Thought leadership 1: How to maximise radiators alongside heat pumps

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Overview

In November 2020, the UK Government announced the Green Industrial Revolution and a Ten Point Plan in order to lay the foundations needed to end the UK's contribution to CO_2 affecting climate change. One of the headline promises was for 600,000 heat pumps to be rolled out to homes across the country every year by 2028.

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To achieve this target, a great deal of work clearly needs to be done in the heating industry, not least of all when considering how heat pumps, which utilise lower flow temperatures, integrate with heat emitters in new and existing homes. Here, greater understanding is required across the industry, from developers and housebuilders to contractors and installers.

With this in mind, it is important to note that 80% of all homes occupied by 2050 will have already been constructed – and 98% of these are likely to utilise hydronic radiators as their main source of space heating. This fact highlights the need for the industry to clearly understand how heat pumps can be incorporated into existing heating systems as a replacement technology to gas or oil boilers – which are identified as greater contributors to climate change.

The move to lower flow temperatures

With the proliferation of heat pumps set to increase, the design of residential heating systems will need to change significantly.

Flow temperatures from heat pumps are notably lower, ranging from 45°C to 55°C, compared to the higher flow temperatures of 75°C to 80°C, typically associated with gas/oil boilers. The reason for this reduction is that a heat pump's efficiency is optimised for working at low water temperatures, in conjunction with low temperature heat distribution systems. As hot water flow temperatures increase, heat pump efficiency (Coefficient of Performance) falls.

Flow temperatures from heat pumps are notably lower, ranging from 45°C to 55°C

How lower flow temperatures affect the choice of heat emitters

When considering the options for combining a low water temperature heat source (such as a heat pump) with a heat emitter, underfloor heating (UFH) is often seen as the first port of call.

Consisting of a series of pipes, usually installed in a layer of screed under the floor, the operating water temperatures are typically around 45°C with a Delta T of 20-25K and thermal power outputs around 100 W/m^2 of floor area. This type of installation can be well suited for use in new build properties as it complements the latest building standards, which incorporate high levels of air tightness and insulation. On the other hand, older properties that are poorly insulated would struggle to maintain a comfortable temperature for occupants with such an installation.

Although underfloor heating is one option for new build homes, it is radiators that are once again proving to be key players in the market, with their dominance set to continue as the emitter of choice for both new and established properties. Reasons for their popularity include:

- Ease and speed of installation
- Variety of models and designs available
- Modulation rates
- Familiarity within the heating industry

The use of radiators alongside heat pumps has proven to be a beneficial and flexible option, as we will now discover. However, the approach to their partnership differs slightly depending on the age of a property.

Modern radiators offer excellent modulation rates for a flexible heating system

Heat pumps and radiators in established buildings

Upon installation of a low temperature heating system, such as a heat pump, there is a common misconception that some, if not all, of the radiators in a property may need to be replaced with models that offer a larger thermal output to ensure an appropriate level of heat is supplied. However, this is not the case.

A study carried out by the Department for Business, Energy and Industrial Strategy (BEIS)*, discovered that, in general, radiators connected to traditional central heating systems within existing homes are usually oversized. It suggests the reason for this could be due to plumbers considering it better to add a margin of error to ensure the radiators' output will be able to provide adequate thermal comfort for the occupants. The study also states that, despite it becoming easier to calculate radiator sizes since the mid-2000s, 53% of dwellings in the UK could still be sufficiently heated with their existing radiators at a flow temperature of 55°C – making them already appropriately sized for use with a heat pump. It's important to note this calculation is based on an average temperature for the coldest winter month, rather than a peak heating day.

The BEIS study also outlines that, provided a heat pump can meet the maximum requirements for peak heat demand (kW), flow temperatures could be reduced for much of the heating season, thereby increasing the overall efficiency and reducing running costs. This takes into account that many modern heat pumps can operate with variable flow temperatures.

Essentially, the study identifies that over half of all UK properties could be in a position to benefit from low temperature and highly efficient heating provided by the latest heat pump technology and, more crucially, without having to alter any other aspect of the existing heating system. Or, if changes are required, the BEIS study suggests there may be an opportunity for "hybrid heat pumps, or heat pumps with additional heat sources, to be used with no changes to heat distribution systems, with the heat pump providing the vast majority of the annual heating demand (kW), across a relatively large portion of the housing stock". This not only makes the roll-out of heat pumps for retrofit projects more credible, but it also provides assurances to homeowners that the capital cost will not be unduly high.

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Radiators in new build properties

As outlined in the BEIS study, radiators are still regarded as the default choice for new build homes due to their "price, reliability, and ease of installation". So from an ongoing perspective, it is clear that property developers will be keen to maintain their relationship with this type of space heating, regardless of the heat source.

It is also interesting to note that there are increased demand and market share growth in column and aluminium radiators, with their purchase stemming from an ongoing space saving requirement and improvements to the interior décor of a property. This trend has certainly been gathering momentum over the last decade, but it is now at a tipping point in new builds, where the use of traditional steel panel models no longer offers developers the flexibility or desired aesthetic demanded by discerning property purchasers.

With increasingly higher levels of insulation and air tightness, modern properties require far less heat than older properties to maintain a comfortable environment. As a result, this affords housebuilders the opportunity of reducing the number of radiators in a property, so where in previous years there may have been two units per room, there is now only one. Also, in residential apartments where there is often limited wall space available, it is again aluminium radiators that are becoming a strong contender as the models of choice.

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Aluminium radiators

Traditionally, the vast majority of homes will have been fitted with steel panel radiators and, indeed, the BEIS study discovered that the most common models installed were Type 10, 11, 20, 21 and 22.

However, in more recent years, there has been significant growth in high performance aluminium radiators, which feature very low water volumes compared to their steel panel counterparts and also provide far higher heat conducting capabilities. This advantageous combination enables aluminium radiators to be highly compatible with heat pump technology and they are fast becoming the preference for new builds. Plus, in retrofit scenarios, they offer a much improved method of distributing heat around a property when used as a replacement for steel panel models.

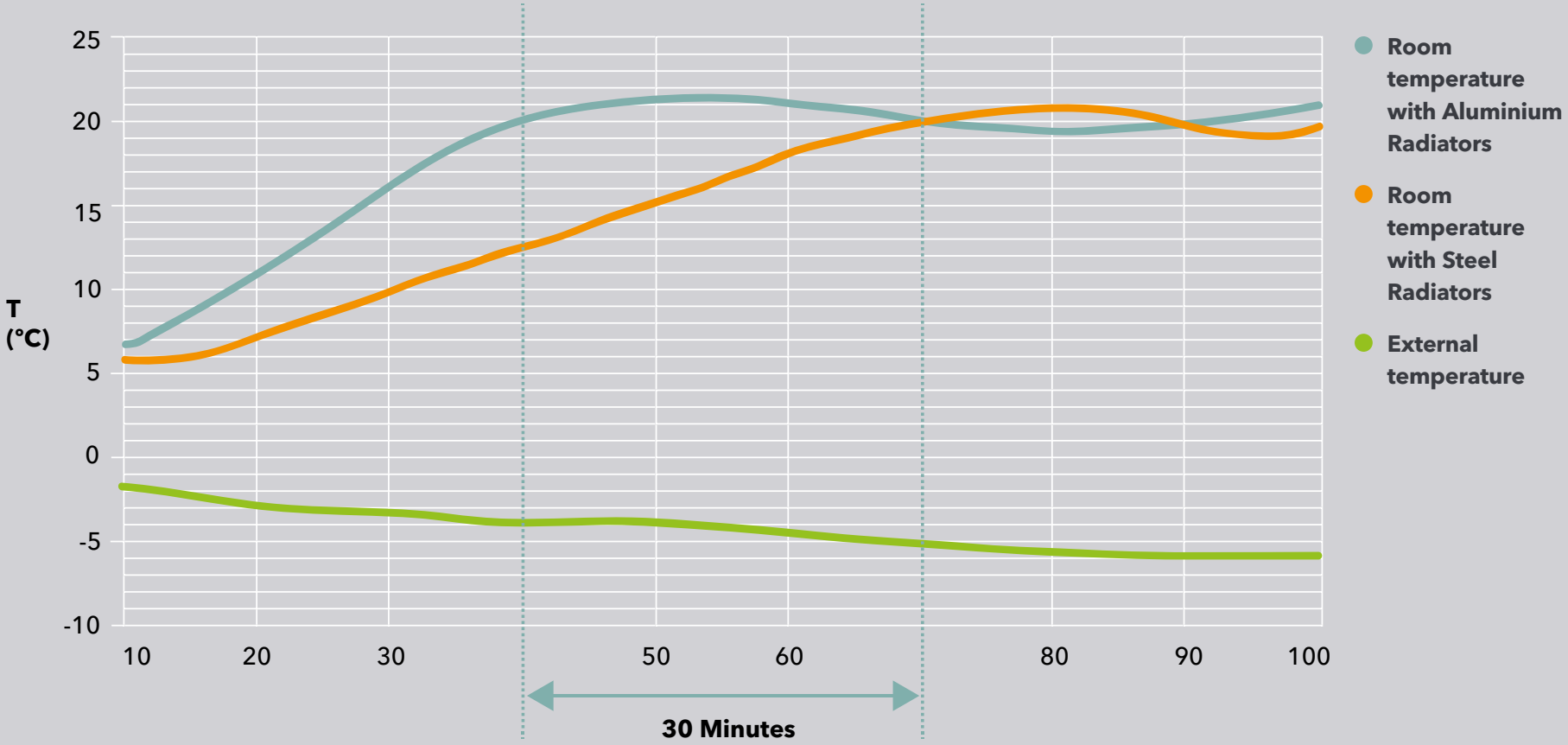
As outlined, the higher efficiencies gained by heat pumps are only achieved when running the low flow temperatures of 50°C and a Delta T 20-25K. At these levels, the performance differences between steel and aluminium radiators are substantial. The lower thermal inertia of aluminium (with its inherent ability to absorb the heat from the water and radiate it to the room at faster rates) helps achieve greater thermal comfort and control within a property.

This basic difference relates to the chemical properties of the two metals and figure 1 opposite illustrates how this works in practice, with aluminium's lower thermal mass heavily reducing the time taken for a radiator to meet the desired temperature. Since aluminium models are quicker to heat up and cool down, there is less chance of 'overshooting' the desired temperature and wasting energy, making them far more suitable for use with the lower flow temperatures associated with heat pumps.

Aluminium models are quicker to heat up and cool down

Decoral from MHS Radiators

Fig 1. Relative heat up times for aluminium vs. steel radiators



The graph shows the time taken to bring a medium sized apartment from 5°C (41°F) to a optimal temperature of 20°C (68°F) using a 24kW boiler

Aluminium radiators

A further benefit of aluminium radiators over their steel counterparts is a heightened capability to modulate (see figure 2).

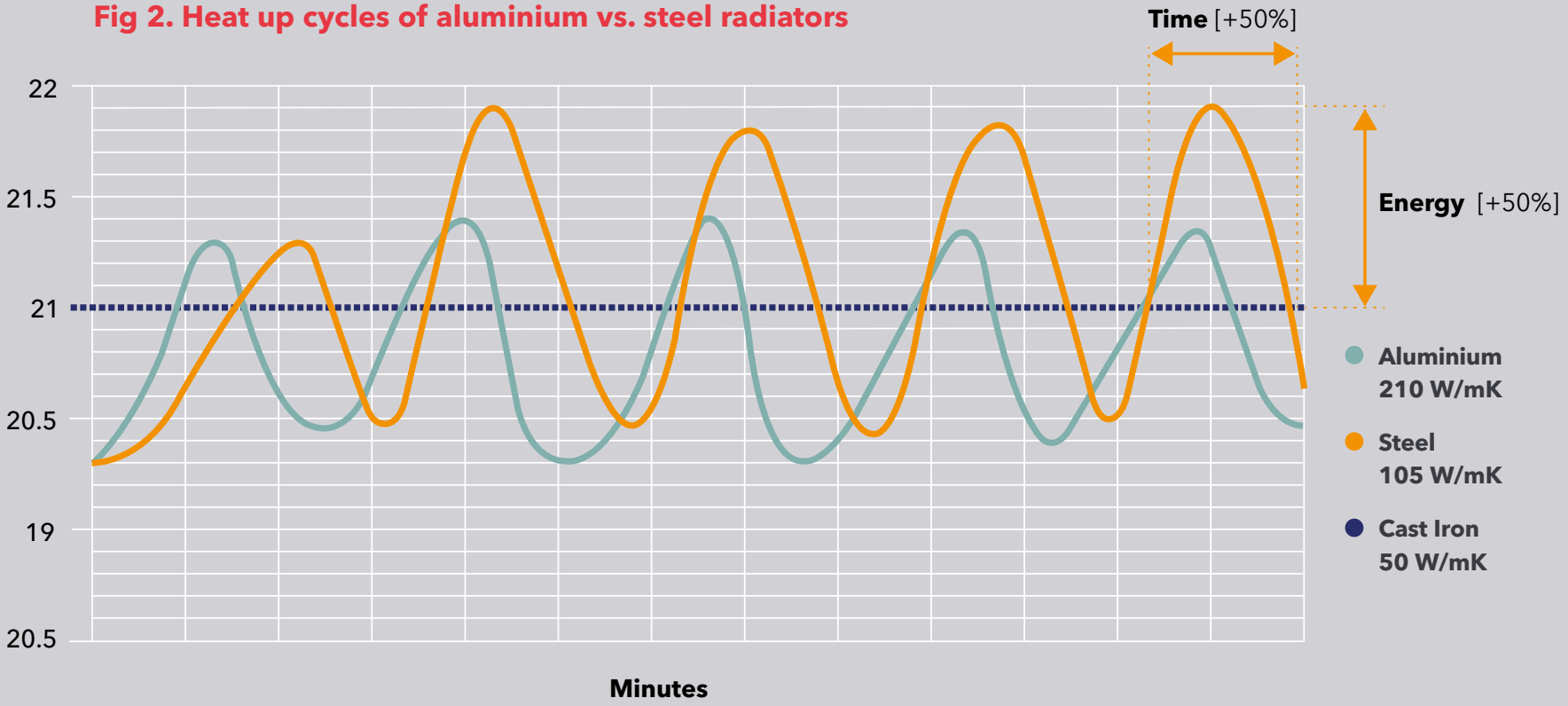
This diagram compares the modulation levels of steel and aluminium radiators and plots their paths to reach a set level. Here, it is clear to see that aluminium delivers lower peaks and troughs compared to steel, making it more efficient at reducing energy wastage. It also highlights the material's suitability for use with low temperature heating systems.

Decoral Slim from MHS Radiators

The design of most aluminium radiators also benefits the even distribution of heat throughout a room. While steel models utilise fins on the backs of the panels, aluminium models, such as the Decoral from MHS Radiators, feature lateral fins and checked back sides to further increase surface area and enhance air convection.

The design of aluminium radiators also benefits the distribution of heat throughout a room.

Fig 2. Heat up cycles of aluminium vs. steel radiators



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Weight matters

Another major benefit to combining a heat pump with aluminium radiators, as opposed to steel panel models, is the relative weight differential, as shown in figure 3.

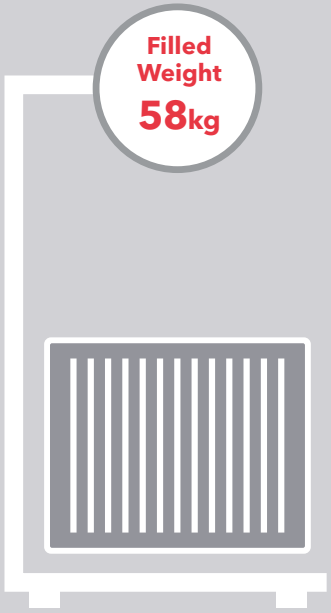
If a move to a low temperature heat pump system requires the replacement of radiators, the ease of installing aluminium models is a major benefit. Firstly, thanks to their low water content and lightweight materials, the comparative weight of an aluminium radiator makes it far simpler to handle and install. Secondly, their sectional design allows larger models to be made beyond the sizes traditionally available with steel panel models, as well as offers the option of very large models to be assembled onsite. Finally, the lightweight design simplifies the installation process, as any concerns surrounding a wall's loadbearing capacity are reduced, which can add up to significant sums in an apartment building.

The smaller size and lightweight design of aluminium models simplifies the installation process

Fig 3. Weight comparison of aluminium and steel radiators

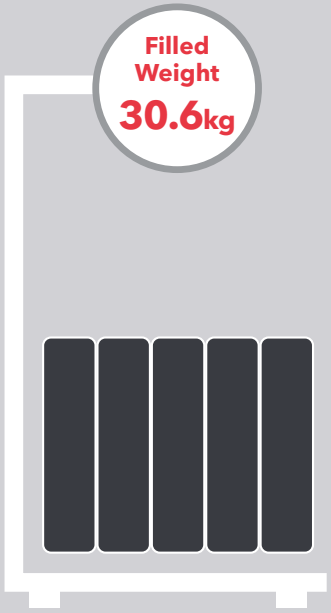
Steel

Stelrad Compact K2 (Steel)
Dimensions: (H) 600 x (W) 1400
Output at Δ25°C (50-40-20): 984
Dry Weight: **48.7kg**
Water content: 9.3 litres



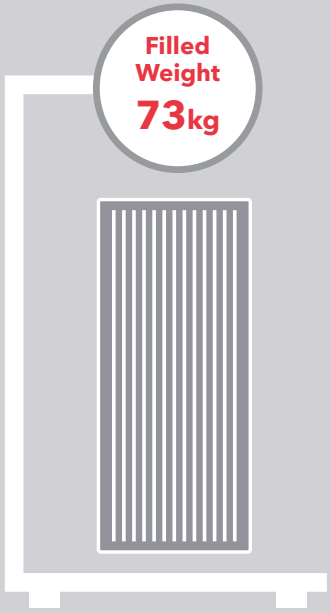
Aluminium

MHS Decoral (Aluminium)
Dimensions: (H) 600 x (W) 1380
Output at Δ25°C (50-40-20): 991
Dry Weight: **25.5kg**
Water content: 5.1 litres



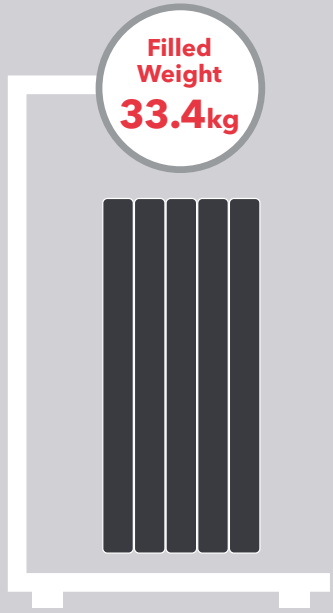
Steel - Vertical

Stelrad Compact K2 (Steel)
Dimensions: (H) 1800 x (W) 600
Output at Δ25°C (50-40-20): 964
Dry Weight: **63.5kg**
Water content: 9.5 litres



Aluminium - Vertical

MHS Decoral (Aluminium)
Dimensions: (H) 1800 x (W) 660
Output at Δ25°C (50-40-20): 974
Dry Weight: **27.2kg**
Water content: 6.2 litres



The move to vertical

On new build sites, these factors are becoming even more relevant, with developers looking to maximise every inch of wall space by the clever introduction of vertical radiators. So, when a low temperature heating system is to be utilised, but there is only space for a single radiator in a particular room, using a vertical model makes perfect sense.

At this point, aluminium once again comes into its own, with models such as the Decoral Vertical from MHS Radiators, offering supreme flexibility in its sizing. Thanks to a sectional design, Decoral radiators can be specified in a variety of heights and widths, depending on the requirements of an application.

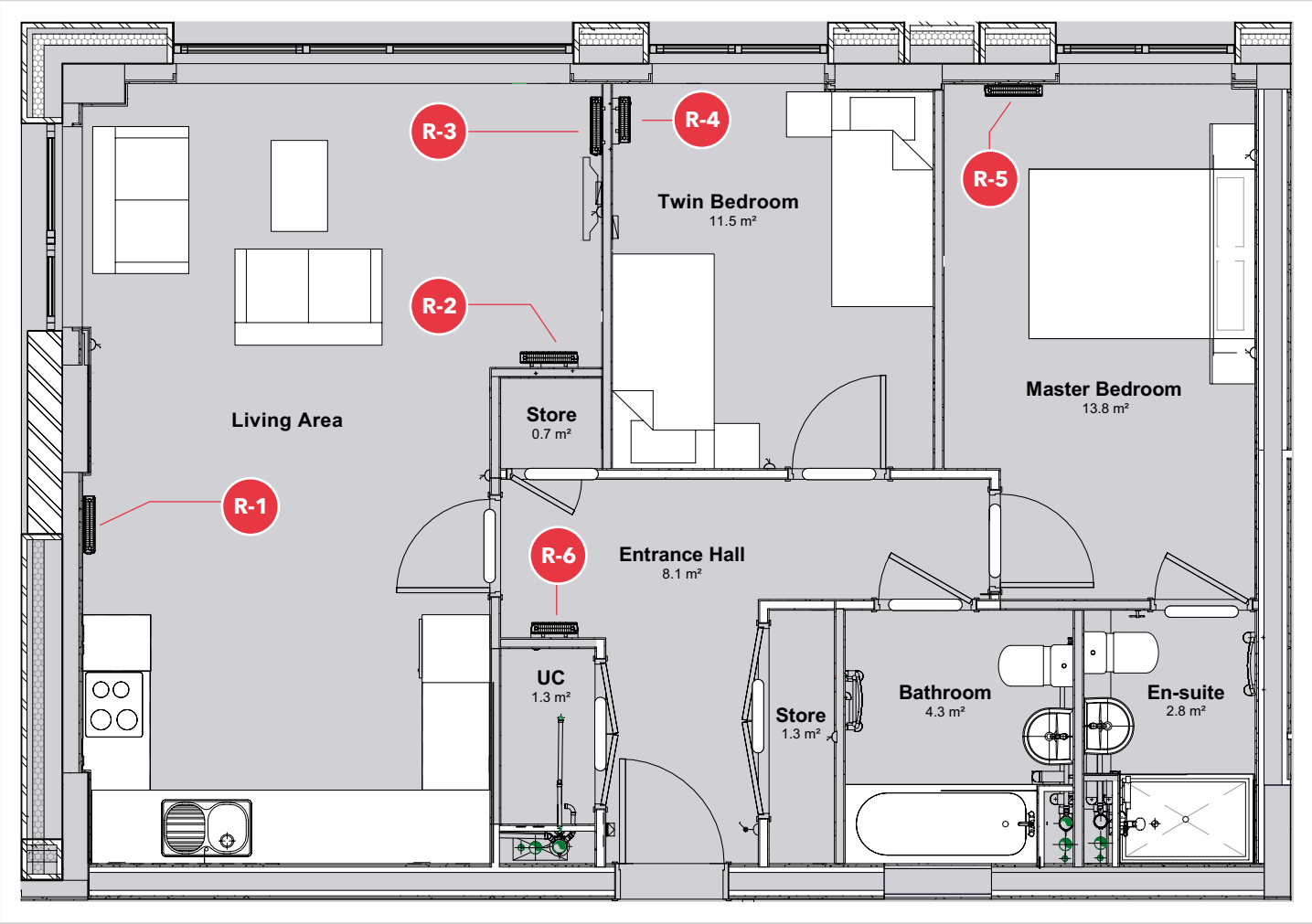
To illustrate this change in approach, figure 4 shows a typical two bedroom new build apartment. Here the developer had a heating system designed to operate at ΔT 23°C, but also needed reserve wall space as much as possible to provide efficient property layouts.

As a result, the project specified 791 Decoral Vertical radiators, with outputs ranging from 590 watts to 1298 watts, at ΔT 23°C. Achieving this design with steel panel models would not have been possible, due to the high outputs required from a single radiator.

Vertical radiators maximise space without sacrificing output or style

Decoral Vertical from MHS Radiators in White and Anthracite

Fig 4. A typical two bedroom new build apartment



Discover MHS aluminium radiators

The Decoral radiators from MHS are made with 100% recycled aluminium, and feature the following benefits:

- Low thermal inertia
- Energy savings
- Excellent weight to output ratio

Aluminium is an incredible material. It can be recycled indefinitely without ever losing its properties, guaranteeing a low carbon footprint throughout its lifecycle. This also helps reduce the uptake of the metal in its raw state, and instead promote the use of materials that would otherwise be sent to landfill.

The aluminium recycling process requires only 5% of the energy used in the production of the primary metal. This equates to a carbon footprint of 0.5 kg CO_2eq per kg of aluminium produced, compared to 6.7 kg CO_2eq per kg from primary extraction.

By carefully controlling the production chain, from scrap metal found throughout Europe, through to the finished product, MHS aluminium radiators are guaranteed to be of high quality – from both an environmental and technical perspective.

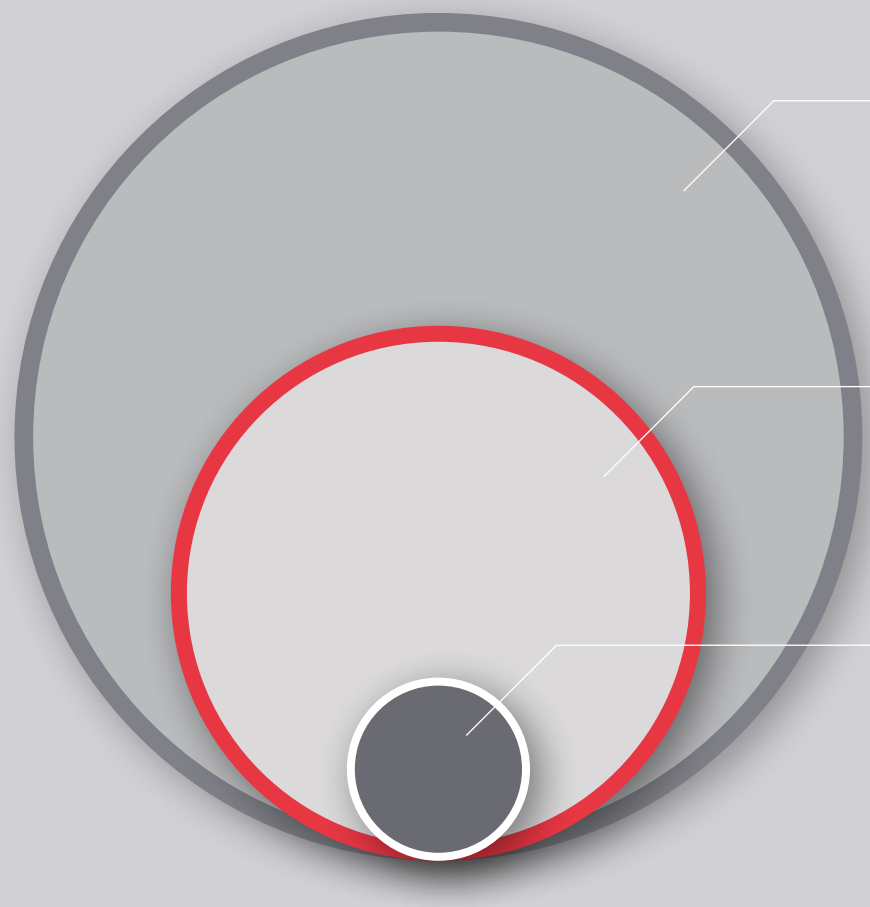
And thanks to our radiator manufacturing site being strategically close to the raw material supplier, MHS aluminium radiators are constructed using recycled liquid aluminium**.** This provides considerable sustainability benefits:

- **90%** reduction in emissions
- **80m³ saving in natural gas usage**, resulting in a reduction of **156 kg CO_2 per ton of aluminium**
- **1.5% increase in casting yield**, by reduced deterioration of remelting ingots

The production process is also certified according to the latest environmental and energy management systems. As a result, MHS aluminium radiators offer maximum efficiency and sustainability, without sacrificing performance.

The aluminium recycling process requires only 5% of the energy otherwise used in the production of the primary metal.

Fig 5. Manufacturing recycled aluminium compared to extracting primary aluminium



PRIMARY ALUMINIUM GLOBAL AVG

17kg CO_2e/kg | **100%**

PRIMARY ALUMINIUM EUROPE AVG

6.7kg CO_2e/kg | **39.4%**

RECYCLED ALUMINIUM EUROPE AVG

0.5kg CO_2e/kg | **2.9%**

Source: European Aluminium

Conclusions

90% of existing dwellings use wet heating systems comprising a boiler and radiators. As a result, despite the promise of increased installations of heat pumps, residential homes will still rely on radiators as the core heat emitters – either as part of a new build or refurb project.

For existing properties, there is evidence that 53% of homes are already capable of running a 55°C flow temperature from a heat pump, due to oversizing of radiators. This will inevitably reduce the financial restrictions previously placed on a heat pump installation. In a retrofit scenario, where there is a need to replace or update radiators, the use of aluminium models offers a high performance solution, without the need to increase the size of a radiator. This also makes the transition to heat pumps and low flow temperatures easier and more cost effective, with heating systems able to retain any existing pipework and locations of radiators on the wall.

Radiators offer a controllable and highly reactive heat emitter for modern properties, which has benefits over underfloor heating. Aluminium radiators also present themselves as the model of choice for highly insulated modern homes. Their combination of a compact, lightweight and contemporary design, alongside flexibility in sizing, ensure aluminium radiators are suitable for the wide majority of modern living – and it is anticipated that they will continued to be widely used for decades to come.

53% of homes are already capable of running a 55°C flow temperature from a heat pump

Sources:

*https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/976021/beis-dhds-final-report_1_.pdf

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