



People, Demand and Governance in Future Energy Systems

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Abstract:

The energy system within Great Britain has to decarbonise whilst maintaining security and affordability, and this requires coordinated action across the whole energy system. The energy system is already undergoing fundamental change due to a wide range of technological, social and economic drivers, and there is some consensus that direction of travel is towards decentralisation and the demand side. These changes are much closer to people and there is a need to recognise, and value, the central role that they play within the energy system, not only in terms of creating demand, but also in terms of adopting technologies, changing behaviour and accepting change in the places that they live and work. This paper explores these issues by taking a high level overview of the energy system and the pressures it faces and by examining how systems are beginning to change and how they might change. This leads to a number of key findings including the need to put end users at the centre of the energy system to enable engagement, gain meaningful consent and to build legitimacy and trust. In addition, the central role that governance plays in enabling this to happen is highlighted, along with its importance for facilitating a coordinated approach to a demand focussed, future energy system. This requires a new fit for purpose governance framework.

Keywords: Governance, people, end users, demand side, demand reduction; demand side response; distributed energy resources; energy transformations; consent; trust.

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1. Introduction

This paper examines the governance of the GB energy system in terms of the role of end users within it, focussing in particular on the domestic sector and the demand side (D3¹). It is one of a series of IGov working papers that considers the governance of the energy system, which includes the rules, regulations and institutions that are in place and specifically how these enable or hinder a move towards a more sustainable, demand focussed energy system. The other papers examine electricity and heat networks (Lockwood 2014) and energy suppliers (Kuzemko 2015).

The focus on the demand side within IGov reflects the integral role that it plays in shaping the design and operation of the energy system and importantly the wide range of benefits that a focus on the demand side could bring to the creation of a more sustainable energy system. To better understand these issues, Section 2 provides a high level overview of the energy system and the pressures it faces in terms of decarbonisation, energy security, and affordability.

How the energy system might change is discussed in Section 3. This includes a discussion on some of the uncertainties that exist around system change and the role of models and scenarios in considering change. The current issues with the relationship between supply and demand are also examined and the importance of shifting the focus towards the demand side are set out. This is then explored in more detail in relation to D3 (demand reduction, demand side response, and distributed energy resources). A range of other measures are also discussed in more detail, including energy storage and interconnection, and smart meters and collectively how these and wider D3 options might sit within the energy system of the future.

Section 4 goes on to explore the relationships between energy demand, people and energy governance. It makes the point that system change is not just about technical change, but also how central people are expected to become, given that many of the changes are closer to the demand side and people. A discussion on how end users drive energy demand and how the system has been designed to just meet this, leads into a detailed summary on the importance of engagement. This reflects the way that people are currently narrowly viewed as just consumers of energy, how this has resulted in a mainly passive role and how this narrow view has also in part led to a growing mistrust of the energy industry by end users. This leads into a discussion on the growing need to gain meaningful public consent for how the energy system now evolves. The section ends with an overview of the importance of governance in relation to the above issues and for system change more widely.

¹ D3 includes: Demand Reduction; Demand Side Response; and Distributed Energy Resources

Section 5 takes a step back to shed some light on energy consumption within the UK. Firstly looking at total primary and final energy demand at the national level, including long term trends in demand and the fuel mix. The section then goes on to consider final energy demand across the four main consuming sectors, i.e. domestic, industrial, commercial and transport, and some meter point data which provides further insights on the level of demand between sectors, based on volume sales of electricity and gas (for GB). A detailed summary of the domestic sector is then provided to show the complexity in understanding demand trends and some of their drivers. This includes a high level overview of the sector, historic trends in final energy demand and the fuel mix. It then looks at demand in terms of end use and the fuel mix. Consideration is also given to what drives demand in the domestic sector, in terms of energy services and the technologies and controls associated with them. The section ends by considering people's behaviour and the central role that this has in determining energy demand.

Within Section 6 a high level overview of the policies for a demand focused system are provided, including how external and internal factors have shaped policy decisions. A summary of the policy landscape for D3 is provided along with a discussion of some of the problems that exist within this, such as coordination, cost-effectiveness, policy overlap, etc. Some of the more recently institutional and policy changes within energy and demand policy are then set out, across demand reduction, demand side response and distributed energy. The links back to, and importance of, governance are set out in the final section.

Section 7 brings together much of the above discussion to consider in detail the importance of people and governance in future energy systems and provides some conclusions. This comes back to how systems are changing and some of the emerging consensus that exists from a range of organisations for the direction of transformation. The discussion then focusses on the reasons for, and ways of, looking at people's role within the energy system, reflecting on how New York and Australia are doing this. The importance of this in terms of engagement, trust, consent and system optimisation are set out. The central role of governance in all of this is then highlighted, in terms of the issues that currently exist and the IGov solutions to them. This includes a set of six high level principles and a proposed framework for institutional change that would help to create a more people and demand side focussed energy system that is low in carbon, secure and affordable.

A few key points about this working paper:

- The IGov project is interested in what is happening within Great Britain (GB) in respect to energy system governance. However, national statistics for demand are based for the most part on the UK as a whole; therefore this working paper mainly considers demand at the UK level.
- Technically, consumption and demand are not the same thing, but they are used fairly interchangeably throughout this paper, when used I am referring to the overall level of final energy demand.
- The main focus of this paper is on electricity and gas (heat), with little focus on transport, although the importance of taking a whole system approach cannot be overstated.
- This working paper provides some detail into the nature of demand within the domestic sector, to primarily show the complexity behind energy demand. To really understand energy demand and its implications and opportunities for the future energy system, it would be beneficial for deeper analysis of demand in others sectors to also be completed.
- People have multiple roles within the energy system, and some of these take place simultaneously; this can include people as: end users of energy as consumers or customers; citizens and voters, which have wider and important implications for energy policy in GB; and as practitioners individually or collectively. These differing roles can be influenced by how people relate to each other, to work, to companies, to government and wider society. An issue is that these differing roles are often used interchangeably within reports, or very narrowly e.g. people are just seen as consumers. This paper doesn't seek to address these issues, instead it takes the view that end users and/or people best describes the multiple roles that exist.

2. The Energy System and the Pressures it faces

Energy underpins nearly all human activity and ultimately the purpose of an energy system is to meet the demand for energy services such as mobility, warmth, light, etc. which satisfy human needs (Willis 2011, Grubler, Johansson et al. 2012, Eyre 2014). It is these energy services that customers are interested in and which need to be provided, regardless of how energy systems change in the future.

As a starting point, this paper takes a high level, simplified view of what an energy system is – Figure 1. Within this it can be seen that an energy system encompasses the entire process of production, conversion and the use of energy via the numerous, complex, and interconnected supply chains that make up the system (Hoggett 2013). In reality, an energy system is a system of systems which creates complexity and means that changes to one part of the system can easily impact other areas of the system. As energy moves through this system it is converted from one form to another in a one way flow, from high grade resources, such as fossil fuels, through to lower grades such as dissipated heat (Grubler, Johansson et al. 2012). As such there are losses along the whole system. Whilst interconnected, energy systems are often described and considered in respect to the supply side which encompasses all of those processes by which primary and secondary energy are provided and delivered via energy networks; and the demand side where that energy is used, to provide the energy services that people desire.

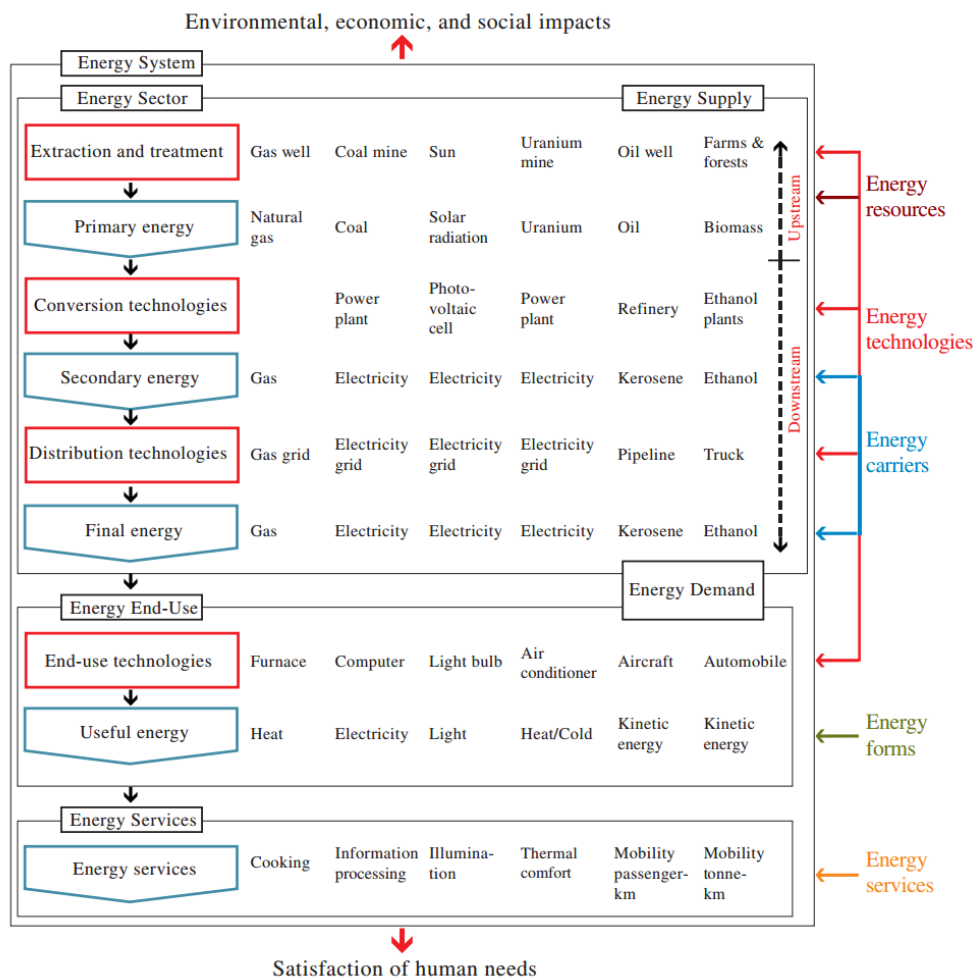


Figure 1: An Energy System
Source: (Grubler, Johansson et al. 2012): 43

Within the UK, this energy system is centralised, with electricity mainly provided by large generation plants connected to end users via electricity networks; heat provision based on centrally distributed gas; and transport enabled by a few large central depots (Hunt 2013). This system emerged from a more decentralised model in which demand was met by small and localised public and private providers (Roelich 2014). This shift towards a centralised model began in the 1920s, driven by a desire to seek economies of scale and to develop a national grid, it was nationalised by the mid-20th Century (Energy 2014, Roelich 2014). A high level overview of the system that has emerged for electricity and gas is shown in Figure 2 and 3² below. For all intents and purposes these systems are designed around the one way flow of energy from generation/supply through to consumption.

² This figure was kindly provided by SGN Ltd, so where it states they are the owner of the high, intermediate and medium/low pressure systems that is only the case for the distributed network areas they own, there are 8 distribution networks in the British Isles owned by 5 companies – see ENA for more info: <http://www.energynetworks.org/info/faqs/gas-distribution-map.html>. In addition LNG shipments can also feed into this network, but are not included within the figure.

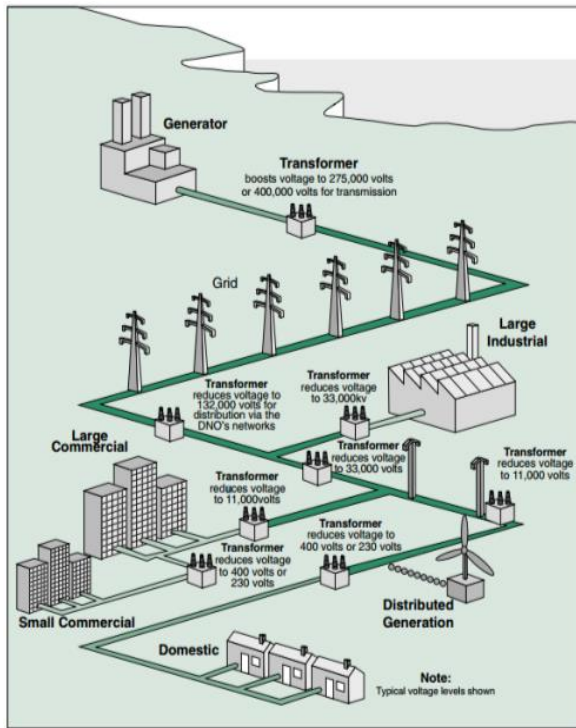


Figure 2: Overview of electricity system
Source: (HCECCC 2010): 6

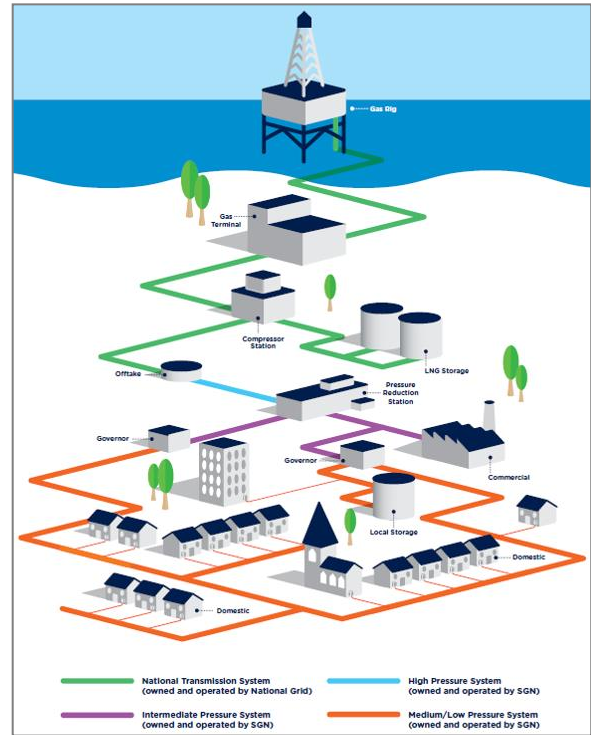


Figure 3: Overview of gas system
Source: Scotia Gas Networks Ltd (04958135)

In the post war years the focus was to maximise energy output to support economic growth and produce as much energy domestically as possible to keep pace with the growth in demand; this was a period of asset creation (Helm 2004). As Helm highlights, this process was enabled through the construction of coal power stations, nuclear power and from the discovery and exploitation of domestic oil and gas reserves. The system design and underlying philosophy remained largely in place under the late 1980s when, under a new conservative government, a new approach based on privatisation, liberalisation, and competition was introduced (Helm 2007). Enabled in part through falling energy prices, a central part of the thinking at the time was that energy was just a commodity that should be left to markets, because they would be more efficient at allocating costs and setting prices (Lawson 1992 , Rutledge 2010, Kuzemko 2015). The energy system thus moved from the State into the private sector and what followed was a separation of generation and supply, the liberalisation of gas and electricity retail markets, along with the privatisation of transmission and distribution networks, which became regulated monopolies (Lockwood 2014, Roelich 2014).

This is the system that largely remains in place today, although there has been significant restructuring within the industry since the process began (Lockwood 2014, Kuzemko 2015). It has also resulted in a framework in which the private sector now plays a pivotal role in UK

energy policy and it is within this world that the government now has to work in to deliver their strategic goals (Skea, Ekins et al. 2011).

Throughout the developments described above there have been multiple co-evolving innovations - socially, politically, institutionally and technically (Pearson and Foxon 2012). This includes a growth in the number and range of actors with a role in the system, right along the supply chain, and the way in which they interact with each other and the system; and the wider institutional and political structures that govern the system (Lockwood, Kuzemko et al. 2013, Bale, Varga et al. 2015). The combination of all these factors have led to an energy system which is mature, highly interconnected and complex, making it prone to inertia and lock-in (Unruh 2000, Unruh 2002). Whilst the system that emerged has been effective in meeting the demand for energy services, for a number of reasons, it is becoming outdated and is facing a range of pressures (Lockwood 2014, Roelich 2014, Mitchell C. 2016).

In part these pressures reflect the unwanted environment, social and economic by-products that the energy system has (Grubler, Johansson et al. 2012), most of which are framed in respect to the energy trilemma, namely: reducing greenhouse gas emissions from the use of fossil fuels; ensuring that the system is secure; and trying to keep costs for consumers and the economy as a whole, affordable. To address these, the UK has developed a range of policies, although balancing the trilemma is challenging because the three areas are often in tension (Eyre 2014). In addition, it is apparent that at different times the relative political weight placed on these differing objectives changes (Kuzemko 2015).

2.1 Decarbonisation

Energy systems are both the primary cause of climate change and a primary means for its mitigation (Scarse and Ockwell 2009), and this is an issue for the UK as the current system is heavily reliant on fossil fuels, they provided around 82% of the UK's energy consumption in 2015 (DBEIS 2016). In order to be decarbonised the current energy system needs to undergo rapid change (RCUK 2010, HMG 2011) requiring action along the whole energy supply chain, including the rapid and effective deployment of existing and new technologies, and changes to the wider non-technical social, economic and political frameworks that shape the governance of the system (Foxon and Pearson 2008, Foxon, Hammond et al. 2010).

In respect to decarbonisation, the UK has a legally-binding target to reduce the UK's carbon emissions by 80% by 2050 (from 1990 levels) a target consistent with limiting global temperature rise to as little as possible above 2°C (CCC 2015). This target is set out with the 2008 Climate Change Act (HMG 2008), which also established the independent Committee on

Climate Change (CCC) to advise the UK Government and Devolved Administrations and report to Parliament on progress made in reducing greenhouse gas emissions. The Act also introduced a system of five-yearly carbon budgets, to serve as stepping stones to the 2050 target. Currently the UK is in the second carbon budget period (2013-17), but the first five carbon budgets leading to 2032 are already set in law. To meet the targets, action is required across the whole economy, including the energy sector, buildings, industry, etc. In the latest progress report to parliament, the CCC highlight how the UK is currently on track to outperform the first two carbon budgets, but also highlight this is largely due the impact of the recession and that the underlying rate of emissions reduction from low-carbon measures was less than 1% in 2011 and this needs to be nearer 3% a year to meet future carbon budgets, requiring progress to speed up across the whole economy (CCC 2015).

2.2 Energy Security

At the same time as decarbonising the system, the economic and social importance of energy also means that energy security is a key concern (Scarse and Ockwell 2009, Kuzemko 2013). This is often described in respect to ensuring the uninterrupted provision of vital energy services (Cherp, Adenikinju et al. 2012), although in reality it is far more complex (C. Mitchell 2013). Unlike decarbonisation, the need to ensure security is enshrined in the various licenses and codes that govern the energy system (Lockwood 2014, Kuzemko 2015, Lockwood 2015). Whilst it is recognised that no energy system can be completely secure (Ekins, Skea et al. 2011) the importance of energy security led to the system being gold plated in respect to capacity margins, network infrastructure, etc (Soutar 2013); although from the 1990s the priority became to drive down costs and as such the existing assets were 'sweated' (Helm 2003, Skea 2011). The situation has now changed, to the point where there is a need for substantial reinvestment within the system (Bolton and Hawes 2013) and there are direct interventions from government into the market to ensure security, such as the development of a capacity market in the electricity sector (DECC 2014), however questionable this is (Mitchell 2014).

2.3 Affordability

The third part of the trilemma is concerned with affordability, a term with a wide range of potential meanings and timescales (Black 2014), but generally encompassing the cost of energy for consumers and the economy as a whole (Eyre 2014). There are a large number of interrelated factors that impact affordability, such as: policy costs introduced to address the trilemma; commodity prices in the global energy markets; global shifts in the centres of supply and demand; the cost of maintaining existing and developing new infrastructure; the cost of

capital for investment; the efficiency by which energy service needs are met; issues such as the age and type of building stock, etc (Willis 2011, Energy 2014, Lockwood 2014, Kuzemko 2015).

This all makes straightforward assumptions about how best to achieve an affordable, secure and low carbon energy transformation, difficult; and whilst the issues are interconnected, the main framing of affordability tends to be on infrastructure investment costs and the price of consumers' energy bills.

2.3.1 Infrastructure

In respect to infrastructure, the level of investment that might be needed over the coming decades is significant, for example Ofgem's Project Discovery suggested that up to £200 billion would be required between 2010 and 2020 to secure energy supplies and meet Britain's climate change targets (Ofgem 2010). The Government's own assessment suggests that between 2014 and 2020, up to £100 billion could be needed in the electricity system alone (DECC 2014). More recently the Energy and Climate Change Committee have suggested that £110 billion will be needed by 2030 (ECCC 2015). Regardless of the exact figure, this is a major challenge for government as they need to create sufficient confidence for the industry to invest, whilst keeping the costs on customers' bills manageable (ECCC 2015). It should however be noted that many of the estimates on infrastructure needs are based on an assumption that demand will continue to rise, which is not necessarily a correct assumption anymore – see section 2.3. In addition, the creation of a smarter, more flexible system (section 2.2.2) would help to reduce the need for network reinforcement and its associated costs.

2.3.2 Bills

This has direct links to the second concern, namely the rising cost of energy bills, which often dominates affordability debates. After a long period of falling energy prices, over the last decade there were significant increases in the prices of gas and electricity for the domestic, commercial and industrial sectors (CCC 2012, Bolton 2014, DECC 2014, DECC 2015). For example, in the case of domestic bills, between 2004 to 2014 electricity prices increased by around 75%, whilst gas prices rose by 125% (in real terms), far outstripping rises in inflation (CMA 2015). These price increases were mainly attributed to changes in the global demand for energy, which impact commodity prices that the UK has become more exposed to (Energy 2014, Holmes 2015); with additional costs relating to social and environmental costs, operating costs, higher supplier margins and rising network costs (Dempsey 2016), also adding to the cost of bills. Ofgem suggest that social/env costs and network costs will account for around 7% and 23% respectively in a typical domestic dual fuel bill over the next year (Ofgem 2015).

The pressure on prices is expected to grow in the future (CMA 2015) and one of the issues highlighted by the CMA from these rising prices has been a perception from the public that

energy company profits are too high, and this has played a role in a growing lack of trust in the industry. One impact of rising energy bills, particularly during a time of austerity, has been the cost of energy becoming a major source of public concern; which has also led to considerable media attention and increased political debate, given that customers are also voters. Part of this concern is because although there have been some price cuts over the past years, they tend to be smaller than price rises (Dempsey 2016). The initial political response was to weaken many of the policies relating to social and environmental measures (DECC 2014) despite the relatively minor impact they have on bills, with numerous cuts to many low carbon policies since the re-election of the Conservative government in 2015 (C 2015). There have also been political and media calls for the big 6 energy suppliers to cut their costs with falling wholesale energy prices, particularly in 2016.

2.3.3 Competition and fuel poverty

Two of the concerns over the cost of energy bills is the potential impact this can have economically and socially. Part of this concern is directed towards the competitiveness for the industrial and energy intensive sectors within international markets and how cost could impact them if they are competing in markets that face lower energy costs and obligations (Eyre 2014). Although, analysis by the CCC (CCC 2012), suggests that in terms of competitiveness for energy-intensive and internationally traded sectors, the risks are concentrated in sectors accounting for a very small part of overall GDP and that the risks could be offset through appropriate government policies. In addition, there is also evidence to suggest that the costs of environmental regulations has a negligible impact on competitiveness compared to broader market conditions (Dechezleprêtre 2014).

In respect to social concerns, rising energy costs can impact the levels of fuel poverty, which for a long time was defined in respect to those households that need to spend more than 10% of their income on maintaining an adequate level of heating³. A new methodology was adopted for England in 2013⁴ – see (Hills 2012). Although fuel poverty is driven by a range of issues beyond the cost of energy bills⁵ (Preston 2014) the last time figures were released for the whole of the UK, it was suggested that 4.5 million or 17% of the UK's households were in fuel poverty (DECC 2014). Policy support to try and reduce fuel poverty to a large extent has been funded through long running supplier obligations with the costs passed through on consumer bills. Although there is a lack of transparency about exactly how costs are passed back to consumers, these

³ This definition is still in use in the devolved governments in Scotland, Wales and Northern Ireland

⁴ A household is said to be in fuel poverty if the cost of keeping their home at a reasonable temperature is above the national median level, and if they were to spend that amount they would be left with a residual income below the official poverty line. This is known as the 'Low Income, High Costs' (LIHC) definition (Dempsey, 2016)

⁵ It should be noted under the LIHC definition, prices do not have a substantial effect on the number of households defined as fuel poor because the measure is relative so price changes that have a similar effect on all households do not cause the number of households defined as fuel poor to increase (Dempsey, 2016).

social obligations (along with environmental obligations within energy bills) have been shown to have disproportional distributional impacts on lower income households (Preston 2014). A more progressive approach would be to fund more of these measures designed to help the fuel poor through general taxation, rather than energy bills (HCECCC 2013). They should also be better targeted at those that need them most.

It should also be noted that some of the social and environmental policies that add costs to bills, also offer direct benefits to customers to reduce their energy bills. Also in respect to policy costs, there is analysis from government and the CCC to suggest that many of these will have a limited impact on future energy bills, given that energy prices are expected to rise (CCC 2012, DECC 2013). There are also a range of scenarios to suggest that the most likely factor in determining average fuels bills in the future will be network and wholesale energy costs (Croft 2014). That said the latest analysis on the impact of meeting the carbon budgets from the CCC does suggest that for some energy customers like the fuel poor and energy-intensive industries that government support may be needed to help reduce some of the price impacts of policy costs (CCC 2014).

Some of these issues will be returned to in Section 5 when energy policies for the demand side are considered in more detail. What is apparent from the above summary is that whilst the evolution of the energy system has allowed our economy and society to prosper through access to secure and relatively affordable energy, there are growing pressures on the current system that are difficult to reconcile. This includes how best to maintain a secure system, how to attract investment and keep energy prices affordable for customers whilst also rapidly decarbonising the system in order to tackle the growing impacts of climate change. There is no straightforward solution to this and it is an area that is subject to a wide range of debate, scenarios, modelling and analysis, from many different stakeholders. The next section goes on to consider these issues in more detail.

3. How might Energy Systems Change?

Nobody can say with any certainty how energy systems will change; for example, Ofgem recently quoted the Florence School of Regulation's summary of changes within the power system, these they said *"...will keep changing and evolving throughout the coming decade. Nothing that we know from the past might be taken as granted. Technologies, system and market parties' behaviours and strategies, hence business models, will come to change and surprise us"* (Crouch 2016). As Ofgem described, energy systems have their own momentum and within the UK they suggest *'change is fundamental and accelerating'* because of a range of different drivers, including: technology; behaviour; policy and incentives; and new business models. Furthermore, there is an ongoing blurring of boundaries between the electricity and gas system and new interactions between heat, transport and financial services, such as:

- demand and supply ("prosumers", storage, responsive demand);
- transmission and distribution and off-grid;
- controls, aggregation, disaggregation, internet of things (Crouch 2016:4).

There are also other important factors that influence the rate and the type of system change. As highlighted above, energy systems are large and complex with considerable inertia and path dependency, reflecting the interconnected webs of technical, institutional and social components (Pearson and Foxon 2012) that exist. This means that changing one part of the system will have consequences elsewhere within that system (Eyre 2014), be that in terms of system design and operation, technology choice, etc (Mitchell 2014). In addition, these properties of the system often lead to a suggestion that transitions can take decades or centuries to come about, although there are examples within energy that show this is not always the case, albeit most of these have been driven by a crisis (Sovacool 2016).

There are also many competing visions for energy system change and this can vary within a country as well as between countries, reflecting: different interests and lobbies; differing political ideologies; wider underlying cultural and historical factors; local resource availability; and international relations (Eyre 2014). This section provides a high level summary of some of the models and scenarios that exist, sets out some of the IGov thinking about future energy systems and then considers in more detail the relationship between supply and demand and the options that might exist for developing a more demand focussed system.

3.1 Models and Scenarios

Some insights into how energy systems could change are available through the plethora of modelling and scenarios that exist, from academia, large fossil fuel multi-nationals, the IEA, government and wider actors like the CCC and National Grid. They show a huge range of possible outcomes, rather than provide simple or clear answers (Evans 2014). A recent review across models by UKERC shows that because different assumptions are taken on a range of variables such as, cost, technology development etc, it can be hard to draw robust conclusions about system change (Ekins 2013). However, their analysis makes clear that the various models do unanimously show that technologies to meet the challenge exist and that these will be much cheaper than dealing with the consequences of climate change.

The UKERC analysis (Ekins 2013) also highlights that because many different variables are used in differing models and scenarios, that when there is some consistency in the possible pathways that they produce, more confidence about potential system change can be assumed. Some examples of these sorts of consistencies include, amongst other things: the need for greatly increased energy efficiency and conservation in all sectors; a need to decarbonise electricity supply by at least 80% by 2030 (although uncertainty over which technology can optimally provide low carbon electricity); at least some electrification of heat, power and transport; and a likely demise of internal combustion engines in transport (Ekins 2013); similar findings have also be found by others (CCC 2010, HMG 2011, Skea, Ekins et al. 2011).

Although there are some areas of agreement, the optimal way to achieve a secure, affordable, low carbon transformation is not straightforward and is uncertain and contested, with contrasting energy priorities often articulated by different sectors (Watson 2014). Some of this disagreement, at least in part, is a reflection of the biases and interests of different actors that develop scenarios (Evans 2014). This often comes back to who the winners or losers might be in a system transformation, especially for energy systems like the UK's, where there is resistance from incumbent actors that have sunk investments in the existing infrastructure and the current way of doing things (Scrase 2009, Mitchell 2014).

To deal with some of the uncertainties and issues highlighted above, it is generally accepted that, as far as practicable, options need to be kept open, based on social, political and organisational priority setting (Ekins, Skea et al. 2011). Also that policies should seek to stimulate innovation and technological change in a desired direction of transformation, whilst ensuring that they meet the broad aims of the trilemma and that this all requires a strong, sustained and adaptive policy approach (Skea, Ekins et al. 2011, Eyre 2014). Arguably this adaptive approach is also needed within the modelling community, given that rapid socio-

economic changes are occurring and energy systems are also changing, as such they need to reflect these changes to consider 'what if' situations (Mitchell 2015).

3.2 The Supply - Demand Relationship

Another area there is some agreement that change is needed is around the relationship between energy supply and energy demand. The system we have in place reflects its centralised evolution which have led to the arrangements for gas and electricity, from production, through to networks and retailing, being designed to provide secure supply for whatever consumers demand (Lockwood 2014) and for whenever they demand it. This predict and provide mentality shapes the whole culture and philosophy of the system (Strbac 2013: EV14). The supply led approach also shapes the wider governance of the system in respect to the rules, regulations and institutions that have been put in place which have reinforced action on supply side over the demand side. As Lockwood (2014: 5) summarises, the result has been that as energy service demand has grown, the infrastructure geared simply to meeting, as opposed to influencing, that demand has also grown.

This apparent obsession with supply can be seen in wider policy narratives about decarbonisation, with the push for action tending to concentrate on approaches in which we can just substitute high carbon fuels/technologies with low carbon alternatives on the supply side without the need to consider in more detail what the drivers of demand are (Willis 2011). As Willis & Eyre (2011) highlight, the domination of supply side thinking also reflects the industry structure that has emerged, with a relatively small and defined group of actors with responsibility for supply, compared to demand, which is more complex, diffuse and embedded across a wide range of actors outside of the boundaries of traditional energy policy. This, they suggest, has resulted in a policy approach largely dominated by supply which is inadequate and arguably misleading, perhaps even damaging for the challenges we now face.

Instead there should be a greater focus on the demand side to help rebalance the relationship between supply and demand to enable a low carbon transformation (Stirling 2014, Walker 2014). A demand focussed system is one of the central building blocks of a sustainable energy system, as the smaller energy demand is, the easier and less costly it is to achieve a low carbon transformation (Lockwood 2014, Mitchell 2015). This has been shown across a range of scenarios for GB energy system decarbonisation, with those that have lower demand also being those with lower costs (Steward 2014). This is not only the case for total demand, but also for peak demand, which tends to occur at particular times of day and year, with the most significant peak occurring during the winter, in early evening (Lockwood 2014). It is this peak in demand

that the energy system is effectively sized to meet, and it impacts on system balancing, pricing and future grid development (Torriti 2015).

The main focus of peak demand is in respect to electricity⁶, and reducing this peak by making demand more flexible is expected to become increasingly important as decarbonisation proceeds (Strbac 2008, ECCC 2010), particularly if electricity plays a growing role in the heat and transport sectors. Ofgem (Ofgem 2010) quantified the potential benefits of reducing peak electricity load by 10% at between £550 million and £1.2 billion a year, although with more renewables and higher use of electric vehicles and heat pumps, the benefits are likely to be higher. Over ten years this would be between £5.5 billion and £12 billion. More widely the recent National Infrastructure Commission report suggested that by moving to a smart power system built around interconnections, storage and maximising demand flexibility the potential saving to consumers could be up to £8 billion a year by 2030 (NIC 2016).

As well as taking steps to reduce total and peak demand, action on the demand side can also include other decentralised measures including generation, low carbon heat and energy storage. Such approaches offer new ways for the dynamics of demand to be reshaped to match available supply (Walker 2014, Torriti 2015). Collectively these different demand side actions include: demand reduction (DR); demand side response (DSR); and distributed energy resources (DER) (DECC 2014). DECC (2014b) have described these actions as D3 and they highlight that they cut across the demand side and as such there is no single approach – different solutions will suit different customers under different circumstances.

3.2.1 Demand Reduction (DR)

DR encompasses those measures that result in a long term reduction in the level of demand for energy services. Reducing energy demand and improving energy efficiency, are seen to be both cost effective and essential to decarbonisation and tackling the energy trilemma (CCC 2008, HMG 2011, Eyre 2014, Sorrell 2015, Watson 2016). Much of the discussion tends to focus on energy efficiency as a way to reduce demand (DECC 2014); with efficiency⁷ improvements enabling the same level of energy service to be achieved for less energy input, or allowing more services to be provided for the same energy input (Hoggett 2013). Energy efficiency has been described as the ‘first fuel’ by the IEA, given the amount of energy use that has been avoided as a result of reducing demand (IEA 2014). The IEA (2014) also highlight for

⁶ Peak demand is less of an issue for gas as the network is already sized to meet it and it seems unlikely that the peak will increase.

⁷ Efficiency in this sense is about the ratio between the useful output of a process and the energy input into that process (Patterson, 1996).

most energy services there is still considerable scope for further increases in efficiency and that such improvements bring multiple benefits – Figure 4.

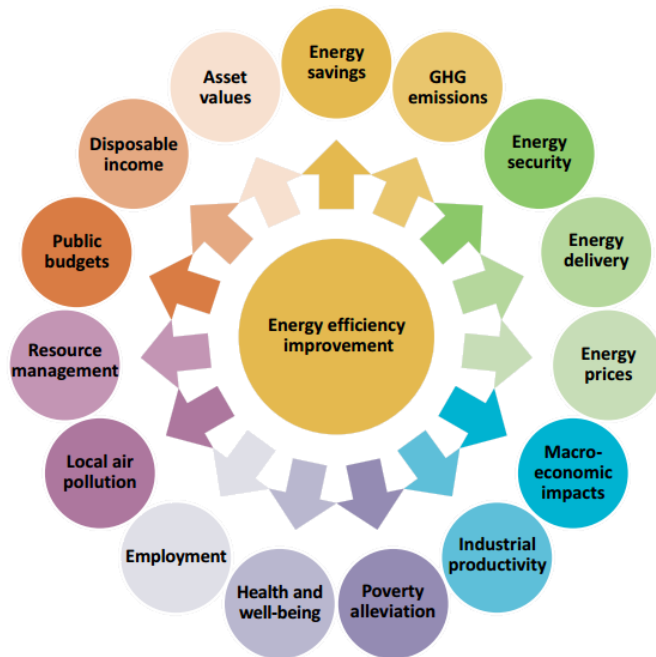


Figure 4: Some of the multiple benefits of energy efficiency improvements

Source: (IEA 2014):20

A broad range of measures can be considered under demand reduction, such as: fabric improvements to buildings in respect to their thermal efficiency through insulation and/or improved airtightness; the installation of more efficient heating, lighting and appliances; the adoption and use of building energy management systems and better controls (heating, lighting, cooling, etc); the use of smart meters; optimisation software; more energy efficient motors and electrical products, etc; as well as changing consumer habits and behaviours (DECC 2014, CCC 2015).

3.2.2 Demand Side Response (DSR)

Most of the focus of DSR is on electricity, although interruptible gas contracts are an example of DSR for dealing with potential supply constraints on the gas network. In simple terms, rather than supply following demand, DSR offers a range of ways to flex or shift demand in response to variations in supply. Figure 5, shows a simplified view of how DSR can operate: a) shows how demand can be shifted to reduce a peak; b) shows that DSR can also provide flexibility to match supply and demand continuously. There are a number of ways DSR can be used, such as:

- Turn-down DSR: reducing demand by reducing consumption;
- Turn-up DSR: increasing demand by increasing consumption;

- DSR by on-site generation: reducing demand on a network by using on-site generation or stored energy (Goater 2014).

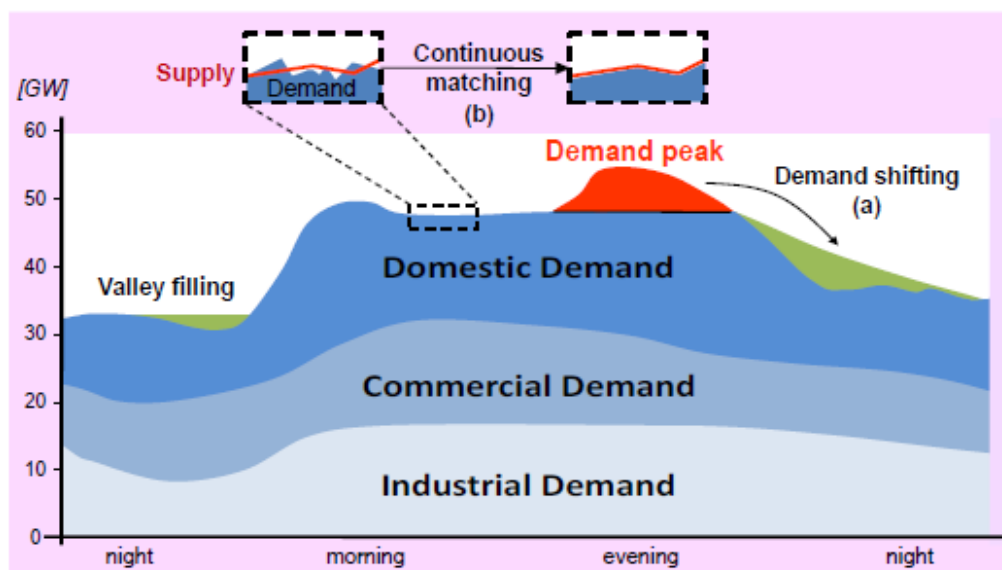


Figure 5: Effects of DSR on Typical UK Demand Profile

Source: (Goater 2014): 1

The flexibility DSR offers provides new routes to reduce the problem of peak energy demand, as well as help to accommodate growing amounts of intermittent generation and support the electrification of heat and transport (Goater 2014, Economics 2015, NIC 2016). As such, it is expected to play an increasingly important role in low carbon energy systems, although uncertainties do exist (Economics 2015). The roles that DSR can play within the system will vary for different actors (SO, TNOs, DNOs, suppliers, end users), and may offer both short and long term opportunities, such as: load shifting to help balance supply and demand; increasing export or taking excess energy from a network; reducing potential reinforcement costs; reducing the wholesale costs of energy; and reducing possible imbalance charges (DECC 2014, Economics 2015, Torriti 2015). Much of the provision of these services will depend on how value within the system is revealed and then rewarded (Mitchell 2016). Given these variables, different sorts of DSR could have different uses and there could be both synergies and conflicts in terms of how it is used, and who it is used by, within the overall energy system (Economics 2015).

Although DSR is widely used in many countries, the National Infrastructure Commission suggested that it is currently underused in the UK (NIC 2016). This they suggest is in part due to poor communication of its benefits as well as problems with some of the policy and regulations that favour generation over flexibility. Although these problems need to be addressed, the NIC

suggest it could play a significant role in the future energy system across different sectors, including the domestic sector once the smart meter roll out is completed. It should be recognised there are already a wide range of new entrants offering DSR services within GB, mainly for commercial and industrial customers at present.

3.2.3 Distributed Energy Resources (DER)

As well as reducing and flexing demand, the third element of D3 includes other decentralised measures including generation, low carbon heat and energy storage located on site or with the distribution network (DECC 2014). Often also referred to Distributed Energy, some view DER as another form of DSR as it can be used to provide load shifting and flexibility (Economics 2015). Within these definitions back-up generation is often included, although this can also include the use of diesel generation which does not help with decarbonisation – this has been a growing problem within the UKs capacity market (Macalister 2015). This paper takes the view that DER should be provided through sustainable means, such as those suggested by DECC in respect to D3:

“photovoltaics (PV), heat pumps, solar thermal systems, biomass boilers, renewable and gas fired combined heat and power (CHP) systems; and the use of heat networks, which can deliver lower carbon heating to homes and businesses when connected to a variety of sources including CHP, energy from waste stations, anaerobic digestion plants, large scale heat pumps or even waste heat from industry” (DECC 2014):4

This definition clearly comprises a wide range of different technologies, to which storage can also be added (see below) (Akorede, Hizam et al. 2010). Collectively these different technologies will be appropriate for different end users, at different scales, and mainly connected to the network at the local level. The growing use of DER at the distribution level is seen as a reduction in demand at the transmission level; e.g. in a recent Summer Outlook report from National Grid, they suggested that demand would be around 37.4 GW, the lowest level they have ever predicted and they put this down in large part to embedded solar generation (Evans 2015).

There are numerous potential benefits for a growth in DER within the energy system. For example the Rocky Mountain Institute suggest that in comparison to centralised electricity supply, DER can be: cheaper, cleaner, less risky, more flexible, and quicker to deploy; as well as improving the efficiency and overall costs of the system by helping to reduce losses (Institute 2016). Similarly, it has been highlighted that given many of the uncertainties in transforming an energy system, those technologies that demonstrate high levels of resilience, flexibility and adaptability will be able to provide a secure route to a low carbon future and that these

characteristics tend to be shown by smaller scale DER technologies (Hoggett 2013). Finally it is important to recognise that DER can provide whole system opportunities in a low carbon transformation given that the technologies and practices can cut across heat, power and transport. The most likely cross over with transport initially would be via the flexibility offered by storage within electric vehicles which could be used in a grid-to-vehicle and vehicle-to-grid mode to help balance demand and supply (Sweco 2015).

3.2.4 Energy storage and interconnection

In addition to the forms of D3 above, energy storage and interconnection are of importance in future energy systems. Both are seen as central innovations by the National Infrastructure Commission in the creation of a smarter power system (NIC 2016). In respect to interconnections they suggest that the physical linking of markets across national borders could become a key source of flexibility within the system given their ability to shift large amounts of power from where it is not need to where it is. They also suggest that they have the potential to do this at lower costs to consumers, whilst helping to meet decarbonisation and security challenges. The 4GW capacity GB current has is expected to increase to around 11 GW by 2020 (NIC 2016:8-9).

Storage has been described by the government as one of the eight great technologies, based on the UK's scientific and business capabilities (BiS 2013). The National Infrastructure Commission also see it as a key innovation in creating a smarter power system for different actors within the system (NIC 2016). Whilst the IEA have described storage as a key integration technology that gives opportunities for the improved management of supply and demand, which can also provide multiple services (IEA 2014). Many think storage could become a game changer in a low carbon future, given that it can complement increasingly amounts of variable generation, can be used at a variety of scales, and play a role across power, heat and transport. The IEA have suggested its role within developed and developing energy systems could include:

- improving energy system resource use efficiency;
- helping to integrate higher levels of variable renewable resources and end-use sector electrification;
- supporting greater production of energy where it is consumed;
- increasing energy access;
- improving electricity grid stability, flexibility, reliability and resilience.

In respect to electricity, currently very little is stored, partly because costs of storage have been prohibitive, compared to just supplying power, but also because the current rules and regulations make it difficult for storage to compete within the market (NIC 2016). There are already a variety of different technologies available for storing electricity, which have different

characteristics and potential roles, including large established technologies like pumped hydro, through to smaller scale technologies, such as battery's, compressed air and supercapacitors (Luo, Wang et al. 2015, NIC 2016). These technologies are at different stages of maturity and readiness (IEA 2014, Luo, Wang et al. 2015), but some are already being deployed into the GB system from the household level through to grid scale applications. Many expect the market will change quickly as deployment increases, efficiencies increase and prices continue to fall (Chediak 2015).

Whilst much of the discussion on interconnectors and storage focusses on electricity, many of the benefits discussed above also apply to gas and/or heat in GB. Currently the UK has physical gas connections with Norway, Belgium, Holland and Ireland as well as a number of LNG terminals for accessing international gas markets. The UK also has the ability to store around 4.6 billion cubic metres of gas⁸ with increases in the capacity and deliverability of gas storage currently being considered at existing and new sites (DECC 2015). Although recent research has highlighted that the future of gas in a low-carbon UK is very limited (McGlade 2016).

3.2.5 Smart meters

Smart meters are seen as another important facilitator of enabling a more efficient, greener, smarter energy system which could help lay the foundations for smart grids and new way of running the energy networks (GB 2016). Work is already underway to install an estimate 53 million smart electricity and gas meters into to all homes and small business in GB by 2020; by Sept 2016 around 4 million had been installed (DBEIS 2016). The total cost of the roll out was estimated at £11.7 billion, which will be funded through consumers bills, and the government estimated that this will result in savings of around £17 billion⁹ (Stedman 2016), although the level of savings have recently been revised downwards¹⁰ (DBEIS 2016). These costs and benefits are subject to ongoing change, with some research already highlighted costs are increasing due to delays around the communication infrastructure and because higher numbers than expected of the less advanced SMETS 1 smart meters are being installed (Consultants 2016). Some countries have also commissioned research that suggest the cost-benefits of installing smart meters in their country will not provide an overall cost benefit consumers e.g. Germany, Canada, Australia (Curwen 2016).

⁸ According to national statistics the total gas demand in 2014 was recorded at 70 billion cubic metres

⁹ This net gain of over £6 billion (NPV) comes from assumptions related to reduced energy consumption, enable through smart meters and reduced costs savings in several areas e.g. reduced expenditure on energy infrastructure and operational efficiencies such as reduced site visits for meter reads – Sustainability First in Elam, S. (2016). Smart Meter Data and Public Interest Issues – The National Perspective Discussion Paper 1, TEDDINET, CSE and Sustainability First.

¹⁰ The latest figures from the Government in August 2016 saw the net benefit of the roll out falling from £6.2bn to £5.7bn, due a combination of increased costs for the scheme and reduce estimates of the benefits it will bring.

The potential benefits to consumers of smart meters have been summarised in terms of: giving real time information on energy use and making it more visible via a display in the home; allowing people to better manage energy use and therefore save money and emissions; providing accurate billing without the need for traditional meter readings (DECC 2013); and helping with engagement and ease in switching suppliers (Consultants 2016). They could also potentially enable greater involvement in the energy market by opening up access to new tariffs and services, including for demand flexibility, providing regulatory and cultural barriers are addressed (NIC 2016). A regular tracking survey commissioned by Smart Energy GB (n=10,000) on people that have installed smart meters shows, amongst other things, that the majority of them: would recommend a smart meters to others; are taking at least one step to reduce energy use; and have a better idea over energy costs (GB 2016).

It is apparent that smart meters will provide an unprecedented volume and granularity of energy consumption data, including from smart appliances and apps that potentially connect to them (Britton 2016). This data could play an important role in helping to modernise the energy industry, facilitate the evolution of a smart grid, and aid the development of new energy services (Elam 2016). As well as benefits to end users in terms of making energy more visible and potentially offering an easier route to engage with the system, the data could also help to improve policy making and bring wider benefits, such as supporting: the development of smart cities; targeting/monitoring of local energy programmes; social housing and health services; new opportunities for community energy and other local approaches to balance supply and demand (Britton 2016).

However, as Britton (2016) makes clear, there are a number of potential challenges for how this data might be accessed for these wider uses, particularly in respect to data sharing, aggregation and disaggregation of data at a local scale (where many of these initiatives are focussed). The key issue is how best to make use of the wealth of new data, whilst ensuring customer information is protected. Currently access to smart data, beyond regulated purposes, will require consumer consent data, who can access data and in what way is summarised in Table 1 below.

User	Data Access
Energy consumers or households	<ul style="list-style-type: none"> • Direct access to their own data vi an In-Home Display (IHD)/other Consumer Access Devices (CADs) • This could include access to data provided by third parties, where consent has been given.
Energy suppliers	<ul style="list-style-type: none"> • Monthly data is accessible to energy suppliers without consent but it can only be used for billing purposes or to fulfil statutory requirements. • The use of data for marketing purposes is only allowed with explicit, opt-in consent • half-hourly data (which is considered to be the most intrusive) can also only be accessed with explicit, opt-in consent.
Network operators	<ul style="list-style-type: none"> • Network operators should be able to access half-hourly energy consumption data from all domestic customers without consent, provided that: <ul style="list-style-type: none"> ○ Its only used for regulated purposes ○ Network operators submitted plans detailing which data they would access, for which purposes, and how the data would be treated ○ That these plans were approved by Ofgem, before data was accessed.
Third parties or Other Users	<ul style="list-style-type: none"> • Third parties who want to access smart meter data directly will be required to accede to the Smart Energy Code (SEC) and become a Data Communications Company (DCC) Gateway user in the category of “Other”. • There are a number of conditions that they will have to apply with to access this data

Table 1: Current anticipated arrangements on uses of smart meter data

Source: Adapted from (Elam 2016:25-28)

Better data will be very important going forward, but it should be recognised that the installation of smart meters may not help overcome the issues of data access. Even with protections in place, the need to actively opt in to data sharing from consumers could be a considerable barrier for many new innovative projects. Even in those sectors that already have smart or half hourly meters there can also be problems, e.g. in the industrial sector data can be inaccessible because it is buried in industry or unavailable because of concerns that it is commercially

sensitive (Skea 2013). It is also possible that the costs and complexity for third parties, such as new entrants, in terms to joining the Smart Energy Code and becoming a Data Communications Company (DCC), will be prohibitive for enabling innovation¹¹.

Its early days for the smart meters, there have been a number of problems and the scale of effort needed to reach the 2020 target is not insignificant¹². There are also a range of substantial issues to overcome relating to 'data security, privacy and the reliability of the equipment and associated processes' (Eyre 2016). However, they are seen as an integral part of the development of a smarter energy system which will offer new ways for people to engage; as such they could become an important enabling technology. Depending on how the market responds in terms of business models, new tariffs, etc., it could open up a range of methods to provide demand side flexibility for the benefit of end users and the system as a whole. Clearly, technology advances around metering and monitoring will continue to develop a pace – linked to apps and other applications. It seems likely smart meters will be an area dynamic change in coming years in respect to the roll out, the technology used, and the developments that occur around them.

3.2.6 D3 in a sustainable system

As it appears from the discussions above, D3 in all its forms is likely to grow in importance as our energy system transforms to a more sustainable model. Below are two figures for how the system could change – Figure 6 from the NIC just focuses on the power system, whilst Figure 7 considers a more integrated power, gas and transport system. The respective roles of DER and DSR at the transmission and distribution levels is shown for different end users, as well as how the system will increasingly incorporate two way flows of power within its design. In respect to the gas network some of the developments could include new fuels feeding into the network such as bio-methane and hydrogen, more dynamic or smarter network monitoring, as well smart metering on the customer side (Lowes 2016). Within Figure 7 the potential roles and cross-over between green gas (green line), natural gas (blue line) and electricity (black line) are shown. DR is not shown in the figures, but as highlighted above is the central element in any sensible efforts to enable a low carbon transformation.

¹¹ It was strongly suggested at a recent IGov conference <http://projects.exeter.ac.uk/igov/category/events/igov-events/energy-governance/> that the way the SEC and DCC have been set up will prevent smaller companies from engaging with them.

¹² Some are suggesting that 2020 deadline will have a negative impact on consumers and that a more sensible strategy would be for government to adopt the EU target of achieving 80% of smart meter installs by 2020 and 100% by 2025. Consultants, C. (2016). Smart Move: Taking stock of the smart meter rollout programme in Scotland. A report for the Consumer Futures Unit by CAG Consultants in association with Changeworks and the University of Edinburgh, Citizens Advice Scotland.

Another important potential benefit from a more demand focussed system utilising D3 is it will provide new opportunities for end users to engage with the system in different ways. In part this reflects the fact many of the applications of D3 are closer to people in terms of their scale and position within the system. With a direction of travel increasingly towards decentralisation, the role of people now and into the future will be vital for the creation of a sustainable energy system, linked to the way that they perceive, adopt and use DR, DSR and DER. The next section provides a broader context for the importance of people within the system and how this links to wider issues of energy governance.

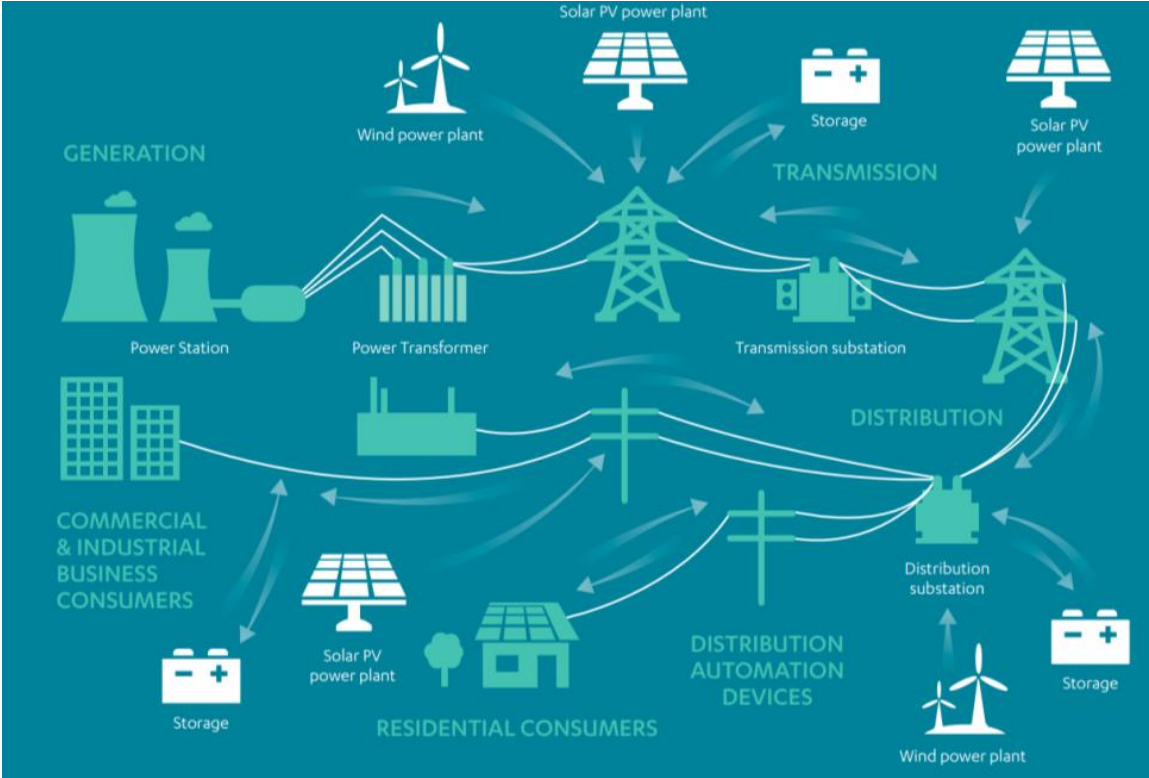


Figure 6: A Future Power System

Source: (NIC 2016:6)

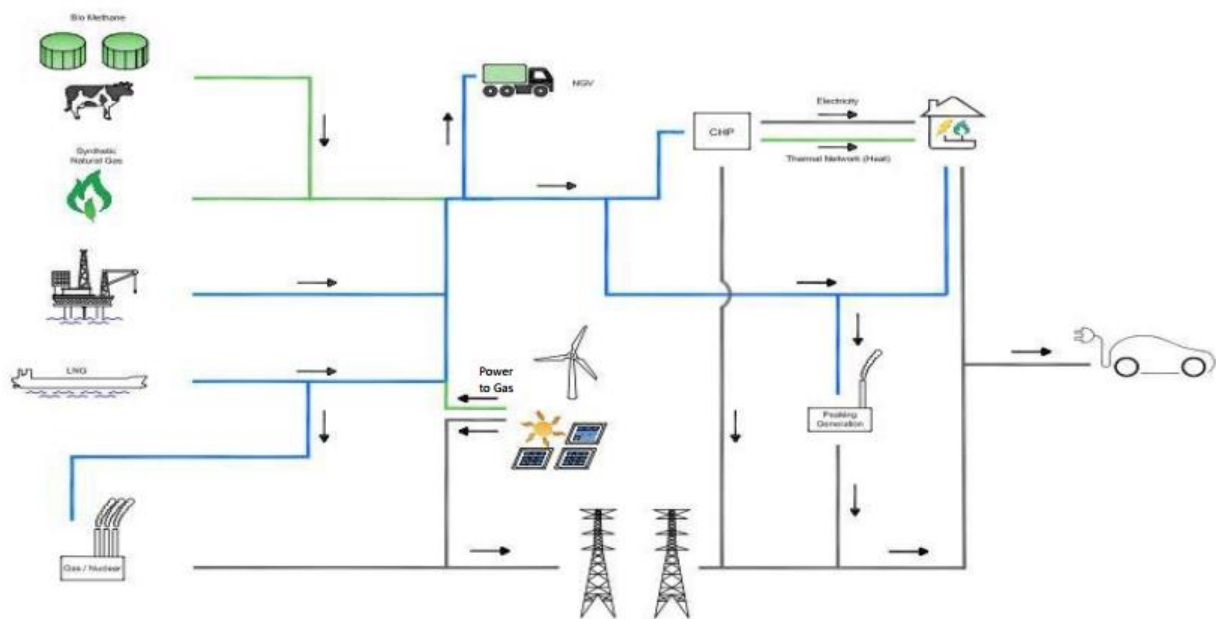


Figure 7: An Integrated Energy Infrastructure

Source: (Edwards 2016)

4. Energy Demand, People and Energy Governance

The above section sets out some very high level changes that could occur to the energy system, based on observations from a wide range of actors within the system, including those that develop models and scenarios. Within all of this discussion, the role that technology is expected to play in a low carbon transformation is central to much of the analysis, and these are subject to continuous innovation and technical change, such as improvements in efficiencies, performance and cost (Eyre 2014). However, there are also ongoing innovations in respect to practice, such as how technologies are used, the rate of adoption, how people interact with energy, changes to markets, networks, new business models, etc (Hole 2012, Mitchell 2014). In addition, the reality is that many of the technologies and solutions discussed above in relation to D3 are much closer to end users and the demand side within the system. As such, the case for taking a more demand focussed approach to system change grows in importance.

Importantly, the shift towards the demand side also requires that end users are put into the centre of thinking within the energy transformation. Lifestyles and consumer behaviour will play a crucial role in the energy system of the future because they will in part influence which technologies and measures are accepted, and deployed, as well as the way in which they are used (Eyre 2014). This, along with the efficiency of the technologies and the wider infrastructure in which they are used e.g. an efficient house versus an inefficient one, are what will shape the overall level of demand within the system. Given that system changes are also happening closer to people and often paid for by them through their bills, the need to engage with the public on the energy transformation is also increasingly vital.

In addition, as the IGov research has been examining, the effective governance of the energy system is vital for enabling a transformation. How the energy system operates and develops is a reflection of the governance that is in place and the politics that shape this. This includes the rules and regulations that have been developed and the institutions, including markets and regulatory structures that have been put in place (IGov 2012, Kuzemko, Lockwood et al. 2016, Mitchell C. 2016). These all have implications for the way energy is conceived of by people, for the amount of energy that is used, the way it used, and for the changes that occur (Mitchell 2014).

This section explores these board issues, first looking at the way that the demand is framed and the issues this creates for an energy transformation. This includes how demand links to end users within the system, how the system views these end users and what this approach has meant for engagement, consent and trust. The links between this and governance are then explored in more detail.

4.1 Energy Demand

Within national statistics, consumption (demand) is broken down into four main sectors: industry; transport; domestic; and 'other final users' or 'services' which comprises a number of sub-sectors (public administration, commercial, agriculture and miscellaneous). This data really only gives a broad understanding of consumption and trends at a national level within each of these sectors; it tells us very little about the end users who are behind that demand or how and why they are using energy (Willis 2011). There is also little insight into how energy is used to produce goods and provide services, which are also 'consumed' etc, nor the embedded energy or carbon associated with these. Both within each sector, and between sectors, demand will vary considerably and it is recognised there is no such thing as a 'typical consumer' (Ofgem 2011). So whilst useful for understanding total levels of demand within different sectors the way consumption is viewed nationally tells us very little about the drivers behind it, or what opportunities and barriers exist in moving towards a more flexible, demand focussed system.

Part of the problem is that understanding energy demand is complex, as both total demand and peak demand vary on a daily and seasonal basis and can be largely uncontrollable, given there have not been incentives or a need to encourage responsiveness (Strbac 2008). Demand is influenced by a wide range of factors, such as: the weather, types of appliances, types of buildings, spatial planning, number/age/types of buildings, the type of economy a country has, as well as more social factors such as the behaviour and actions taken by individuals, households, businesses, etc (Willis 2011, Torriti 2015). However, at a high level, energy demand is what ultimately drives and shapes the system: the *"level of demand for energy"*

services and the efficiency with which they are delivered, by definition, dictate the level of supply that is needed; the demand for energy services is [therefore] the underlying driver for the whole energy system..." (Hoggett 2013):93. As these authors go on to discuss, the demand for energy is the result of the consumption decisions people take, which includes the direct consumption through energy services i.e. heat, light, mobility, etc., as well as the energy needed from indirect consumption of wider goods and services. Arguably then, people really are at the heart of the system and any transformation therefore has to consider their role within the system now and in the future. This includes the way that they are encouraged to act through the governance and policy arrangements that are in place and whether these hinder or enable change in a shift towards a more sustainable energy system.

4.2 End User Engagement

Currently it can be argued that end users as a whole are not at the heart of the system, at least in terms with how they are perceived by policy makers and many industry actors. The development of the large, technical, centralised system that is now in place, has led to, for the most part¹³, a passive role for people – one in which they are unaware, unengaged and distanced from the production, distribution and use of energy (Boardman 2007, Devine-Wright 2007, Science 2008). As Devine-Wright (2007) suggests “..the centralized energy system is embedded within, and has helped produce, a social representation of the ‘energy public’ that is overwhelmingly characterised by deficits of: interest, knowledge, rationality and environmental and social responsibility”. This he suggests can also include policymakers and big actors within the system, who have tended to consider energy primarily as a commodity, which results in decisions and actions focussing on supply, demand and price.

This view of energy as a commodity and as people as simply consumers of energy, is embedded within the way the energy system has developed. Prior to privatisation and liberalisation, the system was nationally owned and operated and the monopoly generator supplied captive customers (Soutar 2013); there was no need for these customers to be active, the approach was simply based on meeting whatever their energy demand was. This sort of approach was not challenged during the privatisation process, instead the underlying approach to end users was about them benefiting from competition in respect to ‘lower prices, better choice and higher standards of service’ (DTI 2001 in Kuzemko 2015). What is more, that narrative on end user participation within energy markets led to a view that switching suppliers is the de-facto measure of engagement - by regular switching the hope was that market would respond and prices would be kept down – competition would drive the market (Rutledge 2010, HCECCC 2012). The switching narrative for engagement for the most part has not really changed since privatisation from either the regulator, government or many industry actors (Hoggett 2013).

There were bigger ideologies at play in the privatisation process, such as a desire from government to create a ‘shareholding democracy’, which would give people a stake in the markets, although it’s apparent that many of the cheap shares offered to individuals were subsequently sold – in gas for example, the 4.5million shareholders at the time of privatisation

¹³ In reality end user passivity will vary across and within sectors. In very general terms it is likely that smaller consumers in the domestic sector and SMEs will be more passive than larger energy users whose energy costs make up a large part of operation/production costs, or who have a policy incentive to reduce energy use or carbon emissions. There will obviously also be exceptions within these, for example past segmentation work by the Energy Saving Trust and Defra (on pro-environmental behaviours) has shed light into the way consumers do and don’t take action.

fell to just 1.67 million by 1996 (Rutledge 2010). The Conservative government that came to power in 1979 did so with a mandate to reduce state interference in markets (Mallaburn and Eyre 2014) and as part of this the role of energy within society was reframed, moving away from notions of it being a public good, toward it being treated like 'just another commodity' (Kuzemko 2013, Soutar 2013). It was also the start of the process of Government trying to move out of energy policy - as stated by Nigel Lawson in 1982: *"I do not see the government's task as being to try and plan the future shape of energy production and consumption. It is not even primarily to try to balance UK demand and supply for energy. Our task is rather to set a framework which will ensure that the market operates in the energy sector with a minimum of distortion"* (Lawson 1982 in Soutar 2013). Within ten years of this statement, the Department for Energy was abolished and its remaining responsibilities transferred into the Department of Trade and Industry. Regulation was brought together into one body, Ofgem, in 1999, who had a primary duty to protect consumers through competitive means where possible (Mitchell 2010). Subject to this delegation of power to Ofgem, the government approach became one based on leaving it to market, something that dominated subsequent policy documents even when New Labour came to power in the 1990s and this approach was not really questioned until 2009/10 (Helm 2004, Rutledge 2010).

Much has been written on the theoretical benefits that were put forward during the privatisation and liberalisation processes and how the theory behind this turned out in reality (Helm 2007, Rutledge 2010, Pearson 2012, Kuzemko 2015). Within all of this, end users were left to make their choice in the market, subject to some regulations to protect them including early price controls and some policies to support them in respect to affordability, etc. How the markets developed for different customers varied to some degree, the market for larger consumers were open for competition first and they were able to access retail and wholesale markets to find the deals. The retail markets for smaller energy customers opened up later and then went through a process of gradual concentration through buyouts and mergers, to the point that by the mid 2000s just six suppliers dominated the market. At the end of 2015 in electricity, these 6 suppliers still had around an 88% share of the market in the domestic sector (Ofgem 2016), in gas the share was 87% (Ofgem 2016). Although more recent analysis suggests the market share has now fallen to around 83% as there has been a steady shift in people moving to independent suppliers, with a suggestion that now 1 in 6 customers get their energy from a non-big 6 supplier (Energy 2016). So even though there are around 188 licensed suppliers for electricity, of which 43 only supply to the non-domestic sector (Ofgem 2016) and in gas there are 191 licensed suppliers of which 82 only supply non-domestic customers¹⁴ (Ofgem 2016)¹⁵;

¹⁴ These figures exclude private network suppliers.

¹⁵ It's worth noting that some of these companies will offer both gas and electricity to their customers

the market is clearly dominated by the big 6. This concentration in the market is important because it has shaped and influenced how end users have engaged with the market and also has dominated much of the focus on the regulatory, government, politicians and the media, particularly in recent years.

In respect to engagement, there are a wide range of issues that have shaped how end users do and don't engage in markets post-privatisation. For example, in respect to smaller users, it is apparent that from a suppliers perspective, it has suited them to have passive customers with predictable demand, as this helps to reduce risk¹⁶ in the balancing market (Kuzemko 2015), so there has been little or no desire from suppliers to incentivise a more active customer. Whilst energy costs were low very little attention was given to this approach and in the run up to privatisation energy prices were falling and retail prices for most classes of consumer continued to fall post-privatisation (although the reasons for this are not solely due to opening up of the markets (Pearson 2012)). This downward trend continued until the early 2000s (Rutledge 2010) but as energy prices and the levels of fuels poverty began to increase, media attention and growing consumer discontentment started to have an impact on policy makers and the regulator. Many of the issues that emerged were set out in an inquiry run by the Energy and Climate Change Committee in 2012 (HCECCC 2012). This showed that there was a large body of customers (in the domestic sector) that have never switched suppliers, often referred to as 'sticky consumers', Ofgem suggested in the inquiry 60% of people had never switched. The inquiry suggested that in part this was due to a wide array of complex energy tariffs that were offered in the market, resulting in confusion and an impression that there was little point in switching suppliers. Ofgem's own tracking research in the same year suggested the reasons for lack of engagement included: consumers not being convinced it's a good use of their time and effort; confusion over what's on offer; and worries over the switching process (Ofgem 2012).

4.3 Trust and Transparency

The issues of 'sticky consumers' that came to the fore in the research above was part of a bigger story that was emerging. This was a time of falling retail energy prices, but as the Ofgem market research showed, many customers were reporting little difference in their bills (Ofgem 2012). As Ofgem suggested, many customers did not think suppliers were working in their interest and that there was growing lack of trust in them. This is echoed in the ECCC inquiry (HCECCC 2012), which reported a growing lack of trust and a perception that suppliers were

¹⁶ In respect to the treatment of risk within the market, it was also the case that companies were allowed to pass price and policy costs (and therefore risk) through to consumer bills Rutledge, I. (2010). *UK Energy Policy and Market Fundamentalism. UK Energy Policy and the End of Market Fundamentalism*. I. a. P. W. e. Rutledge. Oxford, Oxford Institute for Energy Studies.

making excess profits at consumers' expense. There was also further evidence that some people that had switched had ended up paying more for their energy and that some customers with the same company were getting worse deals than others – particularly those that have never switched. There were also reported cases of high pressure door step selling and growing questions over the profits that energy suppliers were making – all of which were receiving growing amounts of media and political attention.

Tracking surveys at the time showed trust as a key issue for people. For example the Edelman's annual trust barometer (Figure 8) showed that trust in the energy sector in the UK was very low in 2012 and well below other sectors (Edelman 2016), although it has now recovered somewhat, it still remains low in 2016¹⁷. As Dermot Nolan, the Chief Executive of Ofgem, highlighted in his speech at the launch of the Edelman 2016 survey, trust has been eroded by energy companies for multiple reasons such as overcharging and poor customer service, suggesting that there is now a relatively small window to rebuild that as part of the smart meter roll out (Ofgem 2016). Looking at other surveys, Citizens Advice highlighted that although there is some consistency in terms of the low levels of trust shown for the sector, actual levels can vary by the sub-sector of consumer¹⁸ (Advice undated). In respect to the factors that influence trust they suggest that these include: different aspects of the cost of energy, both absolute costs and price volatility are important; perceptions of excess profit levels in the industry; customer service. Collectively the lack of trust and lack of engagement raised concerns over how competitive energy markets had become and this is what ultimately led Ofgem to refer the issue to the Competition and Markets authority in June 2014. It also seems likely the growing mistrust of the energy industry did little to convince people of the value of engaging with the system.

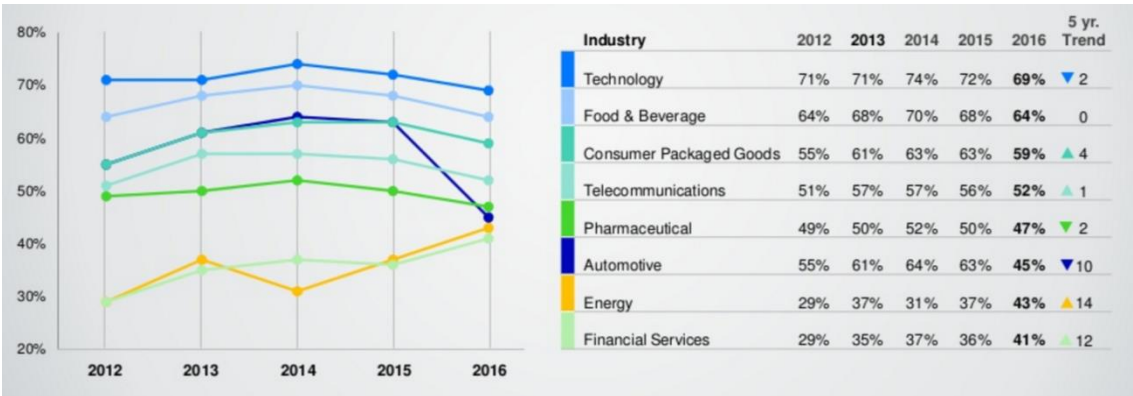


Figure 8: Trust in different UK sectors

¹⁷ This is based on a question 'please indicate how much you trust businesses in each of the following sectors to do what is right'.

¹⁸ Groups showing higher than average levels of trust include: older; lower education attainment; no internet access; black and minority ethnic communities. Those showing lower than average levels: those who are more engaged in the market; pre-payment user's, consumers in fuel poverty; consumers who rent their home.

Source: (Edelman 2016)

It is too early to tell how effective the recommendations from the CMA (CMA 2016) will be in turning around the problems that have developed within the supply sector. Some commentators have, for example, highlighted that the CMA has not proposed radical change to retail markets, despite the problems that exist, and as such it's not clear that existing structures will be able to deliver the required levels of investment, innovation or engagement of decentralised actors (Eyre 2016).

What is also apparent from the issues above, is that the current market design have, for the most part, reinforced the passive role of end users (particularly smaller customers), and created a range of barriers for action on the demand side. This, along with a lack of trust and transparency in companies and markets, will become a growing issue in the transformation of the energy system. In part because even with the best policies in place and the best technical solutions available, without the effective participation of energy users, reducing energy demand and reductions in carbon emissions may not occur (Boardman 2007). Importantly creating a more flexible, demand focussed system, will also require people to adopt low carbon technologies and behaviours, as well as accept decentralised infrastructure in their homes, businesses or local area. All in all then, people are expected to have a much more central role within the energy system than is currently the case (Sweco 2015), how to potentially facilitate this is the focus of the next section.

4.4 Trust, Engagement, and Consent in System Change

4.3.1 Rebuilding trust

Clearly, rebuilding the public's trust in the energy system will be increasingly important as the system changes. There are some interesting insights from Australia (Association 2015) on this issue, where they have suggested that incumbent energy actors have eroded their social licence with customers, resulting in them feeling that they have no control electricity costs or have little understanding of what makes up their bills; in addition, there is a perception that networks are not on their side and are not offering value for money. The combined result of this is that it fosters a lack of 'permission' from customers (Association 2015:28). There are clearly parallels here with what has been happening in the UK in respect to trust and transparency in the retail sector, which resulted in increasing political and media attention over the cost of energy and quality of service, much of which ultimately lead to the CMA Energy Inquiry.

The idea of a 'social license to operate' emerged from the mining industry, building on previous work around corporate social responsibility work (Hall, Lacey et al. 2015). It is seen as a mechanism to provide a more legitimate way for companies to gain acceptance and approval

from local communities and the wider stakeholders (e.g. customers) that they are involved with (Association 2015). The social licence is based on a hierarchy moving upwards from legitimacy (e.g. to operate), through to credibility (e.g. to provide reliable information and honour commitments) and ultimately resulting in trust (e.g. by building common or shared experiences) – Figure 9.

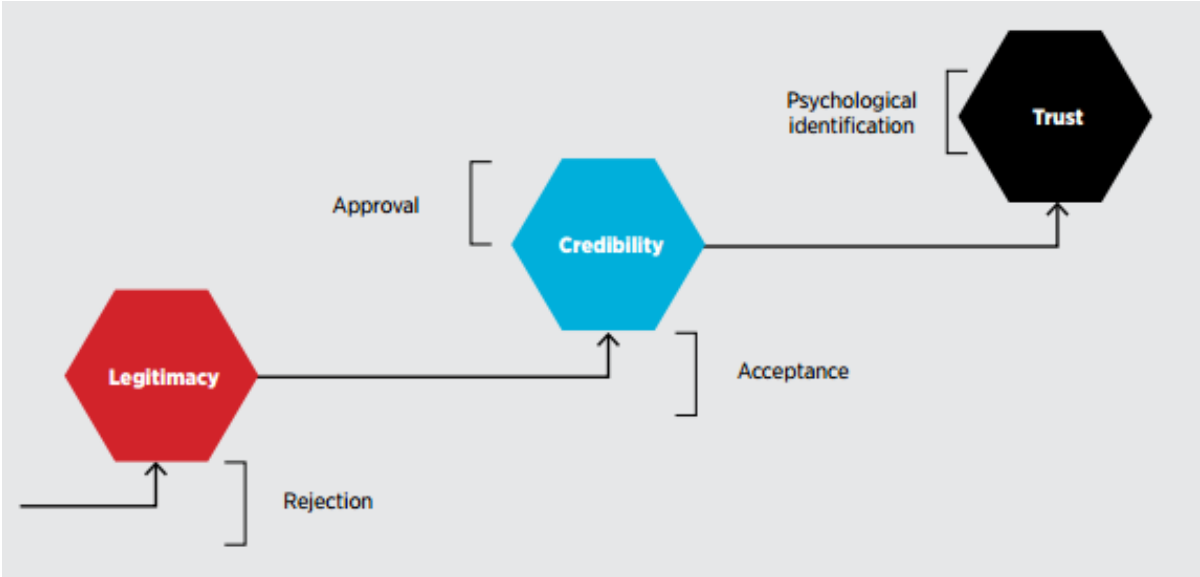


Figure 9: Hierarchy of Social Licence to Operate
Source: (Association 2015:29)

The use and application of a Social Licence to Operate within the mining sector has not been without problems, not only in terms of its definition and application (Colton 2016), but also in terms of its intent where there have been examples of it being principally used as a way to try and avert opposition, rather than seek meaningful engagement (Owen and Kemp 2013). Its use and application therefore needs some care (and further analysis), but it has gained popular appeal across a number of sectors and there are several varieties of social licence in use – see (Colton 2016:8-18) for details. As these authors highlight, the idea links to more broad terms like ‘acceptance, support or public confidence’, and in looking across the different varieties of social licence they propose that social licence, legitimacy and social acceptability are essentially synonymous.

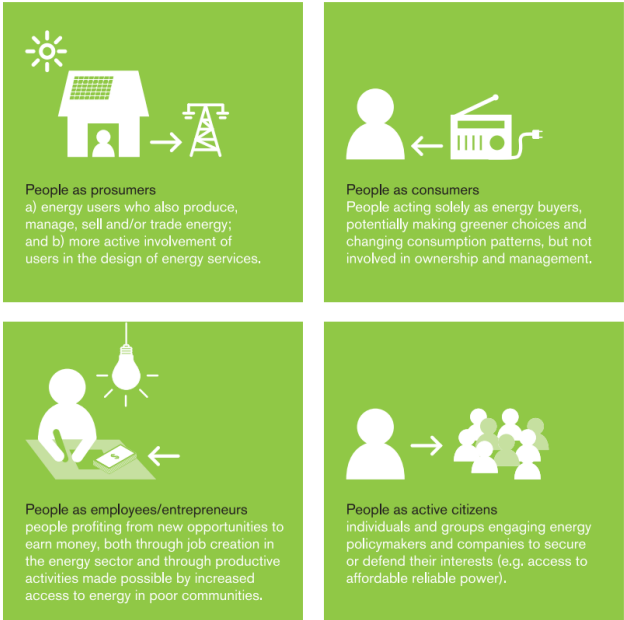
Its application to date in other sectors and countries has not been as a legal licence, rather it has been through self-governance (Owen and Kemp 2013). Given the issues we have found with the self-governance of codes in GB (Lockwood 2015), any use of a social license would need to become a regulated activity and therefore would need close scrutiny to ensure this was not unnecessarily costly or burdensome in comparison to the potential benefits that it could bring. An alternative approach put forward in the research in Canada is that trust and

confidence could be enhanced through the rationalisation of existing regulator vehicles (Colton 2016). Whichever approach is more appropriate requires further research, but developing a governance framework that can foster legitimacy and trust in a more customer focussed approach seems to be an important step in enabling an efficient energy transformation.

The idea of a social licence clearly has some appeal and the argument being put forward in Australia within the energy sector, is that it could play an important role in helping to develop a more customer-orientated approach (Association 2015). As well as potentially rebuilding the legitimacy, credibility and trust that has been lost, it might be that a social licence could also be a useful tool to help gain both the engagement and consent for change within the energy system in GB.

4.4.2 Engagement within the system

The way the system is changing means we need to rethink and re-engage with the role that people play within the system, if we want to create a legitimate low carbon energy system that is also secure and affordable. People can and do play multiple roles within energy systems and society more widely and can both move between roles and play different roles simultaneously, which can be a source of tension (Best 2015). In looking at these issues from an international development perspective, the IIED and Hivos provide some interesting insights on the sort of role that people play within any energy system - Figure 10 (Best 2015)¹⁹. Some of these differing roles are expanded on below.



¹⁹ This report asked leading energy thinkers and practitioners around the world about the role of people within energy systems, in both developed and developing countries.

Figure 10: Differing roles of people in energy systems

Source: (Best 2015:5)

This sort of thinking clearly starts to take a more nuanced approach to the role that people can and could play within the energy system. There are some useful insights in how thinking is changing within some countries in respect to moving away from the dominant narrative of people as consumers. For example, in the US state of New York as part of their Reforming the Energy Vision (NY REV) (Mitchell 2016), they are developing new ways to create value for both end users (of all types) and the system itself; and they recognise that the system needs to be optimised at the customer end as well as the centralised production end. With a growing uptake of DER they also suggest that the distinction between consumer and producer begins to dissolve, making it increasingly important to provide end users with new value signals to engage with the system. Specifically in respect to end user types, they think about people based on how they might interact with the energy system, rather than which sector they are in (eg domestic, commercial, industrial). This includes:

- Traditional customers - those who do not choose to actively manage their energy usage, or for whom it is difficult to do so;
- Active customers - those who undertake DER²⁰ measures that allow them to actively modulate their usage in response to rate signals with the purpose of reducing their bills;
- Prosumers - those who install or participate in DER including generation or other technologies that allows them to provide services to the grid (Service 2015).

In Australia, the Australian Energy Networks Association (ENA) and CSIRO have produced an Electricity Network Transformation Roadmap which also takes a customer-orientated approach to system change (Association 2015). As CSIRO and ENA (2015) explain, this is partly a response from network companies grappling with the rapid system changes that are happening as a result of the uptake of PV and how further uptake of this and energy storage could impact network funding and operation. In addition, they recognise that these developments are part of a wider transformation in customer aspirations and new levels of empowerment, not just about technologies themselves. Comparisons are made to the sort of changes that have been seen in terms of taxis, accommodation, newspapers and telecommunications where conventional approaches to service delivery have been upended. The uptake of DER, like PV, which are more decentralised in terms of geographic location, ownership status and operation profiles are influencing how customers use, produce and value electricity services. Ultimately it is leading the Australian network companies to recognise that

²⁰ New York define DER as energy technologies that include energy efficiency, and distributed generation, which are engaged at the low voltage, distribution level of the electric grid, either on the customer side or utility side of the meter. In Australia in discussing DER they include distributed generation, storage, DSR.

the design and operation of the wider system needs to be rethought and that begins with putting people into the centre of their thinking, in terms of what they will value as the system changes. The shift is from a supply side focus based on historical or existing products and services towards the demand side based on customer needs and aspirations – focussing on the outcomes that end users seek. It is also a resetting of the industry’s mind-set so that they have a process whereby they automatically think about how they can actively and meaningfully engage with people within the process.

As part of their analysis, and in a way that is not dissimilar to New York, they are moving away from thinking of end users as passive consumers to a segmentation based on the role that they might play based on an ‘empowered-engaged-essential’ categorisation. In addition, the CSIRO/ENA (Association 2015) provide a range of finer detail on each segment e.g. empowered users are further segmented into those that are ‘autonomous’ or ‘Tech-focussed’, etc - a summary of the different end-user types in the domestic sector²¹ is shown in Figure 11 and much more detail on each segment is available in Table 2. They have an expectation that the majority of customers will become engaged (either actively or passively) within the electricity system going forward.



Figure 11: Example market segmentation curve for residential customers in 2025

Source: (Association 2015):p33

²¹ For non-residential customers the sub-segmentations are: Empowered (Autonomous); Engaged (Active and Passive); Essential (Vulnerable and Service Dependent).

Segment	Empowered		Engaged		Vulnerable
	Autonomous	Tech focused	Hands on (Active)	Be my agent (Passive)	Service dependent
Distinctive features	<p>Independent: Wants full control, granular cost management and the ability to configure the operation of the electricity solution.</p> <p>Will often involve disconnecting from the grid entirely, and may be motivated by locational cost or reliability issues.</p>	<p>Empowered: Has a strong affinity with technology and desires control.</p> <p>Wants to influence directly the design and operation of the customised solution.</p> <p>System cost is important but maximising returns on investment from trading energy services with the grid is critical.</p>	<p>Active: Wants to understand what each available option has to offer and to be involved fully in the selection process.</p> <p>Willing to maintain a moderate to high involvement in the ongoing operation.</p> <p>System cost and return on investment from interacting with the grid to trade energy services are both important.</p>	<p>Passive: Prefers electricity solutions that provide ease and convenience at a reasonable cost.</p> <p>Desires an agent to provide a shortlist of options that make sense, are easy to deliver and require a minimum of ongoing involvement.</p> <p>May invest in additional cost saving measures if simple and convenient.</p>	<p>Dependent: Needs affordable network services and help to identify the most suitable options.</p> <p>Includes vulnerable customers experiencing energy hardship.</p> <p>Also includes households that cannot adopt new electricity solutions, given rental property constraints or a lack of access to capital.</p>
Common features	<p>All customer segments will value solutions that provide secure and reliable electricity for Australia's modern lifestyle. Some customers may want to trade off some aspects that have been standardised traditionally, in return for a financial benefit.</p> <p>Participation in a given segment is fluid and bi-directional. Households will transition between segments at different stages of the life cycle, either towards greater autonomy or increased dependence.</p> <p>Customer segments are likely to be less affected by income level, as evolving business models and financing mechanisms make complex solutions available to larger proportions of customers.</p>				
Segment reference descriptors	<p>Actively invests in distributed energy resources to have, and to be seen to have, control.</p> <p>Seeks a diversity of energy options and many will pay a premium.</p> <p>Has an appetite for high degree of self-effort.</p> <p>Willing to invest in distributed energy resources for interacting with market.</p> <p>Features are very important; desire highly customised products/services.</p> <p>At extreme, will choose greatest form of engagement, 'self-reliance'.</p> <p>Willing to be either highly integrated (on their perceived terms) or 'disconnected'.</p> <p>In future, new payment arrangements (for example power purchase agreements) may reduce the upfront cost barriers to make leaving the grid more accessible to customers. So cost alone may not be a barrier to customers who want to seek to leave the grid.</p> <p>Technical complexity could be managed by third parties, but consumers in this segment would still have to accept increased complexity and risk that comes with being grid-disconnected or less reliant on grid supply.</p>	<p>Will invest in distributed energy resources to reduce costs and enhance sense of control.</p> <p>Moderate market involvement and energy management.</p> <p>Like technology and the ability to manage energy.</p> <p>Willing to pay more but cost is still important (for most).</p> <p>Prefer degree of customisation and individualised products/services.</p> <p>Interconnected (energy and information).</p> <p>Favour grid-integration of distributed energy resources to sell, buy and maximise financial value.</p>	<p>Favour personal convenience and simplicity.</p> <p>Want to reduce cost and complexity.</p> <p>Relatively passive market involvement (either by choice or necessity).</p> <p>Energy may be viewed as a simple commodity.</p> <p>May invest in energy packages - but only if simple and convenient.</p> <p>Vulnerable customer groups require ongoing access to affordable and reliable network services.</p>		

Table 2: summary of residential customer segments in 2025

Source: (Association 2015): p 35

From a network perspective, the ENA (Association 2015) also highlight that there could be an emergence of new intermediaries, either new or existing service providers and other market actors who function as a 'value network'. It is anticipated that they will collaborate and/or compete with network businesses to provide diverse energy and other solutions to end-users. Again, this is not dissimilar to what is expected to occur in the New York REV through the creation of Distribution Service Providers.

The approach in New York and Australia of considering end users in respect to how able or willing they are able to engage is markedly different from the dominant discourses in the UK. Not only is the tendency to view end users as just consumers within a particular sector, as discussed above, engagement in the domestic and SME sectors is measured in respect to switching rates. That is not to say that this is the only discourse, there are a number of terms used in relation to consumers in the UK that could be applied to the Australian segments above:

- the ‘service dependent’ segment has similarities with fuel poor and vulnerable customers and could also include those that live within the private rented sector, based on the description in the table 2.
- the ‘be my agent’ segment shares some similarities with work on ‘next generation intermediaries’ which examined ways to transform how people engage with complex and essential markets (Scorer 2013, Bates 2014). There are also other examples of agent type roles, such as collective switching schemes, and some community and local authority energy schemes. Aggregators, agents and other actors offering D3 services are already playing this role for larger energy users.
- The ‘autonomous’, ‘tech focused’ and ‘hands on (Active)’ shares similarities with discussions in the UK (and elsewhere) around prosumers²². There has been a growth in the number of prosumers in the UK, linked to a rapid expansion in the installation of distributed energy resources like PV on homes and businesses in the UK²³. This has mainly been driven by the introduction of the Feed-in-tariff and previous grant schemes like Clear Skies, etc; and there has also been a growth in community energy schemes. Generally there has been an expectation that prosumers will become more common within energy systems through the ongoing deployment of DER (Sweco 2015, Kampman B. 2016).

Beyond just providing low carbon supply, prosumers and more active end users can also provide a route to wider D3 services such as flexibility through DSR, especially if linked to other technologies like energy storage (and/or electric vehicles) or the introduction of time of use tariffs. These prosumers include a range of end users, such as households, energy collectives, public entities, small enterprises; through to large industrial and commercial customers who can have on-site generation to provide power, in response to market signals or for back-up power, and CHP for on-site heat and power (Sweco 2015, Kampman B. 2016).

²² These can include individuals, households, public or private companies that move from being only energy consumers to also produce energy, or actively take part in the energy system by providing flexible demand or energy storage Kampman B., B. J. A., M. (2016). The potential of energy citizens in the European Union, CE Delft..

²³ Recent estimates from the Solar Trade Association suggest that over 1 million homes now have solar installed on their roofs STA (2016). UK reaches 1 million solar homes milestone Solar Trade Association.

Clearly these changing roles for people within the energy system either as prosumers, or via agents could become increasingly important as the energy system becomes more decentralised with growing amounts of DER. Although it is an under researched area, a recent high level attempt to model the potential, at the EU level, suggested that around 83% of EU households could become active participants in the system by 2050 (Kampman B. 2016). For the UK it was estimated that there could be up to 24 million energy citizens (prosumers) by 2050, using a range of technologies such as solar PV, wind, electric boilers, electric vehicles, demand response and energy storage, which could provide around 44% of the UK's electricity demand (FoE 2016, M. 2016). The role of people in the energy transformation is clearly going to grow in importance and we therefore need to find ways to enable this to happen, for the benefit of end users, the system and the environment as a whole.

There have been policy efforts to try and understand the potential changing role of end users within the energy system, including for example, the government's work on D3 (DECC 2014), smart energy systems (DECC 2015) and community energy (DECC 2015). Ofgem have also been researching Non Traditional Business Models (NTBMs)²⁴, which sought to map and understand some of the emerging non-traditional ownership structures within the market – see Figure 12. In analysing responses to a discussion paper they issued, Ofgem suggested that NTBMs could transform the energy system, through increasing competitive pressure, unlocking more value for consumers, driving improved consumer engagement, enhancing system resilience; and could deliver desirable consumer outcomes, in particular lowering bills, reducing environmental impact and improving services (Ofgem 2015:3). There have also been reports and analysis from business, NGOs, think-tanks, academia, etc on the potential changing role of people within the energy system (Martiskainen 2009, Anable 2011, Accenture 2013, Goulden, Bedwell et al. 2014, Platt 2014, Best 2015, UKDRA 2015, Hoggett 2016).

²⁴ Business models offering new products or services, or new ways of delivering these, that are different to those traditionally provided in the existing energy market. Those offering such services have diverse motivations (technological, financial, social and environmental) and ownership arrangements, and operate at various scales. Ofgem (2015). Non-traditional business models: Supporting transformative change in the energy market, Ofgem.

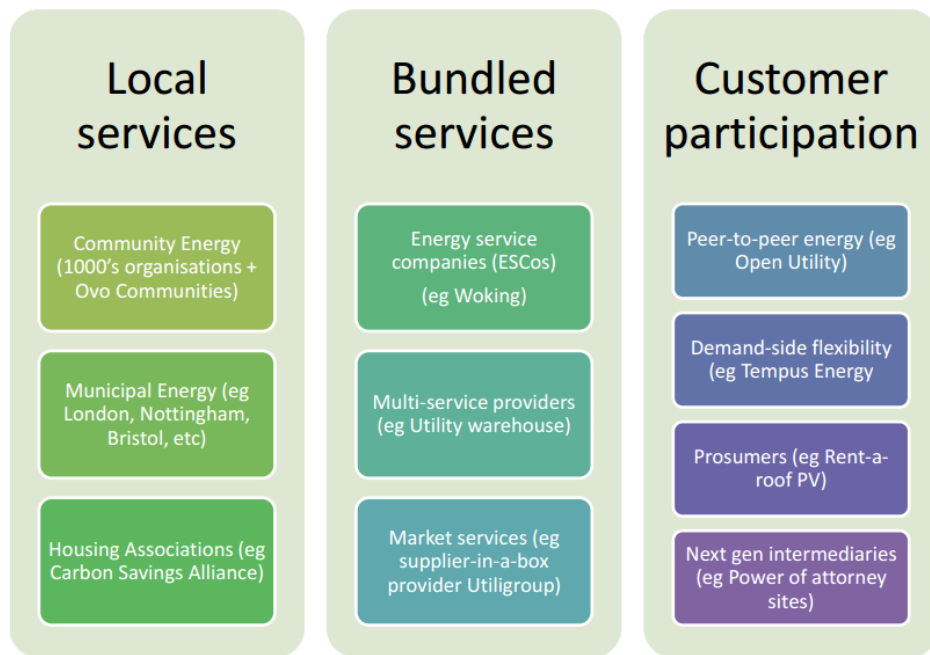


Figure 12: Ofgem summary of NTBMs

Source: (Hardy 2015)

There is an existing literature that discusses the shift away from people just being passive consumers to more active actors within the system. As well as thinking of them as prosumers, it has also been suggested that people can become energy (or green) citizens (Martiskainen 2009, Best 2015) or more broadly it has been framed in terms of 'energy citizenship' (Devine-Wright 2007), which describes a public that is actively involved within the energy system, takes responsibility for climate change and helps to improve governance, supports technological change and increases acceptance for a new type of energy system. As already highlighted people can move between these differing roles, but there is some evidence to suggest by installing DER or becoming involved in community schemes makes energy more salient helping to facilitating a shift towards a more active role in the energy future (Best 2015). Of course there will also be consumers that are less able or willing to act, which is why the wider segmentations used in New York and Australia are important. However, the way people are facilitated to become involved with system is likely to become increasingly important in enabling a more decentralised demand focus future.

4.4.3 Peer-to-Peer and Blockchain

One potentially important enabler of change, for people and the system as a whole, which Ofgem highlight in Figure 12 above is the idea of Peer-to-Peer selling/buying of energy. The ability to do this links with the development of computer code commonly described as Blockchain, but also described as a distributed ledger and shared ledger – terms that are often

used interchangeably²⁵. Blockchain is the computer code that underpins Bitcoin, a peer-to-peer digital cash system that was developed in late 2000s (Walport 2016); its functionality is described by its developers as a distributed ledger that enables individuals to transact with each other without the need of a trusted third party, like a bank (NESTA 2017). The consensus is, that whilst the work behind it was for financial transitions Blockchain has far wider potential, and is already being introduced into other sectors, including the energy sector (Proctor 2016, Walport 2016, NESTA 2017). As well as providing confidence for potential peer-to-peer transactions, Blockchain also gives individuals far more control over their personal data, which could become increasingly valuable and important in a smarter energy system. It does this by enabling people to own and maintain their own data and make decisions on who can and can't have access to it within the Blockchain (NESTA 2017).

In its role of opening up opportunities for consensus-driven, peer-to-peer transactions that allow any parties to transact with each other (Proctor 2016), Blockchain provides new ways for people to participate within markets. For example, Blockchain in combination with smart-meters and storage could open up markets for prosumers, allowing them to sell to neighbours or their neighbourhood; a move that would challenge bilateral agreements that currently exist and which favour institutionalised energy suppliers over prosumers (Fovino 2016). Examples of this are already starting to emerge. In New York a Blockchain trading mechanism is being made available as 'community energy market' on the Brooklyn microgrid; it is seeking to enable micro energy generators on one side of the street to sell their generated energy directly to their neighbours (Engerati 2016, Proctor 2016). Another example from Australia is using a Blockchain approach to allow consumers to buy, sell or swap excess solar electricity directly with each other, rather than selling it to the grid (Vorrath 2016).

These sorts of project are in their infancy, but if they take off in sufficient volume, as many expect, they will present new opportunities for people to engage within the energy system, gain more control over their energy and data, unlock and access new value, and create challenges and opportunities for suppliers, network companies and the system as a whole. There are other initiatives linked to Blockchain at different scales, such as companies developing new platforms for energy metering and billing systems could open up innovative consumer energy services, and big utilities that are actively looking at the new opportunities that it could bring to their business (Proctor 2016). There are also examples of peer-to-peer projects such as Open Utility's Piclo marketplace for renewable electricity which they have trialled with Good Energy that uses meter data, generator pricing and consumer preference information to match

²⁵ For definitions see (Walport 2016: 17-18)

electricity demand and supply every half hour (Utility 2016). This sort of peer-to-peer marketplace could be an important step towards the development of local energy markets, an area that is now starting to emerge, for example the Cornwall Local Energy Market is due to launch soon is (Centrica 2016).

4.4.4 People as investors

Another important point about the role of people within energy systems is that some are becoming investors in GB energy infrastructure, by choosing to install D3 in homes, businesses, etc. Just looking at the DER – recent data on the Feed in Tariff suggests that nearly 5000 MW of new capacity was installed by July 2016. This represents a significant investment in energy infrastructure in the GB energy system (Department for Business 2015) and whilst some of that came from large schemes, it includes a significant number of smaller scale installations on domestic and commercial properties. For example, in just looking at PV, there was an estimated 871,000 installations in total as of July 2016 - of these over 99% were sub 4kW in size, representing nearly 2,395 MW of installed capacity. The REA suggest that there are already over one million energy citizens in the UK generating or storing their own energy (M. 2016), which represents a significant investment in the overall energy infrastructure.

There has also been a rapid growth in investment in community based energy projects that have used share offers, crowdfunding and other approaches to pull in investment. Recent figures suggest there are over 5,000 active community energy groups who are generating, managing, purchasing and reducing energy and that since 2012 community share offers alone had raised over £35m (DECC 2015). This sort of data is further argument for moving away from thinking about end users just being consumers - individuals, organisations, communities are investors, not just bill payers, which is the main framing used by policy makers and the regulator currently (Rhodes 2012).

4.4.5 Understanding and consent for change

A final, but important, consideration is how people are involved in decisions around energy system change so they are able to consent to them. The Centre for Sustainable Energy have carried out work in this area, arguing that there is a need to gain 'meaningful public consent' for the way the energy system could or should develop, which they suggest are essential for achieving the goals of creating a low carbon, secure, and affordable energy system (Roberts 2014). As Roberts sets out, there has been a collective failure in recent decades to sustain and nourish public understanding and consent for energy system change and this creates a risk for what we are trying to achieve because public involvement and consent directly influences the success or failure of any policy or programme. As CSE summarise, the need to gain consent is important because people:

- pay for the energy system through their bills and taxes, so may resent initiatives which increase costs without delivering benefits which they understand or value;
- host much of the low carbon infrastructure in their communities and they could resist decisions taken without their involvement which show little by way of local benefit;
- will need to take action themselves such as changing behaviours or investing in D3 solutions. (Roberts 2014).

CSE suggest that many developers of energy projects have taken public consent largely for granted, creating a backlash, most notably against onshore wind, which ultimately led to the Government stating that a project can now only go ahead if it's backed through the local planning process (Roberts 2015). In an update on their thinking in 2016, CSE provided some helpful insight into what 'meaningful public consent' might actually look like:

"....people are quite willing to accept large scale renewable energy infrastructure in their locality provided the decisions are taken at a very local level (their ward or village) – so that they get a proper say in what happens and where. And, fundamentally, they want opportunities for local ownership and control so they have a genuine stake in the sustainable energy future which they are enabling; the same proposals emerging from a district level planning process or an external developer are given short shrift. This consent emerges from well supported local conversations involving a diverse range of local voices. Our focus for several years now has been on neighbourhood planning – that grassroots but official process which can shape the future of the places in which we live. To achieve a just and fair energy transition, we are now convinced that this process needs both much wider participation and a requirement from government that it gives due consideration to sustainable energy and the transition to a low carbon future." (CSE 2016:p7)

Meaningful public consent is then, an important part of, the energy transformation process. It also directly links to the discussion on engagement - viewing the public simply as energy consumers erodes consent, people should be viewed as "active citizens connected with one another, with views and influence" (Roberts 2014). The implication is that to create a low carbon, demand focussed system that is flexible, secure and affordable will require policy makers and wider energy actors, including companies, to consult and engage much more effectively than they have done to date.

The need for consent and the possible ways to gain it have also been highlighted by others. For example the last chapter of the Select Committee report on consumer engagement in 2012 (HCECCC 2012) flagged the need for having 'an honest conversation' with consumers over the

cost of energy, highlighting the confused nature of much of the national conversation on energy and the lack of discussion on the energy challenges the UK faces.

The need for engagement has also been flagged as an issue with infrastructure planning and development more widely. A recent report from Green Alliance highlighted that the public can feel excluded from discussions and decision making on the siting of infrastructure and that this can lead to disengagement, distrust and the risk of protest and delays (Mount 2015). The report highlighted three fundamental challenges for the current approach to infrastructure planning: 1) conventional politics alone cannot secure a public mandate for new infrastructure; 2) the public is not involved enough in defining infrastructure need; and 3) there is a gap in strategic planning, and associated public engagement, between the national and local levels (Mount 2015:2). By addressing these challenges, Green Alliance suggests that a much more people focussed approach to infrastructure development would result in *“a more strategic, effective and democratic planning system with greater public support for the resulting infrastructure projects”*. The solutions put forward to enable this include:

- the need for a top down strategic approach with the creation of a new ‘civil society advisory panel’ to help create better alignment between policies and greater transparency;
- better alignment between national policy and local plans accompanied by public dialogue;
- the creation of an impartial facilitator for public engagement a ‘Citizen Voice’ who would support the processes above and ensure effective public engagement (Mount 2015:3) –

Figure 13.

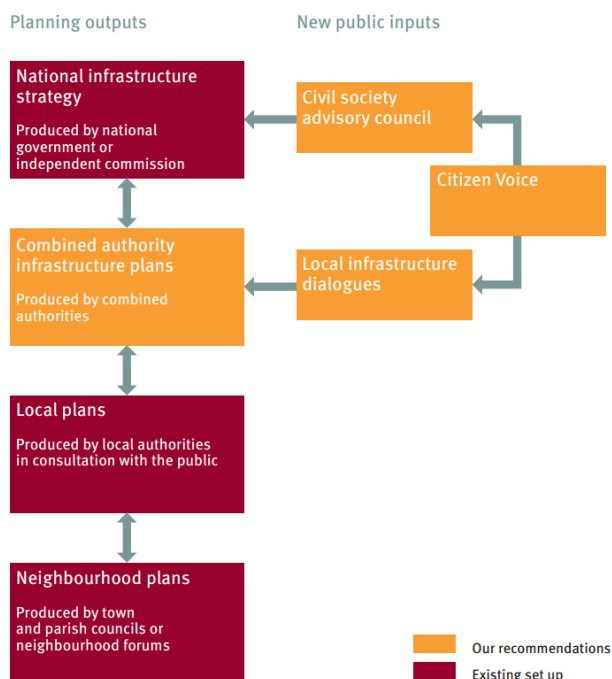


Figure 13: Building public engagement into strategic infrastructure planning

Source: (Mount 2015:4)

Some of these issues were brought together by the Energy Policy Group in a submission to the National Infrastructure Commission in 2016 (Mitchell 2016). One of the central issues highlighted within this was the near absence of meaningful debate and consent in choices about infrastructure and energy policy needs. In other countries, political systems are more able to produce stable societal consensus for large-scale long-term investments, but the UK's majoritarian system produces more short-termism, the response to which has been the delegation of long-term strategy to technocratic bodies. One of the weaknesses of this approach is that it does not, by itself, produce consensus, and decisions about politically controversial investments are not necessarily resolved through this route. To address this it was suggested that a robust and transparent means of enabling a meaningful debate, identifying a consensus, and then acting upon it is at the heart of UK's decision-making problems which would require national bodies like the NIC, to put a particular premium on not only being open and consultative, but actually helping to facilitate greater consensus between societal groups. In the past, something of this role was played by Royal Commissions, especially standing Commissions such as that on Environmental Pollution, which existed for over 30 years. A possible option put forward to address this would be a body specifically for this energy sector, although it could also be part of the NIC's role or incorporated into other institutions (Mitchell 2016:1-2).

Importantly there is a body of research funded through UKERC and a number of subsequent papers that have looked at public values and perspectives on whole energy system change (Parkhill 2013, Pidgeon 2014, Butler, Demski et al. 2015, Demski, Butler et al. 2015). These have demonstrated that a varied cross-section of the British public are positive about the need for energy system change, and that this is both wanted and expected in terms of the way that energy is supplied, used and governed (Parkhill 2013). This includes a strong public preference for a shift towards renewable energy and away from fossil fuels, as well as a commitment to improve energy efficiency and reduce energy demand, and the development of technology and infrastructure to support lifestyle changes. These link to, and highlight the importance of, some emerging values within the research including a view *"(a) that society should in the long term be moving away from the exploitation of finite (typically fossil fuel) resources in favour of renewable technologies coupled with (b) greater efficiencies and a reduction in energy use as a whole"* (Pidgeon 2014:26). How willing the public are to accept energy system change depends on how well it fits into their set of values including these and wider ones such as social justice, avoiding energy waste, protecting the environment, having a secure energy supply, and gaining a real system improvement (Parkhill 2013).

In addition the UKERC research showed the public is “*perfectly capable of deliberating complex issues of energy policy and technology with which they have little day-to-day familiarity*” providing that they are given the right tools, information and opportunity to do so (Pidgeon 2014:27). The same report makes clear the importance of social dimensions in system change – public perspectives “*..are never solely about technology, but are ultimately about what the technology symbolises and represents, as well as people’s views on the actors, institutions and processes embedded in system change*”. These insights, along with the importance of people’s values, highlight the need for, and potential opportunities to be gained, from engaging the public in system change and as such can help for the basis of a social contract for change (Parkhill 2013).

Arguably, the energy system we have is centralised, top down, supply focussed, in respect to the infrastructure that is in place and the fuels that are used to provide energy services. This linear one way design of the system is for the most part mirrored by the governance system that is currently in place, which is also top down, centralised, technocratic and expert-led, with policies and approaches that barely acknowledge or seek engagement or consent from the public (Roberts 2014). As Roberts highlights, whilst that may have worked to date, it ultimately loses traction and has led to some clear policy failures like the Green Deal. If it is recognised that people are central to how the system develops, the policy and governance approach will need to be turned on its head to consider the change from both the top down and bottom up. This includes the importance of gaining public acceptance and consent, based on values and building real engagement for what is happening, which in turn links to the overall governance of the energy system.

4.5 The Importance of Governance

A central problem for transforming the energy system is that the governance arrangements that are in place shape the design and implementation of regulations, markets and institutions. As such, in its widest sense, the governance framework is what ultimately shapes the way in which actors make money within the energy system, and it influences which actors, technologies and approaches are encouraged, undermined or excluded (Mitchell 2010, IGov 2012). Getting the governance system right is therefore a key aspect in enabling an effective energy transformation as it plays a central role in the technical, economic and social changes that occur.

In addition, the governance framework will also largely determine how end users are viewed and treated within the system. It can influence how active or not people might become in the system, including things like technology acceptance/adoption and behaviour change. It can also

shape what role people play as decision makers within system change nationally, regionally and locally. Governance is also the means by which ‘consumers’ are represented across the various institutions operating within the energy system; as well as protected i.e. going forward it will be important that sufficient safeguards are built into the system to protect those end users that are vulnerable or unable to engage.

An issue currently, as the IEA recently reported, is that as technology races ahead, both infrastructure and regulation are lagging behind, If this continues, they suggest it could undermine security and the low carbon transition itself (IEA 2016), it is also very likely to increase the cost of the transition. It is, then, slowing down the pace of the energy transformation as we are lacking the strong government intervention that, as highlighted above, is needed to enable change to occur more quickly (Sovacool 2016).

Looking at the current situation, IGov has argued the current governance framework has slowed down change (Catherine Mitchell 2014), and still continues to do so, recent examples including the way that the demand side is treated in the capacity market (Lockwood 2014); and the significant amendments to demand side policies in recent years – see Section 6. There are a number of challenges that have to be addressed in order to move from the current energy system to one which is clean, secure and affordable – Figure 14.

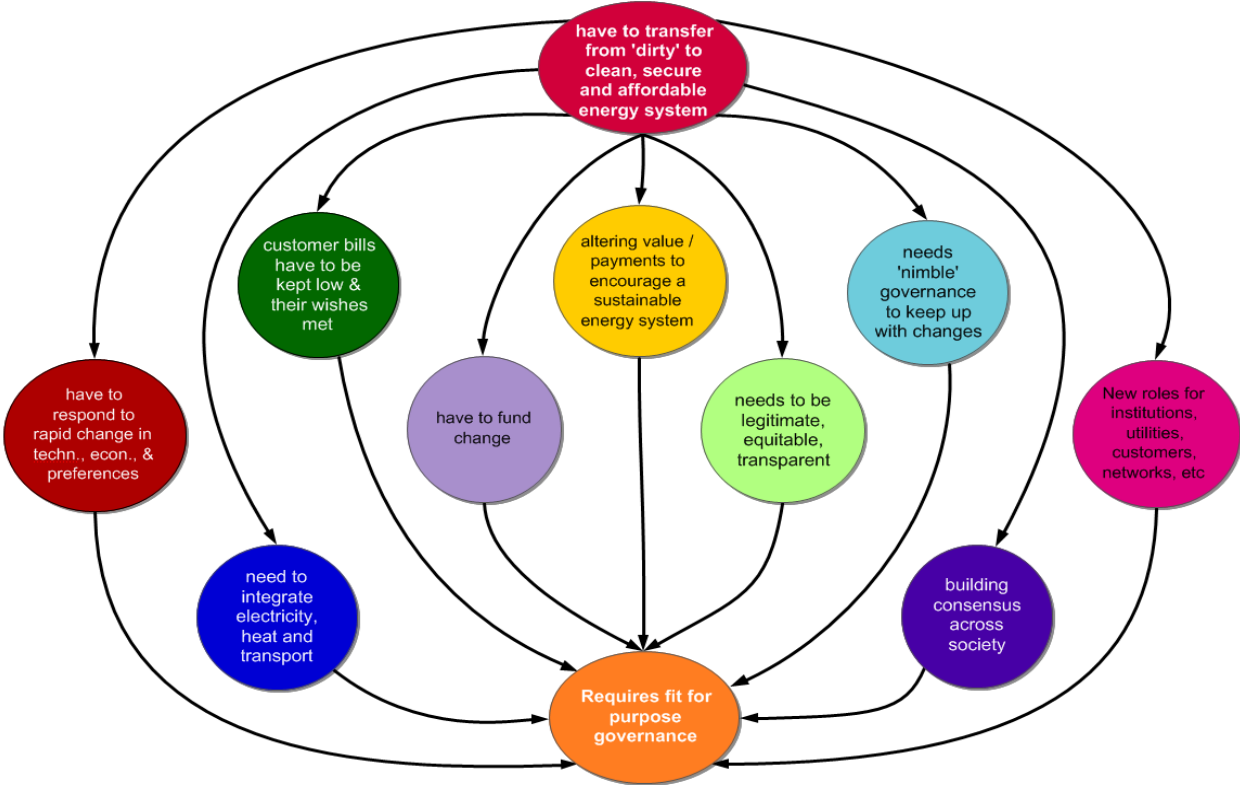


Figure 14: General challenges of transforming energy systems
Source: (Mitchell 2016)

Meeting these challenges and responding to the wider changes that are occurring within the system (towards a decentralised, demand, and people focussed system), will require institutional reform. Fundamentally, many of these challenges relate to governance and inertia within governance of the energy system (Mitchell C. 2016). As the IGov team have argued, the current institutional framework is not fit for purpose for facilitating innovation and transformation (Mitchell 2016).

Broadly then, there are a wide range of changes occurring within energy systems and regulations and overall governance of the system also needs to change, not least in order to keep up with this momentum. Arguably, the shift towards a sustainable energy system is increasingly about how to manage and operate the system and the political will to enable and embrace change (Mitchell 2015); and this requires a no-regrets view to system change based on reducing and managing demand, providing supply through renewable sources and having a flexible approach to keep demand and supply in balance (Mitchell 2015). Such a system would provide and value flexibility via a diversity of renewable energy supply, demand side response, storage, interconnectors and have (minimal) flexible fossil fuels. It will also put people at the centre of decision making. These issues and an institutional framework that might better enable it to happen are returned to in section 7.

This section has considered the relationships between energy demand, end users and governance. It has set out a number of issues that need to be addressed to enable the effective transformation of the energy system. It has argued that central to this will be to recognise the role of people within the energy system, so that they become active and engaged in system change. Changes to the governance system will be central to enabling this to happen. It will also be important to rethink the relationship between demand and people and the next section considers demand in more detail at the national level, across sectors, before focussing specifically on what is happening within the domestic sector.

5. Energy Consumption in the UK

This section provides a brief summary of historic and current trends in energy consumption within the UK. This includes total demand, the fuel mix, and then the level of demand from the four main sectors used within national statistics i.e. industrial, domestic, commercial (or ‘other final users’ – which comprise public administration, commercial, agriculture), and transport. This high level data provides some insight in trends in demand within and between sectors, but provides little detail of what is behind that demand.

It is also noteworthy, that historically national statistics on energy aggregate data on large geographic areas, which can be of limited value to many research, policy or public interest uses, where more granular data is often required (Elam 2016). As Elam highlights, there are some sources of finer level detail, for the domestic sector, including sub national datasets, nationally representative surveys, various projects and pilots, etc, but there are several issues with these that limit their utility. There are also recognised issues with data in other sectors, for example there are increasing problems with industrial demand data where energy use is often allocated to ‘other industries’ or is unclassified – both globally and within the UK (Skea 2013). The effective roll out of smart meters should help improve our data and understanding of demand, subject to the rules on access to it – see section 3.2.5.

5.1 National and Domestic Energy Demand

5.1.1 Primary and final energy demand

The national energy balance for 2015 suggests that total ‘primary energy demand’²⁶ stood at 202.5 million tonnes of oil equivalent (mtoe) (DBEIS 2016). This demand is broken down in Figure 15, showing that around: 4% is for non-energy use²⁷; 22% is from losses in transformation processes and distribution; 6% is from consumption within the energy industries; and 68% (145.7 mtoe in 2014) is used by end users (DBEIS 2016). This consumption by end users is generally referred to as ‘final energy demand’ (Skea, Xinxin et al. 2011) and it is this final energy demand that is the main focus of this working paper.

²⁶ Primary energy is the level of consumption prior to any losses due to conversion or transformation.

²⁷ This includes the consumption of energy products which have not been used to directly provide energy, e.g. chemical feedstock, solvents, lubricants and road making material (DECC 2014b).

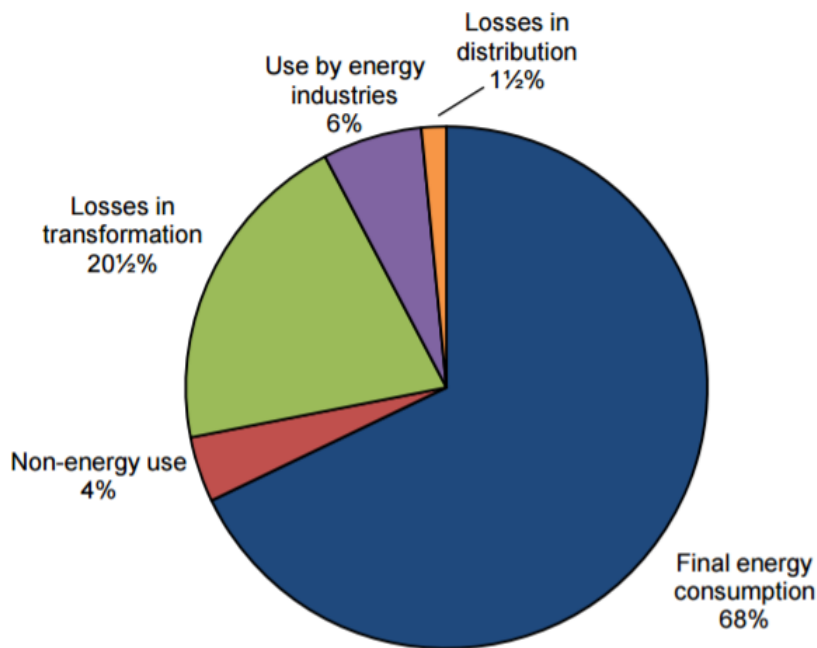


Figure 15: Primary Energy Demand 2015

Source: (DBEIS 2016:15)

Figure 16 shows the long term trends in total primary energy demand and its relationship to final energy demand. It shows that final energy demand is around two thirds of the UKs total primary energy demand, a ratio that has been relatively consistently in recent decades (DECC 2012).

Looking first at the historical trends in the UKs total primary energy demand (unadjusted for temperature) it can be seen that until recently, this has fluctuated between 200 and 240 mtoe per annum. Two significant dips occurred pre-1985 reflecting policy and market responses to two oil crises, which was then followed by a steady growth in demand (Skea, Xinxin et al. 2011). Demand peaked in 2001 at nearly 237 mtoe and since then has shown a steady decline, albeit with some jumps, primarily as a result of fluctuating temperatures, it stood at 195 mtoe in 2015, the lowest level since 1970 (DECC 2015).

The changing levels of primary energy demand are influenced by a wide range of factors, such as: structural shifts within sectors, such as a decline in manufacturing; changes in fuel prices; changes in household numbers and type; and fluctuating temperatures. In addition, there has been a decline in energy intensities²⁸; improvements in energy efficiency; reductions in energy consumption; fuel switching; and the recession. Collectively all these factors help to explain the steady downward trend in demand (Skea, Xinxin et al. 2011, DECC 2012, DECC 2014), whilst

²⁸ "Intensity is defined as the amount of energy consumed per unit of output" so a fall in intensity can be an indication of improvements in energy efficiency or a move to less energy consuming activities DECC (ECUK 2014)

also making straightforward assumptions about the main drivers behind it complicated (Hoggett 2013).

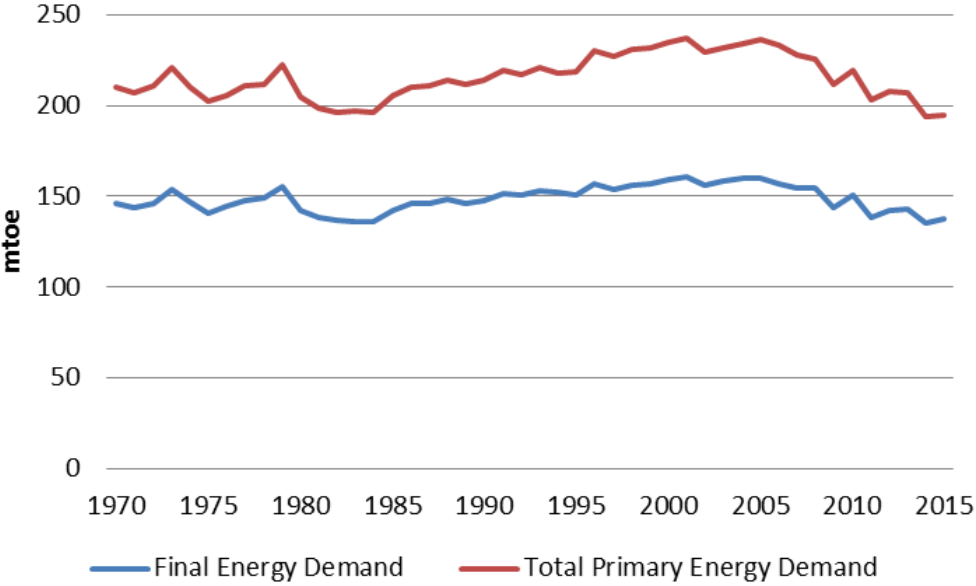


Figure 16: Total Primary Energy Demand and Final Energy Demand 1970 – 2015

Source: (DBEIS 2016) Tables 1.02 and 1.10

In respect to historic trends in final energy demand, it can be seen that this varies from year to year, and has until recently been somewhere between 140 – 150 mtoe per year²⁹, in 2014 it fell to its lowest level at 135 mtoe. As highlighted above, a number of factors influence this, although temperatures play an important part in final energy demand, especially in respect to space heating demand; DECC suggest that two of the largest reductions in demand since 2010 were mainly influenced by mild winters that reduced gas consumption (DECC 2015).

5.1.2 Final energy demand and the fuel mix

Figures 17 and 18 set out the fuels that have been used to meet the level of final energy demand, and how these have changed with time. Excluding those fuels used for electricity generation³⁰, it can generally be seen that there has been a significant shift away from solid fuels which provided over 30% of final demand in 1970 to less than 2% in 2015. That petroleum use fell during the 1970s, mainly as a response to the oil crises (Skea, Xinxin et al. 2011), but remains the dominant fuel, accounting for around 45% of final energy demand in 2015. Gas use

²⁹ Although demand appears to have remained at a reasonably steady level this has happened over a time of considerable growth in the UK’s GDP, so reflects the that more wealth has been generated for every unit of energy that is used. A good summary of this is available from Simon Evans on Carbon Brief: <http://www.carbonbrief.org/blog/2014/07/six-charts-that-show-how-challenging-decarbonising-the-uk-really-is/>.

³⁰ This includes natural gas, coal, nuclear, renewables and oil – a useful summary of percentage share of these different fuels is available in DUKES online version (Chapter 5: Long term trends in electricity and chart 5.1.1) https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/454484/DUKES_2015_Long_Term_Trends.pdf

has shown a significant growth (Skea, Xinxin et al. 2011) and now accounts for around 30% of final demand. Electricity use has steadily increased over time, accounting for around 19% of final demand in 2015; whilst bioenergy, waste and heat sold have gradually increased, their use remains low level compared to other fuels (DBEIS 2016).

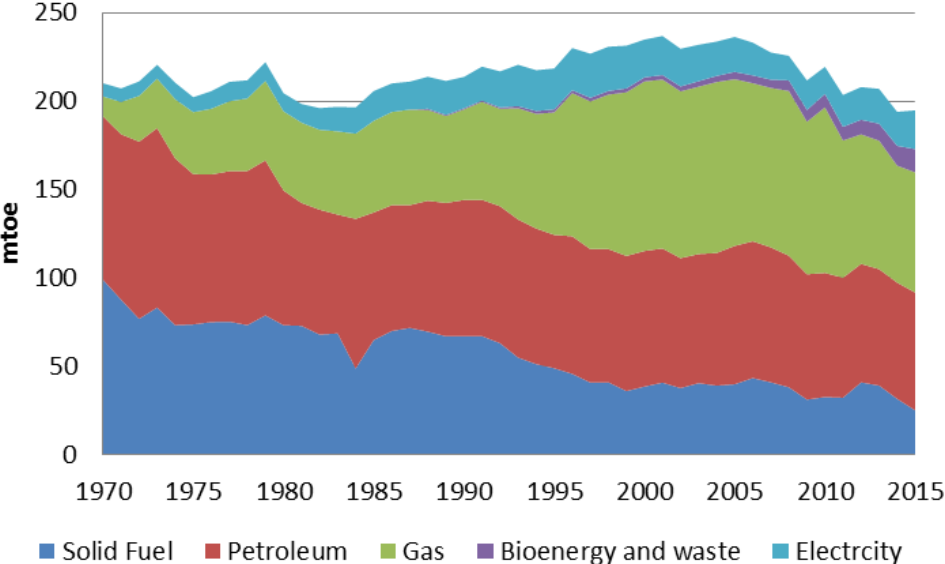


Figure 17: Final Energy Demand by fuel 1970-2015

Source: (DBEIS 2016: table 1.10)

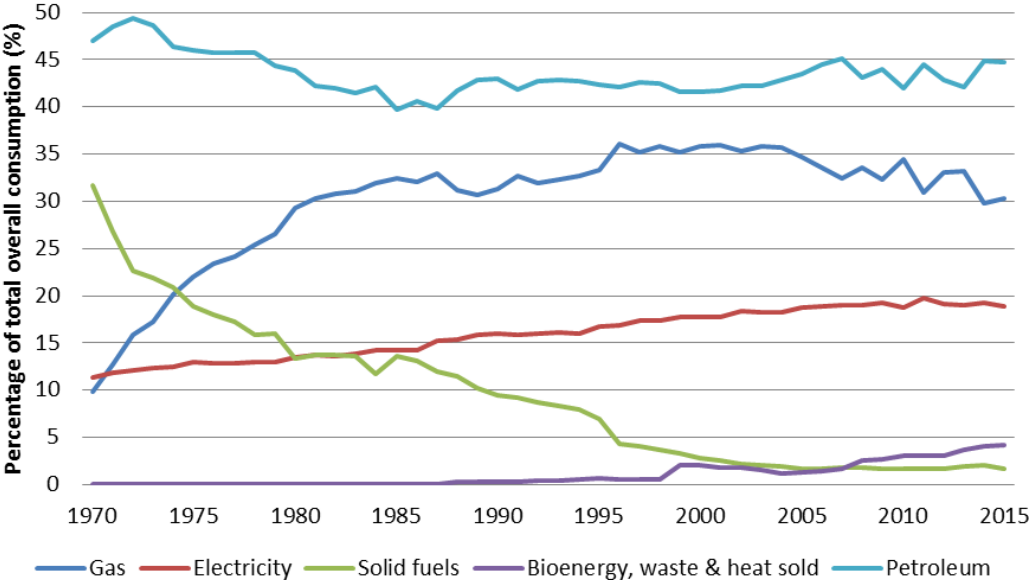
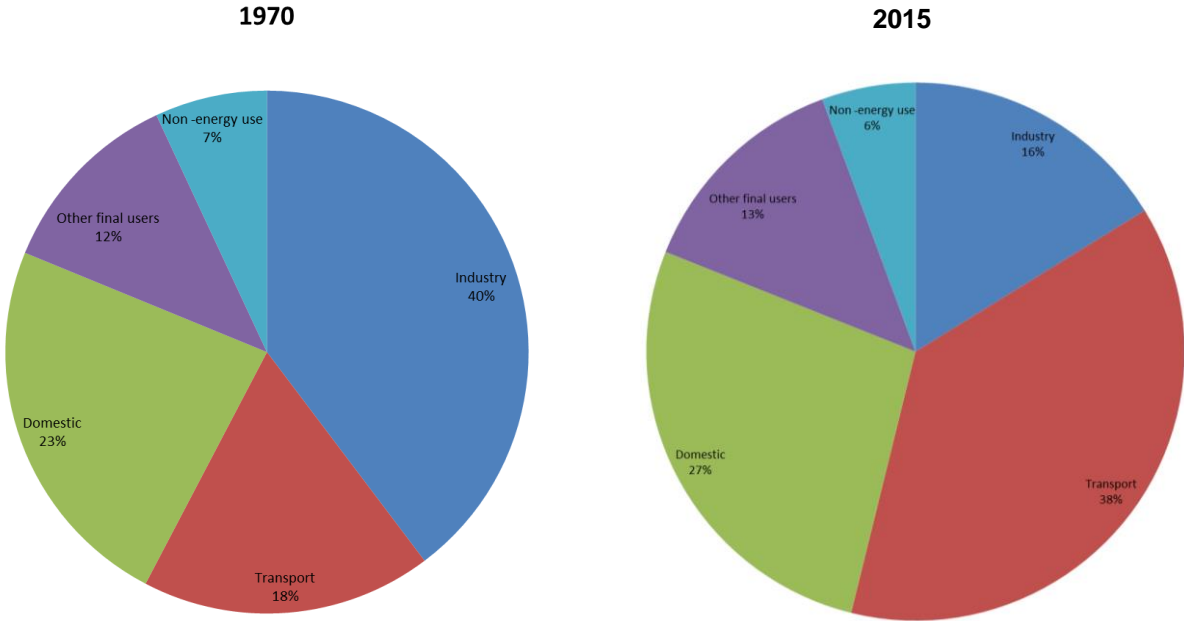


Figure 18: Final Energy Demand Percentage by fuel 1970-2015

Source: (DBEIS 2016: table 1.02)

5.2 Final Energy Demand by Sector

Before moving on to look at the domestic sector in detail, it is useful to put this into context with all the sectors that make up final energy demand. Figure 19 and its accompanying table show the split in final energy demand in 2015 and show how this has changed since 1970. Although the percentages vary from year to year, it can broadly be seen that final energy demand for other final users and non-energy use has remained fairly static; that there has been a significantly reduction in demand within the industrial sector; whilst there has been a growth in the share of overall demand for both the domestic sector and more noticeably the transport sector.



	Industry	Transport	Domestic	Other final users	Non -energy use	TOTAL	mtoe
1970	62.3	28.2	36.9	18.6	10.9	156.8	
2015	23.6	54.8	39.6	19.4	8.2	145.6	

Figure 19: Final energy consumption by sector in 1970 and 2015

Source: (DBEIS 2016: table 1.01)

Figures 20 and 21 provide further insight into the sectoral shifts in final energy demand, showing the historic record from 1970 to 2015, and the non-stacked trends since the 1980s. As highlighted above, there are numerous reasons behind these changes and it is only by looking at each sector in detail can a better insight be gained. Looked at the trends in recent decades it is clear that since the late 1980s the main share of consumption has been for transport, followed by the domestic sector, whilst industry demand fell to close to the level used by the service sectors.

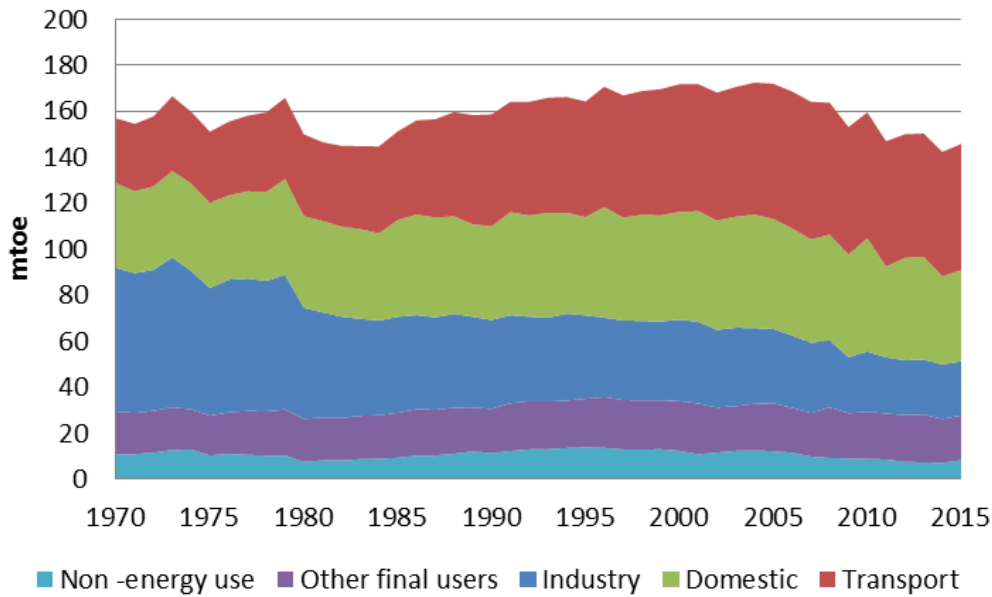


Figure 20: Final energy consumption by sector 1970-2015

Source: (DBEIS 2016: table 1.01)

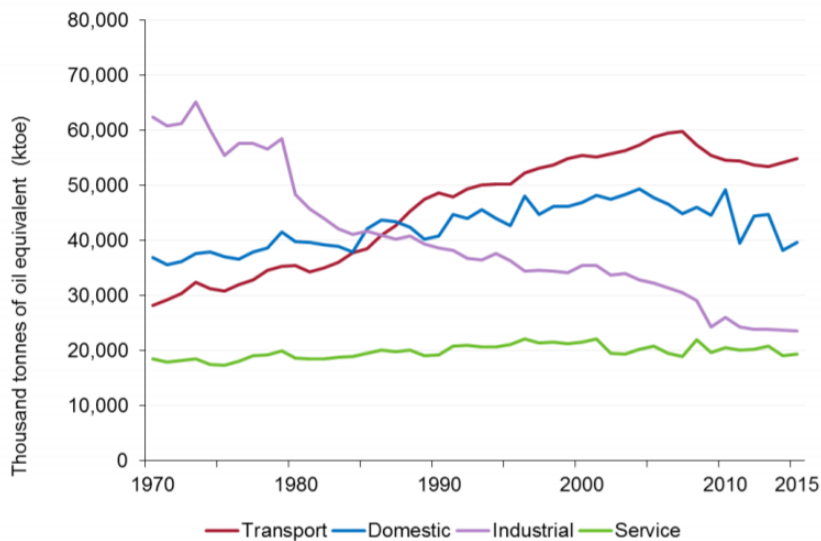


Figure 21: Final energy consumption by sector 1970-2015 (non-stacked)

Source: (DBEIS 2016: 7)

Understanding how this total consumption breaks down in terms of end use by sector is problematic and is no longer updated in national statistics. The exact reason for this is not stated although based on the commentary provided (DECC 2014) it seems likely that gathering robust information on actual end use may be the problem, particularly within the industrial and service sectors. The latest analysis on end use by sector was for 2013 and is shown below in Figure 22. It can be seen that there are considerable similarities between end uses in the

domestic and service sectors, with space heating being the main source of energy use. Within the industrial sector end use is far more diverse.

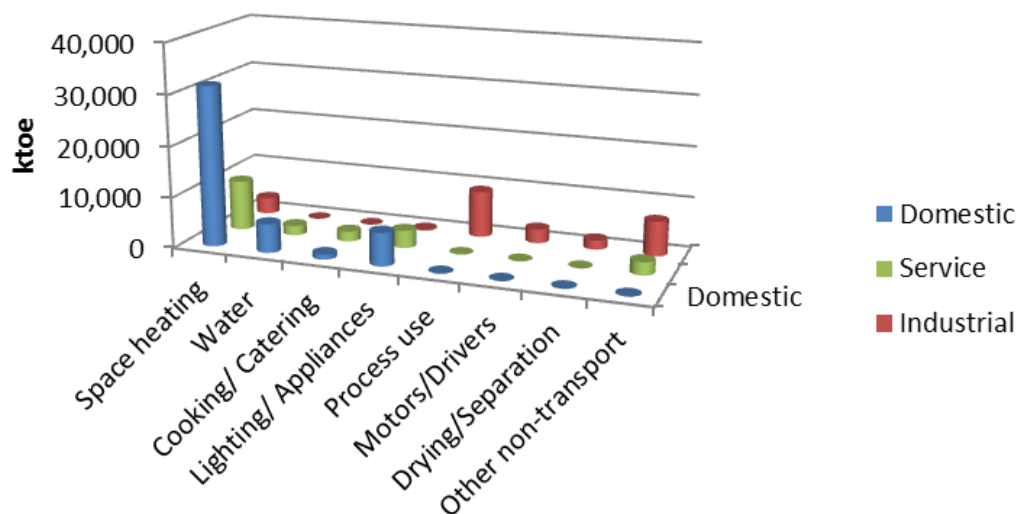


Figure 22: Summary of energy consumption by end use by sector 2013

Source: (DBEIS 2016: table 1.03)

Further insights on the level of demand between sectors can be gained by looking at volume sales of electricity and gas (within Great Britain). Table 3 from Cornwall Energy (Energy 2016) shows that in terms of electricity around 35% of power is used by households and they account for 91% of all customers; whilst the 9% of customers within business sector account for around 65% of total demand. In terms of consumption, total demand is around 288 TWh (approximately 25 mtoe) of electricity (100 TWh in households, 188 TWh in business). For gas, the domestic sector accounts for 96% of all customers and around 55% of consumption (301 TWh) whilst the business sector account consume around 239 TWh and account for just 4% of customers. In terms of total consumption this is around 540 TWh (approximately 46 mtoe). Around 85% of households with access to both gas and electricity have dual fuel contracts.

Fuel	Demand	Household*	Business*	All
Electricity	Customers (k)	27,510	2,665	30,175
	Consumption (TWh)	100	188	288
Gas	Customers (k)	22,795	876	23,671
	Consumption (TWh)	301	239	540
Household dual fuel	Customers (k)	19,435	N/A	N/A
	Dual fuel as % gas accounts	85.2%	N/A	N/A

Source: Cornwall Energy. Household customers are accounts, business customers are meters live on supply at reporting date. Consumption is energy volume billed to customers in the year to the reporting date. Household and business figures are for the year to 31 October 2015.

Table 3: Overview of British electricity and gas market

Source: (Energy 2016:10)

The Cornwall Energy analysis (Energy 2016) further breaks down business energy use into Small and Medium size Enterprises (SMEs), including micro-business³¹ and Industrial and Commercial (I&C), including the public sector – Table 4. In electricity, SMEs account for around 68% of total customers, but only 20% of the total consumption (37 TWh or 3.2 Mtoe); whilst the 80% share of electricity consumption by I&C customers accounted for 151 TWh (13 Mtoe) of demand. In terms of gas, SMEs comprise around 73% of the business market customers, but only 16% of the demand (37.9 TWh), whilst volume sales for I&C for the year stood at 201 TWh (17 Mtoe) (Energy 2016).

Fuel	Demand	SME	I&C	All
Electricity	Electricity meters (k)	1803	862	2665
	Electricity volume (TWh)	37	151	188
Gas	Gas meters (k)	642	234	876
	Gas volume (TWh)	37.9	201	238.9

Table 4: Breakdown of business energy accounts and consumption 2015

Source: Adapted from (Energy 2016):11

To get a sense of the average levels of consumption across these different sectors:

- average consumption with the households in 2015 was around 3938 kWh of electricity and 12,962 kWh of gas³² (DBEIS 2016)
- average electricity consumption within SME’s for the year to 31 October 2015 was 20,521kWh of electricity and 56,398kWh of gas (Energy 2016)
- average electricity consumption with I&C customers was 175,174kWh and for gas average consumption was 857,265kWh (Energy 2016).

It is apparent in the above analysis, excluding transport, that although most customers sit within the domestic sector, much of the total demand sits within the other sectors, particularly the I&C sectors. This highlights the need to take action across all sectors (and all fuels) in order to transform the energy system. It is not possible within the scope of this paper to provide a detailed overview of the drivers of demand in each of these sectors, so instead the next section goes on to look at detail at just the domestic sector, to provide an example of the sort of complexities involved in trying to understand demand in any sector.

³¹ Micro-business is a regulatory definition which from 31 March 2014 captures businesses that: consume less than 100,000kWh of electricity per year; or consume less than 293,000kWh of gas per year – Cornwall Energy 2016
³² These household consumption figures have not been adjusted for temperature.

5.3 Domestic Energy Demand

This section takes a detailed look at final energy consumption within the domestic sector, which accounts for the around a quarter of the UK's final energy demand³³. Understanding this energy demand is complex as it relates to a wide range of variables from the type, tenure and location of homes, through to the various appliances and equipment that are used (and their efficiency) and people's energy use behaviour. Although only a high level summary, it shows the complexity involved when trying to understand what role the sector could play within the energy transformation. Other sectors will have different characteristics and challenges, clearly all need to be understood to develop effective approaches to engaged and encourage D3.

5.3.1 Sector overview

Within the UK there are around 27.5 million households, up from 18.8 million in 1970, and during the same time the population has increased by around 17%, resulting in a reduction on the number of residents per household (DBEIS 2016). As DBEIS (2016) highlight, whilst generally a household with fewer occupants will result in lower consumption per household, the increase in the number of households tends to increase consumption as a whole. In terms of the housing mix, this comprises different types of property e.g. detached, semi-detached, flats, etc. and different tenure types e.g. owner occupier, privately rented, social housing, etc – Figure 23. The majority of dwellings are in the owner occupier sector (around 63% in 2013), followed by the private rented sector (19%). Since the mid-2000s there has been a significant growth in the private rental stock and a growth in social housing, whilst the decline in local authority housing is attributed to a large scale housing stock transfer, low new-build rates and the introduction of right to buy (Beckett 2014).

³³ This is also around 15% of the UK's carbon dioxide emissions, although demand and emissions vary from year to year depending on temperature and the impact this has on heating demand:
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/416810/2014_stats_release.pdf

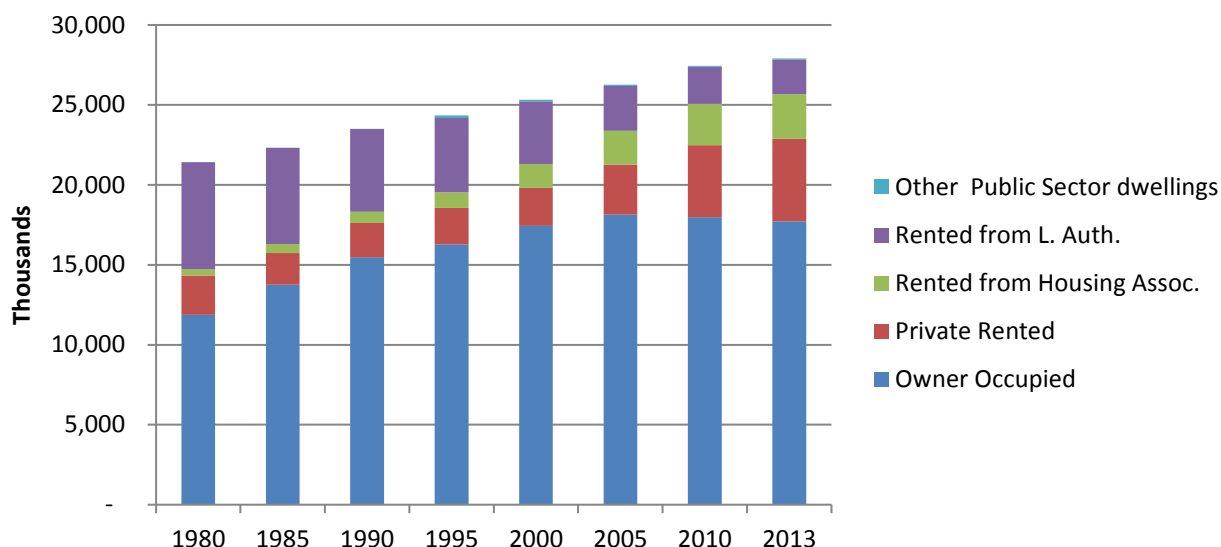


Figure 23: UK Dwellings numbers by tenure type 1980 – 2013

Source: (DCLG 2015): Live Table 101

The type of property and tenure type can influence the potential for taking action on the demand side and the overall demand for energy. For example in the case of housing type, one factor influencing the level of heating demand is the external wall and window area – flats have less of these per floor area, so compared to detached/semi-detached houses they have lower levels of heat loss (Palmer 2014). In respect to tenure Palmer (2014) suggests that there is expectation that housing in the registered social landlord and local authority housing to have above average energy efficiency, followed by owner occupier homes, with private rented homes tending to have below average energy performance (part of a well-recognised split incentive that exist between the tenant and landlord in the private sector). Some of these issues will be returned to later.

There are a number of other insights provided in the UK Housing Energy Fact File 2013 (Palmer 2014) that are worth mentioning. Firstly the geographic location of a property can impact energy use as some parts of the UK have more severe winters, stronger winds, etc – which influence heating requirements on any particular day. The majority of the UK housing stock is within England – Figure 24 and generally speaking there is a very slow shift in the concentration of housing towards milder parts of the UK – mainly the Southwest, South and Midlands. The location of a dwelling also impacts what government support or advice for demand side measures may be available due to devolved powers³⁴.

³⁴ In Scotland and Wales, the encouragement of energy efficiency is devolved, while the regulation of energy efficiency is reserved; whilst the promotion and regulation of energy efficiency is devolved to Northern Ireland https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/65602/6927-energy-efficiency-strategy-the-energy-efficiency.pdf

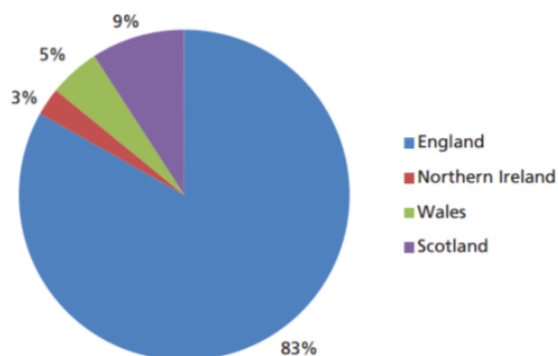


Figure 24: Distribution of housing in UK (2008)

Source: (Piddington J. 2013)

The age profile of homes, demolition rates and replacement rates also impact energy demand. Both demolition rates and replacement rates are low, so the overall housing stock only changes slowly. This impacts the demand for space heating as the level of insulation and efficiency of the heating system are generally related to the age of a property³⁵. The age profile of homes (in England) is shown in Figure 25 – it can be seen that a large part of the housing stock across all housing types is relatively old. This is important because new housing tends to be more energy efficient, due to ongoing improvements in building regulations.

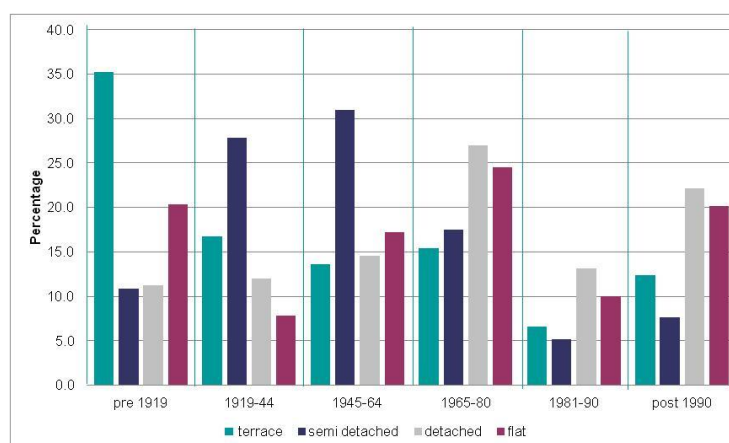


Figure 25: Dwelling type by dwelling age (England – 2013 data)

Source: (DCLG 2015): Chapter 1 - Tables, Figures and Annex Tables

³⁵ Whilst the efficiency of heating tends to improve with time, due to natural replacement of systems with more efficient options, it is less straight forward in respect to thermal efficiency within homes, particularly older stock that are difficult or costly to retro-fit with insulation measures.

The current energy performance of the UK housing stock is shown in Figure 26 – it can be seen that as of 2012 a very large percentage of the stock has an Energy Performance Certificate at band D or lower. The implication being the stock is generally of poor quality in respect to energy efficiency and the scope for improvement is therefore significant. As (Boardman 2007) highlighted in her strategy for achieving an 80% cut in carbon dioxide emissions in the housing market, the efficiency of the stock will need to shift towards an average at the top of band C (SAP 80) a level other organisations have also called for (Council 2014).

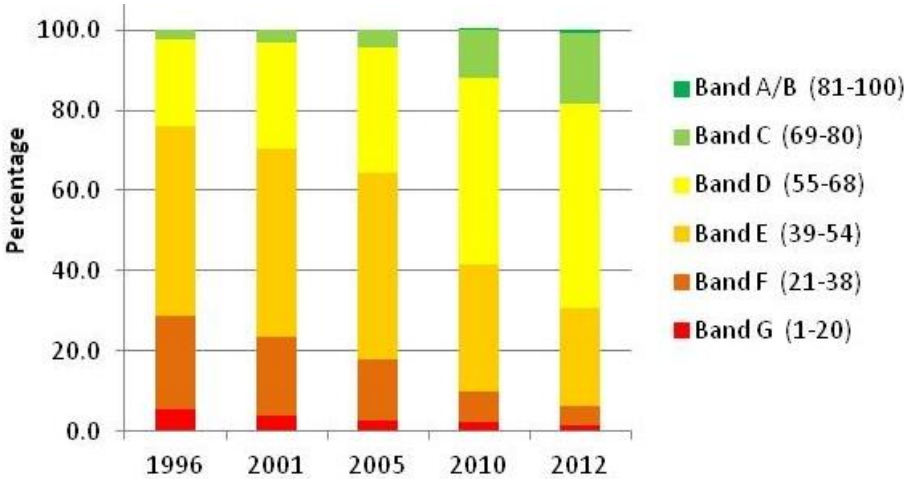


Figure 26: English housing energy efficiency ratings & EPC Bands
Source: (Wilcox 2015): table 24

All of this is important because a large part, maybe as much of 80%, of the current stock will still be in use by 2050 (Boardman 2007). This implies that there is a considerable effort will be needed to improve the efficiency of existing housing and there have been growing calls to make homes and energy efficiency a national infrastructure priority (Council 2014, Molho 2015). This context provides an overview of many of the factors that influence the level of energy demand in homes, as well as some of the possible opportunities and barriers for taking demand side action, particular in respect to energy efficiency. The next section goes on to consider in more detail the level of demand, how this has changed with time and what some of the drivers and influences within the sector are, beyond the more structural issues highlighted above.

5.3.2 Total domestic final energy demand

The long term trend in final energy demand within the domestic sector is shown in Figure 27. The most obvious thing to note is the annual variability in demand, which is primarily due to changes in temperature from one year to the next, which influence energy use for space heating (returned to below). Generally speaking peaks in demand occur in cold winters and troughs occur when it is mild. This aside, it can be seen that final energy demand within the sector gradually increased from the 1970s peaking in 2004s at 49.3 mtoe, since then demand has

declined to just 39.6 mtoe in 2015, or 42 mtoe when seasonally and temperature corrected (DBEIS 2016). The significant falls in demand in 2011 and 2014 are due to mild winters in these years, whilst the steadier decline since 2004 is likely to reflect both improvements in the thermal efficiency of the housing stock and the installation of more efficient heating systems (Hoggett 2012). The decline in final energy demand has happened despite an increase in the number of households and the size of the UK population (DECC 2015).

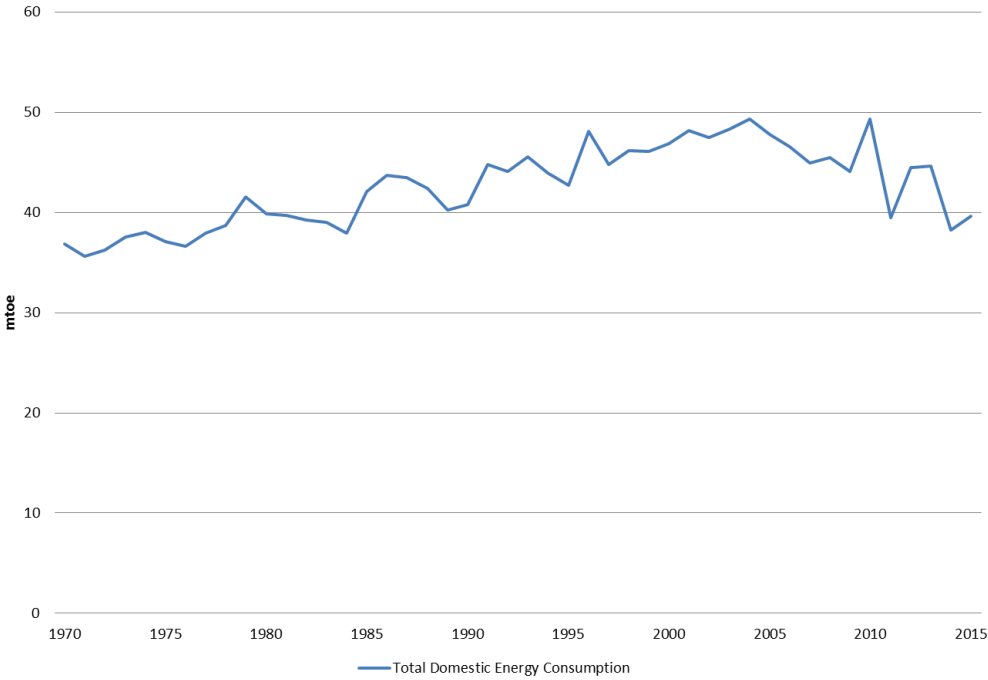


Figure 27: Total Domestic Energy Consumption (1970-2015)

Source: (DBEIS 2016): table 3.01

5.3.3 The fuel mix and end use

The final fuel mix to meet demand within the domestic sector in 2015 is shown in Figure 28 and the historic trends are shown in Figure 29. The dominance of natural gas in the domestic sector is clearly evident, showing gas met 63% of final demand, compared to 24% electricity, 6% oil, with the rest coming from solid fuels, bio energy and waste. Looking at the historic trends, a clear shift in the fuels used to meet final demand is seen. The most significant changes are the dramatic fall in the use of solid fuels, the growth in the use of natural gas and a gradual rise and then levelling off in the use of electricity.

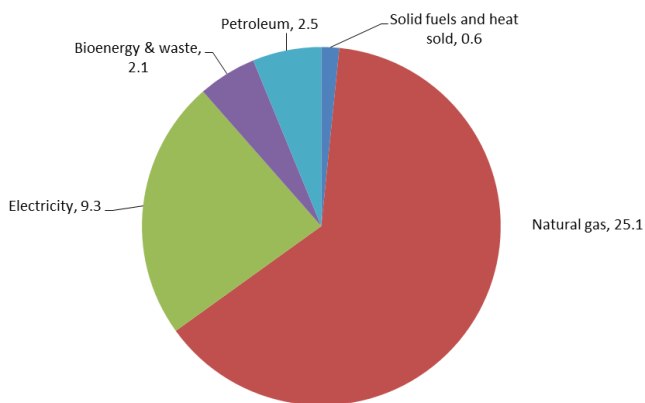


Figure 28: Domestic consumption in the UK by fuel 2015 (Mtoe)

Source: (DBEIS 2016): table 3.01

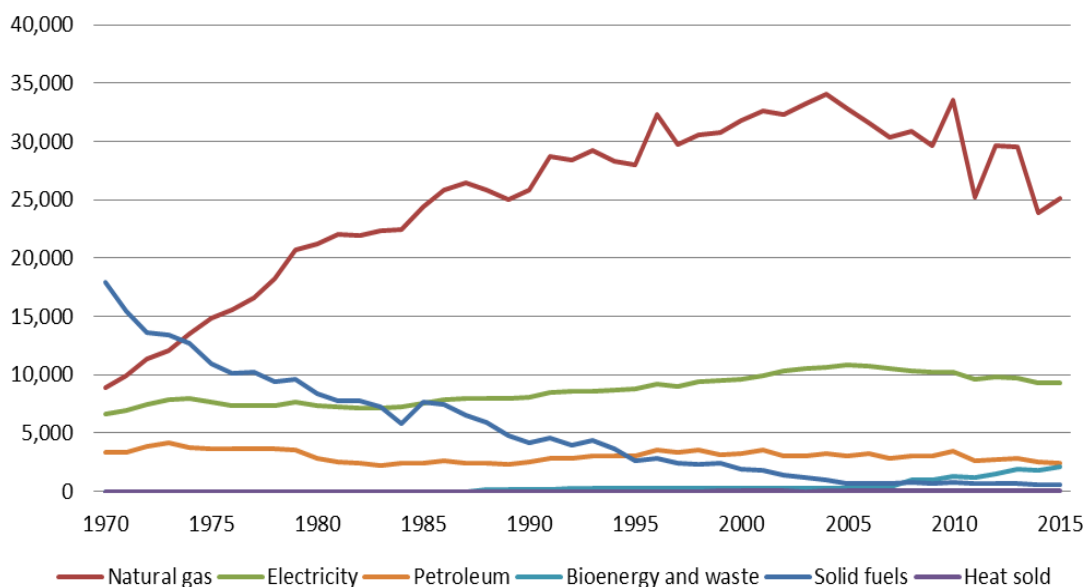
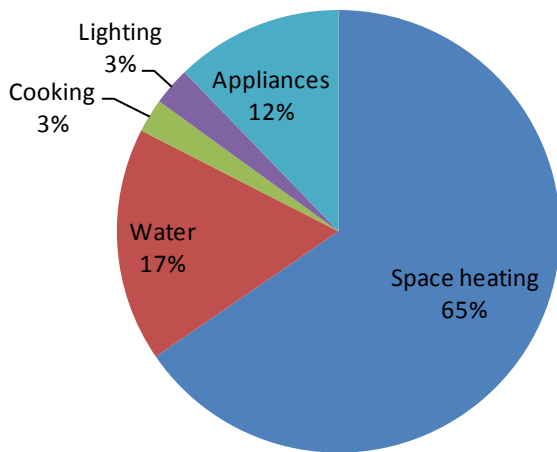


Figure 29: Historical Domestic consumption in the UK by fuel 1970 to 2015

Source: (DBEIS 2016): table 3.01

Understanding end use in homes is based on modelling and such is subject to a range of uncertainties (DECC 2015), so the figures used in the following series of charts only give an indication of the possible level of energy service demand. That aside, the 2013 modelled data (the last year currently available) is shown in Figure 30. What is immediately apparent is the dominance of heat demand within the sector – space heating accounts for around two thirds of final demand and when hot water is taken into account over three quarters of final energy demand is for heat. Although susceptible to temperature fluctuations, this demand for space and water heat accounts for around 80% of final energy consumption in homes (DBEIS 2016).



End Use	mtoe
Space Heating	29.3
Water	7.7
Cooking	1.1
Lighting	1.2
Appliances	5.5
Total	44.6

Figure 30: Domestic energy demand by end use 2013

Source: (DECC 2015): table 3.04

When the fuel mix and end use are brought together, the importance of gas in providing energy services is immediately apparent. Leaving aside, appliances and lighting, gas plays a central role in providing space heating, hot water and cooking – Figure 31. There are a number of reasons this fuels dominants, firstly most homes (around 84%) are on the gas network, secondly gas is a relatively cost effective fuel compared to alternative fuels for space heating, and finally there is an established supply chain in place in respect to infrastructure, manufacturing and installation/maintenance of heating systems (Hoggett 2012).

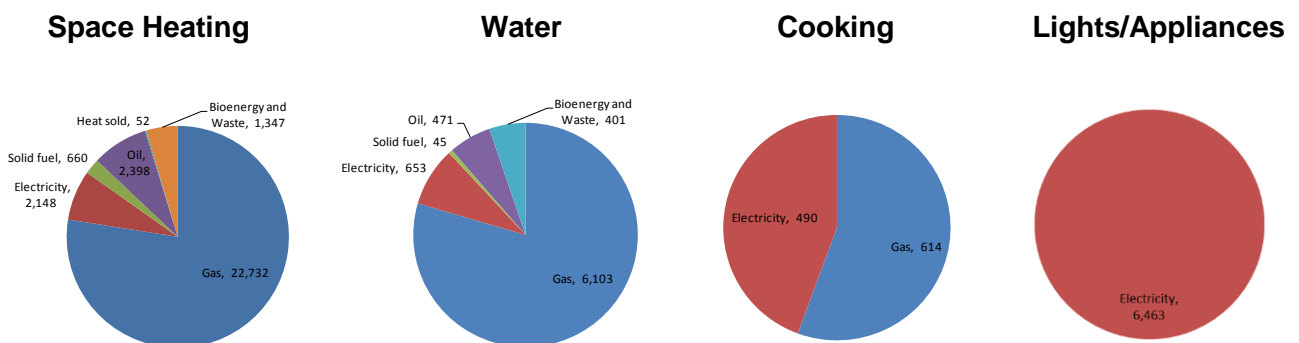


Figure 31: End Use by Fuel Type (2013) ktoe

Source: (DECC 2015): table 3.05

Understanding the fuel mix and end use are important when considering what the options might be for taking action on the demand side. It is also necessary to consider the different technologies that are used to provide energy services and the role that people’s behaviour plays in determining final energy demand.

5.3.4 Drivers of domestic energy demand

As is apparent above there are a number of structural or infrastructural issues that play a role in energy demand within the domestic sector, such as: the age, type and number of homes; tenure; geographic location; whether it is on or off the gas network; or in a urban or rural area; efficiency measures like insulation, etc – this list is not exhaustive. There are also socio-economic factors that influence domestic fuel consumption, such as the level of disposable income and energy prices. In addition to these high level issues, other key areas that influence energy use within homes that are considered in this section are: 1) the technologies that are used to provide energy services and 2) the way in which people behave and interact within them.

The choice of technologies and how they can or could change over time are important considerations for a low carbon transformation and the energy trilemma. Many scenarios assume the wide scale electrification of heat and transport for example, although this is by no means certain, it would require a major shift from the present situation. End use technologies have ongoing innovations that influence energy demand, such as improvements in efficiency through improved designed and/or regulations such as product standards – this means natural replacement of equipment improves the efficiency by which energy services are met, e.g. improved boilers for heating, LED lighting, etc. Natural replacement can also be speeded up through specific policy support to subsidise measures such as boiler replacement. In addition, new products come to market that are widely used in homes creating new areas demand – such as ICT and entertainment.

Space heating

As shown in the figures above, space heating is currently the biggest area of consumption within UK dwellings, accounting for nearly two thirds of final energy demand. Unlike some other areas of demand, space heating can be strongly influence by external temperatures, or more accurately the difference between outside and inside temperatures (Palmer 2014). As Palmer highlights, if it's cold outside and people chose to heat the home to 25°C they will inevitably use more heat than if it were mild or they choose to only heat the home 18°C. This is obviously influenced by how efficient any particular home is and people's behaviour and practices around heat and comfort, but generally speaking, average winter temperature plays an impotent role in determining final energy demand in any one year. This also helps to explain the reason peaky nature of gas demand in the figures above – given this is the most common fuel for space heating.

Looking at space heating in more detail, Figure 32 models both total energy use and the share of all household energy use. It can be seen that until the early 2000s, the demand for space heating steadily increased and has since trended downwards. The trend downwards in part

reflects the fact that winters have generally been getting warmer in recent years, but it also reflects improvements in the thermal efficiency of homes, improvements in the efficiency of heating systems³⁶, and possibly has also been impacted by the rising cost of energy in the late 2000s (Hoggett 2012, Palmer 2014).

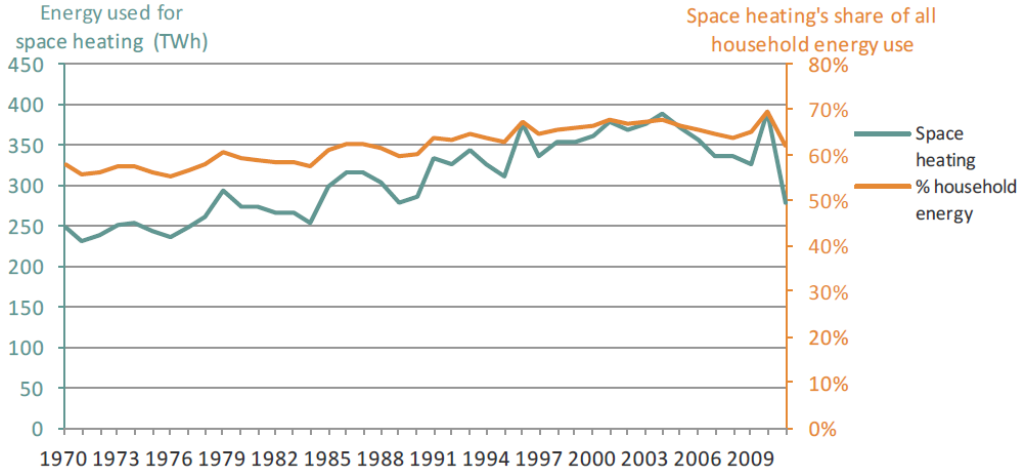


Figure 32: Modelled household energy use for space heating 1970 to 2013

Source: (Palmer 2014): graph 5b

Most space heating is currently provided via central heating systems, which are now present in over 90% of homes (Hoggett 2012, DECC 2013). The majority of these are wet based systems that use a boiler and radiators to distribute heat around the home and as most homes are on the gas network, this fuel dominates. Those homes without central heating use a combination of different technologies and fuels to provide space heating (Hoggett 2012). This in part can depend on location, for example in dense urban environments electricity is often used, whilst in rural settings, heating demand can be provided by electricity, heating oil and to a lesser extent solid fuels and liquefied petroleum gas (DECC 2013).

There are multiply reason for the growth and dominance of central heating, including: high levels of satisfaction with it use, compared to alternatives; a growing desire for thermal comfort, including a rise in average internal temperatures and heating a number of rooms simultaneously³⁷; and in respect to gas, having systems that are reliable and familiar, and

³⁶ Since 2005, gas central heating boilers fitted in England and Wales should be high efficiency condensing boilers, unless there are exceptional circumstances. The same requirement has applied to oil-fired boilers since 2007. Similar regulations are in force in Scotland and Northern Ireland. DECC (2013). The Future of Heating: Meeting the challenge. D. f. E. a. C. Change.

³⁷ It should be noted that average internal temperatures have also increased in homes without central heating Palmer, J. a. C., I. (2014). United Kingdom housing energy fact file 2013. D. f. E. C. Change.

supported by a mature market for repairs, replacements, etc. (Hoggett 2012). In part this helps explain the growth in final energy demand for space heating in the sector, although it is also apparent that part of the long-term increase in energy use for space heating is associated with a home's being increased in size with extensions, conservatories, etc which increases the overall heating volume of properties ([DECC, 2013](#)) (Palmer 2014).

Heating controls

Linked to space heating are the controls used with central heating. Since 2010, building regulations have set out minimal level of controls for new buildings, such as a timer, room thermostat and thermostatic radiator valves. Such controls give people the ability to control the amount of heat and time that heat is provided. However it is apparent that controls are not always used efficiently and looking at the housing stock as a whole DECC estimated that in 2013 70% of households lack the minimum level of controls set out in building regulations (DECC 2013).

Hot water

Most homes (around 86%) also use their central heating boiler to provide hot water, either instantaneously through combination boilers or via a hot water cylinder. Given this dominance of gas for providing space heating, this is also the main fuel used to provide hot water (Hoggett 2012). However, there is some divergence in technologies and fuels used to provide hot water. For example there has been growth in the use of combination boilers that can provide instantaneous hot water which now account for around two-thirds of all boilers in the UK, which have also resulted in hot water tanks being removed (DECC 2013). In respect to fuels electricity plays a relatively bigger role in meeting hot water demand including in appliances that heat their own water i.e. showers, washing machines, dishwashers, etc and immersion heaters within some systems (Hoggett 2012).

Looking at the modelling for energy use for hot water, Figure 33, a steady and significant decline in energy use for hot water is apparent – despite household numbers increasing over the same period. These improvements are contributed to a reduction in heat loss from stored hot water e.g. better insulation on tanks and pipes, the uptake of more energy efficient boilers, the removal of water tanks, a greater use of electricity in meeting hot water needs – fuel switching essentially³⁸ (DECC 2013) ([Palmer, 2014](#)).

³⁸ Equipment like electric showers and dishwashers heat water separately using electricity, so reduce energy use recorded as 'water heating' in statistics ([Palmer, 2014](#)).

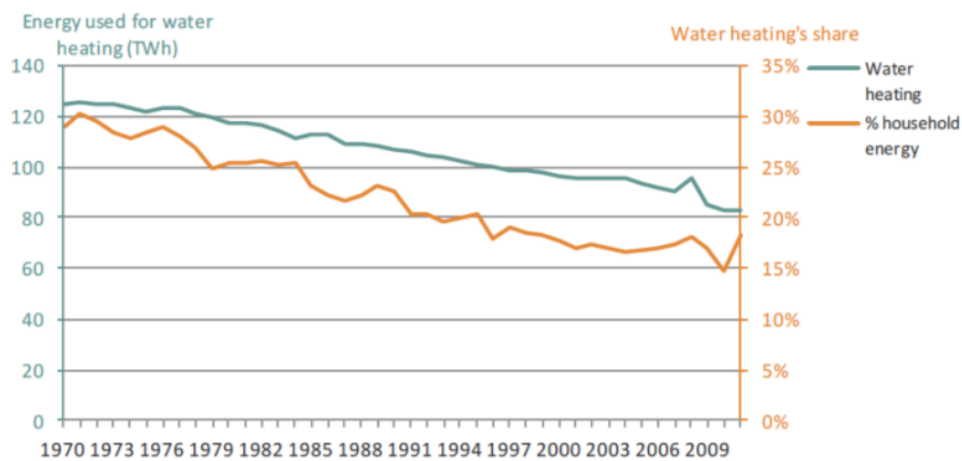


Figure 33: Modelled household energy use for water heating 1970 to 2013

Source: (Palmer 2014): Graph 5c

Cooking

Energy use for cooking is shown in Figure 34, showing a significant decline to the late 1990s and then a levelling off. Cooking now accounts for a very small proportion of a household's energy use. This decline reflects a change in cooking habits, appliances and lifestyle preferences, such as an expansion in 'ready meals' and takeaways and the greater use of microwaves and fan-assisted ovens (Palmer 2014). As highlighted in Figure 31 above, in terms of fuel use there is a fairly even split between gas and electricity, with a preference shown towards the use of gas hobs and electric ovens (Hoggett 2012).

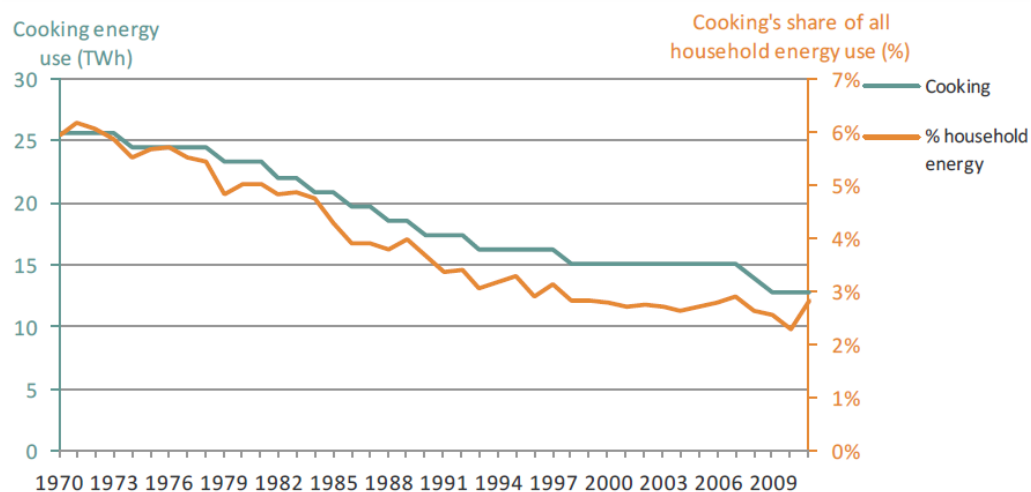


Figure 34: Modelled household energy use for cooking 1970 to 2013

Source: (Palmer 2014): Graph 5f

Lighting

Energy use for lighting is shown in Figure 35. This now accounts for a similar level of final demand as cooking, but unlike cooking it increased year on year until the early 2000s. The increase in demand reflected a change in lighting types, such as replacing strip lighting with spot

lights and the installation of more lighting generally in kitchens and bathrooms (Palmer 2014). This growth in the use of light in homes has not resulted in large increase in energy use in homes, in part from mechanisms like phasing out the sale of incandescent bulbs and supplier obligations that provided low energy lighting for homes. With the uptake of LED lighting, which combine high energy efficiency and very long lifespans (EST 2011) the expectation is that electricity use for lighting will continue to decline (Boardman 2014).

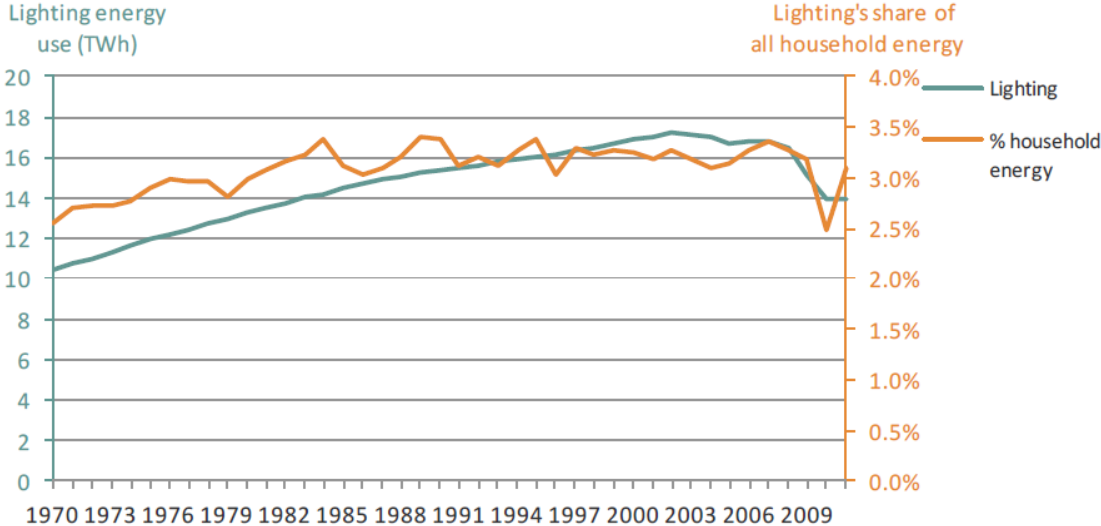


Figure 35: Modelled household energy use for lighting 1970 to 2013

Source: (Palmer 2014): Graph 5d

Appliances

The housing energy fact file (Palmer 2014) provides a helpful summary of the final energy demand for appliances in homes - Figure 36. It shows a sharp growth in the percentage of final energy demand – a tripling in 40 years and suggests there are three main factors influencing this: 1) a growth in the number of electric gadgets in homes (washing machines, tumble dryers, hairdryers, computers, consoles and chargers, etc); 2) the use of these appliances has increased, for a number reasons³⁹; 3) much greater use of cold appliances to store food, which are also often larger in size.

³⁹ Such as higher disposable incomes, lifestyle changes, automation of jobs previously done by hand, etc

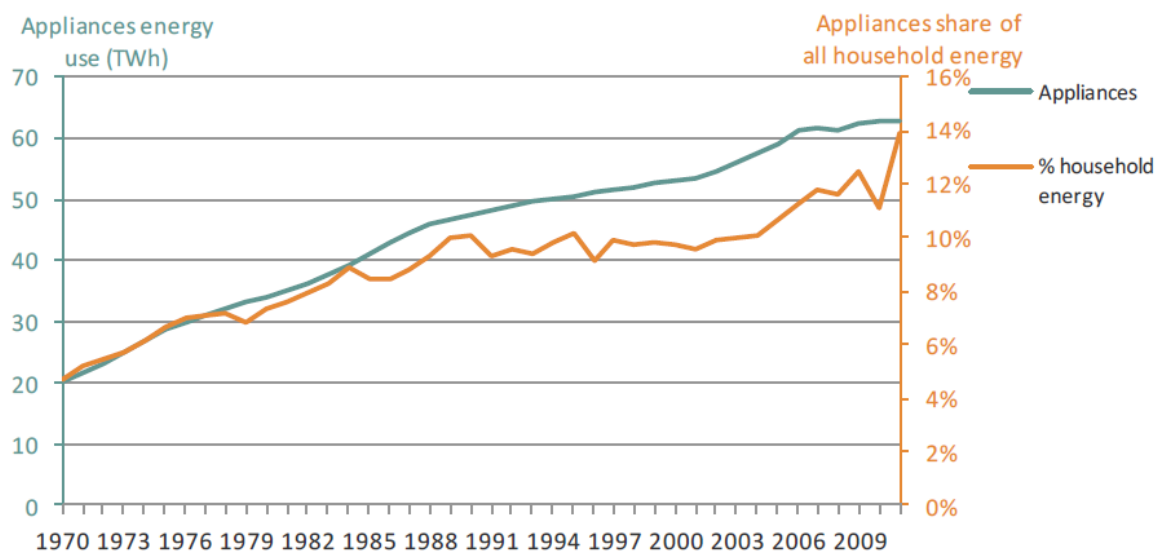


Figure 36: Modelled household energy use for appliances 1970 to 2013

Source: (Palmer 2014): Graph 5e

Palmer (2014a) also highlights a DECC report, *Powering the Nation*, which provides a more in depth analysis of electricity consumption in a sample of homes. This suggested that at least half of electricity consumption in homes is used for appliances, and of this: 16% is for cold appliances (fridges and freezers); 14% is for wet appliances (washing machines and dishwashers); 14% is for consumer electronics; and 6% is for ICT. The remaining electricity demand is from other end uses like cooking, lighting, etc.

An update to *Powering the Nation* in 2014 provided some further insights into appliances within homes, including: a large variation in the ages of appliances in people’s homes; the fact that only a small proportion of households have the most efficient appliances available; and that the size of many appliances is increasing, especially for cold appliances and washing machines. Their analysis also suggested that potential savings from efficiency improvements are significant, and include things like replacing individual appliances with more efficient models (Palmer 2014). In the research, total potential savings for the UK from efficiency gains could be in the region of 15,000 GWh/yr – an average of 570 kWh per household⁴⁰, more than the annual output of two large power stations (Palmer 2014:2)

5.3.5 Energy behaviour

The technology and fuels used to provide the energy services that people desire and the wider infrastructure in which they sit, are only part of the factors that shape the level of energy demand. There is a strong behavioural component to energy use and wider sustainability

⁴⁰ It should be noted that around half of these savings could come from energy efficiency improvements, the rest comes from switching from electric heating to other forms of heat.

(Costa 2015), such that neither technical or physical improvements to a home are enough to guarantee a reduction in energy demand - human behaviour is at least as important (Darby 2006, Hole 2012, Kelly 2013). As an example, the data in Figure 37 is based on a sample of 40 households showing electricity use for different end uses during the peak demand on the system period. As the authors highlight, electricity use is highly diverse, not only between different households, but also for the same household on different days (Grünewald P. and Layberry 2015).

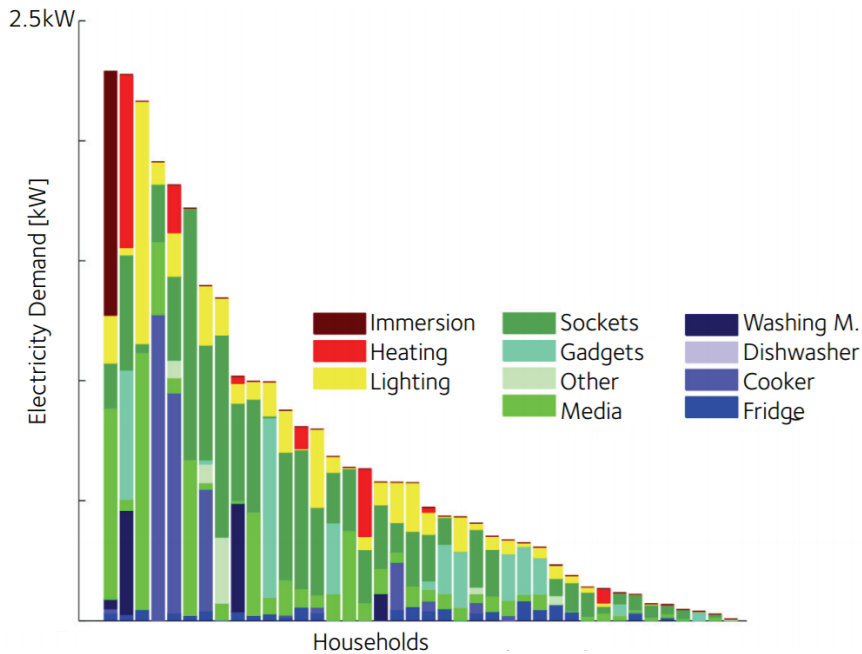


Figure 37: Distribution of household electricity uses during peak demand
Source: (Grünewald P. and Layberry 2015: 2090)

Encouraging changes in behaviour is not straight forward, challenges include things like the intangibility of impacts that appear far into the future, such as climate change; and a recognition that energy use is an abstract issue for many that creates a disconnect between people’s intentions and actions (Costa 2015). This can manifest itself in people routinely deviating from a ‘rational choice’ model of human behaviour in which “*one objectively weighs up the costs and benefits of all alternatives before choosing the optimal course of action*” (Frederiks, Stenner et al. 2015):1385). There is also a recognition that people behave in respect to energy consumption is highly complex, with behaviours taking many different forms (Palmer 2014) and having many different outcomes, in respect to final energy demand, leading to the sought of results shown in Figure 37. Insights from social theory and practice research highlights the complexity of social practices that constitute daily life - energy demand is bound up with what people do - it is dynamic, social, cultural, political and historical; it is therefore shaped by infrastructures and institutional arrangements that exist and in a literal sense demand and the

means to consumer constitute each other (Shove and Walker 2014). All of this makes energy use and actions to reduce demand difficult to predict (Frederiks, Stenner et al. 2015).

Examples of some of uncertainties that exist in relation to behaviour change include understanding how people might respond to policies to encourage them to behave differently, this is over and above the technological and economic uncertainties that already exist within energy policy (Eyre 2014). There is also uncertainty because of the considerable complexity in understanding behaviours and interactions within the home in respect to the energy services that people seek; a useful summary of some of these are provided in Table 5 below, from (Palmer 2014b). This includes consideration of: relatively infrequent *investment decisions* which can lead to long-term locked-in consequences; *infrequent actions* that can have persistent effects; habits and routines (or *repeated actions*) that have recurring or accumulating effects on energy demand; and *spontaneous reactions* that have one-off effects.

Investment Decisions	Infrequent Actions	Habits & Routines	Spontaneous Reactions
whether to extend or upgrade a home	the times people want their heating systems to go on and off	whether people have a bath or take a shower (and how full or long they run them)	to hang out washing to dry on sunny days rather than tumble dry it
what types of energy consuming equipment (e.g. heating, lighting, ventilation and cooling systems) people choose to install	the temperatures at which they set their room and water heating thermostats	the temperature and programme length they select on their washing machines and tumble dryers	to take off clothes, open windows or turn the heating down/off when hot
how many and what types of appliances (e.g. cookers, fridges, TVs and computers) they bring into their home.	the settings at which they run their fridges and freezers	whether they regularly turn appliances off or leave them on or on standby when not in use.	to turn lights on/off when entering or leaving an empty room.
	windows being kept open		to put on more/heavier clothes or turn the heating on/up when cold

Table 5: Examples of different types of behaviours

Source: (Palmer 2014): 63

Most energy using practice then arise from a combination of factors, such as new purchases, habitual routines, daily practices, and many are influenced by social norms and purchases that have already made (Willis 2011). In respect to some of these points, (Palmer 2014) also highlights that they all vary in terms of frequency and that within any household different behaviours will be happening simultaneously, some of which will save energy, some of which will increase energy demand. The result is that there are varied and multiple interactions in any one household, leading to very different levels of energy consumption in very similar property

types as well as considerable diversity in demand from one day to the next in any particular household (Grünewald P. and Layberry 2015). There are also some issues that are less influenced by choice, such as some of wider structural issues highlighted above such as land use patterns, infrastructure, the physical properties of a home, or the composition of a household (Eyre 2014, Palmer 2014).

Despite the difficulties, behaviour change is a key component in enabling an affordable, secure and low carbon transition and its importance is likely to grow given that many of the changes that are happening within energy systems are closer to end users. What is more, it is likely to grow in importance in respect to the demand side in the domestic sector because as homes become more energy efficient, people's behaviour will have an increasingly important role in influencing final energy demand (Palmer 2014). A common theme across the many scenarios that the CCC have developed, is that reducing the level of demand through improved efficiency and changes to behaviour is needed and will greatly reduce the cost of meeting the 2050 target (CCC 2015). In their 2015 analysis, they suggest more progress will need to be made on behaviour change, including steps facilitated by current trends; such as better control over heating, whilst others will require changes to how people demand and use products. A focus on lifestyles and behaviour change is also seen to have an important role in shaping how the energy system develops and operates, including which technologies are deployed and used, and how they are used (Darby 2014)⁴¹

Over the last decade there has been a significant increase in the policy interest on the importance of behaviour change, including select committee inquiries, the creation of a Behaviour Insights Team within the Cabinet Office⁴², and research e.g. (POST 2012, Darby 2014). These recognise the interdisciplinary nature of behaviour science, which cuts across psychology, sociology, behaviour economics, etc as well as highlighting the socio-technical nature of behaviour change, with technologies and behaviour interacting and co-evolving with each other over time (Darby 2006). Generally speaking, there is a need to understand the interactions between behaviour and the wider variables of buildings (physical and technological) in order to both untangle the complex relationships that influence energy demand and also understand where there are opportunities for taking action to change the level or patterns of demand are (Kelly 2013).

⁴¹ As UKERC highlight, as well as individual consumers these issues also apply to institutions, such as markets and regulatory structures

⁴² Now an independent organisation

Research has also highlighted that both individuals and communities are important for enabling change on the demand side, with many scenarios highlighting the need for considerable behavioural change and the need for social acceptability of interventions (Eyre 2014). Examples of the sort of interventions that are important include: choosing to take action such as installing insulation; the uptake of new technologies like low carbon heat; and adopting new social norms around more efficient appliances and modes of transport, as well as different ways of doing things (POST 2012, Eyre 2014, CCC 2015). Ultimately, this reflects the fact that the underlying driver of energy demand are people and the decisions we take about what technologies to use (i.e. equipment, appliances, lights, etc), when to use them and for how long, so understanding how and why decisions, habits, practices and actions are taken and how these influence final energy demand is vital.

Much of the policy focus to date has been linked to understanding people's opinions and their behaviours (Owens and Driffill 2008). However, far more research attention is now being given to understanding energy demand, such as through the work of the recent RCUK end use energy demand centres (RCUK 2016). UKERC are also developing new insights in energy participation and societal engagement within energy systems (Chilvers 2015). All of this research will play an important role in providing new insights into the importance of behaviour and people within the demand side, including their role within smarter energy systems built around the components of D3 described above.

In addition to behaviour change, this section has highlighted national trends in final energy demand across sectors and within the domestic sector. Collectively this builds the background for understanding some of the trends and drivers of demand, not least the complexity behind it. The importance of the demand side has never been greater in addressing the energy trilemma, as UKERC have highlighted:

"...it should always be remembered that very often the cheapest and most secure way of meeting energy service demands is to increase the efficiency with which energy is used, such that any given level of energy services can be delivered with less energy supply. Allied to changes in lifestyle and behaviour that reduce energy demand, and demand responses to the availability of energy that are facilitated by the information technologies incorporated in smart grids and smart meters, the importance and potential of the demand side in addressing the energy trilemma has never been greater. Failing to give it adequate consideration in policy can result in energy systems being more costly, less secure and more environmentally destructive than they need to be." (Skea 2014:7)

The next section goes on to look at more detail on how policy has evolved on the demand side and what policies are in place in respect to D3.

6. Policies for a Demand Focussed System

As already discussed above, the dominant energy policy paradigm has, and to a large extent remains, focussed on the supply side. This is despite the emerging evidence that the system is moving more towards the demand side. This is not to say that there has been no action on the demand side just that it has tended for the most part to play a secondary role in energy systems thinking within government.

6.1 The View and Development of Demand Policy

There have been cases, notably as a result of external factors, where the demand side has come to the fore, e.g. demand reduction/energy efficiency became strategic priorities for government as a result of the 1970s oil crisis (Mallaburn and Eyre 2014). However, as the Mallaburn & Eyre's review of UK energy efficiency policy and programmes over three decades shows, the relative importance of the demand reduction is influenced by a wide range of internal and external factors within energy markets. This includes issues like: the political will of the time, both party political and/or based on the importance that any particular energy minister places on demand; where policy responsibilities and mechanisms are placed within government departments; the relative importance placed on technologies compared to information and behaviour change; the importance placed on supporting action within different sectors; and the way that cost and benefits were considered over time.

Looking at the current situation, across D3, a fairly recent mapping exercise of government policies that promote greater demand side action which was produced for DECC in 2014 –Table 6. This shows a range of different policy instruments that are in use to encourage the uptake of D3 technologies including forms of taxation, reporting requirements and financial support mechanisms (DECC 2014). As the analysis in that report showed, this includes crossing cutting policies in terms of the sort of demand side action that was sought and/or the sector it was aimed at; as well as more specific targeted policies. The report also highlights the range of departmental groups that existed within DECC (as was) with responsibility for demand side policy; and initiatives from other government departments that support demand side measures, that at the time of writing included DCLG, DfT, DoH, DfE, DEFRA, HMT, CO and BiS. In addition, the research sheds light on the role of other institutions involved with demand side policy, including Ofgem, the Environment Agency, the Energy Saving Trust, Carbon Trust, Salix Finance and the GIB. What quickly becomes apparent is the complexity within the policy landscape for action on demand side.

		D1 Demand Reduction	D2 Demand Side Response	D3 Distributed Energy
Currently in Operation				
Sector	Policy			
Domestic	Energy Company Obligation (ECO)	x		x
I&C	Enhanced Capital Allowances (ECAs)	x		x
ALL	Planning	x		x
I&C	Climate Change Levy/Climate Change Agreements (CCAs)	x		
I&C	Carbon Reduction Commitment (CRC)	x		
Domestic	Green Deal/Green Deal Communities	x		x
ALL	Products Policy	x	x	
I&C	Energy Performance Certificates (EPCs)	x		
I&C Public	Heat Networks			x
Public	Display Energy Certificates (DECs)	x		
I&C	Combined Heat & Power (CHP)		x	x
ALL	Feed in Tariffs (FITs)		x	x
	Renewable Heat Incentive (RHI)			x
I&C Public	Renewables Obligation			x
ALL	2014 Building Regulations	x		x
I&C	Defra Environmental Reporting Guidelines	x		x
To be introduced				
I&C Public	ESOS (Energy Saving Opportunity Scheme)	x		
Domestic	Private Rented Sector Energy Efficiency requirement	x		
I&C	Demand Side Response (DSR) (in Capacity Market)		x	x
I&C	Electricity Demand Reduction Pilot	x		
Domestic	Domestic RHI			x
Domestic	Smart Meters	x	x	x
ALL	Allowable Solutions	x		x
Under Development				
Domestic	2016 Zero Carbon Homes	x		x
I&C	2019 Zero Carbon Buildings	x		x
ALL	Smart Grid	x	x	x
ALL	Energy Storage		x	x

Table 6: Government policies to support demand side energy measures

Source: (DECC 2014)

In analysing the policy landscape for D3, the independent expert appointed by DECC highlighted a number of important issues (DECC 2014:17-18) including:

- a lack of a coordinated or holistic plan for demand side action resulting in a fragmented approach;
- a lack of understanding about the potential cost-effective contribution that D3 could make, which could result in the adoption of more expensive options;

- the risk that the current approach will create confusion around what individual policies are supposed to collectively achieve, possibly undermining the policies themselves as well as investor, industry and consumer confidence;
- a risk of policy overlap that could reduce effectiveness;
- a risk that all of this will result in the government being unable to effectively plan for how the demand side will impact on the future energy system.

7.2 Recent Changes in Demand Policy and its Implications

Since the above D3 analysis was published there have been a number of significant institutional changes, including a new government, the Brexit vote, a new Prime Minister, and the merger of DECC and BiS into the new Department of Business, Energy and Industrial Strategy (BEIS).

There have also been some notable policy changes that impact action on the demand side, particularly in respect to demand reduction:

- the failure of the Green Deal resulted in the government ending funding for the Green Deal Finance Company, effectively removing financial support for the measures (Ares 2016);
- the ECO has also gone through a number of changes, to reduce the cost of delivering it on household energy bills (Hough 2015) essentially cutting the level of ambition to save money. From 2017 it is due to be replaced with a 'new cheaper domestic energy efficiency supplier obligation' which will be more targeted to the fuel poor⁴³;
- a new Productivity Plan from HMT in 2015 that the Zero Carbon Homes Standard would be cancelled, along with the Allowable Solutions that were developed to support it (also a DER support mechanism) (Council 2015, Ares 2016);
- although reference was not included in the Productivity Plan to the 2019 Zero Carbon Buildings policy for non-domestic buildings, the government subsequently confirmed to the UK-GBC that the announcement relates to both the policy for homes and non-domestic buildings⁴⁴ (Council 2015);
- following a consultation on reforming the business energy efficiency tax landscape from HMT, the CRC has been significantly weakened and is due to be abolished in 2019 (Watson 2016). This is part of a shift toward a system in which there is one energy consumption tax

⁴³ These changes have been consulted on, but the results and final decision have not yet been reported <https://www.gov.uk/government/consultations/energy-company-obligation-eco-help-to-heat>

⁴⁴ It should be noted that powers to set Building Regulations standards are devolved, and the Scottish and Welsh Governments both had their own zero carbon standards Council, U. G. B. (2015). UK-GBC Briefing: Zero Carbon New Buildings Policy

based on the CCL and then the development of the single reporting framework based on the ESOS (HMT 2016).

Most Demand Side Response is still within the I&C sectors or contracted by the system operator to help balance the system – which is carried out under regulatory rules in the form of ancillary services contracts for electricity balancing, and interruptible gas supply contracts for gas balancing. In respect to policy changes, DSR has been introduced into the Capacity Market now, although not on a level playing field with supply, resulting in relatively low amounts of DSR compared to supply (Lockwood 2014, Watson 2016), an issue that will need to be addressed if government want to support a growth in DSR (HCECCC 2015). DSR for smaller energy users will be closely linked to the ongoing roll out of smart meters and how people and companies respond to options that they may offer, as well as other technological developments that may occur around these.

There have also been a number of changes in respect to Distributed Energy Resources. The domestic RHI is now operational, running alongside the commercial RHI and it is possible that district heating will be expanded as the 'heat networks delivery unit' within BEIS becomes a more substantial programme. In response to forecasts of spending under the Level Control Framework a series of cuts to renewable energy support were announced by the government in 2015 (Yeo 2015). This included the early closure of the RO for onshore wind (Ares 2016) and the full closure of the RO from 2017, being replaced by a new auction mechanism - Contracts for Difference (CfDs). CfDs are a much more complicated mechanism for smaller actors and arguably, in comparison to the RO, create some new risks and potentially lower returns (Fitch-Roy 2016); it is too early to know what the impact of the CfDs will be for a growth in Distributed Energy. There were also changes to the Feed in Tariff for smaller scale renewables – with reductions in tariff rates and a limit on the number of installations supported, which has had a considerable impact on smaller scale schemes and particularly community energy projects.

The above is not a comprehensive analysis of policy changes, just a highlight of how some key areas of D3 have changed since 2014. Given the issues that already existed for demand side policy highlighted in DECC's own analysis (DECC 2014), these changes arguably add further confusion and a weakening on demand side policy in the UK. A further complication for D3 will be created as a result of the Brexit vote given that many of the policies in this area, and more widely in terms of energy and climate, are shaped by EU legislation (Ekins 2016). A range of issues might arise in terms of demand reduction and product standards, alternative low carbon building standards, vehicle emission standards, as well as impact investments across D3 (Anable 2016, Guertler 2016, Watson 2016).

Even without these changes, one of the early findings within the IGov research was that despite demand side policies being in place they can find it hard to break through the centralised supply-orientated system, resulting in a limited and slow rate of change within the energy system (Catherine Mitchell 2014). Much of this relates to governance, including the pre-existing rules, regulations, infrastructure, user practices and supply chains, which tend to support continuity and create inertia (Unruh 2000, Geels 2014, Kuzemko, Lockwood et al. 2016). The problem, as Kuzemko et al (2016) highlight, is that new policies, like those aimed at supporting D3, co-exist in practice with pre-existing policies, regulations and rules that are driving less sustainable practices. Policies themselves, therefore, are not enough to lead to practice change within energy systems (Kern, Kuzemko et al. 2014), particularly if the policies for action on the demand side are poorly coordinated and being weakened, as the above analysis suggested.

The relative importance placed on the role of markets vs the state as a route to encourage action on the demand side is a key issue. Following privatisation and liberalisation the market clearly came to the fore and created some key problems, particularly within the domestic sector, as the early price controls used volume drivers that allowed increased revenues with higher sales; and tariff structures that encouraged energy users approaching a tariff boundary to consume more in order to secure a lower price (Mallaburn and Eyre 2014). Giving responsibility to energy suppliers to become a key player in improving efficiency in homes through Standards of Performance was also clearly not aligned with their main interests (Kuzemko 2015). It is not that market should be ignored, it is just about getting the right balance between government intervention and market support (Mallaburn and Eyre 2014), and this needs a well-designed and coherent approach across D3 and the whole energy system.

Recent government support for Hinkley Point C and the ongoing support for shale gas, alongside what appears to be a weakening policy landscape for D3, suggests the supply side continues to dominate. This is potentially bad news for end users within the system, bad news for taking a whole system approach to transforming the system, and bad news for the trilemma as a whole. Addressing these key issues comes back down to the way that people are considered within the energy system and how governance thinks about their role and wider system change.

7. Discussion and Conclusions

7.1 Future Energy Systems

We have to transform our energy system in order to tackle climate change, whilst also maintaining security and affordability. Although there are a range of uncertainties for how best to do this, as discussed above, there is some agreement that a transformation to a sustainable energy future is already technically practicable, economically feasible and socially viable (Sovacool and Watts 2009, Ekins 2013); and that such a change is not particularly radical to implement (C. 2015, Mitchell C. 2016). There is also evidence to show that energy transitions do not have to be long, decadal affairs, much depends on how they are framed and supported, with the potential for them to occur in a fraction of the time (Sovacool 2016). As Sovacool suggests, for this to happen requires significant shifts in a range of areas, such as technology, political regulations, tariffs and pricing regimes, and the behaviour of users and adopters. If these are not left to evolve by themselves but instead driven by strong government intervention and shifts in consumer behaviour, through incentives and pressure from stakeholders, change can occur more quickly, i.e. transformations need to be designed and supported to occur quickly.

Energy systems are constantly changing, but as many have highlighted, including the National Infrastructure Commission the energy sector is currently undergoing fundamental change (NIC 2016). As Ofgem have highlighted, there are a wide range of drivers for this, including actions on both the supply side and the demand side (Crouch 2016). Much of this change is being driven by the development and deployment of new technologies, which are enabling new outcomes and practices. However, change is not just limited to technologies as there are new actors wanting to do things differently, including people (in multiple roles) at a range of scales e.g. households, communities, cities, etc. Examples of some of the changes include: the deployment of renewable heat and power; falling costs and increased deployment of energy storage; increased interconnections between energy systems; the emergence of new business models and new entrants; an increase in aggregation and companies offering demand side services; a growing interest and options for disaggregation; new products and services from non-traditional energy companies; the emergence of local energy markets; advancements and deployment of ICT solutions into new areas within energy systems, like blockchain (many of which are facilitating some of the developments above), (Carrie Armel, Gupta et al. 2013, Platt 2014, DECC 2015, Ofgem 2015, Roberts 2015, Centrica 2016, Kahya D. & Parr 2016, Mitchell 2016, NIC 2016).

Within all of this there is some consensus that the future will be much more decentralised than it currently is and that the system will become more flexible, a trend that is already occurring in many countries, and one that is acknowledged by the CEO of National Grid (Beckman 2015), as well as some banks, investors and utilities themselves (Mitchell 2014, Vidal 2014, Mitchell 2016). Recently EnergyUK who have a track record for defending fossil fuels (Macalister 2016), issued an industry view report suggesting that by 2030 the power system will be: more responsive to customer needs; will be more decentralised, with higher levels of distributed generation, storage and local heat; and that customers will become more active in generation and demand side response (EnergyUK 2016). In an interview about the report the head of EnergyUK suggested that the UK effectively needs its own version of Germany's "Energiewende" (Evans 2016).

The focus of much of this change is on the development of a smarter energy system, although there are still many theoretical and operational definitions to be agreed on and defined within the 'smarter' future (Balta-Ozkan 2014). Much of the focus on 'smart' is on the electricity system and in their first report, the NIC suggested that three innovations would help the system of the future: interconnection; storage; and demand flexibility (NIC 2016). Another key development in a smarter system will be the universal roll out of smart meters within homes and small businesses, which is due to be completed by 2020; this should create new opportunities for enabling a sustainable energy system. Whilst the focus is dominated by power, it is clear that heat and transport will also have to be decarbonised and have an integrated role within a smarter system; some changes like their electrification or developments in power to gas, should help to facilitate this (Walker, van Lanen et al. 2016). It cannot be overstated how important it will become to take a wholesystems approach to energy system change that more effectively links these different vectors in order to create a truly sustainable, secure and affordable system; policy and governance will have to address this.

As IGov have highlighted, while some of these changes are being driven by aspects of the current governance framework, this is typically happening in an uncoordinated, volatile way e.g. changes to FITs, the structure of the Capacity Market and embedded benefits for DER, etc (Mitchell C. 2016:6). It is also apparent when speaking to developers and new actors within the system, that many of the new solutions that are entering the system across generation, heat and the demand side, are doing so in a random way – it's all a bit of a scramble as companies chase value in the system (Hoggett 2016). This is perhaps an obvious outcome of predominantly relying on a market driven approach to system change. In respect to wider governance, IGov would argue that change is happening but often in spite of, rather than because of, the governance that is in place; and arguably the current governance framework does not complement the technological, business and social changes that are underway. As apparent from the previous section, the policy landscape is also still dominated by the supply

side with initiatives to support D3 uncoordinated, messy and in the case of demand reduction increasingly absent. In addition, the dominant view of people within the system remains narrowly focussed on them being consumers, which a competitive market can best serve, and they are given little or no say in how the energy system might develop. This is increasingly out of step with what is happening and is likely to make the transformation more difficult, slower and potentially more costly than it needs to be. Governance has to be reformed to deal with multiple issues.

7.2 Rethinking People's Role

As this paper has discussed, the energy system in GB has been designed to meet the energy demand of end users, whether they are domestic, commercial or industrial users, regardless of the level or timing of that demand. This has led to a supply oriented focus, based on a highly centralised (but siloed) system across electricity, heat and transport. Within this, energy moves in one direction from production through to consumption, and policy and the wider governance framework have reinforced this approach. It has also led to end users being narrowly viewed as consumers that are for the most part, especially for smaller energy users, passive and disengaged from the system.

The energy system is now undergoing rapid and profound changes, many of which are focussed at the distribution level and there is an expectation that many of these trends will continue as the system gradually moves away from linear to multiple energy flows within and across different vectors. This covers all aspects to D3 including low carbon generation as well as options for demand reduction, demand side response, storage, etc, which are being driven in part by new entrants in the market, including local authorities and companies offering a range of services, such as aggregation, virtual power plants, local energy markets, etc. There has also been a growth in individuals installing measures and/or becoming more active through community energy schemes or by investing in renewable energy schemes.

All in all then, the momentum for change is much closer to the demand side and end users, and as such there is a growing need to rethink the multiple roles that people play as customers, consumers and citizens within the energy system in GB. This should be based on a new approach that starts to focus on how people might engage with the system – away from the idea of them being passive takers of supply in different sectors, towards an approach that recognises how active, or not, they become. This is about finding new ways to engage people and it is a long way from the currently narrow framing of people as consumers where engagement is viewed in terms of supplier switching. Furthermore, it seems likely that as we move towards trying to find wholesystems solutions the need for engagement will grow in importance. For

example, whilst some solutions in just one vector like PV on buildings or automated appliances or storage may not impact day to day living, in others vectors, changes could be much more disruptive, such as a move to electric vehicles, or changes to the way that we currently heat buildings. It will be impossible to bring about change that impact on people’s current lifestyles and behaviours if efforts to engage them are not made.

As discussed in Section 4.4.2, there are some useful lessons on the engagement of people within energy systems from the work that is taking place in New York and Australia. Here, end users are thought about based on how active they are, or will become in the system, from those that are passive who cannot or will not engage, through to those that are willing to be active, and ultimately those that are willing to fully participate, e.g. prosumers. The approach developed in Australia in particular provides a nuanced approach to people, based on three main segmentations – Figure 38 and then some further sub-segmentations – where people are seen as: empowered; engaged; or essential energy users. A more detailed description of each of the segmentations is provided in Table 2 in Section 4.4.2.



Figure 38: Example market segmentation curve for residential customers in 2025
Source: (Association 2015):p33

This is a much more helpful way to start thinking about the role of people in a more decentralised, demand focussed system. However, a crucial point is, that in both New York and Australia, it is not just about thinking about segmentations that people might fall into and then move between, it’s about how the whole system and its governance views and values them. For example, in New York they highlight that the distinction between consumer and producer begins to dissolve in the new system, making it increasingly important to provide customers with new value signals to engage (Service 2015). To facilitate this there is a strong focus on how to create value for both end users (of all types) and the system itself as it transforms. Whilst in Australia, they recognise that the system is becoming more decentralised in terms of

geographic location, ownership status and operation profiles, and that this influences how people use, produce and value energy services (Association 2015). Here, they are looking at the design and operation of the energy system, with a recognition that begins by putting end users into the centre of thinking, in terms of what they will value as the system changes. They also expect that new customer types will emerge, such as new and existing service providers and other market actors who function as a 'value network', collaborating and/or competing with network businesses to provide diverse energy and other solutions to end-users. This is all part of a shift from a supply side focus, based on historical or existing products and services, towards the demand side based on customer needs and aspirations – focussing on the outcomes that customers seek.

Clearly the approaches above provide some useful insights about the role of people within energy systems, which could be applied to what is happening within GB. This would provide a way to move away from the current, narrow, view of people that exists towards a process that automatically thinks about the role of people in terms of how actively and meaningfully they might engage with the system around them. This directly links to a wider discussion on section 4.4.3 that highlighted the sustained lack of action to inform the public of what changes are happening, why they are happening or what the implications may be. As the Green Alliance highlighted, this can result in disengagement, distrust, protest and delays, which could be overcome by taking a much more people focussed approach to infrastructure development (Mount 2015). In addition, the research by the Centre for Sustainable Energy (Roberts 2014, Roberts 2015, CSE 2016) highlighted the growing importance of gaining 'meaningful public consent' given that people: will pay for some of the costs of transforming the energy system through their bills; will have to accept change within their communities and landscapes; and will need to be willing to act e.g. such as through behaviour change, investment decisions and through giving permission for data sharing. This, they suggest, will require more efforts to ensure that people have a genuine opportunity to have a say and a stake in what is happening and where it is happening, based on developing supported local conversations with a diverse range of local voices. This has similarities with the Green Alliance research, which suggests that there is a need for overall better public dialogue to create a citizen voice, and that could be facilitated through a new civil society advisory panel (Mount 2015).

The implication of all of this debate is that to create a low carbon, demand focussed system that is flexible, secure and affordable will require policy makers and wider energy actors, including companies, to consult and engage with people much more effectively than they have done to date. This links to a third consideration on changing the role of people within the system, which comes back to the problems that exist in terms of trust and transparency.

The erosion of trust has been well documented in the UK, linking to costs of energy, how ‘sticky customers’ appear to pay much more for energy, confusion over costs and tariffs, and concerns over the switching process. There was also evidence of high pressure selling and a perception that suppliers make excess profits, as well as issues over poor customer service. All of these have seen a growth in scrutiny within the system from the media and politicians and have led to Ofgem and government interventions as well as the CMA inquiry. How successful the changes suggested by the CMA to overcome these problems will be, is not yet clear. Interestingly, whilst it seems likely that an ongoing lack of trust could result in some people continuing to remain unengaged and passive with energy, conversely it could also have the opposite effect, by encouraging people to act individually or collectively to regain some power and control within the system. There is certainly evidence that this is happening within Australia, although for a number of reasons beyond just trust.

Rebuilding trust and finding new ways to engage with the system are equally important for system change. Dealing specifically with trust, one of the findings of the research in Australia was that people felt that they cannot control electricity costs, or understand what makes up their bills, and this has led to a perception that energy networks are not on their side or offering value for money (Association 2015). They concluded from this that incumbent energy actors have eroded their ‘social licence to operate’ with customers and to address this advocate the introduction of a new social licence. This is based on a hierarchy moving upwards from legitimacy (e.g. to operate), through to credibility (e.g. to provide reliable information and honour commitments) and ultimately resulting in trust (e.g. by building common or shared experiences). As discussed in section 4.3.1, its introduction into GB would need care, but policy and regulation could require the energy industry to meet the terms of a social license or the spirit of it, if it was more of a principles based regulation. The important thing would be to ensure that terms of the social licence were openly agreed with actors within the system, including people and consumer groups that represent them. It would also need independent monitoring and verification in order for suppliers, networks and wider energy companies to be granted a social licence. In this way it could almost become a charter mark that could perhaps be administered and monitored through a trusted group like Citizens Advice or Which?

There is a final observation within the discussions on the role of people that links some of the strands above, namely the opportunities that might exist for optimising the system from the bottom up. This reflects the way that energy systems are changing and the thinking that is emerging on how to create a smart and flexible energy system, which involves people, including the need to take a wholesystems approach that looks across heat, power and transport. The current approach is uncoordinated, change is predominantly market driven, and policy makers tend to observe and react to system change. The risk is that this approach may mean that the

most sensible solution for any particular area is not being implemented – not only in terms of the system and its operation, across different vectors, but also in terms of cost and acceptability. We could easily be locking-in the wrong technologies, in the wrong place, for the wrong cost, with little or no public consent. A more strategic approach is needed and looking at the options for optimising⁴⁵ from the bottom up could play a central role within this.

The case for bottom up optimisation was coherently made by Matthew Rhodes from Encraft at an IGov conference on Progressive Energy Governance (IGov 2014). He argued that there is a need to create a more dynamic, nuanced system that builds on the opportunities that new technologies, ICT, storage, controls, and microgeneration offer. Such an approach can be enabled by optimising the system at each level, i.e. starting with the household, then the street, neighbourhood, town, city, region, etc working up to the national level. This is based on a much more granular approach to energy thinking – it's about the type of houses we live in, where they are in the country, the places we work, the local renewable resources, the local networks and the wider infrastructure that exists in terms of transport, heat, etc. It is only at this more local level that we can really know what the best solution might be in terms of demand reduction, demand side response, distributed energy, storage, heat production, EVs, biomethane, power to gas, etc. It is also a very effective way to really focus on people and place, creating new opportunities to have meaningful conversations about the energy system and collectively choose the best technical, economic and social solutions across all the vectors. Energy infrastructure is fundamentally local (Rhodes 2013).

Giving more attention to bottom up optimisation seems a powerful way to really focus on people and place, given that both are central to the energy system and its transformation. However, even this approach cannot be viewed in isolation. Buildings, people, networks are all interlinked so whilst optimising from the bottom up is very important, in terms of overall system change there is a requirement to both optimise the system at the end user and the centralized production end (Service 2015). Arguably the organisations that sit between the top and bottom also have to facilitate change to ensure overall system optimisation and coordination. This links squarely back to the governance framework that is in place, as this is what will ultimately shape the direction and speed of energy system transformation.

⁴⁵ Optimisation is not an end point, the energy system is a complex socio-technical system that is under constant change – optimisation needs to be dynamic to respond to this.

7.3 A Fit for Purpose governance framework

As introduced in the Section 4.5 getting the governance right is a key enabler of the energy transformation as it shapes the technical, social and economic changes that occur. To do this a number of problems have to be solved, which broadly have to do with transparency and legitimacy, current institutions and system operation, as well as some aspects of governance that are currently missing – Figure 39. These all need to be addressed in order to get a governance framework that is fit for purpose.

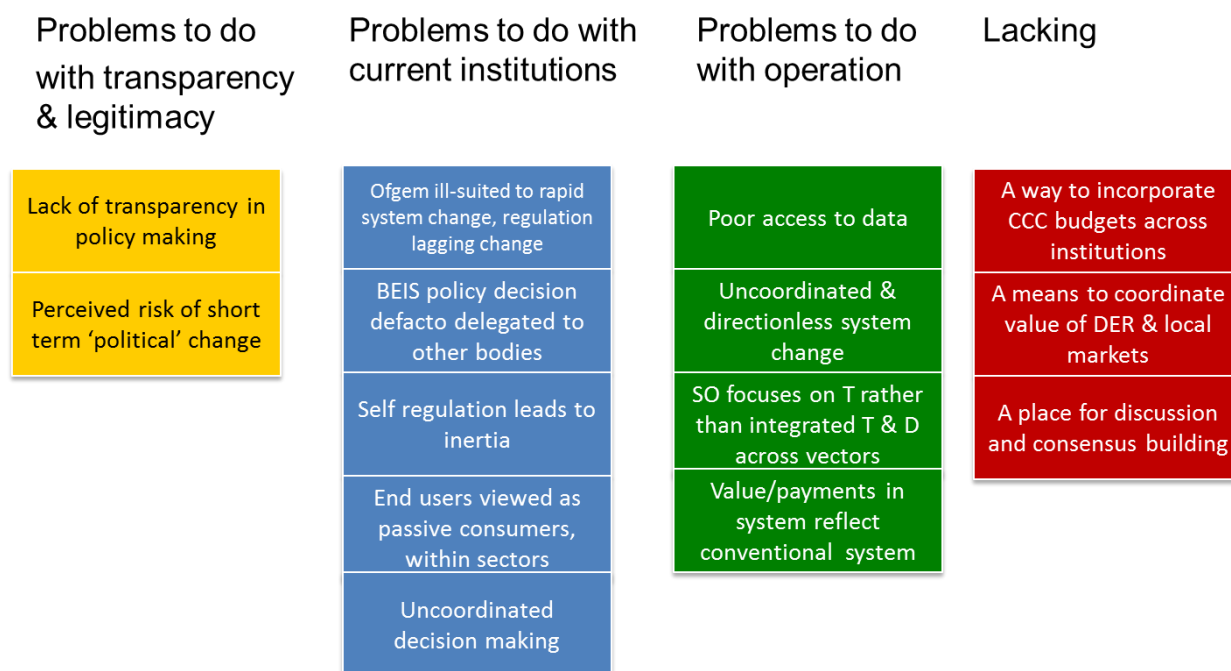


Figure 39: Specific GB governance problems to solve

Source: (Mitchell 2016)

In order to address these problems and move towards a system that focusses on people and addresses the issues in the section above, the IGov team have argued that there is a need for institutional reform to create a governance system that can facilitate change to a more sustainable, lower cost and secure energy system (Mitchell C. 2016). The analysis sets out some basic principles of reform and the functions required from a new institutional arrangement, based on the following six principles:

- Starting with, and centre on, end users;
- Facilitating local markets;
- Open and transparent access to data;
- Greater co-ordination;
- Long-term political stability;
- Transparency and legitimacy in policy making.

Collectively these principles provide a means to reform the governance of the GB energy system and they require a new institutional framework that is fit for purpose in delivering these functions – Figure 40. Within the proposed changes it is recognised that there will be both winners and losers, including a risk of stranded assets (Mitchell 2016), however, the framework will facilitate a new approach to governance that will better meet the challenges faced by the GB energy system, in a more legitimate and transparent way than is currently the case. The proposed approach is broadly based on a combination of the Danish and NY State regulatory system, and it is felt that it is not particularly radical or costly to implement, and would be reasonably straight forward to create (Mitchell C. 2016). Importantly it takes a holistic, system-wide approach to institutional change and places an emphasis on building institutional capacity to enable them to be adaptable and responsive.

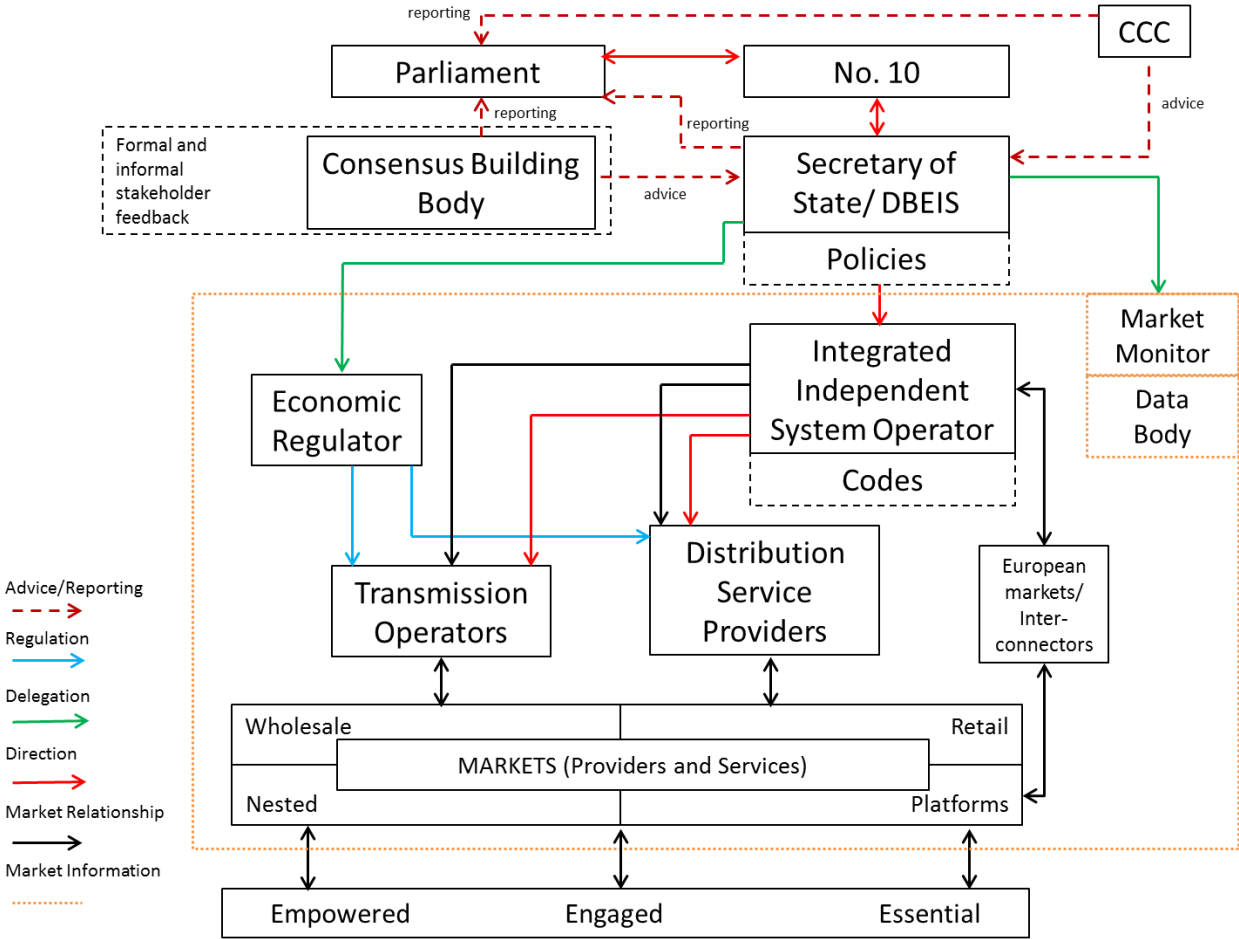


Figure 40: IGov institutional framework
Source: (Mitchell C. 2016: 18)

Within the framework there are a number of specific institutional changes that help to embed people within the energy system. This starts with the first principle above, that reform should start with, and be centred on, end users within the energy system. As the IGov framework papers sets out:

“The first principle is that an agenda for institutional reform that aims to reorient the energy system towards the demand side above all has to place people at the centre, with changes to institutions following from this starting point. A number of other points follow from this basic principle.

First, in contrast to the current approach of poor quality, mass-market customer service, policy should create incentives for personalised service and interaction. The energy system should be run in such a way that it fulfils people wishes, rather than consumers having to fit into the wishes of companies and the regulator wishes, but which also provides a better service in terms of system operation cost.

Second, unlike the current categorisation of end users as consumers by sector and size, people should be seen in terms of the degree of their engagement and of the vulnerability of their circumstances, where it is recognised that both of these will change as they move through the life-cycle and as the economy changes.

The degree of engagement of people is the new dimension, and so is important to emphasise. This goes far beyond the numbers who switch suppliers, which is at the centre of the current debate. End users will make or break the move to a smarter and sustainable system; many of the changes that are occurring are on the demand side, and as such are close to people. The energy system therefore needs to become more facilitative of what they want in respect to energy consumption, energy production and energy services, enabling those who want to be active players to become so, whilst protecting those that are unable, or unwilling to be active. Efforts to connect people with the possibilities for energy use, services and production are therefore essential, including ‘conversations’ about energy with end users in some form.

The area of greatest interest is not energy per se, but rather energy services, both for the end user and from the end user to the system. The last of these is the newest and also the most important in future. Here there are three functions that a new system must deliver. Firstly, ensuring that people can get a fair value for services that they offer the system (most probably through some form of new markets or tariffs). Companies and policy makers must start to view end users as a source of system services, for which the customers are paid and which potentially negates the need for additional infrastructure capacity elsewhere. Secondly, precisely because these are new markets, there is a need to establish trust, credibility and legitimacy. Thirdly, where there are market failures, designing effective interventions to address these will be needed.” (Mitchell C. 2016:14-15)

This high level principle then, provides a way by which the system, its institutions, and wider governance, begins to reorient around people and their role within the system. Along with the wider principles above this provides a route by which the governance can reflect the priorities of the changing system, including the importance of the demand side and end users. As well as moving away from the view of people as simply consumers, to an approach where they are seen in terms of whether they are empowered, engaged or essential energy users, a number of wider institutional changes help to facilitate this. As can be seen in Figure 39, markets in their various forms and the suppliers and providers of services become much closer to end users. Distribution Service Providers become a key facilitator of change at the distribution level by supporting local markets, new entrants and other providers of products and services and connecting these to end users. An integrated and independent system operator (IISO) is tasked with energy system transformation, taking direction from Government. A market monitor and data body ensures that there is open and transparent access to data for the good of the system whilst ensuring end users' data is adequately protected. A new consensus building body brings more legitimacy to decision-making, whilst ensuring that end users' views are represented across the whole system. It also provides a potential mechanism to help support a national discussion on the energy system and start the process of finding ways to develop meaningful consent for system change. Collectively, these organisations help to drive a demand side, people focussed, direction of change – these sit within the wider framework for institutional change; for a full description of the institutions and the rationale for their roles see the IGov Framework Paper: <http://projects.exeter.ac.uk/igov/wp-content/uploads/2016/11/Final-Framework-Paper.pdf>

Ultimately this framework is about providing a clear and legitimate top down steer in terms of system change, restructuring institutions in the middle to enact and facilitate change based on that top down direction, whilst importantly also accommodating and enabling bottom up optimisation from an end user perspective, based on new technologies, social preferences and new entrants and business models within local and national markets. The framework is an important step towards creating a new approach to people, the demand side and the future of the energy system.

7.4 Conclusions

This working paper has set out to explore the relationships between energy system change, people, the demand side and governance. From this there are three main emerging themes and a number of key points that emerge from:

- Future Energy Systems - system change is closer to the demand side, the people that create demand and the places where they live and work;
- Putting People at the Centre of the System - end users need to be put at the centre of the energy system to enable engagement, gain meaningful consent for change and to build legitimacy and trust.
- Fit for Purpose Governance - in order to do this a new governance framework is needed that facilitates the move towards a low carbon, secure and affordable energy system.

7.4.1 Future energy systems

Changing the energy system is technically, practically, economically feasible and socially viable and with political will can be designed and supported to happen at the pace need to tackle climate change, whilst also ensuring security and affordability. There is some consensus that the direction of change will increasingly be towards decentralisation and the demand side and that there are multiple drivers for this. The opportunities offered by taking a D3 approach to system change are clear, reducing demand is the cheapest and easiest way to enable a transformation; DSR offers more ways to increase system flexibility; whilst DER offer multiple technologies at multiple scales that open up a range of choices for the system and for end users within it.

However, policy and regulation remains largely focussed on the supply side and is fixated on the electricity system. There is also a tendency to just focus on technical changes to the energy system. The approach to system change is also siloed and uncoordinated, with the market left to drive change, meaning that 'wrong' solutions (in terms of practicality, direction etc) might be coming forward, in the wrong places, at the wrong cost, in respect to the overall system. The policy landscape for D3 is fragmented and risks making a system transformation more difficult, slower and more costly than it needs to be. To overcome these problems:

- There is a need to rebalance the current dominance of supply side thinking within policy and governance, towards the demand side. This will help to overcome the currently fragmented policy landscape for D3;
- A whole systems approach needs to be taken that looks across heat, power and transport, this will be the only way to decarbonise the system, whilst maintaining security and affordability;
- A more coordinated approach is needed that uses the market intelligently to help deliver change, which is best for the system and the end users within it;

- It is important to recognise that people, their lifestyles and behaviour, are as important as technology change, not least because they will shape which technologies are accepted, adopted and how they are used;
- There is a strong case for thinking about the opportunities for optimising the system from the bottom up (as well as the top down) as it is at this level the most appropriate solutions might emerge, not only socially, economically and technically, but also holistically in terms of the best options for heat, power and transport which can be strongly place specific.

7.4.2 Putting people at the centre of the system

As the system begins to decentralise and shift towards the demand side, it becomes closer to the people that create demand, and the places in which they live and work. It will therefore become increasingly important to rethink the role of people within the energy system, away from them simply being viewed as passive consumers of energy, in which engagement is narrowly viewed in terms of switching energy supplier. There will also be a growing need to gain their consent for system changes, given that: they will pay for some of these changes through their bills; will have to accept change within their localities; and will need to be willing to act. This could also help to create the legitimacy and trust that is currently lacking within the energy industry. In respect to action across heat, power and transport, it is argued that this will become increasingly important, as some changes could be disruptive to the way people currently meet their energy service needs.

Based on these high level issues there are three main findings from this paper and these have to be dealt with collectively to be successful:

- People need to be put into the centre of the system to value what they want and need, as well as what value they can bring. This is best done by thinking of people in terms of their engagement and how the system and its governance supports them based on whether they are empowered, engaged or essential energy users. This recognises that people play various and multiple roles within the energy system and society and that these change over time.
- To gain meaningful public consent for system change will require a new approach from decision makers, away from top down, technocratic and centralised governance, towards bottom up, consensual and legitimate change that seeks to give citizens a voice and role within the system. This can provide people with a deeper understanding, a real say in change and a potential stake in how the system changes nationally, regionally and locally.
- Seeking consent should help to create more legitimacy and trust within the system, and this could be further supported through the development of a social licence within the GB energy sector.

7.4.3 Fit for purpose governance

Ultimately many of the points highlighted above in terms of future energy systems and changing the role of people come back to the overall governance of the energy system. This is because the governance arrangements shape the design and implementation of regulations, markets and institutions and therefore shape and influence which actors, technologies, approaches are encouraged, undermined or excluded. Getting the governance system right is therefore a key aspect in enabling an effective energy transformation as it plays a central role in the technical, economic and social changes that occur. Unfortunately, much of the current governance framework is built around the 'old' energy system and its actors, making many of the changes discussed above, in respect of the system and people, challenging. The governance of the GB energy system is currently not fit for purpose and it has to change.

Based on the discussions within this working paper and the much wider work that has taken place under the IGov project, a key finding in respect to governance is that institutional reform is needed and this should be based on some high level principles, including: starting with, and centred on, end users; facilitating local markets; open and transparent access to data; greater co-ordination; long-term political stability; transparency and legitimacy in policy making.

Ultimately a new, coordinated, institutional framework is needed that can meet the challenges for developing an integrated approach to system change, in respect to a focus on people, this should:

- start with people and direct institutions to focus on what the system is for, what people want and need from it, and what value they can bring;
- place a stronger focus on the distribution level through the creation of DSPs which can drive and facilitate local solutions and local markets, moving markets closer to people;
- put in place new ways to engage people, including through the development of a consensus building body which can help to rebuild trust and gain meaningful consent.

Therefore the three keys to creating a sustainable, secure and affordable system at a pace needed to tackle climate change requires a new approach to: (1) people; (2) the demand side and (3) the governance system. This needs to take account of the direction of travel towards the future energy system, the growing importance of people within this and the importance of their consent and trust. It must also be based on a whole systems, coordinated approach to governance, to facilitate this change.

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