Heat Network Technical Assurance Scheme

Guidance Document

Key Performance Indicator (KPI) Explanations

HNTAS-XX-GD-XX-KPI

Version History

Revision	Notes	Date
V0.1	Draft issue	16/02/26

Disclaimer

The following HNTAS Guidance document is published in draft format. This document is intended to support stakeholder understanding of draft Code documents by providing explanatory text on the intent and application of specific technical items. This document does not introduce additional requirements and should be read alongside the relevant draft Code documents.

The content of this document is still in development and subject to change.

Changes which may be made to this document in future include those to:

- reflect learnings from the New Build and Existing network pilot programmes;
- align with changes to Code documentation following feedback received via the HNTAS Technical Feedback Process;
- align with aspects of HNTAS which are subject to the public policy consultation;
- align with new requirements in TS1 and MMS;
- align the terminology of this document with that used in other HNTAS documentation;
- rectify errors in this draft version; and
- improve clarity of contents.

You can sign up to receive updates on future detailed draft technical documents as they are published by contacting: heatnetworks@energysecurity.gov.uk.

Please be advised that this document references other HNTAS draft Code documents which have not yet been published. References to other documents will also be subject to change following the publication of updated standards. The final version of this document will be released before the launch of HNTAS.

Contents

Foreword

This Guidance Document forms part of the UK Government's Heat Network Technical Assurance Scheme (HNTAS, The Scheme) delivered by the Department for Energy Security and Net Zero, in partnership with the Scottish Government and Ofgem. The Department for Energy Security and Net Zero appointed FairHeat as technical author for this document.

The Scheme has been designed and developed in consultation with a range of experts across the Heat Network industry in the form of Technical Sub-Working Groups, culminating in a series of Technical Specifications and Assessment Procedures to facilitate the validation and verification of performance outcomes of Elements within a Heat Network.

This document provides guidance to support stakeholder understanding of the meaning, purpose and rationale for each Key Performance Indicator (KPI) which is used to measure and assess Heat Network performance and reliability within the Heat Network Technical Assurance Scheme.

This document sits within a series of Guidance Documents which provide supplementary guidance to support the Code documents.

This Guidance Document has been issued in draft format and will be updated prior to scheme launch.

Authors

Faizah Ahmed (FairHeat)

Tom Burton (FairHeat)

Charlie Davies (FairHeat)

Gareth Jones (FairHeat)

Scope

This document provides guidance to support stakeholder understanding of the meaning, intent and relevance of Key Performance Indicators (KPIs) defined under the Heat Network Technical Assurance Scheme (HNTAS). It intends to explain the issues each KPI is designed to address and support participants in interpreting compliance requirements.

This document discusses KPIs for low-temperature hot water (LTHW) Heat Networks serving both domestic and non-domestic connections. It can be applied to District Heat Networks and Communal Heat Networks of all categories (New Build, Pre-Operation, Existing, and Certified).

The KPIs discussed within this document for Consumer Heat Systems are applicable from the New Build Concept Design stage (Stage 2) to the Commissioning stage (Stage 6), but are not applicable in operation.

This document does not cover KPIs for:

- Ambient Loop Heat Networks;
- Shared Ground Loop (SGL) Heat Networks; and
- 4-pipe LTHW networks,

which are due to be addressed in future guidance documentation.

This document specifically covers guidance on the purpose of KPIs; for guidance on other aspects of the Scheme, the relevant Guidance Document(s) should be referred to.

This document does not introduce any additional requirements and should be read alongside the relevant draft Code documents.

Guidance Documents should be used once the reader is familiar with the Code documents which provide the primary overview of the Scheme, the Scheme Rules, and the Technical Specifications and Assessment Procedures that form the basis of Assessment and Certification under the Scheme.

References

Normative References

There are no normative references in this document.

Informative References

The following informative references apply to this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

- Heat Network Technical Standard (TS1) (HNTAS, 2025).
- Heat Network Technical Assurance Scheme – New Build Heat Networks – Technical Specification – [ELEMENT] – Overview (HNTAS, 2025).
- Heat Network Technical Assurance Scheme – Existing Heat Networks – Technical Specification – [ELEMENT] – Milestone 2.
- Heat Network Technical Assurance Scheme – Existing Heat Networks – Technical Specification – Consumer Connection – Milestone 3B.
- Heat Network Technical Assurance Scheme – Existing Heat Networks – Technical Specification – [ELEMENT] – Milestone 4 (HNTAS, 2026).

1. Introduction

The Heat Network Technical Assurance Scheme (HNTAS) (the "Scheme") is designed to be a performance-based assurance Scheme. Within the Scheme, assessment is to be made with regards to claims made by a Responsible Party as to whether minimum standards *will be* met (validation process) or *have been* met (verification process) for identifiable Elements of a Heat Network. This approach ensures that certain performance outcomes are achieved and maintained across the design, construction, and operation of Heat Networks.

To support the Scheme's core principle of being outcomes-orientated, the Scheme requires a clear and consistent mechanism for measuring performance and reliability outcomes of Heat Networks. This is achieved through the measurement of quantifiable metrics which are defined through a set of KPIs.

The set of proposed KPIs were developed through engagement with the HNTAS technical working groups and were approved in draft by the HNTAS Code Management Committee comprised of representatives from the Department of Energy Security and Net Zero, Ofgem and Scottish Government.

Within HNTAS, KPIs are calculated on an Element basis. The Responsible Party for an Element is responsible for determining the applicable KPIs for that Element and ensuring that these are reported to HNTAS. This responsibility may be delegated to other parties, including Duty Holders, where appropriate.

KPI requirements (including the applicable KPIs, required Monitoring Points, and required reporting frequency) are defined within the relevant HNTAS Technical Specifications:

- New Build Heat Networks:
  - Heat Network Technical Assurance Scheme – New Build Heat Networks – Technical Specification – [ELEMENT] – Overview.
- Existing Heat Networks:
  - Heat Network Technical Assurance Scheme – Existing Heat Networks – Technical Specification – [ELEMENT] – Milestone 2.
  - Heat Network Technical Assurance Scheme – Existing Heat Networks – Technical Specification – Consumer Connection – Milestone 3B.
  - Heat Network Technical Assurance Scheme – Existing Heat Networks – Technical Specification – [ELEMENT] – Milestone 4.

KPIs are split into two types.

- Assessed KPIs: These are KPIs which are assessed against pre-determined thresholds in order to achieve and maintain HNTAS Certification and to demonstrate that the Heat Network is operating as intended.
- Reported KPIs: These are KPIs which are not assessed against pre-determined thresholds, but can still provide valuable information to the Responsible Party and HNTAS, so are to be reported in the same format.

For New Build Heat Networks, KPIs are used to:

- validate that performance outcomes will be achieved at design and installation stages; and
- verify that they have been achieved at the point of commissioning and during operation.

Because KPI values and thresholds are defined during design stages, it is expected that Heat Networks will be designed to meet the minimum KPI thresholds during operation. Evidence of compliance is required at the Commissioning stage through Acceptance Testing to achieve Certification 1, with ongoing compliance required to achieve and retain Certification 2.

For Existing Heat Networks, KPIs are assessed at defined Milestones to ensure that appropriate performance and reliability outcomes are achieved and maintained throughout their operation. More permissive minimum thresholds might apply during earlier Milestones, which become more stringent at later Milestones and at the point of Certification.

For Certified Heat Networks within the Ongoing Regime, KPIs are reported to HNTAS at specified intervals. Where a KPI value falls outside minimum thresholds for a reporting interval, the Responsible Party is required to provide justification to HNTAS. Where a KPI value remains outside its threshold for three consecutive reporting intervals, the Responsible Party is required to undertake a detailed investigation, and identify and undertake remedial actions to restore compliance.

1.1. Key principles

To ensure that KPIs are robust, meaningful and effective in indicating performance and reliability outcomes in Heat Networks, a set of key principles has been defined for their application across both New Build and Existing Heat Networks. These key principles are outlined in Table 1.

Key principle	Description
Measurable	The KPI must be able to be quantified and allow for performance to be objectively assessed.
Controllable	The KPI must be able to be influenced by factors which are under the control of the Responsible Party (RP).
Internally valid	The KPI must accurately measure the specific outcome it is intended to represent.
Manageable	The KPI must be able to be practically managed in relation to: • the collection of data; and • the ability to achieve the thresholds set.

Table 1: KPI key principles

1.2. Overview of KPI categories

KPIs within HNTAS are used to assess different aspects of Heat Network operation and are therefore grouped into categories to support interpretation. These categories reflect key aspects of a Heat Network's performance and reliability, including heat delivery, efficiency, costs, consumer experience, and water quality. Grouping KPIs in this way provides a structured framework for assessing performance and reliability outcomes and aligns with the Scheme's objectives and core principles.

The KPI categories and their aims are summarised in Table 2.

The following sections provide detailed guidance on each KPI, explaining its meaning, purpose and intent, as well as the performance issues it addresses and the rationale for its inclusion within the Scheme.

Category	Aim
Monitoring and data capture	To ensure that Heat Networks have adequate provision for monitoring and data capture. This will ensure accurate monitoring of Heat Networks, which improves performance monitoring, issue diagnosis and issue rectification, as well as enabling compliance with other HNTAS KPIs to be assessed.
Reliability	To improve Heat Network reliability and ensure the Heat Network operates to provide a stable heat supply to consumers with a sufficient system longevity (e.g. through adequate maintenance of the water quality in the system).
Performance	To ensure that Heat Networks are designed, built, and operated in a way that reduces heat loss and operational costs and ensures system longevity.
Domestic consumer outcomes	To ensure Consumer Connections and Consumer Heat Systems are designed, installed and commissioned to provide a suitable service level for domestic Heat Network consumers.

Table 2: Categories of KPIs

2. Monitoring and data capture

Effective monitoring and data capture is important because it underpins confidence in how a Heat Network's performance and reliability is measured and reported. Confidence in reported data plays a key role in the affordability of the Scheme through avoiding the need for more manual checks (which commonly can incur a higher cost). Reliable data is essential in demonstrating that Scheme outcomes are being achieved through:

- the accurate calculation and interpretation of all other KPIs by providing a representative view of Heat Network performance;
- the early identification of faults, deterioration or abnormal behaviour, allowing issues to be addressed before they escalate.

Sufficient monitoring and data capture supports Scheme objectives as it underpins an improved consumer experience with improved reliability and quality of heat supplied, and facilitates the development of an evidence base through improved data collection and reporting.

To understand the quality of monitoring and data capture, the following three core aspects are considered:

- Connectivity: whether Monitoring Points remain linked to an Automatic and Remote Monitoring System, enabling remote visibility and data access.
- Completeness: whether expected data readings are received at the correct frequency and without gaps, allowing performance to be assessed over time.
- Operational status: whether Monitoring Points are functioning correctly and producing accurate, meaningful data.

These aspects are each measured through a separate KPI. They can be affected by different parts of the Metering and Monitoring System, such as communications infrastructure, system configuration, power supply, or Monitoring Point (e.g. sensor) performance. Tracking them individually provides better insight into where issues arise and supports more targeted remedial actions when problems are identified.

Together, these KPIs aid in highlighting data loss, reducing uncertainty in reported performance, and supporting proactive assurance by making issues visible earlier. These KPIs also underpin confidence in the accuracy and precision of other KPIs, and are therefore crucial in understanding the performance and reliability of a Heat Network. Table 3 shows the applicability of the monitoring and data capture KPIs across different Heat Network Elements.

The following subsections explain what each KPI is, outlining the outcome it is intended to measure and why it is important to the Scheme.

KPI	EC	DD	SS	CD	CC	CH
Automatic and Remote Monitoring System (ARMS) connectivity	X	X	X	X	X	-
Monitoring Point data completeness	X	X	X	X	X	-
Monitoring Points operational	X	X	X	X	X	-

Table 3: Applicability of monitoring and data capture KPIs to each Element

2.1. Automatic and Remote Monitoring System (ARMS) connectivity

The ARMS connectivity KPI measures the connection status between Monitoring Points and the ARMS. This is measured as a percentage of the total number of days where Monitoring Points have connected to the ARMS at least once within 24 hours of last connection.

This is important because connectivity indicates whether Monitoring Points are online and visible, which enables continuous data collection and review.

Typical issues that could impact the connectivity of monitoring infrastructure include:

- faults within the device(s) which form a Monitoring Point;
- infrastructure being installed, but not properly commissioned to the ARMS;
- configuration errors in gateways or networks;
- power failures or signal failures which affect the ARMS (e.g. originating from a telecommunications network failure);
- other changes in infrastructure which affect the connectivity of the ARMS (e.g. in a phased Heat Network development, or arising from the construction of surrounding buildings).

2.2. Monitoring Point data completeness

The Monitoring Point data completeness KPI measures how many readings were received by the ARMS over a defined period, compared with how many readings were expected for each Monitoring Point.

Low Monitoring Point data completeness can be caused by:

- Monitoring Points not connecting to the ARMS; or
- Monitoring Points not reporting all required data points to the ARMS - this could include:
  - extended gaps in time-series data;
  - not reporting at the correct frequency;
  - intermittent readings that fall below the expected sampling frequency.

It should be noted that, if a period of low Monitoring Point data completeness coincides with periods of peak heat demand, this could hinder understanding of the Heat Network's operation during peak-demand events.

This is important because it verifies that Monitoring Points are providing readings at the intended frequency, which enables accurate performance assessment and confidence in the calculation of other KPIs.

Typical issues that could impact data completeness include:

- misconfigured devices (e.g. incorrect logging intervals);
- configuration errors in gateways or networks;
- unreliable communication paths (e.g. gateway failures, network dropouts);
- weaknesses in data ingestion (e.g. incorrect timestamp handling, time-sync errors);
- firmware defects.

2.3. Monitoring Points operational

The Monitoring Points operational KPI measures the proportion of Monitoring Points that are connected to the ARMS, have complete data, and are working as expected. Only data that is within thresholds for the ARMS connectivity KPI and the data completeness KPI is considered for this assessment.

In this context, "working as expected" means that devices show:

- no error codes;
- no negative or unrealistic readings (e.g. negative flow or energy); and
- no values outside the normal operating range for the Monitoring Point type.

Monitoring Points that are working as expected provide data which allows for other KPIs to be calculated with sufficient confidence. This supports meaningful insights to be made regarding the operation of the Heat Network and interventions to be made in a timely manner.

Typical failures that could impact the operational status of a Monitoring Point include:

- incorrect installation of the Monitoring Point (e.g. incorrect flow sensor orientation);
- incomplete commissioning (e.g. uncalibrated thermal energy or utility meters);
- issues arising from insufficient maintenance of devices (e.g. battery depletion);
- hardware faults (e.g. sensor degradation, damaged cabling);
- firmware or software defects that require updates; or
- environmental factors such as condensation.

3. Reliability

Reliable operation is important because it directly affects the continuity of heat supplied to consumers by Heat Networks and the longevity of Heat Network assets. Measuring reliability provides a clear view of the actual performance of a Heat Network, and makes issues visible at an earlier stage so they can be addressed before they escalate.

Ensuring that Heat Networks operate with sufficient reliability supports Scheme objectives as it underpins an improved consumer experience with improved reliability and quality of heat supplied, and is a notable aspect of improving reputation and investor confidence in Heat Networks.

Reliability in the context of Heat Network operation can be more easily understood by defining KPIs which are categorised by:

- interruptions;
- flow temperature;
- approach temperature;
- pressure; and
- water quality.

Within each of these topics, a range of KPIs is used to measure risks to reliability and to support timely, targeted action.

3.1. Interruptions

Interruptions are one of the most visible ways that a consumer experiences insufficient reliability. It is important to measure interruptions since disruptions to heating and hot water supply can directly impact consumers' comfort and service quality. A high frequency of unplanned interruptions can signal poor reliability, which could mean that investigation and remedial action might be necessary.

An interruption is defined as an event causing:

- the flow temperature at the specified Monitoring Point to be below the minimum required flow temperature for more than 12 hours; or
- the differential pressure at the specified Monitoring Point to below the minimum required differential pressure for more than 12 hours.

This definition has been defined to capture major outages to the operation of Heat Networks, as each of these will have a significant impact on consumer outcomes.

Outages of shorter durations, which also have impact on consumer outcomes, are captured by the uptime KPIs discussed in Sections 3.2.1 and 3.4.1.

Interruptions are assessed at an Element-level rather than at a Heat Network-level. Issues originating in upstream Elements (i.e. other Elements which supply heat to the Element of interest) would not be counted when calculating interruptions KPIs for downstream impacted Elements.

Table 4 shows the applicability of these interruptions-related reliability KPIs across different Heat Network Elements.

The following subsections explain what each KPI is, outlining the outcome it is intended to measure and why it is important to the Scheme.

KPI	EC	DD	SS	CD	CC	CH
Unplanned interruptions	X	X	X	X	X	-
Planned interruptions	X	X	X	X	X	-

Table 4: Applicability of interruptions-related reliability KPIs to each Element

3.1.1. Unplanned interruptions

The unplanned interruptions KPI measures the number of unplanned interruptions reported each year, where an unplanned interruption is an interruption (as defined in Section 3.1) where the network end user has not been provided with at least 48 hours written notice of such interruption.

Recording unplanned interruptions provides evidence of the resilience and operational reliability of a Heat Network. It demonstrates whether the Heat Network can maintain service continuity, and highlights areas where remedial action is required to prevent future repeated failures.

Where an unplanned interruption occurs which affects many end users, this may indicate a wider resilience issue within the Heat Network. In such cases, a review and update of the network's Resilience Strategy might be required.

Typical issues that could lead to unplanned interruptions include:

- equipment failures (e.g. pump breakdown, valve misfunctions), which are often driven by wear, aging and corrosion;
- control system faults (e.g. sensor failures);
- incorrect control settings (e.g. setpoints, schedules, limits);
- inadequate maintenance (e.g. overdue servicing, clogged strainers or filters); or
- poor commissioning.

3.1.2. Planned interruptions

The Heat Network planned interruptions KPI measures the number of planned interruptions reported each year, where a planned interruption is an interruption (as defined in Section 3.1) where the network end user has been provided with at least 48 hours written notice of such interruption.

Planned outages which are minor in nature are necessary for the maintenance and improvement of Heat Network infrastructure, however these commonly take place over a time period of less than 12 hours, and longer planned outages are typically only required for major plant replacement/refurbishment works.

Typical issues that could lead to planned interruptions include:

- major plant/pipework replacement;
- major control system upgrades;
- poor planning/scheduling of maintenance and improvement works.

3.2. Flow temperature

The provision of heat at sufficient flow temperatures is an important aspect of the quality of service experienced by end users in Heat Networks. The measurement of flow temperatures is an important part in demonstrating that Scheme outcomes are being achieved through the supply of heat at a flow temperature which is above minimum threshold levels with suitable stability.

Events which affect the flow temperature of heat supplied to consumers can impact the consumer experience, but might not otherwise be captured by the KPIs for interruptions outlined in Section 3.1. To capture such events, KPIs have been developed to measure:

- the proportion of time for which the flow temperature of heat supplied is above minimum threshold levels;
- the stability in the flow temperature provided by the Heat Network;
- the average flow temperature provided when accounting for the reduction in flow temperature in Distribution Networks during periods of peak heat demand (i.e., weighting by volume of water flowing through the system).

Table 5 shows the applicability of these temperature-related reliability KPIs across different Heat Network Elements.

The following subsections explain what each KPI is, outlining the outcome it is intended to measure and why it is important to the Scheme.

KPI	EC	DD	SS	CD	CC	CH
Flow temperature uptime	X	X	X	-	-	-
Flow temperature stability	X	-	X	-	-	-
Volume weighted average flow temperature (VWAFT)	X	-	X	-	-	-

Table 5: Applicability of temperature-related reliability KPIs to each Element

3.2.1. Flow temperature uptime

The flow temperature uptime KPI measures the percentage of time that the network flow temperature remains above the minimum required temperature needed to deliver acceptable temperatures to consumers or the Heat Network it supplies.

Flow temperature uptime is important because maintaining a flow temperature above the minimum required level is key to the sufficient delivery of heat and the consumer experience. A low uptime could indicate that the Heat Network is unable to sustain its flow temperature under certain operating conditions (e.g. during particularly low, or rapidly changing, heat demand), which might not be indicated from the VWAFT KPI alone.

Whilst the interruptions KPIs outlined in Section 3.1 aim to capture major outages to the operation of Heat Networks, the flow temperature uptime KPI aims to capture occasions where there are multiple, shorter-term outages, and quantify the magnitude of instances of the flow temperature being below a minimum threshold for a very long period. As such, it provides a measure of the overall impact the flow temperature has on consumers over time.

The threshold defined in the flow temperature uptime KPI is the temperature that meets:

- the minimum flow temperature needed to deliver domestic hot water (DHW) above 45 °C to Consumer Heat System outlets; or
- the minimum flow temperature required at a Substation to supply the Heat Network it provides heat to.

A low flow temperature uptime can present itself through:

- intermittent drops in network flow temperature (e.g. during periods of low demand);
- prolonged periods below the minimum required flow temperature (including slow recovery following periods of low heat demand).

Figure 1 illustrates an example flow temperature profile over several days where the measured flow temperature which highlights the instances of the flow temperature being below a minimum required temperature, therefore impacting the flow temperature uptime. There are two such instances in this example:

- An instance of the flow temperature being below the minimum threshold for less than 12 hours.

  This will impact the flow temperature uptime KPI, but is not captured by the interruption KPIs discussed in Section 3.1.

- An instance of the flow temperature being below the minimum threshold for more than 12 hours.

  This will impact the flow temperature uptime KPI, but is also classed as being an interruption. This instance will therefore also be captured by the interruption KPIs discussed in Section 3.1.

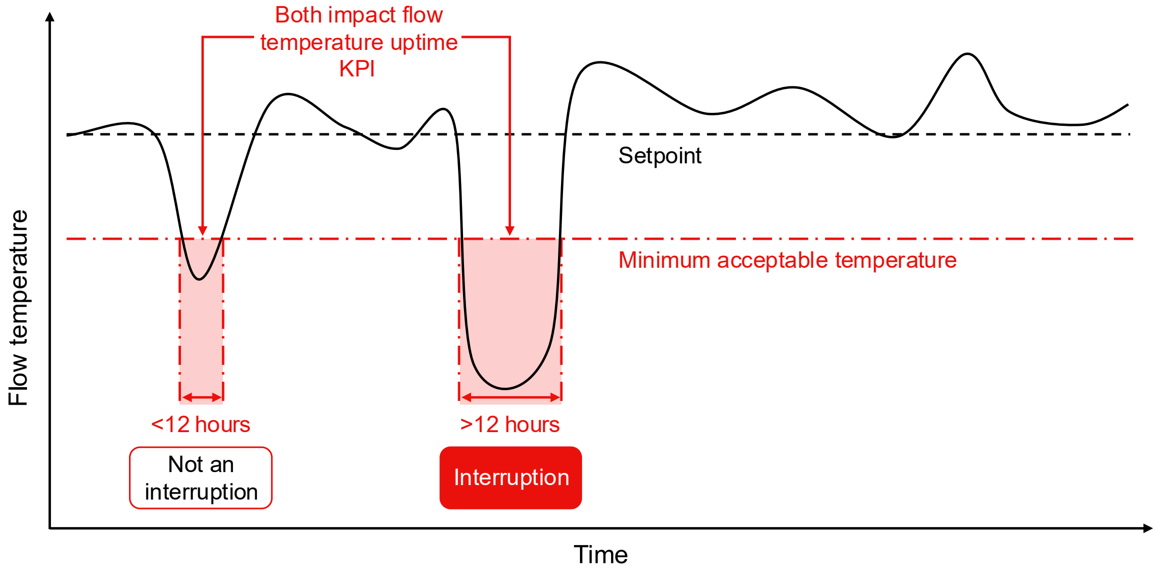

Figure 1: Illustration of flow temperature uptime

Typical issues that could impact flow temperature uptime include:

- issues with control systems (e.g. incorrect tuning of PID control loops, poorly configured weather compensation);
- issues in control strategies (e.g. which result in mix-down through non-operational equipment, cycling, or differing setpoints between individual heat generation assets);
- noise and inaccurate readings from faulty sensors;
- inadequate commissioning of control systems;
- delays in responses from equipment (e.g. valve actuators, pumps).

The flow temperature uptime KPI threshold for Existing Heat Networks at Milestone 4 is set at 99.5 % (equivalent to c. 44 hours a year) in the draft Technical Specifications issued in January 2026. It is proposed that this will be carried forward into future revisions of the Overview Technical Specifications for New Build Heat Networks (which outline a threshold of 98 % in the draft documents issued in July 2025) to ensure consistency for Certified Heat Networks, unless there are changes to this threshold which arise from the HNTAS Change Management Process.

3.2.2. Flow temperature stability

The flow temperature stability KPI measures the percentage of time that the measured flow temperature stays within an acceptable range around its setpoint.

Stable flow temperatures are important because it maintains adequate supply temperatures for space heating and hot water and supports stable equipment operating conditions, supporting reliable service and consumer comfort.

The range defined in the flow temperature stability KPI is defined as:

- no more than ±5 °C from the setpoint; and
- above a lower threshold that meets:
  - the minimum flow temperature needed to deliver domestic hot water (DHW) above 45 °C to Consumer Heat System outlets; or
  - the minimum flow temperature required at a Substation to supply the Heat Network it provides heat to.

If a Heat Network operates with a variable flow temperature setpoint, the flow temperature used for the flow temperature stability KPI is reported as the difference between the measured flow temperature and the current setpoint.

Flow temperature instability could typically present itself through:

- repeated short instances of flow temperatures outside thresholds;
- prolonged periods of flow temperatures outside thresholds;
- overshooting above the upper threshold (e.g. following the start-up of plant); or
- slow recovery back to setpoints after transient conditions.

Figure 2 illustrates an example flow temperature profile over several days where the measured flow temperature fluctuates around a setpoint. The shaded band represents the acceptable stability range of ±5 °C. Periods where the flow temperature is outside this band indicate instability in the flow temperature.

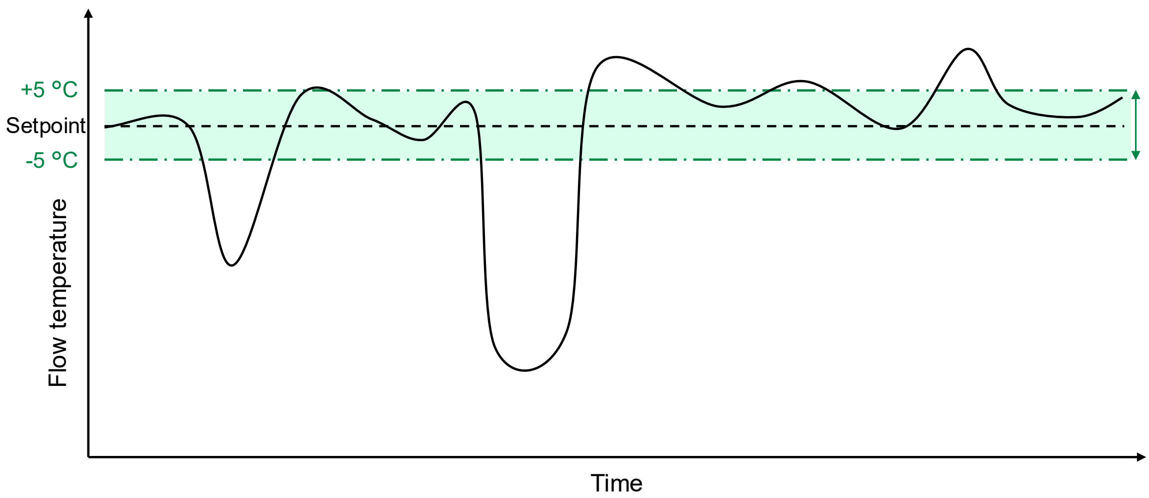

Figure 2: Illustration of flow temperature stability

Typical issues that could impact flow temperature stability include:

- issues with control systems (e.g. incorrect tuning of PID control loops, poorly configured weather compensation);
- issues in control strategies (e.g. which result in mix-down through non-operational equipment, cycling, or differing setpoints between individual heat generation assets);
- noise and inaccurate readings from faulty sensors;
- inadequate commissioning of control systems;
- delays in responses from equipment (e.g. valve actuators, pumps);
- setpoints not being aligned with the design intent.

3.2.3. Volume weighted average flow temperature (VWAFT)

The consumer experience is impacted by the flow temperatures supplied during periods of heat demand (e.g. space heating, domestic hot water) more so than the flow temperatures supplied during standby events.

The volume of water flowing through a Heat Network is significantly higher during these periods of heat demand than standby events. This means that the "overall" flow temperature provided to a Heat Network is expressed more representatively by "weighing" periods of high volume flow rate more heavily, compared to a simple average of all of the flow temperature readings.

This can be expressed through a "volume weighted average flow temperature" (VWAFT), calculated as below:

$$\text{volume weighted average flow temperature (VWAFT)} = \frac{\Sigma(T_t \times q_t)}{\Sigma\, q_t}$$

Where: T_t = temperature at time "t"

q_t = flow rate at time "t"

An example of how this calculation differs to a simple average is shown in Figure 3. In this example:

- the flow temperature during the period of high heat demand is lower than during low heat demand (indicated by the volume flow rate);
- the flow temperature readings during this period are more heavily weighted by the VWAFT calculation; resulting in
- the VWAFT over this period being lower than the simple average (i.e., averaging over all time-series datapoints).

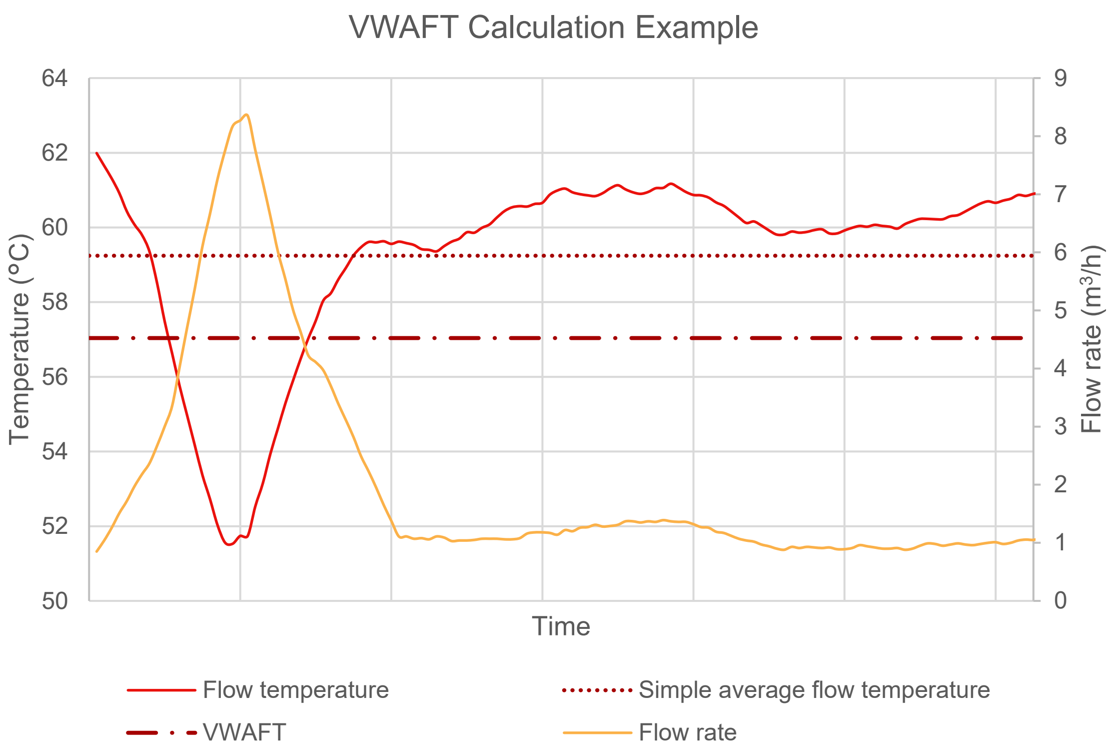

Figure 3: Example comparison between VWAFT and average temperature

The VWAFT KPI measures the average flow temperature, weighted by the volume flow rate, supplied over a defined time period.

Maintaining an adequate VWAFT is important because it demonstrates that the network can sustain sufficient flow temperatures during peak demand periods. A low VWAFT can be caused by either:

- flow temperature which is consistently low;
- reductions in flow temperature during periods of high heat demand (where volume flow rates are high).

If a Heat Network operates with a variable flow temperature setpoint, the flow temperature used for the VWAFT KPI (T_t) is reported as the difference between the measured flow temperature and the flow temperature setpoint at that moment in time.

Typical issues that could lead to a low VWAFT include:

- incorrect control strategy;
- undersized plant;
- delayed response of back up heat sources;

- incomplete commissioning of weather compensation in Heat Networks which use a variable flow temperature setpoint.

3.3. Approach temperature

The approach temperature is the temperature difference between corresponding inlets and outlets on either side of a heat exchanger. There are two definitions for approach temperature:

- The forward approach temperature is the temperature difference between the flow inlet and the flow outlet of a heat exchanger.
- The return approach temperature is the temperature difference between the return inlet and the return outlet of a heat exchanger.

This is illustrated in Figure 4.

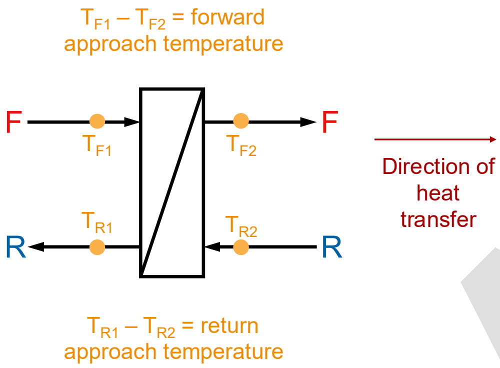

Figure 4: Forward and return approach temperature illustration

Measurement of the return approach temperature is important because excessively high approach temperatures can lead to increased return outlet temperatures, which can increase heat losses and could impact the operation of heat generation plant (e.g. heat pumps). High approach temperatures can also indicate inefficient heat transfer within a heat exchanger.

To understand the impact which the approach temperature has on a Heat Network, an average return approach temperature KPI is measured.

The forward approach temperature could also result in a reduced outlet flow temperature of a Substation. However, unacceptably low flow temperatures from a Substation would be captured by the KPIs discussed in Section 3.2.

Table 6 shows the applicability of the average approach temperature KPI across different Heat Network Elements.

The following subsections explain what this KPI is, outlining the outcome it is intended to measure and why it is important to the Scheme.

KPI	EC	DD	SS	CD	CC	CH
Average approach temperature	-	-	X	-	-	-

Table 6: Applicability of temperature-related reliability KPIs to each Element

3.3.1. Average return approach temperature

The average return approach temperature KPI measures the average difference between:

- the outlet return temperature at the Substation; and
- the inlet return temperature at the Substation,

as shown in Figure 4.

The average return approach temperature is important because it reflects how effectively heat is transferred between circuits at a Substation. Excessive approach temperatures increase upstream return temperatures, reducing network efficiency and increasing heat losses.

Typical issues that could impact the average return approach temperature include:

- incorrect balancing of flow rates across the Substation plate heat exchanger;
- poor configuration or sequencing of control valves;
- incomplete or inadequate commissioning of Substation control systems;
- incorrect valve setpoints or actuator settings; or
- insufficient maintenance of plate heat exchangers, resulting in degradation (e.g. fouling).

The average return approach temperature KPI is referred to as "average approach temperature" in the draft Overview Technical Specifications for new Build Heat Networks issued in July 2025. It is proposed to supersede this wording with "average return approach temperature" to ensure consistency with other HNTAS documentation such as TS1, which was issued in draft format in November 2025.

3.4. Pressure

Keeping the pressures which are present throughout Heat Networks within acceptable limits is a significant aspect of:

- sufficiently delivering heat to end users throughout the Heat Network;
- preserving equipment longevity; and
- preventing disruptions to the provision of heat which might arise from the operation of pressure safety systems.

The pressures throughout Heat Network can be understood through measurement of:

- the differential pressure across the system which heat is being supplied to;
- the amount of time in which this differential pressure exceeds its maximum;
- the amount of time in which the operating pressure exceeds its maximum.

Table 7 shows the applicability of these pressure-related reliability KPIs across different Heat Network Elements.

The following subsections explain what each KPI is, outlining the outcome it is intended to measure and why it is important to the Scheme.

KPI	EC	DD	SS	CD	CC	CH
Pressure differential uptime	X	-	X	-	-	-
Maximum allowable differential pressure exceedance	X	-	X	-	-	-
Maximum allowable operating pressure exceedance	X	-	X	-	-	-

Table 7: Applicability of pressure-related reliability KPIs to each Element

3.4.1. Pressure differential uptime

The pressure differential uptime KPI measures the percentage of time the pressure differential at a specified differential pressure measurement point in the Heat Network remains above its minimum setpoint.

Maintaining sufficient differential pressure is important in ensuring that sufficient flow is being provided to consumers of a Heat Network (whether this is a Building Connection, or a Consumer Connections, such as a Heat Interface Unit (HIU), which can affect the delivery of heat to consumers even if flow temperatures are sufficient. This is an important aspect of providing sufficient heat throughout the Heat Network and ensuring an adequate quality of service for end consumers.

A low pressure differential uptime can present itself through:

- intermittent drops in differential pressure (e.g. during periods of low demand);
- prolonged periods below the minimum required differential pressure.

Measurements are taken at a defined differential pressure measurement point in the Heat Network. This is commonly located at the index point of the Distribution Network which the Energy Centre or Substation provides heat to. Where this is not practicable, measurement might be taken across the distribution pumps within the Energy Centre or Substation.

Typical issues that could impact pressure differential uptime include:

- incorrect sizing or configuration of network distribution pumps;
- unstable or poorly-tuned differential pressure control strategies;
- air ingress, resulting in flow restrictions in pipework;
- inappropriate throttling of valves.

The pressure differential uptime KPI threshold for Existing Heat Networks at Milestone 4 is set at 99.5 % (equivalent to c. 44 hours a year) in the draft Technical Specifications issued in January 2026. It is proposed that this will be carried forward into future revisions of the Overview Technical Specifications for New Build Heat Networks (which outline a threshold of 99 % in the draft documents issued in July 2025) to ensure consistency for Certified Heat Networks, unless there are changes to this threshold which arise from the HNTAS Change Management Process.

3.4.2. Maximum allowable differential pressure exceedance

The maximum allowable differential pressure exceedance KPI measures the percentage of time that the differential pressure at the specified differential pressure measurement point remains below its maximum threshold.

Maintaining differential pressures within threshold values is important in mitigating against:

- damage to equipment in the Heat Network which can be sensitive (e.g. plate heat exchangers, pressure-independent control valves, HIUs);
- noise;
- vibration;
- wear on seals and moving components.

Maximum allowable differential pressure exceedance can present itself through:

- intermittent instances of exceedance (e.g. caused by incorrect placement of differential pressures);
- persistent operation above the maximum allowable differential pressure.

Measurements are taken at a defined differential pressure exceedance measurement point in the Heat Network.

Typical issues that could impact maximum allowable differential pressure exceedance include:

- incorrect sizing or control of network distribution pumps;
- incorrect differential pressure setpoints;
- unstable or poorly-tuned differential pressure control systems;
- incorrect placement of differential pressure sensors; or
- inappropriate throttling of valves.

3.4.3. Maximum allowable operating pressure exceedance

The maximum allowable operating pressure exceedance KPI measures the percentage of time that operating pressure at the specified measurement point remains below its maximum threshold. Measurement is taken at an operating pressure measurement point identified by the Designated Designer on a project basis.

Maintaining operation pressures below threshold limits is important in preventing against putting excessive stresses on components such as pipework, valves, seals and pressure vessels, which can lead to component failure or loss of system integrity (e.g. due to an uncontrolled release of stored energy).

Maximum allowable operating pressure exceedance can present itself as:

- persistent operation above the allowable operating pressure limit, or
- frequent short-duration exceedances indicating inadequate pressure control.

Measurements are taken at a defined operating pressure exceedance measurement point in the Heat Network.

Typical issues that could impact maximum allowable operating pressure exceedance include:

- incorrect sizing or control of network distribution pumps;
- incorrect pressurisation equipment setpoints;
- miscalculated network operating pressures;
- failed or incorrectly configured pressurisation equipment or components which comprise a pressure safety system;
- incomplete commissioning of pressurisation systems.

3.5. Water quality

The water quality of system water in a Heat Network has a material impact on the integrity of the system and the longevity of pipework, plant and other equipment. Sufficient measurement and maintenance of water quality through preventative interventions can aid in mitigating the need for major repairs or replacement works.

Understanding the water quality of a Heat Network is an important part in demonstrating that Scheme outcomes are being achieved through improving the reliability of heat supplied, as well as improving the reputation and investor confidence in Heat Networks.

To understand water quality within a Heat Network, water quality KPIs have been developed regarding:

- the volume of top up water, to aid in the indication of leaks in the Heat Network.
- other water quality KPIs, to aid in the indication of how susceptible the Heat Network could be to corrosion or microbiological proliferation.

Table 8 shows the applicability of these water quality-related reliability KPIs across different Heat Network Elements.

The following subsections explain what each KPI is, outlining the outcome it is intended to measure and why it is important to the Scheme.

KPI	EC	DD	SS	CD	CC	CH
Volume of top up water added to the network	X	-	X	-	-	-
Other water quality KPIs	X	X	X	X	-	-

Table 8: Applicability of water quality-related reliability KPIs to each Element

3.5.1. Volume of top up water added to the network

The volume of top up water KPI measures the monthly volume of water added to the network through the selected top-up technology. This is expressed as a percentage of the total system pipework volume. Measurement is taken at the water meter connected to the top-up technology used (e.g. pressurisation unit).

Keeping the volume of top up water within acceptable limits is important because the introduction of water from the mains cold water service introduces oxygen and contaminants that can contribute to accelerating corrosion and microbiological proliferation. This can pose a risk to component and system longevity.

Typical issues that could lead to high volumes of top up water include:

- leaks within the Heat Network;
- poor installation practices;
- inappropriate setpoints or settings in pressurisation equipment.

The threshold for this KPI in the draft Technical Specifications for Existing Heat Networks at Milestone 4 is set at 0.17 % of the total system pipework volume per month to align with the requirements set out in TS1, which was issued in draft format in November 2025. It is proposed that this will be carried forward into future revisions of the Overview Technical Specifications for New Build Heat Networks (which outline a threshold of 1 % in the draft documents issued in July 2025) to ensure consistency with TS1 across all Certified Heat Networks, unless there are changes to this threshold which arise from the HNTAS Change Management Process.

3.5.2. Other water quality KPIs

Other water quality KPIs are set out in the Heat Network Technical Standard (TS1). These set out acceptable limits for water quality parameters in:

- Chemically Treated Systems, where water quality is controlled through chemical treatment to ensure long-term protection of pipework and equipment against corrosion;
- Depleted Water Systems, where water quality is controlled through demineralisation and preservation of low conductivity in the system water to ensure long-term protection of pipework and equipment against corrosion.

Measurement is carried out through a combination of continuous monitoring and periodic sampling with laboratory testing (depending on the water quality parameter and the type of water quality system).

Typical issues that could impact water quality include:

- inappropriate dosing of system water;
- lack of maintenance of pipework and water quality equipment;
- leaks within the Heat Network;
- the presence of sections of pipework receiving no flow of water (“dead legs”);
- inadequate pre-commission cleaning activities, resulting in debris being present in system water.

4. Performance

The performance of Heat Networks is an important factor in the operating costs, efficiency, and carbon emissions associated with Heat Networks. "Performance" refers to the Heat Network's ability to control its operation such that end consumer heat demands are sufficiently met, whilst being efficient in its operation.

Ensuring sufficient performance in Heat Networks supports Scheme objectives as it underpins:

- the reduction of carbon emissions and cost of heat by making Heat Networks more efficient;
- improving affordability by reducing capital and operational costs;
- the long-term operational benefits which result in improved reputation and investor confidence in Heat Networks.

Measuring the operational performance of a Heat Network in practice allows for inefficiencies to be identified and addressed.

Performance in the context of Heat Network operation can be more easily understood by defining KPIs which are categorised by:

- heat loss;
- heat generation;
- operating temperatures; and
- pumping and distribution.

Within each of these topics, a range of KPIs is used to measure the performance of a Heat Network.

4.1. Heat loss

The management of heat loss is important because it is a key aspect of optimising the operational costs of a Heat Network, and is significant in the management of overheating in buildings and maintaining comfort.

Managing heat losses supports Scheme objectives by improving affordability for consumers, reducing carbon emissions by making Heat Networks more efficient, and improving consumer comfort.

Measuring heat losses in a consistent way is an important factor in understanding whether networks are designed, constructed and operated to achieve heat losses which are within acceptable standards. This can also be used to aid in identifying where improvements are needed.

To gain an understanding of heat losses from a Heat Network in a way which is "controllable" and "internally valid" (as defined in Table 1), the metrics for heat loss are expressed as:

- W/dwelling: the heat loss per dwelling connected to the Heat Network; and/or
- $W/kW_{connection}$: the heat loss per kilowatt of non-domestic connection ($kW_{connection}$) connected to the heat Network.

Expressing the heat loss from a Heat Network through these metrics represents how much thermal energy is being lost by the Heat Network in a way which allows for meaningful comparison between Heat Networks, whilst measuring the specific outcome it intends to represent.

The measurement of heat losses through these metrics is not affected by the heat delivered to end consumers, but is instead influenced by the physical characteristics of the Heat Network (e.g. pipe routing, insulation specification, operating temperatures). This is necessary for the KPI to be "internally valid", because the heat delivered to end consumers is often due to factors such as occupancy and consumer demand, which can be outside of the control of the Responsible Party.

This metric is more representative than expressing heat losses as a percentage of total heat generated, because the total heat generated is dependent on the heat consumed by end consumers as well as heat losses.

An example of how this metric achieves this goal can be taken from comparing two example Heat Networks:

- Heat Network 1 is contained within an older residential building (which is less thermally efficient), and there is hence a higher annual heat consumption per dwelling.

  This Heat Network also has higher heat losses due to the Heat Network's physical characteristics (such as its routing) and operating temperatures.

- Heat Network 2 is contained within a newer residential building (which is less thermally efficient), and there is hence a lower annual heat consumption per dwelling.

  This Heat Network also has lower heat losses than Heat Network 1 due to its physical characteristics (such as its routing, which is more efficient) and has lower operating temperatures.

These characteristics of the two Heat Networks is illustrated in Figure 5, which shows the absolute values for the annual heat delivered per dwelling, as well as the percentage split between the heat loss and heat consumption.

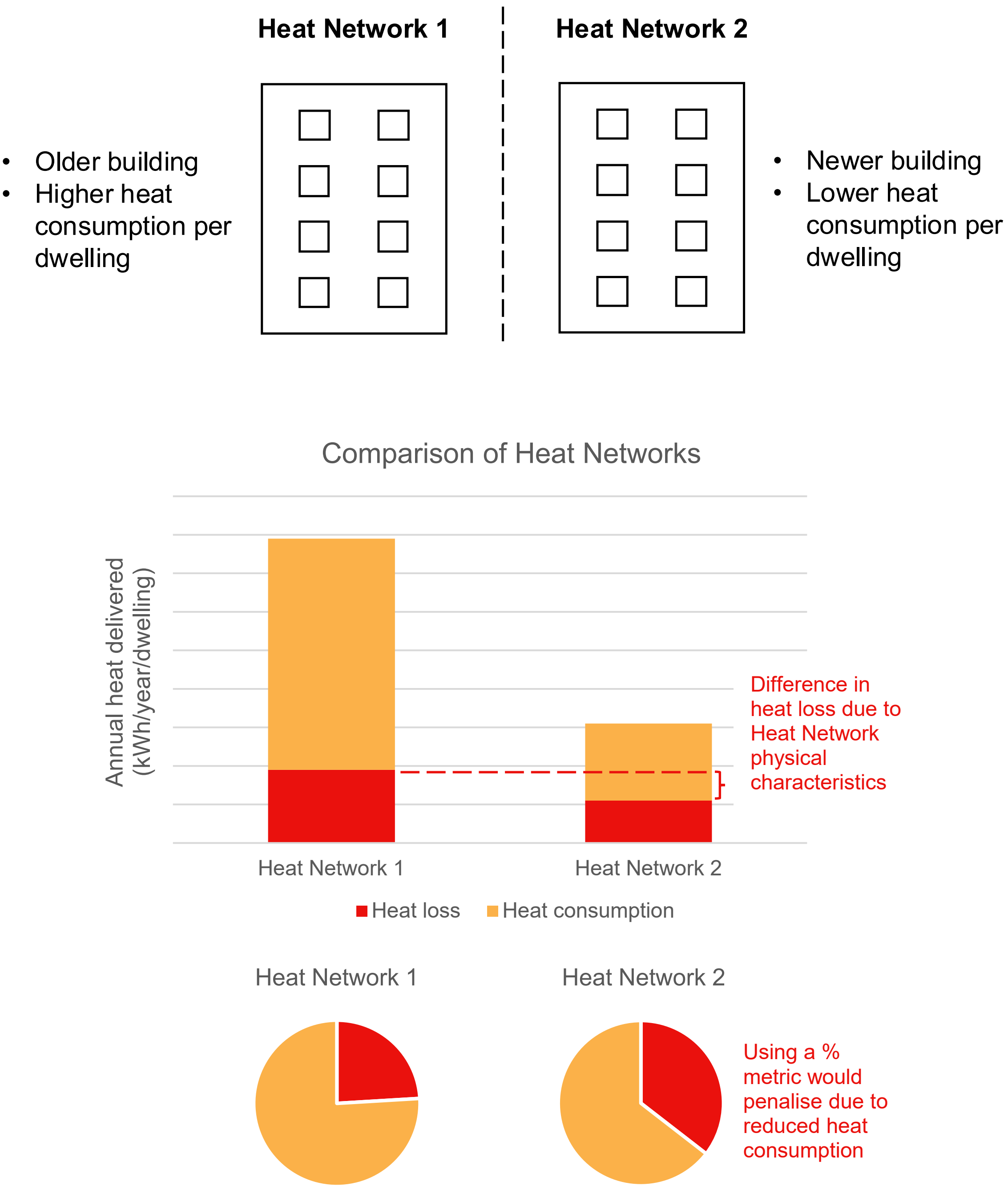

Figure 5: Illustration of comparison of heat loss metrics (distinct Heat Networks)

This shows that, despite Heat Network 2 being a more efficient Heat Network (i.e., less heat is lost from Heat Network 2), measuring the heat loss as a percentage of total heat generated would "penalise" Heat Network 2 for being contained within a more thermally efficient building.

It is also possible for the heat consumed by end consumers in a given Heat Network to vary. For example, if the building containing Heat Network 1 underwent fabric improvements, this would likely in:

- a reduction in the heat consumption for Heat Network 1; and
- a small reduction in the heat loss from Heat Network 1.

Measuring the heat loss as a percentage of total heat generated would result in Heat Network 1 being "penalised" for undertaking fabric improvements in this instance, even though the total heat loss would be reduced. This is illustrated in Figure 6.

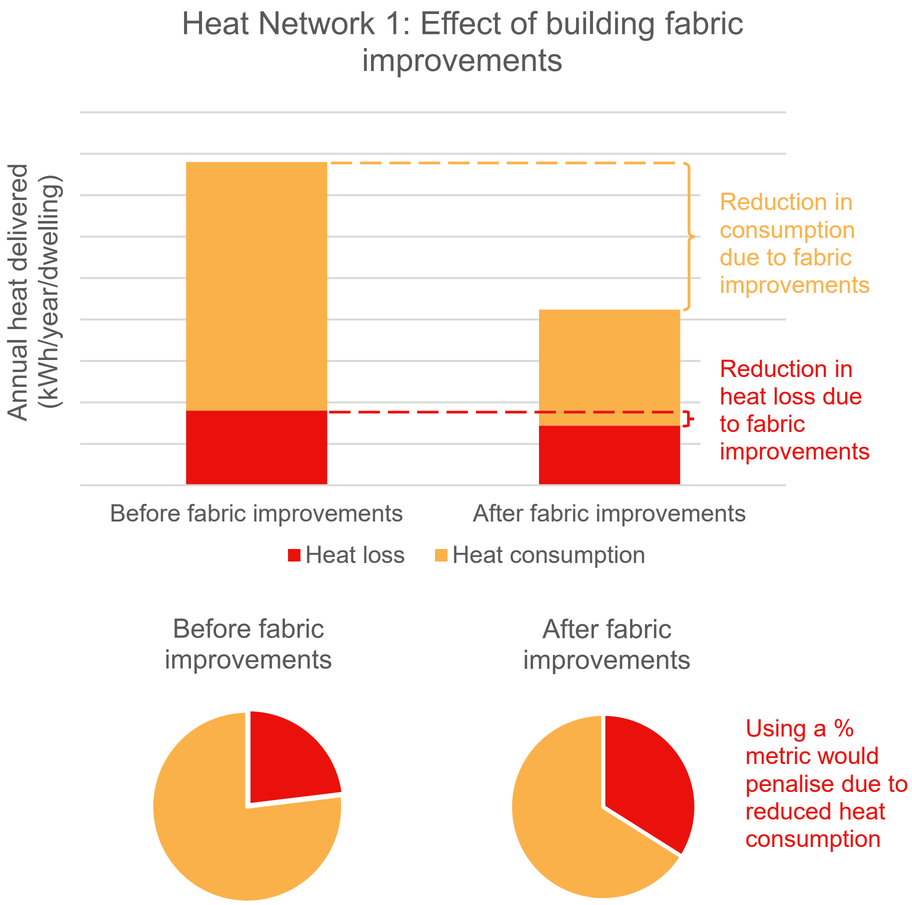

Figure 6: Illustration of comparison of heat loss metrics (same Heat Network, varying heat consumption due to partial occupancy)

Similarly, if a building were not fully occupied, measuring the heat loss as a percentage of total heat generated would result in a Heat Network being "penalised" due to a reduction in the heat consumed by end consumers. An example of this for Heat Network 2 is illustrated in Figure 7.

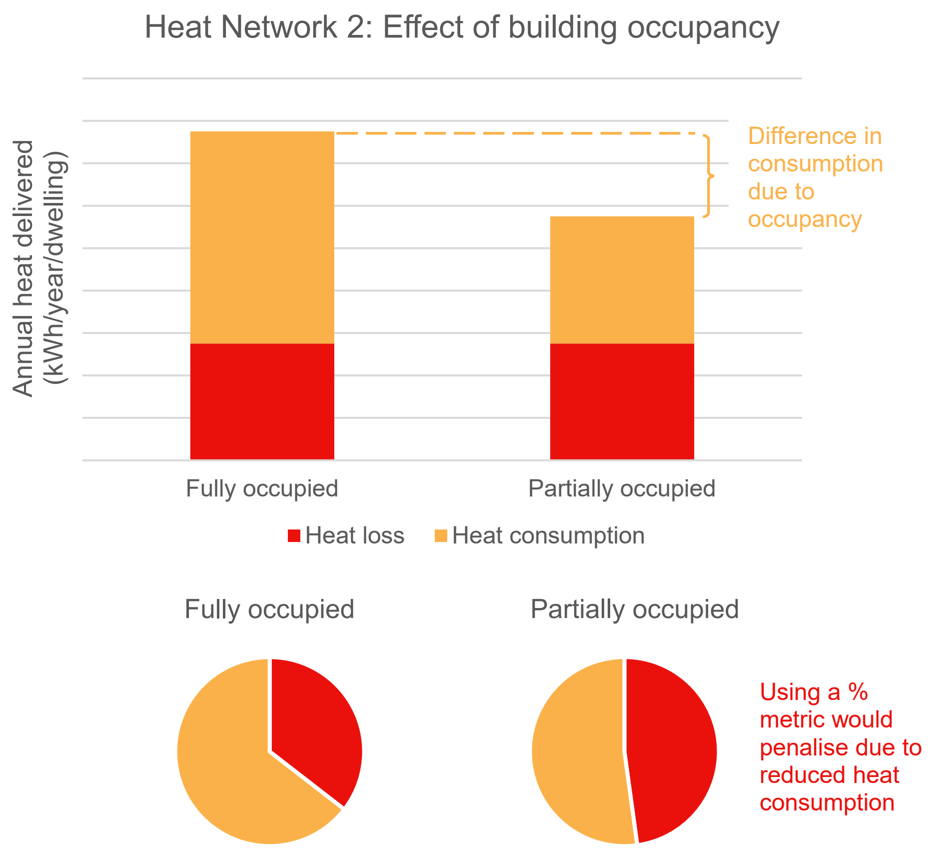

Figure 7: Illustration of comparison of heat loss metrics (same Heat Network, varying heat consumption due to partial occupancy)

Heat losses are measured within the:

- District Distribution Network; and
- Communal Distribution Network,

since the heat loss from these Elements typically dominates the total heat loss from a Heat Network.

Losses associated with Energy Centres and Substations are not considered because they are small relative to the losses from Distribution Networks and have a low impact on overall heat loss performance. Penalising the heat loss from these Elements could also contradict other Scheme objectives, such as in the case of Energy Centres accessing low-carbon heat sources or buildings connecting to large District Heat Networks.

Typical issues that could impact heat losses include:

- oversized pipework, resulting in an increased surface area for heat loss to occur over;
- inefficient routing of Distribution Networks during the Feasibility and Design phases, resulting in increased pipework length and an increased surface area for heat loss to occur over;
- an insufficient thickness/specification of insulation being specified during the design of the Distribution Network;

- insufficient consideration during coordination in the Construction Phase, which can result in increased pipework length and reduced thicknesses of pipework insulation;
- inadequate installation of insulation on pipework and ancillary equipment (e.g. valves, flanges, strainers);
- damaged or degraded insulation (e.g. from water ingress or mechanical damage);
- elevated operating temperatures.

Table 9 shows the applicability of these heat loss KPIs across different Heat Network Elements.

The following subsections explain what each KPI is, outlining the outcome it is intended to measure and why it is important to the Scheme.

KPI	EC	DD	SS	CD	CC	CH
Network heat losses	-	X	-	X	-	-

Table 9: Applicability of heat loss KPIs to each Element

4.1.1. District Distribution Network heat loss

The District Distribution Network heat loss KPI measures the total annual heat loss between the Initiation Point of the District Distribution Network (e.g. an Energy Centre or Substation) and its Termination Points (e.g. Building Connections).

This KPI is measured on an annual basis to account for expected seasonal variations (e.g. arising from variations in external ambient temperatures and ground temperatures).

The calculation methodology for determining the threshold for this KPI can be found in TS1 Objective 2/3.13.

4.1.2. Communal Distribution Network heat loss

The District Distribution Network heat loss KPI measures the total annual heat loss between the Initiation Point of the District Distribution Network (e.g. an Energy Centre or Substation) and its Termination Points (e.g. Consumer Connections).

This KPI is measured on an annual basis to account for expected seasonal variations (e.g. arising from variations in external ambient temperatures).

The calculation methodology for determining the threshold for this KPI can be found in TS1 Objective 2/3.13.

4.2. Heat generation

The generation of heat is a key contributor to the operating costs and carbon emissions associated with the operation of Heat Networks, which can have a material impact on the affordability of Heat Networks for end consumers and the investability of new Heat Network projects.

The quantification of the performance of heat generation can be expressed through:

- heat fraction: the proportion of annual heat generated by each heat source;
- efficiency: the proportion of energy consumed by a heat source which is converted into useful thermal energy.

Table 10 shows the applicability of these heat generation-related performance KPIs across different Heat Network Elements.

The following subsections explain what each KPI is, outlining the outcome it is intended to measure and why it is important to the Scheme.

KPI	EC	DD	SS	CD	CC	CH
Heat fraction	X	-	-	-	-	-
Efficiency of each heat generation item or source	X	-	-	-	-	-

Table 10: Applicability of heat generation-related performance KPIs to each Element

4.2.1. Heat fraction

The heat fraction KPI measures the proportion of the total annual heat that is supplied by each heat source. Where more than one heat source is used in an Energy Centre, the contribution from each heat source is reported separately. This KPI is not required when there is only one heat source.

The heat fraction is important because it demonstrates whether the Energy Centre is operating in line with its design intent, particularly where low-carbon heat sources are used in conjunction with top-up heat sources. The contribution from each heat source can be used to indicate if low-carbon heat sources are being prioritised as intended, or if these sources are operating less frequently than expected.

Typical issues that could result in a low heat fraction include:

- elevated return temperatures into an Energy Centre that are not compatible with the operation of low-carbon heat sources;
- poor implementation of the control strategies for the operation of low-carbon and top-up heat sources;
- under-sizing of low-carbon heat sources; or
- under-sizing of thermal storage.

4.2.2. Efficiency of each heat generation item or source

The KPI for the efficiency of heat generation item or source measures the proportion of energy consumed by that heat source which is converted into useful thermal energy delivered to the Heat Network.

Generation efficiency is important in indicating whether a heat generation item or source is operating as intended. The efficiency of heat sources is a key aspect of the fuel consumption, operational costs, and carbon emissions associated with the operation of a Heat Network.

Efficiency issues can typically be presented through:

- boilers operating below their anticipated gross efficiency;
- heat pumps operating below their anticipated coefficient of performance;
- combined heat and power (CHP) plant operating below its anticipated Quality Index (QI).

The efficiency of each heat source is measured rather than individual modules (e.g. measured across a bank of heat pumps, rather than for each heat pump module). This KPI is measured on an annual basis to account for expected seasonal variations (e.g. arising from variations in external ambient temperatures).

Typical issues that could impact the efficiency of heat generation equipment include:

- unsuitable operating conditions (e.g. elevated return temperatures which can negatively impact the coefficient of performance of heat pumps);
- inadequate commissioning of heat generation plant;
- fouling or degradation of heat transfer surfaces;
- poor combustion control in boilers; or
- insufficient maintenance of heat generation equipment.

4.3. Operating temperatures

The management of operating temperatures is key to providing end consumers with a sufficient quality of service and operating a Heat Network with sufficient efficiency.

It is important to measure operating temperatures due to their impact on the consumer experience and the heat loss from a Heat Network. Measurement of operating temperatures also aids in ensuring that the operation of a Heat Network aligns with its design intent.

To capture the operating temperatures of a Heat Network, KPIs have been developed to measure:

- the average flow temperature at Element boundaries;
- the average return temperature at Element boundaries; and
- the variance in the flow temperature from its setpoint.

Table 11 shows the applicability of these temperature-related performance KPIs across different Heat Network Elements.

The following subsections explain what each KPI is, outlining the outcome it is intended to measure and why it is important to the Scheme.

KPI	EC	DD	SS	CD	CC	CH
Average flow temperature	X	X	X	X	-	-
Average return temperature	X	X	X	X	-	-
Flow temperature variance from setpoint	X	-	X	-	-	-

Table 11: Applicability of temperature-related performance KPIs to each Element

4.3.1. Average flow temperature

The average flow temperature KPI measures the average flow temperature at an Element boundary.

The average flow temperature is important because it indicates whether the Energy Centre or Substation is delivering flow temperatures to the network which are in accordance with its design.

Flow temperature performance issues can present themselves through:

- low flow temperatures, resulting in underheating and unreliable heat supply;
- high flow temperatures, resulting in increased heat losses and a reduced overall Heat Network efficiency.

Typical issues that could impact the average flow temperature at an Element boundary include:

- incorrect configuration of flow temperature setpoints during the commissioning of equipment (e.g. heat generation items);
- poor implementation of control strategies;
- inaccurate readings from faulty sensors.

4.3.2. Average return temperature

The average return temperature KPI measures the average return temperature at the Element boundary.

The average return temperature is important because it can impact:

- heat loss from the Heat Network;
- the flow rate required to deliver sufficient heat to end consumers, which directly impacts the energy required by network distribution pumps;
- the efficiency of heat generation equipment (e.g. heat pumps).

Typical issues that could impact the average return temperature include:

- open bypasses in the Heat Network (e.g. within a Consumer Connection or a Distribution Network);
- poor commissioning or performance of control systems (e.g. within a Consumer Connection);

- inadequately balanced space heating emitters; or
- oversized or incorrectly configured pumps (e.g. space heating pumps within Consumer Connections, pumps at Substations).

4.3.3. Flow temperature variance from setpoint

The flow temperature variance from setpoint KPI measures the average difference between the actual flow temperature and its setpoint for each measurement period.

Where variable setpoints are used (e.g. for weather compensation), this difference is measured relative to the setpoint at that particular measurement period.

Measurement of the flow temperature variance is important because unstable or fluctuating flow temperatures can impair the quality of service for end consumers and create difficulties in controlling the system (which could result in "cycling" of temperatures in heat generation plant).

Whilst the flow temperature stability KPI (see Section 3.2.2) aims to measure the effectiveness ot system controls in maintaining a stable flow temperature, the flow temperature variance from setpoint KPI aims to measure whether the flow temperature in the system is being maintained in accordance with the design intent and the requirements of the Heat Network.

Flow temperature variance issues can present themselves through:

- a persistent deviation from the flow temperature setpoint; or
- large fluctuations from the flow temperature setpoint during normal operation.

Typical issues that could impact flow temperature variance include:

- issues with control systems (e.g. incorrect tuning of PID control loops, poorly configured weather compensation);
- issues in control strategies (e.g. which result in mix-down through non-operational equipment, cycling, or differing setpoints between individual heat generation assets);
- noise and inaccurate readings from faulty sensors;
- inadequate commissioning of control systems;
- delays in responses from equipment (e.g. valve actuators, pumps);
- setpoints not being aligned with the design intent.

4.4. Pumping and distribution

The distribution of system water throughout a Heat Network requires energy to overcome frictional losses. The energy consumed by network distribution pumps can be a significant operating cost for a Heat Network, and is often directly impacted by the flow rate required to meet heat demands.

Sufficient management of flow rates often requires good control throughout the Heat Network, as well as efficient transfer of heat at hydraulic breaks and heat emitters. Issues with flow rate indicate that system water is circulating around the Heat Network without contributing towards meeting consumer heat demands. Elevated flow rates are therefore often accompanied by elevated return temperatures, and could arise due to bypasses in the network or the performance of the Termination Points (e.g. Substations, Consumer Connections) in the Heat Network.

To capture the performance of pumping and distribution, KPIs have been developed to measure:

- the network distribution pump energy;
- the network bypass flow rate;
- the volume weighted average return temperature (VWART) from a Consumer Connection; and
- the volume weighted average temperature difference (VWATD) across a Consumer Connection.

Refer to Section 3.2.3 for further explanation of the use of "volume weighted average" temperatures.

The measurement of the pumping and distribution can aid in identifying causes of inefficiency in a Heat Network.

Table 12 shows the applicability of these pumping and distribution-related performance KPIs across different Heat Network Elements.

The following subsections explain what each KPI is, outlining the outcome it is intended to measure and why it is important to the Scheme.

KPI	EC	DD	SS	CD	CC	CH
Network distribution pump energy	X	-	X	-	-	-
Network bypass flow rate	-	X	-	X	-	-
Volume weighted average return temperature (VWART)	-	-	-	-	X	-
Volume weighted average temperature difference (VWATD)	-	-	-	-	X	-

Table 12: Applicability of flow and pumping-related performance KPIs to each Element

4.4.1. Network distribution pump energy

The network distribution pump energy KPI measures the total energy consumed by the network distribution pumps over a defined time period. This KPI only applies to network distribution pumps and excludes shunt pumps.

The network distribution pump energy is important because the energy consumption of distribution pumps can contribute to a significant proportion of the total energy consumed by a Heat Network.

High pumping energy consumption can present itself through:

- pumps operating at excessively high pump speeds; or
- pumps operating for longer periods than necessary to meet heat demands (e.g. during low-demand conditions).

Typical issues that could impact the network distribution pump energy include:

- excessive flow rates caused by bypasses;
- oversized pumps (e.g. due to over-estimation of peak-demand conditions);
- poor commissioning or performance of control systems;
- lack of pump controls which respond to heat demands (e.g. operating in fixed-speed mode);
- poor configuration sensors used to provide feedback (e.g. due to incorrect identification of the index run of a Distribution Network, or inappropriate location of a differential pressure sensor);
- excessive differential pressures present across the Heat Network (e.g. due to clogged strainers, scaling or fouling within the Distribution Network).

4.4.2. Network bypass flow rate

The network bypass flow rate KPI measures the total flow rate from all Distribution Network Termination Points compared with the flow rate recorded at the Distribution Network Initiation Point. It should be noted that the flow rate through Consumer Connections in standby operation will be captured under the Termination Point flow rate, so would not contribute to the network bypass flow rate KPI.

The network bypass flow rate is important because excessive bypass flow rates can increase the energy consumed by network distribution pumps energy consumption, which can raise return temperatures and increases heat losses from the Heat Network. A high network bypass flow rate can indicate that system water is circulating through the Heat Network without effective heat transfer.

Typical issues that could impact the network bypass flow rate include:

- open or poorly-controlled bypasses within the Distribution Network (e.g. top-of-riser bypasses); or
- poorly-controlled bypass arrangements within Termination Points (e.g. Consumer Connection).

4.4.3. VWART and VWATD

The return temperature and the difference between flow and return temperature (sometimes referred to as "delta T") are closely linked. Both temperatures can indicate how effectively is transferred from the Distribution Network to consumers.

To account for the variations in temperature difference across Consumer Connections which occur during peak-demand conditions, the return temperature and temperature difference are "weighted" by the volume flow rate for each measurement. Refer to Section 3.2.3 for further explanation of the use of "volume weighted average" temperatures.

High return temperatures and low temperature differences can:

- result in increased heat loss from the Heat Network;
- often also present as increased flow rates through the Heat Network, which can increase network distribution pump energy;
- result in reduced efficiencies of heat generation plant.

Return temperatures in operational Heat Networks can be influenced by the usage patterns of consumers and aspects of the design of Consumer Heat Systems that are largely fixed once the system is commissioned. These factors mean that the overall VWART KPI can materially vary between Heat Networks.

As a result, the VWART alone might not always provide sufficient insight into the performance of the Heat Network. The VWATD is therefore considered alongside the VWART to provide further understanding of the effectiveness of heat transfer at Consumer Connections.

Together, the VWART and the VWATD are important high return temperatures which arise from low differences in temperatures across Consumer Connections can:

- result in increased heat loss from the Heat Network;
- indicate high flow rates through individual Consumer Connections, which could impair the supply of heat to other consumers on the Heat Network;
- often also present as increased flow rates through the Heat Network, which can increase network distribution pump energy;
- result in reduced efficiencies of heat generation plant.

Typical issues that could impact the overall VWART or the VWADT include:

- inadequate commissioning of the Consumer Connection;
- ineffective controls at Consumer Connections (e.g. passing control valves within HIUs);
- unbalanced or inadequately balanced space heating emitters;
- the operation of valves being impaired (e.g. due to fouling, or the presence of debris or limescale);
- the effectiveness of heat transfer across heat exchangers resulting in high return approach temperatures;
- excessive standby flow rates in Consumer Connections.

4.4.3.1. Overall volume weighted average return temperature (VWART)

The overall VWART KPI measures the average return temperature, weighted by the volume flow rate, over a defined time period.

The VWART KPI is important because it can be indicative of the impact that an individual Consumer Connection can have on the performance of the wider Heat Network, and if the performance of an individual Consumer Connection is impairing the supply of heat to other consumers on the Heat Network.

4.4.3.2. Volume weighted average temperature differential (VWATD)

The VWATD KPI measures the difference between the volume weighted average flow temperature (VWAFT) and the volume weighted average return temperature (VWART) over the same measurement period. As both inputs are volume weighted, the VWATD represents the average volume weighted temperature difference across two points for each unit of system water which circulated through those points.

The VWATD is important because it can aid in identifying Consumer Connections which are not adequately performing (e.g. due to excessively high flow rates through the

Consumer Connection or the Consumer Heat System) and is expressed as single quantified metric.

5. Domestic consumer outcomes

Domestic consumer outcomes are important because they demonstrate that domestic Consumer Connections and Consumer Heat Systems in New Build Heat Networks can reliably deliver space heating and hot water demands at suitable service levels to meet consumer needs at the point of commissioning.

It is important to measure these KPIs at the point of commissioning to demonstrate that the design and construction of domestic Consumer Connections and Consumer Heat Systems meet acceptable standards before supplying heat to consumers.

This supports the Scheme's objective by improving consumer experience through reliable and high-quality heat supply at the point of commissioning.

The delivery of heating and hot water is a key aspect of consumer satisfaction. To achieve this, domestic consumer outcomes focus on verifying that systems can:

- deliver hot water at the kitchen tap (or furthest outlet with a thermostatic mixing valve) to provide a satisfactory quality of service;
- deliver domestic hot water (DHW) at sufficient temperatures;
- provide acceptable return temperatures to the Distribution Network during DHW operation;
- provide Consumer Heat System space heating systems with a sufficient flow temperature;
- provide acceptable return temperatures to the Consumer Connection and Distribution Network during space heating operation; and
- provide acceptable return temperatures to the Distribution Network during standby operation.

These KPIs only apply to domestic Consumer Connections and Consumer Heat Systems because the service requirements for non-domestic Consumer Connections are not in the scope of the Scheme.

Table 13 shows the applicability of these domestic consumer outcome KPIs across different Heat Network Elements.

The following subsections explain what each KPI is, outlining the outcome it is intended to measure and why it is important to the Scheme.

KPI	EC	DD	SS	CD	CC	CH
DHW delivery time at the kitchen tap	-	-	-	-	-	X
DHW generation temperature	-	-	-	-	X	-
DHW return temperature	-	-	-	-	X	-
Space generation return temperature	-	-	-	-	X	-
Space heating return temperature	-	-	-	-	X	-

KPI	EC	DD	SS	CD	CC	CH
Space heating circuit return temperature	-	-	-	-	-	X
Standby return temperature	-	-	-	-	X	-

Table 13: Applicability of domestic consumer outcomes KPIs to each Element

5.1. DHW delivery time at the kitchen tap

The DHW delivery time KPI measures the time taken to deliver DHW at a temperature of 45 °C at the kitchen tap (or furthest outlet without a thermostatic mixing valve) after the outlet is opened.

The DHW delivery time is important because delivery times within thresholds:

- can indicate that a minimum standard of DHW service is being met; and
- can aid in reducing unnecessary waste of potable water consumption.

Typical issues that could impact DHW delivery times at the kitchen tap (or the furthest outlet without a thermostatic mixing valve) include:

- inadequate response times of instantaneous DHW generation equipment;
- oversized DHW distribution pipework within a Consumer Heat System;
- long distances in a Consumer Heat System between the point of DHW generation and outlets; or
- poorly commissioned flow limiters.

5.2. DHW generation temperature

The DHW generation temperature KPI measures the temperature of domestic hot water generated by the Consumer Connection during stabilised DHW operation.

The DHW generation temperature is an important part of ensuring that domestic consumers receive a suitable quality of service from Heat Networks.

Inappropriate DHW generation temperatures can present as:

- excessively low temperatures which can lead to consumer dissatisfaction; or
- excessively high temperatures which could increase the risk posed by scalding.

Typical issues that could impact DHW generation temperatures include:

- incorrect DHW setpoints at Consumer Connections;
- adjustments of settings in Consumer Connection without appropriate verification against Consumer Heat System requirements;
- mislocated, loose, or faulty DHW temperature sensors;
- poor control of valves (resulting in inappropriate flow rates through the Distribution Network during DHW operation);

- unintended interaction between the control strategies for DHW and space heating operation;
- blocked strainers within the Consumer Connection; or
- the presence of fouling or limescale within DHW plate heat exchangers.

5.3. DHW return temperature

The DHW return temperature KPI measures, over a defined period, the return temperature from the Consumer Connection to the Distribution Network during DHW operation.

The DHW return temperature KPI is important because it indicates how effectively heat is being transferred across the Consumer Connection during DHW operation. High return temperatures during DHW operation can also result in increased heat losses from the Distribution Network.

Typical issues that could impact DHW return temperature include:

- oversized DHW plate heat exchangers;
- inappropriate DHW setpoints;
- inadequate performance of control valves and actuators (e.g. due to faults or inappropriate specification);
- inappropriate operation of mechanical bypasses within a Consumer Connection; or
- the use of DHW storage cylinders in Consumer Heat Systems.

5.4. Space heating generation temperature

The space heating generation temperature KPI measures the temperature of space heating generated by the Consumer Connection during space heating operation.

Space heating generation temperature is important because it can indicate if heat is being sufficiently provided to meet consumer space heating demands.

Space heating generation temperature issues can present themselves through:

- overheating, where generation temperatures are too high, which can lead to reduced consumer comfort; or
- underheating, where generation temperatures are too low and domestic Consumer Heat Systems may not be able to reach or maintain sufficient indoor temperatures.

Typical issues that could impact space heating generation temperatures include:

- inappropriate space heating setpoints at the Consumer Connection;
- adjustments of settings in Consumer Connection without appropriate verification against Consumer Heat System requirements;
- mislocated, loose, or faulty space heating temperature sensors,
- poor control of valves (resulting in inappropriate flow rates through the Distribution Network and/or Consumer Heat System during space heating operation);
- unintended interaction between the control strategies for DHW and space heating operation;

- blocked strainers within the Consumer Connection; or
- the presence of fouling or limescale within DHW plate heat exchangers.

5.5. Space heating return temperature

The space heating return temperature KPI measures the return temperature from the Consumer Connection to the Distribution Network during space heating operation.

The space heating return temperature is important because it can indicate how effectively heat is being transferred from the Distribution Network to heated areas in dwellings.

Space heating return temperature issues can present themselves through:

- elevated return temperatures, indicating poor heat transfer at the emitters and/or Consumer Connection;
- persistently low return temperatures in conjunction with insufficient room temperatures in heated areas.

Typical issues that could impact space heating return temperature include:

- incorrect sizing of space heating emitters;
- poor commissioning of space heating emitters (e.g. inappropriate settings on thermostatic radiator valves, inappropriate underfloor heating flow rates);
- unbalanced or inadequately balanced space heating circuits;
- air within space heating pipework restricting flow through the space heating system;
- insufficient management of water quality in space heating circuit (for indirect space heating systems), which can lead to fouling or debris that restricts flow;
- poor commissioning of pumps in space heating systems; or
- the presence of fouling or limescale within space heating plate heat exchangers.

5.6. Space heating circuit return temperature

The space heating circuit return temperature KPI measures the return temperature received by the Consumer Connection from the Consumer Heat System during space heating operation.

The space heating circuit return temperature is important because it can indicate how effectively heat is being emitted by the Consumer Heat System. Appropriate return temperatures can indicate that the heat supplied to the Consumer Heat System space heating system is being transferred into the consumer space in accordance with the design intent.

Space heating circuit return temperature issues can present themselves through:

- elevated return temperatures, which can indicate insufficient heat transfer from the Consumer Heat System to heated areas in dwellings; or
- persistently low return temperatures in conjunction with insufficient room temperatures in heated areas.

Typical issues that could impact the space heating circuit return temperature include:

- poor commissioning of space heating emitters (e.g. inappropriate settings on thermostatic radiator valves, inappropriate underfloor heating flow rates);
- air within space heating pipework restricting flow through the space heating system;
- insufficient management of water quality in space heating circuit (for indirect space heating systems), which can lead to fouling or debris that restricts flow.

5.7. Standby return temperature

The standby return temperature KPI measures, over a defined period, the return water temperature from the Consumer Connection to the Distribution Network during standby operation (i.e. when there is not an active space heating or DHW demand from the Consumer Heat System).

The standby return temperature is important because it provides an indication of how Consumer Connections behave during periods of no heat demand from the Consumer Heat System, and whether standby operation aligns with the design intent. Monitoring standby return temperature helps identify inappropriate standby operation and commissioning or configuration issues that can affect overall network efficiency.

Typical issues that could impact standby return temperature include:

- incorrect HIU control settings (e.g. keep-warm enabled at inappropriate temperatures, excessively high keep-warm flow rate through a Consumer Connection);
- unintended circulation within the Consumer Connection during standby operation (e.g. due to internal bypasses);
- inadequate performance of control valves and actuators (e.g. due to faults, or inappropriate configuration), resulting in flow rates which exceed the design intent;
- inappropriate keep-warm strategies;
- inappropriate commissioning of the Consumer Connection (e.g. incorrect setpoints, sensor placement, control strategies); or
- faulty components within the Consumer Connection which create unintended flow paths during standby.