INVESTING IN ENERGY EFFICIENCY IN BUILDINGS WITH DISTRICT HEATING

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Summary
District heating (DH), an important source of domestic heat for a number of EU Member States, is often praised as an efficient, clean and cheap technology with significant potential for carbon emissions mitigation. In Central and Eastern Europe, DH systems often perform poorly because of inherited inefficiencies and heat costs are a burden the household budgets of domestic users. In that context, significant energy cost savings and additional co-benefits can be realised through a large scale, deep retrofit of buildings connected to DH, especially if the conditions under which DH is served are also improved. In the long-term, however, the future role of the DH industry may to be reevaluated if nearly-zero energy buildings become the norm, as presently legislated in the EU, and consequently the demand for domestic heat is drastically reduced.

1. Introduction: district heating (DH) in an EU context

1.1. Diverging perspectives in an evolving EU

District heating (DH) has been often celebrated as a sustainable and environmentally friendly way of providing heat to buildings (IEA/OECD, 2009). Indeed, if the heat produced in high-efficiency cogeneration power plants (combined heat and power, or CHP) or is waste heat from industrial processes, and is efficiently distributed to nearby users, DH can be considered as an effective way of improving the overall efficiency of energy use. The bottom line of the technology is that the waste heat of power generation or other sources that would previously go unemployed is put to good use if served as DH to buildings or industries. This, combined with low-emission fuels used as energy source (Euroheat & Power, 2011), may make DH an environmentally very attractive heat source.

At the same time, the heat demand scene of Europe is rapidly changing as a result of the expected proliferation of very low (nearly zero) energy buildings as legislated and planned in Europe, that may question the future economic feasibility of DH systems under several circumstances. Trends towards very low-energy-consuming European buildings are not necessarily in harmony with large-scale DH adoption plans in some Member States like the UK, where it is being promoted as a low-carbon solution for meeting mitigation targets (Poyry Energy Consulting and AECOM, 2009)

Furthermore, in some parts of Europe, DH is often regarded as an undesired legacy. This is mostly the case of countries of Central and Eastern Europe (CEE), where much of the currently used heat is still provided through the same networks as in the former communism. There, DH does not always come from CHP units but also from heat-only plants, sometimes inefficient ones using very polluting fuels (such as in Poland); it is then served through old and often obsolete distribution systems, and end-users often live in dwellings with a poor thermal performance and without the possibility to regulate the amount of heat consumed and charged by inflexible flat rates (Tirado Herero and Ürge-Vorsatz, 2011). Under such conditions, DH is an expensive, inefficient and polluting heat source, frequently perceived as a burden to consumers, as a source of additional emissions, and as an issue of concern to be addressed by public authorities.

1.2. Aim and scope of the paper

A main aim of this paper is to explore a number of key issues related to the successful energy efficiency investments in buildings connected to DH. It also attempts to raise some questions about the future of the DH sector in a prospective EU were low-energy or nearly zero energy buildings become the norm.

From a geographical perspective, part of the paper focuses on the Member States of Central and Eastern Europe (CEE), and more in particular Hungary's prefabricated (*panel*) buildings serve as a case for discussion. This is because of the reasons previously outlined and because CEE Member States will be the primary net beneficiaries of EU funds in the post-2013 framework. However, the discussion is meant to be also relevant – especially the last section on the future of DH in a low-carbon EU – for Member States where better-functioning DH networks exist or are planned for the future. Equally, many of the conclusions are relevant to non-domestic DH users (i.e., commercial or public buildings) even though domestic DH consumption is the primary concern of the paper.

2. Background on DH consumers: a *hidden* type of fuel poverty

Among the claimed advantages of DH (e.g., ease of use, reliability of supply, low maintenance, no need for fuel storage, lower risk of fire and explosions, etc.) is that its cost compares favourably with other sources of heat on the basis of a unit of final heat energy provided (Euroheat and Power, 2011; Stasiūnas, 2011). Whereas this assumption may hold true for many countries of Western Europe, in many CEE nations DH is actually (one of the) most expensive forms of heat, especially if measured on per capita or per m^2 basis. Since dwellings served by DH are often inhabited by lower income groups, the result is a *hidden* type of (fuel) poverty: whereas residents do not suffer from lack of thermal comfort, they are forced to spend a disproportionally large share of their income on their heat, potentially compromising their ability to meet other basic needs, and risk falling into indebtedness to heat providers. This section provides a background to this phenomenon and its causes.

First, households in CEE countries connected to DH often pay on a per dwelling area or volume basis because of the absence of individual consumption meters. This is a legacy from the communist philosophy that regarded energy more as a basic right than as a service to be allocated with economic rationality criteria. This stance is expressed in, for instance, Hungary's prefabricated panel buildings, in which heat circulates through a vertical loop that connects radiators on different floors instead of radiators in the same apartment (Sigmond, 2009) the heat consumption in almost half (49%) cannot be metered independently from other flats (Energia Klub, 2011).. As a result, prefabricated panel dwellings in Hungary are the most expensive to heat when this cost is measured per dwelling floor area (m^2) or per person (Tirado Herrero and Urge-Vorsatz, 2011). As an alternative example, the typical per dwelling winter costs of a conventional, poor quality apartment block in Lithuania of ranges between €100 and €140 per month (Stasiūnas, 2011). This compares to the figures of €680 average monthly household disposable income (2009) and €215 average state social insurance old-age pension (2010) reported by the Lithuanian Statistical Office (Lietuvos Statistikos Deapartmentas, 2011a; 2011b). DH payments become particularly painful when they are concentrated in the winter months instead of split throughout the year. For instance, as acknowledged by the Association of Hungarian District Heating Enterprises (*MaTáSzSz*), in extreme cases (e.g., low-income pensioners) consumers have to use their almost full monthly income to pay their DH bill during the heating season (Sigmond et al., pers. comm.).

For worse-off households, another way to deal with this situation is falling in arrears and eventually indebtedness to DH providers. In fact, the latter is the way households may choose to deal with their DH costs when their budgets are too strained. In Lithuania, for instance, a constant figure of around indebted 100,000 consumers (16-17% of total heat users) of DH users is reported for the period 2001-2009 in spite of the improvements in the efficiency of fuel combustion and reduction of transmission losses reported for the same period (Stasiūnas, 2011). In Hungary, the family support service of Budapest district III – a neighbourhood with many *panel* block connected to DH – has reported that when households are indebted to heat providers, this is often so high that it cannot be managed by the municipality's debt relief services (Tirado Herero and Ürge-Vorsatz, 2011). Users debts' impacts the financial performance of heat providers, which in turn may run into debt with heat producers, and these with fuel suppliers; following that, interruptions in the heat supply may occur. In the long-term, it undermines the capacity to maintain or upgrade the network (Poputoaia and Bouzarovski, 2010). And if non-payment occurs at a large scale, negative economy-wide macroeconomic effects may follow: in Romania DH debts peaked at 0.25% of Romania's GDP in the early 2000s and its reduction became a condition for future IMF lending (OECD/IEA, 2004).

A positive side of households being forced to heat – often overheat – their home is that fuel poverty-related health problems can be avoided. It is known that living at low temperatures has been associated to higher incidence of physical and mental diseases and identified as a cause of excess winter mortality (Liddell and Morriss, 2011; Healy, 2004; Wilkinson et al., 2001). Though evidence is still lacking, it can be assumed that their incidence in sufficiently heated blocks connected to DH is lower. However, similar and better thermal comfort levels procuring an equally healthy indoor environment can be achieved with much lower energy consumption levels in energy efficient homes.

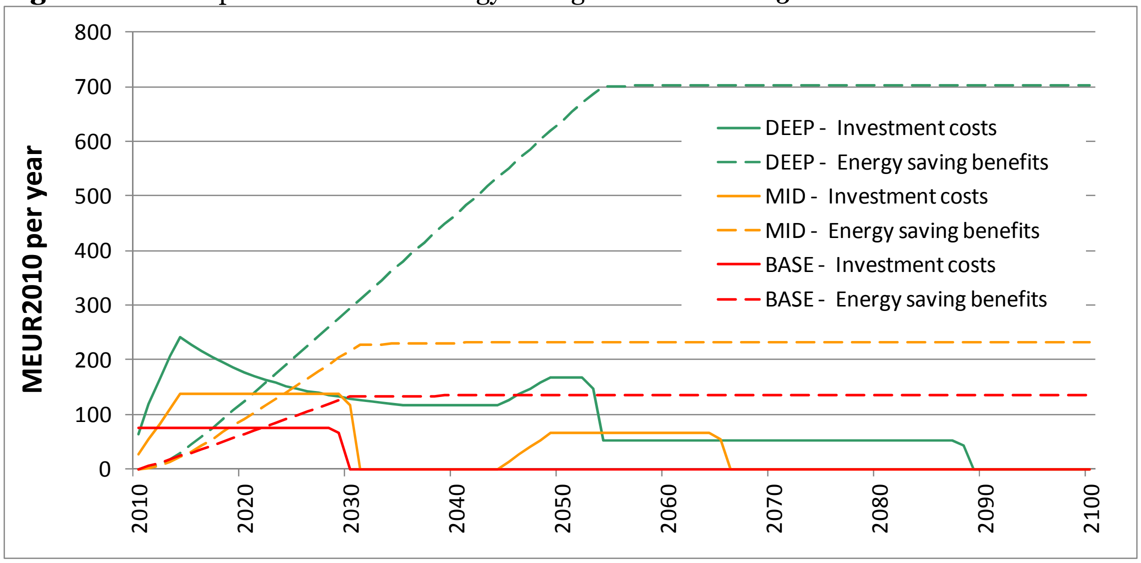
3. How far to go with energy-efficient building retrofits? Deep vs. moderate retrofits

If the need to retrofit is acknowledged, a question arises about the depth of the retrofit, i.e., the energy savings to be achieved with the intervention.

For that, the case of Hungarian prefabricated panel buildings, which are mostly supplied by DH (81% of their total floor area), is presented. More specifically, a private cost-benefit analysis was conducted for comparing the financial returns of moving from a BASE or *business-as-usual* scenario (25,000 dwellings retrofitted per year by current programmes delivering 25% savings in space heating energy use) to either a MID or a DEEP scenario. The latter two scenarios were designed after the *Faluház* (50% energy savings, €$_{2010}$ 94 per sqm.) and SOLANOVA (87% energy savings, €$_{2010}$ 314 per sqm.) pilot projects respectively (Tirado Herrero, unpublished).

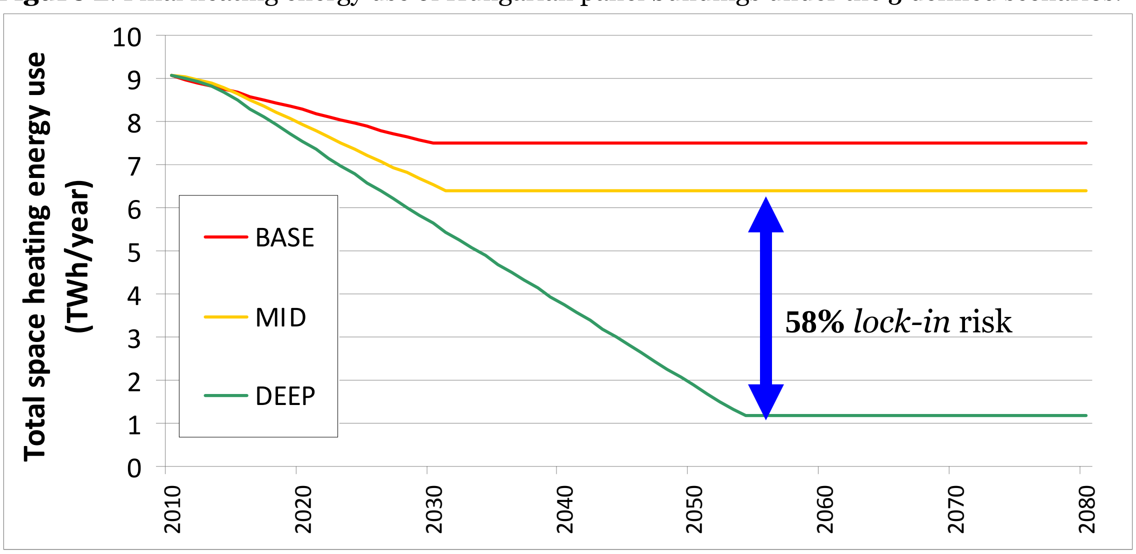
On the costs' side: i) a learning factor was included in DEEP scenario to account for economies of scale-based cost reductions of this non-mature technology (i.e., the cost of a deep retrofit comes down to double the cost of a BASE retrofit – €$_{2010}$ 113 per sqm. – by 2036); ii) transaction costs (e.g., programme management costs) were estimated as 10% of the total annual investment costs of the programme and added to the latter; iii) 2nd round retrofit costs were accounted for, i.e., 35 years after the first retrofit, an update takes place at the cost of 50% of a first retrofit in the given year for maintaining the performance of the dwelling. On the benefit's side, energy saving benefits were estimated based on current and forecasted prices of DH and other energy carriers.

Figure 1. Annual private costs and energy saving benefits for the 3 defined scenarios.



The results (annual investment costs vs. annual energy saving benefits) are presented in Figure 1. Net Present Values (NPV) were then estimated at a 4% real financial discount rate and indicate that, in spite of its higher costs, deep retrofits deliver a larger amount net discounted benefits. Deep retrofits are a thus preferable policy option when compared to moderate (MID) retrofits

Figure 2. Final heating energy use of Hungarian panel buildings under the 3 defined scenarios.



An additional reason why moderate retrofits need to be avoided is because of the *lock-in* risk. This is defined as the unrealised energy saving potential resulting from implementing below state-of-the-art energy efficiency technologies. Thus, non-deep retrofits will force to revisit buildings after a few years in order to capture the remaining potential (which may be technically difficult or uneconomic) or consider other more expensive mitigation options like renewables or CCS (Korytarova and Ürge-Vorsatz, 2010; Tirado Herrero et al., 2011). As shown in Figure 2, MID retrofits lock-in 58% (using as a reference the figure of total energy consumption figure in 2010) of the energy and carbon saving potential of Hungary's panel building stock.

4. Arguments for public sector involvement

4.1. Barriers to energy efficiency investments

Numerous barriers to energy efficiency in buildings have been identified in the literature (e.g., Köeppel and Ürge-Vorsatz, 2007; Clinch and Healy, 2000). In CEE countries, a particularly important barrier has to do with shared ownership character of buildings connected to DH – usually multi-family units –, which increases transaction costs. For instance, this implies that agreements between owners have to be reached before a decision is taken. The legal framework (e.g., power of veto of more reluctant owners) matters in this regard, as does the amount of public support (e.g., subsidies, low interest loans, information, etc.) that an individual household expects to obtain.

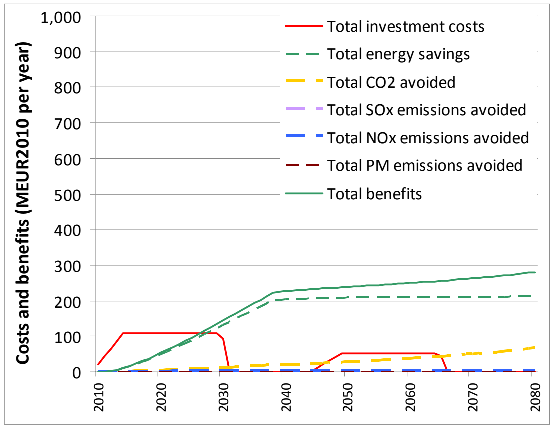
4.2. Co-benefits of energy efficiency investments

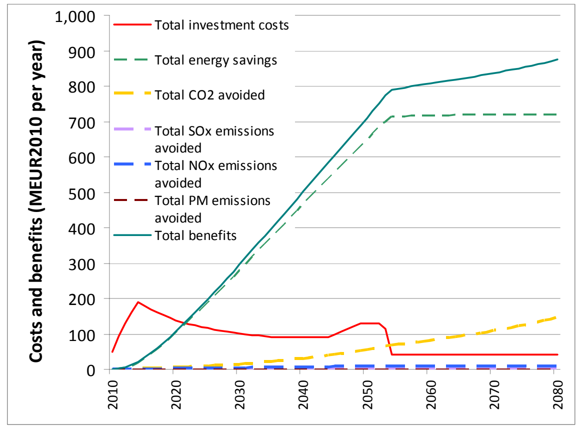
Reducing the energy use of building with DH has wider positive effects on society's welfare in addition to energy cost savings. Even though many of these are non-market benefits they can be economically assessed through economic valuation techniques. This is the case of the avoided emissions of GHG (CO_2, CH_4 and N_2O) and non-GHG pollutants (e.g., NO_x, SO_x, PM), whose economic value has been estimated through their external cost of emission and incorporated into the CBA presented in Section 3. For that, emission factors for all pollutants were obtained from the literature and avoided external cost of GHG (13 $€_{2010}$ tCO_2eq^{-1}, increasing 3% per year) and of non-GHG emissions (3,460, 4,000 and 31,000 $€_{2010}$ per ton SO_2, NO_x and PM_{10}) were retrieved from IPCC (2007) and the *NewExt* project. No health- or excess winter mortality-related fuel poverty alleviation benefits (as in Clinch and Healy, 2001) were considered because it was assumed that Hungarian *panel* buildings meet adequate thermal comfort levels.

In addition to this, labour and material costs and energy prices were corrected and a social discount rate was applied (5.5% for CEE countries, after European Commission, 2008), following the principles of social cost-benefit analysis (OECD, 2006).

Results shown in Figures 3 and 4 indicate that, as in the private analysis, larger energy and non-market benefits are accrued in the DEEP scenario. In the long term, the NPV of moving from BASE to DEEP scenario is positive and larger than the BASE to MID option, thus confirming deep retrofits as a preferable policy option. Note that most social benefits are private energy saving benefits because of the relatively low emissions of CO_2eq and other pollutants associated to DH in Hungary. This situation is substantially different in countries (e.g., Poland) were polluting fuels like coal are still used by hear producers.

Figure 3 and 4. Results of the social CBA (MID scenario – left; DEEP scenario – right)





Retrofitting buildings brings about other co-benefits usually not incorporated in cost-benefit analysis that are also powerful levers for policy action, such as:

- Net employment creation: in Hungary and Poland, detailed estimates accounting for various types of employment effects indicate that tens to hundreds of thousands of additional net jobs can be created through the wide-scale implementation of deep retrofits (Tirado Herrero et al., 2011; Ürge-Vorsatz et al., unpublished)
- Reduced energy dependency: especially for energy-dependent countries like most of the EU and CEE. For instance, deep retrofitting Hungary's building stock would reduce in 2030 up to 39% of natural gas imports in 2006-2008 (depending on implementation rate), with close to 60% of January import savings (Tirado Herrero et al., 2011)
- Fiscal effects: energy efficiency retrofits have the potential to reduce government expenditure (e.g., unemployment and social welfare payments) and increase revenues (e.g., additional income tax and VAT collection). However, a certain decrease in the collection of energy related-taxes has to be also accounted for (Ürge-Vorsatz et al., unpublished).
- Increased market value of properties: a hedonic price analysis of the impact of the EPBD labelling system on the Dutch housing sector found out that A-labelled homes obtain a 12% price premium in transaction prices as compared to G-labelled homes (Brounen and Kok, 2010).

In summary, the presence of significant barriers and the wide range of positive co-benefits to be obtained justify the need for an active involvement of the public sector to provide the conditions for energy efficiency investments.

5. Are technical solutions enough?

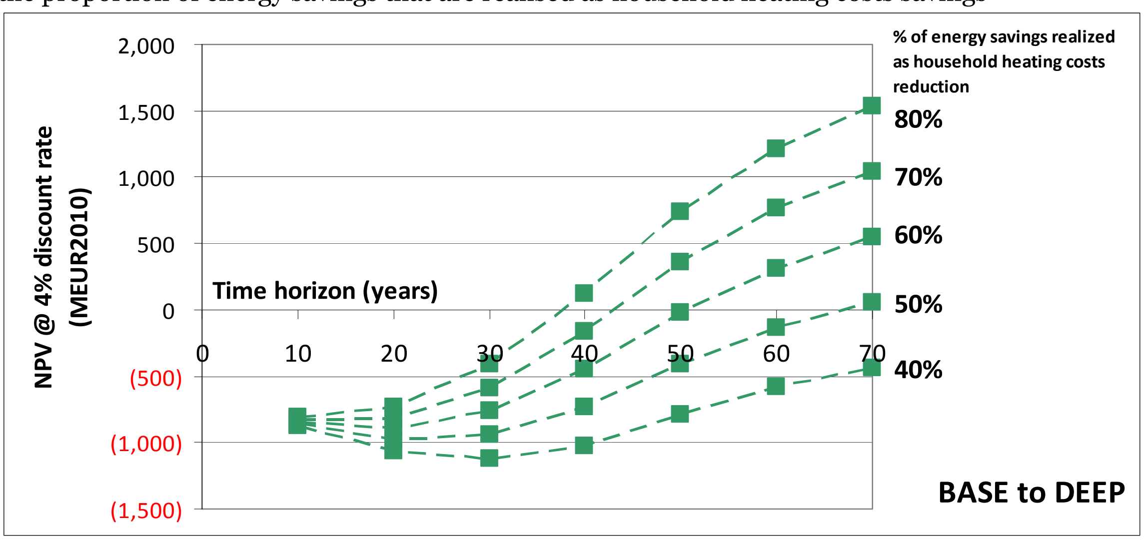
5.1. Subsector-specific obstacles: costs and the structure of residential DH tariffs

DH is peculiar since its energy-efficiency optimum may not always coincide with the cost-efficient optimum. This is because of the large fixed costs of such systems: large capital investment needs (and thus its amortised monthly costs), its infrastructure maintenance costs, its rigid labour costs, etc. In this context, the lower the head demand, the larger these fixed costs become in the final heat costs. Therefore even if fuel costs are reduced to a fraction as a result of highly efficient supply systems, infrastructure and building stock, DH costs will not be reduced proportionally. As a result, the (cost-)optimum of energy-efficiency investments will also be different than those justified on a merely energy basis.

This phenomenon is reflected in the tariff structure of DH. More in particular, due to the cost structure of DH, often a two-tiered tariff is applied with a fixed and variable costs split. Again, Hungary serves as an illustration. According to data collected by the Association of Hungarian District Heating Enterprises (*MaTáSzSz*), roughly 30% of the DH tariff in Hungary corresponds to basic charges and 70% to heating charges. However, the split between fixed and variable cost may be even worse because heating charges also contain a fixed cost percentage: in Budapest, a hypothetical 50% reduction in heat consumption at the block/dwelling level would result (in the short-term) in just a 20% reduction of a household's heat costs (Sigmond et al., pers. comm.). This largely hinders the economic viability of energy efficiency investments for the end-user because it eliminates a good part of the private energy saving benefits and thus a key income source for repaying the initial investment. However, this is a perverse disincentive, since saving the energy would bring the same total economic benefits to the public.

To illustrate the effect of the tariff structure on the financial performance of energy efficiency investments, a new assumption on the percentage of energy savings realised as reduced household heating costs (from 40% to 80%) has been incorporated in the private CBA presented in Section 3. As shown in Figure 5 (only for DEEP scenario), positive NPVs require considerably larger periods, and in worst cases the investment does not make sense from a private perspective.

Figure 5. NPV of deep retrofitting Hungarian panel buildings under different assumptions (%) of the proportion of energy savings that are realised as household heating costs savings



5.2. Improving the conditions under which DH is provided

Based on the above discussions, increasing the energy efficiency of DH- served buildings needs to be accompanied by a range of additional measures, such as the following:

- Meter-based billing is fundamental to incentivise an efficient use of heat after retrofit, and even in vertical-loop heat distribution networks, it can be implemented through heat cost allocators. This is in line with a draft proposal of a Directive on energy efficiency and amending and subsequently repealing

Directives 2004/8/EC (CHP) and 2006/32/EC (energy services) that would oblige Member States to introduce individual billing based on actual consumption for centralised heat and hot water not later than January 1st, 2015 (Jungbauer, 2011). It is important to note, however, that this will likely alter the way people react to high energy costs in DH-served buildings: households presently experiencing hidden fuel poverty (i.e., now paying disproportionately high amounts for heating, but now receiving sufficient heat services) may decide to decrease their energy consumption and thus start suffering from *conventional* energy poverty through low thermal comfort levels (Tirado Herrero and Ürge-Vorsatz, 2011).

- Both regulation and competition are available as governance and business models for the DH sector. In the latter case, competition is normally with other sources of heat (e.g., natural gas) and international evidence has found that it can effectively reduce heat prices if markets are balanced (OECD/IEA, 2004). This in turn relates to the household's right to disconnect from the DH network and switch to another heat source, which may be crucial to ensure that low or nearly-zero energy buildings deliver as many heating cost savings as energy savings.
- Independent, capable regulators are required for tariff setting and energy planning or overseeing fair competition, as well as for avoiding captive consumers to be forced to pay unjustifiably high prices (OECD/IEA, 2004)

6. Prospects for change: nearly-zero energy buildings

In the EU, the Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (EPBD) determines the energy performance requirements of new buildings from 2018-2020. In addition, a large fraction of existing building stocks is expected to be retrofitted during the first half of this century in order to meet the ambitious mitigation targets committed to by the EU in order to avoid a global temperature increase beyond the 2.0 - 2.4 °C threshold.

When nearly-zero energy standards required by the EPBD become the norm for both new and existing buildings, a question arises about the viability, especially the economic viability, of DH. The reason is that while the energy requirements of such buildings are so low that heating becomes almost irrelevant, DH providers and producers bear significant fixed costs (e.g., capital amortization and network maintenance) that still need to be recovered from the consumers (see Section 5.1). This issue has been already brought up in Denmark, a forerunner in adoption of DH and low-energy standards for buildings. Already in 2005 the Danish Energy Authority acknowledged that (p. 25):

> Some of the houses being built today are so well insulated and energy efficient that it is not worth connecting them to district heat [...]. Householders in these cases use so little heat that there may well be no savings, even though district heat is inexpensive. In these cases, there is very little market for public heat supply since such houses are energy efficient and therefore consume relatively little heat.
>
> The Energy Authority therefore considers allowing other forms of heating than district heating, such as electric heat and renewable energy sources, for new, low energy houses

As the Danish example indicates, it is unfair and uneconomical to force residents of such buildings pay more for being connected to a DH network than for the heat itself. In the same direction, the Norwegian experience indicates that the obligation to remain connected to DH networks is a barrier to low-energy residential buildings (Thyholt and Hestnes., 2008). Thus, in the scenario of a large scale deployment of nearly-zero energy technologies (in line with present EU legislation), the future role of DH poses an important question. This question – the economic viability of DH in a very low building energy future Europe – needs to be answered on a case-by-case basis, and much more analysis is needed to understand the right balance between costs, environmental and social impacts. For that it is important that appropriate tariff structures and other billing/market frameworks are developed to maintain the right economic incentives for those parts of the DH industry and their customers in which this heat source is deemed to be environmentally, socially and economically the most optimal solution.

However, there are signs indicating that the DH industry will play a much less significant role in a low-building-energy Europe than today, though in dense city areas is competitiveness may be maintained because of its smaller capital costs (Persson and Werner, 2011). If this is the case, it is important to prepare for this development well in time in order to prepare for the labor and economic implications of a potentially significant contracting industry. Finally, it is also important to see that such prospects may result in the DH industry's hampered acceptance of or collaboration with low-building-energy aspirations in Europe.

7. Conclusion: the future of DH in a low-energy buildings' EU

DH is and will remain for a number of years an important component of the EU's energy system. At the same time, its role in a Europe with nearly-zero-energy buildings needs to be carefully reinvestigated as research signals that the economic viability of DH for buildings with very limited heat demand is questionable.

Even while DH continues to play a key role in many country's heat supply, significant improvements in the way heat is produced, managed and consumed, as well as in the market structure of the DH industry are required to optimise the environmental and social benefits of this industry for EU. First, the cost burden imposed by obsolete DH systems serving inefficient buildings on low-income users in Central and Eastern Europe needs to be addressed through a combination of deep retrofits of the building stock, reforms to DH markets and pricing structures. For these households, who are often unable to regulate the heat they consume, heat bills represent a large fraction of their income. Significant opportunities thus exist for investing in the thermal efficiency of buildings connected to DH. In addition to the substantial energy cost savings (which themselves justify the intervention), energy efficient retrofits reduce the emission of GHG and other harmful air pollutants, create additional employments, decrease the energy dependency of Member States and have potential positive fiscal impacts. These energy and non-energy benefits are maximised when deep retrofits (i.e., aimed at energy consumption levels close to the passive house standard) are implemented instead of moderate retrofits.

However, obstacles exist and energy efficiency investments must be thus accompanied by additional measures that improve the conditions in which heat is served. In particular, reducing the weight of fixed costs in residential DH tariffs, installing individual consumption meters, fostering competition and appointing independent and capable regulators are important steps identified.

In the long-term, the economic viability of DH needs to be re-investigated for the future in which the recent revisions of the EPBD are widely implemented, i.e. nearly-zero energy standards in new and existing buildings proliferate. In areas where DH does become economically undesirable, an early foundation of the exit strategy for the DH industry is necessary.

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