Sizing and Selection of Hot Water Generating Plant

Presentation by:

Rob Larner & David Dutch
SIZING HOT WATER PLANT - agenda

- Consider different sizing methods.
- Arrive at a design example for a 200 bed NHS long stay hospital.
- Calculate the expected demand and peak flow.
- Select an appropriate type of calorifier / heat exchanger. (Identify and discuss types)
- Incorporate sustainable energy sources.
- Recent trends affecting design.
- The future.
Example 200 bed Hospital

Fixture count:

- 16 Baths
- 34 Showers
- 34 Ward basins
- 40 Public sinks
- 5 Utility sinks
## Sizing Calculation Results

<table>
<thead>
<tr>
<th>Reference</th>
<th>Method</th>
<th>Storage l</th>
<th>kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIBSE:</td>
<td>Ward Units</td>
<td>9321</td>
<td>154</td>
</tr>
<tr>
<td></td>
<td>Basic Calculation</td>
<td>6000</td>
<td>300</td>
</tr>
<tr>
<td></td>
<td>Demand Units</td>
<td>n/a</td>
<td>852</td>
</tr>
<tr>
<td>Manufacturers</td>
<td>A</td>
<td>3171</td>
<td>202</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>1155</td>
<td>381</td>
</tr>
<tr>
<td>British Standards</td>
<td>BS6700</td>
<td>n/a</td>
<td>875</td>
</tr>
<tr>
<td>ASHRAE:</td>
<td>Storage</td>
<td>3312*</td>
<td>212</td>
</tr>
<tr>
<td></td>
<td>Demand Units</td>
<td>n/a</td>
<td>599</td>
</tr>
</tbody>
</table>

* Based upon two showers per hour
## Sizing Calculation Results

### Table 3. Daily hot water consumptions in each type of building monitored

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Service</th>
<th>Catering</th>
<th>Max. total</th>
<th>Average Temp. °C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>litres</td>
<td>litres/</td>
<td>litres/</td>
<td>litres/</td>
<td>Average</td>
</tr>
<tr>
<td></td>
<td>person</td>
<td>person</td>
<td>room/</td>
<td>meal/</td>
<td>°C</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>outlet</td>
<td>outlet</td>
<td></td>
</tr>
<tr>
<td><strong>Schools and Colleges</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max.</td>
<td>21866</td>
<td>13.2</td>
<td>122.3</td>
<td>11562</td>
<td>21866</td>
</tr>
<tr>
<td>Ave.</td>
<td>6128</td>
<td>6.2</td>
<td>60.5</td>
<td>3638</td>
<td>6128</td>
</tr>
<tr>
<td><strong>Hotels and Hostels</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max.</td>
<td>44096</td>
<td>463.7</td>
<td>106.8</td>
<td>29394</td>
<td>44096</td>
</tr>
<tr>
<td>Ave.</td>
<td>14534</td>
<td>156.5</td>
<td>53.5</td>
<td>17237</td>
<td>14534</td>
</tr>
<tr>
<td><strong>Restaurants</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Max.</td>
<td>6296</td>
<td>17.3</td>
<td>409.1</td>
<td>2237</td>
<td>6296</td>
</tr>
<tr>
<td>Ave.</td>
<td>2618</td>
<td>7.2</td>
<td>201.2</td>
<td>686</td>
<td>2618</td>
</tr>
<tr>
<td><strong>Large Shops</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max.</td>
<td>13092</td>
<td>25.9</td>
<td>176.8</td>
<td>6667</td>
<td>13092</td>
</tr>
<tr>
<td>Ave.</td>
<td>3411</td>
<td>8.4</td>
<td>65.8</td>
<td>1517</td>
<td>3411</td>
</tr>
<tr>
<td><strong>All Sites Measured</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max.</td>
<td>5455</td>
<td>24.8</td>
<td>101.0</td>
<td>1209</td>
<td>5455</td>
</tr>
<tr>
<td>Ave.</td>
<td>1022</td>
<td>9.8</td>
<td>44.4</td>
<td>423</td>
<td>1022</td>
</tr>
</tbody>
</table>

* Not including sites without either service or catering.  
† One site had a broken thermostat.  
‡ 3.7 litres/meal per day is the average consumption in the restaurants without large bar facilities.

### Table 4. Factors by which plant is too large

<table>
<thead>
<tr>
<th></th>
<th>CHBS Recommendations (X too large)</th>
<th>Actually Installed Plant (X too large)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total Catering Service Total Catering Service</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Boiler Storage Boiler Storage Boiler Storage Boiler Storage Boiler Storage Boiler Storage</td>
<td></td>
</tr>
<tr>
<td><strong>Schools</strong></td>
<td>Max. Ave. 6.0 5.0 4.6 3.5 7.6 6.1 10.6 10.6 3.4 3.5 1.6 1.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ave. 3.7 3.1 2.5 1.9 4.9 3.9 4.0 3.9 2.1 2.1 1.3 1.3</td>
<td></td>
</tr>
<tr>
<td><strong>Hotels</strong></td>
<td>Max. Ave. 4.8 3.8 4.0 3.0 5.2 4.1 3.8 3.9 – – 2.2 2.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ave. 3.2 2.5 2.3 1.8 3.4 2.7 1.7 1.7 – – – –</td>
<td></td>
</tr>
<tr>
<td><strong>Restaurants</strong></td>
<td>Max. Ave. – – 8.2 6.2 – – 0.9 0.4 2.3 2.2 3.9 0.40</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ave. – – 4.6 3.5 – – 0.7 0.4 1.2 1.1 – –</td>
<td></td>
</tr>
<tr>
<td><strong>Offices</strong></td>
<td>Max. Ave. 9.9 8.0 8.9 6.8 11.4 9.1 2.7 2.8 1.2 1.2 5.3 5.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ave. 5.1 4.3 3.7 2.8 7.2 5.8 1.9 2.2 – – 3.5 3.5</td>
<td></td>
</tr>
<tr>
<td><strong>Large Shops</strong></td>
<td>Max. Ave. – – 5.4 4.2 – – 2.9 2.7 – – – –</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ave. – – 3.7 2.9 – – 2.2 2.1 – – – –</td>
<td></td>
</tr>
<tr>
<td><strong>All sites</strong></td>
<td>Max. Ave. 9.9 8.0 8.9 6.8 11.4 9.1 10.6 10.6 3.4 3.5 5.3 5.2</td>
<td></td>
</tr>
<tr>
<td><strong>Measured</strong></td>
<td>Max. Ave. 3.9 3.2 3.3 2.5 4.9 3.9 2.3 2.2 1.6 1.6 2.2 2.2</td>
<td></td>
</tr>
</tbody>
</table>
Sizing by the Fixture Count method

- Complete a detailed list of all fittings
- Assign a volume per hour to each fitting
- Assign a demand factor to each fitting
- Calculate total stored volume requirement

<table>
<thead>
<tr>
<th>Fitting</th>
<th>Vol./ h x No off</th>
<th>Demand Factor</th>
<th>Total Storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baths</td>
<td>60 x 16</td>
<td>0.7</td>
<td>960</td>
</tr>
<tr>
<td>Showers</td>
<td>70 x 34</td>
<td>0.7</td>
<td>2380</td>
</tr>
<tr>
<td>Ward basins</td>
<td>10 x 34</td>
<td>0.7</td>
<td>340</td>
</tr>
<tr>
<td>Public sinks</td>
<td>15 x 40</td>
<td>0.7</td>
<td>600</td>
</tr>
<tr>
<td>Utility sinks</td>
<td>50 x 5</td>
<td>0.7</td>
<td>250</td>
</tr>
</tbody>
</table>
Sizing by the Fixture Count method

Therefore the required hourly stored volume = 3171 l/hour

The required boiler input = l/s x Specific heat of water kJ/kg.K. x dT
= (3171/3600) x 4.187 x (65-10)
= 202 kW

Heating surface = kW / (Log mean temperature x Heat transfer coefficient)

Heat transfer co-efficient is dependant upon the type of exchanger used.
Sizing by the Fixture Count method

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Storage Calorifier</th>
<th>Semi-Storage</th>
<th>Instantaneous</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume l</td>
<td>3200</td>
<td>800</td>
<td>n/a</td>
</tr>
<tr>
<td>kW rating</td>
<td>202</td>
<td>202</td>
<td>875</td>
</tr>
<tr>
<td>Dimensions</td>
<td>1350 x 1550 x 2750</td>
<td>990 x 1265 x 2330</td>
<td>350 x 800 x 1240</td>
</tr>
<tr>
<td>width x length x height</td>
<td>width x length x height</td>
<td>width x length x height</td>
<td></td>
</tr>
<tr>
<td>Op. mass kg</td>
<td>3910</td>
<td>1270</td>
<td>160</td>
</tr>
</tbody>
</table>
Generating Plant Sizing and Selection of Hot Water

Rob Larner - Calorifiers
The Different types of DHW Water Heaters, what are they and how do they work

- Storage Calorifiers.
- Semi-Storage Calorifiers
  - High output calorifier.
  - Instantaneous Plate Heat exchangers with associated Buffer vessel.
- Instantaneous Plate Heat exchangers.
- Domestic Instantaneous heat exchangers.
- Renewable Solutions using all the above.
The Different types of DHW Water Heaters, what are they and how do they work

**Storage type –**

- The water is heated by an Internal heat exchanger via natural convection methods. e.g U tube battery, coil.
- The heat exchanger is fed via a Primary heat source LTHW, MTHW, HTHW or Steam Energy Centre.
- Water is Heated and stored to serve the DHW peak and normal demands.
- Renewable heat sources can be accommodated.
- Restricted power inputs can be accommodated.
- De strat pumps are fitted if deemed necessary to reduce the risk of legionnaires.
Storage Calorifiers

Calorifier is a term used to describe an extensive range of industrial and commercial hot water heaters. This principle is a non fired solution.

Applications: Varied e.g.
- Schools, Universities, Colleges
- Hospitals, NHS clinics
- Offices
- Public Buildings
- Factories
Semi Storage High output Calorifier –

- The water is heated via an Internal heat exchanger, however this is enclosed within an integral chamber within the shell, thus changing it into a forced convection type system.
- The heat exchanger is fed via a Primary heat source LTHW, MTHW, HTHW or Steam Energy Centre.
- Reducing the Capacity means the standing losses are reduced.
- A continuously running charging pump is required to force the cold water through and over the internal exchanger, this also reduces the Risk for legionnaires.(L8)
- Have a proven track record.
- Offer a solution where hard water is of concern.
- Can be used for high pressure systems.
The Semi-Storage Calorifier was developed to meet today’s need for a compact calorifier which will respond to high peak loads with minimal demand for boiler power. This high output semi-storage calorifier is one solution to space limitations, power regulations and energy savings.

Applications:
• Hotels
• Hospitals
• Prisons
• Large Sports Complexes
Semi Storage Plate & buffer system –

- The water is heated via an External plate heat exchanger, this is situated alongside the storage vessel, thus changing it into a forced convection type system.
- The heat exchanger is fed via a Primary heat source LTHW, MTHW, HTHW or Steam Energy Centre.
- Reducing the Capacity means the standing losses are reduced.
- A continuously running charging pump is required to force the cold water through and over the internal exchanger, this also reduces the Risk for legionnaires (L8).
- Offer a solution where hard water is of concern.
- Can be used for high pressure systems.
DHW Plate heat with Buffer Vessels

The DHW Plate Heat exchanger with associated Buffer vessel was developed to help reduce the need for stored water but also reduced the Boiler power required for the exchanger.

The plate exchangers again offer instant and continuous hot water but with the additional stored water to help the plate and buffer meet the simultaneous peak demands.

• Reduces kW power and stored water if compared with the Instantaneous design.
• Varying Combinations can be designed to suit each project depending on project.
• Cost effective to other methods when selected correctly.
• Packaged Principle takes care of the controls/pumps required.
The Different types of DHW Water Heaters, what are they and how do they work

1 – Plate heat exchanger Gasketted type
• High Heat Transfer capability with forced convection principle.
• Flexible and More efficient temperature profiles available.
• Reduced flow rates can be designed to help reduce pipe sizes and pump selections.
• Can be linked with renewable systems with increased output.
• Reduction Plant Size & Weight compared to other methods.
• Reduced maintenance downtime.
• Overall a more energy efficient principle than traditional methods of DHW generation, depending on system usage.
• A reduction in size of associated plant equipment can be used e.g. pumps, pipework, valves etc.

2 – Brazed type
• Non maintainable version of the gasket type
• High operating temperatures & pressures
• Used in the Domestic housing market high volumes easier to supply
The DHW Plate Heat exchanger was developed to help reduce the need for stored water. The plate exchangers offer instant and continuous hot water on demand. The exchangers used have a greater heat transfer coefficient. Plates compliment Condensing Boiler systems due to the reduced primary return temps which can be achieved <50 C.

- Reduced footprint/weight
- Varying Outputs designed to suit
- Cost effective to other methods when selected correctly.
- Simple to install
- Packaged Principle takes care of the controls/pumps required
Domestic Housing Plate heat exchanger

Instantaneous Water Heater

- Instant & continuous LTHW & DHW on demand.
- Increased efficiency using modern Pumps and controls.
- Ranging from 1 bed to 4 bed Dwellings.
- Works in conjunction with Central Boiler Plant/District Heating.
- Fully self controlled, A Single supply needed only.
- Complete with Metering function on request.
- Top or bottom entry connections available.
Recent trends influencing design

David Dutch – Recent trends
Recent trends influencing design

- Implementation of sustainable energy sources whilst maintaining compliance with L8, HTM-04 etc.

- Use of thermostatic flow control valves, pasteurisation cycles and large DHW return flow rates.
DHW Preheat System (Primary store)
Recent trends influencing design

Thermostatic regulating valves.

Advantages:

- Flow regulation.
- Thermal adjustment.
- Thermal disinfection $T > 70$ deg.C.

Other Considerations:

- May result in extremely large secondary return flow rates.
- May incur additional capital cost for pipe work and fittings.
- Potential of additional running costs. (pump motors).
- May require additional boost exchanger if system is designed upon standard semi-storage concept.
Mass flow diagram

Max Flow
11.4 l/sec
100Ø

Secondary Return
7.6 l/sec
80Ø

Calorifer
Package

3.8 l/sec

Peak Flow
3.8 l/sec
65Ø
High secondary return thermal limit
Mass flow diagram

Max Flow
11.4 l/sec
100Ø

Secondary Return
7.6 l/sec
80Ø

Calorifer Package

3.8 l/sec

Peak Flow
3.8 l/sec
65Ø
High secondary return system

- Hot water supply
- PHE 55 - 70 C single pass
- Secondary Return > PHE pump flow
- Buffer
- Cold water supply
- PHE 10 - 60 C single pass
- PHE pump
The Future

Greater emphasis will be placed on water efficiency.

Sustainable energy sources will be more readily adopted.

Control systems integrating various sustainable energy inputs will become the norm.

Power requirements will be reduced by (amongst others):

- Wide use of water efficient fittings.
- Appropriate use of Variable speed drives with high efficiency motors.
- Better insulation techniques/materials
- Smarter electronic controllers
Questions