DISTRICT HEATING AS PART OF THE ENERGY SYSTEM: AN ENVIRONMENTAL PERSPECTIVE ON ‘PASSIVE HOUSES’ AND HEAT REPLACING ELECTRICITY USE

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ABSTRACT

Energy use for space heating, hot tap water and other heat use at comparatively low temperature levels represent a substantial part of the total energy use in Sweden and countries with similar climate. It is thus of importance to meet this demand in a way generating as small environmental impact as possible. However, it is possible to create a system with higher environmental impacts with energy efficient buildings compared to less energy efficient buildings through choice of less good energy carriers. It is not enough that the individual parts of a system are good and efficient to give a low environmental impact; the parts must be connected into the system in a good way. From environmental perspective energy efficient buildings and district heating don’t oppose each other – good parts connected in a good system will give an optimal. The results from the study of the three items of household equipment show possibilities for district heating to be an alternative with good environmental performance, but not under all heat generation regimes.

INTRODUCTION

It is of importance to meet for space heating, hot tap water and other heat use at comparatively low temperature levels in a way generating as small environmental impact as possible. This can be done by increasing the efficiency in the use phase and in the heating systems of buildings as well as through heat generation systems with low environmental impact. During recent years there has been a focus on houses with low need of space heating, low energy houses or “passive houses”. In such buildings the heat from the incoming sun radiation together with body heat from people living in the houses and different household equipment will cover the whole or at least substantial parts of the space heating need over a year (extra heating might be needed during the coldest days of a year). Hot tap water still need to be heated. For parts of the year this can be achieved by solar panels, but there is a need for extra heating during winter. This might result in the extra heating demand being covered by electricity, directly or indirectly.

Increased energy efficiency is in itself a desirable goal for a society – it increases the robustness of the energy system and the possibilities for a resource efficient and more sustainable energy system in the long run. However, it is possible to create a system with higher environmental impacts with energy efficient buildings compared to less energy efficient buildings through choice of less good energy carriers. It is not enough that the individual parts of a system are good and efficient to give a low environmental impact; the parts must be connected into the system in a good way. Thus it is important to identify system solutions that avoids sub optimization and gives us energy efficient buildings and an efficient energy system with good environmental performance.

In a synthesis studies within the framework of Chalmers Energy Center [1] the role of district heating in a future society with more energy efficient buildings have been investigated. Here we report on general findings of this study with a special focus on the environmental performance of the possibility to convert some household electricity use into district heating - for the use in dish washers, washing machines and tumble dryers [2]. The environmental performance is studied using life cycle assessment methodology and different assumptions regarding electricity and district heating generation.

DISTRICT HEATING – DEMAND SIDE

There are today several drivers in the direction of lower total heat market for district heating in future [1]. Among possible such drivers in Sweden are:

- Warmer climate (due to climate change)
- Higher energy prices
- Increased environmental awareness
- Increased energy efficiency of existing building stock
- Limited amounts of new housing
- New housing more energy efficient

However, there are also possible drivers for a larger heat market in future, e.g.:

- Increased wealth giving larger living space per person and higher demands on comfort
Electricity prices might increase faster than heat prices might lead to interest in heat instead of electricity for “new” applications (washer, dishwasher, etc.)

- Heat for comfort cooling
- Increased use of heat for other purposes – e.g. drying of biofuels et c.

With strategic planning the resulting effect for district heating might be a lower total but at the same time more even demand of heat (Fig. 1).

**DISTRICT HEATING – SUPPLY SIDE**

A strategic role of district heating in the energy system is the ability to utilize and deliver resources that otherwise would have been lost. Among possible system drivers on the supply side in Sweden are [1]:

- Increased utilization of industrial surplus heat
- Remaining large potential of waste incineration
- Increase of CHP power production

At the same time we can also expect:

- Increased competition for bio fuel resources
- Higher prices on high quality energy carriers (electricity and fuels) might drive towards smaller fraction as heat.
- Increased energy efficiency in industrial processes.

With strategic planning district heating might utilize residual heat from processes producing combinations of high quality energy carriers (or bio based material production). The focus can probably not be on heat production. Even combined heat and power production from bio fuels might not be efficient enough for competitive district heating (Fig 2).

**Fig. 1** Possible change for district heating demand in future – decreasing demand but more even over the year.

**Fig. 2** Focus on the use of biomass e.g. for making optimal amounts of high qualitative energy carriers with heat as a residue (it could also e.g. be biomaterials production).

**Fig. 3** Illustration of the need for a systemic perspective in planning the details of the energy system; a): A CHP plant and a potential energy customer (building); b): A CHP plant delivering district heat and electricity to a customer; c): A power plant delivering only electricity to a customer with passive house standard using electricity for hot water and peak heat demands – excess heat is cooled away. The total primary energy demand increases; d): A CHP plant delivering both heat and electricity to a customer with passive house standard (less total primary energy demand than in the b case).
THE OVERALL ENERGY SYSTEM

The energy system of a country is complex, and it is important to understand how changes in sub systems may affect the whole system. Sub optimizations might easily occur. A simplified example of a situation where a more energy efficient building through sub optimization of the total system gives a larger overall primary energy need is illustrated in Fig. 3. Obviously it is possible to create a system with higher environmental impacts with energy efficient buildings compared to a system with less energy efficient buildings. It is not enough that the individual parts of a system are good and efficient to give a low environmental impact; the parts must be connected into the system in a good way.

Thus it is important to identify system solutions that avoids sub optimization and gives us energy efficient buildings and an efficient energy system with a good environmental performance.

IMPLICATIONS OF NEW TYPES HEAT LOAD

To better understand implications of different new types of heat load (as illustrated in the right hand side of Figure 1) a life cycle assessment (LCA) has been performed regarding the use of heat instead of electricity for the three examples of house hold appliances: dish washer, washing machine and tumble drier. Basic data regarding the appliances are exemplified with those in the “district heating villa” in Göteborg, Sweden. The LCA model includes energy production (electricity or/and heat) for an average use of each machine and the materials needed to produce it. Different types of energy mixes for electricity and district heat generation were studied. Details of the system boundaries and data can be found in the full report of the study [2].

The results indicate that the total energy system influences the results greatly. If we consider electricity production with large environmental impacts, to utilize district heating is a good alternative, even in cases where the district heating generation in itself is not optimally environmentally friendly. This is exemplified in Fig. 4 where we consider Swedish average district heating fuel mix (bio and residue heat, but also fossil fuels and some peat [5]) and European average electricity generation. If we for the long term development consider electricity generation that is much less fossil carbon intensive and compare it with district heating based on forest bio fuels the results are much more narrow, and it become important what environmental impact category is considered. In Fig. 5 this is exemplified with climate impact and acidification impact.

If district heating should continue to be seen in general as an environmentally preferable option it is important that district heating companies continue to develop district heating production in a favourable direction.

Heat for district heating should originate from resources that are otherwise wasted. In the long term that will mean that bio fuelled district heating is not enough, but heat from other primary production like bio energy or biomaterial combines producing transport fuels and/or bio based materials.

CONCLUSIONS

From environmental perspective energy efficient buildings and district heating don’t oppose each other – good parts connected in a good system will give an optimal. It is not enough that the individual parts of a system are good and efficient to give a low environmental impact; the parts must be connected into the system in a good way. The results from the study of the three items of household equipment show possibilities for district heating to be an alternative with good environmental performance, but not under all heat generation regimes. Heat generation must continuously be considered.
Fig. 5 Environmental impact from using district heat for dishwasher, drier and washer. Case: bio based district heating production and Swedish av. electricity.

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REFERENCES


