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Preliminary assessment of waste heat potential in major European industries

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Abstract

Industrial processes are currently responsible for almost 26% of European primary energy consumptions (275 Mtoe/yr). Furthermore, most of the energy sources that drive the industrial sector are fossil fuel based. Every industrial process is characterised by a multitude of waste heat streams at different temperature levels whose recovery would undoubtedly contribute to the enhancement of the sustainability of the industrial sites and their products. Waste heat recovery systems can offer significant energy savings and substantial greenhouse gas emission reductions. For the latter to materialise technological improvements and innovations aimed at improving the energy efficiency of heat recovery equipment and reducing installation costs should take place. This paper outlines the opportunities and the potential for industrial heat recovery in the European Union by identifying and quantifying primary energy consumption in the major industrial sectors and their related waste streams and temperature levels. Through a systematic analysis considering waste heat and Carnot's potential estimation, detailed results are given for all industrial sectors, temperature ranges and EU countries. The 'big picture' is rather promising with regards to the estimated total waste heat potential.

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Keywords: energy statistics; waste heat potential; Carnot's potential

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1. Introduction

The European Union (EU), with its 28 member states, covers an area of over 4 million km² and has 508 million inhabitants. EU is currently responsible for 11.6% of the world final energy consumptions (9425 Mtoe in 2014) and for 10.8% of the world final CO_2 emissions (33.3 $GtCO_2$ in 2014) [1, 2]. In EU, industry accounts for the 25.9% of the final energy consumptions and for the 47.7% of the final CO_2 emissions [3]. European Union has always been a forefront body in terms of awareness and involvement for the mitigation of nowadays environmental issues. Indeed, current greenhouse gas emissions have been lowered by 22.9% compared to those in 1990, while one of the key EU targets for 2030 is reduction of at least 40% with respect to the same reference year (1990) [2]. To achieve this challenging goal, energy saving and a more intensive usage of renewable energy sources are unquestionably suitable trajectories to pursue.

In addition to them, recovery actions from existing energetic systems can offer significant primary energy savings and substantial greenhouse gas emission reductions. For instance, current industrial processes are characterised by a multitude of waste heat streams at different temperature levels. In this context, waste heat recovery is the process of capturing heat from these waste streams and using this heat directly, upgrading it to a more useful temperature, and/or converting it to electrical power or cooling. The energy generated from heat recovery, if not required by the process or industrial site can be exported to neighboring facilities or to electrical or heat distribution networks.

There is now increasing global interest in the development and application of heat recovery systems, driven by government regulatory requirements with regard to emissions and emission reduction targets, rising concerns over the cost of energy and energy security and general environmental and sustainability considerations.

The waste heat recovery market is projected to reach $53.12 billion by 2018 [4]. Europe dominates this market and in 2012 the European market accounted for 38% of the global heat recovery equipment market. It is also expected that the Asia-Pacific region will experience the highest growth rate in the next five years of 9.7% per annum with China and India accounting for the highest number of installations of heat recovery units. For these projections to materialise, however, and for the European manufacturing and user industry to benefit from these developments, technological improvements and innovations, aimed at improving the energy efficiency of heat recovery equipment and reducing installed costs, should take place.

The main aim of this work is to present the industrial opportunities for waste heat recovery potential available in the member states of the European Union. Prior to the assessment of the waste heat recovery potential in EU industry with detailed results by country and industrial sector, the calculation methodology is introduced.

2. Energy recovery potential in the European Union

2.1. Definition of waste heat potential

When considering different technologies for using the industrial waste heat potential, it is necessary to first distinguish which potential type is considered [5]: the theoretical/physical potential [6], the technical potential, and the economic/feasible potential [7] (Fig. 1.a).

The theoretical potential only considers physical constraints: the heat must be above ambient temperature, bound in a medium, and so forth. Not considered here is whether it is possible to extract the heat from the carrier fluid or whether it is possible to use it. The above-mentioned constraints set the technical potential. In addition, the technical potential depends on the technologies considered. An example of a technical constraint is the required minimum temperature. The technical potential to use waste heat is defined by two major constraints: in addition to the boundary conditions of the technology itself, a heating or cooling demand is necessary.

If we go one step further, then the technical potential can be separated into a theoretical technical potential and an applicable technical potential, which are distinguished by the fact that the first one is calculated using a theoretical/generic process-related analysis, while the second one is calculated by using onsite data with all plant specific parameters taken into consideration (Fig. 1.b). Accordingly, the feasibility of the technology considered is further analysed using economic criteria/analysis.