Fuel poverty alleviation as a co-benefit of climate investments: evidence from Hungary

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Abstract

Fuel (or energy) poverty is understood as a situation in which a household is unable to afford an adequate amount of domestic energy services and/or is forced to pay a disproportionate share of its income on domestic energy.

Taking Hungary as a representative case study, the paper first presents relevant indicators which indicate that 10 to 30 % of the Hungarian population was in fuel poverty as of the late 2000s. The results show that fuel poverty rates in Hungary have increased in parallel to the price of imported natural gas, forcing some households to go back to heating systems based on firewood.

Together with households' income and energy prices, the energy performance of residential buildings has been identified as a key contributing factor of this social and environmental challenge, thus expanding the scope of the benefits of domestic energy efficiency investments. Based on this premise, the second part of the paper presents the results of a social cost-benefit analysis according to which market (energy savings) and non-market (avoided fuel poverty-related mortality, improved comfort and avoided emissions of GHG and other harmful pollutants) benefits more than justify retrofitting Hungary's residential stock to near passive house levels. The results also confirm the relevance of co-benefits for the economic assessment of residential energy efficiency scenarios.

This multi-dimensional analysis of fuel poverty emphasises the importance of co-benefits as policy drivers for the implementation of advanced residential energy efficiency solutions in countries with moderate levels of commitment to global climate goals and high or increasing fuel poverty rates.

Introduction

THE CO-BENEFITS OF CLIMATE INVESTMENTS

Traditionally, energy cost savings and the avoided impacts of climate change have been regarded as key drivers of mitigation efforts such as investing in energy efficiency and renewable energy technologies. Under this perspective, energy prices function as the most important signal that energy users receive for making energy efficiency investment decisions and GHG emissions reductions are a main goal of public policies.

This is certainly the case of energy efficiency in the buildings sector, which is estimated to have the largest mitigation potential at a global level (IPCC, 2007). Since implementing energy efficiency measures in buildings brings about (almost by definition) energy cost savings, a substantial fraction of the mitigation potential of the building sector can be achieved at net negative cost. In that way, it is estimated that, by 2030, 80 % of the world's buildings' mitigation potential can be achieved at less than €0 tCO_{2eq}^{-1}. This is a larger potential than the ones estimated for other end-use sectors (Ürge-Vorsatz and Novikova, 2008).

However, mounting evidence indicates that society also benefits from reducing energy consumption and emissions in a number of indirect ways, e.g., better air quality, reduced energy dependency, (Ryan and Campbell, 2012). These are the so-called co-benefits, ancillary benefits or multiple benefits of climate policies. Acknowledging its relevance, the last IPCC Working Group III report (IPCC, 2007) has identified and described co-benefits in practically all sectors where mitigation efforts are or will be taking place. For the buildings' end-use sector, prior research (Schweitzer and Tonn, 2002; Levine et al., 2007; Stoecklein and Scumatz, 2007; Ürge-Vorsatz et al., 2008; Ürge-Vorsatz et al., 2009a; 2009b) has identified many positive side-effects that energy efficiency can have on residents, owners and building users.

These *forgotten benefits* of climate change mitigation (Jochem and Madlener, 2003) have policy advantages as compared to primary (energy and climate) benefits. Non-energy, non-climate co-benefits are closer to agents bearing the mitigation costs (tax payers), have more immediate effects on welfare and the estimation of their economic value is less uncertain and information-demanding (Markandya and Rübbelke, 2003). They also provide a better understanding of the welfare effects of climate policies (Krupnick et al., 2000).

It can be suggested that co-benefits allow by-passing the apparent trade-off between present and future generations due to the fact that present generations must bear the costs of climate change mitigation, which will in turn benefit future generations. For these reasons, they constitute an alternative entry point for the adoption or implementation of ambitious climate policies. In the absence of a global climate regime, they provide to less-committed nations incentives for attending a new international protocol, and increase the likelihood of accomplishing a more ambitious post-Kyoto agreement (Pittel and Rübbelke, 2008).

FUEL POVERTY ALLEVIATION AS A CO-BENEFIT

Labelled as "perhaps the strongest adverse social impact resulting from the inefficient consumption of energy in the domestic sector" (Healy and Clinch, 2002, p. 329), fuel poverty can be described as a combined social and energy challenge with significant implications in terms of climate change.

Based on previous research (Boardman, 1991; BERR, 2001; Healy and Clinch, 2002; Buzar 2007a) fuel poverty has been defined (Ürge-Vorsatz and Tirado Herrero, 2012, p. 84)

> […] as a […] concept encompassing the various sorts of affordability-related challenges of the provision of adequate energy services to the domestic space. These typically represent situations in which households with access to modern energy carriers cannot comfortably satisfy their energy service needs, be it because of their inability to afford sufficient energy services and/or because of the disproportional costs they have to bear for those energy services[.]

Note that this definition includes all domestic end-uses, even though research often focuses to a larger extent (but not exclusively) on space heating because it is usually the most burdensome to household budgets and because of the distinct health impacts of cold housing. It should not be confused with the lack of access to modern energy, which has been referred to as *energy poverty* (Pachauri and Spreng, 2003; Birol, 2007).

The incidence of fuel poverty can be expected to increase in forthcoming years and decades as a result of two trends. First, energy prices are expected to continue on increasing as the global demand for fossil fuels expands, unless the potential of unconventional reserves (e.g., shale gas) is exploited to a large extent. Second, climate change concerns are also likely to affect energy prices as more expensive (renewable) technologies substitute fossil-fuel based ones, and the external cost of carbon is progressively internalised into energy prices via carbon taxes or the price of emission permits.

On the positive side, rising global temperatures may reduce the wintertime domestic energy demand, though climate change is rejected as a solution to the fuel poverty problem (Ürge-Vorsatz and Tirado Herrero, 2012).

In the theoretical framework of the co-benefits of climate investments, it can be argued improving the energy efficiency of residential buildings for climate purposes can have substantial positive effects in terms of fuel poverty alleviation and the affordability of domestic energy services.

AIMS AND STRUCTURE OF THE PAPER

This paper attempts to address two interrelated research questions using Hungary as a case study. First, it aims at measuring the extent and welfare impacts of fuel poverty in Hungary, and at exploring the role of domestic energy prices in the evolution of fuel poverty rates during the decade of the 2000s. This research question is dealt with in the first half of the paper. Second, it aims at evaluating the relevance non-market co-benefits (including fuel poverty alleviation benefits) in the economic assessment of residential energy efficiency scenarios. For this, it conducts both a financial and social cost-benefit analysis in the second part of the paper.

Hungary as a case study

While fuel poverty in Central and Eastern Europe (CEE) still remains "virtually unknown to the relevant academic and policy literatures" (Buzar, 2007a, p. xii), it is suspected that economies in transition are particularly affected by this phenomenon (Boardman, 2010). In this region, fuel poverty is associated with the economic and political changes of the early 1990s, which progressively brought energy prices to full-cost recovery levels, reduced household incomes and left a legacy of inefficient and deteriorating residential buildings lacking basic energy efficiency requirements. It has been also related to the inability of post-1989 democratic governments to provide an adequate level of social protection and to the failure to develop adequate frameworks for improving the efficiency of the homes occupied by low income households (Buzar, 2007a).

These trends described for the CEE region are applicable to Hungary. In this country, economic and political changes after 1989 amplified income inequality and poverty due to adjustments in the labour market and price subsidies withdrawal (Kremer et al., 2002). The transition also affected energy prices: Hungary's transformation into a market economy brought substantial increases in previously subsidized prices of utility services and other maintenance expenses in order to bring prices closer to production costs and create conditions for the privatization of utility companies. As a result between 1992 and 2010 nominal prices of domestic energy experienced 13-fold increase whereas salaries became *just* by 9 times, according to data from the Hungarian Central Statistical Office (KSH). This process went in parallel with the privatization of most of its residential stock (Kocsis, 2004).

Additionally, from the perspective of fuel poverty and residential energy efficiency, the following structural elements of Hungary's energy system are highlighted:

- Natural gas represents a large percentage of the country's final energy consumption as compared to other EU economies. This is partially attributable to the discovery of large domestic gas reserves in the 1960s and 1970s (Kessides, 2000).
- Hungary is one of the most gas-dependent IEA (International Energy Agency) member countries. As of 2009, imports from the former Soviet Union represented around 75 % of total gas consumption (OECD/IEA, 2012). Since the continuity of the supply has been threatened several times in recent years, energy security issues have become a priority for the Hungarian government, which has motivated the development of strategic gas storages to buffer the effect of future disruptions (OECD/IEA, 2007).
- As of 2008, 91.1 % of all settlements and 76.5 % of all households were connected to the natural gas grid (KSH, 2010). The reliance of the household sector on natural gas is partially the result of a massive fuel switching between 1990 and 1998 that replaced most tile stoves and coal and oil boilers with more efficient gas boilers, a process fuelled by subsidised domestic gas prices (Energia Központ, 2008). In fact, Hungary's residential demand was one of the most gas-dependent of Eastern Europe as of 2006 (Buzar, 2007a).

Under these conditions it is reasonable to foresee that a sizeable share of Hungarian households are struggling to pay for the energy (mostly heating) they need at home. It is also suspected that energy affordability problems are connected to the strong dependency of the residential sector from natural gas imports coming from former Soviet Union suppliers. Even though previous research has highlighted selected elements of the issue (Kocsis, 2004; UNDP/Autonómia Alapítvány, 2004; KSH, 2004; 2006; 2008; 2011; Fülöp, 2009) it was not until the publication of the report *Fuel poverty in Hungary. A first assessment* (Tirado Herrero and Ürge-Vorsatz, 2010) that a proper analysis of the phenomenon was produced. Later on, the *Energia Klub* recognised the lack of data and of a commonly accepted definition of fuel poverty as barriers to policy action (Fülöp and Fellegi, 2012).

Fuel poverty in Hungary

FUEL POVERTY RATES IN THE DECADE OF THE 2000S

Expenditure-based approach

A key element of expenditure-based estimates is the notion of a fuel poverty line that defines what disproportionate energy costs are. The implicit hypothesis in this notion of affordability is that if a household's domestic energy costs are above the designated threshold, it is likely that such a household is experiencing difficulties to afford sufficient energy services.

Rather than a direct transfer of the UK 10 % fuel poverty line, the analysis for Hungary has transferred the criteria used by Boardman (1991) to set the UK fuel poverty line at 10 %. It was decided to calculate fuel poverty rates in Hungary according to a 10 to 20 % (annual energy expenditures vs. income) fuel poverty line range:

- The lower bound of the chosen interval (10 %) is based on the UK rule first proposed by Boardman (1991) and still applied in the UK (DECC, 2012). The higher bound (20 %) is Hungary's twice the median energy expenditure in 2005; 20 % is also the affordability threshold suggested by Fankhauser and Tepic (2005) for domestic energy services.
- The middle point of the interval (15 %) is selected as a representative fuel poverty line for the 10–20 % range. It is roughly the median percentage of energy cost vs. income of the lowest 3 income deciles in Hungary in 2005 (14.6 %) and in 2008 (16.9 %).

For Hungary, these calculations are based on Household Budget Survey (HBS) microdata on household expenditures detailed by COICOP[1] categories for the year 2005 and 2008. A key difference with the UK methodology is that the Hungarian HBS microdata report actual energy expenditures instead of the energy expenditure required to guarantee and adequate thermal comfort indoors – 20 ºC in the living room and 18 ºC in other rooms, as set by the official UK definition (BERR, 2001). This drawback of the Hungarian microdata results in fuel poverty rates in Hungary underestimated as compared to the UK ones. The reason is that actual domestic energy expenditures are often below required energy expenditures for keeping an adequate standard of warmth – 18 to 21 ºC as recommended by the World Health Organisation (BERR, 2001).

Consensual or self-reported approach

A fuel poverty rate based on the consensual approach focuses on the non-monetary or material aspects of deprivation. They thus rely on attributes commonly accepted as a necessity in a given society (i.e., enough heating at home during the cold season) whose enforced lack is indicative of deprivation. Since the data source for this indicator used in this research comes from surveys where respondents are asked to self-assess their own household's living conditions, it is also referred to as self-reported approach.

Following Healy (2004) and Healy and Clinch (2004), the self-reported primary indicator of fuel poverty in Hungary is Eurostat's Survey on Income and Living Conditions (EU-SILC) item HH50 – *Inability to keep the house adequately warm*. The relevant question reads as follows (EC, 2010, p. 176),

> Can your household afford to keep its home adequately warm?

In this case, the data used are aggregated results of the EU SILC dataset retrieved from Eurostat's website.

Comparison of results: fuel poverty rates in Hungary in the decade of the 2000s

Results presented in Figure 1 indicate that between 10 to 30 % of the Hungarian population belonged to a household living in fuel poverty in the period 2005–2008. A notable divergence is also visible. On the one hand, there is a clear increase in fuel poverty rates measured through the expenditure approach between 2005 and 2008. On the other hand, a clear downward trend can be also observed for consensual fuel poverty rates in the 2004–2009 period, with only a slight increase in 2010–2011. This is an unforeseen result because it would be expected that

1. Classification of Individual Consumption According to Purpose (COICOP).

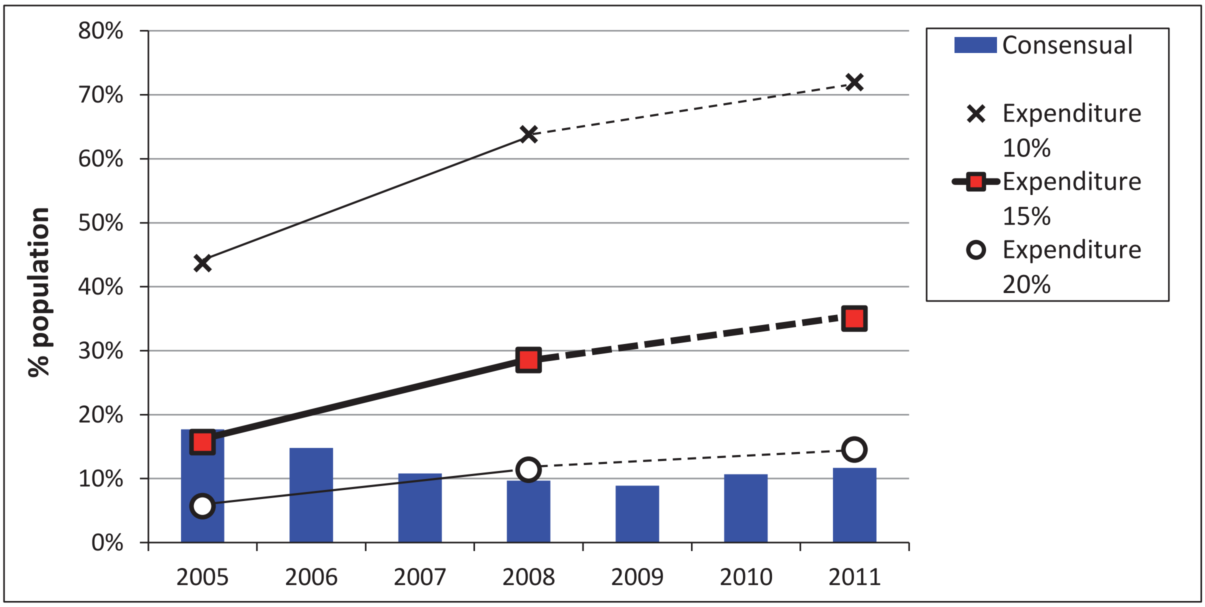

Figure 1. Recorded and forecast evolution of consensual and expenditure-based fuel poverty rates (2005–2011). Note: the discontinuous line corresponds with the forecast increase in expenditure-based rates estimated for 2008–2011. Source: Authors' own elaboration based on data from (KSH) and Eurostat.

the consensual fuel poverty rate would have also risen following the substantial domestic energy price increases that occurred throughout the 2000s and particularly after 2006 (see below).

This finding relates to an important drawback of the consensual or self-reported approach, which is the subjective, declared character of the responses to the survey, i.e., respondents may have significantly different perceptions of what thermal comfort and inability to pay is (EPEE project, 2008). As there is no indication about how people from different Member States or household types recognize themselves as unable to afford enough heating, some caution is needed when comparing the results for this indicator between Member States. Furthermore, it has been argued that fuel poor households make a biased self-assessment of their living conditions because of the so-called *adaptive preferences* (i.e., poor households tend to have lower expectations and thus understate their energy affordability problem) or are reluctant to admit their incapacity to pay for energy they need – the so-called *denial of reality bias* (Eurostat, 2009; Boardman, 2010).

An alternative explanation to the decreasing consensual fuel poverty rate is the fact that people may have reacted to higher energy prices by means other than reducing their thermal comfort (e.g., by reducing their consumption of other goods and services, by falling into indebtedness to utility companies, or by switching to less quality fuels like firewood). Or it may be that a raise in energy prices does not automatically translate into increasing (perceived) difficulties to provide enough thermal comfort the living space of the dwelling. The way these perceptions are formed and then reported by households is probably a key element of this detected divergence.

The evolution of expenditure-based fuel poverty rates after 2008[2] has been forecasted through sensitivity factors indicating by how much the incidence of fuel poverty increases for a 1 % rise in real energy prices. Results presented in Figure 1 show that the 7 % increase in real domestic energy prices recorded for the period 2008–2011 may have resulted in 35 % of the Hungarian population being in fuel poverty as measured by the expenditure approach (i.e., spending more than 15 % of their annual income on domestic energy) in 2011. These forecasts illustrate the on-going effect of rising energy prices on fuel poverty rates.

CONTRIBUTING FACTORS: IMPORT PRICE OF NATURAL GAS

The evolution of domestic energy prices (combined with household incomes) can have substantial short-term effects on fuel poverty rates. This is the case of Hungary, for which the state of affairs in the period 2000–2011 has been analysed through statistical data on current (nominal) prices, wages and pensions retrieved from KSH.

Data presented in Figure 4 leads to the conclusion that even though wages and pensions had grown more rapidly than energy prices during the first half of the 2000s, this situation came to an end in 2006, when the price of natural gas – the most common source of heat for Hungarian households – started its rapid increase until more than doubling in five years (2006–2011). And for the whole period 2000–2011, the nominal price of natural gas experienced a four-fold increase. Such a daunting price hike has substantial fuel poverty implications given that natural gas is the most used fuel for domestic space heating in Hungary.An underlying cause of the unprecedented increase in the price of natural gas is the monopolistic structure of Hungary's natural gas supply in international markets. This way, most of the imported natural gas is Russian and Russia-transiting Turkmen natural gas, with Western European suppliers (France and Germany) functioning as minor providers. As of 2009–2010, imports represented 75 to 80 % of Hungary's annual consumption and the remaining 20 to 25 % was covered by indigenous production (OECD/IEA, 2012; Hungarian En-

2. Expenditure-based fuel poverty rates could be calculated only for 2005 and 2008 – the two years for which microdata were purchased to the Hungarian Central Statistical Office (KSH).

ergy Office, 2011), which has declined steadily since the 1990s (Andzsans-Balogh, 2011). A likely consequence of the unfavourable conditions under which Hungary imports natural gas is the substantial increase in import prices recorded in the 2000s. As OECD/IEA (2020) data indicate, the import price (in current units) of natural gas more than doubled between 2004 and 2009.

However, this rapid increase in the current price of natural gas cannot be solely explained by import prices. A key reason for the *price hike* seems to be the regulated prices from which residential consumers apparently benefitted between the late 1990s and the mid-2000s. The government had the capacity – through the Hungarian Energy Office – to buffer the impact of import prices on domestic consumers by regulating the increases in retail prices. This practice was put in place in the late 1990s by the ruling government in those days as a reaction to the Hungarian electorate's anger against the massive increases in residential gas prices between 1988 and 1998, which were a hot issue in the 1998 elections (Kessides, 2000; OECD/IEA, 2007). This led to the accumulation of losses in the balance sheets of distribution companies until the year 2006, when the retail price of natural gas was below the import price and the accumulated losses of the wholesaler peaked at HUF 112 billion. A major increase in regulated prices decreed in 2006 allowed reducing the accumulated losses of the regulated wholesaler. In 2009, the Gas Act eliminated the figure of the regulated wholesaler and the obligation to compensate the losses incurred because of the difference between import prices and retail prices (E.On, Földgaz, 2008). Still, after 2009 the retail price of natural gas has kept on increasing at similar rates as in 2006–2008.

The upgrading of the country's strategic storage capacity has probably contributed to the *price hike* as well, but it is unknown to what extent. In 2000, the World Bank noted that MOL's underground storage was equivalent to 60 days of peak demand, whereas the IEA recommended a 90-day storage capacity (Kessides, 2000). The four-day disruption of supply occurred during the January 2006 Russia-Ukraine gas dispute triggered the decision to increase the country's strategic gas storage capacity, which was realised at a cost of US$750 million borne by end-users through gas prices (Andzsans-Balogh, 2011). However, the International Energy Agency (IEA) recommended in its 2007 review of Hungary's energy policy (OECD/IEA, 2007) warned about the impact of this measure on the price paid by gas consumers.

Yet another cause of the price hike is the increase in the standard VAT rate from 20 to 25 % occurred in July 2009 – one of the conditions of the 2008 IMF bail-out package. This increase affects all energy carriers used by Hungarian households but district heating, which currently benefits from a very reduced (5 %) VAT rate. From January 2011, the VAT rate went up a further 2 % (to 27 %) and became the highest in the EU.

FUEL SUBSTITUTION AND OTHER COPING STRATEGIES

Fuel substitution

Hungary's residential stock is characterised by high rates of access to quality energy carriers such as gas and electricity. According to data from the Hungarian Central Statistical Office (KSH), in the year 2011 76 % of Hungarian dwellings were connected to the natural gas network – with most of the remaining homes having access to other forms of natural gas (bottled or in containers). However, in a sizeable fraction of Hungarian dwellings traditional fuels are still used for space heating, with substantial differences by income levels. There is ground for analysing these statistics from a fuel poverty perspective.

In spite of the large changes in the structure of the energy supply of domestic heat that has occurred in the last 20 years in Hungary, there was always a fraction of households relying on this traditional fuel (Energia Központ, 2008). However, data of the Household Budget Survey (HBS) indicate that since 2006 solid fuels (firewood to a large extent) have increased their importance in the average Hungarian household's energy budget. The result of this process is that firewood, which is often bought from commercial traders but in some case also self-collected by households, is nowadays the second most used energy carrier for space heating in Hungary. As of 2009, data collected by Energy Use module of the Household Budget and Living Conditions Survey (HEF2009)[3] confirm that natural gas is the most common heating fuel, but also indicates that as many as 22 % of Hungarian households burn traditional fuels, mostly firewood (20.4 % of all households, with the remaining 1.6 % relying on other solid fuels like coal). More recent data collected by Hungary's *Energia Klub* (2011) indicate that, in addition to the 22 % of households using firewood as a primary source of heat, an additional 11 % rely both on natural gas and firewood for space heating[4].

From a fuel poverty perspective, a relevant research question is to what extent is firewood substituting natural gas as a source of heat. This has been analysed through the microdata of the Hungarian Budget Survey (HBS).

The results are shown in Figure 2 and indicate that over 20 % of all Hungarian households were using firewood as a significant source of heat in 2005–2008, a percentage which is in line with that reported by other statistical data sources above. However, these were not only households without access to piped gas (though bottled gas is in most cases combined with firewood use): as much as 10 % (in 2005) and 16 % (in 2008) of households connected to the natural gas grid were reporting a significant use of firewood. This is a key finding because it provides evidence of a substitution of a more expensive and comfortable fuel (natural gas) by a cheaper, less comfortable alternative (firewood) in a context of rapidly rising natural gas prices.

It may be argued, however, that the fuel substitution is not a symptom of fuel poverty but also a matter of consumer's preferences (e.g., recreational use of firewood) or a consequence of the adoption of advanced biomass-based heating systems that are not necessarily more inconvenient than those based on natural gas. However, an analysis of the income elasticities of energy carriers in Hungary (Szájko et al., 2009) indicates traditional fuels are inferior goods, i.e., their consumption decreases as household income rises. This suggests that households (particularly low-income households) are voluntarily giving up the

3. *Háztartási Költségvetési és Életkörülményfelvétel. Energia Felhasználási Modul 2009.* This is an *ad-hoc* module of the Household Budget Survey with data only for the year 2009. Data provided László Elek (Energia Központ).

4. Electricity is not alternative to natural gas because it is the most expensive domestic energy carrier: Wh^{-1} vs. 4.2 (natural gas), 4.1 (district heating) and 3.7 (firewood) €$cents_{2010}$ kWh^{-1} (Tirado Herrero, 2012).

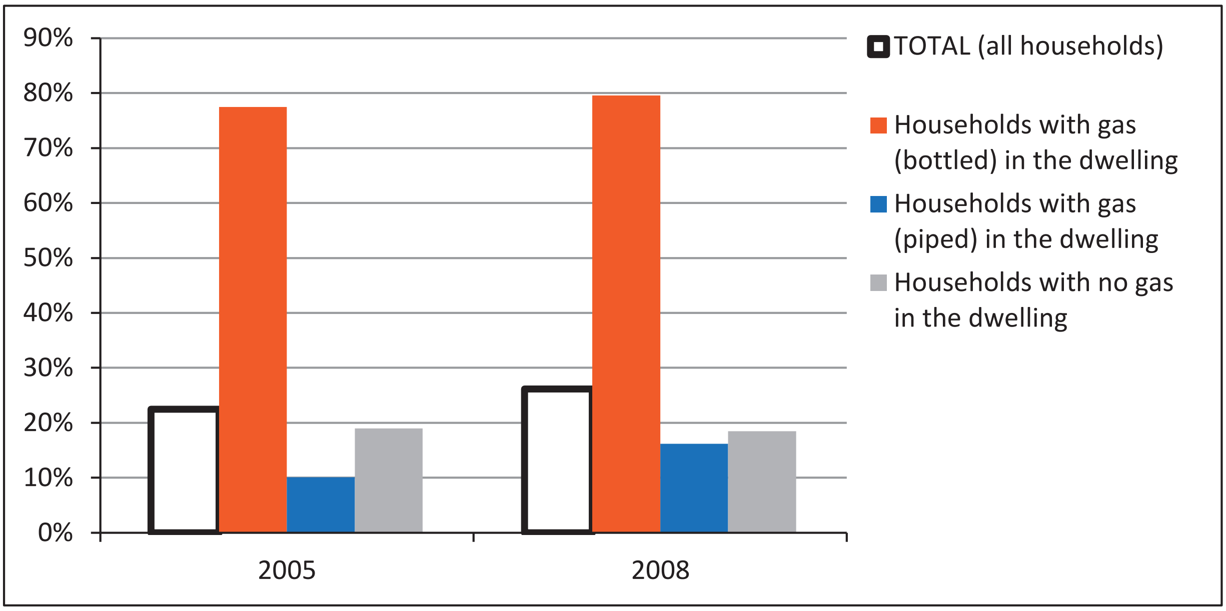

Figure 2. Percentage of households in which firewood is more than 10 % of their total energy expenditures, by relevant household categories. Source: own elaboration after data from the Hungarian Household Budget Survey (KSH).

possibility to use natural gas and choosing to use traditional fuels as a strategy to deal with increasingly high gas prices.

However, it cannot be claimed that all households relying on lower-quality fuels do so because of their inability to afford other more expensive and comfortable heat sources. However, it is likely that a fraction of the households using traditional fuels – especially in the case of the lower income strata – have adopted this strategy as way to reduce the burden of energy costs on their budget. This is clearly illustrated by the case of households with access to piped gas that have voluntarily moved back to firewood as a main source of heat. However, it remains an open question whether having given up voluntarily the possibility of using natural gas can be interpreted as an indication of the enforced lack of an item widely consumed by the reference society (i.e., a lifestyle that cannot be afforded, as defined by Nolan and Whelan, 2009) and, therefore, of fuel poverty.

This facet of the fuel poverty phenomenon is not exclusive to Hungary – it has been detected also in other post-socialist countries of Eastern Europe (Fankhauser and Tepic, 2005). It has a number of negative implications, as households using traditional fuels bear the opportunity cost of the time needed for collecting fuel, are more likely to suffer from health problems related to indoor air pollution, cause deforestation and provoke micro-conflicts with forest authorities (Lampietti and Meyers, 2003; UNDP, 2004; Euractiv, 2010; 2012).

Other coping strategies

The evidence collected in Hungary and the literature reviewed indicates that households deal with energy affordability problems in many different ways: switching to lower-quality and cheaper fuels, lowering indoor temperatures, reducing the fraction of dwelling floor area heated, consuming less goods and services other than domestic energy, delaying the payment of utility bills, by-passing electricity meters, etc. These *coping strategies* or *behaviours* (Buzar, 2007a; Anderson et al., 2010; Brunner et al., 2011) can be defined as actions undertaken by households to reduce the burden of energy costs on their budget and/or to ensure the provision of an adequate amount of energy services. The behavioural side of these solutions is shaped by people's perceptions and expectations of domestic energy use, which have been referred to as energy cultures (Brunner et al., 2011).

The existence of a variety of coping strategies suggest that being fuel poor does not mean submissively bearing disproportionate domestic energy costs or being unable to provide an adequate amount of energy services to the household's living space (e.g., living in a cold home). Households are not just passive subjects but often try to actively overcome this situation or to buffer its impact on their wellbeing.

Cost-benefit analysis

OVERVIEW

It is widely acknowledged that the energy performance of the residential stock and domestic end-use equipment is a structural cause of fuel poverty. From a policy perspective it is also a relevant element: since the inefficient consumption of energy in the domestic sphere explains a large share of the household sector's emissions (a main contributor to total emissions in Hungary and the EU27), one key assumption of this paper is that residential energy efficiency offers the only long-term solution to both climate change and fuel poverty challenges.

Based on this assumption, the paper presents a cost-benefit analysis in order to assess economically two alternatives (MID and DEEP scenarios) for the upgrade of Hungary's current energy efficiency policies (represented by BASE scenario) for residential buildings.

SCENARIOS AND MAIN ASSUMPTIONS

Three scenarios have been defined for the cost-benefit analysis (see summary in Table 1):

- a business-as-usual or BASE scenario that describes the current situation in which buildings are renovated at the current rate of 1.5 % of the 2010 residential stock (over 70,000 dwellings) per year and 10 % of energy savings is achieved (see Ürge-Vorsatz et al., 2010). The exception to this is panel prefabricated buildings, which have been the main focus of building energy efficiency programmes in Hungary mostly through the Panel programme. For them, it has been assumed a retrofit rate of 25,000 dwellings or 3.4 % of its stock per year and 25 % energy savings based on data collected from Hungarian municipalities and the Ministry of Local Government by Czakó (2010);
- a MID scenario proposing a medium upgrade in current energy efficiency policies: it increases the business-as-usual renovation rate to 100,000 units per year (or 2.3 % of the 2010 stock) and delivers 40 % of energy savings for all building typologies;
- a DEEP scenario proposing a high-level upgrade in current energy efficiency policies implementing passive house-like retrofits delivering 79 to 90 % of *deep* energy savings of previous energy consumption (depending on the building typology). It also assumes a feasible implementation rate of 100,000 dwellings per year.

A relevant aspect is that BASE and MID scenarios do not revisit the 250,000 panel dwellings that we estimate have been retrofitted in the decade of the 2000s. The rationale is that the MID scenario simply upgrades the BASE scenario but leaves out the already retrofitted buildings by the State-supported Panel programme. On the contrary, the DEEP scenario represents a major transformation of Hungary's residential energy efficiency policy and therefore aims at having the whole building stock achieving a high energy performance level.

The residential stock model is based on 6 building typologies with different energy use characteristics (only for space heating). It has been adapted from a previous building and Input/Output model used for estimating the employment effect of large scale, deep retrofit program of Hungary's building stock (Ürge-Vorsatz et al., 2010; Tirado Herrero et al., 2011). Key assumptions of the model on the evolution of energy prices and the learning curve-based reduction of DEEP retrofit costs have been also adapted from this source.

FINANCIAL VS. SOCIAL COST-BENEFIT ANALYSIS

Fundamentals of the cost-benefit analysis

Cost-benefit analysis (CBA) is regarded as the major appraisal technique for public investments and public policy, especially in the fields of environmental policy, transport planning, and healthcare. It offers a practical decision-making tool intended to ensure the efficiency of large scale public investments grounded on the theory of welfare economics (Pearce et al., 2006).

In essence, CBA is a discounted sum of the cost and benefits of investment alternatives following the equation

$$NPV = \sum_{t=0}^{t=T} \frac{(B_t - C_t)}{(1+r)^t}$$

where *NPV* is the net present value (decision rule), B_t are the benefits accrued in year t, C_t are costs incurred in year t, r is the discount rate, and T is the last year in which costs and benefits are considered (i.e., time horizon).

Two types of CBA can be conducted. On the one hand, financial CBA merely consists of a discounted cash flow of market costs and benefits (e.g., in a residential energy efficiency programme realised from the perspective of households, these basically are investment costs and energy saving benefits). On the other hand, social CBA defines benefits and costs as utility gains and losses and thus measures the net contribution of each of the defined policy options to the aggregated welfare of a society (EC, 2008).

Taking financial CBA as point of departure, the following methodological specifications must be followed in a proper social CBA (Pearce et al., 2006; EC, 2008):

- Prices sometimes emerge from imperfect markets (i.e., affected by oligopoly or monopoly, trade barriers, taxes and subsidies, etc.) or because they are non-cost reflective tariffs set by the Government for public services. This often implies corrections in the cost of labour (through shadow wages) and fiscal corrections: some taxes and subsidies must be deducted from prices because they are considered pure income transfers between agents that do not create any economic value.

Table 1. Summary of scenarios.

	BASE	MID	DEEP
Description	Current BAU retrofits, non-energy efficiency oriented (but in panel buildings)	Non-state-of-the-art retrofits, upgraded current policies	State-of-the-art retrofits based on passive house technology, highly upgraded current policies
Stock subject to retrofit	302 million m^2	302 million m^2	314.8 million m^2
Implementation rate [units per year]	70,320 dwellings (incl. 25,000 panel) 4.91 million m^2 1.6% of the 2010 stock	100,000 dwellings 7.57 million m^2 2.5% of the 2010 stock	100,000 dwellings 7.44 million m^2 2.4% of the 2010 stock
End-year of scenario	2086	2051	2054
Energy savings [% reduction over previous energy use]	25% panel 10% rest	40% (for all building types)	79–90% (depending on building type)

Table 2. Key differences between the financial and social CBA.

Categories	Financial CBA	Social CBA
COSTS		
Retrofit costs	From Ürge-Vorsatz et al. (2010) – updated to €$_{2010}$ m^{-2} prices	Corrected costs: deducted, VAT of material costs, shadow wage factor
Programme management costs	Not considered	5 (MID scenario) to 10% (DEEP) of total retrofit costs
BENEFITS		
Energy savings	Obtained from Hungarian Central Statistical Office (KSH), Hungary Energy Office (MEH), Sigmond et al. (pers. comm.) and Dibaczi et al. (2010)	Corrected prices: VAT deducted (firewood); variable (generation) costs for district heating and electricity, import price for natural gas.
Avoided GHG emissions	Not considered	Valued at the sale price of surplus CO_2 emission permits traded under Green Investment Scheme (GIS)
Avoided non-GHG emissions	Not considered	Avoided external cost of emission of a range of pollutants (Preiss et al., 2008)
Avoided excess winter mortality	Not considered	1,000 fuel poverty-related excess winter deaths can be avoided when all buildings are retrofitted; Value of a Life Year (VOLY) approach adopted (Desaigues et al., 2011).
Comfort benefits	Not considered	Increase in dwelling floor area heated and avoided use of firewood as source of heat valued through difference in heating costs before and after retrofit.
DISCOUNT RATE	4.5% – real financial interest rate based on Hungary's lending and inflation rates	5.5% – social discount rate for new Member States suggested by EC (2008)

- Non-market costs and benefits (e.g., externalities) are usually incorporated. For that, a whole range of valuation tools for estimating their monetary value based on estimates of willingness to pay for benefits or willingness to accept for compensation of losses (amongst others) is available.
- Costs and benefits occurring in different years are discounted through a social discount rate (different from the financial rate) that reflects how society weighs future costs and benefits against present ones.

Key differences between the financial and the social CBA

Both a financial and social CBA have been conducted with the purpose of measuring the relevance of co-benefits (particularly of fuel poverty-related co-benefits) in the assessment of energy efficiency scenarios.

The financial CBA is consistent with a narrower understanding of the proposed intervention that only computes the private costs and benefits (retrofit costs and energy savings) to be borne by households. As a methodological framework, financial CBA is constrained because it cannot incorporate non-market benefits for which no explicit monetary cash flows can be identified. However, non-market co-benefits can be incorporated into the analysis by moving from the financial to the social CBA framework because the latter evaluates welfare gains and losses calculated from the perspective of the whole Hungarian society (Azqueta Oyarzun, 2007; EC, 2008). Consequently, the social CBA incorporates costs other than those directly incurred with the retrofits (i.e., programme management costs), and a range of non-market co-benefits (with a focus on fuel poverty alleviation effects) additional to the energy saving benefits – see Table 2. Note that a number of co-benefits (e.g., physical and health effects of improved thermal comfort, energy security improvements, etc.) have not been considered, though transaction costs are only partially captured as programme management costs.

KEY RESULTS

Though the financial and social NPVs obtained are not directly comparable[5], the sign and evolution of both NPVs illustrates how important non-market co-benefits are for the economic assessment of residential energy efficiency scenarios (see Figure 3):

- In the social CBA, the MID scenario delivers a positive NPV around 2022 and the DEEP scenario around 2035; in the financial CBA, this does not occur until 2045 (for both scenarios).
- In the social CBA, the NPV of DEEP scenario surpasses the NPV of MID scenario around 2040. In the financial CBA, the break-even point occurs around the year 2045.

Though these differences may be partially explained by differences in data and assumptions[6], the comparison suggests that the incorporation of co-benefits effectively enhances the policy

5. The financial NPV is simply a discounted sum of a cash flow (financial costs minus benefits); the social NPV is an estimate (measured in monetary units) of the net effect of the proposed intervention on the aggregated welfare of Hungarian society.

6. The social CBA applies a different discount rate, corrects the per unit value of retrofit costs and energy saving benefits and incorporates programme management costs. These factors explain to some extent the differences between financial and social NPV.

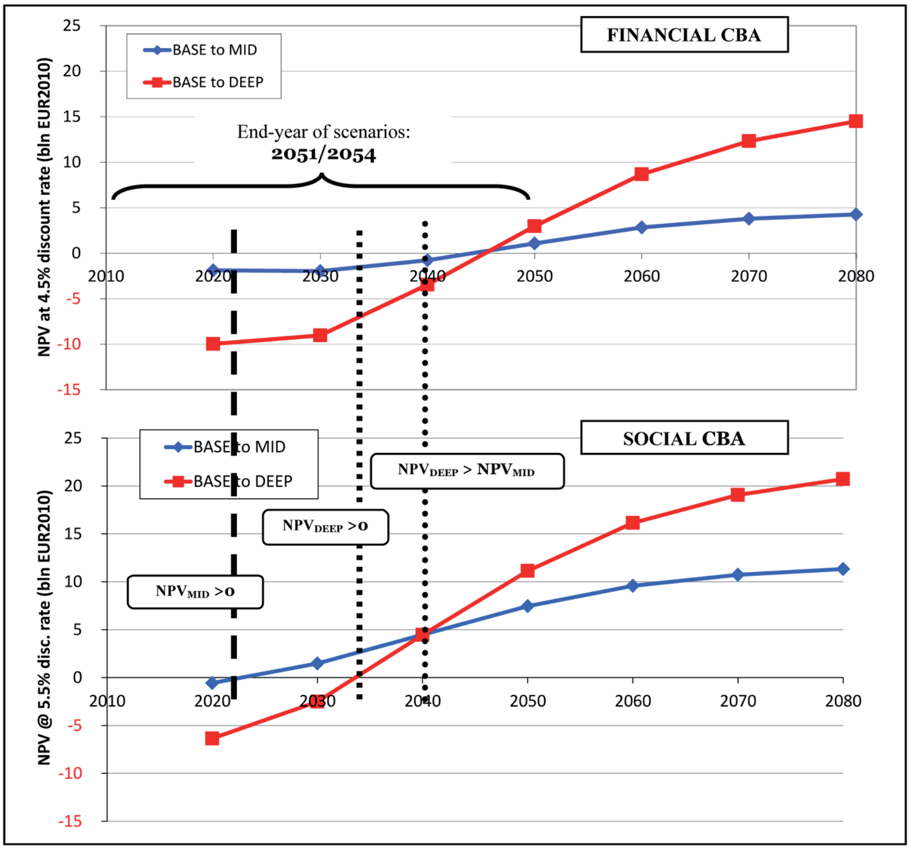

Figure 3. Comparison of key break-even points in the social and financial cost-benefit analysis. Note: both in the financial and social analysis NPVs are calculated as an additional net benefit, i.e., MID minus BASE and DEEP minus BASE costs/benefits. Source: model's results.

appeal of intervention scenarios as it makes positive NPV appear earlier. It also reinforces DEEP scenario as a policy option (as compared to MID) because it brings the break-even pint a few years forward, even though DEEP retrofits entail substantially larger investment costs, especially during the first years of the programme. The hypothesis of co-benefits being important for the economic assessment of energy efficiency scenarios is therefore supported with this semi-quantitative indication of their relevance.

A subsequent and equally important conclusion of the CBA is that improving the energy efficiency of Hungary's residential buildings to high (near passive-house) levels results in large positive net welfare gains for the Hungarian society. Though moving from BASE to MID scenario delivers positive NPVs at an earlier stage a BASE to DEEP scenario upgrade delivers a larger amount of discounted net social benefits in the long run.

Based on these results, the substitution of current policies by DEEP scenario retrofits (100,000 dwellings per year, near passive house level retrofits saving 79 to 90 % of energy consumption for space heating) is recommended.

Conclusions

One first key conclusion of this paper is that fuel poverty, which may be affecting between 10 to 30 % of the Hungarian population and has been on the rise since the mid-2000s, is a significant social impact of the inefficient consumption of domestic energy in Hungary. In spite of its distinct effects on households' welfare, until recently (2010) fuel poverty has remained unattended. As a consequence, the energy efficiency of homes and domestic end-use equipment was not given enough attention as a key structural cause of domestic energy affordability problems.

Fuel poverty in Hungary is experienced as disproportionate domestic energy costs as well as an enforced deficit of domestic energy services. However, rationing the consumption of energy services is just one of the behaviours displayed by affected households to deal with their energy affordability constrains. As the review of coping strategies indicates, households have also opted for fuel substitution (mostly natural gas by firewood), a growing trend in past years. These coping strategies demonstrate the resourcefulness and resilience of affected households but also illustrate the various ways in which their wellbeing is harmed by fuel poverty. Note that even some State-sponsored price support and residential energy efficiency schemes are available in Hungary, it is suspected that they benefit fuel poor households only to a small extent.

Without disregarding the importance of low incomes and poor domestic energy efficiency, fuel poverty in Hungary is closely connected to the country's energy dependency from its former Soviet Union suppliers of natural gas. As natural gas is supplied under monopolistic conditions, gas prices charged to domestic prices have increased at a faster rate than inflation, pensions and salaries in recent years. In fact, it can be hypothesised that if prices keep on increasing as in recent years, Hungary may be facing in a few years' time a much larger problem of domestic energy affordability affecting a large fraction of its population.

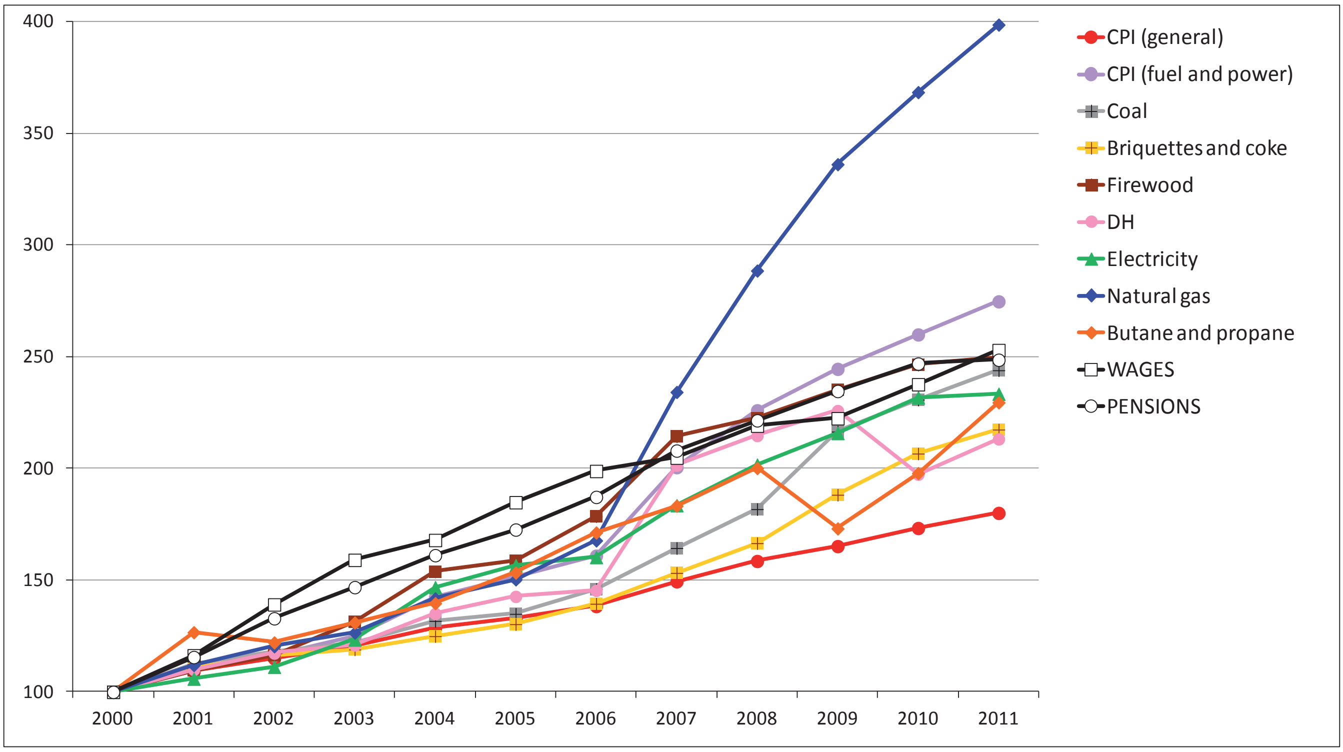

Figure 4. Changes in prices of energy carriers and main household income sources (wages and pensions) in Hungary (2000-2008) [2000 = 100]. Source: own elaboration based on data from the Hungarian Central Statistical Office (KSH).

A second key conclusion of this research is that improving the energy efficiency of Hungary's residential buildings to high (near passive-house) levels results in large positive net welfare gains for Hungarian society.

The implications of this economic assessment of residential energy efficiency scenarios in Hungary extend beyond its borders. Several additional conclusions are proposed in this regard.

First, co-benefits are important conceptual and operational categories because they allow incorporating a wide range of positive side-effects of climate investments in decision making tools like cost-benefit analysis. Among the many existing typologies of co-benefits, fuel poverty alleviation is highlighted in contexts (like Hungary) where domestic energy costs are on the rise and/or are a heavy burden to household budgets.

Second, co-benefits highlight the short-term effects of climate investments and contribute to redefining their rationale. Understanding that these investments have substantial short-term welfare effects puts the intergenerational conflict implicit in climate policies (present vs. future generations) under a new light.

Third, co-benefits are often disregarded because they are in many cases non-market benefits. Consequently, their quantification is often subject to uncertainties and valuation methodologies are not always available – their economic value cannot be always estimated and therefore added to or compared to, for instance, energy saving benefits or retrofit costs.

Fourth, the cost-benefit analysis of Hungary's residential energy efficiency scenarios warns about the following risk: decision-makers may be tempted to invest in below state-of-the-art solutions (represented in this research by the MID scenario) because they have earlier positive welfare effects and are not so burdensome to public budgets. This risk is particularly evident during times of economic turmoil in which long-term policy priorities are often side-lined in favour of quick wins. Still, the results of the social CBA clearly indicate that going for ambitious solutions (like DEEP retrofits) has larger positive effects on welfare levels in the long term.

To sum up, the multi-dimensional analysis of the effects of residential energy efficiency presented in this dissertation emphasises the importance of the co-benefits as policy entry-points for advancing the implementation of advanced residential energy efficiency solutions. In countries with moderate levels of commitment to global climate goals and high or increasing fuel poverty rates, these results may contribute to redefining the rationale behind climate investments.

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