DECERNA

Delivering, unlocking & advancing the low-carbon economy

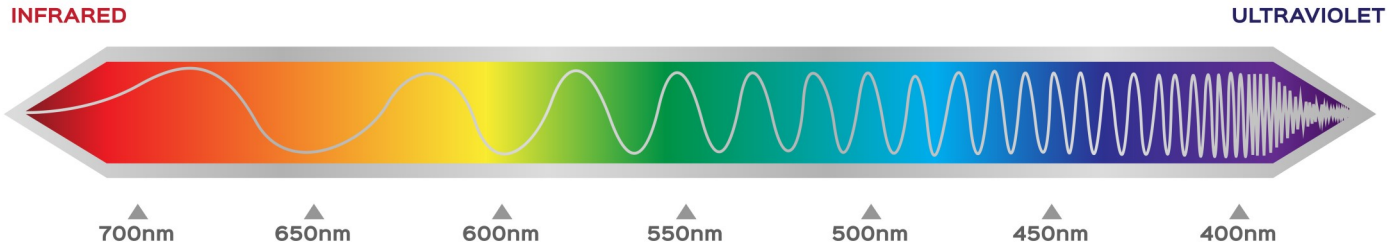
Radiant Heating

CASE STUDY	
Business Type:	Boxing Gym
Location:	Middlesbrough
Existing space heating:	Portable electric heaters
Proposed system:	11 x 3kW electric radiant panel heaters
Installed cost:	£6,800
Lifetime:	25 years
Simple payback period:	2.0 years

ANNUAL SAVINGS	
Electricity:	23,937kWh
Energy costs:	£3,777
Carbon:	7.1tCO_2e (BEIS 2022)

WHAT IS RADIANT HEATING?

Heat can transfer from one place to another in three main ways; conduction, convection and radiation. Traditional heating systems, which use boilers and radiators, deliver most of their heat to a room by heating the air, which in turn keeps us warm. This is an example of convection, whereas if you placed your hand on a radiator it would immediately feel warm, due to conduction. Radiation transfers heat in the form of electromagnetic waves, where a hot object emits radiation, which is then absorbed by objects or people, subsequently heating them up. This is the process by which the sun's rays heat the earth, or how a campfire can keep people feeling warm even though the outdoor temperature is below freezing. The radiation that is most useful for heating people is infrared. We can't see this infrared radiation as it lies just beyond the red part of the visible light spectrum, but we feel its warming effect.



Infrared to Ultraviolet Electromagnetic Spectrum

Radiant heaters can take various forms and can be directly heated by either gas or electricity, or heated indirectly from a boiler in much the same way as standard radiators. The goal of all of these heaters is to limit the amount of energy they emit in the form of conduction and convection, and to maximise the energy emitted as infrared radiation.

The main advantage of radiant heating is that, unlike convective systems such as radiators or blow heaters, they do not rely on the air in a room becoming warm before occupants feel warm themselves. Radiant heat heats people and objects directly, without having to heat the air first. This has two benefits; firstly, it is more economical to heat people rather than the entire air volume; secondly, if a building is very draughty, any air escaping does not take large amounts of heat along with it.

WHY SHOULD I GET A RADIANT HEATING SYSTEM?

Removing the need to heat the air in a building can save large amounts of energy. This is especially true if the building is poorly insulated, has large draughts or if doors and windows are open a lot of the time. Large spaces such as factories, warehouses, sports halls and large retail stores are particularly well suited to this technology. In spaces such as these, it is also possible with radiant heating to only heat areas of the space where people are present, potentially making further savings possible.

WHAT DO RADIANT HEATING SYSTEMS LOOK LIKE?

Radiant heaters take many forms, but can be divided into three main categories based on how they are heated; gas, electricity and hydronics.

GAS RADIANT HEATERS

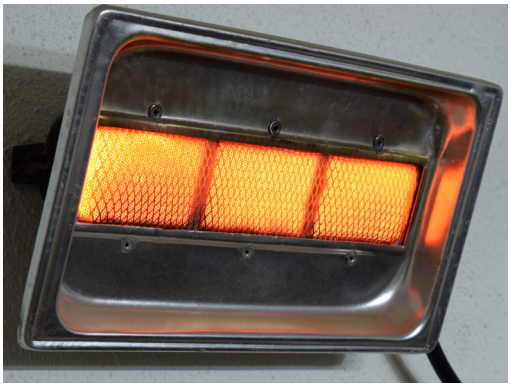
In large buildings where a mains gas connection is available, the most common type of radiant heater is the gas radiant tube. These use a long, blackened metal tube, inside which a gas flame is used to raise the tube's surface temperature. The tube's shape and colour ensure that as much of this heat as possible is emitted as infrared radiation, and a polished steel reflector surrounding the top side of the tube is used to direct as much of this radiation as possible downwards.

Space	1,667m^2 warehouse
Existing heating type:	Gas fired space heaters
Replacement:	Gas tube radiant heaters
Energy Savings:	72,819kWh
Simple payback time:	5.9 years

GAS PLAQUE HEATERS

Gas tube radiant heaters do a good job of providing thermal comfort to large spaces as described above, but it is not always necessary or desirable to provide such uniform coverage as this. In many cases, for example in factories and workshops, where occupants spend a large part of their time at a particular workstation, a more localised heating option may be more useful and cost effective. In these cases, where gas is available, a 'plaque' heater may be used. Plaque heaters usually consist of a gas burner which distributes the flame over a flat ceramic plate or plaque. As the plaque heats up, it emits infrared radiation along with a small amount of red/orange visible light. An aluminium reflector surrounds the plaque which helps direct the radiation to where it is needed.

These heaters can be wall or ceiling mounted and can be small enough to heat a single occupant or workstation. As the gas burns with a live flame, the combustion products (CO2, water vapour, carbon monoxide etc) are released into the surrounding air. They are therefore only suitable for very well-ventilated spaces. The high surface temperature and resulting high intensity of radiant heat means that minimum clearances around plaque heaters are often much higher than for other radiant heater types.

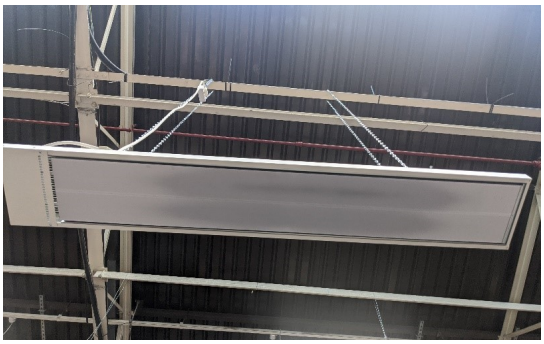


Gas plaque radiant heater

ELECTRIC RADIANT HEATERS

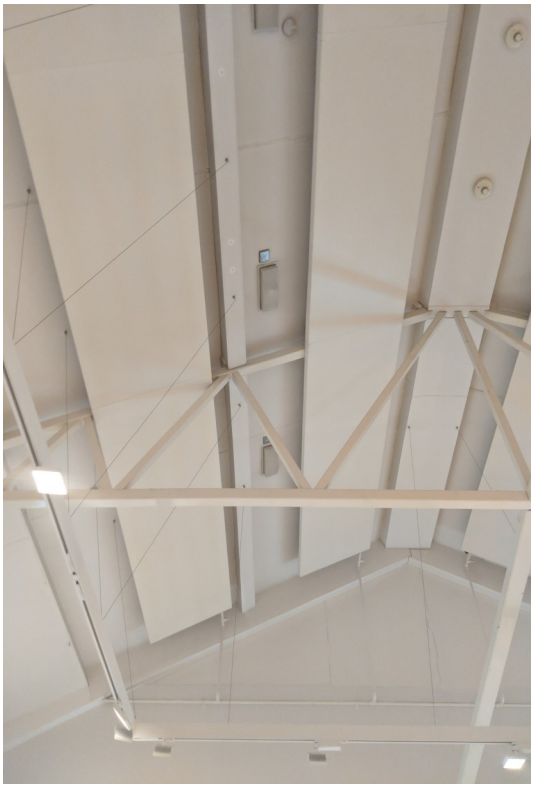
As electricity is the costliest source of energy, it is not an attractive option if mains gas is available. Where oil, LPG or direct electric heating are the only viable options, electric radiant heaters may be the best choice. These take many forms, and use a number of technologies to convert the electricity into heat. Some products such as quartz heaters emit a combination of visible light and infrared, and use reflectors to direct the beam in a similar way to the gas tube heaters. Other types, based on advanced ceramics, operate at a lower temperature and only emit infrared. Due to their lower temperatures, the heat emitter needs to have a larger surface area to deliver sufficient power, taking the form of flat panels.

Space	579m^2 warehouse
Existing heating type:	Oil fired space heaters
Replacement:	17 x 2kW electric radiant panel heaters
Energy Savings:	179,424kWh of oil saved , for 24,565kWh of electricity
Simple payback time:	5.9 years



HYDRONIC RADIANT HEATERS

Most boiler fed heating systems deliver their heat to a room via water filled radiators. Despite the name 'radiator', radiation is only a small part of their heat output. The majority of their heat is emitted in the form of convection – heating the air, which then circulates around the room. It is possible to reduce this convection component so that the radiation component is as large as possible.



These low-temperature hot water (LTHW) radiant panels have well-insulated backs and sides, with a smooth front face that radiates heat. Convection is further minimised by placing these heaters on the ceiling, meaning hot air does not easily move away from the heater's surface. Their lower temperature in comparison with other radiant heater types means they need to cover a large surface area in order to deliver sufficient infrared heating. This often results in a series of rows of panels covering a large part of the ceiling area.

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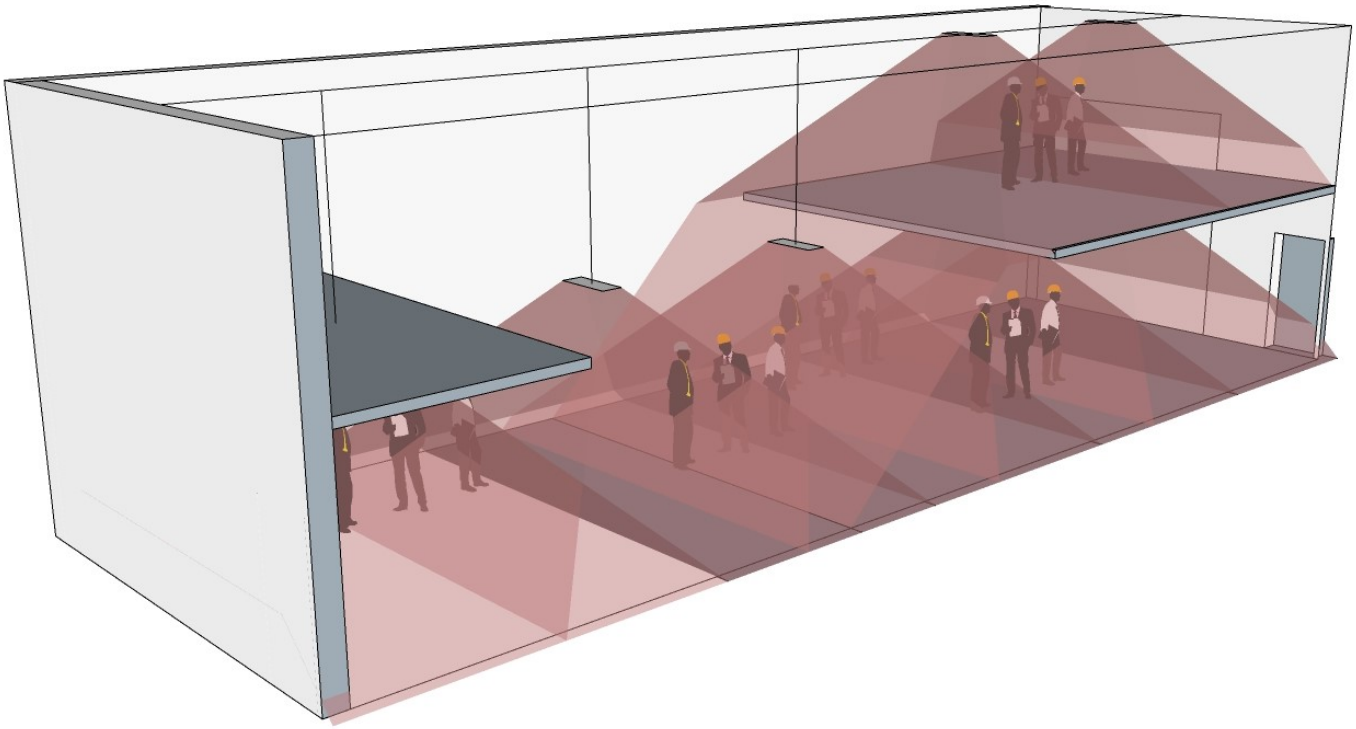
DESIGN CONSIDERATIONS

Traditionally, heating systems are sized to match or slightly exceed the amount of heat in kW that escapes through the walls/floor/roof of the building, so that a comfortable indoor air temperature can be maintained even in cold weather. Radiant heaters, however, are specified on their coverage in m^2. Infrared radiation is emitted in a beam in the same way as visible light, and the design of such a system is quite similar to that for lighting, in that it should achieve uniform coverage at the right intensity in the areas that need it.

A model of the heated space can be created with the design criteria that the infrared beams overlap at average adult shoulder height. This ensures there are no cold spots in the heated area and anyone sitting or standing should feel the effects of the heaters.



3D model of beam overlaps from multiple radiant panels

One disadvantage of a radiant heating system is that as the air is not directly heated, any areas of a space that do not have a direct line of sight to the heater will be 'shaded' from the infrared radiation and experience very little heating. In buildings with high shelving units or other obstructions, radiant heaters must be positioned so that they do not prevent the infrared radiation from reaching occupants.

Radiant heating may also be unsuitable for rooms with low ceilings or where flammable materials are stored at high level. Radiant heating products should always quote a minimum safe clearance from flammable objects. This must be taken into account during system design and signage should be placed anywhere where there is a risk of flammable items being placed nearby.

CONTROLS

As radiant heating does not rely on maintaining a particular air temperature, traditional ambient thermostats are not suitable to control the heaters. Although radiant systems will eventually heat the air by first heating the objects within a space, measuring only the air temperature does not capture the full heating effect of the radiant system.

An alternative device for measuring this effect is a 'black bulb thermostat', which consists of a blackened, non-reflective dome that covers a temperature sensor. This setup senses the 'mean radiant temperature' of the surfaces surrounding the sensor, such as walls, furniture, heaters and people. This value gives an idea of how warm it feels in that location, and can be used to control the radiant heaters by switching on or off to maintain a desirable thermal environment. Despite this, it is very common to see radiant heating systems controlled by a conventional room thermostat. Unless these thermostats are replaced with something that measures the radiant heat directly, it is likely that the system will be slow to respond and a large portion of the potential energy savings will be missed.

Black bulb thermostat

ENERGY CONSUMPTION

Regardless of the specific technology used, the energy consumption of a radiant heating system depends on how it is controlled. These heaters are basically on or off, with little in the way of modulation available, meaning that it is possible to significantly overheat a space and waste large amounts of energy by using the incorrect controls. There is a risk that if occupants treat the system in the same way as a standard heating system, that they will set the temperature set point to something they are familiar with, such as 21°C. This will result in a far higher consumption than is necessary, as radiant heating provides thermal comfort with a much lower air temperature.

Manufacturers of radiant heaters often quote very high savings, and independent verification of these values is not very common. It is generally reasonable, however that in a large, uninsulated and highly ventilated space, that a radiant heating system would reduce kWh consumption by approximately between 10% and 25%.

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Decerna provides a wide range of consultancy and development services, to ensure that the right decisions are made, to support our customers in the whole journey, from initial concept through to implementation of low carbon systems and infrastructure. Please get in touch to find out how we can help your organisation to de-carbonise.

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