Annex 46 DHW Heat Pumps

UK Country Report

• UK Policy

• Examples

• Research
UK Policy
Clean Growth Strategy, Heat Networks, Clean Air, Building Regulations
Clean Growth Challenge

UK Policy

• Clean Growth Focus - Why?

• UK has indicated that it will be near zero carbon by 2050

• Clean energy technologies are estimated to account for over 85% of the $10.2 trillion investment in power generation capacity by 2040).
Heat Networks Delivery

Heat Recovery

**CO2 Emissions**
Gas is assumed to produce 0.19kg/kWh

If we can utilise 28 TWh of waste heat displacing gas for space heating

5,320,000 tonnes of CO2 will be saved

UK residential buildings currently emit 63.4 Million tonnes of CO2/year

~10% of Residential CO2 emissions can be saved if waste heat is fully utilised
Clean Air Strategy
A political challenge

• The strategy sets out how UK will:
  
  • protect the nation’s health
  • protect the environment
  • secure clean growth and innovation
  • reduce emissions from transport, homes, farming and industry
  
  monitor our progress

CLEAN AIR STRATEGY 2019
UK Building Regulations
Fit for Purpose?

- the UK’s legally-binding climate change targets will not be met without the near-complete elimination of greenhouse gas emissions from UK buildings.
- emissions reductions from the UK’s 29 million homes have stalled, while energy use in homes – which accounts for 14% of total UK emissions – increased between 2016 and 2017.
- efforts to adapt the UK’s housing stock to the impacts of the changing climate: for higher average temperatures, flooding and water scarcity, are lagging far behind what is needed to keep us safe and comfortable, even as these climate change risks grow.
DHW Heat Pumps
UK Examples
DHW Heat Pumps

UK Example

Parkside Place, Hammersmith, London
Building scale: 40 apartments
Type: New build
Heat pump type: Individual exhaust air source heat pumps and air source heat pumps
Status: In operation
Contact: NIBE

The 23 single-level apartments were each equipped with the NIBE F470 exhaust air heat pump system. The 16 split-level duplexes and one mews house were each fitted with an air source heat pump package system made up of an 8kW NIBE F2040 air source heat pump and a NIBE VVM320 combined water storage and controls unit.
## DHW Heat Pumps

### UK Example

<table>
<thead>
<tr>
<th>Type</th>
<th>Ref</th>
<th>Examples</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIR SOURCE</td>
<td>Small-A2</td>
<td>Split systems</td>
<td>The heat pump is split into two units: an external one and an internal one. Refrigerant circulates between the two units.</td>
</tr>
<tr>
<td></td>
<td>Small-A4</td>
<td>Exhaust air heat pump</td>
<td>The whole heat pump is located internally in a packaged unit. It combines an air source heat pump (using exhaust air) and a mechanical ventilation system.</td>
</tr>
</tbody>
</table>
DHW Heat Pumps

UK Example

The exhaust air source pump (left) and air source heat pump package (right) (© Nibe)

Source Greater London Authority
Great House Farm is a development of one-, two- and three-bedroom properties that boast some of the most advanced sustainability measures of any UK housing project. The homes have been fitted with rainwater harvesting, green roofs, electric car charging points, extensive insulation and thermally treated windows throughout – achieving a Code for Sustainable Homes Level Four for building fabric alone.

NIBE F410 Heat Pumps provide Heat and Hot Water for each home

Refrigerant R290
DHW Heat Pumps
Belfast, Northern Ireland, UK

17 units Installed capacity 1.5kW
Edel by Dimplex
Refrigerant R290
Heat demand 4kW
Heating temperature 20°C
Domestic hot water temperature 60°C
UK Research Example

UKRI-EPSRC 4SDHW
Task 2

Thermal Mass

Typical household of 100 sq.m

Space heating demand of 10kW

Maximum Demand 35kW

Air Source Heat Pump in a retrofit situation

Condenser Mass = 40kg

<table>
<thead>
<tr>
<th>Heat Pump</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Refrigerant</td>
<td>r407c</td>
</tr>
<tr>
<td>$\Delta t$ Cond</td>
<td>4</td>
</tr>
<tr>
<td>$\Delta t$ Evap</td>
<td>7</td>
</tr>
<tr>
<td>Ambient T</td>
<td>-2</td>
</tr>
<tr>
<td>Compressor Efficiency $n$</td>
<td>0.8</td>
</tr>
<tr>
<td>Winter mains water temp</td>
<td>10</td>
</tr>
</tbody>
</table>
Task 2
Simplified Heat Pump Cycle Integration – U/F Heating/Cold Start

Start

10°C
42°C

Bypass for Rapid Heating

46°C
42°C

42°C
10°C

42°C
Task 2
Simplified Heat Pump Cycle Integration Thermal Mass Response
Task 2
Retrofit Operation

65°C
10°C
61°C
Bypass for Rapid Heating
Task 2
60°C Heating from cold…. (Mixer in constant position)

Retrofit ASHP Heat Up Time (seconds)

Water Temperature °C
Task 2
Research Challenges (1)

Initial calculations made at 3600 rpm
   How quickly can the compressor come to 7200 rpm?
   Different information from the same manufacturer

Overcoming thermal mass
   PCM or other form of heating
   As part of the condenser insulation?
   Integrated with as part of the internal heat exchanger?

Compressor lubrication and the boost cycle
   How to make best use of this
Task 2
Research Challenges (2)

There is a relationship between compressor capacity range, household heating demand, hot water demand => Household Characterisation => Target Markets

Maximum Heat Demand and limited Capacity Control
Below this point

3Ø Power Supply (UK)

Highest Capacity Bath Taps
4S-DHW

Layouts

Compressor: Emerson: XP/00302E-4X9
Condenser: Swep: B904s-28
EEV: Emerson in package
Receiver: ESK Schultz: SGS-11-CD

Circulating Pump (3 speed)
4S-DHW
Layouts

3 Phase & Single-Phase Electric Meter

ED3 3 Phase Inverter for Variable Speed Copeland Scrolls (~6kW at 400 Volts)

Sec Mono (Emerson) Superheat & Envelope Controller
4S-DHW
Layouts
## Initial Challenges

<table>
<thead>
<tr>
<th>Date</th>
<th>Time Start</th>
<th>Time End</th>
<th>Cond Flow Rate</th>
<th>Heat Demand SEC (kW)</th>
<th>Cond Inlet (degC)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>15/01/2019</td>
<td>10:43</td>
<td>13:10</td>
<td>Pump setting 3</td>
<td>6</td>
<td>30</td>
<td>Oil return at around 11:45 ramped up to 3500rpm for 120sec (see configuration mod monitoring)</td>
</tr>
<tr>
<td>15/01/2019</td>
<td>13:11</td>
<td>15:45</td>
<td>Pump setting 3</td>
<td>8</td>
<td>30</td>
<td>2:05 switched to go through tank coil, around 2:24 tap through tank to draw of heat also.</td>
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<tr>
<td>15/01/2019</td>
<td>15:45</td>
<td>16:25</td>
<td>Pump setting 3</td>
<td>10</td>
<td>30</td>
<td>Running through tank, taps slightly on</td>
</tr>
<tr>
<td>15/01/2019</td>
<td>16:25</td>
<td>17:02</td>
<td>Pump setting 3</td>
<td>11</td>
<td>30</td>
<td>Running through tank, taps slightly on</td>
</tr>
<tr>
<td>15/01/2019</td>
<td>17:02</td>
<td>17:26</td>
<td>Pump setting 3</td>
<td>11</td>
<td>25</td>
<td>Running through tank, taps slightly on</td>
</tr>
<tr>
<td>15/01/2019</td>
<td>17:26</td>
<td>18:00</td>
<td>Pump setting 3</td>
<td>12</td>
<td>25</td>
<td>Running through tank, taps slightly on</td>
</tr>
</tbody>
</table>
4S-DHW
Initial Runs

- DLT - Condenser Refrigerant In (degC)
- Condenser Water Out (degC)
- Condenser Refrigerant Out (degC)
- Condenser Water In (degC)
- Compressor Suction (degC)
- Compressor Speed (RPM/100)
- Heating Capacity Request (kW)

- RPM of up to 3500 for 120 sec for compressor oil return (programmed into SEC controller)
- Changed from 30 degC condenser inlet to 25 degC
<table>
<thead>
<tr>
<th>Heating Demand (kW)</th>
<th>Cond Inlet Set Point (degC)</th>
<th>Av_Cond Water Inlet (degC)</th>
<th>Av_Cond Water Outlet (degC)</th>
<th>Av_deltaT (degC)</th>
<th>Av_COP</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>30</td>
<td>28.7</td>
<td>40.2</td>
<td>11.5</td>
<td>4.61</td>
</tr>
<tr>
<td>8</td>
<td>30</td>
<td>28.6</td>
<td>43.6</td>
<td>15</td>
<td>4.85</td>
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<tr>
<td>10</td>
<td>30</td>
<td>28.1</td>
<td>50.5</td>
<td>22.4</td>
<td>3.92</td>
</tr>
<tr>
<td>11</td>
<td>30</td>
<td>27.1</td>
<td>53.7</td>
<td>26.6</td>
<td>3.6</td>
</tr>
<tr>
<td>12</td>
<td>25</td>
<td>24.1</td>
<td>54.9</td>
<td>30.8</td>
<td>3.39</td>
</tr>
</tbody>
</table>
4S-DHW

Compressor Challenges at 11 kW
4S-DHW
Compressor Challenges at 11 kW
4S-DHW
And there is still work to do…….
And to Conclude

Work to do

- DHW Heat pumps are being used
- Requires highly insulated home
- Challenges for 29 million UK homes
- Retrofit heat pumps also face many challenges
- However hot water need not be separate when avoiding legionella