HSSMI | Scottish Enterprise | ARUP

Manufacturing for Clean Heat in Scotland

Factsheet 5: Building Energy Efficiency

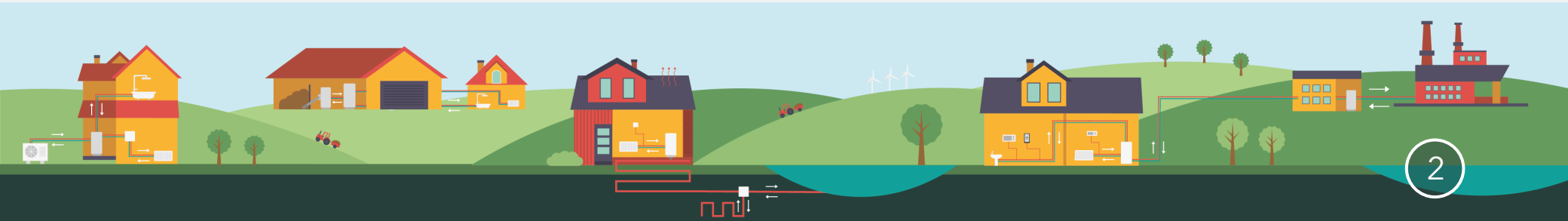
What is Clean Heat?

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 5 focuses on key technologies used for Building Energy Efficiency.

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).



Building energy efficiency involves optimising the design, construction, and operational practices to use energy more effectively.

Key building energy efficiency components include:

- Cladding
- Insulation
- Doors and Windows
- Ventilation
- Offsite Manufacturing

What is building energy efficiency?

Building Energy Efficiency refers to the strategies and technologies used to reduce the energy consumption of buildings while maintaining or improving comfort, functionality, and health for occupants. This involves optimising the design, construction, and operational practices to use energy more effectively within buildings.

Benefits of Building energy efficiency

Improving building efficiency offers a multitude of benefits, impacting not just the environment but also economic and social aspects. Here are some key advantages:

- Environmental Benefits – Reduced greenhouse gas emissions, conservation of resources
- Economic Benefits – Cost Savings, increased property value, job creation
- Health and Comfort Benefits – Improved indoor air quality, enhanced comfort
- Social Benefits – Energy security, resilience
- Community and Environmental Impact – Reduced strain on the grid, support for renewable energy

Cladding a building can significantly reduce a building's energy consumption.

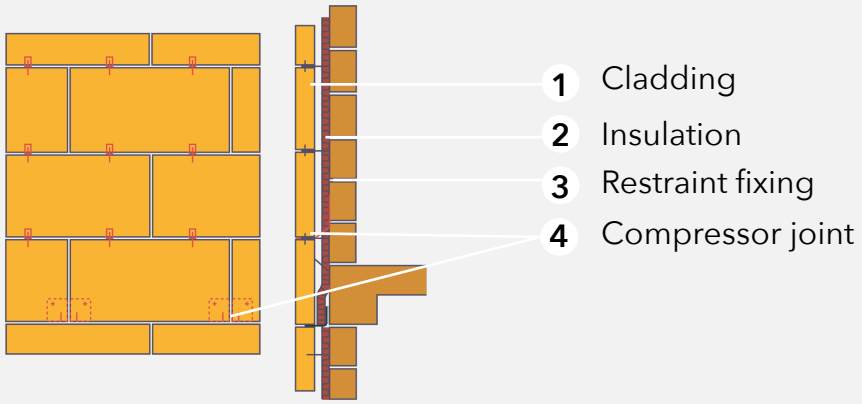


Diagram of cladding.

Cladding

Cladding refers to the application of one material over another to provide a protective or aesthetic layer. Commonly used in construction, cladding serves as an outer skin for buildings, enhancing their appearance, improving insulation, and protecting against weather, moisture, and external damage.

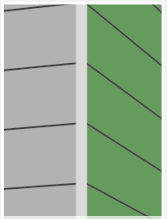
Subcomponents	Cladding material, fillers, insulation, membranes, brackets, cavity barriers, flashing, fixings, gaskets and sealants
Thickness	1 - 80 mm
Dimensions	1 m^2 – 36 m^2 per sheet
Weight	5-100 kg/m^2
Standards	BS 8414 – Fire performance of external cladding systems PAS 9980:2022 - Fire Risk Appraisal of External Walls & Cladding of Flats Different material may have additional applicable standards

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

The typical manufacturing processes of cladding are detailed below.

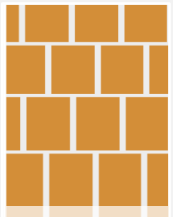
Design and Engineering → Component Manufacture → Component Subassembly → Assembly → Finishing and Painting → Testing and Quality Control

Cladding (Metal) and Cladding (Composite) : Manufacturing Process



Metal Cladding

Coating: Exterior and interior surfaces are treated to prevent corrosion → **Roll Forming:** Plates are rolled to desired shape, using sets of mated rolls making incremental changes to the form → **Cutting:** Sheets are fed through a guillotine, which cuts them to the required length → **Forming:** The sheets are further processed into modular cladding panels. → **Testing and Quality Control:** Quality checks to meet specifications and performance standards



Composite Cladding

Extrusion: Materials heated to required temperature and extruded through a die into the desired shape → **Drying:** Residual moisture is removed to harden the material using appropriate drying and firing processes → **Cutting and Shaping:** The material sheets are then cut and shaped to the desired size and panel design → **Surface Finishing:** Exterior layers coated with paint or anodized for color and corrosion protection, increasing durability. → **Testing and Quality Control:** Quality checks to meet specifications and performance standards

The main materials and characteristics required for cladding manufacturing.

Materials	Advantages	Disadvantages	Thermal resistivity (R) W/mK
Timber	• Versatility • Durability	• Risk of insect damage • Flammability	• 0.12 – 0.18
Composite	• Low maintenance • Wide range of design options	• High cost • Not able to refinish	• 0.2 – 0.4
Metal	• Fire safety • Lightweight	• Rust • Chalking	• 0.29 - 50
uPVC	• Low maintenance • Low cost	• Flammability • Environmental impact	• 4.4
Natural Stone	• Fire safety • Durability	• High upfront cost • Complication with installation	• 1.1 – 2.3
Terracotta	• Sustainable credentials • Resistant to sun damage	• High upfront cost • Risk of frost-damage	• 1.3
Porcelain	• Weatherproof • Fire safety	• High upfront cost • Difficult to shape	• 1
Fibre Cement	• Easy to install • Low maintenance	• High upfront cost • Fitting issues	• 0.19 – 0.22
Brick	• Durability • Fire safety	• High upfront cost • Difficult to install	• 0.56 – 0.77

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

Insulating or improving the pre-existing insulation in a building can significantly increase a building's energy efficiency.

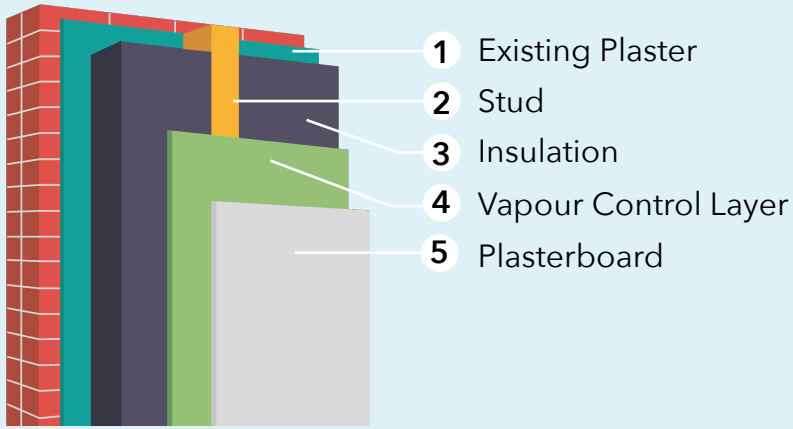


Diagram of insulation.

Insulation

In a typical house as much as 30% of heat can be lost through the walls and 25% through the roof. Insulation offers resistance to heat flow, reducing the need for heating and cooling. This lowers energy consumption, also minimising the building's carbon footprint.

Insulation thermal efficiency is given in a product's R-value, measured in m^2K/W. The best insulation has high R-values at low thicknesses.

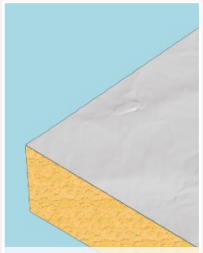
Subcomponents	Insulation material, vapour control layer			
Thickness	40 – 100 mm			
R-value	Walls	3.30 m^2K/W	Roofs	4.54 m^2K/W
Standards	BS EN 14064 - Thermal insulation products for buildings. In-situ formed loose-fill mineral wool products BS EN 16809 - Thermal insulation products of buildings. In-situ formed products from loose-fill expanded polystyrene (EPS) beads and bonded expanded polystyrene beads Different material may have additional applicable standards			

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

The typical manufacturing processes for the assembly of insulation materials.

Design and Engineering → **Component Manufacture** → **Forming** → **Drying** → **Finishing and Painting** → **Testing and Quality Control**

Synthetic Composites and Natural Materials: Manufacturing Process



Synthetic Composites

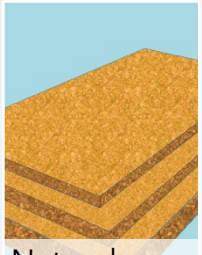
Melting: Raw materials are mixed in a furnace, where they are heated until they become molten

Spinning: Materials flow past air jets that spin the fibres, coating them with a liquid binder, and breaking them into pieces.

Mixing: Binding agents and additives are added to the mixture.

Forming: Fibres are carefully arranged and aligned to create a dense, uniform material.

Curing and Drying: Quality checks to meet specifications and performance standards



Natural Materials

Sorting: The material is sorted into different classifications based on its qualities

Baling: Bales of material are opened and mixed to produce a particular blend which meets the required specifications.

Scouring: This blend then undergoes a scouring process, whereby it is washed in warm water through a series of baths.

Drying and Thickening: The material is combed so fibres run in the same direction. Layers are bonded to increase strength

Packaging: These rolls are wound, packaged and colour-coded to facilitate easy handling during installation.

The main materials and characteristics used for insulation manufacturing.

Materials	Advantages	Disadvantages	Thermal Resistivity (R) W/mK
Fibreglass	• Fire safety • Flexibility	• Poorer thermal resistivity value • Health concerns	• 0.03 – 0.04
Rock Mineral Wool	• Fire safety • Durability	• Health concerns • Heavy material	• 0.03 – 0.04
Foam board (extruded polystyrene)	• Low cost • Insulation performance	• Derived from petroleum • Limited recyclability	• 0.02 – 0.03
Cellulose	• Flexibility • Sustainable credentials	• Risk of packing down • Mould and moisture issues	• 0.04
Sprayed Foam	• Acoustic comfort • No joints	• High upfront cost • Health concerns	• 0.02 – 0.03
Wool	• Sustainable credentials • Naturally thermally regulating	• High upfront cost • Risk of insect damage	• 0.03 – 0.04
Cork	• Sustainable credentials • Acoustic comfort	• High upfront cost • Complication with installation	• 0.03 – 0.04
Structural Insulated Panels	• Cost-effective • Design versatility	• Risk of moisture damage • Little room for improvements	• 0.02 – 0.04

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

Energy efficient windows and doors can help to reduce heat loss and improve a building's energy efficiency.

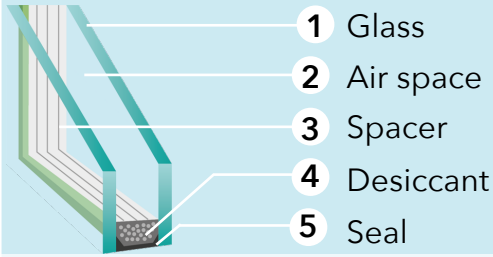


Diagram of window

Windows

Glazing contributes to energy efficiency. 18% of heat loss in buildings occurs through windows. Making windows more energy efficient lowers a building's carbon footprint.

Subcomponents	Glass, spacer, gas fill, seal, desiccant, frame material	
Dimensions	Height	0.5 – 2.0 m
	Width	0.5 – 3.0 m
Building regulations	In habitable rooms the openable area in a window must be at least 0.33 m² and at least 450 mm high or wide.	
U-values	New builds	≤1.2 W/m²K
	Existing dwellings	≤1.4 W/m²K
Standards	BS EN 1279-2:2018 – Glass in building. Insulating glass units BS 7950:1999 – Specification for enhanced security performance of windows	


Door

Doors

Energy efficient doors come in a range of frame materials and styles. The energy performance of these units depends on how well these materials stop heat from passing through, and how little air can leak around them.

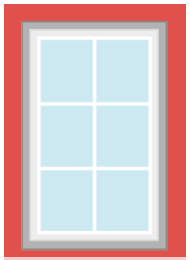
Subcomponents	Glass panes, door material, weather striping	
Dimensions	Height	1.9 – 2.1 m
	Width	0.7 – 0.9 m
	Thickness	0.4 – 0.5 m
Building regulations	In habitable rooms the openable area in a window must be at least 0.33 m² and at least 450 mm high or wide.	
U-values	≤1.8 W/m²K	
Standards	BS 8213-1:2016 - Code of practice for the survey and installation of windows and external doors	

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

The typical manufacturing processes of windows and doors.

Component Manufacture → **Glazing** → **Hardware Assembly** → **Testing and Quality Control** → **Finishing and Packaging**

Frame Fabrication and Glass Production: Manufacturing Process



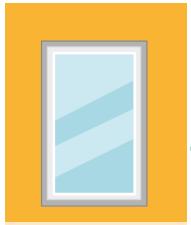
Frame Fabrication

Extrusion: Aluminium / uPVC / composites
Material extruded through a die, creating hollow or solid shapes of the frame.

Hot and Cold Rolling: Steel / Aluminium
Material is hot or cold rolled depending on the shape of the frame.

Cutting and Milling: Wood
Advanced machinery cuts and mills the wood into the size of the frame.

Finishing:
Protective coating, painting or staining the frame, depending on the material. The polishing procedure contributes to weather protection (corrosion)



Glass Production

Mixing and Heating:
Glass is created by mixing sand and other substances like sodium bicarbonate. Then it is heated to extreme temperatures using a furnace.

Glass Formation:
As the mixture cools it stiffens, and technicians shape the glass before it becomes too cool. It is strengthened using either annealing or tempering processes.
Both techniques are intended to restore the strength of the glass and prevent shattering

Glass Cutting:
Various techniques, like waterjet, laser, and diamond wheel cutting, are used based on the type of glass and the desired cut quality.

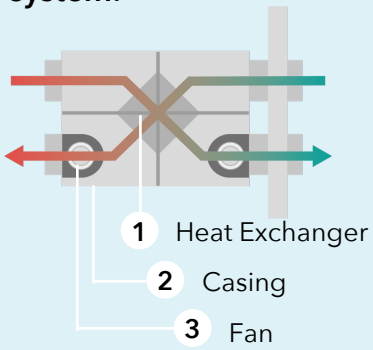
The main materials and characteristics for window and door manufacturing.

Materials	Advantages	Disadvantages
 uPVC	• Low maintenance • Durability	• Hard to modify • Prone to sagging
 Fibreglass	• Acoustic comfort • Low maintenance	• Susceptible to UV light • Require professional installation
 Wood	• Design versatility • Aesthetically pleasing	• Risk of insect damage • Requires maintenance
 Steel	• Durability • Low maintenance	• Heavy material • High upfront cost
 Aluminium	• Low maintenance • Recyclable	• High upfront cost • Corrosion if exposed to saltwater
 Composites	• Low maintenance • Excellent insulation	• High upfront cost • Unsustainable production
Gas Windows (Dehydrated air)	• Lower thermal conduction than air • Lower acoustic conductivity	• Not as effective as inert gases
Gas Windows (Inert gases)	• Argon: Colourless and odourless chemical is the most used gas in windows • Xenon: The densest of them all, and highly insulating. It is more expensive than argon and air • Krypton: Denser than argon / air but not xenon. An expensive option, but arguably best	

***Dimensions and weights are approximate and can vary based on specific requirements of the windows and doors and the manufacturer's design standards.**

Ventilation is an important component of an energy-efficient building to control airflow in and out and to prevent dump.

Typical ventilation system:



Ventilation

Most domestic, and small non-domestic properties in the UK have natural ventilation, driven by pressure differences between one part of a building and another, or pressure differences between the inside and outside.

Larger non-domestic buildings require mechanical ventilation. These circulate fresh air using ducts and fans. Adding energy and heat recovery is the solution to the ventilation of energy efficient buildings.

Heat recovery ventilators (HRVs) and energy recovery ventilators (ERVs) provide controlled ventilation while minimising energy loss. They reduce the costs of heating and cooling ventilated air using heat transfer principles. ERVs can also transfer moisture alongside heat. Requirements for ventilation units outline minimum thermal efficiency requirements (73%) for heat recovery systems in air handling units.

Subcomponent	Material
Casing	Plastic composite, steel, aluminium, stainless steel
Fan	Steel, copper, aluminium, plastic composite
Heat Exchanger	Stainless steel, cast iron, copper titanium, carbon

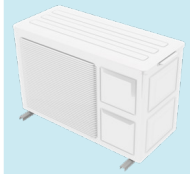
Subcomponents	Fans, heat exchanger, casing, filters
Operational temperatures	-25 °C – 50 °C
Filter class	G4, G7
Airflow	150 – 1000 m^3/h
Standards	Scottish Government - Building standards technical handbook 2022: domestic & non-domestic CIBSE guidance (primarily Guide B2 Ventilation and ductwork) Under the 2016 EU Ecodesign directive, all new bidirectional ventilation units must have a heat recovery system incorporated within their design.

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

The typical manufacturing processes for the assembly of a ventilation system.

Design and Engineering → **Component Manufacture** → **Component Subassembly** → **Assembly** → **Finishing and Painting** → **Testing and Quality Control**

Ventilation System Components: Manufacturing Process



Ventilation System

Heat Exchanger manufacturing
Refer to the heat generators factsheet 1 for more information

→ **Fan Manufacturing:** The production of the fan utilises CAM software, which supports metal injection molding (casting).

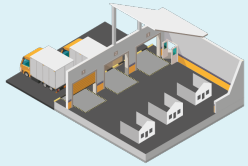
→ **Casing manufacturing** Fabrication involves cutting, bending, and welding the metal sheets to form the enclosure according to the design specifications.

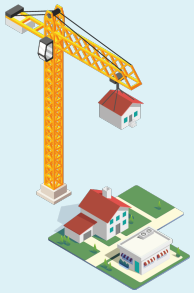
→ **Finishing:** A protective coating or paint is applied to the material. The polishing procedure contributes to aesthetic appeal and weather protection (corrosion)

→ **Testing and Quality Control:** Heat exchanger, fan, casing and components undergo quality checks to meet specifications and performance standards

Offsite construction allows elements to be designed, planned and constructed using pre-fabricated products in a factory.

Typical processes flow in offsite manufacturing:





Offsite Manufacturing

Offsite manufacturing is considered a modern method of construction (MMC). MMC can have a broad meaning, with a wide range of associated terms and definitions.

This prefabricated approach can shorten construction time by up to 70%, reducing material and labour costs and improving the quality control of construction.

Regulations and standards relating to MMC and offsite construction are limited, consequently the BSI is reviewing its standards.

Materials	Lightweight steel, timber framing, prefabricated and precast concrete, cross-laminated timber, gypsum board, insulation, glass, cladding					
Typical panel size	Height:	1.0 – 7.0 m	Width:	1.0 – 4.0 m	Thickness:	0.1 – 0.5 m
Standards	BOPAS Accreditation - Recognised assurance for innovative construction BIM ISO 19650-2:2018 - Information management using building information modelling BREEAM – Sustainability assessment and certification for the built environment and infrastructure. Used by project owners to help achieve sustainability goals Regulations and standards relating to MMC and offsite construction are limited, consequently the BSI is reviewing its standards.					

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

The typical manufacturing processes of offsite manufacturing.

Component Manufacture → **Subassembly** → **Final Assembly** → **Testing and Quality Control** → **Transportation** → **Onsite Assembly**

Design Development:
Modular buildings offer a high degree of customisation and flexibility, allowing the design to satisfy unique needs. Advanced software tools such as CAD & BIM are used.

Component Procurement:
High-quality materials and components are sourced from trusted suppliers, which are delivered to a central warehouse location.

Manufacturing:

Whilst the foundations are put in at the construction site, the modules are manufactured in the factory under controlled conditions.

Modular components are prefabricated using precise machinery and multi-skilled labour. Individual assemblies are combined, so that the product is in a recognisable form. Production lines can include CNC machines, cutting, aligning, screwing, nailing, painting and handling equipment.

The result can range from assembled timber frames to finished insulated walls and floors, which already include electrical and plumbing systems.

Each module is subjected to a defined quality assurance procedure, which ensures legally required inspections are carried out and standards are met.

Transportation:
Each completed module is transported as a complete section to the preprepared construction site for subsequent assembly.

Onsite Assembly:
The site is prepared, and the modules are assembled, often with the help of cranes and skilled installation crews.

Summary of the key processes and equipment required for manufacturing building energy efficiency components.

Process	Equipment/Facilities	Cladding	Insulation	Doors and Windows	Ventilation Systems	Offsite Manufacturing
Design and Prototyping	CAD Software, 3D Printers, CNC Machines	X	X	X	X	X
Casting, Milling, Drilling	Furnaces, CNC Machining, Drilling Machines			X	X	
Tube / Metal Forming and Bending	CNC Tube Benders, Roll Bending Machines, Stamping Presses, Wire Drawing				X	
Manufacturing Facilities	Furnaces, CNC Machines, Mandrel Milling Equipment, Cutting Stripping and Assembling Machines, Molding, Extrusion and Foaming Machines, Blowers and Fans	X	X	X	X	X
Welding, Brazing and Soldering	Welding Machines, Cutting Torches, and Fabrication Tools, Furnace			X	X	
Painting Powder Coating and Plating	Spray Booths, Powder Spray Guns, Powder Feed System, Curing Ovens, Electroplating, Mixing and Dispensing Systems	X	X	X	X	X
Assembly Line	Conveyors, Robotic Systems, Assembly Machines				X	
Testing and Quality Control	Inspection Tools, Testing Equipment	X	X	X	X	X
Calibration Facilities	Calibration Equipment, Testing Benches	X	X	X	X	X

Market size and growth.

Cladding

- The UK cladding market, installed an estimated area of 48.7 million m² in 2023.
- The global cladding market is expected to have a compound annual growth rate of 7.3% to 2030 with terracotta installations accounting for more than a 35% share of global revenue in 2023.

Insulation

- During 2020 around 9 million m² of internal insulation was installed, with the UK market valued at £1.4 billion.
- There remains significant potential for retrofit insulation growth in the UK, with an estimated 7.7 million uninsulated dwellings with solid walls, 5.7 million with lofts that are easy to fill and 3.9 million with uninsulated cavity walls.
- The global insulation market is expected to continue expanding rapidly across residential, commercial, and industrial sectors. Forecasts estimate the market to reach £67.4 billion by 2032, expanding at a compound annual growth rate (CAGR) of 4.8% from 2023 to 2032

Windows and Doors

- To meet net-zero targets, 80 million UK home windows must be replaced. The global windows and doors market exceeded £114 billion in 2020, with a projected CAGR of 6.2% (2021–2027).
- PVCu makes up 78% of UK installations but only 56% of market value, while in Scotland, it holds a 92% market share.

Ventilation

- The UK MVHR market, valued at £90 million in 2024, is expected to grow to £200 million by 2031 at a 10.7% annual rate.

Offsite Manufacturing

- The UK's offsite construction sector accounts for 7% of total output, worth £1.5 billion. Sweden leads in prefabricated timber homes (84% of detached homes), and UK imports of modular units have doubled since 2019.
- Europe's modular construction market is set to grow from $33 billion (2021) to $49 billion (2030).

Support available and competitor analysis.

Scotland

The Scottish Government's Heat in Buildings Strategy supports clean heat and energy efficiency, with a new Heat in Buildings Act expected aiming for zero emissions from buildings by 2045. New build passivhaus equivalent standard expected in 2028.

Scottish Local Authorities have Local Heat and Energy Efficiency Strategies (LHEES) and a LHEES officer (or similar) who can provide a local view of plans for energy efficiency retrofit.

Grants and loans to support energy efficiency:

- Home Energy Scotland (domestic properties)
- Business Energy Scotland (commercial properties, SME Loan Fund)
- Warmer Homes Scotland (low-income homes)

UK

- ECO4 requires energy firms to address fuel poverty.
- The Great British Insulation Scheme funds cavity wall and loft insulation.

England and Wales

- The Warm Homes Grant supports energy efficiency for low-income homes.
- The Energy Saving Trust lists home energy efficiency programmes.
- Some Local Authorities offer business energy efficiency support.

Competitor Analysis - manufacturing

Cladding: Net Zero Facades, and SIPS Eco in Scotland, Kingspan Group Ltd (Ireland), GB Architectural Cladding Products Ltd(England), Saint Gobain (France)

Insulation: Superglass Insulation, Sisaltech and IndiNature in Scotland, Kingspan Group Ltd (Ireland), Saint Gobain (France)

Windows and Doors: CR Smith Glaziers, Scotia Windows and Doors, Sidey Solutions in Scotland. CPA Engineered Solutions (industrial).

Ventilation: Ductform HFE, Mitsubishi, CPA Engineered Solutions and Envirovent in Scotland, Danfos (Denmark) and Siemens Energy (Germany)

Offsite manufactured units: CCG, Donaldson Group, Scotframe and SipsEco in Scotland

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

- Energy Efficiency Market Assessment (2023)
- Economic Value of Clean Heat in Scotland (2024)

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