Heat emitters for Heat Pump systems

Bill Bucknell
The Institute

• Founded in 1964
• Systems incorporating circulating pumps needed for small-bore pipework
• Need careful design
• Entry into membership via one-year design course
• Higher grades of membership for consulting engineer members
The Institute

- Membership by qualification
- Membership by experience
- Members chair various industry groups
  - Heating Strategy Group of the Energy Efficiency Partnership for Homes
  - CIBSE Domestic Building Services Panel
  - HHIC Training Group
- Members serve on various committees
  - Most industry related BSI groups include, and some chaired by, IDHEE members
The Institute

- Major contributor to the CIBSE Domestic Guides
  - Domestic Heating Design Guide
  - Underfloor Heating Design & Installation Guide
  - Solar Heating Design & Installation Guide
- Originator of Energy Efficiency for Domestic Heating course and assessment
- Provider of courses
  - Domestic heating design
  - Solar heating design
  - Ground Source Heatpumps system design (work in progress)
Radiators with GSHPs

- Radiator outputs influenced by temperature of circulating heating medium (water)...
- ...and the design air temperature of the space being heated
- The greater the temperature difference between the water and the air, the greater the output per m$^2$ of radiator surface
- Radiators with lower circulating temperatures require greater surface area, i.e. bigger
Radiators with GSHPs

• Radiators installed with older non-condensing boilers were probably oversized in the first place and may well provide the required output with a condensing boiler (not guaranteed)
  – 82°C / 70°C flow / return (non-condensing)
  – 70°C / 50°C flow / return (condensing)

• Radiators installed with GSHPs will need larger radiators (more surface area)
  – 50°C / 42°C flow / return (typical)
Radiators with GSHPs

• So, how much larger?
• To demonstrate the difference we will use a design room temperature of 21°C
• The mean water to air temperature differences for the three system types under discussion are
  – 55 degC for older non-condensing boiler systems
  – 39 degC for modern condensing boiler systems
  – 25 degC for ground source heat pump systems
Radiators with GSHPs

- So, how much larger?
- Radiator outputs are quoted at a mean water to air difference of 50 degC
- If the difference is 55 then the radiator will emit 12.6% more heat than the catalogue states
- If the difference is 39 then the radiator will emit 26.5% LESS heat than the catalogue states
- If the difference is 25 then the radiator will emit 57.7% LESS heat than the catalogue states
Radiators with GSHPs

• So, how much larger?
• For a design heat load of 1500 Watts
• With a non-condensing boiler select a radiator from catalogue for 1332 Watts
Radiators with GSHPs

- So, how much larger?
- For a design heat load of 1500 Watts
- With a condensing boiler select a radiator from catalogue for 2041 Watts

Double Panel
530 high x 1760 wide
Radiators with GSHPs

- So, how much larger?
- For a design heat load of 1500 Watts
- With a heatpump select a radiator from catalogue for 3546 Watts

Double Panel with extra fins
690 high x 1760 wide
Radiators with GSHPs

• Is there a solution?
• Underfloor heating to the rescue!
• If the underfloor heating is designed to provide comfort at design conditions with a flow temperature to the coils of 35°C, the resulting MWT of 31°C will produce between approximately 27 W/m² (deep pile carpet or floorboards) to 49 W/m² (ceramic tiles) from pipes at 200mm centres in a 75mm screed
• A table of typical outputs per m² of heated floor follows
Radiators with GSHPs

- Is there a solution? - Underfloor heating to the rescue!

<table>
<thead>
<tr>
<th></th>
<th>Ceramic tiles</th>
<th>Parquet blocks</th>
<th>Carpet</th>
<th>Deep pile carpet</th>
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<tbody>
<tr>
<td>Underfloor pipe centres :: W/m² output</td>
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Radiators with GSHPs

- Is there a solution? - Underfloor heating to the rescue!

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<td>Underfloor pipe centres :: W/m² output</td>
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<td>160</td>
<td>119</td>
<td>119</td>
<td>93</td>
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</tbody>
</table>

MWT = 46°C :: (Flow = 50°C) :: Room temp. = 20°C

Source: Underfloor Heating Design & Installation Guide
Radiators with GSHPs

• What does all mean for systems that mix radiators with underfloor heating?

• The heatpump must operate to deliver water to the system at not less than 50°C (to satify the radiators’ requirements)

• This means a typical CoP will be 2.8

• What does this mean for systems with only underfloor heating, on each floor?

• The heatpump can operate to deliver water to the system at 35°C

• This means a typical CoP will be 4.0
Radiators with GSHPs

- Are heat pumps with radiators viable?
- Take a heating system with a design load of 11 kW
- The cost of gas is around 3p per kWh (average)
  - Typical heating season fuel cost £385.00
- The cost of electricity is around 10.8p per kWh (average)
  - Typical heating season fuel cost £445.00 (H/P CoP 2.8)
Underfloor Htg with GSHPs

- Are heat pumps with underfloor heating throughout viable?
- Take a heating system with a design load of 11 kW
- The cost of gas is around 3p per kWh (average)
  - Typical heating season fuel cost £385.00
- The cost of electricity is around 10.8p per kWh (average)
  - Typical heating season fuel cost £312.00 (H/P CoP 4.0)
In conclusion….

- Beneficial to design GSHPs into new build
  - all space heating requirements can be satisfied using underfloor heating
  - CoP of heatpump means cost per kWh of delivered heat is less than natural gas at current prices
  - but consider payback period to cover the difference in cost of gas boiler installation or GSHP installation

- If any radiators used for heat emission
  - lower CoP raises cost per kWh of delivered heat above that of natural gas
  - Cannot raise stored domestic hot water to a safe temperature
In conclusion….

- If any radiators used for heat emission
  - lower CoP raises cost per kWh of delivered heat above that of natural gas
  - but if not on mains gas, GSHPs show significant running cost savings over both oil-fired or LPG-fired boiler/radiator systems
  - still cannot raise stored domestic hot water to a safe temperature
In conclusion….

• Adding GSHPs into existing heating systems
  – not before improving insulation levels in every way possible
  – even with improved insulation (if possible) radiators may not be large enough for lower water temperatures

• If any radiators used for heat emission
  – lower CoP raises cost per kWh of delivered heat above that of natural gas
    • but still lower cost than oil or LPG
  – Cannot raise stored domestic hot water to a safe temperature
....and finally, based on running costs

<table>
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<tr>
<th></th>
<th>GSHP 35°C</th>
<th>GSHP 50°C</th>
<th>Nat. Gas Boiler</th>
<th>Oil Boiler</th>
<th>LPG Boiler</th>
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<td>Underfloor Heating</td>
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<td>Radiators throughout</td>
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<td>DHW (No supplementary)</td>
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? Depends on available radiator surface area
Thank you for your attention

CIBSE Domestic Design Guides are available from the IDHEE online shop

Domestic Heating
Underfloor Heating
Solar Heating

www.idhee.org.uk

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