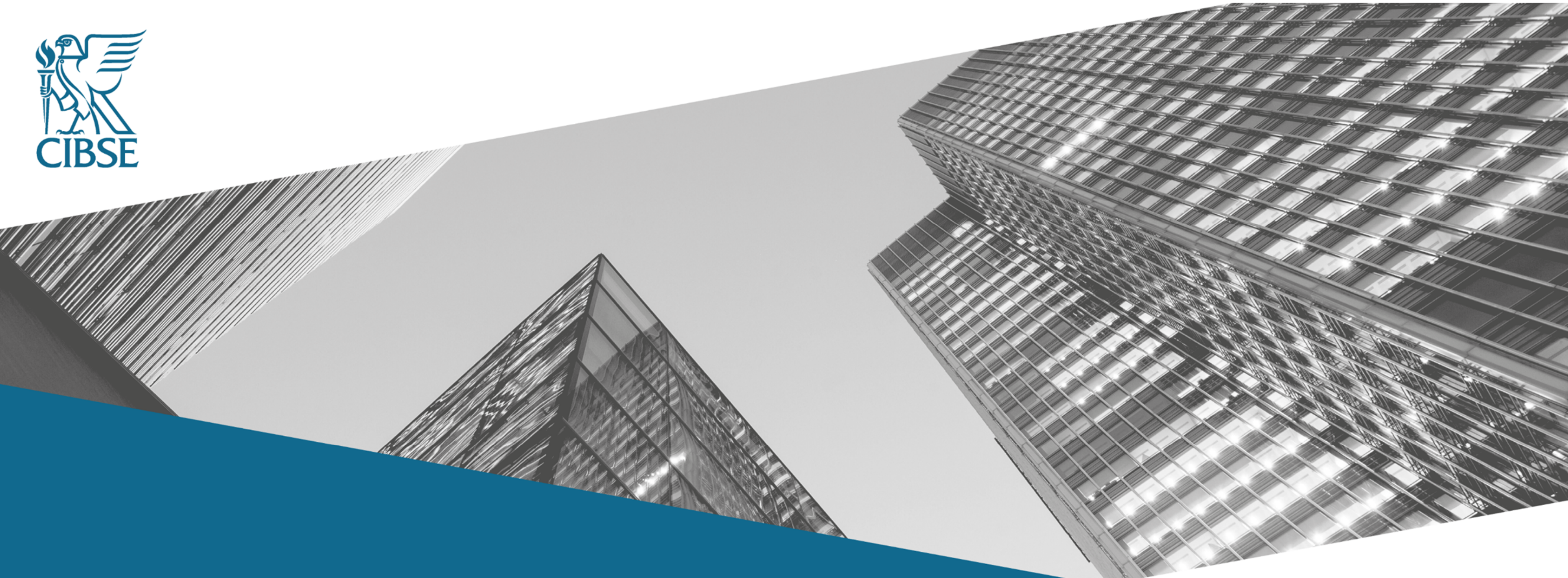


The Impact of Domestic Hot Water Temperatures on Public Health

Steve Vaughan – Regional Director, AECOM

Public Health Engineering

From a Public Health engineering perspective:

- Legionnaires disease
- Scalding risk
- TMV and dwelling requirements

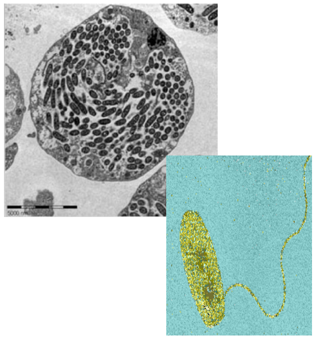
Public Health Engineering

- Designers of:
  - Safe and efficient:
    - Water supply systems
    - Drainage systems
    - Fire Protection Systems

Legionnaires Disease

- Within the domestic water systems we have to consider safe and efficient control of legionella bacteria

  - Legionella bacteria is found everywhere in the environment.
  - It is a natural inhabitant of water and can survive in sterile tap water
  - Can survive and multiply in non-sterile sources.
  - Warm water between 20 – 45^{o}C is the perfect water temperature for the bacteria to multiply
  - It is killed at temperatures above 60^{o}C
  - You cannot usually get legionnaires disease from drinking water containing the bacteria



Legionnaires Disease

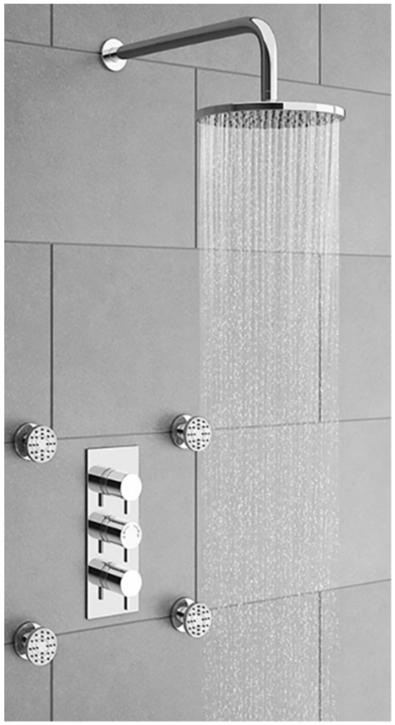
- It is not harmful to drink water which contains Legionella bacteria

dwi
guardians of drinking water quality
DRINKING WATER INSPECTORATE

- The bacteria needs to enter your lungs to create a risk of contracting Legionnaires disease

Legionnaires Disease

- Therefore plumbing outlets such as showers, spray taps are potential risks

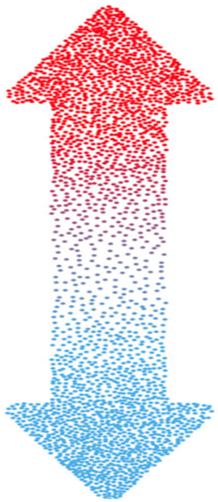


Legionnaires Disease

The Ideal Legionella Growth Temperatures:

Legionnaires Disease

- Principles of good design for domestic water systems:
  - Keep the hot water HOT
  - Keep the cold water COLD

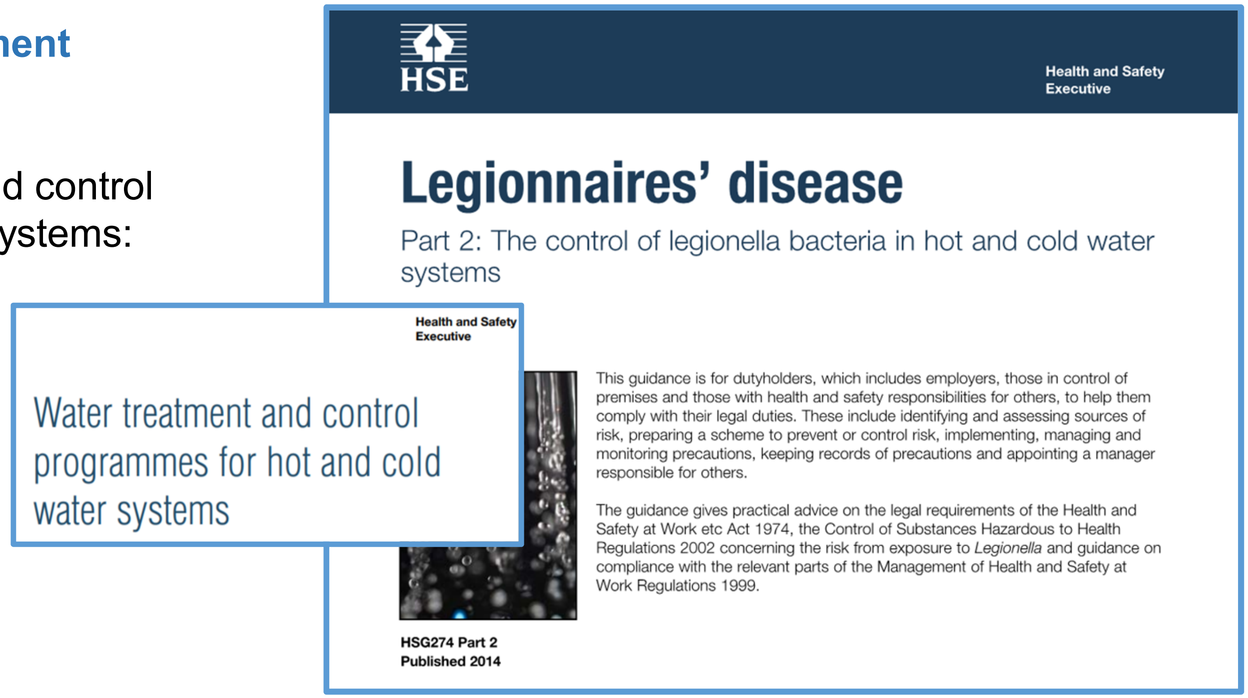


Legionnaires Disease

Heath and Safety Executive document
HSG 274 Part 2

States options for water treatment and control programmes for hot and cold water systems:

- **Temperature regime**
- **Biocide treatments**
- **Supplementary measures**
    - For point of use applications



HSE

Health and Safety Executive

Legionnaires' disease

Part 2: The control of legionella bacteria in hot and cold water systems

This guidance is for dutyholders, which includes employers, those in control of premises and those with health and safety responsibilities for others, to help them comply with their legal duties. These include identifying and assessing sources of risk, preparing a scheme to prevent or control risk, implementing, managing and monitoring precautions, keeping records of precautions and appointing a manager responsible for others.

The guidance gives practical advice on the legal requirements of the Health and Safety at Work etc Act 1974, the Control of Substances Hazardous to Health Regulations 2002 concerning the risk from exposure to *Legionella* and guidance on compliance with the relevant parts of the Management of Health and Safety at Work Regulations 1999.

HSG274 Part 2
Published 2014

Health and Safety Executive

Water treatment and control programmes for hot and cold water systems

AECOM

Legionnaires Disease

Heath and Safety Executive document
HSG 274 Part 2

HSE
Health and Safety Executive

Legionnaires' disease

Part 2: The control of legionella bacteria in hot and cold water systems

- **TEMPERATURE REGIME: Keep the hot water HOT and the cold water COLD**
    - **Cold** water outlets – **below 20^{0}C**
    - **Hot** water outlets - **at least 50^{0}C**
        - Hot water outlets - Where TMV's are fitted: supply pipe at least 50^{0}C
        - Hot water **storage** at a minimum of **60^{0}C**
        - Hot water circulation – Secondary **flow** at least **60^{0}C**
        - Hot water circulation – Secondary **return** at least **50^{0}C**

Scalding risk

Burning risk

The Number of SECONDS it takes to get a deep burn in hot water:

70°C - 1 second

60°C– 6 seconds

50°C– 60 seconds

Scalding risk

Building regulations Approved Document G

Part G3 – Hot Water Supply and Systems

- **Prevention of excessive temperatures**
- **Prevention of scalding**

HM Government

The Building Regulations 2010

Sanitation, hot water safety and water efficiency

G

APPROVED DOCUMENT

3.67 In-line blending valves and composite thermostatic mixing valves should be compatible with the sources of hot and cold water that serve them.

3.65 The hot water supply temperature to a bath should be limited to a maximum of 48°C by use of an in-line blending valve or other appropriate temperature control device, with a maximum temperature stop and a suitable arrangement of pipework.

(4) The hot water supply to any fixed bath must be so designed and installed as to incorporate measures to ensure that the temperature of the water that can be delivered to that bath does not exceed 48°C.

Scalding risk

Heath and Safety Executive document
HSG 274 Part 2

Also provided guidance on the use of TMVs to safeguard against the risk of scalding

- **Info box 2.3 should be considered for WHB's within Accessible apartments**

Info box 2.3: Thermostatic mixing valves

Where a scalding risk is assessed as low (eg where healthy users immerse their whole body), type 2 TMVs that can be overridden by the users are required by building regulations. Where a scalding risk is considered significant (eg where users are very young, very elderly, infirm or significantly mentally or physically disabled or those with sensory loss) then type 3 TMVs that are pre-set and fail-safe should be provided (but are required at healthcare premises) and should be checked regularly to ensure they are fail-safe if the cold water supply pressure is interrupted.

Thermostatic Mixing Valves

TMVs accurately control water temperatures for hand-washing, bathing, showering and bidets. They are designed to maintain the desired water temperature, even when pressures or flow rates change.

TMV requirements

Temperature stability - They must maintain a set mixed hot water temperature of ±2°C.

In order to prevent scalding, the TMV must default to shut off in the event that the cold water supply is lost.

TMV2 and TMV3 Approval Schemes set testing criteria

Dwelling requirements

Supply temperatures

AD G3 (dwellings) stated a maximum **Bath** supply temperature of **48°C.**

BS7942 and NHS D08 (healthcare) show tables which indicate the maximum temperatures relating to different bathroom applications:

- **WHB or shower** should be set at a maximum of **41°C**
- **Bath** should have a maximum of **44°C**
- **Bidet** should be set at a maximum of **38°C**

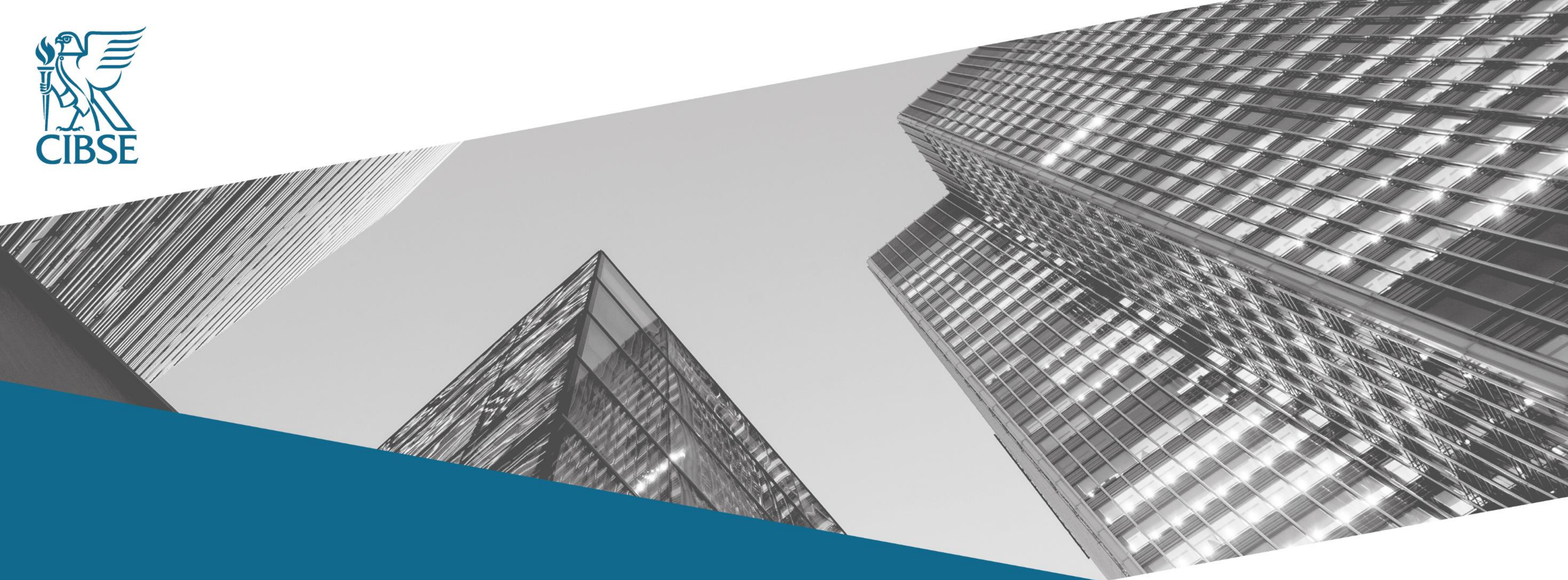
NHBC, In addition to the AD G3 requirements, **Sinks** are required to be supplied **at 55°C**

Outlet	Supply temperature °C [3]
Bath (from storage)	48
Bath (from combi)	40
Shower (non-electric)	40
Wash basin	40
Sink	55

Dwelling requirements

Supply times

HSG 274 Part 2 states Minimum of 50°C at the outlet within 1 minute



Domestic Hot Water Working Group

Andrew MacKay

Senior Mechanical Engineer at Arup | Chair of CIBSE Domestic Hot Water Working Group

Domestic Hot Water Working Group

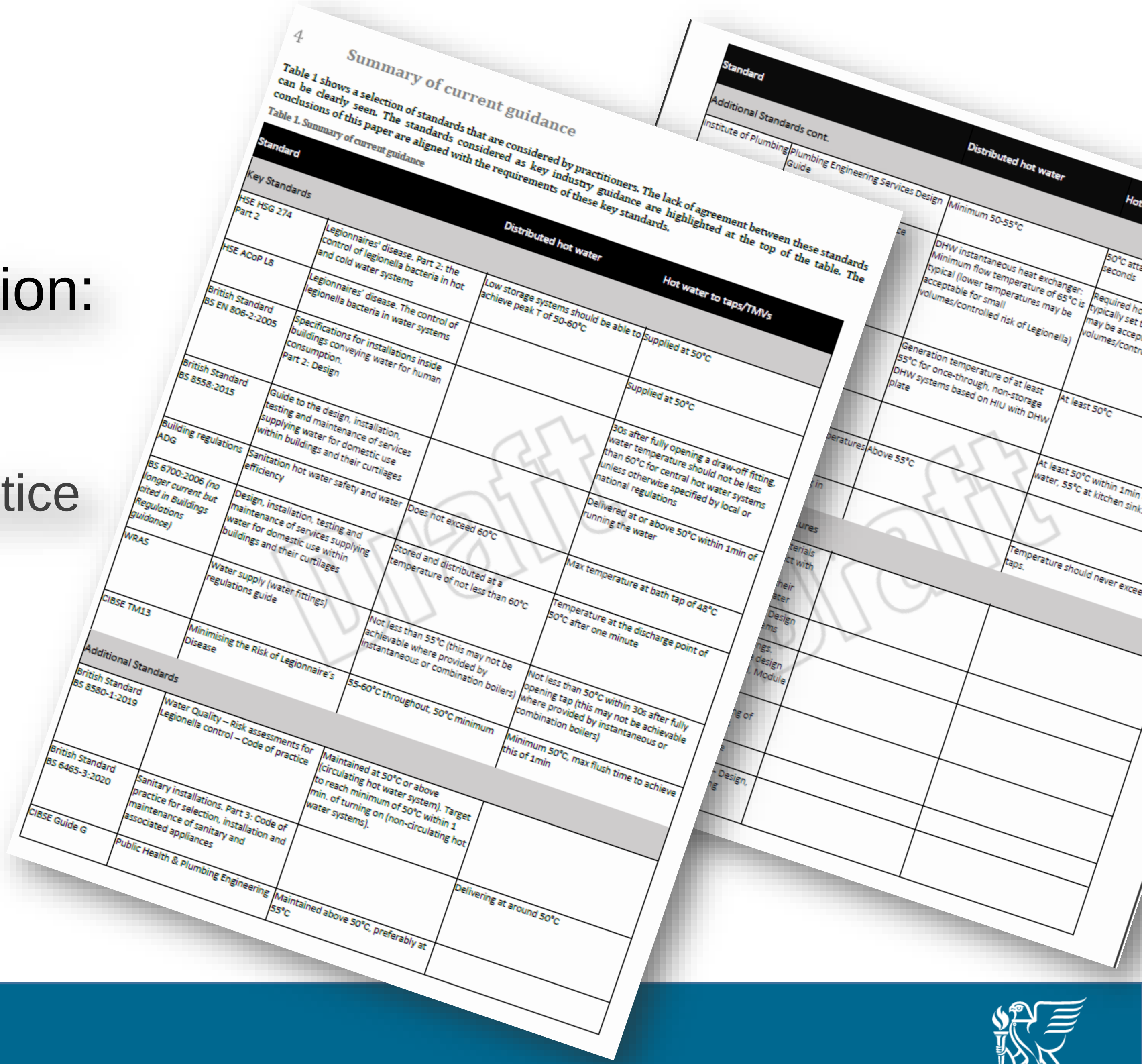
- Collaboration between
  - CIBSE Homes for the Future Group
  - Heat Network Practitioners
  - SoPHE
  - Domestic Building Services Panel

- Public health still primary driver

- Focus on residential market initially

Current legislation

- Safety and function legislation:
  - Multiple sources
  - Conflicting guidance
  - Not relevant to current practice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Summary of current guidance

Table 1 shows a selection of standards that are considered by practitioners. The lack of agreement between these standards can be clearly seen. The standards considered as key industry guidance are highlighted at the top of the table. The conclusions of this paper are aligned with the requirements of these key standards.

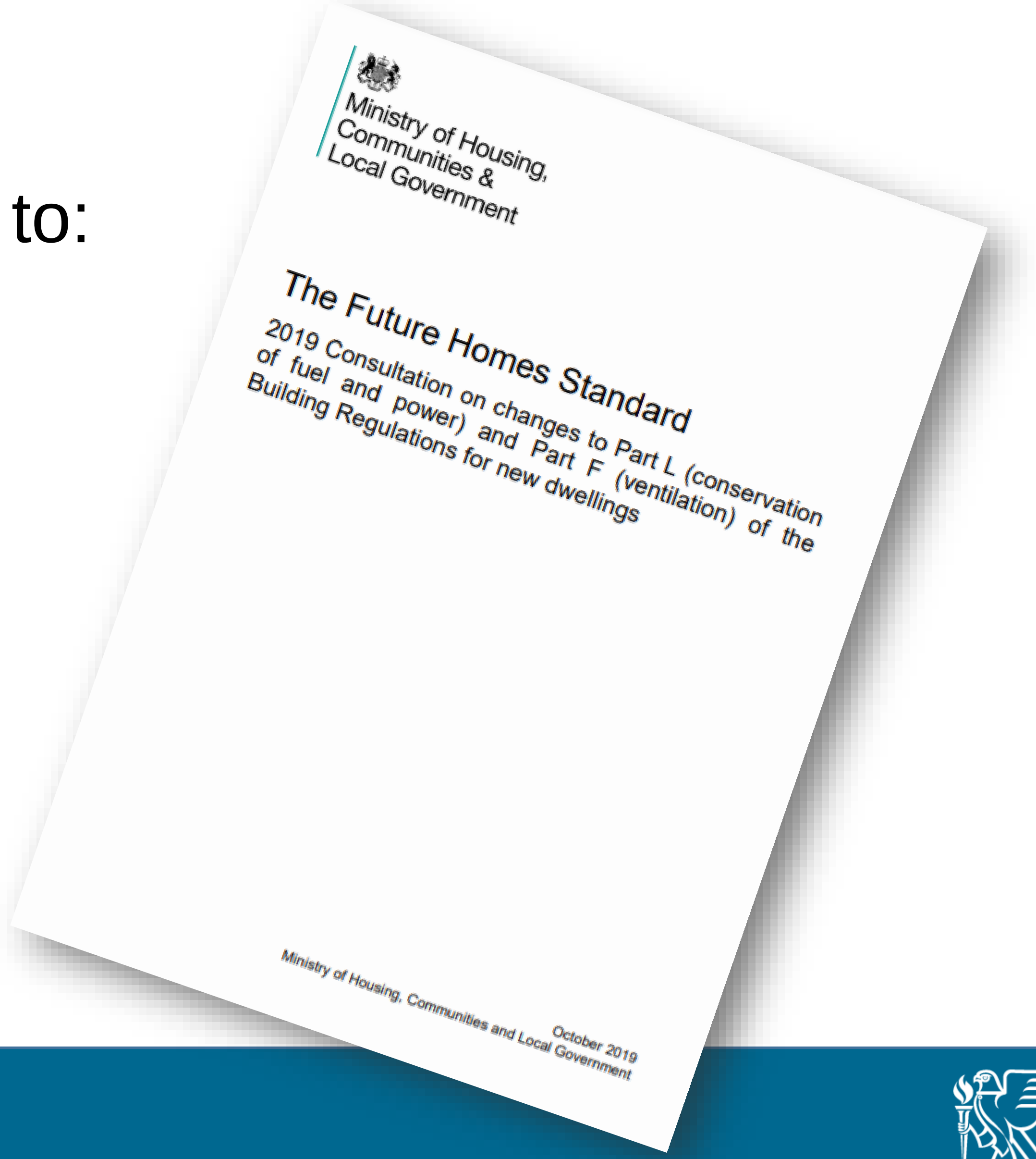
Table 1. Summary of current guidance

Standard		Distributed hot water	Hot water to taps/TMVs
Key Standards			
HSE HSG 274 Part 2	Legionnaires' disease. Part 2: the control of legionella bacteria in hot and cold water systems	Low storage systems should be able to achieve peak T of 50-60°C	Supplied at 50°C
HSE ACoP L8	Legionnaires' disease. The control of legionella bacteria in water systems		Supplied at 50°C
British Standard BS EN 806-2:2005	Specifications for installations inside buildings conveying water for human consumption. Part 2: Design		30s after fully opening a draw-off fitting, water temperature should not be less than 60°C for central hot water systems unless otherwise specified by local or national regulations
British Standard BS 8558:2015	Guide to the design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages		Delivered at or above 50°C within 1min of running the water
Building regulations ADG	Sanitation hot water safety and water efficiency	Does not exceed 60°C	Max temperature at bath tap of 48°C
BS 6700:2006 (no longer current but cited in Buildings Regulations guidance)	Design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages	Stored and distributed at a temperature of not less than 60°C	Temperature at the discharge point of 50°C after one minute
WRAS	Water supply (water fittings) regulations guide	Not less than 55°C (this may not be achievable where provided by instantaneous or combination boilers)	Not less than 50°C within 30s after fully opening tap (this may not be achievable where provided by instantaneous or combination boilers)
CIBSE TM13	Minimising the Risk of Legionnaire's Disease	55-60°C throughout, 50°C minimum	Minimum 50°C, max flush time to achieve this of 1min
Additional Standards			
British Standard BS 8580-1:2019	Water Quality – Risk assessments for Legionella control – Code of practice	Maintained at 50°C or above (circulating hot water system). Target to reach minimum of 50°C within 1 min. of turning on (non-circulating hot water systems).	
British Standard BS 6465-3:2020	Sanitary installations. Part 3: Code of practice for selection, installation and maintenance of sanitary and associated appliances		
CIBSE Guide G	Public Health & Plumbing Engineering	Maintained above 50°C, preferably at 55°C	Delivering at around 50°C

Draft

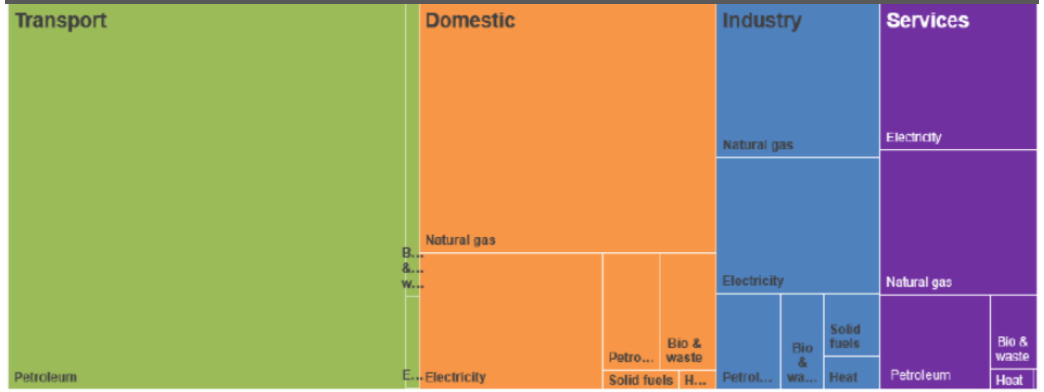
Current legislation

- Energy efficiency guidance limited to:
  - Storage cylinder insulation/controls
  - WWHR
  - DHW Heat pump COP >2

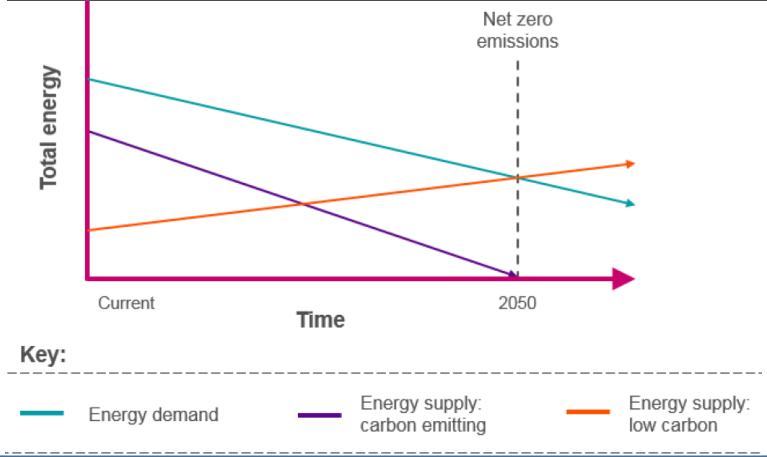


Context

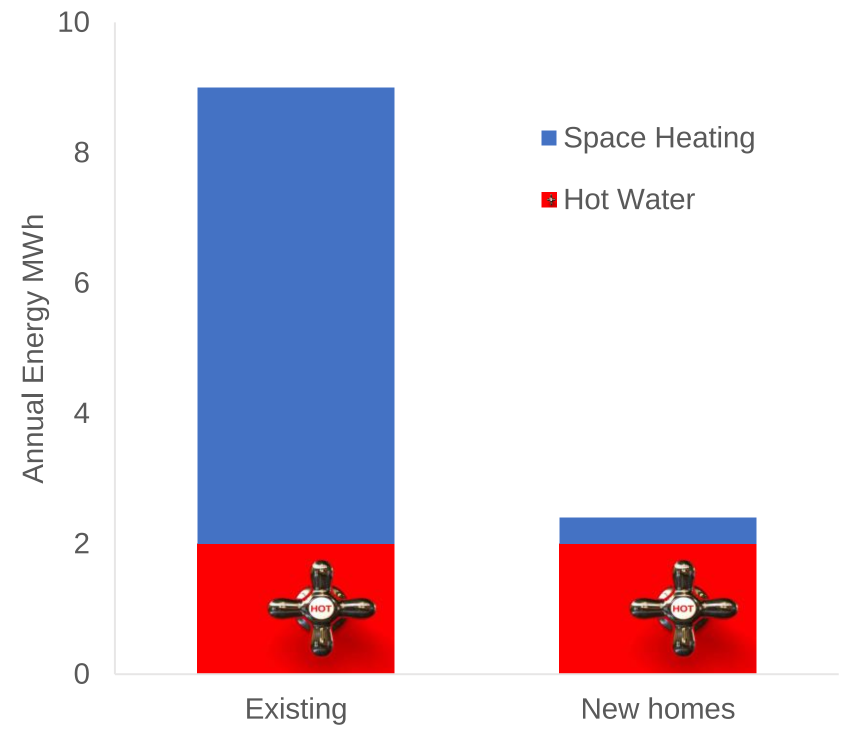
From UK Government figures for energy consumption, 2018



From UKGBC – Paris Proof Targets concept



From Arup project specific analysis for multi-residential development refurbishment



Clarify and unify

HSE

NHBC

BSRIA

WRAS

et al

CIBSE Guidance Note

Future standards

Domestic Hot Water Temperatures from Instantaneous Heat Interface Units (HIUs)

1 Executive summary

Legislation and guidance on domestic hot water temperatures are unclear for low-volume instantaneous hot water heating systems, e.g. using plate heat exchangers within Heat Interface Units (HIUs). This Guidance Note summarises the relevant guidance documents and provides a recommended design approach that is in line with key guidance documents and all functional and safety requirements for instantaneous HIUs.

The main conclusions of this Guidance Note are:

- **GENERATING instantaneous hot water temperature at 50°C would satisfy the requirement to reduce the risk of Legionella growth with a minimum risk of scalding.**
- **DELIVERING instantaneous hot water to the kitchen tap at 45°C within 45 seconds of opening the tap to full flow rate would demonstrate an acceptable service level for users and sets a requirement that also limits water use.**

By using a hot water generation temperature of 50°C for instantaneous HIUs, the risk of Legionella growth will be controlled in line with the requirements of HSG 274. This temperature is optimised to maximise energy efficiency and allow the use of a wide range of heat pump technologies and will further reduce the risk of scalding.

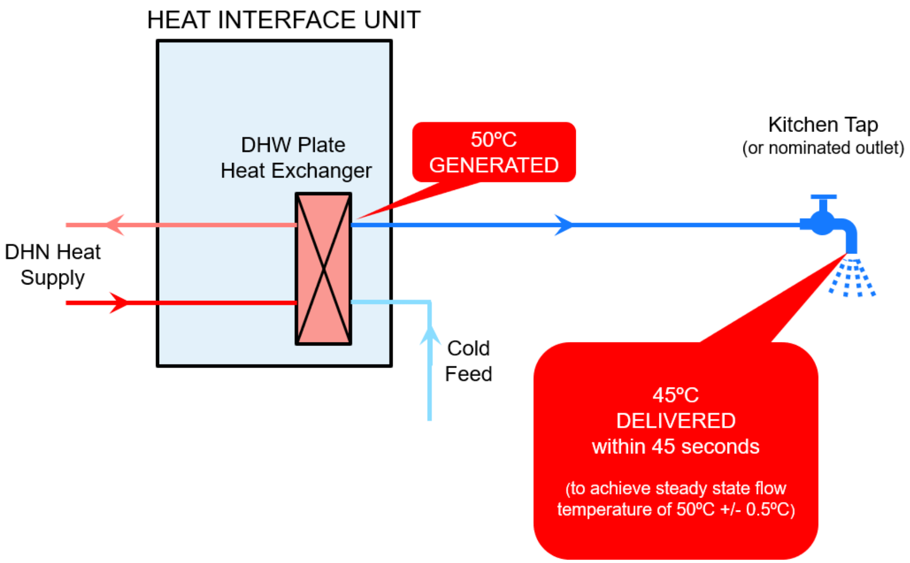
These conclusions are from the CIBSE DHW Working Group and are supported by HSE, NHBC and CIBSE. This Guidance Note presents a unified approach with clearer guidance for domestic hot water practitioners. Following this Guidance will reduce energy consumption and carbon emissions whilst ensuring safety and functionality for users.

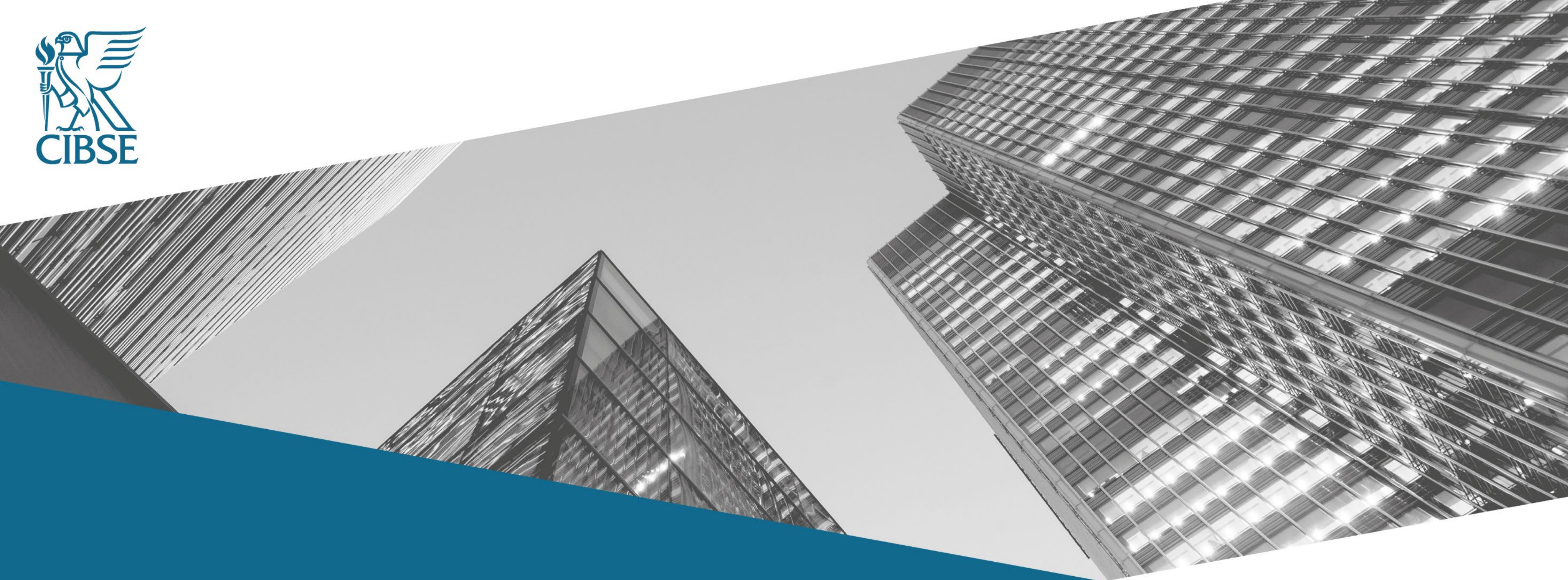
Unified guidance

- Applies to HIUs in residential only
- Excerpt from guidance note below

Lower risk scenario **– this scenario has been agreed with the HSE as a lower risk system**

- *Block of flats served by communal heating system and communal boosted cold water system*
- *Each dwelling/flat has own low-volume heat interface unit to generate instantaneous hot water (SYSTEM TYPE 2 from Section 3)*
- *No stored hot water and small volume of water within pipework to outlets*





Considerations of instantaneous domestic hot water compared to stored water systems

Considerations of instantaneous domestic hot water compared to stored water systems

- Jonathan Gaunt - Associate Director
- SoPHE (Society of Public Health Engineers) Chairman
- Member of the CIBSE DHW Working Group

Spotlight on…….

Legionella constraints for stored water and how best to store it and energy implications of reducing DHW temperatures in instantaneous systems

'I will now run this bath without the aid of a thermostat'

Main Goals

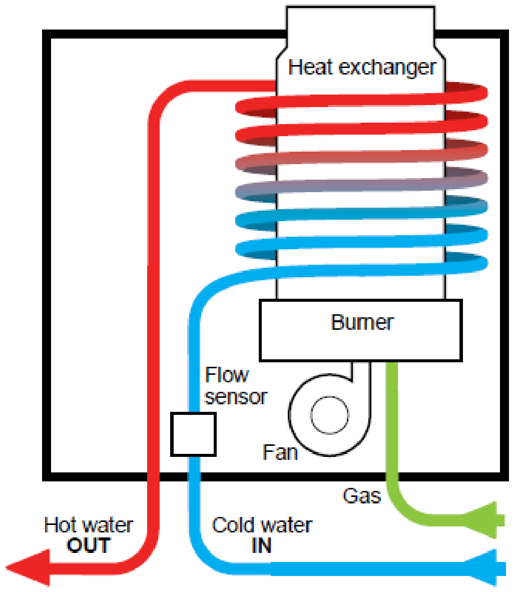
- The United Kingdom has a target to reach net zero-carbon by 2050
- In 2019 the UK government announced that gas-fired heating will not be used for new-build homes after 2025
- Improved building fabric and air tightness now resulting in DHW generation becoming the main heat load
- How can DHW generation be improved to promote net zero-carbon?

  - **Reduction in generated temperature to reduce energy input while maintaining water quality**

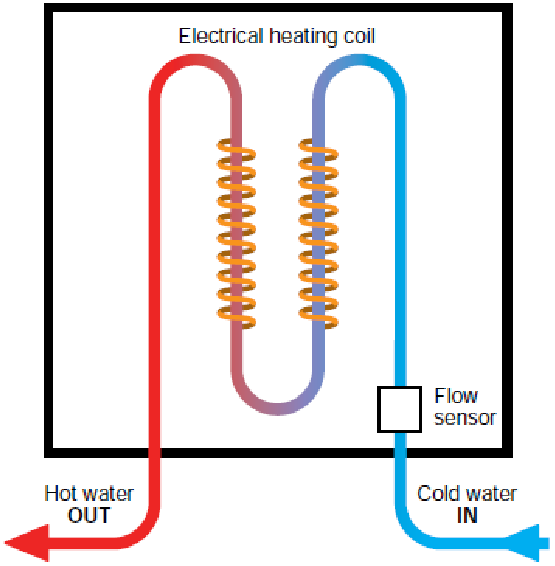
Central Storage vs Instantaneous DHW

So what are the key issues?

Instantaneous Hot Water



Combination boiler



Instantaneous water heater

Combination Boilers, District Heating HIU's etc.

Pros:

-Reduced plant space

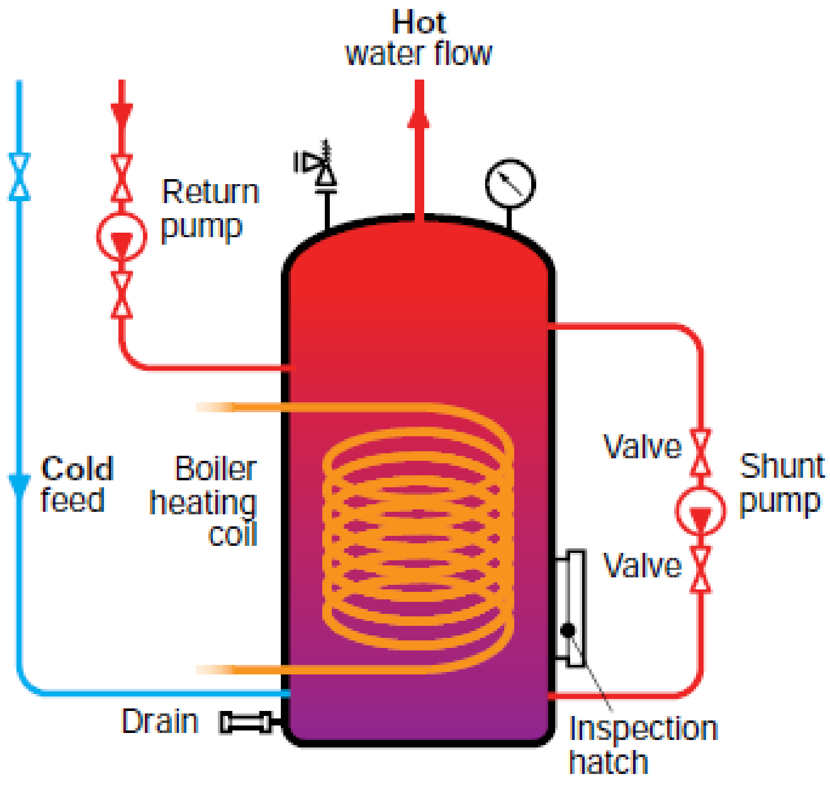
-Easier water quality control

-Single pipe DHW supply system

Cons:

-Increased energy required due to instantaneous heating?

Stored Unvented Hot Water



Central storage calorifiers etc.

Pros:

- Stored water allowing for potential boiler system down-time
- Reliable approach for thermal disinfection
- Circulating return allows for 'instantaneous hot water at point of use'

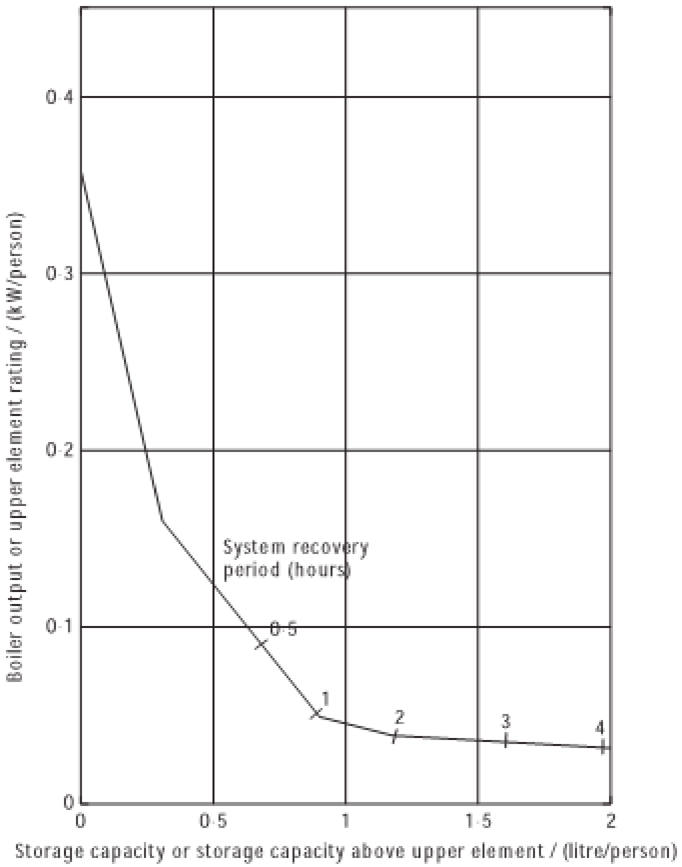
Cons:

- Incorrect sizing can lead to stagnation
- More stringent water treatment required
- Greater likelihood of limescale build-up

Stored Unvented Hot Water – Effective Sizing

Type of building	Daily (litres)	Stored (litres)	Unit
Dwellings			
- 1 bedroom	115	115	Bedroom
- 2 bedroom	75	115	Bedroom
- 3 + bedrooms	55	115	Bedroom
- Student en-suite	70	20	Bedroom
- Student, comm	70	20	Bedspce
- Nurses home	70	20	Bedspce
- Children's home	70	25	Bedspce
- Elderly sheltered	70	25	Bedroom
- Elderly care home	90	25	Bedspace
- Prison			Inmate
Hotels			
- Budget	115	35	Bedroom
- Travel Inn/Lodge	115	35	Bedroom
- 4/5 Star Luxury	135	45	Bedroom
Offices & general work places			
- with canteen	15	5	Person
- without canteen	10	5	Person
Shops			
- with canteen	15	5	Person
- without canteen	10	5	Person

Institute of Plumbing – Plumbing Engineering Services Design Guide



CIBSE Guide G

Legionella Constraints – What the Regs. State

The Water Regulations Guide:

Hot water should be stored at a temperature of not less than $60^{o}C$ and distributed at a temperature of not less than $55^{o}C$. This water distribution temperature may not be achievable where hot water is provided by instantaneous or combination boilers.

HSG 274 Part 2 –Legionnaires Disease – The control of Legionella bacteria in hot and cold water systems :

- Maintaining a supply temperature of at least $60^{o}C$ from the heat source and/or storage vessel (calorifier)

- The hot water circulating loop should be designed to give a return temperature to the calorifier from each loop of at least $50^{o}C$ ($55^{o}C$ in Healthcare premises)

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Legionella Control – Alternative measures

Alternative measures to Temperature Management for Legionella control:

‘Although temperature is the traditional and most common approach to control, sometimes there can be technical difficulties in maintaining the required temperatures, particularly in older buildings with complex water systems. Control methods including water treatment techniques when used correctly and if properly managed, can be effective in the control of legionella in hot and cold water systems’

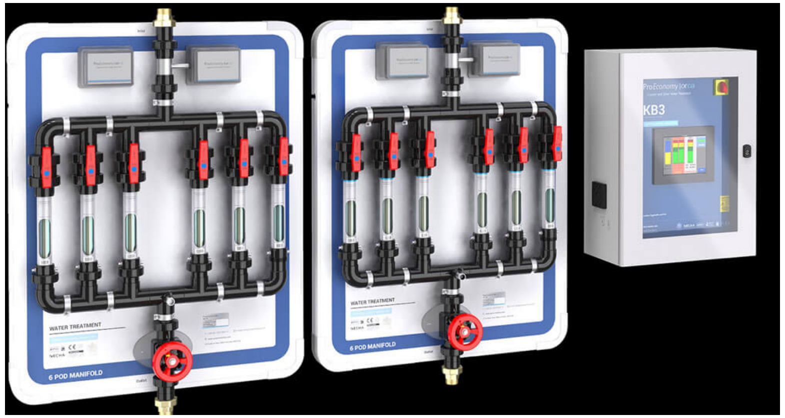
Legionella Control – Alternative measures

Alternative measures to Temperature Management for Legionella control:

Site: Great Ormond Street Morgan Stanley Clinical Building

Water Treatment:	Copper & Silver Ionisation
Study Period:	September 2011 to June 2017
Supply Temperature:	42^{o}C (average)
Sampling:	1,598 samples taken
Results:	100% L pneumophilia control 33% energy savings 24% reduction in carbon emissions

Great Ormond Street Hospital



Legionella Control – Alternative measures

The Lightbulb Moment

…so is this the answer we have all been looking for?

Chemical Treatment as opposed to Thermal treatment?

- Effectiveness of chemicals
- Maintenance regime
- Stability of supplier input
- Carbon cycle of chemicals being used

Legionella Constraints – What the Regs. State for Low Storage Units

….but what happens where low storage volume heaters are incorporated?

HSG 274 Part 2 states the following:

- *Low storage volume heaters (i.e. no greater than 15 litres) such as instantaneous units and PoU heaters may be generally regarded as lower risk.*
- *Example of low-risk situation is where hot water is fed from instantaneous heaters or low storage volume water heaters (supplying outlets at 50^{o}C)*

Legionella Constraints – What the Regs. State

HSG 274 Part 2 continues with……

Such lower risk systems:

- Should be able to achieve a peak temperature of 50° C to 60° C; and
- Recommend using temperatures <50° C only where there is high turnover (or alternative control).

Legionella Constraints – What the Regs. State

BS 8558 - The minimum delivery time to taps or fittings, which requires the design temperature at the tap to be achieved at 50^{o}C within **60 seconds** of running the water

The Water Regulations - require the temperature at the tap to be 50° C within **30 seconds** of running the water, **however this does not apply where hot water is provided by instantaneous or combination**

There is no requirement for either temperature at the tap or delivery time to the tap.

Instantaneous DHW Supply Performance

However if we generate at 50°C, what is the resultant temperature at the tap?

Pipe ∅ (mm)	Initial temp.	Purge time (s)	Heat loss (W)	Tap temp.
28	50.0°C	65	81	49.7°C
22	50.0°C	38	72	49.8°C
15	50.0°C	17	66	49.8°C
10	50.0°C	7	60	49.8°C

5l/m tap with 10m between generation point and outet

Instantaneous – Reduced Supply Temp.

Many benefits from reduced supply temperature:

- Effective incorporation of heat pump technology without requirement for thermal top-up
- Reduction in uncontrolled heat emitted from pipework (as demonstrated in following table)

  - Reduced overheating & potential discomfort to residents
  - Reduced system energy consumption
  - Reduced heating costs for residents

CIBSE

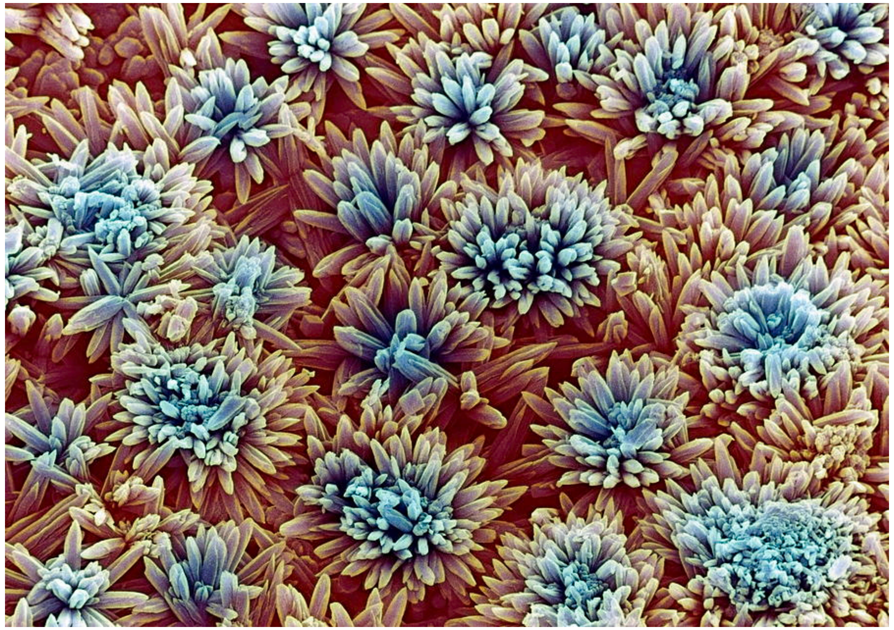
Reduced Pipework Temperature Energy Impact

	Typical practice	Recommended practice
HIU generation temperature	55°C	50°C
Heat network flow temperature	60°C	55°C
Annual heat loss per dwelling	550 kWh	496 kWh [-10%]

Calorifier Standing Heat Loss Comparison:
305 l Calorifier @ 65°C
900kWh/annum

Instantaneous – Reduced Supply Temp.

Further benefits from reduced supply temperature:



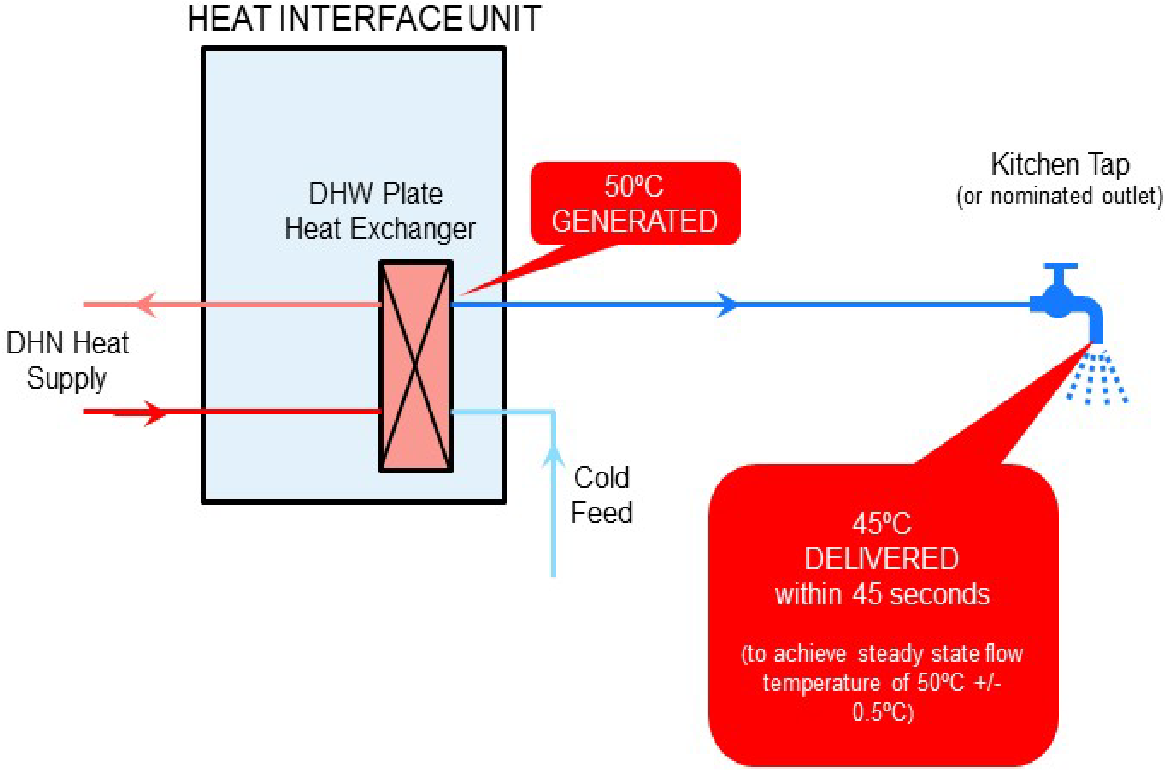
- Reduction in Limescale
  - Caused by deposits of calcium carbonate that are naturally dissolved in water
  - Reduces the performance of equipment by impeding water flow and heat transfer
  - Calcium carbonate solubility increases as the temperature of the water decreases
  - More than a 10% increase in solubility of calcium carbonate when water temperature is reduced from 55C to 50C
  - Reduction in maintenance & improvement in energy performance

Instantaneous Hot Water

….so what do I need to consider as a designer?

- Simultaneous use reduces water temperature
- If generating temperature is reduced, hot water flow rate must increase
- If pipework is undersized, flow restrictions will occur and performance reduced.
- Pipework must be sized using the correct distribution and mixed supply temperatures
- **The recommendations of reduced supply temperature do not apply to systems with vulnerable users, where it is expected that the risk assessment is appropriate to their needs**

What does BEST PRACTICE look like for **Instantaneous** Hot Water



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