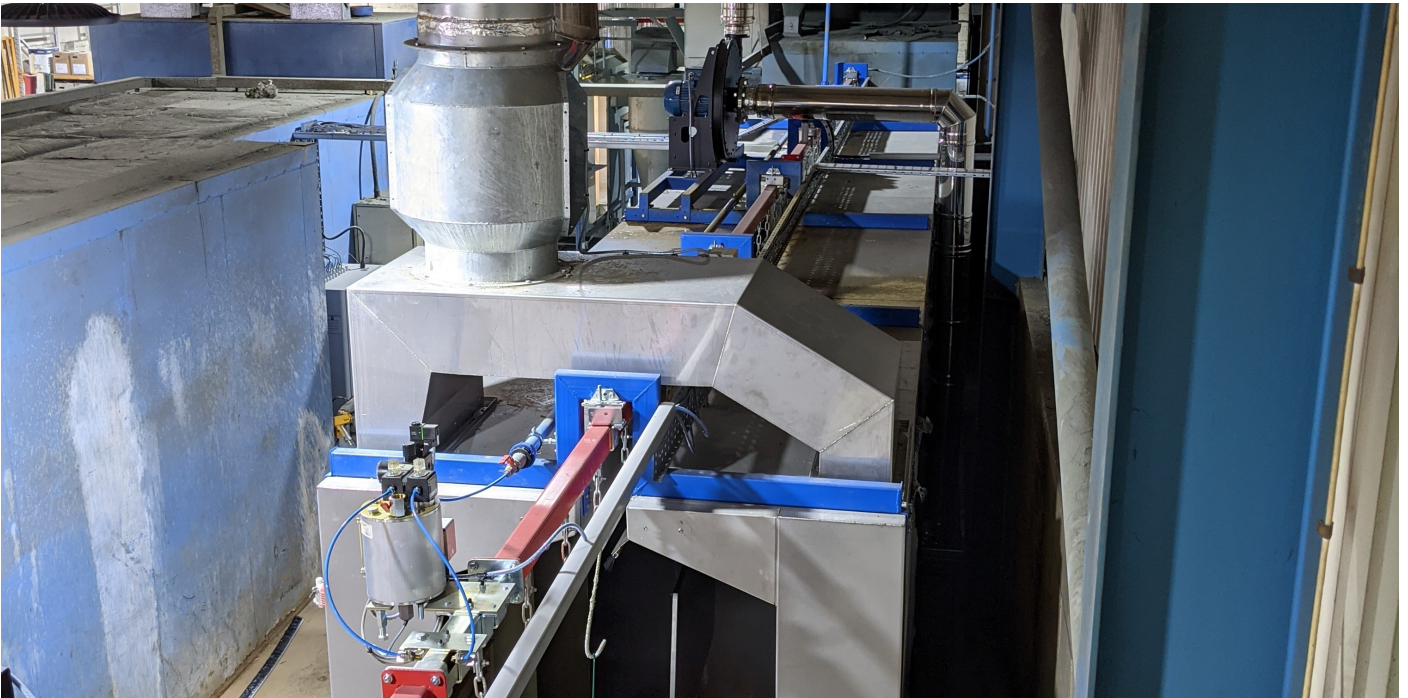


## Heat Recovery Systems



### CASE STUDY

Business Type:	Factory
Location:	Hartlepool
Measure	Ducting on compressor exhaust to inside the building with control system
Installed cost:	£12,000
Simple payback period:	3.6 years

### ANNUAL SAVINGS

Electricity:	12,552kWh
Cost:	£3,340
Carbon:	12.0 tCO <sub>2</sub> e

## WHAT IS HEAT RECOVERY?

Everywhere that heat is used, some of it is wasted. This occurs either by inefficiency of burning a fuel, losses during the distribution and containment of heat in a system or because there is a need to reject heat to make a process work properly, such as in refrigeration or electricity generation.

Historically, heat has been generated so cheaply through the burning of fossil fuels such as coal, oil or gas, that this wasted thermal energy has been of low value and therefore not seen as a problem. For similar reasons, rejecting heat intentionally has just been viewed as an acceptable cost of many processes and recouping these energy losses has not been a highly valued activity. More recently, however, the combined increase in the cost of fossil fuels and the growing need to reduce our carbon footprint has made wasted heat something worth taking seriously.



When assessing the energy efficiency of a business, it is important to look at how heat is used; where it comes from and where it ends up. In some situations it can be economically feasible to capture a portion of this waste heat before it escapes into the environment and put to use either back into the process it originated from or for a completely separate function.

Heat recovery is particularly important because so many processes emit heat as a by-product. If there is a use for this waste heat, as much of it as possible should be collected and utilised.

To assess the potential for heat recovery, the whole site should be assessed to identify all major heat inputs and outputs, in other words where heat is needed and where it is escaping.

In the vast majority of cases, recovered heat is classed as 'low grade', meaning it is below the boiling point of water, and therefore only suitable for applications such as space heating, domestic hot water, washing/ cleaning and some drying processes.

## BOILERS

One of the most familiar types of heat recovery is found in modern gas boilers. When gas is burned to create heat, one of the by-products is steam which leaves via the boiler's flue pipe, taking part of the heat energy with it. Modern boilers are mostly of the 'condensing' type, which means that this steam is allowed to condense back into water inside the flue, returning most of its heat back to the boiler via a heat exchanger as it does so. This gives rise in an improvement in boiler efficiency of around 10-12% under the right operating conditions.

## VENTILATION

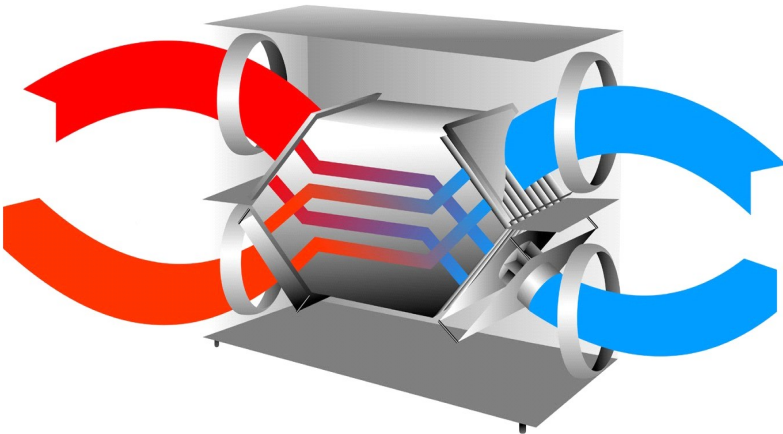
Once a space has been heated, retaining that heat is a challenge met as far as possible by insulating the building fabric and by preventing air leakage. Draughtproofing a building does help to minimise heat loss but without sufficient ventilation, the indoor air quickly becomes stale and CO<sub>2</sub> concentrations can become unacceptably high. Commercial buildings often have centralised air supply and extract systems, known as Air Handling Units (AHUs), which are designed to replace stale indoor air with fresh air from outside. The problem with this is that along with the rejected indoor air is a large amount of heat, and the indoor space is constantly being cooled down with air from outside. To combat this, it is possible to send the exhaust air out of the building via a route that runs adjacent to the incoming fresh air, and use a heat exchanger between the two air streams. The result is that a large part of the heat lost through ventilation is recovered; with warm, fresh air entering the building and cool, stale air leaving.

This process is known as Heat Recovery Ventilation (HRV) or Mechanical Ventilation and Heat Recovery (MVHR). There are a number of arrangements to achieve this, including air to air heat exchangers (recuperators), 'thermal wheels' or air to water to air heat exchangers (otherwise known as 'run around coils').



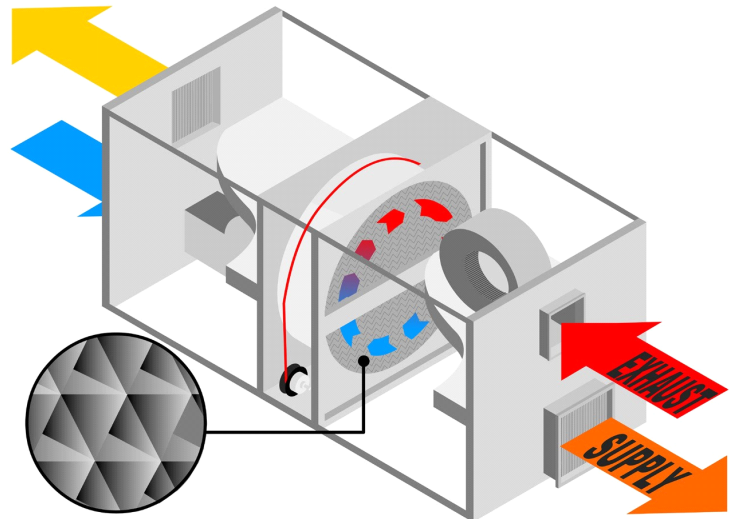
## FIXED PLATE HEAT EXCHANGER

Supply and exhaust air streams are passed as close as possible to one another via a thin-walled plastic or aluminium heat exchanger with many small channels to maximise its surface area. These tend to have the highest efficiency in certain applications.



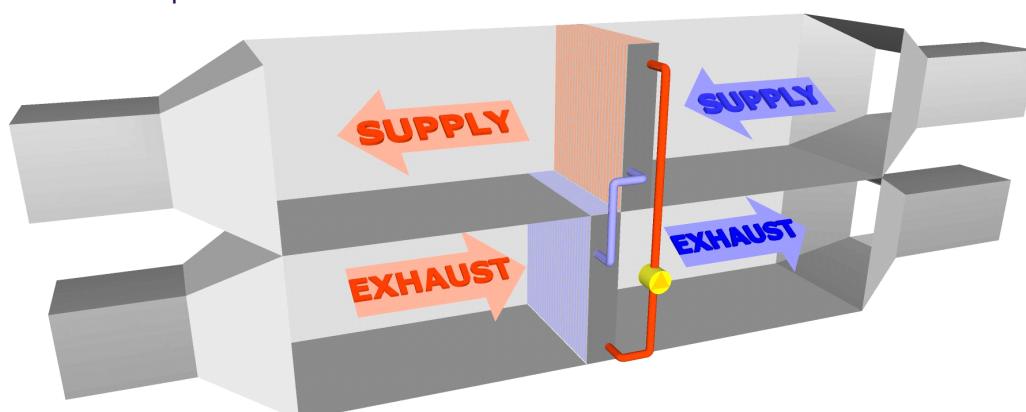
## THERMAL WHEEL

Some of the heat from the stale exhaust air is absorbed as it passes through a porous wheel which rotates to transfer the heat into the incoming fresh air. Due to the short duration that air takes to pass through the wheel, there is a lower pressure loss across it than across a fixed plate heat exchanger. They do not completely separate airflows so some contaminants in the exhaust air are transferred to the incoming air.



## RUN-AROUND COIL

These are useful for recovering heat between air streams in different locations. A pump drives water between an air/water heat exchanger on the exhaust air side and a water/air heat exchanger on the supply air side. As this involves two heat exchanges and losses through pipework, plus energy consumption from the pump, run around coils tend to be less efficient than the previous two options.



## RETROFIT

Generally, this kind of heat recovery is difficult to retrofit, and usually forms part of the initial building services fit-out of a new building. The most commonly retrofitted option is HRV, which can involve small fan driven, ducted heat exchangers that are often hidden in ceiling voids. Such devices are commonly known by trade names such as VAM or Lossnay, with many other products marketed for domestic use. They can either have the heating and/or cooling supply fed directly into them with a built-in water to air heat exchanger or they can act purely as a ventilation and heat recovery system, with heating and/or cooling provided separately.

An example of this type of ventilation heat recovery studied by Decerna for a music venue revealed a potential for heat recovery of 75% of heating energy in the room, which would otherwise have been expelled to the outdoors due to requirements for a high ventilation rate. This heat recovery was estimated to cost £9,200 to supply and install, but save 8,508kWh (£4,254) per year in air source heat pump consumption meaning it would pay for itself in around 2.2 years.

## REGRIGERATION

Wherever something needs to be cooled to a temperature lower than its surroundings, it will involve removing heat and releasing it elsewhere. Typical commercial refrigeration systems do this with a refrigerant system and external condenser to reject heat outdoors. Rather than simply lose this heat, there may be a requirement for heat either in another process or for space heating and domestic hot water for another part of the site, such as site offices.



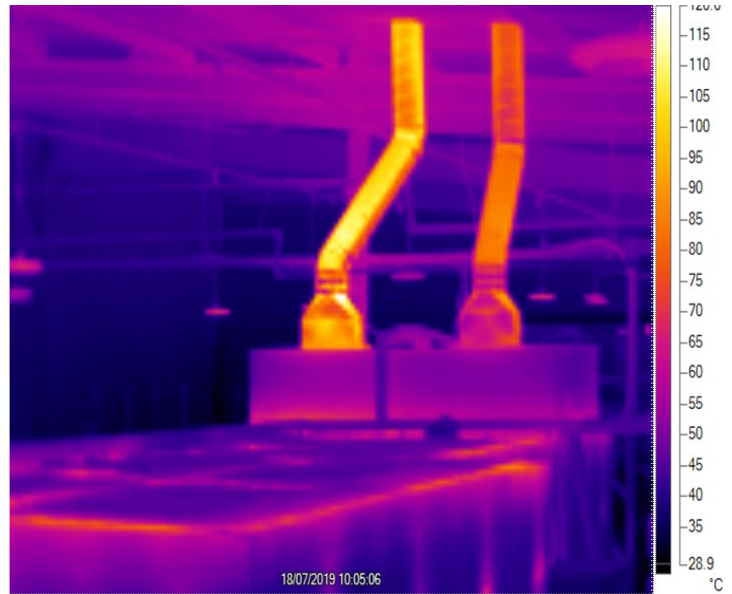
Depending on the type of refrigeration, the condenser may already be water cooled, meaning it can be a relatively uncomplicated improvement to channel the cooling water into somewhere that the heat can be used. An example of this is an ice cream factory, where water was used to cool the condenser of their batch ice cream making equipment. As the product has to be chilled very quickly, the power consumption and heat output is very high for what is quite a compact machine. As a result, water passing through the condenser was raised from approximately 13°C to 40°C. This was captured in a hot water cylinder to feed into the domestic hot water supply for their catering kitchen, where there was a constant demand for hot water for dishwashing. As a result of this intervention, it was estimated that the savings would amount to 9,875kWh of electricity per year, worth £4,937. The initial capital cost of £3,200 was therefore estimated to be paid back through energy savings in 0.6 years.

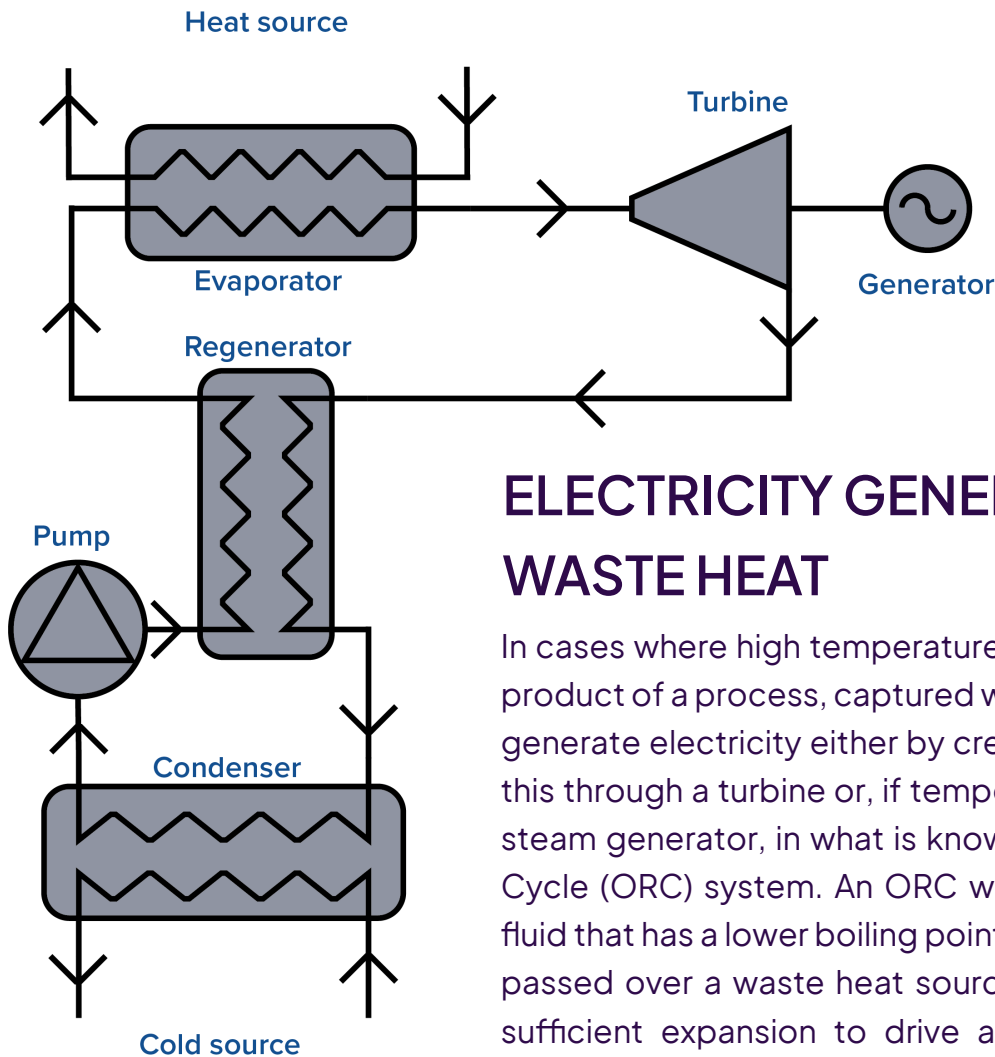
## OVENS AND DRIERS

Another common use of heat in industry is for the vast number of ovens and driers used for production of food, materials manufacturing, moulding and almost any other type of manufacturing. If these ovens operate as a batch process, they often need to be allowed to cool in between batches to allow for safe handling. If they are a continuous process, they are often open ended to allow product to pass through. Both of these types of process are therefore responsible for large quantities of heat loss.

Due to the point at which heat escapes, however, it is harder to capture heat from an open-ended process, whereas the batch process can be cooled with water or air in a much more directed manner. Ceramics kilns, for example, can be cooled by a water jacket that surrounds the exterior. This passes cool water over the kiln, taking excess heat away with it. Heat from this water is then cooled down via chiller and/or outdoor free cooling.

Many ovens have to allow combustion gases, steam and other fumes to be removed for safety reasons. Along with this exhaust, a significant proportion of heat energy from the oven is allowed to escape. This is an ideal area to focus heat recovery efforts, since there is a contained flow of heat which is straightforward to capture by installing an air to water heat exchanger. With proper system design it can be possible to recover a large majority of this energy in the form of heated water. This water can be put to a variety of uses depending on its temperature and volume. Often in manufacturing there are processes that require washing or drying of parts and materials, which can be served by this store of recovered heat. Alternatively, space heating and hot water can be provided for site offices or even neighbouring properties.





## ELECTRICITY GENERATION FROM WASTE HEAT

In cases where high temperatures are generated as a by-product of a process, captured waste heat can be used to generate electricity either by creating steam and passing this through a turbine or, if temperatures are too low for a steam generator, in what is known as an Organic Rankine Cycle (ORC) system. An ORC works by using an organic fluid that has a lower boiling point than water, so that when passed over a waste heat source, it evaporates and has sufficient expansion to drive a turbine. The cycle is a closed system, so that the working fluid is contained and allowed to return back to the heat exchanger as a low temperature liquid, ready to be evaporated again.

## AIR COMPRESSORS

As highlighted in our Compressed Air factsheet, the process of pressurising air is quite inefficient and the majority of electrical energy used in the process is wasted as heat. Some of this energy can often be captured at the compressor's oil cooler, which can then be sent to use for hot water and/or heating. As with most types of heat recovery, the waste heat tends to be at a temperature suitable for producing hot water for other industrial processes in the same site, or for reducing the energy required to produce sanitary hot water for handwashing and welfare facilities.

## LOW TEMPERATURE HEAT RECOVERY

As recovered heat is often at a much lower temperature than what is generally needed on site, it can be of little use without some additional process to increase the temperature. This can be done in two main ways.

Firstly, recovered heat in the form of hot water can be returned to preheat the primary heating process. This means the primary heater does not have to do as much work to achieve its required output temperature, therefore saving energy.

Secondly, particularly when recovered heat is to be used for space heating, the low grade recovered heat can be 'upgraded' via a heat pump to raise its temperature to a useful level. This is normally more feasible when there are very large volumes of modest temperature water or air being recovered. It is imperative to consult a heat pump design engineer so that the correct system is selected and that it uses refrigerants that will work with the temperatures specific to the application.

## SAFETY CONSIDERATIONS

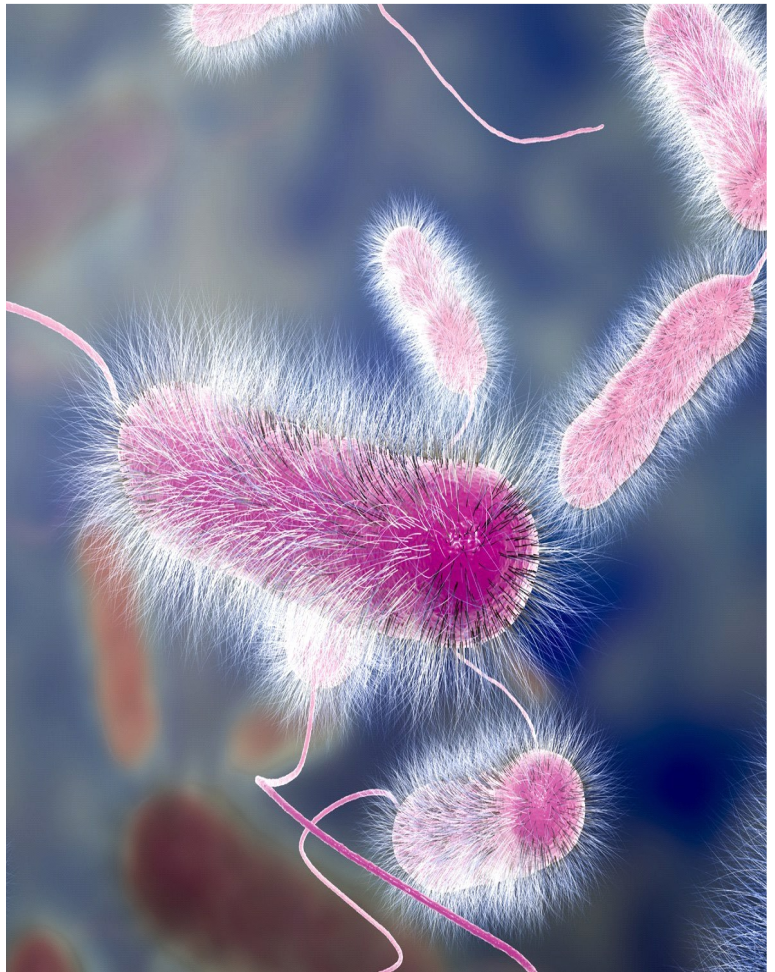
Modifications to existing plant and machinery to recover heat should be carefully planned and risk assessed to ensure that the safety of the overall plant is not compromised. Hot water and steam are potentially dangerous and safety guidelines should be observed during system design and operation. It is imperative that a suitably qualified and experienced engineer is appointed to design the heat recovery system and that a competent contractor is commissioned to carry out any alterations to existing equipment. It is also important to ensure that documentation and plant maintenance procedures are updated after the installation takes place.





## LEGIONELLA RISK

Many opportunities for heat recovery result in heated water, which needs storing until it is ready for use. In cases where recovered heat creates temperatures between 20-45°C, there is a risk of harbouring or proliferating Legionella bacteria. To combat this, systems that involve water at these temperatures must have additional controls such as electrical heaters and mixing pumps which ensure that the water can be periodically heated to a sufficiently high temperature to reduce the bacteria populations to safe levels. If this is not feasible then the system should have a biocide added to the water to prevent bacterial growth at lower temperatures. The Health and Safety Executive gives detailed guidance on the control of Legionella bacteria in Approved Code of Practice L8.



## ABOUT US

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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