INDUSTRIAL EXCESS HEAT RECOVERY – TECHNOLOGIES AND APPLICATIONS

Reference

International Energy Agency (IEA) IETS Annex XV:
Based on the Final Report from Annex XV Phase 1, published at the IETS website in 2015. Phase (Task) 2 of the Annex, which was finalized in 2019, will be covered by a separate topic sheet.

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The full report as well as information about current projects can be found at the IETS website.

Introduction, Background and Aims

There is an increasing awareness about industrial excess heat as a potential resource for contributing to an improved economy and sustainability in larger systems. Although industrial excess heat has been used and is being used to a large extent, the potential for an even wider use is considered to be substantial. It can be used

- internally in an industry for primary energy saving
- in another industry or other industries in an industrial cluster
- between an industry/ industrial cluster and a district heating system
- between an industry/industrial cluster and e.g. greenhouses or for other low-temperature purposes
- as a heat source in refrigeration plants for industrial or district cooling

Industrial Excess Heat – a definition

Excess heat can, in part, be used internally or externally in many situations. Several definitions and concepts exist about this, e.g. waste heat, surplus heat, secondary heat, low-grade heat, black, white or green excess heat. To overcome this confusing situation, the following concepts are used:

Excess heat is the heat content of all streams (gas, water, air, etc.) which are discharged from an industrial process at a given moment. A part of that can be internally or externally **usable heat**, technically and economically. If heat from a process is used externally and cannot be used internally as an alternative it can be called excess heat. **Non-usable excess heat** is the remaining part of the excess heat, when the internally and externally usable parts have been deducted. This part can be called **waste heat**.

Methods for Assessing Industrial Excess Heat

Several approaches for performing inventories of excess heat amounts, temperature levels and types (air, water, gases, etc.) have been developed and applied.

Normally, methods for identifying excess heat is classified as either top-down or bottom-up methods. Furthermore, the identified potentials could be the theoretical, technical or economic potential.

The top-down approach: Starting from the primary energy use, assumptions about efficiencies and distribution of the energy use allows to estimate the excess heat potential for different sectors. The method hardly allows to conclude on excess heat temperature levels and availability.

The bottom-up approach: Using questionnaires, or even measurements, specific data from representative companies and sites is collected. Depending on the level of detail of the questionnaire this method allows drawing conclusions on the technical potential for a given company or sector. Measurements are by far the most complex method.

The actual excess heat temperature level in an industry is the temperature of the cold utility used, i.e. cooling water, air, etc. However, the possible temperature level for collecting excess heat is higher, as an improvement in the heat exchanger network can increase the temperature level for a given amount, sometimes considerably. These aspects are important in excess heat projects.

Technologies and Systems for Excess Heat Recovery/Usage

Technologies for excess heat recovery/usage can be classified as belonging to one of the groups

- Direct use without upgrading
- Use after upgrading, through heat pumping
- Power generation

Traditional technologies are heat exchangers, industrial heat pumps, heat to district heating systems, or from industry to industry, district cooling, low temperature applications (e. g. greenhouses) and power generation in e. g. CHP plants. Emerging technologies and applications are new types of power generation technologies (Organic Rankine cycles, thermoelectric devices) as well as usage for drying (e. g. biomass) and in integrated biorefineries. One example of a future technology is industrial Carbon Capture and Storage (CCS), in which heating (at relatively low temperatures) would be the by far most expensive part without the use of excess heat.

The main technologies/applications investigated in ongoing and planned pilot/demo projects are heat pumping, organic rankine cycles, thermoelectric devices, power production at higher excess heat temperatures, district heating and internal heat recovery.

Policy Instruments and Climate Consequences

The existing or possible policy instruments for external use can be divided into at least four different categories (of course number and types of instruments vary from country to country):

- Regulatory/Administrative
- Economic/Taxes/Subsidy
- Information/Behavioural changes
- Technical improvements/Research

One of the most important policy instruments for excess heat use will be the ones directed towards GHG emissions, especially for CO_2. Regardless of how this is done fiscally, a charge on CO_2 will influence also future prices for fuel and emissions, which will have a high influence on the economy for excess heat. To meet the uncertainties about the possible levels, different scenarios have been developed by many organizations. One important example is IEA, which has developed three different scenarios with very varying future CO_2 charges. The influence on the economic viability of future possible CO_2 charges is still to be examined.

One important possible competitor to industrial excess heat is combined heat and power (cogeneration), CHP. The reason is that both technologies need a, normally large, heat sink. Both the economic and the climate consequence aspects must be favourable in this comparison in future situations. In a comparison of climate effect aspects between the two technologies, it was shown that probably the most important parameter for reducing CO_2 emissions through the use of excess heat is the build margin power production technology in the power grid system. A comparison between GHG emissions from natural gas- or biomass based- CHP and excess heat showed:

- If the marginal power production technology in the grid is coal condensing plants, excess heat cannot in most cases compete with CHP.
- If the marginal power production technology is natural gas combined cycle (NGCC) or a system with even lower emissions, excess heat is normally more advantageous than CHP.

These general findings are applicable to both fossil-fuel based and biomass based CHP. It is reasonable to assume that less emitting margin technologies will be introduced more in the future. Hence, there is a likelihood that excess heat will be one important technology for GHG emissions reduction in future systems.

Further Work and Findings

Some aspects which are important to go into more depth are:

Industrial excess heat has caught an increasing interest in recent years and much work has been done concerning the potential for industrial excess heat. The national situations differ considerably, so more national studies should be performed and it is clear that existing material can be used to draw more conclusions than has been done so far.

Methods for making inventory studies is a crucial area for promoting the use of excess heat. A synthesis of experiences and sharing of approaches, experiences and results from earlier and planned studies is important.

It is most likely that policy instruments will change in the coming years. This will influence both the economic performance and the sustainability aspects for industrial excess heat usage. Hence, policy instrument development will most probably have a high influence on the economic viability to use excess heat in many countries.

Definitions of different types of excess heat differ considerably between organisations and it is important to develop a common terminology. IEA could be an organisation to be responsible for this.

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About IETS

The IEA TCP on Industrial Energy-Related Technologies and Systems (IETS), founded in 2005, is dealing with new industrial energy technologies and systems.

The mission of IETS is to foster international cooperation among OECD and non-OECD countries for accelerated research and technology development of industrial energy-related technologies and systems. In doing so, IETS seeks to enhance knowledge and facilitate deployment of cost-effective new industrial technologies and system layouts that enable increased productivity and better product quality while improving energy efficiency and sustainability.

Through its activities, IETS will increase awareness of technology and energy efficiency opportunities in industry, contribute to synergy between different systems and technologies, and enhance international cooperation related to sustainable development.

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