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Methods to estimate the industrial waste heat potential of regions – A categorization and literature review

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ABSTRACT

To investigate heat demand, one can usually base the estimation on sales data for the energy carriers or even use the data directly. This works for companies, regions, towns and sectors (e.g., industry or domestic sector). But for the waste heat produced by the industry it is not that simple: waste heat is an output value, which neither costs nor earns any money and it is therefore seldom measured or reported. In this paper, different methods to estimate the excess heat of industrial production within a region are categorized and compared. Besides the obviously necessary distinction between theoretical, technical and economic potential, the authors suggest categorization of the methods in three dimensions: study scale, data collection and approach/perspective (bottom up vs. top down). Following this schematic, previous regional waste heat studies are reviewed. Studies focusing on single sectors or companies are not considered in this review, as well as studies estimating the heat demand. As a result it can be seen that the available data are the driving force in the choice for the used estimation method. For general factors, the resulting waste heat potential ranges between 5 and 30% of the energy demand of the industrial sector of a region. Once derived, key figures are often reused in other studies for other countries. Therefore, more data and a thorough meta study of the available figures are desirable.

Contents

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1. Introduction

In the light of preventing global warming and therefore reducing CO_2 emissions, the way we use energy to produce our goods has to be looked upon. Industries worldwide use 38% of the final energy or more than 58,600 TWh (2010) [1]. That is why the energy consumption of industrial processes should be reduced as far as possible. But even optimized systems will release waste heat; waste heat that in some cases can still be used in other processes with a lower temperature demand. Despite this direct reuse there is also the possibility to use the industrial waste heat to produce cold, heat or electricity by applying different exhaust heat technologies, as it is being done for power plants. Industrial waste heat has, for a long time, been neglected, since it is lot more fragmented than power generation. Still, as the industrial sector uses 38% of the end energy, the potential is considerable and should be investigated. The largest amounts of waste heat in industries are usually found in basic metals, chemical industry, non-metallic minerals, food and tobacco, and pulp and paper.

In this paper, first different methods to estimate the waste heat potential of a region are categorized. Second, previous studies are reviewed according to the presented characterization. The presented paper focuses on studies that consider the whole industry within a certain region or country, not single sectors or companies. Those studies usually focus on energy-intensive sectors or technologies and their applicability. For example, De Beer [2] investigated the waste heat in the board and paper industry in the United Kingdom (UK), while Fleiter et al. [3] did the same for Germany. Dittmar et al. [4] evaluated data centers, which are a very promising waste heat source as they increase in number and improvements in efficiency are outnumbered by increased size and capacity. Neelis et al. [5] approximated the waste heat in the petrochemical industry. There are also many studies on waste heat from power production plants (e.g., [6]). [7] focuses on industrial furnaces and their heat recovery potential.

This paper focuses on studies that consider the whole industry within a certain region or country, rather than just single sectors.

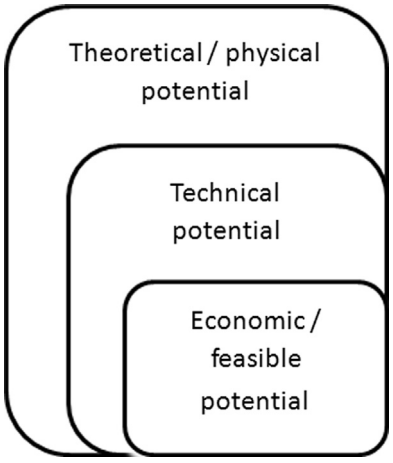

Fig. 1. Types of potential, graph based on [9–11].

It is independent of technological constraints. In addition, only exhaust heat that is bound in an air or gas stream is considered.

Studies estimating the heat demand are also not considered. It is important not to mix up the often found studies of the heat demand of a sector with the waste heat: the energy used does not equal the released waste heat since energy remains in the product or is released diffusively.

1.1. Definition of waste heat and its potential

1.1.1. Definition of waste heat

In this paper, waste heat is considered as all forms of heat (latent as well as sensible) that escape a system are not the purpose of the system. Heat from combined heat and power plants is therefore not considered. Sources for waste heat in industries can be single machines or whole systems that release waste heat into the environment. These sources include furnaces, waste water from washing, drying or cooling processes, and also refrigeration systems, motors or the exhaust air from production halls [2]. Waste heat can be released either diffusively as radiation or convection at a surface or through a heat carrier medium like exhaust gas, cooling fluids or steam [8]. In the presented studies the diffusive waste heat is not considered.

1.1.2. Definition of waste heat potential

When considering different methods to estimate the waste heat potential it is necessary to first distinguish which potential type is considered. In general, three different kinds of potentials should be distinguished: the theoretical or physical potential [9], the technical potential and the economically feasible potential [10] (Fig. 1). The theoretical potential only considers physical constraints: only heat above ambient temperature that is bound in a medium, etc. Thus, heat that is released diffusively, for example by radiation, is not assessed. In this case, whether or not it is possible to extract that heat from the carrier fluid or whether there is any way of using it, is not considered. These constraints define the technical potential. This potential therefore depends on the technologies used. Technical constraints are, for example, the minimum temperature to allow the operation of a system, temperature losses due to heat transfer, etc. The economic point of view is considered in the economic potential. This is often referred to as feasible potential as well. Financial parameters like energy prices, interest rates and payback periods are considered.

1.2. Obstacles to using waste heat

Financial and regulatory constraints are very common obstacles for new technologies, so they are for waste heat technologies as well. In addition, making profit from their waste heat is not the main business case for manufacturing companies. But as the International Energy Agency [12] points out, there are also significant technical challenges and limitations to excess heat recovery. These technical challenges are sometimes the main barriers to the implementation of industrial excess heat recovery