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Assessing the techno-economic impact of low-temperature subnets in conventional district heating networks

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Abstract

The 4th generation Low-Temperature District Heating (LTDH) is envisioned as a more efficient and environmentally friendly solution to provide heating services to the building stock. Specifically, in countries already with a large share of well-established DH systems, conventional DH and LTDH technologies will be operating simultaneously in the near future. Newly built or refurbished buildings have lower heat demands, which in combination with LTDH brings potential savings compared to conventional DH. This work explores the advantages in DH operation by connecting these loads via LTDH subnets to a conventional DH system, supplied by a Combined Heat and Power (CHP) plant. A techno-economic analysis was performed, through modelling and simulation, by estimating the annual DH operating costs and revenues achieved by the reduction in return temperatures that LTDH would bring. The savings are related to: (1) the reduction in distribution heat losses in the return pipe; and (2) lower pumping power demand. Likewise, additional revenues are assessed from: (3) improved Power-to-Heat ratio for electricity production; and (4) enhanced heat recovery through Flue Gas Condensation (FGC). The annual savings per kWh of delivered heat are estimated as a function of the penetration percentage of 'energy efficient' loads over the conventional DH network. Key outcomes show the trade-offs between the potential savings in operating costs and the reduction in heat demand: relative losses in this scenario are maintained at 13.1% compared to 15.3% expected with conventional DH; and relative pumping power demand decreased as well. In other words, the costs of supplying heat decrease, even though the total heat supplied is less.

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1. Introduction

The current district heating technology is facing changing circumstances that challenge the profitability of the DH industry in the future. Existing DH production and distribution networks have been appropriately designed technically and economically for typical levels of heat demand. However, due to factors such as new energy efficiency policies in place, the heat demand in urban areas is expected to gradually decrease in the future [1],[2]. New directives on the construction and refurbishment of buildings define higher requirements of building energy performance, so the existing DH system may not be as technically and economically effective to cope with a decrease on heat demand and heat density. Thus, the system requires an enhancement to effectively adapt to the changing conditions so as to maximize their benefits [3].

Heat demand and linear heat density are two related parameters that determine the profitability of a DH system. However, heat density in the future will decrease due to multiple factors, including building renovation and global warming [4],[5]. Consequently relative distribution heat losses are higher, and so, from the supply and distribution perspectives, investment and operating costs increase relative to total heat sales. Since the return of investment in DH systems is based on heat sales, which depend on the heat demand over periods of several years, the profitability of new DH networks, expansions and/or refurbishment of the existing ones should be carefully planned and analysed.

The DH industry is facing challenges of lower linear heat density in existing DH networks, on top of servicing newly built energy efficient buildings, whose connection might not be either effective or profitable if the conventional DH technology is used. In light of these issues, the 4th generation Low Temperature District Heating (LTDH) set of technologies described in [6] is projected as a solution able to cope with the coming challenges to be able to cost-effectively provide heating services to the building stock.

Nomenclature

Acronyms

CHP	combined heat and power
DH	district heating
DHW	domestic hot water
FGC	flue (exhaust) gases condenser
HEx	heat exchanger
LEB	low energy buildings
LHV	low heating value
LT	low-temperature
LDC	load duration curve
SH	space heating
TMY	typical meteorological year

Latin Characters

C	cost	[EUR]
h	specific enthalpy	[kJ/kg]
l	pipe length	[m]
$\dot{m}$	mass flow rate	[kg/s]
P	power	[kW]
$\dot{q}$	heat load	[kW]
Q	heat	[kWh]
t	temperature	[°C]

Greek symbols

α	power-to-heat ratio	[MW_{el}/MW_{th}]
Δ	delta, difference	[-]
λ	thermal loss coefficient	[W/m_K]

Subscripts and superscripts

amb	ambient/outdoor
el	electrical
eq	equivalent
g	ground
loss	heat losses related
mch	marginal cost of heat
r	return line
s	supply/forward line
sav	savings related
sr	substation return
th	thermal
tot	total

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