Heat Pumps
The Future of Heating in the UK?

Introduction

by
Mike Nankivell, MInstR
President
Heat Pump Association (HPA)

ACR Show 18th February 2016
Heat Pump Association

an Introduction

by

Graham Hazell

Consultant, Heat Pump Association (HPA)

ACR Show 18th February 2016
We do exactly what it says on the tin!

Find out more at: www.heatpumps.org.uk

Call us now: 0118 940 3416
The Heat Pump Association  
Formed in 1995, member of FETA (Federation of Environmental Trade Associations)

Objectives:
• To promote the responsible deployment of heat pumps through education, public relations and lobbying
• To increase public awareness of the technology via media services
• To provide application advice to potential designers and end-users
• To liaise with Government Departments on renewable heat strategies, incentives, building regulations and policies
• Instruct and inform all interested parties

For more information about the Heat Pump Association www.heatpumps.org.uk
The Heat Pump Association...

Where do we fit in?

- Govt
- GSHPA
- Commercial HVCA Heating Sector
- CLIENT
- HP Industry Members
- Trade Association of manufacturers/distributors: ALL genres of HP’s
- Trade Association of GS installers

- The Heat Pump Association…
  Trade Association of manufacturers/distributors: ALL genres of HP’s
Heat Pump Association members

- NIBE
- LG
- EMERSON
- DAIKIN
- Eaton-Williams
- MITSUBISHI ELECTRIC
- TOSHIBA
- LENNOX
- SAMSUNG
- Mitsubishi Heavy Industries, LTD.
- Hitachi
- Space Air
- Carrier
- e.on
The Heat Pump Association

Activities:

• Renewable Energy Standards (Microgeneration Certification Scheme- MCS)
• Building Regulations
• Government Incentives (Renewable Heat Incentive- RHI)
• Consumer groups
• Training initiatives
• European standards & harmonisation

For more information about the Heat Pump Association

www.heatpumps.org.uk
Types of Heat Pump

by
Graham Hazell
Consultant
Heat Pump Association (HPA),

ACR Show 18th February 2016
‘Pumping’ Heat

Efficiency % = \frac{\text{output power}}{\text{input power}} \times 100

Efficiency > 100%

“Coefficient of Performance” (CoP)

CoP = \frac{\text{output power}}{\text{input power}}

CoP here = \frac{3.5 \text{ kW}_\text{heatout}}{1 \text{ kW}_\text{elec energy in}} = 3.5 \text{ (or } 350\% \text{ efficient)}
Air Source Heat Pumps

Air to Water
Air Source Heat Pumps
Reverse Cycle Air-to-Air
(£130 million/annum)
VRF Heat Recovery (Simultaneous) System (‘3 Pipe’ or ‘R series’)

External Heat Pump

Room Units

First unit to last unit = 70-90 max (max difference 40m)

Heat is recovered from area’s being cooled (i.e. Rejected heat)
AIR SOURCED HEAT PUMP

profile for Hurn Airport Bournemouth 10 year average
Ground / Water Source Heat Pumps

**‘GROUND’ SOURCE**

- HORIZONTAL ARRAY (c. 0°C)
- VERTICAL BOREHOLE (c.5°C)

**WATER SOURCE**

- OPEN LOOP GROUND WATER Aquifer (c.10°C)
- CLOSED LOOP LAKE or RIVER (c. 0-5°C)

www.heatpumps.org.uk
Ground Source Heat Pumps

- **HORIZONTAL ARRAY**
  - Source temperature circa 0 °C

- **VERTICAL BOREHOLE**
  - Source temperature circa 5 °C

www.heatpumps.org.uk
Ground Source Heat Pumps

OPEN LOOP

OPEN LOOP / GROUNDWATER
(source temperature circa 10°C)
Water Source Heat Pump Systems

LAKE or RIVER:
Closed loop
(source temperature circa 0-7 °C)
Effect of Source & Delivery Temperature on Efficiency

- Ground Source Zone
- Effect of Source & Delivery Temperature on Efficiency
- Open Loop
- Closed Loop
- Water Source Zone
- CoP μ
- Source Temp °C
- 30°
- 35°
- 40°
- 45°
- 50°

www.heatpumps.org.uk
Heat Source: Ground Closed Loop

Fluid through pipework MUST be lower temperature than ground i.e. <10°C, in order to pick up heat (Laws of Thermodynamics & Heat Transfer)

Ground array is NOT high heat transfer material or surface type therefore fluid temperature often 5-10°C below soil temp i.e. 0-5°C actual
UK Subsoil Annual Temperature Profile

Figure 1 – Approximate UK Annual Ground Temperatures
Ground Aquifer excellent because good temperature (10-11°C) AND excellent thermal capacity.....but

most uncertain in terms of yield... don’t really know what you’ve got till you’ve got it
Heat Source: Open Water Source

Either abstract water directly = greater efficiency BUT greater risk of fouling and corrosion!

Or place heat exchanger in medium (as shown above) or in circuit = less risk but less efficient

Risk v Reward Again!
Risk v Reward

Reward = Greater Efficiency

Risk = Availability and/or temperature of heat

ASHP
GSHP Closed Loop
WSHP Closed Loop or HE
WSHP Open Loop
GSHP Open Loop

www.heatpumps.org.uk
Types of Heat Pumps: Energy Source/Delivery

- Air Source
  - Air to Water
  - Air to Air

- Ground Source
  - Closed Loop (tubes in ground) W-to-W
  - Open Loop (Aquifer extraction) W-to-W

- Water Source (open surface water)
  - Water to Water
  - Water to Air
Exhaust Air Heat Pumps

Air to Water
Exhaust Air Heat Pumps

Air to Water
Air Heat Recovery Heat Pumps

Exhaust Air to Fresh Air (= Active Heat Recovery)

STANDARD UNIT

A. Fresh Air Intake
B. Supply Fan
C. Supply Air Heat Exchanger
   Transfers energy (heat/cool) to the fresh air
D. Extract Air Heat Exchanger
   Recovers energy (cool/heat) from the exhaust air
E. Exhaust Air Fan
F. Heat Pump
Water Loop Heat Pumps (WLHP)

The Energy Loop: in principle

A balance is achieved in the energy loop through different uses and net rejection or injection.

Heating Demand – Hot water

Heat Rejection

Air, Ground, River or Lake (not a pond!)

Constant Cooling Demand – e.g. Servers or refrigeration

Regular Cooling Demand – Hotel (Office & Retail)

Heating Demand - Residential
The Business Case for Heat Pumps

by

Graham Hazell
Heat Pump Association (HPA), Consultant

ACR Show 18th February 2016
# The Case for Heat Pumps

Relative Emissions of Heating Fuels
source to delivery

<table>
<thead>
<tr>
<th></th>
<th>Gas</th>
<th>Oil</th>
<th>LPG</th>
<th>ASHP</th>
<th>GSHP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net Fuel CO² /kWh</td>
<td>0.194</td>
<td>0.297</td>
<td>0.245</td>
<td>0.496(1)</td>
<td>0.496(1)</td>
</tr>
<tr>
<td>(source)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>System Efficiency</td>
<td>85%</td>
<td>85%</td>
<td>85%</td>
<td>260%</td>
<td>320%</td>
</tr>
<tr>
<td>Effective CO²/kWh</td>
<td>0.228</td>
<td>0.350</td>
<td>0.288</td>
<td>0.191</td>
<td>0.155</td>
</tr>
<tr>
<td>to produce 1 kWh of</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>heat (delivered</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>energy)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost per delivered</td>
<td>4.7</td>
<td>6.5 ± 1.5</td>
<td>7.7 ± 1.5</td>
<td>4.6</td>
<td>3.75</td>
</tr>
<tr>
<td>kWh of Energy (p/kWh)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOTE 1:** According to DEFRA figures
Capital v Running Cost?

<table>
<thead>
<tr>
<th>Heating type</th>
<th>Nat Gas</th>
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<tbody>
<tr>
<td>Capital Cost (yr0 (£))</td>
<td>£4,000</td>
</tr>
<tr>
<td>Fuel Cost (£/kWh)</td>
<td>0.04</td>
</tr>
<tr>
<td>System* Efficiency</td>
<td>85%</td>
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*Note: System* Efficiency is calculated based on the efficiency of the heating system.

www.heatpumps.org.uk
Capital v Running Cost?

Total Life Cost 10 kW New Domestic (no RHI)

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<td>Capital Cost yr0 (£)</td>
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<td>£4,500</td>
</tr>
<tr>
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<td>0.04</td>
<td>0.055</td>
<td>0.065</td>
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Capital v Running Cost?

### Total Life Cost 10 kW New Domestic (no RHI)

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<tr>
<td>Capital Cost yr0 (£)</td>
<td>£4,000</td>
<td>£6,500</td>
<td>£4,500</td>
<td>£9,000</td>
</tr>
<tr>
<td>Fuel Cost (£/kWh)</td>
<td>0.04</td>
<td>0.055</td>
<td>0.065</td>
<td>0.12</td>
</tr>
<tr>
<td>System Efficiency</td>
<td>85%</td>
<td>85%</td>
<td>85%</td>
<td>280%</td>
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Capital v Running Cost?

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<th>GSHP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital Cost yr0 (£)</td>
<td>£4,000</td>
<td>£6,500</td>
<td>£4,500</td>
<td>£9,000</td>
<td>£12,500</td>
</tr>
<tr>
<td>Fuel Cost (£/kWh)</td>
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<td>0.055</td>
<td>0.065</td>
<td>0.12</td>
<td>0.12</td>
</tr>
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<td>85%</td>
<td>85%</td>
<td>280%</td>
<td>320%</td>
</tr>
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Total Life Cost 10 kW New Domestic (no RHI)
# Capital v Running Cost?

## Total Life Cost 10 kW New Domestic ('custom build' inc RHI) 2016

<table>
<thead>
<tr>
<th>Heating type</th>
<th>Nat Gas</th>
<th>ASHP</th>
<th>GSHP</th>
<th>Oil</th>
<th>LPG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital/Refurb Cost (£)</td>
<td>£4,000</td>
<td>£9,000</td>
<td>£15,000</td>
<td>£6,500</td>
<td>£4,500</td>
</tr>
<tr>
<td>Fuel Cost (£/kWh)</td>
<td>0.04</td>
<td>0.12</td>
<td>0.12</td>
<td>0.055</td>
<td>0.065</td>
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<td>280%</td>
<td>320%</td>
<td>85%</td>
<td>85%</td>
</tr>
</tbody>
</table>
Capital v Running Cost?

Total Life Cost 10 kW Domestic Retrofit system (inc RHI)

<table>
<thead>
<tr>
<th>Heating type</th>
<th>Nat Gas</th>
<th>ASHP</th>
<th>GSHP (Horiz)</th>
<th>Oil</th>
<th>LPG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital/Refurb Cost (£)</td>
<td>£750</td>
<td>£9,000</td>
<td>£15,000</td>
<td>£1,250</td>
<td>£1,000</td>
</tr>
<tr>
<td>Fuel Cost (£/kWh)</td>
<td>0.04</td>
<td>0.12</td>
<td>0.12</td>
<td>0.055</td>
<td>0.065</td>
</tr>
<tr>
<td>System* Efficiency</td>
<td>75%</td>
<td>260%</td>
<td>300%</td>
<td>65%</td>
<td>75%</td>
</tr>
</tbody>
</table>
Capital v Running Cost?

Total Life Cycle Cost 100 kW Non Domestic system including RHI
(correct as 4th Dec 2013 announcement)

Accumulative Ownership Cost (£)

- Nat Gas
- ASHP
- GSHP (Vert)
- GSHP (Horiz)
- Oil
- LPG

Year

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

Gas 85%, 3.5p/kWh; LPG 85%, 7.0p/kWh; Oil 85%, 6.0p/kWh; Elec: 100%, 12/kWh; GSHP (V) 340%; GSHP (H) 320%; ASHP 290%;
Thank you

by

Heat Pump Association (HPA)

ACR Show, 18th February 2016