District Heating Strategy Factsheet

Application of Industrial Waste Heat Recovery in District Heating Strategy

Contents

1 Introduction

Recent reports published by the Department of Energy and Climate Change (DECC) and the Scottish Government reveal that over 50% of total energy consumption in Scotland is for the purposes of heating. Reducing this consumption through limiting heat demand, increasing efficiency in production and distribution, and recovering energy from waste heat streams is key to meeting challenging heat use ambitions for 2020, as set out in the Scottish Government's Heat Policy Statement, 2015.

Heat use in industry is a key target area for savings. The most suitable application for industrial waste heat is re-use on site, where practicable, through integration with existing processes or other means. A further, less explored, application is supply to local district heating networks. Viability for the latter is dependent on site location, demand levels & proximity of local heat users and the practicalities of heat recovery. The early stage of development of heat networks in Scotland is a further obstacle as there is significant cost in establishing the distribution infrastructure. Despite the challenges, there is significant potential. Large industrial sites are frequently key heat supply assets to extensive district heating networks on the continent.

This fact sheet discusses the principles that lie behind heat recovery and highlights a number of key issues for considering industrial waste heat recovery as part of a district heating strategy.

2 Learning Objectives and Outcomes

2.1 Learning Objectives

The learning objectives for this module are to:

- Understand the principles of heat recovery;
- Understand how heat recovery can be successfully applied; and
- Understand how to identify opportunities for industrial heat recovery in a district heating strategy

2.2 Learning Outcomes

The learning outcomes for this module are to:

- Describe the principles of heat recovery;
- Identify opportunities for heat recovery;
- Describe the main heat recovery technologies, including their typical efficiency range and the advantages and disadvantages of each technology;
- Be able to prioritise the opportunities for applying heat recovery; and
- Evaluate the key aspects in relation to heat recovery projects when building a business case.

3 Introduction to Heat Recovery

There are different types of heat recovery systems, and it is worth first having an understanding of the principles that lie behind heat recovery. The most basic principle is that heat only ever flows one way down a temperature gradient from hot to cold. In this way a cold drink on a hot day will warm due to the effect of heat transfer from the warm air around it.

These basic laws of thermodynamics apply to all fluids and to all ranges of temperature. They also dictate what can and can’t be done in terms of heat recovery. For example, it is possible to recover water at 60°C from a Solar Thermal Panel. However, this heat cannot be used in a circulating water heating system where water is being returned to the boilers at 70°C. This is because the heat could not flow from the 60°C fluid to the 70°C fluid; in fact the opposite would happen.

Although these laws cannot be violated, equipment such as a heat pump can take lower grade heat and use mechanical work (i.e. motorised compressor) to convert it into higher grade heat.

There are many mechanisms by which heat can be transferred from one place to another. All heat recovery systems involve a heat exchanger of some sort and the heat exchanger’s role is to allow the transfer of heat from one fluid to another in a manner that can be controlled. Heat exchanges are applied to moving fluids, for example a warm exhaust air stream from an office building. This means that the source of recovered heat is effectively always being replenished.

Heat can move around in three distinct ways. Conduction is where heat moves through a solid object. Convection where heat moves around inside a fluid, and radiation is where energy/heat is transferred between objects by electromagnetic waves (primarily infrared). For example, in a boiling pot, conduction allows heat to pass from the underside of the pot to the inner surface to heat the water, convection causes the boiling water to circulate and because of radiation the heat from the pot, the gas hob and the surface of the water can be felt at a distance.

All of these types of heat transfer may be considered as part of the design of a heat exchanger. The most important in terms of heat recovery is conduction as the heat exchanger usually incorporates a conducting solid barrier between the two fluids. Convection is also used, but to a lesser extent.

4 Introduction to Heat Recovery Systems

4.1 Waste Heat from Industrial Flue Gasses

Flue gases are produced when coal, oil, natural gas, wood or any other fuel is combusted in an industrial furnace, boiler system or other large combustion device. Flue gasses often contain contaminants or particulate matter and are required to be emitted at high temperatures (>200^{0}C) to maintain buoyancy, allowing for dispersal over a wide area. The minimum flue gas temperature requirements for individual sites are set as part of SEPA's stack emissions permit. Additionally, cooling flue gasses below around 150^{0}C can cause condensation and maintenance issues for the flue itself. As such, heat recovery from flue gasses is limited by both regulatory requirements and the operational parameters of the exhaust equipment.

To recover heat from flue gas emissions, a gas to water heat exchanger can be installed within the stack to recover heat before emissions are dispersed to the atmosphere. Flue gas emissions from industrial processes remain relatively constant all year round and as such could supply the base load for a nearby district heat network.

There are several practical risks associated with this flue gas heat recovery such as heat exchanger contamination and dangers associated with steam and pressurised systems

4.2 Waste Heat from Effluent Streams

A number of industries produce hot water effluent from cleaning, treatment or manufacturing processes. Such industries include Pulp and Paper, Textile manufacturing, Food and Drink, Iron & Steel, Chemicals & Water Treatment. The temperature of effluent streams discharges into Scottish water courses (including discharges to sewer) are governed by the Pollution Prevention and Control (Scotland) Regulations 2012 (PPC 2012) where a permitting process can set maximum and minimum temperatures.

In most cases, a water source heat pump is required to increase the temperature of the waste stream to allow for useful supply to a district heating network. A common problem with waste heat from effluent streams can be the fouling of heat exchangers with particulates and contaminants, resulting in a loss of efficiency and requirement for regular maintenance.

4.3 Waste Heat from Cooling Processes

Another source of heat in many buildings relates to cooling. Conventional cooling or refrigeration system (defined technically as a vapour compression cycle) involves the use of a refrigerant to provide cooling in one space. For this to happen, heat has to be rejected somewhere else. This is the purpose of the external units present in most air conditioning systems.

Where large air conditioning systems are present, these are commonly close control air conditioning systems used in applications such as server suites and data centres. The associated externally located cooling equipment for these can be very large.

There is potential to recover heat from these systems at high grade or temperature using a de-superheater. This is a device which removes heat prior to the refrigerant entering the condenser. It can yield heated water at 60°C to 90°C depending on the system. Lower grade heat can be taken directly from the condenser exhaust (i.e. the heated air rejected at the condenser). This can provide temperatures of 20°C to 40°C and involves merely ducting the warmer air to the desired location. Water cooled condensers also feature in some air conditioning systems. This is perhaps easier to apply to a heat recovery system but has downsides in terms of the grade of heat and controllability during colder weather.

Another less commonly encountered opportunity involves heat recovery in laundry spaces where, as per steam boiler systems, a significant amount of heated water is rejected to drain. Heat can be recovered from such systems using a heat exchanger and/or water source heat pump system to raise the temperature if necessary.

Table 4.1 – General applications for heat recovery

Site Processes	Potential Heat Recovery Options
Cold rooms and chilled water systems	• Heat captured from desuperheater • Heat recovery from condensers
Space or process cooling/refrigeration	• Heat captured from desuperheater • Heat recovery from condensers
Air compressors	• Gas to liquid heat exchanger • Heat Pump
Effluent Streams	• Liquid to liquid heat exchanger (corrugated pipe) • Heat Pump
Cooling Towers	• Liquid to liquid heat exchanger (corrugated pipe) • Heat Pump
Industrial Flue Gas	• Liquid to liquid heat exchanger (corrugated pipe)

5 Building a Business Case

5.1 Considering Energy Efficiency Improvements

Before deciding to apply industrial heat recovery as a source for district heating, it's essential to consider other energy efficiency improvements that could be made to reduce waste heat or to re-use the heat on-site. Some of these could affect the benefits available through heat recovery and in some cases they could negate the availability for heat recovery through district heating entirely. Where supply to a heat network is to be considered, there are a number of things to consider.

5.2 Suppling Heat Networks

In many instances, there is no practical on-site use for low grade heat streams and these are consequently rejected as waste, often in significant quantity (MW-scale). The most likely application for such lower grade streams is supply to local district heating networks, however, the early stage of development of heat networks in Scotland presents a major obstacle as there is significant capital cost in establishing the heat distribution infrastructure needed to enable such opportunities. Despite the challenges, there is great potential. Large industrial sites are frequently key heat supply assets to extensive district heating networks on the continent, with surplus heat sales being an important element of business revenues.

Potential users of waste heat need to have realistic expectations in terms of security of supply – industries have expressed that they cannot offer guarantees or sign up to lengthy supply contracts. As such, the location of heat networks should be demand led and projects should firstly be financially viable using conventional and reliable heat supply technologies. Opportunities can then be investigated for additional benefits (cheaper heat) from the use of surplus waste heat from industry in the vicinity of proposed networks.

5.3 Delivery Vehicle/ Ownership Structure

Cooperation between surplus heat suppliers and end users will be required for projects to be realised. As heat network development is not core business for industrial waste heat producers, local networks need to be developed independently to create viable opportunities for off-site supply. Heat networks are most likely to be built and operated by a Local Authority, utility company or other commercial developer. Identifying who is roles and responsibilities for network development, operation and heat supply at an early stage are key to the success of a project.

For a network developer to secure investment to develop a project, they will have to develop a detailed business case that includes the cost of generating heat for the network. At this stage, a developer may seek to establish a long-term heat supply agreement with industrial waste heat producers. The agreement will likely detail the price that the network owners will pay for heat per kWh. The agreement may also commit the network owner to purchasing a minimum amount of heat per year with this amount increasing in line with any phased development of the network.

6 Useful Links and References

Title	Source	Link
Zero Waste Scotland	-	www.zerowastescotland.org.uk
Heat Recovery – A Guide to Key systems and applications (CTG057)	The Carbon Trust	www.carbontrust.com/media/31715/ctg057_heat_recovery.pdf
Heat Recovery Checklist	The Carbon Trust	www.carbontrust.com/media/175667/ctl142-heat-recovery-checklist.pdf
How to implement Blow down heat recovery (CTL020)	The Carbon Trust	www.carbontrust.com/media/147111/j7940_ctl020_how_to_implement_blowdown_heat_recovery_aw.pdf
How to recover heat from a compressed air system (CTL166)	The Carbon Trust	www.carbontrust.com/media/147009/j7967_ctl166_how_to_recover_heat_from_a_compressed_air_system_aw.pdf
Introduction to Heat Transfer	The Heat Transfer Society	www.hts.org.uk/downloads/introductiontoheattransfer.pdf
BS EN 1216:199 Heat Exchangers. Forced Circulation air- cooling and air-heating coils. Test procedure for establishing the performance	The Institute of British Standards	www.bsigroup.co.uk
Building Standards Handbook 2013- Mon Domestic Section – 6.6.4 Efficiency of MVAC equipment	Scottish Government	www.scotland.gov.uk/Resource/0043/00435261.pdf