ERP Heat Pump Workshop

Meeting Note – 23 January 2017

The workshop brought together experts from the energy industry, appliance manufacturers, engineering consultants and system analysts to discuss and identify the issues affecting the deployment of heat pumps and if there are any low-regret options that could be pursued now.

This note provides an overview of the discussion at the meeting. Addressing some of the points raised will require broader strategic consideration, which is being considered by the Analysis Team of ERP in the Transition to Low Carbon Heat, due to publish in summer 2017. In attendance were:

Bosch Thermotechnology	Energy Systems Catapult
Energy Saving Trust	Energy Networks Association
Carbon Trust	BEIS
National Grid	Atkins

The discussion was broken down into three sections – customer involvement in uptake, supply chain development, and the impact of deployment on the energy system and infrastructure. These three groups are interrelated, which is reflected in the structure of this note.

Low-Temperature Heat Pumps are assumed to become a common type of low-carbon heat, but they are not suitable in all homes, unless measures are taken to reduce the over-all heat load. Hybrid heat pumps were included in the discussion. Gas-driven heat pumps were also considered: these have the most potential for technical innovation, although they are dependent on the gas grid and hence are currently not low-carbon, so their future is dependent on decisions on whether the gas grid can be decarbonised.

Summary of key points

The UK is going to have to spend £billions on its energy infrastructure, but this presents an opportunity to ensure that the transition is coordinated so that it delivers an energy system that meets future needs.

Improving the customer offer and increasing uptake will impact on the local energy supply networks, which may incur additional costs that may be hard to predict. Any policy decisions will need to be clearly targeted so electricity and gas network and transmission companies can predict and plan necessary upgrades and allocate their regulated financial resources.

Setting a clear, long-term policy objective, that enables a reliable market to develop, was viewed as vital for industry. Appliance manufacturers and installers need clarity about the market size if they are to invest in developing the necessary supply chains and to plan steps to ensure that the necessary infrastructure is in place. Some performance improvements and cost reduction would be delivered if the market was available.

Local authorities could play an important role in delivering the transition to low-carbon heat through, for example, assessment of heating options. In order to do so, they would require more duties and powers, and they would also need to enhance their capacity, capability and tools.

A: Priority areas – general approach

Consideration was given to whether it was possible to identify areas, characteristics, or segments of the heating sector, where heat pump could be prioritised: noting the importance of identifying least-regret options, which are less vulnerable to future policy changes. With alternative options possibly becoming available that would allow continued use of the gas-grid, the following three groupings were proposed: on-gas grid, off-gas grid and new-build. It was noted that these could be segmented further into rural and urban, and then by building type.

While some areas may offer lower regret opportunities, such as rural, off-gas grid where there are fewer options are available (unless more bioenergy alternatives become available), they may incur higher costs, because of the need to upgrade the local electricity network. Furthermore, deployment may need to be matched with thermal fabric upgrades.

Policy certainty that provides a suitable market volume and a secure timeframe would give industry confidence to develop a supply chain and invest in HP training. For example, even if only for 10 years of deployment in off-gas areas, this could feasibly deliver 180,000 installs per year.

New-Build

New Build should be '2050 ready' to avoid need for remedial work in the next 30 years. Building regulations should deliver high standards of fabric energy efficiency, such as the original 2016 Zero Carbon Home standard (or preferably better). There is no reason for new buildings to be connected to gas grid; even poorly-built new-build has low enough heat demand to allow heat pumps to work efficiently. The dilemma of volume-vs-quality was recognised.

Regulations currently give developers choice as to which technologies to use, but it is unclear if heat pumps could be prescribed or pushed in revised regulations. For developers Heat Pumps are not the lowest cost way to meet regulations.

Off-gas grid vs on-gas grid

Prioritising rural off-gas buildings has several benefits, as they have fewer low-carbon options. Replacing oil and LPG heating systems should be a priority as they already have a wet heating system and would deliver significant carbon reductions; although the current low price of oil means that the customer offer is weaker.

Off-gas areas present additional challenges compared to on-gas, irrespective of current heating system. Deploying heat pumps in off-gas areas will be more expensive per building, because the sections of distribution network, particularly in rural areas, that need upgrading tend to be longer and hence more expensive. Off-gas is also vulnerable as there is a wide variety of buildings, many of which are old and poorly insulated: these higher thermal loads would have a greater impact on the electricity network. Urban off-gas areas would be lower cost, as the network upgrades would be cheaper (per building) and the homes tend to be smaller than in rural areas, so insulation would be cheaper. However, it was noted that these characteristics of urban off-gas also favour other options such as heat networks.

The lowest cost option is likely to be on-gas urban areas, as upgrades to the network for heat pumps are likely to coincide with early demand from electric vehicles (EV), which is expected to be later in rural or more remote areas where sparser charging infrastructure would detract from their appeal.

Most attendees agreed that off-gas grid would be a good place to start deploying heat pumps, and developing a heat pump supply chain. On-gas may have a wider range of options, depending on decisions about decarbonising the gas grid, and hence there is merit in waiting until these options become clearer. However, the scale of the on-gas grid challenge was emphasised and any early action for off-gas should not distract from determining the options for on-gas.

Policy considerations

Decisions will be needed as to how to socialise the cost of grid upgrades. It is possible that by installing a heat pump the home owner could be responsible for the cost of upgrading the network to meet increased power demand, although this would be shared amongst any subsequent installations. However, without accurate data on installations this may be hard to attribute. But it raises the question of how best to apportion costs and whether they should be socialised across the network, potentially as a coordinated heat pump deployment and network upgrade plan.

In a rural area, with long networks between customers, this could be very high, which if socialised across the DNO would lead to urban areas (where the upgrade costs would be lower) effectively subsidising rural areas. Such considerations would have to be built into the assessment of the suitability of a heat pump in any home.

It was noted that reactive, short-term changes to any policies can be disruptive. For example, shifting existing support mechanisms to prioritise a particular geographical area or type, while potentially providing benefits could, without adequate assessment of the potential impact on local electricity networks, lead to significant unforeseen costs or failures in service delivery.

Text Box: Balancing thermal heat load and low-carbon heat supply

Thermal load of a building is the critical factor as it has to be matched by the thermal output of any low-carbon heat supply. A balance is needed between the scale and cost of intervention to improve the thermal performance of the fabric of the building and the specification of the low-carbon heat supply and its associated costs and impacts on the energy system.

The maximum output of a domestic heat pump on a single-phase electricity supply is 15kW. Insulation may be needed to reduce the thermal load of the building down to these specifications. Alternatively, if thermal load remains above 15kW, a 3-phase electricity supply will be needed, which adds cost. The UK's distribution grids have lots of 3-phase cables, but, unlike most European Countries, most domestic connections are single-phase. A 3-phase connection may be an appropriate solution as they can overcome phase imbalance on single-phase supplies that have only a few customers to provide natural diversity. Innovation could improve how HPs can be integrated into the system.

In some instances changes may be required to internal, wet heat-distribution systems. But if a HP is sized correctly then even low-temperature systems can use current radiators, although they would require some changes in heating behaviour (leaving HPs on full-time for low-temperature trickle heating). In Germany, this heating behaviour is commonplace: it is ensured by heating controls, although the homes are generally more efficient than in the UK and hence better suited to HPs.

B: Customer Offer

Considered: delivery models and the role of the consumer; installation trigger points; and potential for innovation.

Awareness and consumer protection

Awareness of Heat Pumps is low. The lack of uptake in new homes means they are not yet seen as attractive. Heating installers need to understand heat pumps as they provide most of the guidance (EST report 2013/14 on why customers replace heating system). This is similar to Solar PV where installers drove most of the uptake.

HPs are more susceptible to installation issues than boilers, leading to stories of bad performance. A whole-house assessment should be undertaken to ensure the suitability of the building, appropriate heat pump sizing, and its power connections, and any issues addressed that might affect or inhibit performance. Consumer assurance and protection schemes, such as Switzerland's heating ombudsman, would help to address this.

Heating controls need to be explained to customers in order to get heating efficiencies, which would have to be done by industry. The private rental market presents an additional challenge for uptake of heat pumps and using heating controls efficiently as the user is generally not involved in choosing the option.

The physical size of heat pumps makes them difficult to put into UK homes, particularly as most boilers are in kitchens (as opposed to basements in Germany, for example). Hot water storage tanks are also being removed in favour of combination boilers. This could be overcome, but depends on recognising the benefits of storage and willingness to pay for it. The Netherlands is nearest example to UK (in terms of percentage using gas for heating), but heat pumps uptake is also low, as boilers tend to be in roof-spaces where it is hard to put HPs.

Policy and regulatory levers

Regulations should target desired outcomes, and be technology neutral. However, technology neutrality needs to recognise that heating options are likely to be highly regional and may be dependent on a large customer base to spread the cost of upfront investments, such as retrofitting heat networks or upgrading local power networks. Soft-touch regulations were regarded as insufficient. Hard regulations would need money to help those that cannot afford. Scotland is trialling equity release; it is necessary to map needs and options for various areas.

Customers need to be alert to the fact that current heating systems are not future-proof. The costs for the energy services are also expected to increase, which is contrary to the current emphasis on keeping energy bills low. Carbon pricing would provide signals, but the costs are not just due to the cost of carbon. Heat pumps have much higher upfront cost than boilers, both unit cost and initial installation. Enabling a shorter pay-back time would be beneficial for home-owners. An early market could be large property-owning organisations and social housing who have longer-term interests.

Solutions should be based on the overall cost of providing the energy service. Sweet-spots should be identified, that finds the most cost-effective balance between installing energy efficiency measures, the most cost-effective low-carbon heating system and any associated network support costs. But incentivising this is complex and challenging.

Customers are primarily concerned about heat and are not particularly concerned about the technology. Performance and service packages may be a preferable means of managing the transition and its costs. The Energy Systems Catapult is looking at projects where performance would be guaranteed to improve the consumer offer. Solutions need to be validated before they are installed. This could be similar to the Dutch Energiesprong scheme that delivers whole-house insulation solutions, and is being trialled in UK.

Energy Performance Certificates (EPCs) for all buildings could drive improvements in buildings, for example if linked to financing and mortgages. The Domestic Heating Strategy Group is looking at how to simplify the EPC, although it was noted that simplification reduces the usefulness of EPC for making detailed retrofit plans (as per the more complex assessments used in Germany).

It was noted that the mandate on the private rental sector, due to come into force in April 2017, for a minimum EPC rating of 'E' would still allow oil boilers (condensing).

The new-build market is different to promoting heat pumps to existing householders. Developers base technology choices on what hits the SAP target, but this does not favour heat pumps because the carbon intensity of electricity is too high. The SAP rating process should be modified to take account of future carbon rating of electricity rather than just the current level.

C: Supply Chain

Considered: key constraints that limit the ability of the market to deliver large-scale roll-out of heat pumps; potential for cost reduction through scale and innovation; and ensuring quality of installations.

Industry will engage if long-term policy stability is provided - ten years would be long enough. This would allow manufacturers and large players to invest in instilling quality standards for the supply chain and installation. Policies that only provide a short-term incentive lead to smaller companies coming in for a quick buck, often with poor quality.

A clear, long-term market would help installers, who are the main retailers for heat systems. Many are small businesses and, at present, are reluctant to take the risk of promoting heat pumps, because of concerns about reputational damage, either from installation quality, or if they are seen to promote non-credible technology options. Some are also reluctant to take the risk of investing in training on the basis of a small market.

Cost-savings could come from innovations in retrofit practices, which reduce the need for bespoke projects for each building. These include non-invasive pre- and post-installation assessments, and off-site fabrication reducing the disruption of installation. Current retrofit mainly uses standard building practices, e.g. large trucks full of building materials and turning homes into building sites. Off-site construction has lessons to pass on to the retrofit market

Standardisation of boilers is making them cheaper and easier to install as UK gets close to reinstall market (i.e. most homes already have gas boilers). HPs would be a new-install market.

Off-gas market is big enough to justify developing a supply chain. The biggest challenges would be for electricity grids. Limiting the market to natural replacements would be sufficient, as would focusing only on fully replacing oil. A market of 60,000 units per year would allow a manufacturer to commit one whole factory.

D: System Implications

Considered: impacts on electricity and gas networks; grid and generation capacity; impact on deployment; and potential to enable innovation.

Predicting uptake is difficult but important, as Network and Transmission price-setting cannot be changed reactively, for both gas and electricity. A policy that prioritises only off-gas customers is not a clear enough steer for grid companies. Establishing a clear policy and approach to deployment would enable DNOs and Ofgem to be proactive and plan well-justified investments. Prioritising heat pumps in rural off-gas areas could lead to high-levels of uptake and would need to be built into DNO planning.

In some cases even very low numbers of heat pump installations can cause network issues creating local system stress and affecting the power quality, leading to reinforcement of the local distribution network. These are major concerns for DNOs; if deployment is unplanned or unpredictable it could put DNO (and GDN) resources in high demand, for upgrading grids, disconnecting gas customers, etc.

Emerging technologies, such as new modulating heat pumps and control systems, could help by providing very different demand patterns to current offerings, but these will need to be deployed along with the appropriate control systems – see also DSR below.

Data needs

DNOs and TNOs should be involved in the local strategic planning to ensure that their plans are coordinated with local needs and deployment plans. Detailed deployment plans for heat pumps would allow necessary network upgrades to be coordinated, which wold allow the costs to be socialised as part of the network development plan. Unpredictable deployment could lead to reactive investments making the costs harder to manage.

Predicting customer decisions is complex, both at a national uptake level and on an individual, location specific basis. Many scenarios for future uptake of heat pumps have lowered their estimates, so more detailed assessments are needed. For example National Grid's annual Future Energy Scenarios have downgraded expected uptake every year since the first scenarios in 2011.

DNOs would benefit from additional data, such as locations of RHI installations. Currently DNO analysis suggests they have visibility of only a small proportion of heat pump installations, even though notification is encouraged through the Micro-generation Certification Scheme (MCS).

Data is needed about building stock, especially for off-gas. English Housing Survey has data about segmentation of building stock, but need site visits to confirm details of the heating systems installed. Suggested that a minimal EPC should be mandated every time a plumber / heating engineer is in a home, with data passed to a government database. Rural off-gas reinforcement for HPs is also unlikely to overlap with reinforcement for EVs, as early demand is expected to be low.

Given the need for DNOs to be able to plan how to allocate their resources, there was discussion about the level of certainty that was required, e.g. will it require a clear sequence of areas to be converted? It was suggested that geographical delineation would be preferable but recognised that this could be hard to achieve. Uptake could be predicted by analysing regional demographics / social status / income. The upgrading of rural broadband could also be used as an example. EV uptake could follow similar customer profiles, and it would also share the need for systems upgrades. Data sharing was encouraged including access to data held by central and local governments.

Electricity generation needs to be considered. The main challenge is how peaking capacity is delivered as HPs may use it at some times, even with deployment of DSR and the development of storage within heat pumps.

Demand-Side Response (DSR)

Heat load generally coincides with peak electricity. In many cases HPs will work best if run constantly at lower levels, but would still need extra grid capacity. Heat pumps could add big loads to the electricity system, so controlling them will be important (much more so than fridges).

DSR on heat pumps is not a silver bullet, with caution raised as to how effective it would be for DNOs as a means to avoid network reinforcements, and doubts as to whether customers would opt in, particularly for heating. Unlike EVs, which are easier to control and can therefore add diversity, both in demand and possibly even supply, heat demand and heat pumps offer very little diversity (i.e. almost all customers want heat at the same times).

DSR needs to be appropriately valued in the transition to the future energy system.

DSR for heat will be technically feasible in the medium term, but will require:

- HPs that can switch on/off easily.
- Smart controls built into HPs as standard.
- Customers to change heating behaviour, away from wild swings in energy demand.
- A control philosophy to be developed.
- Good communications systems to allow heating to come on early and store the heat, and then turned down or off at peak times.
- Open-source communication protocols to encourage innovation and will be able to interface with home energy systems. Smart meters are currently moving towards closed protocols, which will restrict the opportunities.
- An energy market that can provide enough value for each player in the DSR chain.

Thermal storage in heat pump systems could help offset local system stress, but apart from hot water tanks the technology was seen as some time away. Buildings could be designed for thermal-mass storage, but it would require changes to the heating control and building philosophies – altering the balance between fabric work, insulation and demand reduction.

Managing hot water will play an important role. To deliver the higher temperature, HPs have boost immersion heaters. Some HP models do the boost at the same time as the space heating, while others reduce the maximum electricity load by boosting after the HP. They are also programmed to come on at least once a week to kill off legionaries' disease, which could be timed to be off-peak.

The ancillary market is expected to grow as renewables expand and electricity demand increases. Grid services are worth £1bn/yr, mainly provided by generators. National Grid is running a campaign to get more demand-side involvement. HPs could be an incremental change for this, but not a huge change. However, EVs and vehicle-to-grid (V2G) technologies are likely to mature before heat pumps as providers of grid ancillary services, and therefore saturate the market before heat pumps – assuming that customers plug them in reliably.

New business models, such as Energy Service Providers (ESP), could promote heat pumps. Upfront cost could be removed and any value from DSR could be leveraged to pay for the heating system. Regulatory decisions will be needed as to whether ESPs (Energy Service Provider) could sell DSR services, etc. ESPs are anyone who can provide services to customers, e.g. guarantee heat, comfort, etc., offer EPC assessment, aggregate DSR, etc.