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Abstract

District heating in general is seen as an important opportunity to decarbonise the heating sector especially in urban areas and therefore important to reach European and global climate goals. In this case study we analyse possible future scenarios for the city of Brasov, Romania. Like in many other cities in Eastern Europe a district heating system exists in the city, however, facing severe challenges like old and inefficient infrastructure and loss of consumers due to unreliability of supply over the last decades. This work assesses the impact of different policies on the feasibility of renewable and efficient heating under various conditions and suggests favourable policy frameworks to ensure an economically and ecologically viable future heating system for the city.

Keywords: District heating; heat savings and supply; policy assessment; Eastern Europe; Romania

Highlights

- Analysis of least-cost combinations of heat savings in buildings and heat supply by individual or district heating
- Analysis of policy frameworks for renewable energy and district heating in Brasov, Romania
- Only selected and strong standalone policies can make district heating cost competitive against an existing gas infrastructure
- A combination of policies is most efficient to allow for a cost competitive modernisation of old district heating networks

1 Introduction

Decarbonising the heating sector is essential to reach the climate goals agreed on at COP 21 in 2015. In this context, district heating (DH) is an important decarbonisation option especially in urban areas, where it is often the only possible option to integrate large shares of renewable and / or excess heat into the heating sector [1-3]. In many Eastern European cities DH systems exist, however, at the moment not providing efficient and renewable heat supply. These systems typically were installed in the communist era, without relevant re-investments since that time. They often still have installed old supply technologies and are based on fossil fuels. High losses due to overdimensioned and old infrastructure and outdated technology make these DH systems economically unfeasible and lead to unreliable supply. At the same time in many areas where DH networks were placed also a gas grid was placed. This led to disconnection of many customers, further increasing the inefficiency of these systems. [3-6]

The aim of this work was to a) identify technical solutions for increasing the efficiency and the share of renewable energy in the heating systems of the city of Brasov at minimal costs, and b) assess the effect of various policies to enforce the use of renewable energy in the heating system. Based on the results for the city of Brasov conclusions should be drawn also for other Eastern European countries in similar situations.

2 Method

The assessment performed in this paper is based on the case study of the municipality of Brasov with around 275 thousand inhabitants and 1 760 inhabitants per km² on average. The city is located in the centre of Romania with 3 413 heating degree days. The existing DH system is supplied by heat from an external producer in combined heat and power (CHP) engines as well as heat only boilers all fuelled with natural gas, and in the distribution system currently more than half of the inserted heat is lost before reaching the consumers.

2.1 Modelling framework

The modelling framework to analyse the defined research question combines different tools and approaches: (1) The existing DH system and possible alternative supply portfolios for the future of the DH system until 2030 were modelled in energyPRO [7] to calculate the DH generation costs, CO_2 emissions and fuel use and also to obtain the sensitivity of the costs to disconnection or additional customers based on optimal dispatch of the supply portfolio. (2) The costs and potentials for decreasing thermal losses through the building envelope in existing buildings (heat savings) of the city until 2030 were calculated, hereby distinguishing ten typical building types with three different construction periods[2]

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[2] Buildings of a certain type with a certain construction period are further on called building of a certain building class

and eight renovation levels for each of these buildings with the Invert/EE-Lab model [8,9]. (3) Costs for the supply of heat with five different individual heating technologies were calculated for the same building types, construction periods and renovation levels. (4) The municipality was divided into four different types of areas according to resulting costs of connecting buildings to the existing DH system: a) The so-called “DH area” is the area of the currently existing distribution network including the zone of 50 m distance to this network. In this area it is assumed that additional buildings can be connected to DH without further expansion of network but by investing only in connecting pipes and heat exchangers. b) The so called “next-to-DH area” is the area within 1 000 m of the current transport network that is not within the “DH area”. In this area it is assumed that further buildings can be connected by investing in an additional distribution network plus connecting pipes and heat exchangers. c) The “individual area” is defined as the area outside the “next-to-DH areas” that is not sharing a border with the existing DH area. For buildings located in these areas, it is necessary to invest in transmission pipes, distribution pipes, connecting pipes and heat exchangers to be able to connect to DH. d) Scattered buildings, which are spread across the municipality and not close enough to other buildings, are not considered to be possibly connected to the DH system. (5) For all building classes and all areas within the municipality the cheapest combination of heat savings and heat supply was calculated for different technical scenarios and policy settings. For all combinations of technical scenarios and policy settings total system costs, total CO_2 emissions, energy demand for space heating and hot water preparation, share of renewable energy and share of DH were calculated. The total system costs hereby include the investment costs in supply technologies, DH network infrastructure and heat saving measures, the operation and maintenance costs for supply technologies and the DH network as well as the fuel costs. Used investment and energy costs are stated in the Annex of this paper.

2.2 Technical scenarios

Two technical scenarios of the future DH system were considered in the analysis: the reference scenario represents the continuation of the current DH system where heat is mainly purchased from an external heat producer and also in own natural gas heat only boilers, however, re-investments into the existing network infrastructure are included to reduce the currently high network losses to 20%. The alternative scenario additionally includes investments into renewable heat supply options for the DH system including a 0.5 MW biomass boiler, a 3 MW_{el} heat pump and 2 000 m² of solar thermal collectors.

2.3 Policy settings

Table 1 describes the status quo, the assessed standalone policies and the combination of these policies in the policy package. All of them had been discussed with local and national stakeholders from Brasov and Romania and were considered as interesting to analyse. In a first step each policy was assessed as a standalone policy for both technical scenarios (“Reference” & “Alternative”). In a second step it was assumed that all investments into the DH system are made by a public service following a long term investment horizon without additional profit and therefore assuring the “Long Term Loan” policy. Under this condition again the combination with all other policies was investigated (“Public Reference” & “Public Alternative”). As last step the effect of a “Policy Package” including the most promising policies was assessed.

Table 1 Assessed policy settings

Policy Name	Description
Status quo	The status quo represents the current situation where district heat is purchased from an external heat producer at a fixed rate of 35.5 EUR/MWh and more than half of the inserted heat is lost before reaching the consumers. Further cost assumptions are stated in the appendix.
Long Term Loans	This policy instrument ensures low interest rates of 1.5% and long depreciation times of 40 years for investments made into DH infrastructure compared to 6% and 25 years as stated in the appendix.
CO_2 Tax	This policy instrument reflects the implementation of a tax on CO_2-Emissions caused by burning fossil fuels in individual heating technologies. Two different price levels are investigated: (1) The same CO_2 price per ton as it is expected for the ETS sector in the EU Reference Scenario 2016 [10] for the year 2030 (31.5 €/t) and (2) a price level that is needed to reach an impact with CO_2 tax as a standalone policy.
DH connection Subsidy	This policy instrument supports the connection of buildings to the DH network by covering the connection costs.
RES DH Subsidy	This policy reflects investment subsidies of 45% of eligible costs for investments into renewable heating technologies in DH systems. The maximum value for a project cannot exceed 15 Mio Euro.
Zoning / forbid Gas	This policy reflects the obligation of having a GIS based heat planning resulting in different zones for certain energy carriers to avoid double infrastructure and ensure a high connection to DH by not allowing individual gas boilers within the designated DH area.
Policy Package	The policy package includes long term loans for investments into DH infrastructure together with subsidies for DH technologies using RES and a CO_2 tax of 35 €/t.

3 Results

Figure 1 shows the least cost combination of heat savings and heat supply for the different technical scenarios and policy settings compared with the status quo. It can be seen that a reduction of the total heat demand of around 250 GWh (18%) can be achieved in all scenarios. This demand reduction results mostly from the cost-effective heat savings in buildings until 2030 and not from the assessed policies, which do not directly target a heat demand reduction.

Without any policy, the DH system would only have a share of 1.5% of the overall heat demand in both the reference and the alternative scenario assuming that all consumers apply the cost optimal combination of heat savings and heating supply for their building. According to this assumption most detached single family houses would switch to air source heat pumps after renovation resulting in almost 16% of the demand supplied by this technology. Other single family houses and row houses would switch to individual biomass boilers as the cheapest option after renovation, resulting in more than 9% of the heat demand supplied by biomass. Restrictions like the availability of biomass or consumer preferences are not reflected in the modelling framework but probably would inhibit the expansion of biomass resulting in more natural gas boilers.

Comparing the different standalone policies for the two technical scenarios it can be seen that most of the assessed policies alone do not affect the results regarding the cheapest heat supply combination. Only a high CO_2 tax on fossil fuels of 130 €/t would increase the cost for natural gas to an extent so that individual heat pumps become cost effective in more buildings and that DH would become competitive for most of the larger buildings within the "DH area", where no additional network has to be built. As another policy, the regulatory measure of forbidding natural gas boilers in designated "DH areas" would also enforce most of the buildings within this area to switch to DH leading to a DH share of almost 18%.

In the "Public Alternative" setting, where long term loans by a public service are available to finance investments in DH, higher RES and DH shares can be achieved with not too strong additional policies like an additional CO_2 tax of 31.5 EUR/t or investment subsidies for RES in DH. Alternatively banning natural gas from the DH area allows reaching similar shares.

The "Policy Package" setting allows reaching the highest share of RES for heating without very high CO_2 taxes and without the strong regulative measure of forbidding natural gas within the "DH area". Therefore combining different policies lead to similar shares of RES and DH without overstressing single measures.

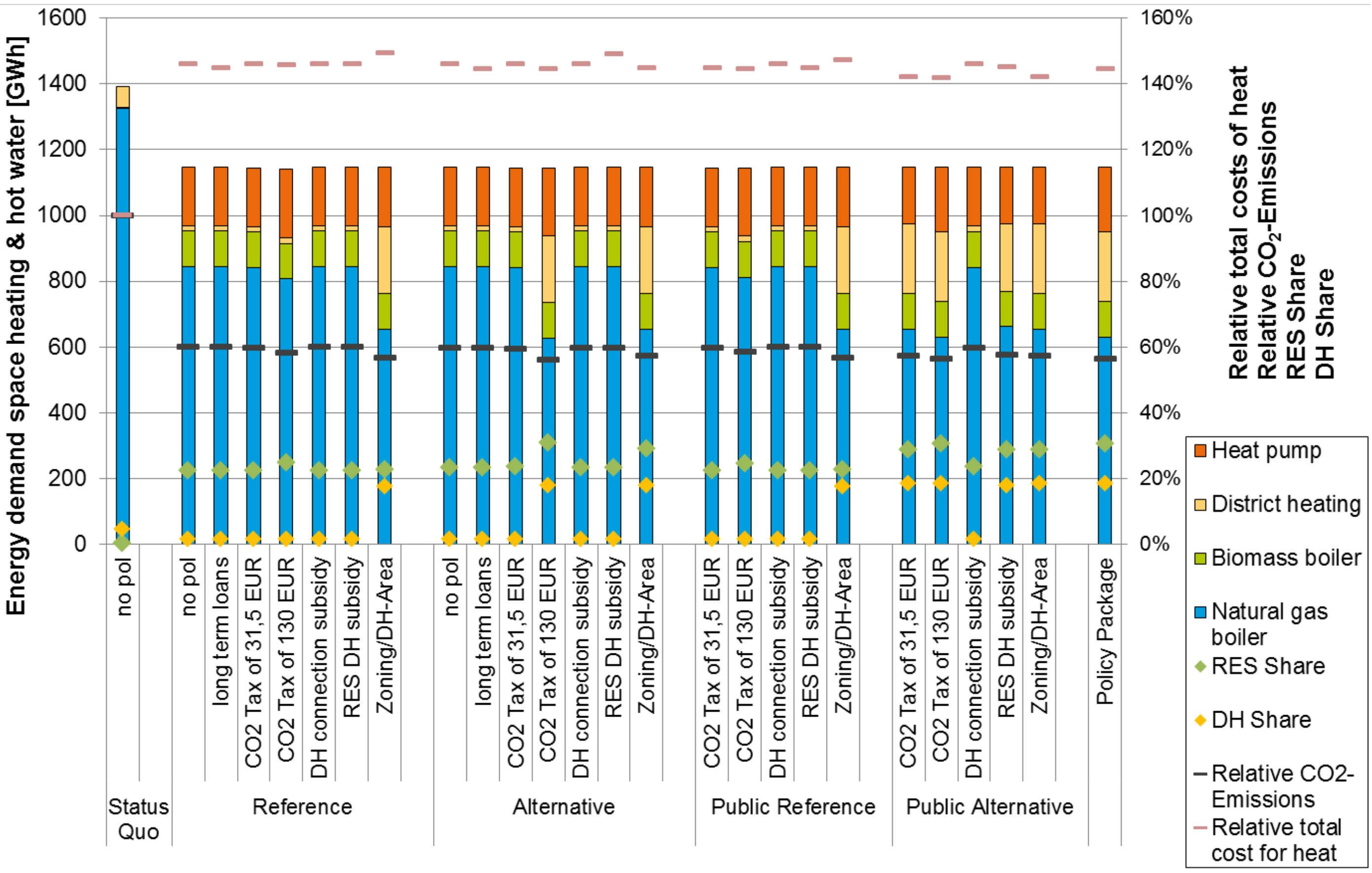

Figure 1: Final energy demand for space heating & hot water preparation, share of RES and DH, as well as CO_2 emissions and total costs of heat relative to the status quo for the analysed technical scenarios and policy settings in 2030

The results show that from a climate policy point of view it only makes sense to force increased shares of DH when the DH system is transformed to include higher shares of RES ("Alternative" & "Public Alternative"). When DH is forced in by zoning and the prohibition of gas but the DH system stays with the fossil reference supply there is no positive effect on the CO_2 emissions.

4 Discussion

Although the proposed approach is not capable to fully reflect the real behaviour of all actors, and certain barriers like comfort or consumer preferences couldn't be integrated in the modelling framework, the impact of different policies on decisions based on a least-cost-approach could be assessed. The results showed that standalone policies would have to be very strong to make DH competitive again and thus allow for the integration of higher shares of RES in the entire heating system. Rather it is more efficient to combine different policies to ensure a modernization of the old DH system and to bring back consumers. On the one hand it is crucial to trigger investments into the outdated network infrastructure and into renewable supply, and on the other hand it is essential for the feasibility of a DH network to share the infrastructure costs amongst as many customers as possible. The former can be reached by guaranteeing a long term investment planning horizon and low rates of return by giving long term loans from a public fund to a private operating company or by guaranteeing an ownership structure that allows investment calculation under these conditions: This could be a public service or a consumer owned cooperative both operating without profit and following a long term planning horizon. The latter can be reached either by making DH economically more attractive compared to fossil supply with connection subsidies or taxes on fossil fuels, or by a stronger planning approach in terms of strategic local and regional heat planning by defining zones where certain supply technologies are preferred.

5 Conclusion

Many DH systems in Eastern Europe are currently old and inefficient due to a lack of investments in past decades leading to unreliable supply and the loss of consumers. Identifying DH as an important means to reduce CO_2 emissions especially in urban areas, policy frameworks have to be adopted to enable economically end ecologically feasible DH systems.

With a modelling framework calculating the least cost combination of heat savings and supply with individual heating technologies or with DH for 30 different building classes located in four different areas related to their possible access to the existing DH network, the ability of different policies was assessed to generate favourable conditions for DH modernization.

Five different policy measures were assessed one at a time and as a combination of two policies for a technological reference and a technological alternative scenario, as well as a policy package including the most promising policies. In the technological reference scenario it is assumed that the current supply situation is maintained and only investments into the network infrastructure are made whereas in the technological alternative scenario different renewable supply options will be integrated into the DH system.

The assessment showed that only selected standalone policies are able to generate a favourable policy framework for economically and ecologically efficient DH, however, these policies would have to be rather strong. In contrast, integrated policy packages combining several policy measures at lower intensities would lead to even stronger effects on RES and DH shares as well as CO2 emission reduction. The policies should tackle different aspects: Guarantee a long term planning horizon, trigger new investments into the outdated network infrastructure and into renewable supply options, make DH more attractive compared to fossil alternatives and generate enough customers to share the infrastructure costs.

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