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District heating and cogeneration in the EU-28: Current situation, potential and proposed energy strategy for its generalisation

Antonio Colmenar-Santos [a,*,1], Enrique Rosales-Asensio [a,1], David Borge-Diez [a,b,1,2], Jorge-Juan Blanes-Peiró [b,2]

[a] Department of Electric, Electronic and Control Engineering, UNED, Juan del Rosal, 12 – Ciudad Universitaria, 28040 Madrid, Spain
[b] Dpto. de Ing. Eléctrica y de Sistemas y Automática, de LeonUniversidad de León, Campus de Vegazana s/n. Escuela de Ingenierías, 24071 León, Spain

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ABSTRACT

Yearly, EU-28 conventional thermal generating plants reject a greater amount of energy than what ultimately is utilised by residential and commercial loads for heating and hot water. If this waste heat were to be used through district heating networks, given a previous energy valorisation, there would be a noticeable decrease in imported fossil fuels for heating. As a consequence, benefits in the form of an energy efficiency increase, an energy security improvement, and a minimisation of emitted greenhouse gases would occur. Given that it is not expected for heat demand to decrease significantly in the medium term, district heating networks show the greatest potential for the development of cogeneration. However, to make this happen, some barriers that are far from being technological but are mostly institutional and financial need to be removed. The purpose of this review is to provide information on the potential of using waste heat from conventional thermal power plants (subsequently converted into cogeneration plants) in district heating networks located in the EU-28. For this, a preliminary assessment is conducted in order to show an estimate of the cost of adopting an energy strategy in which district heating networks are a major player of the energy mix. From this assessment, it is possible to see that even though the energy strategy proposed in this paper, which is based on a dramatic increase in the joint use of district heating networks and cogeneration, is capital-intensive and would require an annual investment of roughly 300 billion euros, its adoption would result in a reduction of yearly fuel expenses in the order of 100 billion euros and a shortening of about 15% of the total final energy consumption, which makes it of paramount interest as an enabler of the legal basis of the "Secure, Clean and Efficient Energy" future enacted by the EU-28 Horizon 2020.

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* Corresponding author.
E-mail addresses: acolmenar@ieec.uned.es (A. Colmenar-Santos), enrique.rosales.uned@gmail.com (E. Rosales-Asensio), david.borge@unileon.es (D. Borge-Diez), jorge.blanes@unileon.es (J.-J. Blanes-Peiró).
[1] Tel.: +34 913 987 788; fax: +34 913 986 028.
[2] Tel.: +34 987 29 19 93; fax: +34 987 29 17 90.

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1. Introduction

From the simplified energy balances performed annually by EUROSTAT (2013 is the last year for which data is available), conventional thermal power plants located in the EU-28 waste more energy in the form of residual heat than what finally residential and commercial buildings use for heating [1,2]. As is clear from (Fig. 1), if this residual heat could be used previous energy valorisation from cogeneration in district heating networks, a noticeable decrease in the amount of imported fossil fuels and greenhouse gases emitted into the atmosphere would occur (in the Section 3, additional information on the relation between electricity and heat in a cogeneration plant is included), which would result in economic, environmental, and energy security benefits.

From (Fig. 1), it is impossible to determine how much heat can be used. Many power plants have to be necessarily located far from the thermal loads of cities (e.g., coal power plants are usually located close to a port to stock). However, in a future scenario, it could be more beneficial, from an economic perspective, to place those plants in the vicinity of the cities. As they are environmentally friendly they can be located closer to them. The old plants should be dismantled when their useful life ends. This supposes an additional expense of transporting coal or lignite in order to be able to use waste heat from power plants [3].

In (Fig. 2), it can be seen as another way of representing the energy balance (which again shows the importance of waste heat from power plants) [4].

As seen in (Fig. 3), about 80% of the energy used in homes has as ultimate goal to provide heating and hot water; this means that, according to (Fig. 2), there would be potentially about 15,000 PJ/year (4100 TWh) to be satisfied through the waste heat from power plants (note that this amount is less than the residual heat emitted by power plants located in the EU-28, 19,608 PJ/year; Fig. 2). Finally, (Fig. 4) shows the energy share for each district heating resource —it is possible to see that, for the EU, most of the heat comes from waste heat from power plants.

Despite these data, it should be noted that, due to the lack of energy matching throughout the year, as well as to the problem of the reject heat temperature (cogeneration can conduct an energy valorisation of this low-temperature heat in an economical way), not all of these thermal loads can be satisfied by the waste heat from thermal power plants. This makes necessary to estimate their real potential including assumptions as close as possible to the reality and to conduct an economic and environmental assessment (reduction of greenhouse gas emissions) that includes a generalised spread of district heating networks using as an energy source waste heat from conventional thermal power plants in the EU-28, which will be conducted in this review.

The objective of this paper is to propose an energy strategy which enables, through the generalisation of the joint use of district heating networks and cogeneration in the EU-28, the fulfilment of the legal basis of the H2020 “Secure, Clean, and Efficient Energy” goals in a feasible, reliable, economically advantageous, and sustainable way. The method proposed here uses a systematic and easy approach (neither strong mathematical skills nor non-widely used software is required) and manages to propose an energy strategy for such a big region as EU-28 based mostly on available public data (with the exception of the plant data obtained through the GESTIS database by using the ArcGIS software). This is of great importance as other methods are network-oriented (district heating network); lack from massive surface applicability [6], being inadequate for such a big area as Europe; are limited to industrial sites [7]; or present assessments which need a district heating network taxonomy [8], information not available in the vast majority of the cases. As a consequence, they are not useful for the purposes of this paper. To our knowledge, there is not a single scientific paper which specifically addresses the potential of the joint use of thermal power plant reject heat into district heating networks across the European Union. Thus, we offer new insights into this matter.

In the Section 1, the first approach to the energy balance of the EU-28 member states is described, and the potential of using the

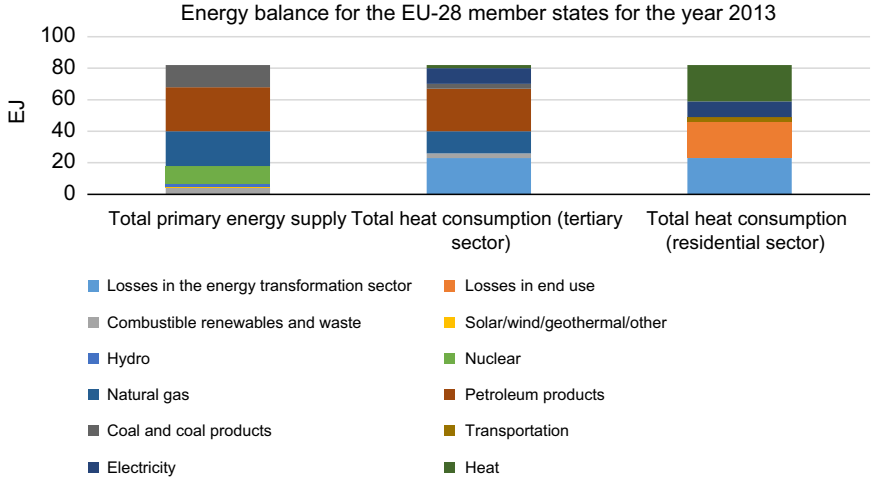

Fig. 1. Energy balance for the EU member states for the year 2013 [2].