Early results from the FREEDOM project
Fully-optimised hybrid heat pumps providing demand flexibility

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Flexible Residential Energy Efficiency, Demand Optimisation & Management
Overview

• FREEDOM: £5.2m project to evaluate hybrid heating systems

• Programme of simulation and analysis work
  • Commercial and energy network perspectives
  • Optimised controls for heat pumps and hybrids

• Field trials of hybrid heat pumps
  • Four home pilot trial underway (since Feb 2017)
  • 75 homes in Bridgend, South Wales preparing for roll-out (winter 2017-2018)
FREEDOM project partners

← Gas distribution system operator
← Electricity distribution network operator
← Heating control system & project management
← Gas and electricity network impact modelling
← User interactions and consumer trust
← Market analysis and technology assessment
FREEDOM project objectives

- Use the ability of the hybrid heating system to allow **smart switching between gas and electric load** to provide fuel arbitrage and highly flexible demand response services.

- Demonstrate the **consumer cost, carbon and energy system security benefits** of large-scale deployment of hybrid heating systems.

- Gain insights into the means of **balancing the interests of the consumer, supplier, and network operators** when seeking to derive value from the demand flexibility.

What is the overall value proposition of wide scale hybrid heat pump deployment?
Provision of Network Services

Operation of HHP

...without Network Service

... with Network Service

Impact of HHP operation at the distribution network level
Evolution of the installed base of heat pump appliances in WWU gas distribution area: Below, we illustrate how the installed base of hybrid heat pumps and pure electric heat pumps in WWU’s region until evolve to 2050. Under alternative scenarios, we could see a more significant penetration of hybrid heat pumps.

Evolution of the installed base of heat pump appliances in WWU’s area until 2050 – REFERENCE SCENARIO

Under the reference scenario, electric heat pumps and hybrid heat pumps could be installed in 10 – 15% of homes in WWU’s region by 2050.

Almost 220,000 hybrid heat pumps will be in the installed base, accounting for ~10% of gas dwellings. A small proportion of ASHPs will be installed in gas properties.

WWU housing stock: ~3.17 million dwellings ~2.43 million gas dwellings
The value framework can be visualised to identify monetary and non-monetary values.

In this report we propose to focus on those values which can be easily monetised today or in the near future i.e. those which could bring a clear financial benefit to an actor in the HHP value chain.

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<th>Monetary values</th>
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<td>Energy bill savings</td>
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<td>'Do the right thing'</td>
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<td>Reduced fuel poverty</td>
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<td>Increased product sales</td>
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<td>New market opportunities</td>
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Key:
- Technology benefit
- Electricity market values
- Social/environmental benefits
- Added value to business
- Customer 'soft factors'

These values are assessed in detail in this report as a direct benefit of HHPs.
Conventional heat pump control

Should a householder turn their heat pump off overnight?
PassivSystems heat pump control

• User simply chooses when they want to be warm
  • Remote control with friendly smartphone app
  • Feedback on system operation increases trust

• PassivSystems software learns thermal properties of the home and calculates the optimal control strategy
  • Manually-set weather compensation curve replaced by dynamic flow temperature control
  • Comfort requirements met consistently

• Predictive approach is smart grid ready
  • Energy forecasts, time-of-use tariffs and demand response all integrated
Predictive Demand Control

- Target water flow temperature (output)
- Weather forecast (input)
- Target room temperature (output)
- User set point (input)
- Maximum power limit (input)
- Expected power consumption (output)

**Dynamic flow temperature**

**Optimised set-back**

**Prediction for the smart grid**
Controlling hybrid heat pumps

• Conventional approach: programme to switch to gas boiler if colder than (for example) 0°C outside
  • Not easy to choose the transition temperature correctly
  • Fuel switch strategy based on current conditions only
• Passiv optimised approach: predict the most cost-effective transition strategy
  • Results in a heat pump “base load” and uses the boiler to provide “bursts” of heat
  • Set gas/electricity price ratio and that’s it
  • Automatically handles heat pump capacity limit (enabling smaller cheaper heat pumps)
Optimised hybrid heat pump control

Gas:electricity price ratio of 1:3
Hybrid heat pump: “Economy 7” tariff

Gas 3.07p/kWh, electricity 7.62p/kWh night (0h-7h), 13.84p/kWh day
Simulations: conventional control

External transition temperature: 6°C

Heating Power (kW)

below 5°C

5°C to 10°C

above 10°C

Hour of the day

Heating Power (kW)

Hour of the day

Hour of the day
Simulations: optimised control

Gas/electricity price ratio: 0.26

- e.g. 2.8p/kWh gas, 10.8p/kWh electricity

Below 5°C

5°C to 10°C

Above 10°C

Heating Power (kW)

Hour of the day
Simulations: conventional control

External transition temperature: 4°C
Simulations: optimised control

Gas/electricity price ratio: 0.28

E.g. 2.8p/kWh gas, 10.0p/kWh electricity
Pilot trial (four homes, early 2017)

- Three manufacturers (MasterTherm, Daikin, and Samsung) provided standard bivalent installations
Pilot trial (four homes, early 2017)

- High resolution monitoring data recorded; analysis underway

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Conclusions

- We believe hybrid heat pumps provide a cost-effective route for decarbonising domestic heating.
- Connected, coordinated controls will be essential to execute smart switching to gas to avoid electricity capacity restrictions.
- Smart controls also bring consumer benefits: low costs, reliable comfort levels, and straightforward controls they can trust.
  - Optimised fuel switching can reduce running costs, and avoids guesswork at commissioning time.
- FREEDOM main trial: 75 hybrid heat pumps, winter 2017-2018.
  - Fully optimised heating control with friendly customer interfaces.
  - Demonstration of coordinated demand flattening (using fuel switch).
  - Gathering insight into real-world operation and consumer reaction.
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