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Manufacturing for Clean Heat in Scotland

Factsheet 3: Heat in Properties

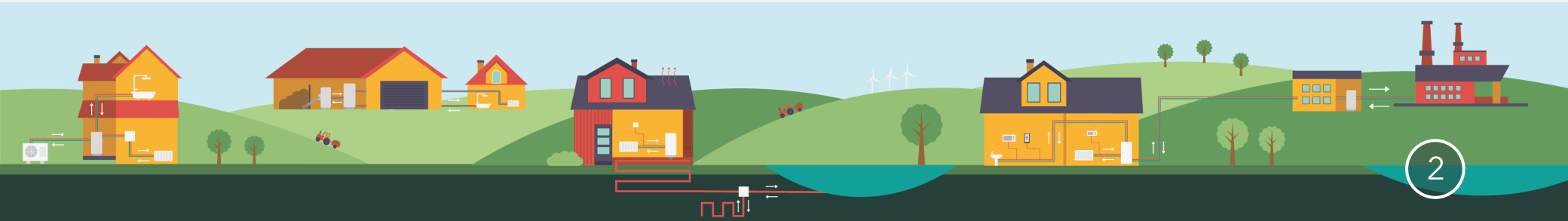
What is Clean Heat?

Clean heat refers to heat generation, distribution, and building energy efficiency technologies that provide heating and hot water with minimal environmental impact. Key technologies include heat pumps, heat networks, and direct electric systems, supported by measures to reduce heat demand and optimise usage through sensors, controls, and efficient design.

These factsheets aim to guide Scottish manufacturers to understand and enter the clean heat sector. Factsheet 3 focuses on key technologies used for heating in properties.

Factsheet 1	Factsheet 2	Factsheet 3	Factsheet 4	Factsheet 5	Factsheet 6
Heat Generation	Heat Network Distribution	Heat in Properties	Technology Enablers	Building Energy Efficiency	Energy Centre Construction
• Industrial Heat Pumps • Domestic Heat Pumps • Electrode Boilers • Electric Boilers • Geothermal Drill Rigs	• Pipework • Circulation Pumps • Valves • Corrosion Control • Storage Buffers	• Radiators • Underfloor Heating • Infrared Panels • Hot Water Cylinders • Storage Heaters	• Control Panels • Thermostats • Sensors and Meters • Actuators • Design Apps	• Cladding • Insulation • Windows & Doors • Ventilation Systems • Offsite Manufacturing	• Large Thermal Store • Large Pumps • Structural Steel • Electrical Switchgear • Cabling

Clean heat presents significant market opportunities for Scotland, UK and internationally. Clean heat is essential for all buildings to meet Scotland's 2045 net-zero target. This will be achieved via Local Heat and Energy Efficiency Strategies, regulations, and the proposed Heat in Buildings Act. Already, from April 2024, all new buildings must include clean heat systems. Existing buildings will require energy efficiency upgrades and clean heat retrofits and urban areas will see new heat networks (Heat Networks Act 2021).



Clean heat technologies in properties are designed to reduce greenhouse gas emissions and improve energy efficiency.

Key heat in property technologies include:

- Radiators
- Underfloor heating
- Infrared panels
- Hot water cylinders
- Thermal storage heaters

What are cleat heat in property technologies?

Clean heat in property technologies are systems designed to emit or store heat within a property.

Benefits of Clean Heat in Property Technologies:

The benefits of clean heat in property technologies are amplified when used in conjunction with clean energy sources.

- Radiators – Even heat distribution, quiet operation, improved air quality, durability
- Underfloor Heating – Even heat distribution, space-saving, improved air quality, comfort
- Infrared Panels – Direct heating, energy efficiency, low maintenance, health benefits, aesthetic flexibility
- Hot Water Cylinders – Reliable way to store and provide hot water for household needs. Heat can also be stored in heat batteries using phase change materials, but this specialist equipment is not included in this factsheet
- Thermal Storage Heaters – access to off-peak electricity prices, reduce peak grid demand and provide grid stability

Radiators as part of a clean heat solution can efficiently heat buildings using renewable energy sources.

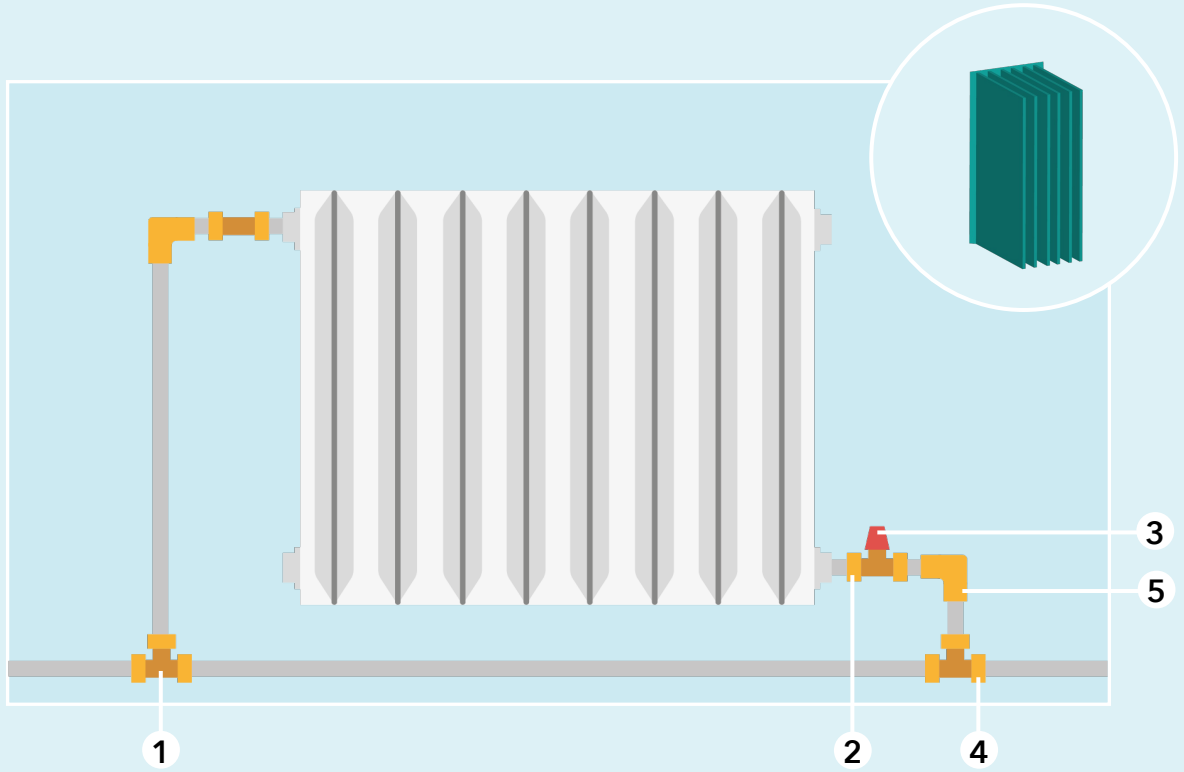


Diagram of a radiator.

Key Bill of Materials

1. 90 spigot elbow (HD4/10)
2. Radiator Drainlock
3. Thermostatic Radiator Valve
4. Pipe Clip (HX84/10)
5. 90 elbow (HD5/10)

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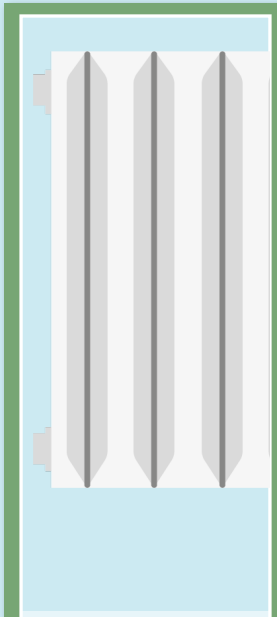
Key subcomponents of a radiator are the body panel, heating elements along with their associated pipes and valves.



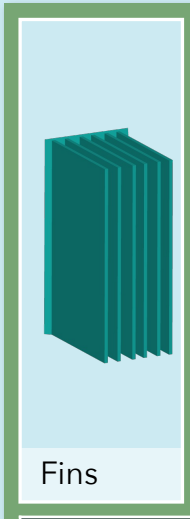
Body panels

Body Panels

These panels contribute to the radiator's appearance, protect the internal heating elements, and can direct heat output.

Some radiators also come with protective covers for child safety or aesthetic purposes.

Typical Weight	Dependent on size and material used.
Typical Dimensions	70 cm (h), 100 cm (l), 10 cm (d).
Standards	BS EN 442

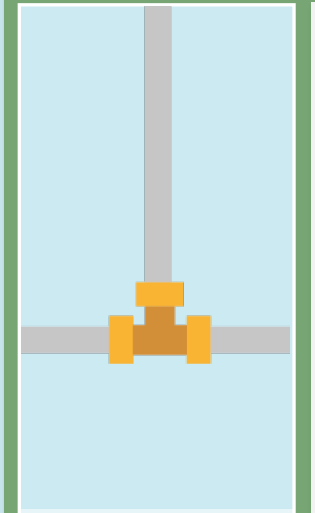


Fins

Heating Element (Fins)

The fin heating element component designed to maximise the heat transfer from the radiator to the surrounding air through convection and radiation in the surrounding air.

Typical Weight	Dependent on size and material used.
Typical Dimensions	Length and width are dependent on size and capacity of radiator. Thickness is approximately 0.3mm to 1mm.
Standards	BS EN 442

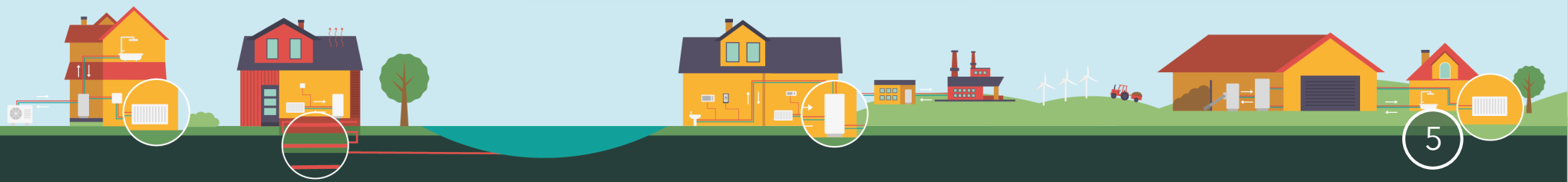


Pipes and valves

Pipes and Valves

Inlet valve controls flow of hot water or steam from heating system into radiator. Outlet valve allows water or steam to exit radiator and return to heat source. Bleed valve used to remove air trapped inside radiator.

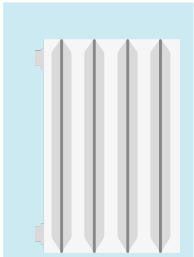
Subcomponents	Inlet and outlet valves, bleed valve, caps/plugs.
Typical Weight	0.5 kg to 1 kg
Typical Dimensions	15 mm (diam).
Standards	BS EN 442, BS EN 14236, EN 12828, EN 378



The typical manufacturing processes are detailed below for the assembly of a radiator.

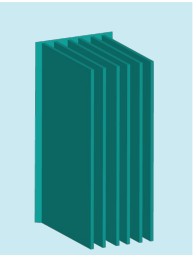
Component Manufacture → Forming → Welding → Assembly → Testing and Quality Control → Finishing and Coating

Body Panel and Heating Element (Fins): Manufacturing Process



Body panel

Cutting and Shaping: Raw materials are cut and shaped into the required components to be formed → **Forming:** Components formed into final shapes using bending, rolling, and stamping → **Assembly:** Connectors, wall mounts and formed parts, such as the casing → **Testing and Quality Control:** Tested mechanically and under temperature operational conditions → **Finishing and Coating:** Coated with protective layer and painted to protect against corrosion and wear.



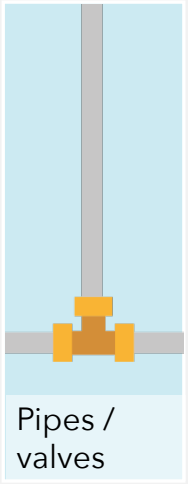
Fins

Cutting and Shaping: Materials cut and shaped into the required components to be formed → **Forming:** Components formed into final shapes using bending, rolling, and stamping → **Welding:** Components welded to form assemblies of plate packs → **Assembly:** Assembled into heat exchanger. Including gaskets, seals, and critical components → **Testing and Quality Control:** Components undergo quality checks to meet specifications and performance standards

The typical manufacturing processes are detailed below for the assembly of a radiator.

Component Manufacture → Casting → Machining → Assembly → Finishing and Coating → Testing and Quality Control

Pipes and Valves: Manufacturing Process



Pipes / valves

Casting: The expansion valve body is created using casting or forging methods

Machining: Precision machining, such as CNC, used to create intricate valve parts, including the orifice, stem and seat

Assembly: Machined parts are assembled. This includes fitting the diaphragm, spring, and components that regulate the operation of the valves and pipes

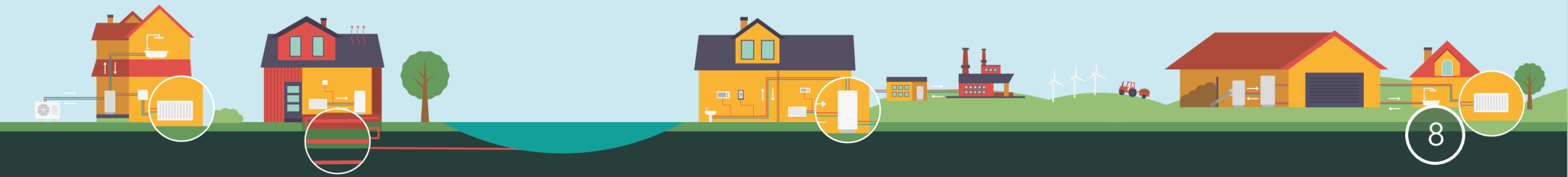
Cleaning and Surface Treatment: Valves and pipes are thoroughly cleaned. Electroplating or passivation may be applied to enhance corrosion resistance

Testing and Quality Control: Valves and pipes tested for leaks, pressure tolerance, and operation. Calibration ensures valve opens and closes correctly

Main materials and characteristics used radiator manufacturing.

	Component	Material	Dimensions*	Weight*	Standards
Body Panel	Casing	Steel or Cast Iron	70 cm (w), 100 cm (l), 10 cm (d)	1 kg to 3 kg	BS EN 442
	Wall mounts	Steel or Cast Iron	5 cm to 10 cm (w), 5 cm to 10 cm (l), 5 cm to 10 cm (d)	0.05 kg to 0.1 kg	BS EN 442
	Protection (optional)	Paint coating	-	Negligible	BS EN ISO 12944, BS 3962-6, EN 71-3
Heating Element	Fins	Steel or Aluminium	0.3 mm to 1 mm (t)	0.1 kg to 0.3 kg	BS EN 442
Pipes & Valves	Pipe / Valve Body	Stainless Steel or Brass	0.01 m to 0.15 m (d), 0.05 m to 0.3 m (l)	0.2 kg to 2 kg	ISO 5149, EN 378
	Diaphragm	Rubber or Synthetics	0.025 m to 0.15 m (d), 0.0025 m to 0.005 m (t)	0.02 kg to 0.2 kg	ISO 5149, EN 378
	Spring	Various	0.01 m to 0.05 m (d), 0.0025 m to 0.15 m (l)	0.01 kg to 0.1 kg	ISO 5149, EN 378
	Orifice	Stainless Steel or Brass	0.0005 m to 0.01 m (d), 0.005 m (l)	0.005 kg to 0.05 kg	ISO 5149, EN 378

***The dimensions and weights are approximate and can vary based on the specific requirements of the materials and the manufacturer's design standards.**



Underfloor heating offers high energy efficiency, reduced emissions, and enhanced safety, whilst minimising maintenance.

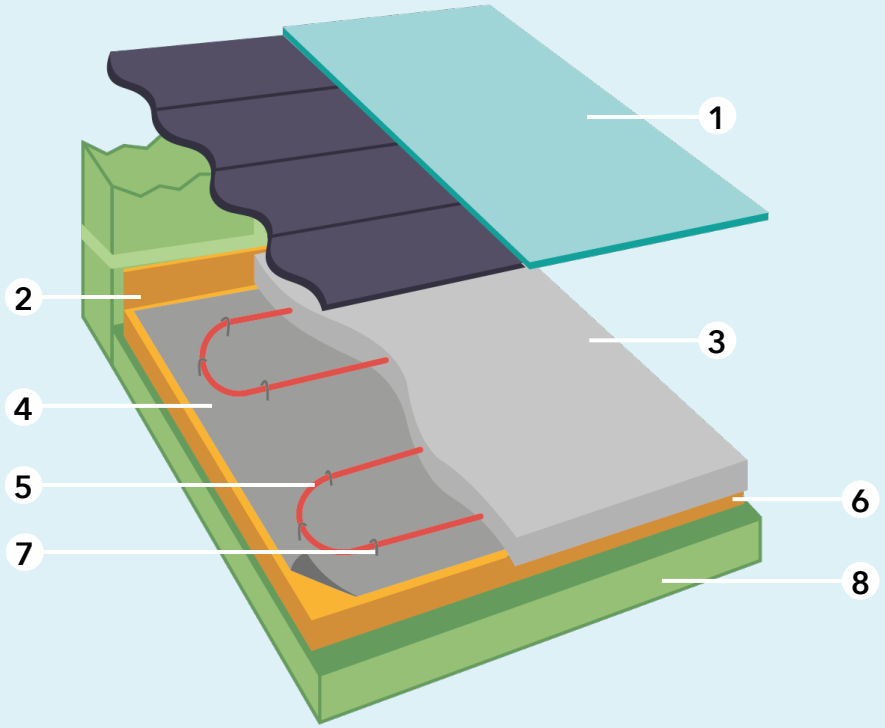
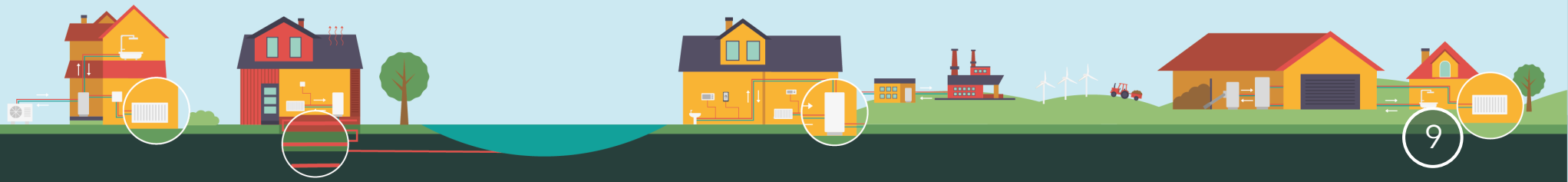


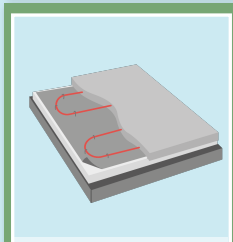
Diagram of underfloor heating.

Key Bill of Materials

1. Floor finish
2. Perimeter insulation
3. Screed
4. Slip layer
5. WARMUS 16x2 MLC pipe
6. Floor insulation
7. UFH clips
8. Acoustic layer (if required)



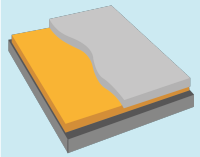
Key subcomponents of underfloor heating are shown below, along with their key parameters.



Heating Elements

Heating Elements (Pipes and Valves)
A network of pipes embedded under the floor surface; they carry warm water across the floor area.

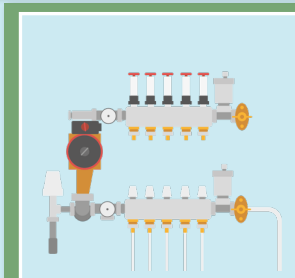
Subcomponents	Polyethylene pipes
Typical Weight	0.1 kg / m for 16 mm (diam) pipe
Typical Dimensions	12 mm to 20 mm (diam) (16mm most common), spacing typically 200mm, these values are highly dependent on designed heat output, floor type and room insulation.
Standards	BS EN 1264, BS 5955-8, ISO 11855, ISO 10508



Insulation Layers

Insulation Layers
Prevent heat loss to the ground or subfloor, directing the heat upward into the room, enhancing energy efficiency and reducing heating costs.

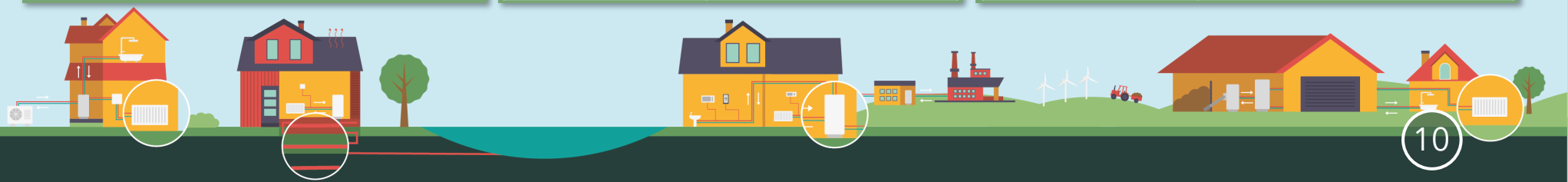
Subcomponents	Polymer mortar, hard foam boards, bottom reflective insulation foil.
Typical Weight	1 kg to 2.5kg / m^2 for foil-faced EPS/XPS
Typical Dimensions	Covers full floor area, 30 mm thickness on average
Standards	BS EN 1264, BS 5955-8, BS EN 12086, ISO 11855, ISO 6946.



Manifold

Manifold
Acts as the central distribution hub that regulates the flow of heated water from the boiler or heat source to various underfloor heating circuits.

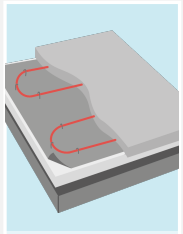
Subcomponents	Supply and return pipes, flowmeters, valves
Typical Weight	5 kg to 8 kg (brass) or 3 kg to 6 kg (stainless steel) for an average of 4-6 circuits
Typical Dimensions	50 cm x 50 cm x 15 cm for an average of 4-6 circuits
Standards	BS EN 1264, BS EN 12165, BS EN 14324



The typical manufacturing processes are detailed below for the assembly of an underfloor heating system.

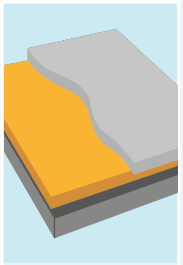
Component Manufacture → Extrusion → Forming → Subassembly → Sizing and Cutting → Testing and Quality Control

Heating Element and Insulation Layer : Manufacturing Process



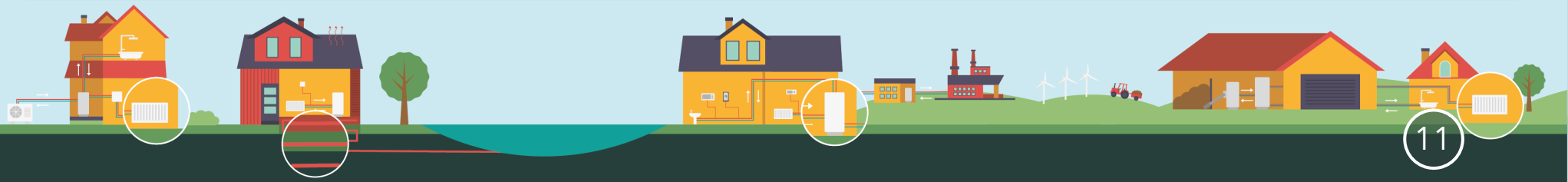
Heating Element

Plasticising and Extrusion: The Polyethylene resin is conveyed, compressed, melted and homogenised → **Forming:** The Polyethylene resin is then passed through a die to create a hollow pipe → **Cooling and Shaping:** Shaped by the vacuum cooling tank, the inside of the pipe is spray cooled, setting the shape. → **Sizing and Cutting:** Measured for uniform diameter and wall thickness, then the pipes are cut using a planetary cutting machine. → **Testing and Quality Control:** Pressure and temperature testing, Impact and flexibility testing and dimensional checks.



Insulation Layer

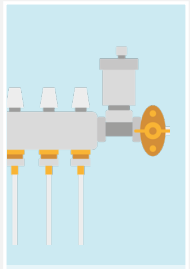
Plasticising and Extrusion: Polystyrene is produced by mixing with blowing agents and forcing the mixture through an extruder. → **Forming and Curing:** The foam is formed into a rigid board. Then undergoes a curing process to solidify and bond the cells. → **Foil Lamination:** The foam is passed through a lamination line where reflective aluminium foil is applied. The foam is then cured. → **Cutting and Trimming:** The laminated foam blocks or continuous sheets are cut to the desired dimensions. → **Testing and Quality Control:** Visual inspection, density and thermal testing, adhesion testing, mechanical strength testing.



The typical manufacturing processes are detailed below for the assembly of an underfloor heating system.

Component Manufacture → Casting → Machining → Assembly → Finishing and Coating → Testing and Quality Control

Manifold Pipes, Valves and Pump : Manufacturing Process



Manifold pipe / valve

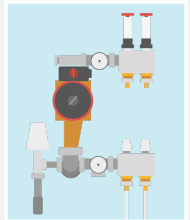
Casting: The pipes and valves are created using casting or forging methods

Machining: Precision machining, such as CNC, used to create intricate pipe and valve parts, including the orifice, stem and seat

Assembly: Machined parts assembled. This includes fitting the diaphragm, spring, and components that regulate the valve's operation

Cleaning and Surface Treatment: Thoroughly cleaned. Electroplating or passivation applied to enhance corrosion resistance

Testing: Tested for leaks, pressure and operation. Calibration ensures valve opens / closes at correct pressure and temperature



Manifold pump

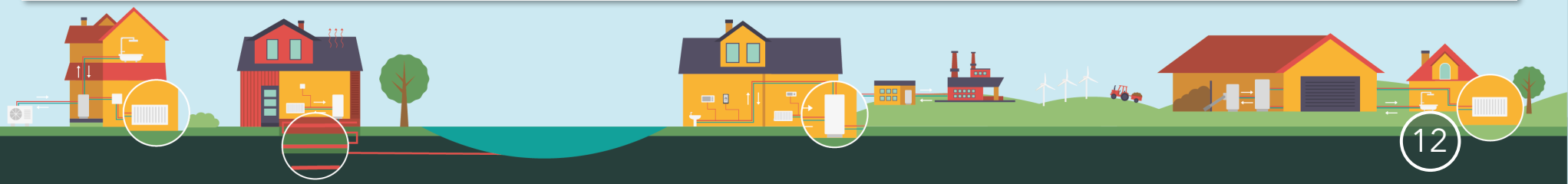
Casting: Pump casing and impeller are cast from metals such as stainless steel or cast iron

Machining: After casting, components machined to precise dimensions. To include drilling, milling

Subassembly: Machined parts assembled into subassemblies, such as the pump housing and rotor assembly

Assembly: Subassemblies put together to complete pump. Includes installing seals, bearings, and other critical components

Testing: The assembled pump is tested under operational conditions.



Main materials and characteristics used in underfloor heating manufacturing.

	Component	Material	Dimensions*	Weight*	Standards
Insulation Layer	Reflective Foil	Aluminium	Dependent on requirements	Dependent on requirements	BS EN 1264, ISO 8302
Heating Element	Inner PEX	Cross-linked Polyethylene	12 mm to 20 mm (diam)	Dependent on requirements	BS EN 1264, BS EN 60335-2-96
	Core	Aluminium			
	Outer PEX	Cross-linked Polyethylene			
Manifold Pump	Pump Casing	Stainless Steel or Cast Iron	0.1 m to 0.6 m (diam), 0.15 m to 1.5 m (l)	1 kg to 3 tonnes	ISO 5199, ANS/HI 9.6.1
	Impeller	Bronze or Stainless Steel	0.5 m to 0.4 m (diam), 0.05 m to 0.3 m (l)	0.2 kg to 500 kg	ISO 9906
	Motor	Copper, Steel and Carbon	0.1 m to 0.5 m (diam), 0.15 m to 1 m (l)	2 kg to 3 tonnes	IEC 60034
	Shaft	Carbon or Stainless Steel	0.1 m (diam), 0.1 m to 0.3 m (l)	0.1 kg to 500 kg	ISO 1940
Manifold Pipe & Valves	Body	Stainless Steel or Brass	0.01 m to 0.15 m (diam), 0.05 m to 0.3 m (l)	0.2 kg to 2 kg	ISO 5149, EN 378
	Diaphragm	Rubber or Synthetics	0.025 m to 0.15 m (diam), 0.0025 m to 0.005 m (t)	0.02 kg to 0.2 kg	
	Spring	Various	0.01 m to 0.05 m (diam), 0.0025 m to 0.15 m (l)	0.01 kg to 0.1 kg	
	Orifice	Stainless Steel or Brass	0.0005 mm to 0.01 m (diam), 0.005 m (l)	0.005 kg to 0.05 kg	

***The dimensions and weights are approximate and can vary based on the specific requirements of the materials and the manufacturer's design standards.**

Infrared heating panels offer high efficiency, reduced emissions, and enhanced safety, whilst minimising maintenance.

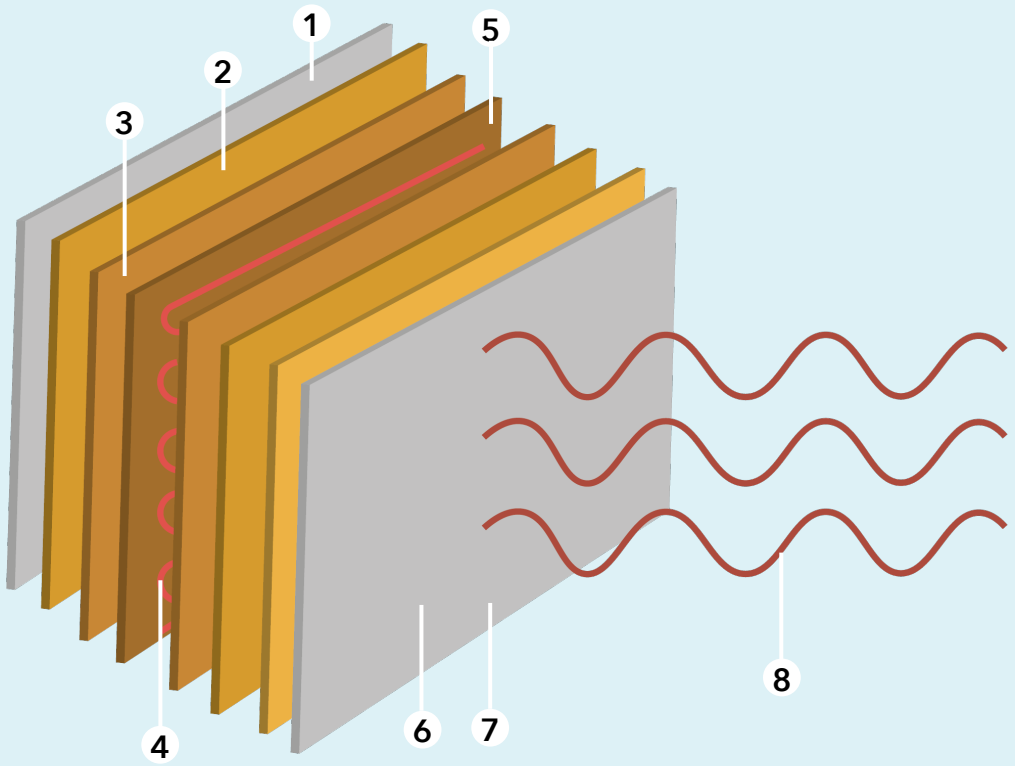
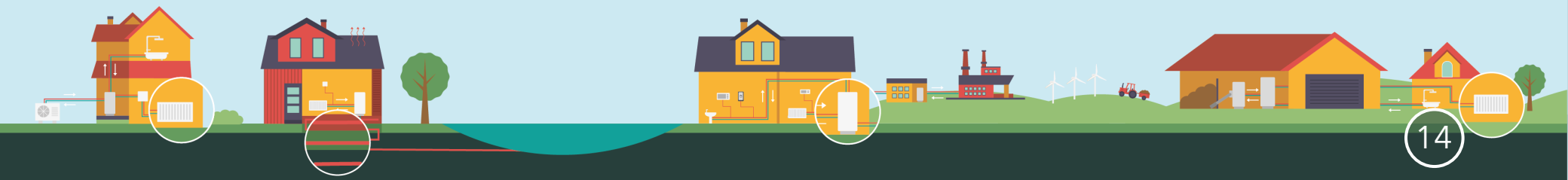


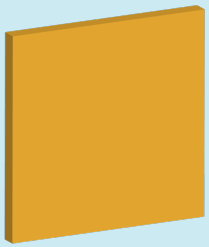
Diagram of infrared heating panels.

Key Bill of Materials

1. Metal case with double layer of paint
2. Protective layer
3. Thermal insulation
4. Ceramic heating element
5. Heat-dissipating quartz layer
6. Front temperature up to 80°C
7. Back temperature up to 50°C
8. Infrared long wave heating



Key subcomponents of infrared heating panels are shown below, along with their key parameters.

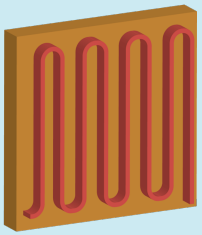


Insulation Layers

Insulation Layers

These layers directs heat outward, ensuring minimal energy loss to the back or sides of the panel, hence increasing energy efficiency.

Subcomponents	Reflective layer, insulation
Typical Weight	Dependent on size and material used.
Typical Dimensions	100 cm x 60 cm for an average infrared panel
Standards	ISO 8302

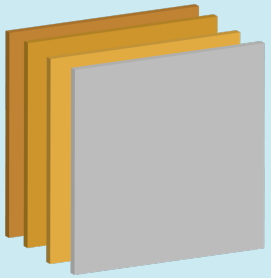


Heating Element

Heating Element

The heating element converts electrical energy into heat and emits infrared radiation in the desired wavelength range.

Subcomponents	Heating element core, substrate, electrical insulation
Typical Weight	Dependent on size and material used.
Typical Dimensions	Dependent on size
Standards	BS EN 60335-2-96, BS EN 55014

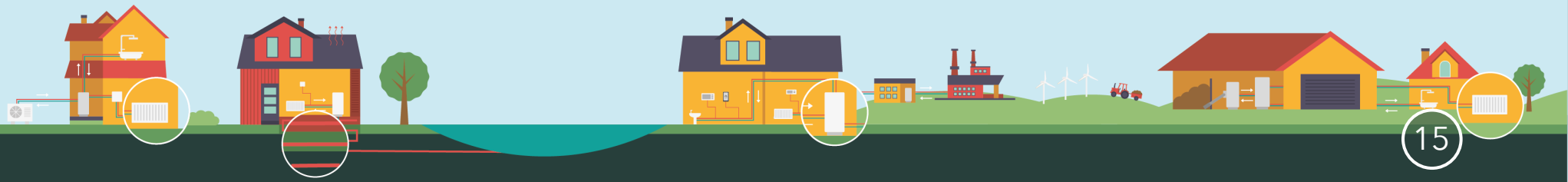


Structural Parts

Structural Parts

Serve as the supporting structure for panels.

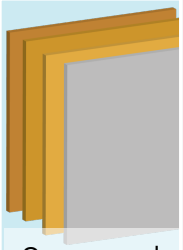
Subcomponents	Backing plate, surface layer, outer frame, mounting & supports
Typical Weight	Dependent on size and material used.
Typical Dimensions	100 cm x 60 cm for an average infrared panel
Standards	BS EN ISO 10456



The typical manufacturing processes are detailed below for the assembly of an infrared heating panel system.

Component Manufacture → Forming → Subassembly → Assembly → Testing and Quality Control → Finishing and Coating

Structural Parts and Heating Element: Manufacturing Process



Structural Parts

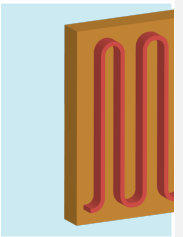
Component Manufacture: Selected materials are cut and shaped into the required components to be formed

Forming: Components formed into final shapes using bending, rolling, and stamping

Assembly: Connectors, wall mounts and formed parts, such as the casing

Testing and Quality Control: Body panel is tested mechanically and under temperature operational conditions

Finishing and Coating: Body panel is coated with protective layer and painted to protect against corrosion.



Heating Element

Component Manufacture: Element materials are drawn into wires of the desired diameter

Forming: Element formed into final shapes and size using coiling

Insulation and Encapsulation: Coiled wire is insulated and encapsulated in a protective cover

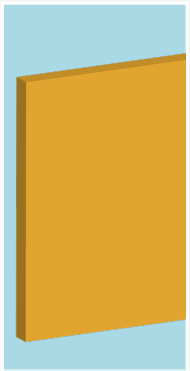
Assembly: Encapsulated element is assembled into heat the infrared panel to ensure uniform heat distribution

Testing and Quality Control: Panels tested for electrical continuity, insulation, resistance and functionality

The typical manufacturing processes are detailed below for the assembly of an infrared heating panel system.

Component Manufacture → Extrusion → Forming → Lamination → Cutting and trimming → Testing and Quality Control

Insulation Layer: Manufacturing Process



Insulation Layer

Plasticising and Extrusion: Polystyrene is produced by mixing with blowing agents and forcing the mixture through an extruder under high pressure.

→ **Forming and Curing:** The foam is formed into a continuous rigid board. The foam then undergoes a curing process to solidify and bond the cells

→ **Foil Lamination:** The foam is passed through a lamination line where reflective aluminium foil is applied using an adhesive. The foam is then cured.

→ **Cutting and Trimming:** The laminated foam blocks or continuous sheets are cut to the desired dimensions using hot wire cutters or precision saws

→ **Testing:** Visual inspection, density and thermal testing, adhesion testing, mechanical strength testing.

The table below summarises the key design data required for infrared heating panel manufacturing.

	Component	Material	Dimensions*	Weight*	Standards
Structural parts	Backing plate	Aluminium or Steel	100 cm (l) x 60 cm (w) x 0.2 cm (d)	2 kg to 5 kg	BS EN ISO 10456
	Surface layer	Tempered glass, Aluminium, Ceramic	100 cm (l) x 60 cm (w) x 0.2 cm (d)	2 kg to 5 kg	
	Outer frame	Aluminium or Stainless Steel	100 cm (l) x 60 cm (w) x 0.2 cm (d)	2 kg to 5 kg	
	Mounting & supports	Aluminium or Stainless Steel	10 cm to 20 cm (l), 0.2 to 0.4 mm (d)	0.5 kg to 1 kg	
Heating Element	Substrate	Nichrome Alloy (Nickel-Chromium), Carbon Fibre or Ceramic	Dependent on system requirements	Dependent on system requirements	BS EN 60335-2-96, BS EN 55014, BS EN 60335-2-30
	Electrical insulation	Magnesium Oxide			
Insulation Layer	Insulation	Fibreglass or Mineral wool	100 cm (l) x 60 cm (w) x 2.5 cm (d)	1 kg to 6 kg / m^2	ISO 8302
	Reflective layer	Aluminium	100 cm (l) x 60 cm (w)	0.5 kg to 1 kg / m^2	

***The dimensions and weights are approximate and can vary based on the specific requirements of the materials and the manufacturer's design standards.**

Hot water cylinders store hot water and can enable grid flexibility services (see page 3).

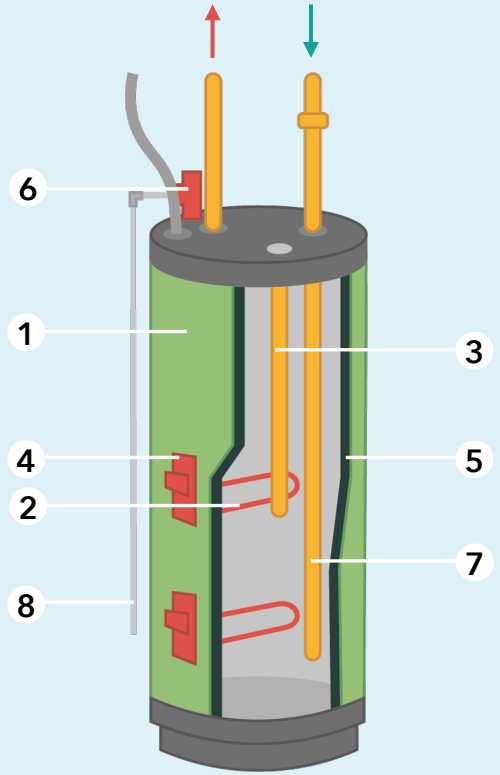


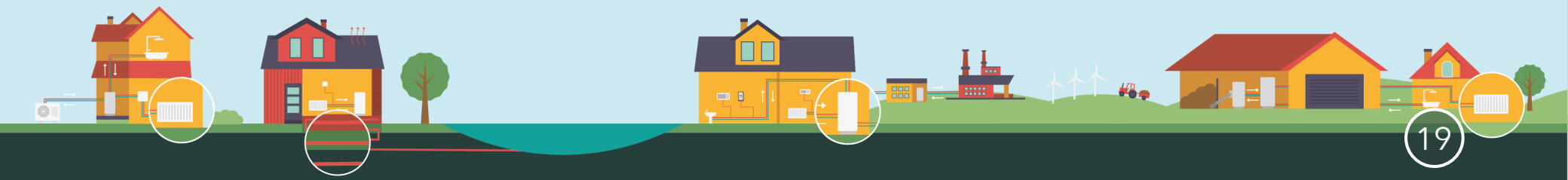
Diagram of a hot water cylinder.

Key Bill of Materials

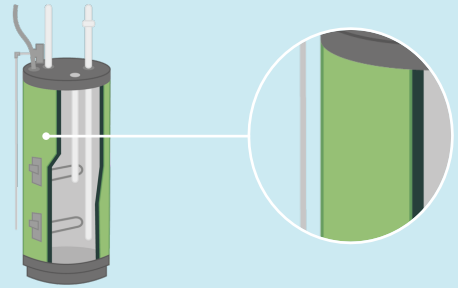
1. Cylinder Shell
2. Heating Element
3. Anode Rod
4. Thermostat
5. Insulation
6. Relief Valves
7. Dip Tube
8. Overflow Pipe

Cold water in

Hot water out



Key subcomponents of hot water cylinder are shown below.

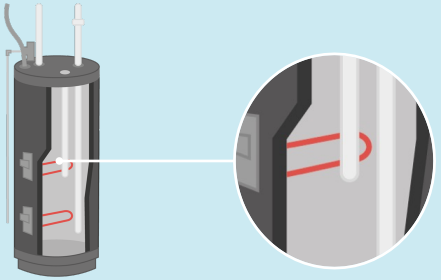


Cylinder Shell

Cylinder Shell

Closed metal vessels for heating and storing water under variable pressure.

Subcomponents	Insulation, Anode rod, dip tube, thermostat, safety devices
Typical Weight	30 kg to 40 kg (150 litre stainless steel cylinder)
Typical Dimensions	0.5 m to 2 m (d), 1 m to 3 m (l)
Typical Capacity	90 litres to 300 litres
Standards	BS 1566, BS 3198, BS 6700



Heating Element

Heating Element

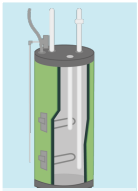
Immersion heating elements that convert electrical energy into heat.

Subcomponents	Metal sheath, resistance wire, insulation, thermostat, safety sensor
Typical Dimensions	Generally small and lightweight. Typically, up to a kilogram each.
Standards	BS EN 60335-2-21

The typical manufacturing processes for the assembly of a hot water cylinder.

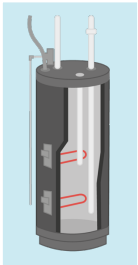
Component Manufacture → Subassembly → Electrical Component Assembly → Testing and Quality Control → Finishing and Packaging

Water Cylinder and Heating Element: Manufacturing Process



Water Cylinder

Cutting and Shaping: Raw materials are cut and shaped using bending and rolling → **Welding:** High quality welding is crucial to provide a watertight cylinder → **Assembly:** Parts such as the heating element, thermostat, anode rod, pipework are installed → **Testing:** Cylinder is pressure tested under to verify performance → **Finishing and Coating:** Surface treatments such as coating to protect against corrosion and wear



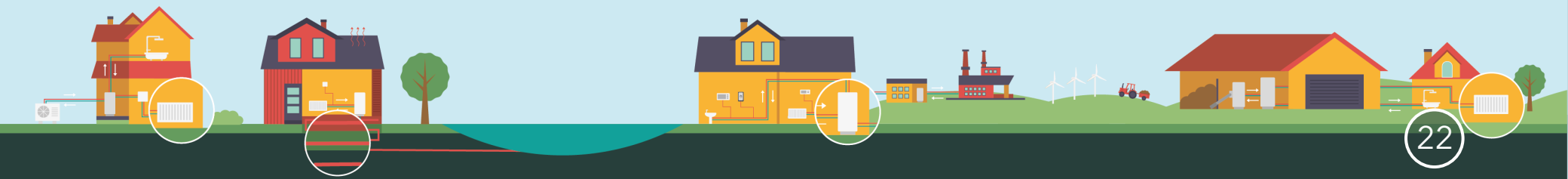
Heating Element

Cutting and Shaping: Raw materials are cut and shaped into the required components, such as heating elements → **Forming:** The heating element wire wound into a coil. To ensure even heat distribution and efficient performance → **Assembly:** Element component obtained by insulating, sheathing, compaction, sealing and annealing → **Testing:** Element tested for electrical compliance: Electrical Resistance Insulation Resistance High Voltage → **Finishing and Coating:** Fittings/connectors to integrate into cylinder system. To include mounting brackets or other hardware

Main materials and characteristics used in hot water cylinder manufacturing.

Component	Material	Dimensions	Weight	Standards
Cylinder Shell	Stainless Steel, Copper	0.5 to 2 m	Tens of kilograms	BS 6700, BS EN 12897
Electric Heating Elements	Copper, Stainless Steel	0.5 m	0.5 kg to 1 kg	IEC 60335-2-21 for safety of Electric Heating Elements
Anode Rod	Magnesium, Aluminium	0.02 m (d) x 1 m (l)	1 kg to 2 kg	ASTM B843 for magnesium alloy anodes
Safety Valves	Stainless Steel, Brass	0.1 m	Few kg	ASME BPVC Section VIII for pressure relief devices
Thermostat	Plastic, Copper, Stainless Steel	0.1 m	0.1 kg to 0.2 kg	IEC 60730-1

***The dimensions and weights are approximate and can vary based on the specific requirements of the materials and the manufacturer's design standards.**



Thermal Storage Heaters offer access to cheaper electricity tariffs making the transition to an electric solution affordable.

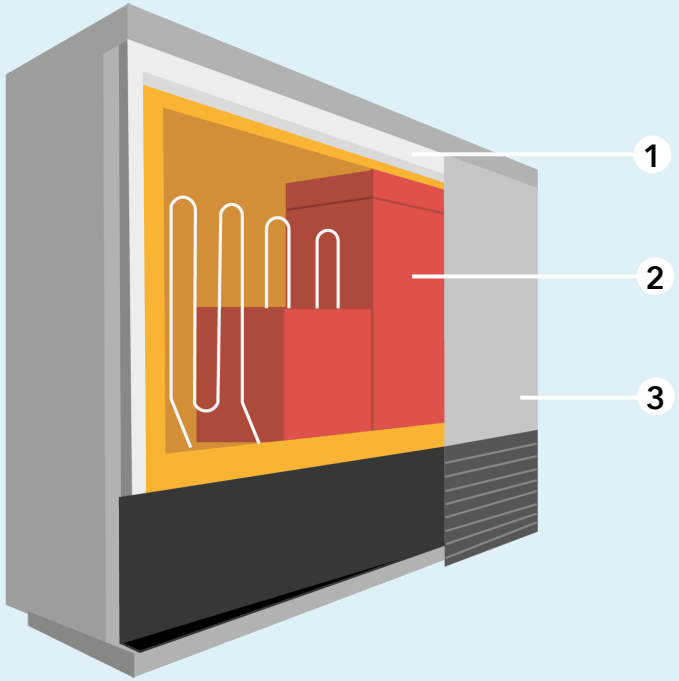
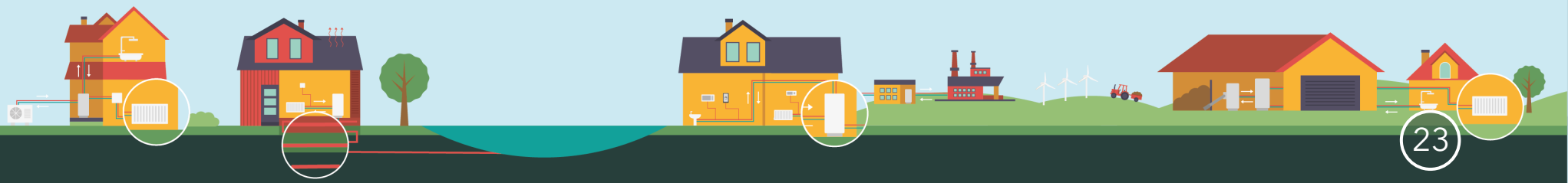


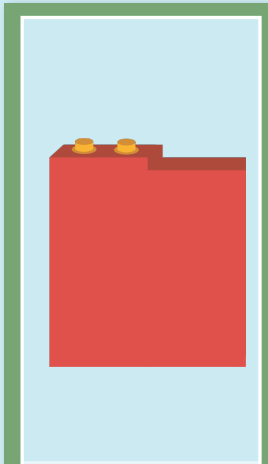
Diagram of a thermal storage heater.

Key Bill of Materials

1. Vacuum Insulation Panels
2. Heat Battery
3. Aluminium Case



Key subcomponents of thermal storage heaters are shown below, along with their key component parameters.

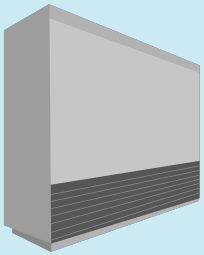


Heat Battery

Heat Battery

Stores and releases high thermal energy using high heat retention storage materials

Subcomponents	Heat retention materials, Insulation
Typical Weight	20 kg to 200 kg
Typical Dimensions	0.5 m to 1 m (h,w,l)
Standards	BS EN 60335-1, BS EN 303-5

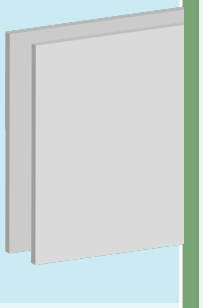


Aluminium Case

Aluminium Case

A white powder-coated aluminium case, which offers pipework knockouts on any face for easy installation.

Subcomponents	Supply and return pipes, flowmeters, valves, pipes.
Typical Weight	5 kg to 10 kg
Typical Dimensions	Dependent on use case
Standards	BS EN 1264, BS EN 12165, BS EN 14324



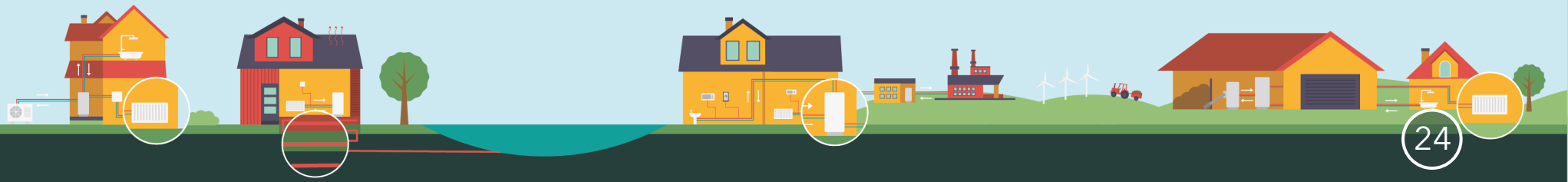
Vacuum Insulation Panels

Vacuum Insulation Panels

An insulation panel providing low internal pressure and low density contributing to high thermal performance.

Heat resistance: -50°C to +120°C

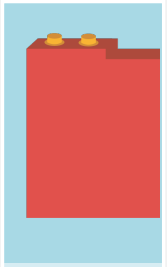
Subcomponents	Microporous material
Typical Weight	0.75 kg to 1.5 kg
Typical Dimensions	Covers full area, 20 mm thickness as minimum
Standards	DIBT Z-23.11-1662



Typical manufacturing processes for the assembly of thermal storage heaters and the fabrication of the major components.

Materials Selection → Forming → Subassembly → Final Assembly → Testing and Quality Control

Heat Battery and Vacuum Insulation Panels : Manufacturing Process



Heat Battery

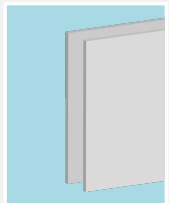
Materials Preparation: High quality materials e.g., ceramics and concrete are chosen, with mixers used to combine materials

Forming: Materials are molded into forms, such as bricks or blocks. Some materials are extruded to create the required shapes.

Drying and Curing: Moisture is removed from using drying ovens. They are then hardened by curing

Coating and Finishing: Conductive or protective coatings are applied to enhance performance.

Testing and Quality Control: The thermal performance, efficiency and durability of the heat batteries are validated



Vacuum Insulation Panels

Forming: Core insulation material is shaped and prepared to fit panel dimensions

Encapsulation: The core material is placed inside a multi-layer barrier film, which is sealed to create an airtight enclosure

Evacuation: Panel is placed in a vacuum chamber to create a vacuum inside the panel. Then panel is sealed.

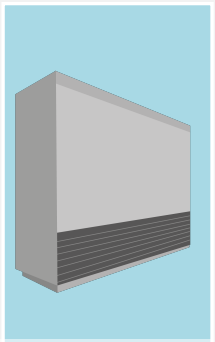
Quality Control: Panel is tested for vacuum integrity and panel tested to verify thermal insulation properties

Integration: Panels integrated into thermal energy storage system, ensuring proper placement

Typical manufacturing processes for the assembly of thermal storage heaters and the fabrication of the major components.

Materials Selection → Forming → Subassembly → Final Assembly → Testing and Quality Control

Aluminium Case manufacturing process



Aluminium Case

Materials Selection: The material is cut and prepared to the required dimensions

Forming: The material is cast, extruded, or formed to create the required shapes

Machining: The parts are cut, drilled and finished using CNC machines, with surface finishing applied to enhance quality and reduce corrosion

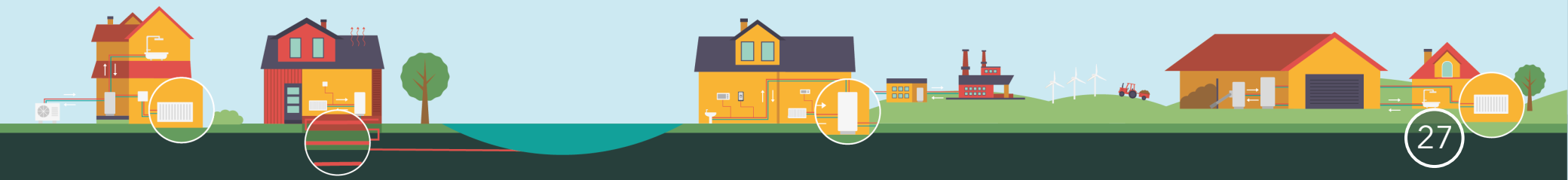
Assembly: Parts are joined using welding and fastening to assemble finished casing

Testing and Quality Control: Parts tested to meet thermal performance, dimensions and tolerances

Main materials and characteristics used in thermal storage heater manufacturing.

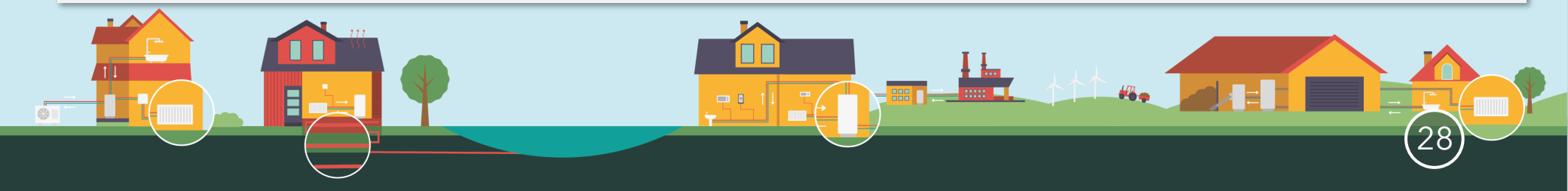
	Component	Material	Dimensions*	Weight*	Standards
Thermal Energy Storage	Heat Battery	Ceramics, Concrete, Masonry	Capacity – 70 to 300 litres 0.7 m to 1.5 m (h) x 0.3 m to 0.6 m (w) x 0.3 m to 0.6 m (d)	20 kg to 200 kg	BS EN 60335-1, BS EN 303-5
	Vacuum Insulation Panel	Polyethylene (PE), Polyethylene terephthalate (PET), Polyurethane, Glass Fibre, Fused Silica	Thickness – 20 mm to 50 mm Panel Size – 1 m (w) x 1.3 m (h)	0.75 kg to 1.5 kg	DIBT Z-23.11-1662
	Casing	Aluminium	Dependant on use	Dependent on use	ISO 9001

***The dimensions and weights are approximate and can vary based on the specific requirements of the materials and the manufacturer's design standards.**



The table below summarises the key processes and equipment required for radiator manufacturing.

Process	Equipment/Facilities	Body Panel	Heating Element (fins)	Pipes and Valves
Storage and Logistics	Shelving and Racking systems, Forklifts, Conveyors, Warehouse Management Systems	X	X	X
Casting	Furnaces, Molds, Casting Machines	X	X	X
CNC Machining	CNC Machining Centres, CNC Lathes, CNC Plasma Cutting Machines, CNC Grinders,	X	X	X
Milling, Drilling and Turning	CNC Drilling Machines, CNC Boring Mills	X	X	X
Tube/Pipe Forming and Bending	CNC Tube Benders, Roll Bending Machines, Press Benders	X		X
Sheet Metal Forming and Bending	Press Brakes, Stamping Presses, Folding machines	X	X	X
Welding, Brazing and Soldering	Welding Machines, Cutting Torches, Fabrication Tools, Furnace	X		X
Electronic Controls, Cabling and Wiring	Motors, PCB's, HMI & Various Components, Connectors, Cable, Insulation		X	
Assembly Line	Conveyors, Robotic Systems, Assembly Machines	X	X	X
Final Test & QA	Vision Inspection, EOL testing	X	X	X

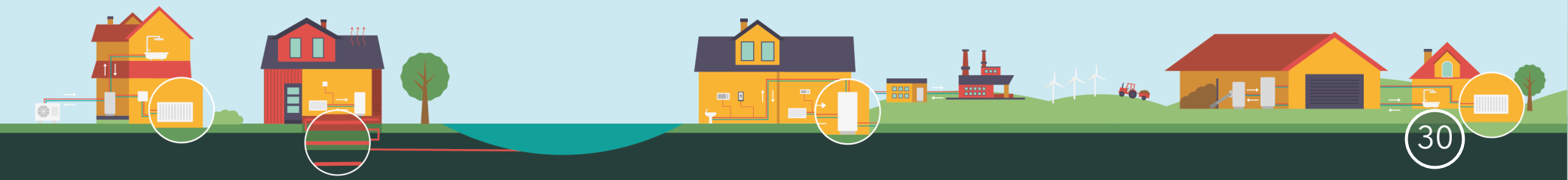


The table below summarises the key processes and equipment required for underfloor heating manufacturing.

Process	Equipment/Facilities	Heating Element	Insulating Layers	Manifold Pump	Manifold Pipes & Valves
Storage and Logistics	Shelving and Racking Systems, Forklifts, Conveyors, Warehouse Management Systems	X	X	X	X
Casting	Furnaces, Molds, Casting Machines	X		X	
CNC Machining	CNC Machining Centres, CNC Lathes, CNC Grinders,	X		X	X
Milling, Drilling and Turning	CNC Drilling Machines, CNC Boring Mills	X		X	X
Tube/Pipe Forming and Bending	CNC Tube Benders, Roll Bending Machines, Press Benders	X		X	X
Sheet Metal Forming and Bending	Press Brakes, Stamping Presses, Folding Machines	X		X	X
Welding, Brazing and Soldering	Welding Machines, Cutting Torches, Fabrication Tools, Furnace	X		X	X
Electronic Controls, Cabling and Wiring	Motors, PCB's, HMI & Various Components, Connectors, Cable, Insulation	X		X	X
Assembly Line	Conveyors, Robotic Systems, Assembly Machines	X	X	X	X
Final Test & QA	Vision Inspection, EOL testing	X	X	X	X

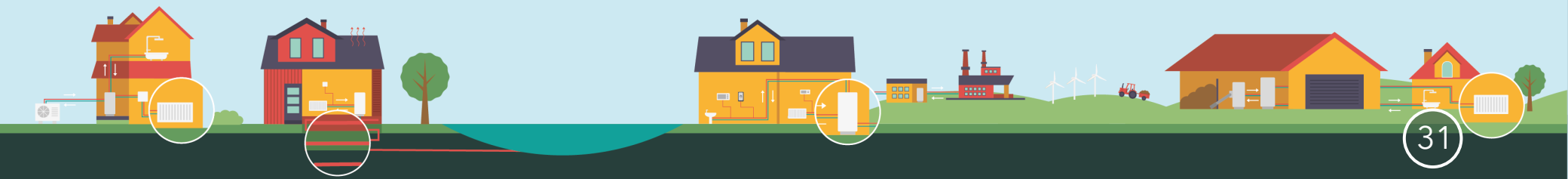
The table below summarizes the key processes and equipment required for infrared heating panel manufacturing.

Process	Equipment/Facilities	Structural Parts	Heating Element	Insulation Layers
Storage and Logistics	Shelving and Racking Systems, Forklifts, Conveyors, Warehouse Management Systems	X	X	X
Forming	Furnaces, Extrusion Equipment, Wire Drawing, Coiling Machines, Drilling / Cutting Machines	X	X	X
CNC Machining	CNC Machining Centres, CNC Lathes, CNC Plasma Cutting Machines, CNC Grinders,	X		
Sheet Metal Forming and Bending	Press Brakes, Stamping Presses, Folding Machines	X		
Welding, Brazing and Soldering	Welding Machines, Cutting Torches, Fabrication Tools	X		
Electronic Controls, Cabling & Wiring	Motors, PCB's, HMI & Various Components, Connectors, Cable, Insulation		X	
Assembly Line	Conveyors, Robotic Systems, Assembly Machines	X	X	X
Final Test & QA	Vision Inspection, EOL testing	X	X	X



Summary of the key processes and equipment required for manufacturing hot water cylinders.

Process	Equipment/Facilities	Hot Water Cylinder
Tube / Metal Forming and Bending	Roll Bending Machines, Stamping Presses	X
Welding, Brazing and Soldering	Welding Machines, Cutting Torches, and Fabrication Tools, Furnace	X
Heat Treatment	Furnaces, Quenching Equipment, Induction Hardening Machines, Tempering Furnaces	X
Painting including Powder Coating and Plating	Spray Booths, Powder Spray Guns, Powder Feed System, Curing Ovens, Mixing and Dispensing Systems	X
Electronic Controls, Cabling and Wiring	Motors, PCB's, HMI and Various Components, Connectors, Cable, Insulation	X
Assembly Line	Conveyors, Robotic Systems, Assembly Machines	X
Clean Room	Air Filtration and Ventilation Systems, Environmental Control Systems, Monitoring and Testing Equipment	X
Final Test and Quality Control	Pressure and Electrical Testing Equipment, Vision Inspection, EOL Testing	X



The table below summarises the key processes and equipment required for thermal storage heater manufacturing.

Process	Equipment/Facilities	Heat Battery	Vacuum Insulation Panels	Aluminium Case
Storage and Logistics	Shelving and Racking Systems, Forklifts, Conveyors, Warehouse Management Systems	X	X	X
Forming	Extrusion and Molding Machines, Stamping Press, Mixing Machines, Folding Machines, Cutting Machines , Vacuum Chambers	X	X	X
Machining	CNC Machining Centres, CNC Lathes, CNC Plasma Cutting Machines, CNC Grinders,			X
Milling, Drilling and Turning	CNC Drilling Machines, CNC Boring Mills			X
Welding, Brazing and Soldering	Welding Machines, Cutting Torches, Fabrication Tools, Furnace			X
Assembly Line	Conveyors, Robotic Systems, Assembly Machines	X	X	X
Final Test and QA	Vision Inspection, EOL testing	X	X	X

Key market data for heat in properties over the coming decade.

Radiators

The global heating radiator market was £3.5 billion in 2021, with a compound annual growth rate (CAGR) of 4.5% from 2022 to 2030.

Europe's heating radiators market size was £2 billion in 2022 and is poised to grow at a CAGR of 8% to £4 billion by 2030.

Underfloor Heating

Underfloor heating accounts for 8% market share by value in 2021. The current UK market size is £435 million and is estimated to grow at 7% CAGR to £670 million by 2029.

Growth drivers are energy efficiency, low maintenance and supply of consistent heating to properties.

The water-based market is expected to grow faster than the electric market due to higher efficiency. Domestic applications dominate, but growth is expected in schools, hospitals and commercial properties. Most are installed in new builds but is becoming popular when renovating properties.

The market in Europe and USA is valued at £4 billion in 2024, growing at 7% CAGR to £6 billion by 2029.

Infrared Heating Panels

The global infrared heaters market size was estimated to be £800 million in 2023 and is projected to grow at a CAGR of 6% to £1.1 billion by 2030.

Growth is driven by their ease of installation and compatibility with renewable energy sources, such as solar panels.

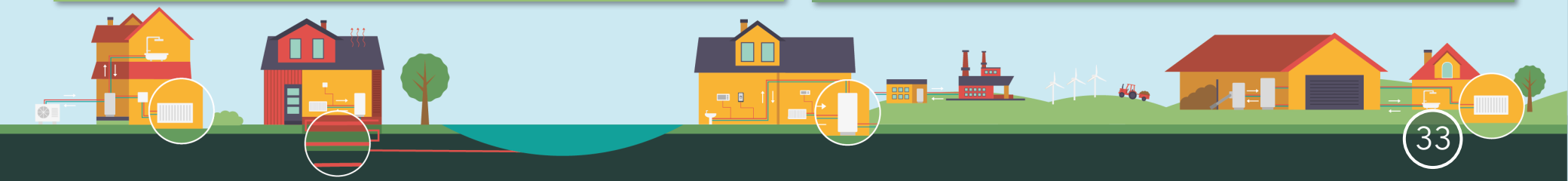
Hot Water Cylinders

The UK market is predicted to grow at 4% per year between 2024 and 2027, supported by the Future Homes and Buildings Standard (2025).

Thermal Storage Heaters

1.4 million UK homes have thermal storage heaters as their primary heating system. The market is poised for growth, supported by technological advancements and policy measures aimed at reducing carbon emissions.

Modern storage heaters feature advanced controls, smart thermostats, and can integrate with grid services and renewable energy sources.



Support available and competitor analysis.

Scotland

The Scottish Government's Heat in Buildings Strategy details the main support mechanisms to encourage clean heat in Scotland. A new Heat in Buildings Act is expected soon outlining the route to achieve zero heating emissions by 2045.

Scottish Local Authorities have a Local Heat and Energy Efficiency Strategy (LHEES) and a LHEES Officer (or similar) providing a local view of plans for clean heat systems.

There are grants and loans available to encourage the installation of clean heat systems:

- Home Energy Scotland administer these for domestic properties;
- Business Energy Scotland administer these for commercial properties, including the SME Loan Fund.

The Smart Direct Electric Heat Forum, based in Scotland and administered by SELECT, is a new forum for manufacturers of direct electric heat solutions.

Competitor Analysis

Radiators

- Manufacturers are Zehnder (Switzerland), Reina (England), Paladin England), Eskimo (England), and AEON (England).

Underfloor heating

- Manufacturers are Flexel International (Scotland), Nu-Heat (England), Polypipe (England), Emmeti UK (England), and Timoleon (England)

Infrared Heating Panels

- Flexel International (Scotland), Herschel (England), and Tansun (England), are examples of manufacturers.

Hot Water Cylinders

- McDonald Water and Mitsubishi manufacture in Scotland, along with Dimplex (England), Worcester Bosch (England), Baxi (England) and Vaillant (Germany)
- Sunamp manufacture phase change heat batteries in Scotland, as an alternative to hot water cylinders.

Thermal Storage Heaters

- GlenDimplex manufacture storage heaters in Ireland and England.

Scottish Enterprise can support you to explore growth in clean heat.

Clean Heat Market Opportunities

Clean heat will play a crucial role in meeting Scotland's net zero targets. There is a huge growth potential for Scottish businesses too.

- For general enquiries, and to access our Clean Heat team, please contact us
- For specialist advice on manufacturing and productivity, contact the Scottish Manufacturing Advisory Service (SMAS)
- For information on domestic and international markets contact our Market Research service
- If you are based in the Highlands and Islands, or the south of Scotland, please contact Highlands and Islands Enterprise or South of Scotland Enterprise respectively.

Newsletter

Please complete this subscription form if you would like to receive an occasional newsletter from Scottish Enterprise on market opportunities relating to clean heat.
Subscribe here

Further Reading

- Economic Value of Clean Heat in Scotland (2024)
- Market Opportunities for Scottish Direct Electric Heat (2023)

External Innovation Support Services in Scotland

- National Manufacturing Institute Scotland (NMIS) provides access to world-leading manufacturing facilities for collaborative R&D projects
- Built Environment - Smarter Transformation (BE-ST) provides collaborative innovation space and expertise for projects and materials for the built environment