WHY ENERGY COMPANIES WILL NEED SMART HEAT PUMPS – AND POTENTIALLY SMART HYBRIDS

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Abstract: The direction of travel is clear for European markets – demand side flexibility will be an essential requirement of the future energy system. In some markets (e.g. Germany, France, Denmark), the first signs of the requirement are there. In other markets (e.g. the UK), future penetration of renewables and increasing distribution network congestion will see increased requirements for flexibility.

The demand side is well positioned to provide this required flexibility. Our research indicates that electric heating can play a significant role in this flexible demand revolution, if it can both maximise available flexibility, and benefit the customer.

We see a huge amount of activity and different approaches to using heat pumps - and electric heating - as a flexible demand resource. Smart hybrid solutions are an approach which our research indicates has particular potential as a flexible demand resource. In the short-term hybrid solutions can increase penetration of electric heat pumps in new and challenging market sectors (e.g. the on-gas grid sector in countries like the UK and Netherlands). In the long-term, hybrid solutions offer opportunities to increase available flexibility by enabling the switch between electricity and other energy sources.

Key words: smart heat pump, hybrid, heat pump, boiler, retrofit, smart grid, control

Market Summary: How do European markets compare?

In the following article we outline examples of smart heat pump, hybrids and electric heating activities across Europe. Each country has its own characteristics and is a different stage in terms of the drivers for smart, which mean the conclusions draw for each market will be different. In terms of the drivers for 'smart', the German and Danish markets already face challenges related to the growing penetration of wind, and the UK will follow. In Sweden and Finland, the generation is relatively more stable, but these nordi markets are arguably the furthest ahead in terms of allowing the customer to benefit from 'smart' – in Sweden flexible tariffs for end-users is already a possibility, and this should come in in Denmark in 2015. In other markets in Europe, we could see flexible tariffs in 5 years. The potential for 'smart hybrids' may be highest in gas dominated markets such as the UK and the Netherlands.

Why energy companies will need smart heat pumps

It may be hard to make money from smart heat pumps today, but the signs are that 'smart' will be an important part of heat pumps' future. All of Europe's top five energy companies (GDF, EDF, E.ON, RWE, Enel), plus several others (e.g. Vattenfall, Fortum, SSE, British Gas) are already engaging in smart projects involving heat pumps – we provide some examples in this article. 'Smart' heat pumps bring value to the electricity industry. Aside from parts of the Nordic region, it's not always easy to extract this value today. Hence, most of the activity is at the early stages, mainly involving small-scale pilot projects, though with

some commercial roll-out of smart electric heating from Finnish utility Fortum and from Vattenfall in Germany.

To Delta-ee, the direction of travel is clear. Smart heat pumps will be a key component of the long term future of heat pumps, driven by the value they can bring to the electricity market – and, if flexible tariffs are rolled out beyond some Nordic countries, the value they can bring to the customer as well. For energy companies, smart heat pumps are not just an R&D plaything. If you examine the mainstream investor presentations of two European giants, it is clear that they understand opportunities from working with large numbers of distributed assets such as heat pumps. One of E.On's main focuses is to deliver "service-based business models and virtual combination of distributed assets". RWE plan to increase "investment in energy services in Germany", particularly for "special products such as virtual power plants". Smart is certainly on the agenda, and it is clear that heat pumps have a role to play.
So why is 'smart' important to these energy companies? They are facing several challenges – and some opportunities - as they move to a low carbon future.

Table 1: Energy company problems and opportunities – and how heat pumps can help
The table highlights some of the utility problems which 'smart' heat pumps can play a role in resolving:

Problem / opportunity	Heat Pump solution
Electricity retailers face increasingly volatile wholesale electricity prices due to intermittent generation such as wind. Huge spikes in prices can be followed by negative power prices	HP operating times can be influenced according to fluctuating energy prices – delivering running cost savings for the end user (if they have flexible tariffs) or increased margins for the retailer
Aggregators, often independent and emerging in several European markets, require flexibility in demand to sell their packages of aggregated 'negative demand' and distributed generation on energy markets	Smartly operated heat pumps provide demand-side flexibility which can form part of an aggregated load to trade on energy markets
Distribution Network operators need to avoid the costs of new grid infrastructure, for example to support demand peaks from loads such as heat pumps and electric vehicles, or manage export from PV	The smart operation of heat pumps can for example, reduce peak demand, or increase the self-consumption of PV
System operators face an increasing challenge to balance generation (less predictable, more intermittent) and demand (peak demand is growing more rapidly than average demand in a number of markets).	Smart operation of heat pumps provides an extra source of flexible demand for system operators

Where is the value?

Heat pump manufacturers stand to gain through the greater market opportunities available to them if they are 'smart-ready', and are able to maximise the value captured by utilities. We identify five key value sources for flexible demand in Figure 1. While it is difficult to exploit many of these value sources today, we see developments in market and regulatory structures which will ultimately open up more of these value streams.
The way in which this value is shared across the different stakeholders in the electricity value chain – and critically how much is shared with the customer - will determine the size and exact timing of the flexible demand opportunity. The opportunity could be significant if the

smart operation of heat pumps brings with it attractive customer propositions – as are emerging and being tested in the Nordic region, and as we expect to emerge over time in other markets.

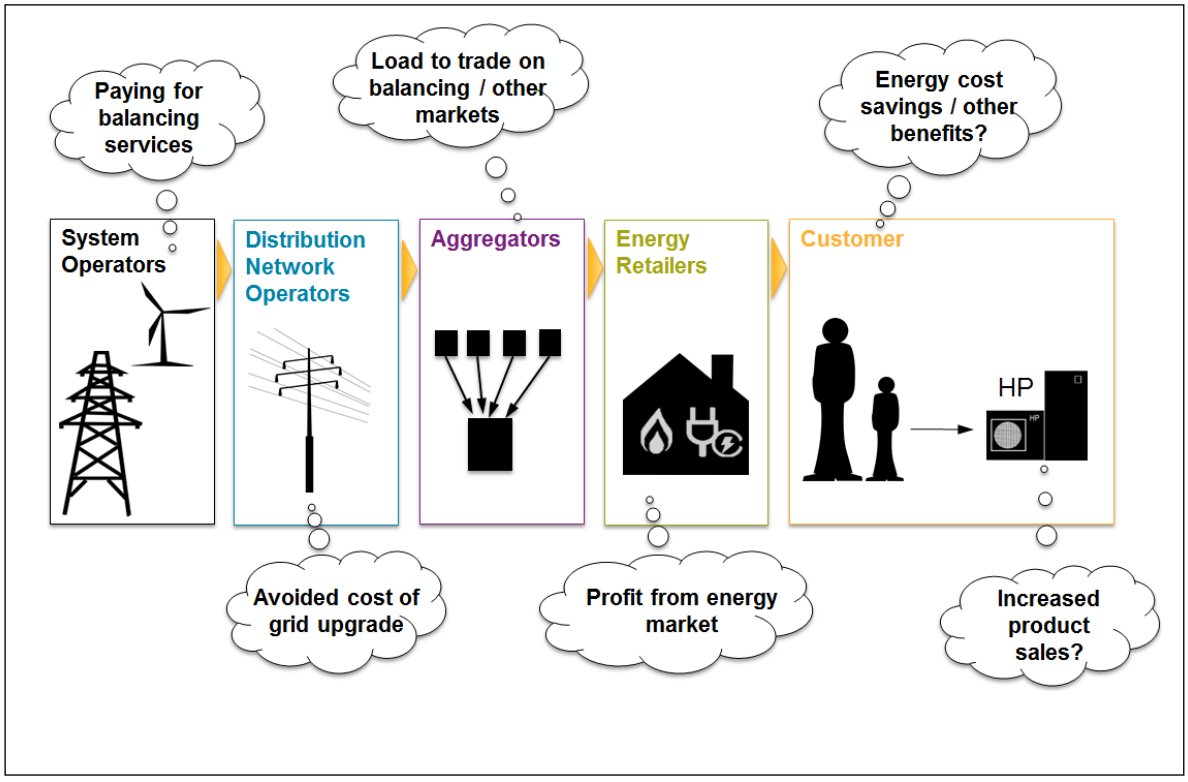


Figure 1: Where is the value in smart heat pumps?

How can this value be exploited?

The Energy and heating industries in Europe are stepping up their engagement in heat pumps and electric heating as the need for flexible demand increases. And new market entrants are spotting opportunities for new business. Examples of approaches to exploiting the opportunities include:

- The huge number of demonstration projects across Europe testing how much flexible demand can come from electric heating (including heat pumps), and how much value this can create for customers, utilities and others (Smart Electric Lyon in France, Customer-Led Network Revolution in the UK, and many more).
- The increasing engagement from energy companies in projects using heat pumps and electric heating as flexible demand (e.g. EDF, British Gas) and already launching 'smart electric heat' offerings (e.g. Fortum)
- The host of new players finding business opportunities for themselves in the emerging flexible demand market – for example HEMS companies (e.g. There Corporation), and independent aggregators (e.g. Voltalis).
- The increasing number of "smart-ready" heat pumps on the market from manufacturers (e.g. including from NIBE, IVT, Neura and several others) – albeit all with very different approaches
- The emergence of hybrid solutions, including heat pump-boiler systems (from several of Europe's major boiler brands and heat pump players), and a smart electric heat

offering which can arbitrage between electricity and oil (e.g. Fortum). This is one possible approach to increasing the potential flexibility from electric heating.

We highlight examples of different approaches to solving utility problems with smart heat pumps (all information drawn from Delta-ee Heat Pump Research Service):

1. **Customer-Led Network Revolution**: Distribution Network Operator (Northern Power Grid) testing ways to managing distribution grid congestion and energy retailer (British Gas) testing the best ways to get demand-side flexibility.
2. **Entelios**: Independent aggregator already making money from trading flexible loads on energy markets – in some cases including air conditioning.
3. **PowerMatchingCity:** Using hybrid heat pumps to offer flexibility for retailers and network operators.
4. **Enel Green Power**: Smart control of heat pumps to manage the impact of PV on distribution networks.
5. **Fortum Fiksu:** Smart electric heating and 'dual fuel' offering from energy supplier

Customer-led network revolution: Network company and energy supplier testing ways to manage distribution grid congestion

This demonstration project (funded by the UK Low Carbon Network Fund) has been led by the Distribution Network Operator (Northern Powergrid) with the Energy Supplier (British Gas) to test the application of smart grids on the distribution network.



The project includes 1,000 heat pumps as well as electric vehicles and other microgeneration in 14,000 homes & businesses. Different mechanisms to influence operating times are being tested – from price signals to direct control. 18 'smart-ready' heat pumps from Neura have been included in the pilot which are being directly controlled in response to peaks on the distribution grid.

The project is still on-going – a key outcome is to understand the customers. This will provide valuable learning experience about how to engage customers, which is critical to the success of demand response projects.

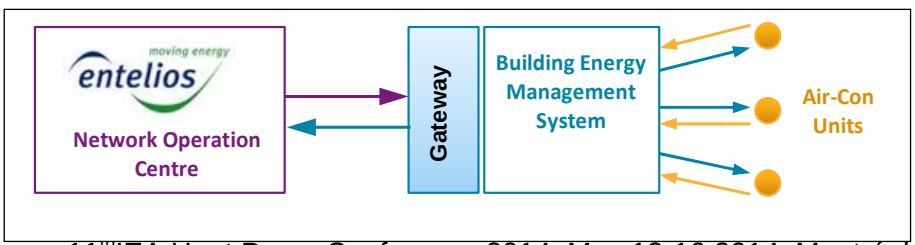
How to engage customers – what propositions will attract them?

How will customers react to third party control?

How much flexibility can customers provide – and which control mechanisms are most effective?

Entelios: Independent aggregator already making money from trading aggregated flexible loads on energy markets

Germany-based Entelios aggregates controllable electrical loads and decentralised generating plants belonging to commercial and industrial energy users, capturing value through trading the flexible loads on power markets (either itself, or on behalf of energy companies, sharing the captured value with the customer). While HVAC is a small part of Entelios' current business, it is an important building block in the development of aggregated loads.



This is not a pilot project – it is already a commercial

business. The next step is to roll out the model in other markets and potentially with smaller-scale assets, which could increase the flexibility of the aggregate-able loads. Keeping the customer happy is a critical concern, and one key aim for Entelios regarding the use of HVAC in demand response, is to better understand how much temperature change a customer will accept.

Power Matching City: Using hybrid heat pumps to manage grid peaks

Power Matching City is a demonstration project in the Netherlands which has already been running for more than 5 years. It is supported by the utility Essent, and aims to use demand-side resources (including hybrid heat pumps and micro-CHP) to manage peaks in the grid, and address supply/demand imbalances.

Condensing boilers have been replaced with hybrid HPs in 12 homes. A range of mechanisms for influence/control of the HPs is being tested – from flexible Time of Use Tariffs to Virtual Power Plant operation, with developed "powermatcher" technology as the control hub for the system. Essent's current role in the project is developing possible customer propositions to test which will engage customers and provide maximum flexibility.

Enel Green Power: Smart control of heat pumps integrated to manage the impact of PV

Enel Green Power has partnered with home automation company There Corporation (from Finland), and are now selling There's Virtuoso Service across in Italy. The Virtuoso Service is a smart control system which links the home and the energy market – it controls the operation of PV and Heat Pumps according to energy prices, delivers energy savings to customers, and is a way to manage the impact of escalating PV installations. There Corporation is also working with Fortum in the Nordic markets.

In the future we expect that influencing the timing of heat pump operation for the wider electricity system will be standard practice. By 2020, 15-20% of annual installations could be 'smart', and the value to the energy system could be in the order of 100s of millions of euros per year. Heat pump manufacturers need to balance their efforts between focusing on the 'here and now', where smart is largely not yet valued, to preparing themselves for a future when smart capability is an essential part of their product's functionality. Companies involved in some of these early pilot projects are preparing themselves well for the future.

Fortum Fiksu: Smart electric heating and 'dual fuel' offering

Fortum launched a smart electric heating controls offering "Fortum Fiksu" in October 2012 (first in Finland, then Sweden), to allow customers to take advantage of the dynamic ToU pricing which is now available in Sweden & Finland via Nordpool hourly prices. The customer signs up to an hourly price electricity tariff from Fortum, and Fortum Fisku effectively automates the heating system response to the tariff, enabling the value to be captured by the customer. Fortum has three main offerings (Bergerland, C, 2014):

1. Comfort control	2. Smart electric boiler	3. Dual fuel electric/oil
Fortum's "base" smart product, aimed at holiday homes (of which there are many in Finland), providing control capability to **automatically pre-heat the home** to ensure it is warm when the end-user arrives.	Finland has many electric boilers with integrated water storage. This product can **automatically control when the water is heated** according to a ToU tariff.	Aimed at bivalent systems where oil boilers backup electric immersion heaters. This product can **automatically choose the lowest price energy source (electric or oil)** according to hourly electricity price. Field trials in 2012-13 indicate **customer savings in the range 15-40% can be achieved** with this product.

Of particular interest is the dual fuel offering where "Fortum Fiksu makes a smart choice between oil and electricity…", heating the home with oil or electricity, depending on which is cheapest in that hour. Although this dual fuel customer offering uses separate oil and electric heating systems, in principle, it indicates what could be possible with the new generation of packaged hybrid systems emerging…

A Role for "Smart" Hybrids?

There is an emerging market in Europe for hybrid systems – boilers packaged with heat pumps and combined via an intelligent control system. All of the top 5 boiler companies in Europe have launched a system, and the first heat pump players are now involved (i.e. Daikin). We illustrate the potential with modelling from the UK – Europe's biggest heating market. We see two key reasons for their strong potential in many markets in Europe:

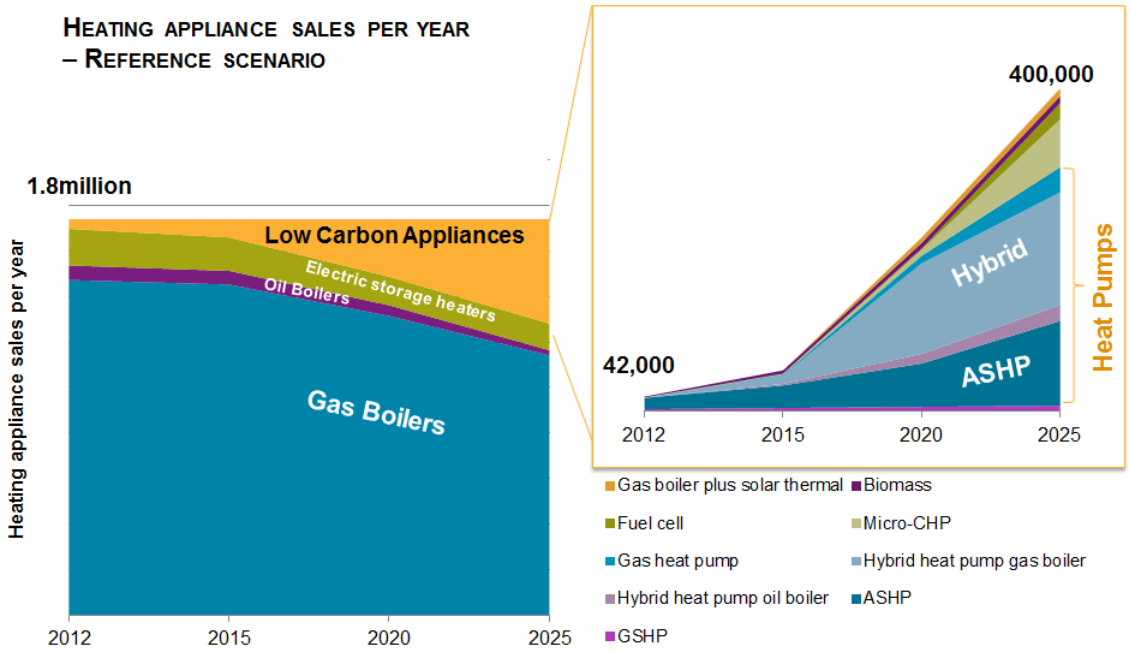
1. These systems offer new opportunities to decarbonise heat
2. Hybrids can increase demand side flexibility whilst minimising impact on the end-user

Hybrids offer new opportunities to decarbonise heat.

For example, new hybrid concepts creating opportunities to tap into the 8 million units-per-year European gas boiler replacement market - a sector which has traditionally been notoriously difficult for electric heat pumps to penetrate in many of Europe's biggest national heating markets.

Hybrids can increase demand side flexibility whilst minimising impact on the end-user

Smart, intelligently controlled hybrids – which could potentially be operated in response to dynamic tariffs in a similar way to Fortum's dual fuel offering – can ultimately offer increased demand side flexibility, because they can enable the electric heat pump to be switched off for long periods of time without the need for an overly large hot water storage tank. A large tank is problematic from an end-user point of view, especially in markets where space it at a premium.



Source: Delta-ee Pathways & Roadmap Service

Figure 2: UK Market projected growth of hybrid heat pumps

Hybrids are a way to reduce the investment requirements for upgrading the electricity distribution network to manage peak demand

If heat is to be electrified (away from gas / oil), in order to meet decarbonisation targets, then large investment in distribution networks will be required in order to meet peak heating needs. Hybrids will help to reduce the scale of this challenge, because the 2nd fuel (i.e. gas,

oil or other source) can be used at peak times, reducing electricity consumption. Figures calculated for the UK in the Delta-ee report for the UK Energy Networks Association (Delta-ee, 2013, 2050 Pathways for Domestic Heat), estimated that peak demand from electric heat pumps will add 48 GW to the winter peak under a full electrification of heat scenario. In contrast, under the Balanced Transition Scenario – which makes use of hybrids, this additional winter peak is reduced to 24 GW (saving £8 billion of investment). This gives an indication of the scale of the challenge (which we believe is comparable to other gas-dominated countries in Europe), and highlights the possible role that smart hybrids could play in the future energy system.

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See also:

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