Optimising Designs For Electrification
CIBSE ANZ Seminar Series
Sam Snutch - September 5th, 2023
Why Electrify?

Gas Characteristics
- Simple technology
- Low Cost
- Low Cost Distribution
- Not capacity sensitive
- High Energy Density (55MJ/kg)
- Efficient at high temperatures
- High Delta Ts – Efficient Pumping
- Robust Operation
- Low Embodied carbon
- Very High Operational Carbon

Electric / Heat Pump Characteristics
- Complicated
- High Cost
- High Cost Distribution
- Capacity sensitive
- Low Delta T’s
- Efficient at low temperatures
- Flow Sensitive
- High Embodied Carbon (4.5x Boiler)
- Low / Zero Operational Carbon possible
- High COPs
- Capable of use in high total efficiency systems
Capacity Sensitivity

Cost

<table>
<thead>
<tr>
<th>Load</th>
<th>Air cooled HP</th>
<th>Boiler</th>
<th>Electrification Uplift</th>
</tr>
</thead>
<tbody>
<tr>
<td>800kW</td>
<td>$x</td>
<td>$y</td>
<td>4.48</td>
</tr>
<tr>
<td>1000kW</td>
<td>$1.17x</td>
<td>$1.03y</td>
<td>5.07</td>
</tr>
<tr>
<td>Capacity Uplift</td>
<td>117%</td>
<td>103%</td>
<td></td>
</tr>
</tbody>
</table>

Prices indicative based on Rawlinson's
Capacity Sensitivity

Spatial

800kW vs 1000kW
25% Increase in capacity
Unit Footprint within 5%

Room Footprint within 2%

Example – Automatic Heating Eurogen Condensing Boiler

Dimensional Data

<table>
<thead>
<tr>
<th>Mod</th>
<th>KV/KR DIN16</th>
<th>HT DIN16</th>
<th>SV DIN16</th>
<th>KK R³</th>
<th>KE R³</th>
<th>DR</th>
<th>L</th>
<th>B</th>
<th>H1</th>
<th>L1</th>
<th>B1</th>
<th>H2</th>
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<tbody>
<tr>
<td>450</td>
<td>100</td>
<td>50</td>
<td>50</td>
<td>45 mm</td>
<td>32 mm</td>
<td>300</td>
<td>2085</td>
<td>9110</td>
<td>1595</td>
<td>1810</td>
<td>710</td>
<td>1710</td>
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<td>100</td>
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<td>50</td>
<td>40 mm</td>
<td>32 mm</td>
<td>300</td>
<td>2110</td>
<td>990</td>
<td>1736</td>
<td>1810</td>
<td>190</td>
<td>1890</td>
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<td>125</td>
<td>65</td>
<td>65</td>
<td>40 mm</td>
<td>32 mm</td>
<td>300</td>
<td>2510</td>
<td>990</td>
<td>2136</td>
<td>2110</td>
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<tr>
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<td>40 mm</td>
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<td>400</td>
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<td>1080</td>
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<td>40 mm</td>
<td>32 mm</td>
<td>400</td>
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<td>40 mm</td>
<td>32 mm</td>
<td>400</td>
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<td>80</td>
<td>40 mm</td>
<td>32 mm</td>
<td>450</td>
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<td>1300</td>
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<td>164</td>
<td>2242</td>
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<td>40 mm</td>
<td>32 mm</td>
<td>450</td>
<td>2200</td>
<td>1130</td>
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<td>50 mm</td>
<td>32 mm</td>
<td>700</td>
<td>2100</td>
<td>1750</td>
<td>2070</td>
<td>2350</td>
<td>1750</td>
<td>2350</td>
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</tbody>
</table>

Example – Automatic Heating Eurogen Condensing Boiler

Automatic Heating reserves the right to change specifications without notice.
Capacity Sensitivity

Spatial

25% Increase in Capacity

25% Increase in Footprint

Example for illustrative purposes
approx. 400kW
Capacity Sensitivity

Cost

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Spatial

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</thead>
<tbody>
<tr>
<td>800kW</td>
<td>97m²</td>
<td>40m²</td>
<td>2.42</td>
</tr>
<tr>
<td>1000kW</td>
<td>106m²</td>
<td>41m²</td>
<td>2.58</td>
</tr>
<tr>
<td>Capacity Uplift</td>
<td>109%</td>
<td>102%</td>
<td></td>
</tr>
</tbody>
</table>
Defining Loads for Electric Systems

Heating load calculations and sizing methodology

Figure 1.3 Heating system calculation process chart

Select space heating and DHW system type

- Select design conditions for room
- Select design criteria for mechanical ventilation systems
- Calculate room heat emission characteristics
- Calculate room heat emission duty
- Repeat procedure for all systems

Select mechanical ventilation heating

- Select design criteria for mechanical ventilation systems
- Select mechanical ventilation system
- Calculate design steady-state heat demand
- Repeat for all other ventilation systems

Domestic hot water heating duty

- Select design criteria for DHW
- Select DHW system including storage
- Calculate design steady-state heat demand
- DHW system heating duty = steady state heat demand
- Repeat for all other DHW systems

Airah DA09

HEATING LOAD ESTIMATE
(Warm air heating only)

The heating load evaluation is the foundation for selecting air heating equipment. Normally, the heating load is estimated for the winter design temperatures (Chapter 2) usually occurring in the morning just before occupancy; therefore, no credit is taken for the heat given off by internal sources (people, lights, etc.). This estimate must take into account the heat loss through the building structure surrounding the spaces and the heat required to offset the outdoor air which may infiltrate and/or may be required for ventilation. Chapter 5 contains the transmission coefficients and procedures for determining heat loss.
Defining Loads for Electric Systems

Worked Example

<table>
<thead>
<tr>
<th>ITEM</th>
<th>BASE CASE</th>
<th>NON GREENSTAR (OPTION 1)</th>
<th>MINIMUM OA (OPTION 2)</th>
<th>DATA ANALYSIS (OPTION 3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fabric Load (Estimated)</td>
<td>420 kW</td>
<td>420 kW</td>
<td>420 kW</td>
<td>640 kW</td>
</tr>
<tr>
<td>OA Load (Estimated)</td>
<td>690 kW</td>
<td>460 kW</td>
<td>230 kW</td>
<td></td>
</tr>
<tr>
<td>Warm Up Cycle (Estimated)</td>
<td>70 kW</td>
<td>70 kW</td>
<td>70 kW</td>
<td>70 kW</td>
</tr>
<tr>
<td>4-Pipe @ 80%</td>
<td>710 kW</td>
<td>570 kW</td>
<td>-20%</td>
<td>440 kW</td>
</tr>
<tr>
<td>Capacity Installed</td>
<td>1420 kW</td>
<td>1140 kW</td>
<td>880 kW</td>
<td>820 kW</td>
</tr>
</tbody>
</table>

*4-Pipe chillers are sized at 60% of the total load to meet the PCA redundancy requirements and to add an additional 20% total safety factor*
Defining Loads for Electric Systems

Worked Example

- Maximise Simultaneous Heating and Cooling
- Utilise 4-Pipe In total cooling
- Additional water saving low load option

50% CHW LOAD
25% HHW LOAD
DHW Consideration

What is demand? Could point of use electric systems be sufficient?

- Reduced distribution and storage losses
- Improved use vs consumption characteristic
- Reduced embodied carbon

Are Separate Systems A Missed Opportunity?


Heat Recovery and Ambient Loops
Heat Recovery and Ambient Loops

Heat Pumps and District Ambient Loops – 5th Generation Heat Networks

Bankside Yards
Fifth-generation energy network

- Heat sharing
  Low-temperature fifth-generation network allows energy sharing

- Optimised façades and efficient systems
  Optimised façades, systems and infrastructure, combined with energy sharing and green energy purchasing, will achieve net zero carbon in operation

- Air source heat pumps
  Air source heat pumps supplement heating and cooling energy balance across site

- Future-proofed
  Future connection to external district heat network infrastructure

Glossary: next generation

- Third generation: Heat distributed at 90/70°C flow/return usually fuelled by a combined heat and power energy centre.
- Fourth generation: Temperatures are below 55/25°C flow/return, which leads to greater efficiencies, especially if using heat pumps or energy from waste. Onsite renewable generation can be integrated.
- Fifth generation: An ambient temperature energy network (which will run below 25/20°C at Bankside Yards) has a wider range of lower-grade heat sources, and accepts simultaneous cooling heat rejection, along with heat supply.

Existing Building Considerations

Hybrid Solutions

- Dependent on-site constraints/opportunities
- Never assume like-for-like capacity
- Be Data led
Existing Building Considerations

Phased Solutions

- Don’t let perfect be the enemy of best for project
Take Away Messages

• Design for the technology you are using
• Never assume like-for-like
• Capacity sensitivity amplifies importance of ‘right sizing’
• Be data driven
• Detailed Analysis gives better results capital and operational results
• Test and rethink the business as usual and accepted norms
• Be flexible
• Consider wider Sustainability impacts
Thank you