CARBON TRUST
Making business sense of climate change

Heat recovery checklist and briefing note

This document should enable you to undertake an initial assessment to determine whether using heat recovery could be a feasible option for your building. The recovery of heat could be either from your building or site's heating, cooling or ventilation system or from any process plant you may have installed.

If your assessment shows that there is the potential to use one or more forms of heat recovery, then the next stage is to commission a more detailed economic and technical assessment from a suitably qualified individual.

The checklist is divided into two parts: one for heat recovery from building services (heating, ventilation, cooling, and so on) and one for processes (any other uses of heat or energy in your building).

You should refer to the Heat Recovery Overview Guide (CTG057) and other information on our website at www.carbontrust.co.uk/heatrecovery. Keep it to hand when going through the checklist so that you can review the information as you need.

What is heat recovery?

Heat recovery is the collection and re-use of heat arising from a process that would otherwise be lost or 'wasted'.

To reclaim this wasted energy there needs to be a lower temperature 'heat sink' where it can be effectively/economically used.

Where can recovered heat be used?

Recovered heat is a valuable and flexible resource. The following is a list of the most common uses for recovered heat:

- pre-heating of combustion air for boilers, ovens, furnaces, etc
- pre-heating fresh air used to ventilate the building
- hot water generation, including pre-heating of boiler feed water
- space heating
- drying
- other industrial process heating/pre-heating
- power generation.

If you answer yes to the following two questions, then it's likely that you could benefit from investigating heat recovery opportunities further.

Do you have any of the following potential sources of waste heat?

If you have any of the below in your building and you have direct control of them, then you should go to the building heating, cooling and ventilation section and work through the checklist to see whether there is the potential for heat recovery.

- A boiler providing space heating or hot water.
- Ventilation/air conditioning systems without any means of recirculation or heat recovery.
- Water chiller or other cooling plant rejecting heat to outside.
- Temperature stratification in high spaces (particularly using warm air heaters or radiators in lieu of radiant heating).

If you have any of the below as part of the processes in your building, you should work through the processes and industrial heat recovery section of the checklist as there is likely to be some opportunity for you to use heat recovery.

- Boiler providing heat for any process.
- Steam boiler blowdown.
- Flash steam.
- Process cooling systems heat rejection.
- Air compressors.
- Hot exhaust air from dryers, etc.
- Heat stored in products leaving the process.
- Heat in gaseous and liquid effluents leaving the process.
- Heat in cooling hydraulic oil systems.

The first step should be to assess which of these are applicable to your building or site and establish the temperature (or grade) of this 'source' of heat. Generally, the higher the temperature, the greater the value for heat recovery.

The next step is to make an approximation of the quantity of heat being wasted. This will require details of the plant performance, including air, flue gas or water/process flow rates and temperatures. If data on plant performance is not available then an energy audit will probably be required.

Is the source of waste heat coincident with any potential heat sink?

Ideally, your source of waste heat and the sink where it can be put to use are coincident, meaning that they exist at the same time and in the same place. Where this isn't the case, systems can sometimes be arranged such that heat can be used in a remote location or at a different time.

Figure 1 *Building, heating cooling and ventilation systems checklist*

Building heating, cooling and ventilation systems	Complete YES/NO	Actions/ comments
Are you sure that your existing systems are as efficient as possible?		
Before considering heat recovery, you should ensure the existing systems in your building are as efficient as they can be and that the building itself is as 'leak free' as possible. Establish how efficient your existing system is, by checking: • whether fresh air ventilation rates have been minimised • that adequate controls are installed to automatically manage the amount of air provided (such as CO_2 sensors linked to variable speed fans) • that internal temperature controls (thermostats) are not set too high for heating or too cold for cooling • that automatic controls are in place to only run heating, cooling and ventilation plant when required, ie, when the building is occupied • that equipment is regularly and professionally maintained • that the building does not suffer from unnecessary draughts, either from poorly fitting doors and windows or from issues such as delivery doors being open for unnecessarily long periods. For further information on ensuring you're getting the most from your systems, visit the following pages: Heating: www.carbontrust.co.uk/heating Ventilation: www.carbontrust.co.uk/ventilation Air conditioning: www.carbontrust.co.uk/airconditioning		
Do you have mechanical ventilation or an air conditioning system?		
Does the system have the facility to recirculate some or all of the air? If not already provided, this may be a more cost-effective solution than heat recovery, provided cross contamination of the fresh air supply with exhaust air is acceptable. • In modern, well-insulated buildings without heat recovery, heating just the minimum fresh air can represent up to 75% of the annual heating load. In older buildings, with typical 1970s levels of insulation and air permeability, this could be 35%-40% of the annual load. Recirculation may save a larger proportion of overall energy use on newer sites, but it is still a significant opportunity in any age of building. Refer to further information on website: www.carbontrust.co.uk/ventilation		

Do existing fans have sufficient capacity to cope with the addition of heat recovery equipment? You're unlikely to know the answer to this right now, but whatever type of equipment you finally use, adding it to existing systems can increase the load on fans so you need to check that they have enough capacity. If not, they'll require upgrading before proceeding. • Heat recovery equipment means that fans need to work slightly harder but the increase in power demand should normally be no more than 10%-15% of recovered energy. Keep this in mind and make sure any specialist you speak to checks on the capacity of existing systems.		
Are air intakes and exhausts close together? Check whether air intakes and exhaust ducts are in close proximity. If not, it's likely that your options may be limited to either a run around coil or heat pump system. Both these systems connect the supply and extract ducts with either pumped water or refrigerant to transfer heat between the two. If they are close together, you may have more choice of system – you should consider the potential efficiencies of the various types of recovery device, which include: • plate heat exchanger: typically 55%-65%, maximum 80% • thermal wheel: typically 65%-75%, maximum 80% • run-around coil: typically 45%-50%, maximum 55% • heat pump: typically 35-50%, maximum 60% • heat pipes: typically 50%-65%, maximum 75%. In some cases it may be possible to achieve the maximum efficiencies shown but these devices are likely to be more expensive with higher running costs, which can result in longer payback periods.		
Is your building air conditioned (ie, does it have cooling as well as mechanical ventilation)? If you use heat recovery in a building which is air conditioned, the incoming air can be pre-cooled in summer, reducing refrigeration load. In mid-season however, when the outside air is cooler than the exhaust, a bypass should be provided to facilitate 'free cooling' and avoid warming the fresh air particularly with plate type heat recovery devices.		

Do you have a boiler providing heat for space or water heating?		
How old is your boiler? Modern boilers producing low temperature hot water for heating are likely to be either condensing (where heat recovery is provided as part of the boiler) or high efficiency non-condensing (where the addition of heat recovery is likely to be uneconomic). Older boilers (producing hot water or steam), particularly on large sites, are likely to be up to 10% less efficient than modern boilers and therefore more suited to the addition of a heat recovery device (economiser) in the flue. Uses for this heat include: pre-heating the return water or feed water to steam boilers; heating hot water; and pre-heating combustion air. You should also check whether the boiler burners and flue will require modifying to accommodate the economiser to avoid problems with insufficient air supply.		
Here are some key facts and figures about applying heat recovery to boilers: • Typically a flue economiser will increase the net boiler efficiency by 3%-5% (to qualify for ECAs the unit must increase efficiency by at least 3%). • Condensing economisers (or 'thermo condensers') can increase the boiler efficiency by 10%-15%. To optimise their performance the return water temperature from the heating system should be no more than 50°C and less than 40°C if possible. These can be used on gas or low sulphur fuel oil boilers, but it is important that the water temperature after the economiser is raised to at least 55°C to prevent condensation of the flue gases in the boiler. • Increasing the combustion air supply temperature by 20°C can increase boiler efficiency by around 1%. This is usually only economic on large boilers. • In a steam system, installing 'blowdown heat recovery' can reduce boiler blowdown losses by up to 75%, giving a total energy saving of up to 3.75% of heat input.		

Do your heating and cooling systems operate at the same time?		
If your building has coincident cooling and heating requirements, for example chilled water for air conditioning for server rooms and hot water heating for other areas, then it's worth considering installing water chillers with integral heat recovery or retrofitting heat recovery devices in the refrigeration circuit. • 'High grade' heat (~60ºC) can be recovered by installing a desuperheater to extract heat between the compressor and condenser. Alternatively, a heat recovery condenser can be used to provide 'low grade' heat (~40-45ºC). • 15%-20% high grade heat can be recovered. • Up to 80% low grade heat can be recovered. If you have air cooled chillers, it's also worth investigating the feasibility of ducting the warm air discharge directly into the building to reduce heating load.		
Is your building a factory or warehouse or does it have a heated tall space (such as an atrium)?		
If you have a factory or warehouse (or other tall space) that doesn't already have de-stratification fans installed, you should carry out an audit of the building fabric and type of heating. De-stratification fans push hot air back down to the occupied space and reduce the heating load. De-stratification isn't strictly speaking heat recovery but you can find out more by reading our guide on: how to implement de-stratification fans (CTL023)		
What should you do next? If, after running through the above, you think there may be an opportunity to implement heat recovery, you should contact a professional building services engineer. They can: • carry out a more detailed feasibility study • provide sufficient details about the equipment and work required to allow you to establish the capital outlay required • help you to establish the financial and carbon savings from implementing heat recovery.		

Figure 2 Process and industrial heat recovery checklist

Process and industrial heat recovery	Complete YES/NO	Actions/ comments
Where is heat being wasted and where might it be used?		
You should first establish both the amount and temperature of all significant waste heat streams and heating demands on the site. This will help you to establish how much waste heat you can recover. You should: • list all significant heat sources and possible heat sinks • determine the temperature of the heat source (known as its 'grade' or 'quality') • quantify the heat sources and sinks to understand when the energy flows to waste occur and whether they coincide with heat demands • calculate the scope of heat recovery. This can be done by specialists who can undertake a 'Pinch Analysis' using specialist software. Most plants have a 'Pinch Point': a temperature above which there is an overall shortage of heat and below which there is a surplus. It's then possible to calculate the maximum amount of recoverable heat and thus the minimum amount of fuel required for the process. A key issue for you to consider in consultation with a specialist is the risk of condensation of corrosive elements in the exhaust streams caused by lowering the temperature in heat recovery units. This may limit the potential for heat recovery to fluids with a temperature above 120°C-150°C.		

Here are some typical waste heat sources and their potential uses: Do you have hot flue gases from combustion processes? The higher the temperature, the greater the potential for heat recovery in these cases. You could use the energy from the flue gases to pre-heat combustion air or, if it's hot enough, to pre-heat part of a process. Do you have steam boilers? To maintain correct water quality, steam boilers have to discharge some of their water (which can reach 180°C) on a regular basis. You can use the heat contained in the blowdown for another use. See the building heating and cooling systems section for more information. Do you have a hot vapour stream leaving a process? It may be possible to use this heat, provided the vapours are not corrosive. Does the outer casing of the equipment you're using get very hot? If collected, this low grade heat may be useful for space heating or fresh air pre-heating. Do you use water to cool equipment or the products coming out of your processes? This low grade heat can be used to pre-heat incoming fresh water or within a heat pump to heat the building or pre-heat hot water. Do you have water chillers or other refrigeration plant? You can recover either low or high grade heat from this equipment depending on the system. See the building heating, cooling and ventilation systems section for more information. Are the products/stock leaving your processes hot? It may be possible for you to recover some of the heat from this product and, whilst it's likely to be low grade, it could be put to good use. Does your process produce hot gas or liquid effluents? The heat can be high or low grade and you could put it to use if it isn't contaminated. The use of heat recovery in these instances will require the services of a specialist – refer to the Heat Recovery Overview Guide (CTG057) for the names of organisations who can put you in touch with one.		

Do you use compressed air in your building?

Compressors are a particularly energy intensive and relatively inefficient item of equipment and generally provide good opportunities for heat recovery.

Do you have a packaged air-cooled compressor?

As much as 80%-90% of the energy used in the generation of compressed air is converted into heat. Depending on the application, you could recover as much as 50%-90% of this waste heat. For a typical 100 cubic feet per minute (47 litres per second) compressor that consumes 22 kilowatts (kW) of electrical energy, 20kW can typically be recovered as heat.

If you have a packaged air-cooled compressor, heat can be ducted elsewhere in the building to be put to use. Here are some key facts and figures about heat recovery from air-cooled compressors.

- To use the heat, a separate fan would be required, along with the facility to discharge the hot air to the outside in summer.
- Hot water can be generated from air-cooled compressors by installing a heat exchanger in the lubricant cooling system.
- For a heat recovery system to be financially viable, compressors generally need to have an electrical rating greater than 15kW.
- If the compressor is located close to boilers, it may be possible to duct hot air discharge to the boiler fan to pre-heat the combustion air, improving efficiency.
- Rule of thumb – 1kW of compressor power can heat 10-20m^2 of factory space.

You can refer to the How to implement heat recovery from a compressed air system guide (CTL051) for more information.

Do you have a water-cooled compressor?

If so, you could be using it to generate hot water at up to 80°C-90°C.

You can pipe the hot water to heat exchangers to deliver either water for space heating, using radiators, or hot water for domestic purposes at 50°C-60°C.

An air blast cooler should be installed to dump the heat to atmosphere when there is no demand for the heat.

What you should do next

If, after working through the checklist, you think there's an opportunity to implement heat recovery in your building, here are some key next steps which you should consider.

- Ensure you have senior level support for the potential of heat recovery by engaging internally within your organisation.
- Make contact with a suitably qualified person to help you with a detailed feasibility study – the study should include the following as a minimum:
  - capital cost of equipment and installation
  - annual energy and carbon saving assessment
  - simple payback
  - Net Present Value calculation if required by your organisation to assess investments.
- Develop a business case in order to secure funding for your project(s). Refer to our Business case guide, which may also help you 'sell' the project to the decision makers.

If your business is involved in light manufacturing or warehousing, you can watch our heat recovery webinar which will give you more technical detail about specific opportunities which may be available for you.

Where you can find further information

You can find out more about heat recovery by referring to the following Carbon Trust documents:

- NEW: Heat Recovery Overview Guide (CTG057)
- How to implement industrial heat recovery equipment (CTL037)
- How to implement HVAC heat recovery (CTL030)
- How to recover waste heat from a compressed air system (CTL051)
- How to implement blowdown heat recovery (CTL020)
- How to implement de-stratification fans (CTL023)
- Steam and high temperature hot water boilers technology overview (CTV018)
- Low temperature hot water boilers technology overview (CTV008)