# AHU DECARBONISATION
## The Complete Guide

MANSFIELD POLLARD
AIR MANAGEMENT EXPERTS

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MANSFIELD POLLARD AIR MANAGEMENT EXPERTS

# Section 1: Understanding the Opportunity

## Why are air handling units a priority for building decarbonisation?

Air handling units are among the most direct levers to reduce building carbon because they combine significant electrical fan power with substantial thermal duty for heating and cooling. HVAC (Heating, Ventilation and Air Conditioning) typically accounts for 25 to 40 percent of a building's energy use, and AHUs are often the dominant mechanical loads within that mix in high-ventilation buildings. Unlike many passive fabric measures, AHUs are discrete assets with measurable boundaries: fan power, coil duty and ventilation rates can be metered, trended and validated. That measurability makes AHU interventions attractive because they yield verifiable carbon reductions and can be rolled out in a repeatable way across an estate. For portfolio owners, this repeatability produces predictable carbon savings per site that scale across dozens or hundreds of units.

Beyond measurability and scale, AHUs are operationally important. They run when people are present, but many run continuously, often including night and weekend periods. They influence downstream plant performance. An inefficient AHU increases boiler cycling, chiller load, or both. In many systems, AHUs house gas-fired heating coils. Like central boilers, these contribute directly to onsite emissions. These direct emissions are typically categorised as Scope 1, a term defined further below. For these reasons, AHU improvement is one of the first and highest impact actions recommended in estate decarbonisation roadmaps.

## What are the main sources of carbon emissions from AHUs?

Carbon associated with AHUs falls into two principal buckets: operational carbon and embodied carbon.

Operational carbon is produced each hour the unit runs. It includes the electricity for supply and extract fans, the thermal energy used to heat or cool supply air, and the energy consumed by controls and ancillary systems. Where heating is provided by on-site combustion, this produces Scope 1 emissions. Where heating, cooling and fans consume purchased electricity, this produces Scope 2 emissions.

Embodied carbon refers to the lifecycle emissions associated with materials, manufacture, transport, maintenance and disposal. These are usually classified as Scope 3 emissions within carbon accounting frameworks. Steel frames, aluminium panels, copper coils and plastic components all carry material carbon. Filters, belts and consumables add repeated embodied carbon through replacement over time. Standards such as CIBSE TM65 provide the accepted methodology to quantify that embodied impact so it is not ignored in whole-life analysis.

To make these concepts concrete, consider a typical medium AHU. Embodied carbon ranges widely by size and material choice but commonly falls between 500 and 2,000 kgCO2e. Operational carbon will usually dominate over the life of the unit, but embodied carbon is non-trivial and must be considered when comparing a refurbishment with a complete replacement.

## Where do AHUs typically underperform from an energy and carbon perspective?

Underperformance arises from both poor original specification and performance degradation over time. Common technical causes and the way they translate into wasted energy include:

- Belt-driven fans and poor fan selections. Mechanical losses and fixed-speed operation result in elevated fan energy consumption and poor efficiency across varying loads.
- No variable speed drives. Fans operating at fixed speed deliver constant airflow regardless of actual demand. As there is no turndown capability, the system consumes full electrical power even when the building is operating at part load.
- Gas-fired coils. These create persistent Scope 1 emissions and prevent the site from leveraging the decarbonisation of the national electricity grid.
- Absence of heat recovery. Extracted air is expelled without reclaiming its energy content. As a result, heating plant must provide additional input to meet space conditions.
- Poor casing leakage (lower EN 1886 classes). Conditioned air escapes before delivery to the space. This increases total system energy use, as more air must be treated to achieve the same result.
- Weak or absent BMS integration. Without responsive controls, systems often run to clock schedules or fixed setpoints. This leads to wasted energy during periods of low or no occupancy.
- Dirty coils and blocked filters. These create elevated pressure drop and reduce thermal transfer efficiency. The result is higher fan energy and increased load on chillers or boilers.

Each issue above contributes to increased energy consumption and reduces both the practical service life and maintainability of the asset. The positive reality is that most can be addressed through focused engineering interventions that deliver measurable improvements.

## How much carbon and energy can be saved by upgrading an AHU? Workable examples.

Worked examples are essential because decision makers need realistic, auditable numbers.

**Example A.** Fan and control upgrade on a medium AHU

- Baseline fan energy: 100,000 kWh per year.
- Typical achievable saving from EC fans plus VSD and control tuning: 30 percent. Calculation: 100,000 × 0.30 = 30,000 kWh saved.
- Using an electricity carbon factor of 0.18 kg$CO_2$/kWh, $CO_2$ saved = 30,000 × 0.18 = 5,400 kg$CO_2$ = 5.4 tonnes $CO_2$ per year.

**Example B.** Heat recovery retrofit saving useful heat of 100,000 kWh per year that would otherwise come from a gas boiler

- Useful heat avoided: 100,000 kWh per year.
- Boiler efficiency assumed: 90 percent. Required fuel input = 100,000 ÷ 0.90 = 111,111 kWh of gas.
- Using a gas carbon factor of 0.184 kg$CO_2$/kWh, $CO_2$ avoided = 111,111× 0.184 = 20,444 kg$CO_2$ = 20.444 tonnes $CO_2$ per year.

**Example C.** Electrification comparison for 200,000 kWh useful heat per year

- Gas coil scenario: required gas input = 200,000 ÷ 0.90 = 222,222 kWh. $CO_2$ = 222,222 × 0.184 = 40,888 kg$CO_2$ = 40.889 tonnes per year.
- Heat pump COP 3.5: electricity use = 200,000 ÷ 3.5 = 57,142 kWh. $CO_2$ = 57,142 × 0.18 = 10,285 kg$CO_2$ = 10.286 tonnes per year.
- DX COP 3.0: electricity use = 200,000 ÷ 3.0 = 66,666 kWh. $CO_2$ = 66,666 × 0.18 = 12,000 kg$CO_2$ = 12.0 tonnes per year.
- Electric resistive COP 1: electricity use = 200,000 ÷ 1.0 = 200,000 kWh. $CO_2$ = 200,000 × 0.18 = 36,000 kg$CO_2$ = 36.0 tonnes per year.

These worked numbers show why heat pumps deliver the largest carbon reduction and why direct electric without high-COP plant is rarely the optimal solution for substantial heating loads.

### Why are AHU upgrades a key step in a decarbonisation strategy?

AHU upgrades are attractive because they typically offer low to medium capital cost with high measurable impact. They can eliminate local combustion, improve electrical efficiency, introduce heat recovery and improve control strategies. They also produce verifiable outcomes: specific fan power, heat recovery effectiveness and seasonal coil energy are measurable and auditable. For an estate, AHU programmes can be phased, which spreads capital and minimises disruption while delivering early wins. These features make AHU upgrades especially useful where boards and stakeholders demand tangible evidence of progress.

### How do AHU interventions map to Net Zero goals and ESG reporting?

AHU measures align directly with Scope 1 and Scope 2 carbon reductions, and also help clarify Scope 3 decisions. Replacing gas-fired heating coils with heat pump or direct expansion (DX) systems eliminates the on-site combustion associated with Scope 1 emissions. Optimising or replacing fan systems reduces electrical demand and therefore Scope 2 emissions, particularly when paired with high-efficiency controls. Where replacements use lighter materials such as aluminium, the overall embodied carbon may also be reduced. This benefit depends on the recycled content of the aluminium used, as life-cycle emissions differ significantly between primary and secondary production.

AHU projects also produce valuable operational data for TM54 analysis and corporate disclosure frameworks such as SECR and GRESB. The combination of commissioning records, BMS trends and metered energy use provides a verifiable audit trail that supports ESG reporting and Net Zero accountability.

## Section 2: What are the main options for decarbonising an existing AHU?

### What are the strategic options for decarbonising an AHU?

Air handling units can be decarbonised in three main ways:

**1 - Refurbishment:** - upgrading existing casings with new fans, coils, controls, and sealing to reduce operational carbon while retaining embodied carbon.
**2 - Replacement with modular new units:** delivering modern high-performance AHUs in sectional form, allowing rapid installation where access or footprint is limited.
**3 - Replacement with tailor made solutions** - designing one-off AHUs for complex, critical, or high-performance environments where modular is insufficient.

Each pathway can incorporate electrification, heat recovery, and advanced controls, and in many estates a combination of refurbishment and replacement is required. Choosing the right route depends on asset condition, lifecycle stage, space and access, downtime tolerance, budget, and decarbonisation timetable.

### When is AHU refurbishment the right option?

Refurbishment is best suited to mid-life AHUs where the casing is structurally sound but energy-consuming components are obsolete. Typical interventions include:

- Replacing belt-driven fans with EC plug fans or fan walls
- Upgrading motors to IE4 or IE5 and adding variable-speed drives
- Modernising controls for demand-led ventilation and supply-air temperature reset
- Sealing casings and upgrading filters to lower resistance types

Example: Hospital Theatre AHU refurbishment

- Baseline fan energy: 90,000 kWh per year
- Retrofit EC fan wall reduces consumption by 30 percent, equating to 27,000 kWh saved
- Carbon saving: 4.86 tonnes $CO_2$ per year at 0.18 $kgCO_2$ per kWh
- Cost saving: approximately £4,860 per year at £0.18 per kWh electricity
- Payback: typically under three years

Limitations
Refurbishment cannot overcome casing corrosion, poor leakage classes or lack of space for new recovery or electrification coils. Attempting refurbishment in such cases may yield short-term savings but lead to long-term failure.

Best suited to: hospitals needing minimal disruption, retail chains with many mid-life AHUs, and offices where embodied carbon retention is a key driver.

### When is modular replacement the right option?

Modular AHUs are designed in factory-built sections and assembled on site. This makes them ideal when plantrooms, risers, or roof access restrict full unit delivery. Modular designs like Mansfield Pollard's MPX or compact recovery units like Xe offer modern casing standards integrated heat recovery, electrification-ready coils, and smart controls.

Example: Supermarket estate modular replacement
- Existing gas-fired AHUs consuming 150 MWh heating/year each.
- Replaced with modular MPX units with 70 percent plate heat recovery and heat pump coils (COP 3.5).
- Annual heating demand reduced by ~100 MWh.
- Carbon saving = ~18 tonnes $CO_2$/year per unit.
- Multiplied across 200 stores, this equals 3,600 tonnes $CO_2$/year reduction.

Advantages
- Factory-tested sections improve quality assurance.
- Rapid on-site installation reduces downtime.
- Repeatable design enables roll-out across estates.

Limitations
- Still requires craning or sectional assembly.
- May not accommodate highly specialised requirements (e.g. HTM 03-01 hospital designs, extreme acoustic performance).

Best suited to: supermarkets, universities, retail estates, and offices needing rapid, repeatable upgrades with minimum disruption.

## When is bespoke replacement the right option?

Bespoke AHUs are designed from first principles to meet specific performance or compliance requirements. They are used where modular solutions cannot deliver the required airflows, pressures, acoustic attenuation or hygiene standards.

Example: Bespoke AHU for hospital critical care:

**Requirement:** compliance with HTM 03-01, including low leakage, thermal bridging control and typical 80 percent system redundancy

**Solution**: custom-built AHU with heat recovery run-around coil, EC fan wall, HEPA filtration and integrated electrification-ready coils

**Benefit**: removes gas-fired plant, reduces operational carbon by 60 percent and supports compliance with the NHS Net Zero roadmap

Example: Bespoke AHU for data centre cooling

**Requirement:** continuous 24/7 operation with N+1 redundancy, integrated evaporative cooling and high-efficiency fan wall arrays

**Solution:** custom-built containerised AHUs with engineered fan selections to achieve a Power Usage Effectiveness (PUE) below 1.2

**Benefit:** enhances system resilience while aligning with ESG and sustainability targets

Advantages
- Tailored to performance, compliance and resilience requirements
- Factory-engineered with complete design flexibility
- Future-proofed for complex environments including healthcare, data centres and industrial applications

Limitations
- Higher capital cost than modular options
- Longer lead times due to full design and manufacture process

Best suited to: hospitals, pharmaceutical facilities, data centres and industrial plant with unique or critical operational requirements

## How should estates choose between refurbishment, modular, and bespoke replacement?

The choice depends on condition, lifecycle, and strategy. A structured decision process includes:

- Survey and condition audit — casing, leakage, corrosion, access, space.
- Energy modelling — baseline SFP, coil loads, heat recovery potential.
- Lifecycle carbon analysis — embodied carbon retention (refurbishment) versus operational savings (replacement).
- Disruption tolerance — whether downtime is acceptable, or phased works are required.
- Regulatory requirements — compliance with EN 1886, Ecodesign, HTM 03-01, NHS Net Zero Roadmap.
- Estate strategy — roll-out potential across multiple sites vs one-off critical upgrades.



Typically, refurbishment suits mid-life assets, modular replacement suits estate-wide programmes, and bespoke replacement suits complex or critical assets.

## Can AHU decarbonisation be delivered in phases across an estate?

Yes. Phased programmes are often the most practical approach for large estates:
- Hospitals: refurbish critical AHUs first to gain savings without disruption, then replace secondary units in phases.
- Supermarkets: start with fan and control refurbishments across the estate, then roll out modular replacements as budgets allow.
- Universities: retrofit recovery to large teaching space AHUs first, then replace smaller units with modular Xe systems.

Phasing allows capital planning, minimises downtime, and delivers early carbon reductions while building toward full estate compliance with Net Zero targets.

## What pitfalls cause AHU decarbonisation projects to underperform?

Across all pathways, common causes of underperformance include:

- Underestimating electrical capacity for electrification or fan wall retrofits.
- Ignoring system pressure drop when adding heat recovery, negating savings.
- Attempting refurbishment on corroded or low-leakage casings, wasting capital.
- Not rewriting control strategies, leaving efficient hardware locked into inefficient operation.
- Poor logistics planning, leading to excessive downtime and cost overruns.
  These pitfalls are avoided by disciplined front-end engineering: measured surveys, TM54 operational modelling, TM65 embodied carbon assessment, and fully re-engineered controls sequences.

# Section 3: What does electrifying an AHU involve, and what are the options?

## What does it mean to electrify an AHU?

Electrifying an air handling unit means removing fossil fuel heat from the ventilation system and delivering all required air-side heating using electricity. In practice this replaces gas-fired hot water coils or direct-fired burners with electric heater batteries, direct expansion coils fed by condensing units or VRF systems, or coils served by heat pumps.

The objective is twofold. First, to eliminate Scope 1 emissions at the point of use. Second, to align the AHU with a grid that is decarbonising over time so that the carbon intensity of each kWh delivered to the airstream falls year on year. Electrification is not a like-for-like swap of “one coil for another.” It changes plant topology, electrical demand, sequences of operation, resilience strategies and maintenance requirements.

Getting it right requires a whole-system view of the AHU, the plantroom and the estate energy strategy.

## Why is AHU electrification a priority in decarbonisation programmes?

Gas combustion has a relatively fixed carbon intensity, while grid electricity in the UK has fallen dramatically over the last decade and continues to trend downward. If an AHU continues to rely on gas-fired coils, a significant fraction of building emissions remains locked into Scope 1 regardless of improvements elsewhere.

Electrifying the AHU removes that constraint and enables real reductions that are measurable at asset level. It also simplifies ESG reporting because the ventilation system moves fully into Scope 2, which is typically easier to meter, verify and normalise across an estate than mixed fuel systems. Finally, electrified plant integrates naturally with other decarbonisation measures such as heat recovery and demand-led control, amplifying total savings.

## What are the practical options for electrifying an AHU and when is each appropriate?

There are three main routes. Each can deliver full electrification, but they differ in efficiency, capital cost, integration effort and suitability by building type.

**Electric heater batteries**
Electric elements installed in the supply airstream are simple, compact and quick to integrate with existing casings. They have no moving parts and are straightforward to control. Their limitation is physics: the coefficient of performance is 1, so every kWh of heat requires one kWh of electricity. They are well suited to smaller AHUs, frost protection, trim or reheat duties, and as resilient backup in hybrid strategies. For large base-load heating they are rarely the most economical option unless paired with on-site renewables or time-of-use tariffs that materially reduce cost.

**Direct expansion (DX) coils with condensing units or VRF**
DX coils provide reversible heating and cooling using refrigerant circulated by outdoor units. Seasonal COPs are typically higher than direct electric, often in the 2.5 to 4 range depending on ambient conditions, refrigerant and control. DX is attractive in retail and commercial settings where roof or yard space is available for outdoor units and where modular AHUs benefit from compact integrated coil sections. The key design issues are refrigerant selection and charge, line lengths, oil return, leak detection and compliance with EN 378, all of which must be addressed early to avoid commissioning delays.

**Heat pump coils served by central heat pumps**
Air-to-water or water-to-water heat pumps serving AHU coils offer the highest seasonal efficiency, typically achieving COPs of 3 to 5. They can be designed to deliver low-temperature hot water for space heating and supply-air reheat while also providing chilled water for cooling, enabling all-electric campuses. Heat pumps demand careful attention to source temperature, capacity at low ambient, defrost management and hydraulic integration, but in hospitals, supermarkets, universities and data centres they usually deliver the strongest carbon and lifecycle cost case.

## How do AHU electrification options compare in efficiency, cost and retrofit difficulty?

The most important metric is seasonal COP because it governs both carbon intensity and running cost. Direct electric sits at COP 1, DX improves on that with 2.5 to 4, and central heat pumps lead at 3 to 5. Capital cost tends to move in the opposite direction, with electric batteries lowest, DX mid-range and heat pumps highest once you include external plant and distribution.

Retrofit complexity depends on available space, crane access, electrical capacity and whether existing casings can accommodate new coil depths and clearances. In constrained plantrooms, DX is often the most practical step away from gas without a full unit replacement. On new projects or major refurbishments, central heat pumps with low-temperature coils provide the best long-term platform.

## What design and integration issues must be solved for a successful AHU electrification?

Electrification succeeds or fails on details. The most common pitfalls are avoidable with disciplined design.

**Electrical capacity and diversity.** Quantify the coincident electrical demand of electrified AHUs at peak heating, not just nominal coil ratings. Consider diversity across multiple AHUs, harmonic mitigation for large VSD populations, switchboard space, cable containment and emergency power strategy. Engage the DNO early if headroom is limited.

**Coil selection and psychrometrics**. Size coils for realistic air-on conditions, supply air temperatures and design ambient. For heat pumps, expect lower hot-water temperatures and verify that required leaving air temperatures and reheat duties are met. Check face velocities, fin spacing and condensate behaviour to avoid carry-over and icing.

**Defrost and low-ambient operation**. Heat pumps and DX systems lose capacity and enter defrost cycles at low ambient. Control sequences must prevent cold air discharge, typically via supply temperature hold, preheat stages or temporary volume reduction with pressure reset. Provide clear reversion to backup heat for resilience.

**Refrigerant safety and compliance**. Select low-GWP refrigerants where practical. Design for EN 378 compliance, including leak detection, ventilation, isolation valves and safe drip trays. Respect line length and elevation limits to protect compressor life and ensure oil return.

**Integration with heat recovery.** Electrification and heat recovery are complementary. Confirm pressure drops across recovery devices and optimise bypass and frost protection so that fan energy gains do not erode recovered thermal savings.

**Controls and BMS**. Rewrite sequences of operation rather than grafting electric heat onto gas-era logic. Implement supply air temperature reset, demand-controlled ventilation, fan static pressure reset, coil valve authority checks and alarm strategies for plant enable, lockouts and defrost states. Trending and dashboards are essential for post-occupancy tuning.

**Acoustics and structure.** Outdoor heat pumps and condensing units introduce new noise sources and mass. Validate roof loading, vibration isolation, breakout noise and boundary conditions at façades, especially for night operation.

**Water, drainage and frost.** Provide reliable condensate removal, heat-trace where needed, and correctly sized traps. In cold climates or exposed rooftops, review frost coils and enclosure detailing to prevent freeze events.

## Can existing AHUs be electrified in situ, or is full replacement usually required?

Many existing units can be electrified without replacing the entire casing, provided three conditions are met.

First, casing integrity must be adequate, otherwise the energy saved at the coil is wasted at the casing.

Second, there must be sufficient section length and access to accommodate new coil blocks, safety clearances and maintenance space.

Third, the plantroom or roof must support any new outdoor plant with compliant structure, access and noise control.

Where any of these conditions cannot be achieved economically, a new modular or bespoke AHU designed for low-leakage casings, larger coil face areas and integrated controls is usually the better route.

## How does electrifying an AHU change operating costs and carbon in practice?

A worked example illustrates the trade-offs. Assume an AHU needs to deliver 200 MWh of useful heat to supply air over a year.

- Existing gas coil. With a seasonal boiler efficiency of 0.90, fuel input is 200 ÷ 0.90 = 222 MWh. At a gas carbon factor of 0.184 $kgCO_2/kWh$, annual emissions are 222,000 kWh × 0.184 = 40.9 $tCO_2$. If gas costs £0.06/kWh, annual cost is about £13.3k.

- Heat pump coil, COP 3.5. Electricity use is 200 ÷ 3.5 = 57.1 MWh. At 0.18 $kgCO_2/kWh$, emissions are 57,100 kWh × 0.18 = 10.3 $tCO_2$. If electricity costs £0.18/kWh, annual cost is about £10.3k. That is a carbon reduction of roughly 75 percent and a cost saving of about £3k on these assumptions.

- DX coil, COP 3.0. Electricity use is 66.7 MWh, emissions about 12.0 $tCO_2$, cost about £12.0k at £0.18/kWh.

- Electric heater battery, COP 1. Electricity use is 200 MWh, emissions about 36.0 $tCO_2$, cost about £36.0k at £0.18/kWh.

Prices and carbon factors vary by contract and year, but the pattern is robust. Heat pumps usually deliver the strongest carbon and operating cost case. DX improves significantly on gas with moderate capital cost. Direct electric reduces carbon versus gas in many grid scenarios but typically increases operating cost unless paired with low-cost renewable electricity or used only for trim and backup.

## What types of buildings benefit most from AHU electrification, and why?

Benefits are greatest where ventilation energy is a large share of total load, operating hours are long, or conditions are tightly controlled.

**Hospitals and healthcare**
Acute hospitals operate continuously and require elevated air change rates, filtration and close temperature control. Ventilation can account for a substantial fraction of total energy, so removing gas coils yields large Scope 1 reductions. Electrified AHUs also align with NHS Net Zero commitments and simplify HTM 03-01 compliance where heat recovery is restricted by infection control, because lower supply temperatures can be delivered efficiently with heat pumps and reheated precisely with electric trim where needed.



**Supermarkets and food retail**
Stores have long opening hours and high latent loads from door openings and product moisture. Many sites already have significant refrigeration plant that rejects heat. Electrified AHUs can be integrated with heat reclaim to preheat supply air, with heat pumps covering the remainder. The combination of long hours, recoverable heat and standardised unit sizes produces strong estate-wide business cases.

**Large offices and campuses**
Demand varies through the day and by zone. Electrified AHUs paired with demand-controlled ventilation and supply temperature reset use less energy at part load and avoid boiler cycling at low loads. For all-electric campuses, central heat pumps serving AHUs and terminal units create a consistent, low-temperature platform.

**Multi-site portfolios**
Retail parks, universities and commercial estates often operate many small to medium AHUs. Electrification enables a standard specification that is repeatable across dozens of sites, eliminating Scope 1 from ventilation in a controlled, auditable way and simplifying ESG disclosure.

## What control strategies are essential to unlock the benefits of electrified AHUs?

Sequences must be rewritten for electric heat, not copied from gas systems. At minimum implement supply air temperature reset against outdoor air and internal loads, fan static pressure reset based on VAV damper positions, $CO_2$ or occupancy based ventilation with minimum outdoor air floors, economiser and free-cooling logic, preheat coordination with defrost states, staged or proportional electric trim reheat, and clear lockouts for conflicting modes.

Commissioning should include witnessed tests for low-ambient performance, defrost behaviour, backup heat cut-in, supply temperature stability and fail-safe states. Post-occupancy tuning using BMS trend analysis is where a large share of the real savings are realised.

## What pitfalls cause AHU electrification projects to miss targets, and how can they be avoided?

AHU electrification projects fail when thermal and electrical integration is not engineered in detail. Common issues include assuming electrical headroom without verifying capacity, selecting coils without accounting for real air-on conditions and humidity, or exceeding refrigerant charge and line-length limits. Heat pump and DX systems are especially vulnerable to poor control strategies, constant-volume operation and fixed setpoints significantly undermine their efficiency.

Additional snagging often includes unmanaged condensate, missing frost protection and unacceptable noise from outdoor units. These problems are specific to the introduction of electrically driven heating and cooling, rather than general ventilation system upgrades.

The remedy is rigorous front-end engineering. This includes a measured survey, load calculations based on full psychrometric data, early engagement with the DNO, refrigerant design in accordance with EN 378, and development of controls cause-and-effect matrices prior to manufacture. All systems should be factory tested and site commissioned against defined performance acceptance criteria to ensure that electrification delivers its intended carbon and energy reductions.

# Section 4: How can heat recovery systems support AHU decarbonisation?

## What is heat recovery in an AHU, and why does it matter for decarbonisation?

Heat recovery is the process of capturing energy from exhaust air and transferring it to incoming supply air, reducing the demand on boilers, heat pumps, or chillers. In heating-dominated climates such as the UK, this typically means using warm extract air to pre-heat cold incoming air during winter. In cooling-dominated or mixed climates, recovery systems can also be used in reverse to pre-cool.

From a decarbonisation perspective, heat recovery is one of the most effective interventions because it directly reduces the thermal energy required to condition outside air. Since ventilation loads are among the largest drivers of building energy use, recovering even 60–80 percent of this otherwise wasted energy can deliver dramatic reductions in both gas and electricity consumption.

## How much energy and carbon can heat recovery save?

Worked Example: Large teaching building in the UK

- AHU supply: 50,000 $m^3$/h, 10 hours/day, 5 days/week, heating season = 2,000 hours/year.
- Outdoor winter design condition: −2°C, indoor setpoint: 20°C.
- Without recovery, heating requirement = (1.2 kJ/$m^3$·K × 22K × 50,000 $m^3$/h × 2,000 h) ÷ 3.6 = ~733 MWh/year.
- With 70% plate heat exchanger: recovered energy = 513 MWh/year.
- Net heating requirement = 220 MWh/year.
- Saving = 513 MWh/year.
- If heated by gas (0.184 kg$CO_2$/kWh), avoided $CO_2$ = 513,000 × 0.184 = 94 tonnes $CO_2$/year.

This single AHU retrofit would cut gas demand by more than 500 MWh and reduce emissions by almost 100 tonnes of $CO_2$ annually.

## What types of heat recovery systems are used in AHUs?

There are four principal heat recovery technologies used in air handling units. Each presents specific trade-offs in efficiency, maintenance, regulatory compliance and retrofit viability.

**1. Rotary thermal wheels**

High efficiency, typically 70 to 85 percent depending on wheel type and operating conditions
Capable of transferring both sensible and latent heat, which can significantly reduce humidification and dehumidification loads
Include moving parts, require motorised rotation and ongoing maintenance of seals
Introduce a small but continuous electrical energy demand to rotate the wheel
Carry an inherent risk of cross-contamination, making them unsuitable for systems are infection-controlled or healthcare environments regulated by HTM 03-01

**2. Plate heat exchangers**

Static aluminium or polymer plates with no moving parts
Compliant with ERP 2018 minimum efficiency of 73 percent (EN 308 standard)
Typically provide 50 to 75 percent sensible heat recovery, depending on flow balance and conditions
Cannot transfer latent heat in standard configurations. While cross-flow enthalpy heat exchangers exist, HTM 03-01 precludes their use due to hygiene constraints associated with moisture transfer
Add significant pressure drop and require well-engineered frost protection strategies in cold climates

**3. Run-around coil systems**

Separate supply and extract coils connected by a pumped water or glycol loop
Typical efficiency ranges from 40 to 55 percent, with ERP requirements now stipulating a minimum of 68 percent for compliant designs
Completely eliminates risk of air-stream cross-contamination, making it suitable for healthcare environments
Provides flexible layout options where supply and extract systems are physically separated
Requires pumps, controls and insulated pipework, introducing parasitic electrical demand and system complexity

**4. Heat pipes**

Refrigerant-based passive systems that transfer heat via a sealed phase-change cycle
Medium efficiency of 50 to 65 percent, but limited by ERP 2018 minimum of 73 percent, which restricts their use in regulated markets
Contain no moving parts and offer a compact footprint
Highly dependent on correct orientation and gravitational alignment, which limits their practicality in most retrofit or modular configurations
Rarely used in new designs due to efficiency constraints and regulatory limits

## Which buildings benefit most from AHU heat recovery?

**Hospitals**
Due to 24/7 operation and high ventilation rates, hospitals offer significant potential for heating energy recovery. Infection-control requirements restrict the use of rotary wheels in most clinical spaces. Plate heat exchangers are the preferred solution under HTM 03-01, especially in theatres and isolation suites, due to their physical separation of air streams. Run-around coil systems are also common in large installations where physical separation of plant makes direct recovery impractical.

**Universities and schools**
Lecture theatres, classrooms and auditoria have high fresh air requirements, often intermittent but intensive. Thermal wheels are widely used in these settings due to their high recovery efficiency and compact footprint. They offer rapid payback where operating hours are extended or systems serve multiple zones.

**Supermarkets and retail chains**
Retail buildings with long operating hours and steady footfall benefit from energy recovery, particularly in standardised AHUs across estates. Thermal wheels are often preferred for their high efficiency and compact design, especially where floor space or ceiling voids are limited.

Plate heat exchangers may be used where simplicity and low maintenance are prioritised.

**Commercial offices**
Offices with extended occupancy and demand-controlled ventilation are well suited to recovery solutions. Thermal wheels and plate exchangers help reduce heating and cooling demand while supporting compliance with TM54 modelling, NABERS UK and BREEAM certification. Recovery also improves part-load system efficiency, particularly where variable air volume (VAV) systems are deployed.

**Leisure and hospitality**
Swimming pools, gyms and hotels generate significant sensible and latent loads that make them excellent candidates for heat recovery. Rotary wheels or run-around coils are typically used in pool environments to preheat incoming air and support dehumidification. In hotels, guestroom ventilation systems benefit from recovery to reduce central plant load and improve overall building energy performance.

**Data centres**
Data centres are typically cooling-dominated and rarely benefit from traditional heat recovery within the air handling process. However, where waste heat can be captured, it is increasingly being redirected to local heat networks. This approach allows surplus thermal energy to support space heating or hot water demand elsewhere, improving site-wide carbon performance without compromising critical cooling systems.

## What are the design considerations for effective heat recovery?

**Pressure drop**
All recovery devices introduce resistance to airflow, increasing the work required from supply and extract fans. Careful selection, correct sizing and fan re-specification are essential to ensure that the energy gains from recovery are not cancelled out by elevated fan consumption.

**Bypass and control**
In shoulder seasons and mild weather, systems must be capable of bypassing the recovery device to avoid overheating the supply air. This can be achieved through mechanical dampers or modulated valves, depending on the recovery type.

**Frost protection**
Plate heat exchangers are vulnerable to freezing at sub-zero outdoor conditions. Effective strategies include preheat coils, air bypass, or flow modulation to maintain minimum temperature thresholds and prevent frost damage.

**Cross-contamination**
Rotary thermal wheels present a risk of extract-to-supply leakage due to rotation and pressure imbalance. This makes them unsuitable for infection-sensitive environments such as healthcare or cleanrooms.

**Maintenance**
Each recovery type has distinct servicing needs. Rotary wheels require periodic cleaning and seal inspection. Plate exchangers must be kept free of blockages to maintain pressure and heat transfer efficiency. Run-around coil systems require pump maintenance and periodic cleaning of coils to prevent fouling and sustain thermal performance.

**Integration with electrification**
Effective heat recovery reduces the thermal load on both heating and cooling coils. This lowers the required capacity of heat pumps or DX systems, improving turn-down efficiency and making low-carbon heating systems easier to size and operate.

## What are the risks if heat recovery is poorly implemented?

- Overestimated savings: If pressure drop is ignored, fan energy increases may offset heating savings.
- Frost damage: Lack of frost control can cause plates or coils to freeze, leading to catastrophic failure.
- Hygiene risks: Rotary wheels used in hospitals can transfer pathogens if not properly specified.
- Controls failure: Without good sequencing (e.g., economiser integration), heat recovery may run when not needed, wasting energy.

## How does heat recovery align with Net Zero and ESG commitments?

Heat recovery directly reduces Scope 1 emissions where fossil fuels are used for heating, and reduces Scope 2 when coils are electrified. It also supports electrification by cutting peak coil loads, allowing smaller heat pumps and lower capital costs. In embodied carbon terms, retrofitting recovery often has a favourable TM65 profile compared to full AHU replacement, making it highly defensible in ESG reporting.

## Can existing AHUs be retrofitted with heat recovery, or is replacement required?

Many existing AHUs can be retrofitted with plate exchangers or run-around coils, but retrofit feasibility depends on:

- Section length available for new modules.
- Access for installation (e.g., craning in new sections or breaking down for plantroom entry).
- Structural integrity of casings to handle additional pressure drop.
- Controls integration for bypass and frost.

If casings are corroded or undersized, or if recovery requires a complete redesign of the airflow path, full replacement with modular or bespoke units is often the better choice.

# Section 5: How can advanced controls and digitalisation support AHU decarbonisation?

## What role do controls play in AHU decarbonisation?

Controls are the brain of the air handling unit. Even the most efficient fans, coils, or recovery systems will underperform if control logic is outdated or poorly configured. Many existing AHUs still run on fixed time schedules, constant air volume, and static temperature setpoints — approaches that waste energy whenever the building is partially occupied or outside conditions are favourable.

Modern controls unlock carbon savings by making the AHU responsive. They match ventilation, heating, and cooling output to the actual needs of the space, not a theoretical worst-case design load. This reduces both Scope 1 and Scope 2 emissions by cutting wasted hours of fan energy and unnecessary coil loads.

## What are the most effective control strategies for reducing AHU energy use?

Several control strategies consistently deliver significant carbon reductions when properly implemented:

- Demand-controlled ventilation (DCV): Adjusts outside air based on $CO_2$ or occupancy sensors. Prevents over-ventilation when spaces are partially occupied.
- Supply air temperature reset: Dynamically raises or lowers supply air setpoints depending on outdoor air conditions and zone demands, reducing heating and cooling loads.
- Static pressure reset: Lowers fan setpoints when downstream dampers are partially c losed, cutting fan energy while maintaining comfort.
- Night set-back / shut-off: Reduces or stops ventilation in unoccupied periods, with override options for cleaning or security.
- Economiser/free cooling control: Uses cool outside air to reduce chiller loads during mild weather.
- Frost protection sequencing: Coordinates pre-heat and bypass to avoid inefficient all-year coil heating.
- Reheat optimisation: Ensures that heating and cooling do not run in conflict, especially in VAV systems.

Each strategy delivers incremental carbon savings; together, they transform the performance of existing plant.

## How much carbon can advanced AHU controls save?

Worked Example: Office AHU with constant-volume operation

- Baseline: Supply fan at 20 kW, operating 4,000 hours/year = 80,000 kWh.
- Static pressure reset reduces average load by 25% = 20,000 kWh saved.
- $CO_2$ saving = 20,000 × 0.18 = 3.6 tonnes/year.

Worked Example: University lecture theatre AHU with no supply-air reset

- Heating load without reset: 200 MWh/year.
- Resetting supply temperature upward by 2°C during mild weather cuts load by ~10% = 20 MWh saved.
- If gas-fired: 20,000 ÷ 0.9 = 22,222 kWh gas avoided = 4.1 tonnes $CO_2$/year.
- If electrified with heat pump COP 3.5: 20,000 ÷ 3.5 = 5,714 kWh electricity avoided = 1.0 tonne $CO_2$/year.

Controls alone rarely deliver headline-grabbing savings in one step, but across an estate the cumulative effect is significant. Dozens of AHUs upgraded with modern controls can save tens of thousands of kWh and hundreds of tonnes of $CO_2$ annually.

## How does digitalisation enhance AHU performance beyond traditional controls?

Digitalisation extends control strategies with monitoring, analytics, and cloud-based optimisation. Examples include:

- BMS integration: Ensures AHUs operate in sync with boilers, chillers, and room systems. Prevents conflicting heating and cooling loads.
- IoT sensors and wireless networks: Provide granular data on occupancy, IAQ (indoor air quality), and energy use without extensive rewiring.
- Cloud-based analytics: Compare actual performance with benchmarks, detect inefficiencies, and recommend corrective actions.
- Digital twins: Model AHU operation under different scenarios, helping optimise control strategies before applying them live.
- Fault detection and diagnostics (FDD): Automatically identifies stuck dampers, fouled coils, or failed actuators before they waste energy.

By moving from reactive maintenance to predictive optimisation, digitalisation ensures carbon savings persist rather than erode over time.

## What are the risks if AHU controls are poorly implemented?

Controls can backfire if poorly engineered. Common pitfalls include:

- Sensor misplacement or calibration drift: Leads to false readings and incorrect control actions.
- Conflicting setpoints: Heating and cooling systems fighting each other.
- Overcomplicated sequences: Operators disable systems because they are too complex to understand or maintain.
- Lack of commissioning: Controls left at factory defaults or installed but never tuned to site conditions.
- No post-occupancy review: Without trending and adjustment, savings decay over time.

To avoid these, controls upgrades should include thorough design of sequences, witnessed commissioning, operator training, and ongoing performance monitoring.

## How do advanced AHU controls support Net Zero and ESG reporting?

Controls generate the data that underpins ESG disclosure. With modern BMS and IoT sensors, estates can track actual AHU energy use, ventilation rates, and $CO_2$ savings with high confidence. This data feeds directly into frameworks such as:

- Streamlined Energy and Carbon Reporting (SECR).
- GRESB (Global ESG Benchmark).
- Corporate Net Zero pathways.

Because controls enable both operational efficiency and auditable performance data, they are a cornerstone of demonstrating compliance and progress to stakeholders.

## Which building types gain the most from advanced AHU controls and digitalisation?

- Hospitals: 24/7 operation makes optimisation critical; demand control and reheat prevention are major opportunities.
- Universities: Large estates with many teaching spaces benefit from standardised strategies rolled out across dozens of AHUs.
- Supermarkets: Consistent ventilation across chains allows repeatable upgrades, with digital dashboards providing estate-wide oversight.
- Offices: Supply-air reset and demand control avoid over-conditioning during partial occupancy, especially in hybrid working patterns.
- Data centres: FDD and predictive analytics help maintain resilience while optimising energy efficiency.

# Section 6: How does maintenance, monitoring, and optimisation impact AHU decarbonisation?

## Why is ongoing maintenance critical for decarbonised AHUs?

Even the most efficient AHU will drift off-spec without proper maintenance. Filters clog, coils foul, dampers stick, sensors drift out of calibration, and control sequences are overridden. Each of these issues increases energy consumption and carbon emissions. For example, a blocked filter can add 100 Pa to system resistance, raising fan power by 5–10%. A leaking damper can allow uncontrolled outside air, increasing heating or cooling loads.
Maintenance ensures that energy savings from refurbishment, retrofit, or replacement are preserved throughout the lifecycle. In decarbonisation programmes, neglecting maintenance is one of the fastest ways to erode the carbon benefits of capital investment.

## What maintenance practices are most important for sustaining low-carbon AHU performance?

Key practices include:
- Filter management: Replace filters based on pressure drop rather than fixed time. Low-resistance filters save fan energy but must be monitored to maintain IAQ.
- Coil cleaning: Fouled coils reduce heat transfer efficiency and increase fan energy. Ultrasonic or chemical cleaning restores design performance.
- Damper inspection: Leaky dampers undermine economiser and demand-control strategies. Check seals and actuator function regularly.
- Belt/fan condition (if not EC): Belt slip and wear reduce fan efficiency. Converting to EC eliminates this risk, but where belts remain, tensioning is essential.
- Control system checks: Verify setpoints, reset logic, and sequencing. Operators often override controls temporarily and forget to restore them.
- Sensor calibration: $CO_2$, temperature, and pressure sensors must be checked periodically to ensure demand-led strategies work correctly.

Planned Preventive Maintenance (PPM) tailored to these elements extends AHU life, reduces failures, and locks in carbon reductions.

## How does monitoring improve AHU efficiency and carbon performance?

Monitoring provides visibility of whether AHUs are operating as intended. Without it, underperformance can go unnoticed for years. Effective monitoring includes:

- Trend logging: Energy use, airflow, and temperatures trended via the BMS allow deviations from expected performance to be spotted early.
- Specific fan power (SFP) tracking: Comparing measured SFP to design values highlights rising resistance or fan issues.
- Heat recovery effectiveness monitoring: Calculating temperature differentials across recovery devices ensures they are working at design efficiency.
- Alarms and alerts: Automated notifications for filter pressure, damper position, or abnormal coil energy prevent extended energy waste.

For example, if a plate heat exchanger designed for 70% effectiveness is only delivering 50%, this can trigger inspection of fouling, bypass damper leakage, or frost protection settings.

## What role does optimisation play after AHU commissioning?

Commissioning gets an AHU to "work," but optimisation ensures it works efficiently.
Optimisation includes:
- Supply air temperature tuning: Raising or lowering setpoints seasonally or dynamically to minimise heating and cooling.
- Air volume adjustment: Matching airflow to actual occupancy rather than design maximums.
- Control sequence refinement: Adjusting reset parameters, economiser thresholds, or defrost cycles based on real performance data.
- Performance benchmarking: Comparing identical AHUs across a portfolio to identify underperformers.

Worked Example: Office AHU optimisation
- Baseline: AHU supply air setpoint fixed at 20°C year-round.
- Optimisation: Seasonal reset raises setpoint to 22°C in summer shoulder periods.
- Saving: ~15 MWh cooling avoided per AHU.
- Carbon saving = 15,000 × 0.18 = 2.7 tonnes $CO_2$/year.

Optimisation is not a one-off task but an ongoing process. Estates that continuously refine AHU settings capture an additional 5–15% efficiency compared to estates that stop at commissioning.

## How can digital tools support AHU maintenance and optimisation?

Digitalisation enhances both monitoring and optimisation:
- IoT sensors: Provide granular data on IAQ, energy, and system health.
- Fault detection and diagnostics (FDD): Identifies failing actuators, clogged filters, or overridden setpoints automatically.
- Cloud dashboards: Allow estate-wide oversight of AHU performance, highlighting units drifting off target.
- Digital twins: Simulate AHU performance under different strategies, helping engineers test optimisation before applying changes.
- Predictive maintenance: Uses data trends to forecast failures (e.g., fan bearing wear, damper motor degradation) before they cause downtime or energy waste.

These tools ensure that AHUs remain in low-carbon operation throughout their lifecycle rather than drifting back toward baseline inefficiency.

## What are the consequences of poor AHU maintenance and monitoring?

If AHUs are neglected, the consequences are significant:
- Energy waste: Blocked filters, fouled coils, or failed recovery systems can add 10–30% to annual energy use.
- Carbon creep: A decarbonised AHU can slowly return to near-baseline emissions without detection.
- IAQ deterioration: Poor filtration or uncontrolled air volumes compromise occupant health and comfort.
- Unplanned downtime: Failures are more likely, disrupting critical spaces such as hospital theatres or data halls.
- Shortened asset life: Neglected AHUs require premature replacement, adding embodied carbon.

These risks directly undermine Net Zero pathways and ESG commitments.

### How does proactive maintenance and optimisation align with Net Zero and ESG reporting?

Proactive maintenance ensures operational carbon reductions remain permanent and verifiable. Continuous monitoring provides data to support ESG disclosure under SECR, GRESB, and corporate Net Zero pathways. TM54 requires operational energy data; without monitoring, compliance is impossible. TM65 embodied carbon assessments also benefit, as refurbishment and extended service life reduce replacement frequency.
In other words, maintenance, monitoring, and optimisation are not secondary to decarbonisation  they are the means of protecting the investment and ensuring savings persist.

## Section 7: What role does embodied carbon play in AHU decarbonisation?

### What is embodied carbon, and why is it important for AHUs?

Embodied carbon refers to the greenhouse gas emissions associated with the extraction, processing, manufacture, transport, installation, maintenance and end-of-life disposal of a product. For an air handling unit, this includes all materials and components: aluminium frames, steel panels, copper coils, motors, insulation, filters and fasteners.

Historically, the focus in HVAC design has been on operational carbon, the emissions produced during the unit's in-use phase. However, as systems become more energy efficient, the relative impact of embodied carbon is increasing. If an AHU is replaced prematurely, the embodied carbon of the discarded unit and the new unit can cancel out or even outweigh the operational savings. This makes embodied carbon a critical factor in deciding between refurbishment, retrofit or full replacement.

Standards such as CIBSE TM65 now provide clear methodologies to quantify embodied carbon in building services equipment, enabling informed decisions that balance carbon, cost and compliance over the full lifecycle.

### How much embodied carbon is in a typical AHU?

The embodied carbon of an AHU depends on size, materials, and complexity. Industry guidance from CIBSE TM65 and Environmental Product Declarations (EPDs) suggests:

- Small to medium AHUs: 500–2,000 $kgCO_2e$.
- Large bespoke AHUs: 3,000–10,000 $kgCO_2e$ or more.

Worked Example: Medium modular AHU

- Steel casing and frame: ~1,000 kg at 1.9 $kgCO_2e/kg$ = 1.9 tonnes $CO_2e$.
- Aluminium panels and profiles: ~400 kg at 9 $kgCO_2e/kg$ = 3.6 tonnes $CO_2e$.
- Copper coils and piping: ~200 kg at 2.1 $kgCO_2e/kg$ = 0.4 tonnes $CO_2e$.
- Motors, electronics, insulation, filters: ~0.5 tonnes $CO_2e$.
- Total embodied carbon = ~6.4 tonnes $CO_2e$.

This can be equivalent to several years of operational carbon savings, meaning the timing of replacement is as important as the efficiency of the new unit.



### How does embodied carbon compare to operational carbon in AHUs?

Over a 20-year lifecycle, operational carbon normally dominates. For example:
Scenario: 50,000 $m^3/h$ AHU running 4,000 hours/year

- Fan and coil energy = 400 MWh/year.
- At 0.18 $kgCO_2/kWh$, annual operational emissions = 72 tonnes $CO_2$.
- Over 20 years = 1,440 tonnes $CO_2$.

Compared to an embodied carbon footprint of 6–8 tonnes $CO_2e$, operational emissions are much larger. However, if a unit is replaced prematurely, embodied emissions add up across the estate and erode net savings. Balancing embodied and operational carbon is therefore essential.

### How can refurbishment reduce embodied carbon in AHU decarbonisation?

Refurbishment retains the casing, frame, and most materials, avoiding the need for new steel and aluminium production. Only components such as fans, coils, and controls are replaced.

Example: Hospital AHU refurbishment

- New fans, coils, and controls: ~1 tonne $CO_2e$ embodied carbon.
- Replacing entire AHU: ~7 tonnes $CO_2e$ embodied carbon.
- Avoided embodied carbon = ~6 tonnes $CO_2e$.
- Combined with 20 tonnes/year operational savings, refurbishment often delivers the best short-term carbon balance.

### How do modular and bespoke replacements affect embodied carbon?

**Modular replacements:** Standardised designs can optimise material use and reduce waste. Embodied carbon per unit can be lower than bespoke if roll-out efficiency is achieved. However, full replacement always carries higher embodied carbon than refurbishment.

**Bespoke replacements**: Larger structures and custom materials increase embodied carbon. These units are justified where performance or compliance demands cannot be met by modular or refurbishment options. For example, HTM 03-01 compliance or data centre resilience requirements.

Lifecycle assessments must weigh the embodied carbon against operational savings. A poorly performing legacy AHU may burn enough extra energy in one or two years to outweigh the embodied cost of replacement.

### How is embodied carbon assessed and reported for AHUs?

The industry standard is CIBSE TM65. This methodology estimates embodied carbon based on material quantities, manufacturer data, or Environmental Product Declarations (EPDs).
Key steps include:

- Breaking down components into material categories (steel, aluminium, copper, plastics, insulation).
- Applying published carbon factors for each material.
- Accounting for manufacturing processes, transport, and end-of-life scenarios.
- Reporting in $kgCO_2e$ for modules A (upfront), B (use phase), and C (end of life).

Some manufacturers are beginning to publish EPDs for AHUs, which provide more accurate cradle-to-grave embodied carbon data. Estates increasingly require TM65 outputs in tender submissions to demonstrate whole-life carbon responsibility.

## How does embodied carbon influence estate-level decarbonisation strategies?

At portfolio scale, embodied carbon becomes a strategic driver:

- Hospitals: Refurbishing mid-life AHUs avoids large embodied carbon spikes while still achieving significant operational savings.
- Supermarkets: Rolling out modular replacements across hundreds of stores accumulates embodied carbon quickly, so phased refurbishment-then-replacement programmes are preferred.
- Universities and offices: TM65 reporting is often required to meet ESG disclosure frameworks such as GRESB, influencing procurement choices.

Balancing embodied and operational carbon ensures estates do not simply "churn" equipment in the pursuit of operational efficiency but achieve real net reductions in total lifecycle emissions.

## How does embodied carbon reporting support Net Zero and ESG goals?

Embodied carbon reporting allows organisations to:

- Demonstrate compliance with corporate Net Zero commitments.
- Meet disclosure requirements under SECR, GRESB, and UKGBC frameworks.
- Show that procurement decisions are evidence-based, not just cost-driven.
- Optimise investment by targeting refurbishment where embodied carbon savings are highest and replacement where operational savings outweigh material impact.

For Mansfield Pollard, publishing TM65 data and supporting clients in whole-life carbon assessments builds trust and positions the company as a partner in genuine Net Zero delivery.

# Section 8: How do regulations, standards, and compliance frameworks shape AHU decarbonisation?

## Why are regulations and standards important for AHU decarbonisation?

Regulations and standards define the minimum performance, safety, and sustainability criteria that AHUs must meet. They ensure that decarbonisation is not optional but a legal and contractual requirement. For estates, compliance frameworks also provide a benchmark for carbon reporting, enabling progress against Net Zero targets to be measured and audited.

In practice, AHU design is influenced by a combination of UK building regulations, European Ecodesign requirements, and sector-specific standards such as HTM 03-01 for healthcare. Understanding and applying these frameworks is essential to ensure projects deliver both regulatory compliance and real carbon reductions.

## Which regulations govern AHU efficiency in the UK and Europe?

The most important regulatory framework governing AHU performance is the Ecodesign Directive, often referred to as ErP. This sets minimum energy performance standards for ventilation units across both the UK and EU. For non-residential AHUs, the directive mandates:

- Fan efficiency: Specific Fan Power (SFP) limits based on unit configuration and airflow

- Heat recovery: Minimum thermal efficiency thresholds depending on system type and application, in line with EN 308 methodology

**Motor efficiency:** Legal requirement for IE3 motors as a minimum for most power ratings, with IE4 motors used in high-efficiency designs

**Control capabilities:** Requirement for integrated control systems, including demand-led ventilation where applicable

These standards apply at the point of sale. All new AHUs placed on the market must meet or exceed Ecodesign thresholds. For refurbishment or retrofit projects, system performance should be benchmarked against these standards to ensure regulatory equivalence and long-term viability.

## How do UK Building Regulations affect AHU decarbonisation?

Part L (Conservation of fuel and power) is the key section of UK Building Regulations affecting AHUs. It requires that building services are designed and installed to achieve reasonable standards of energy efficiency. For AHUs, this translates to:

- Minimum specific fan power (SFP) limits depending on system type.
- Requirements for variable speed drives and demand-controlled ventilation.
- Limits on air leakage and thermal bridging in casings.
- Commissioning requirements to verify performance.

In new builds and major refurbishments, AHUs must be specified to meet or exceed these limits. In practice, most decarbonisation projects aim to go beyond minimum compliance, as regulatory standards typically lag behind best practice.

## What role does EN 1886 play in AHU decarbonisation?

BS EN 1886:2025, which recently replaced the 2007 version of the standard, defines the mechanical and thermal performance classifications for air handling unit casings. It is a foundational specification that governs leakage integrity, thermal efficiency and structural resilience — all of which directly influence the energy and carbon performance of AHUs.

Key casing performance parameters include:

**Air leakage (L1–L3):** Now tested with updated pressure-tier brackets aligned to fan system duty, with leakage still assessed at 400 Pa and optionally at 700 Pa

**Thermal transmittance (T1–T5):** Retains existing classes, but with more consistent test rig calibration and panel measurement accuracy

**Thermal bridging (TB1–TB5):** Includes revised correction factors to better reflect true frame continuity across varied temperature gradients

**Mechanical strength and deflection (D1–D3):** No change in classes, but testing methods now enforce stricter geometry and measurement fidelity

From a decarbonisation perspective, BS EN 1886:2025 reinforces the need for low-leakage, thermally efficient casing design. For example, a unit classified as L3 may leak up to 6 percent of conditioned air, wasting fan energy and compromising control. In contrast, an L1 unit with less than 0.15 percent leakage ensures that the energy used in heating, cooling or humidifying the supply air is not lost through casing inefficiency.

The revised standard also introduces optional reporting fields for component energy class, leakage as a percentage of fan duty, and material recyclability. These additions support whole-life carbon assessments and allow designers to align mechanical specifications with broader sustainability and Net Zero goals.

### How does HTM 03-01 affect AHU decarbonisation in healthcare?

HTM 03-01 sets specific ventilation standards for UK healthcare facilities. Key implications for decarbonisation include:

- Filtration requirements: High-efficiency filters increase pressure drop, so fans must be upgraded to maintain performance efficiently.
- Cross-contamination control: Rotary wheels are typically prohibited in clinical areas, so run-around coils are required for heat recovery.
- Redundancy: N+1 fan arrangements and dual supply lines are often required, influencing refurbishment and replacement strategies.
- Criticality of downtime: AHU refurbishment must often be phased or delivered out-of-hours to avoid service disruption.

For NHS estates, HTM 03-01 compliance is non-negotiable, meaning AHU decarbonisation must be achieved without compromising infection control or patient safety.

### How does CIBSE guidance influence AHU decarbonisation?

CIBSE provides technical guidance widely used by engineers:

- Guide B2: Details on ventilation and air handling design, including SFP targets and energy efficiency options.
- TM54: Predicting operational energy use, critical for validating AHU savings in practice.
- TM65: Assessing embodied carbon, required increasingly in tender submissions.
- AM17: Guidance on heat pumps, relevant for electrifying AHU coils.

These documents set the engineering context and provide methodologies that align with best practice and ESG reporting requirements.

### How do Net Zero and ESG frameworks affect AHU decarbonisation?

Beyond engineering standards, AHU decarbonisation is shaped by broader frameworks:

- UK Net Zero Strategy (2050 target). Requires elimination of fossil fuel combustion in buildings, making electrification of AHUs essential.
- NHS Net Zero Carbon Roadmap. Targets Scope 1 and 2 elimination by 2040, driving removal of gas-fired coils.
- GRESB and SECR. Require disclosure of carbon savings from building systems, including AHUs.
- Corporate ESG commitments. Many organisations commit to Science-Based Targets (SBTi) that require evidence of carbon reductions at asset level.

These frameworks mean that AHU upgrades are not just technical choices but central to corporate reporting and compliance.

### What risks arise if AHU regulatory and compliance frameworks are ignored?

Failure to align AHU upgrades with regulations and standards carries major risks:

- Non-compliance fines or rejection of planning approval.
- Inability to operate in regulated sectors (e.g., healthcare) without HTM compliance.
- Underperforming systems if minimum efficiency standards are not met.
- Missed ESG credits in GRESB or other reporting schemes.
- Reputational damage if upgrades fail to align with Net Zero commitments.

### How can estates ensure AHU compliance while maximising decarbonisation?

Best practice is to integrate regulatory and decarbonisation requirements at the design stage:

- Benchmark AHU performance against Ecodesign, Part L, and EN 1886.
- Use CIBSE TM54 modelling to predict operational savings.
- Include TM65 embodied carbon assessments in procurement.
- Align with sector frameworks (e.g., HTM 03-01 for NHS).
- Require suppliers to provide evidence of compliance through factory testing and certification.

This approach ensures AHU projects not only meet legal obligations but also deliver measurable, reportable carbon reductions aligned with corporate Net Zero strategies.

## Section 9: How do AHU upgrades fit into wider building and estate-level decarbonisation strategies?

### Why are AHUs central to building decarbonisation strategies?

Ventilation systems are one of the largest contributors to building energy consumption. In commercial buildings, AHUs can account for 25–40% of total HVAC energy use, which in turn can represent 40% or more of total building energy consumption. Because AHUs are continuous-load systems, even modest efficiency improvements translate into large absolute savings.

Decarbonising AHUs therefore directly supports estate-wide targets by lowering both Scope 1 (gas-fired coils) and Scope 2 (electricity for fans and cooling) emissions. Just as importantly, AHUs influence occupant comfort, indoor air quality, and compliance with standards. They are both a carbon reduction opportunity and a strategic enabler of healthy, high-performing buildings.

### How do AHU upgrades interact with other building decarbonisation measures?

AHU upgrades rarely occur in isolation. They are most effective when integrated with wider building strategies:

- Heat pumps: AHU coil electrification aligns with a building's transition away from fossil fuel boilers.
- Building fabric upgrades: Improved insulation and airtightness reduce heating loads, allowing AHU supply air temperatures to be reset and fan energy reduced.
- Lighting and equipment efficiency: Lower internal gains can change cooling loads, requiring recalibration of AHU sequences.
- On-site renewables: AHU efficiency improvements reduce overall load, making solar PV or wind integration more impactful.
- Smart building platforms: AHUs are often the largest controllable load in a building and are key assets for demand response and load shifting.

### How do AHU upgrades contribute to corporate Net Zero pathways?

Corporate Net Zero strategies require measurable reductions in operational carbon. AHU upgrades contribute by:

- Eliminating Scope 1 emissions through electrification of heating coils.
- Reducing Scope 2 emissions by cutting fan and cooling loads through refurbishment, retrofit, and recovery.
- Reducing embodied carbon by choosing refurbishment or modular replacement over premature disposal.
- Providing auditable data from modern controls and monitoring systems for ESG disclosure.

Because AHUs often operate across large estates, cumulative savings can be enormous. A 10% reduction in AHU energy use across 100 supermarkets can equate to thousands of tonnes of $CO_2$ saved annually.

### What are the benefits of an estate-level AHU decarbonisation programme?

Taking a portfolio-wide approach delivers benefits that go beyond single projects:

- Consistency: Standardised refurbishment or replacement packages simplify procurement and ensure predictable savings.
- Economies of scale: Bulk purchasing and repeatable designs reduce unit cost.
- Data visibility: Estate-wide monitoring platforms allow benchmarking and optimisation across hundreds of units.
- Strategic planning: Phased upgrades align with capital budgets and Net Zero milestones.
- ESG reporting confidence: Consistent methodology ensures reliable disclosure to stakeholders.

### How should estates prioritise AHU decarbonisation projects?

Prioritisation should be based on:

- Condition surveys: Identify AHUs near end-of-life versus those suitable for refurbishment.
- Carbon impact: Model which units deliver the largest absolute savings (e.g., 24/7 hospital AHUs).
- Compliance risk: Address units that fail to meet EN 1886, HTM 03-01, or Part L requirements first.
- Disruption tolerance: Schedule upgrades for buildings or areas where downtime can be managed.
- Estate strategy: Align with wider electrification, renewable, and ESG timelines.

A decision matrix weighing condition, carbon savings, cost, and disruption is often used to map out a phased estate programme.

### How do phased rollouts of AHU upgrades work in practice?

Most large estates cannot decarbonise all AHUs at once. Phased approaches are common:

- Hospitals: Begin with refurbishments to critical AHUs during night or weekend shifts, followed by phased bespoke replacements.
- Supermarkets: Deploy fan and controls refurbishments across the estate first, then roll out modular MPX or Xe replacements region by region.
- Universities: Retrofit heat recovery in lecture theatres first, then replace smaller AHUs with electrified modular units.



This approach delivers immediate carbon savings while spreading capital investment and disruption over multiple years.

### What risks arise if AHU upgrades are not integrated into wider strategies?

If AHU upgrades are pursued in isolation, risks include:

- Stranded assets: Installing new gas coils just before a building-wide electrification programme makes them obsolete.
- Mismatched systems: AHUs upgraded without aligning to heat pump capacity or BMS platforms may require rework.
- Missed opportunities: Failure to integrate with fabric or lighting upgrades reduces total carbon savings.
- Inconsistent reporting: Lack of standard methodology across projects undermines ESG disclosure.

### How does Mansfield Pollard support estate-level decarbonisation?

Mansfield Pollard delivers decarbonisation across refurbishment, modular, and bespoke AHUs, enabling estates to:

- Audit existing assets with condition surveys and energy modelling.
- Select refurbishment, modular, or bespoke replacement depending on lifecycle stage.
- Phase delivery across estates to maximise early carbon savings.
- Integrate AHU upgrades with wider building electrification and Net Zero programmes.

By aligning technical solutions with estate-level strategy, Mansfield Pollard ensures AHU decarbonisation delivers maximum impact and measurable ESG outcomes.

## Section 10: What pitfalls commonly undermine AHU decarbonisation projects?

### Why do some AHU decarbonisation projects fail to deliver expected carbon savings?

Many AHU decarbonisation projects underperform because assumptions made at the design stage are not validated in practice. Surveys may miss critical information, component selections may be mismatched, or controls may not be re-engineered to suit the new equipment. As a result, upgrades that should deliver 20–40% energy savings sometimes achieve only 5–10%. Failure usually arises from three areas: incomplete pre-project assessment, poor integration during delivery, and lack of monitoring after handover.

### What are the most common mistakes in AHU electrification upgrades?

Electrification delivers large carbon reductions, but poorly planned upgrades often fall short. Common errors include:

- Ignoring electrical capacity: New DX or heat pump coils can overload switchboards if headroom is not checked.
- Oversizing coils: Incorrect selections lead to excessive fan resistance and pump power.
- Inadequate defrost strategies: Heat pumps underperform in cold conditions if sequences are not carefully engineered.
- Stranded assets: Replacing a gas coil just before a site-wide boiler decommissioning programme wastes capital and embodied carbon.

Proper load calculations, electrical surveys, and integration with estate-level electrification strategies prevent these mistakes.

### What problems occur when retrofitting heat recovery into AHUs?

Heat recovery is one of the most effective decarbonisation measures, but retrofits can fail if not engineered carefully. Pitfalls include:
- Underestimating pressure drop: A new plate heat exchanger adds resistance, which may increase fan power enough to offset savings.
- Inadequate frost protection: Without pre-heat or bypass control, plates can freeze in sub-zero conditions and fail.
- Cross-contamination risks: Rotary wheels in healthcare can transfer pathogens if not excluded.
- Bypass dampers not working: If dampers leak, effectiveness is lost.

These risks highlight the need for detailed fan and psychrometric calculations, frost design checks, and commissioning of bypass systems.

### Why do new fans or controls sometimes fail to reduce energy use in AHU refurbishments?

It is common to see refurbished AHUs with new EC fans or variable-speed drives that show little improvement in energy bills. The main reasons are:
- Fans are installed without recalculating system resistance, so they operate inefficiently.
- Controls are bolted on but sequences are left unchanged, leaving fans running in constant-volume mode.
- Sensors are miscalibrated, giving false signals to demand-control logic.
- Operators override controls after complaints and forget to reset them.

Without re-engineering controls and verifying system integration, new fans and controls cannot deliver their full savings potential.

### How can maintenance issues cause AHUs to waste energy after decarbonisation?

Even well-designed projects lose effectiveness without sustained maintenance. Once upgraded, an AHU still relies on the performance of consumables, controls and moving parts to maintain energy and carbon benefits. Typical failure points include:

- Clogged filters: A 100 Pa increase in pressure drop can raise fan energy consumption by 10 to 15 percent if airflow remains constant

- Fouled coils: Dirt accumulation on heating or cooling coils reduces thermal transfer efficiency, forcing longer run times and higher load on plant

- Sensor drift: $CO_2$ or temperature sensors that fall out of calibration can disable demand-control logic, causing systems to run at full load unnecessarily

- Disabled recovery systems: Heat recovery wheels or coils that are bypassed after faults or alarms are often not reinstated, reducing overall system efficiency

Without proactive maintenance and ongoing performance monitoring, even high-efficiency AHUs can revert toward baseline energy use within months. Planned servicing, recalibration and periodic re-commissioning are critical to ensure that decarbonisation gains are retained over time.

### What financial mistakes do estates make in AHU decarbonisation programmes?

Financial pitfalls often stem from short-term decision-making:
- Replacing units prematurely, adding unnecessary embodied carbon and cost.
- Choosing lowest-cost options without lifecycle modelling, leading to stranded assets.
- Failing to align AHU upgrades with wider estate programmes, such as fabric improvements or heat pump rollouts.
- Neglecting to budget for commissioning, monitoring, and verification, leaving ESG reporting unsupported.

Whole-life costing, including embodied carbon and operational savings, ensures investment delivers true value.

### How can organisations avoid common AHU decarbonisation pitfalls?

Best practice for avoiding underperformance includes:
- Comprehensive surveys covering condition, leakage, space, duct resistance, and electrical capacity.
- Whole-life carbon modelling using TM54 for operational energy and TM65 for embodied emissions.
- Integrated design linking fans, coils, recovery, and controls from the outset.
- Commissioning and seasonal testing to validate savings in real operation.
- Monitoring and optimisation to sustain performance year after year.
- Single-source responsibility with suppliers who design, manufacture, install, and commission complete solutions.

By following these steps, estates can ensure AHU decarbonisation delivers reliable, reportable progress towards Net Zero.

## Section 11: How to choose the right partner for AHU decarbonisation

### Why does choosing the right partner matter for AHU decarbonisation projects?

AHU decarbonisation is complex. It requires detailed surveys, correct component selection, integration of fans, coils, and controls, and careful phasing to avoid operational disruption. Projects often fail not because of the technology but because of fragmented delivery and lack of accountability. Choosing the right partner ensures that design, manufacture, installation, and commissioning are coordinated, savings are validated, and risks are managed.

### What expertise should an AHU decarbonisation partner have?

The most effective partners combine engineering capability with delivery experience. Key areas of expertise include:
- Refurbishment and retrofit design: Understanding when existing casings can be reused and how to integrate new fans, coils, and controls.
- Modular and bespoke manufacture: Ability to deliver both repeatable modular solutions

and one-off designs for critical environments.
- Electrification integration: Experience with DX, VRF, and heat pump coils, and the electrical and control upgrades these require.
- Compliance knowledge: Familiarity with EN 1886, Ecodesign, HTM 03-01, TM54, and TM65.
- Controls engineering: Capability to re-engineer control logic, not just install hardware.
- Site delivery: Expertise in sectionalisation, cranage, plantroom logistics, and phased rollouts.

A partner lacking in any of these areas may compromise project outcomes.

### How can clients evaluate potential AHU partners?

Clients should evaluate partners using both technical and organisational criteria:
- Technical track record: Evidence of completed refurbishment, modular, and bespoke projects across relevant sectors.
- Factory capability: Size, capacity, and equipment to deliver large, complex projects (e.g., welding, CNC, fan array testing).
- Quality assurance: ISO 9001, EN 1886 test facilities, and factory acceptance testing.
- Sustainability credentials: Carbon-neutral operations, TM65 reporting, and embodied carbon expertise.
- People and culture: Highly skilled, engaged staff with strong retention and training records.
- References and case studies: Proof of delivering savings, compliance, and successful estate programmes.

### What questions should estates ask before appointing an AHU decarbonisation partner?

Relevant questions include:
- Have you delivered both refurbishment and replacement projects in our sector?
- How do you model both operational and embodied carbon savings?
- Can you provide TM54 and TM65 outputs?
- How do you manage phasing and downtime in critical environments?
- Do you design and manufacture in-house, or outsource key elements?
- How do you ensure controls are re-engineered, not just reused?
- Can you provide factory acceptance testing before delivery?
- How will you support monitoring and optimisation after installation?

The answers to these questions quickly reveal whether a partner is capable of delivering reliable outcomes.

### What happens if you choose the wrong AHU decarbonisation partner?

Risks include:
- Underperforming systems: Poorly integrated fans, coils, or controls deliver little real saving.
- Compliance failure: Non-compliance with EN 1886, Part L, or HTM 03-01 leads to rework or regulatory issues.
- Unplanned downtime: Critical services disrupted by poor phasing or logistics.
- Cost escalation: Budgets overrun due to late recognition of electrical, access, or cranage requirements.
- Reputational damage: Failure to meet Net Zero commitments or ESG reporting standards.



### How does Mansfield Pollard support clients as a decarbonisation partner?

Mansfield Pollard is uniquely positioned to support estates across the full spectrum of AHU decarbonisation:

- Refurbishment: In-house expertise in upgrading fans, coils, and controls while retaining embodied carbon.
- Modular replacement: MPX and Xe product ranges deliver rapid-install, high-efficiency units for estate-wide programmes.
- Bespoke replacement: Custom AHUs for healthcare, data centres, and critical infrastructure, designed to meet the most demanding specifications.
- Electrification: Experience integrating DX and heat pump coils, enabling transition away from gas.
- Compliance: Full alignment with EN 1886, Ecodesign, HTM 03-01, TM54, and TM65.
- Factory capability: 321,000 sq. ft. facility with CNC, welding, and test facilities for large, complex builds.
- Carbon credentials: Independently verified carbon-neutral operations, supporting client ESG reporting.

By combining engineering expertise, factory capacity, and sustainability leadership, Mansfield Pollard provides estates with a single-source partner for reliable AHU decarbonisation.

## Section 12: What does the future of AHU decarbonisation look like?

### What innovations will shape the next generation of AHUs?

The next decade will see AHUs evolve from static ventilation units into intelligent, integrated energy systems. Key innovations include:

- High-efficiency heat pumps integrated directly into AHUs for fully electric heating and cooling.
- Next-generation heat recovery devices with efficiencies above 85%, using novel materials and coatings.
- Advanced fan arrays with AI-driven optimisation to balance redundancy, efficiency, and acoustics in real time.
- Hybrid systems that combine mechanical ventilation with natural ventilation where conditions allow.
- Lightweight materials such as aluminium profiles and composites, reducing embodied carbon without compromising strength.

These innovations will push both operational and embodied carbon performance beyond today's benchmarks.

### How will digitalisation transform AHU decarbonisation?

Digitalisation will shift AHUs from passive assets to continuously optimised systems. Trends include:
- AI-driven controls that predict demand based on occupancy, weather forecasts, and energy pricing.

- Digital twins that simulate AHU performance, enabling predictive optimisation and scenario testing before changes are applied.
- Cloud-based analytics for estate-wide benchmarking and automated performance alerts.
- Integration with smart grids to enable demand response, shifting ventilation loads to times of low carbon intensity.

These tools will ensure that AHU performance remains optimised throughout the lifecycle, closing the performance gap between design intent and real-world operation.

### How will embodied carbon reduction influence future AHU design?

Embodied carbon will become as important as operational energy. Designers will increasingly:

- Use CIBSE TM65 assessments at concept stage to compare material choices.
- Select low-carbon materials such as recycled aluminium and steel.
- Design AHUs for disassembly and reuse, enabling panels, coils, and fans to be repurposed at end-of-life.
- Offer Environmental Product Declarations (EPDs) as standard for procurement.

Clients will demand not only energy-efficient AHUs but also units that demonstrate minimal lifecycle impact.

### How will regulation drive the future of AHU decarbonisation?

Regulatory pressure will intensify as Net Zero targets approach:

- Tighter Ecodesign standards will raise minimum fan, motor, and recovery efficiencies.
- Stricter building regulations will mandate electrification of heating systems and higher airtightness standards.
- Healthcare compliance will require HTM 03-01 units to deliver both safety and carbon reduction.
- Corporate ESG reporting will demand transparent operational and embodied carbon data for all HVAC equipment.

Estates that fail to modernise AHUs in line with these regulations risk non-compliance, reputational damage, and escalating costs.

### What does the future mean for estates planning AHU upgrades today?

Estates need to balance immediate carbon reductions with future readiness. Best practice is to:

- Prioritise refurbishment where embodied carbon savings are strongest, but design upgrades with electrification in mind.
- Adopt modular replacements that can be rolled out across estates quickly, standardising performance and compliance.
- Invest in bespoke units where compliance or resilience demands exceed modular capability.
- Specify controls and monitoring that can integrate with future digital platforms and ESG reporting.
- Choose partners with a clear roadmap for innovation, not just today's compliance.

By acting now with a future-proof mindset, estates can avoid stranded assets and ensure AHUs continue to support Net Zero pathways well into the 2030s.

### How is Mansfield Pollard preparing for the future of AHU decarbonisation?

Mansfield Pollard is actively developing the next generation of AHUs:

- Electrification-ready designs with integrated heat pump coils.
- Lightweight modular aluminium enclosures (ALX) reducing embodied carbon.
- Advanced fan arrays designed for resilience and efficiency.
- Digital integration through smart controls, monitoring, and TM54/TM65 outputs.
- Sustainability leadership as a carbon-neutral business with a clear roadmap to 2026 and beyond.

By combining innovation, compliance expertise, and carbon responsibility, Mansfield Pollard ensures clients benefit from AHUs that are not only efficient today but also aligned with the future of building decarbonisation.

# AHU DECARBONISATION
The Complete Guide

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