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ScienceDirect

Energy Procedia 116 (2017) 128–137

Energy Procedia

www.elsevier.com/locate/procedia

The 15th International Symposium on District Heating and Cooling

Simulation based multi-criteria evaluation of design scenarios for an industrial waste heat based micro district heating network supplying standard and low-energy buildings

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Abstract

This paper presents the results of a multi-criteria evaluation of different design scenarios for a micro-DH network in Vienna, Austria, which involves energy efficient buildings (supplied by heat-pumps and solar thermal panels) and a standard building (equipped with gas boilers). The aim is to assess the integration of industrial waste heat available on-site together with high and low-temperature storages, to balance the heat production and demand, and a heat-pump booster, to supply the network with the required temperature level. The integration of different temperature levels and different profiles from both the production side and consumption side constitute the main challenges.

Peer-review under responsibility of the Scientific Committee of The 15th International Symposium on District Heating and Cooling.

Keywords: Micro-district heating ; Waste heat ; Heat storages ; Design scenarios

1. Introduction

The efficient waste heat recovery (excess heat from industrial processes, waste incineration and power stations) and use in district heating networks, together with other renewable energy (geothermal energy, large-scale solar thermal energy or large-scale heat pumps), is currently one of the main issues studied in order to make District

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1876-6102 © 2017 The Authors. Published by Elsevier Ltd.
Peer-review under responsibility of the Scientific Committee of The 15th International Symposium on District Heating and Cooling.
10.1016/j.egypro.2017.05.061

Heating networks (DHN) more sustainable and to reduce their CO2 emissions [1]-[3]. For instance the studies [4] and [5] show the potential of waste heat use in DHN, from a country perspective and from a system perspective. The conclusion is that industrial excess heat in district heating is beneficial in most cases and the incentives proposed by the European Commission to improve the efficiency of resource use should be taken to increase excess heat recovery, also reflected in national roadmaps, e.g. [6]. Concrete cases of waste heat utilization in DH networks are also being studied. For example in [7] a scheme is proposed to integrate the surplus heat of two steel plants into a large-scale district heating network. [8] presents a new system which recovers waste heat of exhausted steam from a steam turbine to power a CHP based DHN. In [9], a comparison between systems integrating both industrial waste heat and fossil-fuel heat shows that the heat sources are complementary. The base load of the DH system is provided by the industrial waste heat, while the fossil-fuel heat acts as the peak back-up solution.

Despite of its high potential, in our industrialized societies, waste heat is rarely used, because it presents several challenging characteristics [10]. Indeed, the availability profile as well as the temperature levels of the waste heat, can be predictable or completely random depending on the type of waste heat producer and doesn't always meet the heat demand requirements. These issues make it necessary to integrate other components together with the waste heat source into the DH system, such as heat storages, heat pump boosters, back-up solutions, in order to always satisfy the heat demand.

There are as many different ways to integrate components into a sustainable DH system as various corresponding control strategies and business models. Therefore the best solution is not always straightforward, leading to the need of simulation tools to select the optimal design according to specific criteria. Indeed the integration of various sources is difficult to handle, since standard tools and operation strategies don't consider low-temperature and fluctuating sources with a significant share. These issues are tackled in the CITYOPT project [11] and illustrated in particular with the Vienna demonstration case, which consists of an industrial fed micro-DH network including existing and new buildings together with a high-temperature and low-temperature storages and renewable energy supply.

This paper is structured as follows. First, the CITYOPT project is briefly presented and the Vienna case study, one of the case studies addressed within that project, is described. The methodology used for the modelling of this case together with the scenarios simulated is described afterwards. Eventually, the results of the different simulated scenarios are presented and discussed.

Nomenclature

Tb	Techbase
Eb	Energybase
Fb	Futurebase
Ab	Additional building
RTA	Industrial waste heat producer
HTS	High Temperature Storage
LTS	Low Temperature Storage
DH	Vienna main District Heating Network

2. Background

Within the FP7 framework, the project CITYOPT, a collaborative European project, aims at developing a set of applications and guidelines to support the planning, the design (CITYOPT Planning tool) and the operation (CITYOPT Operational tool) of sustainable energy solutions in cities, based on social, energy, environmental and economic criteria. In particular, the CITYOPT Planning tool proposes a web-platform for simulation, optimization and analysis of urban energy systems. The simulations are performed by an external software coupled to the CITYOPT Planning tool, which is designed to be able to interact with any energy simulation engine and handle the simulation of a huge amount of scenarios. The simulation results are used further on within the tool in an