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The role of district heating in achieving sustainable cities: comparative analysis of different heat scenarios for Geneva

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Abstract

In many European cities, the heat demand remains mostly supplied by individual fossil fuel-fired boilers, contributing to an inefficient and non-sustainable energy system. In order to decrease the fossil fuel consumption in the heating sector, an improvement of energy efficiency and an increase of renewable energy use must be achieved. This study assesses and compares the impacts of implementing different heat strategies regarding both demand and supply side of the heating system, through a case-study in the city of Geneva, Switzerland. Different heat scenarios for 2035 were developed, based on an input/output hourly energy system model which ensures the matching between heat demand and energy resources. This model is coupled with spatial data that enable to identify the areas where district heating could be developed. The results show the impacts of the different strategies regarding the energy supply, the CO_2 emissions and the related socio-economic costs. The findings demonstrate the importance of district heating networks, which offer the possibility to use local heat sources that otherwise would be unused due to technical, spatial or economic constraints. Compared to a scenario essentially focused on very high energy savings in buildings, a more flexible scenario, combining district heating expansion and a smaller reduction in heat demand, enables to achieve the same reductions in fossil fuel consumption and CO_2 emissions, but with lower socio-economic costs.

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Keywords: District heating; renewable energy; energy modeling; heat scenarios

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1. Introduction

In accordance with the IPCC recommendations [1], the core of the Swiss government sustainability strategy is based on the concept of 1 ton of emitted CO_2 per inhabitant by the end of the 21st century [2].

In Geneva, 482,500 inhabitants in 2014, the present CO_2 emissions related to the energy sector represents 4.2 tCO_2 per capita, of which 2.2 emitted by the heating sector, 1.1 by the transport sector (not including the airport) and 0.8 by the electricity sector (considering the CO_2 content of the Swiss electricity consumption mix in 2014: 139 gCO_2/kWh) [3-4]. Consequently the main CO_2 emissions reduction potential lies in the heating sector, which represents about half of the final energy consumption in the city.

In 2014, the energy consumed by the heating sector in Geneva amounts to 5,444 GWh or 40.6 GJ/capita [3] and it is mainly based on fossil fuels (Fig. 1). The energy targets of the state of Geneva for 2035 are to reduce this consumption to 29.0 GJ/capita, from which only 19 GJ/capita would be supplied by fossil fuels [5]. Considering an expected population of 557,000 inhabitants in 2035 [6], the use of renewable energy in the heating sector should increase from the current 362 GWh to 1,543 GWh, while the use of fossil fuels should decrease from 5,072 to 2,945 GWh.

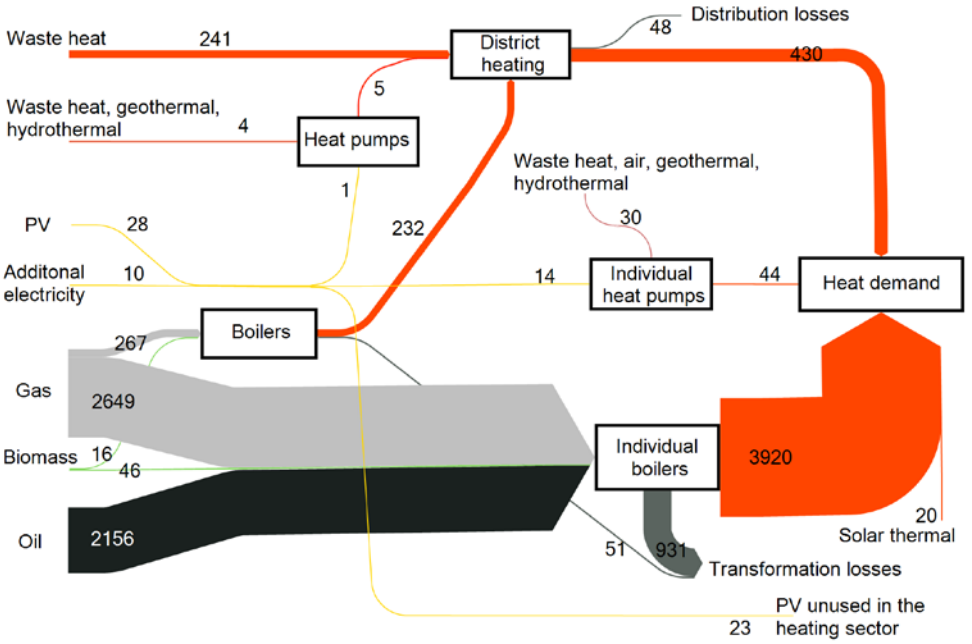

Fig. 1. Energy flow chart of the heating sector in 2014, unit: GWh/y.

Although it has now been demonstrated that district heating (DH) could play an essential role in order to decarbonise the European energy system [7-8], its share in the heat market is still marginal in Switzerland (4-5%) [9] and in the city of Geneva (9-10%) [3].

In this context, fundamental questions were addressed through the project REMUER [10]: What is the role of district heating in order to achieve the energy targets? Is there a synergy or a competition between the development of DH on the one hand and the investments in buildings' energy renovation on the other hand? How could be designed the heating system in 2035? How could it fit into the overall energy system?