IEA HPT Programme Annex 42:
Heat Pumps in Smart Grids

Task 4:

Roadmap

30th January 2018

Report compiled by:

Delta Energy & Environment

Table of Contents

Table of Figures

1. Executive Summary

HP in Smart Grids: Why do we need them? Scale and timing of the challenges lying ahead on the road to an electrified future in the heating sector

In order to largely decarbonise its heating sector to meet the target of 80% greenhouse-gas emission reductions by 2050, the UK may require a large scale roll-out of electric heat pumps.

Such a scenario, which has been detailed in the UK Government's Heat Strategy and, with a varying focus on electric heat pumps in several other studies on the topic, poses to major challenges to the UK's power system:

- Ensuring that the peak electricity demand during a particularly cold and long winter spell can be fully met.
- Avoiding the overload of local areas of the electricity network from a high number of heat pumps or other systems (e.g. electric vehicles) drawing electricity from the grid at the same time.

There are several different solutions for meeting these challenges, like the deployment of grid storage, flexible generation or interconnectors with other countries' electricity grids, but this report focusses on the amount of flexibility and demand response capacity which could be provided by the heat pumps themselves.

Preliminary modelling results from a study commissioned by BEIS suggest that the current levels of insulation and building fabric in the existing stock may be sufficient to maintain comfort for modest DSR interventions (2 hours) without additional storage. In order to maximise the flexibility available from heat pumps for residential heating, a particular focus should be on activating thermal mass for storage and increasing thermal insulation of the UK's building stock as well as ensuring that sufficient time is being provided between signalling a DR event and the actual event, so that the intelligent controls can "preheat" the building.

Where are we and what needs to be done next? – Messages for policy makers, industry and other stakeholders

A critical element for achieving a smart HP system is the development of a strong regulatory framework which fosters business model innovation and the creation of value from distributed smart demand assets. This will provide heat pump manufacturers, utilities, network operators and energy service providers with sufficient security and incentive to invest in the development of the necessary control interfaces and business models to exploit the value streams created by the new market framework.

Policy makers should:

- Develop a stable regulatory framework which fosters business model innovation in the 2020s.
- Leave the decision on the exact level of communication required between the different parts of the smart grid to the relevant industry bodies, such as norms and standards committees and/or industry initiatives which are already developing communication standards to solve these issues.

- Provide ongoing support for research and development around smart heat pump control technologies, heat storage solutions for the UK market and the requirements and behaviour of the end-customer.
- Consider providing initial support for the uptake of storage solutions and smart heat pump technologies or service offerings if required.

2. Heat Pumps in Smart Grids: Why do we need them?

Scale and timing of the challenges lying ahead

2.1. Why is it necessary to make heat pumps “smart”?

Over the coming decades the UK’s electricity supply sector could face a significant transformation: from a centralised system largely based on easily dispatchable fossil fuel power plants, where supply largely followed demand, to a system reliant on a higher amount of intermittent renewable generation assets, which would require an integrated management of both supply and demand in order to ensure system stability.

As the National Infrastructure Commission pointed out in its recent report, more than two-thirds of all existing power stations in the UK are expected to have reached their end-of-life and be closed by 2030.[1] This means that the UK is currently in a crucial phase of its transition to a smarter power system, as the choices made now will have strong impacts on the future shape of the system.

Heat Pumps, which are the focus of this report, are expected to play a significant role in the way we heat our homes in a low carbon economy. Given their high efficiency in converting electricity into heat, and the expectation that the power sector will largely decarbonise between now and 2030, they are an important element of any attempt to decarbonise residential heating. But this also means new demands on the power systems which have previously been met by the gas grid. The “Smart Power” report has identified three major vectors for making our power system fit for the 21st century and beyond, two of which, storage and demand flexibility, can be provided by heat pumps in the future in order to manage this additional demand.

One specific issue is that of peak demand during the winter which could be significantly affected by the increase role for heat pumps replacing gas boilers. It is therefore important to assess how a heat pump system, including storage and the building fabric, may be able to mitigate these peaks in demand by shifting the time of operation and making use of a more flexible system.

2.2. What does the increasing electrification of heat mean for the electricity grids and what is the scale of the challenge?

The increasing electrification of heat in the UK will lead to an increase in power demand which the current power system is not prepared to meet. As the graphic below shows, the demands for heat in the particularly cold winter of 2010 were subject to very large variations in demand and particularly high peaks.

[1] National Infrastructure Commission (2016) – Smart Power

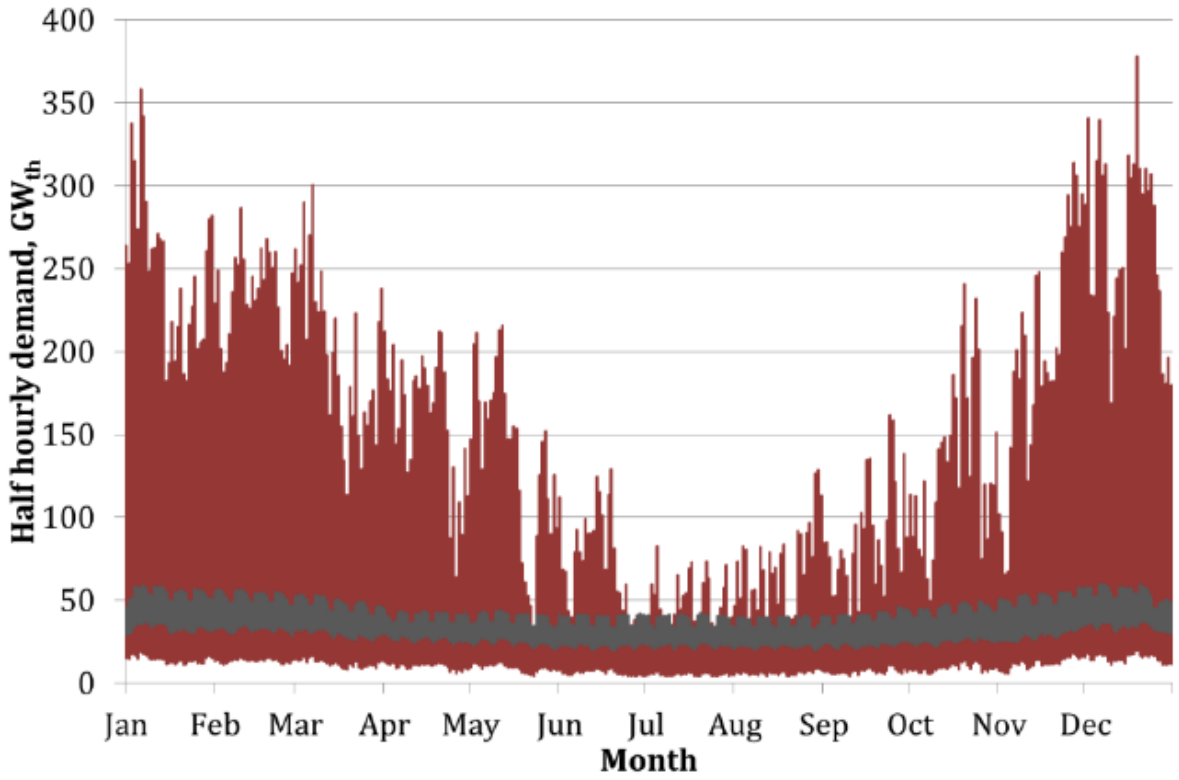

Figure 1: Half-hourly profile of the UK's heat and electricity demands in 2010

Source: Robert Sansom (2015) – Decarbonising Low Grade Heat for a Low Carbon Future

The maximum demand for heat was six times higher than the highest demand on the electricity grids that occurred in that year. This has several consequences:

- Distribution networks are currently not set up to meet the full demand that would occur on a very cold winter day if all homes are heated electrically. In particular the increasing coincidence factor under such circumstances (i.e. the fact that all heating systems are likely to be on at the same time) are a worry for many DNOs. This issue will have to be addressed either through an upgrade of the distribution networks or through controlling demand in order to alleviate the pressure on individual network sections.
- There are also challenges for the supply infrastructure, which is currently not in a position where it could meet all the demand from a largely electrified heating sector. The UK is faced with a declining generation capacity margin, a problem which will only be exacerbated by switching large parts of the heating demand to electricity. Whereas additional generation assets will have to be built to meet parts of this increased demand, a smart demand side management could help to alleviate some of this pressure, by reducing peak demands on a system level.

2.3. What is the timeframe of the challenges?

Currently, there are still very few heat pumps being installed in the UK. But with the Government's aim to decarbonise the residential heat demand, a significant growth

in this market will need to occur in order to stay on track for meeting this target. Whereas it is difficult to provide a date for when the challenges facing the power sector will turn into immediate problems, it is likely that this will start to occur from the late 2020s onwards. By then heat pumps could have become the heating system of choice in new build and could also increasingly be seen installed in retrofit properties likely to be in off-gas grid areas. In combination with an increased amount of renewable generation that will likely be online by then this would trigger the need for more demand side flexibility.

3. What are the possible solutions and where are we with implementing them?

In order to assess the challenges posed by a large-scale electrification of residential heat demand, BEIS has worked in partnership with the Energy Technologies Institute on modelled analysis looking at the potential contributions of heat pumps to a smart demand response system in different building types and technology scenarios.

It is the aim of the modelling study to determine which factors most strongly influence the availability of flexibility from a heat pump system and thus answer the question how much they can contribute to peak demand reduction in the UK. The main variables which are being tested in the modelling are the type and capacity of the heating system, the availability and type of storage, the building archetype, the level of insulation and thermal mass, the temperature control and the flow temperature of the heat supply.

In terms of buildings, the study models six different UK property archetypes, from a small single-bedroom flat to a large detached four-bedroom property from before the 1980s, which together account for approximately 40% of the total residential building stock. Taking into account the heat and comfort requirements of different household types, a total of 18 different combinations of dwelling and occupation are being modelled. Three different types of heat pump are being modelled, combined with different capacities of heat storage.

All combinations of house type, occupancy, heating system, storage, etc are being modelled in a fully dynamic system under two scenarios, addressing the two key challenges arising from a large-scale rollout of heat pumps in the UK:

- How to mitigate a large peak in electrical demand over a cold Winter spell e.g. a sustained period of unusually cold temperatures which would require a sustained, and significant, increase in national electrical capacity.
- Ways to address the daily peak of a large number of heat pumps in a localised area. Requiring a replicable level of flexibility.

All in all, the modelling study is going to be one of the most comprehensive assessments of the amount of flexibility which can be provided by a smart HP system in the UK. Final results from the study, with an indication of the ideal system configuration for maximising flexibility are expected to be available in Summer 2017.

3.1. Solutions – What are the options and where do we need to be when?

Preliminary results from the modelling suggest that there are two factors which very strongly influence the ability of a smart HP to provide flexibility to the wider energy system.

- The quality of the thermal envelope and thermal mass of the building seems to be an important factor determining the amount of time a heat pump can be switched off during a DR event without the temperature in the home dropping below the comfort levels.
- The amount of time between sending the demand-response signal and the heat pump needing to shut off seems to be another important factor which influences the period during which a HP can be switched off. This is mainly due to the fact that the heat pump can "pre-heat" the house before the DR event if it has been "informed" early enough. This then allows the heat pump to stay switched off for longer before the temperature starts to drop below the comfort levels.

The key findings from the first few model runs therefore suggest that in order to maximise the flexibility available from heat pumps for the mitigation of system-wide and local demand response requirements the insulation of the building stock together with an increase in thermal mass and a certain level of "pre-warning" are required. Whether this preliminary trend is confirmed will be subject to further modelling and analysis to be carried out on a wider set of building archetypes.[2]

4. What are the next steps?

4.1. What are the pre-requisites and what progress has been made?

Creating a smart heat pump system will require four different elements to come together: Technical barriers will need to be overcome, the regulatory framework will have to be set up in the right way, end-user behaviour will have to be understood and adapted for and there will need to be new sources of value in order to promote and reward participation in a smart heat pump system.

[2] For more detailed information on the preliminary results of the modelling exercise please refer to the UK's input to Annex 42's Task 3 report.

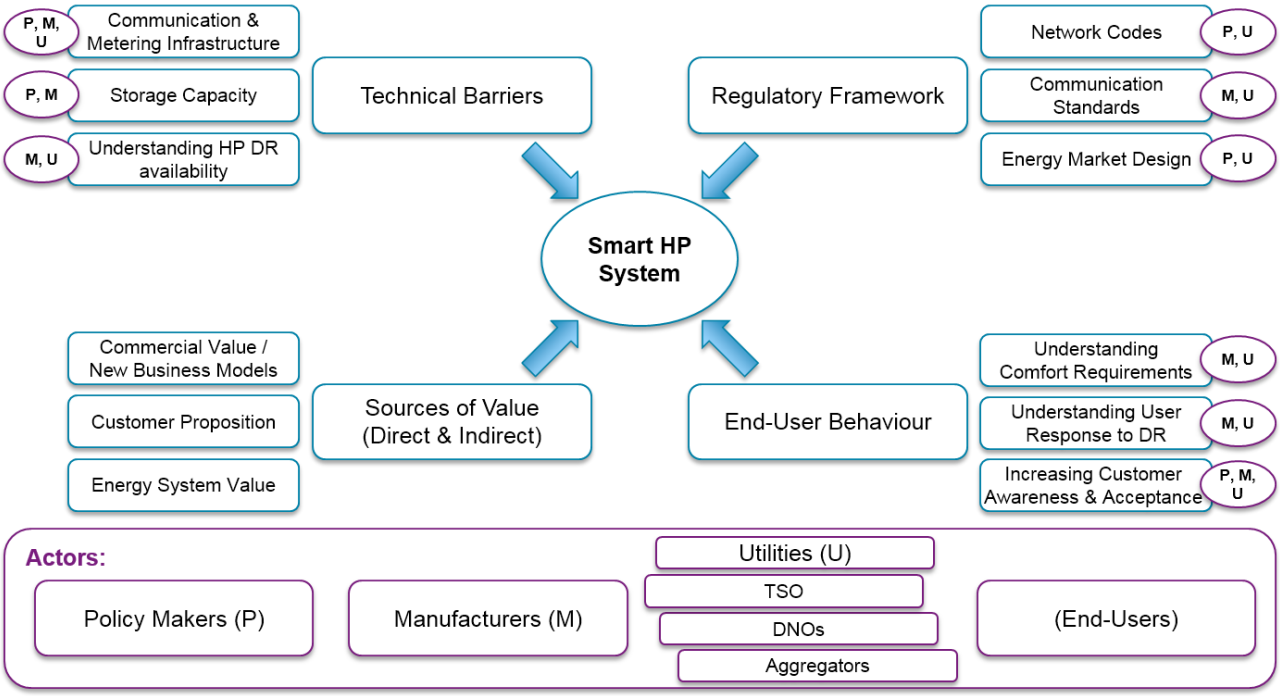

Figure 2: Key enablers for a smart heat pump system

Technical Barriers

The main technical barriers for the development of a smart heat pump system are the communication and metering infrastructure, heat storage capacities and understanding the availability of demand flexibility from heat pumps, in particular during a very cold period.

Communication and Metering Infrastructure

In a smart grid, heat pumps will have to communicate and exchange information with a control infrastructure which manages their operation. The level of communication that has to occur between the heat pumps and the control infrastructure and the means of communication used is still open to debate, but future smart heat pumps should reflect at least Smart-Readiness Level 3. This means their control system should allow for dynamic responses to external signals, e.g. flexible tariffs, and ensure that flexibility is maximised while minimising the impact of any demand response event on the comfort of the end-user.[3]

The smart metering infrastructure is also a vital part of any smart grid, as it allows half-hourly settlement and thus enables the introduction of dynamic time-of-use tariffs, which are expected to be a main source of value for smart heat pumps. The successful roll-out of this infrastructure in the UK, complemented by the right type of tariffs, will therefore be pivotal in the development of a smart heat pump system. At the end of June 2016, a total of more than 2 million smart electricity meters had been installed in homes throughout Great Britain, leaving around 26 million homes to be fitted with the technology by the end of 2020.

[3] As described in Delta-ee (2014) Review of Smart Ready Products – United Kingdom.

Heat Storage Capacities

Heat storage could play an important role in enabling flexibility in a smart heat pump system. As space in the average UK home is at a premium, and many water cylinders are currently being replaced with combi-boilers, creating new heat storage capacities in people's homes will be challenging and rely on products tailored to the UK market.[4]

In response to this challenge, research and development is carried out to address this product gap. Two examples for this are the development and market launch of a heat storage product using phase-change materials in order to reduce its footprint in the home[5] as well as the exploration of the use of heat pumps for instantaneous domestic hot water production[6].

Understanding flexibility availability

Understanding how a smart heat pump system, from the individual home up to system level, will react to a demand response event is crucial for the design and operation of such a system. Despite several studies and trials having already shed some light on this issue,[7] the topic is not yet sufficiently understood and will require further investigation over the coming years, with a particular focus on the performance of smart heat pump systems in unusually cold external temperatures.

Several trials are currently underway to address this question in more detail. Amongst others the Smart Community trial with a total of 550 HP systems funded by the Japanese New Energy and Industrial Technology Development Organization (NEDO) and supported by BEIS in the Greater Manchester Area and a planned trial of up to 100 hybrid heat pumps for smart demand response in the FREEDOM project, funded through the Network Innovation Allowance and located in the network areas of Western Power Distribution and Wales & West Utilities.[8]

Regulatory Framework

The regulatory framework of the energy system is another important element that needs to be set up in the right way in order to enable a smart heat pump system. The future energy market and network regulations will need to be geared towards an

[4] Between 1996 and 2014, the share of English homes with a hot water cylinder installed has reduced from 63% to as little as 38% (or about 10.8 million homes). DCLG (2016) – English Housing Survey: Energy Report 2014 (https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/539570/Energy_report.pdf).
[5] As for example by the Scottish company SunAmp (http://www.sunamp.com).
[6] Ongoing research at Ulster University.
[7] Cf. two studies prepared in the context of Annex 42 for an overview of both field trials and modelling studies having looked at this topic. Delta-ee (2014) – Task 2: Review of Modelling Studies & Delta-ee (2014) – Task 3: Demonstration Projects, downloadable here: http://www.delta-ee.com/consultancy/delta-ee-heat-pump-reports-decc.html
[8] For more information on these trials, please refer to the demonstration project summary (part of Annex 42's Task 4).

inclusive system, where customers will have a more active role in the energy system than today.[9]

Network Codes

The network connection codes can sometimes be a barrier to the uptake of heat pumps, e.g. requiring significant additional expenditure to be borne by the customer for an upgrade to his electrical connection. Both the Distribution Code (DPC 5.2.1) and the National Terms for Connection require customers to notify the local DNO of any significant changes to their connection.[10]

Whereas this requirement is necessary for the DNO's capacity planning and potential upgrading of parts of the network, the costs of such measures to the customer should be kept to a level which does not put the installation of the HP into question, ideally a flat fee, with the remainder of the cost borne by the DNO who can then recoup the cost of this investment from its client base.

Whereas the ENA and the DNOs have already taken steps to simplify and streamline the notification process through the provision of templates, more could be done to reduce the hassle factor for installers with regards to this topic. A possible solution would for example be an automated online platform on which an installer can choose from a range of provided HP models in order to submit a notification.[11]

Communication Standards

An open standard for the communication between the heat pumps and the control infrastructure would be preferable, as it would allow easier compatibility between different products and service providers. The end-customer could therefore more easily switch service provider, which would increase competition and therefore reduce costs of a smart heat pump system.

Steps towards the development of open and interoperable standards are currently being taken by the industry, e.g. the EE-Bus and openADR standards, which are both supported by a wide range of industry and utility stakeholders.

Energy Market Design

The energy market will need to be adapted in order to allow the creation of new flexible (time-of-use) tariffs or the access to other sources of value through the end-customer or the aggregator who provides their demand response services to the market. These tariffs are different from today's offerings like Economy 7 and Economy 10 in that they change their pricing dynamically on a day-ahead or even

[9] Note that this does not necessarily require an active engagement from their side, as many of the reactions to e.g. demand response needs will most likely be taken over by automated systems in the smart residential environment.
[10] http://www.energynetworks.org/electricity/futures/heat-pumps.html
[11] Similar to the SPF- and Noise-Calculators from the German HP Association for example. Automating the notification and approval process as much as possible would also allow HPs to be deployed more easily in distress situations (currently the Guaranteed Standard of Service for receiving a quotation from the DNO is 5 working days) and will also be a key element if the uptake rates of HPs should reach the levels required to decarbonize the UK heating sector.

intra-day basis, mirroring the needs and requirements of the electricity system at any given time.

Access barriers to the already existing markets for supply and demand side flexibility are a key area of concern in the Government's and OFGEM's recent joint call for evidence on "A Smart, Flexible Energy System", published in November 2016.[12] After the input to this call for evidence has been analysed, the Government and the regulator will set out whether new routes to access existing balancing and flexibility markets will be required. On the basis of this decision, a new regulatory framework for aggregators and other new players in the flexibility markets, which also provides access to these markets to new types of flexibility, is to be developed until 2020.

Sources of Value

Creating value for all stakeholders in a smart heat pump system will be a key element on the way to creating such system.[13] Value should be created for all actors of the energy system, from businesses to the end-user, in order to ensure a sufficient penetration of smart heat pump systems in the future. This does not necessarily need to be value in a monetary sense, especially at customer level this value could e.g. be created through increased comfort or other sources of convenience enabled by smarter, connected controls.

Commercial Value / New Business Models

A key driver for the development of a smart heat pump system will be the creation of commercial value which can be turned into cash-flow, in order for companies to invest in smart heat pump technology and to build and maintain the necessary infrastructure. New business models will allow actors to tap into the commercial value of the smart heat pump system and there is already evidence of such business models being developed.

Examples for a successful commercialisation of such business models are for example the Swiss smart grid company TIKO[14], who successfully use a pool of more than 5,000 heat pumps and other electrical devices at customer level in order to provide services to the Swiss balancing market.

The requirement for the effective remuneration of flexibility services has also been identified in the aforementioned call for evidence. Amongst other measures this call for evidence identifies the need for an improvement of price signals in the market place as a key element for action by the regulators.

In the same document a decision on the introduction of mandatory half-hourly settlement on the basis of the UK's smart metering infrastructure is currently expected to be taken by the regulators in the first half of 2018. This decision, if positive, should provide a clear signal for developers of innovative business models to engage with the potential for demand response from residential customers.

[12] BEIS, OFGEM (2016) – A Smart, Flexible Energy System, A Call for Evidence, available here: https://www.gov.uk/government/consultations/call-for-evidence-a-smart-flexible-energy-system
[13] Unless mandatory elements are being introduced.
[14] See www.tiko.ch for more information.

Customer Proposition and Protection

The customer proposition will be an important element for engaging the end-customers in the smart heat pump system and make the capacity of their heat pumps available for the smart grid. A successful customer proposition will have to provide end-customers with monetary or other tangible benefits as well as maintain comfort at a desired level.

Again, TIKO is a good example of how such value can be created. TIKO currently does not reward its customers for allowing the company to control their heating systems remotely. Value for the customer is created on the one hand by potential energy savings (although these are not guaranteed) as well as through giving the customers access to an online platform which allows them to monitor and control their heating system.

Another important element of a future smart heat pump system is the sufficient protection of customer interests. This has been identified as a field of action in the Government's smart, flexible energy system call for evidence. A decision on whether additional consumer protection is required in a smart energy system will be included in the final Government plan. This plan is expected to be published in spring 2017, after the analysis of the stakeholder responses to the call for evidence.

Energy System Value

In order for it to be a reasonable investment, a smart heat pump system will have to provide value to the wider energy system. Valuable services provided on a system level can include for example load balancing on a day-ahead and intra-day basis as well as local network constraint management. Other services which could potentially be provided by a smart HP system could be frequency response or participation in the Short Term Operating Reserve (STOR) market. The future energy market design will have to provide possibilities for co-ordination, combination and arbitrage between these services, as they can potentially be combined, but can also have opposing aims. One example for such an opposing aim could be a situation where a nation-wide oversupply of electricity pushes the party responsible for balancing the energy supply and demand[15] to request an increase in consumption in order to avoid curtailing the supply side. If a large number of smart consumer devices in one particular area start increasing their demand as a response to such a request, this can lead to local overloading of the network. Such situations could lead to a default of critical infrastructure and local power outages and therefore need to be avoided. In order to assure this, players in the smart HP system on all levels, aggregators, distribution system operators and the balancing responsible party need to be able to effectively communicate to find the cost-optimal solution for a specific demand-response need occurring in the network. One example for a market structure allowing the arbitrage between opposing demand-response requests from different

[15] In the UK this role is fulfilled by National Grid, whose responsibility it is to constantly balance supply and demand of electricity in the UK's network.

players is the Universal Smart Energy Framework (USEF) initiative in the Netherlands.[16]

End-User Behaviour

Understanding the end-user preferences and their behaviour with regards to the use of energy and their needs for comfort will be paramount to ensuring the success of a smart heat pump system. Negative experiences with smart heat pump will damage customer acceptance and therefore jeopardise the roll-out of smart heat pump technology.

Understanding Comfort Requirements

Understanding the comfort requirements of different types of end-users and how they can be maintained or increased while also providing flexibility to the energy system is a key task of the smart heat pump developers. Maintaining comfort levels within an acceptable range is paramount to the acceptance of demand response by heat pumps by end-customers.

Understanding User-Response to DR

Questions like: “Do end-customers want to be informed about a demand-response event?”, “How likely is it that they are going to override any external intervention to their heating system?” or “Has the information that a demand-response is taking place a psychological effect on the customer`s comfort perception?” are only a few of the questions that will need to be explored in more detail in order to create a successful smart heat pump system.

Work has been carried out in this area by a company called Passiv Systems[17] in co-operation with the University College London, where it was found that the user-response to DR events is *highly dependent on maintaining the comfort level requirements of each individual customer*. More research into these questions is also being carried out under the Greater Manchester Smart Communities project. Preliminary findings indicate that manual opt-outs from DSR interventions occur in less than 10% of properties even during the coldest periods.

Increasing Customer Awareness & Acceptance

A successful roll-out of smart capabilities in heat pumps and their subsequent use through end-customers (e.g. through the uptake of a flexible tariff or the co-operation with an aggregator) will require raising the end-customers’ awareness & acceptance of such solutions.

[16] The USEF is a joint initiative by energy and IT infrastructure as well as distribution network operators which aimed at developing and trialling a market framework for a smart, decentralised energy network. See https://www.usef.energy/news-events/publications/ for more information on their work and findings (reports in English).
[17] See www.passivsystems.com for more details on their work.

4.2. What is the critical path to reach these solutions?

In order to reach the target of a fully flexible and smart heat pump system a series of steps and actions need to be taken by the Government and other stakeholders of the energy market. The graphic below summarises these steps on the way to a successful roll-out of a smart heat pump system.

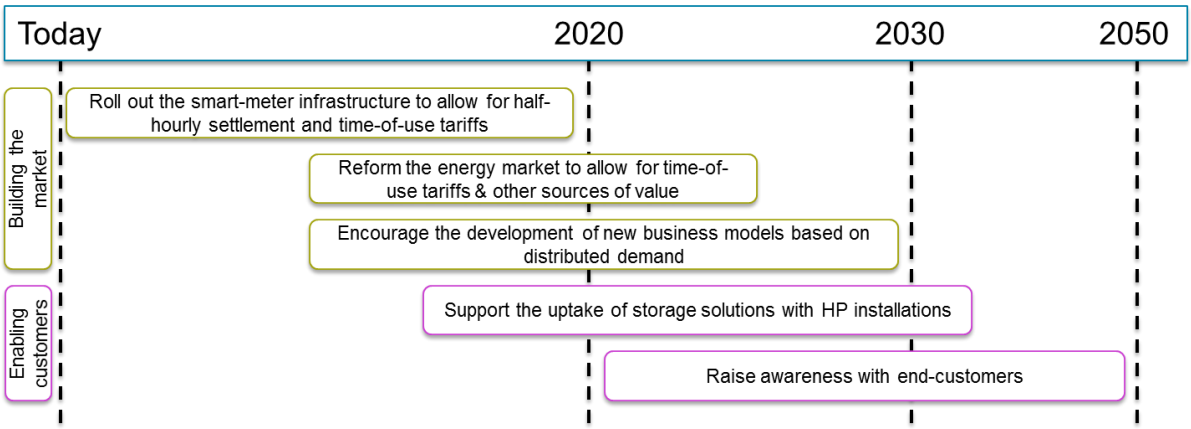

Figure 3: The critical path for reaching a smart heat pump system between now and 2050

The necessary actions and steps along the way to a smart heat pump system can be divided into two major fields of action:

- **Building the market:** Creating the right market conditions and rolling-out the infrastructure for time-of-use tariffs is going to be the most important step on the way to a smart heat pump system, as a lack of adequate infrastructure and regulation would prevent new business models from emerging.
- **Enabling customers:** The customer is a central part of the smart heat pump system and providing them with the necessary technology and information how to use it will be important for the uptake of smart heat pump solutions.

Although some of these actions will have to be carried out simultaneously, there is a clear path with regards to what should happen when, with the creation of the right technical and regulatory framework for the smart heat pump system being the bottleneck of the process. Ideally the following steps should be taken:

By 2020:

- A successful roll out of the UK's smart meter infrastructure is the first step to enabling a widespread adoption of smart heat pump technology in the market.

By 2020-25:

- By the middle of the coming decade the energy markets should have been reformed so that time-of-use tariffs and other sources of value for distributed smart demand have become widely available and easily accessible, incentivising the heat pump industry to develop or refine the control systems necessary to exploit these tariffs and the energy services industry to develop the services to exploit these sources of value.

Ongoing from today, further research into customer attitudes and behaviour as well as the role of storage for providing flexibility should be carried out. By 2025 a strong evidence base surrounding these topics should have been built in order to support the transition to a smart heat pump system. This does not mean that research into these topics should be abandoned thereafter, as market requirements and end-customer attitudes will evolve in the future.

By 2030:

- Between the wide-spread introduction of smart meters and the late 2030s the Government should enable and support the development of new business models based on distributed smart demand installations. The reforms of the energy market in the first half of this decade (see above) should aim at enabling new business models to be developed which provide valuable services to the energy system and the end-customer.

By the mid-2030's:

- Up to the mid-2030's a core task for creating a smart heat pump system will be the development and subsequent deployment of storage solutions which are suited to the particular needs of the UK heating system market. I.e. the research and development should target compact, low cost heat stores with a high energy density, which will provide sufficient amounts of energy storage to enable demand side response capacity, while keeping the level of space loss inside end-customer's homes acceptable.
- As it is unlikely that end-customers will want to give up the space they have gained in their homes through the replacement of existing hot water tanks with combi-boilers, policy intervention in the form of a support scheme and/or mandating minimum levels of heat storage to be available for a heat pump installation is likely to be required.

4.3. What policy interventions can support this path?

The main policy interventions required in order to achieve the critical path towards a smart heat pump system are the development of a strong regulatory framework which fosters business model innovation and the creation of value from distributed smart demand assets.

Having such a framework in place should provide heat pump manufacturers and energy service providers with sufficient security to invest in the development of the necessary control interfaces and business models to exploit the value streams created by the new market framework. What this market framework looks like should be determined in close cooperation with utilities, service providers, network operators and consumer protection bodies, in order to ensure that value is distributed across all stakeholders of the energy system.

Although the exchange of information on energy prices or demand response between stakeholders will become an important part of the smart heat pump system, the development of the necessary communication standards and protocols should be

left to the relevant standardisation bodies and/or industry initiatives which have already formed in order to solve this communication challenge. The mandating of a specific communication protocol by policy makers should only be considered if there are clear signs that the market place cannot decide on a communication standard or standards which will provide the required capabilities and services to the UK's energy system.

The Government and policy makers should also ensure that further research and development support is made available to developers of smart heat pump control and heat storage technologies, in order to ensure the availability of adequate hardware for the development of the smart heat pump system's business models.

It is also likely that there will be a need for policy intervention in order to promote the uptake of additional storage solutions, should the heat storage capacities provided by the building fabric of a typical UK home prove to be insufficient for providing demand response services to the wider energy system. This can be done through incentivising the installation of storage, or through mandating a minimum level of flexibility that a heat pump installation has to be able to provide without impacting customer comfort. The same might be the case for the initial uptake of smart heat pump technology and service offerings, while the technology is still unknown to the average customer and business models are still under development and having to prove their long-term viability to the end-customer.

Last but not least, policy makers should ensure that the roll out of the smart meter infrastructure, which is going to be a backbone of the smart heat pump system, is going to plan and is finished around the year 2020, in order to give sufficient time for new business models and technologies to be developed and to penetrate the heat pump market.

4.4. What are the key messages to policy makers?

To summarise, the key messages to policy makers are the following:

- Providing a stable regulatory framework which fosters business model innovation by providing clear value opportunities. Delivering smart meter infrastructure should provide the necessary security for product manufacturers and energy service providers to invest into the development of a smart heat pump system.
- The decision on the exact level of communication between the different parts of the smart grid should be left to the relevant industry bodies, such as norms and standards committees and/or industry initiatives which are already developing such communication standards.
- Ongoing support for research and development around smart heat pump control technologies, heat storage solutions for the UK market and the requirements and behaviour of the end-customer will provide a sound basis for the development of a stable and successful smart heat pump system.
- Initial support for the uptake of storage solutions and smart heat pump technologies or service offerings might be required, in order to overcome

potentially high upfront costs at market introduction and the “awareness barrier” surrounding new tariff models.