Understanding the BESA Test
Standard for HIUs – VWARTS and all

Evinox Energy

CIBSE Approved CPD
About Evinox

- Specialise in providing Communal & District heating solutions
- More than 14 years of experience
- Own range of heat interface units, designed and developed internally and manufactured in our own production facility
- Support Services
Today’s Seminar

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Heat Networks – Where are we now?
Policy, Legislation, Guidelines
International & European Drivers

- Decarbonisation of heat and power central to Government energy strategy
  - Climate change
  - Energy security
  - Energy costs

- Heating and hot water for UK buildings make up around 40% of our energy consumption, and around 20% of our greenhouse gas emissions.

- Two thirds of these emissions are from housing

- These emissions need to be reduced by over 20% by 2030, with a near complete decarbonisation by 2050, as a contribution to the legally-binding targets set by Parliament in the Climate Change Act
The Climate Change Act 2008 is the basis for the UK’s approach to tackling and responding to climate change.

It requires that emissions of carbon dioxide and other greenhouse gases are reduced and that climate change risks are prepared for. The Act also establishes the framework to deliver on these requirements.

The Climate Change Act commits the UK government by law to reducing greenhouse gas emissions by at least 80% of 1990 levels by 2050.
UK Heat Network Policy

- Heat networks form an important part of the Government’s plan to reduce carbon and cut heating bills.
- It is estimated by the CCC that around 18% of UK heat will need to come from heat networks by 2050 if the UK is to meet its carbon targets cost effectively.
- Heat networks are considered one of the most cost-effective ways of reducing carbon emissions from heating.
- Their efficiency and carbon-saving potential increases as they grow and connect to each other.
- Heat networks provide a unique opportunity to exploit larger scale – and often lower cost – renewable and recovered heat sources that otherwise cannot be used.
“The Mayor expects 25 per cent of the heat and power used in London to be generated through the use of localised decentralised energy systems by 2025. In order to achieve this target the Mayor prioritises the development of decentralised heating and cooling networks at the development and area wide levels, including larger scale heat transmission networks."

The recent London Environment Strategy consultation also places a heavy emphasis on the continued uptake and development of heat networks, for both new and existing buildings as a key carbon abatement measure.
UK Heat Networks

- Heat Network (Metering & Billing) Regulations now require all heat networks to be registered with BEIS
- 17,000 registrations in total
- 492,000 connections in total – of which 447,000 residential

Image Source: ADE website – Major Heat Networks
UK Heat Networks

Heat Network Delivery Unit Funding

- 7 rounds of funding (to date)
- Supports LA’s for heat mapping and high level feasibility studies into Heat Networks
- 139 LA’s have received a share of £14m to date

Heat Network Investment Project

- 9 local authorities have received a share of £24m (grants and loans)
- Total £320m to be allocated through future phases over 5 years
- Real projects, ready for deployment
  - Sheffield City Council: £5.73m
  - Camden Council: £1m
  - Manchester City Council: £7.9m
  - Colchester Borough Council: £3.5m
  - Crawley Borough Council: £1.4m

Image Source: ADE website – Major Heat Networks
# Legislation for Heat Networks

## Regulation

| Heat Network (Metering and Billing) Regulations 2014 |

## Industry Guidelines

| CIBSE & ADE Heat Networks: Code of Practice for the UK |
| BSRIA Heat Interface Units Guide: BG 62/2015 |
| Evinox Energy Heat Network Design Guide for ModuSat® Systems |
| Manufacturer’s guidelines |

## HIU Standard 2017

| The Building Engineering Services Association (BESA) published the UK’s first test standard for Heat Interface Units (HIUs) |
Heat Networks – Key Considerations

From Design to Successful Delivery

Evinox Energy
Heat Network – Project Considerations
Temperature selection on the primary and secondary is the key for efficient heat network as it will affect: plant efficiency, heat loss, pumping cost etc.

Low Temperature = Low Carbon

- Lower primary flow temperatures becoming increasingly common
- Allows low return temperatures to be achieved
- Working on wider dT results in lower flow rates for the same power (kW) delivered
- Means small pumps and pipes
- Weather compensation on primary network should also be considered
Smaller pumps result in lower capital costs and lower power consumption.
Smaller pipes mean less surface area so lower heat losses.
Lower heat losses mean less heat input required to the DH network.

- Reduces unwanted heat gains
- Lower return temperatures improve boiler/CHP efficiency
- Low carbon technologies
Low Temperature Heat Networks

- Design for efficiency vs abundance of DHW
- Pragmatic approach to diversity will reduce overall peak demand
  - Reduced pipe sizing
  - Reduced heat losses
  - Reduced plant capacity and cost
- Increased plant efficiency
- Increased HIU efficiency
  - Operating closer to full load more of the time
- Reduced maintenance and whole life cost
How Does HIU Performance & Sizing Impact on Heat Network Efficiency?
Low Temperature Heat Networks

- Lots of factors affect Heat Network efficiency
- Recent studies illustrate poor HIU performance also a significant factor
- If HIU performs poorly, it is hard to limit primary return temperatures

- HIU’s are not “one size fits all” – network design (flow temp, return temp, flow rates) need to be closely matched
- Requires performance-led specification
- Low return temperatures and large delta T’s are the key!
Low Temperature Heat Networks

- HIU’s therefore need to be selected that can:
  - Deliver required capacity at specified flow rate and flow temperature
  - Especially important for lower flow temperature networks
  - Demonstrate they can deliver low return temperatures to the network
  - Provide fast response to demand for DHW

- Correct sizing of HIU’s is also critical
  - Peak capacity (DHW) often over estimated
    - Response/abundance of DHW considered over network efficiency/return temp
  - Optimal sizing means:
    - Operating closer to full load more of the time
    - Lower maintenance – “self-cleaning” plates
  - Considerate sizing therefore works hand in hand with reducing plant and pipework capacity to reduce capital costs and improve network efficiency

Network Pipework Sizing

Plant Room Sizing

Capacity (KW) Calculation

Heat Interface Unit Selection
Low Temperature Heat Networks

UK Heat Interface Unit Test Regime

New technical performance test standard – developed by industry
BESA Test Standard Overview
A bit of background...

2015: FairHeat develop a demonstration HIU test scheme, as part of the Heat Networks Demonstration project – funded by DECC

Six manufacturers took part:
- Evinox Energy
- Altecnic
- SAV
- Pegler Yorkshire (Meibes)
- Thermal Integration
- Wilson Energy (KaMo)

Aimed at providing a comparable set of HIU performance figures under typical UK operation conditions

Calculated VWART – volume weighted average return temp

“The BESA standard is based on an initial regime developed as part of a Heat Networks Demonstration SBRI research project funded by DECC (now BEIS). This regime and results should be used for background only, and should not be used for the purposes of comparing HIU performance.” Source: FairHeat website
- Developed by BESA and industry stakeholders
- Purpose is three-fold:
  - To enable the performance of different HIUs to be evaluated within the context of typical UK operating conditions
  - To generate operating data on the expected performance of specific HIUs given “normal” operating parameters.
  - To provide a framework for HIU manufacturers to evaluate the performance of their equipment within the UK context
- Results will allow manufacturers to evaluate the performance of HIU’s under typical UK conditions and will give designers the opportunity to see the impact of a particular HIU on their network
UK Standard for Heat Interface Units, 2017

www.thebesa.com/ukhiu
UK Standard for Heat Interface Units

- Individual HIU’s are **independently** tested against a set of criteria representing typical UK heat network operating conditions, including tests to measure performance at part and full load;

- Two network conditions: “High” and “Low” temperature

<table>
<thead>
<tr>
<th>Network Conditions</th>
<th>Space Heating</th>
<th>Domestic Hot Water</th>
<th>Keep Warm</th>
<th>DHW Response</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High Temperature</strong></td>
<td>Measure the return temperature at 1/2/4kW load</td>
<td>Measure the return temp at ultra low / low / med / high flow rates</td>
<td>Measure the return temperature with Keep Warm facility switched on</td>
<td>Confirm ability to deliver 45°C water at the HIU outlet within 15s of tap opening at low/med/high flow rates</td>
</tr>
<tr>
<td>Primary: 70°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DHW set point: 55°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Space Heating: 60/40°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Low Temperature</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary: 60°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DHW set point: 50°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Space Heating: 45/35°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Outcome from the first three test results** are used to calculate a VWART for each HIU at High Temp and Low Temp conditions (with/without Keep Warm, if HIU has ability to switch Keep Warm off)
Key output is the calculation of the annual **Volume Weighted Return Temperature** (VWART) from the HIU

The above figures are provided for

- (High/Low temperature) network condition tests
- With/without Keep Warm active

**UK Standard for Heat Interface Units, 2017**

**Domestic Hot Water (°C)**

**Space Heating (°C)**

**Keep Warm Functions (°C)**

**Overall HIU Specific VWART (°C)**
The VWART “volume weights” the quantity and temperature of water returned to the network per annum.

- Domestic Hot Water = 101 hours per year
- Space Heating = 644 hours per year
- Keep Warm = 8014 hours per year

UK Standard for Heat Interface Units, 2017

www.thebesa.com/ukhiu
For the tests, Evinox submitted its latest ModuSat® XR-ECO Twin Plate model.

- Fast and responsive Domestic Hot Water performance
- SmartTalk® 2-way communications provide remote commissioning, diagnostics/support and metering
- Flexible (and remotely configurable) Credit or PAYG metering options – no additional equipment required
- Pressure Independent Control Valves (PICVs) provide electronically controlled flow modulation + timed K/W flexibility
- Designed for modern, low-temperature heat networks (60°C primary)
- Low DHW return temperatures; Low VWART
Space Heating
Measure the return temperature at 1/2/4kW load

Estimated Annual Space Heating Demand (kWh/yr)

- Space heating load based on a typical new build flat;
- **Total 1450 kWh/yr. space heating load**, split between 1kW/2kW/4kW demand as shown
- Return temperatures measured at each load, for each of the network conditions (above)
- Secondary temperatures reflect radiators (60/40) and UFH (45/35)
Heat Interface Unit’s Operating Temperatures

Approach temperature Tapp – the temperature difference between primary flow and secondary flow, or primary return and secondary return.

70°C – 60°C

Tapp = 10°C

~41.6°C

40°C
ModuSat® XR-ECO: Space Heating Test Results

**HIGH TEMPERATURE TEST CONDITIONS**
- Domestic Hot Water
- Space Heating (41.6°C)
- Keep Warm Functions

**LOW TEMPERATURE TEST CONDITIONS**
- Domestic Hot Water
- Space Heating (35.7°C)
- Keep Warm Functions
Dynamic DHW Performance
Modern Flats – Heating vs Hot Water Load

- 50% or more of heat energy consumed in modern apartments is for hot water. In the BESA model, 1470kWh/yr (calculated from SAP)
- The flow rate of DHW use also has an impact on HIU return temperature
CIBSE Guidance – Domestic Hot Water

CIBSE Code of Practice for Heat Networks (CP1):

**Secondary Return Temperature:** Maximum 25°C at 10°C cold feed temperature

![Diagram of heat network with temperatures 70°C, 55°C, 25°C, and 70°C, indicating flow and return temperatures in a heat network system.](image)
Dynamic DHW Test

The test measures the DHW return temp at low / medium / high flow rates

**Network Conditions**

**High Temperature**
- Primary: 70°C
- DHW set point: 55°C

**Low Temperature**
- Primary: 60°C
- DHW set point: 50°C

**Domestic Hot Water**

Measure the return temp at ultra low / low / med / high flow rates

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(Table 6) Domestic Hot Water Annual Demand

<table>
<thead>
<tr>
<th>Description</th>
<th>Flow Rate (l/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>0.06</td>
</tr>
<tr>
<td>Medium</td>
<td>0.1</td>
</tr>
<tr>
<td>High</td>
<td>0.13</td>
</tr>
</tbody>
</table>

(Table 7) Domestic Hot Water Annual Events and Duration

<table>
<thead>
<tr>
<th>Description</th>
<th>Number of events (events/year)</th>
<th>Average Duration (seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>10,000</td>
<td>30</td>
</tr>
<tr>
<td>Medium</td>
<td>660</td>
<td>70</td>
</tr>
<tr>
<td>High</td>
<td>300</td>
<td>145</td>
</tr>
</tbody>
</table>
ModuSat® XR-ECO: DHW Test Results

HIGH TEMPERATURE TEST CONDITIONS

- Domestic Hot Water (14.6°C)
- Space Heating
- Keep Warm Functions

LOW TEMPERATURE TEST CONDITIONS

- Domestic Hot Water (15.1°C)
- Space Heating
- Keep Warm Functions
The role of the Keep Warm Function
How Does Keep Warm Operate

Instantaneous HIU’s generally feature a stand-by mode ‘keep warm’ function, which keeps warm the primary pipework to the HIU and the domestic hot water plate to ensure quick hot water response.

<table>
<thead>
<tr>
<th>KEEP WARM TYPE</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>POOR:</strong> Constant Trickle Bypass Keep Warm</td>
<td>Continually bypasses water across the DHW plate. No temperature or time control. Inefficient and wasteful</td>
</tr>
<tr>
<td><strong>BETTER:</strong> Temperature controlled Keep Warm</td>
<td>Bypasses water across the DHW plate once the plate temperature drops below a “setback” temperature</td>
</tr>
<tr>
<td><strong>BEST:</strong> Electronic Time &amp; Temperature controlled Keep Warm</td>
<td>Allows the function of KW to be timed, so is de-activated during times of low demand (eg middle of the night)</td>
</tr>
</tbody>
</table>
CIBSE Code of Practice for Heat Networks (CP1):

Recommends to keep Bypasses to a minimum
DHW Response after Keep Warm

Test measures the Return Temperature while the Keep Warm function is active for 8 hours

Also requires HIU’s to deliver 45°C water at the HIU outlet within 15 seconds at tap opening at highest flow recommended by BESA (0.13l/s)

This ensures that the KW test is fair and consistent across HIU’s

• \(I_{\text{e}}\) prevents a low KW temperature from skewing the result

RESULT - 45°C in 9 Seconds
Timed Keep Warm

The Keep Warm VWART figure is calculated using a weighted average that has been designed to reflect real world conditions.

The test is based on Keep Warm being switched ON for an average of 90% of the year.

Real life VWART and network efficiency can be greatly improved by –

- Reducing the Keep Warm temperature settings
- Enable residents to set their own schedules for the timing of the keep warm function to reflect more realistic periods of occupation.
ModuSat® XR-ECO: Keep Warm Test Results

**HIGH TEMPERATURE TEST CONDITIONS**

- Domestic Hot Water
- Space Heating
- Keep Warm Functions (44.0°C)

**DHW response: 9 secs**

**LOW TEMPERATURE TEST CONDITIONS**

- Domestic Hot Water
- Space Heating
- Keep Warm Functions (45.1°C)

**DHW response: 7 secs**
VWART Calculation –
A benchmark for HIUs
Understanding the Volume Weighted Return Temperature (VWART) calculation

A key metric from the test is the calculation of the annual Volume Weighted Return Temperature (VWART)

Results reflect the expected impact of the HIU in different operating modes

A lower overall VWART represents a lower average annual return temperature from the HIU to the primary network and therefore a better performing HIU
Understanding the Volume Weighted Return Temperature (VWART) calculation

HIGH TEMPERATURE TEST CONDITIONS
- Domestic Hot Water (14.6°C)
- Space Heating (41.6°C)
- Keep Warm Functions (44.0°C)

VWART ModuSat® XR (33.4°C)

LOW TEMPERATURE TEST CONDITIONS
- Domestic Hot Water (15.1°C)
- Space Heating (35.7°C)
- Keep Warm Functions (45.1°C)

VWART ModuSat® XR (35.6°C)
Understanding the Volume Weighted Return Temperature (VWART) Calculation

**High Temperature VWART Calculation for Evinox HIU**

Primary flow temperature = 70°C, DHW set point = 55°C, Space heating temperatures = 60°C/40°C
Test carried out by RISE in August 2017, Test Reference 7P03172
Manufacturer: Evinox Energy Ltd.; Model: MTP4R-1R-TL1/1B; Serial number: MTPE1B1317A11; Year of manufacture: 2017
VWART calculation prepared by Freddie Valletta of FairHeat Ltd on 6 September 2017

<table>
<thead>
<tr>
<th>VWART (°C)</th>
<th>Volume (m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DHW</td>
<td>14.6</td>
</tr>
<tr>
<td>Keep warm</td>
<td>44.0</td>
</tr>
<tr>
<td>Space heating</td>
<td>41.6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Period</th>
<th>VWART (°C)</th>
<th>% Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>No heating</td>
<td>32.8</td>
<td>93%</td>
</tr>
<tr>
<td>Heating</td>
<td>40.8</td>
<td>7%</td>
</tr>
<tr>
<td>Overall</td>
<td>33.4</td>
<td></td>
</tr>
</tbody>
</table>

VWART with keep warm active

<table>
<thead>
<tr>
<th>Period</th>
<th>VWART (°C)</th>
<th>% Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>No heating</td>
<td>14.6</td>
<td>93%</td>
</tr>
<tr>
<td>Heating</td>
<td>40.6</td>
<td>7%</td>
</tr>
<tr>
<td>Overall</td>
<td>16.6</td>
<td></td>
</tr>
</tbody>
</table>

* HIU has ability to deactivate keep warm function
Putting the results in Context

BESA Test Results in Context (High Temperature Condition)

- 4 manufacturers have now published results
- All within a close range of final VWART temperatures
- DHW response time must also be considered!
- For High Temp conditions (70/40°C), a VWART below 35°C can be considered very good
- Timed Keep Warm can improve VWART and network efficiency
# Keep Warm - BESA Conditions

<table>
<thead>
<tr>
<th></th>
<th>Ann Hours</th>
<th>Ann Hours %</th>
<th>Ann Volume m3</th>
<th>Ann Volume %</th>
<th>VWART °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space Heating</td>
<td>645</td>
<td>7%</td>
<td>46.7</td>
<td>42%</td>
<td>41.6°C</td>
</tr>
<tr>
<td>DHW</td>
<td>101</td>
<td>1%</td>
<td>24.2</td>
<td>22%</td>
<td>14.6°C</td>
</tr>
<tr>
<td>Keep Warm</td>
<td>8014</td>
<td>91%</td>
<td>39.2</td>
<td>36%</td>
<td>44.0°C</td>
</tr>
<tr>
<td>TOTAL</td>
<td>8760</td>
<td></td>
<td>110.1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Example: Evinox ModuSat® XR-ECO, High Temperature Test condition
## Timed Keep Warm

<table>
<thead>
<tr>
<th></th>
<th>Annual Hours</th>
<th>Annual Hours %</th>
<th>Annual Vol m3</th>
<th>Annual Vol %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space Heating</td>
<td>645</td>
<td>7%</td>
<td>47.7</td>
<td>56%</td>
</tr>
<tr>
<td>DHW</td>
<td>101</td>
<td>1%</td>
<td>24.2</td>
<td>28%</td>
</tr>
<tr>
<td>KW On</td>
<td>2671</td>
<td>30%</td>
<td>13.1</td>
<td>15%</td>
</tr>
<tr>
<td>KW Off</td>
<td>5343</td>
<td>61%</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>8760</strong></td>
<td><strong>85.0</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**KEEP WARM ACTIVE 8 HRS/DAY**

<table>
<thead>
<tr>
<th></th>
<th>Annual Hours</th>
<th>Annual Hours %</th>
<th>Annual Vol m3</th>
<th>Annual Vol %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space Heating</td>
<td>645</td>
<td>7%</td>
<td>47.7</td>
<td>56%</td>
</tr>
<tr>
<td>DHW</td>
<td>101</td>
<td>1%</td>
<td>24.2</td>
<td>28%</td>
</tr>
<tr>
<td>KW On</td>
<td>4380</td>
<td>50%</td>
<td>19.6</td>
<td>23%</td>
</tr>
<tr>
<td>KW Off</td>
<td>3634</td>
<td>41%</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>8760</strong></td>
<td><strong>91.5</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**KEEP WARM ACTIVE 12 HRS/DAY**

**LOWER WATER RETURN VOLUME = LOWER VWART!**
Putting the results in Context

BESA Test Results in Context (High Temperature Condition)

Timed Keep Warm can improve VWART and network efficiency
Other Key Considerations
Electronic Versus Mechanical HIU

- Electronic Proportional Integral Derivative (PID) logic over valve control and HIU functionality
- Pressure Independent Control Valves (PICVs) provide electronically controlled flow modulation
- 2-way communication over bus comms network; provides remote commissioning, diagnostics/support and metering
- Flexible (and remotely configurable) Credit or PAYG metering options – no additional equipment required
- Enhanced functionality, such as Timed keep-warm and weather compensation
- ViewSmart heating programmer/thermostat with Ene3 compliant energy display option
Heat Network Weather Compensation

- Primary and secondary can have the same weather compensation function
- Better indoor temperature controllability
- Improved heat source efficiency and reduced distribution heat loss especially under no load conditions
- Particularly relevant to UK weather fluctuations
Value of two-way communication

- Remote Control – the final customer support
- Remote Diagnostics – the HIU operation can be tested remotely by the operator
- Change set points remotely – Including Keep warm set point or apartment weather compensation
- Fault Alarms –
  - high/low pressure,
  - faulty components
  - overheated supply temperature
  - energy meter disconnected
  - and other
- Avoids unnecessary call-outs
- Data logging of apartment temperatures

55
Consider Metering & Billing at an Early Stage

- Communication Network
- Credit or Pre-payment Required?
- What are the requirements of the Metering and Billing Regulations?
Why specify an HIU that isn’t Independently tested to the BESA standard?

The BESA Standard is currently optional, however we see this becoming a mandatory requirement in the near future.

BUT, remember its not just about the VWART – Also consider everything we have discussed today -

• Timed Keep Warm Function can improve efficiency
• Low Temperature = Low Carbon
• Correct sizing of HIU’s is critical
• Benefits of two-way communication for billing and support
Questions & Discussion
Visit our Website for more Information about our Products & Services - www.evinoxenergy.co.uk