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A Network+ for the Decarbonisation of Heating and Cooling

Heat pump trials and data sources in the UK: past, present and future

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Introduction

This document includes a preliminary list of UK heat pump trials and data sources, past, present and future. It does not provide summaries of findings of the trials – these can be found following the links to the research reports and papers referenced. First, a short introduction sets the context, and then a list of trials and data sources is provided.

This draft will be added to by experts attending the Heat Pump Trial workshop on 25th January, 2023. This list is not exhaustive - it is intended as a starting point.

Heat pumps currently occupy a small niche within the UK residential heating market. The UK has a hugely ambitious target of meeting 600,000 residential heat pump installations per year by 2028 – this stands in stark contrast to the current installations of less than 50,000 per year. This is in contrast to some other countries, where they have been much more widely adopted, adoption rates being influenced by a wide variety of economic, social, energy-related and technological factors.

There have been, and continue to be, a number of heat pump trials in the UK. They explore different aspects of HP technical and economic performance, system design issues, user satisfaction, changes in heating patterns and so on. Early relatively large-scale trials (EST 2010, 2013) have provided good evidence for the development of improved installation standards and given some insight into the technical issues that were not being addressed consistently. Recently there has been a focus on the intersection of flexibility and heat pumps – exploration of the benefits to the electricity system and users of reducing on-peak demands of heat pumps.

To borrow the definition used by Carroll et al (2020), field studies are a research methodology used to understand a problem in its natural setting. They generally gather qualitative and quantitative data to help contextualise the problem. They aim to interpret the attitudes and actions taking place in the field, and to identify actionable solutions. Field trials in occupied homes are expensive and need consent from the occupants, where this can include the disruption and possibly the cost of installing new heating systems. The data has to be securely managed and privacy ensured. In trials, the heat pump system design parameter settings and configurations cannot be freely adjusted. The funding and commitment to run a high-quality, publicly reported trial is difficult to obtain. Some of the trials listed may not fully fit this definition of ‘field trials’.

By reflecting on past, current and planned heat pump trials in the UK, we can consider what additional information, of what quality, is needed to improve our social, technical, economic and environmental understanding of these technologies, their users and uses. This will help inform the low carbon transition.

Completed UK trials

Trials reporting data pre-2010

Singh, Muetze et al. (2010) found only two UK studies reporting data. They concluded that very few installations have been subjected to monitoring to establish their effectiveness and running costs. The two studies they listed were by Pither and Doyle (2006) and Harrogate Borough Council (2007).

Energy Saving Trust Trials (2009-2011)

In 2010 the Energy Saving Trust published results on the first phase of the most comprehensive field trial of the technologies ever undertaken in the UK, which studied heat pumps at 83 sites, 54 ground source and 29 air source (EST, 2010). The population of 83 sites included a range of: building forms, type of heat emitter, new and retrofit installations, tenant and owner-occupied properties and hot water provision. A few systems were integrated with solar thermal systems. The trial began in early 2009 and monitored both technical performance and customers' experiences for a full 12 month period. In addition to the system electrical demands and heat outputs, other data collected included ground loop temperatures, internal and external air temperatures, energy costs, installation configuration and sizing data. This trail was funded by a number of energy and several heat pump manufacturers and installers. A total of 14 different heat pump manufacturers' equipment were included in the sample. The broad aim was to evaluate the differences between stated (lab-based) performance and the seasonal performance when installed and operated in typical households.

The second phase of the national field trials sought to take advantage of what had been learnt from the detailed technical analysis and saw implementation of a set of intervention measures at 32 of the original sites identified as poorly performing (EST, 2013). Some well-performing sites from phase 1 were also included in the sample. The sample comprised 21 GSHP installations and 15 ASHP.

Carroll et al's 2020 systematic review

Carroll et al (2020) carried out a review to assess the literature to identify what field trials have been implemented; whether any anonymised data or models are publicly available to assess the coefficient of performance of air source heat pumps (ASHPs) when deployed in the homes of end users. Specifically their review sought to answer the following research questions:

1. Which academic articles describe ASHP field trials?
2. How were the field trials designed? Particularly: the sample size, the data gathered, the trial location and duration, etc.;
3. What statistical/modelling approaches were used to analyse/characterise the field trial data?
4. What ASHP field trial data is publicly available?

The authors identified 34 relevant papers which met their inclusion criteria, the majority of which were from China. Table 1 briefly describes those from the UK.

Table 1: UK ASHP studies identified in Carroll et al, 2020

Paper reference	Brief description
Caird S., Roy R., Potter S. (2012)	83 homes (of which 29 ASHPs), Scotland and England, UK – the Energy Saving Trust trial sample
Kelly N., Cockroft J. (2011)	Eight retrofit homes, Scotland, Feb–July 2008 space-heating ASHP. Heat output, air temp, humidity and power consumption at 2.5 min resolution.
Le K.X., Huang M.J., Shah N., Wilson C., Artain P.M., Byrne R., *et al.* (2019)	Terraced home, Northern Ireland. Coupled high temperature and thermal storage system
Le K.X., Huang M.J., Shah N.N., Wilson C., Artain P.M., Byrne R., *et al.* (2019)	
Sweetnam T., Fell M., Oikonomou E., Oreszczyn T. (2019)	76 Family homes, Southwest England in 2014/15 evaluating home energy-management system

Source: Adapted from Carroll et al, 2020

Other trials

This list (Table 2) contains a range of HP trials not listed above, some with results which have been published via the peer-reviewed literature.

Table 2: UK heat pump trials, complete and ongoing

Name	***Tech***	***Funder***	***Status***
HyCompact	Hybrid ASHP, smart control	Ofgem	Complete
Re-heat	ASHP, PCM heat batteries and direct load control	Ofgem	Live - no reports published as yet
Right to Heat	Solar PV, electric battery and hybrid gas boiler/heat pump	Ofgem	Live - progress report published
Equitable Novel Flexibility Exchange (EQUINOX)	Working with previously installed heat pumps to test direct load control for peak demand reduction.	Ofgem	Live - progress report published
FREEDOM - Flexible Residential Energy Efficiency Demand Optimisation and Management	HHP, smart controls including for DR (automated response to TOU tariffs - Economy 10 and Economy 7 - plus DLC by DNO in response to network constraints)	Ofgem	Complete
Multi Asset Demand Execution (MADE)	Hybrid heat pump (heat pump retrofitted to existing gas boiler?) plus electricity storage in 5 homes. Time varying pricing - Octopus Go and Agile tariffs.	Ofgem	Complete

CrowdFlex: Discovery	CrowdFlex:Trial will assess how the impact of EV charging, heat pumps, and other emerging low carbon technologies on customers electricity bills can be reduced when consumers participate in domestic flexibility.	Ofgem	Live
Greater Manchester Demonstration Project (NEDO)	HP + DR - reported in part in Calver et al 2022 & Crawley et al 2021		Complete
Low Carbon London	Heat pump trials were limited to monitoring, not flexibility.	Ofgem	Complete
BREATHE - *Bringing Renewable Energy Automation to Homes Everywhere*.	Homes equipped with heat pumps, solar photovoltaic panels and batteries. Flexibility trial. Reported in Gupta & Morey, 2022	BEIS	Complete
FLATLINE	Ground source heat pumps, thermal and electrical energy storage and PV, in new build homes.	BEIS competition for domestic DSR	
HyMaker	Demonstration of hybrid heat pump comprising air source heat pump and hydrogen fuelled boiler to supply multi-occupancy buildings.	Welsh Government	
Milford Haven: Energy Kingdom	Demonstration of a hybrid heat pump comprising air source heat pump and hydrogen fuelled boiler, installed in a port office.	Welsh Government	

Sources of heat pump data

Renewable Heat Premium Payment (RHPP) Scheme Data

The RHPP programme was a means of providing capital grants to householders and RSLs for renewable heating equipment in anticipation of the RHI tariff scheme. Monitoring of heat pump installations was incorporated into the programme and built on the methodology developed in the earlier national field trials. Householders were incentivized to participate in the monitoring exercise by modest additional grant payments.

The UK Data Service hosts “the Renewable Heat Premium Payment Scheme: Heat Pump Monitoring” data (Lowe, 2015) The data are for households from Great Britain who had an air or ground-source heat pump installed via the Renewable Heat Premium Payment policy and who participated in the heat pump monitoring campaign. The data are fully analysed and described in Lowe et al (2017).

Retrofit for the Future

‘Retrofit for the future’ (www.retrofitforthefuture.org) included evaluation of retrofits which included in heat pumps in some existing buildings. This data only partially publicly available. Some of the data has been made use of in PhD Theses (e.g. Topouzi, 2015).

Customer Led Network Revolution

The Customer Led Network Revolution was a UK smart grid demonstration project to test and develop innovations and commercial arrangements among stakeholders in the electricity sector. Test Cell 3 of the project was a trial to understand the potential impacts of heat pump deployment on grid operation. Electricity consumption data for ASHPs in 89 households are available. The households were monitored for a one year period from May 2013 to April 2014 (DEI and Element Energy, 2015).

SERL

SERL is a consortium of universities led by UCL undertaking research with smart meter data (http://serl.ac.uk). SERL is funded by the Engineering and Physical Sciences Research Council (EPSRC). SERL gathers and makes available data from 13,000+ GB households. SERL's robust governance framework ensures that accredited researchers can access controlled datasets using established protocols. SERL categorises heat pumps under 'other electric, e.g. heat pump' heating system category. It is thought 68 homes in the database have heat pumps (P Grunewald, pers comm, 2023).

Ongoing & future UK trials and data sources

Innovate UK Demonstrator Projects

Currently three large demonstrator projects on 'smart local energy systems' are coming a close. Each of the three – Energy Superhub Oxford, Project LEO and ReFLEX Orkney - has some heat pumps as part of the overall project.

https://energysuperhuboxford.org
https://project-leo.co.uk
https://www.reflexorkney.co.uk

BEIS Electrification of Heat Demonstration Project

Three large projects were awarded under this funding stream. Results not yet published (?)
https://www.gov.uk/government/publications/electrification-of-heat-demonstration-project-successful-bids/electrification-of-heat-demonstration-project-winning-bids

E.ON: E.ON will install 250 innovative heat pumps along with a range of innovative secondary technologies, such as thermal stores, to suitable homes in Newcastle. By seeking to understand how heat pumps could appeal to more consumers, the project will demonstrate that heat pumps are one of the smart, personalised and sustainable solutions that will help us in meeting the challenge to move away from fossil fuels and combat the climate crisis.

OVO Energy: This trial gives 250 pioneering customers the opportunity of installing up to £15,000 worth of technology and energy efficiency measures in their home, in return for participating in the research and monitoring aspects of the project.

Warmworks: This project will see Warmworks installing 250 innovative heat pumps in a range of households across South East Scotland. They will be provided free of charge in return for

participating in the research and monitoring aspects of the project. The project aims to understand how participants perceive the performance of different types of heat pump and what challenges may be faced by households who want to switch away from traditional gas central heating to a renewable heating system.

BEIS Heat Pump Ready Programme

The programme supports the development and demonstration of heat pump technologies and tools, and solutions for optimised deployment of heat pumps. Began 2022.
https://www.gov.uk/government/publications/heat-pump-ready-programme

Energy Demand Observatory and Laboratory

EDOL, the Energy Demand Observatory and Laboratory, which commenced 1 January 2023, is a five-year programme, funded by EPSRC and working with BEIS, will establish a national energy data platform to help facilitate the transition to net-zero carbon emissions. EDOL will provide a high-resolution data resource that will track energy use in real households, enabling us to understand how, why, and when domestic activity is impacting energy demand and associated carbon emissions.

There will be many opportunities to recruit HP-using households, and undertaking a full range of social and technical monitoring and experiments with them.
https://eng.ox.ac.uk/news/energy-demand-observatory-and-laboratory-to-help-meet-uk-net-zero-ambitions/

Community heating with heat pumps

There are a number of installations of heat pumps in combination with district / community heating. These may be framed as demonstration projects, rather than field trials – with lower monitoring and evaluation requirements. Two examples are listed, but there are others throughout the UK.

Heat the Streets is an ERDF funded project that will support the development of a sustainable ground source heating network in Stithians, Cornwall, led by Kensa Utilities (https://heatthestreets.co.uk/about-sustainable-heating-cornwall-heat-the-streets/)

Swaffham Prior Heat Network, Cambridgeshire. The renewable heat network in Swaffham Prior delivers instant heat and hot water to homes across the village. Alongside the significant grant funding provided by BEIS programmes HNIP and HNDU, Cambridgeshire County Council have made a strategic investment in the project. (https://www.cambridgeshire.gov.uk/residents/climate-change-energy-and-environment/climate-change-action/low-carbon-energy/community-heating/swaffham-prior-heat-network)

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