mains grid);
   b. a lesser important heating configuration linking the electricity system to heating systems by means of another national infrastructure (electricity grid), following a very similar model, but also ‘piggy-backing’ on the electricity supply requirements of housing;

2. **Smaller, decentralised, off-grid configurations** (e.g. petrol, solid fuel).

3. **Collective heating systems** relying on central heat production and local heat networks (e.g. district heating) in individual buildings. In most cases, these configurations are connected to the main grid but they could also be envisaged as self-sufficient (e.g. CHP-district heating in closed loop).

These distinctions are represented in Figure 5, according to their degree of collectivism and their grid-dependence.
Configuration 1a (described above) is by far the predominant heating configuration in the UK, with other configurations corresponding to relatively isolated and small market pockets. The domestic heating regime is largely dominated by ‘gas mains individual heating’ (over 90%), with most of the remaining demand articulated around off-grid configurations (petrol or solid fuels). While in other countries ‘network heating’ niches have grown into stable configurations and supporting regimes, the same cannot be said for the UK. Developments within this regime are considered in detail in section 4, with particular attention to the prevailing configuration revolving around individual gas heating.

**Housing regime.** The main purpose of this regime, as far as heat is concerned, is to maintain thermal comfort (conserving heat/cool) within the home. With respect to the housing regime, Figure 4 suggests that the main technical elements relate to thermal specifications (insulation, ventilation, etc.) and mainly to the building envelope. Thermal efficiency provides a handy metric for the thermal performance of housing. However, in practice, this may be difficult to measure and vary significantly across the building stock. Thermal efficiency of residential buildings in the UK is relatively poor. Developments within this regime are considered in detail in section 5.

### 1.2.2 Data-sources

The research conducted for this report was empirically challenging as it addresses multiple dimensions, i.e. techno-economic, socio-cognitive, and political ones. Quantitative information for ‘tangible’ system elements was collected from official statistical sources and other openly available publications. Qualitative data and interpretations draw on the knowledge of the analysts who are sector experts and secondary sources (books, articles, and reports), complemented with primary sources (policy documents, newspapers, trade associations, consumer information portals, etc.). This heterogeneous data was integrated in order to construct an interpretive analysis.

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3 One could question whether these alternative configurations should be considered as niches or alternative regimes. While their market relevance is small in the UK, they do correspond to fairly established and stable configurations worldwide. Hence, in (global) evolutionary terms, they may be classified as regimes due to their stability while in (localised) ecological terms, they may be classified as niche-applications due to their relative size and limited ability to compete for a larger market share, as well as the natural protection they may benefit from (e.g. off-grid).
### 1.2.3  Report structure

The report is structured as follows: Chapter 2 describes overall system characterisations, trends and longitudinal developments, which positions the different sub-regimes and their contribution to environmental improvements over time. Chapter 3 identifies the main external landscape developments that affect the electricity regime. Chapter 4 describes longitudinal developments in the UK (gas-fired) domestic heating regime. Chapter 5 does the same for the domestic housing regime. Chapter 6 provides conclusions on stability and cracks in domestic heat in the UK, with attention to both sub-regimes considered.
2 Overall system trends and regime characterisation

2.1 Regime characterisation
The UK has historically enjoyed plentiful supply of gas (first as a by-product of coal, later from the North Sea). This has resulted in a heating system that relies mainly on gas—resting on a dense, centrally operated, piped network (Figure 4). The UK domestic heating domain is largely dominated by natural gas boilers, with a low penetration of both heat networks and renewables heat. This market has also seen a rapid expansion of central heating systems, installed in 90% of homes (DECC 2013), and the move to condensing and combi-boilers. While central heating comes with an increasing potential for control (and related potential efficiency gains), thermostats for individual rooms are not commonly in use in the UK. It has also been observed that the penetration of central heating in the UK has been accompanied by a rise in internal temperatures.

Figure 6: Schematic representation of ideal elements of a socio-technical system for heating

Figure 6 provides a rough sketch of the main components of a socio-technical system for heat in the UK. The system consists primarily of technical artefacts (appliance and housing), supply and distribution infrastructure (fuel and heat), manufacturing and services (system installation, maintenance, servicing, etc.), but also less tangible socio-political elements (regulations and policies, markets and practices, cultural and symbolic attributes).

Heat in households consists mainly of space heating, water heating, and cooking applications (Figure 7), supplied by a variety of appliances and their combinations. Figure 4 provides an overview of the main technical elements involved in domestic heating in the UK, clearly outlining the dominant regime defined as ‘individual mains gas heating’ as individual households connected to a national gas main infrastructure.
The demand for heat within the home is influenced by a number of factors, including the desired temperature (thermal comfort preferences, occupancy, etc.), the heating pattern management (individual room heating, thermostat controls, etc.), the efficiency of heating appliance (including synergies with parallel appliance or distributed networks), the nature of the heat delivery system (radiator, underfloor heating, etc.), and the energy performance of housing (insulation, air-tightness, ventilation, etc.).

Heat in the UK is a highly decentralised matter, with most heat production located at the point of consumption, i.e. in individual appliance for the domestic sector. This is reflected by the relative low proportion of energy sold as heat in total energy consumption, and particularly in the domestic sector. Most households can be considered self-contained heating generation and consumption units. Central heating systems have been installed in 90% of homes. Domestic heating in the UK is largely dominated by boilers (95% of homes), of which 80% are connected to the gas grid (DECC 2013). Around 1.5 million condensing boilers are sold yearly in the UK (DECC 2013a:74).

As outlined above (Figure 3), we distinguish two main components in the UK’s domestic heat regime in order to facilitate the analysis: 1) a heating regime, and 2) and housing regime. These two ‘subaltern’ regimes have traditionally been the object of specific technical developments and policies although there are many overlaps.

2.2 Longitudinal system development

There have not been any major changes in the usage of primary fuels for space heating in the UK over the last 20 years (Figure 2). Gas is predominant.

Simultaneously, there is a slow upward trend in space heating energy consumption in the UK (Figure 7), which is commonly attributed to the diffusion of central heating and increased internal temperatures.

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4 The UK building stock is relatively old (Victorian), with a large proportion of semi-detached and terraced houses (DECC 2012a) which suggests a high potential for energy efficiency improvements.
In terms of housing efficiency, improvements have been relatively slow over the past decades—despite raised energy performance requirements for new builds (Eyre and Baruah 2015, see also section 5).

Overall, the UK is slowly waking up to the necessity of addressing the decarbonisation of heating.

### 2.3 Environmental performance

There is little detailed data available on the environmental performance of buildings in the UK. The general trend, however, is that the efficiency of domestic heating has improved incrementally, and that CO₂ emissions have dropped slightly since 2000 (see declining emission from gas in Figure 8). The gradual improvement of heating system efficiencies as well as the gradual introduction of basic insulation measures (with limited success) are mostly responsible for these trends⁵. Figure 9 shows an estimate of their relative contribution.

![Figure 8: CO2 emissions from housing UK. (Source: Palmer and Cooper 2013:12)](image)

The UK Government has ambitions to fully reconfigure the heat supply system through 1) encouraging energy efficiency in buildings, and 2) moving towards low carbon heat with an overwhelming reliance on the electrification of heat via heat pumps (see Figure 10 for an indication of the kinds of technological scenarios put forward). While the feasibility of such ambitious plans to be delivered is questionable, it is becoming increasingly clear that reaching the legally binding targets of 80% GHG emission reductions by 2050 is “incompatible with retaining a residential heating sector with anything like the current structure” (Eyre and Baruah 2015:2).

⁵ Palmer and Cooper (2013:51) provide a realistic picture of the appalling energy efficiency of buildings in the UK: “there are hardly any homes with no insulation, but more than two thirds of the stock still has insufficient insulation by modern standards”, and further suggest the definition “fully insulated” buildings (a small third of the building stock) is “well below modern standards of insulation”.

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Figure 9: Energy savings from insulation measures and condensing boilers 1970-2007. (Source: DECC 2012:28)

Figure 10: Domestic space heat and hot water output by technology, RESOM core run. (Source: DECC 2013:78)

In the UK, renewable heat is struggling to generate significant momentum (see PATHWAYS D2.1 for a detailed analysis). Meanwhile, it is developing quite steadily in a number of other European countries (Germany, Sweden, Austria, etc.), which causes both emerging competitive pressure as well as a potential for adaptation (if new technologies, skills, and infrastructure can be absorbed).
3 Main landscape developments influencing the system

A number of long-term dynamics are affecting the development of heating regimes. Such dynamics can influence established socio-technical trajectories both negatively (destabilise) and positively (stabilise).

3.1 Main destabilising pressures

Climate change and sustainability. Increasing awareness and policy salience of climate change over the past decades have led to ambitious policy commitments in the UK, particularly in terms of cutting GHG emissions. This landscape change is affecting every economic sector. Initial efforts have been concentrated on setting carbon reduction targets, and implementing change in the electricity sector. There are signs that policy commitments are turning into action, with grand ambitions becoming legally binding. At the same time, there is a sense that environmental problems have been pushed to the background since the economic downturn, and only become salient when associated with positive economic discourses, i.e. sustainable jobs, industry creation, market formation, etc.

Gas and energy prices. Historic price stability and the relative low cost of gas is causing increasing anxiety related to the exhaustion of North Sea reserves and potential international tensions resulting from dependence on imported fuel from more or less stable countries. This landscape change is raising the strategic and cultural salience of energy security issues in a way unprecedented since the 1970s energy crises. In the absence of large long-term domestic reserves or foreseeable gas market stability, the gas proposition is bound to become weaker in the UK. Indeed, the UK has increasingly had to compensate the decline of its own resource with imports from Norway (pipeline) and Qatar (liquefied natural gas (LNG)). However, changes on global markets are pushing prices up and suppliers are showing a greater appetite for deliveries to the Asian market, which is becoming a serious challenge to UK energy security and fuel price stability.

Self-sufficiency and energy independence. A related landscape development in the energy domain relates to the raised profile of self-sufficiency. Self-sufficiency discourse is linked to concerns of energy dependence. At national level, this is translated into the objective to develop an energy strategy that relies on domestic energy resources, and the diversification of energy carriers (including renewable energy). This clearly contradicts the current highly mono-fuel heating regime. At a local level, this is translated into an emerging aspiration by local authorities to master their energy supply and distribution, which offers increased prospects for networked forms of energy delivery (e.g. district heating, CHP, etc.).

Fuel poverty. With rising social inequalities and rising fuel prices, fuel poverty is becoming an increasing concern in the UK (Figure 11). The economic downturn since the financial crisis in 2008 is contributing to a worsened outlook. It is also leading to increasing awareness of fuel costs and the search for savings through e.g. greater efficiency as well as ambitions for energy independence.
These issues are challenging the socio-cultural, policy, and practical legitimacy as well as economic viability of established heating arrangements in the UK. They are likely to contribute to shaping the future of heating. Decision-makers in the heating domain are faced with what is commonly referred to as the ‘policy trilemma’: issues of energy security, rising fuel costs, and low carbon imperatives within the energy sectors. These challenges have “multiple overlapping uncertainties” (Pye et al 2015:1), which means that tradeoffs may be necessary under current circumstances.

3.2 **Main stabilising landscape aspects**

In contrast to the outlined pressures, a number of landscape developments are stabilising the current gas-fired heating regime, making it more difficult for alternatives to break through.

**Low overall cultural significance.** Heat has relatively low cultural significance and visibility in the UK, in particular within the domestic sector. Historically, English households were strongly attached to their main source of heat (Turnheim and Geels 2012). The transition to gas heating in the home, which accelerated throughout the 1970s and 1980s led, however, to a form of emotional and cultural detachment, with heating becoming relegated to a technical function with less visibility and user interaction. This landscape development means that heat users are less likely to engage with heating issues on a collective level and to challenge prevailing practices.

**Low policy salience.** Despite successive historical waves of interest in fuel policies (e.g. linked to poverty, coal-miners fuel allowance) and in building improvements, heat has not been a main focus for programmatic policies in recent years. In fact, the 2007 Energy White Paper (DTI 2007) barely mentions heat. Heat has been so low on the energy policy agenda that it has been qualified as the ‘hidden sector’ of energy supply (Green Alliance 2007), or the ‘Cinderella’ of energy policy – denoting the lack of dedicated attention to fulfil its decarbonisation potential. Heat may, however, be acquiring new policy salience as it is increasingly seen as a future priority area for decarbonisation and related strategic intervention. Section 4.2.2. takes a more detailed look on policy matters.

**Financial crisis.** The economic downturn since 2008 has led to reduced availability of funding for daring innovation schemes and to tighter restrictions which are conducive to
conducting ‘business as usual’. Grand plans for decentralised energy in the UK have suffered from reduced demand and spending cuts (Finney et al. 2013). This works in favour of the prevailing regime.

**Building stock.** A number of landscape developments in the building sector contribute to stabilising the present heating configuration, leading to a situation that is conducive to incremental improvements but not to major transformations of heat delivery. These developments are 1) a low rate of building stock renewal that tends to increase barriers to energy efficient solutions, and 2) the rapid decrease in local authority-owned houses over the past 40 years, which have reduced the scope for network heating systems (see also section 5):

> “Fewer council-owned properties make it harder to carry out wholesale improvements to a whole street or estate, because of fragmented ownership” (DECC 2012a:24)

**Neoliberal ideology and policy.** The UK strategic utility industries and related policies are characterised by the prevalence of the market logic. Liberalisation and privatisation have led to a system valorising short-term payback and to reduced scope for visionary long-sighted involvement of e.g. public authorities in planning and operations of energy schemes (e.g. Hawkey 2012; Helm 2010):

> “societies need to move beyond the traditional governance model for distribution (and other energy) networks which prioritises short term efficiencies in incumbent sectors (gas and electricity). A more “innovation friendly” governance model is needed to take into account the challenges to be faced at different stages of what we refer to as the infrastructure lifecycle — from early stage development of local networks, through to the transformation of incumbent national grids.” (Bolton and Foxon 2014:539)

Overall, the neo-liberal mentality in the UK tends to favour individual solutions over more collective ones. Similarly, much emphasis is put on the role of markets in driving change as opposed to a stronger role of the state. This inclination, manifest in the way liberalised energy markets function, may generate further barriers for infrastructure-intensive and/or mono-supply options such as District Heating (DH) and Combined Heat and Power (CHP) (Toke and Fragaki 2008).
4 Development in the individual (gas-based) heating regime in the UK

The distribution of fuels used for domestic space heating in the UK has been relatively stable for the past 20 years (Figure 2). This section reviews developments of the main tangible system elements, the main social groups and intangible regime elements, and their positioning vis-à-vis landscape changes.

4.1 Technology and market developments

The technological system around individual (gas-based) heating is characterised by substantial inertia linked to commitments to a specific fuel (gas) in given appliances (gas boilers), and a stable and wide-ranging distribution infrastructure (gas grid). Despite inherent stability, the heating regime in the UK is also showing some early signs of change. Recent trends and developments point to the increasing recognition of external pressures and challenges, with greater attention to environmental issues, renewable heat options, experimentation with decentralised heat production and distribution, and the development of a dedicated heat policy strategy.

Appliance improvement. The current heating regime has marginally adapted to efficiency issues through performance improvements:

- the massive uptake of central heating from the 1960s to the mid-2000s (Figure 12)
- the diffusion of more effective heating systems, in roughly 2 waves (Figure 13)

![Figure 12: The uptake of central heating in the UK (Source: DECC 2012b:41)](image)

While such system efficiency improvements are important, they are limited, and may even lead to greater energy use via higher indoor temperatures. System-level change is required if the current heating regime is to contribute to delivering energy decarbonisation in the UK.
The gas boiler installation market is relatively stable, in the absence of major challenging alternative (see PATHWAYS D2.1). Gas boilers are routinely replaced as old boilers break down. However, the current government plans, under the Heat Strategy (2013), suggest a very rapid phasing out of existing gas boilers, set to virtually disappear by 2030. Meeting such projections practically rules out any new installation of gas boilers past 2018, which is difficult to envision under present circumstances (Eyre and Baruah 2015).

Greater user control. The control of indoor temperature is a potential source of efficiency improvement in heating. This may involve innovative metering, billing and controls that provide greater feedback to heat users (e.g. by highlighting inefficiencies, or potential for energy savings). Controls are the interface between heat users and their heating system. They provide a gateway to heating performance management, and hence potential energy use and cost savings. Basic control technology (e.g. timer, room thermostats, radiator valves) are a standard feature of heating systems but 70% of British households do not have the full set (DECC 2011a). The miniaturisation of consumer electronics has expanded their features (e.g. heating programmers, timed settings). Smart meters may potentially also pave the way for heating system improvements by better-informed users and more automated forms of use optimisation, and have been put forward as a major option supported by a nation-wide rollout initiative (see PATHWAYS D2.1). They cannot, however, make up for inefficient heating systems or poorly insulated homes, as well as the long-term trend towards higher indoor temperatures. Evaluating efficiency and cost savings from such devices is inherently tricky and contested.

Diversification of supply. In the face of dwindling domestic natural gas reserves, the UK increasingly relies on imports to meet its demand (Figure 14), and has been a net importer since 2004. These imports are, to a large extent, supplied from other European countries through a large network of interconnected pipelines, with the exception of LNG imports from Qatar. While this diversification can be seen as a positive reaction to energy dependence issues, leading to greater flexibility, the interconnected nature of the global gas market and the emergence of major demand in Asia and South America limits the UK’s ability to control prices (Arapostathis et al. 2014). The price squeeze on gas weakens its position as the main heat option in the long run and provides further arguments for the development of
competitive alternatives entailing lesser dependence on international markets. Shale gas developments, currently mainly located in North America, may provide greater stability in the medium to long term. The National Grid does not rule out an important role of shale gas, including sourced in the UK, by 2035 (National Grid 2013).

Figure 14: UK Imports of Natural Gas 2000 to 2013 (Source: DUKES 2014:98)

**Infrastructure lock-in.** In a more “traditional” (techno-economic) sense, high sunk cost in infrastructure and equipment can be seen as strong source of inertia in established technical configurations. The massive (and to date effective) nation-wide gas distribution infrastructure is thus a strong source of stability in the established regime. The existing national gas grid is extensive, supplying around 80% of British homes. Rolling out a comparable infrastructure is difficult within a liberalised market that does not reward long-term collective investment. Infrastructure lock-in is the single most important factor inhibiting the diffusion of renewable heat in the UK. However, there is increasing recognition that gas supply is becoming problematic, and that this infrastructure has to be abandoned in the long term, unless options for the development of new uses are seriously considered.

Conversely, moving away from the established heating configuration in the UK (e.g. within a low-carbon pathway) would generate “substantial reduction in gas demand, and consequential issues for owners of the gas infrastructure” (Eyre and Baruah 2015:8). The destabilisation of gas demand that would result from such a move towards non gas-based, lower carbon heat supply in the UK may face substantial resistance from the interests involved. Correspondingly, options that may open up a role for the existing distribution infrastructure (e.g. piped biogas, hydrogen, etc.) would benefit from greater support from this constituency. To date, this seems rather unlikely as a whole range of new issues would emerge in terms of competition with uses in other domains (e.g. mobility), and required technological adjustments.

**Decarbonisation plans.** Policy interventions, particularly related to low-carbon objectives, are discussed in detail in sections 4.2.2 and 5.2.2. The main technological considerations of these policy interventions and underlying discourses can be summarised as follows: Decarbonisation objectives and commitments are substantial in the UK, but there is great
uncertainty as to the means and modalities for the required transformation of the heating domain. Within the Heat Strategy, the ambition is a full transition to heat pumps and district heating by 2050 (Figure 15), with the most part to be implemented by 2030 (Figure 10). Indeed, the Heat Strategy (DECC 2013) relies on 80% of residential heat requirements to be met by heat pumps by 2050.

![Figure 15: Domestic aspects of the heat decarbonisation strategy to 2050 (Source: DECC 2012b)](image)

However, the evidence of developments on the ground is pointing to a deep feasibility disconnect between policy ambitions and their materialisation. The Committee on Climate Change (CCC), although one of most fervent advocates of the ‘all-electric’ solution in 2008 (Bolton 2011), has underlined the slow progress to date (particularly with heat pumps) in its 4th Carbon budget review (CCC 2013), which has led it to revise its projections:

“We have revised our assumptions about heat pump uptake down from 7 million installations in 2030 (meeting 143 TWh of heat demand) to 4 million (72 TWh). This is partly offset by an assumed increase in penetration of district heating (up from 2% (10 TWh) to 6% (30 TWh) in 2030’ (CCC 2013:74)

These revisions have led to lower emission reduction predictions within the residential sector, down to 38% by 2030 on 1990 levels, with a significant contribution from low-carbon heat (around two thirds) and lesser contribution of energy efficiency (around one third).

**Development of renewable heat options.** While renewable heat is developing fast in some European countries (see other case studies in PATHWAYS D2.1 and D2.2), the UK Government recognises that the development of a mass market for low carbon heat is unlikely before 2020 (HM Government 2011:42). Most of its short-term carbon reduction potential is derived from the phase-out of dirtier heating systems. There are, however, high hopes to generate the conditions for a breakthrough of micro-generation heat technology and related expectations of positive market spillovers into new trade and skills base, leading to “new installer jobs, and upskilling of existing jobs as existing gas installers cross-train” (DECC 2013:74). Figure 16 displays the recent market uptake of renewable heat technology in the UK, which is on the rise, but remains very small when compared to the 700 TWh yearly heat consumption in the UK. With regards to domestic heat consumption in particular, biomass seems to be the only substantial market existing to date. Solar thermal and heat pumps are making shy early contributions (see also PATHWAYS D2.1).
4.2  **Actors and institutions**

The heating regime is stabilised by actors, initiatives and institutions that contribute to existing lock-in. These include powerful actors and their strategies to retain business models unchanged, the current lack of capabilities and skills to support innovative change, and the lack of awareness and expertise of individual heat operators.

4.2.1  **Main actors and their positioning**

**Privatisation context.** The 1986 Gas Act provided the framework for the privatisation of the British Gas Corporation, retaining its monopoly structure but gradually allowing larger customers access to its infrastructure. The Office of Gas Supply (Ofgas) was established (Arapostathis et al. 2014). There have been successive measures to encourage competition in the sector. In 1998, freedom of supplier choice was established for all customers. By 2000, Ofgas and the Office of Electricity Regulation (OFFER) were merged into a single regulator: The Office of Gas and Electricity Markets (Ofgem). Along with the privatisation of energy supply and distribution came a preference for individual solutions over collective ones.

**Gas supply and infrastructure.** The National Grid (owned by regional electricity companies since privatisation in 1990) is in charge of transporting gas through its pipelines to individual users, without being involved in retail. It plays a central role in enabling the existence (and to some extent stability) of a gas market in the UK. This incumbent distribution network is highly regulated and centrally governed as opposed to more emergent forms of heat. According to the National Grid’s business plan, “the utilisation of gas will remain an efficient approach to space heating, particularly during winter peak demand”.6 National Grid projections foresee a gradual reduction of gas consumption for residential heating in two major steps: an initial reduction from 2020 to 2035 due to energy efficiency improvements, followed by a more pronounced reduction with the mainstream introduction of heat pumps from 2035 to 2050 (Figure 17).

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6  [www.talkingnetworkstx.com](http://www.talkingnetworkstx.com)
Perhaps not surprisingly, the National Grid – which also has interests in the distribution of electricity – supports a gradual move to heat pumps:

“In our projections heat pumps are initially concentrated in houses not connected to the gas grid, encouraged by government policy to electrify heat through the RHI, the Renewable Heat Premium Payment (RHPP) incentive scheme, the high price of non-gas fuels and the Green Deal / ECO. The next tranche of heat pumps are installed in new houses with their better insulation and lower heat demand fuelled by changes in building regulations i.e. path to zero carbon homes by 2016. Finally heat pumps enter the mainstream heating market for houses on the gas network (assuming cost benefit) as economies of scale reduce heat pump installation and unit costs to levels similar to gas boilers today” (National Grid 2013:34)

There are 67 registered gas suppliers in the UK. While most of the market has been captured by the ‘Big Six’ (Centrica, E.ON, NPW, SSE, Scottish Power and EDF), with Centrica retaining a substantially larger share of the market, recent years have seen the emergence of new, smaller players (Figure 18). Individual market contribution of these smaller suppliers is limited and it is not likely that “any single existing supplier will achieve sufficient scale in the near term to act as a disruptive constraint on the six largest suppliers across the market” (Ofgem 2013:9). Furthermore, Ofgem (2013) has recently noted that the industry is characterised by weak competition and tacit coordination amongst the main industry actors (mainly on prices), which may suggest an ability to also collectively resist change.

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Heating equipment supply and installation. Leading heating equipment manufacturers tend to operate at a global level, with local specialisation. This means that although there are not too many UK suppliers with cutting edge products, a renewable heat industry is building up in different European countries (e.g. Germany, Denmark, France, Sweden), which could cater to the British market if it were to develop or change. The supply side is hence not necessarily a main source of inertia in the medium term as equipment supply will follow market creation and consolidation, and products and services have matured elsewhere (see for instance German and Swedish cases). However, it is also recognised that any key transition of the heating sector, such as moving towards high electrification of heat (in accordance with the Heat Strategy) would imply “major changes in heating installer products, supply chains and practices” (Eyre and Baruah 2015:12) for which there is currently a lack of evidence. In order to deploy low carbon technologies to the extent and with the urgency called for, skills and capabilities must be developed on the ground. There is a need for translating national objectives translated into local implementation (‘preparedness phase’) and “building supply chain momentum” (Energy Technologies Institute 2015:40). Failing to deliver on this by 2020 “will inevitably lead to higher costs driven by harder pressed resources, along with missed targets and business opportunities” (Energy Technologies Institute 2015:43).

There is no shortage of skilled heating equipment installers in the UK (e.g. builders, plumber and heating engineers). This community is made up of widely dispersed actors but a relatively homogenous trade structure throughout the country. These localised actors are federated through national trade associations such as the Chartered Institute of Plumbing and Heating Engineers (www.ciphe.org.uk), the Association of Plumbing and Heating Contractors (www.aphc.co.uk), the Heating and Hot Water Industry Council (www.centralheating.co.uk), but also more general trade associations such as the Building and Engineering Services Associations (www.b-es.org). The sector is characterised by a substantial proportion of self-employed or small business, with a handful of larger companies operating nationwide (e.g. Pimlico Plumbers). Overall, this industry is characterised by a
high level of inertia and slow rate of change in the skills and practice bases, with an inherent preference for established solutions.

**Individual heat users.** Operating a domestic heating system is a rather seamless process, as daily use requires very little effort (e.g. flicking a switch or relying on thermostat-controlled heating) compared to other socio-technical practices such as driving where user involvement is critical. However, following a similar trend as in electricity or automotive mobility, the main user of heating appliances is usually not autonomous in terms of installation, tuning and maintenance, relying instead on manufacturer and/or fuel supplier servicing. The average user is also relatively non-expert (and hence disempowered) in the technical aspects of heating and cooling, e.g. regarding the question of how to optimise such processes. Current heating habits are thus mainly determined by installation specifications and routines. The increasing relative cost of fuel and the development of detailed billing are somehow changing this pattern, with stronger user involvement. Individual gas consumers are characterised not only by low levels of engagement but also trust and consumer satisfaction with gas suppliers (Ofgem 2014), which is troubling given the importance of this service. With respect to low-carbon technologies, WWF highlights poor market development on both supply and consumption sides:

“Both consumers and installers are unfamiliar with low-carbon heat technologies, and there is little awareness and incentive to install them. Consumers often lack confidence in new and unfamiliar technologies, and the lack of advice available exacerbates this” (2014:11)

**Environmental consumers and awareness.** Individuals adopting or seeking to adopt micro-generation heat technologies tend to be highly dedicated pioneers that are “unafraid to experiment” (Roy et al 2008:5). They are motivated by reduced carbon emissions and savings on fuel bills, have usually prior interest or skills related to the environment, and are clearly not representative of the wider population. Micro-generation policies, besides supporting greater take-up through financial incentives, seek to raise awareness and encourage interest in technologies that are available and promising, but with which consumers are not familiar. The Energy Saving Trust is a major actor in terms of offering advice to consumers.

**Skills and capabilities.** In the UK, given the current infancy of the renewable heat market, there are important barriers to renewable technology adoption, namely in terms of supporting necessary new skills and capabilities. Specifically in heat, the lack of specialised installers (i.e. skilled and accredited) is a foreseeable issue that will slow down change even in the case of significant consumer interest, acceptability and market demand. The Heat Strategy (DECC 2013) seems to consider this aspect, but there is little evidence of progress in the development of a skilled supply side for low-carbon heat. If the decarbonisation of heat is going to materialise in the UK, overcoming the skills and capabilities barriers will be critical (Eyre and Baruah 2015; Energy Technologies Institute 2015). With political commitment to invest in substantial long-term industry build-up, this area could offer great economic prospects.

**Socio-cultural aspects.** The adoption of renewable micro-generation technology also requires an ‘active’ form of social acceptance by individuals “in terms of the willingness to install these technologies in their homes” (Sauter and Watson 2007:2770) to break established institutional logics and inherent resistance to change (e.g. familiarity with gas-fired boiler installation making it a default choice), short-termist cost calculations and business models (Pan and Cooper 2011) that do not take long-term energy cost savings into account, and lack of awareness and information about new technologies and their operation. The Energy Saving Trust seeks to fill this awareness gap by making reliable information available to the public.
4.2.2 Policy

The heat domain, although long overlooked, is increasingly becoming the focus of carbon emission reductions, which is manifest in the recently published Heat Strategy (DECC 2012b, DECC 2013). While gas fares relatively well with respect to environmental performance compared to its historical alternatives (coal, petrol), substantial improvements in the past decades are challenging that position. Low-carbon heat policy can be seen as linked to climate targets and dedicated support to renewable energy technologies.

Climate policy. The 2008 Climate Change Act has set ambitious targets, with legally binding commitments to CO₂ reductions of at least 80% by 2050 (1990 baseline) as well as 5-year carbon budgets (total caps on CO₂ emissions) to gradually meet this target. Each economic sector⁸ is subject to reduction objectives, which are balanced out over the whole economy. The 2009 Low Carbon Transition Plan (HM Government 2009) provided more detailed implementation to reduce CO₂ emission by 34% by 2020, in an effort to achieve substantial decarbonisation but also to build up low-carbon industries, and to increase energy independence.

Support for renewables. Renewable energy technologies, along with demand reduction and efficiency improvements, are seen as the main technological options for the decarbonisation of energy. The UK is committed to obtaining 15% of all its energy from renewable sources by 2020, of which 50% should derive from bioenergy contributions (DECC– DfT–DEFRA 2012). Recognising the need to stimulate their development and uptake, the UK Government has developed a number of frames for their support. Successive energy White papers (2003, 2007) have emphasised carbon reductions potential from local and decentralised energy production. The Micro-generation Strategy (DTI 2006, DECC 2011b) and the Low Carbon Transition Plan (HM Government 2009) introduced targets and support measures for the expansion of renewable energy sources, further elaborated in yearly Renewables Energy Roadmaps in accordance with European ambitions (set out in article 4 of Directive 2009/28/EC). Renewable policy efforts have been wary of providing support to alternative technologies without, however, ‘picking winners’.⁹

Regulations and standards. Under the EU Energy Labelling Directive, labelling requirements have been introduced for the thermal efficiency of buildings and appliances as a means to inform consumers. Boiler standards have been introduced in 2005, making condensing boilers mandatory for all new gas boilers installed in England and Wales. With respect to renewable options, the Microgeneration Certification Scheme (MCS) provides a list of certified suppliers from which homeowners have to choose if they want to be eligible for Government support.

Targeted financial support instruments. In order to address the poor diffusion of low-carbon heat, a number of targeted financial incentives have been put in place. The Low Carbon Building Programme (LCBP) grant, running from 2006 to 2010, provided co-funding for domestic microgeneration technologies and distributed energy projects. Funding was subject to an obligation to use certified technology suppliers and installers. The scheme was criticised, however, for not being generous enough to have any substantial impact. The

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⁸ With the exception of international shipping and aviation.

⁹ “Existing technologies, such as solar thermal and biomass, and others under development, can play a full role in delivering against long-term objectives. Across all the different heating strands, the Government wants to make progress without prescribing the use of specific technologies.” (HM Government 2011:78-9)
Renewable Heat Premium Payments ran from 2011 to 2014 and offered a single payment to assist domestic investors with their purchase of renewable heating technology (solar thermal panels, heat pumps and biomass boilers). The Renewable Heat Incentive (RHI) consists of tariffs introduced in 2011 for non-domestic heating systems based on renewable sources (Biomass boilers, heat pumps, deep geothermal and solar thermal) (DECC 2013). Following a consultation, the Government has extended the RHI to domestic buildings in April 2014.10

Heat Strategy. The development of heat-specific low-carbon policy is a very recent phenomenon in the UK, with strategies for the future of heating being published only in 2012 and in 2013 (DECC 2012b, DECC 2013). This strategic policy framework stakes out major heat challenges and areas of priority focus. In the residential sector, the policy suggests a 3-tier strategy: a) expansion of heat networks in urban areas, b) expansion of renewable heat in remote, off-gas grid areas, and c) heating efficiency improvements throughout the building stock. In the Government’s vision, the early years (up until 2020) shall be spent reaping the low hanging fruits (e.g. energy efficiency improvements) and preparing the market and supply chains for the roll out of renewable heat, initially penetrating over the 2020-40 in an initial hybridisation (with heat pumps) on the way to full electrification (Chaudry et al. 2014).11 The widespread penetration of renewable heat technologies is only expected during the 2020s and 2030s (DECC 2013).

The historic lack of commitment to heat policy in the UK may be changing. However, the current Renewable Heat Incentive (RHI) is a long way away from a stable long-term frame for low-carbon heat, and has been criticised for lacking ambition and commitment.12 When supporting technological niches, there is a clear need for policy stability, especially in terms of incentives as they can provide price and market stability. However, there are concerns that frequent renewable energy policy change in the UK has led to a great deal of instability and the reluctance of customers and investors to commit financial resources in the context of uncertain pay-back times (Williams 2010).


11 It is important to note that for the electrification of heat puts pressure on the development of low-carbon power generation, and cannot be taken for granted.

5 Development in the housing regime in the UK

5.1 Technology and market developments

Housing stock. The British housing stock is relatively mature and poorly insulated, which means that low energy retrofits are crucial to meet carbon reduction targets. Millions of British houses have poorly insulated solid walls, single glazed windows, and other sources of waste heat. The existing building stock is “by far the biggest challenge for housing and energy policy” in the UK (Boardman 2007:41). The overall poor state of housing conditions in the UK is not restricted to energy performance and insulation as an estimated 20% of all English homes does not meet the ‘Decent Homes’ standard, this figure rising to nearly 30% when considering only privately rented homes (DCLG 2015:53-6).

There are over 20 million dwellings in the UK. Around 80% of the current building stock will still be in use by 2050 (Dowson et al. 2012). Despite some improvement over the last decade, most English houses have deceptively low energy performance (Figure 19), with over 80% of dwellings corresponding to Energy Efficiency Rating bands D or lower. The potential market for retrofits is massive, provided there are the right incentives. Retrofitting remains a voluntary measure, however bad a building’s performance, as “there is currently no strategy to ensure a minimum level of efficiency for all occupied dwellings” (Roberts 2008:4485).

![Figure 19: Energy Efficiency Rating (EER) bands across a sample of English dwellings, 1996 to 2012 (Source: English Housing Survey)](image)

Efficiency improvements. To some extent, the current housing regime has adapted to some of the pressures it is facing through the diffusion of basic insulation options and thermal performance improvements (see Figure 20 for an overview of the penetration of different measures). In a European comparative perspective, these improvements are not very impressive. Furthermore, these technology penetration rates do not tell us much about the overall effectiveness of energy efficiency interventions. Indeed, there has been a tendency, explained in part by the structure of financial incentives, to implement partial insulation measures (DECC 2012a) with little attention to the overall insulation of the housing unit, e.g. resulting in houses with well-insulated lofts but draughty windows.
Spontaneous customer demand for energy efficient retrofits in the UK is low due to high upfront costs, little certainty about economic gains and payback periods, technical difficulties and the disruptive nature of refurbishments. The cost-effectiveness of energy-saving retrofit measures varies greatly across measures and from house to house (Shorrock et al. 2005). However, there is some interest, particularly from homeowners, which does have the potential to develop into a healthy market. An estimated 40% of the existing housing stock is considered ‘hard-to-treat’ as they “possess solid walls, no loft space to insulate, no connection to the gas network or are high-rise” (Dowson et al. 2012:296) and can therefore difficultly be retrofitted using conventional techniques. This is an additional barrier for the diffusion of efficiency retrofitting. Energy efficiency improvements could, however, play a major role in future decarbonisation of heat, and are recognised as an integral part of the Heat Strategy, particularly in the earlier decades.
Housing tenure. British homes fall into three main categories: owner-occupied (outright owned and owned with mortgage), private rental, or social rental (local authority or housing association owned), representing 64%, 19% and 17% of English tenure, respectively (Figure 21). Private rental is on the rise since the turn of the century. Social rental has been declining ever since the 1980s’ Right to Buy policy\textsuperscript{13} (DCLG 2015). There is a big difference in average length of residence across tenure type, ranging from 17.1 years for owner-occupied, 11.5 years for social renters, to 3.5 years for private renters (DCLG 2015:25). Similarly, the energy efficiency of homes varies greatly according to tenure type, with privately rented homes ranking poorer on average. Privately rented homes are less likely to benefit from cavity wall insulation, loft insulation, or double glazing (Figure 22).

![Insulation measures in English houses by tenure, 2013 (Source: DCLG 2015:50)](image)

Interestingly, however, this difference does not hold with respect to overall energy efficiency, as social housing tends to have higher EER ratings than privately rented homes, which, in turn, are more efficient than owner-occupied homes (Figure 23). This is in part attributable to the type of dwelling with a higher proportion of flats in (socially and privately) rented tenures, of which a greater proportion of purpose-built in social housing.

\textsuperscript{13} The Right to Buy policy gives eligible people who live in council properties in England the right to buy the home they live in at a large discount.
5.2 **Actors and institutions**

5.2.1 **Main actors and their positioning**

**Construction sector.** In the UK, the appropriate construction skills required for high performance retrofits are rare and the supply of high efficiency standard components is underdeveloped:

“The relatively small scale and short history of the UK retrofit market means that many components and systems need to be sourced from overseas” (Lowe et al. 2012:32)

Furthermore, the immaturity of the supply chain may lead to unnecessary delays, inexperience, mistakes, and cost increases—potentially discouraging a readily small customer base.

The UK construction sector lacks coordination between the different actors involved. The construction process is characterised by “largely separate operations undertaken by individual designers, constructors and suppliers who have no stake in the long term success of the product and no commitment to it” (Egan 2002:13). Energy efficient retrofitting remains a specialised niche with a small number of specialised architecture and engineering firms. While it is possible to find builders and contractors for refurbishments, these are far from standard, come at high expenses, and mistakes are common due to inexperience. Individual components, such as double- or triple-glazed windows or high performance coating, are difficult to get by and often sourced abroad.

There is a need for skills and supply chain improvements in the building industry. This involves measures such as improved training, professionalisation, and greater standard requirements. Programmes stimulating demand could also be crucial to support the development of a low-carbon refurbishments industry. A number of organisations promote the development of low-energy skills in the building sector. The UK Green Buildings Council, for instance, is a not-for-profit organisation aiming to “facilitate dialogue between industry and Government to promote greener approaches in the construction sector”\(^\text{14}\), hence

\(^{14}\) [www.ukgbc.org](http://www.ukgbc.org)
lobbying for the government to make energy efficiency in buildings an infrastructure priority. There are a number of information sources about low-emission retrofitting standards and practice, such as the Energy Saving Trust.

**Individual homeowners and tenants.** Section 5.1 has evoked structural reasons for performance disparities in housing, related to characteristics of the building stock and housing tenure. There is a certain degree of inertia attributable to building owners as “there are numerous, cost-effective measures that could be installed in many, if not most, houses, but the building owners are not putting them in” (Boardman 2007:41). Furthermore, until recently, energy efficiency improvements have been by-and-large the initiative of building owners with only limited government support. Exceptions include financial measures to tackle fuel poverty, limited incentives within the LCBP, and more recently the Green Deal. Of all types of occupancy, private tenancies (nearly 20% of the UK housing stock) tend to offer the least motives for efficiency refurbishments due to the principal-agent problem (it is the tenant, not the landlord, who would reap the benefits of investment), and the market structure, which does not value energy performance.

On the other hand, there is also evidence of the emergence of ‘greener’ homeowners that engage with lower carbon construction or refurbishment, aware of the environmental benefits, the potential financial savings from energy efficiency improvements, and the different kinds of financial incentives that can be sought. Energy efficient refurbishing is a growing market, though nowhere as dynamic as the Heat Strategy would require it to be.

5.2.2 Policy

**EU policy developments.** There are two main pieces of EU regulation that are relevant for the thermal performance and efficiency of buildings: 1) the Energy Performance of Buildings Directive (EPBD), and 2) the Energy End-Use Efficiency and Energy Services Directive (ESD) (Ekins and Lees 2008). The EPBD is mainly targeted at the application of minimum standards and certification of buildings, namely around the Energy Performance Certificate for sale and rental transactions. The ESD relates to the encouragement of “energy efficiency through the development of a market for energy services and the delivery of energy efficiency programs and measures to end-users” (Ekins and Lees 2008:4582), which in practice means implementing measures such as energy auditing, energy metering, and the development of energy efficiency funds.

**Regulations and standards.** Under the EU Energy Labelling Directive, labelling requirements have been introduced for the thermal efficiency of buildings and appliances as a means to provide information to inform consumer choice. Energy Performance Certificates (EPC) have been introduced in the UK in 2007, and rate a building’s performance via and Energy Efficiency Rating (EER) from G to A++. Eyre (2010) suggests that energy efficiency regulations in the UK have been successful in focusing and structuring improvements in specific product markets (appliances, insulation, etc.) but less so in the main trades involved (e.g. construction, builders, etc.). Regulations in the building sector (e.g. constraints on alterations that can be done on listed buildings) can also be seen as a major barrier to efficiency improvements, further contributing to inertia in the building stock:

> “An important factor that impedes reduction in emissions from some buildings can be planning constraints” (Royal Academy of Engineering 2012:10)

**Targeted financial support instruments.** The Low Carbon Building Programme (LCBP) grant, running from 2006 to 2010, counts as one of the early financial incentives supporting
home energy efficiency refurbishments. In terms of energy efficiency, recent policy momentum has been generated around the Green Deal (which is a system of loans mostly relevant for whole house retrofit and efficiency improvements through insulation):

“The Green Deal is the Government’s flagship energy efficiency policy, designed to overcome barriers to improving the UK’s building stock. The framework, launching in 2012, will mean that households and businesses will have the opportunity to improve their energy efficiency at no upfront or additional cost, paying back through future savings on their energy bills.” (HM Government 2011:36)

Introduced in January 2013, the Green Deal was intended as a broad programme to encourage energy efficient home improvements across the country, offering loans for refurbishments loans with the opportunity to pay them back through savings on bills. Following energy efficiency assessments, and eligibility checks, funding is made available via the Green Deal Home Improvement Fund. The policy scheme has been heavily criticised and received far less interest than expected in its first years. Core criticisms include the unfair nature of the scheme benefitting only well-off middle-class homeowners, the high interest rates and penalties it introduces, the uneven quality of assessments, and the fact that the company managing certification is owned by the Big Six, hence reproducing existing power structures in the energy sector.
6 Conclusions: stability and tensions

We here provide conclusions by reviewing the extent of lock-in and tensions of the current regime. These are summarised in two tables for the heating and the housing regime, respectively, although many overlaps exist.

6.1 Domestic (individual gas-fired) heating regime

The heating regime is fairly stable in particular due to strong infrastructural lock-in (gas grid / housing stock), the concentration of powerful actors on the supply side, the captivity and relative lack of awareness on the demand side (consumers), and a tendency for business as usual in the equipment installation and maintenance trade. However, this stability does not seem to be strongly related to active resistance strategies, which is hopeful for future change.

There are major tensions ahead for the heating regime, potentially developing towards a high degree of alignment (energy security and price stability, climate concerns, emergence of credible alternatives elsewhere). The current heating arrangement, relying on an increasing proportion of imported gas is seen as unsustainable in the long run. There are some signs of willingness to make strategic decisions and commitments on the policy side (although the credibility and durability of such discourse remains questionable). There are however substantial sources of uncertainty regarding current ambitions to stimulate a transformation in this domain.

### Stability and tensions in UK heat regime

<table>
<thead>
<tr>
<th>Lock-in, stabilising forces</th>
<th>Cracks, tensions, problems</th>
</tr>
</thead>
</table>
| **External landscape pressures** | Low cultural significance of ‘heat’  
Low policy salience of ‘heat’  
Financial crisis  
Neoliberal ideology and policy | Climate change and awareness of sustainability matters  
Gas and energy prices (related to resource availability and geopolitical change)  
Self-sufficiency and energy independence agenda  
Fuel poverty |
| **Heating equipment supply** | STRONG/MODERATE  
Gas boiler efficiency improvements over the years (incremental change)  
Gas assumes dominant market position  
No strong alternative in UK context  
Industry characterised by slow rate of change in skills and practice bases with preference for established solutions | WEAK/MODERATE  
Plans to rapidly phase out of existing gas boiler by 2030 (Heat strategy) (are these credible?)  
Many leadership and best practice examples in different European countries. Awareness of UK as laggard in comparative perspective |
| **Gas supply and distribution infrastructure** | STRONG  
Strong infrastructural lock-in (sunk costs, etc.), well functioning network. Competitive advantage from past network investments.  
Organisational linkages with electricity supply | MODERATE  
Rising price of gas is major concern  
Opening to competition beyond Big Six (though weak)  
Gas supply under increasing criticism and |
### Building regime

While the table in 6.1. aims to focus on characteristics of the heating regime, the majority of listed points do account also for the following table on the building regime. This is due to the highly interconnected nature of these regimes as was underlined throughout this report. In particular, the overall assessment is largely congruent.

<table>
<thead>
<tr>
<th>Users /consumers</th>
<th>STRONG/MODERATE</th>
<th>WEAK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumers do not actively pursue heat-related choices. Individual users do not interact much with this kind of technology. Heating equipment purchases are often not planned but follow from breakdown. Awareness and interest about different heating and energy efficiency options are relatively low.</td>
<td>Gas prices lead to greater interest in more efficient options Low levels of engagement, trust and consumer satisfaction with gas suppliers Increasing sources of information about heating alternatives for interested consumers (e.g. Energy Saving Trust)</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Policy-makers</th>
<th>MODERATE</th>
<th>POTENTIALLY STRONG (but uncertain)</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘Unknown territory’ for policy, as low-carbon heat has only recently been put on the agenda. History of support for micro-generation measures, but highly criticised in their effectiveness and scope Historic instability of energy policy in the UK not conducive to long-term financial commitments (of consumers and investors)</td>
<td>New phase of low-carbon heat policy programme (Heat Strategy): - ambitious technological rollout vision (mainly energy efficiency and electrification via heat pumps) - specific instruments that follow from that (Renewable Heat Incentive) but how effective and realistic is this? Difficult to distinguish symbolic discourse from substantial action at this early stage</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Public debate and opinion</th>
<th>MODERATE/STRONG</th>
<th>MODERATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas framed as relatively clean heating option (compared to coal and oil) Lack of salience of heating as issue not conducive to change</td>
<td>Potential alignment of climate change, energy price and security concerns in favour of destabilisation</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pressure from social movements, NGOs, scientists</th>
<th>MODERATE</th>
<th>MODERATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low cultural visibility and salience of heat makes social mobilisation difficult.</td>
<td>NGOs and energy researchers have contributed to put Low-carbon Heat on the policy map (e.g. Green Alliance 2007). NGOs and scientists critically evaluate policy progress to date as relatively poor, and roadmaps ahead (high uncertainties) but with little leverage.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Overall assessment</th>
<th>MODERATE/STRONG</th>
<th>MODERATE</th>
</tr>
</thead>
</table>

6.2 Building regime

While the table in 6.1. aims to focus on characteristics of the heating regime, the majority of listed points do account also for the following table on the building regime. This is due to the highly interconnected nature of these regimes as was underlined throughout this report. In particular, the overall assessment is largely congruent.
The building regime in the UK is characterised by strong inertia, which is predominantly related to infrastructural elements such as the housing stock, but is also translated in low consumer interest, and unpreparedness of the construction sector. The sources of inertia are mainly structural, rather than the fruit of active resistance strategies.

The scope for change in terms of crack and tensions is currently relatively low, and unlikely to counterbalance the current stability. A number of early changes in social mobilisation, awareness raising with respect to energy efficiency, and the development of the Heat Strategy are however signs that the current situation could be changing.

### Stability and tensions in UK building regime

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<tr>
<td></td>
<td>Fuel poverty</td>
</tr>
<tr>
<td>Construction sector</td>
<td>Development of specialised companies catering for a niche market of high efficiency retrofits.</td>
</tr>
<tr>
<td></td>
<td>Emerging markets elsewhere in Europe, developing supply chains, skills, markets.</td>
</tr>
<tr>
<td>Housing stock</td>
<td>WEAK</td>
</tr>
<tr>
<td></td>
<td>The energy performance of newly built houses has much improved, but replacement rates are low.</td>
</tr>
<tr>
<td>Users/consumers</td>
<td>WEAK</td>
</tr>
<tr>
<td></td>
<td>Rising gas prices lead to greater interest in efficiency matters</td>
</tr>
<tr>
<td></td>
<td>Increasing interest among house owners to retrofit but not in private tenancies due to principal-agent problem</td>
</tr>
<tr>
<td></td>
<td>Emergence of ‘greener’ homeowners</td>
</tr>
<tr>
<td></td>
<td>Energy efficient refurbishing increasingly recognised as growing market</td>
</tr>
<tr>
<td></td>
<td>Increasing sources of information for interested consumers (e.g. Energy Saving Trust)</td>
</tr>
<tr>
<td>Policy-makers</td>
<td>MODERATE</td>
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<tr>
<td>---------------</td>
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<td>‘Unknown territory’ for policy, as low-carbon heat has only recently been put on the agenda.</td>
<td>New phase of low-carbon heat policy programme (Heat Strategy):</td>
</tr>
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<td>Energy efficiency improvements have largely been instigated by home owners with only limited government support</td>
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</tr>
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<tr>
<td>NGOs and energy researchers have contributed to put Low-carbon Heat on the policy map (e.g. Green Alliance 2007).</td>
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7 Conclusion

The importance of implementing large-scale changes in the heat regime is progressively being recognised. The UK has recently shown ambitious commitments for a transition to a low-carbon heat regime, including an anticipated full decarbonisation of residential heat by 2050. There are however a number of challenges and barriers for reaching its goals. An inefficient and slow moving building stock and a generally poor track record with low carbon heat are two challenges to be named. Nevertheless, if these commitments are taken seriously and hence the necessary steps implemented sincerely (e.g. effective roll-out of efficiency measures, a virtual replacement of all gas boilers with heat pumps, and support for District Heating (DH)), vast opportunities can open up for the development of a sustainable heat industry. However, a history of ‘changing moods’ in UK energy policy and the failure to guarantee long-term stable conditions for low carbon solutions raises further doubts as to the feasibility of the current ambitious strategic objectives for heat.
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