Warwick Gas Heat Pump and Thermal Transformer Update, October 2017

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The vision:

- Box-for-box exchange for conventional gas boiler → Retrofit market (> 90% of annual sales)
- Air source
- 7kW (3 bedroom semi-detached house)

✓ 30 - 40% reduction in gas consumption
Study of potential impact on emissions in the UK

Market Scenarios:

Two scenarios are considered:

▶ The first assumes that the market for Gas Heat Pumps will saturate at a 70% share of gas heating appliances annual sales after approximately 12 years (the rest of the market remaining as condensing boilers).

▶ The second assumes that after 7 years on the market, the cost of Gas Heat Pumps reaches the point where legislation requiring their use is introduced, in much the same way as was carried out for condensing boilers replacing non condensing boilers.

▶ A 2.6% reduction in UK annual CO₂ emissions by 2040 is possible.

▶ There is a potential for an eventual 4.2% reduction in annual CO₂ emissions if all gas boilers were replaced by gas heat pumps.
R&D at Warwick:
1: Carbon – ammonia adsorption
Experimental Results (June 2016)

Heating Power: 7.5 – 9 kW
COP: 1.19 – 1.34

<table>
<thead>
<tr>
<th>Cycle Time [s]</th>
<th>Load Inlet</th>
<th>Load Outlet</th>
<th>Evaporating Temperature</th>
<th>COP Experiment</th>
<th>COP Model</th>
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**Conclusion:**

Machine performed as predicted, however, high manufacturing cost of the generators prohibited further development.
New Generator Design

Shell and Finned Tube

Design Parameters:

- Tube diameter
- Tube pitch
- Carbon thickness
- Fin thickness
- Turbulator tube insert

Detailed simulations in Matlab
Large Temperature Jump Test

100 mm Long Test Sample
Large Temperature Jump Test

Match obtained between experiment and model predicted pressure rise

Time constant ~50 seconds
Machine Construction
Performance Predictions

Performance envelopes for each pitch

COP

Power (KW)
Bed Water Temperatures

- Bed A In
- Bed A Out
- Bed B In
- Bed B Out

Temperature [°C] vs. Time [s]
Test results analysis

• Heat transfer as predicted
• Desorption as predicted
• Adsorption slower than predicted
• Mass transfer being improved by material tweak
• On course to publish full performance map by end of year.
BEIS Low Carbon Technology Heating Innovation Fund

• Funding awarded provisionally to develop to a product
• 2½ years from July??
• Working with Dynamiq Engineering
R&D at Warwick: 2: Salt – ammonia adsorption – joint project with ECN
Desorption at low pressure

Phase 1: Storage of heat at 90°C

Adsorption at high pressure

Phase 2: Discharge of heat at 150°C

1-Salt Thermal Transformer (TT)
2-Salt Thermal Transformer (TT)
(CaCl$_2$ & MgCl$_2$?)

Phase 1: HT salt desorbs, LT salt adsorbs

Phase 2: LT salt desorbs, HT salt adsorbs

- 2 salts have lower pressures compared to 1 salt with condenser/evaporator
- less susceptible to sensible heat thermal mass losses

Heat in at 90°C

Low pressure

High pressure

Heat out at 150°C
Low pressure

Phase 2: LT salt desorbs, HT salt adsorbs

High pressure

Phase 1: LT salt adsorbs, HT salt desorbs

We can also have heat pumps, refrigerators, etc.

HT Salt —> LT Salt

Heat in at 150°C

Heat out at 60°C

Heat in at 0°C

HT Salt —> LT Salt

HT Salt

LT Salt

HT Salt

LT Salt

Phase 2: LT salt desorbs, HT salt adsorbs
Thank you for your attention

- Any questions?