A dissertation submitted to the Department of Environmental Sciences and Policy of Central European University in partial fulfilment of the Degree of Doctor of Philosophy

FUEL POVERTY ALLEVIATION AS A CO-BENEFIT OF CLIMATE INVESTMENTS: EVIDENCE FROM HUNGARY

Supervisor: Prof. Dr. Diana Ürge-Vorsatz

Internal member: Prof. Dr. Alan Watt

External member: Dr. Jonathan D. Healy

Opponent: Prof. Dr. Tamás Pálvölgyi

Sergio TIRADO HERRERO

January, 2013

Budapest

(3) For bibliographic and reference purposes this dissertation should be referred to as:

Tirado Herrero, S. 2013. *Fuel poverty alleviation as a co-benefit of climate investments: evidence from Hungary*. Doctoral dissertation, Department of Environmental Sciences and Policy, Central European University, Budapest.

Author’s declaration

No portion of the work referred to in this dissertation has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.

Furthermore, thisdissertation contains no materials previously written and/or published by another person, except where appropriate acknowledgment is made in the form of bibliographical reference, etc.

Sergio TIRADO HERRERO

THE CENTRAL EUROPEAN UNIVERSITY

ABSTRACT OF DISSERTATION submitted by:
SergioTIRADO HERRERO
for the degree of Doctor of Philosophy and entitled: *Fuel poverty as a co-benefit of climate investments: evidence from Hungary*

Month and Year of submission: January, 2013.

This dissertation evaluates the relevance of co-benefits (i.e., non-climate benefits) for improving the rationale and scale of climate investments. It focuses on fuel (or energy) poverty, a situation in which a household is unable to afford sufficient domestic energy services and/or is forced to pay a disproportionate share of its income on domestic energy. Fuel poverty is understood as a combined social, environmental and energy challenge whose alleviation results in considerable welfare gains for the affected population.

Taking Hungary as a case study, the dissertation has assessed the extent, causes and characteristics of fuel poverty in Hungaryand conducted a cost-benefit analysis of two scenarios proposing a significant upgrade of Hungary's currently existing residential energy efficiency policies.

One first key conclusion is that fuel poverty, which is affecting a substantial fraction (between 10 to 30%) of the Hungarian population, has been on the rise since the mid-2000s in parallel to a rapid increase in the price of imported natural gas. Faced with this situation, households are resorting to the use of traditional fuels and other imperfect coping strategies harming their welfare in various ways. Collected evidence has also identified two previously unreported typologies of fuel poverty (among poor Roma households in rural areas and in prefabricated *panel* buildings connected to district heating) that defy conventional notions of fuel poverty as defined in Western Europe.

Even though household incomes and energy prices are important causes of fuel poverty, the energy performance of residential buildings is regarded as a key structural factor and lever for its solution. Based on this premise, the dissertation has assessed through a financial and social cost-benefit analysis (CBA) two residential energy efficiency scenarios: MID (40% energy savings for heating per dwelling) and DEEP (79 to 90% energy savings for heating per dwelling). In the financial CBA only monetary cash flows (retrofit costs and energy savings benefits) are considered. In the social CBA, building retrofit and program management costs (as transaction costs) are compared against energy saving and other non-market benefits (avoided GHG and non-GHG emissions, reduced fuel poverty-related excess winter mortality and comfort benefits).

The results of the social CBA indicate that even though MID scenario delivers positive Net Present Values (NPV) at an earlier stage, DEEP retrofits delivers a larger amount of discounted net social benefits in the long term (from 2040). Compared with the financial CBA, the social CBA results in earlier positive NPVs for both scenarios and enhances the appeal of DEEP retrofits from an applied policy perspective. This comparison evidences the relevance of fuel poverty-related non-market co-benefits in contexts where domestic energy costs are on the rise and/or a heavy burden on household budgets.

This multi-dimensional analysis of the effects residential energy efficiency 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.

Keywords: co-benefits, fuel poverty, climate investments, residential energy efficiency, social cost-benefit analysis, Hungary

ACKNOWLEDGMENTS

First and foremost, I would like to sincerely thank my supervisor, Diana Ürge-Vorsatz, for her steady support throughout the various stages of my PhD, for the many sensible suggestions to frame my research and make it relevant, and for the opportunities offered to develop my profile as a researcher.

I am truly indebted to Jonathan D. Healy for finding the time (in his free time) to carefully review all sorts of aspects of my dissertation, and for his always kind and meaningful advice. His research on fuel poverty in the EU and Ireland has been a real inspiration for my PhD.

I am very thankful to the Department of Environmental Sciences and Policy at Central European University (CEU), and especially to professors Alan Watt and Tamara Steger for their guidance, support and interest in my research. Many thanks also to the Open Society Institute (Budapest) and the *Fundación Mutua Madrileña* (Madrid) for their generous financial support.

No matter the time past, I would like to acknowledge my professors at the University of Alcalá (Madrid) – Diego Azqueta, Gonzalo Delacámara and Carlos M. Gómez. With them I learnt the beauty of research and most of the economics I know. Marta Santamaría (CIEMAT), my peer and good friend, was always available at the other end of the line for asking questions, sharing uncertainties and having an always reassuring talk.

I would also like to thank for their involvement, support and contributions: Észter Kovách and Tracey Wheatley (*Védegylet* – Protect the Future Society); Daniele Arena, Veronika Czakó, Felix Bubenheimer and Mike Labelle (3CSEP/CEU); José Luis López, Eduardo Perero and my many friends of the *Asociación de Ciencias Ambientales* (ACA); Stefan Buzar (University of Birmingham); the InCluESEVcluster; Éva Ménesi and Dr. Judit Salamin (Hungarian Central Statistical office/KSH); László Elek (Energy Centre); György Sigmond (*MaTáSzSz*); Kornél Andzsans-Balogh and Zsuzsa Pató (REKK/Corvinus); and Györgyi Puruczky (CEU).

Budapest is a unique place but our friends here (Alberto, Alexandra, Eija, Elena, Emilio, Gerda, Huba, Iñaki, Izaskun, Katya, *Marton*, Meli, Montse, Nora, Özge, Pep, Sergi, Serkan, Valdas, Vanesa, Yulia, Zoltan and many others) made it unforgettable. Thanks for the great times enjoyed together during these last 4 and a half years. My friends in Alcalá, Bogotá, Cuenca, Kigali, Madrid, Tenerife and many other places are also remembered; especially Diego and Jorge, who provided long hours of special conversations and brotherly companionship even in the distance.

A special dedication to my family: to my parents, Antonio and Visi, for their support and care, for being an inspiration in ways that cannot be easily explained; to my brother Pablo, for being such a good pal helping me with the data and much more. My other family in little Zülow patiently put up with my sometimes too long working hours and provided the most welcoming shelter one can find east of the Elbe.

And of course a more than special mention to Andrea, *meine Liebe*, for the long winter nights and the bright summer days spent together all these years. Without you it simply wouldn't have been the same ☺

Gracias

Table of contents

List of figures

List of tables

List of abbreviations

3CSEP	Center for Climate Change and Sustainable Energy Policy
AAU	Assigned Amount Units
ÁNTSz	*Állami Népegészségügyi és Tisztiorvosi Szolgálat* [National Public Health and Medical Officer Service]
BPIE	Buildings Performance Institute Europe
CBA	Cost-benefit analysis
CEE	Central and Eastern Europe
CEU	Central European University
CIA	Central Intelligence Agency
CO_{2eq}	Carbon dioxide equivalent
COICOP	Classification of individual consumption by purpose
CPI	Consumer Price Index
CV	Contingent Valuation
DH	District heating
EBRD	Europeran Bank for Reconstruction and Development
EC	European Commission
ECB	European Central Bank
ECF	European Climate Foundation
EPEE	European Fuel Poverty and Energy Efficiency project
EU-SILC	EU Survey on Income and Living Conditions
EWD	Excess winter death
EWM	Exces winter mortality
FP	Fuel poverty
fSU	former Soviet Union
GDP	Gross domestic product
GHG	Greenhouse gases

GIS	Green Investment Scheme
GWP	Global Warming Potential
HBS	Household Budget Survey
HCPI	Harmonised Consumer Price Index
HEF2009	Energy Use moduleof the Household Budget and Living Conditions Survey
HDD	Heating degree-days
HUF	Hungarian forint
HCS	English Household Condition Survey
IEA	International Energy Agency
IMF	International Monetary Fund
IPA	Impact Pathway Approach
IPCC	International Panel on Climate Change
IRR	Internal rate of return
KSH	*Központi Sztatiskai Hivatal*[Hungarian Central Statistical Office]
kWh	Kilowatt-hour
LNG	Liquefied natural gas
MAC	Marginal Abatement Cost
MaTáSzSz	*Magyar Távhőszolgáltatók Szakmai Szövetségé*[Hungarian Professional Association of District Heating Enterprises]
MEH	*Magyar Energia Hivatal* [Hungarian Energy Office]
MEP	Member of the European Parliament
MNB	*Magyar Nemzeti Bank* [Hungarian National Bank]
NCV	Net calorific value
NMS12	12 New Member States (that joined the EU after 2004)
NPV	Net Present Value
OECD	Organisation for the Economic Co-operation and Development

PPP	Purchasing Power Parity
PPS	Purchasing Power Standard
SCC	Social cost of carbon
UNDP	UN Development Program
UNFCCC	United Nations Framework Convention on Climate Change
VAT	Value Added Tax
VOLY	Value of a Life Year
VSL	Value of a Statistical Life
WHO	World Health Organisation

Igy élünk mi. Horkolva alszunk s törten,
egymás hátán, mint odvas farakás
s hazánk határát penész jelzi körben
a málló falon; nedves a lakás

József Attila. Munkások.

Chapter 1

INTRODUCTION

"Energy is Eternal Delight"

William Blake. *The marriage of Heaven and Hell.*

1. INTRODUCTION

1.1. SETTING THE SCENE

In a 2009 National Geographic magazine article on energy conservation at the family level, senior editor PeterMiller (2009) recalled the words of R. James Woolsey, former CIA director, about a new alliance forming behind energy efficiency: "some people are in favour of it because it's a way to make money, some because they're worried about terrorism or global warming, some because they think it's their religious duty […] But it's all coming together, and politicians are starting to notice."

There are many reasons to believe that the solution to the global energy and climate challenges lies on reducing energy consumption while increasing the provision of energy services. From the perspective of society's welfare, those various reasons can be sorted into categories of co-benefits, i.e., positive side-effects of mitigation investments different from the avoided impacts of climate change. The identification of co-benefits and the estimation of their economic value– especially in the case of residential energy efficiency, where substantial opportunities for cost-efficient GHG emissions reduction exist – carriy an important message to decision-makers and may eventually lead to a new way of approaching climate change mitigation.

This PhD dissertation draws upon theoretical and methodological achievements on the identification and valuation of the social benefits of climate investments in the residential sector to focus on fuel poverty alleviation as a relevant, yet insufficiently explored, co-benefit category. The focus in Central and Eastern Europe (and on Hungary specifically) is grounded on the assumption that fuel poverty is a distinct type of material deprivation affecting this region in a particular way as a result of the profound transformations undergone in recent history.

1.2. BACKGROUND

1.2.1. The big context: a missing global climate regime

Climate change is a global environmental problem whose particular nature prevents co-ordinated international action. Since the climatic stability of the atmosphere (which depends on GHG concentrations) is an underprovided public good whose consumption is non-rivalled and non-excludable, climate change can be taken as an updated example of the *tragedy of the commons* (Hardin, 1968). Because of that, the (primary) benefits of mitigated climate change will be spread globally, irrespective of whether a nation is contributing to the mitigation effort or not. This provides incentives for individual actors to *free-ride*, so that certain nations bear mitigation costs and others just benefit fromglobal mitigation efforts (IPCC, 2007a).

This explains some of the difficulties of achieving meaningful global agreements for reducing GHG levels to levels that minimise the risks of large-scale disruptions in the world's ecosystems and societies. A significant example is the Kyoto protocol: initially adopted in 1997, it took 9 years until it entered into force (in 2005) and as the end of its first commitment-period (2012) it is still unclear when a similar successor agreement will be adopted, mostly due to the reluctance of large industrial nations like the US and emerging economies like China.

1.2.2. The co-benefits of energy efficiency in buildings

Traditionally, energy cost savings and the avoided costs of climate change benefits have been regarded as key drivers of mitigation efforts such as investing in energy efficiency and renewables. 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 the main goal of public policies aimed at reducing the energy consumption of buildings.

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, 2007b). Since implementing energy efficiency measures in buildings brings about (almost by definition) energy saving benefits, 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 much larger potential than the ones estimated for other end-use sectors (Ürge-Vorsatz and Novikova, 2008).

In addition, mounting evidence indicates that by reducing energy consumption and emissions, society also benefits in a number of indirect ways through the so called *co-benefits* of climate policies.Acknowledging its relevance, the last IPCC Working Group III report (IPCC, 2007b) 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 andScumatz, 2007; Ürge-Vorsatz et al., 2008; Ürge-Vorsatz et al., 2009a; 2009b) has identified many positive side-effectsthat 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 benefits are closer to agents bearing the mitigation costs (tax payers), have more immediate effects on welfare and the estimation of theireconomic value is less uncertain and information-demanding (Markandya and Rübbelke, 2003). They are also important because they provide a better understanding of the welfare effects of climate policies (Krupnick et al., 2000). In a way, it can be suggested that co-benefits allow by-passing the apparent trade-off between present and future generationsdue 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.

For this reason, in the absence of a global climate regime, co-benefits provide to individual actors (especially 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). Such a contribution is particularly important at thetime of the expiration of the Kyoto Protocol and given that a new international agreement including major polluters such as the US, China and India is still on its way.

1.2.3. Fuel poverty as a combined social and environmental challenge

Fuel poverty has been defined as "perhaps the strongest adverse social impact resulting from the inefficient consumption of energy in the domestic sector" (Healy and Clinch, 2002, p. 329). It can be described as a combined social and energy challenge with significant implications in terms of climate change. As a field of research, it covers a wide array of aspects– from domestic energy prices and residential energy efficiency to household subsidies and the health impacts of cold indoor environments – that fall under and beyond the scope of energy, environmental and social policy-making.

Though somehow gaining priority in the political and research agendas, fuel poverty is far from being a common issue of concern. In the EU, developments such as the Declaration of Budapest 2008 on the Future of Europe's energy supply (EUFORES, 2008), the European Fuel Poverty and Energy Efficiency project (EPEE, 2009a), the EU-wide energy poverty review commissioned by MEP Eluned Morgan (2008) and the opinion of the European Economic and Social Committee on *Energy poverty in the context of liberalisation and the economic crisis* (Official Journal of the European Union, 2011) indicate the growing relevance of the topic. These concerns are reflected in the Directive 2009/72/EC and 2009/73/EC, which recognise energy poverty as a growing problem in the EU, requireMember States to develop national action plans to tackle energy poverty through social policy and energy efficiency, call for a high level of consumer protection and refer to the prohibition of disconnection of vulnerable customers in critical times(Official Journal of the European Union, 2010a; 2010b).More recently, the Energy Efficiency directive (Directive 2012/27/EU) has suggested that energy efficiency obligation schemes should target households in fuel poverty (Official Journal of the European Union, 2012).

However, very few Member States have developed specific fuel poverty-alleviation programmes. In fact, only the UK, where fuel poverty should be eliminated "as far as is reasonably practical" by legal mandate by 2016-2018 (Boardman, 2010, p. 4) and to some extent Ireland (MacAvoy, 2007) have put in place policies or measures specifically aimed at this issue.

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 keep on increasing as the global demand forfossil fuels expands, unless the potential of unconventional reserves (e.g., shale gas) is exploitedto 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 asolution to the fuel poverty problem (Ürge-Vorsatz and Tirado Herrero, 2012).

1.3. FUEL POVERTY IN CENTRAL AND EASTERN EUROPE

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.

Under a centrally-planned economic system, domestic energy was regarded as an entitlement or basic necessity of the people rather than as a consumption good or commodity to be allocated with economic criteria. However, changes in the three main causes of fuel poverty (energy prices, household income and energy performance of the residential stock) suggest that fuel poverty rates in the CEE region increased after 1989.

First, the structural reforms of the transition process starting in the early 1990s eliminated the State-owned energy monopolies, lifted subsides, applied full-cost recovery tariffs and liberalized energy markets (Ürge-Vorsatz et al., 2006), which resulted in higher effective energy prices. Second, CEE countries' GDP per capita – as a proxy of households' income– is still (in most cases substantially) below Western European standards and, in the case of CEE EU Member States, their per capita income is in all cases lower than the EU average. Third, the high energy consumption of the average residential unit is a consequence of the long time subsidised energy prices and of the deterioration of the residential stock. Although multifamily apartments – in principle less energy demanding because of their better living space vs. exposed wall area ratio – are a common feature in CEE urban settlements, this effect is believed to have been "many times offset by the lack of basic energy efficiency requirements in apartments, built of cemented blocks or concrete panels" (*ibid.*, p. 2285).

The low energy performance of the CEE building stock is connected as well to the privatization of the residential sector, which transferred the responsibility for house repair and maintenance, previously managed by state-owned companies, to households with little understanding, preparation, information and resources for accomplishing such tasks. In other cases, mixed private owner-occupancy and public rental unitsmadeit difficult to reach consensus on maintenance and repair projects and collecting the necessary fees (Duncan, 2005).

In addition, fuel poverty has also been related to the inability of the region's post-1989 democratic governments to provide an adequate level of social protection and to the failure to develop adequate policy frameworks for improving the energy efficiency of the residential stock occupied bylow income households (Buzar, 2007a). This eventually led to a situation in which many homes have become *prisons* for households unable to properly heat their living space (Buzar, 2007b).

From a critical perspective, the notion thata "neat" single-lane transition from a centrally-planned to a market-based system could be achieved by the liberalisation, privatisation and unbundling of energy-related activities has been contested. Acknowledging that shared socio-technical legacies and path-dependencies determine the current functioning of CEE post-socialist energy systems, such a perspective has emphasised the importance in this regard of regulatory and institutional frameworks and of power relations, frictions and conflicts of interests between actors (Buzar, 2007a; Bouzarovski, 2009; 2010). In this process, different transition paths were followed, resulting in three models or *geographies* of fuel poverty (Table 1).

Table 1. The geographies of fuel poverty in CEE and the fSU

Insular geography	Potential geography	Pervasive geography
Central Europe, Baltics	**Central Asia, Caucasus, Russia**	**Balkans, fSU republics**
- Residential energy provided at long-run marginal costs - Energy sectors operate under market principles - Energy affordability problems concentrated among specific social groups - Wide range of policy tools for energy efficiency investment	- Below cost-pricing for residential energy - Energy sectors not fully marketised - Widespread non-payment for energy services - Inadequate frameworks for energy efficiency investments	- Energy pricing approaching long-run marginal cost - Regulation of energy sectors still struggling with leftover fromCommunist policies - Widespread energy affordability problems - Inadequate framework for energy efficiency investment

Source: Buzar, 2007a.

Despite the overall paucity of information, several key contributions by Buzar (2007a; 2007b; 2007c) have provided a region-specific conceptual framework for the analysis of fuel poverty as well explored its incidence in Macedonia and the Czech Republic. International organisations have also assessed the affordability of basic utility services (including energy) in the region in order to understand the impacts of charging full-cost recovery tariffs (Fankhauser and Tepic, 2007; EBRD, 2003), explored the connection of unsustainable energy use and poverty (UNDP, 2004),and evaluated the existing subsidy schemes (World Bank, 2000). On the impacts' side, the WHO (2004) reported figures of up to 240,000 excess winter deaths per year in the region, 48,000 of them possibly related to housing conditions. Country-specific excess winter mortality figures also exist for Poland, Romania (Morgan, 2008) and Macedonia (WHO, 2007).

1.4. HUNGARY AS A RELEVANT CASE OF STUDY

1.4.1.1. Fuel poverty in Hungary

Many of the aspects and trends described for CEE in the previous Section 1.3 are applicable to Hungary.

Economic and political changes happening after 1989 amplified income inequality (the gap between the highest and lowest income deciles was 8 times larger in 1999 than in 1982) 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. This process went in parallel with the privatization of most of its residential stock (Kocsis, 2004).

Under these conditions it is reasonable to foresee that a sizeable share of Hungarian householdsarestruggling to pay for the energy (mostly heating) they need at home. In fact, a preliminary assumption of this dissertation is that Hungary (as many of the former socialist states of Central Europe and the Baltic) is a case of *insular geography* of fuel poverty that, as defined by Buzar (2007a), implies that energy affordability problems concentrate around vulnerable population segments rather than being a pervasive phenomenon.

The 2011 Constitution of Hungary recognises the right to a healthy environment (art. XXI), the right to have physical and mental health (art. XX), the right of children to protection and care (art. XVI) and the right of consumers (art. M); it also refers to special measures of support for children, older people and other disadvantaged groups (art. XV)and to the need forproviding every person withdecent housing and access to public services (art. XXII). These articles of the fundamental law of Hungary give legal ground to any effortto improve the affordability of domestic energy services ofHungarian households.

Still, in Hungary (as in all EU member states but the UK), there is no official definition of fuel poverty. Even though domestic energy prices (or, more widely, energy affordability problems) are recurrently discussed, until recently these have neither been conceptualised as fuel poverty issues nor discussed in the theoretical framework of fuel poverty. However, this does not imply that society and institutions are unaware of the increasing difficulties experienced by households to afford their domestic energy needs,northatthere are no relevant pieces of previous research.

As early as 1987, a WHO report included a case study from Hungary exploring the influence on children's morbidity of housing construction type and indoor hygrothermal conditions WHO, 1987). More recently, the Hungarian Central Statistical Office (KSH) published statistical summaries on household expenditures (KSH, 2004; 2006; 2008; 2011) with relevant data on the burden of energy expenses in household budgets. At a local level, Kocsis (2004) analyzed heating and house maintenance expenses in a study on housing poverty in Budapest. In rural areas, a survey carried out by the *Autonómia Alapítvány*[1](UNDP/*Autonómia Alapítvány*, 2004) found evidence of the very poor quality of the insulation, fuel sources and heating equipment of Roma households in the Borsod county. Finally, the Budapest-based *Energia Klub* has produced a critical analysis of the various state-funded schemes supporting residential users and pointing at the need to eliminate subsidies

[1]Hungarian Foundation for Self-Reliance

that distort the market, keep energy prices artificially low and do not provide enough incentives to invest in domestic energy efficiency (Fülöp, 2009).

It was not until 2010 that the first piece of research focusing specifically on the topic was published in Hungary. It was the report *Fuel poverty in Hungary. A first assessment* (Tirado Herrero and Ürge-Vorsatz, 2010), a study commissioned by the Hungarian NGO *Védegylet* – Protect the Future Society on which this dissertation is partially based. Later on, the *Energia Klub* (Energy Club) produced a paper with a proposed definition of fuel poverty in Hungary. It also recognised thelack of data and of a commonly accepted definition of fuel poverty in Hungary as barriers to policy action whilepointing at the low energy efficiency of the residential stock as a main cause of fuel poverty in Hungary. Based on data collected in a survey on the energy use of the household sector in Hungary (*Negajoules* project), the paper also identifiessingle family houses as the most likely dwelling to be occupied by a fuel poor household because of their large floor area and low thermal performance (Fülöp and Fellegi, 2012).

1.4.1.2. Characteristics of Hungary's energy system

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

- The energy intensity of the Hungarian economy decreased significantly and it is expected to keep its downward trend in the nearfuture (OECD/IEA, 2007). Still, this change is mostly based on the restructuring of the country's productive structure, as the energy efficiency of the residential sector hasnot shown much improvementin the last 20 years.

- Natural gas represents a large percentage of the country's final energy consumption as compared to other EU economies. Apparently, this is attributable to the discovery of large domestic gas reserves in the 1960s and 1970s (Kessides, 2000).
- The structure of energy demand is different from the EU average: residential and commercial sectors are the largest end-use sectors, taking up in 2008 over 45% of the country's final energy consumption (EnerCEE.net, 2012). They represent 80% of the total final consumption of natural gas, the highest percentage in the EU (EUROSTAT, 2009a).
- 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).
- Hungary is one of the most gas-dependent IEA (International Energy Agency) member countries. As of 2009, imports from the former Soviet Union (the almost only source of imported gas) represented around 75% of total gas consumption (OECD/IEA, 2012a). 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).

In summary, Hungary's energy system provides an example of negative path-dependencies, legacies and the intertwined relationship between energy (gas) dependency and fuel poverty.

1.4.1.3. Relevant trends

Two significant trends in the evolution of two indicators – total GHG emissions and the fuel and power price index – provide additional evidence supporting the relevance of Hungary as a case study (see Figure 1 and Figure 2).

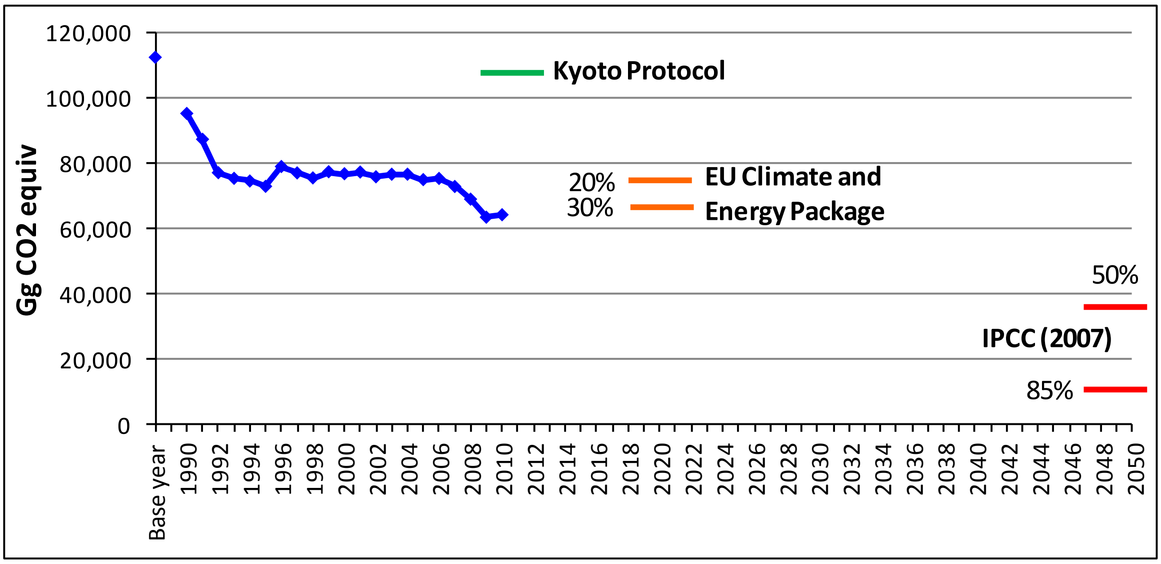
Due to the substantial changes in the country's political and economic structure that occurred in the 1990s, Hungary is easily able to meet its Kyoto protocol targets, which were set at 94% of base year emissions – around 108 ktCO_{2eq} – see Figure 1. This is largely the result of the restructuring of Hungary's industrial sector but is also based on the decrease in total emissions that occurred since 2007, which is linked to the post-2008 global economic downturn and instability. This recent reduction in total CO_{2eq} emissions has brought them down by 15% compared to the 1995-2005 levels. It may be just enough for Hungary to meet short-term (2020) mitigation targets set by the EU Climate and Energy Package – a 20% reduction in EU greenhouse gas emissions from 1990 levels, which may increase to 30% if "other major economies in the developed and developing world commit to undertake their fair share of a global emissions reduction effort" (EC, 2012a)[2]. However, it is still unclear whether the drop in Hungary's aggregated GHG emissions since 2007 is just temporary or responds to structural changes and can be thus maintained when(or if) Hungary and its EU partners return to the growth path.

The prospect for Hungary meeting longer term mitigation targets looks less hopeful, though – see Figure 1. If global decision-making is successful in creating a new agreement setting a maximum temperature increase target of 2° C (as compared to pre-industrial levels), Hungary may have to reduce GHG emissions to unprecedented levels. As indicated by IPCC's

[2] The 20 to 30% emissions reduction target is set for the EU as a whole. Each Member State will be assigned a country-specific mitigation target that can be below or above the EU-wide 20-30% target.

4th Assessment Report, a 50 to 85% reduction in year 2000 emissions would be required in order to limit the increase in global mean temperature to 2.0-2.4° C (IPCC, 2007b). Even though the distribution of the burden is very uncertain at this point, current Annex I countries (like Hungary) would probably bear a large share of the responsibility to cut emission levels. In fact, as acknowledged by the European Commission (EC, 2012b), a 2°C target may require developed economies to deliver reductions in the range of 80 to 95% by 2050.

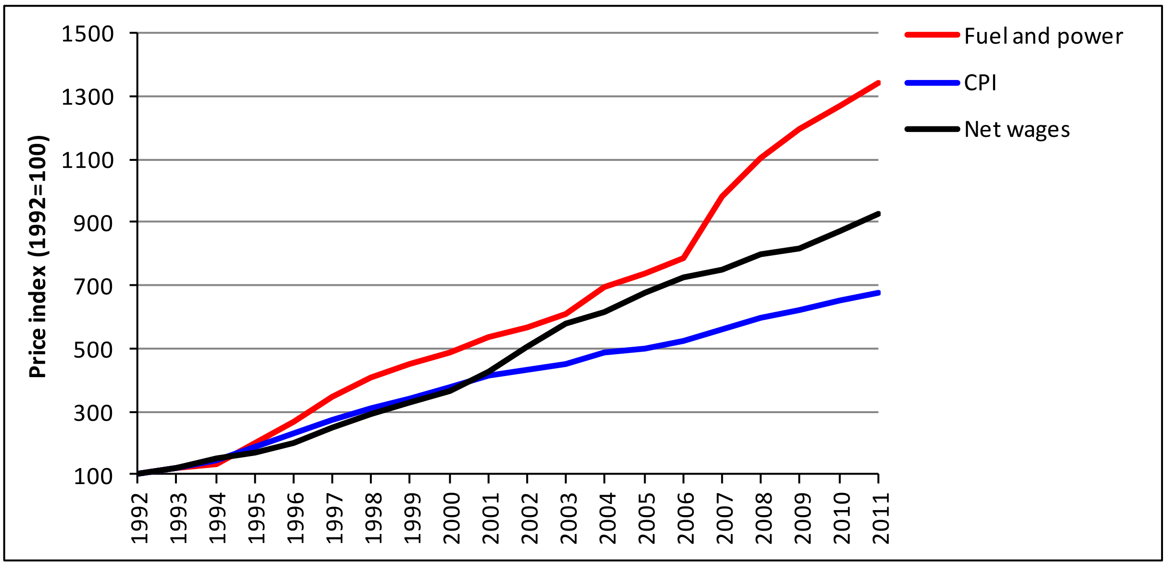
Figure 1.Total GHG emissions (all gases considered under the Kyoto protocol) in Gg CO_2eq per year (Hungary, base year – 2010) plus agreed and hypothetical mitigation targets until 2050



Source: own elaboration after UNFCCC (2012a) data for Hungary

In parallel, Hungary has witnessed a sustained increase in residential energy prices in the last 20 years. This trend, which has accelerated during the second half of the 2000s, resulted inHungary's domestic fuel and power price index tripling the inflation rate: as shown in Figure 2, nominal prices of energy experienced a 13-fold increase between 1992 and 2011, whereas the overall price level of the Hungary economy increased *just* by 7 times in the same period. This happened as domestic energy tariffs moved towards full-cost recovery levels but is also a consequence of Hungary's weak position as an energy importing nation that depends almost entirely on its former Soviet Union suppliers of natural gas. This pattern indicates that fuel poverty is partially a consequence of the 1990s transition but also a contemporary issue resulting from the substantial increase in domestic energy prices driven by the price of imported natural gas since 2006 – see Chapter 5.

Figure 2.Fuel and power price index and Consumer Price Index (CPI) in Hungary, 1985-2011; 1985=100



Note: the fuel and power price index is contained in the CPI index
Source: own elaboration after data retrieved from the Hungarian Central Statistical Office (KSH)

The trends presented both in Figure 1 and Figure 2illustrate two fundamental challenges that Hungary's energy policy needs to address in the next 40 years. Furthermore, they indicate that even if climate change has not been a significant policy driver, it may soon be; and it will have to be addressed in a context of steadily rising energy prices that has already put a large fraction of the Hungarian population in fuel poverty (see Chapter 4). Given the scale of the required transformation, the importance of the residential sector in Hungary's final energy demand and the social co-benefits deriving from the decarbonisation of Hungary's energy system, fuel poverty and climate change need to be aligned as synergetic drivers of Hungary's forthcoming energy efficiency policies.

1.5. RESEARCH QUESTION AND OBJECTIVES

This dissertation attempts to address the following overarching research question, which is divided into two related sub-questions:

- *What are the extent, causes and characteristics of fuel poverty in Hungary; and*
- *what is the relevance non-market co-benefits (including fuel poverty alleviation benefits) in the economic assessment of residential energy efficiency scenarios in Hungary?*

This questionclosely relates to the dissertation's research aim, which is contributing to a better understanding of non-climate co-benefits as alternative drivers for the design and implementation of more ambitious climate policies. This aim is referred to the context of the transition economies of Central and Eastern Europe, and more specifically to Hungary, for the reasons outlined above (Sections 1.3 and 1.4). Despite its relative specificity, the Hungarian case is presented as representative of other post-socialist economies of Central and Eastern Europe, where similar low levels of commitment with climate change mitigation and fuel poverty-related challenges (increasing domestic energy prices, stagnating incomes and poor energy efficiency of the dwelling stock) can be found.

To achieve this aim and provide an answer to the overarching research question, several objectives and sub-objectives have been defined:

- Objective 1: To estimate the incidence of fuel poverty in Hungary, and to analyzeits relationship with three causes or contributing factors (domestic energy prices, household incomeand energy efficiency of the residential stock).
  - *Objective 1.1*: To measure the current incidence of fuel poverty in Hungary following the main approaches identified in the literature (Chapter 4).

- *Objective 1.2*: To explore alternative indicators of fuel poverty that capture specific aspects of fuel poverty in Hungary (Chapter 4).
- *Objective 1.3*: To examine the link between all collected indicators and the three causes/contributing factors identified (Chapter 5).

▪ Objective 2: To present two previously unreported cases or sub-typologies of fuel poverty representative of Hungary and Central and Eastern Europe (poor Roma households in rural areas; *panel* dwellings connected to DH) and to analyze theirsignificance in terms of the understanding of fuel poverty (Chapter 6).

▪ Objective 3: To provide a financial assessment of the costs and benefits of improved scenarios of residential energy efficiency and to estimate their net effect on the aggregated welfare of Hungarian society through a social cost-benefit analysis that incorporates the value of co-benefits.

- *Objective 3.1*: To define feasible scenarios for an upgraded, nation-wide residential energy efficiency programme (Chapter 7).
- *Objective 3.2*: To realize a financial assessment of the defined scenarios based on financial implementation costs and energy saving benefits, including the financing of the capital costs of individual retrofits (Chapter 8).
- *Objective 3.2*: To complete a social cost-benefit analysis of the defined scenarios that incorporates the economic value of fuel poverty-related and other non-market co-benefits(Chapter 8).
- *Objective 3.3*: To provide evidence about further co-benefits that could not be incorporated in the social cost-benefit analysis(Chapter 8).

▪ Objective 4: To assess the significance of co-benefits for climate decision-making.

1.6. SCOPE OF THE RESEARCH

Thisdissertation has been framedwithin the following boundaries that define the scope of the research:

- Geographical: main results are produced for the whole Hungarian society and its 201 dwelling stock. Results for indicators are sometimes disaggregated by building or heating systems typologies and income groups, but not by counties or other administrative divisions. In some cases, Hungary is compared against EU27 Member States to assess differences in the incidence of fuel poverty rates and analyse the link with contributing factors.
- Timeframe: the analysis of fuel poverty through indicators concentrates in the decade of the 2000s, with a particular focus on thesecond half because of the substantial increase in natural gas prices registered since 2006. The social cost-benefit analysis spans between 2010 and 2080. Despite the uncertainty associated with the long-run forecast of parameters, a lengthy timeframe is requiredto assess properly the welfare effects of retrofits.
- Energy end-use sectors: the residential sector is the one and only considered because fuel poverty is defined exclusively as a household energy affordability issue.
- Domestic energy services: as discussed in Section 2.1, indoor space heating and wintertime thermal comfort are central elements of the fuel poverty concept, though other domestic end-uses of energy (i.e., hot water, lighting, appliances, etc.) are also important. The dissertation explores mostly heating-related fuel poverty, though some indicators (e.g., expenditure-based fuel poverty rates, arrears in utility bills)consider implicitly other end-uses.

- Energy carriers: given that dwelling space heating is the main end-use considered, natural gas, DH and solid fuels (mostly firewood) are the most common energy carriers. Electricity, which is very seldom used as a source of domestic heat, is nevertheless incorporated in expenditure-based fuel poverty rates and in the case study of poor Roma families in rural areas.
- Types of co-benefits: fuel poverty-related co-benefits (i.e., avoided excess winter mortality and improved comfort) are key categories in the social cost-benefit analysis, which also incorporates other non-market benefits such as the value of avoided emissions of GHG and other pollutants with negative effects on health and the ecosystems. Other co-benefits such as energy security, net employment creation or the enhanced rental or sale price of dwellings are also qualitatively discussed in Chapter 8.

1.7. JUSTIFICATION: GAPS ADDRESSED AND PRACTICAL CONTRIBUTION

This dissertation addresses (to a certain extent) two large gaps located in the literature, which also justify the selection of Hungary as well-suited study case:

- The still unknown extent and characteristics of the fuel poverty phenomenon in Central and Eastern Europe. Certainly, Hungary is no exception to this. Though previous research (Kocsis, 2004; UNDP/*Autonómia Alapítvány*, 2004; KSH, 2004; 2006; 2008; 2011; Fülop, 2009) has examined selected elements of the problem, the first proper assessment of fuel povertyin the country is the report *Fuel poverty in Hungary. A first assessment*(Tirado Herero and Ürge-Vorsatz, 2010), on which this dissertation is partially based.
- The insufficiently understood relevance of co-benefits for the adoption of more decisive climate policies, especially in jurisdictions with low to moderate commitment to climate

change mitigation. Previous research has quantified and incorporated co-benefits in decision-making tools (Aaheim et al., 1997; Aunan et al., 1998; Clinch and Healy, 2001; Jakob, 2006; Chapman et al., 2009) but has never dealt with fuel poverty in Central and Eastern Europe. Against this background,focusing on Hungary gives the opportunity to fill this gap (however marginally) because this country has a residential energy efficiency policy with large room for improvement and also because the availability of a ready-to-use bottom-up model of the residential sector (Novikova, 2008; Ürge-Vorsatz et al., 2010) – see Chapter 7.

This research is also justified for practical reasons. First and foremost, it presents the first-ever description and assessment of the fuel poverty phenomenon realised in Hungary. Until the release the report *Fuel poverty in Hungary. A first assessment* in 2010, fuel poverty was implicitly discussed but mostly through the narrower lens of energy prices and household incomes. Since then, a growing trend in the use of the Hungarian equivalent to fuel poverty (*energiaszegénység*) in the media and policy discourses has been detected.

In addition, the social cost-benefit analysis incorporating fuel poverty alleviation and other co-benefits provide further evidence-based forecasts of the wider positive effects of investing in residential energy efficiency. This dissertation is part of a series of studies carried out with this purpose by the Center for Climate Change and Sustainable Energy Policy (3CSEP), some of which have had an impact on actual decision making. A relevant example in this regard is the report *Employment Impacts of a Large-Scale Deep Building Energy Retrofit Programme in Hungary* (Ürge-Vorsatz et al., 2010), which convinced a newly elected Hungarian government in June 2010 about the need to adopt a more ambitious residential energy efficiency programme.

1.8. STRUCTURE OF THE MANUSCRIPT

This dissertation is organised in nine chapters. This first chapter introduces the background and research problem and justifies the need for research. Chapter 2 introduces the concept of fuel poverty and relates it to three relevant theoretical frameworks: poverty, justice and the co-benefits of climate change mitigation. Chapter 3 describes the three basic methodological approaches used in the dissertation (methodologies for the measurement of fuel poverty, case studies and social-cost benefit analysis) as well as the data sources employed.

Chapters 4 through 8 are all results-based: i) chapter 4 presents a set of primary and secondary fuel poverty indicators for Hungary; ii) chapter 5 explores the link between fuel poverty indicators and three causes or contributing factors; iii) chapter 6 contains two unconventional cases of fuel poverty found in Hungary (but also representative of the Central and Eastern European region); iv) chapter 7 introduces the residential stock model used in the cost-benefit analysis, and reports the results of the financial assessment of cost and benefits of two intervention scenarios; and v) chapter 8 reports the assumptions and results of the social cost-benefit analysis, including the valuation of non-market co-benefits.

Finally, chapter 9 summarises the key results and conclusions of the dissertation, discusses the implications of the research in theoretical and practical terms, compiles the contributions of the doctoral research and propose avenues for future research.

Chapter 2

THEORETICAL FRAMEWORK: (FUEL) POVERTY, JUSTICE AND CO-BENEFITS

"It is theory that decides what can be observed"

Albert Einstein

2. THEORETICAL FRAMEWORK: (FUEL) POVERTY, JUSTICE AND CO-BENEFITS

2.1. DEFINITIONS OF FUEL POVERTY

A number of definitions of fuel (or energy) poverty have been proposed in the last two decades in Europe. The most relevant ones located in the scientific and policy literature are summarised in Table 2. This review highlights the following elements:

- Definitions refer in all cases to fuel poverty as an issue of affordability of domestic energy services. Affordability in this sense refers to two interrelated aspects – the two sides of the fuel poverty coin: poor satisfaction of a household's energy needs and disproportionate expenses on domestic energy. As the definition by Liddell et al. (2011) suggests, fuel poverty does not simply refer to an enforced deficit of domestic energy services (e.g., a cold house) but also to an unbalanced household budget in which energy costs press on other essentials like food.
- Some definitions (Boardman, 1991; BERR, 2001; Hills, 2012) have a clear policy motivation, i.e., they aim at quantifying and identifying households in fuel poverty in order to orientate policy action and monitor progress. They are linked to an objective measurement methodology based on expenditure, income and prescribed indoor temperatures. These definitions, currently prevalent in the UK, have been criticised because they fail "to capture the wider elements of fuel poverty, such as social exclusion and material deprivation" (Healy, 2004, p. 36). Consequently, an alternative *consensual* approach was developed, which favours a more subjective, measurement approach based on household self-reported statements and perceptions (Healy and Clinch, 2002; 2004) – see Section 3.2.1.2.3. Likewise, Buzar (2007a) has stressed the role of societal norms in setting the threshold of what is considered fuel poverty.

- Most definitions reflect a bias towards the use of energy for domestic space heating. In fact, some of the definitions (Healy and Clinch, 2002; 2004) refer exclusively to heating as a relevant end-use for defining fuel poverty. This is explained by the importance of excess winter mortality and other related health impacts in the fuel poverty discourse, and also by the fact that heating is usually the most expensive end-use for households. However, other domestic energy services, often provided by electricity (e.g., hot water, lighting, powering appliances, etc.) are important for a household's decent life and may take up a substantial part of total domestic energy expenses. Additionally, the demand for cooling may increase in the future as a result of climate change, which may enhance the relevance of summertime thermal comfort. This has been referred to as *summertime* fuel poverty (Healy, 2004).
- Transport is not considered as a domestic energy service. The only exception is the definition proposed by the European Economic and Social Committee (Official Journal of the European Union, 2011), which suggests transport as an energy end-use to be includedin the energy poverty concept. This is interpreted as a misunderstanding of the fundamentals of the fuel poverty concept.
- The concept of fuel poverty is connected to, but substantially different from, the issue of the lack of or inadequate access to modern energy services, also referred to as energy poverty. At a global scale, this refers to the growing number of people that, mostly in developing countries, rely on traditional solid fuels – such as charcoal, coal, wood, dung or crop residues – and lack access to quality energy services as those provided, for instance, by electricity (Birol, 2007; Pachauri and Spreng, 2003). This is an issue of a much larger (global) scope as it is estimated that 2 billion people worldwide, many of them in rural areas of less developed nations, suffer from three major energy poverty-related problems (Sagar, 2005): increasing amount of time and efforts needed to collect

biomass, higher relative energy prices (subsidies are more common in commercial energy carriers) and the health impacts of indoor air pollution coming from burning traditional fuels.

Table 2. Definitions of fuel/energy poverty in the scientific and policy literature

Reference	Definition
Boardman (1991, p. 201, in Morrison and Shortt, 2008)	"Inability to obtain adequate energy services for 10% of a household income"
UK Fuel Poverty Strategy (BERR, 2001, p. 6)	"A fuel poor household is one that cannot afford to keep adequately warm at reasonable cost. The most widely accepted definition of a fuel poor household is one which needs to spend more than 10% of its income on all fuel use and to heat its home to an adequate standard of warmth. This is generally defined as 21ºC in the living room and 18ºC in the other occupied rooms - the temperatures recommended by the World Health Organisation". Fuel costs include "spending on water heating, lights, appliances and cooking" (DEFRA/BERR, 2008, p. 40).
Healy and Clinch (2002, p. 331), after Lewis (1982)	"Inability to heat the home adequately because of low household income and energy inefficient housing"
Healy and Clinch (2004, p. 207)	"The problem of fuel poverty occurs […] when a household does not have the adequate financial resources to meet these winter home-heating costs, and because the dwelling's heating system and insulation levels prove to be inadequate for achieving affordable household warmth"
Buzar (2007a, p. 9)	"The inability to heat the home up to a socially- and materially-necessitated level. A household is considered energy-poor if the amount of warmth in its home does not allow for participating in the 'lifestyles, customs and activities which define membership of society"
European fuel Poverty and Energy Efficiency (EPEE) project (2009b, p.4)	"We have defined fuel poverty as a household's difficulty, sometimes even inability; to adequately heat its dwelling, at a fair price"
European Economic and Social Committee (Official Journal of the European Union, 2011)	"One option would be to define energy poverty as the difficulty or inability to ensure adequate heating in the dwelling and to have access to other essential energy services at a reasonable price [...] Energy poverty occurs where a household finds it difficult or impossible to ensure adequate heating in the dwelling at an affordable price (by way of reference, it might be worth adopting the definition used by the World Health Organization, which considers an adequate standard of warmth to be 21 °C in the living room and 18 °C in the other occupied rooms, or any other definition deemed technically appropriate) and having access to other energy-related services, such as lighting, transport or electricity for use of the Internet or other devices at a reasonable price. Although this is a general definition, other criteria could be added in order to update the concept when necessary."
Liddell et al., 2011 (p. 65)	In order to protect health and well-being, all households require a minimum standard of heating and electricity in their home. […] Households that are in fuel poverty are unable to afford this minimum standard. Consequently: - many go without heat and electricity because they cannot afford it - others go without essentials such as food in order to pay for heat and light."
Hills (2012, p. 9)	"The Government should adopt a new indicator of the extent of fuel poverty under which households are considered fuel poor if: • They have required fuel costs that are above the median level; and • Were they to spend that amount they would be left with a residual income below the official poverty line."

It is important to note the terminological confusion surrounding the fuel/energy poverty concept that seems to exist in the literature. On the one hand, *fuel poverty* is the most favoured wording in the UK (e.g., Boardman, 1991; BERR, 2001; DECC, 2012) and Ireland (e.g., MacAvoy, 2007). On the other hand, key references for continental Europe (Buzar, 2007a; 2007b; 2007c) and other institutional sources like Morgan (2008), EUFORES (2008) and the Directive 1972/2009/EC refer to the same phenomenon as *energy poverty*, which refers to a different (although related) issue as noted above. In her latest contribution, Boardman (2010, p. 15) has stated that "they mean the same thing" even though the term *fuel poverty* suggests that space heating is the main concern (electricity, which is the main source of energy for other end-uses like lighting and appliances, is not a fuel). Still, in an EU context, academics and practitioners seem to use both terms indistinctly and with the same meaning. And this apparent terminological disagreement may be relevant only in English, as in most languages of continental Europe the term is consistently translated as the equivalent of energy poverty (e.g., *Energiearmut*, *précarité énergétique*, *energiaszegénység*, *pobreza energética*, etc.).

In the context of this dissertation, fuel poverty is defined, following Ürge-Vorsatz and Tirado Herrero (2012, p. 84):

> "[…]as a broader 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 this doctoral research focuses to a larger extent (but not exclusively) on space heating) because this energy service is usually the most burdensome to household budgets and because of the distinct health impacts of cold housing.

The original and more common wording *fuel poverty* is adopted in this dissertation. Fuel poverty was preferred to the more encompassing (and perhaps more precise) *energy poverty* mainly because the former is more widely used in the scientific and policy literature, especially in the UK. Still, fuel poverty is problematic to some extent given that households also use energy carriers that are not fuels (e.g., district heating or electricity) and also because it puts perhaps too much emphasis on dwelling space heating as a domestic energy end-use.

2.2. THEORETICAL FRAMEWORKS FOR THE ANALYSIS OF FUEL POVERTY

2.2.1. Poverty and social exclusion

The concept of fuel poverty has become important in developed countries, where absolute poverty has been more or less eradicated (as compared to developing nations) but specific inequalities in the living conditions of the population still prevail. In this sense, particularly important is the definition of relative poverty by Townsend (1979, p. 31), according to which

> "[i]ndividuals, families and groups in the population can be said to be in poverty when they lack the resources to obtain the types of diet, participate in the activities, and have the living conditions and amenities which are customary, or are at least widely encouraged and approved, in the societies in which they belong."

Some fuel poverty definitions (Healy, 2004; Buzar, 2007a) have been explicitly grounded on Townsend's conception of poverty; it is as well implicit in the quantitative criteria first defined by Boardman (1991) for setting up the 10% energy expenses vs. net income ratio in the UK (see Boardman, 2010). From this perspective, fuel poverty can be emphasised as one of the ways in which the worse-off members of a society are unable to enjoy the same living conditions as their peers.

Building upon this conception, Mack and Lansley (1985) came up with the notion of *enforced lack of socially perceived necessities* as a concept that is central to current understanding of poverty, capable to discriminate between chosen lifestyles and lifestyles that cannot be afforded. Nolan and Whelan (2009) have subsequently pointed at two central elements in this conception of poverty: the inability to participate in the reference society (thus connecting poverty with social exclusion) due to the the lack of adequate resources.

This approach based on socially perceived necessitieshas pioneered the use of non-monetary deprivation indicators such as the EU SILC items used by the self-reported/consensual measures of fuel poverty. Non-monetary deprivation indicators focus on the conditions that a decent life should fulfil and identifies a list of items (e.g., diet, clothing, shelter, environment, etc.) that define the necessities that are recognised as such in a society (Eurostat, 2009b). They highlight the inability of the worse-off members of a society to live a decent life in the sense that their living conditions are below what is customary in the society they belong.

Enjoying an adequate provision of domestic energy services is one of those basic needs that a household is expected to meet. In this sense, fuel poverty is one component of a multi-faceted notion of deprivation that encompasses the various aspects of human life.

2.2.2. Social and environmental justice

In broad terms, fuel poverty can be labelled as an issue of distributive justice as it refers to a problem of unequal access to material goods, i.e., domestic energy services (rather than energy itself). Under this perspective, inequality in the access to domestic energy services can be expressed in Rawlsian terms: it is about a primary good whose distribution should be done according to the Rawls' *veil of ignorance,* as if it could be allocated by a person unaware of her status, wealth or position in the society she belongs[3] (Walker and Day, 2012).

Additionally, these authors argue that fuel poverty needs to be seen also from the perspective of procedural justice in the sense that the fuel poor neither have enough access to relevant information nor are sufficiently involved in processes that determine the conditions under which fuel poverty is experienced (e.g., design and implementation of housing or energy policies); and fuel poverty is a matter of injustice in its lack of recognition too because the differential needs of the fuel poor are not always properly recognised, with some population segments sometimes stigmatised or regarded as undeserving of social support (*ibid*.)

Fuel poverty can be also explored through the related optics of environmental justice – "the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies" (EPA, 2012a). Though originally proposed for denouncing the disproportionate environmental burdens borne by the worse-off members of society, a broader understanding of the environmental justice notion includes the right to have sufficient access to environmental resources (and the services they provide) for living a healthy life (see Stephens et al., 2001). Under this framework, fuel poverty can be viewed first in terms of an unequal distribution of energy resources and of energy end-use equipment and infrastructure; and then also in terms of differences in the outcomes of the use of energy

[3] Rawls' *A Theory of Justice* defines the *veil of ignorance* in the following terms (Rawls, 1971, p. 136):"Somehow we must nullify the effects of specific contingencies which put men at odds and tempt them to exploit social and natural circumstances to their own advantage. Now in order to do this I assume that the Parties are situated behind a veil of ignorance. […]It is assumed, then, that the parties do not know certain kinds of particular facts. […] no one knows his place in society, his class position or social status; nor does he know his fortune in the distribution of natural assets and abilities, his intelligence and strength, and the like". This concept was first outlined by the Budapest-born economist John Harsanyi (Moreno-Ternero and Roemer, 2005).

at home. The latter is particularly relevant in the case of the health impacts of fuel poverty, which is demonstrated to increase the incidence of cold-related diseases and excess winter mortality rates (The Marmot Review Team, 2011). And since these health impacts are disproportionately experienced by the elderly (i.e., excess winter mortality), fuel poverty provides the opportunity to incorporate age in environmental justice discourses, which so far have remained mostly focused on race and class as socio-demographic signifiers (Day, 2010). In any case, this does not imply that race and class are irrelevant for fuel poverty as an environmental justice issue. As this and previous research has demonstrated, the low-income strata are more likely to be in fuel poverty, and some heavily disadvantaged minorities experience a particularly harmful type of fuel poverty, e.g., the poor Roma in Central and Eastern Europe face fines and detentions for illegal firewood collection or electricity theft and are exposed to indoor air pollution coming from the burning of firewood or other low-quality solid fuels – see Chapters 5 and 6.

2.2.3. The co-benefits of residential energy efficiency

2.2.3.1. Concepts: primary benefits vs. co-benefits

In a broader sense, co-benefits can be defined by opposition to the *primary benefits*, i.e., the intended benefits of a given measure. They can be understood as positive secondary or side-effects that are unrelated with the original main purpose of the measure or policy.

In the context of climate policies, primary benefits can be defined in terms of the avoided damages of climate change. Primary benefits are thus the welfare effects of decreasing GHG emissions respective to a business-as-usual baseline, and therefore can be defined as an estimate of the marginal reduction of the social costs of the impacts of climate change (e.g., sea level rise, changes in agricultural productivity, spreading of biological vector-transmitted diseases, etc.). Estimates of this sort– referred to as the social cost of carbon (SCC) – provide a benchmark for assessing the rationality of GHG mitigation: theoretically, if SCC calculations were complete and markets were perfect, following a cost-benefit rationale no emissions reductions costing to society more than the SCC should be put in place (Yohe et al., 2007). IPCC's Fourth Assessment Report (Yohe et al., 2007) points out that, although according to Tol (2005) the SCC is unlikely to exceed US$ 50 tC^{-1} following standard assumptions on discounting and equity weighting, Downing et al. (2005) considered the US$ 50 tC^{-1} limit as a lower benchmark coherent with a modest level of aversion to extreme risks, relatively low discount rates and equity weighting.

*Ancillary benefits*are another category used in relation to the positive side-effects of climate policies different from climate change mitigation. Though often used as a synonym of co-benefits, according to the glossary of IPCC's Working Group III report (IPCC, 2007b), the term ancillary benefits refers to the positive outcome of measures applied to a specific policy area (in this case, mitigation of GHG emissions) in regard to other policy objectives (e.g., employment, energy security, etc.); in contrast, co-benefits relate to an integrated, cross-sectoral perspective in which multiple policy goals are allowed. Along the same line, the expression*multiple benefits*also refers to the diversity of policy goals that can be achiveved with energy efficiency interventions (OECD/IEA, 2012b).

Related terms are *non-climate benefits* (IPCC, 2007b) and *non-energy benefits* (Mills and Rosenfeld, 1996; Schweitzer and Tonn, 2002); the latter refer to energy cost savings (instead of to climate change mitigation) as the primary benefit of policies.They are particularly important in contexts where climate change mitigation is not the priority because other goals (like reducing energy costs or energy dependency) are a primary policy driver.

In this dissertation, co-benefits are primarily defined as non-climate benefits, though non-energy benefits are also given relevance. As discussed in Chapter 8, the focus is on non-market co-benefits (especially of those related to fuel poverty alleviation) different from the value of saved energy and avoided GHG emissions, which have been the ones traditionally considered in the assessment of residential energy efficiency policies. *Co-benefits*is the preferred wording (instead of ancillary benefits) because, as noted above, it refers to multiple policy goals, a view which is closer to the perspective adopted in this dissertation.

2.2.3.2. Ancillary costs

Additionally, the so-called *ancillary costs* must be also considered in the picture (Krupnick et al., 2000). These can be defined as the costs of mitigation policies that are different from investment and operation and maintenance costs, especially if they are placed on public goods or considered as externalities. For instance, Nabuurs et al. (2007) found that mitigation measures such as reducing deforestation or enhancing bio-fuel production from plantations may have negative impacts in terms of decreased local incomes (because of stricter forest protection rules) or damaged ecosystem properties (biodiversity, water and soils affected by mono-specific, short-rotation energy crops). Their existence suggests, as noted by IPCC (2007b), that a two-way relationship exists between climate change mitigation and sustainable development, and that such connection is not always mutually beneficial. In relation to this, the glossary of IPCC's Second Assessment Working Group III report (IPCC, 2001) included the term *co-impact* as a way to refer in a more generic sense to both the additional positive and negative side-effects of primary benefits.

For the case of energy efficiency in buildings, an example of ancillary costs is the environmental impact of retrofit activities (e.g. life-cycle emissions of retrofit materials and activities, additional resource consumption and waste disposal, etc.). Though the identification of such ancillary costs is beyond the scope of this dissertation, they cannot be disregarded as unaccounted negative effects of improving the energy efficiency of buildings.

2.2.3.3. The economic and policy relevance of the co-benefits of climate change mitigation

The understanding of the relevance of co-benefits has developed in parallel to the science of climate change since the first IPCC's assessment reports released in the early 1990s (Pearce, 2000). An important milestone in that process was an OECD experts' workshop that gathered substantial input and contributed to frame the importance of the issue. The related statement by Krupnick et al. (2000, p. 1) is still up to date and defines with clear precision the significance of the issue under discussion:

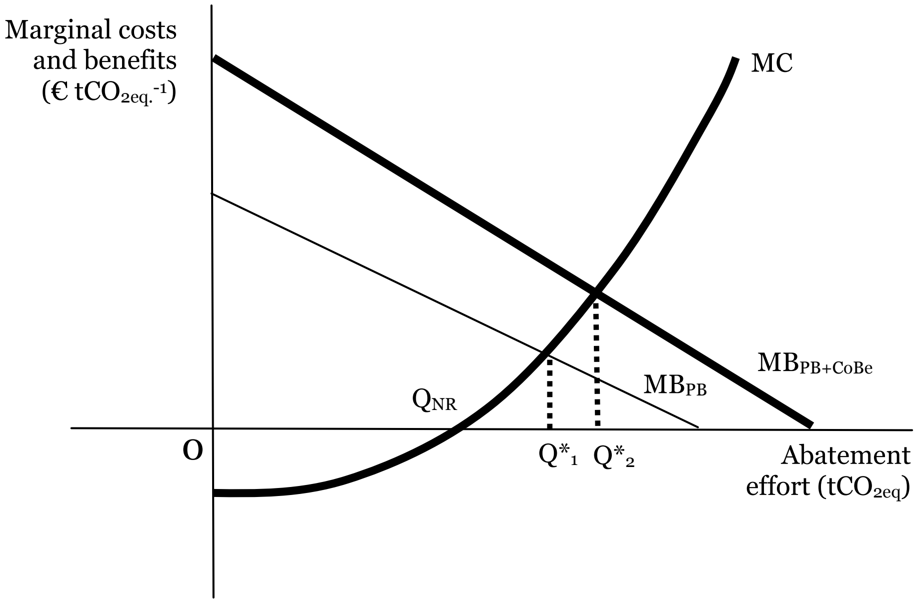
> "A great deal is at stake […]. If these ancillary benefits are significant [...] then perhaps the development and implementation of climate policy should be altered. At the very least, knowing that the possibly high cost of climate change mitigation might be largely offset by ancillary benefits could speed up and spread the commitment to action as well as implementation itself. On the other hand, if these effects are "small" relative to the other costs or the benefits of reducing GHGs, perhaps they can be safely ignored in the debate over climate change mitigation policy — at least from the perspective of efficiency — simplifying an already too complex debate"

This idea is graphically presented in Figure 3. Following the optimal pollution level hypothesis (Turner et al., 1993), it is proposed that the efficient level of emissions reduction is reached (theoretically) when the marginal cost of abating one additional unit of pollutant (MC)[4] equals the marginal benefit of reducing that unit. In the case of climate change, the most often considered primary benefits of abating GHG emissions are the energy savings and the value of avoided GHG emissions (i.e., avoided social cost of carbon). If only these are considered (MB_{PB}), then the optimal abatement effort is set at Q^*_1, whereas if primary and co-benefits are accounted for ($MB_{PB+CoBe}$), a more ambitious abatement optimum (Q^*_2) is obtained. And not only that: if co-benefits are considered, larger net benefits (the area

[4] Note that energy efficiency in buildings, unlike other mitigation options like renewables or carbon capture and storage, delivers emission reductions at negative costs (when energy saving benefits more than offset its costs). Consequently, a *no-regret* level of emissions reduction (Q_{NR}) can be also defined.

comprised between $MB_{PB+CoBe}$ and MC) are achieved, thus enhancing the appeal of energy efficiency investments from the perspective of society's aggregated welfare.

Figure 3.The optimal pollution level hypothesis: the case of co-benefits of energy efficiency in buildings



Source: adapted from Turner et al. (1993) and Pearce (2000).

In addition, co-benefits can contribute to tackling an important barrier at the decision-making level that prevents the adoption of ambitious climate policies. It has been suggested that policy-makers are far more concerned about short-term mitigation costs than with long-run balances of costs and benefits. This sort of loss aversion is the result of perceiving that even if strong mitigation action is started in the present, its effects on global temperatures will be hardly discernible and considerably delayed in time; in fact, at an inter-generational time scale (Pearce, 2000). Since they emphasize the positive effects on the welfare of the present generation, it can be argued that co-benefits allow by-passing the apparent conflict existing between the interests of present of future generations.

2.2.3.4. Monetary values of co-benefits

Theoretically, for the co-benefits identified in Table 3, a monetary value could be estimated based on willingness-to-pay or willingness-to-accept methodologies (see Pearce et al., 2006). However, for some of the categories identified (e.g., employment effects) limited examples of valuation techniques are yet available and for other (e.g., value of reduced mortality) some uncertainties remain. Though reporting results in physical units (e.g., net employment effects, life-years saved, etc.) is advisable in such cases, monetary values provides a common *measuring rod* that, by expressing the value of changes in welfare through a single, monetary unit, allows comparing and adding co-benefits to the financial costs and benefits usually considered in the economic assessment of energy efficiency interventions.

As some categories of co-benefits overlap, special care must be taken in order to avoid *double counting*, especially if monetary values wants to be incorporated into cost-benefit analyses and supply curves. This is for instance the case of the various categories of co-benefits related to fuel poverty alleviation (lower utility expenses, increased thermal comfort and reduction of fuel poverty-related mortality and morbidity). A paradigmatic case of double counting is the category *Increased rental or selling prices* since many of the positive effects enjoyed by building owners or users end up reflected in the price of the property.

Table 3. Co-benefits of energy efficiency in buildings

	Category	Definition	Economic valuation tool	Key references
Direct impacts on residents and on building users and owners	**Reduced utility expenses**	Benefits mostly realised as reduced energy expenses, but also water and other utilities.	Energy and other utility prices	Hermelink (2006) ; Kats (2006)
	Increased thermal comfort	Improved indoor temperatures, especially in fuel-poor households	Willingness to pay	Milne and Boardman (2000); Healy and Clinch (2002)
	Improved indoor air quality and environmental conditions	Reduced concentration of indoor air pollutants, avoiding sick building syndrome	Hedonic prices	Jakob (2006)
	Enhanced protection against outdoor noise	Better protection again external noise, avoidance of noise-related diseases and risks	Hedonic prices	Jakob (2006)
	Fuel poverty alleviation	Reduction in the number of households unable to meet their basic energy needs, namely heating.	Avoided costs	Clinch and Healy (2001)
	Reduction of fuel-poverty related mortality and morbidity	Reduction in the number of excess winter deaths and in the incidence of mental and physical diseases related to inadequate indoor temperatures	Avoided costs	Clinch and Healy (2001)
	Improved safety conditions, lower maintenance costs and extended lifetime of buildings	Particularly when old and poorly-maintained space and water heating systems are used	n.a.	Schweitzer and Tonn (2002)
	Increased rental or selling prices	*Ceteris paribus*, efficient buildings have a number of advantages that make them more attractive to the demand of real estate markets	Hedonic prices	Jakob (2006)
Regional env. and health	**Reduced regional air pollution levels**	Reduced energy consumption in buildings will lead to lower concentration of regional air pollutants (NO_x, NH_3, SO_2, VOC or PM)	Avoided costs	van Vuuren et al. (2008)
	Lower resource consumption and waste disposal	Lower water usage and sewage production, less construction and demolition wastes.	n.a	Kats (2005)
ider societal gains	**Better functioning of energy provision systems**	Transmission and distribution (T&D) loss reduction, fewer emergency service calls, utilities' insurance savings and lower bad debt write-off	n.a.	Schweitzer and Tonn (2002)
	Improved energy security and reduced energy dependency	Reduced economic losses related to energy prices above competitive market levels, reduced supply disruptions, reduced costs of oil security enhancing policies.	Contingent valuation, avoided costs	Maibach et al. (2007)
	Employment effects	Net employment creation, when there is persistent unemployment due to some failure in labour markets	Choice experiment	Soliño (2010)
	Improved worker productivity and enhanced learning in schools	Improved worker performance as a result of better indoor environmental conditions	n.a.	Seppänen (2008)
	Lower long-term energy prices	Following a reduction in the demand. Lower prices may incentive subsequent increases in energy consumption (rebound effect)	Energy prices	Wiser et al. (2005)

Source: own elaboration based on references

Chapter 3

METHODOLOGICAL APPROACH AND DATA SOURCES

"It is the mark of an instructed mind to rest satisfied
with the degree of precision which the nature of the subject admits
and not to seek exactness when only an approximation of the truth is possible."

Aristotle

3. METHODOLOGICAL APPROACH AND DATA SOURCES

3.1. DISSERTATION RESEARCH DESIGN

This dissertation is organised in three blocks from the perspective of the results and the methodological approaches employed:

- methodologies for the estimation of fuel poverty rates (see Section 3.2.1.2), for measuring the incidence and investigating the causes of fuel poverty in Hungary – Chapters 4 and 5;
- case studies (see Section 3.2.2), for an analytical exploration of two country-specific sub-typologies of fuel poverty in Hungary – Chapter 6; and
- financial and social cost-benefit analysis (see Section 3.2.3), for understanding how the valuation of non-market co-benefits enhances the appeal of residential energy efficiency investments from a public policy perspective.

3.2. METHODOLOGICAL APPROACHES EMPLOYED

3.2.1. The measurement of fuel poverty

3.2.1.1. Introduction

Quantitative research techniques have been employed for the study of fuel poverty since its inception. Boardman (1991) explicitly linked the notion of fuel poverty to a10% ratio of energy expenses vs. household income, thus making indicators become a central piece of the scientific examination of this socio-environmental issue. Later on, as a social welfare issue subject to the attention of public institutions (mostly in the UK), objective measurements have been sought by practitioners and policy-makers in order to calculate its extent and to monitor progress and the impact of policies and measures– as an example, see the UK's latest annual report on fuel poverty statistics (DECC, 2012). With that purpose, researchers and institutions have first resorted to existing datasets collected for more general purposes and then designed and carried out on fuel poverty-specific surveys and measuring instruments.

3.2.1.2. Approaches to measuring fuel poverty rates

3.2.1.2.1. Temperatures

Recognising the emphasis posed on indoor thermal comfort by the fuel poverty literature, the temperature approach measures fuel poverty rates as the percentage of households unable to guarantee an adequate indoor thermal regime. An often cited threshold of minimal thermal comfort based on World Health Organisation standards is the 18-21 ºC temperature range[5] (Collins, 1986; BERR, 2001; Healy and Clinch, 2002), with temperature levels often recommended to be at the higher end of the range for more vulnerable population (e.g., the elderly and children) and for the living room.

Though in theory this approach would provide direct, objective measurements of fuel poverty, in reality faces significant difficulties (e.g. intermittentoccupancy of the dwelling) for its practical implementation that call into question the adequacy of the method and the reliability of the data (Healy, 2004). Because of this, surveys of temperatures are almost non-existent (Buzar, 2007c), which means that temperature-based fuel poverty rates are not reported.

However, this does not imply that data on indoor temperatures is not being collected and analysed in fuel poverty studies. For instance, a 1,500-household survey conducted in Ireland in March 2001 (Healy and Clinch, 2002) found that home temperatures measured during the time of the interviews ranged between 12 ºC and 26 ºC, though researchers noted as a

[5] In Scotland, slightly higher minimum indoor temperatures (23ºC) have been set as a target by the national government for the elderly and infirm households (Scottish Executive, 2002), though no scientific evidence is provided for supporting this administrative decision.

drawback of the method the suspect that some households may have purposely pre-heated the room to a temperature higher than usual before the interview. Temperatures can be also used as an indicator of the success, e.g., a study on the effects of the UK's *Warm Front* scheme found after the intervention an effective increase in mean indoor temperatures (from 17.1 ºC to 19 ºC) and a slight increase (from 18.9 ºC to 19.1 ºC) in the perceived neutraltemperature, i.e., the temperature at which most residents feel comfortable (Hong et al., 2009).

An important drawback of this approach is that it only focuses on space heating, disregarding other domestic energy end-uses such as lighting, hot water or appliances. Even though heating is usually the most expensive item of a household's energy budget, and therefore the most likely end-use for which a deficit or unmet needs are reported, focusing on temperatures alone leads to a narrower, biased understanding of fuel poverty.

3.2.1.2.2. Expenditure approach

The usual way the expenditure approach is implemented is through the estimation of an energy expenses vs. net income ratio. If a threshold indicating the level at which fuel poverty starts is defined and a representative sample of households is available, then it is possible to estimate the number or proportion of fuel poor households. Indicator and concept largely overlap following this approach, as clearly shown by the first recorded definition of fuel poverty according to which fuel poverty occurs when a household is unable "to have adequate energy services for 10 per cent of income" (Boardman, 1991, p. 227).

A crucial aspect of this approach is how energy expenses are measured. The official UK methodology estimates fuel poverty rates based on the required (not actual) energy expenditures required to maintain an adequate "standard of warmth". This standard is explicitly defined by a temperature range – “21ºC in the living room and 18ºC in the other occupied rooms” – based on recommendations of the World Health Organisation (BERR, 2001, p. 6). These theoretical energy requirements are calculated by modelling the fuel requirements required to achieve and adequate level of warmth and then combining those with fuel prices. Fuel requirements are modelled upon factors such as the size of the dwelling, the energy mix of the household (i.e., fraction of energy needed for different domestic uses), the heating regime of the household (standard, full or partial), energy prices (disaggregated by regions and payment method) and the energy efficiency of the building (DECC, 2012).

However, no other country but the UK has a fuel poverty-specific measuring instrument such as the Household Condition Survey. Households’ actual energy expenditure is nevertheless available in alternative statistical data sources such as household budget surveys, which are conducted in EU countries for more general purposes like the calculation of inflation rates and national accounts. However, as the UK experience shows (Hills, 2012), households systematically use less energy than what would be required for the satisfaction of an adequate thermal regime. The reason is that households ration their consumption of energy services (Waddams-Price et al., 2006) as they are pressed by other competing domestic budget headings and income constraints. As a consequence, fuel poverty rates calculated with actual energy expenditures will be consistently below fuel poverty rates calculated with (modelled) required energy expenditures. In other words, the percentage of households spending more than 10% of their income on energy costs is below the percentage of households having to spend more than 10% of their on energy to guarantee an adequate satisfaction of domestic energy needs.

An important element of the expenditure approach is where to put the fuel poverty line, i.e., the percentage of energy expenditures vs. income above which a household is considered to be in fuel poverty. In the UK, since 2001 fuel poverty rates have been estimated upon a 10% fuel poverty line (DECC, 2012, p. 3): “A household is said to be fuel poor if it needs to spend more than 10 per cent of its income on fuel to maintain an adequate level of warmth”. The 10% threshold was first proposed by Brenda Boardman (1991) in her book *Fuel Poverty: from Cold Homes to Affordable Warmth.*

Even though this simple quantitative rule has been criticised because of the lack of scientific evidence supporting the 10% threshold (Healy, 2004), factual evidence seems to have supported this decision originally. As Boardman (2010, p.22) herself recalls:

> This was based on 1988 data when household average expenditure on energy for use in the home was 5 percent of the weekly budget, and the 30 per cent of households with the lowest income did, indeed, spend 10 per cent. The figure of 10 per cent was, therefore, in some sense ‘affordable’ for the poorest households. It was what they were spending, although they were often cold as well. Another reason for taking 10 per cent was that work by two economists at the Department of Health and Social Security had stated that expenditure at a level equivalent to twice the median is ‘disproportionate’ (Isherwood and Hancock, 1979). For households, this only occurred with expenditure on housing and with fuel. […] There was another useful synergy between the two approaches: the Isherwood and Hancock (1979) definition of twice the median indicated that it was the households in the lowest three deciles who had disproportionate fuel expenditure, which confirmed the approach that I had taken. The ‘catchment’ area for the fuel poor was not the lowest two deciles or some other proportion, but the 30 per cent of households with the lowest incomes.

As noted by Liddell et al. (2011, p. 18), Boardman’s proposal (10%) was based on previous work on the by Isherwood and Hancock (1979) on the affordability of domestic energy, which defined households with “high fuel expenditure as those spending more than twice the median (i.e. 12%) on fuel, light and power”.

It is nevertheless unclear why the 10% adopted by the UK Fuel poverty Strategy in 2001 was based on data from 1988 (Liddell et al., 2011). And it is also uncertain why if the early calculations of the 1970s and 1980s were based on data on actual expenditure, the 10% threshold is calculated with the modelled energy expenses required for guaranteeing and adequate thermal standard.

To add further confusion, there has been a tendency to apply uncritically the 10% threshold outside the UK context, even if, as expressed by its original proponent, it was only applicable to the UK in the year for which it was proposed, i.e., 1988 (Boardman, pers. comm.). Still, the 10% fuel poverty line has also been applied to other countries like Ireland (Healy and Clinch, 2001; Scott et al., 2008), New Zealand (Lloyd, 2006) or Spain (Tirado-Herrero et al, 2012)[6]. For this reason, Boardman (pers. comm.) has proposed an EU transferable fuel poverty line according to which "a household is in fuel poverty if it would need to spend more than twice the median (as a proportion of expenditure) on all energy uses in the home." This proposal, which is not exempt of problems, was taken up by the European Commission (EC, 2010a) – seeSection 4.2.1.3; however, it wasthen applied as twice the average energy expenditure (and not median), which hasnot contributed to making things more harmonised.

Related limitations of the expenditure approach are the various ways in which expenditure (e.g., actual or required) and income may be accounted for (e.g., housing costs included or not; gross vs. net income) and the difficulty to make cross-country comparisons as countries may lack the required data or have different purchasing power and energy prices (Healy and Clinch, 2002; Healy and Clinch, 2004; Healy, 2004).

In a way, the critique about the arbitrariness of fuel poverty lines is shared by indirect poverty indicators based on income data (with an income cut-off or poverty line used to identify the poor), like the EU's at-risk-of-poverty ratio (Willits, 2006). As argued by opponents, indirect (objective, income-based) measures of poverty also face difficulties for making an accurate

[6] In this latter case, a reason for choosing the 10% threshold is that it coincided with twice the average energy expenditure (as a proportion of annual income) of Spanish households for the period of analysis (2006-2010). This is in line with the proposal of the European Commission (2010).

estimate of a household's income and fail to capture the multi-dimensionality of the poverty phenomenon (*ibid.*).

On a more positive note, a clear advantage of the expenditure approach is that it considers all end-uses of energy at home (i.e., hot water, cooking, lighting and appliances) and not only heating.

All in all, the expenditure-based approach, which is inextricably linked to the 10% fuel poverty line, has remained practically unchanged since its proposal in the 1990s. However, since 2012 it is being challenged by a new methodology proposed by the Hills Fuel Poverty Review commissioned by the British government. According to this newly proposed indicator, households should be counted as fuel poor if (Hills, 2012, p. 33):

> a) They had required fuel costs that were above the median level; and
> b) Were they to spend that amount, they would be left with a residual income below the official poverty line.

Even though more sophisticated in its formulation (as it relies on two threshold or poverty lines that change along the time), it does not avoid the inherent arbitrariness of this measurement approach.

3.2.1.2.3. Self-reported or consensual approach

The self-reported approach relies on a household's self-assessment of its living conditions for determining whether it can be considered as fuel poor or not. Referred to also as *consensual* approach, according to Healy's (2004) definition it is meant to account for certain basic goods (e.g., adequate heating facilities) or essential household attributes (e.g., a damp-free home) that are consensually considered as *socially perceived necessities* (Mack and Lansley, 1985) and whose absence can be taken as an indicator of fuel poverty.

The self-reported or consensual approach is the fuel poverty-equivalent of direct measures of non-monetary or material deprivation (see Willits, 2006). It identifies fuel-poor households as those lacking certain attributes (e.g., ability to afford enough heating or pay utility bills on time) commonly accepted as a necessity in a given society. Unlike indirect, income-based (i.e., the expenditure approach, see Section 3.2.1.2.2), material deprivation indicators focus on *outcomes* and assess the actual standard of living depending on income but also “needs, health conditions, social networks or other personal constraints and abilities” (Eurostat, 2009b, p. 1). Since it recognises the importance of household resources and the multi-dimensional nature of poverty, advocates of this approach consider it preferable to indirect, income-based measures, though recognising that a combination of both is often a good solution (Willits, 2006).

The consensual approach for measuring fuel poverty has relied on three indicators of the EU Survey on Income and Living Conditions (EU SILC)[7]: *Inability to keep the house adequately warm, Arrears on utility bills,*and *Leaking roof, damp walls, floors or foundation, or rot in window frames or floor*(see Healy and Clinch, 2002; 2004; Healy, 2004; Waddams-Price et al., 2006; Scott et al., 2008). It must be noted the large consensus about their character of socially perceived necessities: as shown in Table, over 95% of the Hungarian and EU population considered them as necessary[8] in 2007. Its enforced lack can thus be safely assumed to be an indicator of domestic energy-related deprivation.

[7]These three items are part EU SILC’s material deprivation rate, which also includes the inability to pay rent or mortgage, to face unexpected expenses, to eat or meat or proteins regularly, to go on holiday and the enforced lack of a TV set, a washing machine, a car or a telephone. These are all items that most Europeans consider essential for having an adequate life.

[8] With the exception of *No leaking roof, damp walls floor or foundation* Hungary is the EU27 country with the lowest proportion of the population who consider that living in a home free of these energy-deprivation indicators is necessary (74%, as compared with the EU27 average – 96%).

Table 4.Proportion of the population considering as necessary and absolutely necessary EU-SILC items. EU27 and Hungary (2007)

EU-SILC item	EU27 Necessary	EU27 Absolut. necessary	Hungary Necessary	Hungary Absolut. necessary
Able to face unexpected expenses	75%	32%	82%	44%
One week annual holiday	44%	15%	63%	29%
Not having arrears on rent/mortgage	96%	62%	96%	65%
Not having arrears on utility bills	98%	68%	98%	72%
Not having arrears on loans	88%	48%	97%	65%
Meat, chicken or fish every two days	80%	43%	73%	39%
Able to keep the home adequately warm	97%	62%	99%	78%
Washing machine	89%	48%	97%	66%
Colour TV	55%	19%	84%	47%
Landline telephone	55%	18%	47%	18%
Mobile telephone	38%	12%	57%	21%
Car	51%	17%	43%	13%
No leaking roof, damp walls floor or foundation	96%	68%	74%	54%
Home with enough natural light	83%	39%	96%	61%
Bath or shower	94%	63%	97%	72%
Own indoor flushing toilet	96%	69%	96%	75%
Enough space and privacy for everybody in the household	72%	31%	84%	46%

Note: the category 'necessary' includes the percentage of the population who answered 'absolutely necessary'
Source: EC, 2007.

Advocates of the self-reported or consensual approach argue that it is preferable to the expenditure-based approach because it is based on households' actual perceptions and statements and can be adjusted through time to incorporate variations in socially perceived necessities (Healy, 2004). However, this also connects with the most significant shortcoming of this approach. The subjective way in which different households understand thermal comfort and dwelling attributes makes the assessment of these indicators a difficult task. In relation to this, the fact that the poor have lower individual expectations (a phenomenon labelled as *adaptive preferences*) and that they may feel ashamed to admit their inability to satisfy certain necessities or to afford certain items, have been identified as drawbacks of EU-SILC material deprivation indicators (Eurostat, 2009b). Equally, Boardman (2011) has suggested that the fuel poor are subject to a *denial of reality* bias (e.g., they will often not admit being uncomfortably cold at home). She has also warned about the distorting effects of cultural differences in the perception of indoor warmth and affordability of energy costs for consensual approach-based cross-country comparisons of fuel poverty in the EU.

An additional shortcoming is the clear bias of the self-reported approach towards heating. Though in an EU context space heating is probably the most relevant domestic end-use of energy, other uses cannot be disregarded.

3.2.1.2.4. Comparing approaches: are they capturing the same fuel poor households?

Though necessary, a systematic exploration of the level of coincidence between the expenditure and consensual approaches is still lacking. Nevertheless, studies indicate some level of disagreement, as discussed below.

The correlation between expenditure and self-reported measures has been analysed by Waddams-Price et al. (2006). Based on a 3,417-household sample, these authors assessed to what extent households spending more than 10% of their net income on energy also declared to be unable to satisfy their heating and hot water needs. Even though a chi-square analysis indicated strong correlation between both measures, only 25.6% of the sample that were above the 10% threshold acknowledged being unable to pay for their heating and hot water. All in all, 28% of all households were defined as fuel poor by the expenditure approach and 16% under the self-reported approach. Such results suggest that in the UK the number of fuel poor households as counted by the expenditure approach is larger than consensual or self-reported estimates.

Similarly, advocates of the self-reported approach have hypothesised that this method *under-declares* levels of thermal discomfort and other sorts of hardship and housing deprivation.

Based on evidence from Ireland, Healy and Clinch (2002; 2004) have argued that households suffering from intermittent strains of fuel poverty are less likely to report thermal discomfort than the chronic fuel-poor, and have questioned whether the two approaches – self-reported vs. expenditure-based – are in fact measuring two types of fuel poverty – persistent vs. intermittent. If this is the case, the self-reported approach would then offer more conservative estimates that mostly account for chronic fuel poverty.

The same authors (Healy and Clinch, 2002) have also compared the results obtained by the temperature and self-reported approach in a survey of 1,500 Irish households that recorded living-room temperatures at the time of the interviews in March 2001. Their results indicate that households self-declaring to be in fuel poverty were more likely to live in an inadequately heated home, though figures are far from offering a perfect match between the two approaches. This way, only 29.4% of the self-reported fuel-poor households had a living-room below 18 ºC (68.6% below 20 ºC), whereas 10.8% of non-fuel-poor were in a living room under 18 ºC (49.3% below 20 ºC). The researchers concluded that not all the households defined as (self-reported) fuel-poor were suffering from thermal discomfort, and pointed at the flaws of the temperature method (see Section 3.2.1.2.1) as a main cause of this apparent disagreement.

The picture that arises is that even though the three identified approaches to measuring fuel poverty are certainly correlated (i.e., households spending over a certain percentage of their income on energy tend to live in cold homes and to declare being unable to afford the energy they need), substantially different fuel poverty rates can be obtained for the same location and time. However, since a unified dataset with household microdata on expenditures, temperatures and self-reported perceptions/statements is not yet available, a proper comparison of approaches is still missing.

3.2.1.3. Approach adopted in this doctoral research

For measuring fuel poverty rates in Hungary, both the expenditure and consensual/self-reported approaches have been applied. As presented in Chapter 4, two primary or headline indicators (or fuel poverty rates) based on each of these two approaches are complemented by four secondary indicators that illustrate related aspects of the fuel poverty phenomenon in Hungary (e.g., proportion of households with significant expenditure of firewood, percentage of the population with arrears in utility bills, etc.). These secondary indicators are also expenditure-based and self-reported/consensual.

The analysis of contributing factors or causes of fuel poverty (Chapter 5) is based on the whole range of indicators presented in Chapter 4. The assessment is realised at two scales: i) first through a cross-country comparison (Hungary vs. other EU Member States), when data are only available at a country level; and ii) at a national level, when disaggregated results or microdata for Hungarian households (or household categories) is available.

The temperature approach is not considered because of the absolute lack of data on indoor temperaturesof Hungarian dwellings.

3.2.2. Case studies

3.2.2.1. Case studies as a research strategy

According to Yin (2003, p. 1), case studies are "the preferred strategy when *why* and *how* questions are being posed, when the investigator has little control over events, and when the focus is on a contemporary phenomenon within some real-life context". They consist of an intensive (i.e., rich in data and detail) investigation of a selected unit with functioning coherence focusing on developmental factors in relation to its environment. As a research technique, its uniqueness is due to the choice of the individual unit rather than on the methodology applied for its investigation, which can of be of various sorts (Flyvbjerg, 2011).

The anecdotal character of evidence collected through case studies may raise some concerns about the validity of the findings. This way, it has been pointed that generalising on the basis of individual cases is risky, or that case studies have a bias towards verification (i.e., they tend to confirm the researcher's hypothesis). These critiques have been labelled as "misunderstandings" by advocates of case studies who defend the methodological and theoretical soundness of this research technique (see Flyvbjerg, 2011).

In the fuel poverty literature, case studies have been used to illustrate research findings with real-life examples (Lomax and Wedderburn, 2009), to make an exploration of previously uncharted issues or locations (Brunner et al, 2011) and also to report on best practices (Eaga Partnership Charitable Trust, 2003). They are often based on qualitative data (interviews) as a primary source of information.

3.2.2.2. Approach adopted in this doctoral research

Quantitative paradigms are thought to be prevalent in the analysis of fuel poverty (Harrington et al., 2005). This dissertation is not an exception to this rule. However, recognizing the importance of understanding how fuel-poor households live and deal with their energy affordability constraints, this research has also devoted time and efforts to analyse some specific cases of fuel poverty that are more likely to inform on the specific features of fuel poverty in Hungary – and to a certain extent in Central and Eastern Europe – or on typologies of fuel poverty that have not been previously described in the fuel poverty literature.

Case studies are thus used in this doctoral thesis as a complementary research technique to the quantitative analysis based on fuel poverty indicators and contributing factors that is presented in Chapters 4 and 5. Its inclusion stems from the preliminary findings obtained in the report *Fuel poverty in Hungary. A preliminary assessment* (TiradoHerrero and Ürge-Vorsatz, 2010). In this study, the two cases contained in Chapter 6 (fuel poverty among the poor Roma households in rural and Hungary and among households living in *panel* buildings connected to district heating) were already present. They were identified in collaboration with the Hungarian NGO *Védegylet* – Protect the Future Society, which commissioned the study, and reflect a wider concern in Hungary society and social organisations about the intensity and differential characteristics of the fuel poverty endured by these two household typologies.

The cases selected do not illustrate the average experience of a Hungarian household in fuel poverty, which would be represented by a low-income family living in an energy inefficient single family house using either natural gas or firewood for space heating. However, they explore two typologies of fuel poverty not previously described in the fuel poverty literature which are very likely to be present in other CEE countries. Their quite specific features also allow for reflecting on the boundaries of the fuel poverty notion, which as presently defined may be too narrow to contain a more complex reality. The analysis of case studies thus aims not only at describing how people actually experience fuel poverty but also at drawing more general conclusions for the understanding of the fuel poverty concept.

3.2.3. Social cost-benefit analysis (CBA)

3.2.3.1. Fundamentals of the social CBA

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). Theoretical and methodological developments have made CBA a sophisticated device that, as long as it can be fed with good enough information, provides a framework for the comparison of a set of relevant policy options from an aggregated welfare perspective.

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

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

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, investment and operation costs and energy saving benefits). On the other hand, social CBA defines benefits and costs as increases and reductions in human wellbeing (i.e., utility) and thus measures the net contribution of each of the defined policy options to the aggregated welfare of a society (European Commission, 2008).

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

- 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. Cost and benefits thus need to be estimated as shadow prices or accounting prices, i.e., prices that would prevail in competitive markets and reflect the social opportunity cost of forgone resources. 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.
- 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 is available.
- Costs and benefits occurring in different years are discounted through a social discount rate that reflects how society weighs future costs and benefits against present ones. This may be different from the financial discount rate in the case of failures in financial markets.

3.2.3.2. Social CBA for the assessment of residential energy efficiency interventions

Although somehow scarce, several CBA examples that have examined the social wellbeing effects of fuel poverty alleviation via residential energy efficiency investments exist. Perhaps the most relevant and complete available case is Clinch and Healy (2001), an *ex ante* cost-benefit analysis assessing a large scale programme upgrading 1.2 million Irish dwellings to the 1997 Irish building regulations that incorporated a range of primary benefits and co-benefits: the value of the energy savings and associated lower CO_2 emissions, the benefits of reduced SO_2, NO_x and PM_{10} atmospheric concentrations and the mortality, morbidity and comfort benefits linked to the positive fuel poverty-alleviation effects.

Another relevant example is the *ex post* valuation of the health effects of an already implemented local scale retrofitting project in New Zealand that added the most common energy and CO_2 emission savings to the value of the reduced number of visits to general practitioners, hospitalizations, days off school and days off work registered in the intervention group (Chapman et al., 2009).

Other similar cases of relevance to the two main topics of this dissertation are Taylor and Lloyd (2004) for insulation retrofits in under-heated homes in New Zealand; and Winkler et al. (2000) for energy efficiency investments in low-cost housing in South Africa.

3.2.3.3. Approach adopted in this doctoral research

The social CBA analysis presented in Chapters 7 and 8 is based on two previously existing bottom-up models model (Novikova, 2008; Ürge-Vorsatz et al., 2010) – see Section 3.3.1. Consequently, it inherits the methodological features, assumptions and limitations of bottom-up modelling: it is an assessment tool rich in data about technologies and the sector (e.g., composition of the residential stock, cost and energy savings of technological options, etc.) that disregards inter-sectoral relationships, e.g., effects of the increased demand of materials and labour on general price levels (Novikova, 2008).

The social CBA methodology has been applied in this dissertation following basic principles of the literature (especially Pearce et al., 2006; EC, 2008a) and more specifically the example of Clinch and Healy (2001). It consists of both a financial (Chapter 7) and social cost-benefit analysis (Chapter 8) of two energy efficiency scenarios (MID and DEEP) compared against a *business-as-usual* scenario with current policies. For the valuation of certain non-market co-benefits (i.e., reduced excess winter mortality and avoided emission of pollutants different from GHG), in the social cost-benefit analysis, the benefits transfer technique has been applied.

3.3. DATA SOURCES

3.3.1. An overview of the data sources employed

To fulfil its research objectives, this dissertation has relied on the following data sources:

- Secondary sources:
  - Existing statistical information retrieved from or purchased to Eurostat, the Hungarian Central Statistical Office (KSH) and other Hungarian and foreign organisations:

    Household Budget Survey (HBS): this annual survey collects on an annual basis statistical information on the housing conditions and as well as on household income, consumption and composition. This is then used for the calculation of the inflation index, subsistence levels and national accounts (KSH, 2012). Two types of data from this source were used: i) aggregated results on the structure of household consumption and expenditures, which can be retrieved online from the website of KSH; ii) two datasets (years 2005 and 2008) with anonymised microdata on annual income, expenditures by COICOP categories and characteristics of the household and the dwelling, which were purchased to the KSH through a CEU research grant. These data were used to analyse the evolution of domestic energy expenditure in household consumption and for the estimation of expenditure-based fuel poverty rates and indicators (Section4.2.1 and 4.3.2) and for the case study on fuel poverty among households living in prefabricated panel blocks served by district heating (Section 6.3.1).

<u>2009 Energy Use moduleof the Household Budget and Living Conditions Survey (HEF2009)</u>: this is a one-time survey carried out in 2009 by the Hungarian Central Statistical Office (KSH) and owned by Hungary's Energy Centre (Energia Központ). Since the original microdata had to be purchased and referred to one single year, only aggregated results coming from a summary table generously provided by Lászlo Elek (Energy Centre) were available. These data were used for understanding the characteristics of fuel poverty in households living in pre-fabricated panel buildings connected to district heating – see Section 6.3.3.

<u>Survey on Income and Living Conditions (EU SILC)</u>: this is an EU reference source for comparative statistics on income distribution and social exclusion at European level on which structural indicators on social cohesion are based (European Commission, 2008). For the analysis of fuel poverty following the consensual or self-reported approach Healy (2004), three survey items are considered: Inability to keep the home adequately warm (HH50), Arrears on utility bills (HS020) and Leaking roof, damp walls, floors or foundation, or rot in window frames or floor (HH040). With this aim, aggregated and disaggregated results for Hungary and other EU Member States (presented for comparative purposes) were retrieved online from the website of Eurostat. These were later used for presenting results of self-reported fuel poverty rates and indicators (see Section 4.2.2 and 4.3) and for analyzing the relationship between fuel poverty and income poverty (see Section 0).

2007 ad hoc module on housing conditions of EU SILC: also a one-time survey (only for the year 2007) on housing conditions. It is part of a series of ad hoc modules developed on supplementary social inclusion elements not considered in the range of permanent variables collected by EU SILC each year. More specifically, data for item MH060 (Dwelling equipped with air conditioning facilities) and MH070 (Dwelling comfortably cool during summer time) were retrieved on-line from the Eurostat website. They were employed for presenting results of self-reported summertime fuel poverty indicators (see Section 4.4.2) and for analyzing the relationship between fuel poverty and income poverty (see Section0).

Negajoules project: a 2000-household detailed survey conducted by the Budapest-based Energia Klub in 2010. It contains detailed information on the characteristics of the residential stock (buildings, heating systems, lighting, appliances, etc.), on the planned and realised improvement in the energy efficiency of homes, on domestic energy expenditures, etc. Some of the many data contained in this source were employed in the cost-benefit analysis (Chapter 7 and 8) and also in the the case study on fuel poverty among households living in prefabricated panel blocks served by district heating.

ODYSEE[9]: a database of energy efficiency indicators for key end-use sectors (industry, transport, households and services) presented at a Member State level. It is coordinated by France's energy and environment agency (ADEME), supported under the Intelligent Energy Europe programme and participated by the energy efficiency agencies of the 27 Member States plus Norway and Croatia (ADEME, 2009). Access to the datasets was possible through CEU's subscription; data were used in the

[9] ODYSSEE database [URL: http://www.odyssee-indicators.org/].

analysis of contributing factors to fuel poverty in Hungary in an EU context (Section 5.4).

- Scientific and policy literature located through intensive archival review of relevant documents during the doctoral research period. These documents are widely cited throughout the whole dissertation with multiple purposes, e.g., for a better understanding on the causes of fuel poverty in Hungary (Kessides, 2000; Elek, 2007), for the valuation of co-benefits through the benefits transfer technique in the social cost-benefit analysis (Desaigues et al., 2011), etc.

▪ Semi-structured interviews with a number of individuals in relevant Hungarian organisations (e.g., Energy Centre, Energy Club, the Budapest electricity company ELMŰ, two NGOs working with the Roma, etc.) and four rural Roma households affected by fuel poverty. They are mostly used as complementary sources of information for illustrating, commenting or qualifying findings obtained from secondary sources. However, in one of the two unconventional fuel poverty cases presented in Chapter 6 (poor Roma households in rural areas of Hungary), interviews are the main data source given that practically no recorded secondary information is available for this particular issue and population group.

▪ An existing Excel-based model used for forecasting the employment effects of a large scale, high energy efficiency retrofit of the Hungarian building stock (Ürge-Vorsatz et al., 2010), which was itself based on a previously existing model developed for the estimation of the carbon mitigation potential of residential energy efficiency measures in Hungary(Novikova, 2008). The author of this dissertation was involved in the elaboration of the employment model (Ürge-Vorsatz et al., 2010), which was subsequently expanded, refined and adapted to the purposes of the cost-benefit analysis in this dissertation – see Section 7.3.1.

As shown above, the research mostly relied on secondary sources. The reason is that even though very little information on fuel poverty and the co-benefits of residential energy efficiency is available as such in Hungary, the country has a wealth of statistical information and other data sources produced by national organisations. For the sake of efficiency, this doctoral research has attempted to make a comprehensive assessment of the existing information from a fuel poverty perspective rather than producing new data.

3.3.2. Limitations of the data

Quantitative data from secondary sources provide a key input for this dissertation. Even though, as said above, a large amount of fuel poverty-relevant data is available, none of the statistical datasets was purposely designed to measure or analyse fuel poverty. This is actually the same situation as exists in the rest of the Member States but the UK; they all lack a fuel poverty-specific measuring instrument like the UK's Household Condition Surveys.

This has implications for the significance and comparability of the results obtained:

- The Hungarian Household Budget Survey (HBS) collects data on actual expenditure, whereas a proper fuel poverty measurement needs estimates of the energy required for guaranteeing an adequate level of thermal comfort and for provision of other domestic energy services. This is why the UK's fuel poverty statistics are based on modelled energy costs, which depend on household lifestyle and dwelling and heating system characteristics provided by the Household Condition Survey (DECC, 2012). Since actual energy costs are consistently below required or modelled energy costs (especially in low-income strata; see Hills, 2012), fuel poverty rates calculated upon actual energy expenditures (as it is done for Hungary in this dissertation) will be systematically underestimated for a given fuel poverty line.

- For practical reasons (limited budget), only two full datasets (2005 and 2008) with anonymised household level microdata were purchased. Therefore, expenditure-based fuel poverty rates are only available for those two years. Still, they capture the substantial increase in natural gas prices that occurred after 2006 – see Section 4.2.1.4.
- Regarding self-reported or consensual fuel poverty indicators based on EU SILC, the subjective nature of the responses to material deprivation survey questions has been pointed as the main shortcoming of this approach – see *adaptive preferences* and the *denial of reality bias* in Section 3.2.1.2.3.
- Expenditure-based fuel poverty rates based on HBS data cannot be directly compared with self-reported rates based on EU SILC because the former are expressed as a percentage of households and the latter as a percentage of the total population. However, since HBS microdata also inform about the size (i.e., number of members) of each surveyed household, expenditure-based rates can be also expressed as a percentage of the total population for comparative purposes – see Section 4.2.3.

Qualitative data collected through interviews and employed in this study has not been analysed as a source of symbolic information, i.e., it has not been used to analyses the meaning the fuel poverty-related elements for actors involved.On the contrary, interviews are primary sources providing just factual information about the experience, characteristics and policy of fuel poverty in Hungary. Thus the information retrieved from interviews has been checked for consistency to some extent through comparison with other data sources (literature and quantitative data) following the principles of triangulation.

Finally, regarding the data used for the cost-benefit analysis, two limitations can be mentioned. First, the building stock model operates with a number of assumptions that simplify the inherent complexity of the Hungarian residential stock (e.g., no detailed sub-division by age of the building or construction material) inherited from the original employment model of Ürge-Vorsatz et al. (2010). Second, the values used for the transfer of results contained in the valuation exercise of non-market co-benefits has been done mostly using non-Hungary specific values, which hinders its reliability. These and other issues are dealt with in the cost-benefit analysis itself (e.g., sensitivity analysis) – see Chapter 7 and 8.

Chapter 4

INDICATORS OF FUEL POVERTY IN HUNGARY

"[Statistics], like veal pies, are good if you know
the person that made them, and are sure of the ingredients"

Lawrence Lowell- President of Harvard University (1909)

4. INDICATORS OF FUEL POVERTY IN HUNGARY

4.1. INTRODUCTION: A SET OF FUEL POVERTY-RELEVANT INDICATORS

This dissertation is organised in two blocks of results-based chapters. The first block (chapters 4, 5 and 6) addresses the first half of the dissertation's overarching research question:*what are the extent, causes and characteristics of fuel poverty in Hungary?*

In that framework, chapter 4 attempts starts by addressing the following set of research sub-questions: what is the extent of the fuel poverty problem in Hungary? Can fuel poverty rates be measured in the absence of specific data sources? How can the Hungarian case contribute to the methodological discussions around the different approaches to measuring fuel poverty?

With that purpose, rather than relying on a single – often expenditure-based measurement – this research proposes and analyses a number of indicators organised in sub-sets. This decision was taken because of two reasons.

First, no single method is yet capable to satisfactorily measure fuel poverty as defined in this research, i.e., a situation in which a household is either unable to afford sufficient energy services and/or bears disproportionate domestic energy costs as a proportion of income (Ürge-Vorsatz and Tirado Herrero, 2012). Available data sources and methodologies only provide a somewhat imperfect approximation of that number, even in the case of a country like the UK where an official definition and a specific data source and calculation methodology are available. This implies that a gap still remains between the concept and the indicators. For instance, it cannot be claimed that all households allocating more than a certain percentage of their income on energy are actually failing to meet their energy service needs (and vice versa).

Second, fuel poverty is a complex phenomenon because different households experience and react to energy affordability problems in a number of different ways, which have been referred to as *coping strategies* – see Section 6.4.2. What this means is that households do not simply experience fuel poverty as a cold home but display a range behaviours that help them cope with high domestic energy costs. For this reason, indicators on the use of traditional fuels (firewood) and on arrears on utility bills are also necessary.

A set of six indicators, organised in three sub-sets, is presented in this chapter:

- Primary indicators (Section 4.2), which estimate fuel poverty rates as a percentage of total households or the total population according to two well established methodological pathways: the expenditure and the consensual or self-reported approach[10]. These are headline indicators, the only ones used for reporting fuel poverty rates in Hungary.
- Secondary indicators (Section 4.3), which provide quantitative information on households' attributes closely related to fuel poverty. The two proposed secondary indicators (arrears in utility bills; fuel poverty-related housing faults) are self-reported or consensual. .
- Proposed indicators (Section 4.4) are secondary indicators that have not been used as such in previous fuel poverty studies (in Hungary and elsewhere). Based on available data, one of them (use of traditional fuels for heating) is meant to be a nation- and perhaps region-specific indicator as it reflects a particular way in which a sizeable share of Hungarian and Central and EasternEuropean households are suspected to deal with

[10] This category of indicators refers to non-monetary aspects of energy deprivation and reflect households' subjective or stated views about their material living conditions. They are labelled or self-reported or consensual – in the sense that they reflect a minimum threshold of material living conditions arising from social consensus (Healy, 2004).

energy affordability constraints; the other one (*summertime* fuel poverty) explores indoors thermal discomfort as an issue still unexplored in the fuel poverty literature.

Attempts to capture the complexity of the fuel poverty phenomenon have produced, for instance, *composite indices* that have rated EU Member States through a weighted combination of household-level self-reported indicators such the inability to afford enough heating, being in arrears on utility bills and occupying a dwelling with fuel-poverty related faults (Healy, 2004; Buzar, 2011). However, such an option was discarded for this research because the indicators collected are not always measured in the same units (e.g., percentage of total households vs. percentage of the total population). Besides, it is suspected that some of the effects captured through these various indicators cancel out each other to some extent (i.e., soaring rates of arrears on utility bills may be a reason why the number of people unable to afford heating in winter remains at a lower level). Therefore, all selected indicators are estimated individually though they are later analysed and interpreted in relation to each other.

Finally, when retrieveddata are available for both Hungary and the EU27, cross-country comparisons are presented. Time series illustrating the variation of effects in the decade of the 2000s are also displayed whenever possible.

4.2. PRIMARY INDICATORS: FUEL POVERTY RATES

4.2.1. Expenditure approach

4.2.1.1. Energy expenditures in the household budget (2000-2010)

4.2.1.1.1. Structure of household expenditure in Hungary

Prior to estimating expenditure-based fuel poverty rates, the structure of household consumption in Hungary has been first explored.

For this, ratios of expenditure categories vs. total household expenditure have been estimated using the results of the Hungarian Household Budget Survey (HBS). This source, compiled yearly by the Hungarian Central Statistical Office (KSH), provides average annual per capita expenditures of Hungarian households by COICOP[11] categories at current prices for the period 2000-2009. The results presented are meant to be representative of the average Hungarian household.

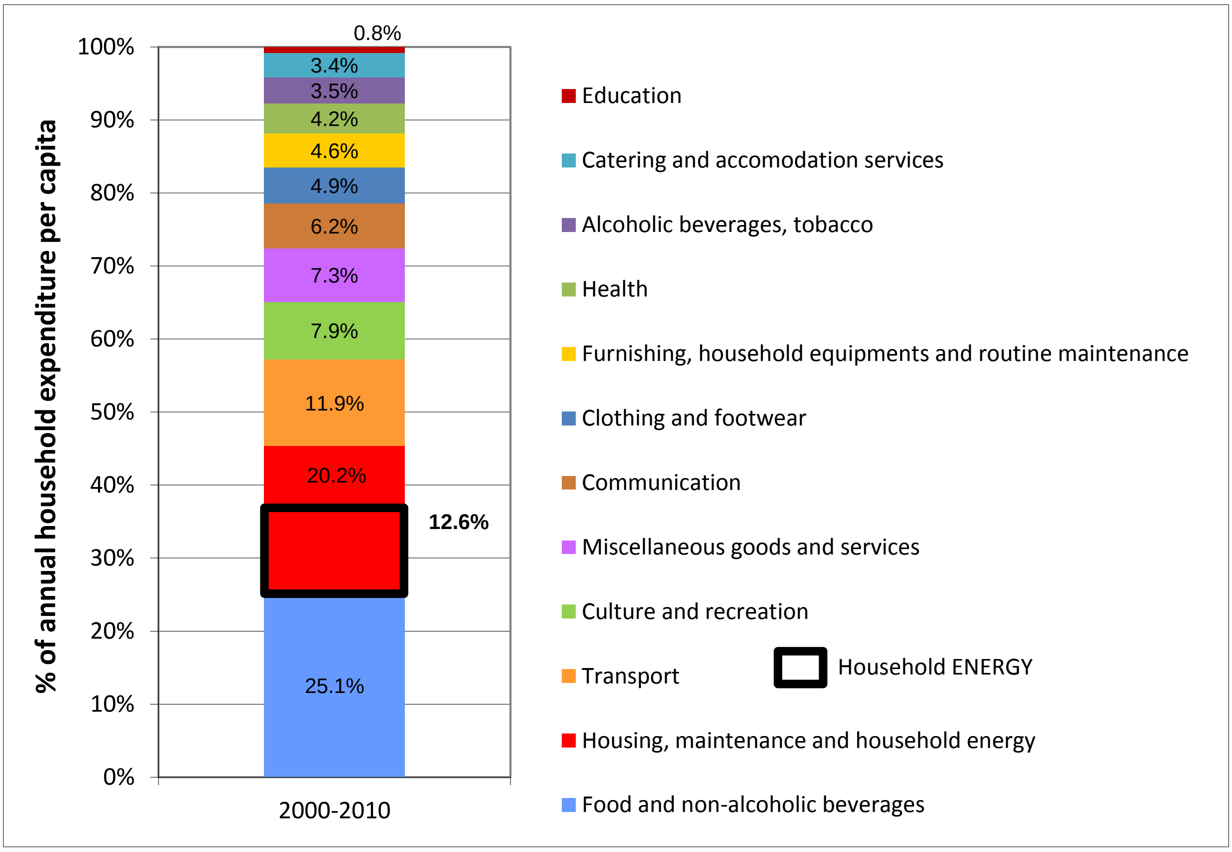
A first analysis of the structure of consumption of Hungarian households (Figure 1 and Figure 5) indicates that food and non-alcoholic beverages, which as an average took up 25.1% of a household's annual expenditure per capita in 2000-2010, was the most important COICOP category in that period. The second largest COICOP item is *Housing, maintenance and household energy* (20.2% of a household's annual expenditure per capita). If household energy were considered a COICOP category of its own, it would be the second most important item as it represents 12.6% of a household's annual expenditure per capita. The remaining 7.6% of the *Housing, maintenance and household energy* category corresponds to actual rentals and water supply and sewerage collection.

The current situation is nevertheless better than in the early 1990s, the starting point of energy affordability issues in the recent history of Hungary. Previous research indicates that the political and economic changes of the transition to a democratic, market-based political system were a tipping point in this regard: as reported by Hegedűs et al. (1994), house

[11] COICOP stands Classification of Individual Consumption by Purpose. Expenditure data are recorded following this classification of the goods and services typically consumed by households. Under COICOP, energy expenses are recorded in the 'Housing, maintenance and household energy' [*Lakásfenntartás, háztartási energia*]category.

maintenance costs12 represented as much as between a 49.2% (lowest income quintile) and 15.1% (highest income quintile) of a households' income in 1992, while a little earlier, in the late 1980s, the average for this ratio was just 9%. In the transition years of the early 1990s, the elimination of subsidies to rents and energy prices hit many households, for whom maintaining the relatively large dwellings that they had been able to afford until the late 1980s became considerably more difficult (Dániel, 1996).

Figure 4. Structure of consumption of an average Hungarian household in 2000-2010, by COICOP categories



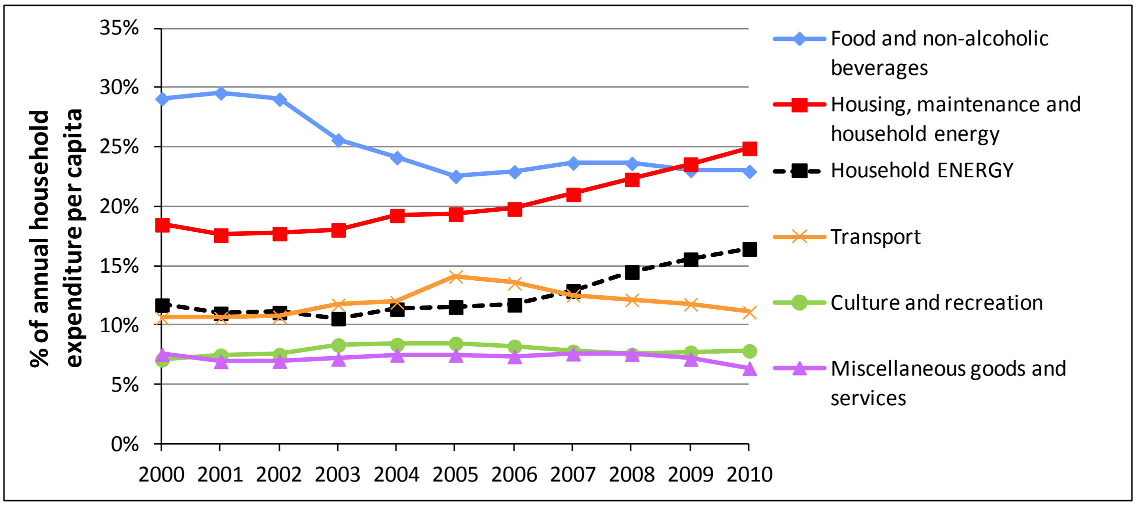
Source: Household Budget Survey – Hungarian Central Statistical Office (KSH)

The structure of households'consumption has changed perceptibly between 2000 and 2010, as presented in Figure 5 (displaying the 4 more important COICOP items plus the household

[12] Energy expenses are the bulk of house maintenance expenses, which also include items such as water provision, waste and sewage collection, products and services for maintenance and repair, and the house rental. KSH data from 2000-2008 indicate that energy expenses representaround 60% of the COICOP category 'Housing, maintenance and household energy'.

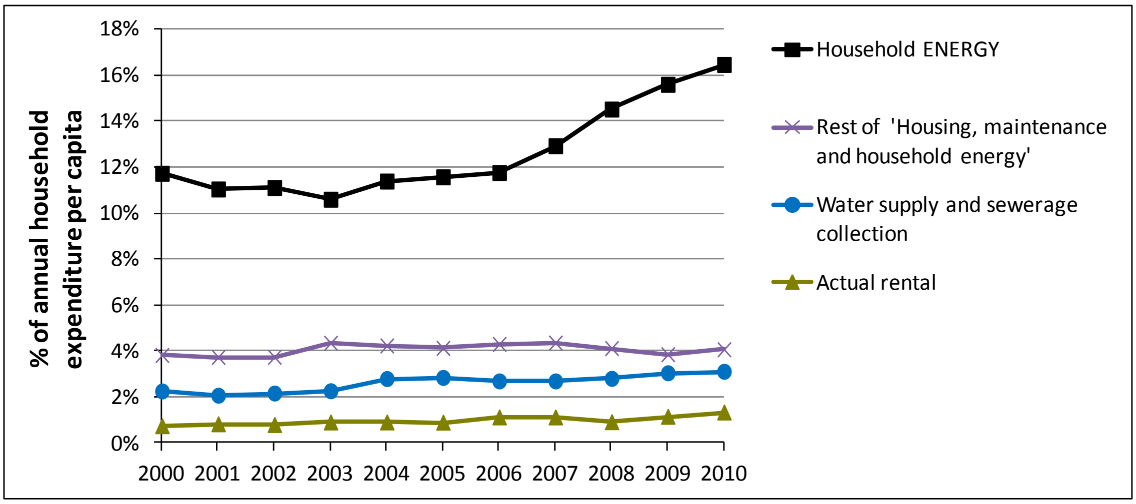
energy sub-category). On the one hand, a sizeable reduction in food and non-alcoholic beverages expenditures can be noted. On the other hand, the category Housing, maintenance and household energy has increased steadily its share on total household expenditure per capita until becoming the most important item in 2009. This trend has continued in 2010, as shown by the newest HBS results presented in KSH (2011). As shown in Figure 6, this is primarily the result of the increasing importance of household energy on annual expenditure per capita.

Figure 5. Evolution of the composition of consumption patterns in an average Hungarian household in 2000-2010, for the 4 most important COICOP categories



Note: Household energy is shown separately for the sake of the analysis but is part of the COICOP category 'Housing, maintenance and household energy' as in the previous Figure
Source: Household Budget Survey – Hungarian Central Statistical Office (KSH)

Figure 6. Evolution of the components of COICOP category 'Housing, maintenance and household energy' in 2000-2010



Source: Household Budget Survey – Hungarian Central Statistical Office (KSH)

In an international comparison with other European countries, a significant difference emerges between Hungary and EU27 Member States. The most relevant is the fact that in Hungary the COICOP category ‘Food and non-alcoholic beverages’ had been until 2008 the most important component of a household’s budget. By contrast, *Housing, maintenance and household energy* is usually the largest COICOP item in the budget of the average EU15 household (KSH, 2009).

Various reasons (e.g., differences in prices, household income, lifestyles and preferences, income elasticity of purchased items, etc.) can be thought of to understand these differences. However, two particular explanations have been suggested by the Hungarian Central Statistical Office (KSH, 2009). First, households in lower-income countries tend to spend more on food and non-alcoholic beverages, whereas in richer nations households spend more on non- essential budget items like recreation or culture. This trend is confirmed by HBS data from the EU27. Second, the structure of the housing sector is also important. In the older Member States, a larger proportion of households’ income goes into renting the house where they live, thus increasing the importance of the category ‘Actual rental’ (which is part of the COICOP category *Housing, maintenance and household energy*) on total household expenditure. In the Central and Eastern European countries of the EU27, most households live in a dwelling they own, thus making the COICOP sub-category ‘Actual rental’ weigh less on total household expenditure[13].

In Hungary, since 2008 households spend more on ‘Housing, maintenance and household energy’ than on ‘Food and non-alcoholic beverages’, thus following the trend of the average EU27 Member State. This is the result, on the one hand, of the decrease in the importance of

[13] Note that mortgage payments are not included as such in the Hungarian Household Budget Survey and therefore are not counted in the COICOP category ‘Housing, maintenance and household energy’.

food and non-alcoholic beverages on total household expenditure (see Figure 5). This reduction concentrated in the period 2001-2005 but has since then stopped. On the other hand, it is also a consequence of the marked increase in the prominence of household energy on total household expenditure occurred since 2005 (see Figure 6). Note that the ownership structure of Hungarian housing sector has not changed much in the decade (most households live in a home of their own), which is reflected in the low, stable percentage of the sub-category 'Actual rentals'.

Based on the aggregated results of the Hungarian HBS(Figure 5), it can be hypothesised that the gains in purchasing power (income per capita) experienced by Hungarian households in the first half of the 2000s allowed an increase in their consumption of non-essential items such as transport, culture and recreation, communications and catering and accommodation services[14]. After 2005, however, this trend stops, coinciding with the beginning of the sharp increase in domestic energy prices recorded in price statistics (see Section 5.3). This energy price rise may have forced households to limit their expenditure on those non-essential goods and services whose consumption was increasing until around 2005. From 2008 onwards, the evolution of these parameters is probably also influenced by the impact of the global financial crisis.

4.2.1.1.2. Energy vs. total household expenditures

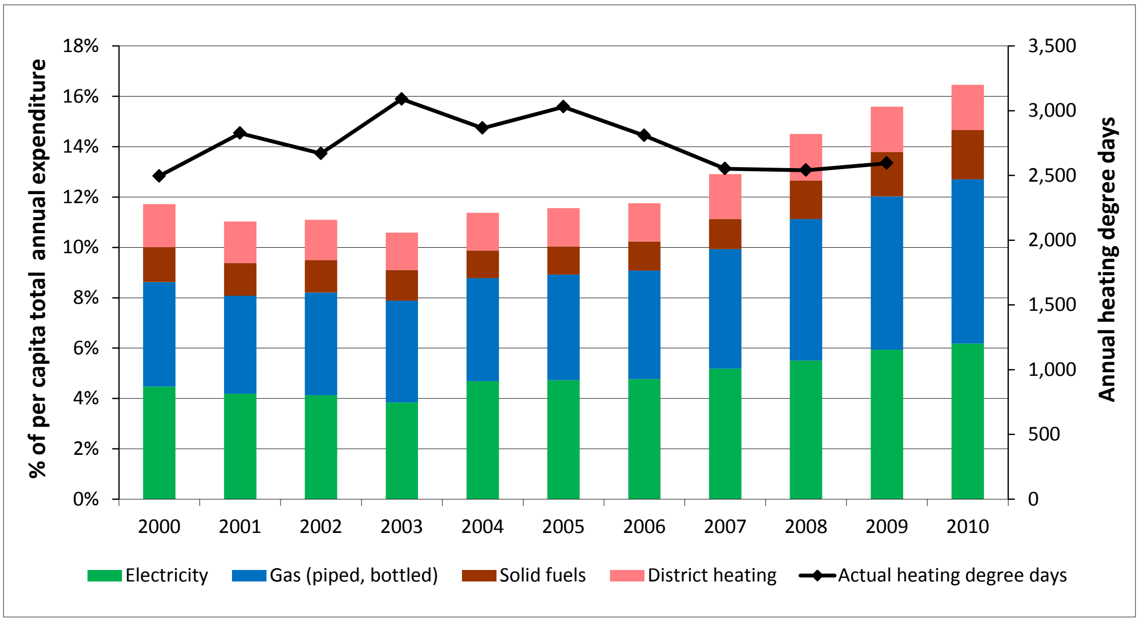
Ratios of household energy vs. annual expenditures per capita were estimated using aggregated results of the Hungarian Household Budget Survey (HBS) for the period 2000-2010 and are presented in Figure 7. These show that energy expenditures were always more

[14] The importance of transport on total household expenditures increased from 10.6% (in 2000) to 14.1 % (in 2005); communication – from 5.3% (in 2000) to 7.1% (in 2006); culture and recreation – from 7.1% (in 2000) to 8.5% (in 2005); catering and accommodation – from 2.9% (in 2000) to 3.5% (in 2004) – see Figure 5.

than 10% of the average Hungarian household's annual expenditure (12.6% as a mean for 2000-2010).

The importance of energy expenditures has increased steadily since 2003 until reaching in the last year with available information (2010) the 16.5% level. However, as indicated by the number of actual heating degree days[15] per year presented in Figure 7, the evolution of this percentage had little to do with the severity of the winters. This is particularly clear in the period 2005-2008, during which subsequently warmer winters did not bring lower energy vs. total expenditure ratios (but rather the opposite).

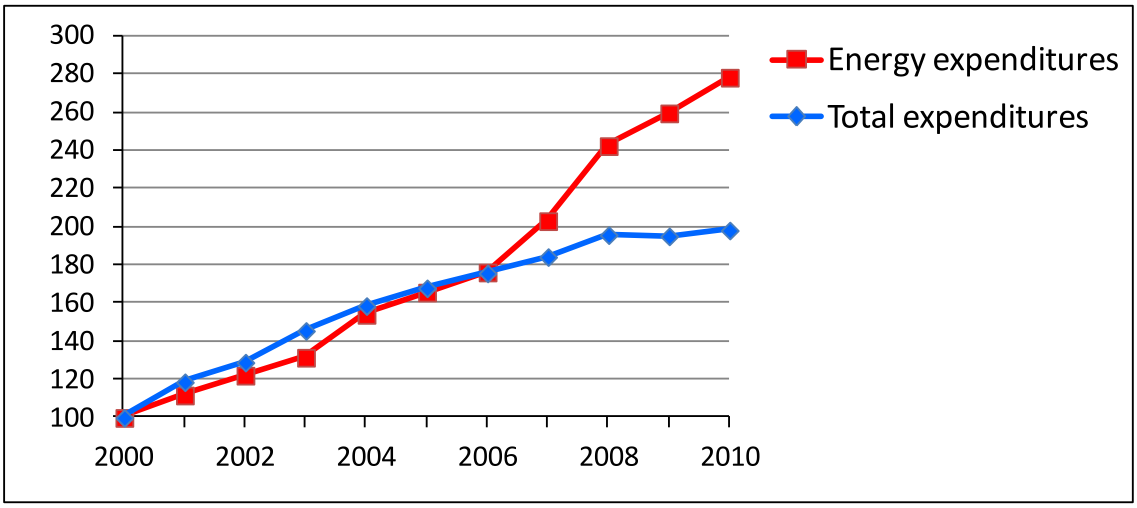
Figure 7. Percentage of household energy vs. annual per capita expenditures of the Hungarian average household compared with the number of actual heating degree days per year in Hungary (2000-2010)



Note: number of actual heating degree days not available for 2010
Source: Household Budget Survey – Hungarian Central Statistical Office (KSH); Eurostat.

[15] "Actual heating degree-days express the severity of the cold in a specific time period taking into consideration outdoor temperature and room temperature.To establish a common and comparable basis, Eurostat defined the following method for the calculation of heating degree days: (18 °C - Tm) x d if Tm is lower than or equal to 15 °C (heating threshold)and are nil if Tm is greater than 15 °C where Tm is the mean (Tmin + Tmax / 2) outdoor temperature over a period of d days. Calculations are to be executed on a daily basis (d=1), added up to a calendar month -and subsequently to a year- and published for each Member State separately" (Eurostat, 2012)

Figure 8.Evolution of the energy and total household expenditures per capita index at current prices (2000=100), for Hungary in 2000-2009



Source: Household Budget Survey – Hungarian Central Statistical Office (KSH)

The increase in the percentage of energy vs. total household expenditure is rather the result of the following process, illustrated in Figure 8: whereas total household expenditure and domestic energy expenditure increased at a similar pace until 2005, from 2006 onwards the energy expenditures took the lead and went up at considerably faster rates. This pattern largely reflects the rise in energy prices (especially for natural gas) reported for the same period in Section 5.3.1.1.

By energy carriers, both natural gas and electricity expenditures were the most important. Of those two, electricity alone represented around 40% of total energy expenses as an average for 2000-2010, which is explained by the higher price of electricity as compared to other energy carriers (see Section 7.6.1.1) and also because while all households only use electricity for lighting and appliances, several energy carriers are available for heating. It must also be noted that solid fuels represent a sizeable fraction of the total energy expenses of the average household, which is indicative of the importance of traditional fuels still in use nowadays in Hungary. As suggested in Section 4.4.1, the use of traditional fuels – a coping strategy to deal with energy affordability constraints – is taken as a secondary indicator of fuel poverty in Hungary.

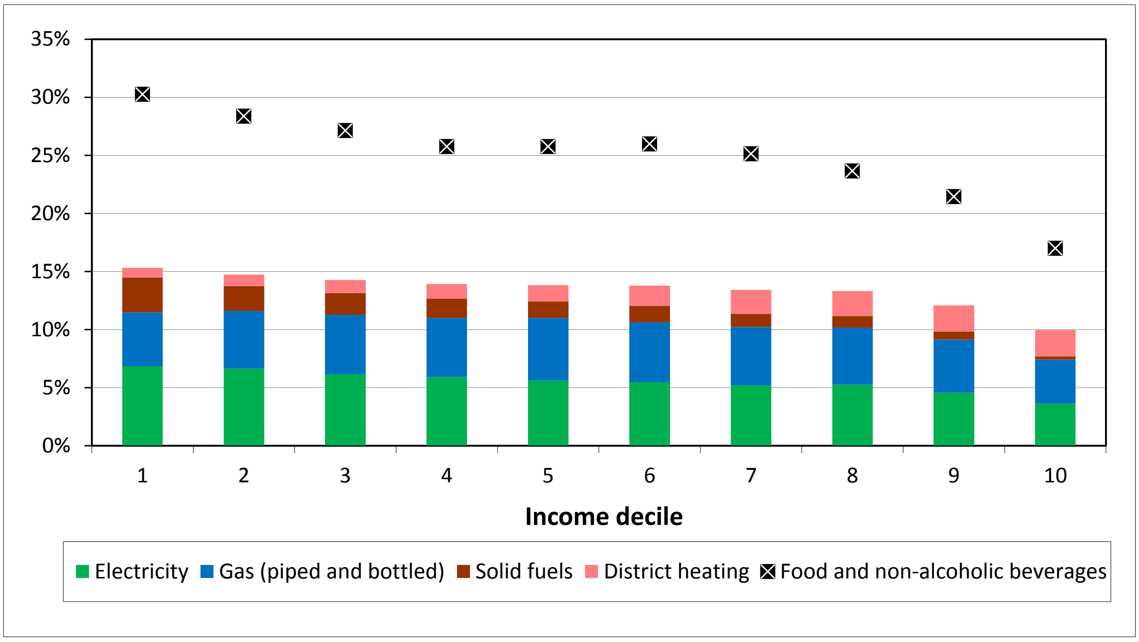
4.2.1.1.3. Energy vs. food expenditures

As seen in Figure 5, domestic energy and food (including non-alcoholic beverages) are the two most important items of a household's budget. It is not surprising because both are very basic household needs. And since both take a large percentage of a household's total per capita expenditure, covering both needs may be challenging for households struggling to make ends meet.

There is some evidence for this circumstance in previous research, which has been referred to as the *heat or eatdilemma*. As an example, Bhattacharya et al., (2003) found out that during unusually cold weather poor families in the US reduce food expenditures by approximately the same amount as the increase in fuel expenditures. And in the UK, a study based on 10 qualitative semi-structured interviews of elderly women in the UK found out that they would reduce food expenditure rather than that on heat if they had to choose (O'Neill et al., 2006).

For Hungary, results disaggregated by income deciles for the year 2007 (the only year with data disaggregated), indicates that households in the lowest income deciles allocate a larger proportion of their annual budget to food (including non-alcoholic beverages) and domestic energy (Figure 9). In the poorest segment of the population (decile 1), food and energy expenditures took up to 45% of total household expenditure in 2007. It is thus likely that low-income households have difficultiesto satisfy both basic needs simultaneously, especially during the cold season. This element is considered for the definition of the fuel poverty line later on (Section 4.2.1.3).

Figure 9. Percentage of total household expenditure spent on energy and on food and non-alcoholic beverages, by income decile; Hungarian average household in 2007



Source: Household Budget Survey – Hungarian Central Statistical Office (KSH)

4.2.1.2. Expenditure- and income-based fuel poverty rates: 2005 and 2008

4.2.1.2.1. Estimating the energy burden: data and assumptions

The first step towards estimating objective expenditure- and income-based fuel poverty rates in Hungary is the calculation of the *energy burden* or affordability ratio (i.e., the percentage of a household income that goes into paying for domestic energy. This percentage has been estimated using Household Budget Survey (HBS) datasets for the years 2005 and 2008 purchased from the Hungarian Central Statistical office (KSH). These datasets contain detailed anonymised microdata on individual households' expenditures, income and socio-economic characteristics (e.g., size and composition, age of the household head, educational attainment, etc.). The sample size for 2005 is 9,058 units (representing a total population of 3,837,087 households) and for 2008 is 7,650 units (representing a total population of 3,809,431 households). These two years were selected because they capture the impact on fuel poverty rates of the large increase in natural gas prices – the main source of heat in Hungarian households – which has occurred since 2006 and is reported in Section 5.3.1.1.

However, it must be highlighted that the energy burden accounts for actual spending, as no calculations are available in Hungary for the energy consumption required for an adequate level of provision of domestic energy services (see Section 3.2.1.2.2). Thus the approach used for the Hungarian survey is not based on the need to spend (which is more correct) but on actual spending. The consequence is that fuel poverty rates measured with the energy burden approach are systematically underestimated because households (especially those in the lower income groups) spend less energy than what would be necessary for a theoretical full coverage of their energy service needs. This is confirmed by HCS data from the UK, which show that for all income groups, actual energy spending is below the calculated required energy spending even in the highest income group[16] - see Table 5.

In Hungary, precise data on indoor temperatures is not available, though it is expected that not all households manage to keep indoor temperatures above a minimum comfort level – as presented in Section 4.2.2, over 10% of the population declare to be unable to afford enough heating at home. Besides, households protect themselves from high energy costs by, for instance, substituting natural gas by firewood, a much cheaper fuel (over 20% of Hungarian households use firewood for space heating, as reported in Section 4.4.1) or by heating only a fraction of the dwelling floor area. Thus, some actual fuel poor households will not be identified as such by the expenditure approach because they have managed to reduce their percentage of energy vs. annual income below the fuel poverty line. By reacting (imperfectly) to high domestic energy costs with these coping strategies, they may become non fuel-poor as defined by the expenditure approach.

[16] For the top income decile, actual energy spending is still 82% of required spending. Such result may indicate that UK's Household Condition Survey (HCS) overestimates required spending even in top income deciles because it is expected that the richest households use as much domestic energy as they need.

Table 5. Comparison between actual required spending on domestic energy in UK households surveyed by the English Household Condition Survey (HCS), 2009.

Table 2.3: *Household energy use by gross income groups (unequivalised) – notional versus actual, 2009, England*

Income group	Average annual household energy requirement (£)	Average annual household energy bill (£)	Ratio of actual expenditure to energy requirement (%)
Bottom	1,278	847	66
2	1,262	933	74
3	1,334	984	74
4	1,379	1,067	77
5	1,437	1,116	77
6	1,465	1,148	78
7	1,501	1,220	81
8	1,583	1,279	81
9	1,663	1,388	83
Top	1,900	1,559	82

Source: Fuel poverty data, 2009 (DECC), Living Cost and Food Survey, 2009 (ONS)

Source: Hills (2012)

In any case, since no country but the UK has a fuel poverty-specific measuring tool based on need to spend on domestic energy, the approach based on the actual energy burden and the Household Budget Survey (which most countries have) is explored as an imperfect methodological alternative that can be applied in absence of a specific survey such as the UK's Household Condition Survey (HCS).

For calculating the energy burdenwith the Hungarian HBS data:

- Net income was taken as reported by households in the HBS. However, as indicated by KSH staff (Salamin and Ménesi, pers. comm.), households tend to under-report their income because they either forget sources of income or declare less than what was actually earned, and the HBS does not check whether total expenditure matches reported income. The consequence is that as much as 30% of households surveyed in 2005 and 2008 reported net income figures below their total annual household expenditure. This overestimates the energy burden and probably fuel poverty rates as well. An alternative suggested by Fankhauser and Tepic (2005) consists of using total expenditure as an approximation of a household's net income; however, this solution confuses expenditures with income and would equally underestimate income (particularly in higher income groups) as it does not capture households' savings.

- Household energy expenditure accounts for all reported energy consumption for domestic purposes (i.e., heating, cooking, lighting, appliances, hot water, etc.) but excluding fuel for transport, which does not belong in the fuel poverty concept and is recorded as a different COICOP category in HBS.
- Though HBS microdata do not disaggregate by type of residence, it is assumed that energy expenditure data provided by KSH include both a household's primary and secondary residences.
- In the case of solid fuels, the value of the self-produced firewood consumed by the household was counted as expenditure because it is forgone revenue.
- The weight given to each surveyed household in the HBS sample is used for all calculations based on the energy burden that require it, like a weighted average or a percentage of total households. The reason is that each of the households sampled by the HBS has a different weight that indicates the number of real households it represents; therefore, the addition of all weights of the annual samples results in the total number of Hungarian households recorded by Hungarian statistics each year.

The equivalisation of household incomes and expenditures is another important element of the calculation of the energy burden. The idea is that the income required for a household to achieve a given material standard of living does not increase linearly with household size because there are economies of scale, i.e., a two-person household will not need the double amount of space, energy or appliances as one-person household because many of these items are shared. Thus for income per capita calculations to be comparable between households of different size and composition, equivalence scales are often applied (OECD, 2009: Eurostat, 2012b) – see its effect on per capita income calculations in Table 6.

Table 6. Comparison: income per capita calculations (based on a fixed amount of 10,000 Euro per year) with and without an equivalence scale

Household size and composition	**Non-equivalised**		**Equivalised** (OECD modified scale)	
	Household size	*Income per capita*	*Household size*	*Income per capita*
1 adult	1	10,000	1	10,000
2 adults	2	5,000	1.5	6,667
2 adults, 1 child	3	3,333	1.8	5,556
2 adults, 2 children	4	2,500	2.1	4,762
2 adults, 3 children	5	2,000	2.4	4,167

Note: OECD-modified equivalence scale applied, which assigns value of 1 to the head of the household, of 0.5 to each additional adult member and of 0.3 to each child. This is the scale that Eurostat has adopted for the calculation of at-risk-poverty ratios
Source: own elaboration after OECD (2009).

For the calculation of the energy burden, a reasonable approach seems to equivalise both household income and energy expenditures. The reason is that, like income, energy expenditures do not increase linearly with household size because of economies of scale in the domestic use of energy.

It wasthus assumed that the same equivalence scale applies to both the numerator (annual energy expenditure, in HUF) and denominator (annual net income, in HUF) of the energy burden equation. If the OECD-modified scale (used by Eurostat for calculating equivalised income) is applied to the case of a family of 4 (2 parents and 2 dependent children) with a reported annual income of 3 million HUF and 300,000 HUF annual domestic energy costs, the energy burden is

$$Energy\ burden = \frac{\frac{300{,}000\ HUF}{2.1}}{\frac{3{,}000{,}000\ HUF}{2.1}} = \frac{300{,}000\ HUF}{3{,}000{,}000\ HUF} = 10\%$$

which is the same as if no equivalence scale was applied because the equivalent household size (2.1) is cancelled out both in the numerator and denominator.

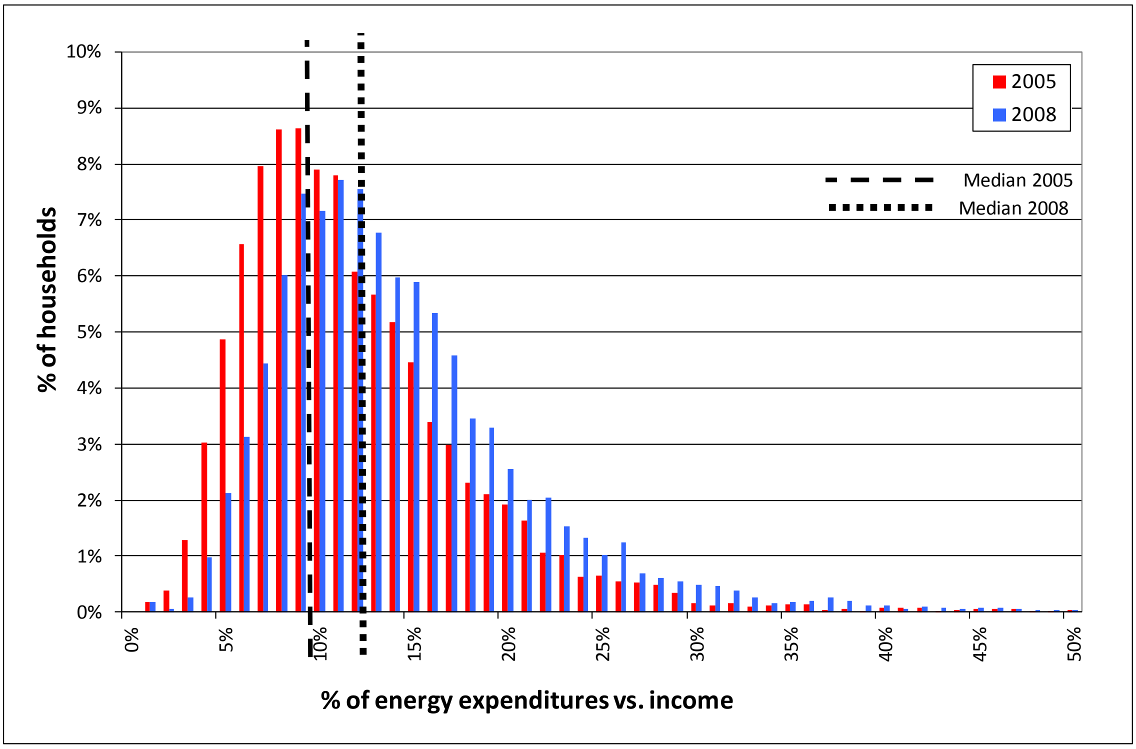
That household income and expenditures are equivalised with the same factors is disputed because economies of scale do not function in the same way in both cases, e.g., it is not more expensive to heat one bedroom shared by two people (as compared to a one-person household) but these two people will take twice as many hot showers as the one person living on its own (Hills, 2012). For this reason, the UK Hills Review recommends the use energy expenditure-specific equivalisation factors that are different from those applied to income.

4.2.1.2.2. The increase in the energy burden between 2005 and 2008

The results of an initial exploration of the two datasets are presented in Figure 4.5, a histogram showing the fraction of Hungarian households allocating a certain percentage of their annual income to domestic energy[17] (displayed at a 1% level of detail). The unambiguous swift to the right of the histogram occurred between 2005 and 2008 clearly reflects the *price hike*that happened in the same period (Section 5.3.1.1). Pushed by the increase in natural gas prices, households of all income levels have been forced to allocate a larger fraction of their income to satisfying their domestic energy needs, which displaced the median annual energy expenses vs. income percentage from 10.1% to 12.4%.

[17] This includes all energy carriers used by Hungarian households, and therefore all domestic uses of energy (space and water heating, space cooling, cooking, lighting and appliances).
[18] For this, equivalised income per capita has been first estimated by applying the OECD-modified equivalence scale (see Table 6) to HBS annual household income data. However, HBS data on household size and composition provide information about the number of dependent children under 20 years old, whereas the OECD-modified scale refers to children under 14. This introduces some error in the equivalisation of Hungarian income and expenditure figures.

Figure 10.Distribution of Hungarian households according to their energy expenditures vs. total income percentage (2005 and 2008).



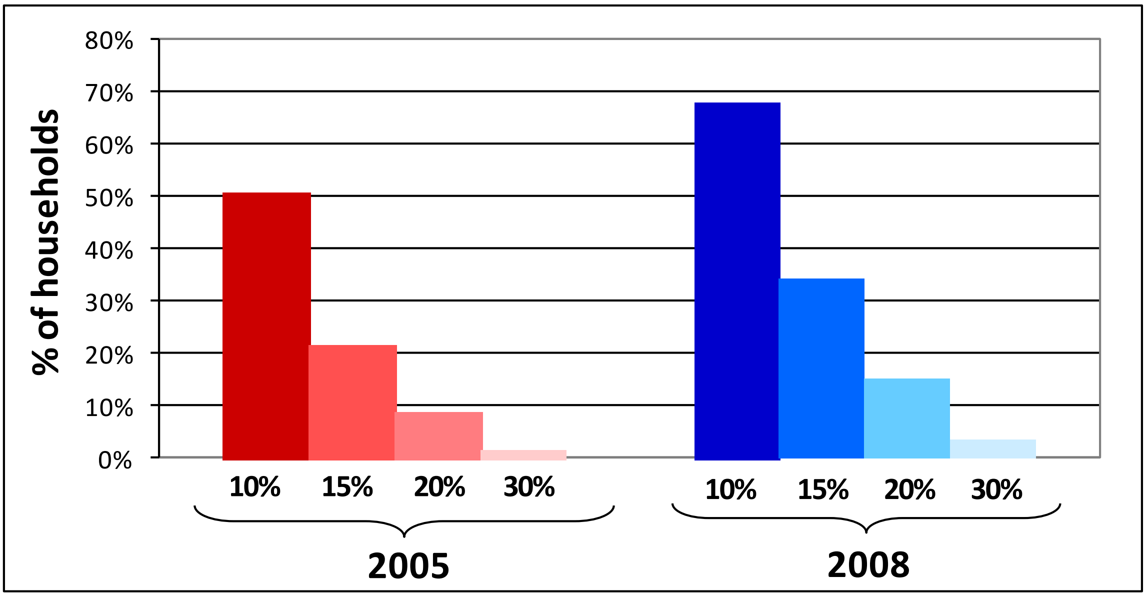
Source: own elaboration based on Hungarian Household Budget Survey (KSH)

4.2.1.3. Setting the fuel poverty line: challenges

A key element of expenditure-based estimates is the notion of a fuel poverty line that defines what *disproportionate* energy costs are. Thus a fuel poverty line is the percentage of actual energy expenditures vs. income above which a household is assumed to be unaffordable. 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 as much energy services as it needs.

Thus the following question arises: what level of energy expenditures (as a proportion of income) makes domestic energy costs disproportionate or unaffordable? How this question is answered is not insignificant because of the large influence of the fuel poverty line on fuel poverty rates. This is illustrated by Figure 11, which compares the fuel poverty rates (i.e., percentage of Hungarian households in fuel poverty) corresponding to 4 different fuel poverty lines – 10, 15, 20 and 30%. Given the shape of the histogram (Figure 10), a variation of a few percentage points in the fuel poverty line results in largely different fuel poverty rates: with a 10% fuel poverty line, more than half of all Hungarian households (51% in 2005 and 68% in 2009) are in fuel poverty; in contrast, at a 30% fuel poverty line, less than 5% of all Hungarian households (2% in 2005 and 3% in 2009) are in fuel poverty. Note that the percentages chosen for the comparison are not just random figures but represent the actual range in which the fuel poverty line for Hungary is thought to be comprised: as shown in Figure 10, the 10 to 30% range contains most households whose domestic energy costs (as a proportion of income) are above the median .

Figure 11. Fuel poverty rates estimated with 4 different fuel poverty lines based on 10, 15, 20 and 30% annual energy expenditure vs. income thresholds



Source: own elaboration based on Hungarian Household Budget Survey (KSH).

Consequently, the designation of a fuel poverty line is a task to be handled with care; and it is perhaps a question that needs to be also answered by policymakers, given that fuel poverty rates are a tool for assessing the evolution of the problem and for the allocation of public resources.

In the case of this research, based on the discussion in Section 3.2.1.2.2, the direct transfer of the UK's 10% (required energy expenditures vs. net income) threshold to Hungary has been ruled out for two reasons: first, because the 10% rule relies on required spending, and not on actual spending; and second, because it is only applicable to the UK, as it was estimated according to the conditions existing at the time it was first proposed in the late 1980s.

The solution adopted consist of transferring to Hungary not the 10% UK fuel poverty line but the criteria upon which this threshold was set. As recalled by Boardman (2010), her original fuel poverty line (Boardman, 1991) was drawn at the 10% level because at the time of its calculation (1988) it was double the median household energy expenditure as a percentage of the weekly budget, and also because it coincided with the representative energy costs of the 30% lowest income households. These criteria, which come from previous work by Isherwood and Handcock (1979), are based on actual energy expenses (and not on required spending) and therefore can be more safely transferred to the Hungarian case.

Accordingly, for Hungary's estimates it has first been calculated the median percentage of energy expenditure vs. income of all Hungarian households, and then of the 30% with the lowest income[18]. This was done based on purchased microdata of the Household Budget Survey (HBS) for 2005 and 2008 and the results are shown in Table 7.

[18] For this, equivalised income per capita has been first estimated by applying the OECD-modified equivalence scale (see Table 6) to HBS annual household income data. However, HBS data on household size and composition provide information about the number of dependent children under 20 years old, whereas the OECD-modified scale refers to children under 14. This introduces some error in the equivalisation of Hungarian income and expenditure figures.

Table 7. Results of the transfer of Boardman's (1991) criteria for defining a fuel poverty line in Hungary

Enery burden [annual energy expenditure vs. income %]	**2005**	**2008**
Median annual energy expenditure vs. income ratio	10.1%	12.4%
Median annual energy vs. income of the 3 lowest income deciles	14.6%	16.9%
Theoretical fuel poverty lines [annual energy expenditure vs. income %]	**2005**	**2008**
Twice the median criterion	**20.1%**	**24.8%**
Median of the 3 lowest income deciles criterion	**14.6%**	**16.9%**

Source: own elaboration after data from the Hungarian Household Budget Survey (KSH)

However, transferring these two criteria to the Hungarian case is problematic for various reasons.

First, for the years with detailed household-level microdata available (2005 and 2008), the median energy burden of the poorest 30% of households is substantially larger than twice the median energy burden of all Hungarian households (see Table 7). This means that for the case of Hungary, the two criteria translate into two different fuel poverty lines, unlike in the UK in 1988.

Second, since calculated medians are year-specific, no fixed fuel poverty line can be defined. The fuel poverty line changes every year (see Table 7), which is problematic for analysing the evolution of fuel poverty rates along time.

Third, fuel poverty lines based on median percentage of energy expenditures vs. income estimated at the national level result in distortedcross-country comparisons. For instance, a country with high energy prices and low incomes would have a higher fuel poverty line (and a lower fuel poverty rate) than a country with high incomes and low energy prices. This is illustrated with the following example.

Aware of the risk of an blunttransfer of the UK 10% rule in countries different from the UK, Brenda Boardman has recently proposed a non-UK, specific, EU-wide fuel poverty rule according to which “a household is in fuel poverty if it would need to spend more than twice the median (as a proportion of expenditure) on all energy uses in the home” (Boardman, pers. comm.). The European Commission has been receptive to this suggestion of a general rule for setting country-specific fuel poverty lines, as evidenced by a recently released working document that reports an expenditure-based estimate of 65 million people living in fuel poverty in the EU (EC, 2010a)[19].

EU-level estimates based on this *twice the median*[20] criterion (EC, 2010) indicate that some countries where energy costs represent a large burden on domestic budgets report relatively lower fuel poverty rates. This is, for instance, the case for Hungary, the Member State with the second largest average household expenditure on energy but where *only* 8.2% of the total households are in fuel poverty (as compared to 19.2% in the UK, 16.2% in France or 11.9% in Austria) – see Table 8.Unsurprisingly, the variables *Average households' expenditure on energy* and *Estimated share of households spending a considerable share of their expenditures on energy* are poorly correlated[21]. This is a consequence of the application of country-specific fuel poverty lines based on the *twice the median* criterion.

The underlying question is whether countries within a shared geographical and policy context like the EU should have different rules to define what a fuel poor household is. To illustrate this with an example from Table 8: is it fair that a UK household is labeled as fuel poor if it

[19] Fuel poverty lines were estimated by the European Commission in that document as the average (and not median, as suggested by B. Boardman) energy vs. total expenditures ratios of Member States. This is indicative of the challenges of developing an accepted *universal* methodology for estimating expenditure-based fuel poverty rates.

[20] Twice the average in this case, which is not accurately calculated in all countries: in some Member States the fuel poverty line has been rounded and in othersnot (see Table 4.2).

[21]The estimated linear correlation coefficient (Pearson’s *r*) is 0.35.

devotes more than 13.8% of its income on domestic, energy when a Hungarian household has to reach the 27.8% threshold to be put in the same category? These questions, which so far have little practical consequences, would have much deeper implications if, for instance, EU funds were to be distributed among Member States for fighting fuel poverty.

Table 8. Fuel poverty rates in the EU27 Member States as estimated by the European Commission

MS	Data reference year	Average households' expenditure on energy	Proposed threshold of for considering significant burden [fuel poverty line]	Est. share of households spending a considerable share of their expenditures on energy [fuel poverty rate]
AT	2005	4.6%	10.0%	11.9%
BE	2008	5.9%	11.8%	8.9%
BG	2008	9.5%	19.0%	6.4%
CY	2005	3.8%	8.0%	6.4%
CZ	2005	11.2%	22.0%	14.5%
DE	2005	5.1%	10.0%	12.6%
DK	2005	7.4%	15.0%	12.4%
EE	2007	7.3%	14.6%	19.7%
ES	2008	7.4%	14.8%	11.2%
FI	2005	3.4%	7.0%	13.0%
FR	2005	5.2%	10.0%	16.2%
GR	2005	3.8%	9.0%	7.6%
HU	2008	**13.9%**	**27.8%**	**8.2%**
IE	2005	3.8%	8.0%	13.5%
IT	2008	6.2%	12.4%	8.6%
LT	2008	8.6%	17.6%	16.0%
LU	2007	3.8%	7.6%	13.6%
LV	2008	6.9%	13.8%	6.1%
MT	2005	1.8%	n.a.	6.4%
NL	2005	4.4%	9.0%	8.1%
PL	2008	11.4%	22.8%	14.1%
PT	2007	4.2%	10.0%	10.0%
RO	2005	11.6%	20.0%	16.6%
SE	2005	3.9%	8.0%	11.2%
SI	2005	6.6%	13.0%	12.0%
SK	2005	14.5%	25.0%	19.0%
UK	2008	6.9%	13.8%	19.2%
UE27		**7 to 8%**	n.a.	n.a.

Source: EC, 2010a.

All in all, these difficulties evidence the inherent arbitrariness of the expenditure approach to the measurement of fuel poverty, which often requires some sort of value judgment about what disproportionate or unaffordable energy costs are (Healy, 2004; Fankhauser and Tepic, 2005).

4.2.1.4. Expenditure-based fuel poverty rates (2005 and 2008)

Without failing to acknowledge the drawbacks of the expenditure approach identified in the previous section, it was decided to calculate fuel poverty rates in Hungary according to a 10 to 20% (annual energy expenditures vs. income) range of fuel poverty line:

- The lower bound of the chosen interval (10%) is based on the UK rule first proposed by Boardman (1991). The higher bound (20%) is twice the median energy expenditure in 2005 –see Table 7; it is also the affordability threshold suggested by Fankhauser and Tepic (2005) for domestic energy services. Higherpercentages (e.g., 25 or 30%) were ruled out because they were deemed too high (more than twice as large) when compared to the UK benchmark.Another reason for choosing a relatively low interval is that the Hungarian HBS data report actual (instead of required) energy expenditures, which underestimates the fuel poverty rate as noted in Section4.2.1.2.1. Given the inherent arbitrariness of expenditure-based fuel poverty line, the 10 to 20% range is proposed as confidence interval.
- The middle point of the interval (15%) is selected as a representative fuel poverty line for of 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%) – see Table 7.4.2.1.2.1.

In addition, a second fuel poverty line has been proposed as an alternative approach using a different household basic consumption item – food and non-alcoholic beverages – as a benchmark. So far an untested approach, this fuel poverty line is based on the assumption that households spending more on energy than on food are probably facing difficulties related to their dwelling's energy consumption. HBS data indicate that food (including non-alcoholic beverages) was until 2009 the largest budget item of the average Hungarian household (see Figure 5), so serious energy affordability constraints may exist if domestic energy costs surpass food costs. As discussed in Section 4.2.1.1.3, there is evidence that low-income households experience the *heat-or-eat dilemma*, especially in periods of intense cold during the wintertime.

Table 9. Criteria for estimating fuel poverty rates in Hungary (2005-2008).

Label	Description	**Fuel poverty line** [energy expenditures vs. annual income %]
Transfer of Boardman's criteria	If the household spends on domestic energy more than 10 to 20% (15% as a middle point of the interval) its annual income, it is in fuel poverty.	10%-20% (15%)
Food expenditure	If the household spends more on energy than on food and non-alcoholic beverages, it is in fuel poverty.	n.a.

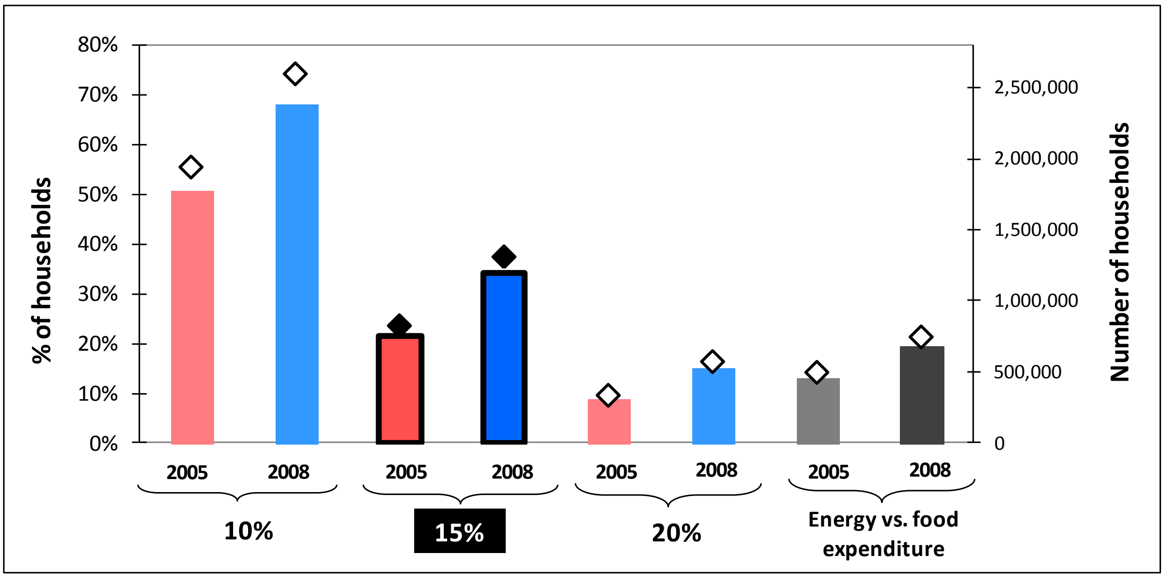
Source: own elaboration after data from the Hungarian Household Budget Survey (KSH)

Fuel poverty rates corresponding to the defined fuel poverty lines in Table 9 have been thus estimated for 2005 and 2008 (Figure 12). The increase registered in all of them between the two years is consistent with the increase in real energy prices, especially natural gas, reported since 2006 (Section 5.3.1.1). As expected, the lower the fuel poverty line, the higher the fraction and number of households in fuel poverty.

These results indicate that as of 2008 (the last year with available microdata), more than one-third (34%) of all Hungarian households was in fuel poverty. In the expenditure approach, this means that they bore disproportionate energy costs (over 15% of their annual income) and therefore it is assumed that they were experiencing some of the typical symptoms of fuel poverty (e.g., cold homes, delays in paying energy bills, etc.).

Given that since 2008 domestic energy prices have kept on increasing faster than salaries and pensions, it is very likely that current fuel poverty rates are now higher – see Section 5.3.2.

Figure 12. Fuel poverty rates and the number of fuel poor households in Hungary (2005 and 2008) defined according to the fuel poverty lines in Table 9.



Note: bars indicate the percentage of fuel poor households and diamonds the number of fuel poor households.
Source: own elaboration after data from the Hungarian Household Budget Survey (KSH)

If the fuel poverty line was at the 20% level, 15% of all Hungarian households (some 570,000 families) would still have been in fuel poverty as of 2008. If the fuel poverty line was set at the UK's 10% level, more than half of all Hungarian households (51% in 2005 and 68% in 2008) would qualify as fuel poor; recallthat compared to the UK this is an underestimation because, as noted previously, actual energy expendituresare consistently below the expenditure required for achieving adequate thermal comfort.

Figure 12 also shows that 13% (in 2005) and 20% (in 2008) of all Hungarian households were spending more money on energy than on food – the alternative criterion tested in this research. This is more or less in line with the results obtained with a 20% fuel poverty line. However, the overlap between fuel poverty lines and the food expenditures criterion is far from perfect; as shown in Table 10, around 40% of the households defined as fuel poor with the food vs. energy expenses criterion were not spending more than 15% of their annual income on domestic energy.

Table 10. Percentage of households defined as fuel poor according to the food expenditure criterion that are also fuel poor according the 10, 15 and 20% fuel poverty lines

Year	With 10% FP line	With 15% FP line	With 20% FP line
2005	81%	56%	31%
2008	90%	65%	40%

Source: own elaboration after data from the Hungarian Household Budget Survey (KSH)

What this comparison may indicate is that the characteristics of households defined as fuel poor according to the food expenditure criterion are different from the ones captured by the energy burden(percentage of energy expenses vs. income). This way, it is suspected that households with a smaller size (e.g., 1-or 2-person) and households with large surface-to-occupancy ratio (in dwelling square meters per person) tend to spend more on energy than on food, but perhaps not always be in fuel poverty. Consequently, the validity of this alternative fuel poverty criterion is not confirmed, and a more detailed exploration of the interaction of food vs. domestic expenditures is recommended. Further research may analyse in more detail to what extent spending more on energy than food is a reliable indicator of fuel poverty, or explore under which conditions under a household prioritises the purchase of domestic energy over food.

4.2.2. Self-reported or consensual approach

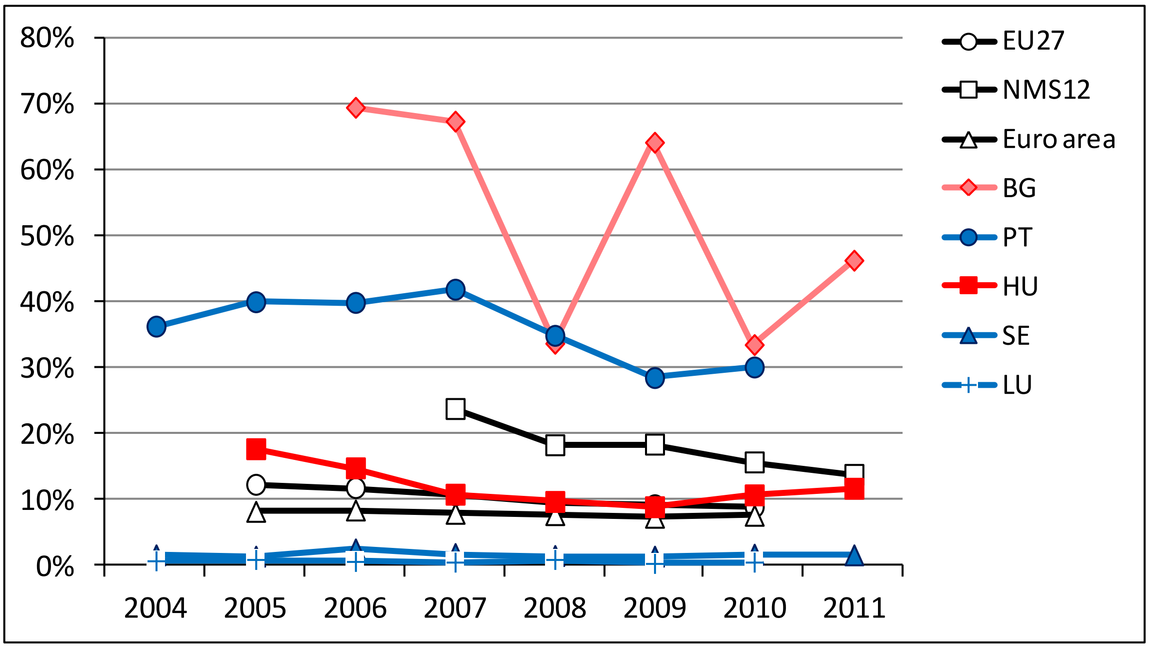
As discussed in Section 3.2.1.2.3, indicators based on the consensual approach focus on the non-monetary or material aspects of deprivation. They thus rely on attributes commonly accepted as a necessity in a given society (i.e., enough heating at home during the cold season) whose enforced lack is indicative 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*. This question reads as follows (EC, 2010b, p. 176),

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

and has only two possible answers (yes/no). It refers to the ability to pay to keep the home adequately warm, regardless of whether the household actually needs to keep it adequately warm (EC, 2010b).

Figure 13.Percentage of the population unable to keep the home adequately warm. Hungary vs. EU27 (2004-2011).



Source: EU SILC (Eurostat)

Aggregated EU-SILC results for this item allow comparing consensual fuel poverty rates (measured as a percentage of the total population) in Hungary, the EU27, Euro Area, the 12 new Member States (NMS12), and the two best and worst performing Member States. As presented in Figure 13, in the period 2004-2011 an average of 12% of the Hungarian population (the 9th highest record in the EU27 and 7th among NMS12 countries) could not afford keeping their home adequately warm. Consequently, some 1.2 million people were in fuel poverty in Hungary as an average for 2005-2011 according to this indicator. As a reference, Hungary's capital city (Budapest) currently has a population of 1.7 million.

The percentages recorded for Hungary are below the average for NMS12 and around the EU27 average. A clear downward trend can be also observed for Hungary (and the NMS12 average) in 2004-2012 period, with only a slight increase in 2010-2011 probably related to deteriorating conditions due to the global economic crisis. This is an unexpected result because of the substantial energy prices increases occurred throughout the 2000s and particularly after 2006, which have not been offset by any significant improvements in the other two key factors for fuel poverty: household incomes and the energy performance of residential buildings. In fact, this energy*price hike* is clearly reflected on the increasing importance of domestic energy costs in the budget of Hungarian households (Section 4.2.1.1.2) and on expenditure-based fuel poverty rates (Section 4.2.1.4).

This perhaps relates to the most important drawback of this measuring approach, which is the subjective, declared character of the responses to the survey. As it happens with the rest of self-reported indicators based on EU SILC data, 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[22] or household types recognize themselves as unable to afford enough heating, some caution is needed when analysing the

[22] Note that in the case of Bulgaria (Figure 13) the indicator follows an erratic trend, which raises concerns about the reliability of the sampling.

results for this indicator. 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, 2011).

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). As with expenditure-based fuel poverty rates, the way people deal with their energy affordability constraints may actually make them disappear also from consensual fuel poverty statistics.

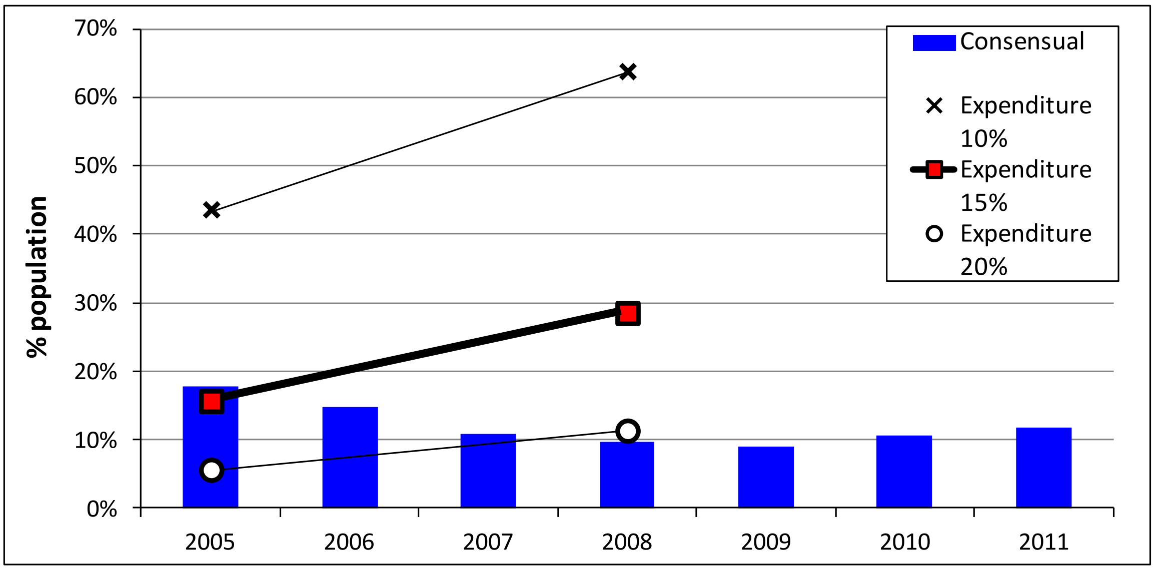
In relation with the previous point, it may be that a raise in energy prices does not automatically translate into increasing (perceived) difficulties to provide enough thermal comfort the living space of the dwelling. The way these perceptions are formed and then reported by the sampled households is probably a key element of this detected divergence.

Even though it is unknown to what extent these elements (or other undetected factors, e.g., sampling bais) interact with each other in the Hungarian case, it is suspected that they are behind the unexpected decrease in consensual fuel poverty rates between 2006 and 2009.

4.2.3. Comparing results: expenditure vs. consensual approach

Fuel poverty rates obtained with the application of the consensual and expenditure approaches are not directly comparable because the former are expressed as a percentage of the total population and the latter as a percentage of total households. Though closely related, both figures are not equal because not all households are of the same size (measured as number of household members).

Figure 14. Comparison offuel poverty rates (% of the total population) in the expenditure and consensual approaches



Source: own elaboration after data from the Hungarian Household Budget Survey (KSH) and EU SILC (Eurostat)

To overcome this constraint posed by the data, a percentage of the total population living in a fuel poor household as defined by the expenditure approach has been calculated by using the variable household size (provided in the HBS 2005 and 2008 datasets). This way a population-based expenditure fuel poverty rate was estimated[23,24] to be compared with the consensual fuel poverty rate – see Figure 14. Note that this is only possible for the years 2005 and 2008 as HBS microdata are only available for those two years.

[23] Example with household #1 of the 2005 HBS dataset: it has a weight of 135 (i.e., represents 135 *real* households of similar socio-economic characteristics) and a size of 4 members. It thus represents 540 (135 x 4) persons. These estimates are subject nevertheless to a certain error because data were collected, and weights calculated, at the household level. The total population of Hungary as calculated with this indirect approach based on household weight and size was 1.5% smaller than the Hungarian population as recorded by Eurostat both for 2005 and 2008.

[24] A collateral conclusion of this conversion is the following: when the rate is expressed as a percentage of the total population, this figure is consistently lower than the rate expressed as a percentage of households. This could mean that fuel poor households are smaller (they have fewer members) than the average Hungarian household; it has implications in terms of the size of the fuel poverty phenomenon in Hungary as relatively fewer people than households are affected.

The opposite comparison was not possible: consensual fuel poverty rates could not be expressed as a percentage of Hungarian households because only aggregated percentages of the total population can be retrieved for this indicator from Eurostat's EU SILC.

Little is yet known about the comparative accuracy for measuring the incidence fuel poverty of the expenditure and consensual approaches. As discussed in Section 3.2.1.2.4, evidence from the UK and Ireland indicates that consensual measures report lower fuel poverty rates than expenditure-based ones calculated upon a 10% fuel poverty line (Healy and Clinch, 2002; 2004; Waddams Price et al., 2006). This is thus adopted as the initial hypothesis for the comparative analysis.

The results obtained for Hungary confirm to some extent this hypothesis (depending on the year and fuel poverty line selected), as shown in Figure 14. Such comparison is in any case influenced by the unexpected decrease of consensual fuel poverty rates which, unlike expenditure-based rates and domestic energy prices, decreased in the 2005-2009 period.

In reality, what this comparison highlights is the sensitivity of expenditure-based results to the fuel poverty line. An idea would be using consensual data for finding a fuel poverty line above which most households declare to be unable to keep their homes adequately warm. However, this would require a unified dataset surveying the same households and containing both questions about household expenditures and EU-SILC deprivation items, like the one analysed by Waddams Price et al. (2006). In Hungary, such a dataset is currently being collected by the KSH but because of the rotational design of the sampling process it will only be available in some years from now (Salamin and Ménesi, pers. comm.).

Besides, it must be noted that expenditure-based rates consider all domestic uses of energy but consensual rates refer only to space heating. Since natural gas provides a range of domestic energy services different from space heating (e.g., cooking and hot water provision) and electricityrepresents 40% of a household’s energy costs (but it is very seldom used for space heating), consensual indicators refer only to only a part of a household’s energy consumption.

4.3. SECONDARY INDICATORS: FUEL POVERTY-RELATED ASPECTS

4.3.1. Arrears on utility bills (self-reported)

Also following Healy (2004), this sub-set of secondary (consensual) indicators of fuel poverty in Hungary opens with another EU SILC item (HS020) – *Arrears on utility bills*, which reads as follows in the generic SILC questionnaire (EC, 2010b, p. 186)

> In the last twelve months, has the household been in arrears, i.e. has been unable to pay on time due to financial difficulties for utility bills (heating, electricity, gas, water, etc.) for the main dwelling?

It has only two possible answers (yes/no)[25]. This includes (at least) heating, electricity, gas, water, sewage and refuse – but not telephone – bills for the main dwelling of the household. However, domestic energy expenditurestake up the largest fraction of household utility bills in Hungary– see Figure 6.

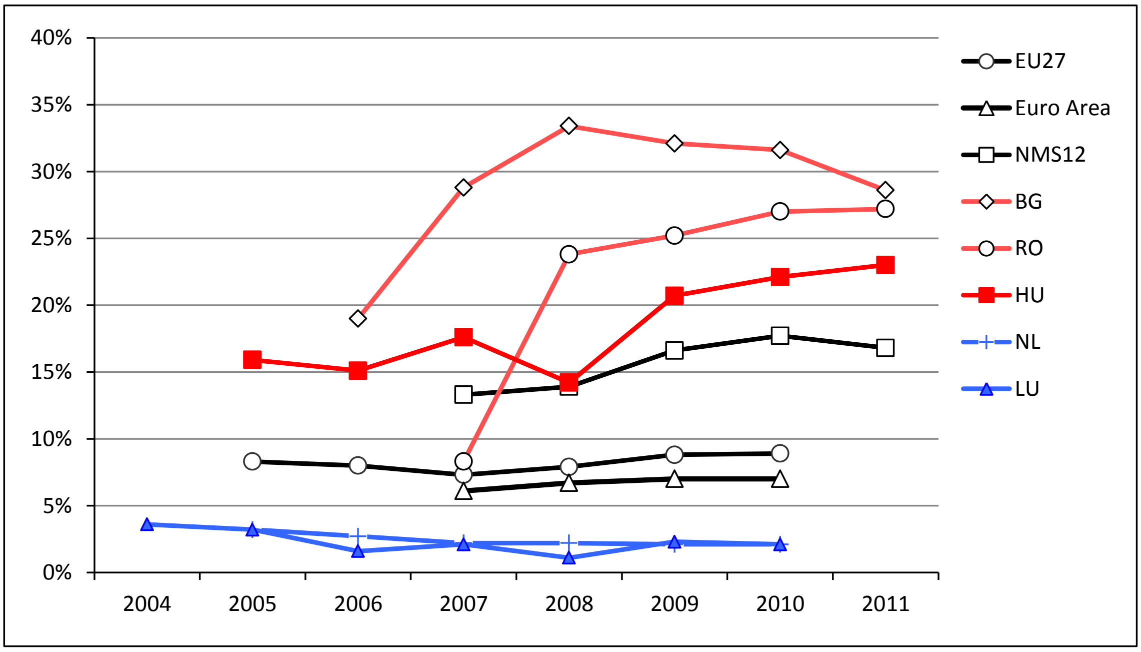
The question only considers financial reasons behind the arrears (i.e., if the failure to pay on time was due to, for instance, being sick, is not considered as an arrear). Additionally, if the household manages to pay through borrowing (from bank, relatives or friends), it is

[25] An updated version of this EUSILC item (HS021) includes three possible answers: 1) yes, once; 2) yes, twice or more; 3) no (EC, 2010b). However, data retrieved from Eurostat for this indicator only offered the percentage of the population in arrears on utility bills per Member State.

considered in the same way as if the household manages to pay through their own resources (EC, 2010b).

The results for this secondary indicator (Figure 15) show that for 2005-2011, an average of 18.4% of the Hungarian population (some 1.8 million people) lived in households that had at a certain point of the year unpaid sums to utility providers. This figure is somewhat higher than the average percentage of the population unable to afford enough heating in winter (12%) in Hungary in 2005-2011. During that period, Hungary was the fourth-worst performer of the EU according to this indicator after Bulgaria, Romania and Greece.

Figure 15.Percentage of the population with arrears on utility bills. Hungary vs. EU27 (2004-2009).



Note: The graph displays the results for Hungary, the two best and worst performing Member States, plus three representative averages of selected clusters of countries (EU27, NMS12 and the Euro Area; red colours represent CEE Member States and blue colours represents Western Member States.
Source: EU SILC (Eurostat)

It must be noted that the 2005-2008 rates for this indicator do not show any significant increase, which would be expected given the large increase in expenditure-based fuel poverty rates (Section 4.2.1.4) and the domestic energy prices (Section 5.3.1.1) occurred in that period. The factors suggested for the headline self-reported indicator (inability to afford the home adequately heated – EU SILC item HH050) may also explain the divergence of this indicator with expenditure-based results – see Section 4.2.2. In the case of this particular indicator, the so-called *social desirability bias*is important as respondents may choose to hide their actual behavior (arrears on utility bills) in order to produce a more socially acceptable response.

After 2008, the increase in the percentage of population with arrears in utility bills is notable because it raised the percentage of the population in arrears on utility bills up to 23 % (2.2 million people) in 2011. This is thought to be a consequence of the global financial and economic crisis.

This indicator is relevant for the analysis of fuel poverty because it highlights two important aspects of the phenomenon.

First, it illustrates that households are not just passive subjects but actors capable to react and resist when experiencing domestic energy affordability problems. For instance, they may choose to delay purposely the payment of expensive energy bills in order not to run out of money in the winter months. This way, households would be transferring (partially and temporarily) the impacts of fuel poverty to utility providers, which may cause troubles in their performance. In the case of generalised lack of or delayed payment, as has happened in the past with district heating providers (DH), the functioning of utility companies has been affected – see Chapter 6.

From the households' perspective, the negative side of this coping strategy is that it means falling into indebtedness or increasing the amount owed to utility companies. As a consequence, they may be disconnected or offered to install pre-payment meters to avoid disconnection (Szivós, et al., 2011). There is also evidence that households may turn to usury lenders as a last resort: in Hungary, Bass et al. (2008) have noted that the households' outstanding debt with utility companies is the main reason that forces them to take usury loans.

4.3.2. Fuel-poverty related housing faults (self-reported)

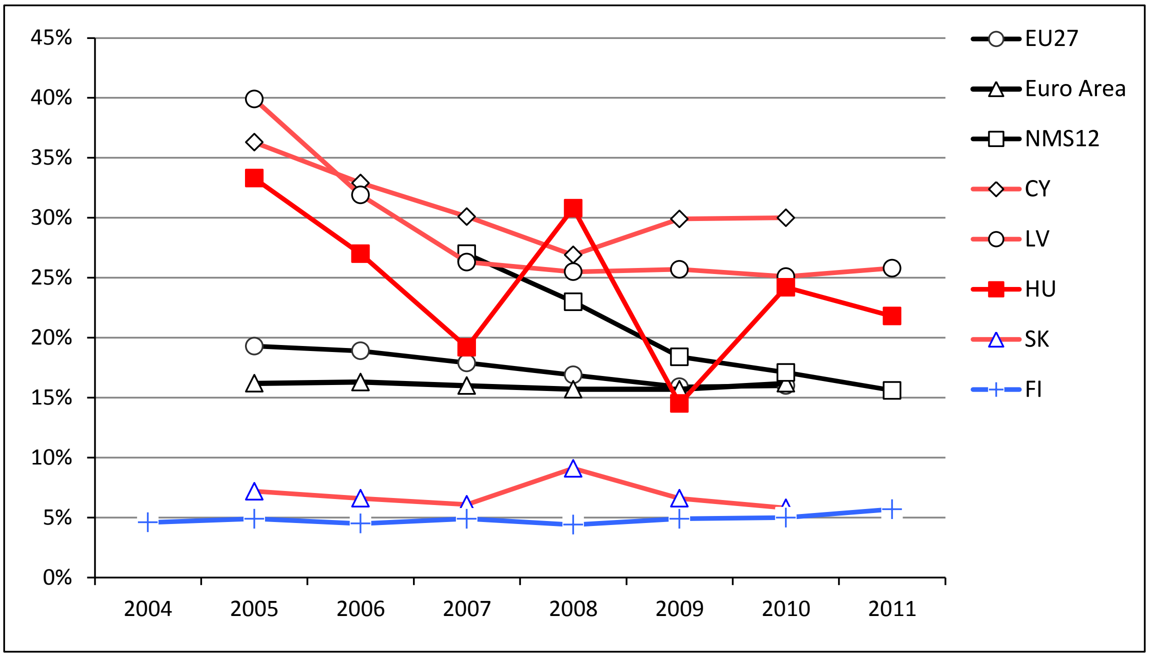
Also after Healy (2004), the EU SILC item HH040 (*Leaking roof, damp walls, floors or foundation, or rot in window frames or floor*) is also proposed to explore the self-reported presence of fuel-poverty related faults in the dwelling. The mentioned item reads as

> Do you have any of the following problems with your dwelling / accommodation?
> - a leaking roof
> - damp walls/floors/foundation
> - rot in window frames or floor

andhas only two possible answers (yes/no), which means that an affirmative answer is expected when at least one of the three proposed faults is present. These various housingconditions are relevant in terms of fuel poverty. Leaking roofs and damp walls, floor or foundations can be related to indoor mould build-up. Dwellings in such conditions will also be more exposed to external weather conditions and (e.g., draughts) and will spend more energy in order to keep an adequate level of thermal comfort.

As presented in Figure 16, the percentage of the Hungarian population living in a house with fuel-poverty related faults decreased between 2005 and 2007 and then follows a somewhat erratic pattern afterwards. However, as an average for the period 2005-2011, 24% of the Hungarian population (around 2.5 million people) experienced some of the above-mentioned bad housing conditions. Hungary is the Member State with fifth-highest value for this indicator after Cyprus, Latvia, Poland and Slovenia.

Figure 16.Percentage of the population with leaking roof, damp walls, floors or foundation, or rot in window frames or floor at home. Hungary vs. EU27 (2004-2009).



Note: The graph displays the results for Hungary, the two best and worst performing Member States, plus three representative averages of selected clusters of countries (EU27, NMS12 and the Euro Area); red colours represent CEE Member States and blue colours represents Western Member States.
Source: EU SILC (Eurostat).

As before, the results and cross-country comparisons presented need to be treated with some caution because of the declared character of the responses to this EU SILC questionnaire item. A second drawback is that dwellings that are affected to very different extents (from slight window rot to overall house maintenance problems) fall under the same category, and then just a fraction of them will probably contain households in fuel poverty. Besides, the physical elements of the dwelling to which the indicator refers to are surely related to its quality but are not a precise measure of its energy performance (i.e., dwellings without any of the defects tracked through this indicator may also be energy inefficient). This aspect – the energy performance of the dwelling as a main cause of fuel poverty – is explored in more detail in Section 5.4.

4.4. PROPOSED INDICATORS: ADDITIONAL ELEMENTS OF THE FUEL POVERTY EXPERIENCE

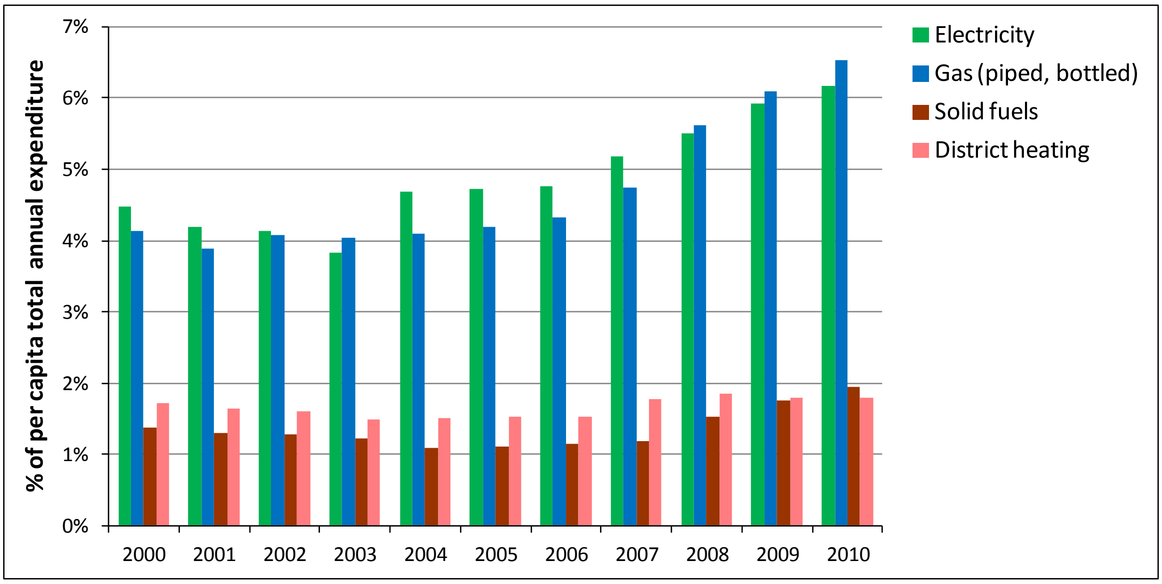
4.4.1. Use of traditional fuels for space heating

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, as discussed below.

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, which has even increased since the early 2000s. In this sense, firewood has behaved quite differently from other solid fuels such as coal and oil, whose importance as heating fuels has largely decreased since 1990(Energia Központ, 2008). The moving away from coal and oil happened as a result of massive fuel switching during the 1990s that replaced most tile stoves and coal and oil boilers with more efficient gas boilers, a process in which subsidised domestic gas prices played an important role (*ibid*.).

The progressive change in Hungary's energy mix for domestic space heating can be also observed in the data of the Household Budget Survey (HBS): results for the 2000-2010 period indicate that since 2006 solid fuels (firewood to a large extent) have increased their importance in the average Hungarian household's energy budget until becoming a more important energy carrier (measured as percentage of total household expenditure per capita) than district heating (DH) – see Figure 17.

Figure 17. Percentage of energy expenditures

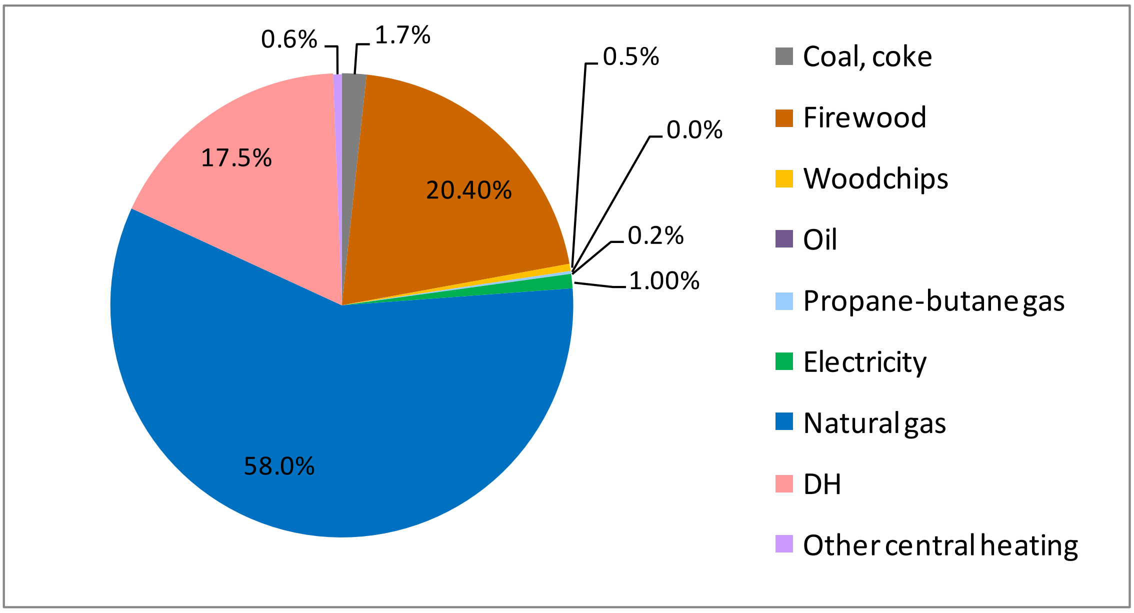


Source: own elaboration after data from the Hungarian Household Budget Survey (KSH)

The result of this process is that firewood is nowadays the second most used energy carrier for space heating in Hungary. As of 2009, data collected by Energy Use moduleof the Household Budget and Living Conditions Survey (HEF2009)[26] 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%) – see Figure 18. 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% use both natural gas and firewood for space heating.

[26]*Háztartási Költségvetési és Életkörülményfelvétel.Energia Felhasználási Modul 2009* - an *ad-hoc* module of the Household Budget Survey with data only for the year 2009.

Figure 18.Distribution of households by energy carriers used for heating (2009)



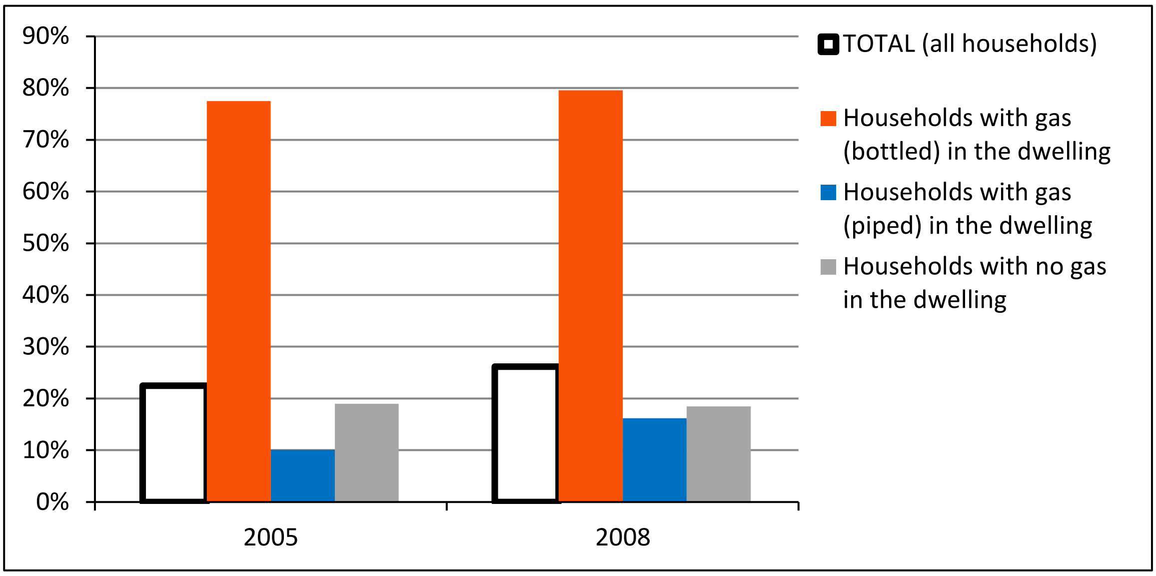
Source: Energia Központ (2009) based on HEF2009 data

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), which is also used for estimating expenditure-based fuel poverty rates (Section 4.2.1.2.1).

For this, the procedure has been the following: since HBS microdata disaggregate energy expenditures by energy carriers a household with significant reliance on firewood has been defined as one in which firewood represents more than 10% of total energy expenditures. This way, households in which the use of firewood is insignificant are disregarded. The percentage of all Hungarian households in which the use of firewood is significant has been then estimated; and then results have been disaggregated by categories of households having access to different types of natural gas (or no access to natural gas).

The results are shown in Figure 19 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[27].

Figure 19. 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)

It is suspected that many of those households are from rural areas, where dwellings are more often prepared for the use of fuel wood (e.g., they have storage space and chimneys) and easy access to the fuel, including direct biomass collection or self-production, is more likely. In cities, on the contrary, fuel wood can be purchased through commercial distributors (Elek, pers. comm.) though the extent to which fuel substitution is occurring in urban areas is

[27] Note that all percentages shown in Figure 19 increased between 2005 and 2008 in parallel to the increase in natural gas prices and expenditure-based fuel poverty rates.

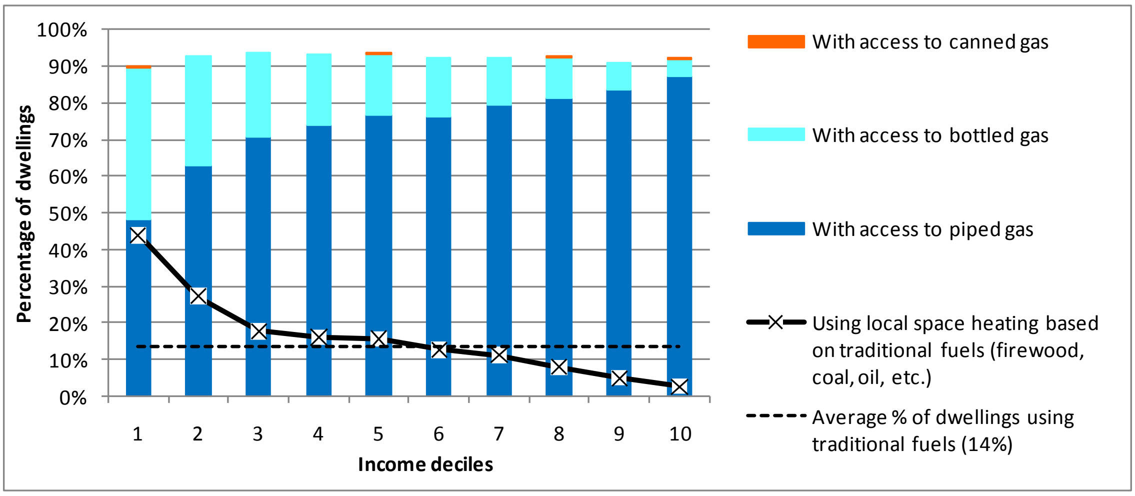
unknown. Anecdotal evidence from interviews suggest that it is a practice not unheard of: the president of a relatively important pensioners' association– a woman over 60 with experience in representing pensioners' interests in the Hungarian Parliament, working in an office located in central Pest – declared when interviewed in July 2009 to be heating her "own flat with firewood because it's cheaper" and also because "her husband organizes it", which suggests that not all persons have the possibility to switch fuels as a coping strategy. In this regard, this same interviewee also noted that in rural areas the use of firewood as a heating fuel can be particularly challenging for elders because of the strength required for carrying out physically demanding tasks like moving and preparing the firewood and operating the stoves.

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.

The socio-economic analysis of this indicator seems to disprove this hypothesis. As shown by Figure 20 (based on data from the 2007 Household Budget Survey), Hungarian lower-income households rely more often on traditional fuels than their higher-income peers. This is particularly the case of the lowest two income deciles, where 30 to 40% of households use firewood, coal, oil, etc. for heating.

What these numbers indicate is that traditional fuels are inferior goods, i.e., their consumption decreases as income rises. This is consistent with the income elasticities of heating fuels in Hungary calculated by Szajkó et al. (2009). And it is also in line with the income elasticity obtained for the use of coal in Irish households by Scott et al. (2008) and Conniffe(2000).

Figure 20. Percentage of the dwellings with access to natural gas and using traditional fuels for space heating in Hungary (2007).



Source: own elaboration after data from the Hungarian Household Budget Survey (KSH)

Some conclusions can be drawn from the data assembled. To start with, most households in Hungary have access to natural gas (either piped, bottled or canned), which is a preferred source of heat as the income elasticities of different fuels indicate. Still, a sizeable fraction of Hungarian households have resorted to traditional fuels for meeting their energy needs, which suggests that households are voluntarily giving up the possibility to use natural gas and choosing to use traditional fuels as an 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, namely because part of the population (8% on average as of 2007) do not have access to any sort natural gas. However, it is likely that many 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. For these households, 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.

A closely related issue to this type of fuel poverty is the illegal collection of firewood by households – see Section6.2.1.3. Estimates indicate that some 3-3.5 million cubic meters of firewood were collected illegally in Hungary per year in the period 1999-2006. This amount is roughly half of the registered 6.5-7 million cubic meters collected annually according to official statistics, which puts the total annual rate of collection in Hungary at around 10 million cubic meters per year (Szajkó, 2009). Most likely all that firewood is not collected illegally by households, which have a limited logging, processing and storing capacity; firewood theft can be also carried out by commercial firms for various purposes.

This facet of the fuel poverty phenomenon is not exclusive of Hungary, as this behaviour has been detected 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 (mainly firewood), are more likely to suffer from health problems related to indoor air pollution, cause deforestation and provoke micro-conflicts between forest authorities and poachers (Lampietti and Meyers, 2003; UNDP, 2004; Euractiv, 2010; 2012).

4.4.2. *Summertime* fuel poverty: a preliminary analysis.

4.4.2.1. Pushing the boundaries of the fuel poverty concept

Traditionally, indoor home temperatures in the winter months have been the main concern of fuel poverty researchers and practitioners. However, since air-conditioning and other cooling systems have become widely available, energy is not only required during the cold season for keeping adequate indoor thermal temperatures. In the EU, this is particularly the case of Mediterranean Member States, but it also applies to continental, landlocked regions – such as the CEE – where temperatures also raise high in the summer months.

In the medium- to long-term, interactions between climate change and fuel poverty are likely to be amplified: if global warming-related temperature increases will reduce the number of heating degree days in the cold season, they may also increase cooling requirements or heat-related welfare impacts on welfare during the hot season. In the UK, an exploratory analysis of the vulnerability to climate change-related heat waves and droughts has indicated the higher exposure of the lower-income population to these negative effects of climate change (Benzie et al., 2011). Interestingly, this has also led to the definition of a *water poverty* that emerged as an extension of the fuel poverty notion, is said to occur when a household spends more a 3% of a its net yearly income on domestic water, which is the threshold defined as a *reasonable cost* for this utility service in the UK (*ibid.*).

Summertime fuel poverty has been so far a largely unexplored sub-field of inquiry in the fuel poverty research landscape. The one and only reference located isa section on cooling affordability in Healy's (2004) *Housing fuel poverty and health. A Pan-European analysis*, which discusses the difficulties of low-income households of Southern EU Member States to purchase air-conditioning units or other cooling systems, presents data on the mortality caused by the 2003 summer heatwave in Western Europe and suggests a link between summertime fuel poverty and excess summer mortality. However, as pointed by the author, scarcity of data makes it difficult to provide epidemiological evidence supporting such a relationship.

Though it has been stated that "poor thermal efficiency is not going to be a factor in any health related impacts of excessive heat exposure" (Healy, 2004, p. 62), summertime fuel poverty also needs to be related to the thermal performance of residential buildings. In the UK, Benzie et al. (2011) have indicated that people living in poorly constructed buildings in urban heat islands[28] are more likely to be exposed to heat waves. In Hungary, case study-based evidence collected indicates that the dwellers of low-quality prefabricated *panel* buildings in Budapest report high levels of dissatisfaction with indoor temperatures in the summer (see Section 6.3.2). Conversely, it is believed that advanced energy efficiency solutions such as the passive house contain insulation and design elements that, while maximising internal and external gains in wintertime, also protect the dwelling against undesired external gains during the summer, with specific passive cooling components and strategies (e.g., reflective roof and windows, exterior and interior shading structures, attic ventilation, etc.) designed for houses in warm climates (see Burkholder and Anderson, 2005). Thus, following one of the main hypotheses of this dissertation, advanced residential energy efficiency solutions can be regarded as a solution to both summertime and wintertime fuel poverty.

4.4.2.2. Indicators of summertime *fuel poverty.*

No previous measurements of summertime fuel poverty incidence rates have been located for any country or region. However, data reported in the 2007 *ad-hoc* module on housing conditions of EU-SILC (EC, 2009) allow a first quantitative assessment in Hungary and the rest of EU nations following the self-reported or consensual approach. More specifically, data were retrieved from items MH060 (*Dwelling equipped with air conditioning facilities*) and MH070 (*Dwelling comfortably cool during summer time*) of the mentioned *ad-hoc* EU-SILC

[28]An urban area with a higher temperature than its non-urban surroundings (EPA, 2012b).

module. This source is a thematic survey that focuses on a different topic every year[29] with the aim of tackling different aspects in the field of social statistics. The results presented here are only representative for 2007, and no time series are available.

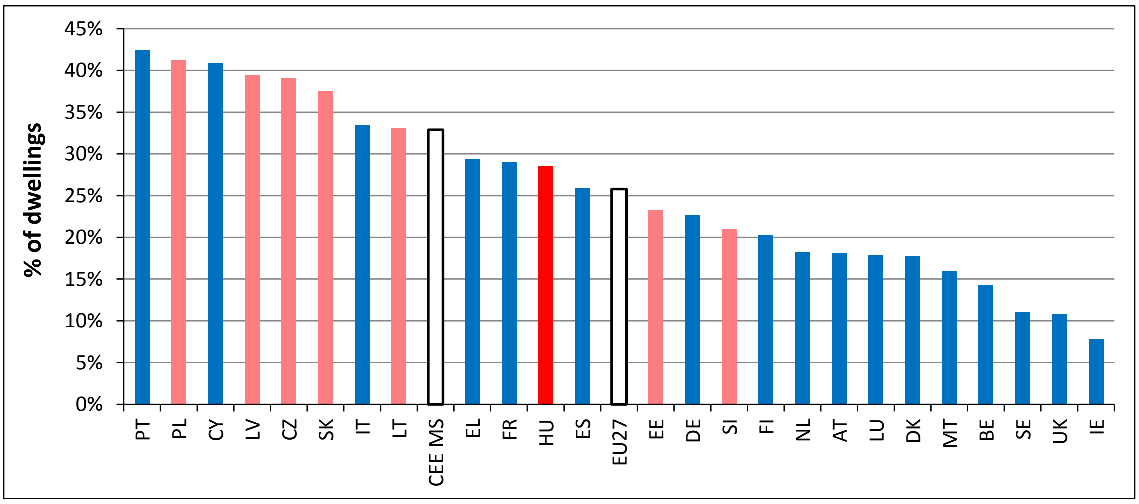
The headline indicator selected for this preliminary analysis is *Dwelling comfortably cool during summer time*. This is very similar to the self-reported *Inability to keep the house adequately warm* primary indicator of fuel poverty as it also relies on the household's self-assessment of its thermal comfort. For this reason, the same cautions regarding the subjective nature of the responses to this item of the questionnaire apply – see Section 4.2.2.

The results for this indicator (Figure 21) show large differences between EU27 Member States, with north-western countries (Ireland, UK, Sweden and Belgium) plus Malta reporting the lowest percentages (10% to 15%) of dwellings being uncomfortably cool in the summer. In the higher range, a mixture of Mediterranean and CEE Member States (Portugal, Poland, Cyprus, Czech Republic, Slovakia, Italy and Lithuania) display the highest rates of dissatisfaction as 30% to 40% dwellings are not comfortably cool during the summer.

Note that, in general, CEE Member States report summer indoor thermal dissatisfaction rates higher than the EU average – even for northern CEE countries with relatively mild summers like Lithuania. Hungary, where 29% of the dwellings were not comfortably cool during the summer in 2007, is below the CEE Member States and in line with the EU27 average. Among CEE, only Estonia and Slovenia performed better than the EU27 average in 2007according to this indicator.

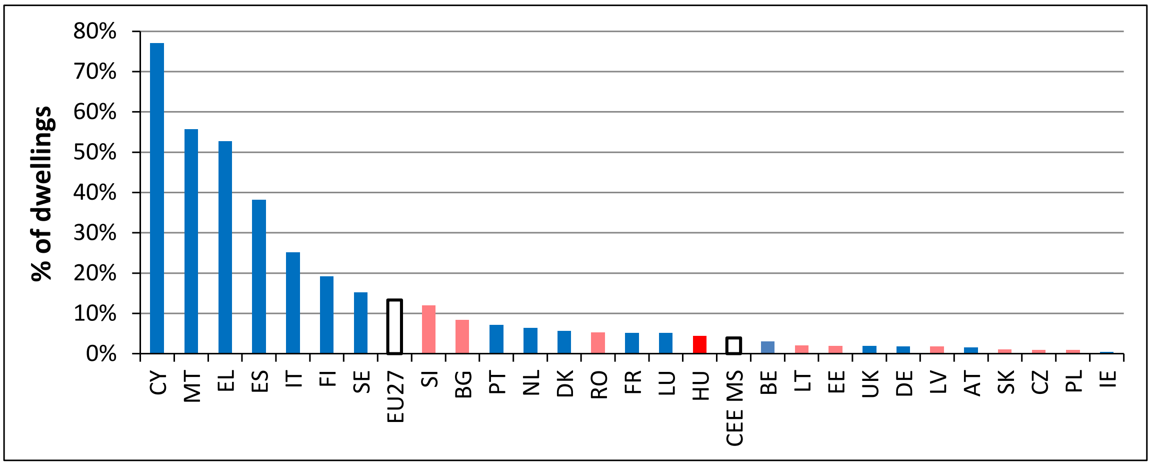
[29] For instance, in 2008 the main focus of the *ad-hoc* EU-SILCmodule was on over-indebtedness and financial exclusion, whereas in 2006 it was on social participation.

Figure 21. Percentage of dwellings not being comfortably cool during summertimein 2007



Notes: No data available for BG and RO. Percentages for CEE EU MS and EU27 estimated unweighted averages of individual CEE Member States with available data; red colours represent CEE Member States and blue colours represents Western Member States.
Source: Eurostat

Figure 22. Percentage of dwellings with air conditioning equipment in 2007



Notes: Figures for CEE EU MS and EU27 estimated as unweighted averages of individual CEE Member States with available data; red colours represent CEE Member States and blue colours represents Western Member States.
Source: Eurostat

A secondary indicator for this type of fuel poverty is the *ad-hoc* EU-SILC item MH060 - *Dwelling equipped with air conditioning facilities*. As shown inFigure 22, large differences exist between Member States, with southern countries, and particularly the Mediterranean island-states (Cyprus and Malta), reporting a much higher percentage of air-conditioned dwellings than the EU27 average. Though summer temperatures seem to be a main explanatory factor for the differences in this indicator, two cold Scandinavian nations

(Sweden and Finland) display a relatively high percentage of homes equipped with cooling devices. In Hungary, just 5% of the dwellings have air-conditioning, a percentage which is below the EU27 average, in line with the CEE average and below the figure reported by other three CEE nations (Slovenia, Bulgaria and Romania).

To sum up, it can be concluded that in 2007 a sizeable fraction of the EU27 (26%) and CEE Member States (33%) dwellings appeared to be not comfortably cool during the summer, according to this proposed self-reported indicator of summertime fuel poverty. Mediterranean as much as CEE Member States are the countries more negatively affected, with Hungary reporting summer indoor thermal discomfort incidence rates (29%) in the lower end of the CEE range. In fact, these two clusters of Member States – Mediterranean and CEE – seem to be the most affected by both summer and wintertime fuel poverty as measured by the self-reported approach.

Interestingly, no significant correlation was detected between summertime thermal discomfort levels and prevalence of air-conditioned homes. Preliminarily, this may imply that high rates of penetration of air-conditioning devices do not necessarily guarantee low percentages of summertime indoor thermal discomfort (e.g., Cyprus has the largest fraction of air-conditioned dwellings of the EU27 – 77% – but still more than 40% of its dwellings are uncomfortably warm in the summer), perhaps because of problems with the affordability of electrical power. In contrast, Malta provides an opposite example as its high rate of dwelling with air conditioning corresponds with one of the lowest rates of summer thermal discomfort, at the same level as Denmark and Belgium.

4.4.2.3. Is there a case for summertime *fuel poverty?*

An additional reflection on how to incorporate summertime fuel poverty to the theoretical framework of fuel poverty is suggested.

First and foremost, it is somehow still unresolved whether, from a household's basic needs' perspective, people deserve to - be as comfortably cool in summer as comfortably warm enough in winter. Put in other words, this means that whereas suffering the summer heat at home is perhaps just taken as a nuisance, living in a cold home in winter is considered as a problem. Since most of the fuel poverty literature comes from temperate nations with mild summers (i.e., the UK and Ireland), this might be a reason why summertime fuel poverty has been largely disregarded so far.

Such perception perhaps has to do with the fact that no negative health effects have been yet linked with inadequate summer in-house temperatures[30]. Consequently, air-conditioning, unlike proper heating, is not yet regarded as a need, and therefore its absence in the dwelling may not be considered as an enforced lack. Of course, things look different in places with long, hot summers.

It is also known that poor households systematically report for all Member States higher summer thermal discomfort levels than non-poor households, and that the self-reported quality of dwellings is an explanatory factor of summertime thermal discomfort rates (see Section 5.4.2.1). These are two features shared by both summertime and wintertime fuel

[30] Still,summer heatwaves are known to increase mortality rates, though only in years with unusually high summer temperatures. A recent example is the summer 2003 heatwave, which according to Vandentorren *et al*. (2004) increased the mortality of the13 largest cities in France by between 4 (Lille) and 142% (Paris). Fort the whole Europe, it was estimated that 70.000 additional deaths occured as a consequence of the extreme climatic conditions during that summer (Robin *et al*., 2008).

poverty that provide an argument to incorporate summertime thermal discomfort as an element of the fuel poverty not to be overlooked.

If it is accepted that there is a case for summertime fuel poverty, the affordability of air conditioning as a domestic energy service can be defined in two senses. It can first refer to the purchase or availability of an air-conditioning system (which often are not in-built in the dwelling, like heating systems); and then comes the issue of the energy costs needed for its operation, which are higher because active cooling systems (i.e., air-conditioning devices) use an expensive energy carrier – electricity. In a longer timeframe, summertime thermal discomfort is related with the performance of residential buildings in the hot season. Thus, summertime fuel poverty is, like wintertime, a capital-related as much as an income-related type of poverty.

More theoretical elaboration is required to differentiate and possibly integrate summer and wintertime fuel poverty. Still, in the light of the results and conclusions drawn from this preliminary analysis, it seems legitimate to explicitly incorporate *summertime elements* in the examination of fuel poverty. In this context, it is believed that the proposed headline indicator *Dwellings not being comfortably cool during summer time* offers a reasonable first approximation of the incidence of summertime fuel poverty in the EU27 following a self-reported approach.

4.5. INDICATORS: SUMMARY OF RESULTS AND SOME METHODOLOGICAL CONCLUSIONS

This chapter has critically assessed the two more widely recognised approaches (expenditure-based and consensual or self-reported) to the measurement of fuel poverty in the Hungarian case. It has later analysed a number of secondary fuel poverty indicators and proposed two indicators not previously examined as such by the fuel poverty literature (*summertime* fuel poverty and use of traditional fuels for space heating).

All in all, six indicators retrieved from various data sources – the Hungarian Household Budget Survey (HBS), the Energy Use moduleof the Household Budget and Living Conditions Survey (HEF2009) of the Hungarian Central Statistical Office (KSH), and the EU Survey on Income and Living Conditions (EU-SILC) from Eurostat – have been examined. This comprehensive assessment has demonstrated that even in the absence of fuel poverty-specific data, a reasonable quantitative assessment of fuel poverty rates is possible by using readily available statistics collected by national statistical offices for more general or different purposes.

A summary of the results obtained with the indicators is presented in Table 11. In addition to that, a few conclusions on the use of indicators for the measurement and characterisation of fuel poverty have been obtained:

- Conventional calculation methods provide somewhat imperfect estimates of the actual number of households in fuel poverty. Significant methodological challenges remain in both the expenditure-based and consensual/self-reported approaches. In both cases, a gap remains between the concept and the indicator; thus common drawbacks to both approaches is that they fail to properly measure the actual deficit or enforced lack of energy services (e.g., inadequate indoor temperatures poor lighting, etc.) and that not a single indicator can capture the complexity of the fuel poverty phenomenon highlighted by the diversity of *coping strategies* that help households to deal with energy affordability problems – see Section 6.4.2.

- The application of the expenditure approach to Hungarian HBS data has been rendered problematic for two reasons. First, having ruled out a UK's 10% (energy expenses vs. net income) threshold, the difficulties experienced in setting a Hungary-specific fuel poverty line (Section 4.2.1.3) have confirmed the arbitrariness of fuel poverty lines. Second, HBS data provide data on actual energy expenditure. For this reason, fuel poor households can remove themselves from expenditure-based fuel poverty statistics either by reducing the amount of energy consumed at home or by switching to lower quality, cheaper fuels. This can be avoided by recording not the actual but the theoretical energy consumption required for an adequate level of provision of energy services, given the household and building characteristics, like the English House Condition Survey (EHCS) does (DECC, 2009). This requires a more complex, specific data collection methodology different from the readily available household budget surveys.
- An expenditure-based criterion not based on anenergy expenditures vs. net income fuel poverty line has been proposed and tested. According to this criterion, a household is in fuel poverty if it spends more on energy than on food and non-alcoholic beverages. It rests on the fact that food (incl. non-alcoholic beverages) is the most important item of a Hungarian household's budget and on the assumption that cutting on food expenses to pay for domestic energy is a coping strategy sometimes adopted by fuel poor households (Bhattacharya, et al., 2003; O'Neill et al, 2006). However, a preliminary exploration has confirmed that many (around 40%) of the households labelled as fuel poor according to this criterion are not so according to a 15% fuel poverty line. Thus further research is suggested to determine the validity of this criterion as a reliable indicator of fuel poverty.
- it was surprising to find a decrease in the amount of fuel poor people according to the consensual/self-reported approach (i.e., stating to be unable to keep their home adequately warm) between 2004 and 2009. This is in contradiction with the increase in

expenditure-based fuel poverty ratesand the large increase in domestic energy (gas) prices registered since 2006 (see Section 5.3.1.1). This largely unexpected divergence may suggest that consensual rates are a less reliable fuel poverty indicator, at least in the Hungarian context. Thus, unless households are coping with the rapidly increasing domestic energy prices by means other than reducing their thermal comfort, the application of the consensual approach (in Hungary, but probably in other contexts too) remains controversial. In spite of that, EU SILC remains the only data source fit for cross-country comparisons in the EU.

- A fair critique to the consensual approach is the subjective, stated character of the responses to EU SILC item HH050 in which respondents are requested to assess the situation of their household in terms of their ability to affordability as much heating as needed. It is suspected that fuel poor respondents may not declare their inability to keep their home adequately warm because their perception is biased or because they are not willing to tell an unknown survey taker about the conditions in which they live. Moreover, cultural differences could explain to an unknown extent differences in self-reported fuel poverty rates recorded within and between different Member States. Still, they are a unique source of primary information about the effects of fuel poverty reported by households in first person.
- The complexity of the fuel poverty phenomenon (see Section 4.5) calls for the inclusion of secondary indicators additional to headline expenditure-based and self-reported fuel poverty rates. This way, this research has presented results for EU SILC indicators *Arrears on utility bills* and *Fuel-poverty related housing faults*, as done by previous research in the EU context (Healy, 2004; Buzar, 2011). In addition, two so far unreported secondary indicators are proposed:

- Use of traditional fuels for space heating: though this issue has already been addressed in the fuel poverty literature, it has not yet been analysed quantitatively as an indicator of fuel poverty. Thedissertation suggests that if an increasingproportion of householdssubstitute a quality source of heat (e.g., connected to the natural gas grid) by a less convenient and cheaper traditional fuel such as firewood, this is indicative of growing energy affordability problems. In the context where a substantial fraction of households rely on traditional fuels as a source of heat, like the post-socialist countries of Eastern Europe, its consideration as an indicator is recommended (Fankhauser and Tepic, 2005).
- *Summertime* fuel poverty: the fuel poverty literature still focuses mainly on wintertime indoor thermal discomfort. The notion of a *summertime* fuel poverty, suggested by Healy (2004), has been explored for the first time through a self-reported indicator obtained from the 2007 *ad-hoc* module of EU SILC proposed – *dwellings not being comfortably cool during summertime* (Section 4.4.2). .

Table 11. Indicators of fuel poverty in Hungary: summary of results

Label	Indicator	Key results	Source	Location
Primary [FP RATES]	*Expenditure-based*	- Domestic energy consumption took 12.6% of the average Hungarian household's total per capita expenditure as an average of the period 2000-2010. In 2010, this percentage had climbed to over 15%. Domestic energy is now the second-largest household expenditure item after food and non-alcoholic beverages. - In the late 2000s,**21% (2005) to 34% (2008) of Hungarian households (0.8 to 1.3 million people) were in fuel poverty** as defined by a fuel poverty line of 15% annual energy expenditures vs. income. - In the late 2000s,13% (2005) to 20% (2008) of Hungarian households (0.5 to 0.7 million people) spent more on energy than on food and non-alcoholic beverages.	Household Budget Survey (HBS)	Section 4.2.1.4 Figure 4 Figure 5 Figure 12 Figure 14
	Consensual or self-reported	- **12% of Hungarian population (~1.2 million people) were in fuel poverty** (i.e., declared to be unable to afford to keep their home adequately warm) **as an average for the period 2004-2011**.	EU SILC. Item HH50.	Section 4.2.2 Figure 13
Secondary [FP-RELATED ASPECTS]	*Arrears on utility bills (consensual)*	- 18% of the Hungarian population (~1.8 million people) declared to be on arrears in utility bills (incl. energy) as an average for the period 2004-2011.	EU SILC. Item HS020.	Section 4.3.1 Figure 15
	Fuel-poverty related housing faults (consensual)	- 24% of the Hungarian population (~2.5 million people) declared to be living in a dwelling with leaking roof, damp walls, floors or foundation, or rot in window frames or floor, as an average for the period 2004-2011.	EU SILC. Item HH040.	Section 4.3.2 Figure 16
Proposed [NEW FP INDCATORS]	*Use of traditional fuels*	- Even though most Hungarian households have access to natural gas (piped, bottled or canned), in 22% of Hungarian dwellings traditional fuels (mostly firewood) were used as a primary source of heat as of 2011. In an additional 11% of the dwellings use natural gas and firewood were used. - In 2005 10% of households with access to piped gas were using firewood; in 2008 this figure had increased to 16%. - In 2007 44% of the dwellings in the lowest income decile and 27% of the second lowest income decile used firewood for heating.	Household Budget Survey (HBS) Energy Use moduleof the Household Budget and Living Conditions Survey (HEF2009) Energia Klub (2011)	Section 4.4.1 Figure 18 Figure 19 Figure 20
	Summertime fuel poverty	- 29% of Hungarian dwellings were not comfortably cool during the summer in 2007. - 95% of Hungarian dwellings did not have air conditioning in 2007.	EU SIL (2007 *ad-hoc* module on housing conditions): items MH060 and MH070.	Section 4.4.2.2 Figure 21 Figure 22

Chapter 5

ANALYSIS OF CONTRIBUTING FACTORS

“Science must have originated in the feeling that something was wrong.”
Thomas Carlyle (1795-1881) British historian and essayist.

5. ANALYSIS OF CONTRIBUTING FACTORS

5.1. AN EXAMINATION OF THE CAUSES OF FUEL POVERTY

Conventionally, there are three causes or contributing factors considered in the analysis of fuel poverty: household incomes, energy prices and energy performance of the residential stock and the domestic energy-using equipment (BERR, 2001; OECD/IEA, 2011a; Ürge-Vorsatz and Tirado-Herrero, 2012). Even though other features such as ownership/tenancy rates and the institutional framework can be also considered, there is a more-or-less wide agreement about the key relevance of the three mentioned factors in the fuel poverty literature.

Based on this premise, this chapter aims at answering the following research sub-questionstaking Hungary as a representative case study: how is the evolution of fuel poverty rates in Hungary connected to changes in household incomes and energy prices? And what evidence provides the Hungarian case for understanding the role of the energy performance of the residential stock as a structural cause of fuel poverty?

With this aim, this chapter has collected and analysed quantitative information on the three main causes of fuel poverty both at the EU and the (Hungarian) national level. These provide ground for understanding the figures reported by the six indicators presented in the previous chapter, as well as the evolution of those indicators in the decade of the 2000s.

5.2. ENERGY PRICES AND HOUSEHOLD INCOMES

5.2.1. Current energy prices in Hungary vs. the EU27

A first task of this chapter is to understand where domestic energy prices stand in relation with other Member States. For this, half-yearly nominal prices of natural gas and electricity for domestic consumers have been retrieved from Eurostat[31] for all Member States (as well the EU27 average) in the period 2007-2011. The consumption band chosen for the comparison is 20 to 200 GJ per household per year for natural gas and 2,500 to 5,000 kWh per household per year and for electricity. These bands are assumed to be representative annual consumption figures of EU households.

Note that the analysis is limited to these two energy carriers because Member State-level data on other important energy carriers for Hungarian households – namely firewood and DH – was not available. In contrast, electricity is irrelevant from a domestic thermal comfort perspective because a minimal percentage (1%) of Hungarian households use it for space heating – see Figure 18. However, since it represents around 40% of the total energy expenditure of the average Hungarian households (see Figure 7), electricityis also relevant from a fuel poverty perspective.

A first step in the cross-country comparison of EU domestic energy prices is based on a calculated average of the nominal prices recorded during the nine semesters comprised between the second semester of 2007 and the second semester of 2011[32]. This average is representative of the current energy prices paid by EU households in those 4.5 years but does not reflect properly the evolution of energy prices in each Member States.

Initial data for this comparison are shown in Figure 5 and Figure 25, which indicate that the average nominal price of both natural gas and electricity for residential customers in the former socialist Member States of Central and Eastern Europe (CEE) is often below the EU27

[31] Data are also available for the period prior to 2007. However, a change in the methodology occurred in 2007 and figures before and after this year are not comparable.
[32] This is the period for which all Member States have full coverage of price data.

average and Western Europe figures. In the CEE region, Hungarian nominal domestic energy and gas prices are among the highest though still below the Union's average.

Eurostat data on gas and electricity prices are also expressed in Purchasing Power Standards (PPS). This is a more useful unit for comparison across countries with different price levels and also avoids exchange rate fluctuations (Eurostat, 2012c). Prices expressed in this artificial currency thus offer a more realistic picture of the effort that households in different Member States make to pay for the energy they use at home.

As presented in Figure 24 and Figure 26, domestic energy prices of CEE Member States are higher than Western Europe's when measured in PPS. Regarding Hungary, its consumers bore the third-highest natural gas prices and the highest electricity prices of the EU during the 2007-2011 period.

When plotted against GDP per capita (also in PPS), domestic gas and electricity prices can be compared with income per capita levels of Member States. Significant differences appear: as seen in Figure 27 and Figure 28, most CEE countries including Hungary have income levels below the EU average but face gas and electricity prices above the EU average. This imbalance is particularly notorious in the case of gas prices in Bulgaria and, to a lesser extent, for electricity prices in Hungary. On the opposite side, Western countries such as the UK, Ireland, France, Finland or Sweden enjoy better income levels and lower domestic energy prices than the EU average.

All in all, these data reflect the large differences in the energy prices paid by EU households living in different Member States, something that has been noted in previous studies (see VaasaETT, 2012). In the CEE region, households are subject to gas and electricity prices which are higher – relative to their economy's general price levels (i.e., measured in PPS) – than those in most Western Member States, in spite of the lower income levels (measured as GPD per capita in PPS) of the former.

Regarding natural gas in CEE countries, higher PPS-based prices occur against the background of a dysfunctional import market given the characteristics of the commodity and the region. Two elements have been recently highlighted by the European Commission's Market Observatory for Energy (EC, 2012c) in this respect. First, Baltic and Central European Member States have a very limited range of options in terms of import sources, As a consequence, they are very dependent on the former Soviet Union for natural gas, as evidenced by the supply disruptions occurred in these countries following the 2006 and 2009 disputes between Russia and the Ukraine. Second, gas prices in these countries are still indexed to oil prices through long-term contracts. They are consistently higher than gas-to-gas competition spot prices settled in trade hubs on which Western Member States are increasingly relying.

In recent years (2007-2011), this is reflected in the fact that nominal gas prices for domestic consumers (including taxes) have risen by 50% on average, whereas the average increase in Western states has been below 20%[33].

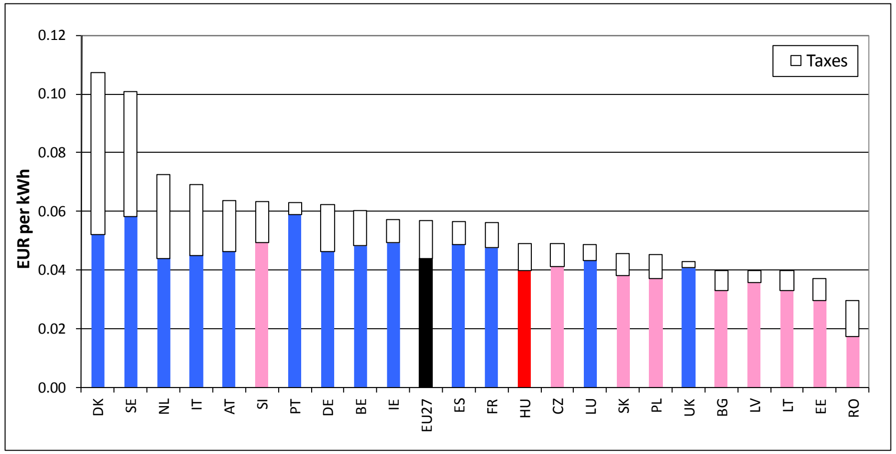
A number of factors are likely to influence the evolution of gas prices in the EU and the CEE region in the future, with two key elements to be considered (EC, 2012; Pearson et al., 2012): i) the potential for further unconventional gas production, which has boomed in the US, is yet to be untapped in EU countries and has distinct environmental impacts; and ii) the progressive integration of natural gas markets both at the EU and global levels occurred as a consequence

[33] Calculations based on Eurostat data collected for Figure 5.

of increased liquefied natural gas (LNG) trade, which is expected the reduce the current fragmentation of regional markets and bring more competition. Other factors such as global changes in the supply and demand of fossil fuels (also dependent on unforeseeable events like Fukushima), more stringent environmental legislation, investments needed to maintain or upgrade the distribution network or the way prices are set (either from gas-to-gas competition or oil-price indexation) will be also having an influence on future prices in the EU (Ofgem, 2011; The Economist, 2012).

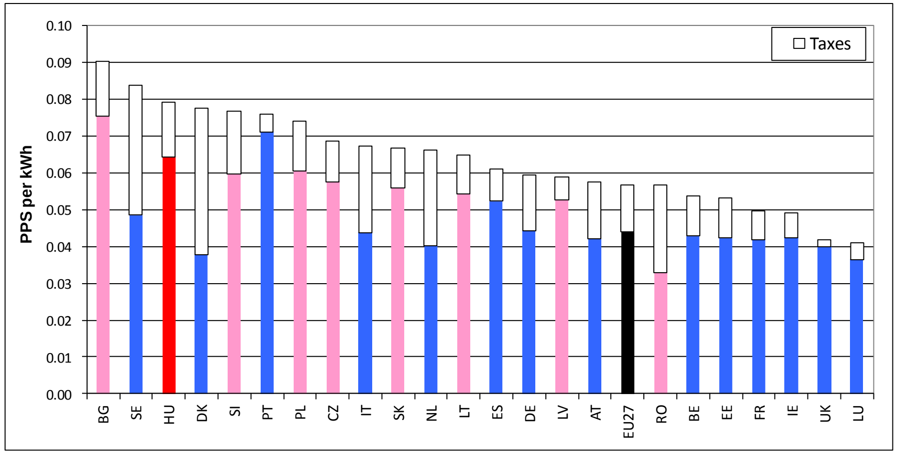
Natural gas is an essential source of domestic heat and therefore a key piece of the fuel poverty puzzle in the CEE region. That its price as a commodity is set in a poorly functioning market with a captive demand (i.e., the consumers of natural gas of CEE states) has substantial implication on the affordability of domestic space heating for CEE households.

Figure 23. Average price of natural gas for domestic consumers (2007-2011) at current prices (EUR per kWh)



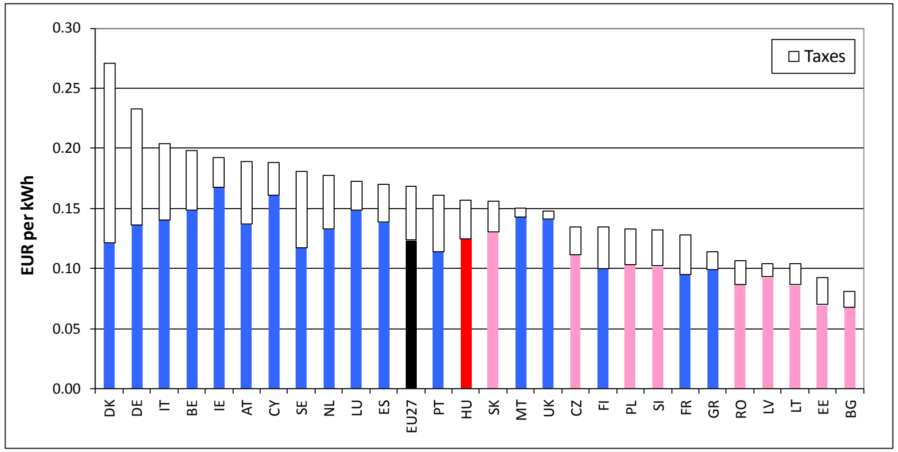
Note: missing data for CY, MT, GR and FI / *Source*: Eurostat

Figure 24. Average price of natural gas for domestic consumers (2007-2011), in purchasing power parity standards at current prices (PPS per kWh).



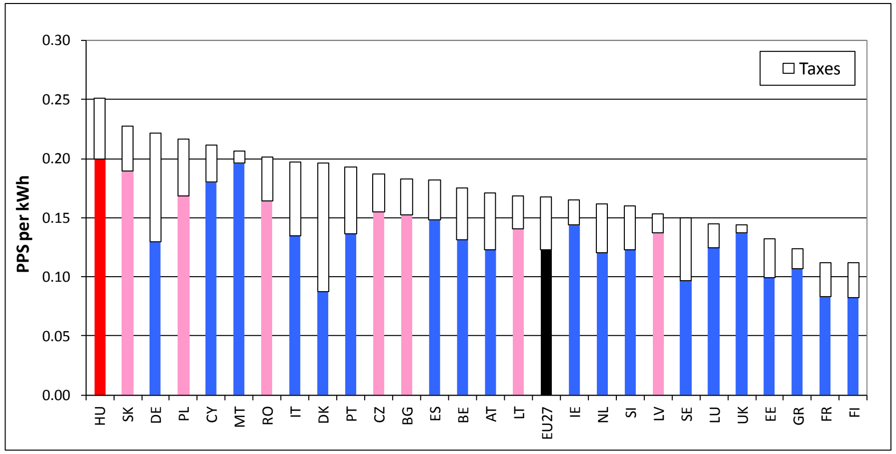
Note: missing data for CY, MT, GR and FI / *Source*: Eurostat

Figure 25. Average price of electricity for domestic consumers (2007-2011) at current prices (EUR per kWh)



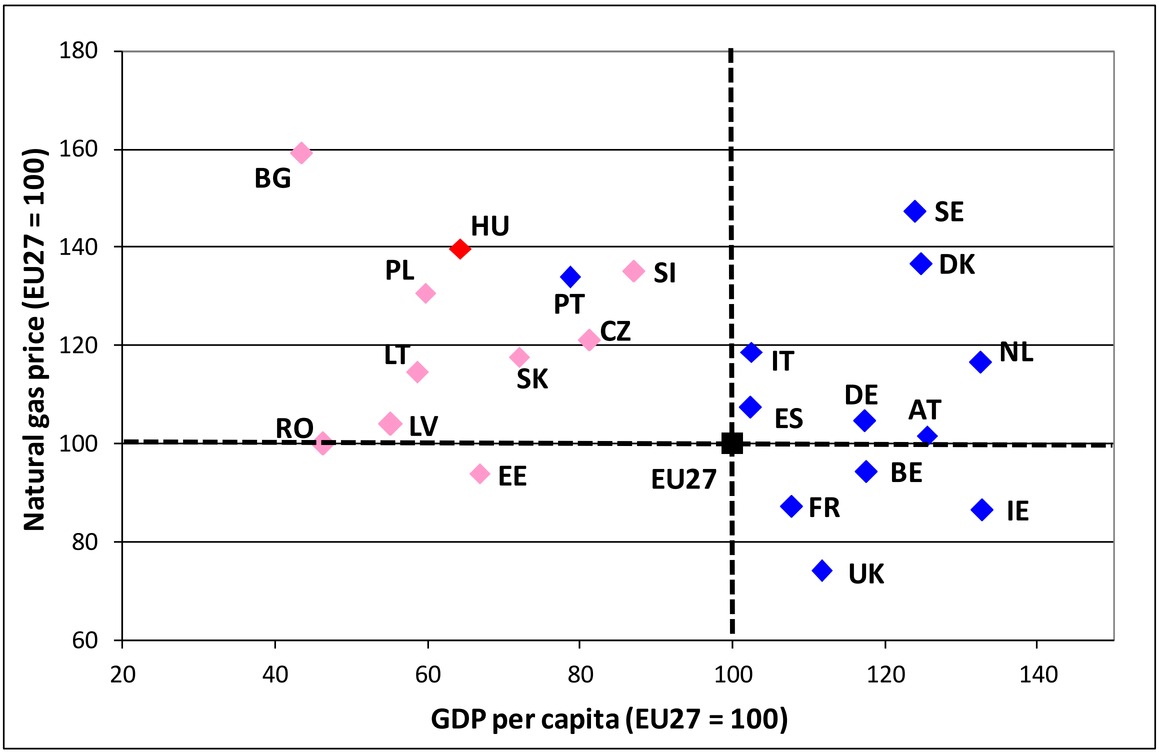
Source: Eurostat

Figure 26. Average price of electricity for domestic consumers (2007-2010 in purchasing power parity standards at current prices (PPS per kWh)



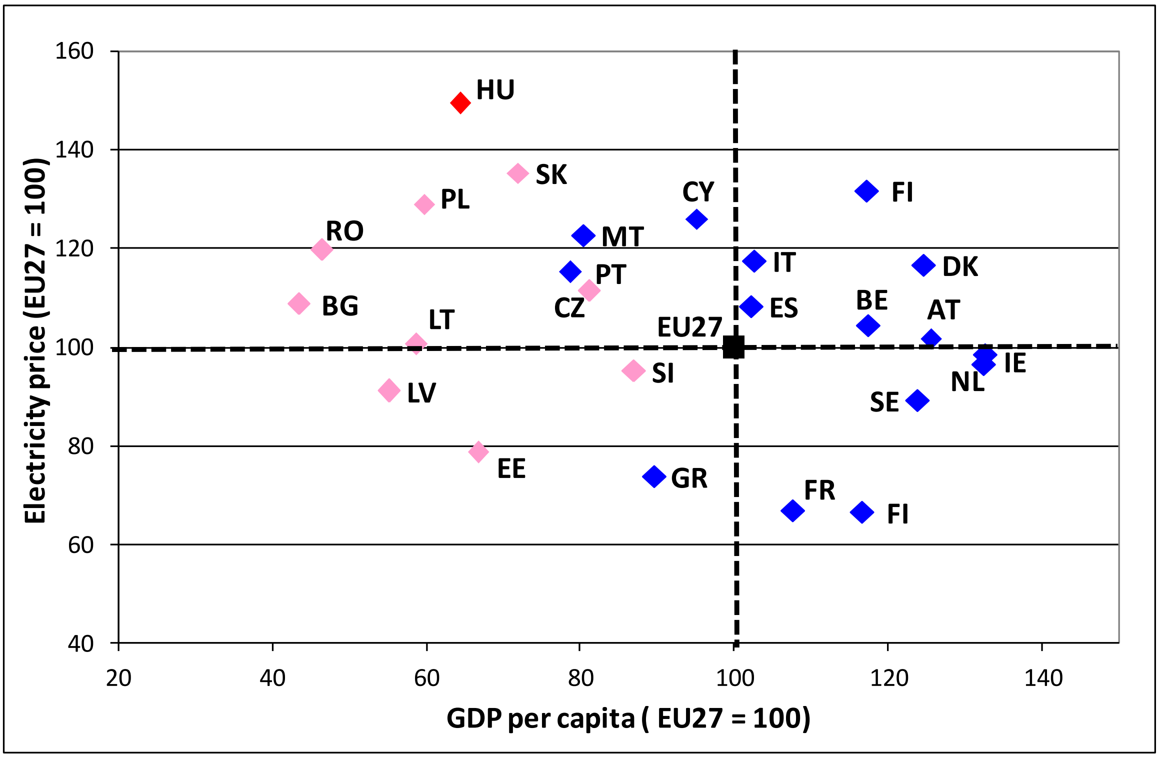
Source: Eurostat

Figure 27. Natural gas prices for domestic consumers (in PPS, scaled to EU27=100) versus income per capita (in PPS, scaled to EU27=100) of Member States (2007-2011).



Note: Missing data for CY, MT, GR and FI; LU removed as an outlier (GDP per capita largely above the EU average)
Source: own elaboration based on Eurostat data

Figure 28. Electricity prices for domestic consumers (in PPS, scaled to EU27 = 100) versus income per capita (in PPS, scaled to EU27 = 100) of Member States (2007-2011).



Note: LU removed as an outlier (GDP per capita largely above the EU average)
Source: own elaboration based on Eurostat data

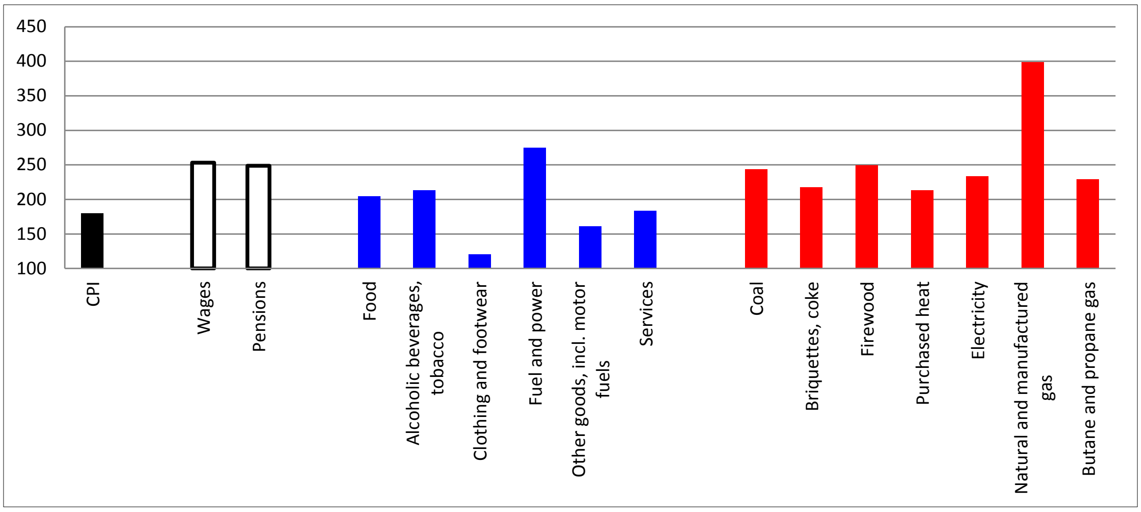
5.3. Hungary's energy prices and household incomes since 2000

5.3.1.1. The price of domestic energy vs. inflation and salaries and pensions

The state of affairs in Hungary in the period 2000-2011 is analysed through statistical data on current (nominal) prices, wages and pensions retrieved from the Hungarian Central Statistical Office (KSH).

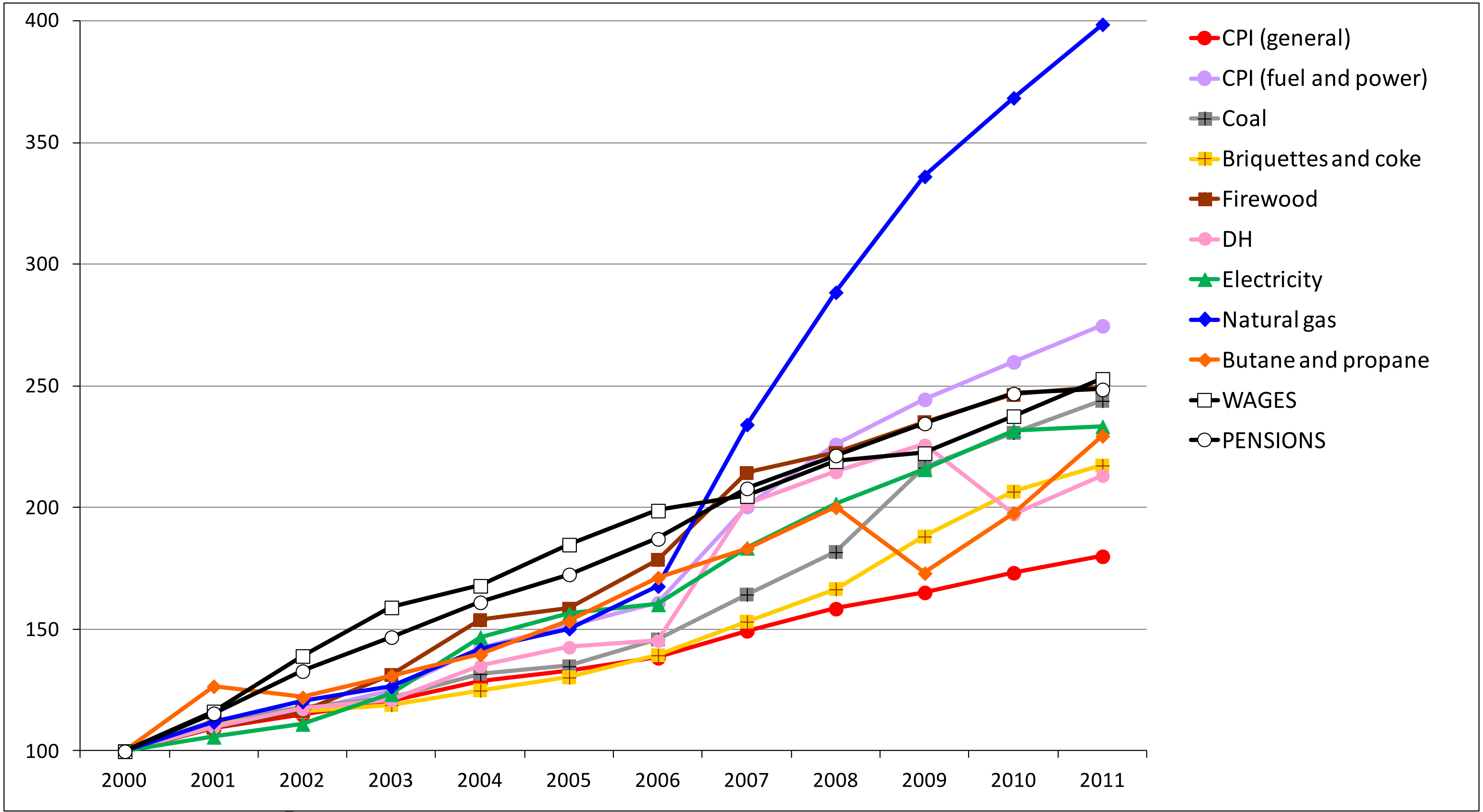
As presented in Figure 29, nominal prices of energy (*fuel and power*) increased in that period at a faster rate than wages and pensions, the general Consumer Price Index (CPI) of the economy and any of the other categories of goods and services that make up the CPI (e.g., food, clothing and footwear, etc.). Even though the purchasing power of Hungarian households improved in real terms in those years, energy price raises were substantially larger than the increasesin wages and pensions. In fact, domestic energy was the household budget item with the single largest price increase in the last decade.

Figure 29.Changes in the Consumer Price Index (CPI), the price index of goods and services included in the CPI, of energy carriers, and increase in wages and pensions. Hungary (2000-2011) [2000 = 100]



Note: i) The category *Consumer and durable goods* registered a decrease in nominal prices over the 2000-2011 period and is not shown in the figure; ii) 2011 data does not incorporate the January increase in pensions
Source: own elaboration based on data from the Hungarian Central Statistical Office (KSH)

Figure 30.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 detailed analysis of the time series (Figure 30) 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 – see Figure 18.

5.3.1.2. Causes of the natural gas price hike*and the situation with other energy carriers*

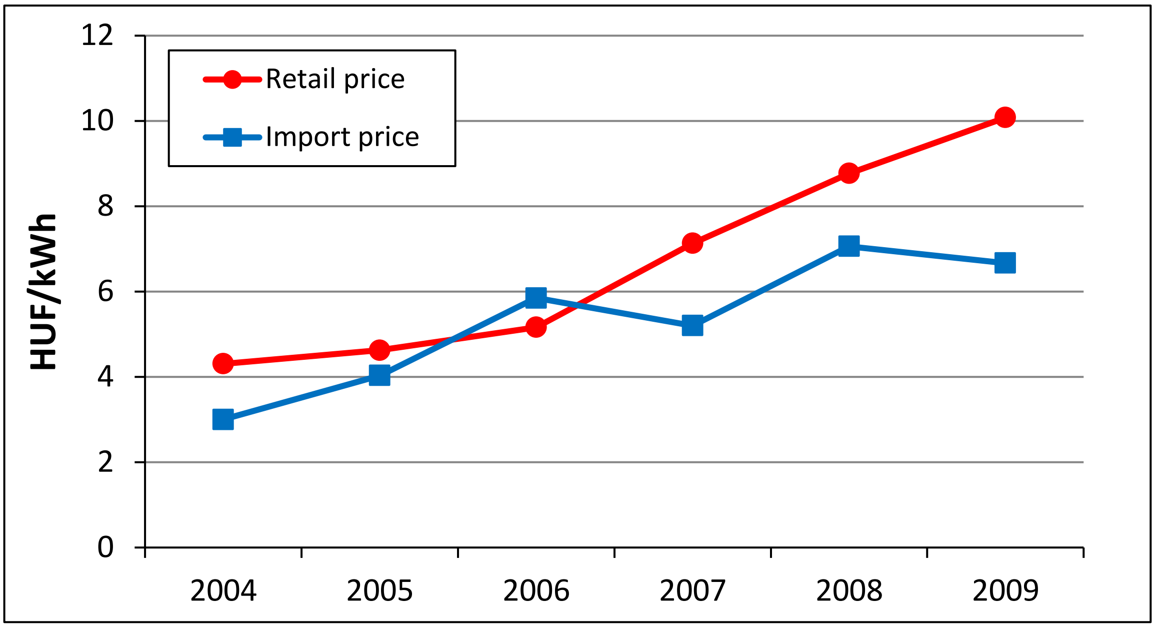
Understanding the reasons for the natural gas *price hike* and why Hungary currently has had between 2007 and 2011 the second highest domestic natural gas prices of the EU (measured in PPS, i.e., relative to the general price level of the Hungarian economy – see Figure 24) is not an easy task.

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, 2012a; Hungarian Energy Office, 2011), which has declined steadily since the 1990s (Andzsans-Balogh, 2011).

As is the case of other countries in Central and Eastern Europe (CEE), natural gas provision is supplied on the basis of an oil price-indexed 20-year contract signed by the Hungarian company MOL with Gazprom in 1996 (Kessides, 2000). This long-term contract substituted previous short-term agreements that made MOL fear Gazprom renegotiating sale prices each time the contract was to be renewed (*ibid*.). However, it has locked Hungary in import prices above spot prices based on gas-to-gas competition, which have recently become a preferred alternative in Western Europe in parallel to the increased availability of LNG (EC, 2012c).

A likely consequence of the unfavourable conditions under which Hungary imports natural gas (monopoly of supply from Russian importers and long-term, oil-indexed contract) 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 – see Figure 31.

Figure 31. Evolution of retail price and import price of natural gas in Hungary (2006-2009)



Note: retail prices were retrieved from KSH (*Annual average prices of selected goods and services 1996-*); import prices come from OECD/IEA (2010a). Both are expressed in current units of Hungarian national currency (HUF) and have been converted to HUF per kWh through the gross calorific value of Russian natural gas – 38.23 MJ per m^3. Data for the comparison are limited to the 2006 and 2009 period.
Source: own elaboration based on data from the Hungarian Central Statistical Office (KSH) and OECD/IEA (2010a)

However, the enormous increase in the current price of natural gas cannot be solely explained by import prices. There are also national factors: as seen in Figure 31, the growth of retail prices to some extent decoupled from the evolution of import prices since 2006. Transmission, storage and distribution fees plus sellers' margin and taxes can be pointed as internal causes of the *price hike*.

In this regard, 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, which has happened in two ways:

- The World Bank (Kessides, 2000) states that around the year 2000 the regulated pricing system favoured residential consumers as the residential-to-industrial price ratio was just 1.3 to 1. In the Bank's view, this rate consisted of a cross-subsidisation from the industrial to the residential sector and recommended this ratio to be raised to 2 to 1.1 (*ibid*.) The argument for this is the higher cost of supplying the domestic demand because of: i) its unpredictability (as compared with the stable demand from industry) due to the randomness of weather conditions; ii) its larger contribution to peak demand, which means the households should bear a larger fraction of the capital costs of network and storage; iii) the fact that the supply to residential consumer cannot be interrupted, unlike industrial demand; and iv) the higher consumer costs (i.e., metering, billing and collecting) of domestic demand (*ibid*.). Nevertheless, between 2007 and 2011 this ratio has fluctuated between 1 and 1.5 according to data on gas prices (without VAT) for domestic consumers retrieved from Eurostat.
- 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 apparently 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. In that year, the retail price of natural gas was below the import price (see Figure 31) and the accumulated losses of the wholesaler (E.On Földgaz Trade) peaked at 112 billion HUF. A major increase in regulated prices was decreed in 2006, which allowed reducing the accumulated losses of the regulated wholesaler up to almost 20 billion HUF in early 2008. 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.

Interestingly, the Wold Bank (Kessides, 2000, p. 53) analysis had forecasted 12 years ago a large increase in residential gas prices because of the unsustainability of regulated rates of the late 1990s to mid-2000s. It also notes that subsidised rates have sent the wrong signals to consumers: "if the present price [as of 2000] is below cost because of an unsustainable subsidy, consumers will discover that they made a costly mistake, in retrospect, when the price of residential gas service later increases by 50 to 8o per cent, as it will inevitably in Hungary"

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 (then followed by a similar event lasting for 13 days in 2009) triggered the decision to increase the country's strategic gas storage capacity, which was realised at a cost of 750 million US$ 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, p. 11) to "consider the introduction of this measure [upgrading the strategic storage capacity] carefully, owing to its high cost, and that it should be implemented as part of a suite of measures, such as increasing energy efficiency and supply source diversification". Consequently, the IEA review team advocated for delivering "the increase in [energy] security at a low cost to the gas consumer" (ibid.).

Yet another cause of the price hike is the increase in the standard VAT rate from 20 to 25%, which occurred in July 2009 and was 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 – see below. From January 2011, the VAT rate went up a further 2% (to 27%) and became the highest in the EU. The accumulated 7% increase, which was directly transferred to domestic gas prices, shows the global crisis is not only damaging the welfareof Hungarian households in the form of reduced income but also from higher prices of basic goods and services.

Finally, another factor that adds to the abrupt increase in natural gas prices starting in 2006 is the progressive removal of direct consumer subsidies. This way, since the first of January 2007 the natural gas subsidy (*gázártámogatás*) was not granted automatically to residential consumers any longer (OECD/IEA, 2009a). From that date onwards, only eligible households benefited from the support. As resultwhile in 2006 80% of all households benefitted from the subsidy, this percentage had dropped to 55% in 2008 (Czakó, 2011).

The evolution of the price of other domestic energy carriers used by Hungarian households has not been as extreme as natural gas. As shown in Figure 30, prices went up in most cases below the rate of increase of salaries and pensions, though in all cases faster than the inflation rate (CPI). Besides, these are not as important in terms of fuel poverty because they are not used for domestic space heating as much as natural gas.

Even though most district heating (DH) power plants in Hungary are gas-fired (Sigmond, 2009), the impact of growing import prices of natural gas on retail prices has been limited. This has occurred because, since DH is the most expensive energy carrier per dwelling square meter (see Section 6.3.3), the government has applied from 2009 onwards the preferential VAT rate of 5% to DH (Kubitsch, 2011), which compares very favorably with the standard 27% rate. This has actually reduced the nominal price of DH between 2009 and 2010, as seen in Figure 30. According to estimates by the *EnergiaKlub* (2010), this measure has almost equalled the annual heating costs of an average 50 square-meter apartment served by DH to those of a similar flat using natural gas for space heating.

Firewood has been the fuel with the second-fastest growing prices after natural gas – see Figure 30. This increase is particularly significant for the Hungarian population without access to piped gas or district heating, or for those that have opted to move back to traditional fuels as a strategy to reduce their domestic energy costs (Section 4.4.1). Such a price trend has been linked to the enhanced wood extraction for biomass power generation that followed the introduction of a preferential feed-in tariff in 2003, which may be forcing poor people to fall back on illegal wood collection (OECD, 2008) and poses an additional question about the social impacts of the development of renewables in Hungary. However, it cannot be discarded that it is a side-effect of the increase of natural gas prices, for which firewood is a (lower-quality) substitute. The situation is nevertheless more complex in the case of this energy carrier because households – especially in rural areas – often obtain (sometimes freely) the firewood by themselves (i.e., self-production or collection) instead of buying it from commercial sources. This means that the current price of firewood collected in statistics is relevant for households purchasing their firewood but not so much for those relying on self-collected or self-produced firewood.

Electricity is a special case because it is very seldom used as source of domestic heat in Hungary but still takes up 40% of the total energy expenses of an average Hungarian household because it provides a range of other important domestic energy services for which some sort of energy poverty can be defined. Its price increased somewhat below the increase in wages and pensions, though definitively more than the inflation rate – see Figure 30.

Other fuels like coal, briquettes, coke and butane and propane gas are not common sources of heat in the Hungarian domestic sector and its price increased in line with wages and pensions.

5.3.2. The sensitivity of fuel poverty ratesto the increase in domestic energy prices.

In order to analyse the effect of increasing domestic energy prices on fuel poverty rates (measured as percentage of the Hungarian population), sensitivity factors have been estimated. These factors indicate by how much the incidence of fuel poverty increases for a 1% rise in real energy prices. For this, percentages of change in the expenditure-based and self-reported rates[34] between 2005 2008 and in real domestic energy prices[35] have been first obtained – see column *% change in 2005-2008*in Table 1.

Results are presented in Table 1 and indicate that practically expenditure-based fuel rates are increase more than proportionally with respect to the price of domestic energy in the period analysed, i.e., a 1% increase in real domestic energy prices results in an increase in a more than 1% increase in the percentage of population in fuel poverty. Sensitivity factors above 1

[34] With two exceptions: the population living in a home with fuel-poverty related faults, which should be unrelated to energy prices; and summertime fuel poverty rates, only available for 2007.

[35] Rates of increase in the nominal price of domestic energy (20001000) collected in Figure 30 have been deflated by the inflation rate (Consumer Price Index or CPI).

are also obtained for the price of natural gas. In contrast, consensual indicators produce negative sensitivity factors because of the unforeseeable decrease in the percentage of affected population unexpectedly occurred while energy prices were growing faster than inflation in 2005-2008.

Table 12.Sensitivity of fuel poverty rates (% of the population) to domestic energy prices.

Measuring approach	% change in 2005-2008	Sensitivity of FP rate to domestic fuel and power price increase	Sensitivity of FP rate to natural gas price increase
Fuel poverty rates			
Expenditure-based approach			
Fuel poverty (FP line =10%)	46%	1.8	0.8
Fuel poverty (FP line =15%)	82%	3.2	1.3
Fuel poverty (FP line =20%)	101%	4.0	1.6
Self-reported approach			
Inability to keep the home adequately warm	-45%	-1.8	-0.7
Real energy prices			
Fuel and power	25%		
Natural gas	61%		

Source: own elaboration

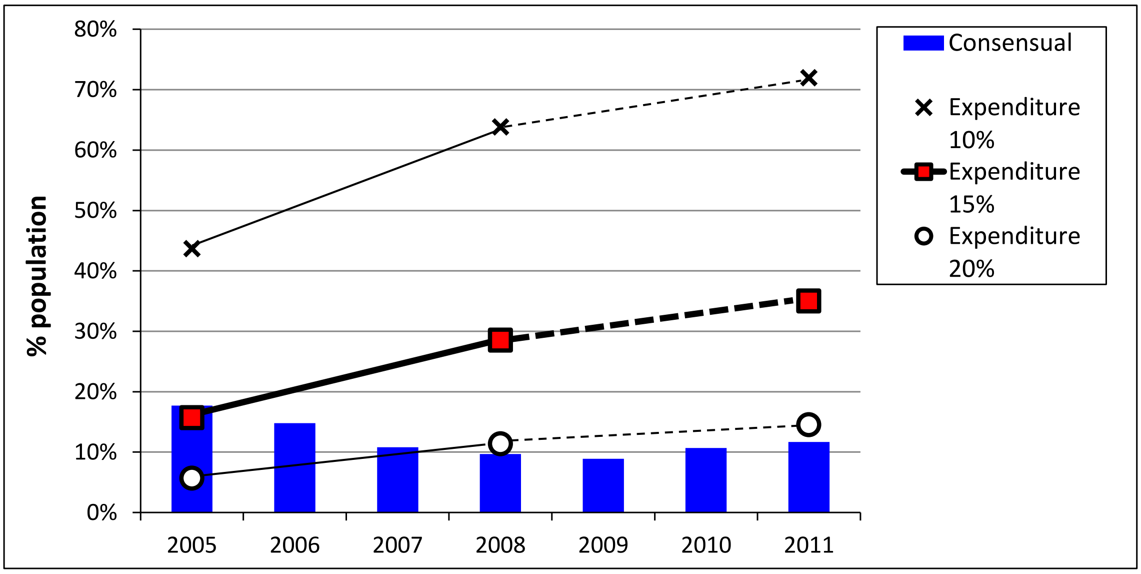
The results evidence the high sensitivity of the expenditure-based fuel poverty rate to energy prices. This way, whereas real domestic energy prices increased *only* by 255% between 2005 and 2008, the percentage of the population in fuel poverty (as estimated with the 15% fuel poverty line) grew by82% (from 16 to 29% of the Hungarian population – see Figure 32). The relevant policy message carried by these results is that more-than-proportional increases in fuel poverty rates are expected if domestic energy prices keep on growing.

Along this line, these estimated sensitivity factors have been then used for forecasting expenditure-based fuel poverty rates up to the year 2011 (recall that these rates could be calculated for 2005 and 2008, the only two years with purchased microdata)[36]. Results are

[36] Forecasts are based on the sensitivity factor of fuel poverty rates to the fuel and power price index (not to the natural gas index, which only captures part of a household's energy bill). They are a linear extrapolation of rates to the year 2011. An example using the case of the fuel poverty rate estimated with a 10% fuel poverty line:

presented in Figure 32, which is an update of Figure 14. They 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 (i.e., spending more than 15% of their annual income on domestic energy) by 2011. These forecasts illustrate the on-going effect of rising energy prices on fuel poverty rates.

Figure 32. 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: own elaboration based on data from the Hungarian Central Statistical Office (KSH) and Eurostat

5.3.3. Fuel poverty and income poverty

A further relevant question in this analysis of contributing factors is to what extent fuel poverty overlaps with income poverty as understood in the EU context. Answering this question would help understand whether fuel poverty can be regarded as one of the ways poverty is experienced or if, on the contrary, it is a situation that affects indistinctly the poor and non-poor.

between 2005 and 2008, a 25% increase in real energy prices resulted in the fuel poverty rate increasing by 46% (see Table 1); correspondingly, the 7% increase in real energy prices recorded between 2008 and 2011 would resulte in a 13% higher fuel poverty rate (from 64 to 72% of the Hungarian population – see Figure 32).

With this aim, the results of the fuel poverty indicators presented in the previous chapter have been disaggregated for two population/households groups: income poor and non-income poor. This disaggregation is based on the at-risk-of-poverty rate threshold used by the EU and Member States (Eurostat, 2012d): 60% of the median equivalised income.

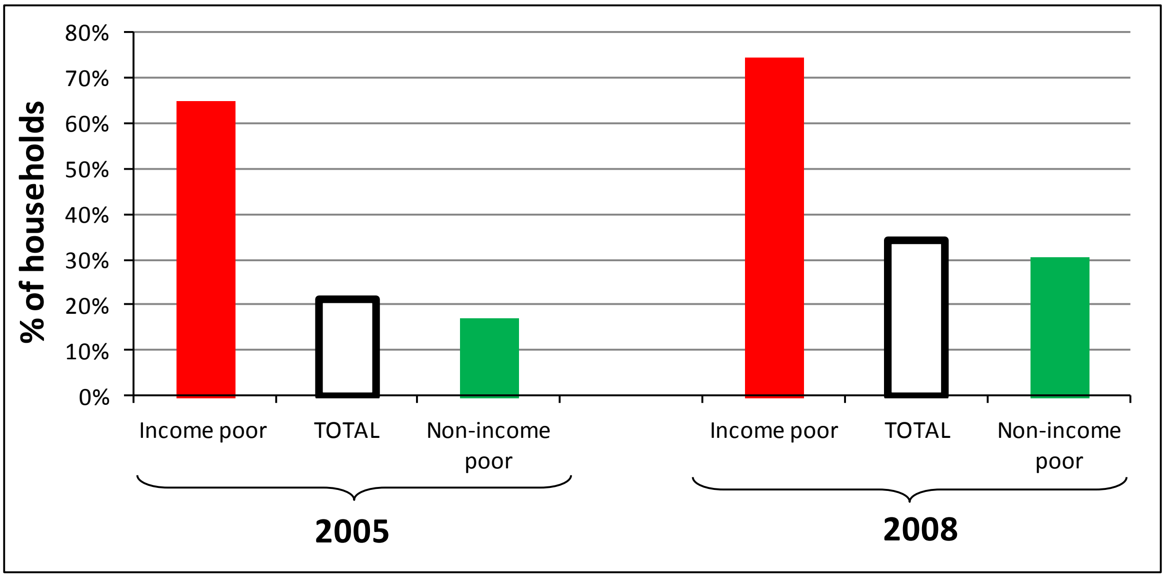
For EU SILC self-reported indicators, disaggregated results for these two income groups can be directly retrieved from Eurostat. In the case of expenditure-based indicators, disaggregated results have been produced by estimating per-capita equivalised income with OECD modified scale, which is the same scale used by Eurostat for equivalised income calculations (Eurostat, 2012b).

Disaggregated results for the two headline fuel poverty indicators are presented in Figure 33 and Figure 34. They clearly show that fuel poverty has a substantially higher incidence among income poor populations and households. Two additional trends can be detected:

- In the expenditure-based indicator, 60 to 70% of income poor Hungarian households have disproportionate domestic energy costs (fuel poverty line: 15% annual energy expenditure vs. net income ratio). However, the energy price increase that occurred between 2005 and 2008 had a stronger impact on the non-income poor, perhaps because income poor households reacted to the new prices by reducing their energy use – see Figure 33.
- According to the self-reported indicator, the income poor are more sensitive to changes in the conditions (income and energy prices) and display a larger variation in the percentage of people unable to keep their home adequately warm. Consequently, most of the new fuel poor since 2009 are income poor – Figure 34.

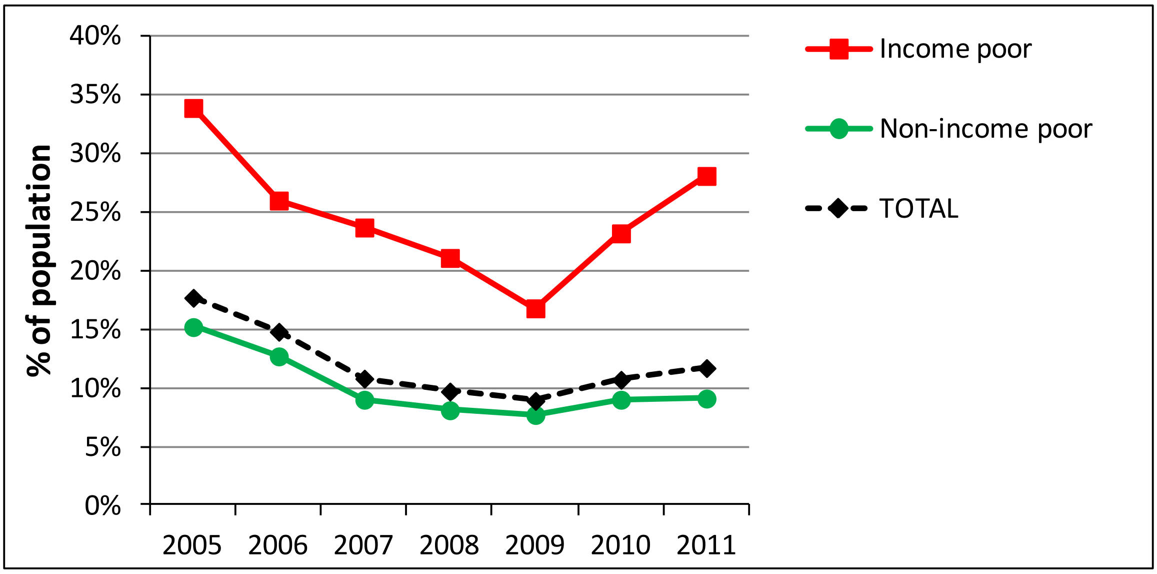
This comparison by income groups was also conducted for other secondary indicators (see Figure 35 to Figure 38). In all cases, the income poor are more likely to experience some of the symptoms of fuel poverty (e.g., being in arrears on utility bills, living in a dwelling with fuel poverty-related faults, using firewood as a source of heat).Fuel poverty is also present among households and population with an income above 60% the equivalised median.

Figure 33. Expenditure-based fuel poverty rates among income poor and non-income poor households in Hungary (2005 and 2008)



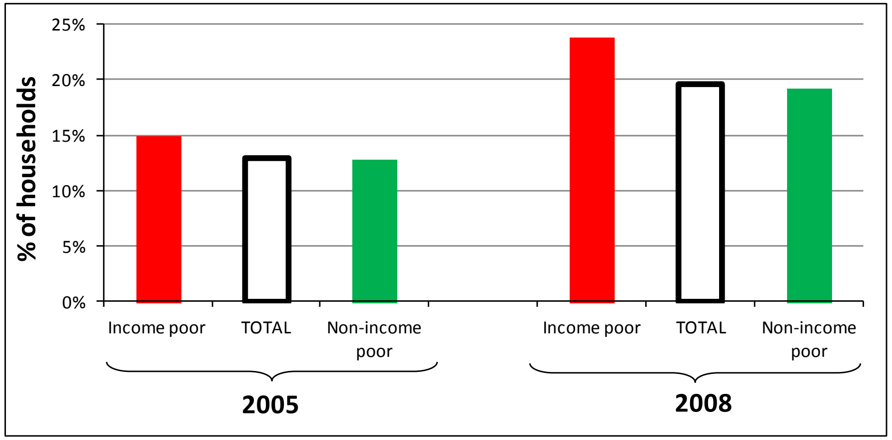
Note: estimates based on the central fuel poverty line of 15% (annual energy expenditures vs. net income ratio) selected for the analysis.
Source: own elaboration based on data from the Hungarian Central Statistical Office (KSH)

Figure 34. Self-reported fuel poverty rates among income poor and non-income poor population in Hungary (2005-2011)



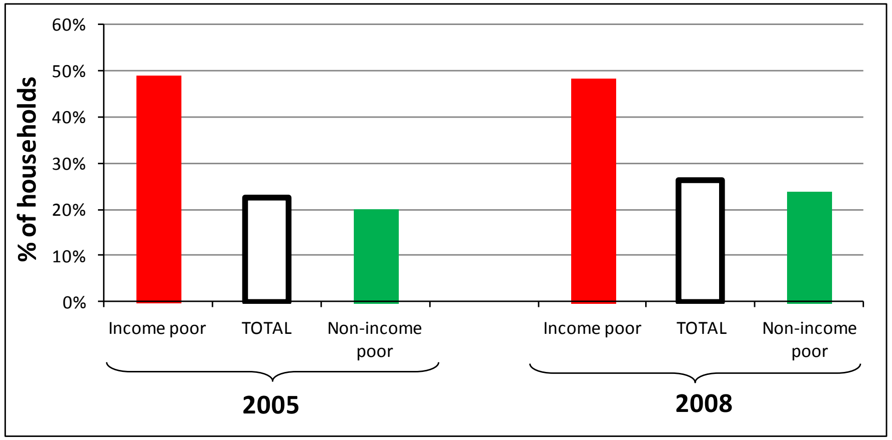
Note: based on EU SILC item HH50 – *Inability to keep the house adequately warm*
Source: Eurostat

Figure 35. Percentage of households that spend more on energy than on food in Hungary (2005 and 2008): income poor vs. non-income poor households



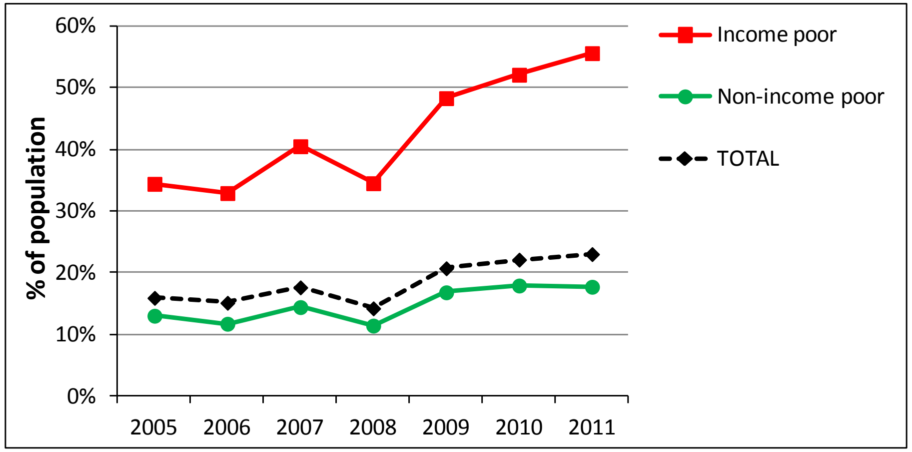
Source: own elaboration based on data from KSH

Figure 36. Percentage of households for which firewood represents more than 10% of their total energy expenditure in Hungary (2005 and 2008): income poor vs. non-income poor households



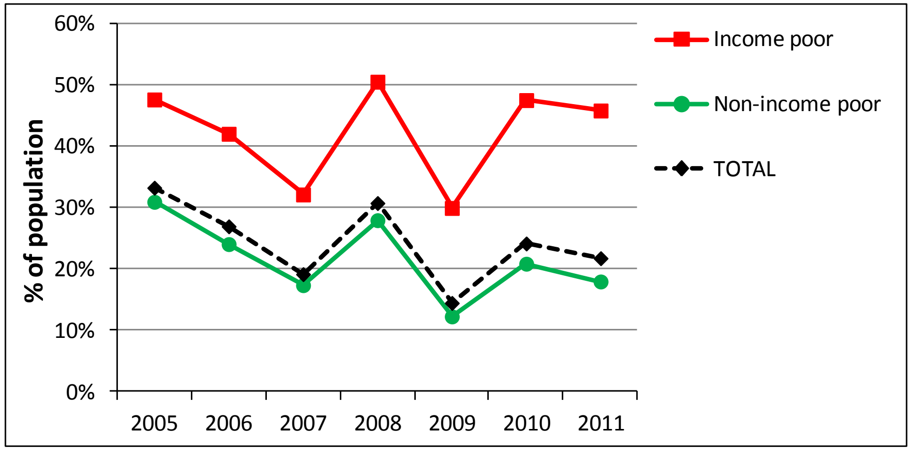
Source: own elaboration based on data from KSH

Figure 37. Percentage of the population with arrears on utility bills in Hungary (2005-2011): income poor vs. non-income poor population



Source: Eurostat

Figure 38. Percentage of the population with leaking roof, damp walls, floors or foundation, or rot in window frames or floor at home in Hungary (2005-2011): income poor vs. non-income poor population



Source: Eurostat

All in all, these results indicate an income poor household or person is twice as likely to be in fuel poverty as a non-income poor person. An exception is the food expenditure criterion (Figure 35). In this case, the non-income poor person is almost as likely as the income poor person to spend more on domestic energy than on food.

Another exception to this rule is the proposed self-reported indicator of summertime fuel poverty based on the 2007 *ad-hoc* module on housing conditions of EU SILC – Section 4.4.2. Disaggregated results by income levels for item MH070 (*Dwelling comfortably cool during summer time*) indicate that 28.7% of the non-income poor population declares it is living in a dwelling that is not cool enough during the summer. Unexpectedly, this proportion is slightly higher than the one registered for the income-poor population (27.6%).

5.4. THE ENERGY PERFORMANCE OF THE RESIDENTIAL STOCK

5.4.1. Energy consumption and carbon emissions of dwellings

Energy prices and household incomes have substantial short-term effects on fuel poverty rates. These two factors are particularly useful to understand temporary changes in the incidence of fuel poverty. As seen in the case of Hungary, the combination of rapidly increasing domestic energy (gas) prices with a deteriorationin the overall economic conditions as a result of the 2008 global crisis has led to increasing fuel poverty rates, especially among the income poor.

In contrast, the energy performance of the residential stock and domestic end-use equipment is more of a structural cause of fuel poverty. It is a capital-related factor that changes more slowly and therefore allows for understanding rates of incidence in longer timeframes. 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 dissertation is that residential energy efficiency offers the only long-term solution to both climate change and fuel poverty challenges.

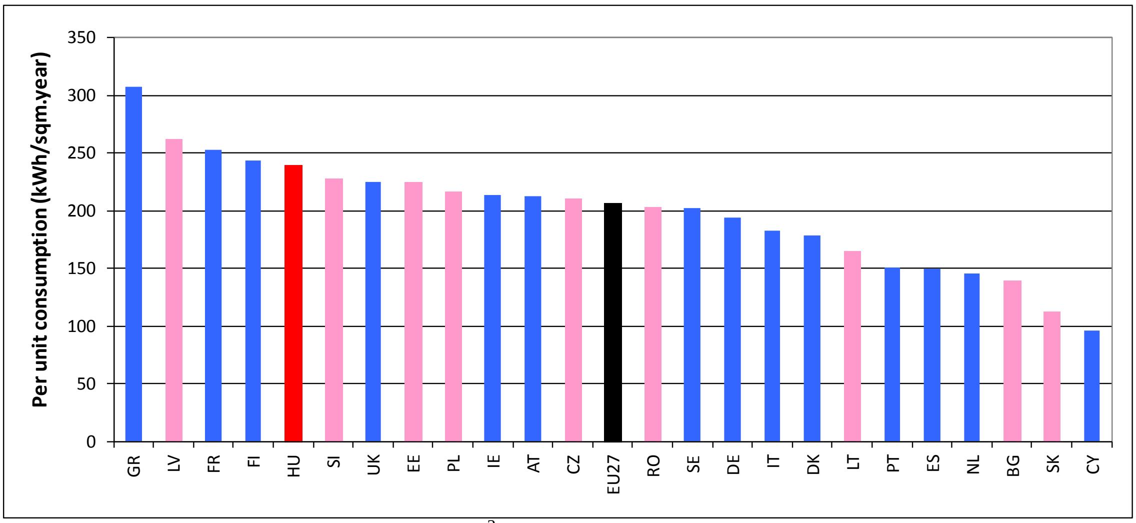
As important as this factor is, little information on the energy performance of residential buildings is available at the EU27 and Member States levels. The main data source located is ODYSSEE[37], a database of energy efficiency indicators for key end-use sectors (industry, transport, households and services) – see Section 3.3.1.It is the most important (and perhaps only) pan-European dataset on energy efficiency in end-use sectors. For instance, The European Environment Agency (2012a) uses it as a basis for monitoring the progress in the energy efficiency of the household sector across EU27 Member States.

The first ODYSEE indicator selected for comparing the energy performance of residential dwellings between Member States is the energy consumption (for all domestic uses) per unit of dwelling floor area (m^2) – see Figure 39. These data are scaled to the EU average climate[38] in order to compensate climatic differences and compare Member States on an equal footing.

Being a very aggregate measure of the energy consumption of households, they shed some light on the overall efficiency of the building stock in transforming the energy input (e.g., kWh of electricity, m^3 of natural gas, GJ of district heating, etc.) into domestic energy services (e.g., lighting and heating, hot water, etc.). There is nevertheless little available information about how ODYSSEE collects data on household energy consumption in Member States, e.g., it is unclear to what extent household behaviour is incorporated or dealt with.

[37] ODYSSEE database [URL: http://www.odyssee-indicators.org/]
[38] Based on the relative number of heatingdegree-days of each Member State.

Figure 39. Per unit energy consumption (kWh m^{-2} year^{-1}) climate for all domestic uses scaled to the EU average; EU27 and Member States (average for 2005-2009)



Note: in kilograms of oil equivalent (koe) per m^2 and year in the original data source; missing data for BE, LU and MT / *Source*: ODYSEE

Data presented in Figure 39 illustrate the large differences among Member States in terms of energy usage per residential floor unit. Though no clear patterns are easily identified, the average household of eastern Member States (in pinkcolour) consumes more energy than the one from Western Europe. Two patent exceptions are Bulgaria and Slovakia, which report low-range per unit energy consumption figures (100 to 150 kWh m^{-2} year^{-1}). In the case of Bulgaria, this low value may be indicative of an enforced deficit of domestic energy services since this is the country with the largest self-reported fuel poverty rate – over 40% of the Bulgarian population declares to be unable to afford to keep the home adequately warm (see Figure 13). If, as suspected, these indicators are based on actual energy consumption data from households, they would thus reflect the households' self-imposed constraints on energy use rather than the energy efficiency of the Bulgarian residential stock.

Hungary's dwellings' specific energy use (239 kWh m^{-2} year^{-1}) is in the high range of the EU27 Member States. However, what is perhaps more relevant to point out is the lack of progress in terms of the energy performance of the residential stock during the decade of the 2000s. This is measured through selected ODYSEEE indicators shown in figures below:

- The ODEX index, which is a summary indicator based on a weighted sum of energy efficiency gains achieved by 8 different end-use components/equipment of a household (Lapillone et al., 2004)39: heating, water heating, cooking, refrigerator, freezer, washing machine, dishwashers and TV. As shown in Figure 40, the Hungarian household sector had the second-poorest performance (after Slovakia) as measured by the ODEX index in the 2000-2010 period. In contrast, the domestic sector of other Central and Eastern (CEE) European Member States such as Latvia or Romania substantially improved its energy efficiency in the same period.
- One important component of the ODEX index corresponds to the use of energy for space heating. It is measured in kilograms of oil equivalent per dwelling m2 (not normalised to the EU average climate). The evolution of this metric between 2000 and 2010 is presented inFigure 41, which shows the accumulated percentage of energy consumption reduction or increase (as compared to the 2000 level) occurred between 2000 and 2010 in each Member State and the EU27. Data indicate that most countries managed to reduce the domestic energy consumption for space heating in this period, with some Member States achieving very substantial reductions (e.g., Latvia or Romania). Hungary managed to reduce this metric by a mere 4.7% between 2000 and 2010 – from 156 to 149 kWh m^{-2} $year^{-1}$. This percentage is below the average for the EU27 and the ones recorded for other CEE Member States.

[39] For each end-use, the following indicators are considered to measure efficiency progress:
• Heating: unit consumption per m2 at normal climate (toe/m2)
• Water heating: unit consumption per dwelling with water heating
• Cooking: unit consumption per dwelling
• Large electrical appliances: specific electricity consumption, in kWh/year/appliance

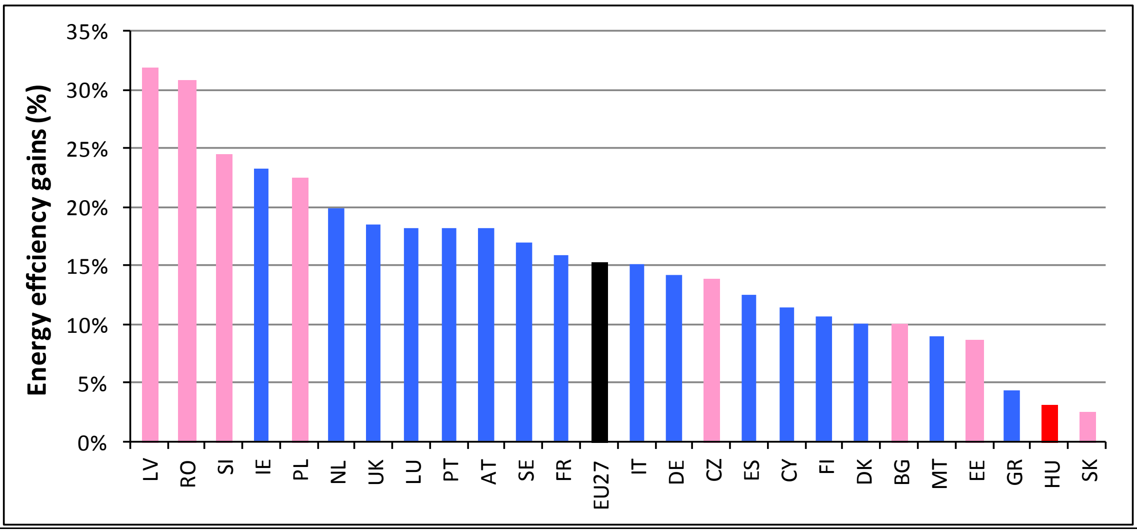
- A second key component of the ODEX index is the energy consumption for lighting and electrical appliances (in kWh per dwelling)[40]. Data on the accumulated percentage of change for this metric between 2000 and 2010 are presented inFigure 42. The increase recorded in the EU27 average and most Member States indicates an on-going electrification of the European domestic sector, with some exceptions. And again Hungary performed worse than the EU27 average (though better than many CEE countries) as it reported a 21% increase in electricity-related energy use – from 1,449 to 1,754 kWh per dwelling – between 2000 and 2010.

Such results indicate that the average Hungarian dwelling is among the most energy demanding (per floor unit) of the EU, and little improvement in its energy efficiency occurred in the decade of the 2000s. They also show that Hungary is lagging behind many other Western and CEE Member States in upgrading its building stock and domestic end-use equipment. This is likely to have had an effect on the incidence of fuel poverty since the 2000s.

However, it must be noted that the evolution of the ODEX index is also influenced by behavioural changes, e.g., increased ownership of appliances, higher indoor temperatures, switching between energy carriers (DECC, 2012). This may perhaps explainwhy Slovakia is the worst performing country according to the ODEX index (see Figure 40) when its domestic sector has notably reduced its energy use for space heating (Figure 41) and lighting/electrical appliances (Figure 42).

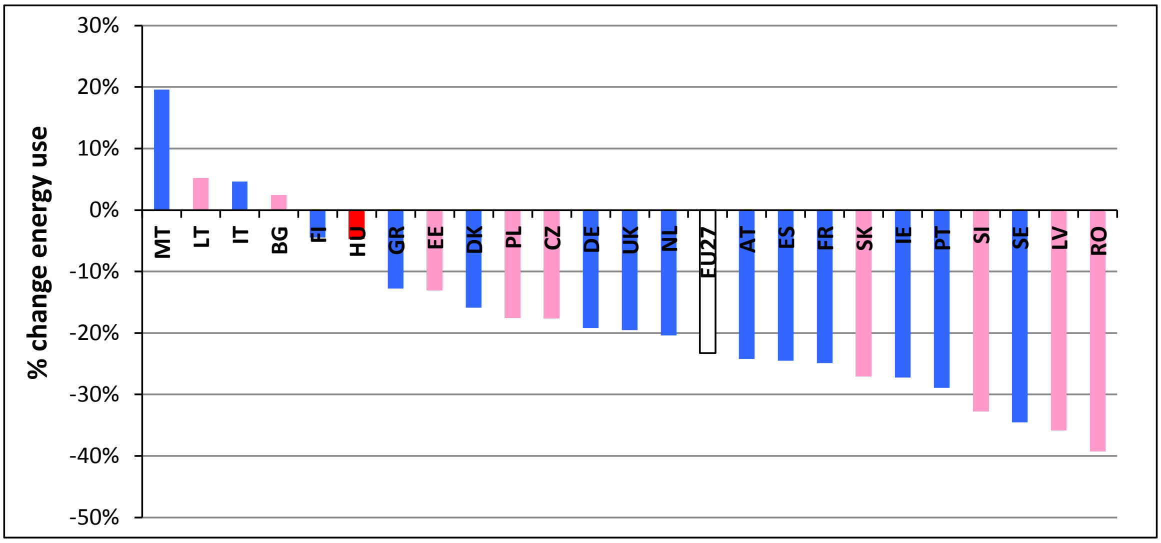
[40] Note that in this case the increase in the floor area of the average dwelling occurred between 2000 and 2010 has an influence on the year-to-year variation of this metric.

Figure 40. Energy efficiency gains measured by the ODEX index for the households sector; Member States and the EU27, 2000-2010



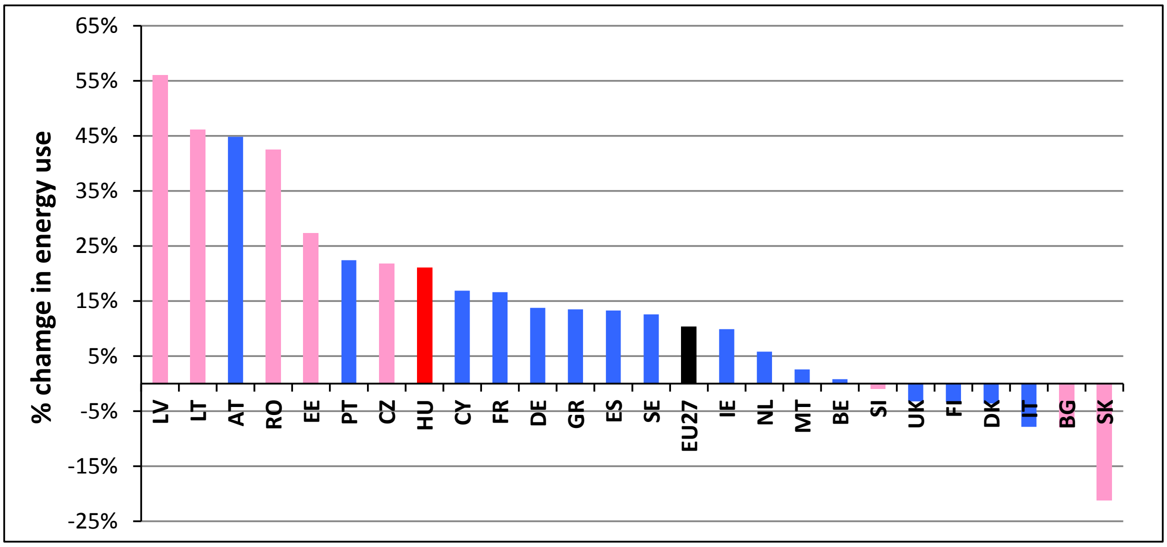
Note: missing data for LT and EE / Source: ODYSSEE

Figure 41. Accumulated change in energy use for space heating in the household sector (koe m^{-2} $year^{-1}$); Member States and the EU27, 2000-2010



Note: missing data for BE, CY and LU; 2000-2007 for LT; 2005-2010n for MT; 2005-2010 for CZ
Source: ODYSSEE

Figure 42. Accumulated change in energy use for lighting and electrical appliances in the household sector (kWh per dwelling); Member States and the EU27, 2000-2010



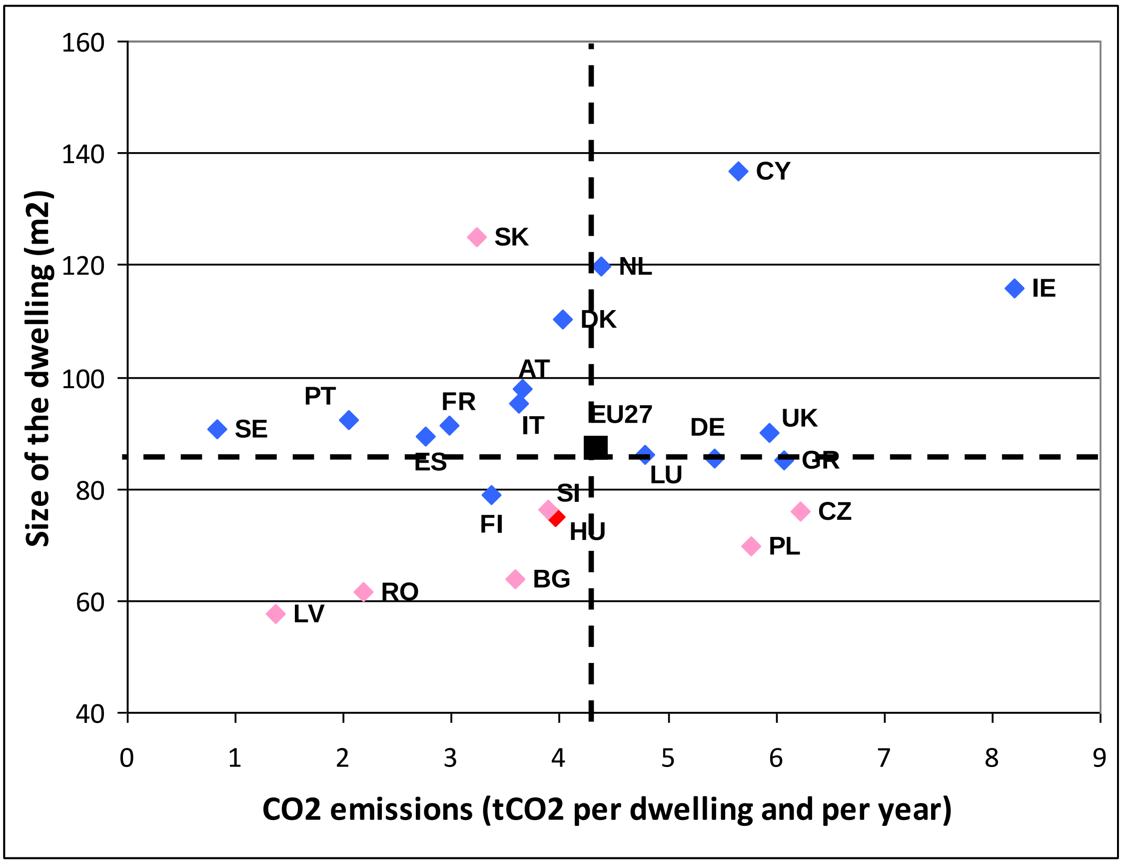
Note: missing data for LU and PL; 2000-2009 for BE; 2001-2010 for LV; 2000-2007 for LT
Source: ODYSSEE

Complementing these data, a comparison of per dwelling carbon emissions and average dwelling size (both obtained from ODYSSEE) is also presented. Domestic carbon emissions are an important additional aspect because residential energy efficiency has been traditionally considered as a climate change mitigation measure. In this light, they are indicative of the emissions reduction potential of improving the energy performance of residential buildings.

As presented in Figure 43, large differences exist between the amount of carbon emitted by the average Member State household relative to the size of the dwelling, e.g., an average Irish dwelling emits 8 times more carbon than a Swedish one in spite of being less than 20% bigger. In general, the data indicate that dwellings in CEE countries are more carbon intensive per unit of floor area. For instance, Hungary, whose average household occupies a 75 m^2 home, emits as much carbon as the average 110 m^2 Danish dwelling. The fact that CEE Member States have a more carbon intensive and fuel poverty-prone residential stock is an argument for EU policies to prioritise action in these countries.

Finally, it must also be noted that the thatthe energy mix of each country and the corresponding carbon emission factors are equally important elements for the carbon emissions indicator. This is a likely reason why the Czech Republic and Poland, countries where coal is still an important source of domestic energy, report per-dwelling carbon emission rates 50% higher than Hungary or Slovenia in spite of having dwellings of the same size and specific energy consumption for square meter (see Figure 39).

Figure 43. Per dwelling carbon emissions for all domestic uses (incl. electricity) with climate correction vs. average size of the dwelling; EU27 Member States (average for 2005-2008).



Note: missing data for BE, EE, LT and MT / *Source*: ODYSEE

5.4.2. Analysing the relationship between the energy performance of the residential stock and fuel poverty

5.4.2.1. The EU27 context: ODYSSEE, EU SILC and EC (2010)

The relationship between fuel poverty and the energy performance of the residential stock has been explored at the EU27 level through the analysis of statistical correlations between a number of relevant fuel poverty and energy performance indicators presented in this chapter. For that, Pearson's correlation coefficients (*r*) have been estimated in order to find out the level of linear dependence between the previously reviewed five fuel poverty indicators and three energy performance indicators[41]summarised in Table 13.

Table 13. Fuel poverty and residential energy efficiency indicators

Indicator	Description	Years of reference	Source
FUEL POVERTY			
FPRATE_EXP	Percentage of households spending a considerable share of their expenditures on energy.	2005 through 2008	EC (2010) (see Table 8)
AVG_ENERGYEXP	Average expenditure on energy as a percentage of total household expenditure.	2005 through 2008	EC (2010) (see Table 8)
FPRATE_CONS	Percentage of the population unable to keep the home adequately warm.	2005-2008	EU SILC (Eurostat) (see Figure 13)
FPRATE_SUMMER	Percentage of dwellings not comfortably cool during summer time.	2007	EU SILC (Eurostat) (see Figure 21)
ARREARS	Percentage of the population with arrears on utility bills.	2005-2008	EU SILC (Eurostat) (see Figure 15)
ENERGY PERFORMANCE OF DWELLINGS			
ODYSSEE1	Per unit energy consumption with climatic corrections (kWh m^{-2} $year^{-1}$) for all domestic uses.	2005-2008	ODYSSEE
ODYSSEE2	Per unit energy consumption scaled to the EU average climate (kWh m^{-2} $year^{-1}$) for all domestic uses.	2005-2008	ODYSSEE (see Figure 39)
HOUSING FAULTS	Percentage of the population with leaking roof, damp walls, floors or foundation, or rot in window frames or floor at home.	2005-2008	EU SILC (Eurostat) (see Figure 16)

Source: own elaboration.

[41] Note that the ODEX energy efficiency index is not considered because it is an indicator of progress but not of the state (energy performance) of the residential stock. This is better measured by indicators ODYSSEE1 and ODYSSE2 (energy consumption per m^2). ODYSSEE1 (energy use per m^2 with climatic corrections) is similar to ODYSSEE2 and was not reviewed previously as ODYSSEE2 (energy use per m^2 scaled to EU average climate) was selected as a better proxy of energy performance for cross-country comparisons – see Figure 39.

The sampling unit for all variables is the Member State and the maximum sample size is 27. This exploratory analysis of lineal correlations is referred to the period 2005-2008. The reason is that even though some variables are available for a longer timeframe, some other (namely FPRATE_EXP, AVG_ENERGYEXP and FPATESUMMER) are only available for the 2005-2008 period.

The results of this one-on-one analysis of correlation coefficients are presented in Table 14. Assuming a 0.5 threshold value of Pearson's r for a relatively strong correlation, only in three cases (shaded in grey) are moderate to strong positive correlations found. A two tailed t-test was run in order to check the statistical significance of correlation coefficients when Pearson's r was above 0.5. In all those three cases the correlation coefficients were found to be significant at the 0.01 level.

The results show that three moderately strong, statistically significant correlations occur only between EU SILC indicators, which is consistent with the findings of the EU cross-country review by Thomson and Synell (2012). Consequently, EU SILC item HH040 (Leaking roof, damp walls, floors or foundation, or rot in window frames or floor) is the only relevant indicator of buildings' energy performance in this EU27 cross-country analysis. The results indicate that Member States where a larger fraction of the population declares to be living in a dwelling with such problems also report higher percentages of people unable to afford to keep their homes adequately warm, of people who do not pay their utility bills on time and of dwellings not comfortably cool in summertime. However, rather than establishing a cause-effect link between the quality of the building and the incidence of fuel poverty, these results indicate that an association between the perception of a poorly maintained residential stock42and self-reported thermal discomfort rates (both in summer and wintertime) as well as declared problems to pay utility bills on time.

Table 14.Correlation coefficients (Pearson's *r*) between selected fuel poverty and residential energy performance indicators.

	ODYSSEE1	ODYSSEE2	HOUSING FAULTS
FPRATE_EXP	0.07	0.27	-0.20
AVG_ENERGYEXP	-0.14	0.02	0.39
FPRATE_CONS	-0.36	-0.38	0.58**
FPRATE_SUMMER	-0.22	-0.23	0.62**
ARREARS	0.20	-0.01	0.65**

Note: ** significant at the 0.01 level; * significant at the 0.05 level.
Source: own elaboration.

Without discarding comparability problems between data retrieved from different sources and datasets, this may indicate that the ODYSSEE's per-unit energy consumption figures are not a good predictor of fuel poverty rates at the EU27 level. It may also be indicative of the divorce between consensual and expenditure-based fuel poverty rate calculation methods.

The three correlations that turned out to be stronger and more significant (marked in darker grey in Table 14) have been plotted (Figure 44 to Figure 45) in order to analyse the relative position of Hungary and other Central and Eastern European (CEE) Member States (displayed in red and light red colour). These figures illustrate the strength and direction of the found correlations but also offer a map of fuel poverty in the EU27 as measured by the correlated four consensual indicators.

Mediterranean[43] and former socialist CEE Member States are the most affected by self-reportedfuel poverty (both in summer and winter time), with a cluster of countries (BG, PT,

[42] Note that the EU SILC item does not ask directly about the energy performance of the building but simply about the presence of a leaking roof, damp walls, floors or foundation, or of rot in window frames or floor.
[43] Prior to the accession of the Eastern European Member States, Mediterranean nations (Italy, Spain, Portugal and Greece) reported the highest consensual fuel poverty and excess winter mortality rates of the EU. In the mid-

CY, RO, LT, LV and PL) performing worse than the rest. Among CEE Member States, Bulgaria stands out as the country with the highest percentages of population unable to keep their home adequately warm and to pay their utility bills on time. On the other end, Slovenia, Estonia, the Czech Republic and Slovakia perform better according to the selected indicators, while Hungary sits in a middle ground which may be representative of the average CEE Member State.

Regression lines have been drawn in order to show the direction and nature of the relationship between variables. With full samples, relatively low values of r^2 (between 0.3 and 0.4) are obtained. However, when one or two outliers are removed from the sample (see details in each Figure), the value of r^2 increases up to a 0.5-0.6 range, i.e., 50 to 60% of the variance in self-reported fuel poverty indicators is explained by differences in EU SILC indicator *Leaking roof, damp walls, floors or foundation, or rot in window frames or floor*. Note that this is a self-reported indicator of fuel poverty-related housing faults; however, the absence of such faults does not necessarily imply that the dwelling of the surveyed household has a good energy performance.

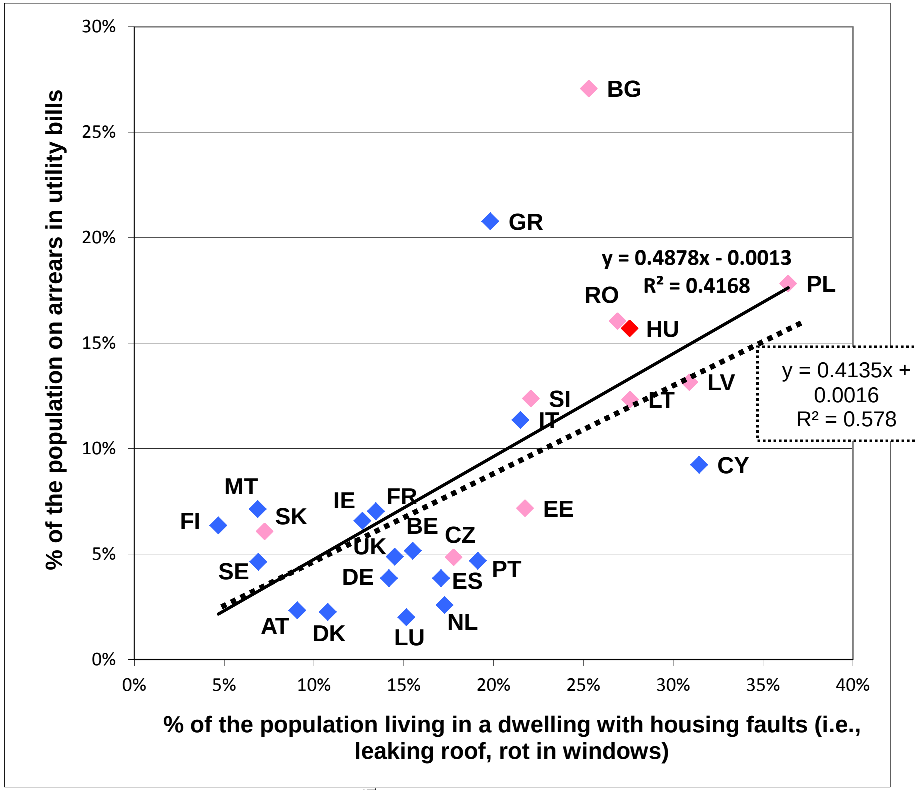
The slope coefficient is in most cases below 1, which indicates that the percentage of the population affected by fuel poverty according to self-reported indicators is below the percentage of the population living in a home with faults or in poor conditions.

1990s, Portugal achieved a record figure of population unable to afford to keep the home adequately warm – 74.4% (Healy, 2004).

Figure 44. Percentage of the population in dwellings with housing faults vs. percentage of the population unable to keep the home adequately warm. EU27 Member States (average for 2005-2008).

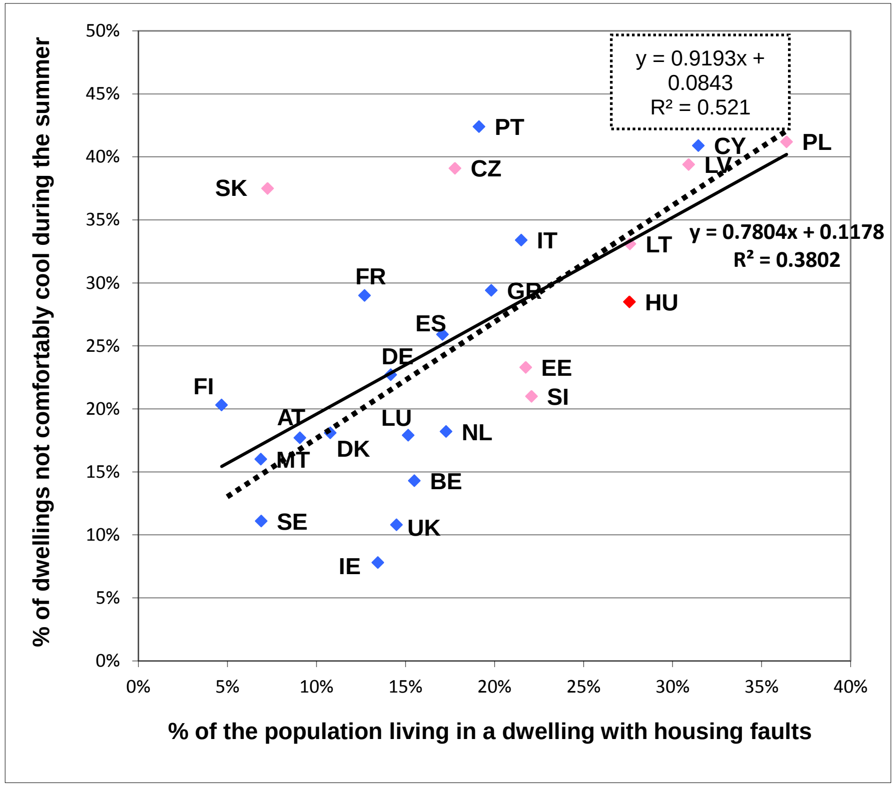
Note: BG and PT removed as outliers for the calculation for the calculation of an outlier-free regression line (discontinuous line)
Source: Eurostat

Figure 45.Percentage of the population in dwellings with housing faults vs. percentage of the population on arrears in utility bills. EU27 Member States (average for the period 2005-2008).



Note: BG and GR removed as outliers for the calculation for the calculation of an outlier-free regression line (discontinuous line)
Source: Eurostat

Figure 46.Percentage of the population in dwellings with housing faults (2007) vs. percentage of the population in dwellings not comfortably cool during the summer (average in 2005-2008). EU27 Member States for the average for the period.



Note: missing data for RO and BG; SK removed as an outlier for the calculation of an outlier-free regression line (discontinuous line)
Source: Eurostat

5.4.2.2. In Hungary: Household Budget Survey (HBS)

The relationship between the energy performance and the incidence of fuel poverty can be analysed at a national level through microdata from the Hungarian Household Budget Survey (HBS). In addition to data on actual expenditure of each surveyed household, the HBS also contains information about various characteristics of the dwelling (e.g., size, structure, year of construction, etc.). For this analysis, the HBS item *Condition of the building of the dwelling* has been selected. This is an ordinal variable with four values: excellent (i.e., newly constructed or renovated building), good, sufficient and *underpinned* (assumed to be the worst quality). This is a rather imperfect proxy to the energy performance of the dwelling, but it is the best available in HBS.

Results for the expenditure-based fuel poverty rate44, two related indicators and two secondary indicators of fuel poverty are disaggregated by the condition of the dwelling (from excellent to underpinned) in Figure 47 and Figure 48. In most cases, they show a worsening of the living conditions in terms of fuel poverty as the quality of the dwelling shrinks, e.g., fuel poverty rates are higher among households living in underpinned buildings. This gradient can be explained for two reasons:

- Households living in better-quality dwellings (i.e., good or excellent) also enjoy a higher living standard measured as income per capita. This is proven by HBS data, which confirm the presence of a strong income gradient between dwellings of different quality: the equivalised income per capita of the average household living in an excellent dwelling is 60 to 70% higher than the income per capita of the household living in an underpinned dwelling (both in 2005 and 2008). This simply indicates that more affluent families live in better quality dwellings.

[44] Calculated with a 15% fuel poverty line

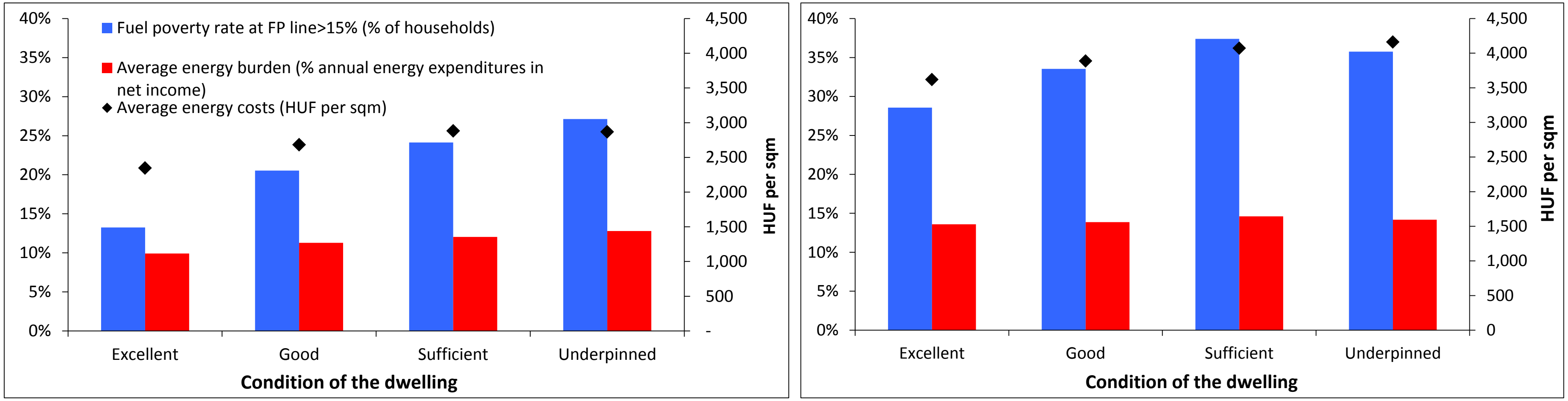
- However, there is another significant trend in the data: the energy costs per m^2 of dwellings increase as the quality of dwellings decreases – see Figure 47. The difference is not negligible: in 2005, the average dwelling in underpinned conditions reported an energy cost per m^2 22% higher than the average dwelling in excellent conditions[45]. This divergence can be taken as an indication of the poorer energy performance of lower quality dwellings, especially because: i) a lower income household is more likely to live in a home in poor conditions; ii) a lower income household uses less energy at home; iii) a lower income household is more likely to use firewood (see Section 4.3.2); and iv) a household living in a poor-quality dwelling is of a smaller size[46]. The last three factors reduce energy expenses per m^2 of dwelling; in spite of that, the energy costs per floor area unit of households living in a poor quality dwelling are higher.

All in all, these findings also demonstrate the double nature of fuel poverty as an income- and capital-related phenomenon. Wealthier families not only have a larger income to spend on energy and other domestic goods and services; they can also afford to live in better quality buildings that are more energy efficient.

[45] 2,347 vs. 2,869 HUF per m^2 – see Figure 47.
[46] In 2005 and 2008, the average size (measured through the OECD modified equivalence scale) of a household living in an excellent dwelling was 1.9-2.0; for household in an underpinned dwelling, 1.6-1.7.

Figure 47. Expenditure-based fuel poverty rate and two related indicators, disaggregated by condition of the dwelling; Hungary (2005 and 2008)

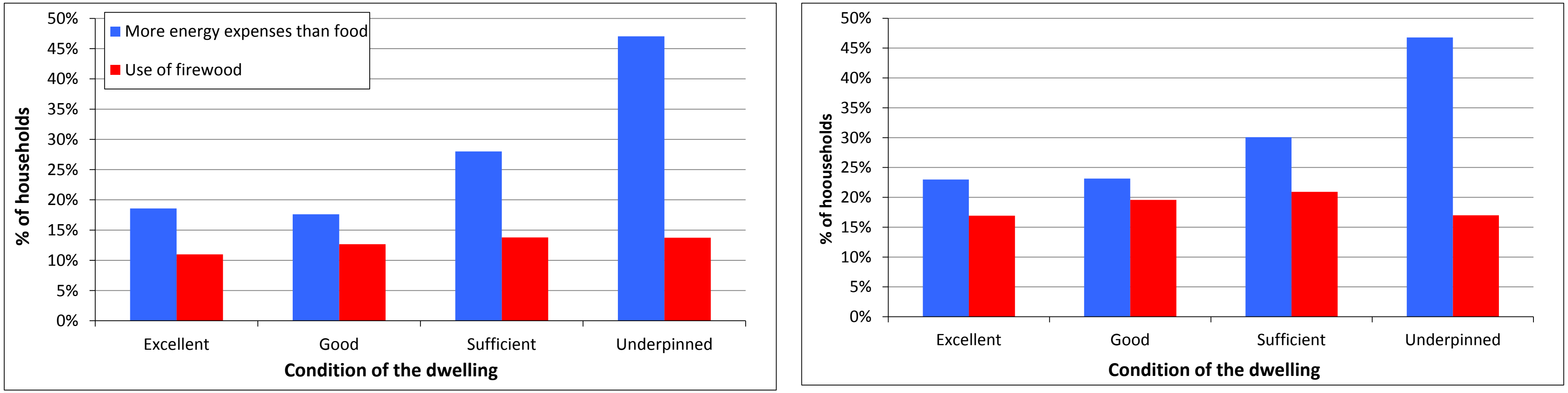
2005 2008



Source: own elaboration based on data from the Hungarian Central Statistical Office (KSH)

Figure 48. Secondary expenditure-based fuel poverty indicators, disaggregated by condition of the dwelling; Hungary (2005 and 2008)

2005 2008



Source: own elaboration based on data from the Hungarian Central Statistical Office (KSH)

Chapter 6

TWO CASES OF FUEL POVERTY IN HUNGARY

"A romák az utcát fütik - The Roma heat the streets"
From a report of the Autonómia Alapítvány

"Panel technology was not just a technology but rather a doctrine of the entire state. It was considered that the housing problem could only be solved by building such housing estates."
Heinz Willumat, urban planner with the Berlin Senate's Department of Housing

6. TWO CASES OF FUEL POVERTY IN HUNGARY

6.1. TWO UNCONVENTIONAL TYPES OF FUEL POVERTY

Households in fuel poverty experience this condition in different ways, depending on their size and composition, the characteristics of their dwelling and other contextual features.

Based on a preliminary assessment of fuel poverty in Hungary (Tirado Herero and Ürge-Vorsatz, 2010), two sub-typologies of fuel poverty have been selected for the more detailed analysis presented in this chapter:

- Poor households of the Roma minority living in rural areas of Hungary, perhaps the most deprived communities of the whole country.
- Households living in prefabricated (*panel*) blocks connected to district heating (DH). These units were built by the socialist state in suburban areas of main towns and cities and were a central element of housing policy in the previous regime.

These two case studies are not representative of the average fuel poor household in Hungary, which is likely to be living in a large single-family house located in a rural area and using natural gas as a main source of domestic heat. By contrast, the two cases selected represent a relatively small fraction of Hungary's population. .

The first case refers to the fraction of the Hungary's Roma population (200,000 to 1 million people, depending on the source[47]) which is currently living in rural areas. Even though many

[47] The 2001 census reported 205,720 people declaring to belong to the Roma nationality (no data on composition of the population of Hungary still available for the census 2011). However, it has been suggested that many Roma in Central and Eastern Europe are attempting to "pass" as non-Roma in order to avoid the stigma and shame associated with being "Gypsy". Since nationality is self-declared in the census, the actual number of Roma population is suspected to be largely underestimated. For Hungary, unofficial estimates indicate that the number of Roma could be as high as 1 million, or 10 % of the Hungarian population (Cahn, 2007)

of the rural Roma are suspected to be in fuel poverty (and often are in deep fuel poverty), they represent a relatively small percentage of the total Hungarian population. The second case (panel buildings connected to DH) concerns roughly the 400,000 households (equivalent to over 1 million people) living in prefabricated buildings in Hungary – see Section 6.3.2. All in all, these two subsets could represent around 15% of the total population of Hungary.

The reason why these two cases have been selected is because they are unconventional examples of fuel poverty illustrating the variety of conditions experienced by households in this condition. As atypical cases of fuel poverty, they challenge to a certain extent the traditional understanding of fuel poverty in Western Europe.

The case of poor Roma families in rural areas is unusual because it pushes the fuel poverty experience to limits previously unreported in Europe by the mainstream literature. Evidence collected suggests that these households suffer from indoor air pollution related to the inadequate combustion of solid fuels and adopt risky coping strategies such as illegal firewood collection and electricity theft (see Section 6.2). This extreme version of fuel poverty (by European standards) is in some sense closer to that reported for developing countries and experienced as lack of access to modern energy. Even though gas (bottled) and electricity are available even in the most remote areas of rural Hungary, the severe deprivation endured by some Roma households in these regions makes them actually unable to afford anything but a minimal level of consumption of these energy carriers. As a result, in some severe cases they are almost effectively disconnected from modern domestic energy services. It is also suspected that specific fuel poverty-related coping strategies (i.e., illegal firewood collection, and by-passing electricity meters) are reinforcing negative *Gypsy* stereotypes existing in the European and Hungarian social imaginary.

In the case of panel buildings connected to DH (Section 6.3), fuel poverty is not experienced as a deficit – sometimes rather the opposite – of energy services but as disproportionate domestic energy costs. In the author's view, this challenges what has traditionally been understood as fuel poverty in Western Europe and is a prominent example of negative path-dependencies and legacies in the post-socialist states of Central and Eastern Europe. It also poses additional questions about the need to supplement residential energy efficiency programmes with non-technical elements (e.g., tariff structure or regulatory issues) and about to the future of DH in a low energy buildings' EU.

6.2. IN THE OUTBACK: DEPRIVED ROMA HOUSEHOLDS IN RURAL AREAS[48]

6.2.1.1. Roma and rural: a case of environmental justice

Roma constitute a particularly deprived and socially excluded fraction of the Hungarian population, with employment rates, educational qualifications, and life, dwelling and health status standards worse than the national averages (The Government of the Republic of Hungary, 2006). At the same time, like in other European countries, poverty rates are higher in rural areas because of a combination of demographic, educational and labour market factors, and the quality of the housing stock is usually lower than in urban areas (EC, 2008b). In Hungary (2005), the poverty risk rate was three times higher for the rural population than for the inhabitants of large cities (*ibid.*). Both features – being Roma and living in rural areas –define the general context for the analysis of this insufficiently researched sub-typology of fuel poverty.

[48] This section is based on a case study prepared for the report "Fuel poverty in Hungary. A first assessment" (Tirado Herero and Ürge-Vorsatz, 2010) co-authored by the PhD candidate and commissioned by the Hungarian NGO *Védegylet* – Protect the Future Society.

Roma communities in Central and Eastern Europe often inhabit risk areas prone to flooding or exposed to environmental pollution such as waste treatment facilities, industrial sites, garbage dumps and major thoroughfares; they have also poorer access to environmental goods such as water, sewerage and energy (Steger, 2007; Harper et al., 2009). These are all elements of a situation of environmental injustice also reflected on the constraints experienced by rural Roma households in their daily use of domestic energy, as discussed below.

6.2.1.2. Data sources

Qualitative data collected for this case study were collected between 2009 and 2010 mostly through interviews with Roma households and two other relevant individuals working in organisations supporting the Roma. This information corresponds to three areas of the Borsod-Abaúj-Zemplén county, a former industrial region of north-eastern Hungary on the border with Slovakia:

- Mezőcsáti sub-region (*kistérség*), a 15,000-people group of settlements inhabited by both Roma and Hungarian populations lying some 40 kilometres south of Miskolc (the capital of the county) near the river Tisza and the Hortobágy national park. For this area, information was retrieved through an interview with Kristóf Szombati, who at the time was working as project coordinator of the Hungarian *Polgár Alapítvány az Esélyekért*[49] in the Ároktő settlement. At the time of the interview (June 2009), Szombati had been recently involved in a 3-month period of interviews and focus group work, mostly with Roma communities, in order to identify priorities and make proposals for project applications. The aim was assessing the energy demand of Roma families and the use of off-grid renewable energy installations for providing Roma communities with their own means of energy generation.

[49] Civil Foundation for Opportunities

- Sajószentpéter, a town located some 10 kilometres north of Miskolc by the river Sajó. Some 3,000 of the over 12,000 inhabitants are Roma, many of whom live in a settlement on the northern bank of the Sajó, physically detached from the rest of the city by the river. For this town, information was provided primarily by Judit Bari, a woman born to a Roma family living in the settlement of Sajószentpéter who holds a degree in Biology and a post-graduate degree in organizational management from a Danish university. At the time of the interview (June 2009), she lived in Budapest, working as a consultant and representative for Hungarian Roma organizations for environmental and health issues. She was also an active member of the Sajó-menti Közösség *és Környezetfejlesztők Egyesülete* (SAKKF–E), a local Roma organization first created as a legal entity for renting some natural lakes near the town for fish production. This goal was never achieved but then SAKKF–E remained to promote "community and environmental development" and was subsequently employed for carrying out different projects. Secondary information was also retrieved from the Sajószentpéter case study reported in Harper et al. (2009).
- Bodválenke, a small rural settlement in the Edelényi sub-region located 65 kilometres north of Miskolc and a few kilometres away from the Slovakian border. At the time of the visit (June 2009 and June 2010), most of it 190 inhabitants were Roma families with numerous children, whereas the small non-Roma population were mostly retired people. For this town, information was directly provided by 3 households (referred to as H1, H2 and H3) during a visit in June 2009 facilitated by a Budapest-based interpreter and social entrepreneur (Eszter Pásztor) and the appointed community leader for her development project (a local Roma man in his thirties). The latter selected the families to be interviewed, was with us for most of the visit and provided some of the answers recorded in the three households. In the three cases, women – mothers – answered most of the questions. All interviews were conducted in Hungarian and translated into English on the spot by Eszter Sára Kovách (*Védegylet* – Protect the Future Society). Some further

information from a fourth Roma household was spontaneously collected in a subsequent visit (June 2010) without data gathering purposes.

- Encsi sub-region, also a rural area located around 40 kilometres north of Miskolc. In this case, the information comes from a UNDP-supported project carried out by the *Autonómia Alapítvány*[50] between 2003 and 2004, which assessed the use of domestic energy by Roma households (UNDP/AutonómiaAlapítvány, 2004).

6.2.1.3. Fuel poverty in poor Roma households in rural Hungary

Based on evidence gathered for the Borsod-Abaúj-Zemplén county, Roma households in rural areas of Hungary rely on the following sources of energy: i) electricity, which in some casesis obtained through an illegal connection to the grid; ii) gas, in most cases bought in cylinders but sometimes also obtained through the pipe network, and mainly used for cooking; and iii) firewood, in some cases illegally collected, for cooking and heating.

Some rural areas in Hungary are not served by the natural gas grid. But even in areas connected to the network, many low- and middle-income households (Hungarian and Roma alike) have to make an important initial investment to connect the house to the grid, which has prevented a number of families throughout Hungary from gaining access to this source of energy. According to Judit Bari, the possibility of getting connected to natural gas exists in the Roma settlement of Sajószentpéter. Occasionally, Roma families organize joint money collections to extend the gas grid to the sections where they live. However, only some “richer” Roma families can use piped gas on a regular basis.

[50] Autonomy Foundation

The evidence collected indicates that poor Roma households in rural areas of Hungary often face serious problems to meet their basic energy needs. Among the various strategies devised by Roma households to deal with this situation, two – illegal firewood collection and electricity theft – have been identified as particularly representative of this sort of fuel poverty (though not exclusive of Roma population).

Illegal firewood collection, reported for Sajószentpéter, Bodválenke and the Mezőcsáti microregion, is probably a reality for many of the poor Roma communities living in rural areas. Though also practiced by non-Roma, this is something many Hungarians consider to be a typical “gypsy” activity and is a part of a more complex picture related to the prejudice towards this minority. Kristof Szombati reports that in the Mezőcsáti microregion, as firewood is often collected in the territory of neighbouring Hortobágy national park, there is a constant threat to be fined by the rangers of protected areas. In this part of the country, more control and increased fines have forced women, who are mostly responsible for gathering firewood (which adds a gender perspective to the issue of illegal firewood collection), to walk into more remote areas less likely to be surveyed and has increased the time need for collection. On the side of the national park management, there does not seem to be much understandingtowards the behaviour of the Roma in this regard (Szombati, pers. comm.).

Harper et al. (2009) have argued that the Roma are chided for their short-sightedness in the use of environmental resources. Through this socially constructed lens, Roma are seen as people overharvesting flowers to sell in the city, engaged in hazardous scrap metal collection and processing and exploiting the forest for collecting firewood. (Illegal) firewood collection related to fuel poverty may be thus reinforcing the non-Roma stereotype that regards Roma as a group with a deep lack of environmental awareness.

As seen in the households interviewed during the field visit in Bodválenke, most Roma dwellings use electricity to power a number a domestic appliances: TV and DVD, fridge, washing machine, microwave, mixer, coffee maker, radio, hi-fi system, etc. In fact, some of these appliances (like the TV) seem to be a must-have in Roma homes in Bodválenke[51]. Consequently, Roma households struggle to some extent with electricity expenses (in the range of 5,000 to 10,000 HUF per month in the case of Bodválenke), and eventually have to take more or less difficult decisions when allocating their income between basic needs such as energy and education. For instance, the mother of H3 household in Bodválenke stated her household was delayed with their electricity bill payments because "she preferred to pay for her [17 year old] daughter's studies" in a professional training secondary school (s*zakközépiskola*) in Miskolc. In other cases, households are forced to make intermittent use of their appliances. For instance, the H4 household in Bodválenke stated that they "don't use the fridge every day, only when they have something to conserve"; for instance, when they "buy meat", which is of the cheapest sort ("200 HUF per kg").

In this context, electricity theft or illegal connection to the electricity grid is sometimes adopted as a coping strategy, though it is not an exclusively Roma activity[52]. In the Sajószentpéter settlement, various neighbours are able to by-pass house meters, e.g., "there is a woman in my community who is very skilled." In this location, if a family is disconnected, the community will help to regain access to the electricity grid(Bari, pers. comm.).

[51] This seems to be the case also of the Encsi sub-region. There, the *Autonómia Alapítvány* (UNDP/Autonómia Alapítvány, 2004) report found out that 70% of Roma households had refrigerators, 85% washing machines and 95% televisions.

[52] According to Eddy (2001), in 2001 N. Boross (ELMŰ) stated that electricity theft in Budapestaccounted for half of the so-called "non-technical losses" (13.9%) and that it was "more likely to [happen in] a house with a heated swimming pool than in a poor area". Power theft is now a smaller problem for ELMŰ and "commercial losses" are currently at around 8%. The improvement of the situation has to do with the changing of metering systems that disposed of the old, "easy-to-manipulate" equipment and also the "temptation" to steal electricity, especially after a significant increase in prices happened prior to 2001 (Boross, pers. comm.).

The way poor Roma families in rural areas deal with energy supply has consequences for their welfare and security. First, both illegal firewood collection and power theft often end up with fines and, if they are not paid, imprisonment at least for some days depending on the amount owed, as the fieldwork in Bodválenke and the interview with Judit Bari indicate. It is also suspected (though no clear evidence was collected in this regard) that overdue energy bills may be a reason for usury lending, i.e., charging high interest rates in informal money lending schemes. As noted in Hungary's *National Strategy Report on Social Protection and Social Inclusion 2008-2010*, this poverty-related phenomenon affects mostly the Roma and is a mechanism leading households to a debt trap (EC, 2010c).

There is also the uncertainty about how to cope with cold in winter months. In Sajószentpéter, heating is "the topic of discussion in the beginning of the winter" and expressions like "we will freeze to death this winter" can be heard (Bari, pers. comm.). The inadequate combustion of biomass as a source of domestic heat has been identified as a negative health effect of fuel poverty. In the Mezőcsáti microregion, respiratory problems have been identified as particularly visible health impact of indoor air pollution related to firewood burning. Choking, coughing children and parents are a reality, something which could be connected to the problem of poor attendance of children at school. (Szombati, pers. comm.). In the Encsi microregion, the low quality of heating technologies – usually a multi-function heating device (*sparhelt* or *masina*), often in bad conditions – and the burning of waste (including hazardous items, like shoes, plastic bottles and bags, old furniture and old rags) fills the room with smoke, damaging people's respiratory health, especially children's (UNDP/Autonómia Alapítvány, 2004). In Bodválenke, the mother of H3 household – the poorest of the fourvisited – recalled that in winter they open windows to let the smoke out (and the cold air in) and stated that they would prefer electric heating to avoid the "dust" caused by burning firewood. In this regard, it must be noted that fuel poverty may be a explanatory factor for the substantial health disparities detected between the Hungarian and Roma population – it is estimated that the life expectancy of the average Roma is 10 to 15 years below the non-Romas' (Steger, 2007).

It is nevertheless difficult to generalize about these behaviours and conditions: although perceived as such, Roma "do not live in homogeneous communities" (Bari, pers. comm.), meaning that families and individuals may be dealing in different ways with the situation (related to fuel poverty or not) in which they live. "They are solving their problems as families, not as communities" (*ibid*.).

Low-incomes are not the only cause of fuel poverty among the poor Roma in Hungary's rural areas. The low quality of the buildings and energy end-use equipment of Roma homes is also to blame for their inability to afford adequate energy services. In Bodválenke, most buildings are old traditional peasant family houses built in adobe and tile roofs. Dwellings occupied by the poorest families are in worse conditions (e.g., corrugated asbestos roofing) and the *Állami Népegészségügyi és Tisztiorvosi Szolgálat* (ÁNTSz)[53] has recommended demolishing some of the units located or right besides the swamp because of health reasons. In this settlement, only one family (H1) – out of the three interviewed – uses some sort of simple insulation strategy (cloth around window frames) in winter.

In the Encsi sub-region, the Autonómia Alapítvány (UNDP/Autonómia Alapítvány, 2004) found scarce wall insulation, roofs in poor conditions and many broken and single-pane windows. There, people seemed to be aware of the heat losses, as respondents to the survey said that "Roma heat the streets" (*A romák az utcát fütik*). End-use appliances also contribute to the overall inefficiency of these homes as their purchase is based on their price rather than

[53]Hungarian National Public Health and Medical Officer Service

on any estimates of energy savings (*ibid*.). In Sajószentpéter, a community photography project aimed at finding out about the environmental concerns of the local Roma identified energy (both as the energy efficiency of the houses and the access to fuels for cooking and heating) as one of the environmental issues represented in the more than 400 pictures taken by the Roma participants (Harper et al., 2009). This evidence indicates the level of awareness of the Roma population about the structural factors of fuel poverty.

6.3. TRAPPED IN THE HEAT: PANEL BUILDINGS CONNECTED TO DISTRICT HEATING[54]

6.3.1. Introduction: district heating in the EU and Central and Eastern Europe

District heating (DH) has often been 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 its 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. If combined with low-emission fuels (Euroheat & Power, 2011), DH potentially becomes an environmentally attractive heat source.

Among the claimed advantages of DH for final users (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

[54] This section is based to a large extent on two papers co-authored by the PhD candidate: Tirado Herero and Ürge-Vorsatz (2012), an article published in a special issue on fuel poverty of the *Energy Policy* journal; and Tirado-Herrero and Ürge-Vorsatz (2011), a policy paper prepared for the European Commission and presented in the workshop *Cohesion policy - Investing in energy efficiency in buildings* (Brussels; November 29th -30th, 2011).

provided (Euroheat and Power, 2011; Stasiūnas, 2011). Whereas this assumption may hold true for many countries of Western Europe, in many Central and Eastern European nations DH is actually perceived as an expensive form of domestic heat.

In Central and Eastern Europe (CEE), DH is a common source of domestic heat and hot water for prefabricated residential blocks built between the 1960s and 1980s, serving in some countries (i.e. Latvia) as many as 60% of all households (Buzar, 2007a). However, much of the currently served heat still provided does not always come from higher efficiency cogeneration (or combined heat-and-power) units but also from heat-only plants (Euroheat & Power, 2006; Sigmond, 2009). These plants sometimes produce heat in inefficient power plants using polluting fuels like coal, e.g., as of 2010, 76% of the DH produced in Poland was coal-based (Ürge-Vorsatz et al., 2012). Finally, heat is typically 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, 2012).

These structural deficiencies are closely linked to a number of drawbacks – poor consumer focus, low efficiency, excess capacity, lack of investment and an inadequate policy framework – that have prevented many DH systems from proper functioning following the political changes of the 1990s (OECD/IEA, 2004). All in all, its decline in the CEE region has been related to a vicious institutional trap that links consumers' dissatisfaction and disconnection, overcapacity, shrinking utility revenues and increasing costs (Poputoaia and Bouzarovski, 2010).

Unsurprisingly, in these circumscriptions DH is regarded as an undesired legacy in the former centrally planned economies, as a burden to consumers and decision-makers, and as an issue of concern to be addressed by public authorities. However, its role in the occurrence of fuel poverty in the CEE region has remained largely unexplored.

In the context of this dissertation, DH is identified as one of the root causes of a post-socialist type of fuel poverty prevalent in dwellings served by DH (Tirado Herrero and Ürge-Vorsatz, 2012). This section extends the concept of fuel poverty by examining households that live in adequately heated (and sometimes overheated) dwellings but still face disproportionately high energy costs.

What does this newly identified type of fuel poverty entail? How can it be best measured? To what extent are households living in inefficientbuildings connected to DH affected by fuel poverty? What is the experience of fuel poverty in these units? How effective are the policy responses provided so far? This section attempts to answer some of these research questions through an analysis of quantitative data sources complemented with a literature review and a few interviews with relevant stakeholders, using the case of Hungarian prefabricated buildings heated by DH (*lakótelep* or *panelház*, in Hungarian) as a case of study. However, since prefabricated DH-supplied buildings are a typical feature of former socialist states (e.g., *paneláky* in the former Czechoslovakia; *Plattenbauten* in the former GDR), the conclusions of this analysis are applicable to other countries with energy-inefficient, DH-serviced buildings in the CEE and the former Soviet Union (fSU) and beyond.

6.3.2. Hungary as a study case

Though DH is not as extensive as in other countries of the region[55] (OECD/IEA, 2007), a first comprehensive assessment of fuel poverty in Hungary (Tirado Herrero and Ürge-Vorsatz,

[55] As of 2007, over 200 DH systems belonging to 98 utility companies supplied with heating and other services such as hot water to 650,000 householdsin 92 urban settlements all over Hungary. They are largely dependent on

2010) suggested that the residents of DH-served prefabricated buildings experience this post-socialist type of fuel poverty. This was based on a widespread perception, shared by many Hungarians, of panel buildings as low-quality, expensive units to live in.

As acknowledged by the Hungarian Professional Association of District Heating Enterprises *MaTáSzSz* (Sigmond, 2009), many DH systems in Hungary are now obsolete and need modernization both on the heat providers' and on the consumers' sides (e.g., installation of individual meters and control valves in apartments, improved insulation, upgrading of heat production units to cogeneration power plants, etc.). Understandably, newly built residential units often choose to use other energy carriers and some households sometimes disconnect if their financial situation allows for it. The consequence is that the percentage of dwellings served has declined in the last twenty years from 16.6% in 1990 to 15.2% in 2007. Of the currently remaining 650,000 connected dwellings, more than three-quarters are prefabricated apartment blocks built between the 1960s and 1980s located in suburban areas of Hungary's largest towns and cities (KSH, 2004; Sigmond, 2009). Currently, 81% of panel dwellings are served by DH, with the remaining 18% and 1% being connected to the natural gas and electricity grid respectively. Other building typologies – multi-family blocks and single-family houses – are also part, though a minor one, of the DH network (Energia Klub, 2011). This puts the number of DH-served dwellings in panel buildings at roughly 400,000 units.

6.3.3. The energy burden in panel buildings connected to DH

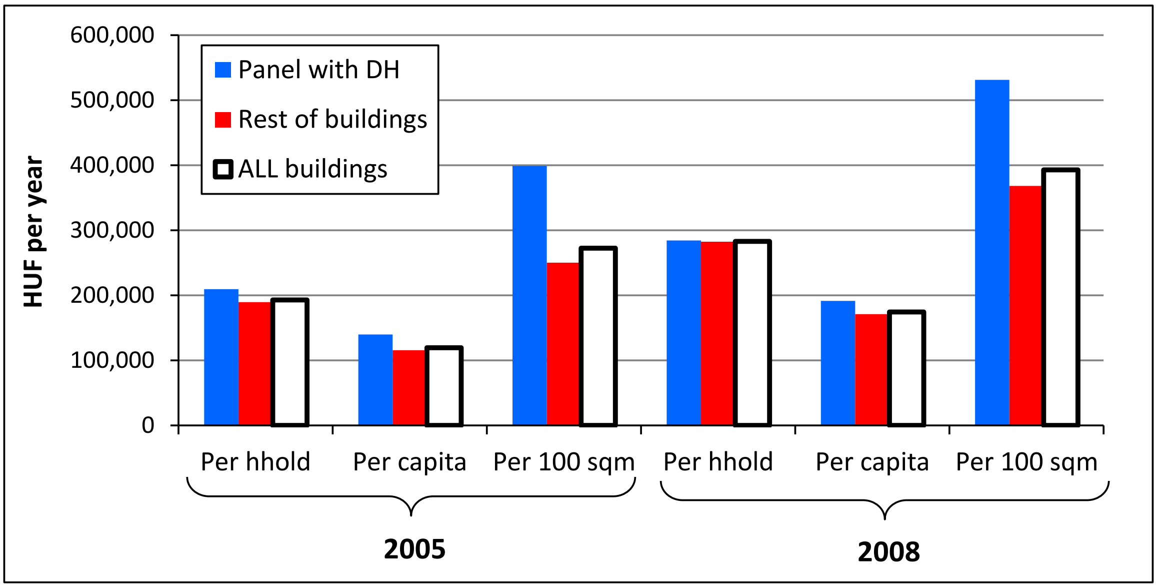
A household's domestic energy burden by a household depends on the cost per unit (e.g., per kWh) of the type of energy used but also on the characteristics of the building stock and energy supply system. The latter is particularly important for DH, as discussed further below.

---

fossil fuels, mostly natural gas (82.7% of its primary energy in put in 2007). The over hundred combined heat-and-power DH plants in operation generate a sizeable fraction (17.5% in 2007) of the country's total electricity production (Sigmond, 2009).

For a comparison of the energy burden borne by households living in panel apartments connected to DH versus other building typologies, microdata from the Household Budget Survey (HBS) for 2005 and 2008 have been used. However, since the HBS dataset does not contain a specific category of DH-connected prefabricated buildings, an *ad hoc* "panelwith DH" class was created as a combination of multi-family buildings constructed between 1960 and 1989 in urban areas (Budapest, county capitals and big cities, and other cities) and having DH as their main source of heat. The resulting size of this made-up "panelwith DH" class is roughly 580,000 units. This is an overestimation of the calculated 400,000 DH-served panel dwellings currently existing in Hungary (see previous Section 6.3.2)[56].

Figure 49. Energy burden for all domestic end-uses (HUF per year) – panel with DH versus other building categories; Hungary, 2005 and 2008



Note: OECD corrected scale applied for equivalised expenditure per capita calculations
Source: own elaboration based on Hungarian Household Budget Survey (KSH)

[56] This divergence has two likely causes: either the assumptions behind the 400,000 unit are not precise (as they come from different data sources) and/or the *ad hoc* "*panel* with DH" class based on HBS microdata contains buildings connected to DH that are not pre-fabricated blocks (i.e., multi-family buildings built with traditional technologies)

The results are presented in Figure 49 and are expressed in annual energy costs (for all domestic end-uses) per household, per capita and per 100 m^2 of dwelling. They indicate that the energy burden per household and per capita is roughly the same for “panel with DH”, “rest of buildings” and the average Hungarian dwelling (“ALL buildings”), both for 2005 and 2008. However, paneldwellers bear a substantially higher energy burden on a HUF per m^2 basis, which is offset by the smaller size of panel apartments, as discussed below.

Expenditure data from the HBS refer to total domestic energy consumption. Because of this, additional data obtained from a summary table of results of the Household Energy Use survey (HEF2009)57 are presented in Figure 5 and Figure 51. The latter source disaggregates by heating and non-heating domestic end-uses of energy.

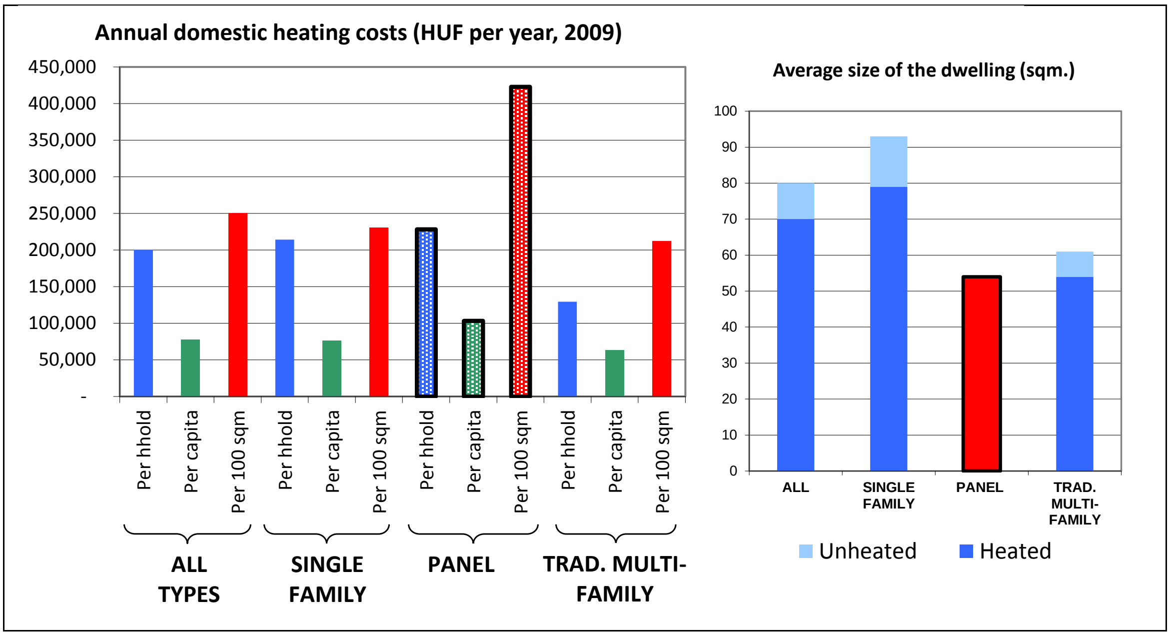
HEF2009 data indicate that in 2009 the annual heating cost per 100 m2 in a panel building with DH was 69% higher than the Hungarian average; and that its annual heating costs per capita were 34% higher than the Hungarian average – see Figure 5. Still, the heating burden per household is not much above the Hungarian average. This is primarily explained by the small size of apartments of pre-fabricated building: even though in non-panel categories part of the dwelling remains unheated in wintertime, the average floor area of a panel apartment (54 m2) is the smallest of all. In other words, the energy burden of households living in panelapartments is not much higher than in other household categories just because households in panel apartments live in the smallest dwellings of the country (on average).

Note that this difference is also explained by the fact that a fraction (e.g., less frequently used rooms) of non-panelhomes remains unheated as a cost-saving measure; in most panel

[57]HEF2009 is a one-time survey carried out in 2009 by the Hungarian Central Statistical Office (KSH) and owned by Hungary’s Energy Centre (*Energia Központ*). The summary table of results was generously provided by Lászlo Elek (Energy Centre).

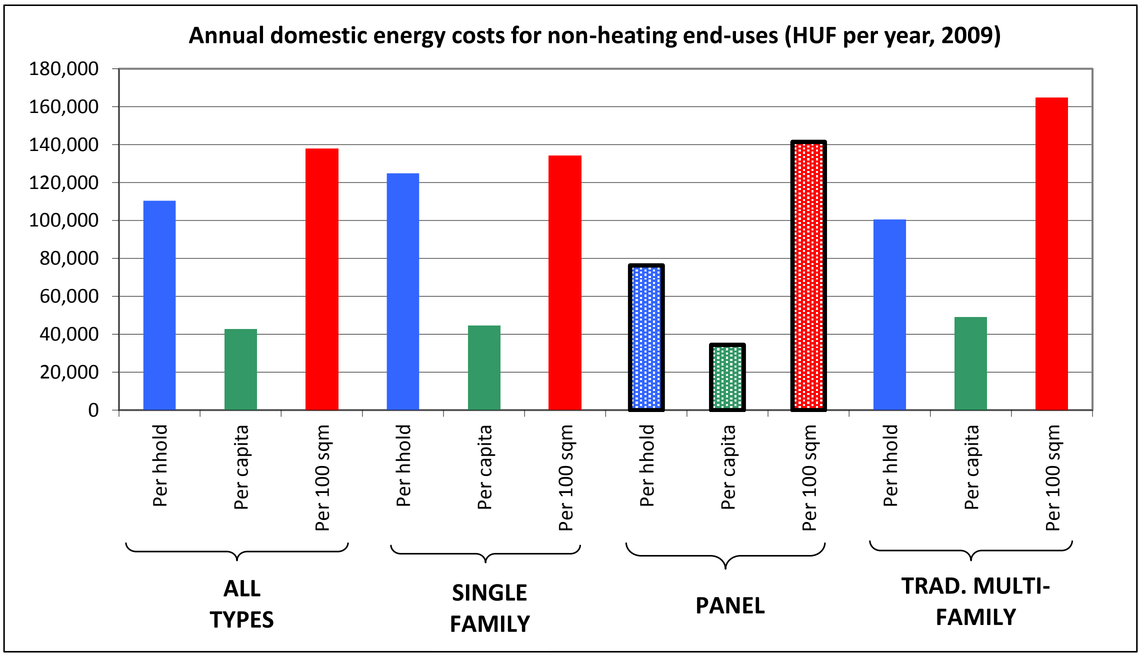
apartments the whole floor area is heated because DH is paid on a flat rate-basis (per square or cubic meter of dwelling), which removes incentives to keep part of the dwelling unheated.

Figure 50. Size (m^2) and energy burden space heating (HUF per year) – panel with DH versus other building categories; Hungary, 2009



Note: the panel category contains buildings using both gas and DH a source of heat; income per capita figures are assumed to be non-equivalised (no reference in original data)
Source: Hungarian Household Energy Use survey (HEF2009)

Figure 51. Energy burden for non-heating end-uses (HUF per year) – panel with DH versus other building categories; Hungary, 2009



Note: the panel category contains buildings using both gas and DH a source of heat
Source: Hungarian Household Energy Use survey (HEF2009)

HEF2009 data also show that heating is the key reason behind the higher energy costs per capita and per floor area of panel apartments. As shown in Figure 51, the energy costs for non-heating end-uses (i.e., hot water, lighting, appliances, etc.) are similar to the Hungarian average. Thus the high energy burden experienced by panelhouseholders can be blamed almost exclusivelyon DH-based space heating as an energy service – and not on other end-uses of domestic energy.

6.3.1. Fuel poverty rates in panel buildings connected to DH

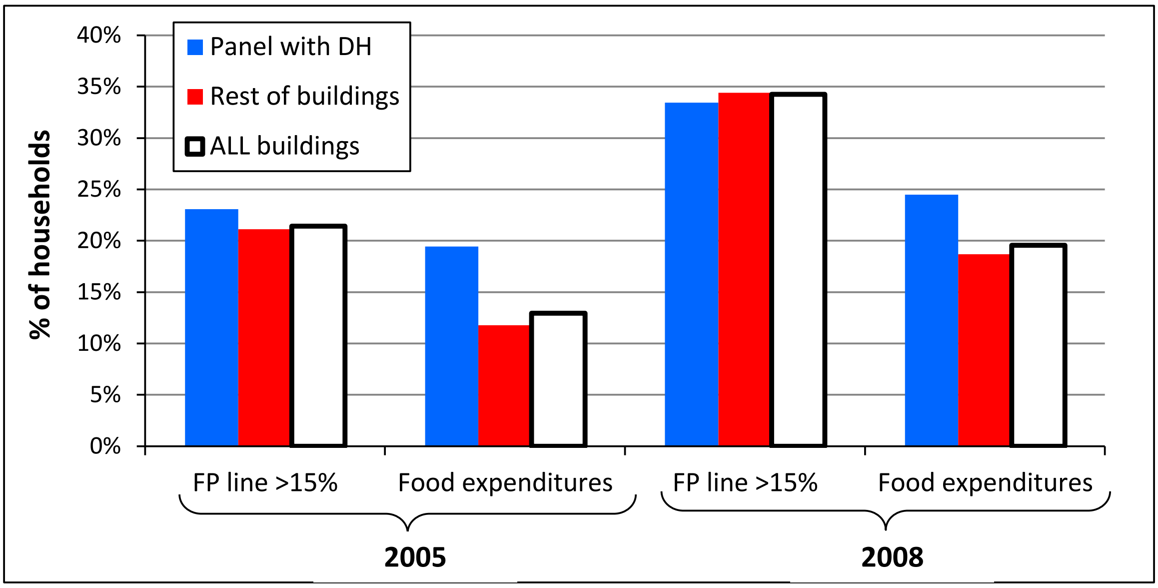
For the estimation of fuel poverty rates in panel buildings with comparative purposes, only expenditure-based indicators based on Household Budget Survey (HBS) data are presented. A chief reason is the lack of data disaggregated by building typology and source of domestic heat for item HH050 of Eurostat's Survey on Income and Living Conditions (EU-SILC)[58] – *Inability to keep the house adequately warm*. But even if data were available with the required level of detail, it is questionable whether this question can produce meaningful responses when a household cannot decide on the amount of heat consumed because heat is paid on a per square or cubic meter basis, a common feature of DH-served panelblocks.

Estimates of expenditure-based fuel poverty indicators are based on 2005 and 2008 HBS microdata on detailed household expenditures (by COICOP categories) and characteristics provided by the Hungarian Central Statistical Office (KSH). Figure 52 displays results for the expenditure-based headline fuel poverty indicator (% of households spending more than 15% of their net annual income on domestic energy) and the energy expenditure alternative (% of households spending more on domestic energy than on food). They compare the "panel with

[58] EU SILC item HH050 is the key source of information for the consensual approach to measuring fuel poverty (Healy, 2004).

DH" category described in the previous section with the rest of the buildings and the Hungarian average ("ALL buildings").

Figure 52. Expenditure-based fuel poverty indicators – panel with DH versus other building categories; Hungary, 2005 and 2008



Source: own elaboration based on Hungarian Household Budget Survey (KSH)

These results indicate that according to the headline fuel poverty indicator, there are as many fuel poor households living in panel buildings with DH as in any other Hungarian building typologies. This is an unexpected finding because it was suspected that these households would be more affected by fuel poverty because of the inefficiency of the heat supply and distribution system and the widespread perception of panel districts as urban areas with a low socio-economic status. This initial assumption proved to be wrong for two reasons:

- As explained above, even though heat costs per square meter of dwelling are substantially higher in the "panel with DH" category, the smaller size of panel apartments makes their annual domestic energy costs to be practically the same as in the (larger) average Hungarian home (see Section 6.3.3).

- Households in the "panel with DH" category have a higher income per capita than the average Hungarian household. This can be expected because they are urban households, living in cities with more and better job opportunities. However, it was also found out that in 2006 and 2008 panel dwellers also had a higher income per capita (5 to 8%) than the average Hungarian urban households (see

- Table 15). This is consistent with other socio-economic characteristics of "DH-panel" households, which seem to be slightly better educated, younger, less likely to have a pensioner as head of the household and to have fewer dependent children to look after (Tirado Herrero and Ürge-Vorsatz, 2012). These findings are at odds with a widespread perception in Hungary that regards panel blocks as areas of low-income, predominantly retired population (see, for instance, Sigmond, 2009).

Table 15. Income per capita of Hungarian households (million HUF per year) – panel with DH versus urban households and the average Hungarian household; Hungary, 2005 and 2008

	2005			2008		
	All	**Urban**	**DH panel**	**All**	**Urban**	**DH panel**
Equivalised income per capita (average)	1.22	1.31	1.42	1.41	1.48	1.54

Note: OECD corrected scale applied for equivalised income per capita calculations
Source: own elaboration based on Hungarian Household Budget Survey (KSH)

On the other hand, the energy vs. food expenditure indicator shows that a higher proportion of DH-panel households spend more on domestic energy than on food – see Figure 52. This may be explained by the rigidity of DH systems: in these dwellings, energy expenditures cannot be adjusted by reducing indoor temperatures, the percentage of dwelling floor area heated or switching to lower quality fuels, as households living in other building categories do.

6.3.2. The thermal trap: an unconventional case of fuel poverty

Residents in Hungarian DH-connected panel blocks do not suffer from fuel poverty in the form of cold indoor temperatures. In fact, as it is widely perceived by Hungarian householders, residents are often satisfied with their home temperatures during the cold season, and the whole floor area of the apartment is usually heated, unlike in other building types (see Figure 5). However, this does not imply that thermal comfort requirements are perfectly satisfied. First, notably different indoor temperatures between apartments of the same block are a common feature, with dwellings on higher floors often receiving more warmth (Csagoly, 1999); additionally, in overheated dwellings residents sometimes still use the old communist method to heat regulation: opening the windows. Second, panel apartments seem to be more affected by unpleasantly high summer temperatures (Hermelink, 2005; Faluház/Staccatto project, unpublished). This probably has to do with the structural properties of the buildings (long and exposed structures, no shading, thin walls, etc) and may be indicative of *summertime* fuel poverty as defined by Healy (2004).

Whereas indoor temperatures in winter are not the biggest concern of DH users, high energy costs are. As presented in Figure 5, prefabricated buildings served by DH report up to 50% higher heating costs per m² than other dwelling typologies. The paradox is that even though panel dwellings are only relatively energy inefficient and the smallest of all Hungarian residential units, these households bear the highest heating costs per square meter and per person. And DH payments become particularly painful when they are concentrated in the winter months instead of split throughout the year. For instance, as acknowledged by a representative of 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.).

In addition to the inefficiency of power plants, apartment blocks and transmission systems, an important reason why energy costs are higher in DH-supplied panel apartments is the absence of individual heat consumption meters: as shown in Table 16, 48% of panel households report not having a heating control device at home, and it is likely that most of them are connected to the DH network because of the inherited technical features of DH systems (i.e., single-loop heat distribution systems, see Sigmond, 2009). In those apartments, users pay flat-rate fees (e.g., per square or cubic metre) and almost the whole floor area is heated during the winter months (see Table 16 and Figure 5), which means that rationing the heat consumed – either by reducing indoor temperatures or the proportion of floor area heated – cannot be adopted as a coping strategy for households experiencing energy affordability constraints. This has implications in terms of the thermal comfort of the dwelling (e.g., the use of open windows to regulate room temperatures) and removes incentives to undertake energy efficiency investments at the household level. All in all, these features can be viewed as a legacy from the communist philosophy that regarded domestic energy more as a citizen's basic right than as a scarce resource to be allocated with economic rationality criteria.

Table 16. Key energy use features of dwellings in *panel* and other Hungarian building typologies (Hungary, 2011)

	Non-panel apartment blocks	Panel apartment blocks	Family houses	Source
Specific energy consumption for space heating and hot water [kwh m^{-2} $year^{-1}$]	300-350	~220	400-500	Fülop (pers. comm.)
Percentage of total floor area heated	94%	98%	86%	Energia Klub 2011
Percentage of households without a heating control device.	15%	48%	19%	Energia Klub, 2011.

Note: The specific energy consumption for space heating reported by Fülop (pers. comm.) is theoretical, i.e., calculated for providing an indoor temperature of 20 °C in the heating season

This situation is further aggravated by the difficulty or even impossibility to get disconnected from the DH network or to switch to other sources of heat such as natural gas. This is related to the conditions of monopoly under which heat is often provided (OECD/IEA, 2004) and also to the characteristics of the buildings (multi-family units, often with many apartments per block). Under these circumstances, households do not realistically have the option to reduce individually their heating costs through efficiency improvements because any substantial improvement (e.g., wall, roof or basement insulation) requires agreement between neighbours. This also results in low voluntary disconnection rates, as shown in Table 17, and eventually traps households in sufficiently warm but high-energy-cost dwellings.

Table 17. Percentage of Hungarian households in DH-served condominiums having disconnected or planning to disconnect from the DH system (2010).

	Yes	No	No answer
Already disconnected from the DH system	5%	89%	5%
Planning to disconnect from the DH system	9%	86%	4%

Source: Energia Klub (2011).

In that context, low-income households spend so much on heat that they can be forced to reduce the consumption of other basic goods and services, such as food (as suggested in previously in Section 3). Another strategy to deal with this imposed budget constraint consists of falling into arrears or non-payment of utility (DH) bills[59]. However, these do not always imply disconnection, especially in the case of blocks with one-pipe, single-loop vertical systems (i.e., radiators in the same position on different floors are connected vertically) where disconnecting individual households is technically impossible (OECD/IEA, 2004). Negative consequences follow on both the DH suppliers and consumers' side.

When DH companies cannot control their customers' payment behaviour (because ofthe lack of individual consumption meters) and non-payment rates increase, this negatively affects the financial performance of suppliers. In the long-term, it also undermines their capacity to invest in the maintenance or upgrading of the system (Poputoaia and Bouzarovski, 2010). When non-payment becomes a large scale phenomenon, it may even have wider negative

[59] Other CEE countries face similar difficulties. In Lithuania, for instance, a constant figure of around 100,000 DH consumers (above 15% of total users) is reported to be indebted 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)

macroeconomic effects: in the early 2000s, DH debts amounted to 0.25% of Romania's GDP and its reduction became a condition for future lending from the IMF (OECD/IEA, 2004). Moreover, although arrears or non-payment can initially benefit households with the privilege of avoiding disconnection (compared to gas or electricity users), growing debts will also put them in a difficult situation. As revealed by an interview with the director of the municipality's Family Help Service (*Családsegítő Szolgálat*) of a suburban area in Budapest where panelbuildings are widespread, DH is often the main household debt. In this quarter of the city, DH debts can seldom be solved through the debt-management service provided by the municipality because they are over the limit (1 million HUF, equivalent to 4,000 Euros at the time of the interview in summer 2009) set as a condition for benefiting from this service. According to the same source, the situation is further complicated by the number of fee-collecting companies and utility providers (that sometimes change their denomination, confusing affected consumers) operating in parallel, the uncertainty about the terms and conditions for disconnection and the lack of capabilities of some consumers to deal with their utility expenses and debts.

In some serious cases, the accumulated housing utility arrears force households to move to a less valuable property as a way to repay their debts to energy (and other utility) providers with the capital recovered in the transaction. In the past, this has occasionally resulted in illegal practices that take advantage of the vulnerability of fuel poor households (Hegedűs, 2010):

> In Hungary, a special type of the crime is closely related to the affordability issue. Households with high utility debts (typically having other social problems) are cheated by the so called 'real-estate mafia', which offered an inhabitable home (typically in a dead-end village or slum area of a city) in exchange for the apartment with debt. (The registered number of these cases was more than 400 between 2001 and 2003.)

Finally, 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 Morris, 2011; Healy, 2004; Wilkinson et al., 2001). Though evidence is still lacking, it can be assumed that the incidence of cold-housing related illnesses and deaths in homes 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.

6.3.3. Energy efficiency for panel buildings

Residential energy efficiency programmes have been in operation in Hungary for a number of years. They focus mainly on prefabricatedbuildings and implement component-based renovations (i.e. replacement of specific building components such as windows, walls or roof insulation or heating system upgrade). Between 2001 and 2006 190,000 *panel* apartments underwent some sort of energy efficient renovation at a cost 0f 140 million Euros (Ministry of Labour and Social Affairs, 2008). According to some evidence collected at the municipal level in Hungarian cities, these renovations have resulted inenergy savings in the range of 46% to -3%[60](Bencsik, 2009; Pájer, 2009; Czakó, 2010)). However, this impact is thought to be insufficient for solving the fuel poverty problem, especially if these programmes are supposed to contribute to other policy goals such as climate change mitigation or energy security objectives.

The Hungarian experience provides two examples of more ambitious retrofits than the ones supported by current programmes: the SOLANOVA and *Faluház* pilot projects. They were both realised in panelbuildings connected to DH.

[60] In some apartment blocks, retrofits resulted in a higher (3%) energy consumption (Czakó, 2010),

The SOLANOVA project has achieved 80% to 90% reductions in the energy use for space heating in a 43-apartment block in the city of Dunaújváros and has demonstrated the feasibility of retrofitting conventional panel buildings with passive house technology. The *Faluház* project, on the other hand, is expected to reduce by 50% the heating energy use of the largest panel building in Hungary, located in Budapest. As Table 18 indicates, delivering substantial reductions (over 80%) in the heating energy use requires the application of passive house technologies such as ventilation units equipped with heat recovery systems, which entail larger investment costs.

Table 18. Key features of the *Faluház* and SOLANOVA pilot projects

	Faluház	**SOLANOVA**
Number of apartments	886	43
Year of completion	2009	2005
Characteristics of the retrofit	- Walls (10 cm. expanded polysterene) and roof insulation (12 cm. rock wool) - Windows and balcony doors replacement (five chamber UPVC) - 1,500 m^2 solar thermal panels	- Advanced heat recovery ventilation units (1 per apartment) - Walls (16 cm. polysterene), roof (30 cm. with green roof) and cellar ceiling (10 cm.) insulation - Windows replacement (U_W=1.1-1.4) - 75 m^2 solar thermal panels
Heating energy consumption before and after retrofit	n.a.	220 kWh m^2 $year^{-1}$ (before) 40 kWh m^2 $year^{-1}$ (after)
Cost of renovation	€96 m^{-2} (estimated, 2010)	€250 m^{-2} + VAT (2006)
Reduction in previous energy consumption for space heating	50% (expected)	82% - recorded in 2005/06 91%- recorded in 2006/07
Financing	-33% PanelPlusState programme, - 40% Óbuda municipality and the EU STACCATO programme - 27% owners	Mainly funded by EU's 5th Framework Programme
Self-reported assessment of the retrofit by dwellers	Expectations before retrofit: - 92/90% of respondents believe that they will pay less for heating and hot water. - 84% of respondents believe that the value of their apartment will increase	Comparison of the SOLANOVA building vs. a non-retrofitted reference building: - higher level of satisfaction of winter indoor temperatures - lower level of satisfaction with summer indoor temperatures

Source: Faluház, 2009; Faluház/Staccatto project, unpublished; Hermelink, 2005; 2006.

How deep should an energy efficiency programme go if it aims to effectively eliminate fuel poverty among households living in panel buildings served by DH? It has been argued that the only long-term solution is *fuel poverty-proofing* the housing stock, "which means that a dwelling will be sufficiently energy efficient that regardless of who occupies the property, there is a low probability that they will be in fuel poverty" (DTI, 2006, p. 31). The results of the SOLANOVA project evidence a reduction of monthly DH expenses (in 2006 units) from €96 to €16 (Hermelink, 2007), the latter being affordable even for the least affluent households. If such low energy costs can be systematically achieved in DH-connected panel households throughout Hungary, then it is very likely that only passive house-based, SOLANOVA-like retrofits can effectively eradicate fuel poverty in DH-served panelbuildings.

When in addition to fuel poverty alleviation, other policy goals are also pursued, answering the question of optimal depth of retrofit requires a broader scope of analysis. The proposal of this doctoral research is a social cost-benefit analysis that assesses a range of market and non-market benefits for panel and other building typologies – the whole residential stock of Hungary, in fact (see Chapter 7 and 8).

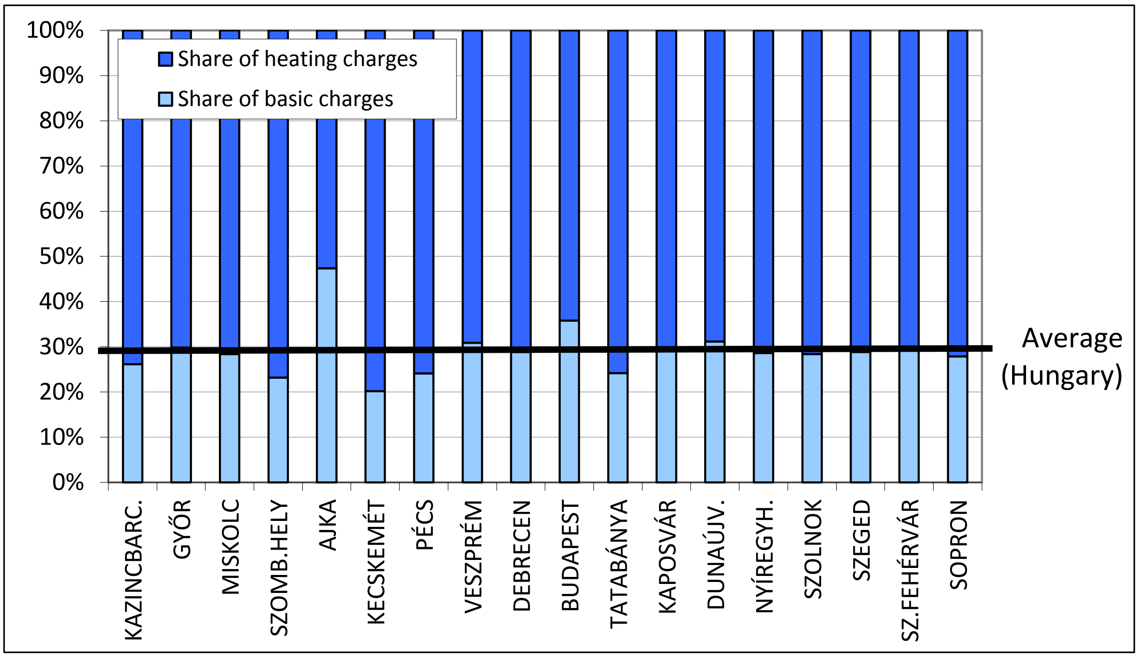
6.3.4. Beyond technical solutions: tariff structure and regulation

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

No matter how technologically feasible or desirable energy efficiency retrofits look from a policy perspective, they face a number of obstacles, starting with the characteristic large fixed costs of DH provision. These reflect its large capital investment needs and infrastructure operation and maintenance costs. Therefore even if (variable) fuel costs are reduced to a fraction as a result of highly efficient supply systems, infrastructure and building stock, costs charged for domestic end-users will not be reduced proportionally. Additionally, it is suspected that the lower the demand for heat, the larger these fixed costs become in the final heat costs.

These elements are reflected in the tariff structure of DH in Hungary. According to data collected by the Association of Hungarian District Heating Enterprises (*MaTáSzSz*), roughly 30% of the DH tariff in Hungary corresponds to basic or standing charges and 70% to heating charges – see the proportion of heating charges (corresponding to variable costs) and basic charges (corresponding to fixed costs) in Figure 53. This way, in Budapest, a hypothetical 50% reduction in heat consumption at the block/dwelling level would result in a short-term reduction of just 20% of a household's DH costs (Sigmond et al., pers. comm.)[61]. 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.

Figure 53. Proportion of basic and heating charges in DH tariffs for main cities in Hungary



Source: *MaTáSzSz*

6.3.4.2. The regulatory framework

[61] In the case of Budapest, heating charges also incorporate a fixed cost fraction, so the proportion between fixed and variable charges is roughly 50%-50% (Sigmond et al., pers. comm.).

Given the special characteristics of the DH sector, increasing the energy efficiency of DH-served buildings needs to be accompanied by a range of additional measures, such as:

- 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 DH-specific fuel poverty (i.e., now paying disproportionately high amounts for heating, but also 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, 2012).
- Both regulation and competition are available as governance and business models for the DH sector. Competition is normally with other sources of heat (e.g., natural gas) as international evidence has found that it can effectively reduce heat prices if markets are balanced. This in turn relates to the household's right to disconnect from the DH network and switch to another heat source (OECD/IEA, 2004).
- Other suggestions of the IEA include: i) substituting direct heat production subsidies with social support programmes; ii) shifting from a production-based to a consumer-focused management model; and iii) having independent, capable regulators tasked with tariff setting, energy planning, and overseeing fair competition, as well as avoiding captive consumers being forced to pay unjustifiably high prices (*ibid.*)

6.3.5. The way forward: prospects for DH in a low-energy buildings' EU

The DH demand scene of Europe is expected to change in the medium-term as a result of the expected proliferation of very low (or nearly zero) energy buildings as legislated and planned in Europe, i.e., Directive 2010/31/EU on the energy performance of buildings (recast). 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 dangerous increase in global temperature. 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 DH adoption plans in some Member States like the UK, where, in spite of its current very low penetration rates, DH is being promoted as a low-carbon solution for meeting long-term mitigation targets (Poyry Energy Consulting and AECOM, 2009)

If nearly-zero energy standards required by the EPBD become the norm for both new and existing buildings, questions arise about the economic viability of DH. The reason is that while the space heating requirements of such buildings are significantly reduced , DH providers and producers bear significant fixed costs (e.g., capital amortization and maintenance and operation) that still need to be recovered from the consumers (see Section 6.3.4.1). This issue has been already brought up in Denmark, a forerunner in adoption of DH and low-energy standards for buildings. In the mid-2000s, the Danish Energy Authority (2005, p. 25) acknowledged that:

> 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 suggest, it is unfair and uneconomical to force residents of such buildings to 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).

However, even if there are signs indicating that the DH industry will play a less significant role in a low-building-energy Europe than today, in dense city areas its competitiveness may be maintained because of its smaller capital costs (Persson and Werner, 2011).

6.4. FUEL POVERTY IN HUNGARY: A SUMMARY OF FINDINGS

6.4.1. Extent, causes and characteristics of fuel poverty in Hungary

Fuel poverty has been until recently an overlooked aspect of the transition of post-socialist societies in Central and Eastern Europe. In Hungary, it was not until the year 2010 that the report *Fuel poverty in Hungary: a first assessment* (Tirado Herrero and Ürge-Vorsatz, 2010) made an initial exploration of the phenomenon on the basis of the theoretical and methodological developments occurred in Western Europe (mostly UK and Ireland) during the 1990 and 2000s.

In the second half of the 2000s, between 10 to 30% of the Hungarian population in was affected by fuel poverty (see Figure 32). The lower bound of the reported range (10%) corresponds to fuel poverty rates measured through self-reported or consensual approach, i.e., percentage of the population living in a household unable to keep their home adequately in the winter time; the higher bound (30%) is roughly the fuel poverty rate as measured by the expenditure approach, i.e., percentage of the population living in a household whose domestic energy expenditures are above 15% of their annual income. The difference in the results obtained for Hungary provides further evidence of the persisting divorce between both calculation methods.

Since the mid-2000s a significant growth in fuel poverty rates as measured by the expenditure approach has been detected. This increase is connected to the rapid rise in domestic energy prices, especially natural gas prices, occurred since 2006. Between that year and 2011, the nominal price of domestic gas has more than doubled, which is primarily a consequence of the weak position of Hungary as an energy-dependent economy that obtains 80% of the natural gas it consumes from one single source – Russia. Other causes include poor regulation, rising indirect taxation (VAT) and the expansion of the country's strategic gas storage capacity.

However, the energy efficiency of the residential stock is usually regarded by the literature as a key strucutural cause of the fuel poverty problem. Acknowledging the relevance of this structural cause of fuel poverty, the results obtained suggest that the quality of the dwelling (as proxy to its energy efficiency) explains to some extent differences in fuel poverty rates both at the EU27 and national (Hungarian) level – see Section 5.4.

Acknowledging the complex and context-dependent character of the fuel poverty phenomenon, a few secondary indicators have been also collected (see Chapter 4):

- Traditional fuels are substituting to some extent natural gas as a source of domestic heat. The percentage of households relying on traditional fuels (mostly firewood) for space heating has increased in the late 2000s in parallel to the rapid increase in the price of natural gas. The consequence is that as of 2011 firewood was used as a primary or complementary source of domestic heat in 20 to 30%of the Hungarian dwellings.

However, that a household uses firewood with this purpose does not necessarily imply that it is in fuel poverty.

- 18% of the Hungarian population were on arrears in utility bills as an average for the period 2004-2011. Given that domestic energy is the largest utility cost of the average Hungarian household, it is reasonable to think that these arrears are connected primarily to domestic energy affordability problems. Indebtedness with utility companies can result in disconnection, installation of pre-payment meters and even resorting to usury lenders.
- Summertime thermal discomfort is a poorly explored side of the fuel poverty phenomenon, as researchers have traditionally focused on heating-related issues. However, the 2007 *ad-hoc* module on housing conditions of EU-SILC (EC, 2009) allow a first quantitative assessment in Hungary and the rest of EU nations following the self-reported or consensual approach. Data retrieved from this survey indicate that as of 2007 29% of the Hungarian population was living in a dwelling that was not comfortably cool during summertime. At the EU27 level, Mediterranean and Central and Central and Eastern European Member States reported in that year a larger proportion of dwellings with uncomfortably high temperatures during the summer.

All in all, based on the quantitative and qualitative data presented in Chapters 4 to 6, it is suggested that three broad types of fuel poverty exist in modern Hungary – see Table 1. These typologies illustrate the diversity of fuel poverty in Hungary, and incorporate the two unconventional cases of fuel poverty presented in this chapter.

Table 19.Typologies of fuel poverty in Hungary

Conventional (natural gas)	Rural (firewood)	*Panel* (district heating)
- Typically in single-family houses connected to natural gas, both in urban and rural areas.	- Typically in rural homes with access to firewood, storage space and stoves; though it may also include urban households	- Typically in *panel* apartments connected to district heating (DH) and paying on a flat-rate basis per dwelling square or cubic meter (no

- Probably the most common type of fuel poverty in Hungary given the prevalence of this building-energy carrier typology. - Larger size, exposed walls/roof and poor insulation explain poor energy performance (over 300kwh m^{-2} $year^{-1}$ for space heating). - Experienced as high energy costs, reduced floor area heated and thermal discomfort; energy costs may press on other basic expenditures like food.	with these features. - Includes dwellings connected to the natural gas grid that have switched to firewood to save on energy costs. - Experienced primarily as the inconvenience to move and prepare firewood and operate stoves; probably also as reduced floor area heated and thermal discomfort. - In extreme cases, connected with illegal firewood collection (Roma and non-Roma population).	heat meters) - It may also include other building typologies connected to DH, and other forms of building central heating - Wintertime thermal comfort guaranteed in almost all cases - Experienced as disproportionate energy costs per square meter, cancelled out to some extent by the small size of *panel* apartments; energy costs may press on other basic expenditures like food. - In worst cases, it results in payment arrears, indebtedness and risk of disconnection

Source: own elaboration

6.4.2. Coping strategies: the multi-faceted nature of fuel poverty

The indicators reviewed in Chapter 4 and the typologies of identified in the Section 6.4.1 above illustrate the multi-faceted nature of the fuel poverty phenomenon in Hungary. They suggest that being fuel poor does not mean submissively bearing disproportionate domestic energy costs (as a proportion of household income) 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.

The evidence collected in Hungary and the literature reviewed indicates that households deal with energy affordability problems in many different ways, which range from simply lowering indoor temperatures at home to more risky solutions like connecting illegally to the electricity grid or being indebted to utility companies. These *coping strategies* or *coping behaviours* (Buzar, 2007a; Anderson et al., 2010; Brunner et al., 2011) and 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 solution adopted will depend on the features of the dwelling and energy-using equipment, the constraints imposed by the social and institutional context (e.g., regulatory framework, values, etc.), as well as on the preferences and understanding of the risks of the household members. The behavioural side of these solutions is shaped by people's perceptions and expectations on domestic energy use, which has been referred to as *energy cultures* (Brunner et al., 2011).

A list of coping strategies/behaviours is presented in Table 2. They are based on this research in Hungary but are also representative of other context and locations in developed and transition economies, as reported by the fuel poverty literature. This collection aims to be a comprehensive collection of strategies though it is very likely that it does not cover all possible solutions devised by the creativity of households struggling to pay for the energy they need at home. And it is also a simplification of the actual, complex behaviour displayed by households to deal with this situation: these strategies are often applied jointly, perhaps depending on how deep in fuel poverty a household is (e.g., a household experiencing serious energy affordability problems will keep low indoor temperatures, heat only a few rooms, buy lower quality food and eventually stop paying the gas bills in the winter months).

What these strategies illustrate is that households often aim at striking a difficult balance between providing enough energy services and controlling domestic energy costs. In some cases, these micro-leveldecisions make some households capable of meeting the demand of energy services at home more satisfactorily. However, coping strategies are frequently imperfect solutions: they come at the (opportunity) cost of, for instance, reduced consumption of other basic goods and services (like education or food) or the risk of being disconnected if utility debt cannot be repaid on time. One way or the other, eitherby being cold at home or employing some other coping behaviour, fuel poverty harms households' welfare.

This has implications on how fuel poverty is understood and defined. A fuel-poor household is not just one unable to provide an adequate amount of energy services or with disproportionate energy expenses as a proportion of income. It may also be a household that has gone back into burning traditional fuels (often in precarious conditions) to reduce its heating expenses; or a household that is forced to cut on food and other basic items in order not to be cold at home. These are all symptoms of fuel poverty that are not necessarily capture by expenditure-based or self-reported indicators. They thus emphasize the importance of incorporating other indicators to reflect the complexity of the fuel poverty phenomenon.

Table 20.Coping strategies or behaviours applied by fuel poor households to deal with energy affordability problems

Coping strategy/behaviour	Description	Impact on household's welfare	Sources
Low indoor temperatures	A cold home has conventionally assumed to be the most common symptom of a fuel poor household. If summertime thermal discomfort is also accepted as a symptom of fuel poverty, the same applies to indoor temperatures during the hot season.	Wintertime thermal discomfort is not only a nuisance for householders but has distinct human health impacts as it increases the incidence of physical and mental diseases, especially among vulnerable population (elders and children). It also has negative effects in terms of social exclusion.	The Eurowinter Group, 1997; Wilkinson et al., 2001; The Marmot Review Team, 2011.
Reduction of the percentage of dwelling floor area heated	As an alternative to a cold home, fuel poor households often heat to adequate levels only a fraction of their living space – usually the rooms where they spend longer time like the kitchen or the living room.	Comfort impacts, plus human health impacts likely if this behavior results in household members exposed to inadequate temperatures at home. Negative effects in terms of social exclusion.	Brunner et al. (2011); Buzar (2007a); UNDP (2004); Anderson et al (2010)
Short-term behavioral responses	Wearing more clothes, wrapping up in blankets, going earlier to bed, drinking hot beverages, spending time away from home like visiting a public library, friends, etc.		Buzar (2007); Anderson et al (2010); Brunner et al. (2011)
Restricted provision of other domestic energy services different from space heating	Not only the provision of space heating is restricted as a result of fuel poverty, but other energy services like lighting, powering appliances or use of hot water too.	Comfort impacts, e.g., low-income households in Vienna use the TV or candles as light sources. Negative effects in terms of social exclusion.	Brunner et al. (2011)
Fuel substitution	Expensive energy carriers such as electricity or natural gas are replaced by cheaper, less convenient ones like firewood and other traditional fuels. It can be related to fuel self-collection or self-production.	Opportunity cost of fuel-collecting time; health problems related to indoor air pollution; comfort impacts related to the operation of traditional stoves.	Lampietti and Meyers (2003); UNDP (2004); See Section 4.3.2
Electricity theft and illegal firewood collection	Self-connection to the electricity grid or by-passing electricity consumption meters, collection of firewood in private woodland. In Hungary, often associated Not exclusively a Roma activity.	Fines and detentions; negative effects in terms of social exclusion: in the case of poor Roma in rural Hungary, it may contribute to their stigmatization as a minority.	Interviews with deprived Roma families in Bodvalenke – see Section 6.2.1.3
Payment arrears and indebtedness with energy suppliers	Households may decide to delay (or even refuse) the payment their energy bills, especially when they concentrate in the heating season.	Risk of mounting debt with utility providers that if it cannot be managed leads to disconnection or installation of pre-payment meters.	Healy (2004); Buzar (2007a); see Section 4.3.1
Reduction in the purchase of other goods and services	Lower expenditures on other household budget items in order to guarantee a certain level of provision of domestic energy services	Reduced purchasing power: it may not only affect leisure and other non-basic needs but also items like food (*heat or eat dilemma*) and education, which has an effect on the opportunities and dietary choices of household members. Negative effects in terms of social exclusion.	Bhattacharya et al., (2003); NEADA (2005); O'Neill et al. (2006); Anderson et al (2010)
Basic energy efficiency	Inexpensive, self-installed measures, e.g., blocking draughts in windows or doors with cloth or fabric pieces, changing bulbs, etc.	Positive impacts: it reduces energy costs and enhances indoor thermal comfort. However, these simple measures have a limited effect on both aspects of fuel poverty.	Brunner et al. (2011)

Source: own elaboration based on references in the Table

Chapter 7

RESIDENTIAL STOCK MODEL AND FINANCIAL COST-BENEFIT ANALYSIS

"If I know what the result will be, it's not worth starting it in the first place"

Albert Szent-Györg, Hungarian physiologist and 1937 Nobel price winner

7. RESIDENTIAL STOCK MODEL AND FINANCIAL COST-BENEFIT ANALYSIS

7.1. THE INCORPORATION OF CO-BENEFITS INTO CLIMATE DECISION MAKING: THE CASE OF RESIDENTIAL ENERGY EFFCIENCY IN HUNGARY

The three previous results-based chapters (4, 5 and 6) offer a wide-ranging picture of the domestic energy affordability problems experienced by Hungarian households. Based on both quantitative and qualitative data, they present the extent and characteristics of the fuel poverty problem in Hungary, and discussits shorter-term causes and structural explanatory factors. Additionally, chapter 5 provides evidence suggesting that the quality of the dwelling is correlated to fuel poverty both at the EU27 and national (Hungarian) level. Such results are consistent with views that consider fuel poverty as an issue of "insufficient capital expenditure" on the quality of the home (Boardman, 2010, p. 13) and argue that domestic energy efficiency is the only long-term solution to fuel poverty (Ürge-Vorsatz and Tirado Herrero, 2012).

However, fuel poverty alleviation benefits, as well as other non-market benefits, are rarely quantified or even considered in the evaluation of residential energy efficiency programmes. This is more often the case in contexts where there is little awareness about the fuel poverty problem, like Central and Eastern Europe.

Along this line of argumentation, chapters (7 and 8) address the second half of the dissertation's overarching research question:*what is the relevance non-market co-benefits* *(including fuel poverty alleviation benefits) in the economic assessment of residential energy efficiency scenarios in Hungary?*

With this aim, a financial and social cost-benefit analysis (CBA) have been conducted. There are two key reasons why both a financial and social CBA have been carried out in parallel:

- The chief reason is that the results (i.e., Net Present Values, NPVs) of the financial and social CBA provide a quantitative answer to the research sub-question above: their comparison provides a measurement of the relevance of non-market co-benefits for the economic assessment of residential energy efficiency policies. 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, 2008a). Consequently, the social CBA incorporates costs other than those directly incurred with the retrofits (i.e., programme management costs, which are a part of the transaction costs), and a range of non-market co-benefits (with a focus on fuel poverty alleviation effects) additional to the energy saving benefits. Though the financial and social NPV are not directly comparable[62], the sign and evolution of both NPVs illustrates how important non-market co-benefits are for the economic assessment of residential energy efficiency scenarios. Moreover, the social CBA provides a measure of

[62] 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.

the relative importance of each market and non-market benefit category the in final results, thus providing evidence aboutwhich benefit categories are the most relevant.

- A secondary reason is that if only the social CBA would be have been carried out, the research would not provide adequate information about the actual (financial) costs borne by households and the State for the implementation of the upgraded policy. These elements are better reflected in the results of the financial analysis and of the financing scheme (*pay-as-you-save* plus State grants) that was developed upon the intermediate results of the financial CBA in order to enhance the policy realism of the exercise (see Section 7.9.3).

The structure of this second block of results-based chapters is organised as follows. Chapter 7 starts with an assessment of Hungary's fuel poverty-relevant policy framework (Section 7.2). This evaluation is done in the light of current perspectives that emphasize the need to align different social, economic and environmental priorities for the redefinition of policies. It focuses on the flaws of the country's current policy framework and provides a justification for the upgraded policy proposal (MID and DEEP scenarios) later assessed through the cost-benefit analysis.

The chapter then continues with a presentation of the fundamentals of the CBA (Section 7.3) and a detailed description of the residential building stock model employed in the CBA (Section 7.4). The latter is based on a previously existing model of the Hungarian building stock (Ürge-Vorsatz et al., 2010) that was substantially expanded, refined and adapted for the purposes of this research. The results of the financial CBA and the evaluation of the proposed financing scheme are presented in Section 7.9. Finally, Chapter 8 proceeds with the social CBA, assesses the sensitivity of the social NPV to key model parameters and compares the results of the results of the financial and social CBA.

7.2. POLICY CONTEXT: RETHINKING HUNGARY'S RESIDENTIAL ENERGY EFFICIENCY POLICY

7.2.1. Synergies between fuel poverty alleviation and climate change mitigation[63]

7.2.1.1. The climate change-fuel poverty link

Fighting climate change has become a widely accepted environmental policy priority, resulting in the re-contextualisation of many seemingly unrelated subjects, which are now often presented from this new perspective. However, sometimes the link may be somewhat artificial.

This happens at a time when large challenges liein frontof national and global decision-makers as a massive decarbonisation of the world economy (i.e., a 50 to 85% reduction in the year 2000 global carbon emissions by 2050, as suggested by IPCC, 2007b) needs to be achieved while improving the life standards of the global population. These challenges are especially difficult in those world regions or parts of society that have benefited less from the developments that have resulted in current GHG atmospheric concentrations. Complex policy frameworks are thus needed to reach a delicate balance between a better satisfaction of the needs of present generations and an effective protection of the rights of future generations to enjoy a stable and safe climate. Additionally, in less affluent geographic and social areas where immediate economic priorities override environmental concerns, climate change alone is often not a sufficient policy goal to be able to mobilise enough political will or adequate action.

[63] This section is based on an *Energy Policy* paper on the synergies between fuel poverty alleviation and climate change mitigation (Ürge-Vorsatz and Tirado Herrero, 2012).

Typically, alleviating poverty is not the most obvious area for policy integration with climate change because these two rank high on rather different local political agendas. Nevertheless, it is argued that alleviating one particular type of poverty – fuel poverty – offers strong synergies with climate change mitigation agendas, for two reasons. First, the buildings end-use sector offers the largest and most cost-effective mitigation potential according to global and regional estimates (IPCC, 2007b; Ürge-Vorsatz and Novikova, 2008; Eichhammer et al., 2009). Second, a key mitigation strategy to capture these potentials in buildings can also alleviate, or even fully eradicate fuel poverty, providing the ground for successfully aligning shorter-term social and longer-term environmental priorities. Otherwise, as Boardman (2010, p. 17) has put it, "there is a risk […] of seeing fuel poverty as a peripheral side issue that can be tackled by social and fuel pricing policy. This is incorrect and has failed for the last 30 years [in the UK]. The obligations to the present generation must not be obscured by our commitment to future generations and they do not have to be."

7.2.1.2. Comprehensive approaches to fuel poverty alleviation

Understanding the roots of fuel poverty offers further key opportunities for alleviating both the energy services affordability and the climate change mitigation challenges, and places the fuel poverty problem on the energy radar screens. From that perspective, three elements usually regarded as main contributing factors to the fuel poverty phenomenon are considered: household income, energy prices and energy efficiency of the dwelling (BERR, 2001; OECD/IEA, 2011a). These underlying factors of fuel poverty provide the analytical framework for this review and offer a ground for key entry points into policy-making.

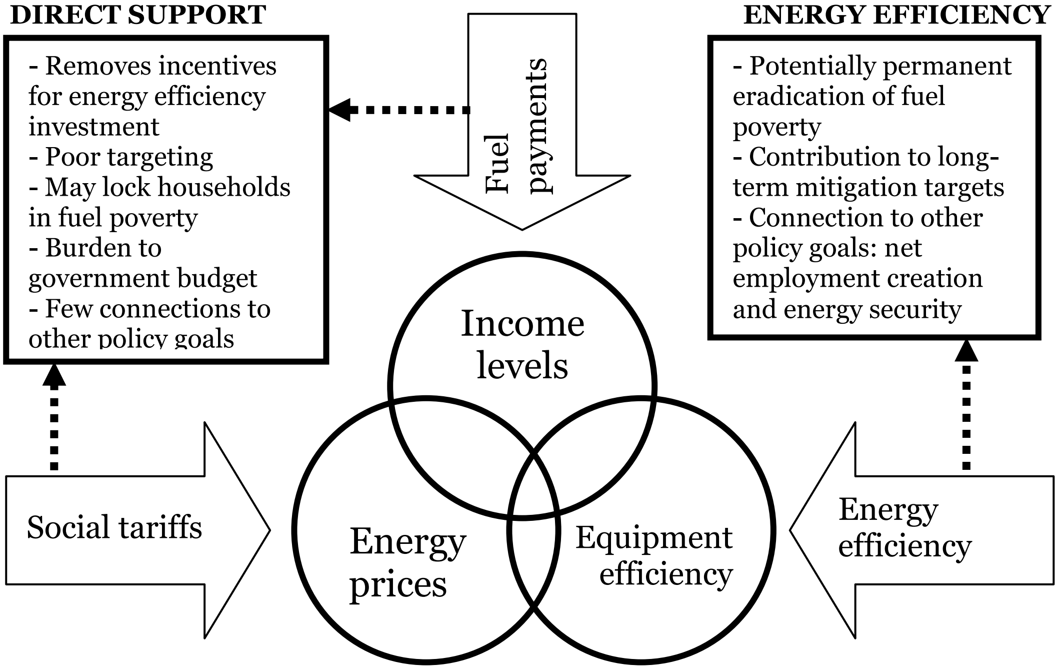
First, low incomes have usually been regarded as an important cause of fuel poverty as less affluent households often live in poorer-quality housing and have more restricted budgets to spend on energy. However, although the literature and documented evidence is scarce, it can be argued that solving the fuel poverty problem via households' income (e.g., through subsidies to energy costs or fuel payments) is often difficult because extra income may not be used by households for covering their unmet energy service needs or for improving the energy efficiency of their dwellings (Healy, 2004; Boardman, 2010).

Energy prices are a second level through which fuel poverty has been traditionally addressed. Though they offer a temporary solution to fuel poverty (ideally, during the transition to a low-carbon residential stock), if provided inthe absence of energy efficiency measures they can be counterproductive for solving the problem, potentially locking the more vulnerable households in fuel poverty because they remove incentives to invest in energy efficiency.

A prime example how an attempt to guarantee widespread access to low-cost energy services through subsidised prices can result in long-term fuel poverty is the case of the former communist countries of Central and Eastern Europe. In this region, low energy prices during sustained periods of time have resulted in the construction of buildings and infrastructure with poor energy performances. The subsequent liberalization of the energy sector, which brought residential tariffs close to full recovery costs at a time when household incomes were shrinking as a result of the economic slowdown, are equally important factors that explain the higher fuel poverty levels reported in Central and Eastern Europe (World Bank, 2000; Ürge-Vorsatz et al., 2006; Buzar, 2007; Boardman, 2010).

The third contributing factor to fuel poverty, identified also as a lever for its solution, is the efficiency of the households' energy-using capital stock, which may be a permanent solution to fuel poverty. However, for this lever to make a marked difference in fuel poverty rates, the efficiency levels achieved with the upgrades need to be substantial (DTI, 2006).

Figure 54.Contributing factors and policy entry points to fuel poverty and their relation to climate change mitigation.



Source: Ürge-Vorsatz and Tirado Herrero., 2012

For the case of fuel poverty, this leaves the energy performance of the dwelling as the key factor to take or keep households out ofit while contributing simultaneously to reducing GHG emissions. But other co-benefits can be accrued as well, as there is evidence of thesignificant net employment creation and energy dependency reduction effects of investing in buildings energy efficiency (Wade et al., 2000; Hong et al., 2007; Li, 2008; Pollin et al., 2009; Tirado Herrero et al., 2011)– see Figure 54. These co-benefits are not present if fuel poverty alleviation policies are based on subsidised energy prices or income transfers.

7.2.2. Hungary’s policy elements in relation to fuel poverty

7.2.2.1. A brief assessment of the current policy framework

The complex nature of fuel poverty, which is unfit “to conventional poverty-amelioration methods”(Buzar, 2007, p. 224) and often hidden behind income-related poverty, has made it difficult to devise appropriate policy responses. Hungary as a representative CEE nation is not an exception in this regard: as no official definition or recognition of the issue exists, not a single, coordinated strategy aimed at reducing its incidence has been defined. However, this does not mean that some components of Hungary's climate, housing, social and even fiscal policies are having an impact on the affordability of energy services for households. Although somehow uncoordinated and overlapping, those various state-supported schemes are contributing to lessening to a certain extent the burden of energy bills on households' budgets.

Table 21 below summarises the various policy elements identified as relevant from a fuel poverty alleviation perspective; it also presents an assessment in terms of their suitability as a long-term solution to fuel poverty. The policy elements have been divided into three groups corresponding to the approaches described in the previous section – energy price support, direct income transfer and energy efficiency. In addition, a debt-management service offered by some Hungarian local governments has been labelled as a separate ('other') category.

Starting with energy price support measures, gas and district heating (DH) price support schemes(gázártámogatás and távhőtámogatás) are the most important in terms of the resources allocated (see following Section 7.2.2.2) and the size of the beneficiary population.In the beginning, they offered generalised support to residential gas and DH users – as of 2004 the subsidy was paid to gas and DH consumers without any consideration to the household's financial situation or status of occupancy (OECD/IEA, 2007). . However, since 2007 the government substituted the system previously benefiting all gas and DH consumers by an income-dependant compensation in order to havea fairer and more efficient structure. However, the loose eligibility criteria selected made that as of 2009 more than 50% of Hungary's domestic gas users and 49% DH users still qualified as recipients of the subsidy (Szivós et al., 2011).

Since they originally benefitted only gas and DH users, it is believed that these subsidies were poorly targeted. This way, theydid not support households in rural areas and relying on other fuels like bottled gas or firewood as a source of heat (Szivós et al., 2011). These households are more likely to be in fuel poverty because of the lower income of the average rural household and also because they often live in a large, inefficient single-family houses. In fact, the combination of poor targeting and lax enforcementof elegibility criteria has probably had regressive effects as it represents a cross-subsidy from poorer to richer households (see the case of Serbia and Montenegro in UNDP, 2004).

Since 2011, these two schemes have been merged with the household maintenance support scheme (*lakásfenntartási támogatás*), which now encompasses a wide range of household basic costs: rent, common costs (for multi-family buildings), garbage collection fees, water and sewer fees and energy costs. Besides, this improved household support scheme also subsidises previously disregarded energy costs – electricity, coal, firewood, liquid fuels, etc. This improved policy tool also allows for the provision of in-kind benefits, e.g., direct provision of fuels (Hirado, 2012).

The integration of the gas and DH price support schemeshas probably simplified the administration of these measures, thus lowering its administration burden and costs.It hasalso improved its coverage by benefitting households depending on energy carriers other than natural gas and DH, which is very relevant to the over 20% of the Hungarian population relying on firewood as a source of domestic heat (see Section 4.4.1). However, it is unclear (with the information that could be retrieved) whether the size of the extended household maintenance support (*lakásfenntartási támogatás*) has increased to the same extent as the amount of the former gas and DH price support schemes.

For DH, a second policy element that eases the burden of DH costs on households' budgets is the VAT payable on DH, which from 25% was first reduced to 18% and then to 5% after consultation with the European Commission (BBJ, 2009; NOL, 2010). This subsidised rate compares rather favourably with the current 27% standard VAT applied to other goods and services. This measure exclusively benefits DH users, which are not the most affected by fuel poverty even though they are forced to bear higher energy costs per .m^2 and per person than other building typologies (see Chapter 6). In addition, legislation passed in 2011 has put a cap on DH prices, which have to be now approved by decree; this decision has been contested by the Hungarian Professional Association of District Heating Enterprises(*MaTáSzSz*) and local governments as they fear that regulated prices will result in considerable losses for DH companies (OECD/IEA, 2011b).

These subsidies aimed at reducing the energy bills or increasing the disposable income of low income households are examples of a common policy tool for alleviating fuel poverty (DEFRA/BERR, 2008;Scott et al., 2008; Tirado Herrero and Ürge-Vorsatz, 2010). Such support schemes have, however, been criticized because, even though they succeed in reducing fuel poverty temporarily, in the long run they lock these households into fuel poverty by creating disincentives to improving the efficiency of energy using equipment and buildings. Healy (2004) has argued that the saved income most likely will be spent on more energy (on more expensive, carbon intensive, less efficient fuels in the case of dwellings without proper heating systems) rather than invested in improving the quality of the dwellings. Subsidies have been also criticised becausethey are often poorly targeted, become a burden in public budgets, may enhance rent-seeking behaviour or commercial malpractice and reduce the competitiveness of renewable energy sources (Scott, 1996; Tirado Herrero and Ürge-Vorsatz, 2010; World Bank, 2010). And in the case of the Hungarian natural gas price support scheme (*gázártámogatás*), it encouraged overconsumption as it was paid in proportion to the amount of gas consumed (Szivós et al., 2011).

On a different course of action, a number of programmes supporting residential energy efficiency investments – Panel programme, National Energy Saving programme and Eco Programme – have been running at the national level between 2001 and 2008 along with other initiatives started at the local level by local authorities. National programmes were substituted in 2009 by 5 sub-programmes promoting energy efficiency financed by the 128.4 million Euros of revenues of the sale of surplus Assigned Amount Units (AAUs) under the Green Investment Scheme (GIS). These are supposed to benefit not only panel condominiums (as the previous schemes did) but also single family homes and new buildings (Czakó, 2011).

Though providing a more permanent solution to the fuel poverty and climate change challenges, these residential energy efficiency programmes can be criticized from the perspective of my analysis along three lines.

First, though the resources allocated are not negligible, residential energy efficiency has received much less State support than energy price subsidies. As reported by Czakó (2011), some 1.3 billion Euros were spent on domestic natural gas and DH price subsidies between 2003 and 2006 (equivalent to 145 million Euros per year), whereas only 160 million Euros was allocated to the Panel programme in the period 2001-2008 (equivalent to 18 million Euros per year), with even less funds devoted to building types other than prefabricated *panel* blocks.

Second, even though the Hungarian Authorities claim that the old (2001-2008) programmes have produced on average 40% of energy savings per building, it is suspected that the actual rate of reduction in energy use is lower. According to data from the municipality of Tatabánya, retrofits in prefabricated blocks supported by the Panel programme resulted inenergy savings in the range of 46% to -3% (Czakó, 2010; Bencsik, 2009; Pájer, 2009)[64.]. These percentages leave a large energy and carbon saving potential unrealised or locked-in (see Section 7.9.1.2) and may not produce enough energy savings to lift out of fuel poverty worseoff households. Besides, the selection of buildings benefitting from this support schemes are not based on fuel poverty criteria.

Finally, these programmes have focused almost exclusively on Panel blocks, a building typology which is affected by fuel poverty more than the average, as see in Section 6.3.1.

The last policy element acknowledged as relevant is the debt management service (*adósságkezelési szolgáltatás*), which is by law provided by the local authorities of large settlements (over 40,000 inhabitants), with similar initiatives carried out by local level authorities, foundations and even utility companies. This service is particularly important to avoid disconnection from basic services (including domestic energy) and also to prevent poor households taking risky usury loans for paying their outstanding debts with utility companies (Bass et al. 2008; Ministry of Foreign Affairs, 2012). However, State debt management programmes have been criticised because they are available only in larger cities, do not support early or preventive action (the household must have been disconnected or have a minimum of 6 months' arrears) and provide assistance to a relatively narrow range of indebted households, i.e., with regular income but below a locally defined income threshold, for certain types of debt, etc. (Szivós et al., 2011). As suggested by the director of a Family

[64] Data reported by Czakó (2010) suggest that the energy savings achieved depend on the characteristics of the intervention and on the building elements replaced or improved. For instance, small energy savings (-15 to +3%) are achieved when only façade heat insulation is installed or windows are replaced. On the contrary, a more comprehensive retrofit involving facade heat insulation, changing stairway and apartment windows and the modernization of the heating system results in large energy savings (-30 to over -40%).

Help Service (*Családsegítő Szolgálat*) in a suburban area in Budapest interviewed in June 2009, urban citizens (and especially in Budapest) have better information, more chances to apply for a wider range of benefits and are more likely to receive a bigger amount of such benefits.

7.2.2.2. The quest for an improved residential energy efficiency policy in Hungary

A main conclusion of this brief assessment is that even though the Hungarian policy framework is containing or alleviating to some extent the incidence of fuel poverty, a proper fuel poverty strategy and reorganisation of policy elements is required. More concretely, residential energy efficiency policies should become a central piece of the efforts to combat fuel poverty. As discussed in the following chapter 8, turning policies into that direction would not only be positive in terms of fuel poverty alleviation but also allow progress in other policy areas such as climate change, urban air pollution, public health, energy security and employment.

Along this line, it is suspected that Hungary's current residential energy efficiency programmes are not ambitious enough and that they should be upgraded both in its size and scope (more units retrofitted per year and more building typologies covered) and in the energy efficiency levels (or energy savings) achieved.However, to be justified, this suggested improvement in the country's residential energy efficiency policy needs to be assessed from the perspective of its costs and benefits. Thus a cost-benefit analysis (CBA) – a recommended investment appraisal tool for projects with effects on the environmental and human health (Pearce et al., 2006) – was conducted. The assumptions, results and implications of the CBA are presented in this and the following chapter of the dissertation.

Table 1. Summary and assessment of the Hungarian policy elements with an impact on the incidence of fuel poverty

Type	Policy element	Description	Suitability as a long-term solution to FP	Remarks	References
Energy price support	Gas-price support [*gázártámogatás*]	Reduction in the amount to be paid in gas and DH bills. Originally, eligibility and amount granteddepended on gas consumption, household size and monthly income. Merged with household maintenance support since 2011.	Low	- Poor targeting and limited covering until 2011, as they benefitted primarily gas users (not always in fuelpoverty) and did not support households in rural areas not using gas or DH as a source of heat. - They may become a burden in public budgets, enhance rent-seeking behaviour or commercial malpractice, reduce the competitiveness of renewable energy sources, remove incentives to residential energy efficiency and encourage overconsumption	Scott, 1996; Tirado Herrero and Ürge-Vorsatz, 2010; World Bank, 2010; Szivós et al., 2011
	DH-price support [*távhőtámogatás*]				
	Residential DH VAT reduction	In agreement with the European Commission, the VAT applied to DH users was subsequently decreased 18% and then to 5%.	Low		BBJ, 2009; NOL, 2010; Varró, 2010
Direct income transfer	Household maintenance support [*lakásfenntartási támogatás*]	Financial support for households in difficulties to afford basic (i.e., household maintenance) expenses. Merged with energy price support schemes since 2011	Low	- It helped reduce utility and service expenses not covered by gas- or DH-price support (e.g., wood, water, garbage collection, etc.), until 2011. - - Unequal distribution depending on the resources available to the local government.	Hirado, 2012;
Residential energy efficiency	Eco, Panel, National Energy Saving and GIS-funded programmes	Various schemes provide financial support for the energy-efficiency renovation of residential buildings, mostly *panel*blocks.	Medium	- The technology employed in these programmes apply suboptimal technology (i.e., reduction of less than 50% of the energy heating consumption). This locks-in the mitigation and fuel poverty alleviation potential of the residential sector. - The selection of building to be renovated is not based on fuel poverty criteria. - SmallState budget allocation in comparison with the gas- and DH-price support schemes. - More ambitious programme started in 2011	Czako, 2010; 2011; Fülop, 2009
Other	Debt management service [*adósságkezelési szolgáltatás*]	Financial support and advice for households with arrears and over-indebtedness on utility and other domestic fixed costs (e.g., rent, garbage collection, etc.) or loan re-payment. Provided by local authorities.	Low (though important to avoid disconnections)	- Particularly important for worse-off households risking disconnection. It does not benefit households without outstanding debts but struggling to pay for domestic energy services. - Only present in cities with more than 40,000 inhabitants. - Does not support preventive action - Relatively narrow range of beneficiary household	Bass et al., 2008; Szivós et al., 2011;Ministry of Foreign Affairs, 2012; NEM, 2012.

Source: own elaboration based on the references indicated.

7.3. A COST-BENEFIT ANALYSIS OF A RESIDENTIAL ENERGY EFFICIENCY PROGRAMME FOR HUNGARY

7.3.1. The precedent: a building stock and Input-Output model of Hungary's buildings (Ürge-Vorsatz et al., 2010)

The financial and social cost-benefit analysis presented in this and the next chapter builds upon the building stock and Input-Output model employed by Ürge-Vorsatz et al. (2010) – later published as Tirado Herrero et al. (2011) – for the estimation of the employment effects of a large scale retrofit programme of the Hungarian residential and public building stock. The research concluded that if Hungary's buildings are deep-retrofitted (upgraded to nearly passive-house levels):

- as many as 180,000 net jobscan be created in the peak year of the most ambitious scenario;
- by 2030, up to 59% of the January net gas imports will be avoided; and
- 85% of the 2010 building energy consumption for space heating (and the corresponding carbon emissions) can be avoided.

Deep retrofits were compared with so-called *suboptimal* or non-state-of-the-art retrofits which, if implemented, would not create as many net jobs nor reduce as much energy imports, and would lock-inaround 45% of the energy saving and climate change mitigation potential of the Hungarian building stock.

The study, commissioned and funded by the European Climate Foundation (ECF), was completed under the direction of CEU Prof. Diana Ürge-Vorsatz between February and June 2010 by a team of several researchers (including the author of this PhD dissertation) of the Center for Climate Change and Sustainable Energy Policy (3CSEP) at Central European

University (CEU). It was based on data on Hungary's residential and public building stock collected by Dr. Aleksandra Novikova (2008) and Dr. Katarina Korytarova (2011) for their PhD dissertations, which were also supervised by Prof. Diana Ürge-Vorsatz.

Because of its different purpose and the short time (5 months) available for completion of the research, the original building stock and Input-Output model of Ürge-Vorsatz et al. (2010) was expanded and modified to adapt it to the requirements of the pursued cost-benefit analysis. In particular, the following changes were introduced:

- The Input-Output module that the original model contained was removed because the purpose of the CBA is not estimating the employment effects of energy efficiency investments.
- Public buildings were not considered in the CBA because they have no fuel poverty relevance. However, it must be noted that in the original model they constitute just 8.4% of the total stock (residential and public).
- The *business-as-usual* scenario has been redefined in order to incorporate the previously unaccounted for 25,000 pre-fabricated apartments retrofitted per year by existing policies.
- More consistent values were sought for the parameter 'percentage of floor area heated' before and after retrofits. New values were also applied to the parameter 'energy mix' (i.e., mix of energy carriers used for domestic space heating before and after retrofit).
- A more comprehensive assessment of energy prices and their forecasted increase was conducted, with the result of slightly different values being applied in the CBA.
- Transaction (i.e., programme management) costs and 2nd round retrofit costs (introduced for consistency given the long implementation timeframe of intervention scenarios) were introduced.

- The learning curve-based decrease of deep retrofit costs adopted from the original model was assessed and checked with learning curves obtained from the literature.
- In the financial CBA, the flow of costs and benefits was assessed in a NPV framework with a Hungary-specific financial discount rate based on Hungary's long-term interest rate and expected inflation rate.
- For the social CBA, market cost and benefits were corrected following the social CBA methodology and five non-market benefit categories – three of them specifically related to fuel poverty alleviation – have been incorporated: i) avoided carbon emissions; avoided non-GHG emissions; iii) avoided fuel-poverty related excess winter mortality; iv) increased floor area heated; and v) substitution of traditional firewood. NPVs were later calculated with a social discount rate.

Even though thismodel and the original model by Ürge-Vorsatz et al. (2010) share many of its basic features (such as the data on the residential stock, scenarios and other starting assumptions), the implementation of the changes enumerated above results in a largely different model developed for the specific purposes of the cost-benefit analysis.

7.3.2. Financial vs. social cost-benefit analysis

Conducting a financial and a social CBA allows comparing the private and social profitability of the investments required for a full upgrade of the energy performance of Hungarian dwellings.

This chapter contains the financial version of the CBA only accounting for private cash flows (investment and project management vs. energy saving benefits). In the following chapter, a full social CBA accounting for net changes in the aggregated welfare of Hungary's society is presented – see differences between financial and social CBA in Section 3.2.3and 8.1.

7.3.3. Policy options: *business-as-usual* vs. intervention scenarios

The three scenarios used for the cost-benefit analysis are based on the alternatives (S-BASE, S-SUB and S-DEEP) of the original model by Ürge-Vorsatz et al. (2010). They are described as follows, emphasising key differences with the original scenarios:

- a *business-as-usual* or BASE scenario that describes the current situation in which buildings are renovated at a rate of 70,320 dwellings per year (or 1.6% of the stock per year) and 10% of energy savings is achieved (with the exception of panel buildings). It is designed after the S-BASE scenario of Ürge-Vorsatz et al. (2010), though it did not consider the currently on-going retrofits of prefabricated buildings, the main focus of energy efficiency investments so far in Hungary through the Panel and similar programmes[65]. For this reason, the model assumes a retrofit rate of 25,000 *panel* dwellings[66] (3.4% of the total *panel* floor area per year[67]) , and 25% energy savings[68] based on data collected from Hungarian municipalities and the Ministry of Local Government by Veronika Czakó (2010). Other building typologies have also received some kind of support from public schemes such as the National Energy Saving

[65] For this reason, the original S-BASE scenario in Ürge-Vorsatz et al. (2010) had an implementation rate of 54,979 dwellings per year (incl. 9,659 panel dwellings). Our model considers that the actual rate of retrofit for panel buildings is 25,000 units per year instead; this brings the implementation rate of our BASE scenario to 70,320 dwellings per year (all building typologies).
[66] Included in the 70,320 annual units per year
[67] According to 2008 data from the Ministry of Local Government, 210,000 *panel* apartments were retrofitted between 2001 and 2008, which equals to roughly 25,000 units per year Czako, pers. comm.). An alternative source (Council of the European Union, 2010) reports 190,000 *panel* apartments retrofitted between 2001 and 2006, which gives a higher figure of over 30,000 per year. The former (25,000 dwellings per year) has been selected because it corresponds to a longer timeframe.
[68] Data collected from the municipality of Tatabánya by Czakó (2011) indicates that retrofits supported by the Panel programme deliver energy savings in the range of -3% to +46% (see Section 7.2.2.1). Based on those numbers, the figure of 25% was picked as a representative energy savings figure for *panel* buildings in the BASE scenario.

Programme or the Eco programme (Czakó, 2011). However, because of the lack of data on the number of benefitted dwellings (which is suspected to be much lower than *panel* buildings in any case) it has been assumed that retrofits in non-*panel* buildings have no specific energy efficiency purposes and thus deliver just the aforementioned 10% of energy savings;

- a MID scenario that proposes a first-level 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. It is based on S-SUB scenario[69]defined for the original building stock of model from Ürge-Vorsatz et al. (2010);
- a DEEP scenario proposing a high-level upgrade in current energy efficiency policies. Like MID scenario, it assumes a feasible implementation rate of 100,000 dwellings per year (or 2.3% of the 2010 stock) and advanced retrofits that deliver energy savings in the range of 79% to 90% of previous energy consumption (depending on building typologies). It is based on S-DEEP3 scenario[70]of the original building stock of model from Ürge-Vorsatz et al. (2010).

The implementation rate of BASE scenario (1.6% of the stock per year), and MID and DEEPscenarios (2.3% of the stock per year)are in line with the ones reported for European countries by BPIE (2011). According to this study, *business-as-usual* rates are in the range of 0.5-2.5% of the building stock per year, with 1% as a central figure for Europe and rhe

[69] S-SUB is a scenario with "suboptimal" retrofits (40% energy savings) and a medium implementation rate of 150,000 dwelling-equivalents per year, including public buildings (Ürge-Vorsatz et al., 2010). It was converted into our MID scenario by reducing the implementation rate to 100,000 dwellings per year.

[70] S-DEEP3 is a scenario with deep retrofits (79% to 90% energy savings) and a slow implementation rate of 100,000 dwelling-equivalents per year, including public buildings (Ürge-Vorsatz et al., 2010). It was converted into our DEEP scenario by making all the 100,000 units per year to be residential dwellings.

suggested implementation rate for BPIE's intervention scenarios (equivalent to MID and DEEP in the model) is 2.6%.

A relevant modelling decision is that the DEEP scenario revisits the 250,000[71] prefabricated dwellings that are estimated to have been retrofitted to low energy efficiency levels[72] in the decade of the 2000s. The rationale is that the DEEP scenario represents a major transformation of Hungary's residential energy efficiency policy and therefore aims at having the whole building stock achieving, including those 250,000 units poorly retrofitted. By contrast, MID scenario simply upgrades the BASE scenario but leaves aside the already retrofitted buildings by the *Panel* programme until 2010 (and of course BASE scenario does not revisit any building either). As a result, the DEEP scenario acts over a slightly larger stock – see Table 21. This assumption distorts to a small extent the comparison of results of scenarios (e.g., it slightly increases the total cost of DEEP scenario relative to MID) but makes DEEP and MID scenarios more plausible. .

This assumption also introduces slight differences in the end-year of the MID and DEEP scenarios (see Table 21), which signals the end of the period required for a full 1st round retrofit of all buildings. The BASE scenario has a longer implementation period because of its slower implementation rate.

Additionally, a 5-year ramp-up period is applied for the renovation industry to learn technologies and acquire the resources following Ürge-Vorsatz et al. (2010). In this period, the floor area renovated increases linearly until reaching each scenario's target retrofit rate

[71] This figure results from assuming that 25,000 panel dwellings were retrofitted to BASE energy efficiency levels (see previous footnote) for 10 years in the decade of the 2000s.
[72] These shallow retrofits allow achieving a specific energy consumption of 172 kWh m^{-2} $year^{-1}$ (with 100% of the floor area heated), equivalent to a 25% reduction as compared to the original BASE energy consumption figure of 230kWh m^{-2} $year^{-1}$.

(only for the DEEP and MID scenarios) shown as "implementation rate (breadth)" in Table 28.

Table 21. Scenarios defined the cost-benefit analysis

	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 (breadth)[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 (depth) [% reduction over previous energy use]	25% *panel* 10% rest	40% (for all building types)	79 - 90% (depending on building type)

Source: own elaboration after Ürge-Vorsatz et al. (2010)

7.3.4. Specific challenges of the proposed cost-benefit analysis

A specific challenge that the proposed financial and social CBA has to deal with is the long timeframe required for a proper assessment of cost and benefits. There are two reasons for this:

- One is the large number of years required for a complete turnover of the residential stock. The implementation rate of the energy efficiency scenarios MID and DEEP achieves a complete retrofit of the residential stock by 2051/2054. In the *business-as-usual* (BASE) scenario, the 1.6% rate turns the whole stock over in 76 years (by 2086).
- The second is that shorter timeframes are detrimental to the benefits of the intervention, which occur mostly in the long run, whereas retrofit and transaction costs concentrate in the early years of the intervention.

The solution adopted consists of presenting final results (Net Present Values or NPV) in 10-year periods during a 70-year span that goes from 2010 to 2080 (see Section 7.9.2). This 70-year period is roughly equivalent to a full retrofit cycle in which all buildings are renovated according to the *business-as-usual* rate (1.5% of the stock per year). It is also more or less equivalent to the number of years required by the energy efficiency scenarios (MID and DEEP) for a full 1st and 2nd round of retrofits.

An obvious drawback of this approach is the uncertainty surrounding the value of the parameters in the very long-term (after 2050), i.e., the longer the timeframe considered, the less reliable NPV results are. In order to minimise possible distortions, key parameters like energy prices and retrofit costs reach theirasymptotic value around 2050 and are stable thereafter. On the other hand, the effect of the discount rate makes long-term costs and benefits weigh little on final results, i.e., because of the discount rate, the costs and benefits occurred in the first years are a larger fraction of the total net present value.

The length of the timeframe for analysis also requires an assumption that ensures that the thermal performance of the retrofitted units is maintained. This is referred to as *2nd round*'retrofits and consists of an update of the 1st round retrofit that guarantees the original thermal performance (and corresponding energy savings level) – see Section 7.5.3. This assumption is consistent with a policy approach that forges a long-term commitment with the low levels of energy consumption achieved with the first retrofit.

Technological change is yet another aspect to be looked at from the perspective of the long timeframe of analysis. To some extent it is incorporated in the learning curve assumption according to which per unit costs of DEEP retrofits decrease at a certain rate in a 40-year period (see Section 7.5.2.3). But it seems reasonable to think that more advanced technologies will improve the existing state-of-art deep retrofits based on the passive house design. In this regard, three elements can be discussed:

- DEEP retrofits assume that the specific energy use of currently existing buildings can be brought to very low energy consumption levels (25 to 35 kWh m^{-2} $year^{-1}$). This is above the passive house standard (15 kWh m^{-2} $year^{-1}$) that corresponds to a building that almost uses no energy for space heating. Of course, there is space for further improvement as zero or positive energy buildings (which necessarily require on-site renewable production) already exist. However, it is debatable whether at these very low levels of energy use it would be more cost-efficient producing renewable energy off-site in large solar or wind installations situated in optimal locations, in order to take advantage of economies of scale of renewable generation.
- Let us assume that improved technologies (e.g., retrofits that reduce energy use to even below the passive house standard for space heating and cooling) will be available for large scale implementation in the longer-term (20 to 30 years' time). These would be more costly than the DEEP retrofits defined in the model (though a learning curve can be expected for those too) but would also save more energy, which would have an uncertain effect on final results.
- In any case, for those advanced technologies to be available, a large scale implementation of DEEP-like retrofits would probably be required; it can be thought that new technologies would be a continuation of the learning curve of DEEP retrofits.

However, no feasible forecast of improved technologies could be produced for the analysisgiven the uncertainty surrounding this foreseeable improvement in technologies and that the assumed energy consumption levels after DEEP retrofits (25 to 35 kWh m^{-2} $year^{-1}$) is already close to the nearly-zero energy buildings standard. It was thus decided to assume no technology improvement in the model beyond the learning curve-based reduction of DEEP retrofit costs.

7.3.5. The issue of additional costs and benefits

The analysis compares a *business-as-usual* scenario (BASE) in which mostly non-energy efficient retrofits are applied with two intervention scenarios (MID and DEEP) which are more ambitious both in their implementation rate and energy savings achieved. An underlying assumption is that MID and DEEP retrofits fully substitute BASE retrofits, i.e., no more BASE retrofits are realised once the implementation of either MID or DEEP scenario is decided.

For the cost-benefit analysis, the MID and DEEP scenarios are compared against BASE. This means that that the costs and benefits of each of the three scenarios are not assessed separately; instead, the additional costs and benefits of moving from BASE to either MID or DEEP scenarios are counted. However, for simplicitythey are referred to as MID or DEEP scenarios (instead of the more burdensome BASE to MID and BASE to DEEP) when reporting results.

In the CBA, this is implemented by calculating the NPV of an annual flow of additional costs and benefits that results from subtracting BASE annual costs and benefits to either MID's or DEEP's. This procedure is followed both in the financial and social CBA.

7.4. THE HUNGARIAN RESIDENTIAL STOCK

7.4.1. Building typologies

As in the original model (Ürge-Vorsatz et al. 2010), six building typologies – from historical and protected buildings to single and multi-family homes built in different periods – make up the stock subject to retrofit (see Table 22). Each is characterised by an average dwelling size (m^2), obsolescence rate (m^2 per year), specific energy use for space heating before and after retrofit (kWh m^{-2} $year^{-1}$), energy mix before and after retrofit (natural gas, district heating, other fuels/firewood and electricity) and percentage of floor area heated before and after retrofit – see summary in Table 27.

Table 22.Residential building typologies and their labels

Description	Label
Historical and protected buildings	Hist
Traditional multi-family homes (<1960)	TradMFH
Multi-family homes industrial technology (*panel* buildings) to 1992	Panel
Single family homes to 1992	SFH1992
Single family homes 1993 -2010	SFH2010
Multi-family homes 1993-2010	MFH2010

Source: Ürge-Vorsatz et al. (2010)

7.4.2. Floor area and specific energy use for space heating

Data on the floor area (m^2)andspecific energy use for space heating (kWh m^{-2} $year^{-1}$) before and after retrofit are the same as in the original model. They come from previous research (Novikova, 2008; Korytarova, 2011) and also from the input of selected Hungary experts collected during a workshop held atCentralEuropeanUniversity on April 27th, 2010 organised by 3CSEP in the framework of the original employment project.

The model assumes that 3% of the Hungarian residential stock is not heated (i.e., summer houses, empty dwellings, etc.), and therefore not subject to energy efficient retrofitting.

Originally not present in the input data from Novikova (2008), the historical buildings (Hist) category was created by assuming that 8% of traditional multi-family and 3% of traditional single-family homes belong to this class.

Obsolescence rates for residential categories come from Novikova (2008).. They are fixed (i.e., the same number of buildings per year) and are the same for allthree scenarios – see Table 27. However, the removal of buildings from the stock stops once the entire building category has turned over to higher energy efficiency levels (by 2051/2054 in MID and DEEP scenarios). Historical buildings are the only category not subject to cessation.

Data on specific energy use for domestic space heating before retrofit (BASE scenario) ranges between 121 kWh m^{-2} $year^{-1}$ (MFH2010 category) and 300 kWh m^{-2} $year^{-1}$ (SFH 1992) – see Table 27. These figures are assumed to be the average per unit heat demand required for keeping an adequate indoor thermal comfort during the cold season in Hungary. However, large differences may exist between individual households living in the same building typology because of their different energy and dwelling use patterns (e.g., pensioners vs. young professionals without children).

In addition, a recent study based on data from 3,400 German households has found that measured energy consumption is often below (on average 30%) the predicted consumption by energy performance ratings, especially in the most inefficient dwellings. Similar results were also found in the UK, Belgium, Netherlands and France. This phenomenon is referred to as *prebound effect* and combined with the better known rebound effect is believed to overestimate energy savings and underestimate payback times, thus discouraging residential energy efficiency investments (Sunikka-Bland and Galvin, 2012).

In the context of this dissertation (as well as in other contexts), this discrepancy between actual and measured energy consumption can be explained by two strategies applied by households to control their domestic energy costs (see Section6.4.2): reducing the actual floor area heated and heating the dwelling to below comfortable levels. In the model this is captured to some extent by the parameter *percentage of floor area heated* (see Section 7.4.3), which effectively reduces the specific heat consumption of Hungarian dwellings by 5 to 11% in the BASE scenario, except for *panel* buildings – see Table 27. However, complete lack of data about actual indoor temperatures in Hungarian dwellings makes unfeasible any estimate of the *prebound* effect related to this other energy costs saving strategy.

Energy consumption figures for MID and DEEP scenarios (after retrofit) have been obtained by applying the energy saving factors reported in Table 21 to BASE scenario figures (see Table 27). They range between 25 and 35 kWh m^{-2} $year^{-1}$, depending on building typology. This is roughly twice as much as the passive house standard (15 kWh m^{-2} $year^{-1}$for space heating and cooling) because it is assumed that reaching such low energy consumption level is more difficult in a retrofit than in a new construction (Ürge-Vorsatz et al., 2010).

All specific energy consumption figures for space heating (before and after retrofit) are assumed to be based on the net calorific value (NCV) of fuels i.e., they refer to the kWh actually delivered to the living space, not to the gross energy content of the fuel – see Section 7.6.1.1.

In terms of total floor area and specific energy use, the three most important categories are the traditional multi-family homes built in the late 19th century and half of 20th (TradMFH), multi-family buildings built with industrial technology or *panel* structures (Panel), and traditional single-family homes (SFH1992). As presented in Table 27, those largest three categories also have the highest heating energy consumption. Particularly important is the SFH1992 category, which takes up more than 50% of the Hungary's residential floor area and is assumed to have the highest specific energy consumption (300 kWh m^{-2} $year^{-1}$).

7.4.3. Percentage of floor area heated

In Hungary, data collected by the 2009 Household Energy Use Survey conducted by the KSH indicate that between 85% and 100% of the interior space of Hungarian dwellings is heated during the cold season. These were used to define the percentage of floor area heated in the BASE scenario and before retrofit73, with the assumption that it does not change after the retrofit because of the low energy savings achieved in this scenario (10%). In the case of DEEP scenario, retrofits allow households to increase the fraction of floor area heated up to the 95% level. In the MID scenario, the assumption is that gains in the additional floor area heated are roughly of the gains achieved in DEEP scenario – see values and Table 27. The values for MID and DEEP scenarios (after retrofit) are author's assumptions.

A special case is the Panel buildings category. Because of the reasons described in Chapter 6 – and mostly due to the lack of individual DH consumption meters – the Household Energy Use survey reports that the whole floor area of these units is heated. In these blocks, MID and DEEP retrofits are supposed to install consumption control devices among other measures and therefore the resulting percentage of floor area heated after retrofit is set at the 95% level (both in MID and DEEP). It is assumed that there is no welfare loss related to this 5% drop but rather a welfare gain as households are able to control the temperature of their apartment after the retrofit.

[73] Only three building categories were used in the Household Energy Use Survey. These are (with their corresponding percentages of floor area heated): single-family houses (85%), panel buildings connected to DH (100%) and multi-family houses (89%). These figures were transferred accordingly to the 6 building categories used in the model.

For comparative purposes, Table 23 and Table 24show alternative values for this parameter in Hungary. They were obtained from the Negajoules project of the Hungarian NGO *Energia Klub* (2011) and from the original employment study Ürge-Vorsatz et al. (2010). In the first case (Table 23), percentages of floor area heated were obtained from a survey but aresuspected to be too high for Hungary (i.e., it is believed that Hungarian households leave unheated a fraction larger than the 2-14% suggested by these figures). In the latter case (Table 24), percentages are authors' assumptions by Ürge-Vorsatz et al. (2010) and therefore thought to be less reliable than survey-based figures.

Table 23.Alternative percentage of floor area heated before and after retrofit for BASE scenario

Building categories	% of floor area heated
Family houses (equiv. to SFH1992 and SFH2010)	86%
Non-panel condominiums (equiv. to TradMFH and MFH 2010)	94%
Panel condominiums (equiv. to Panel)	98%

Source: Energia Klub (2011)

Table 24.Alternative percentage of floor area heated before and after retrofit, for the three scenarios defined

Building categories	***S-BASE* and *S-SUB* (before and after retrofit)**	***S-DEEP* (after retrofit)**
Hist	70%	90%
TradMFH	70%	90%
Panel	95%	90%
SFH1992	70%	90%
SFH2010	75%	90%
MFH2010	85%	90%

Note: S-BASE, S-SUB and S-DEEP are the three basic scenarios used in the original model ; they correspond with the BASE, MID and DEEP scenarios of the cost-benefit analysis.
Source: Ürge-Vorsatz et al. (2010)

7.4.4. Energy mix for residential space heating

Unlike in Ürge-Vorsatz et al. (2010), it is assumed that the energy mix for space heating changes after a building is retrofitted to MID or DEEP. There is a main reason for that: the decrease in energy requirements for space heating, which allows the use of more expensive and convenient energy carrierslike piped natural gas or electricity.For the BASE scenario, however, the model assumes that the energy mix remains fixed throughout the modeling period.

The values selected for this parameter are presented in Table 27. For the BASE scenario, they arethe author's assumptions based on the values of the original model (Ürge-Vorsatz et al., 2010) and the *Negajoules* project (Energia Klub, 2011) shown in Table 25 and Table 26.

For the MID and DEEP scenarios, the main criteria for deciding on the energy mix after retrofit is the substitution of traditional firewood (in the category of 'other fuels') by natural gas and electricity, especially in the single family house categories (SFH1992 and SFH2010). Still, it was decided that in these two building classes 10% of dwellings remain using firewood but with advanced technologies (e.g., high efficiency pellet boilers) instead of in traditional stoves.

Table 25. Percentage of dwellings heated with different energy carriers (or a mix of energy carriers), source values for the BASE scenario.

% of homes heated with	Family houses	Non-panel condominiums	Panel condominiums
Gas	47%	84%	18%
Electricity	2%	2%	1%
DH	0%	4%	81%
Firewood	33%	3%	0%
Gas + firewood	15%	6%	0%

Source: Energia Klub (2011)

Table 26. Percentage of dwellings heated with different energy carriers (or a mix of energy carriers), source values for the BASE scenario.

% of homes heated with	Hist	TradMFH	Panel	SFH1992	SFH2010	MFH2010
Gas	87%	87%	23%	88%	67%	83%
Electricity	5%	5%	0%	0%	3%	0%
DH	3%	3%	77%	0%	0%	17%
Other fuels	5%	5%	0%	12%	31%	0%

Source: Ürge-Vorsatz et al. (2010)

Table 27.Characteristics of the residential building stock (for the three scenarios considered) in Hungary

Residential Building Stock	HistRes	TradMFH	Panel	SFH1992	SFH2010	MFH2010	TOTAL
Average size of dwelling	77	70	53	80	105	57	
Number of units and floor area – BASE and MID							
Number of dwellings (thousands)	131.1	715.8	516	2,227.1	337.0	183.0	4,110.0
Number of heated dwellings (thousands)	127.1	694.2	500,5	2,160.3	326.9	177.5	**3,986.7**
Heated floor area (millions of m^2)	9.6	48.6	26.5	172.8	34.3	10.1	**302.0**
Fraction of total heated floor area (%)	3.2%	16.1%	8.8%	57.2%	11.4%	3.4%	100%
Number of units and floor area – DEEP							
Number of dwellings (thousands)	131.1	715.8	766.0	2,227.1	337.0	183.0	4,360.0
Number of heated dwellings (thousands)	127.1	694.2	743.0	2,160.3	326.9	177.5	**4,229.0**
Heated floor area (millions of m^2)	9.6	48.6	39.4	172.8	34.3	10.1	**314.8**
Fraction of total heated floor area (%)	3.0%	15.4%	12.5%	54.9%	10.9%	3.2%	**100%**
Obsolescence of buildings							
Total number of dwellings ceased per year	0	1700	190	5,830	20	6	7,746
Floor area ceased per year (thousands m^2)	0	119	10	466	2	0.3	598
Specific energy consumption(kWh m^{-2} $year^{-1}$)							
Before and retrofit – BASE scenario	207	207	230	300	144	121	
After retrofit – MID scenario	124	124	138	180	86	73	
After retrofit – DEEP scenario	35	25	30	30	30	25	
Fraction of floor area heated (%)							
Before and retrofit – BASE scenario	89%	89%	100%	85%	85%	85%	
After retrofit – MID scenario	92%	92%	95%	90%	90%	90%	
After retrofit – DEEP scenario	95%	95%	95%	95%	95%	95%	
Energy carrier used (% of total floor heated)							
Before and retrofit – BASE scenario	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	
Gas	87%	87%	18%	54%	88%	87%	
Electricity	2%	2%	1%	2%	2%	2%	
DH	4%	4%	81%	0%	0%	4%	
Other fuels/firewood	7%	7%	0%	44%	10%	7%	
After retrofit – MID scenario	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	
Gas	90%	90%	18%	73%	88%	89%	
Electricity	2%	2%	1%	2%	2%	2%	
DH	4%	4%	81%	0%	0%	4%	
Other fuels/firewood	4%	4%	0%	25%	10%	5%	
After retrofit – DEEP scenario	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	
Gas	90%	90%	18%	75%	75%	90%	
Electricity	6%	6%	1%	15%	15%	6%	
DH	4%	4%	81%	0%	0%	4%	
Other fuels/firewood	0%	0%	0%	10%	10%	0%	

Source: Ürge-Vorstaz et al. (2010), Household Energy Survey, Energia Klub (2011) and authors' assumptions

Lastly, note that the model does not assume a large-scale change in the energy mix (for space heating) of the residential sector. On the contrary, it postulates that retrofitted units keep in most cases their original heating system and energy carrier. The purpose is to avoid further complexity by extending the analysis to the supply side; however, in parallel to building retrofits, a large scale electrification of the residential sector can be envisioned combined with the decarbonisation of the power sector, or a widespread adoption of biomass as a source of domestic heat.

7.5. FINANCIAL COSTS

7.5.1. Cost categories considered

Typically, only investment costs corresponding to the initial upgrade of the existing stock (referred to as 1st round retrofits here) are considered in the assessment of residential energy efficiency programmes (see for instance Clinch and Healy, 1999). However, one more cost category has been added into this exercise for enhancing the policy realism of the intervention scenarios (MID and DEEP)[74]. This is the so-called 2nd round retrofit costs, which are the costs required to update the 1st round retrofit and ensure that its thermal performance is kept throughout the modeling period. As argued in Section 7.3.4, this assumption is imposed by the length of the timeframe for analysis (70 years).

7.5.2. 1st round retrofit costs

7.5.2.1. Retrofit costs in 2010

The financial costs of BASE, MID and DEEP retrofits have been taken from the project on the employment impacts of a large and deep retrofit of Hungary's residential stock (Ürge-

[74] In the BASE scenario, only 1st round retrofit costs have been considered.

Vorsatz et al., 2010). For that, the per unit costs of retrofits of its S-BASE, S-SUB and S-DEEP scenarios (in €$_{2005}$ m^{-2}), which correspond to the BASE, MID and DEEP scenarios of this exercise, have been inflated to €$_{2010}$ m^{-2} through the construction cost base and construction producer price indices obtained from the Hungarian Central Statistical Office (KSH)[75].They are presented in Table 28.

Table 28.Retrofit costs (€$_{2010}$ m^{-2})for the three defined scenarios, by building categories

Building category	BASE	MID	DEEP
Hist	100.5	183.5	691.2
TradMFH	60.3	104.3	351.9
Panel	56.6	94.3	314.2
SFH1992	65.3	108.1	414.7
SFH2010	56.6	115.6	414.7
MFH2010	56.6	94.3	339.3

Source: Ürge-Vorsatz et al., 2010

In Ürge-Vorsatz et al. (2010), these costs of were collected from personal communication with experts and from around 60 case studies collected for the project. In order to deal with the diversity of cost figures located (especially for suboptimal and deep renovations) a *best practice* approach was applied, i.e., rather than average values, the study selected case studies showing that for a certain cost per square metre it is feasible to renovate a building to the required efficiency. The implicit policy message in that assumption is that any large scale retrofit programme has to ensure that per unit costs are kept as low as possible, e.g., avoiding price distortions by ensuring competition.

More specifically, the actual data sources for the retrofit costs collected in Ürge-Vorsatz et al. (2010) are the following.

[75] 2005 prices were multiplied by an estimated factor of 1.257 to inflate them to €$_{2010}$ m^{-2}. In2008, the construction cost base index was substituted by the construction producer price; for this reason both were used to calculate the inflation factor for retrofit costs.

Baseline (S-BASE) costs are estimates for a standard renovation not aimed at improving the building's efficiency. In the original model, they weremostly provided by national experts, in particular byTamás Csoknyai (pers. comm.)[76].They correspond with the financial retrofit costs of the BASE scenario in this exercise.

Suboptimal (S-SUB) retrofit costs – adopted for the MID scenario in the CBA model – mostly came from national case studies, easier to find in Hungary, especially for industrial technology (panel) buildings.Many examples were found in the framework of the Panel programme, a scheme that supports suboptimal energy efficient retrofit investments in panel buildings. Most of such data was provided by the Energy Centre (*Energia Központ*), a State entity managing subsidies and loans for energy efficiency and renewable energywhich plays the role of an energy agency in Hungary.In particular, for the Panel building category, the cost was obtained from a well-known energy-efficient renovation project recently completed in Óbuda (a municipality of Budapest) that targeted the largest panel building in Hungary. The project was partially funded by the STACCATO programme (EU Sixth Framework Programme) and was expected to deliver a 50% reduction in energy consumption for space heating at a cost of 92 Euros per square metre (Faluhaz, 2009). Similar costs and results, with similar (but often smaller) levels of energy savings, were observed in other panel projects in Hungary and abroad (e.g., Passive House Retrofit Kit). For other building categories, the transfer of costs to the Hungarian environment and the averaging of the results were computed in the same way as for the S-DEEP scenarios described below.

[76] Dr. Tamás Csoknyai is a lecturer of the Faculty of Engineering at the University of Debrecen and renowned expert on buildings energy efficiency in Hungary. He was one of the key experts who contributed for the employment project on which the model is based (Ürge-Vorsatz et al., 2010).

Deep renovation costs (S-DEEP) came mostly from outside Hungary and correspond with the DEEp scenario of the social CBA model. Though a 2008 estimate put at 15,000 the number of passive house-buildings in Europe (Rosenthal, 2008), the number of retrofit case studies with available information was much smaller, particularly in Hungary. In fact, very few examples for deep energy-efficient retrofits in Hungarywere located. The most significant is the SOLANOVA project, which in 2005 delivered an 85-90% reduction in the energy use for space heating in a conventional, low-quality prefabricated panel building in the city of Dunaújváros at a cost of 250 Euros per square metre (Hermelink, 2006). However, most other deep retrofit casesand cost figures are from outside Hungary; they all involved savings in space heating energy consumption of at least 80%, and they ranged from a net cost per square meter of 452 Euros for a multi-family home in Germany (Energieinstitut Voralberg, 2010) to nearly 2,000 Euros for a multi-family building in Austria (IG Passivhaus Oesterreich 2010). Since labour and material costs are lower in Hungary, the original model assumed a relatively reduced average cost for DEEP retrofits – see Table 29.

The decision was made for taking the renovation costs of the SOLANOVA as representative for *panel* buildings in Hungary, though it must be noted that SOLANOVA was a pilot project. This means that on one hand it received some discounts from material suppliers interested in marketing opportunities, which lowered implementation costs; on the other hand, costs might be even lower when such a retrofit is not realised as pilot cases but in an open market where thousands of such interventionsoccur (Csoknyai, pers. comm.).

For building categories other than panel, foreign retrofit costs[77] were transferred to the Hungarian environment through a proportional approach that took SOLANOVA as a base and compared costs with similar projects abroad. For example, the case studies examined showed that in Austria, deep renovations of single-family houses cost around one-third more than SOLANOVA-equivalent projects. Thus, cost estimates for single-family house deep renovations in Hungary were set to around one-third more than SOLANOVA.

This description illustrates the extent of the uncertainty surrounding the per-unit cost of retrofits, particularly of deep retrofits. This has to do with the fact that even though there is experience with passive house new construction, only a small number of retrofits have been done following the passive house standards.

Retrofit costs for the first year of the modelling period (2010) are compared to similar data from BPIE (2011) and Galvin (2011) to check for consistency with the literature (see Table 29). The former is a pan-European study that used the original model from Ürge-Vorsatz et al. (2010) as one of the data sources for calculating retrofit costs in different intervention depths; thus they have to be taken with some caution because of the risk of cross-referencing. The latter come from a large thermal renovation project in Ludwigshafen (Germany) undertaken between 2000 and 2003 on 850 apartments built in 1930, which were retrofitted to decrease their energy consumption levels to the 150-30 kWh m^{-2} $year^{-1}$range, as reported originally by Enseling and Hinz (2006).

[77]A number of passive house renovation case studies were found in the databases of the Austrian Passive House Institute (IG Passivhaus Oesterreich, 2010b), the German Passive House Institute Passivhausprojekte, 2010) and the Energieinstitut Vorarlberg's Passive House Retrofit Kit project (Passive House Retrofit Kit, 2010).

This comparison shows that retrofit costs used in this cost-benefit analysis are in line with the values used in or reported by other studies. For the first year of the modelling timeframe (2010), they result in total retrofit costs in the range of 25,000 Euros (Panel) to over 50,000 euros per dwelling (Hist) – see Table 34.

Table 29.Weighted averageretrofit costs (€$_{2010}$ m^{-2})for the three defined scenarios compared to equivalent scenario categories from other studies

<table>
<tr><th></th><th>BASE
-10 to -25%
(109 to 270 kWh m^{-2} yr^{-1})</i></th><th>MID
<i>-40%</i>
<i>(73 to 124 kWh m^{-2} yr^{-1})</i></th><th colspan="4">DEEP
<i>-79 to -90%</i>
<i>(25 to 30 kWh m^{-2} yr^{-1})</th></tr>
<tr><td>CBA model</td><td>63</td><td>109</td><td colspan="4">402</td></tr>
<tr><td rowspan="2">BPIE, 2011</td><td>Minor (-0 to -30%)</td><td>Moderate (-30 to 60%)</td><td colspan="2">Deep
(-60 to 90%)</td><td colspan="2">nZEB
(<-90%)</td></tr>
<tr><td>58</td><td>136</td><td colspan="2">321</td><td colspan="2">565</td></tr>
<tr><td rowspan="2">Galvin, 2011</td><td>275 kWh m^{-2} yr^{-1}</i></td><td><i>193 kWh m^{-2} yr^{-1}</i></td><td><i>70 kWh m^{-2} yr^{-1}</i></td><td colspan="2"><i>40 kWh m^{-2} yr^{-1}</i></td><td><i>30 kWh m^{-2} yr^{-1}</td></tr>
<tr><td>43</td><td>81</td><td>210</td><td colspan="2">279</td><td>414</td></tr>
</table>

Note: Original costs in €$_{2006}$ m^{-2} and €$_{2011}$ m^{-2} from Galvin (2011) and BPIE (2011) were converted to €$_{2006}$ m^{-2} through HICP index for Germany and the Euro area retrived from Eurostat
Source:Ürge-Vorsatz et al. (2010); BPIE (2011); Galvin (2011)

7.5.2.2. Non-energy efficiencycosts of the retrofit: elements not affecting the thermal performance of the dwelling

It has been pointed that energy efficiency retrofits also incorporate the substitution or addition of elements that do not have any relevance for the energy performance of the buildings. These have been referred to as *anyway*costs and are defined as costs incurred on elements not needed for improving the energy efficiency of the dwelling. They can be non-energy efficiency elements required by the retrofit(e.g., weatherproofing the wall exterior with render) or a request of the home owner(e.g., an additional window or balcony). According to cost data collected by Enseling and Hinz (2006) from the Ludwigshafen project mentioned in the previous section, these costs may represent 20 to 50% of total retrofit costs (Galvin, 2011).

It could be argued that only the fraction corresponding to energy efficiency elements should be considered as a cost in the CBA. However, it was decided to compute the whole cost of the retrofit (i.e., including non-energy efficiency costs) for two reasons:

- Part of these costs are anyway required for a successful completion of the retrofit, e.g., weatherproofing the wall exterior may not increase the U-value of the wall but is essential for the insulation layer to last for its lifetime. The cost of other elements such as the additional window or balcony could be deducted, but in principle it is assumed that they are not part of the retrofit cost figures reported in Table 28.
- Given their poor state of conservation (e.g., old rendering, failing roof, outdated heating systems, etc.), a fraction of the Hungarian stock would anyway require fixing or replacing building elements that have no or little influence on energy performance. So when a retrofit takes place, it would make sense to refurbish all parts in bad conditions and not only those strictly related to its energy performance. In fact, it could be even suggested that the intervention scenarios (DEEP and MID) are, from a public intervention perspective, a dwelling quality upgrade programme through which the government is making householders renovate their dwellings not only for energy efficiency purposes but for building maintenance purposes too. Under this perspective, the retrofit programme cannot happen without all the non-energy efficiencycosts.

At the same time it should be acknowledged that that non-energy efficiency costs generate certain benefits, i.e., additional comfort derived from living in a renovated dwelling. This positive side effect of the retrofit will be particularly strong in the case of worse-off households living in poor quality homes (and more likely to be in fuel poverty). Although identified, this co-benefit is not computed as such in the CBA because the lack of a valuation methodology.

7.5.2.3. *A learning-curve based reduction in the cost of DEEP and MID retrofits*

Economies of scale and learning factors are expected to play a key role in bringing down the private costs of DEEPand MID retrofits. In the case of the construction sector, it has been suggested that three conditions are required for a learning factor-based reduction in costs to occur (Thomas, 2009): i) a sufficiently complex task that facilitates learning; ii) repetition in the units being constructed; iii) a stable work environment. The three conditions seem to be met by the assumptions of the intervention scenarios. First, DEEP and MID retrofits – unlike *business-as-usual* – entail a more complex intervention i.e., careful analysis of a building's structure and functionality, advanced design oriented to deliver the required energy savings, installation of heat recovery units, etc. Second, the size of the intervention (100,000 dwellings per year) ensures the large-scale repetition of tasks and operations. Third, the length of the programme (several decades) guarantees a long enough time framework for firms to establish and develop a secure position in the building renovation sector (though the stability of the work environment depends on the organizational success of individual firms).

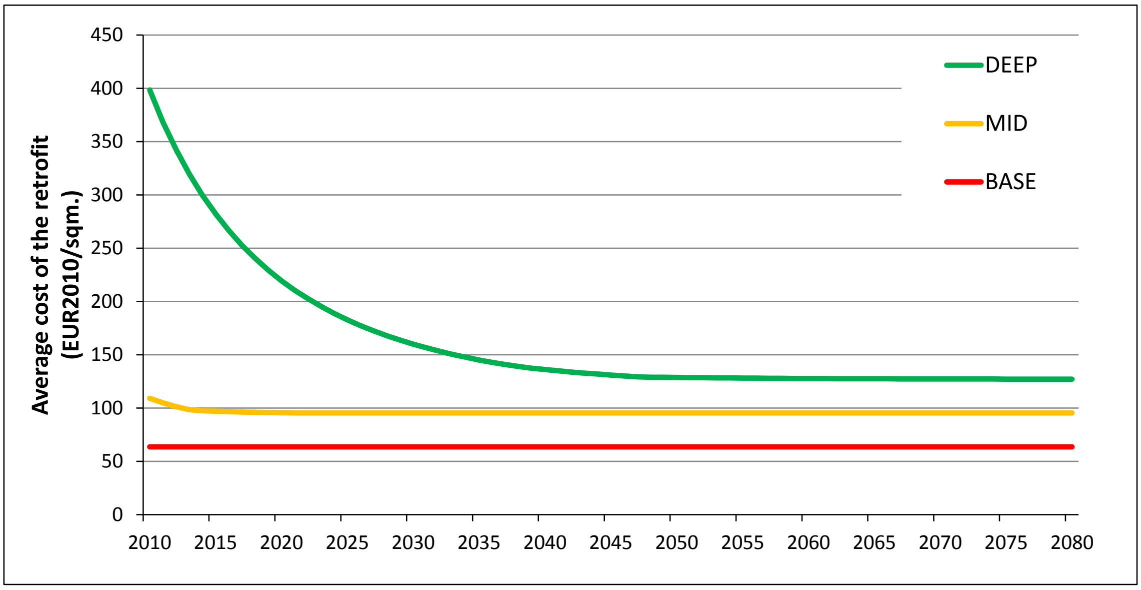
Thus the model assumes a progressive reduction in their per unit (m^2) costs of DEEP and MID retrofits along the implementation period. In particular, the same approach used in the original model of Ürge-Vorsatz et al. (2010) is applied. It is based on the number of years since the start of the programme, an assumed cost reduction rate (which decreases with the years) and the cost of BASE retrofits. In the case of DEEP retrofit, its costs will gradually decrease towards an asymptoteequal to double the price (per square metre) of a BASE (non-energy efficiency oriented)retrofit, following the equation

$$\begin{aligned} C_{2011} &= C \\ C_{y+1} &= \max(C_y \times (1 - l_1 \times (1 - l_2)^{y-2012}), 2 \times C_b) \end{aligned} \quad \textit{Equation 1}$$

whereC_y are the DEEP retrofit cost per square metre in year *y*, C_b the renovation cost per square metre for base renovations, l_1 (8%) is the learning factor and l_2 (6%) is the mitigation factor of the learning factorl_1. Though originally not considered in the original model (Ürge-Vorsatz et al., 2010), MID retrofits are also applied a learning curve-based decrease at a rate (l_1) of 6% in the first year, which is mitigated by 4% (l_2) until reaching the level of 150% the cost of BASE retrofits (1.5 x C_b). Finally, BASE retrofits remain fixed throughout the modelling period because the technology is already mature and cannot benefit fromsignificant reductions due to learning factors.

Consequently, the costsof intervention scenarios do not decrease linearly, but faster in the early years and slower in later years before reaching the equilibrium cost by 2050 (DEEP retrofit) and 2020 (MID retrofit), as Figure 55 shows.

Figure 55. Average financial retrofit costs for the three defined scenarios.

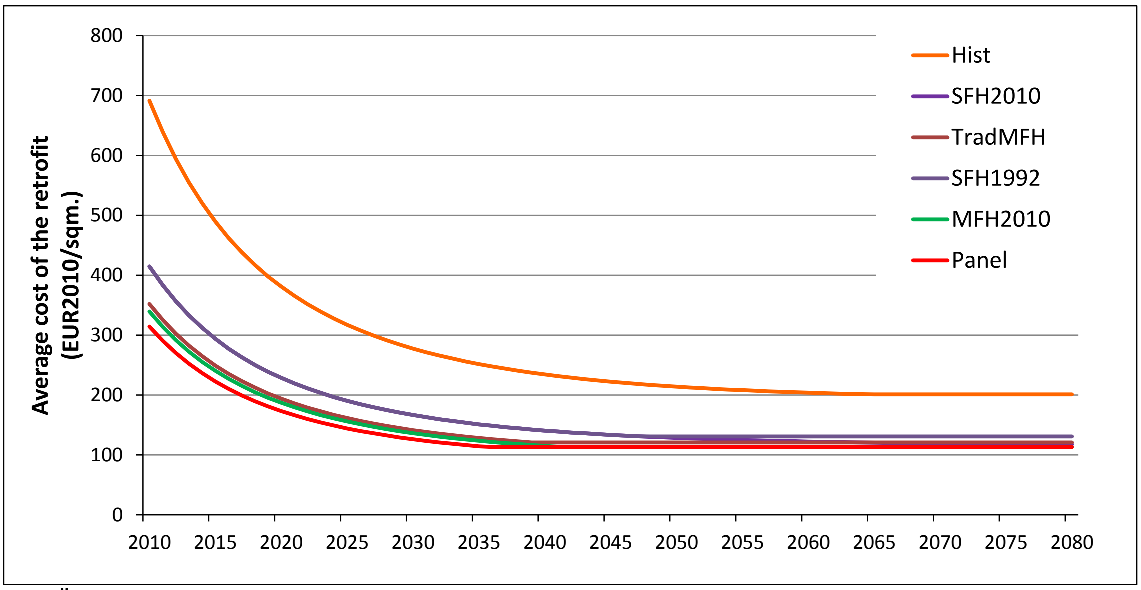


Note: weighted average estimated using as a weighting the share of total floor area of each of the 6 building typologies in the starting residential (2010). This is a simplification because the proportion changes slightly through the modelling timeframe because of the different implementation and cessation rates of each building typology.
Source: Ürge-Vorsatz et al. (2010) and author's assumptions

Equation 1 applies the same learning rates to all building typologies considered in the residential stock model – see DEEP costs disaggregated by building typology in Figure 56. This is a simplification because the cost of larger categories (e.g., SFH1992, containing

57.2% of the total floor area in 2010) is expected to decrease faster because of thelarger number of anticipated retrofits per year.

Figure 56.Learning-curve based reduction in DEEP retrofit costs for all building typologies



Source: Ürge-Vorsatz et al. (2010)

This reduction in DEEP retrofit costs is in line with the learning or experience curve postulate, which predicts a decrease in per-unit production costs every time the cumulative production output increases by a certain amount. First introduced in the industrial (aircraft manufacturing) sector by Wright (1936), it can be formalized as (Gumerman and Marnay, 2004)

$$C_n = C_{1.}n^a \quad \textit{Equation 2}$$

whereC_n is the cost of the *n* unit, C_1 is the cost of the first unit, *n* is the cumulative production output and *a* is a negative number indicating the elasticity of per-unit costs with regard to cumulative output.

Another conventional way of reporting learning curve-based reduction in costs is through the learning rate (*LR*), which is the percentage of reduction in per-unit costs achieved with each doubling of the cumulative production, e.g., a 0.2 learning rate means that every time cumulative production doubles, the per-unit cost is 80% of the original cost C_1. Based on the Wright equation, the relationship between learning rate *LR* and the progress factor *a* is expressed as

a = log (1-LR)/log 2*Equation 3*

For residential retrofits, Giraudet et al. (2009) have come up with the following formulation based on Wright's equation

$$C_t = C_0 \left(\frac{Stock_t}{Stock_0}\right)^{-\frac{(\log 1-LR)}{\log 2}} \textit{Equation 4}$$

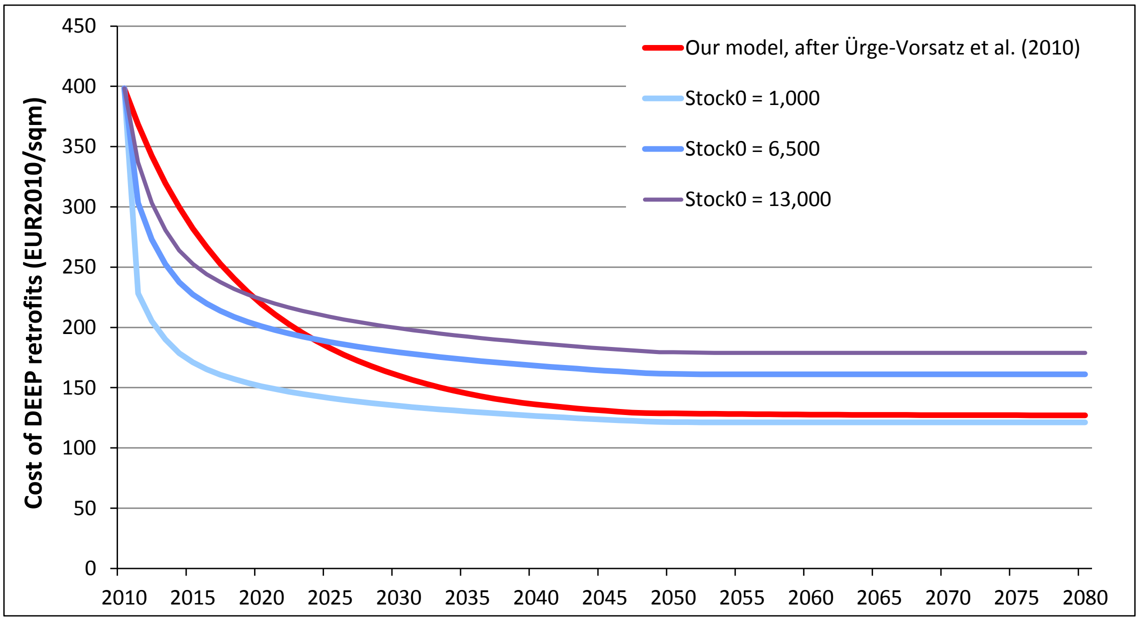
where C_t and C_0 are the per unit cost of the retrofit in time *t* and when time is zero; $Stock_t$ is the cumulative retrofitted stock in in time *t*; $Stock_0$is thenumber of units taken as a reference for the learning rate-related doubling of cumulative production; and *LR* is the learning rate.

For a comparison, it has been estimated how DEEP retrofit costs would be reduced in the time frame underanalysis (until 2080) by assuming a 10% learning rate (i.e., a 10% reduction in per unit costs is achieved every time the cumulative amount of retrofitted buildings doubles). This 10% learning rate is suggested by Giraudet et al. (2009) for building retrofits. It is in the range of the review of McDonald and Schrattenholzer (2002, cited in Yeh and Rubin, 2012), who found a range oflearning rates comprised between -14[78] to 34%, with a median value of 16% for energy related technologies. For supply technologies such as the production of solar PV modules and installed wind energy capacity OECD/IEA (2009b; 2010d) has reported learning rates in the 15 to 22% and 7 to 9% ranges respectively.

[78] A negative percentage indicates a negative learning rate, i.e., an increase in per unit costs as cumulative capacity doubles.

A question then arises about the value of parameter *Stock₀*, i.e., the number of retrofitted units (buildings, not dwellings) with which the learning rate-based reduction of per unit costs occurs with each doubling of the cumulative production. So it was decided to estimate learning curves based on an initial amount of 1,000, 6,500 and 13,000 buildings. This way, one randomly chosen scenario in which the predicted 10% reduction occurs after the 1,000 units is tested against two other scenarios in which half (6,500) and the whole (13,000) stock retrofitted in the first year is taken as $Stock_0$. The value of learning rate (*LR*) was fixed at 10% in the three cases following Giraudet et al. (2009).

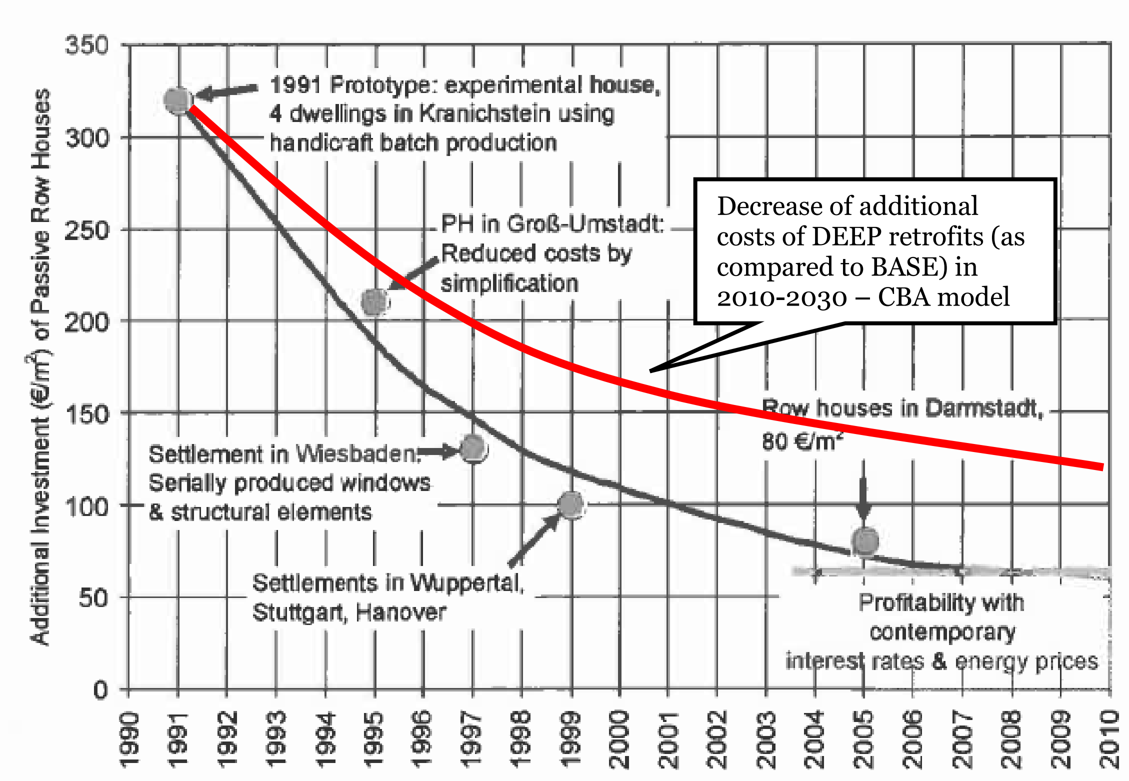
Figure 57. Evolution of average cost of DEEP retrofits in the CBA model and according to the Wright equation



Source: own elaboration.

The results of this comparison are shown in Figure 57 where, as expected, the long-term cost per unit is higher for larger values of Stock0.The figure also indicates that the cost decrease predicted by the Wright (1936)/Giraudet et al. (2009) equation is more aggressive in the first years than the one forecasted by the original model (after Ürge-Vorsatz et al., 2010), which is important given the effect of the discount rate in final results; at the same time, it shows that the long-term retrofit cost per unit in our model is similar to the one predicted by the Wright/Giraudet et al. (2009) equation with a Stock0 equal to 1,000 units (buildings).

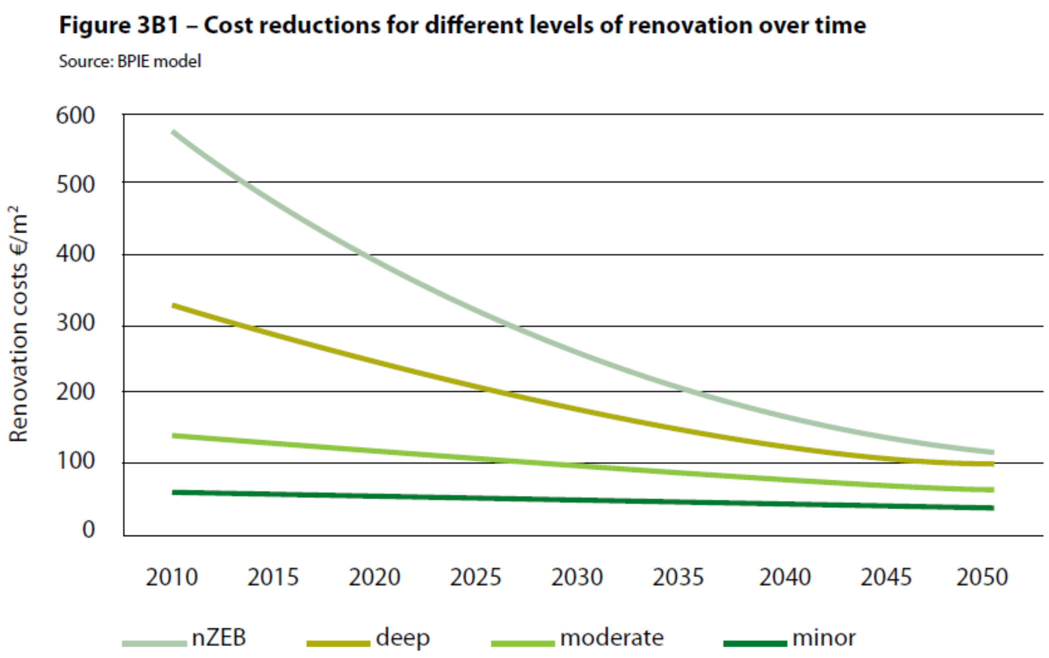
Figure 58. Learning curve showing the decrease in the incremental cost of meeting the passive house standard for the central unit of terraced houses



Source: Feist (2007), in Harvey (2010); CBA model.

An alternative comparison can be realized on the basis of learning curves reported in the literature. For the purposes of this research, of great interestis the reduction in the additional costs of new passive constructions based on data from real projects reported by Harvey (2010). As shown in Figure 58, a six-fold reduction in the incremental costs of meeting the passive house standard in terraced houses was achieved in the period 1990-2010. This compares with the five-fold reduction in the additional cost of moving from BASE to DEEP retrofits as predicted by the time-dependant equation used in the CBA[79], with the difference that in the CBA model this occurs in a much longer period (40 years – between 2010 and 2050, instead of in just 20 years). However, it must be noted that Harvey's figure refers to new passive construction and not to nearly-passive retrofits on existing buildings, for which the learning curve could be different to the one shown in.

Figure 59. Learning curve assumed for Europe's building retrofit scenarios



Note: minor, moderate and deep scenarios in the figure correspond to BASE, MID and DEEP scenarios in the CBA model; nZEB is a nearly-zero energy buildings scenario that does not exist in this dissertation.
Source: BPIE (2011)

A final comparison is presented with the learning curve assumed (i.e., not coming from real data) by BPIE (2011) in its study *Europe's buildings under the microscope*. This is an *ex-ante* research similar to the original building model that has used Ürge-Vorsatz et al. (2010) as a data source (and thus entails the risk of cross-referencing). As shown in Figure 58, deep retrofits experience between 2010 and 2050 a three-fold decrease (from over 300 to 100

[79] Between 20010 and 2050, the difference between the average cost of DEEP retrofits decreased from 339 $€_{2010}$ m^{-2} to 66 $€_{2010}$ m^{-2} (based on data presented in Figure 55); this is roughly equal to a five-fold reduction in 40 years.

$€_{2010}m^{-2}$) which is similar to the one predicted by the time-dependant equation in the same period (from 402 to 128 $€_{2010}$ m^{-2}, see Figure 55). The rate of decrease is more aggressive in the model than in BPIE's, however.

All in all, this review indicates that the chosen approach for DEEP retrofits costs – the time dependant Equation 1 taken from Ürge-Vorsatz et al. (2010) that results in the learning curve of Figure 55 – is in line with what has been reported from real data or predicted by similar learning-curve based models.

As a final comment, the effectcan be noted of the changes that the Energy Performance in Buildings Directive (EPBD) is going to introduce in the construction industry of EU Member States in a few years' time. In its present formulation, the recast directive (Directive 2010/31/ EU) requires all new buildings to be nearly-zero energy buildings by the end of 2020 and all buildings occupied or owned by public authorities to be nearly-zero energy buildings by the end of 2018. This means that by the end of the decade, the market for advanced energy efficiency construction materials and technologies will likely be more developed, thus offering further possibilities for economies of scale and a learning factor. This envisions a medium-term scenario in which both new and existing buildings approach deep energy efficiency levels.

7.5.3. 2nd round retrofit costs

The DEEP scenario assumes that after 35 years the once retrofitted dwelling has to be revisited in order to repair or substitute certain components of its structure. Even though specific components have to be substituted earlier or later than that (see Table 30), 35 years is assumed to be the average lifespan of a deep retrofit when considered as a whole, as suggested by Dr Berthold Kaufmannn, senior scientist at the *Passivhaus Institut Darmstatd* in Germany (Kaufmann, pers. comm.). However, since some components of the retrofit have a longer lifetime (e.g., insulation is thought to last for 50 years) and others have a residual value, the cost of the 2nd round retrofit is assumed to be 50% the cost of a full retrofit in the year when the 2nd retrofit occurs (recall that the per unit cost of deep retrofits is assumed to decrease following the learning curve assumption, as presented in the previous section).

Table 30. Assumed lifetime of building components in thermal retrofits

		Kaufmann, pers. comm.	Jakob, 2006
Insulation	*Roof*	50 years	50 years
	Wall		40 years
Windows		30 years	30 years
Air renewal system	*Fans*	15 years	15 years
	Conductions	30 years	
Airtightness membranes		30 to 50 years	n.a.
Heating system		30 years	n.a.

Source: see references in the table

This assumption is introduced in order to ensure that the thermal performance of the retrofitted units is maintained, and therefore that the energy savings do not decrease in the long-term. Once the second retrofit is completed, the original thermal performance is restored. This assumption is consistent with a policy approach that forges a long-term commitment with the low levels of energy consumption achieved with the first retrofit. It implies that long-term strategies must be in place for effectively keeping a low energy residential stock.

The same assumption (2nd round retrofit after 35 years at a cost of 50% of the MID retrofit cost for the corresponding building category) applies to the MID scenario. However, no 2nd round retrofits are realised in the BASE scenario. The over 70,000 dwellings retrofitted per year are assumed to contain all the non-energy efficiency-oriented retrofits plus the 25,000 panel dwellings panel dwellings retrofitted per year according to the *Panel* and similar programmes (see Section 7.2.2.2).

7.6. FINANCIAL BENEFITS

7.6.1. Energy saving benefits

7.6.1.1. Energy prices in 2010

The values of the precedent model (Ürge-Vorsatz et al., 2010) have been substituted by data obtained from a comprehensive review of sources (see Table 31). The criterion applied has been selecting the value from the most reliable source according to the information available.

Prices for natural gas and ‘other fuels’ (i.e., biomass) have been estimated on a net calorific value (NCV) basis. The reason is that these fuels use up part of their gross calorific value (GCV) in the combustion process itself as heat from vaporization (i.e., the energy required for evaporating the water resulting from the combustion of natural gas or contained in biomass). This implies that the specific energy use for space heating values used in the model (from 121 to 300 kWh m^{-2} $year^{-1}$– see Table 27)are also NCV-based. i.e., they are assumed to be the amount of kWh that each building type actually requires for guaranteeing an adequate thermal comfort level. The NCV/GCV ratio can be thus taken as an efficiency of the combustion process for the production of useful domestic heat.

Consequently, natural gas prices, initially expressed in GCV units (i.e., in HUF per cubic meter delivered to the dwelling), have been converted to NCV through a 0.9 conversion factor specific for Russian natural gas (OECD/IEA, 2010). The category ‘other fuels’ has applied a conversion factor of 0.65 for firewood (assumed to be the 90% of total biomass domestic use in Hungary) and 0.9 for pellets (10% of total biomass use) after Dibáczi et al. (2010).

In the case of DH, it was assumed that prices refer to the unit (GJ) received at the dwelling and therefore the same amount is transferred to the dwelling space (conversion factor is 1).

And the same goes for electricity: it was assumed that all the electricity that reaches the dwelling is transformed into useful heat following (Dibáczi et al., 2010; Szajko et al., 2009).

All prices have been converted into $€_{2010}kWh^{-1}$ from original values in HUF for different years by using energy carrier-specific price index rates from the KSH and the Euro-HUF exchange rate for 2010 (275.41 HUF $€^{-1}$) retrieved from the Hungarian National Bank.

The prices of natural gas, electricity and DH reflect the per unit cost of energy delivered to the dwelling without including basic fees or charges (i.e., fixed costs independent from the amount of energy used such as the cost of consumption meter, maintenance services, etc.). The reason is that even highly efficient buildings such as the ones resulting from DEEP retrofits require a small amount of energy for space heating, which involves paying the fixed basic fee. Therefore the actual reduction in a household's energy costs as a consequence of the retrofit takes place only on the variable part of its energy bill.

Note that the price of firewood is taken as representative of all 'other fuels', a category that should include coal, briquettes and (bottled) propane and butane gas. This decision was made in order to avoid excessive complexity and is conservative in the sense that the price of firewood is probably the cheapest of all those energy carriers and thus in the worst case it underestimates the energy-saving benefits achieved with the retrofit.

Finally, note also that reported DH and gas prices do not consider the rebates provided by State household support schemes (*gázártámogatás* and *távhőtámogatás*– see Section 7.2.2.2) because no data on the size of the rebate and number of benefitted households could be located. This overestimates to an unknown extent NPV results because the actual prices paid by householders areused in the model(Table 31).

Table 31.Available and selected values for energy prices in the financial analysis

Energy carrier	Selected value [$€_{2010}$ kWh^{-1}]	Available values [$€_{2010}$ kWh^{-1}]	Source	Comments
Natural gas	**0.042 (MEH)**	0.042	Hungary Energy Office (MEH)	Weighted average of different providers for Jan-Mar and Apr-Dec 2010. Average price for residential users with consumption 20-100 and 100-500 $m^3 month^{-1}$, net of basic fees. VAT included.
		0.044	Hungarian Central Statistical Office (KSH)	Statistics on the average price of selected goods and services.
		0.065	Eurostat	Average for the first and second half-year of 2010, all taxes included. Prices for residential consumers whose consumption is between 20 and 200 GJ per year.
Electricity	**0.154 (MEH)**	0.154	Hungary Energy Office (MEH)	Average price (net of basic fees) charged to households by main providers for universal service since July 1st, 2010 VATincluded.
		0.155	Hungarian Central Statistical Office (KSH)	Statistics on the average price of selected goods and services.
		0.169	Eurostat	Average for the first and second half-year of 2010, all taxes included. Prices for residential consumers in representative consumption band (5,000 to 15,000 kWh per year) according results of the model
District heating (DH)	**0.041 (Sigmond et al., pers. comm.)**	0.040	Novikova (2008)	Non-sector specific data source, only for Budapest
		0.041	Hungarian Professional Association of District Heating Providers (Sigmond et al., pers. comm.)	Average price (with taxes) per supplied GJ of DH in 16 Hungarian towns containing the largest number of DH users, incl. Budapest (weighting factor: number of DH-supplied dwellings in each of the 16 towns). Basic charges not considered.
		0.074	Sigmond (2009)	Sector specific data source but suspected to include basic charges
Other fuels (firewood)	**0.037 (Dibáczi et al.,2010)**	0.014	Novikova (2008)	Non sector-specific data source
		0.033	Hungarian Central Statistical Office (KSH) + Dibáczi et al. (2010)	Based on KSH per unit price of sawn firewood in Hungary as recorded by KSH (25.3 HUF_{2010} kg^{-1}) and same NCV conversion and efficiency factors as in Dibáczi et al. (2010)
		0.037	Dibáczi et al.(2010)	Sector-specific source, based on the following average data for Hungary: 28.5 HUF_{2010} kg^{-1}; 4.3 kWh/kg gross heating value of firewood and 65% efficiency of heat conversion.

Source: see references in the table

7.6.1.2. Forecast increase in energy prices

The increase in the price of energy carriers is forecasted using the function as in the original model (Ürge-Vorsatz et al., 2010) – see Equation 5. The main assumption behind this functional form is that prices are not expected to increase either linearly or exponentially to infinity but progressively a reach an asymptote. The price of each energy carrier energy in a given year (p_{y+1}) is thus defined as

$$p_{2010} = P$$
$$p_{y+1} = p_y \times [1 + r_1 \times (1 - r_2)^{y-2011}] \qquad \textit{Equation 5}$$

in which p_{2010} is the price in the first year of the timeframe and the energy carrier-specific rate of increase in the first year (r_1) is thus mitigated each year by a factor r_2 – see Table 32.

Table 32.Forecastedincrease in real energy prices, factor for Equation 5

Energy carrier	r_1: annual increase in price in year 1 – 2010 to 2011 (%)	r_2: mitigation factor (%)
Natural gas	15%	15%
Electricity	2.7%	5%
DH	3%	5%
Other fuels	3.5%	5%

Source: Hungarian Central Statistical Office(KSH) and author's assumption

For electricity and other fuels, the price increase factor in the first year (r_1) is the average change in real (i.e., inflation corrected) prices of the four energy carriers considered in the period 2000-2011.

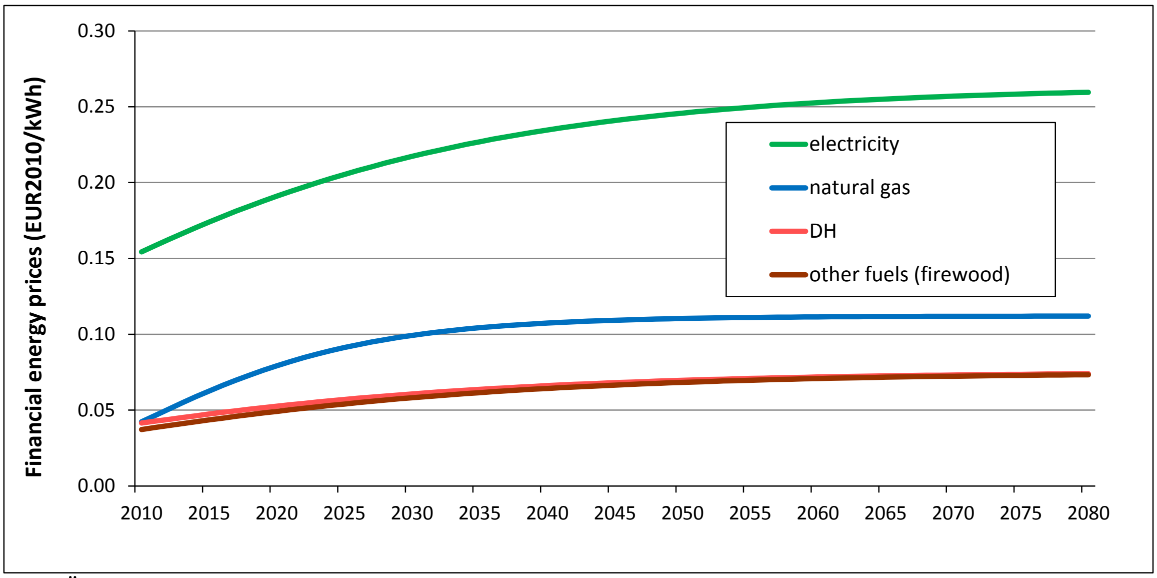
The case of natural gas and DH is more complex. For natural gas, the rate of increase recorded for import prices in the social CBA (see 8.3.1.2) has been applied after checking that retail and import prices increase to some extent in parallel (Figure 31). For DH[80], a 3% rate was taken as representative for the period 2000-2011, in which large fluctuations occurred partly because of the introduction of the reduced VAT in 2010 – see Figure 61.

[80] In 2010 DH prices recorded a record-22.8% decrease in real prices corresponding to the VAT reduction from 27 to 5% .

The mitigation factor r_2, the same for all energy carriers (5%) but natural gas (15%, same as import prices), is an author's assumption. The reason to apply a higher value for the r_2 parameter in the case of natural gas is to to prevent an unrealistic increase in long-term gas prices.

All in all, the application of Equation 5 to the 2010 price of energy carriers (Table 31) results in energy prices increasing as shown in **¡Error! La autoreferencia al marcador no es válida.**.

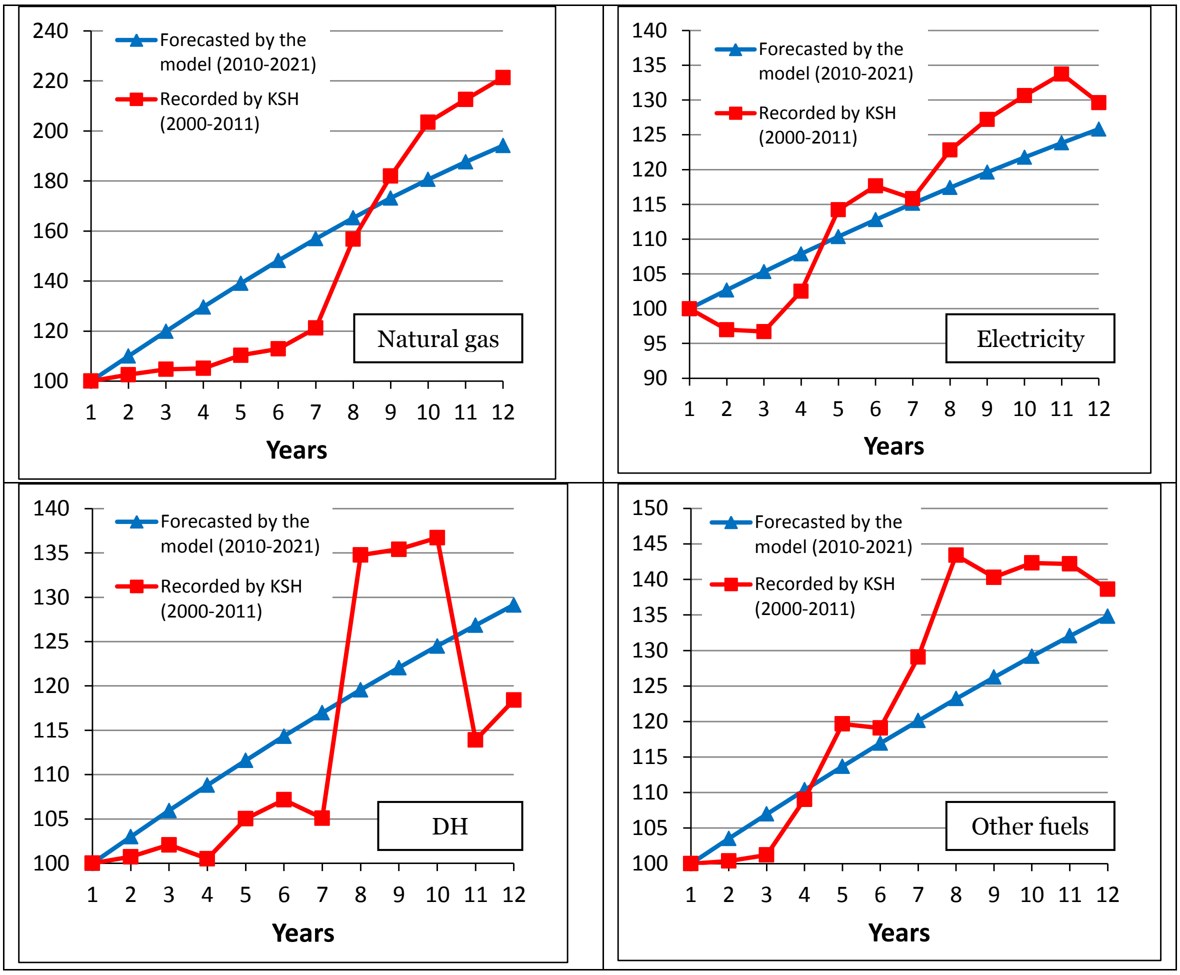
Figure 60. Forecasted increase in real energy prices in the financial CBA



Source: Ürge-Vorsatz et al. (2010); Hungarian Central Statistical Office (KSH) and author's assumptions

For a comparison, the aggregated increase in energy prices in the period 2000-2011 (as recorded by KSH's statistics) is checked against the model's forecasted increase in 12 years' time (2010 to 2021). The results are shown in Figure 61. For electricity and firewood, they indicate that the model's assumption for the coming decade (2010-2021) is below the recorded rates of increase in 2000s. For natural gas (the most important energy carrier for final results), the forecasted increase in the early years of the programme is above KSH's recorded increase in 2000-2005 but otherwise is a smooth continuation of the price *hike*experienced after 2006. DH provides the less clear comparison because of the large fluctuations in prices recorded in the last decade.

Figure 61. Forecasted increase (2010-2021) vs recorded increase (2000-2011) in real energy prices. Starting from up and left: gas, electricity, DH and other fuels (firewood); first year = 100.



Source: Hungarian Central Statistical Office (KSH); CBA model

7.7. FINANCIAL DISCOUNT RATE

The flow of annual net benefits resulting from the model's data and assumptions has been discounted with a real financial discount rate in order to account for the cost of the capital required for the programme.

Following EC (2008a) and the Fisher equation, a real financial interest rate has been estimated on the basis of Hungary's expected inflation rate (i.e., target inflation rate set by the Hungarian National Bank – MNB) and Hungary's nominal financial rate. The latter is taken as the average of: i) the interest rates for Hungary's long-term government bonds (10 years maturity) denominated in HUF, as collected monthly by the European Central Bank (ECB); and ii) commercial lending rates of the Hungarian interbank market as collected daily through the BIRS index (10 year maturity) by the Hungarian National Bank (MNB). These values are shown in Table 33, which contains also the estimated financial discount rate for Hungary (4.5%) calculated with the linear approximation to Fisher equation[81].

For a comparison, the rate suggested by the European Commission for the financial CBA of investment projects supported by EU funds (5%) is very similar to the 4.5% rate calculated based on Hungarian figures.

Table 33.Hungary's nominal interest rates, expected inflation rate and estimated real financial discount rate

Item	Interest rate
Interest rate of long-term government bonds (average 2007-2011)	7.6%
Commercial lending rate BIRS (average 2007-2011)	7.1%
Average	7.5%
Expected inflation rate	3%
Real financial discount rate (estimated)	**4.5%**

Source: Hungarian National Bank (MNB) and European Central Bank (ECB)

Note that this would be interest rate charged by national or international lenders for the capital required for the energy efficiency investments. It is not the discount rate actually (or implicitly) applied by the actors involved in the programme (State and households). In other similar studies BPIE (2011), the discount has been assumed to be 10% for households and 5% for the public sector. In contrast, a conjoint choice experiment survey of 473 Swiss

[81] According to which a real interest rate (*r*) equals to the nominal interest rate (*i*) minus the inflation rate (π): $r \approx i - \pi$

households found that individuals apply an implicit discount rate of 1.5 to 3% to home energy efficiency renovation projects when deciding in a context of no uncertainty about future energy prices (Alberini et al., 2011).

7.8. LIMITATIONS AND CAVEATS

A financial CBA model such as the one presented is subject to a number of limitations and caveats arising from lack of information and uncertain data and forecasts. The most relevant arethe following:

- The model only deals with the stock existing in 2010 without considering new buildings. Whereas this is justified because in the short and mediumterm, this is the fraction of the stock that really matters for lowering energy consumption and emissions. However, the further we move into the long-term – recall the long timeframe of analysis (until 2080) – the more relevant new buildings become because they both substitute the units decommissioned (between 7 and 12% of the initial stock, as predicted by the model – see Section 7.9.1.1) and accommodate the forthcoming demand for residential buildings. In an expanded version of the model, new buildings could have been incorporated by assuming a similar energy performance as retrofits in each scenario.
- No data was available for forecasting the evolution of the energy carrier mix in all three scenarios. In MID and DEEP, it has been assumed that gas substitutes to a good extent firewood burnt in traditional stoves and a higher proportion of electricity-based heating, which is a common feature of passive houses. For the BASE scenario, however, the 2010 mix is assumed to remain without change for the whole modelling period. However, it is known that firewood is substituting natural gas as a result of the increase in gas prices (see Section4.4.1); prior to that, in the 1990s natural gas almost eliminated all coal-fired boilers or heaters that were common in Hungary's residential buildings.

- Hungarian data on the cost of DEEP retrofits was only available the *panel* category, for which the SOLANOVA project provided a best-case example; in the original source (Ürge-Vorsatz et al., 2010), cost data for other 5 building typologies were then transferred from case studies in Austria and Germany with a 1/3 conversion factor that accounted for differences in labour and material costs in Hungary versus these other countries. My analysis, which applies the costs of the original model, also incorporates this source of uncertainty.
- The learning curve-based reduction of DEEP retrofit costs is, along with forecasted energy prices, the largest source of uncertainty of this cost-benefitanalysis. Because of this, the research has undertaken a careful comparison of the learning curve used in the model with the Wright equation and with real data on cost reductions in passive standard new buildings (see Section 7.5.2.3). However, no data on cost reduction associated with the mass implementation of passive retrofits seems to be available.
- The model implicitly follows a partial equilibrium approach, i.e., it assumes that the supply and prices of labour, financial capital and materials in Hungary will not change as a result of the implementation of efficiency scenarios (MID and DEEP). However, given the large scale of the programme (100,000 dwellings per year, some 25,000 more than the current *natural* rate of renovation) if shortages or bottlenecks in the supply of these factors of production occur, these will push the price of retrofits (and of the construction and related sectors too). The consequence in terms of the parameters of my model is that learning curve assumption for DEEP retrofits would not hold as proposed. For this reason, the original model of Ürge-Vorsatz et al. (2010) recommended the implementation of the less ambitous scenario (*S-DEEP3* scenario, which proposed acting on100,000 dwelling-equivalents per year vs. the 150,000 or 250,000 dwelling-equivalents per year proposed by the *S-DEEP1* and *S-DEEP2* scenarios), on which my MID scenario is based for minimising the risk of supply shortages.

- Energy price support schemes, which reduce the effective price of natural gas and DH of eligible consumers, have not been considered in the financial analysis. This has an impact on the results as it enhances the estimated energy savings for those households currently benefitting from the scheme.

These and other factors introduce uncertainty to the results of the model and the financial CBA. However, it was decided to deal with them only once, in the sensitivity analysis of the social CBA (Section8.7); there they are considered along with other sources of uncertainty coming from the methodologies used for valuing non-market co-benefits.

7.9. RESULTS

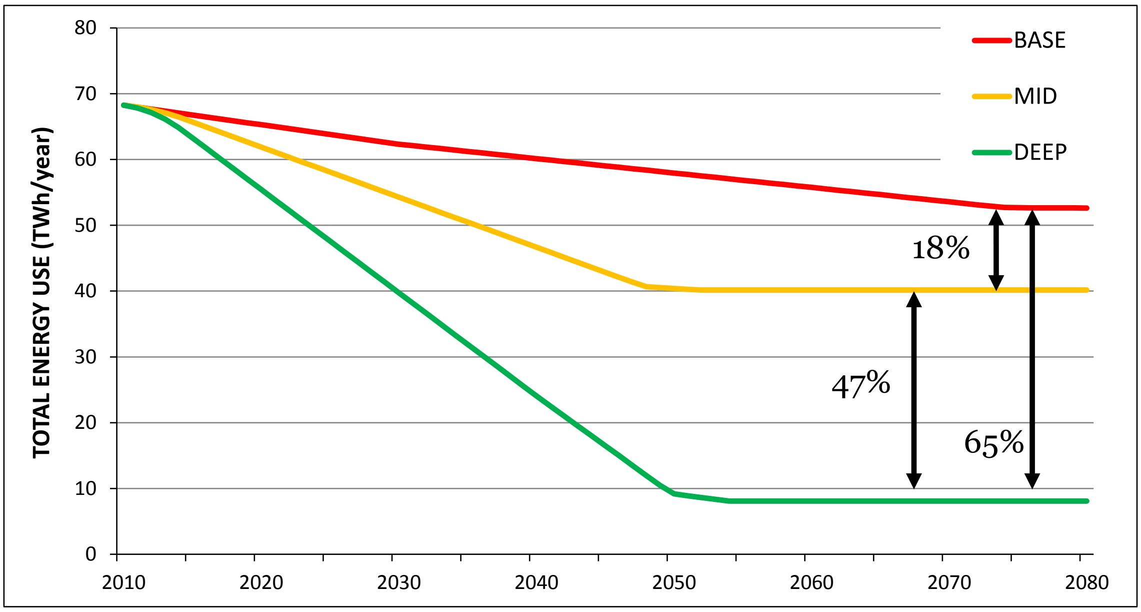
7.9.1. Energy saving and carbon mitigation potential: the *lock-in effect*

7.9.1.1. Estimated potentials

Based on the data on the Hungarian residential stock and the assumptions of each of the three scenarios, annual total energy use for domestic space heating has been estimated until the end of timeframe of analysis (2080). The corresponding annual GHG emissions have been then calculated by multiplying the forecasted total energy use times the $CO_{2eq.}$emission factors reported in Section 8.3.2.1.

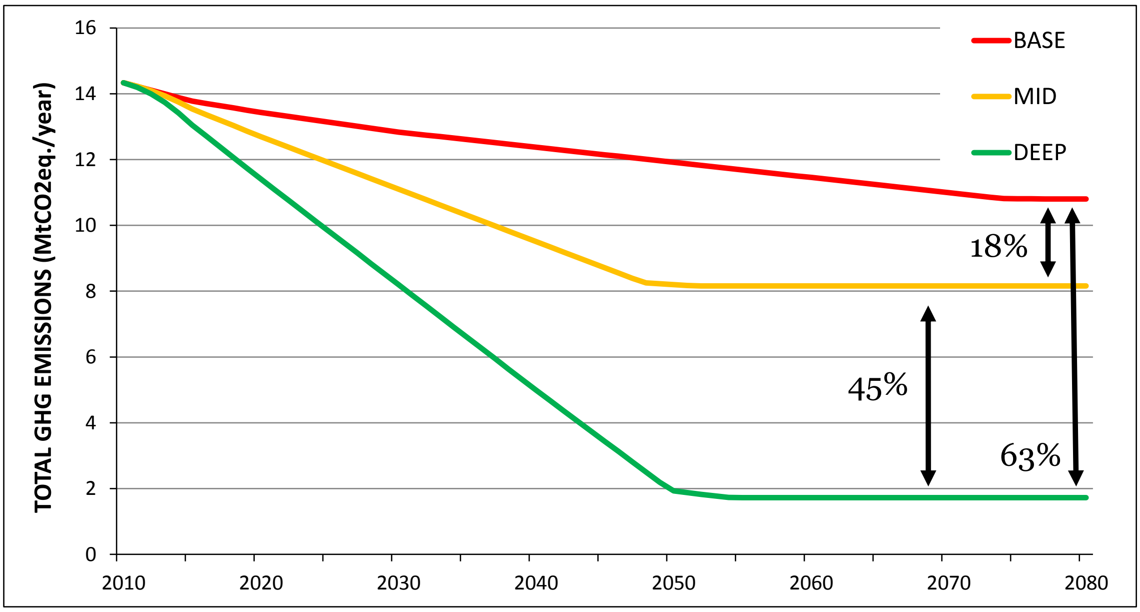
For both total energy use and GHG emission calculations, BASE and MID scenarios take account ofthe 250,000 *panel* dwellings already retrofitted in the decade of the 2000s i.e.in both scenarios (unlike in DEEP) these units are not revisited – see Section 7.3.3. These poorly retrofitted 250,000 *panel* apartments are assumed to use energy at a rate of 172 kWh m^{-2} $year^{-1}$ with 100% of their floor area heated – see footnote 72. The reason for their inclusion is having a common starting point of comparison between the three scenarios.

Figure 62.Total energy use for space heating of Hungary's residential stock according to the scenarios. Percentages of the lock-in risk refer to total energy use in 2010.



Source: model's results

Figure 63.Total space heating-related $CO_{2eq.}$ emissions of Hungary's residential stock according to the scenarios. Percentages of lock-in risk refer to total emissions in 2010.



Source: model's results

Results are presented in Figure 62 and Figure 63. They clearly indicate the very substantial decrease in total energy use that can be achieved with the large-scale implementation of DEEP retrofits: from 2054 onwards (when all buildings in the initial stock have been either retrofitted or decommissioned), total energy use in the DEEP scenario is barely 8 TWh year^{-1}, which represents an 88% reduction compared to the 2010 total energy use for domestic space heating (68 TWh year^{-1}). The predicted reduction in total GHG emissions is very similar (88% as compared to 2010 total emissions).

In comparison, BASE and MID scenarios reduce total energy use and GHG emissions to a considerably lesser extent. This is known as the *lock-in* risk and is discussed in detail in the following section.

It must be nevertheless noted that a fraction of the estimated decrease in total energy use and emissions in all scenarios is due to the on-going decommissioning ofthe residential stock, which occurs at the obsolescence rate defined for each building typology (see Section 7.4). This assumption distorts to a small extent the comparison in the late years of the timeframe of analysis. It actually benefits the BASE scenario, in which buildings decommissioning occurs over a larger number of years (until 2086) and thus 12.1% of the 2010 stock is removed from the stock at the end-year of the scenario. As a comparison, a 7.3% and 7.6% of the stock of MID and DEEP scenarios will have been decommissioned respectively by their end years (2051 and2054). However, these are small percentages and thus almost the whole reduction in total energy use and emissions can be attributed to energy efficiency investments.

7.9.1.2. Lock-in *risk*

Today's state-of-the-art design, know-how and technologies (e.g., the passive house standard – a maximum annual heating demand of 15 kWhm^{-2} year^{-1} irrespective of climate) ensure reductions in heating energy use by a factor of four to five as compared to new buildings, and by a factor of 15 to 25 as compared to existing buildings (Harvey, 2010). In those buildings, heating costs can be minimal and only small backup heating systems are required.

However, many of these efforts mandate or aim at reaching thermal efficiency levels that are far from the state-of-the-art. This leads to the *lock-in* effect or *lock-in* risk, which is defined as the unrealised energy and carbon saving potentials that result of the installation of below state-of-the-art energy efficiency technologies in buildings. This is a critical notion from the perspective of the capital investments needed in the buildings sector for climate purposes.The rationale is that since the emissions related to space heating and cooling in buildings are difficult to mitigate in other ways than addressing them in the buildings themselves, applying sub-optimal[82]retrofits may force households to undertake additional future retrofits after a few years in order to capture the remaining potential,which may be technically difficult or uneconomic; or it may require other more expensive mitigation options (e.g., renewables or CCS) at later stages(Ürge-Vorsatz and Tirado Herrero, 2012; Tirado Herrero et al., 2011; Korytarova and Ürge-Vorsatz, 2010;). In other words, if suboptimal technologies keep on being applied, this will jeopardise reaching any later ambitious mitigation targets

This is largely relevant for the Hungarian case given the current state of in Hungary's energy efficiency policies for buildings. In this country, State-supported retrofits have reduced 5% to 40% of the energy demand for heating (Bencsik, 2009; Pájer, 2009; Czakó, 2010) but the SOLANOVA pilot project[83]has demonstrated that reductions in energy use for space heating of up to 80-90% are feasible(Hermelink, 2007). In fact, as acknowledged by the model, it has been assumed that some 250,000 *panel* dwellings – 33% of the Hungarian stock of pre-fabricated residential buildings – had by 2010 already beenretrofitted with below state-of-the-art technologies delivering just 25% of energy savings.

[82] Suboptimal in the sense that these technologies, which are not as advanced as state-of-the-art, do not fully realize the total energy and carbon savings potential of the building stock.

[83] The SOLANOVA pilot project successfully retrofitted with passive house technology a conventional, low-quality prefabricated *panel*block with 43 apartments located in the Hungarian city of Dunaújváros in 2005 (Hermelink, 2007). To date, it is the most successful case of a deep retrofit of a Hungarian building.

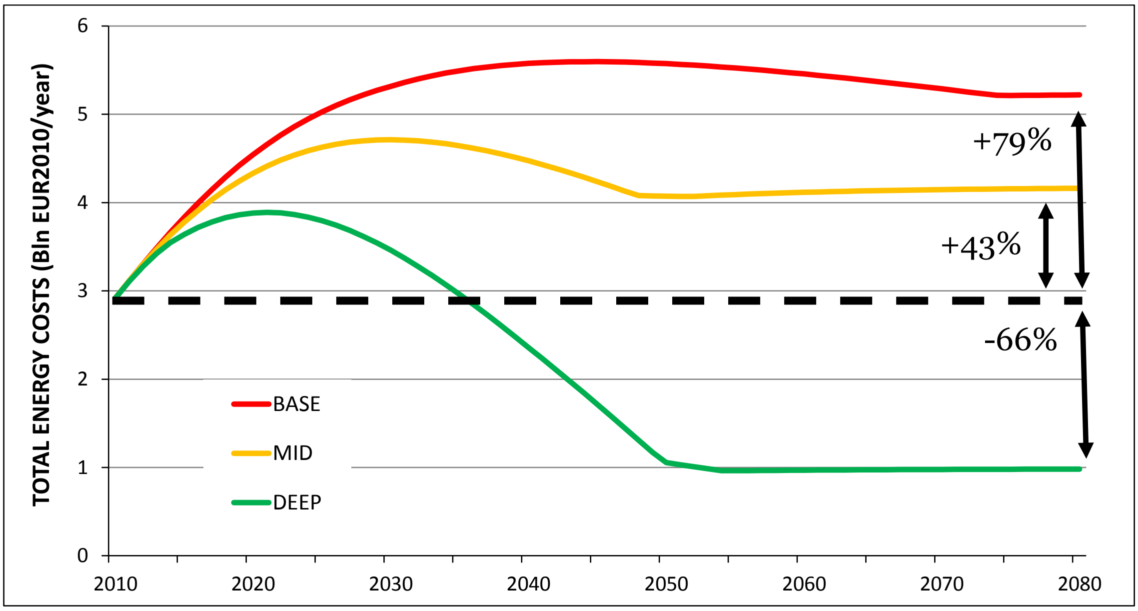
Acknowledging the relevance of the lock-in risk, total energy use and emissions results have been employed to estimate the size of this effect. As shown in Figure 62 and Figure 63, if BASE retrofits keep on being implemented, this will lock-in 65 and 63% of the 2010 total energy use and GHG emissions respectively when compared to the potential of DEEP scenario. And if MID retrofits were implemented instead, this would still lock-in 57 and 45% respectivelyof the 2010 total energy use and GHG emissions[84].

7.9.2. Results of the financial CBA

7.9.2.1. Total energy costs

The CBA model also allows producing results on total energy costs as a relevant by-product – see Figure 64. These three curves are a model-based forecast of the aggregated amount to be paid by all Hungarian households for heating their homes following the assumptions of the three scenarios.

Figure 64. Predicted total space heating-related energy costs of Hungary's residential stock



Source: model's results

[84] The evolution of total energy use and GHG emissions is slightly different given that the emission factors for electricity evolve in time (see Section 8.3.2.1).

According to these results, DEEP scenario is the only capable of more than offsetting the increase in energy prices predicted by the model. It brings about a 66% reduction in total energy costs in 2080 and saves Hungarian households 2 billion $€_{2010}$ per year in domestic heating costs from 2050 onwards. In contrast, total energy costs in BASE and MID scenarios increase total energy costs by 79% and 43% respectively; consequently, they lock-in some 3 to 4 billion $€_{2010}$ per year of potential savings after 2050 (if compared to DEEP scenario).

7.9.2.2. Annual additional costs and benefits

For calculating the financial NPV, the annual cash flow of financial costs and benefits has been first calculated. Note that both costs and benefits are additional because the financial CBA is thus defined (see Section 7.3.5): the purpose is not comparing the performance of each of the three scenarios defined in the model but assessing the convenience of moving from BASE to either MID or DEEP[85]. For simplicity, these two options are referred to also as MID and DEEP scenarios.

These intermediate outputs are presented in Figure 65andFigure 66. In both MID and DEEP scenarios the 5-year ramp up period (until reaching the target rate of 100,000 units per year) is visible, and the learning curve of DEEP retrofit costs is clearly perceptible after 2015. Note thatthe MID scenario reports negative additional costs (only) in 2010 because in this first year the total cost of retrofitting to MID levels the 20,000 homes defined by the ramp-up period is below the total cost of the 70,000 retrofits of the BASE scenario. This is not the case of DEEP scenario, where the cost of retrofitting the first 20,000 homes in 2010 is already higher than the total cost of the 70,000 BASE retrofits.

[85] Additional annual values are calculated by subtracting the annual costs and benefits of BASE scenario to the annual costs and benefits of MID and DEEP scenarios.

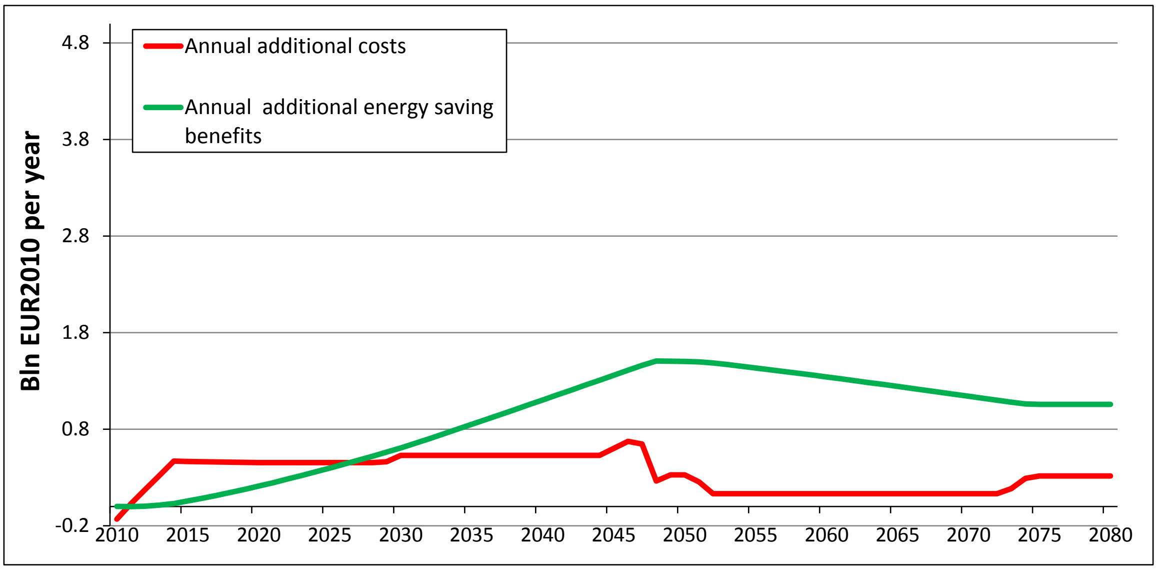
In the MID scenario, post-2051 costs are comprised onlyof (additional) 2nd round retrofit costs; the same goes for DEEP scenario after 2054.

On the benefits' side, no energy savings are recorded in the first modelling year (2010) because retrofits must be finished before starting to save energy. From 2011 there is a slightly exponential increase in additional annual benefits due to the forecasted increase in energy prices until 2051/2054. Beyond this point, their value decreases because the BASE scenario keeps on retrofitting and decommissioning buildings for more than three decades after the end year of MID and DEEP scenarios.

The *lump* that can be seen in the curve of annual costs around 2050 has the following explanation: between 201 and 20435, the cost curve consists of just 1st round retrofits; then from 2045 until the end of MID and DEEP scenarios (2051 and 2054), both 1st round and 2nd round retrofits coexist, thus pushing the curve upwards; and from 2051/2054 onwards, only 2nd retrofits are reported.

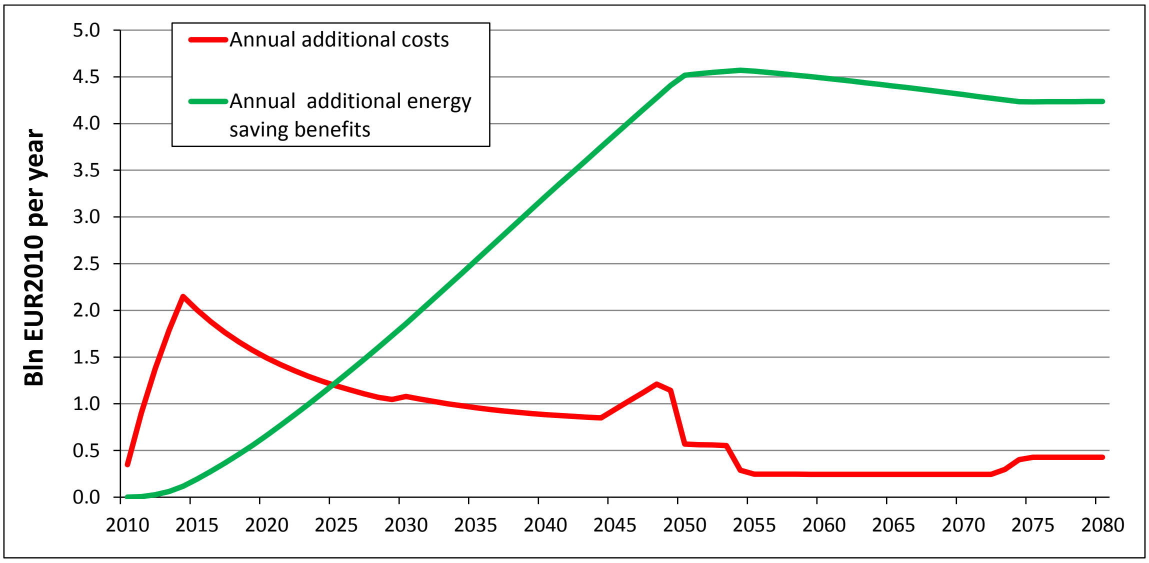
The break-even point (i.e., the year in which annual additional benefits equals annual additional costs) comes a bit earlier for DEEP scenario (2026) than for MID (2028). This enhances the appeal of DEEP scenario from an applied policy perspective.

Figure 65.Annual additional costs and benefits of moving from BASE to MID scenario



Source: model's results

Figure 66.Annual additional costs and benefits of moving from BASE to DEEP scenario



Source: model's results

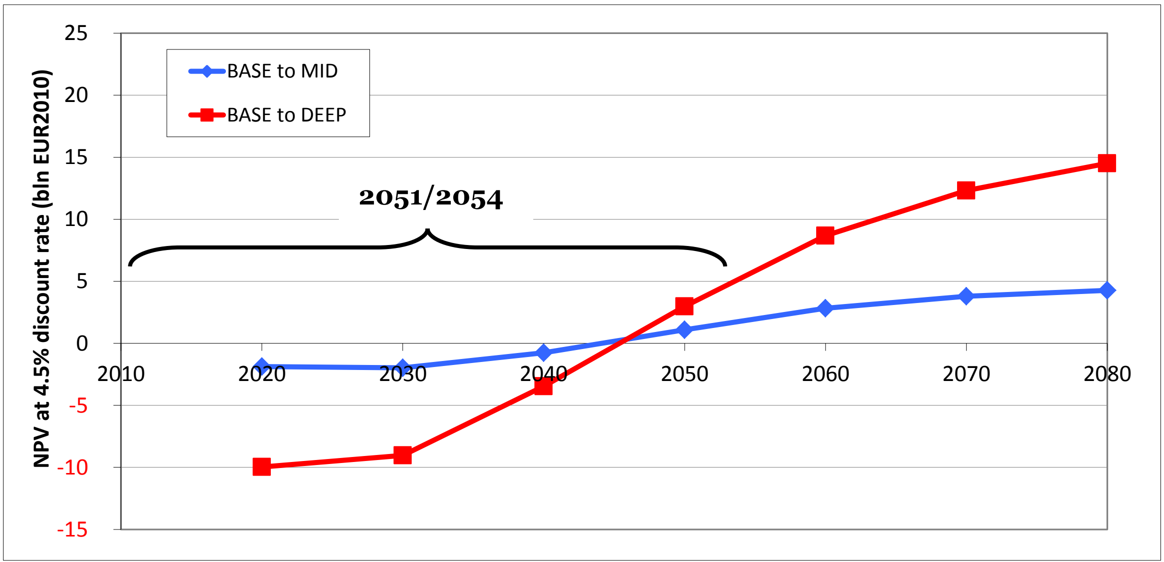
7.9.2.3. Financial NPV – aggregated results

Net Present Values (NPV) have been estimated for 10-year periods after 2010, i.e., in Figure 67, years in X-axis correspond to 2020, 2030, etc. until 2080.

The results indicate that positive NPVs are not achieved until the late decades of the modelling/analysis timeframe (from 2045) onwards. This is a bit earlier than the end year of MID and DEEP scenarios in 2051/2054.Given the uncertainty associated with long-term forecasts, these results are supportive only to some extent of advanced energy efficiency solutions such as the ones proposed by MID or DEEP scenarios. It is therefore useful to incorporate non-market benefits other than energy savings, as is done in the following chapter (social cost-benefit analysis).

These results also highlight the large difference existing between MID and DEEP retrofits. DEEP scenario results in largely negative NPV in the first decades of the programme because of its higher implementation costs but in the long-term delivers a larger amount of discounted net benefits than MID scenario.

Figure 67. NPV of moving from BASE to either MID or DEEP scenario



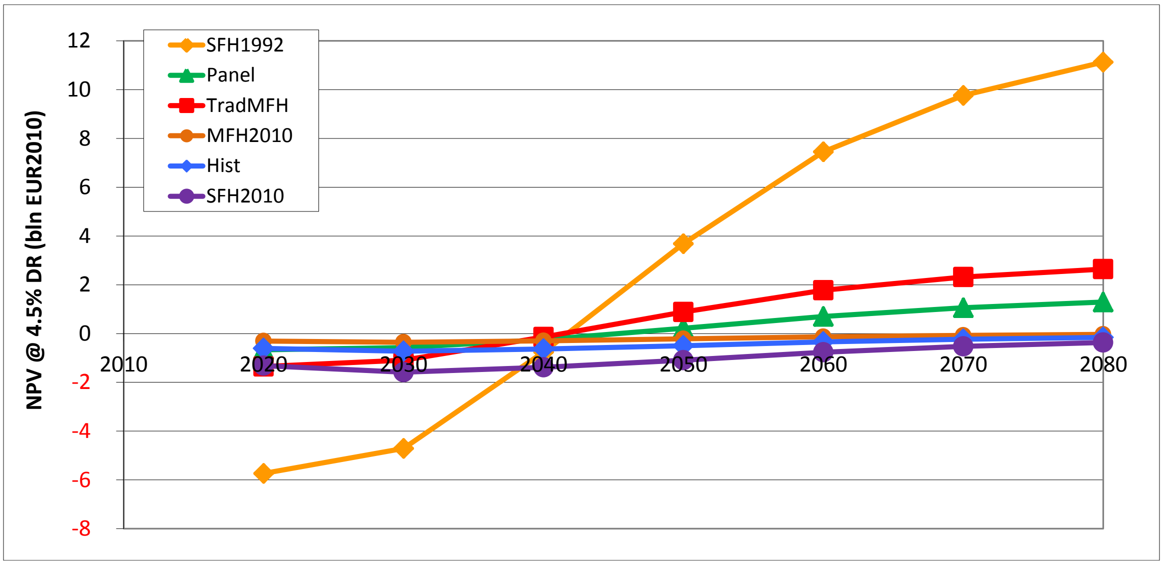
Source: model's results

7.9.2.4. Financial NPV – results disaggregated by building typologies

NPV results for MID and DEEP scenarios have been disaggregated by building typologies.

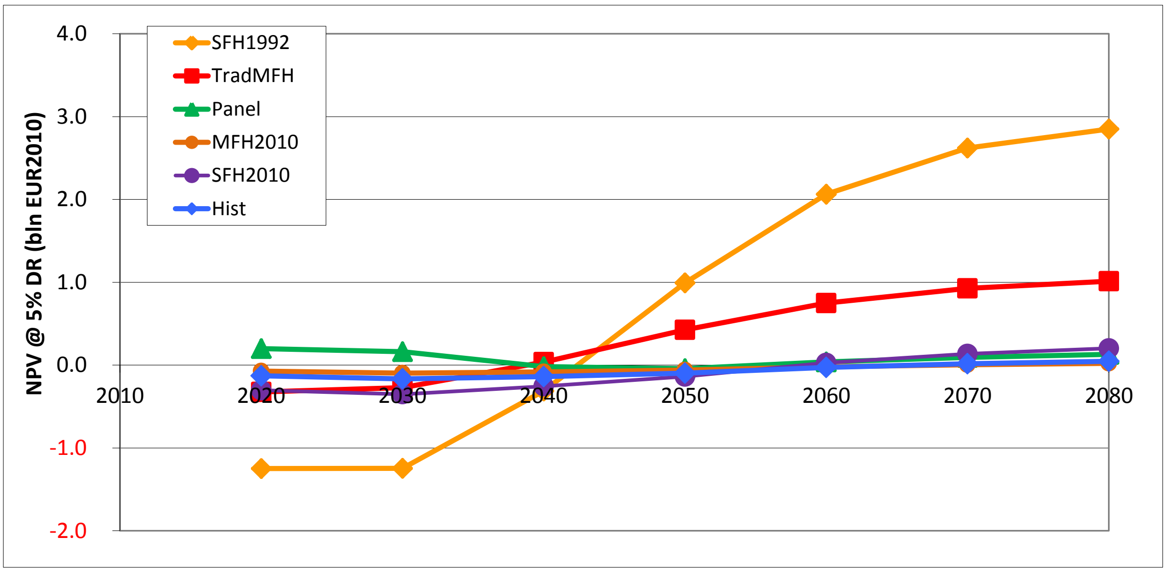
As shown in Figure 68 and Figure 69, only a few building typologies result in positive NPVs in the long-term. These are the categoriesrelating to single-family homes built before 1992 (SFH1992), traditional multi-family homes (TradMFH) and pre-fabricated buildings (Panel). However, these are the three largest building typologies, taking up 83% of Hungary's residential total floor area in 2010.

Figure 68. NPV of moving from BASE to MID scenario, by building typologies



Source: model's results

Figure 69. NPV of moving from BASE to DEEP scenario, by building typologies



Source: model's results

Particularly important is the SFH1992 typology, which represents 51.1% of the country's residential floor area in 2010 and is the most inefficient category (300 kWh m^{-2} $year^{-1}$ for space heating)[86]. Both in MID and DEEP scenarios, it delivers the largest amount of

[86] Like with panel buildings, there seems to be a connection between the Hungary's Socialist recent past and the energy performance of SFH1992 buildings. As indicated by Hegedűs and Tosics (1994), since market-oriented developments were rare until 1989 many of these single-family houses – mostly in rural areas, but also in cities – were built informally by families often working manually with relatives, friends and acquaintances.

discounted net benefits (NPV) after 2050, making up for the losses accrued in the categories reporting a negative NPV.

In contrast, single- and multi-family homes built between 1993 and 2010 (SFH2010 and MFH2010) and historical buildings (Hist) deliver either negative or nearly zero NPV. In the former two cases, this has to do with the fact that model assumes a very similar cost of retrofit than for equivalent pre-1992 categories, though they deliver fewer energy savings because of their better energy performance before retrofit. Historical buildings are on the other hand the most expensive units to retrofit given the technical constraints imposed by their protected nature. These three building categories (SFH2o10 and MFH2010) represent 17% Hungary's residential stock in 2010.

7.9.3. Financing residential energy efficiency investments: an analysis based on representative dwelling typologies

7.9.3.1. A hypothetical pay-as-you-save *scheme*

The results presented in the previous sections prove that the discounted cash flow of financial costs and benefits brought about by MID and DEEP energy efficiency retrofits is positive, i.e., that in the long-term the energy saving benefits more than compensate the implementation costs incurred with the retrofits considering the time value of money (financial interest rate). Though useful to prove this point, it is a simplistic exercise in two senses. First, it considers that all costs are incurred in the year when the retrofit takes place, thus purposely avoiding the issue of financing. Second, it somehow assumes (implicitly) that the whole residential stock has one hypothetical, single owner that bears all costs and receives all energy saving benefits. From this point of view, for instance, retrofitting the whole stock would make sense because the losses incurred in the less profitable categories (SFH2010 and MFH2010) are covered by the large net gains of SFH1992.

The reality is much more complex because (among other reasons) practically each dwelling has a different owner and Hungarian households would be very rarely able or willing to pay on the spot the several thousands (or even tens of thousands) Euros that a MID or DEEP retrofit costs. Reasons for that are that households may(Brophy et al., 1999: be unaware or unsure about the energy saving potential and the benefits that the retrofit will report to them (and also to the wider society), what is sometimes referred to in the literature as the *information gap*;have to take a loan with a high interest rate or face a long payback period;be subject to transaction costs (finding the right builder, coping with the hassle of the retrofit, etc). In addition, there is the uncertainty about the evolution of energy prices, which determines the size of private energy saving benefits.

An advantage of cost-benefit analysis is that it allows the identification of actors will benefit more from the foreseen investments and are thus the likely financers of the project (WHO, 2007). In the case of Hungary, households would be the first and foremost beneficiaries of the retrofits as they are the recipients of energy savings and thermal comfort gains. Besides, the State in itsrole of guaranteeing and improving public health levels (but also as sellerof CO_2emissions allowances under the Green Investment Scheme and recipient of other sources of additional revenues – taxes and contribution to the social security system – generated by the investments) would also benefit positively from the results of the programme. Therefore, it is assumed that total implementation costs are to be shared by the State and households. This opens up the possibility for a hypothetical exercise on the financing of representative dwelling types on the basis of the intermediate results of the financial CBA model.

With this aim, the costs of (1^{st} round) retrofitting to MID and DEEP levels an average dwelling of each of the 6 building typologies in 2010, 2020 and 2030 are first estimated. In parallel, the amount of private energy saving benefits achieved by each representative dwelling throughout the modelling period have been calculated; however, to avoid excessive complexity this calculation has been done only for the most common energy carrier used for space heating before retrofit, which is natural gas in all cases but the Panel category (where DH is dominant).

Table 34. Cost of retrofitting in 2010 a representative dwelling of each building typology (€$_{2010}$)

	MID			DEEP		
	2010	2020	2030	2010	2020	2030
Hist	13,807	11,348	11,348	52,013	28,652	10,856
TradMFH	7,301	6,334	6,334	26,479	14,587	10,735
Panel	4,995	4,496	4,496	23,642	13,024	9,110
SFH1992	8,646	7,842	7,842	31,208	17,191	17,412
SFH2010	12,139	9,051	8,907	31,208	17,191	9,395
MFH2010	5,372	4,835	4,835	25,534	14,066	4,304

Source: model's results

It is assumed that the retrofits would be financed through loans to be repaid through the energy savings achieved with the intervention through *pay-as-you-save scheme* (UK GBC, 2009) because few households have (or are willing to spend) savings for paying for the costs of the retrofit. The retrofit cost of the representative dwelling is used as an input to Microsoft Excel's PMT function, which calculates the payment for a loan based on constant payments once the principal, a constant interest rate and repayment period have been defined.

The purpose is to find out which percentage of the initial investment costs has to be paid on the spot at the moment of the retrofit (and thus not financed) for the annual energy savings to be equal or higher than the loan's annual payment. This percentage is taken as an approximation of the required government's direct subsidy to the total cost of the retrofit.

For setting the value of two key fixed parameters involved in this calculation (the amount of loan repayment andthe length of repayment), the so-called *golden rule* set by the UK government for accessing Green Deal financing has been applied. According to this principle, "[…] the charge attached to the bill [the loan repayment amount] should not exceed the expected savings, and the length of the payment period should not exceed the expected lifetime of the measures" (DECC, 2010, p. 11). In my analysis, the first part of this rule means that in the first year the energy savings generated have to be equal to, or above, the annual loan payment, based on the assumption that households expect to save on energy costs at least the same amount that has to be spent on the repayment of the loan.

Following the second part of the *golden rule*, a 15 year repayment period has been established. The reason is that even though a MID or a DEEP retrofit is supposed to last (on average) for 35 years (see Section 7.5.3), it is estimated that the first pieces to be replaced (i.e., the fan of the ventilation system) need to be replaced after 15 years – see Table 30. Besides, it is likely that a household would not engage in such a financing scheme if it involved a repayment periodlonger than 15 years given that the average term of a credit for buying a new home in Hungary is 17 years (see footnote 92).

All in all, this calculation comprises the following key parameters:

- Interest rate, which in this analysis is a real financial interest rate because both costs and benefits' are expressed in real prices (€$_{2010}$).It has been set at 3%, which is Hungary's current real financial interest rate as estimated by Fisher's equation[87]. However, depending on the evolution on both inflation and nominal financial interest rates, 3% may be either an overestimation or a protected real interest rate (i.e., soft loan) in the future.
- Length of the re-payment period, which has been set at 15 years following the *golden rule* rationale (see above).

[87] Hungary's nominal interest rates as reported by BUBOR and BIRS indexes at 12 months and 10 years were around 7% in 2011, according to data of the Hungarian National Bank. Hungary's inflation rate for 2011 is 3.9% as reported by the Hungarian Central Statistical Office (KSH). The corresponding real financial rate estimated through Fisher equation (see Section 7.7) is roughly 3%.

- Percentage of total investment costs of the retrofit paid on the spot (e.g., when the retrofit has commenced) and which therefore does not need to be financed. This may come (at least partially) from the household's savings but in this context it mostly represents the direct subsidy to the principal of the loan, i.e., the percentage of the initial investment costs to be covered by a State grant. The value of this parameter is the one sought, because the purpose of the calculation is to find out how much government support is needed for the household to decide on the retrofit.

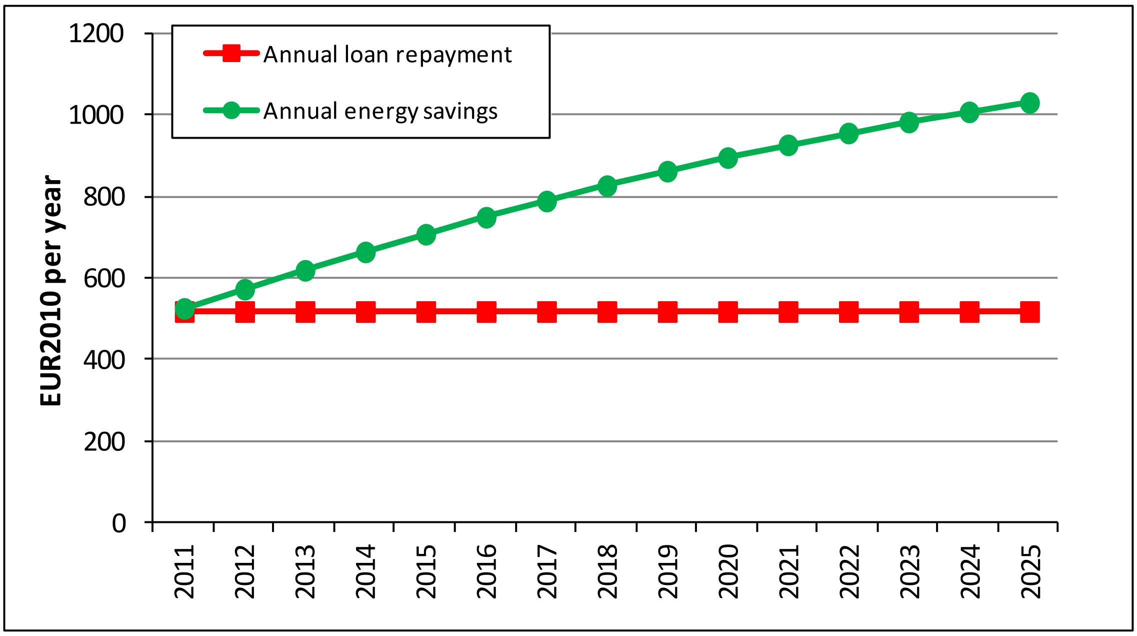
An example of this is shown in Figure 70 corresponding to a representative 75m^{2}dwelling heated with natural gas in a Hungarian historical building retrofitted in 2010 to DEEP levels (at a cost of 52,013 €$_{2010}$). Assuming a constant 3% interest rate and that the government subsidises 89% of the cost of the retrofit, the required payment in 2011[88] would be 474 Euros, which is just below the estimated 500 Euros saved in gas bills during 2011. 89% is the value sought with this calculation.

This procedure has been carried out for all six building typologies, and MID and DEEP retrofits completed in the beginning of 2011, 2021 and 2031 in order to analyze the effect of decreasing retrofit costs and increasing energy prices in the percentage of initial investment costs to be covered by a State grant. The results are shown in Figure 71 and Figure 72. Note that in some cases (SFH1992 and TradMFH with natural gas) a negative value is reported; this shows the maximum percentage in which the cost of a DEEP retrofit could be increased without breaking the *golden rule* (i.e., annual loan payment equal or below annual energy savings). Another interpretation of the same figures is the following: when the percentage of

[88] Note that 2011 is purposely set as the first year for the calculation. Following a more general assumption in the model, the retrofit is completed during 2010 and but it is only in 2011 when homeowners start repaying the loan and enjoying the energy savings. Thus, retrofit costs (and therefore the loan repayment) are estimated with 2010 retrofit costs though energy-saving benefits correspond to 2011 energy prices.

required State grant equals zero, this indicates that from that year on no State grant is required because the energy savings are large enough to cover the annual loan repayment.

Figure 70.Annual loan repayment vs. annual energy savings for a DEEP retrofit (completed in 2010) of a representative 75 m^{2}dwelling in a historical bulding in Hungary heated with natural gas, assuming a 3% real interest rate and 88% government subsidy to retrofit costs

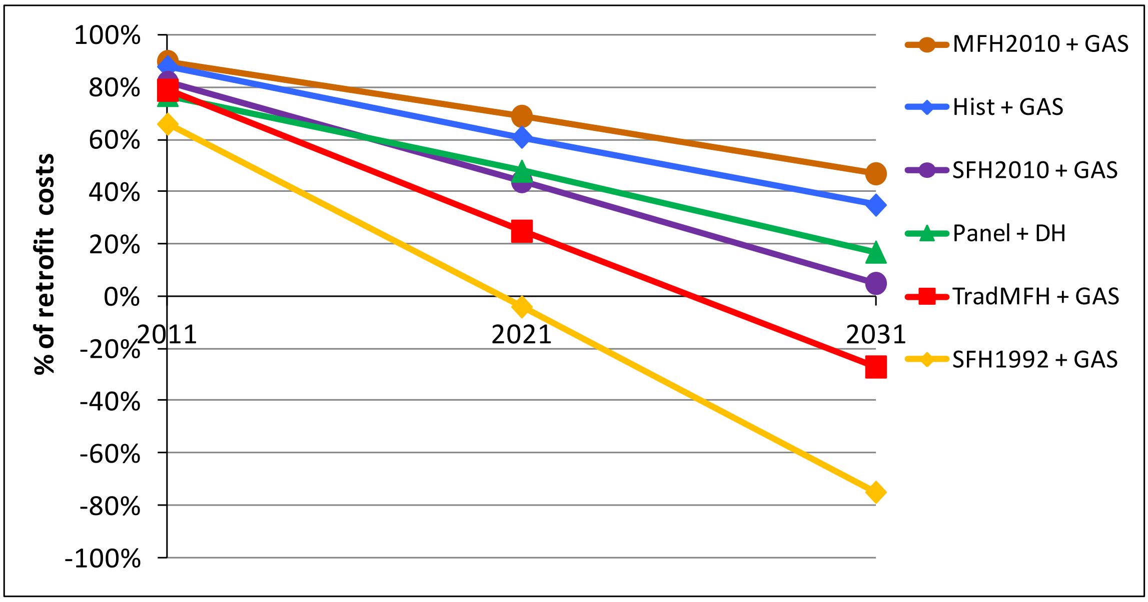


Source: model's results

Figure 71. Percentage of retrofit costs to be covered by a State grant for the annual loan payments to be equal or below annual energy savings in the first year, by building typologies (MID retrofits)

Source: model's results

Figure 72. Percentage of retrofit costs to be covered by a State grant for the annual loan payments to be equal or below annual energy savings in the first year, by building typologies (DEEP retrofits)



Source: model's results

The results indicate that in the early stages of the programme, a large fraction should be subsidised in order to comply with the *golden rule*. For MID retrofits completed in 2010, this percentage is comprised between 45 and 78%, whereas DEEP retrofits are in the range 66-90% of total retrofit costs per dwelling. The percentage to be covered by a State grant decreases faster in the case of DEEP retrofits as a result of the learning curve (Section 7.5.2.3).

By building typologies, single-family homes built before 1992 (SFH1992) and traditional multi-family homes (TradMFH) are the best performers and in the DEEP scenario do not require any State support (i.e., energy savings more than compensate loan repayments) from 2020 onwards. In contrast, the other three categories are openly problematic from the perspective of individual financing because their bad cost-to-benefit ratio already reflected in their financial NPV (Section 7.9.2.4). Such is the case of historical protected buildings (Hist), whose retrofit costs are the highest because the technical limitations posed by their protected character, and also the single- and multi-family buildings built in 1993-2010 (SFH2010 and

MFH2010), which have a lower energy consumption before retrofit and therefore deliver less energy savings.

Finally, results have been also obtained for two different energy carriers (natural gas and ‘other fuels’, i.e., firewood) for analysing the effect of the price of energy. This has been tested in the SFH1992 because these fuels are used to a large extent in this building typology and also because it isthe largest typology in terms of total floor area.

As expected, an SFH1992 representative dwelling heated with firewood performs clearly worse (i.e., it requires more subsidy from the State) thanthe one relying on natural gas for space heating both in MID and DEEP scenarios (see Figure 73 and Figure 74). The consequence is that when these households choose to protect themselves from increasingly higher gas prices by switching to cheaper fuels like firewood, the later implementation of an energy efficiency programme becomes more difficult from the perspective of the amount of State support required.

Figure 73. Percentage of retrofit costs to be covered by a State grant for the *golden rule* – MID retrofit of an SFH1992 dwelling

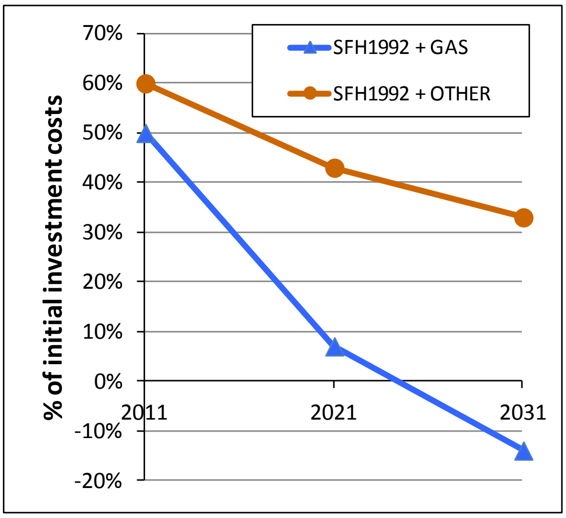
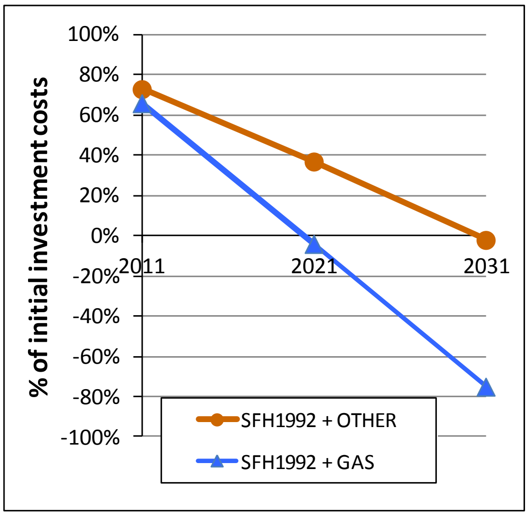


Figure 74. Percentage of retrofit costs to be covered by a State grant for the *golden rule* – DEEP retrofit of an SFH1992 dwelling



Source: model’s results

7.9.3.2. Measuring the State contribution in subsidies to implementation costs

The same calculations as in the previous sectionshave been replicated to all energy carriers in order to estimate the percentage of State support required in each building category and energy carrier. These percentages have been then used for estimating the total contribution of the State in form of grants or direct subsidies to retrofit costs. In concrete, this figure has been calculated and illustrated for the years 2014 (the peak year for MID and DEEP scenario total annual implementation costs because of the *ramp-up* period), 2020 and 2030.

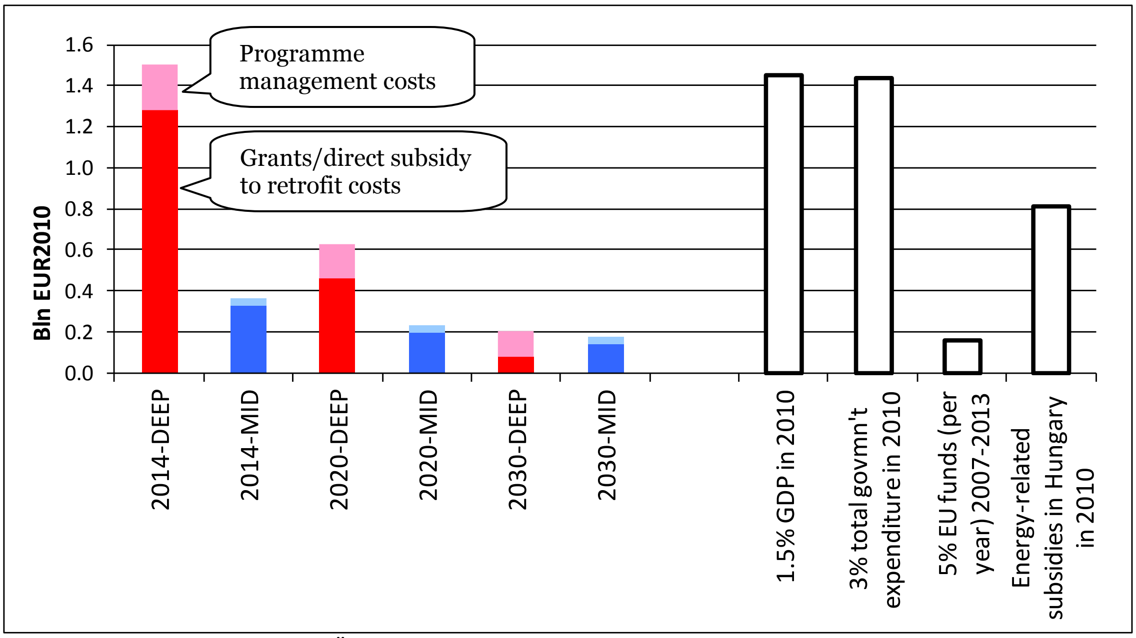
In addition, the model also considers programme management costs (e.g., informing and liaising with building owners and tenants, quality checks for retrofits, ensuring access to credit, facilitating agreements between neighbours, general administration of the State-supported programme, etc.), which are estimated at 10% of total annual 1st round DEEP retrofit costs and 5% for MID retrofits (see Section 8.2.2). The assumption is that these costs are borne entirely by the State in the form of an implementation agency, and therefore added to grant costs.

The results are presented in Figure 75 along with a range of comparative values, which indicates that the resources demanded from the State, though substantial (up to 1.4 billion Euros for the peak year of DEEP scenario), would not necessarily put a large burden on the State budget and could actually be covered by the reallocation of existing budget items or other sources of revenues (e.g., EU funds, cost-inefficient subsidies in the energy sector). More concretely, the peak 1.5 billion €$_{2010}$forecasted for 2014 in the DEEP scenario:

- is roughly equivalent to1.5% of Hungarian GDP in 2010 or 3% of the Hungarian government's total expenditure in 2010;

▪ could be partially covered through the reallocation of a number of energy-related subsidies (roughly 800 million Euros in 2010), many of which, according to Varró (2010), discourage investing in energy efficiency[89], increase the carbon intensity of the Hungarian economy or deliver expensive carbon emission reductions. This amount could be topped up with an increased allocation of EU funds, which, if it was the same as in the 2007-2013 programming period, could provide over 160 million Euros more per year[90](Ürge-Vorsatz et al., 2010).

Figure 75.Estimated total State contribution as subsidies to retrofit costs in MID and DEEP scenarios vs. relevant comparative figures



Source: model's results; Eurostat; Ürge-Vorsatz et al. (2010); Varró, 2010

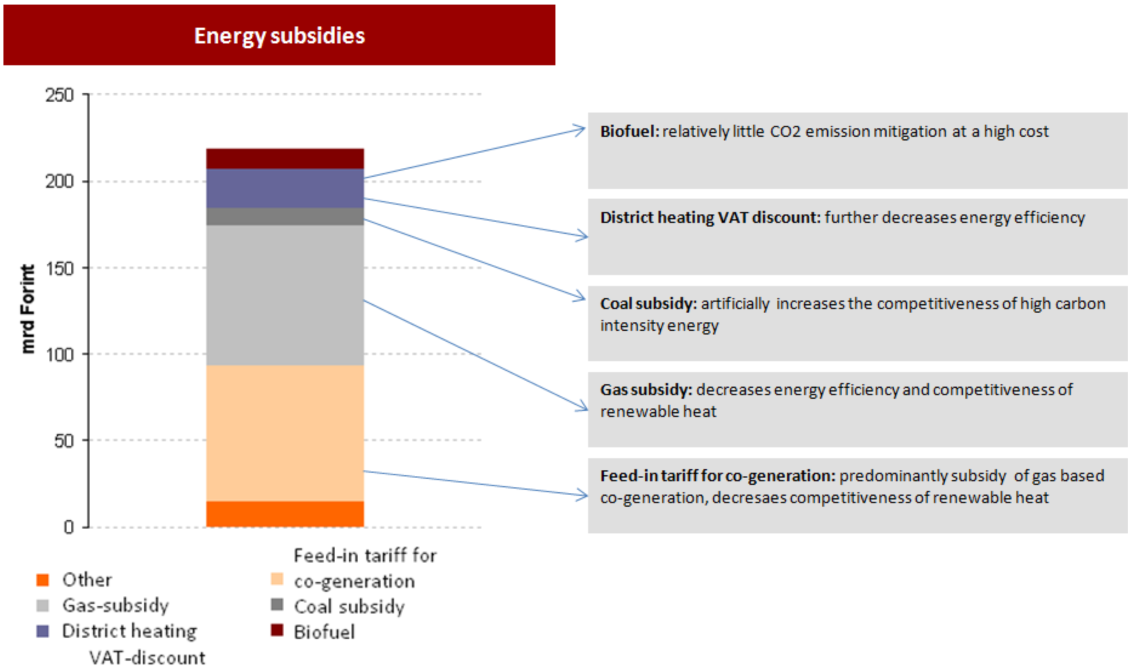
In addition, Figure 75 clearly indicates that the required State contribution shrinks rapidly (especially in DEEP scenario) because of the combined effect of increasing energy prices and the learning curve of retrofit costs. As a result, by 2030, according to the model's predictions,

[89] This includes the energy price support schemes presented in Section 7.2.2.1. However, as argued in Section 7.9.3.4, they cannot be fully substituted by residential energy efficiency until the whole stock has been upgraded to high energy performance levels.

[90] As recorded in the New Hungary Development Plan, Hungary will receive for the planning period 2007-2013 some 22.9 billion Euros (an average of 3.3. billion Euros per year) from three EU funds (European Regional Development Fund, European Cohesion Fund and European Social Fund). For that planning period, less than 1% is being used for energy efficiency projects in different end-use sectors. Assuming that the amount of EU funds received by Hungary after 2013 remains stable and that 5% is allocated to buildings' energy efficiency, some 160 million Euros would be available yearly for the State's financial contribution to the programme.

only around 70 million Euros would be required as State grants for DEEP retrofits, which is, in fact, less than the total funds required as State grants for MID retrofits in that year – see red and dark blue bottom part of the bars for the year 2030 inFigure 75.

Figure 76. Energy-related subsidies in Hungary for the year 2010 assessed from an energy efficiency and climate change mitigation perspective



Source:Varró, 2010

7.9.3.3. Implications for policy implementation

The results presented in the previous section vividly illustrate the real challenge faced by the practical implementation of ambitious residential energy efficiency policies: even if long-term estimates show that energy savings more than compensate the costs of the retrofit (i.e., the discounted value of total energy savings is higher than the discounted value of retrofit implementation costs), the programme would require a large scale subsidisation (over 50%) of retrofit costs for at least the first decade. These are quite substantial numbers that entail large scale involvement of the State. However, it is not very different to actual policy practice in Hungary, where the Panel sub-programme rununder the Green Investment Scheme (GIS) has provided grants covering up to 60% of the total cost of the retrofit in prefabricated buildings (Czakó, 2011). And experimental research has shown that households are particularly sensitive to the size of the State subsidy for deciding about the undertaking of a home energy efficiency renovation project (Alberini et al., 2011).

It can be nevertheless argued that the *golden rule* as defined in this theoretical exercise is too beneficial for households in the sense that energy savings, which increase steadily following energy prices, are always above loan payments, which are a fixed amount per month/year as defined by Excel's PMT function[91]. Besides, loan payments last for 15 years, whereas the retrofit can last for more than three decades before requiring a significant update. However, it is questionable whether households would engage in a programme that does not guarantee energy savings covering loan payments in the first years.

This reluctance is probably exacerbated by the uncertainty surrounding future energy prices (Alberini et al., 2011), as well as by the households' lack of savings or unwillingness to take a loan, especially if it is a mortgage requiring their home (often their most valuable asset) to be put as collateral. According to the Hungarian NGO *Energia Klub* (Fellegi and Fülöp, 2012), 75 to 85% of Hungarian households have no savings and 80% of those planning to invest on improving the energy efficiency of their homes are not willing to take a bank loan to cover the costs of the retrofit. Czakó (2011) also refers to this issue when acknowledging that Hungarian households seldom have enough savings to finance home renovations and are not capable to finance large investments even if they pay back over a certain period. To make things more complicated, the global financial crisis has led to the strengthening of the CHF (the currency in which many mortgage loans are presently denominated in Hungary) against

[91] The Excel PMT function calculates the payment for a loan based on constant payments and a constant interest rate once the following arguments have been defined: interest rate for the loan, total number of payments for the loan, and principal of the loan (Microsoft, 2012).

the HUF (*ibid.*). Combined with the currently uncertain economic conditions in the EU, this factor may increase households' reluctance to take a loan for financing the retrofits

In addition, the worse-off households – the ones more likely to be in fuel poverty – often lack information about the energy saving potential of their dwelling and about the technical and financial tools available, seldom have own funds to finance the upfront costs of the retrofit, experience more difficulties to access credit, may have more pressing priorities to be satisfied by extra funds, and are more likely to live in a rented dwelling (Brophy et al., 1999; Healy, 2004). These are all additional specific barriers to energy efficiency investments that would need to be addressed in a real policy package.

In connection withthis, a large discrepancy betweenthe costs of the retrofit (especially in the early years of the programme) and the current size of housing loans has been detected. Results from the model indicate that the total cost of retrofitting a dwelling in 2010 (5,300 to 13,800 Euros in MID scenario; 25,500 to 52,000 Euros in DEEP scenario – see Table 34) is largely above the current value of a loan for home modernization or enlargement (around 6,000 Euros) or even for buying a new home (around 20,000 Euros) in Hungary, as reported by the Central Statistical Office (KSH)[92]. However, if retrofits were subsidised by the percentages presented in Figure 71 and Figure 72, the actual cost for households in 2010 would drop to an average of 3,200 Euros (MID retrofits) and 7,600 Euros (DEEP retrofits), figures that are much more in line with the value of the housing loans currently taken by Hungarian households.

[92] According to data on housing credits retrieved from the website of the Hungarian Central Statistical Office (KSH), the average value (2000-2011) of a loan for home modernization or enlargement was 1.7 million HUF; the average value (also 2000-2011) of a loan for buying a new home was 5.7 million HUF. Moreover, the average term of these housing credits – 4.7 years for home modernization/enlargement and 17 years for buying a new home – as reported by KSH can be compared with the 15 years loan repayment period assumed by the *golden rule* for our calculations.

A positive feature of Hungary's residential stock are the high ownership rates, which is otherwise common in post-socialist countries where previously State-owned dwellings were transferred at low cost to residents in the 1990s. As shown in Table 35, 9 out of 10 dwellings are occupied by owners in Hungary. This is a relevant feature from the perspective of the actual implementation of a residential energy efficiency programme because it avoids the *split-incentives* barrier[93].

Table 35. Distribution of households (%) in Hungary by ownership/tenancy of the dwelling percentage points)

Dwellings occupied by	2000	2001	2002	2003	2004	2005	2006	2007	2008
Owners	89.3	89.4	89.5	87.9	90.0	89.1	87.2	91.4	92.7
Tenant	6.2	6.2	5.9	7.4	6.3	6.0	7.3	7.2	6.0
Others	4.5	4.4	4.6	4.7	3.7	4.9	5.4	1.4	1.3
Total	**100**	**100**	**100**	**100**	**100**	**100**	**99.9**	**100**	**100**

Source: Hungarian Central Statistical Office (KSH)

Finally, from the perspective of actual real policy implementation faces a much more complex reality made up of a very large diversity of dwellings and households (instead of just 6 representative building typologies). Every household occupies a dwelling with a different specific annual energy use per m^2, may rely on a different energy carrier or mix of carriers for space heating and has a different regime of occupation (and therefore a different total heating demand per year); even disregarding other important households features such as income and preferences, a fine-tuned implementation of the retrofit programme would require finding out the percentage of State grant required for each household to decide on the retrofit.

[93] In the case of residential energy efficiency investments, *split incentives* refer to the fact that, in rented dwellings, tenants and landlords will find it difficult to agree on the financing of the retrofit because, for instance, the former benefit from the energy savings but the latter bear the investment costs. It is known to affect low-income tenants in energy poverty (Bird and Hernandez, 2012).

7.9.3.4. Proposal for an optimal implementation sequence: maximising the NPV of an advanced residential energy efficiency programme in Hungary

The information provided with these results is expected to be helpful in various ways for moving towards a better implementation of an otherwise complex programme.

First, it offers preliminary, back-of-the-envelope estimates of the subsidies required by building type and energy carrier; these estimates could be refined with more detailed data on Hungary's residential building stock such as those contained in the recently collected Census 2011.

Second, it identifies which building typologies are most (Hist, SFH2010 and MFH2010) and least (TradMFH, SFH1992 and Panel) problematic for the perspective of financing. This is useful for devising a hypothetical alternative implementation path for minimising implementation costs.

At the moment the model assumes that the 100,000 retrofits per year forthe MID and DEEP scenario proceed in such a way that all building categories are retrofitted simultaneously at a rate equalto 100,000 units times the percentage in the 2010 total floor area of each building type. This is a straightforward assumption of the model, appropriate for a first approach but not very accurate from a real policy implementation viewpoint.

Thus an idea would be starting first with those categories with a better cost-to-benefit ratio like SFH1992, Panel and TradMFH. After a few years or even decades, when these *easier* retrofits have brought down the per-unit costs of DEEP retrofits, the programme could proceed with SFH2010, MFH2010 and Hist. The underlying hypothesis is that the experience gained with easyretrofits can be transferred to expensive retrofits (as long as experience in single-family and multi-family units accumulates), so that the learning curve assumption holds in this improved implementation path.

An improved implementation path acting first on building typologies with a better benefit-to-cost ratio (SFH1992, TradMFH and Panel) is likely to alter to some extent the results of the financial CBA. It would reduce the programme's total implementation costs and increase energy saving benefits in the first years or even decades. If calculated with an optimisation model, total discounted net benefits (i.e., NPV) could be maximised.

Implementing retrofits in this improved fashion would also be sensible from a fuel poverty alleviation perspective since it is suspected that majority of Hungary's fuel poor households dwell in the SFH1992, Panel and TradMFH categories – the ones to be retrofitted first.

In addition, the following elements are suggested for enhancing the policy realism of the proposal:

- Gas and DH price support schemes and similar direct income transfers (see Section 7.2.2.1) should be removed in parallel to the implementation of energy efficiency retrofits. In an ideal scenario, price- and income-support measures will be phased out as the programme progressively upgrades Hungary's residential stock.Potential drawbacks of this approach are the government's possible lack of resources to pay for both measures simultaneously until all units have been retrofitted, or the practical difficulties for coordinating the *phasing-out*of subsidies with the implementation of retrofits.
- The learning curve occurs, as anticipated, by the government's exerting a tight control over retrofit prices. This is particularly important fromthe perspective of the government's coffers, which will bear a large percentage of total implementation costs of the programme in the early years of the programme (Section 7.9.3.2). Therefore, competition between

firms should be ensured and bottlenecks in production factors (labour, materials or financial capital) avoided. Equally, subsidy-related inflation in retrofit costs (i.e. the cost of retrofits rising in accordance with the level of the State grant) should be considered and avoided in the design and implementation of policy measures.

- Equally, the government's implementation agency should guarantee the quality of the retrofits in order to ensure that they deliver the expected energy savings and remain functional for their expected lifetime. This is a crucial aspect because in a *pay-as-you-save* scheme energy savings are the main source of households' revenues for repaying the initial costs of the retrofit.
- Conventional energy efficiency programmes do not address the above-mentioned specific barriers experienced by fuel poor (or more generally low income) households, such asthe lack of access to credit or access to information. Specific tools such as door-to-door information campaigns, preferential interest rates, or additional grants for covering initial investment costs are probably needed to ensure that these households benefit first from the intervention.

Chapter 8

SOCIAL COST-BENEFIT ANALYSIS

"We have to empower ourselves. Look at those people who live on sordid housing estates. They expect others – the Government – to do everything for them. They are only half human, because only half active. We have to find a way to enable them to grow. Individual human flourishing isn't something that either socialism or conservatism caters for"

Hanif Kureishi -*The Buddha of Suburbia*

8. SOCIAL COST-BENEFIT ANALYSIS

8.1. INTRODUCING THE SOCIAL CBA

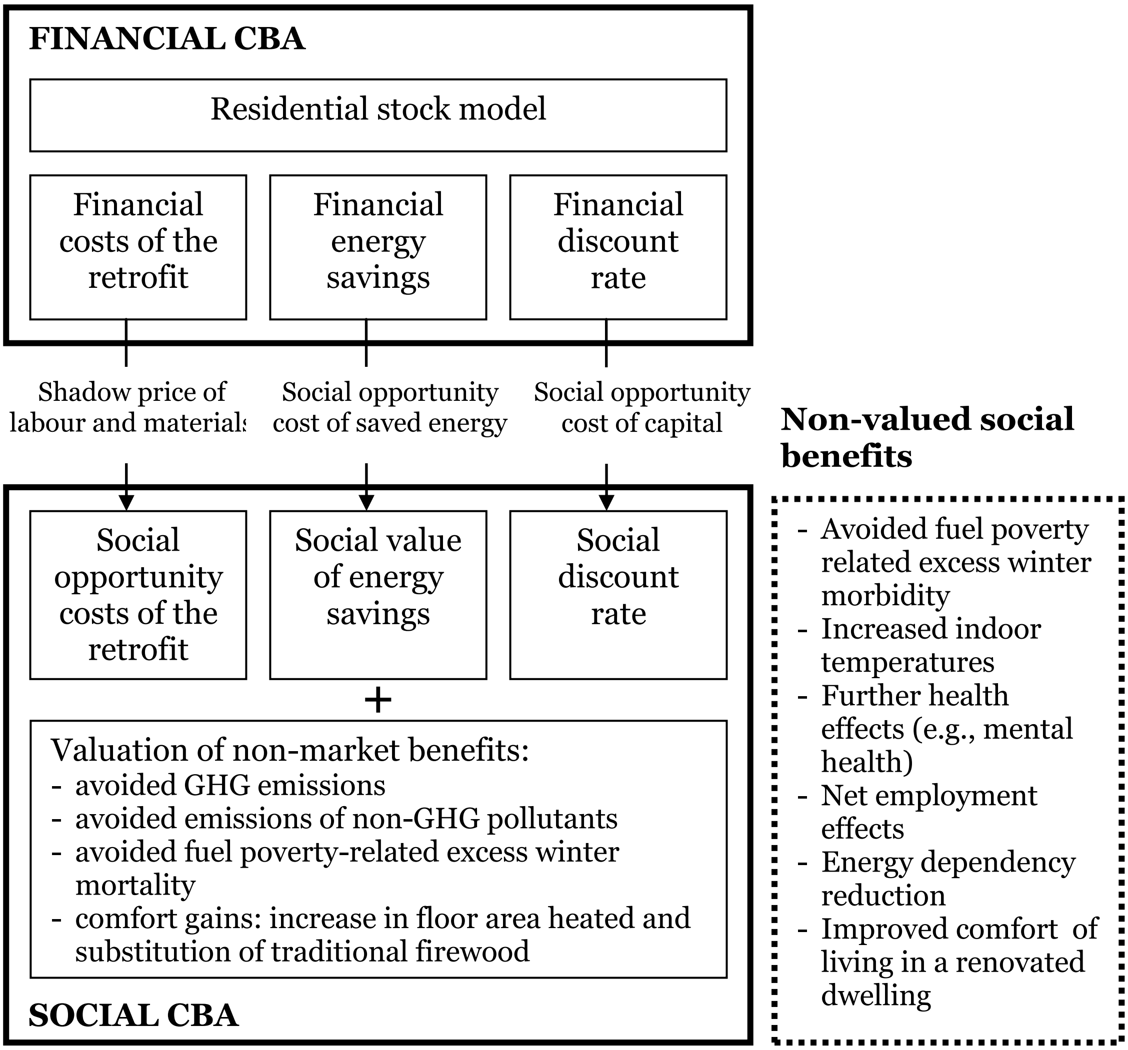
8.1.1. Key elements

The social CBA presented in this chapter is based on Clinch and Healy (2001), whose incorporation of fuel poverty-specific benefits still represents a milestone in the field. Besides the dissimilar geographical and socio-political contexts (Hungary vs. Ireland), key differences with the Clinch and Healy study is that I do not incorporate positive morbidity effects derived from fuel poverty alleviation (because of lack of data for Hungary), the different approach used for valuing comfort gains and the consideration of two different energy efficiency scenarios (MID and DEEP).

A summary of the market and non-market benefits considered in this exercise, as well the key methodological specifications of the social CBA taking as a point of departure the financial CBA, are shown in Graph 1. The latter basically means correcting the price and cost data collected for the financial CBA; valuing non-market benefits (i.e., co-benefits other than energy savings) that are not considered in the financial analysis; and applying a social discount rate (see Section 3.2.3). All of these elements are described in detail throughout this chapter.

Graph 1 also lists other relevant social (non-market) benefits that were not computed because of lack of data or valuation methodologies. Unless these non-computed benefits are totally offset by non-computed costs (e.g., transaction costs), it can be assumed that the results of this social CBA (net present value for the two defined scenarios, see Section 8.6) is an underestimation of the net positive welfare gain experienced by Hungarian society in the long-term.

Graph 1. Methodological summary of the social CBA



Source: own elaboration

8.1.2. Geographical scope of the social CBA

The cost-benefit analysis is realised at a national scale. This means that variations in the aggregated wellbeing of the population residing in Hungary are measured.

A main reason for this is that energy efficiency policies are still defined to a good extent (even in the context of the EU) at a national level and taking into consideration national priorities and interests. Though reducing building-related carbon emissions has substantial positive impacts in terms of global climate change mitigation, it can be assumed that this is an aspect of lesser relevance to national decision-makers. This may well be the case of CEE countries like Hungary, where current GHG emissions are below Kyoto Protocol targets and there is no significant pressure either to comply with forthcoming mid-term (2020 to 2030) climate commitments.

A direct consequence of this methodological assumption is the valuation of social benefits only as those positive welfare effects perceived by the Hungarian society. This way, for instance, avoided GHG emissions is estimated by the revenues obtained by the Hungarian government from the sale of the country's surplus emissions quota (*hot air*) to international buyers (see Section 8.3.2.2). Consequently, reduced carbon emissions have a value even for a totally climate-change sceptical Hungarian decision-maker.

There is one exception to this rule, which is the value of avoided non-GHG emissions. In this case, the external cost of emission employed for their valuation is regional (calculated for Hungary and the rest of Europe) because no Hungary-specific values could be located.

8.1.3. Additional social costs and benefits

Similar to the financial analysis, both MID and DEEP scenarios are compared against a *business-as-usual* or BASE scenario in order to calculate the incurred social costs of implementation and the accrued benefits in terms of energy saving, reduced mortality and emissions and increased comfort levels.

However, it must be noted only MID and DEEP scenarios deliver mortality and comfort benefits (as defined in this exercise) as the BASE scenario is not intended to reduce fuel poverty-related excess winter mortality, increase the fraction of floor area heated or decrease fuel substitution (natural gas vs. firewood) rates – see Section 8.3.

8.2. SOCIAL COSTS

8.2.1. Retrofit costs: 1st and 2nd round

8.2.1.1. Criteria for correction

For their incorporation into the social CBA, the financial costs of the analysed scenarios need to be corrected. Following EC (2008) and Bann (1997), taxes like VAT and personal income tax have to be deducted from the price of inputs and outputs because they are income transfers that do not account as welfare losses, i.e., they are taxes collected by the government and then redistributed to citizensas public expenditure. For the same reason, subsidies granted to a project by a public entity should be also deducted.

However, contributions to the social security and pension funds, which are not taxes, are not subject to this fiscal correction. These are payments for which the services are provided in return (e.g., healthcare, unemployment benefits, disability or retirement pensions, etc.) and therefore are not regarded as income transfers.

Additionally, labour costs have to be corrected with a shadow wage factor. The economic rationale is that they should reflect the social opportunity cost of labour: if the labour used for the project in question may go unemployed in the absence of the project, then its shadow price should be below the wages paid. Consequently, in the case of a competitive labour markets with little or frictional unemployment, shadow wages are close to actual wages. In sectors with involuntary (e.g., structural or cyclical) unemployment, shadow wages should be at least equal to the reservation wage or approximately equal to the unemployment benefit (Pearce et al., 2006; EC, 2008a).

Finally, credit-related payments (i.e., loans, receipts, principal and interest repayments) are also considered transfer payments with no impact on society's aggregated welfare (Aylward, 1994; in Bann, 1997). An additional reason suggested to remove financial transactions from social CBA is that these are implicitly in the discount rate applied to calculate the NPV of net benefits.

Thus the cost of financing the retrofits through for instance household loans or public debt has been disregarded in the social CBA. However, if the programme entails substantial borrowing from international financial markets (e.g., by issuing government bonds, or commercial banks borrowing from foreign financial institutions), interest repayments constitute a net outflow of resources that should be accounted for since this social CBA is conducted from the perspective of the aggregated welfare of Hungary's society.

8.2.1.2. Corrected retrofit costs

Financial costs per square metre for the three scenarios coming from Ürge-Vorsatz et al. (2010) have been presented in Section 7.5.2.1 and are net of subsidies. They have been corrected by assuming, first, a 75%-25% split of material-labour costs and the *crew composition* of energy efficiency retrofits shown in Table 28. These values come from the original building and employment model upon which the social CBA is based (Ürge-Vorsatz et al., 2010).

Table 36.*Crew composition* (percentage of skilled vs. unskilled labour in retrofits)

	BASE	MID	DEEP
Skilled labour (professionals + skilled construction labourers)	70%	87%	77%
Unskilled labour	30%	13%	23%

Source: Ürge-Vorstaz et al. (2010)

The following correction factors have been then applied throughout the whole modelling period (until 2080):

- Two different rates based on current tax regulations (Deloitte, 2011) are applied for the deduction of personal income tax from labour costs. A 16% rate is applied to unskilled labour assuming that the typical annual salary of a construction labourer in Hungary is below the 2.4 million HUF per year threshold (€8,400 approx.). A higher 20.3% rate (according to the Hungarian legislation, this is calculated as a 16% of the taxable base multiplied by a factor of 1.27) corresponds to professional and skilled construction workers, whose annual salary is assumed to be above that limit.
- The shadow wage of skilled and professional workers is 90% of their actual wages (conversion factor = 0.9). The original correction factor suggested by EC (2008a) is 1 but the 0.9 factor was applied in order to reflect the relatively high unemployment even among skilled workers as a consequence of the post-2008 economic crisis.
- The shadow wage of unskilled labour is 60% of their wages (conversion factor = 0.6). This is the factor recommended by EC (2008) because of the higher unemployment of this sub-sector of the labour market[94].
- A conversion factor 0.73 is applied to material costs, which is derived from the current standard VAT rate for the Hungarian economy (27%).

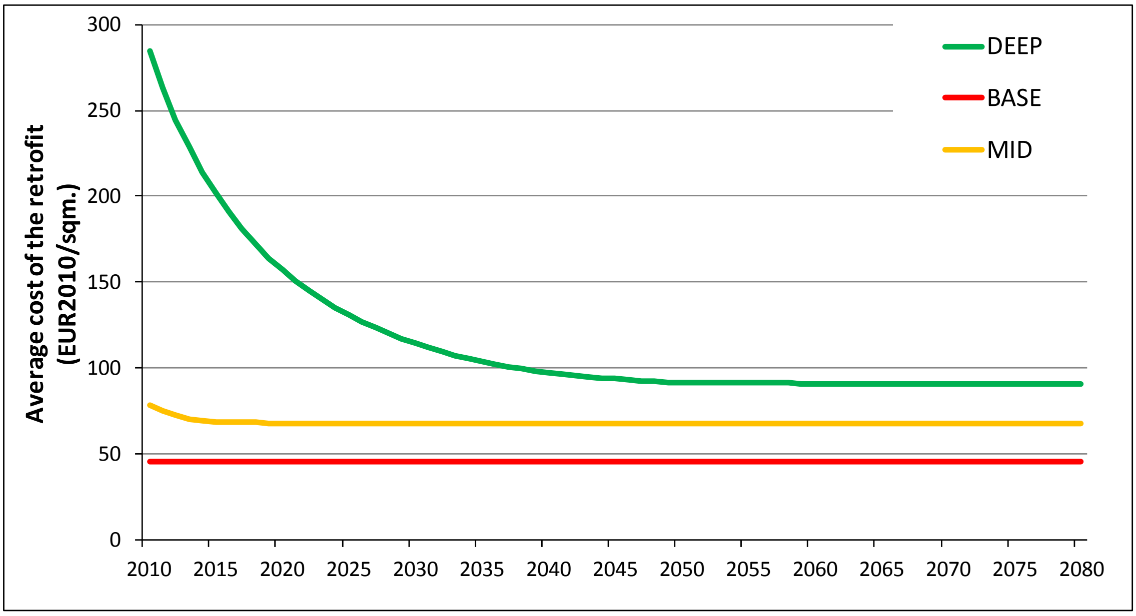
These values result in an implicit conversion factor of 71-72% for retrofit costs of all three scenarios (i.e., the per unit costs of retrofits in the social CBA are 71-72% of financial costs). For a comparison, a general conversion factor of 0.6 (60%) is suggested by EC (2008a) for

[94] In Hungary, unemployment rates in the last 3 years (from 2009 to 2011) have ranged between 10 and 11% according to Eurostat data. This indicates that the Hungarian economy is not in full employment. Unemployment rates are suspected to be among unskilled workers.

general construction activities in the EU. The latter is a less conservative factor than the one applied in my social CBA for Hungary.

This procedure for the correction of financial costs is applied to both 1st and 2nd round retrofit costs.

Figure 77. Average retrofit costs for the three defined scenarios.



Note: weighted average is estimated using as a weighting the share of total floor area of each of the 6 building typologies in the 2010 residential stock. This is a simplification because the proportion changes slightly during the modelling timeframe because of the different implementation and cessation rates of each building typology.
Source: Ürge-Vorsatz et al. (2010), EC (2008) and author's assumptions

As discussed in Section 7.5.2.3, the cost of DEEP and MID retrofits is assumed to decrease in order to reflect the effects of mass production and economies of scale. It is assumed that the same learning curve applies to the corrected costs of retrofits as in the financial analysis; thus 1st round retrofit costs decrease as shown in Figure 55.

8.2.2. Programme management costs as transaction costs

A number of transaction or *hidden* costs are present in a retrofit programme such as the one envisioned by MID and DEEP scenarios. They often correspond to the market barriers to be surpassed for an effective implementation of energy efficient retrofits (e.g., lack of information, restricted access to capital, etc.). They may account for items or tasks such as informing and liaising with building owners and tenants, quality checks for retrofits, ensuring access to financing of individual households, facilitating agreements between neighbours (in multi-family buildings), temporary relocation of dwellers during retrofit works, general administration of a State-supported programme, etc. A fraction of those transaction costs will be borne by the government, probably in the form of an implementation agency.

Its incorporation in the social CBA is justified because transaction costs represent either lost resources (e.g., labour) that cannot be used with any other purpose or negative welfare effects for which willingness to pay or to accept can be defined. However, little information is available on their size in energy efficiency interventions in the residential sector.

Inthe DEEP scenario, the approach adopted consists of estimating transaction costs as equal to 10% of retrofit costs (only for 1st round retrofits). This percentage has been obtained from a UK exemplary demonstration project of low carbon social housing retrofit that has managed to reduce the carbon emissions of 14 social housing properties by 70% to 80% using a range of energy efficiency and renewable energy measures. In particular, its managers estimated a 10% of *hidden* costs of the staff required for fund raising and liaising with tenants and communities (Radian,2010). With this approach, transaction costs are basically incorporated as programme management costsin the form of a State-backed implementation agency. The idea is that a large scale upgrade of a country's residential stock necessarily requires the involvement of the State and consumes resources additional to those employed in retrofit activities.

In the MID scenario, the assumption is that only half of the transaction costs (5% of 1st retrofit costs) have to be incurred. No transaction costs are foreseen for BASE scenario.

Additionally, it was assumed that project management costs of the DEEP and MID retrofits are fully made up of skilled labour (e.g., employees of a government unit and/or sub-contracted agent in charge of promoting the retrofit programme among the public, informing households, preparing project proposals, reaching agreements, ensuring the quality of the retrofit and facilitating the whole process in general).

Consequently, in order to be incorporated into the social CBA, transaction costs have been first corrected exactly like skilled labour in retrofit costs(see previous Section): taxes have been deducted by applying the 20.3% personal income tax rate of skilled labour and then a 0.9 shadow wage correction factor has been applied.

This approach to the valuation of transaction costs only considers those borne by the State. However, households themselves bear a large fraction of the transaction costs such as the hassle of finding builders, putting up with the disruption and nuisance associated with building works, etc. Since no reliable estimate for the latter has been located, the issue of households-borne transaction costs has been dealt with only in the sensitivity analysis – see Section 8.7.2.5.

8.3. SOCIAL BENEFITS

8.3.1. Energy saving benefits

8.3.1.1. Corrected energy prices in 2010

The rationale for the estimation of social energy saving benefits is different from the one applied to the financial CBA. In the latter, data on the residential pricesof energy carriers as reported by Hungarian Energy office and similar sources have been used. However, in the social CBA energy savings are valued with a corrected price in which taxes and fixed costs are deducted. The reason is two-fold: on the one hand, redistributive taxes are deducted, as in the corrected costs of the retrofit; on the other hand, fixed costs (e.g., capital amortisation, plants and network maintenance, etc.) are not considered because no matter how much energy is consumed after the retrofit, society has to incur these costs to keep its DH and electricity supply systems running[95]. In the long term, this assumption is likely to underestimate the value of energy savings because, being the domestic sector Hungary's largest energy-consuming sector, the predicted large drop in total consumption should result in a reduction of its generation and distribution capacity..

For natural gas, the import price was used as per unitvalue of each unit of this fuel saved by scenarios. The import priceapplies to both imported and domestically produced natural gas – Note that domestic production,provided that in 2009 only 25% of the country's gas demand and is declining (OECD/IEA, 2012a). The rationale is that the economic value of domestic production cannot be below that of imports because otherwise domestic sources would be prioritised;the import price thus determines the value of alternative (domestic) sources as well. By using the import price of natural gas, taxes and fixed costs (i.e., gas distribution net work operation and maintenance) are automatically excluded.

[95] The only exception is firewood, for which the price after taxes is supposed to be entirely made up of variable costs (e.g., extraction, processing, transportation, etc.).

In the case of Hungary, the former Soviet Union is practically the only source of imported natural gas. However, since import prices are usually undisclosed, the value was obtained through a consultation with Kornél Andzsans-Balogh, research associate at the Regional Energy Research Centre (REKK) of Budapest's Corvinus University. Quoting the Russian journal Vedomosti, the price reported by this researcher was €348 (with an uncertainty range of €327-383) per tcm (thousand cubic meters). It was then converted into $€_{2010}kWh^{-1}$ through the Federal Reserve 2010 US$-€ exchange rate and the net calorific value (NCV) of Russian natural gas (33,820 KJ m^{-3}) reported by OECD/IEA (2010b) because, as indicated by Andzsans-Balogh (pers. comm.), long term import contact settlement price for Russian natural gas are determined on an NCV basis.This is needed for ensuring consistency with the NCV-based financial prices of natural gas and other energy carriers (see Section7.6.1.1).

The procedure followed for electricity and DH prices was different because both are produced energy carriers as opposed to raw fuels like natural gas or firewood. For those, the social value of saved energy was approximated through the percentage of the residentialretail price of electricity and DH corresponding to variable part costs.

It was thus assumed that the corrected cost of electricity in Hungary is 40% of its financial price following Treso (2008) and Capros et al. (2009), which estimated that this is the percentage corresponding to fuel and other variable costs in the domestic price of electricity. For DH, an equivalent conversion factor of 56% was applied following data of the *Magyar Távhőszolgáltatók Szakmai Szövetségé* – Hungarian Professional Association of District Heating Providers (Sigmond, 2009). Since the efficiency of heat conversion of both DH and electricity is assumed to be 1 (every kWh that reaches the dwelling is converted into one kWh of effective heat), these prices are also NCV-based, like in the financial analysis.

Finally, for the *other fuels* category, the only correction was the deduction of redistributive taxes (VAT=27%) from the NCV-based per unit cost of firewood used in the financial analysis. This corrected price – 73% of the financial price of firewood – incorporate all production, processing and transport costs of firewood supply. These are all supposed to be variable costs. Besides, it is assumed that there is not unsustainable depletion of biomass resulting in externalities (i.e., deforestation leading to a reduced provision of ecosystem services such catchment area protection, provision of recreational area or carbon storage). While this assumption may hold at the national scale given the large amount of available biomass in Hungary, an unsustainable use of wood could occur at smaller scales.

The corrected price of the four energy carriers considered is summarised in Table 37. They are below (and sometimes well below) the prices used in the financial analysis (see Table 31), as expected. It can be also noticed that the corrected price of electricity and DH is below that of firewood as a result of the conversion factors applied to their financial prices (40 and 56%); this is consistent with the fact that only the variable costs of DH and electricity are accounted for in the social CBA (see above).

Table 37. Corrected price of energy carriers

Energy carrier	Selected value [$€_{2010}$ kWh^{-1}]	Source	Comments
Natural gas	0.028	Andzsans-Balogh, pers. comm.	Import price of Russian natural gas. Reported original source: Vedomosti journal (2010).
Electricity	0.062	Hungary Energy Office (MEH); Treso (2008)	Percentage of variable costs (40%) of the financial price of electricity
DH	0.023	Hungarian Professional Association of District Heating Providers (Sigmond et al., 2009; pers. comm.)	Percentage of variable costs (56%) of the financial price of DH
Firewood	0.027	Dibáczi et al. (2010) minus VAT	Financial price of firewood minus VAT (27%)

Source: author's collection (see table)

Note that in this case the rebates provided by State household support schemes (*gázártámogatás* and *távhőtámogatás*) are not relevant, unlike in the financial analysis. The reason is that this kind of subsidy, like some taxes, are redistributive: resources are simply transferred from taxpayers to the beneficiaries of the subsidy, which assumedly has a zero net impact on society's aggregated welfare.

8.3.1.2. Forecast increase in energy prices

The predicted increase in the corrected price of energy carriers follows the same functional form (Equation 1) as in the financial analysis. In the first year (2010 to 2011) it applies the percentage of increase recorded in the previous years (r1) reduced at a known rate (r2) in subsequent years.

Table 38. Forecasted increase in real energy prices, value of the parameters for Equation 1.

Energy carrier	r_1: annual increase in price in year 1 – 2010 to 2011 (%)	r_2: mitigation factor (%)
Natural gas	10%	10%
Electricity	2.7%	5%
DH	10%	10%
Other fuels	3.5%	5%

Source: author's assumptions based on data from OECD/IEA (2010a) and the Hungarian Central Statistical Office (KSH)

For electricity and other fuels (firewood), the value of both r1 and r2parameters is the same as in the financial analysis (see Table 38).The idea is that since corrected prices of these energy carriers are just a percentage of the prices used in the financial analysis, it is assumed that they increase at the same rate based on KSH recorded data on energy prices. In the long run (by 2050), this results in the price of electricity and 'other fuels' being 59 and 83% higher than in 2010 – see Figure 60.

The situation with natural gas and DH is a bit different. In the case of natural gas, import prices from Russia (see above) are the reference for the estimation of the rate of increase in the first year (r_1). Real (i.e., inflation-corrected) prices of imported gas obtained from

OECD/IEA (2010a) have grown at a fast rate between 2004 and 2009, almost doubling in that period (from 0.011 to 0.020 $€_{2010}$ kWh^{-1} – see Figure 79). Thus a high value for parameter r_1(10%) has been adopted. This is an author's assumptionwhich isin any case below the 13.5% average yearly increase rate calculated from OECD/IEA (2010a) data for the period 2004-2009. The decision to apply a lower r_1 is due to the uncertainty surrounding future import prices of natural gas in Hungary, which may not grow at the same high rate as in 2004-2009.

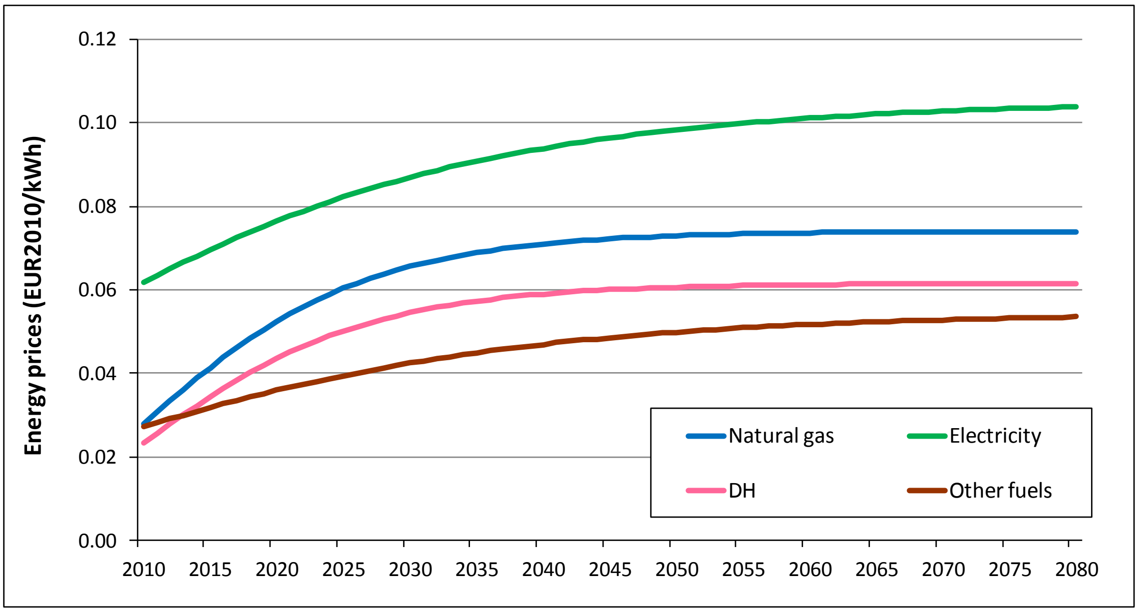
Since natural gas is the main fuel used in Hungary's DH system, the same value for parameters r_1 and r_2 (10% and 10%) has been applied to DH – see Table 38.

The consequence is that the corrected price of DH and natural gas evolve in parallel and are largely decoupled from electricity and firewood. By 2050, they are 160% higher than in 2010 (see Figure 60). This is of course a large increase but in any case not as aggressive as the actual increase recorded for Hungarian gas import prices in the period 2004-2009 – see the comparison of gas price index in Figure 79.

This forecast can also be compared with the historical evolution of the price of domestic natural gas in Hungary, which experienced a more than 4-fold increase between 1990 and 2005[96] according to OECD/IEA (2007) – see Figure 80.

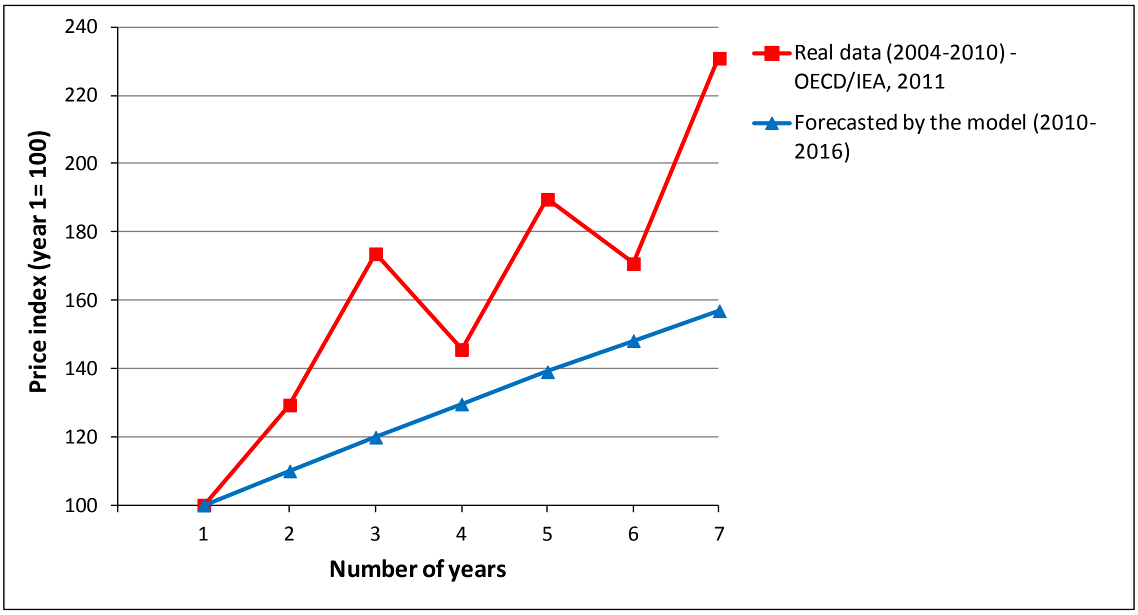
[96] This increase is likely the result of the liberalisation of energy markets occurred as a consequence of the post-1989 changes in the political and economic system. It cannot be extrapolated to other periods but illustrates that increases in energy prices much more radical than the one assumed in the CBA model have in fact occurred in the recent past.

Figure 78. Forecasted increase in real energy prices in the social CBA



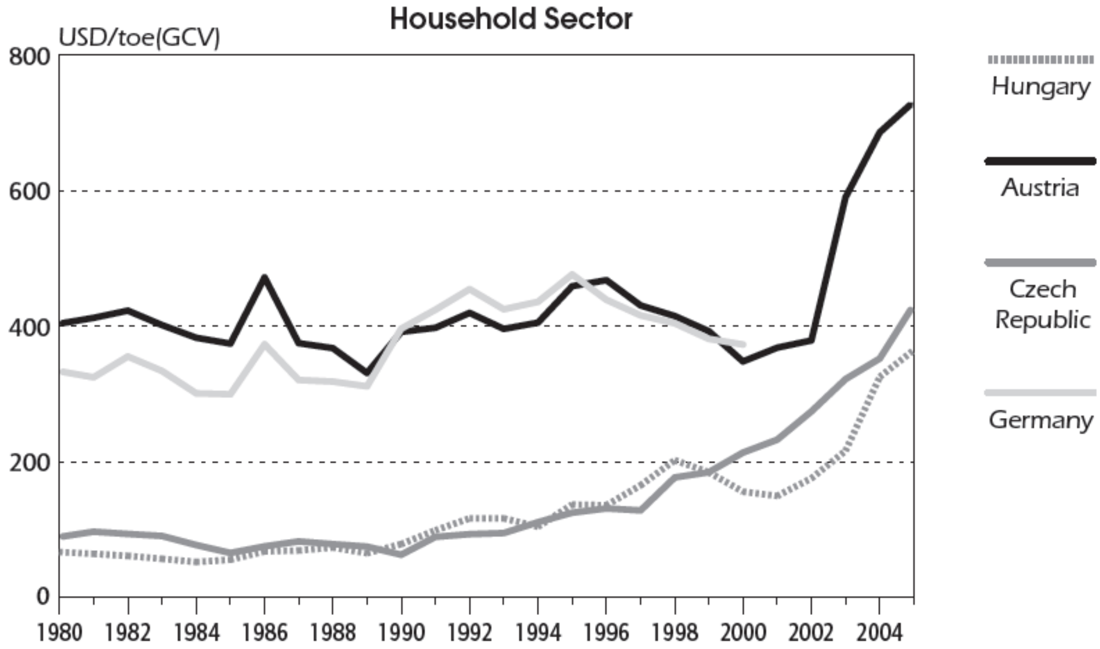
Source: Ürge-Vorsatz et al. (2010); Hungarian Central Statistical Office (KSH); OECD (2010); author's assumptions

Figure 79. Forecasted increase in the corrected price of natural gas in 2010-2015 vs. actual (recorded) increase in import price of natural gas in 2004-2009 (year 1 = 100)



Note: prices normalised to 100 theoretical units corresponding to the year 1 of each of the series
Source: OECD/IEA (2010a); model's results

Figure 80. Evolution of domestic gas prices in Hungary and other IEA member countries



Note: the original source does not detail whether prices are in nominal or real (deflated) US$D/toe
Source: OECD/IEA (2007)

Finally, an alternative authoritative source – the IEA's World Energy Outlook 2009 (OECD/IEA, 2010c – forecasts a more modest increase in the import prices of natural gas in Europe (35% by 2030 in the reference scenario). However, for the purposes of this analysis energy (gas) price forecasts based on Hungary-specific data are considered preferential.

8.3.2. Avoided GHG emissions

8.3.2.1. GHG emission factors

All four energy carriers (natural gas, electricity, DH and other fuels/firewood) are considered for calculating the net additional change in total emissions levels occurred following the implementation of MID and DEEP scenarios. These emissions correspond just to energy for domestic space heating in the 2010 Hungarian residential stock.They refer only to fuel combustion, and therefore no lifecycle emissions are included (e.g., construction and decommissioning of power plants or pipelines, production of insulation and other materials for the retrofit, etc.).

The emission factors for natural gas and the category ‘other fuels’ (firewood) are the default values recommended by IPCC (2006) National Emission Guidelines for stationary residential/agricultural combustion. As indicated in the original source, both are based on net calorific value, i.e., on the kWh actually delivered as heat to the residential space, discounting those consumed during the combustion process.

The emission factor for *other fuels* corresponds to wood and wood waste (IPCC, 2006). However, it is reasonable to assume that part of the carbon contained in the firewood would have beenreleased anyway in the medium to long-term through natural biomass decay processes. For this reason, the value of this benefit is overestimated to some extent.

The emission factors for electricity and DH come from Novikova (2008), whose estimates are based on total energy generation in Hungarian power plants. Though unclear, may they correspond to gross energy use rather than to energy actually served in residential buildings.f such is the case, then the emission factors for these two energy carriers will be slightly underestimated as compared to those from natural gas and ‘other fuels’. However, this is thought to have little impact on final results.

Table 39. Emission factors of the energy carriers used for residential space heating in Hungary.

Energy carrier	**Emission factors [$gCO_2eq\ kWh^{-1}$]**[1]			**Source**	**Comments**
	2010	*2015*	*2020 and beyond*		
Natural gas	202.5			IPCC (2006)	Default emission factors for stationary combustion in the residential category on a on a Net Calorific Basis.
Electricity	336	300	326	Novikova (2008)	Only incorporates CO_2 emissions (no other GHG such as CH_4 and N_2O)
DH	208	178	167	Novikova (2008)	
Other fuels	217.2			IPCC (2006)	Default emission factors for stationary combustion in the residential category on a on a Net Calorific Basis. Reduced by 50% following author’s assumptions.

Notes: 1) Only for natural gas and other fuels (i.e., firewood), for which CH_4 and N_2O emission factors were available.
Source: see Table.

Emission factors are expressed in equivalent GHG emission units (CO_{2eq} kWh^{-1}), though this is only strictly true for natural gas and 'other fuels' because CH_4 and N_2O emission factors were available in the original source (IPCC, 2006). They were later converted into CO_{2eq} kWh^{-1} through IPCC's global warming potentials (GWP) at 100 years – 25 for CH_4 and 298 for N_2O (Forster et al., 2007). Non-CO_2 emissions were not available for electricity and DH in the original source (Novikova, 2008). The error is probably small[97] and in the worst case results in a more conservative social NPV.

Emission factors for natural gas and 'other fuels' are assumed to remain constant for the whole modelling period. Emission factors for electricity and DH obtained from Novikova (2008) include the foreseen changes in the fuel mix used for power and heat generation and the efficiency increase of power plants. Values for 2010, 2015 and 2020 were available from this source and then interpolated for the years in between. However, forecasts are only available for the period 2010 to 2020. Further reductions may be expected after 2020, especially if the power sector keeps on decarbonising by substituting conventional fossil fuel - based power generation with renewable power generation.

8.3.2.2. Per unit value of avoided GHG emissions

The valuation of this social benefit is often done on the basis of the avoided external cost of emitting one additional unit of additional carbon. This approach can be operationalized through the so-called social cost of carbon (SCC), i.e., the net present value of the impact on global welfare of emitting one additional unit of GHG today, which according to IPCC (2007a) is in the region of the US\$ 50 tC^{-1} – equivalent to 13 $€_{2010}$ tCO^{-2}_{eq}.

[97] In the case of natural gas and other fuels, CO_{2eq} kWh^{-1} emission factors are just 8% and 0.3% higher than their corresponding CO_2 kWh^{-1} factors respectively, according to IPCC (2006) default values.

However, even though an SCC-based alternative approach accounting for a global impact on welfare is possible (and actually recommended – see EC, 2008a), this exercise has chosen a different approach based on the value of those avoided emissions for the Hungarian (and not global society). The reason for this is that the geographic scope of the proposed social CBA has been purposely set at the national level. By doing so, it prioritises Hungary's welfare over global welfare, which allows understanding the sort of incentives that a Hungarian decision-maker has for pursuing certain residential energy efficiency targets even when global climate change does not rank high (or at all) in his or her priorities.

In this logic, one first alternative would be valuing avoided emissions on the basis of the cost of emitting one additional unit of GHG. This approach is unfeasible because so far only global estimates of the SCC exist, even though it is understood that different world regions will be affected to a different extent by climate change (IPCC, 2007).

Another more practical option is estimating the value of this social benefit through the price of emission permits. In Hungary, which currently has a surplus of Assigned Amount Units (AAU) allocated under the Kyoto Protocol, this unit has been chosen because it fits better with the characteristics of the exercise. Surplus AAUs or 'hot air' in Eastern Europe result from the large economic downturn experienced by this region in the 1990s. In these countries the baseline for Kyoto mitigation targets was often set in the late 1980s and therefore is substantially higher than current emission levels. Surplus AAUs can be sold to Annex-I countries in need of extra AAUs under the rules of the Kyoto Protocol (article 17 on International Emissions Trading) through a Green Investment Scheme (GIS). The GIS arrangement establishes that the revenues from the sale of surplus AAUs have to be invested in mitigation activities in order to be acceptable to the buyer. This mechanism has been used by Central and Eastern European countries (including Hungary) as a carbon finance instrument (Tuerk et al., 2010).

In other words, the price of AAUs is the actual value that Hungarian society receives from foreign buyers for contributing to mitigating climate change. This figure bears no (or very little) relation to the economic value of mitigated climate change in Hungary (e.g., less frequent floods in Tisza basin, lower summer demand of air conditioning, etc.), which is unknown. It just represents the additional resources earned by the Hungarian society for its commitment with climate change mitigation.

In conclusion, the sale price of AAUs through a GIS is used as the per unit value of reducing carbon emissions for this social CBA. However, two important aspects need to be considered:

- Not all surplus AAUs are actually sold. In fact, only a fraction of the ‘hot air’ owned by countries of Eastern Europe is being traded. In this context, the question should be asked, why is it correct to assume that the emissions avoided by the MID and DEEP scenarios are precisely the ones to be valued with that price? The functioning of GIS provides a good reason: GIS funds obtained from AAU revenues in Hungaryare being used primarily in projects or programmed aimed at reducing energy consumption in the building sector (Sharmina et al., 2008; Ministry of National Development, 2011). Thus from the perspective of buyers, this is precisely the sort of quality, “greened” AAUs that they are willing to pay for.
- AAU sale through GIS is a very short-term institutional arrangement between carbon emission credit buyers and sellers, especially if compared to the long timeframe used for the analysis (beyond 2050). Even though similar arrangements may appear in forthcoming Post-Kyoto agreements, the conditions enjoyed by current AAU sellers may change if, for instance, more stringent national emission targets than the ones of the Kyoto Protocol are

set (thus reducing the current amount of surplus AAU available by AAU holders). However, even if Hungary eventually becomes a buyer, the logic of the valuation exercise still holds; in that case, the value of avoided emissions is no longer the sale price of surplus AAU but the avoided cost of acquiring, in international markets, emission permits that allow Hungary comply with its national emission target. However, it is unclear to what extent the price of currently traded AAUs can be representative of the international market price of emission permits in 30, 40 or 50 years' time.

Even though AAUs only account for a small portion of the global carbon market, there is some evidence that increasing AAU sales in the late 2000s were challenging primary CDM and JI markets (PointCarbon, 2009). This may indicate that AAUs are functioning as a substitute of Certified Emission Reductions (CER) and Emission Reduction Units (ERU) coming from CDM and JI projects. There is nevertheless little information about the price of AAU transactions, which usually is not publicly disclosed.

For Hungary, Sharmina et al. (2008) and Pointcarbon (2009) have reported a price of €13-15 per tCO_{2eq} for a sale of 2 million units to Belgium in September 2008, with another source quoting in 2009 a price €13 per tCO_{2eq} for the combined 8 million AAU sale to both Belgium and Spain that took place in 2008 (ICISHeren, 2012). This was a record-high price for this sort of transactions according to the latter source. Other sources have informed about prices in the following ranges:

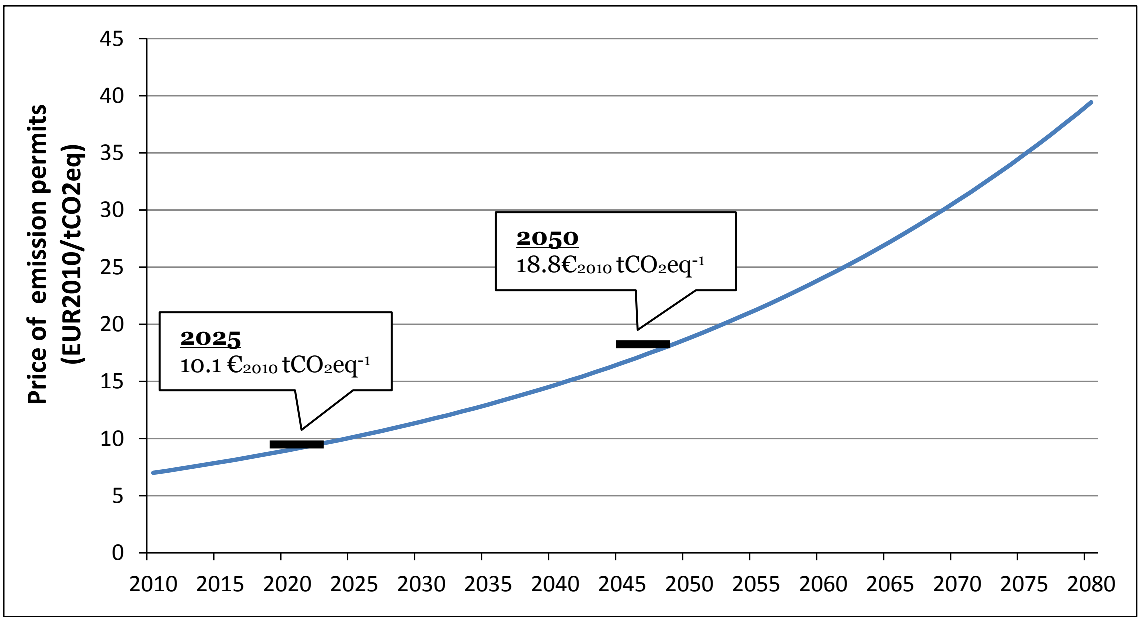
- Tuerk et al. (2010, p. 30) state that "while greened AAUs were assumed to be traded at about 14 Euro per tonne in 2008, the price decreased to a level of about 10 Euro per tonne in 2009 and fell below 10 Euro per tonne in 2010". The same source also tells about a controversial deal of 50 million low quality AAUs sold by the government of Slovakia to the Swiss firm Interblue for a very low price (€ 5.05 per unit).

- In 2009, the Europeran Bank for Reconstruction and Development (EBRD) assumed a range of €9-17 per AAU (sellers' expectations) and €7-12 (buyers' expectations) for estimating the potential size of the AAU market after 2012 (Peszko, 2009).

Based on these figures, a conservative price of 7 $€_{2010}$ per emission permit (tCO_{2eq}) has been selected for valuing the benefit of reducing carbon emissions in the Hungarian building sector through energy efficiency. It refers to equivalent carbon emissions (tCO_{2eq}) because AAUs are thus defined by UNFCCC (2012b). As seen in the previous Section, my analysis uses equivalent carbon emission factors (tCO_{2eq} kWh^{-1}) in two of the energy carriers considered (natural gas and other fuels/firewood).

The per-unit value of 7 $€_{2010}$ tCO_2^{-1} is assumed to increase at a rate of 2.5% per year. This is intended to reflect the likely pressing effect of more stringent national mitigation targets on international market prices of emission permits, as well as the increase in the marginal abatement cost (MAC) of carbon. The result is a mild exponential increase in which the price of emission permits roughly doubles between 2025 and 2050. Such is the increase found by Kuik et al. (2009) in their meta-analysis of 62 global MAC models, upon which the 2.5%/yr. rate assumption is based. Consequently, the model assumes that the price of the AAUs or similar emission permits sold by Hungary through residential energy efficiency projects will grow at the same pace as the global marginal cost of carbon mitigation.

Figure 81. Evolution of the per unit value of avoided CO_{2eq} emissions



Source: own elaboartion after Peszko (2009) and Kuik et al. (2009)

8.3.3. Non-GHG air pollutants

8.3.3.1. Non-GHG emission factors

Fuel combustion is also the source of a wider range of other airborne pollutants that have an impact on human health, the ecosystems, agricultural production and materials. Among those, several major non-GHG pollutants have been considered in this social CBA: ammonia (NH_3), sulphur oxides (SO_x), nitrogen oxides (NO_x), suspended particles or particulate matter (PM_{co} and $PM_{2.5}$)[98], non-methane volatile organic compounds (NMVOC) and heavy metals (Pb, Cd, Hg, As, Cr and Ni). Some of these pollutants (e.g., NH_3, SO_x and NO_x) have been related to ecosystem acidification and eutrophication. And practically all of them are known for their impacts on human health: particulate matter (PM) is a dangerous pollutant that penetrates into sensitive parts of the respiratory system; NO_x is a cause of reduced lung function; heavy metals such as Arsenic (As), cadmium (Cd), lead (Pb), mercury (Hg) and nickel (Ni) are known carcinogens but also have non-cancerous negative effects on human health;

[98] Following Preiss et al. (2008), particulate matter has been divided into two categories depending on their size: PM_{co} (coarse particulate matter – aerodynamic diameter between 10 and 2.5 µm) and $PM_{2.5}$ (particulate matter with an aerodynamic diameter of smaller than 2.5 µm).

tropospheric ozone (O_3) is a secondary pollutant derived from NO_x and NMVOC which can cause respiratory and cardiovascular health problems and lead to premature mortality. High O_3 levels can also damage plants, which will lead to reduced agricultural crop yields and forest growth (EEA, 2012b).

Given their relevance as sources of potential harm to human health, the incorporation of these pollutants incorporation is required because, as noted by Pearce et al. (2006), health benefits dominate in social CBA, usually driving positive social NPVs.

Emission factors for all the above mentioned pollutants were obtained from the 2009 EMEP/EEA air pollutant emission inventory guidebook (EEA, 2009). This is the most up-to-date version of the inventory used by countries to report their emissions of various air pollutants to the UNECE Convention on Long-range Transboundary Air Pollution and the EU National Emission Ceilings Directive (see Table 40).

Table 40.Emission factors for non-GHG air pollutants (g kWh^{-1}).

	Natural gas	Electricity	DH	Firewood
NH_3	0	0	0	0.01368
NMVOC	0.0378	0.00283	0.0054	3.33
NO_x	0.2052	0.322632	0.3204	0.2682
PM_{co}	0	0.007128	0	0
$PM_{2.5}$	0.0018	0.007063	0.00324	2.502
SO_x	0.0018	0.53177	0.00108	0.072
Pb	3.54E-06	5.52E-06	7.2E-07	0.000144
Cd	1.85E-06	1.33E-06	1.8E-06	5.04E-06
Hg	8.42E-07	1.17E-06	3.6E-07	1.8E-06
As	3.37E-07	5.31E-06	3.24E-07	3.6E-06
Cr	2.36E-06	4.2E-06	2.52E-06	1.04E-05
Ni	3.54E-06	4.87E-06	3.6E-06	1.58E-05

Note: emission factor for NH_3only available for firewood; following Preiss et al. (2008), the emission factor for PM_{co} was calculated by subtracting $PM_{2..5}$ to PM_{10} emission factor – the latter two are the ones originally reported by EEA (2009)
Source: EEA, 2009

In the case of natural gas and firewood, these are the default values for residential combustion recommended by the EMEP/EEA guidebook because data on the type and quality of stoves and boilers in residential dwellings in Hungary is not available. For DH, they are also are the default values for public electricity and heat production using natural gas. For electricity, the default emission factors for public electricity and heat production of natural gas and hard coal-based power plants were selected. They were weighted by the contribution thatnatural gas (38%) and coal (18%) makes to Hungary's electricity mix,as reported by EnerCEE.net (2012)[99], thus assuming that these two fuels were the main and only sources of non-GHG pollutants related to electricity production in Hungary. The justification is that even though electricity is currently used to a very limited extent for domestic space heating in Hungary, it is a more significant energy carrier for domestic space heating after MID and DEEP retrofits.

Though not made clear in the original source (EEA, 2009), emission factors are assumed to be per kWh of effectively delivered heat, and have thus been directly multiplied by the specific heating requirements before and after retrofit of the 6 building typologies defined in the model.

Emission factors are assumed to remain the same for the whole implementation period. In the medium to long term, this overestimates to some extent the value of the social benefits because a reduction in the emission factors of electricity and DH is foreseen as renewable capacity is added to the energy mix of these two carriers and other technological developments (e.g., better filters) are implemented).

8.3.3.2. Per unit value of avoided GHG emissions

Improving air quality levels in Hungary has been subject of previous research with the aim of comparing the costs of achieving certain emission reduction levels versus its energy saving

[99] Nuclear-generated electricity contributes to 37% of Hungary's total electricity generation and it is considered carbon neutral for the purposes of this analysis.

and social benefits including human health, crops, ecosystems and materials (Aaheim et al., 1997; Aunan et al. 1998). However, no external cost per unit of emission (i.e., per tonneof pollutant) was reported in these studies.

For non-GHG pollutants, the valuation exercise relies on the Hungary-specific results reported by the EC 6th Framework Programme's NEEDS project (*New Energy Externalities Developments for Sustainability*), from which the values in Table 41 were obtained. These values represent up-to-date estimates of the external cost of emitting one additional tonne of air pollutant (from a in terms of their impact on human health, crops and building materials. They were retrieved by Preiss et al. (2008) from *EcoSenseWeb*, a computer-based assessment tool of the environmental impacts and external costs of electricity generation systems and industrial activities. This tool is based on the Impact Pathway Approach (IPA) developed in the *ExternE* project on the external costs of energy in Europe.

The original values coming from Preiss et al. (2008) are valid for the year 2000 and were updated to $€_{2010}\ t^{-1}$ through the HCPI of the EU27 retrieved from Eurostat. The external cost of SO_2 was applied to SO_x emissions given that EEA (2009) did not provide a specific emission factor for SO2 – the implicit assumption is that all sulphur oxides (SO_x) are emitted in the form of sulphur dioxide (SO_2).

Table 41. Per unit value of non-GHG emissions

Pollutant	External cost of emission	
	$€_{2000}$ t^{-1}	$€_{2010}$ t^{-1}
NH_3	16,685	20,673
NMVOC	520	644
NO_x	10,768	13,341
PM_{co}	1,291	1,600
$PM_{2.5}$	26,492	32,824
SO_2	7,707	9,549
Pb	270,895	335,638
Cd	80,269	99,453
Hg	8,000,000	9,911,983
As	507,005	628,179
Cr	8,754	10,846
Ni	1,418	1,757

Source: Preiss et al. (2008)

One reason of concern regarding the application of these values into the social CBA is that they include the regional (Europe-wide) impact of these pollutants beyond Hungary's borders. The per unit values applied thus conflict with the national scope adopted for the analysis as they refer to the avoided damage bth in Hungary and the rest of European countries. For this reason, they overestimate the social benefit for Hungarian society of reducing these emissions through residential energy efficiency investments[100].

On the other hand, some pollutants like radionuclides, formaldehyde and dioxins could be incorporated into the analysis because of the lack of emission factors in EEA (2009).

8.3.4. Avoided excess winter mortality

8.3.4.1. Additional excess winter mortality (EWM) associated with fuel poverty

Seasonal changes in human health are known for centuries and it is well established that mortality increases at temperatures above and below optimal thermal thresholds (Hassi and Rytkönen, 2005). Respiratory, cerebrovascular and ischaemic heart diseases account for most

[100] The values reported by the NEEDS project (Preiss et al., 2008)disaggregatebetweenthe external costs (impacts) within Europe and outside the regional area of Europe. The latter were subtracted from the total external cost reported by Preiss et al.,(2008)to avoid further overestimation.

of the increase in excess deaths observed during winter months and are explained by a number of physiological and epidemiological reasons and are also connected to inadequate in-house temperatures (The Eurowinter Group, 1997). Most countries suffer from a relative EWM ranging between 5% and 30%, i.e., 5 to 30% more deaths per month in wintertime than in summer time; in Western Europe important differences exist between countries, with Portugal, Ireland and Spain reporting the highest rates (Healy, 2003).

Though fuel poverty research often refers to EWM, this is not an indicator of fuel poverty *per se* but a measure of the impact on public health of the difficulties to afford an adequate amount of domestic energy services. For Hungary, an average EWM was estimated based on disaggregated monthly mortality statistics recorded by the Hungarian Central Statistical Office (KSH) for the period 1995-2007 and following standard calculation methodologies (Johnson and Griffiths, 2003; Healy, 2004). According to these references, total excess winter mortality can be estimated by comparing mortality rates between colder (i.e., December to March) and warmer (i.e., April to November) months, following the equation

$$EWM_{total} = f_{deaths}(Dec + Jan + Feb + Mar) - \frac{f_{deaths}(Aug + Sept + Oct + Nov + Apr + May + Jun + Jul)}{2}$$

in which f_{deaths} are monthly mortality rates (number of deaths) corresponding to the months in brackets. This equation results in the actual number of excess winter deaths (EWD) per year. For obtaining a coefficient of seasonal variation in mortality (CSVM) or relative EWM rate (i.e., percentage of additional winter mortality versus non-winter mortality), which allows comparing between countries with different population size and composition (and therefore different total annual mortality rate), the following equation is used:

$$EWM_{relative} = \frac{f_{deaths}(Dec + Jan + Feb + Mar) - [f_{deaths}(Aug + Sep + Oct + Nov + Apr + May + Jun + Jul)/2]}{[f_{deaths}(Aug + Sep + Oct + Nov + Apr + May + Jun + Jul)/2]}$$

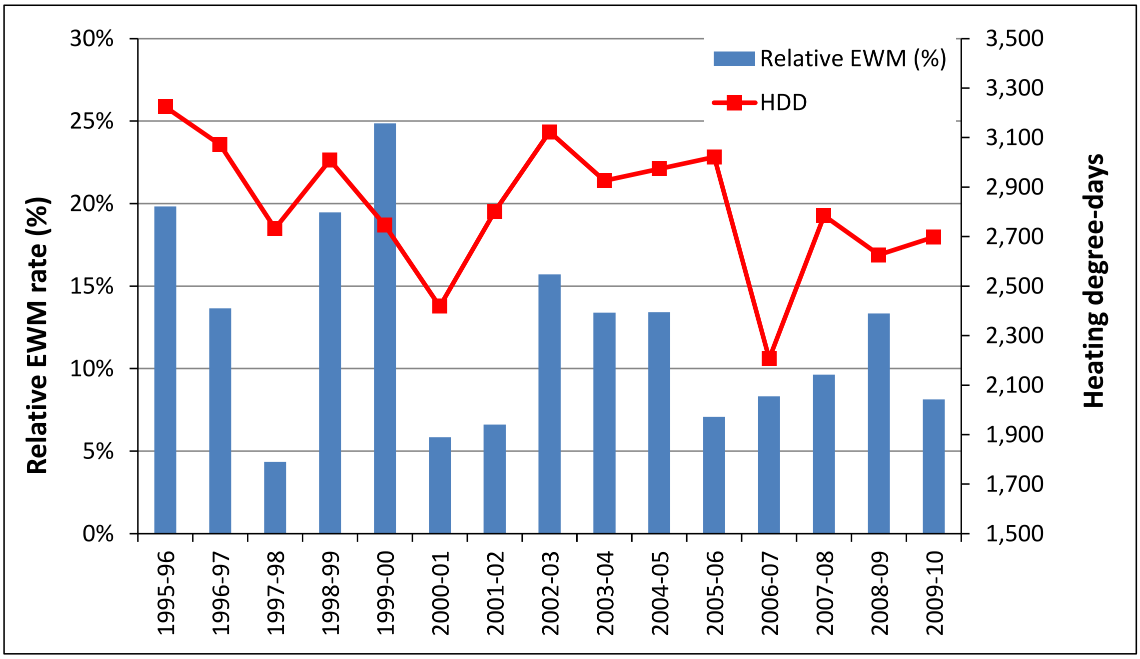
For Hungary, total and relative EWM rates have been estimated by applying these equations to monthly mortality data for the period 1995-2010 retrieved from the Hungarian Central Statistical Office (KSH). As shown in Figure 82, relative EWM rates have oscillated between 4 and 25% (more deaths in the cold months than in warmer months), with an average of 12.2% for the 15-year period analysed (95% confidence interval: 9.0%, 15.5%). This is equivalent to an average total EWM rate of 5,300 excess winter deaths per year (95% confidence interval: 3,900, 6,800). Note that these figures do not correspond to calendar years but to calculation years (12 months from August to July of the following year) according to the equations above[101]. These are crude rates (i.e. non-age-standardised) reflecting the actual evolution of EWM rates in Hungary, which is a result (partially) to changes in the age structure of the Hungarian population.

The severity of the winter (measured as the number of heating degree-days or HDD per calculation year[102]) is correlated to some extent the evolution of EWM rates in the 1995-2010 year period – a linear correlation coefficient (*Pearson's r*) of 0.48 was obtained for the 15-year period assessed (Figure 82). However, the number of days with intense cold is not the only determinant of excess winter mortality, which isalso correlated with the incidence of seasonal flu and air pollution levels (Morris and Liddell, 2010).

[101] i.e., so for the first calculation year (1995-1996), this corresponds to the period August 1995 to July 1996 – and so on and so forth with the rest of the years until 2009-2010.

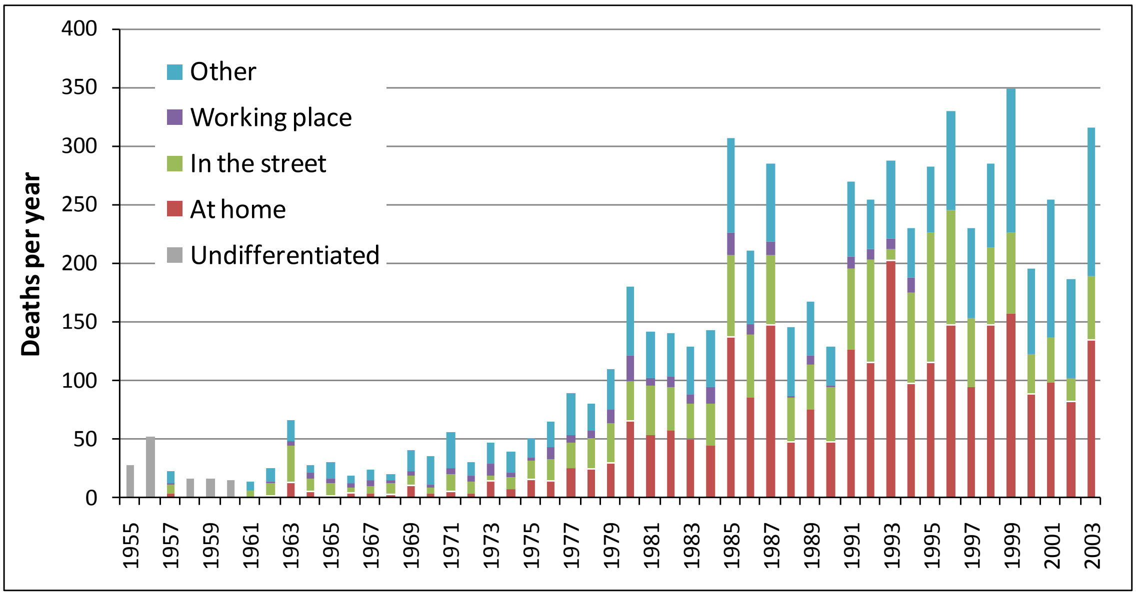
[102] HDD calculations are based on monthly HDD data for Hungary retrieved from Eurostat and correspond to the same 12-month periods used for calculating EWM rates.

Figure 82. Relative Excess Winter Mortality (EW) rate vs. annual heating degree-days (HDD) in Hungary, 1995-2010)



Source: own calculations based on data from the Hungarian Central Statistical Office (KSH); Eurostat

Figure 83.Number of deaths per year during periods of intense cold in winter, by place of occurrence (Hungary 1955-2003)



Source: Győri (2005)

EWM rates were thus disaggregated by the age of the deceased and cause of death (for the period 1995-2007). As expected (Laake and Sverre, 1996; Mercer, 2003) most excess winter deaths (EWD) are registered for the elderly population (92% of all EWD correspond to people aged 60 and above) and are caused by diseases of the respiratory (15% of all EWDs) and circulatory systems (70% of all EWDs). However, KSH data did not allow disaggregating results by income levels, housing conditions, degree of urbanisation of the place of residence or other relevant features (e.g., being homeless) of the deceased.

Regarding the latter element, it was initially suspected that homelessness was an important factor contributing to excess winter mortality in Hungary given the relatively large number of homeless person in the country – some 3,000 people sleep in the street only in Budapest according to estimates of the Hungarian NGO *Menhely Alapítvány* (2005). However, KSH data collected by Péter Győri (2005), chairman of *Menhely Alapítvány*, indicate that this is not the main reason why annually 5,300 more people die in winter than in non-winter months in Hungary. As Győri's data indicate

Figure 83), almost half (45%) of the people who froze to death in Hungary during extreme cold periods in 1990-2003 did so at home, which can be regarded as the most extreme cases of fuel poverty. This percentage is equivalent to an average of 118 people per year freezing to death at home during periods of extreme cold. In contrast, an average of 60 people per year (24% of total deaths during extreme cold) died in the street in 1990-2003; this latter figure is believed to correspond with homeless persons.

The 12.2% EWM rate calculated for Hungary in the period 1995-2010 is in the lower region of the 10 to 28% range found by Healy (2004) in Western European EU14 Member States for the period 1988-1997. This study found high (around and above 20%)EWM ratesin Mediterranean countries like Spain, Greece and Portugal and provides evidence supporting the paradox of countries with mild winters reporting a larger increase in winter mortality (Mercer, 2003). However, it must be noted the difference in the time periods employed for calculations (1988-1997, in Healy, 2004; 1995-2011 for Hungary and the fact that a proper comparison would require an age-standardised Hungarian EWM rate.

The level of EWM depends on a multiplicity of factors (climate, expenditure in healthcare provision, lifestyle, etc.) in addition to the quality of housing stock or on the proportion of people enjoying an adequate indoor thermal comfort (The Eurowinter Group, 1997; Healy, 2003). Because of this, only a fraction (see below) of all annual excess winter mortality can be attributed to low in-house temperatures or inadequate housing conditions related to fuel poverty.

To approximate the number of (elderly) people dying prematurely in winter as a consequence of fuel poverty, a review of previous studies was conducted in order to find a proportion that could be applied to the Hungarian case – see Table 42. These percentages have been then applied to the average total excess winter mortality rate in Hungary for the period 1995-2010 – an average of 5,300 EWDs per year, as estimated above. The results of this transfer of the few values located for the UK and other countries of the Atlantic façade of Europe are presented in

Figure 84 and indicate that fuel poverty may be causing as many premature deaths as motor vehicle accidents in Hungary. However, these initial, rough estimates would need to be assessed through proper statistical analysis as done by The Eurowinter Group (1997), Wilkinson et al. (2001) or Healy (2003; 2004).

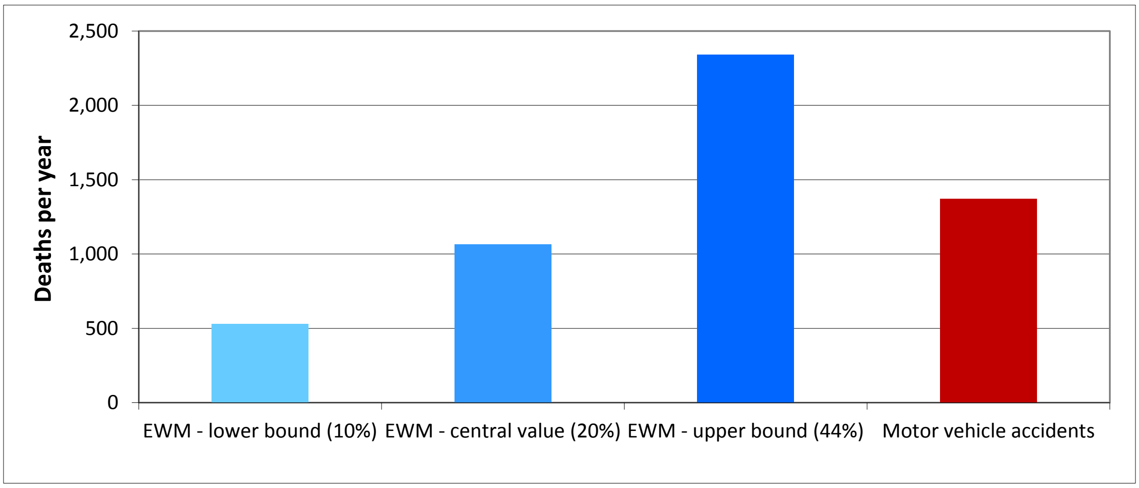
Table 42. Proportion of EWDs attributed to fuel poverty according to previous research in Europe

Reference	Description	% over total EWD
Clinch and Healy (1999)	Percentage of cardiovascular- and respiratory-disease EWD associated to poor housing standards in Ireland, estimated in comparison with Norway.	44%
The Marmot Review Team (2011)	Percentage of EWDs attributable to fuel poverty in the UK – estimate based on Wilkinson (2001)	20%
Hills (2012)	Percentage of EWDs attributable conservatively to fuel poverty in the UK – estimate based on The Marmot	10%

Revbiew Team (2011) and experts' opinions

Source: see Table

Figure 84. Estimated average number of annual fuel poverty-related deaths vs. average annual number of deaths in motor vehicle accidents in Hungary (1995-2010)



Source: own estimates based on data from the Hungarian Central Statistical Office (KSH) and references in Table 42

For the social CBA, the central value (around 1,000 deaths per year, estimated using the 20% percentage of the Marmot Review Team, 2011) has been selected for the evaluation of avoided EWM related to fuel poverty. Recall that an average of over 100 hundred persons per year were found frozen to death at home during periods of extreme cold in Hungary for the period 1990-2003, For this reason, it is believed that the figure of 1,000 fuel poverty-related EWD per year (which includes both the *frozen to death* and the more common non-acute EWDs caused by fuel poverty) is not excessive.

This number of annual fuel poverty-related EWDs (1,000 per year_) is assumed constant for the whole modelling period in the CBA. Therefore the model does not consider important factors for the evolution of EWM rates, such as the increasing proportion of the aged population, changing air pollution levels or even increasing winter temperatures as a consequence of climate change. These factors may either increase (e.g., higher proportion of older population) or decrease (e.g., milder winters) EWM rates to an unknown extent.

More concretely, the following assumptions have been followed:

- Because of the substantial level of energy saving and improved thermal comfort achieved, DEEP retrofits avoid all fuel poverty-related EWDs once the whole 2010 building stock has been upgraded. In contrast, MID retrofits only achieve a reduction of 50% of all fuel poverty-related EWDs in Hungary because it is assumed that some households remain in fuel poverty after the retrofits. In both cases, it is assumed that all future fuel poverty-related EWDs will occur in the building stock existing in 2010, in spite of the fact that in the long-term a fraction of the Hungarian population will be living in dwellings built after 2010. However, it seemed reasonable to suppose that the future elder population in fuel poverty would be mostly living in older (pre-2010) buildings. BASE retrofits do not avoid any EWD given the low level of energy savings achieved.
- Since the spatial and building-typology distribution[103] of the vulnerable population segment (fuel poor elders) is unknown, it is assumed that the number of avoided EWDs is proportional to the percentage of retrofitted floor area up to the year. Consequently, the figure of avoided (roughly) 1,050 EWDs per year is only achieved by the end year year of MID and DEEP scenarios (2051 and 2054). However, if retrofits were implemented in such a way that the dwellings of this population segment were upgraded first, the value of this particular social benefit would be enhanced by making the total number of avoided fuel poverty-related EWDs (1,050 per year) being achieved before the end of MID and

[103] Note that because of the thermal comfort is often guaranteed in in panel buildings connected to DH (see Chapter 6), it can be assumed that no fuel poverty-related EWDs are registered for these sub-typology of buildings.

DEEP scenarios. This improved implementation pathway would therefore increase the social NPV of both intervention scenarios (MID and DEEP).

8.3.4.2. The value of one avoided excess winter death (EWD)

8.3.4.2.1. Approaches to the valuation of mortality benefits

For the economic valuation of the social benefit of reduced excess winter mortality rates, a number of previous relevant studies have been reviewed, with three main approaches identified (Pearce et al., 2006):

- A common approach is the one based on stated-preference surveys in which respondents are asked (through surveys) to elicit their willingness to pay (WTP) for a given reduction in the mortality risk to be achieved with a hypothetical policy that, for instance, reduces air pollution or increases road safety. These valuation exercises are conducted as contingent valuation surveys or choice experiments.
- Another range of studies estimate the value of a (statistical) human life through the hedonic wages method. This approach is based on the fact that professions with a higher risk (e.g., fire-fighters, policemen, etc.) have higher wage rates; these compensating wage differentials are equivalent to the willingness to accept (WTA) a higher risk of suffering a premature death as a result of a professional activity. In contrast with stated-preference surveys, it has the advantage of being based on observed behaviour instead of the WTP elicited from a survey confronting respondents with a hypothetical policy scenario.
- A third alternative consists of looking at actual investment or expenditure with the aim of saving lives in different contexts. As the previous one, this method has the advantage of

showing actual investments realised to reduce mortality risks. However, as shown by the Dutch example of Goebbels et al. (2008), substantially different implicit values of a statistical life – from €1 to almost €11 million – can be expected from the implementation of this approach, which according to this study indicates a lack of consistency between the contexts in which mortality risks are dealt with.

The first approach has been selected estimating the per-unit value of avoided EWDs related to fuel poverty in Hungary. The reason is that, in spite of the hypothetical nature of WTP estimates, these fit better with the nature of the mortality risk posed by fuel poverty, can be more safely transferred between locations or contexts (as required by this exercise) and have actually been used extensively in studies similar to this dissertation. In the case of hedonic wage analysis, the value of human life is obtained from contexts (risk-prone professional activities) largely different from the subject of this study, their transferability is more problematic and, as a WTA estimate it often results in higher values than WTP figures (Pearce et al., 2006). Finally, implicit values obtained from actual life-saving investments are scarce and, as said above, show a large variation in values.

In any case, the valuation of this non-market benefit will rely on the results/benefit transfer technique because no Hungary-specific applicable value of a human life has been located. The only exception is the PhD dissertation of Richard Adorján (2004), which obtained a 250 million HUF (approx. 1 million Euro) figure based on the hedonic wages method. This doctoral research also carried a pilot contingent valuation with a small sample that resulted in a Value of a Statistical Life (VSL) of 130 to 174 million HUF2003. However, none of these figuresare useful for the valuation: the former is a hedonic wage estimate and therefore not fit for valuation of fuel-poverty related avoided mortality, as stated before; the latter was disregarded after consultation with the author because of the reduced size and lack of representativeness of the sample, which consisted of merely 50 university students.

8.3.4.2.2. A VOLY-based value of one avoided EWD

Once the WTP approach is selected, a question then arises about the unit with which the value of an avoided anonymous premature human death is calculated. Two main possibilities exist: the Value of Statistical Life (VSL) and the Value of Life Years (VOLY). In the first case, respondents are asked to state their WTP for avoiding a premature anonymous (or statistical) death irrespective of the age of the deceased; this is for instance the case of traffic accidents, which kill persons in all age ranges and for the VSL has been recommended (Nerhagen and Li, 2010). VOLYs, on the contrary, are based on surveys in which the respondent is asked to elicit his or her WTP for extending for a given period of time (e.g., a few months) the life of a person; this is for instance the case of elder population marginally extending their life expectancy as a result of air quality improvements, for which a more conservative VOLY-based valuation has been recommended (Desaigues et al., 2011).

However, some of the reviewed literature indicates that there is no clear evidence that WTP declines with age, as indicated by the VOLY approach (Pearce et al., 2006; Cropper et al., 2011), and there have been recommendations against 'senior-discounting', i.e., reduction in the WTP-based value of the life of an elder vs. the life of a middle-aged person (OECD, 2011). On the other hand, in Krupnick (2007) half of the studies reviewed showed a statistically significant senior discount. In those, the size of the senior discount was clustered around the 20 to 35% range when looking at a 30-year age difference (the difference between 70- and 40-year-old individuals).

Age is certainly an import factor because, as said in the previous Section (8.3.4.1), fuel poverty-related EWM occurs almost entirely among individuals of 60 years of age or more. Assuming that the VOLY approach is preferable for this reason, the valuation exercise has adopted the value reported by Desaigues et al. (2011) relating to an increase in life expectancy of the elder population following the implementation of a hypothetical policy that reduces air pollution levels. This research is a contingent valuation survey conducted in 9 EU countries (France, Spain, UK, Denmark, Germany, Switzerland, Czech Republic, Hungary, and Poland) and with a sample of 1,463 respondents. Based on the results of the survey, the authors recommended an EU-wide VOLY of 40,000 €. However, they also suggest applying different values for the two sub-samples of countries identified: thus for the EU15 and Switzerland they recommend a VOLY of 41,000 € and for the New Member States 33,000 €. The latter figure (33,000 € per VOLY) was selected as the reference value for this benefit category because it is an up-to-date estimate specifically aimed at valuing mortality benefits in Central and Eastern EU Member States. It seems to be in the range of similar studies, e.g., 29,000 to 54,000 € per VOLY in Switzerland (Jeanreanaud and Marti, 2007); or 20,000 to 200,000 € per VOLY in France (Desaigues et al., 2007).

Certainly, this approach assumes transferring results obtained in a certain risk context (premature mortality associated to air pollution) to a different setting (premature mortality due to low domestic temperatures associated to fuel poverty). It is considered as relatively safe transfer because both are causes of premature death that operate through similar diseases, i.e., cardiovascular and respiratory, though in the case of air pollution other conditions like cancer are also relevant – see The Eurowinter Group (1997) andOstro (2004).

The selected VOLY is applied to the number of life years saved through energy efficiency programmes (MID and DEEP scenario). For the estimation of the total value of this social benefit, this is calculated as

$$VEWM_{avoided} = VOLY \times (LE_{Hu} - AGE_{EWD}) \times EWM_{avoided}$$

where $VEWM_{avoided}$ is the value of the total avoided EWM in a given year, *VOLY* is the selected value of a life year (transferred from Desaigues et al., 2011), LE_{Hu}isthe average life expectancy in Hungary, AGE_{FP} is the average age at which an excess winter death (EWD) occurs and $EWM_{avoided}$ is the total number of fuel poverty-related EWDs avoided in the year, which is proportional to the fraction of the residential floor area retrofitted up to the given year (see previous Section). This is the same as multiplying the VOLY by the total number of life-years saved by the retrofits.

Following this equation, $VOLY\ x\ (LE_{Hu} – AGE_{EWD})$ is thus equal to the value of an avoided EWD associated with fuel poverty. For the calculation of this per-unit value, I have looked into the EWM estimates based on monthly mortality data from the Hungarian Central Statistical Office (KSH), which indicate that over 90% of the EWD happen in the age cohort of people of 60 years of age or more (Section 8.3.4.1). KSH statistics also show that as of 2010 the life expectancy of the Hungarian population at birth was 74 years (70.5 for men and 78.1 for women).

However, the data retrieved do not allow estimating detailed EWM rates disaggregated by age of the deceased, nor it is known either how the fuel-poverty related EWDs are distributed in the 60 years and above age cohort. In other words, it is unknown whether the average EWD caused by fuel poverty in Hungary happens mostly among individuals close to the end of their life or whether they would have enjoyed some more years of life had they not lived in an inadequately heated dwelling. Because of that, three different $(LE_{Hu} – AGE_{EWD})$ periods have been assumed – 3, 7 and 10 years. These three values are within the 14-year period that goes from the lower end of the 60 years or more age cohort (60) to the Hungarian life expectancy (74).

Then, the original VOLY in Desaigues et al. (2011) has been inflated to 2010 Euros through Eurostat's HCPI for the EU27 (36,930 $€_{2010}$) because the survey was conducted in late 2005.

The results are presented in Table 43. The value corresponding to 7life-years saved (rounded to 250,000 $€_{2010}$) is the one selected for the valuation of avoided EWM benefit in the social CBA. It implicitly assumes that the age of the current average Hungarian premature EWD due to fuel poverty is 67 years.

Table 43.Per unit value of an avoided EWD due to fuel poverty in Hungary

. Number of life-years gained by each avoided fuel poverty-related EWD avoided *(LE_{Hu} – AGE_{EWD})*	Per unit value of an avoided EWD	Implicit age of the average EWD
3	110,791	71 years
7	**258,512**	**67 years**
10	369,303	64 years

Source: own elaboration after Desaigues et al. (2011) and KSH data

8.3.4.2.3. <u>The alternative: Value of an Statistical Life (VSL)</u>

As said previously, there is not full agreement among scholars about the prevalence of the VOLY over the VSL for the valuation of avoided mortality benefits concerning older population.

For this reason, an alternative per-unit value of one avoided EWM associated with fuel poverty has been estimated through the VSL approach. I have thus followed the base value and transfer methodology of OECD (2011), a recent meta-analysis that aims to provide a "practical guide […] on how to derive and use mortality risk values, in terms of Value of a Statistical Life (VSL), in policy analyses in individual countries within the OECD" (*ibid*, p. 4). It explicitly offers support to CBA analysts in their task of valuing the effects of policy actions on human health.

Following this paper, the base VSL for the EU27 – US$$_{2005}$ 3.5 million – can be transferred to Hungary following the equation

$$VSL_{p'} = VSL_s \, (Y_p / Y_s)^{ß}$$

where $VSL_{p'}$ is the VSL for Hungary (to be estimated), VSL_s the EU27 base VSL, Y_p is Hungary's GDP per capita in 2005 (14,484 US$$_{2000}$, in constant PPP units), Y_s is the EU27's GDP per capita in 2005 (23,532 US$$_{2000}$, in constant PPP units) and ß is the income elasticity of VSL, which is assumed to be 0.8 following Lindhjem et al. (2001). This resulted in a VSL for Hungary of US$$_{2005}$ 2.4 million, which were then converted to HUF using a PPP-adjusted exchange rate for 2005 and inflated to 2010 prices (HUF$_{2010}$ 406 million, or €$_{2010}$ 1.5 million)[104]. This value – 1.5 million €$_{2010}$ – can be regarded as an alternative to the VOLY-based 0.25 million €$_{2010}$ value of an avoided EWM associated with fuel poverty in Hungary.

Finally, these figures can be gauged against other VSL found in the literature. For that, a review of recently published literature was conducted. This review first identified Cropper et al. (2011) as the most up-to-date meta-analysis of stated preferences VSLs (see Table 44). Then, three relevant studies of VSL, which estimated a reduction in the mortality risk of older age population, were retrieved from Pearce et al. (2006) and are presented in Table 45. As can be seen in both tables, the selected VOLY-based value (0.25 million €$_{2010}$) and even the alternative VSL (1.5 million €$_{2010}$) are in the lower region of the value range found in the literature.

As a further proof of the conservative character of my estimates, it can be noted that the OECD (2011) recommends the use of US$$_{2005}$ 2.9 million and US$$_{2005}$ 3.5 million as a base VSL for OECD and EU27 countries respectively. Equally, a European Commission manual

[104]Following OECD (2001), the data inputted in the equation is from OECD statistics, whereas the CPI for Hungary and the HUF-€ exchange rate for 2010 were obtained from the Hungarian Central Statistical Office (KSH) and the Hungarian National Bank.

on cost-benefit analysis (EC, 2008) suggests a Hungary-specific value of 808,000 €$_{2002}$ per avoided death in a road traffic accident.

Finally, the only VSL used for valuing fuel poverty-related avoided EWM is in Clinch and Healy (2001), which applied a 3.o3 million Euro figure for avoided EWD under the age of 65 and 2.18 million to the above 65 years old. This also confirms the conservative character of my estimates for this particular non-market benefit.

Table 44. Meta-analyses of VSL stated preferences studies.

VSL [M€$_{2010}$]	**Original highlighted VSL** [unit, year]	**Publication dates of underlying studies** and **number of studies**)	**Source**
2.68	2.8 MUS$ (2000)	1988–2002 (14)	Kochi et al. (2006)
2.09 – 6.53	2.4 - 7.5 MUS$ (2004)	1983–2008 (26)	Dekker et al. (2011)
2.44	2.9 MUS$ (2005)	1973–2008 (68)	Lindhjem et al. (2010); OECD (2011)

Notes: Original values converted to €$_{2010}$ through the US Consumer Price Index (Bureau of Labor Statistics) and the Federal Reserve average US$-€ exchange rate for 2010.
Source: Cropper et al. (2011)

Table 45. Meta-analysis for the VSL of reduced mortality risks in advanced-age populations

VSL [M€$_{2010}$]	**Original VSL** [unit, year]	**Country**	**Source**	**Type of study**	**Description**
1.43 – 4.58	1.5 – 4.8 MUS$ (2000)	USA	Alberini et al., 2004	CV	Context-free reduction in mortality risk between ages of 70 and 80.
0.86 – 3.54	0.9 – 3.7 MUS$ (2000)	Canada			
0.20 – 0.41	0.2 – 0.4 MUS$ (1998)	Japan	Krupnick et al., 1999	CV	Context-free reduction in mortality risk between ages of 70 and 80.
1.09 – 2.56 **0.64 – 0.73** **0.82 – 1.73**	1.2 – 2.8 0.7 – 0.8 0.9 – 1.9 MUS$ (2002)	UK	Markandya et al., 2004	CV	Context-free reduction in mortality risk between ages of 70 and 80.

Notes: Original values converted to €$_{2010}$ through the US Consumer Price Index (Bureau of Labor Statistics) and the Federal Reserve average US$-€ exchange rate for 2010.
Source: Pearce et al. (2006)

8.3.5. Increased comfort

Households affected by energy affordability constraints in Hungary often resort to a range of cost reduction strategies – referred to in the context of this research as coping strategies. Among the various types identified and described in Section 6.4.2, three of them have been selected for their incorporation in the social CBA:

- One option consists of diminishing the proportion of the dwelling floor area heated to comfortable levels. This is often done by just switching the heating on in the rooms most used by the household during wintertime, like the living room or the kitchen, and leaving the remaining living space unheated or sub-heated. This strategy can be only applied in dwellings in which the temperature of different rooms can be controlled individually.
- A second alternative is fuel substitution. As discussed in Section 4.4.1, it is suspected that a fraction of all Hungarian households have substituted natural gas by firewood – a cheaper but also less convenient fuel – when their dwellings allow for such a change. As a consequence, more than 20% of Hungarian households (not only in rural areas) now use firewood as a main or complementary source of heat.
- A third alternative is keeping low domestic indoor temperature during the cold season. This is the most commonly regarded coping strategy, or impact, of fuel poor households that has identifiable impacts on human health.

These strategies are often complementary to each other, and it is possible that a household with very limited income occupying an inefficient dwelling burns firewood instead of natural gas (despite having access to piped or bottled natural gas) and heats to suboptimal temperatures only part of the living space of the dwelling, among other things. In fact, that a household is forced to adopt any of these solutions can be regarded as an indication of its fuel poverty status, though not all households behaving in such ways are in fuel poverty.

Some of the information and data collected for the purposes of this CBA can be used for the valuation of the comfort benefits arising from households not having to adopt these coping strategies. However, since no data are available about indoor domestic temperatures before and after retrofit, only two types of comfort benefits have been estimated for MID and DEEP scenarios: the increase in the percentage of floor area heated and the substitution of firewood by higher quality fuels (gas and electricity). Their economic value has been approximated with an *ad-hoc* methodology (i.e., specifically adapted to the available data)that uses the model's assumptions on the percentage of floor area heated and energy mix before (BASE[105]) and after retrofit (MID and DEEP, see Table 27) and the financial prices of energy carriers:

- <u>Increase in the fraction of floor area heated</u>: the per-dwelling value of the welfare gain is equal to the additional costs (at actual prices of energy carriers collected for the financial analysis[106]) of increasing the percentage of floor area heated in an average dwelling type from BASE to either MID or DEEP levels. The value of the additional percentage of floor area heated once the dwelling is retrofitted is multiplied by a reduction factor of 0.5 (my assumption).This decision can be justified on the grounds of the decreasing marginal utility of the heated floor area, i.e., the first floor units of heat provided to the living space (e.g., living room or kitchen) have a higher utility, and therefore value, than the last units corresponding to the less often used areas of the dwelling in the cold season (e.g., sleeping or storage rooms).

  An exception is the Panel buildings category, which is not considered for this benefit. As shown in Table 27, the percentage of floor area heated before retrofit is 100% and then it falls to 95% after the retrofit following the installation of individual consumption meters and controls with MID and DEEP retrofits. It is assumed that there is no welfare loss

105 Since the model assumes no change in Hungary's energy mix for domestic space heating and no increase in the percentage of floor area heated after a BASE retrofit, no comfort gains are accounted for in the BASE scenario.

106 Note that financial prices are used in this case because these are the reference values for a household's WTP for improved heating conditions in their dwelling.

related to this small drop. Actually, the opposite can be said about the effect of retrofitting these units: the installation of individual consumption meters has positive effects on dwellers' wellbeing because it avoids current drawbacks such as the overheating or sub-heating of apartments and having to resort to very inefficient ways to control indoor temperatures like opening the windows – see Chapter 6.

- Substitution of firewood heating by natural gas: in three building typologies (HistRes, TradMFH and SFH1992), it is believed that the use of traditional fuels (i.e., firewood) is mostly a strategic response of households to high energy prices. This way, households minimise their heating costs through substituting a more expensive and convenient fuel (typically natural gas in Hungary) by a less convenient, cheaper one (firewood). The per-dwelling benefit is estimated as the difference between the cost of heating the dwelling with natural gas instead of with firewood (at the actual prices of the financial CBA)[107]. This difference in heating costs is an upper-bound estimate of the value of the welfare gain achieved, i.e., households decide to burn firewood instead of natural gas because the welfare loss associated with burning firewood is below the amount of money saved. Following the same rationale as before (decreasing marginal utility of heat), the result of this calculation is multiplied by a reduction factor of 0.5 (author's assumption) to obtain the value of the benefit.

  Note that this benefit is only estimated for the three aforementioned building categories (HistRes, TradMFH and SFH1992), for which natural gas is the most common and apparently preferred source of heat. The SFH2010, MFH2010 and Panel categories are not considered for this comfort benefit. In the case of panel buildings, no firewood is used for heating according to the residential stock model. For single- and multi-family buildings finished after 1993 (SFH2010 and MFH2010) it is assumed that no fuel poverty resulting

[107]This difference in heating costs is estimated for the percentage of floor area heated in the BASE scenario, because that sets the conditions under which households decide to use firewood instead of natural gas.

from firewood-based heating happens because of the better thermal performance of the average dwelling and also because the suspected higher income level of residents.

With this approach the value of substituting traditional firewood stoves by better quality gas- or electricity-based heating or better quality biomass burners plus the value of fully heating the dwelling floor area is accounted for. The model assumes that comfort benefits accrue progressively as the retrofits take place following the same rationale as with the other benefits. This implies that the per-unit (i.e., per-dwelling) value of this benefit increases along with the increase in the financial price of energy carriers assumed by the model.

8.4. SOCIAL DISCOUNT RATE

In the case of residential energy efficiency investments, the discount rate is particularly relevant because most of the costs are investment or capital costs occurring in the first year(s) of the project whereas most of the energy savings and non-energy benefits are realized along the life-cycle of the investment and, therefore, have a smaller weight in the results of the cost-benefit analysis.

A 5.5% social discount rate was applied, as recommended by EC (2008a) for the Central and Eastern European Member States of the EU and following standard principles of social cost-benefit analysis (Pearce et al., 2006). It is acknowledged, however, that controversy exists surrounding the issue of discounting in projects with long timeframes of analysis. Specifically, authors have debated against the application of a discount rate for intergenerational decisions (Schelling, 1995; Rabl, 1996) or even oppose the utilization of any discount rate to protect the preferences of future generations (Chichilnisky, 1996). Siding with these scholars, Stern (2007) used a nearly zero discount rate for estimates in his review.

In contrast, authors like Yohe and Tol (2008) have argued against climate change-specific low discount rates because they would results in inconsistent policy portfolios in which, for instancedeaths caused by climate change having a higher value than deaths caused by road accidents or other reasons.

8.5. LIMITATIONS AND CAVEATS

Some relevant limitations of the modelling framework were already identified in the previous Chapter (Section 7.8). All of them are relevant for the social CBA. However, a few additional elements that are specific to the social CBA need to added:

- No co-costs or indirect costs of the large scale implementation of retrofits are considered. A relevant example of this cost category in this exercise is the external cost of retrofit materials and activities. Their incorporation would require life-cycle analysis as a way to account for the emissions embodied in retrofitted buildings. However, life-cycle analysis should also account for the emissions embodied in the energy consumed by domestic space heating, i.e., the emission factors applied in the valuation only account for the combustion of fossil fuels and not for fuel extraction and transportation, construction and decommissioning of power plants, etc.
- The model assumes that upgrading every building currently existing in Hungary to a high energy efficiency level is possible. However, some buildings may not have the conditions for achieving the 79 to 90% of energy savings proposed by the DEEP scenario, or at least not at the costs defined for DEEP retrofits. Still, this assumption (i.e., that all residential buildings existing in Hungary as of 2010 can be retrofitted to DEEP levels) was not rejected by any of the Hungarian experts that the original employment study (Ürge-Vorsatz et al., 2010) gathered in two workshops held in spring 2010 in order to assess the validity of the model's data and assumptions. For this reason, the reference case assumes

that the whole building stock can be retrofitted to MID and DEEP levels. Nevertheless, this research takes into consideration the issue of hard-to-retrofit buildings in two ways. First, by assuming an obsolescence rate (over 7,700 buildings per year: the ones in worse condition and therefore more difficult to retrofit)that results in 8% of the 2010 residential floor ceased by the end-year of DEEP scenario (2054) – see Section 7.4. Second, by including this aspect in the sensitivity analysis: the results obtained for a two pessimistic cases defined in which 15% of Hungarian buildings cannot be upgraded to DEEP levels still results in long-term large positive social NPVs for the DEEP scenario (see Section 8.7.2.6).

- Though the link between fuel poverty and excess winter mortality (EWM) is well demonstrated, it is much less understood how energy efficiency retrofits can actually reduce the number of excess winter deaths (EWDs) related to fuel poverty. The model assumes that DEEP retrofits avoid 100% of fuel poverty-related EWDs once all dwellings existing in 2010 have been retrofitted, whereas MID retrofits avoid just 50% of those. But since there is no factual evidence about the EWM-reduction effect of energy efficiency retrofits, this is just a rather crude assumption of the model. However, the influence of this parameter on final results (social NPV) is limited.

- An increase in energy efficiency implies a better use of the energy but does not always result in as less energy consumed as expected. This paradox, known as the rebound effect, happens as a consequence of a shift in the demand of energy. On the one hand, this pushes energy prices down offsetting part of the energy savings achieved (price effect). On the other hand, energy savings increase the income available to consumers (income effect), which in turn intensifies the consumption of more energy or other energy-consuming goods and services (Greening et al., 2000; Nässén and Holmberg, 2009). In the residential sector, previous research suggests a rebound effect of 10 to 30% (of the energy savings initially forecasted) for space heating, less than 10 to 40% for water heating and 5% to

12% for lighting (Greening et al., 2000). In this social CBA, the rebound effect is partially taken care of because the model assumes an increase in the percentage of heated floor area after retrofit and because the specific energy use (kWh m^{-2} $year^{-1}$) of MID and DEEP scenarios are supposed to guarantee full thermal comfort in retrofitted units. However:

- in the short-term, the rebound effect only occurs as an *income effect*, i.e., additional income available to households spent on other energy consuming goods and services. Its impact on the total emissions levels of Hungary is unknown but could perhaps be estimated by looking at the current structure of consumption of Hungarian households and the energy intensities of the corresponding economic sectors;
- the*price effect* would perhaps happen in the long run as a result of a large drop in domestic energy demand (more likely in DEEP than in MID scenario). However, it must be noted the CBA model assumes an increase in real energy prices – and not the decrease predicted by the rebound effect.

▪ The external cost of emission used for the valuation of avoided non-GHG pollutants incorporates the value of their impacts (on human health, ecosystems, crops and materials) both in Hungary and neighbouring European countries. Since the social CBA should consider only welfare gains and losses occurred at a national level (See Section 8.1.2), these external costs overestimate the value of the co-benefit, It is nevertheless believed that most of the negative impacts of the emission of these pollutants, which are harmful occur around the emission point, i.e., in Hungary. In addition, the sensitivity analysis has proven that the influence of the parameter *per unit value of avoided non-GHG emissions* in final results is limited.

▪ Economic values could be not estimated for a number of non-market benefits either because no data on their size or characteristics was available or because their valuation and incorporation into social CBA was methodologically challenging. Particularly important in the context of this research are the health benefits of avoided fuel poverty-related morbidity, which could not be incorporated because of the lack of data on excess winter morbidity rates in Hungary. This implies that the total benefits of MID and DEEP scenarios are underestimated.

- Part of the transaction costs – the ones borne by households (e.g., the hassle of finding builders, putting up with the disruption and nuisance associated with building works, etc.) – could not be incorporated into the analysis (see Section 8.2.2). For this reason, total costs are underestimated. However, the sensitivity analysis has found out that even if if transaction costs were three times higher, positive NPVs would be obtained in the long term.

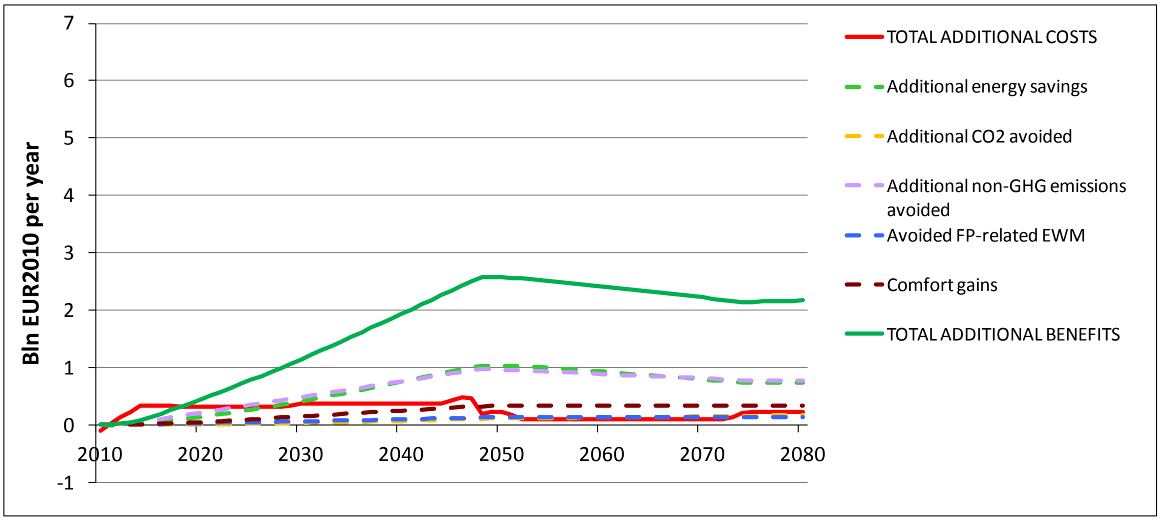
8.6. RESULTS

8.6.1. Annual additional social costs and benefits

As with financial NPV, a first key outcome of the social CBA modelling framework is the calculation of additional social costs and benefits per year under the two scenarios considered. These have been obtained by: i) correcting with social CBA criteria the financial retrofit costs and energy saving benefits as explained in Section 8.2.1.1 and 8.3.1.1.; ii) adding corrected transaction or programme management costs (Section 8.2.2); and iii) incorporating the economic value of selected non-market benefits according to the methodologies presented in Section 8.3.

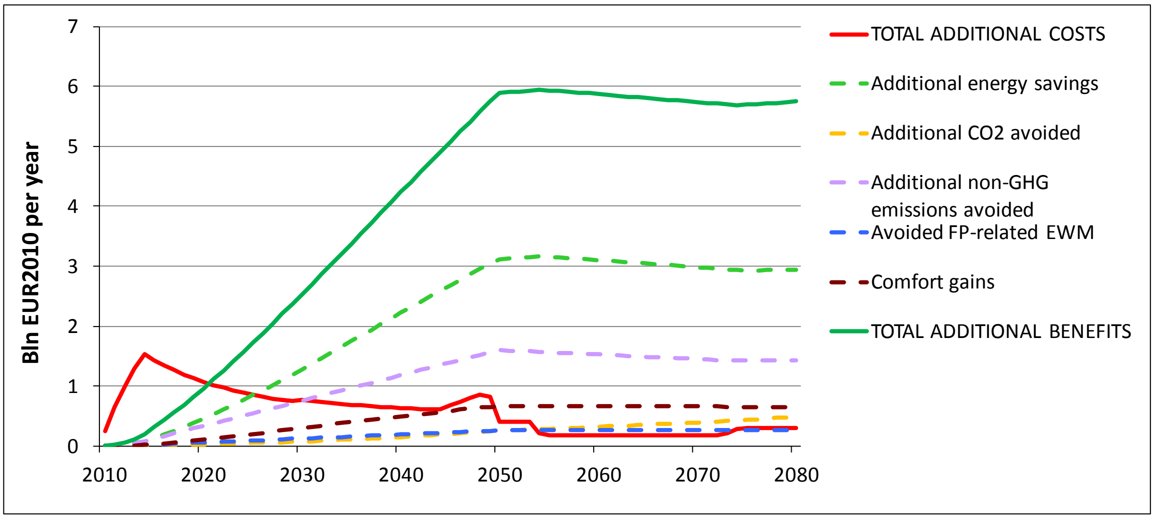
The results are shown in Figure 85 and Figure 86. Recall that these are additional costs and benefits per year with respect to the BASE scenario (see Section 8.1.3): since BASE retrofits also entail implementation costs and energy saving and other benefits, what is presented in these figures is the difference with the values obtained for MID and DEEP scenarios.

Figure 85. Flow of additional annual costs and benefits of moving from BASE to MID scenario



Source: model's results

Figure 86. Flow of additional annual costs and benefits of moving from BASE to DEEP scenario



Source: model's results

Like in the financial analysis, graphs show basic features of the modelling framework such as the learning curve of the costs of DEEP retrofits, the increase in the per-unit value of energy savings and the end of year scenarios. When comparing the results obtained for MID and

DEEP (note that the Y-axis is presented with the same scale for facilitating the comparison), the following conclusions are drawn:

- In both cases, implementation costs (retrofit plus programme management costs) outstrip social benefits in the starting years of the programme. The break-even point (i.e., the year in which annual additional benefits surpass annual additional costs) is reached earlier by MID scenario (2023) than by DEEP scenario (2025). In both cases, this threshold is reached several years before the break-even years in the financial analysis, which demonstrates the importance of including non-energy benefits (or co-benefits) for making the case of residential energy efficiency investments convincing to public decision-makers.
- Non-market benefits different from energy savings make up a substantial fraction of the flow of total annual additional benefits. In the MID scenario they represent over 50% of total annual additional benefits in the medium to long-term (a bit less, over 40%, in the DEEP scenario). This reflects their relevance for the economic assessment of these programmes.
- Analysed by individual benefit categories, results indicate that energy saving benefits are the largest, followed by avoided non-GHG emissions, increased comfort, avoided fuel poverty-related excess winter mortality and avoided GHG emissions. It is interesting to note that from the perspective of a Hungarian decision-maker, climate change benefits (measured in this exercise as revenues obtained through a Green Investment Scheme) are the least important reasons for adopting ambitious energy efficiency goals, even though the revenues obtained from the sale of emission permits through a Green Investment Scheme may be a crucial source for financing the retrofits.

8.6.2. Social NPV – aggregated results

A range of economic indicators – benefit/cost ratios (B/C), internal rate of return (IRR) and net present value (NPV) – can be used as decision rules for ranking scenarios or investment alternatives. Following Pearce et al. (2006), in this exercise the social NPV has ben chosen for deciding whether MID or DEEP retrofits are a preferred option. This indicator is the only correct one for measuring the total effect of investments on the aggregated welfare of Hungarian society (unlike the IRR, which may be misleading in some cases).

Social NPVs were estimated as a discounted sum of social costs and benefits every 10 years between 2010 and 2080. The results, shown in Figure 67suggest that: i) improving the energy efficiency of the Hungarian residential stock from BASE scenario to MID or DEEP levels has a positive net impact on the aggregated welfare of Hungary's society; ii) in the longer-term, DEEP retrofits maximise welfare as compared with MID.

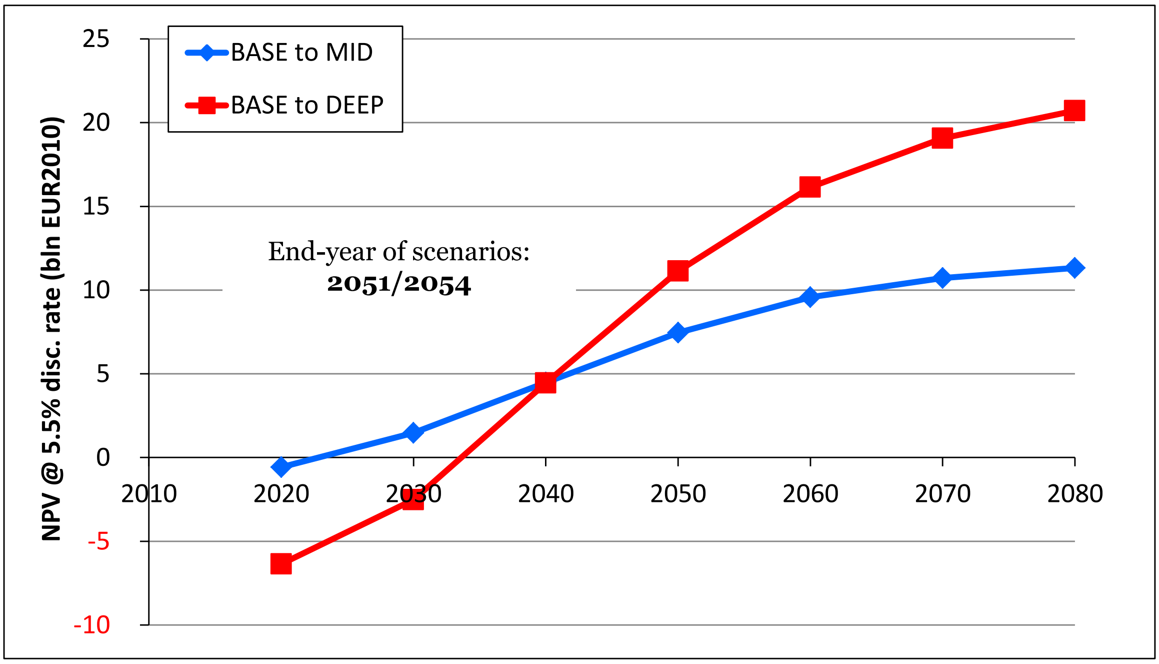
Summary Figure 67also indicates that MID scenario reports an earlier positive NPV (around 2022) than DEEP (around 2033); however, the social NPV of DEEP scenario surpasses the MID scenario around 2040, well before the end year of the DEEP scenario (i.e., the year in which 1st round retrofits stop), which is 2054. The policy interpretation of these results is that even though a MID retrofit programme delivers net benefits earlier (and is less burdensome to the State coffers – see Section 7.9.3.2), going for ambitious, more capital-demanding DEEP retrofits bring about higher welfare levels to Hungarian citizens in the long term.

Another relevant result is that positive NPVs happen well before the end year of MID and DEEP scenarios. This is important given the uncertainty surrounding most of the parameters of the CBA model. That positive NPV are obtained relatively early (before the whole 2010 building stock has been fully retrofitted) provides an additional *no-regret* argument for moving towards ambitious interventions.

When compared with the results of the financial CBA (Figure 67), it can be noticed that the social CBA delivers positive NPVs earlier (around 2020 for the MID scenario and 2035 for the DEEP scenario) than the financial CBA (around 2045 for both MID and DEEP scenarios). Equally, in the social CBA the NPV of DEEP scenario surpasses DEEP's sooner (2040) than in the financial analysis (around 2045).

Even though social and financial NPVs cannot be directly contrasted, the comparison based on break-even years indicates that when non-market co-benefits are considered, the proposed energy efficiency scenarios increase their appeal, i.e., they result in net gains at an earlier stage.

Figure 87. Social NPV of moving from BASE to either MID or DEEP scenario



Source: model's results

Table 46. Net Present Value of benefit categories considered, calculated to 40 years (until 2050) at a 5.5% discount rate

	MID		DEEP	
Benefit category	**Million €$_{2010}$**	**% total**	**Million €$_{2010}$**	**% total**
Additional energy savings	4,479	37%	13,617	51%
Additional CO2 avoided	395	3%	864	3%

Benefit category	MID		DEEP	
	Million €$_{2010}$	**% total**	**Million €$_{2010}$**	**% total**
Additional non-GHG emissions avoided	5,145	42%	8,038	30%
Avoided EWM	690	6%	1,303	5%
Comfort benefits	1,543	13%	3,054	11%
TOTAL	12,252	100%	26,876	100%

Source: model's results

The relevance of individual non-market co-benefits in enhancing the appeal of MID and DEEP scenarios can be measured through the present value of the individual benefit categories considered by the social CBA – see

Table 46, Even though energy savingbenefits dominate (especially in DEEP scenario), non-market benefits make up between 65% (MID) and 49% (DEEP) of the total (discounted) benefits accumulated until 2050. Non-market co-benefits are thought to be the main reason why social NPVs look more attractive than financial NPVs to the eyes of a decision-maker.

By categories of non-energy co-benefits, avoided non-GHG emissions are the most important followed by comfort benefits and avoided fuel poverty-related mortality. The value of GHG emission permits potentially generated by the retrofits (avoided GHG emissions) represents only a small fraction of the total discounted benefits until 2050 – see

Table 46.

It is not possible, however, to estimate the percentage of total benefits specifically linked to fuel poverty alleviation. It is expected that fuel poor households will benefit from the energy efficiency intervention in three different ways: energy savings, comfort benefits and avoided excess winter deaths. Of those, only the latter is a benefit exclusive of fuel poor households; the other two are shared to an unknown extent by fuel poor and non-fuel poor.

Though also relevant, results could not be disaggregated by building typologies, unlike in the financial CBA. The main reason is that mortality benefits cannot be broken down by typologies as it is unknown how fuel poverty-related excess winter mortality is distributed among building categories.

Finally, from the perspective of its practical implementation, prioritising building typologies – and regions, districts or settlements – with a higher incidence of fuel poverty would maximise fuel poverty-related benefits such as mortality benefits and comfort gains and perhaps provide earlier positive social NPVs[108]. This complements the recommendations of Section 7.9.3.4, which identified single-family houses built before 1992 (SFH1992) and traditional multi-family houses (TradMFH) as building typologies to act on first in order to minimise the total costs of the intervention.

8.7. SENSITIVITY ANALYSIS

8.7.1. Checking the robustness of results: a pessimistic case

There is large number of parameters whose chosen value for the reference or central case – the results reported in Section 8.6.2 – is subject to uncertainty. For the sensitivity analysis, however, only four key parameters (those that have a larger influence on final results according to my own experience with the model) are tested – see results in Figure 91 to Figure 94. Another two elements (the issues of transaction costs and hard-to-retrofit buildings) are also considered in the sensitivity analysis.

All tests propose a pessimistic case in order to check the robustness of results to assumptions more conservative than the ones used for the reference case. The sensitivity analysis consists refutability test checking if or under which conditions the social CBA fails to result in: i) a positive social NPV for the efficiency scenarios (MID and DEEP); ii) the NPV of DEEP

[108] For instance, if all fuel poverty-related excess winter deaths could be avoided by 2040 instead of 2054 (in the case of DEEP scenario), this would enhance the NPV for the whole modeling period.

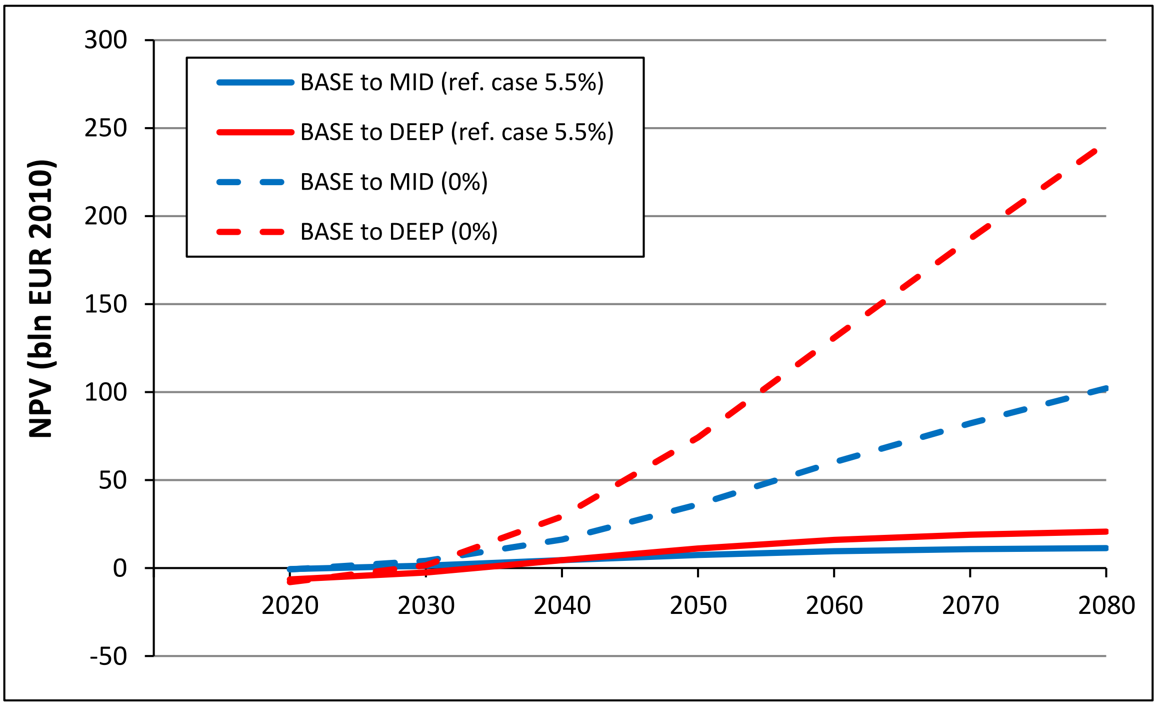
retrofits to be higher than the one obtained for state-of-the-art retrofits (MID scenario).Both are the starting hypothesis assessed in this social CBA.

8.7.2. Parameters tested

8.7.2.1. Social discount rate

The discount rate is a key parameter in sensitivity analysis given the uncertainty about its value in each case and the drastic effect it has on NPV calculations. This illustrated with Figure 88, in which the results of the reference case (calculated with a 5.5% discount rate) are compared with a 0% discount rate case resulting in a substantially higher social NPV. If, as some authors suggest (see Section 8.4), the costs and benefits of decisions with intergenerational relevance should go undiscounted, DEEP retrofits should be adopted without hesitation by today's decision makers.

Figure 88. Social NPV of MID and DEEP scenarios at a 0% and 5.5% (ref.) social discount rate



Source: model's results

For the sensitivity analysis, NPVs to the year 2080 are estimated at a pessimistic 8.1% social discount rate. This is a Hungary-specific rate suggested by the same source as the reference 5.5% social discount rate (EC, 2008a). According to the social time preference rate (STPR) approach adopted by this manual, the social discount rate depends on the *national* value of three parameters: the growth rate of public expenditure, the elasticity of marginal social welfare with respect to public expenditure, and the pure time preference rate. Hungary's specific rate (8.1%) in EC (2008a) is above any of the Western Member States considered and is the largest of the 4 CEE countries included.

As shown in Figure 88 andFigure 91, the results of MID and DEEP scenarios are perceptibly influenced by the choice of a more conservative (higher) social discount rate. It results in negative NPVs for a longer period, especially for the DEEP scenario because of its higher total costs in the first years/decades. In fact, at an 8.1 % discount rate, the long-term NPV of DEEP scenario gets very close to MID's, making the decision about which level of efficiency to pursue very uncertain.

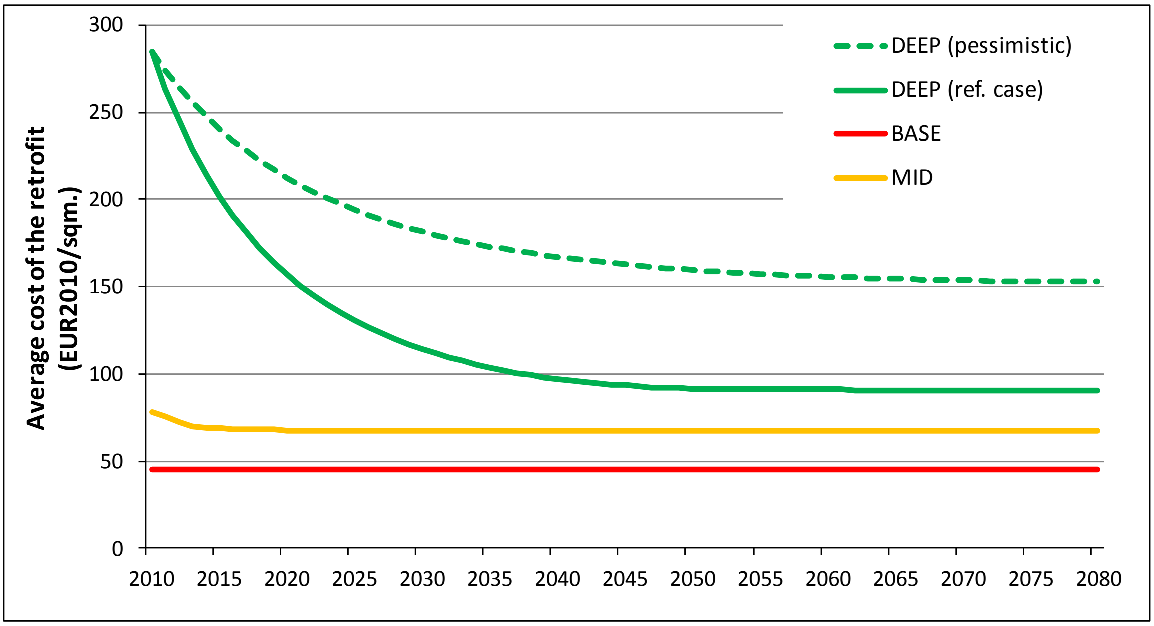
8.7.2.2. Learning curve of DEEP retrofit costs

Given the uncertainty surrounding the shape of the learning curve (no real data on the reduction of retrofits costs could be located in the literature) and its suspected influence on final results, this is one the four parameters tested.

The pessimistic case assumes a less aggressive learning curve for DEEP retrofits. Thus the asymptotic, long-term per unit cost of (1st round) DEEP retrofits is set at 3 times BASE retrofit costs (2xBASE in the reference case), and a rate of decrease of DEEP retrofit costs (parameter l_1 in learning curve equation, see Section 7.5.2.3) equals 4% (8% in the reference case), i.e., in 2011, the cost of retrofitting one square meter is 95% of the 2010 costs instead of 92%. The pessimistic case therefore assumes DEEP costs to decrease more slowly and reach a higher asymptotic cost per m^2 than the reference case – see Figure 89.

Figure 89. Weighted average of DEEP retrofit costs (pessimistic case) vs. DEEP reference case, MID and BASE

Source: model's results



Source: model's results

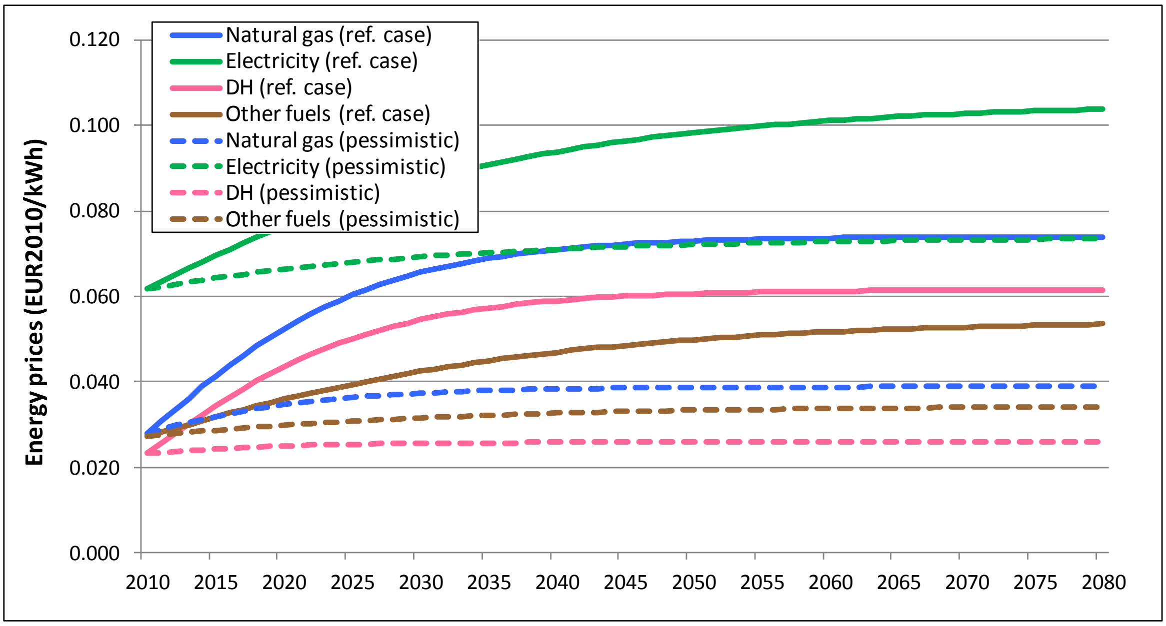
The influence of this parameter on the social NPVs of the DEEP scenario is substantial. A more conservative learning curve such as the one in the pessimistic case results in the difference between MID and DEEP scenarios practically eliminated in the long-term (see Figure 92).

8.7.2.3. Per-unit cost of energy carriers (forecast)

Like in the previous case, no alternative forecasts are readily available. Because of this, for a pessimistic case it was decided to divide arbitrarily by three the annual rates of increase of the reference case (parameter r_1 in Table 38). As a result, long-term energy prices increase to a much lesser extent, depending on the energy carrier. Note that in the case of natural gas, the most important energy carrier in the exercise, this is equivalent to a 39% increase between 2010 and 2080 (from 0.028 to 0.039 $€_{2010}kWh^{-1}$). For a comparison, according IEA (2011) data, import prices of natural gas in Hungary increased by 71% in just 5 years (between 2004 and 2009).

As presented in Figure 93, a more conservative forecast of domestic energy prices results in the difference between the long-term social NPV of DEEP and MID scenarios being largely mitigated.

Figure 90.Evolution of energy prices, (MID and DEEP scenarios): reference vs. pessimistic case



Source: model's results

8.7.2.4. Per-unit value of avoided non-GHG emissions

After energy saving benefits, this is the second largest benefit category in MID and DEEP scenarios – and most important non-market benefit category. Given that no reliable alternative to the reference-case values of avoided non-GHG emissions has been located, the pessimistic case has been defined by dividing by three the per unit value of one avoided tonne of the three pollutants considered (i.e., figures in Table 41).

The result of this test (Figure 94) indicates that a more conservative per-unit value of this external benefit results in a relatively lower social NPV for a DEEP scenario, but still substantially higher than MID's.

8.7.2.5. Further transaction costs

Transaction costs have been partially considered in the analysis as programme management costs, i.e., costs (mostly labour costs) of an State-backed implementation agency in charge of tasks such as informing and liaising with building owners and tenants, conducting quality checks for retrofits, ensuring access to financing of individual households, facilitating agreements between neighbours (in multi-family buildings), etc. These are basically transaction costs borne by the State. But households themselves also bear a substantial fraction of the transaction costs such as the hassle of finding builders, putting up with the disruption and nuisance associated with building works, etc. However, no reliable estimate could be produced for these transaction costs occurring on the households' side.

For this reason, the sensitivity analysis assesses a pessimistic case with higher transaction costs. If in the reference case these are estimated as 10% (DEEP) and 5% (MID) of 1st round retrofit costs, in the pessimistic they are increased by a factor of 3: 30% and 15% of 1st round retrofit costs.

The results of the test are shown in Figure 95. They indicate that even if transaction costs were three times higher, positive NPVs would be obtained in the long term, and the DEEP scenario would be the preferred policy option.

8.7.2.6. Hard-to-retrofit buildings

The uncertainty introduced by the issue of hard-to-retrofit buildings (i.e., buildings that cannot be upgrade to high efficiency levels) is tested through a pessimistic case (only for of DEEP scenario) defined by the following assumptions:

- 30% of historical buildings (Hist) and 20% of the categories SFH 1992 and TradMFH cannot be retrofitted to DEEP levels. Therefore, they are retrofitted to MID levels, at the cost of a MID retrofit. These percentages, which are author's assumptions, make up 15% of the total stock retrofitted by DEEP scenario.
- Homes built after 1993 (SFH2010 and MFH2010) and Panel buildings can all be retrofitted to DEEP levels. In the first case, because they are constructions in better shape; in the second case, because Panel buildings are supposed to have a standard structure and quality,

and the SOLANOVA pilot project has provided a largely replicable example of DEEP retrofits in this building category.

- Programme management costs of DEEP scenario (see Section 8.2.2) remain the same as in the reference case.
- The value of energy savings and avoided GHG and non-GHG emissions are recalculated taking into account the percentage of Hist (30%), SFH1992 and TradMFH (20%) buildings retrofitted to MID levels.
- In the pessimistic case, DEEP scenario avoids 10% less fuel poverty-related EWDs (950 vs. 1,050 premature deaths per year in the reference case). Recall that according to the model‘s assumptions MID retrofits also avoid EWDs, though only half of the avoided by DEEP retrofits (Section 8.3.4.1).
- Comfort benefits are recalculated according to the methodology described in Section 0 with the percentages of Hist, SFH1992 and TradMFH buildings retrofitted to MID levels in the pessimistic case.

The results of the test are presented in Figure 96. Even if the long-term social NPV of DEEP shrinks, it is still higher than the social NPV of MID scenario. In an even more extreme case *pessimistic2*inFigure 96)in which Hist, SFH1992 and TradMFH buildings are retrofitted at DEEP costs but only achieve MID energy savings, long-term results favour DEEP scenario.

8.7.3. Sensitivity analysis: overview of results

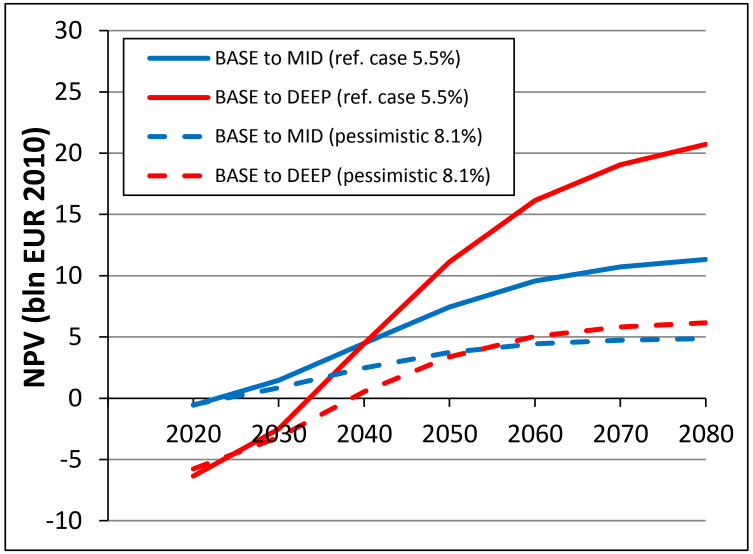
All in all, the sensitivity analysis confirms the relative robustness of the social CBA results with respect to the uncertainty of the model's key parameters. In all 4 cases, improving the energy efficiency of Hungary's residential stock is justified (i.e., it results in a net welfare gain or positive social NPV). However, when the reference values of some key parameters are substituted by more conservative alternatives (e.g., less aggressive learning curve of DEEP retrofits, smoother increase in domestic energy prices, etc.), the DEEP scenario loses its appeal as compared to MID. In fact, some of the pessimistic cases defined for the sensitivity analysis (i.e., a higher discount rate or a less aggressive learning curve for DEEP retrofits) provide an indication of the parameter values that make MID as good alternative as DEEP.

In order of the relevance, the discount rate and the learning curve of DEEP retrofits costs seem to be the parameters with a stronger effect on the results of the social CBA, followed by the forecast of energy prices and the per unit external value of non-GHG emissions. The rest of the parameters (e.g., per unit value of an avoided EWD or avoided tCO_{2eq}) are expected to have less influence on the social NPV of MID and DEEP scenarios.

The issue of hard-to-retrofit buildings have been also addressed in the sensitivity analysis given the uncertainty introduced by the fact that a fraction of the 2010 stock may not be prepared for a high energy efficiency upgrade. The results (Figure 95 and Figure 96) indicate that even if worse quality buildings couldn't deliver DEEP-level energy savings after retrofit, in the long-term DEEP scenario would still result in a larger social NPV than MID scenario's.

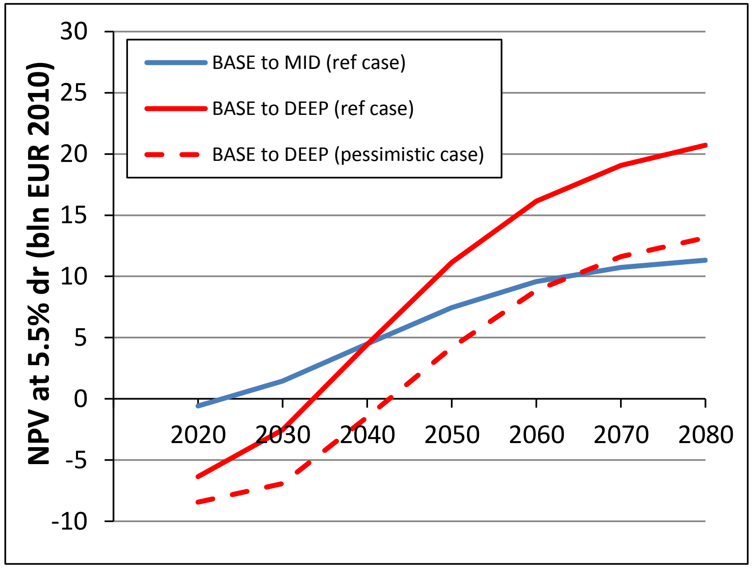
Equally, if transaction costs were increased by a factor of 3 in order to account for the disturbances and nuisance experienced by households, positive NPVs would be obtained.

Figure 91. Sensitivity analysis: discount rate



Source: model's results

Figure 92. Sensitivity analysis: learning curve of DEEP retrofits



Source: model's results

Figure 93. Sensitivity analysis: cost of energy carriers (forecast)

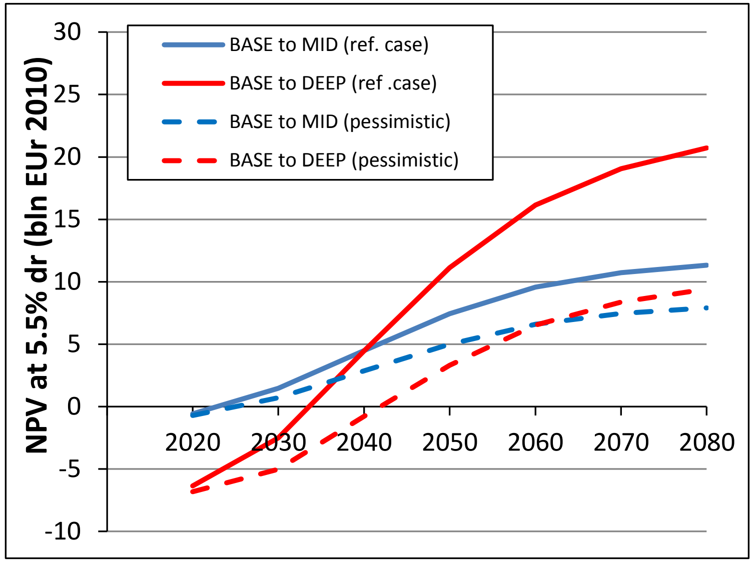
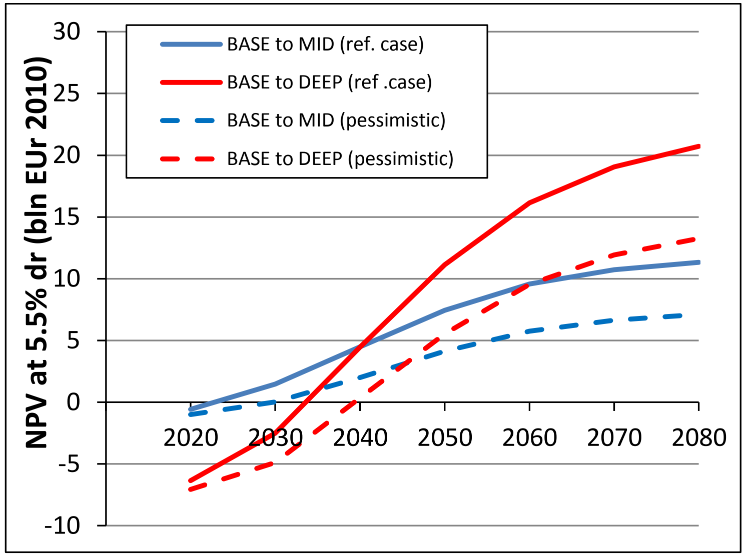
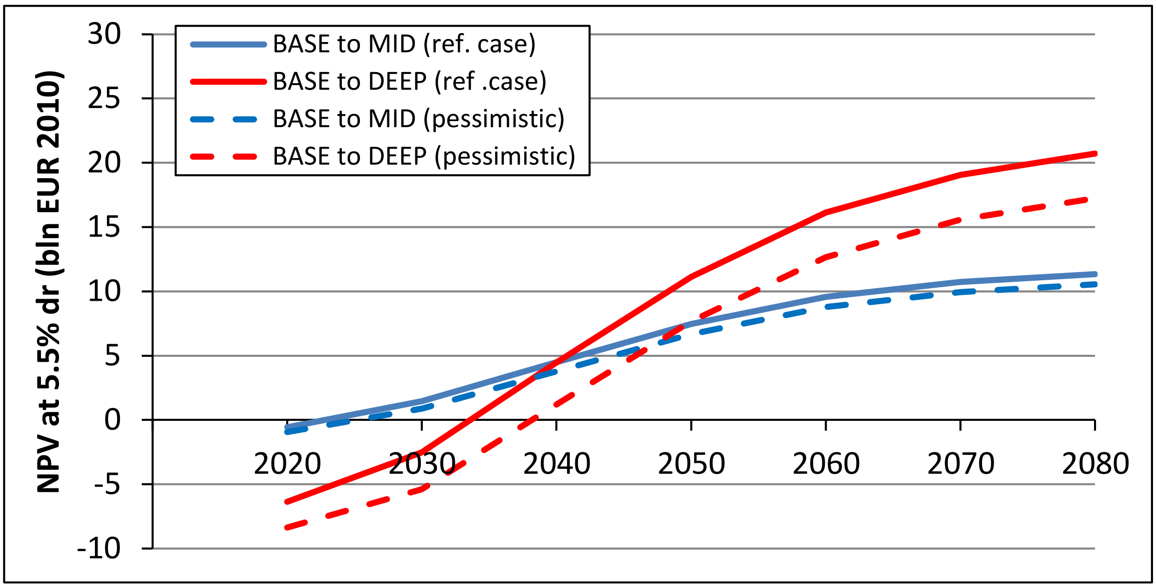


Figure 94. Sensitivity analysis: value of avoided non-GHG emissions



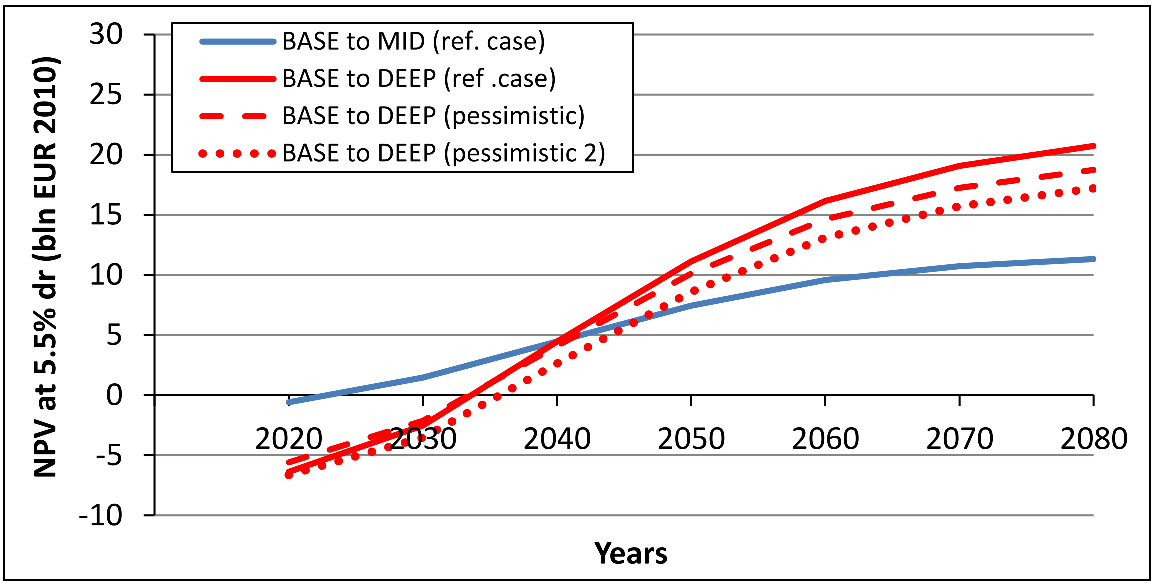
Source: model's results

Figure 95. Sensitivity analysis: further transaction costs



Source: model's results

Figure 96. Sensitivity analysis: hard-to-retrofit buildings



Note: the extreme case is a version of the pessimistic case in which problematic Hist, SFH1992 and TradMFH buildings are retrofitted at DEEP costs but achieve just MID energy savings.
Source: model's results

8.8. NON-VALUED CO-BENEFITS

8.8.1. Further human health benefits

As discussed previously, the inefficient use of energy in the residential sector has a negative impact on human health for two reasons:

- the emission of non-GHG air pollutants as a consequence of the combustion of fossil fuels and other solid fuels like firewood, which has demonstrated negative health effects in addition to impacts on crops, ecosystems and materials;
- the inadequate indoor temperatures experienced by households in fuel poverty, which increases excess winter mortality rates and has a number of other non-lethal effects on vulnerable populations.

The human health benefits of avoided non-GHG emissions have been incorporated into the social CBA as the avoided external cost of emission of 12 pollutants – ammonia (NH_3), sulphur oxides (SO_x), nitrogen oxides (NO_x), suspended particles or particulate matter (PM_{co} and $PM_{2.5}$)[109], non-methane volatile organic compounds (NMVOC) and heavy metals (Pb, Cd, Hg, As, Cr and Ni) – see Section 8.3.3. However, a couple of other pollutants for which an external cost of emission was available in Preiss et al. (2008) – formaldehyde and dioxin – could not be incorporated because of the lack of emission factors in the 2009 EMEP/EEA air pollutant emission inventory guidebook (EEA, 2009). Note that the external cost of emission of dioxins is the highest of the reported by Preiss et al. (2008) – 37 billion $€_{2010}$ per tonne.

Fuel poverty-specific health benefits have been incorporated into the social CBA only through the value of avoided excess winter mortality (Section 8.3.4). However, there is evidence of the relationship between cold and damp dwellings and several physical and mental illnesses (Morrison and Shortt, 2008), with more negative physical and mental health effects detected for vulnerable populations such as the elderly and children (de Garbino, 2004; Howieson, 2005; Liddell and Morris, 2010). More specifically, a recent review of the health impacts of fuel poverty carried out in the UK (The Marmot Review Team, 2011) concluded that:

[109] Following Preiss et al. (2008), particulate matter has been divided into two categories depending on their size: PM_{co} (coarse particulate matter– aerodynamic diameter between 10 and 2.5 µm) and $PM_{2.5}$ (particulate matter with an aerodynamic diameter of smaller than 2.5 µm).

- Living in an inadequately heated home decreases children's performance in school, affects their emotional resilience and wellbeing, and doubles the likelihood that they suffer from respiratory problems. It also affects infants' ability to gain weight, hinders their developmental status and increases their hospital admission rates and incidence and severity of asthmatic symptoms.
- It affects negatively the mental health of adolescents: the probability of suffering from a mental condition is 25% among teenagers living in cold homes, as compared to the 5% probability recorded for teenagers not living in fuel poverty.
- Living in a cold home is a cause of minor illnesses such as flu and cold, and worsens the health conditions of persons affected by arthritis and rheumatism.
- Having disproportionate domestic energy expenses affects negatively the households' dietary choices as it reduces income available for food. This is known as the *heat-or-eat* dilemma.

In addition to these effects, research has also found that living in a cold home is associated with anxiety, shame, guilt and isolation (Anderson et al., 2010). These feelings, which are often connected to diagnosable conditions like anxiety or depression, are beyond the realm of the impacts of fuel poverty on physical mental health and have to do with the way the fuel poor see themselves and relate with other members of society.

These effects on human health and wellbeing, different from fuel poverty-related excess winter mortality, are acknowledged but not incorporated in the social CBA. The main reason for this omission is the absence of data as available Hungarian health statistics do not even provide enough information for estimating excess winter morbidity rates for cardiovascular and respiratory diseases, let alone more elusive conditions such as the mental health effects of fuel poverty.

The non-incorporation of the above described health benefits makes the results of the social CBA to be a conservative estimate of the net effect of MID and DEEP scenarios on the aggregated welfare of Hungarian society. However , their influence on social NPV estimates may not be too important. As the Clinch and Healy (2001) study shows, the morbidity benefits of reducing fuel poverty rates through domestic energy efficiency investments in Ireland (58 million Euro) represented just 4% of the total net social benefit obtained with the programme (3,124 million Euro), at a 5% discount rate.

On the other hand, these elements are relevant also from a State budget perspective because a healthier population also means less pressure on the public healthcare systems. This way, a study in the UK has estimated that the current excess cold hazard costs of energy inefficient homes (F- and G-rated) to the National Health System (NHS) amounts to € 225 million (£192 million) per year (BRE, 2011). Likewise, Liddell (2008) claims that, in the UK, for each pound spent on fighting fuel poverty the NHS gets back 12 pence as reduced costs due to improved children's health (42 pence when adults are also considered).

8.8.2. Further comfort gains: indoor temperatures

Section 8.3.5 has presented an *ad-hoc*methodology for the economic valuation of two comfort gains typologies: increased percentage of floor area heated and substitution of firewood by natural gas as a heating fuel. However, a third component (improved indoor temperatures) could not be incorporated because of the absolute lack of data about thermal discomfort and domestic temperatures in Hungarian dwellings.

However, this co-benefit category would not be expected in all retrofitted dwellings. In the prefabricated *panel* blocks category – representing 16% of the Hungarian stock – this could not be counted as a welfare gain because, as discussed in Chapter 6, dwellings are in most cases sufficiently well heated (and sometimes even over-heated) during the cold season. In these buildings, some positive impacts on households' wellbeing are nevertheless expected following the installation of individual DH consumption meters as parts of the retrofits: users would be able to adjust the temperature of their flats without having to resort, for instance, to opening the windows to let the heat out.

8.8.3. Energy dependency reduction

Improving the energy performance of buildings results in better energy security and less dependence on imported energy, an issue that is gaining priority in the political agendas of energy-importing countries and regions like the EU and Central and Eastern Europe (Harks, 2006; Chen et al., 2008; Checchi et al., 2009). Energy efficiency programmes can be therefore proposed as an alternative to conventional supply-expansion infrastructural developments (e.g., construction of strategic storages and pipelines, discovery of new fossil fuel fields or deposits, etc.)

Energy security in Hungary is closely linked to natural gas import from the former Soviet Union, which as of 2009 supplied around 75% of total consumption. Domestic production covers the remaining 25%, although it is estimated that the country's proven reserves (95 bcm, equivalent to 38 years) can supply natural gas at present rates until around 2020, with production expected to decline sharply afterwards unless new resources are developed for replacing the currently existing mature fields (OECD/IEA, 2012a).

As the most gas dependent IEA member country, the continuity of supply has been a primary concern of the Hungarian government since the interruptions of January 2006 resulting from the Ukraine-Russia dispute (OECD/IEA, 2007). This explains Hungary's involvement in the 'Nabucco' project (Spiegel Online International, 2009) and the ongoing efforts to increase the country's gas storage capacity (Socor, 2009). However, developing such infrastructures not only requires large amounts of money, which could be invested in demand-side solutions, but may also influence long-term energy prices. In this respect, the 2007 IEA review of Hungary's energy policy recommended to "consider the introduction of this measure [creation of a strategic storage] carefully, owing to its high cost, and that it should be implemented as part of a suite of measures, such as increasing energy efficiency and supply source diversification". This statement has patent fuel poverty implications as the IEA advocated for delivering "the increase in [energy] security at a low cost to the gas consumer" (OECD/IEA, 2007, p. 11).

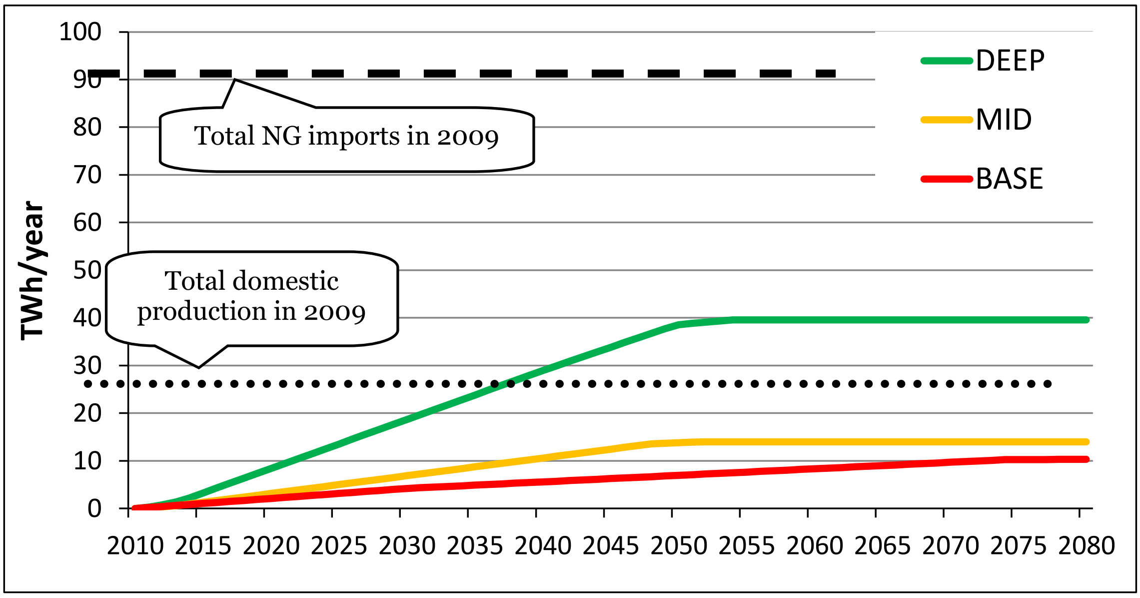
The residential sector can contribute decisively to alleviate Hungary's energy dependency because it accounts for 35% of total gas demand (OECD/IEA, 2012a). In this context, the CBA model has been used for comparing the natural gas saving potential of reducing the space heating requirements of Hungary's dwelling versus the current amount of gas imports and domestic production per year. For this, total natural gas savings for the three scenarios have been estimated by adding the model's NCV-based estimates of direct natural gas consumption as domestic heating fuel to:

- indirect natural gas savings in the DH industry, calculated upon the assumptions that 83% of total DH production in Hungary is based on natural gas and that the efficiency of DH power plants is 89% (Sigmond, 2009);

- indirect natural savings in the electricity sector calculated upon the assumptions that 38% of the Hungary's electricity is produced with natural gas (Enercee.net, 2012) and that the efficiency of natural gas-fired power plants is 50% (author's assumption).

The results are shown in Figure 97, in which the natural gas saving potential of the three scenarios are compared with Hungary's total natural gas imports (91.1 TWh, in NCV units) and domestic production (26.6 TWH, in NCV-units) for 2009, the last year with available data (OECD/IEA, 2012a). In spite of the uncertainty surrounding the future evolution of annual imports and domestic production in the future, these results indicate that the DEEP scenario would realise a saving in the long term of 43% of the 2009 imports (15% and 11% for MID and DEEP scenarios respectively). In addition, the DEEP scenario would save more natural gas than Hungary's 2009 domestic production from 2038 onwards. The underlying policy message is that DEEP retrofits can save in the long-term even more gas than what is currently produced in domestic fields.

Figure 97. Total natural gas savings by scenarios versus total natural gas imports and domestic production in 2009



Source: model's results; OECD/IEA (2012)

The economic valuation of this co-benefit is methodologically challenging once natural gas savings are already accounted for as energy saving benefits valued at import prices (Section 8.3.1). Few actual examples (and none of them related to energy efficiency in buildings) that deal with the specific welfare effects of improving the energy security of an economy have been located in the literature. Nevertheless, estimates based on a review of US studies indicate the marginal external cost of oil dependency may be above 10 US$ per barrel (Maibach et al., 2007), a figure that accounts for the economic losses resulting from oil prices above competitive market levels, the costs of oil supply disruptions and the costs of oil security enhancing policies (e.g., presence of US military in the Middle East).

Another approach relies on stated-preference methods: in Greece, a contingent valuation survey estimated that households are willing to pay a premium of between €4.5 to 12.7 on their electricity bills for securing an uninterrupted gas supply for electricity generation (Damigos et al., 2009).

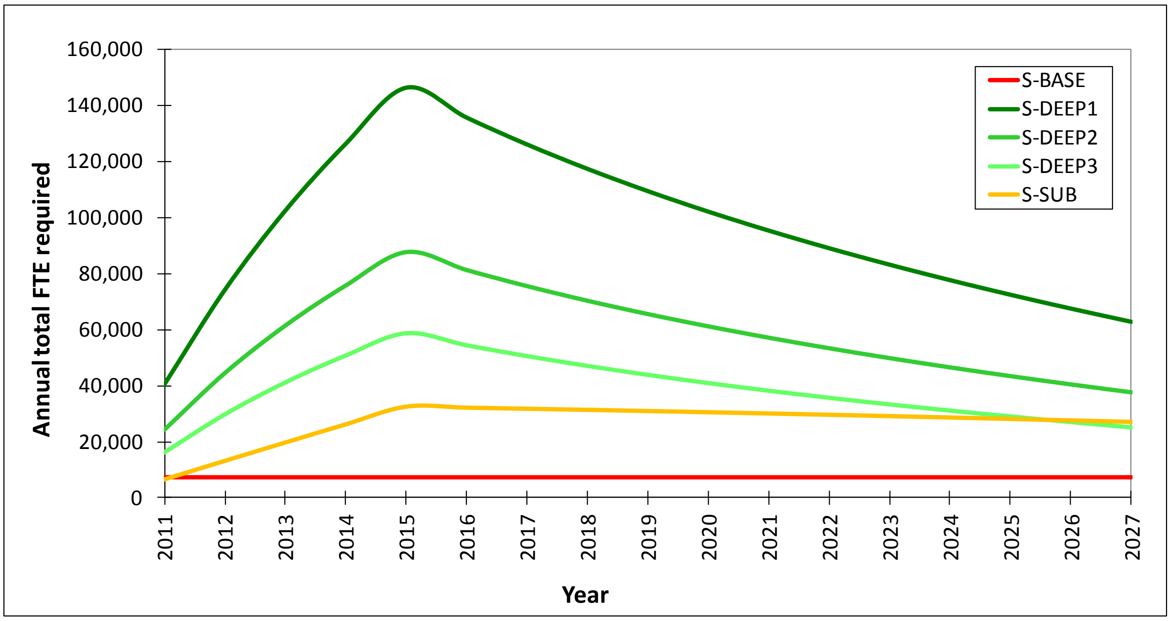
8.8.4. Net employment generation

To be considered as a positive externality of climate policies, employment creation must be measured in terms of changes in human wellbeing (Pearce, 2000), which happens when unemployment reduction is considered as a societal goal. That is not the case of a fully employed economy, in which unemployed labour is soon transferred to new use, but in locations with persistent unemployment due to some type of failure in labour markets (Krupnick et al., 2000).

The employment effects of energy efficiency interventions in the building sector have been sometimes estimated through case studies that record the amount of new positions created in the sectors directly involved in the intervention (Jeeninga et al., 1999; Wade et al., 2000: Tirado Herrero et al., 2012). However, this approach does not allow estimating indirect and induced effects, nor the job losses registered in the energy supply sector. In order to account for the whole range of positive and negative direct, indirect and induced effects, Input-Output models are have been often applied. Estimates based on this methodology indicate that programmes aimed at improving the energy efficiency of buildings typically generate between 10 and 20 net jobs per million Euros invested, more than other *green* interventions or other non-environmental investments (Ürge-Vorsatz et al., 2010).

For MID and DEEP scenarios, the results of the employment study on which this CBA is based (Ürge-Vorsatz et al., 2010) can be taken as a good approximation of their net employment generation potential. In this regard, the results of the study show that *S-SUB* scenario (equivalent to MID scenario) generates over 20,000 Full-Time Equivalents(FTE) per year more than the base scenario (*S-BASE*); and *S-DEEP3* scenario (equivalent to DEEP scenario) creates up to 50,000 FTE per year more than the base scenario. In spite of some differences in data and assumptions (see Section 7.3.1) both models (Ürge-Vorsatz et al., 2010 and this social CBA) are basically the same at their core. Consequently, the above reported numbers can be assumed to be the (rough) job creation potential of MID and DEEP scenarios – see Figure 98.

Figure 98. Net employment impacts of scenarios equivalent to MID (*S-SUB*) and DEEP (*S-DEEP3*) in the original employment model



Source: Ürge-Vorsatz et al. (2010)

However, two important conceptual and methodological issues must be considered prior to valuing employment creation as a co-benefit for its incorporation into social CBA.

First, Input-Output methodology calculates a net number of created jobs in the sense that the it discounts the direct, indirect and induced job losses that may have occurred in the energy supply and related sectors. However, this does not mean that an investment of the same size going into an alternative development project (e.g., expanding the renewable generation capacity of a country or improving its transport infrastructure) would not render similar or higher employment results. Thus, even though the calculated amount of created jobs is net, it is not sure that these jobs are additional.

However, Ürge-Vorsatz et al. (2010) estimated that investing the same amount of money required by the efficiency scenarios on conventional construction activities (such as transport infrastructures) would result in a substantially smaller amount of direct jobs created. The reason for this is that the labour intensity (FTE per million Euro) of general construction activities is well below the labour intensity of building retrofits. This provides some ground to claim that residential energy efficiency investments in Hungary can actually create more jobs than alternative investment paths.

Second, putting an economic value to the number of jobs created is not an easy task. Very few examples of the economic valuation of employment effects exist, and none have been located for the case of energy efficiency in buildings. However, for the case of renewable energy, Soliño (2010) found through a choice experiment a positive willingness to pay (WTP) for a programme that substitutes fossil fuels by forest biomass for the production of electricity, decreasing carbon emissions and delivering additional benefits. These results confirmed that in the context where the survey was conducted (a region of NW Spain whose inhabitants believe in the importance of creating new jobs in rural areas) a marginal positive willingness to pay for employment creation exists.

Pearce et al. (2006) suggest an alternative approach to the incorporation of employment effects in social CBA. According to these authors, the right way to proceed is by shadow pricing labour costs below wage level when the project creates jobs for labour that would be unemployed had the project not taken place. This is in fact the approach followed in my social CBA: the costs of the unskilled labour required by retrofits has been reduced by a 0.6 shadow wage factor (EC, 2008a) based on the assumption that extensive unemployment exists in this layer of the Hungarian labour market – see Section 8.2.1.2.

8.8.5. Enhanced rental and resale price of properties

Compared to similar units with the same location and physical attributes, retrofitted buildings have a number of advantages that make them more attractive to buyers of the housing rental and sale markets. In theory, and assuming perfect information, consumers are willing to pay an additional amount of money equivalent to the net present value of the benefits obtained for living in a house with lower utility expenses, better indoor air quality, less outdoor noise infiltration, improved safety conditions, lower maintenance costs, etc.

Typically, the effect of energy efficiency improvements in real estate prices has been analysed through hedonic pricing techniques. With this methodology, a study from Switzerland valued the presence of energy efficient windows at 2-3.5% of the selling price of existing single-family houses (Borsani and Sali, 2003, in Jakob, 2006).

A more relevant analysis of the Dutch housing sector, where an early, voluntary adoption of the EU EPBD energy labelling system is in place, found out that certified properties (A, B or C certificate) were sold with a 2.8% higher transaction price than those non-certified. Other equally important findings of this study are (Brounen and Kok, 2010):

- The price premium is proportional with the energy performance of the property. A-labelled homes (similar to the ones that result of the implementation of DEEP retrofits) obtained a 12.1% price premium in transaction prices as compared to similar G-labelled homes. On the contrary, F-labelled properties only received a 1.7% premium as compared to G-labelled homes.
- In general, the variation in price premia is equivalent to the present value of the energy savings that result from a higher energy efficiency level. However, for A-labelled properties, the premium is higher than the capitalized value of the energy savings, which may indicate that other attributes of the dwelling (e.g., improved thermal comfort) are also incorporated into the transaction price of high energy efficiency homes.

This last point raises an important methodological issue: the risk of double counting. The question is that some benefits (energy savings and improved thermal comfort) stemming from an energy efficiency retrofit end up reflected in the price of the property. Therefore, adding the increased rental/resale price of the value of those co-benefits would be incorrect if the value of those co-benefits has been already incorporated in the social CBA.

However, that the price of the dwelling as an asset – in fact, often the most valuable asset of households – increases as a result of the intervention is important because it provides an additional financial incentive for households to participate in the programme and for maintaining the energy efficiency gains achieved with the retrofit. They will not be only saving on their energy costs and living in a more comfortable place but will also be able to sell or rent their property at a better price because the new owners/tenants expect their household energy costs to be lower than in a conventional dwelling.

8.9. SUMMARY OF KEY RESULTS: FINANCIAL vs. SOCIAL COST BENEFIT ANALYSIS

Chapters 7 and 8 have presented the data, assumptions and results of the financial and social CBA conducted with the aim of assessing the convenience of upgrading Hungary's current residential energy efficiency policies to either a MID (40% energy savings for heating per dwelling) or a DEEP scenario (79 to 90% energy savings for heating per dwelling).

As discussed in Section 7.1, one main reason to conduct both a financial and a social CBA is to measure the relevance of co-benefits in the economic assessment of residential energy efficiency scenarios. The research question addressed is to what extent the incorporation of non-market co-benefits enhances the appeal (from an applied policy viewpoint) of energy efficiency scenarios. This question is tentatively answered by comparing the final results (NPVs) obtained in the social and financial CBA – Figure 99.

The financial and social NPVs obtained are not directly comparable: the financial NPV is simply a discounted sum of a cash flow (financial costs minus benefits) whereas 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. However,comparing the evolution of both NPVs provides quantitative evidence for the relevance of how important non-market co-benefits in the economic assessment of residential energy efficiency scenarios (see Figure 99):

- 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[110], the comparison suggests that the incorporation of co-benefits effectively enhances the policy 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. 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.

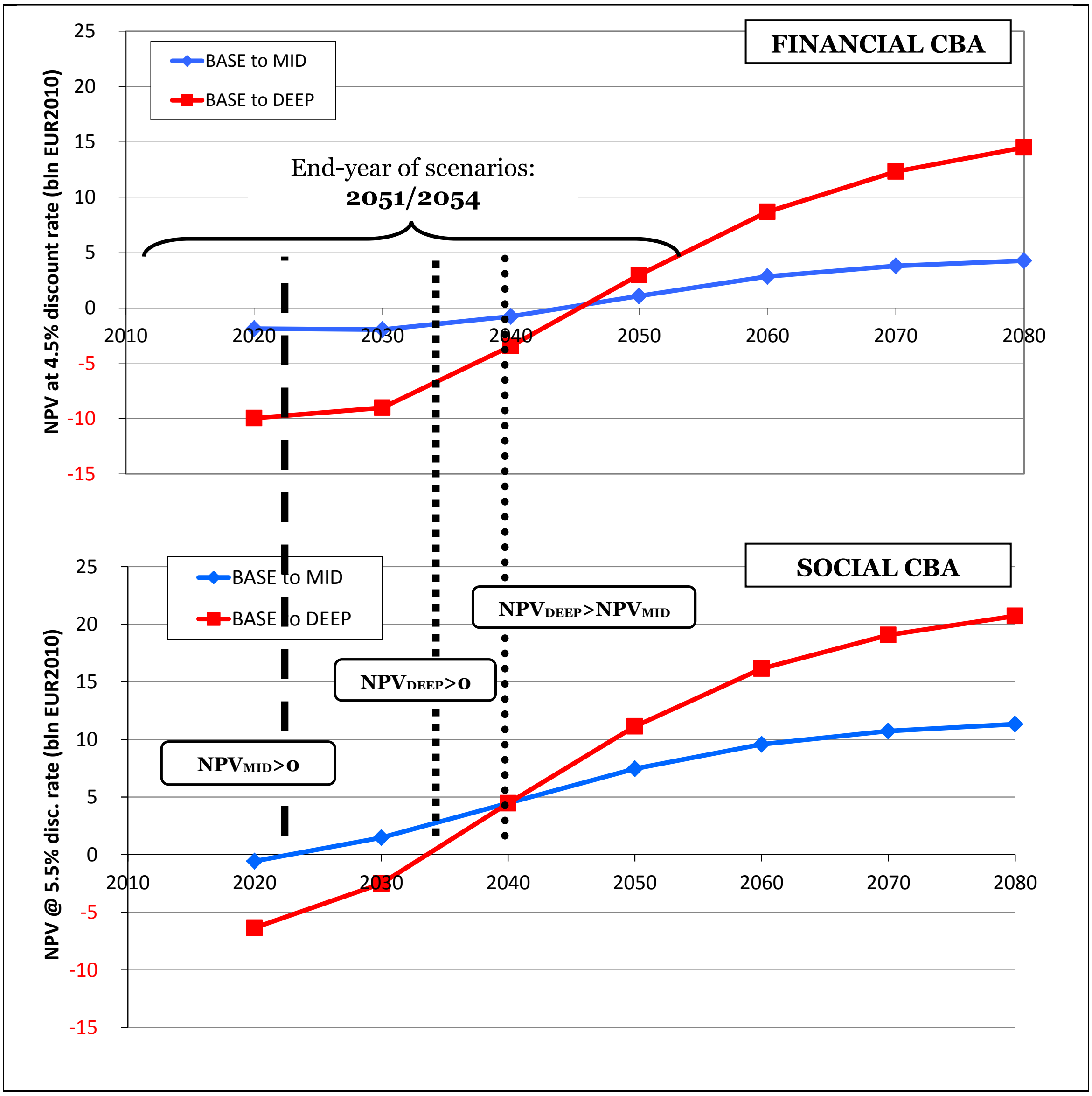
A subsequent and equally important conclusion of the CBA is that improving the energy efficiency of Hungary's residential buildings to high (near passive-house) levels results in

[110] 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.

large positive net welfare gains for the Hungarian society. Though moving from BASE to MID scenario delivers positive NPVs at an earlier stage (from around 2022), 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.

Figure 99.Comparison of key break-even points in the social and financial Net Present Value



Source: model's results

Chapter 9

CONCLUSIONS

"However selfish man may be supposed, there are evidently some principles in his nature, which interest him in the fortune of others, and render their happiness necessary to him, though he derives nothing from it, except the pleasure of seeing it"

Adam Smith -The Theory of Moral Sentiments.

9. CONCLUSIONS

9.1. OVERVIEW OF FINDINGS AND KEY RESULTS

9.1.1. Overview of the dissertation

While climate change remains one of the most (if not the most) important global environmental problem, a large fraction of the world's population is still experiencing a deficit of energy services for their everyday life activities or does not even have access to modern energy services such as the ones provided by electricity or natural gas. In the developed nations and transition economies of Europe, this phenomenon is labelled as fuel poverty (Boardman, 1991) and refers to the inability of households to "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" (Ürge-Vorsatz and Tirado Herrero, 2012, p. 84).

This dissertation addresses the issues of fuel poverty from the perspective of the co-benefits of climate change mitigation, i.e., the positive side-effects of mitigation investments different from the avoided impacts of climate change. The bottom line is that even if climate change has not yet acted as a significant driver of residential energy efficiency policies, other problems directly affecting the welfare of today's voters and taxpayers – like the affordability of domestic energy – may bring about the transformationrequired in the energy systems of developed and transition economies.

This dissertation assesses these interrelated realities using Hungary as a case study. More specifically,it attempts to answer the following overarching research question posed in Chapter 1:

- *What are the extent, causes and characteristics of fuel poverty in Hungary; and*

- *what is the relevance non-market co-benefits (including fuel poverty alleviation benefits) in the economic assessment of residential energy efficiency scenarios in Hungary?*

To answer the first sub-question, this research has first estimated the extent and characteristics of the fuel poverty phenomenon in Hungary through a review of indicators (Chapter 4), and then explored their connection with three widely recognised causes of fuel poverty: domestic energy prices, household incomes and energy efficiency of the dwelling stock (Chapter 5). Two previously unreported cases of fuel poverty (poor Roma households in rural areas; *panel* dwellings connected to DH) are then presented to illustrate the actual experience of energy deprivation in Hungary; they also bring about new perspectives that contest to some extent the traditional understanding of fuel poverty as defined by Western European standards.

Later, a financial and social cost-benefit analysis (CBA) assesses the costs and benefits (energy saving benefits and other non-market co-benefits) of two hypothetical upgraded residential energy efficiency scenarios. The comparison of the financial and social Net Present Values (NPV) provides quantitative evidence for the relevance of non-market co-benefits for this kind of assessments, thus contributing to answer the second research sub-question. The CBA model also serves for evaluating a *pay-as-you save* financing scheme complemented with State grants, and of the pressure the latter may puton the Hungarian government budget (Chapter 7 and 8).

Despite the relative specificity of its energy system, Hungary is taken as a case study representative of the post-socialist states of Central and Eastern Europe. In this region, the higher incidence of fuel poverty (as compared to Western Europe) is thought to be an undesirable consequence of the large scale transformation of economies, policies and institutions following the political events of 1989 (Buzar, 2007c). This makes Central and

Eastern Europe a priority area for the study of fuel poverty alleviation as a co-benefit of climate investments.

9.1.2. Summary of key results

A first key outcome of this research is that between 10 to 30% of the Hungarian population (1 to 3 million people) were in fuel poverty in the second half of the decade of the 2000s. . The width of the range is explained by the substantial differences found in fuel poverty rates calculated by the two measuring approaches applied:

- The expenditure approach, according to which a household is in fuel poverty if its actual energy expenditure is above 10 to 20% the household annual income (with15% as a representative fuel poverty line for the 10 to 20% interval). For the implementation of this approach,microdadata from the Hungarian Household Budget Survey (HBS) –

  Years 2005 and 2008 – were used.
- The self-reported or consensual approach, according to which a household is in fuel poverty if it declares to be unable to keep its home adequately warm in the winter. For the implementation of this approach, data retrieved from the EU Survey on Income and Living Conditions (EU-SILC) were used.

According to the expenditure-based rate, fuel poverty affected 21% of Hungarian households in 2005 and 34% in 2008, i.e., were spending more than 15% of their annual income on energy. These results suggest a very rapid increase in the incidence in fuel poverty in Hungary in a short 4-year period, which is most likely related to the substantial rise of natural gas prices (the most common fuel used for space heating by Hungarian households) that occurred since 2006. The natural gas *price hike* is primarily a consequence of Hungary's weak position as an importing nation depending almost entirely on the price set by its suppliers from the former Soviet Union. But it is also the result of regulated domestic natural gas tariffs, which led to the accumulation of losses in the balance sheets of distribution companies and had to be reverted through an increase in regulated prices decreed in 2006 that has continued since then. Further causes are the increase in VAT (from 20 to 25%) and the upgrade of the country's strategic natural gas storage capacity, which add to the more stringent eligibility criteria for domestic energy price subsidies (*gázártámogatás*) introduced in 2007.

In the same period, the consensual or self-reported fuel poverty rate decreased from 18% (in 2005) to 10% (in 2008) of the Hungarian population. This is an unexpected result given the rapid rise in domestic energy (gas) prices occurred during those same years. It may be perhaps related to the subjective nature of this indicator, which relies on the households' self-assessment of its ability to keep the home adequately warm; though it may also indicate that a raise in energy prices does not automatically translate into increasing (perceived) difficulties to provide enough thermal comfort to the dwelling, or thatHungarian households cope with rapidly increasing domestic heating prices in ways other than reducing indoor thermal comfort.

Regardinf coping strategies, secondary indicators of fuel poverty show that the percentage of the population in arrears on utility bills is on the rise, as it increased from 15 to 23% between 2008 and 2011; the same goes for the percentage of households with a significant use of firewood (i.e., whose firewood expenditures are more than 10% of their total energy expenditures) at home. In the latter case, the proportion increased from 22 to 26% between 2005 and 2008, with even a more significant increase (10 to 16%) recorded for the subset of households that use firewood but still have access to piped gas at home. However, households in these two categories (with arrears in utility bills or using firewood) cannot be classified automatically as fuel poor. These indicators neverthelles illustrate some ways in which households cope (imperfectly) with energy affordability problems.

Additional EU SILC-based secondary indicators point out that as an average for 2004-2011 24% of the Hungarian population was living in a house with fuel poverty-related faults (i.e., leaking roof, damp walls, floors or foundation, or rot in window frames or floor). Data also demonstrated that 29% of Hungarian dwellings were not comfortably cool during the summer in 2007. The latter figure was retrieved from an *ad hoc* EU SILC module only available for the year 2007 and is taken as a first-ever self-reported indicator of the incidence of *summertime* fuel poverty, a category first suggested by Healy (2004).

The increasing trend detected mostly in expenditure-based fuel poverty indicators is expected to continue as long as domestic energy prices (very influenced by the evolution of natural gas prices) continue growing at a faster pace thaninflation and the rate of increase of salaries and pensions. In fact, the sustained, strong rise in domestic energy prices that has occurred since the mid 2000s is changing the structure of consumption of the average Hungarian household. Since 2009, aggregated results of HBS indicate that the COICOP[111] category *Housing, maintenance and household energy*[112] is the most important budget item of the average Hungarian household. And if household energy was considered as a COICOP category of its own, it would be the second most important after (and approaching) *Food and non-alcoholic beverages*.

Even though rising energy (gas) prices are probably the single most important supply-side factor explaining sort-term trends in fuel poverty rates, this dissertation considers the energy

[111] Classification of Individual Consumption by Purpose

[112] Note that this category includes rentals but not mortgage payments, which according to the methodology of budget survey is considered to be an investment and not a expenditure

performance of dwellings as a key structural cause or contributing factor to fuel poverty in Hungary. For this reason, a cross-EU27 analysis of the linear correlation (Pearson's *r*) between fuel poverty indicators and various *proxies* of the energy performance of the dwelling stock has been carried out. This exercise concluded that the EU SILC secondary indicator *Leaking roof, damp walls, floors or foundation, or rot in window frames or floor* explains 50 to 60% of the variance found for the average value of three self-reported indicators of fuel poverty (*Inability to keep the house adequately warm,Arrears on utility bills* and *Dwellings not comfortably cool during summer time*) in EU27 countries between 2005 and 2008. These results illustrate the correlation between self-reported causes and effects of fuel poverty (even of *summertime* fuel poverty); it also suggests the importance of the quality of the building stock to explain differences between fuel poverty rates at the EU27 level.

The quality of dwellings has also been analysed through HBS microdata for 2005 and 2008. The analysis concluded that households living in dwellings in "sufficient" or "underpinned" conditions report an average energy cost per square meter 10 to 20% higher than households living in dwellings in "excellent" conditions. This difference is all the more significant because low-quality dwellings are often occupied by low-income households, more likely to ration their consumption of domestic energy. They provide a confirmation of a central hypothesis in this dissertation and field of research: that the energy performance is the key factor that explains and could solve (if improved) the fuel poverty problem.

Additionally, the case-study based exploration of the experiences of fuel poverty in Hungary has unearthed two sub-typologies not yet described in the predominantly Western European fuel poverty literature: households living in prefabricated *panel* buildings connected to district heating (DH)and poor Roma families living in rural areas. Though they represent roughly 15% of the Hungarian population,it is expected that both sub-typologies will be also found in other CEE nations where obsolete DH systems and poor rural Roma populations are also present. These two cases are succinctly described and analysed as follows.

First, a fraction of the households living in panel buildings connected to district heating (DH) is thought to be *trapped* in dwellings with high DH costs that cannot be neither avoided nor reduced easily. A main reason for this situation is the lack of individual heat consumption meters. These households bear the burden of high energy bills, which in the case of low-income households (e.g., pensioners living alone) can take almost as much as their monthly income. To some extent they live without the possibility to reduce its energy consumption because heat is paid on a flat-rate tariff basis (per dwelling square metre or cubic meter)and also because they neither be easily disconnected from the network nor its energy efficiency improved on an individual basis.

Interestingly, the incidence of fuel poverty in this population subset is not much higher than the Hungarian average if we look at the expenditure fuel poverty rates. According to disaggregated results obtained from HBS microdata (2005 and 2008), the percentage of such households spending 15% or more of their annual income on domestic energy is approximately the same as the Hungarian average. Still, the energy costs per dwelling square meter are substantially higher than in the rest of the buildings. The evidence collected suggestes that thanks to the small size (54 m^2 on average) of panel apartments and the slightly higher income of panel dwellers, fuel poverty rates are not higher than the Hungarian average. Still, it is more likely to find a household spending more on energy than on food in DH-served *panel* districts than in other building typologies in Hungary.

Second, low-income Roma population living in rural areas seem to be in a particularly disadvantaged position in terms of fuel poverty. Based on evidence collected in the Borsod-

Abaúj-Zemplén county (North-Eastern Hungary), it was found that these households sometimes resort to risky strategies – resulting in police fines and even imprisonment – such as illegal firewood collection and by-passing electricity meters to meet their energy needs,though it is acknowledged that not only the Roma undertake this practice.Evidence also indicates that these households suffer from indoor air pollution related to the combustion of solid fuels in poor quality stoves.

Collected evidence suggest that even though gas (bottled) and electricity are available in the most remote areas of rural Hungary, the severe deprivation endured by some Roma households in these parts of the country makes them actually unable to afford anything but a minimal level of consumption of these goods. As a result, they are almost effectively disconnected from modern domestic energy services, a situation which is similar to the experienced by the energy poor in developing countries.

To answer the second research sub-question, the dissertation has assessed in a cost-benefit analysis framework two hypothetical intervention scenarios (MID and DEEP) representing an upgrade of Hungary's current residential energy efficiency programmes (BASE scenario). This is based on the assumption that present policies are not enough neither to deal with the fuel poverty problem nor with the climate challenge.

The two intervention scenarios (MID and DEEP) propose a full retrofit of Hungary's 2010 residential stock at a rate of 100,000 dwellings per year that would achieve a reduction in the energy use for space heating that range from 40% (MID) to 79-90% (DEEP). The cost-benefit analysis is based on a previous building stock and Input-Output model for the estimation of the employment effects of retrofitting Hungary's residential and public building stock (Ürge-

Vorsatz et al., 2010). This previous model was substantially reviewed and expanded for the purpose of the dissertation.

One first relevant outcome of the CBA model is that DEEP scenario would avoid as much as 88% of all space-heating related CO_{2eq} emissions of Hungary's 2010 housing sector; as a comparison, MID scenario would avoid just 43%, thus *locking-in* 45% of the 2010 emissions.

Then, following key assumptions on the evolution of energy prices and a learning curve-based reduction in the cost of deep retrofits, the financial CBA concludes that: i) both MID and DEEP scenarios result in discounted net positive benefits before the end year of scenarios (2051/2054); ii) DEEP scenario results in a larger amount of discounted net benefits than MID, even though MID scenario reports an earlier positive Net Present Value (NPV). This exercise only considers the financial costs of the retrofits and the financial energy saving benefits.

However, the financial CBA simply considers the monetary cash flows associated with the retrofits. Therefore, in order to incorporate non-market benefit and to analyse the effect of MID and DEEP retrofits on the aggregated welfare of Hungarian society, scenarios have been assessed also in a social cost-benefit analysis framework. For this, financial retrofit costs and energy saving benefits have been corrected, programme implementation costs (as transaction costs) have been added and the economic value of several non-market benefits (avoided emission of GHG and other non-GHG pollutants[113], avoided excess winter mortality and increased comfort) has been estimated. The results of this expanded analysis with a focus on

[113] A range of airborne pollutants having an impact on human health, the ecosystems, agricultural production and materials: ammonia (NH_3), sulphur oxides (SO_x), nitrogen oxides (NO_x), suspended particles or particulate matter (PM_{co} and $PM_{2.5}$), non-methane volatile organic compounds (NMVOC) and heavy metals (Pb, Cd, Hg, As, Cr and Ni).

fuel poverty alleviation co-benefitsshow that the discounted net social benefits are large and positive (10 to 20 billion $€_{2010}$ by 2080). Like in the financial analysis, positive social NPVs are obtained before the end year of scenarios and the NPV of DEEP scenario surpasses MID's after a few decades. All in all, these results indicate that improving the energy efficiency of Hungary's dwellings would have a substantial net positive impact on the aggregatedwelfare of the Hungarian society. This positive impact would be maximised if passive house-like retrofits (DEEP scenario) were chosen instead of non-state-of-the-art retrofits delivering just 40% of energy savings (MID scenario). .

The comparison of the sign and evolution of the financial and social NPVs suggests that the incorporation of co-benefits enhances the policy appeal of intervention scenarios as it makes positive NPV appear earlier. It also reinforces the interest of DEEP scenario as a policy option (as compared to MID) because it makes the break-even point arrive a few years earlier. The hypothesis of co-benefits being important for the economic assessment of energy efficiency scenarios is therefore supported with this quantitative indication of their relevance.

By categories of co-benefits, energy savings are the most important category, taking between 37% (MID scenario) and 51% (DEEP scenario) of total discounted benefits in 2050. They are followed by other non-energy, non-market co-benefits ordered as follows: avoided non-GHG emissions, comfort benefits, avoided fuel poverty-related excess winter mortality and avoided GHG emissions. Note that from the perspective of the analysis conducted all benefits are non-climate co-benefits. The reason is that the social CBA has purposefully adopted a national (Hungarian) scope and considered only the impact of the scenarios on the welfare of the Hungarian society. Consequently, the value of avoided GHG emissions has not been estimated as the external global cost of CO_{2eq} emissions but as the revenues obtained from foreign economies through the sale of emission permits traded under a Green Investment

Scheme (GIS). This way, the results support the proposed energy efficiency scenarios (MID and DEEP) even in the eyes of a climate change skeptic decision-maker.

It is important to note thatin the case of the social CBA the total benefits produced by the intervention scenarios (MID and DEEP) are underestimated because the economic value of some important categories, such as energy security and the avoided health impacts of fuel poverty, could not be estimated. On the other hand, part of the transaction costs (those borne by households, e.g., the hassle of finding builders, putting up with the disruption and nuisance associated with building works, etc.) could not be incorporated either. Still, the sensitivity analysis has demonstrated that even in the case of high transaction costs positive NPVs would be obtained for both MID and DEEP scenarios, and that DEEP scenario would be the preferred policy option.

The CBA model has also been used to assess the viability of a *pay-as-you-save* financing scheme (combined with a State grant) that would employ energy savings for repaying the initial investment costs of MID and DEEP retrofits. The basic assumption, based on the *golden rule* of the UK's Green Deal, is that a household would be willing to retrofit its home as long as the energy savings were larger than annual repayments of the loan taken for financing the retrofit, calculated at 15 years and a 3% real interest rate. The exercise is aimed at calculating the size of the State grant (percentage of retrofit costs) required for the household to decide for the retrofit. It concludes that even though in the first year of the programme the State grant should cover up to 90% of the cost of the retrofit per dwelling (depending ob building typology), this percentage decreases in subsequent decades as energy prices rise and the cost of the retrofits is reduced through the learning curve. All in all, the maximum total contribution required from the State for the implementation of the DEEP scenario would be equivalent to 1.5% of Hungary's GDP (or 3% of the Hungarian government budget) in 2010, which could be partially covered through a better allocation of EU funds and a reallocation of current energy sector subsidies. By contrast, the MID scenario would demand a maximum allocation of 0.4% of Hungary's GDP in 2010 (or 0.8% of the Hungarian government budget in the same year).

9.2. DISCUSSION

9.2.1. New perspectives on existing realities: fuel poverty alleviation as a co-benefit of climate investments

One first key conclusion of this dissertation is that fuel poverty, which may be affecting every fifth Hungarian household 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 (e.g., it is thought to cause nearly as many premature deaths per year as traffic accidents), until recently (2010) fuel poverty has remained unattended, perhaps hidden behind more generic discussions about energy prices and household income. As a consequence, the energy efficiency of homes and domestic end-use equipment was not paid enough attention as a key structural cause of domestic energy affordability problems. This feature is thought to be present in other countries in which fuel poverty has not yet been defined as a distinct policy issue.

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 (see Table 20), households may also go for other options like fuel substitution (mostly natural gas by firewood), a growing trend in past years, or reducing indoor temperatures or number of rooms heated; in more extreme cases they may also adopt more risky solutions such as delaying the payment of utility bills, collecting firewood illegally or by-passing electricity meters. These strategies demonstrate the resourcefulness and resilience of affected households but are far from perfect responses to an objectively difficult situation of material deprivation. They also illustrate the various ways in which a household's welfare can be harmed by being subject to fuel poverty.

The Hungarian case also shows that fuel poverty tends to be concentrated among lower income households. The reason is that they not only have more restricted income to afford energy (as well as many other goods and services that make up their consumption basket), but possibly because they also live in lower quality dwellings and are less able to invest on general house maintenance or energy efficiency improvements. This confirms the double nature of fuel poverty as an income- and capital-related type of poverty.

Based on the quantitative and qualitative data collected, it is suggested that three broad types of fuel poverty exist in modernHungary – see Table 19. Their appearance and developments is the result of negative path-dependencies and inherited legacies (though not always from the pre-1989 socialist State) in combination with other factors:

- <u>Conventional/natural gas fuel poverty</u>: path-dependencies and inherited legacies are evidenced by the poor thermal performance of the currently existing residential stock, part of which was built during times when energy was subsidised by the socialist State. This legacy is particularly negative in the case of the relatively large single-family houses built prior to the 1990s. Many of these houses were built informally by families often working manually with relatives, friends and acquaintances because market-oriented developments were rare until 1989 (Hegedűs et al., 1994), which is a likely cause of its poor energy performance. Moreover, the gas dependency of Hungary's household sector is explained by the discovery of large domestic gas reserves in Hungary during the 1960 and 1970s

(Kessides, 2000) and by the 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). The combination of these various factors explains why a fraction of Hungarian households are trapped in large homes that cannot be heated adequately because of the steadily increasing price of imported natural gas.

- Rural/firewood fuel poverty: rising natural prices and the poor energy efficiency of the housing stock, especially of single-family houses built before the 1990s,also explains the growing number of households substituting natural gas by firewood as a strategy to deal with unaffordable domestic heating costs. However, switching fuels is only possible when the conditions are adequate, i.e., households capable to operate the stoves on a daily basis and with access to firewood supply, stoves, storage space, etc. A suspected important element of this firewood-related fuel povertyis the lower income and fewer economic opportunities of the Hungarian rural population. Thus an extreme version of this type of fuel poverty has been identified for the poor Roma population living in rural areas, one of the most deprived social groups of the country.
- Panel/DH fuel poverty: in DH-served panel dwellings, socio-technical legacies are physically embedded in the structure of buildings in the form of one-pipe, single-loop vertical systems (i.e., radiators in the same position on different floors are connected vertically) where disconnecting individual households is technically impossible (OECD/IEA, 2004). As the flagship of socialist housing policies, prefabricated buildings are probably the best example of how the pre-1989 State considered domestic energy as a right of the citizens rather than as a scarce resource to be allocated with economic criteria. In modern Hungary, the fuel poverty experienced by households living in panel blocks connected to DH defies conventional notions in the sense that it is not experienced in the form of a cold indoor environment (often the opposite, in fact), but as higher than average

domestic heating costs, which may translate into reduced consumption of other basic goods and services, payment arrears, indebtedness and risk of disconnection. This transfer of the energy affordability problem to the providers' side also plays a role in the persistence of fuel poverty in panel blocks because declining DH revenues prevent the upgrading of generation and distribution systems, and may increase DH costs among compliant households.

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 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 middle class.

Still, the connection between energy dependency and fuel poverty has not been drawn at a policy-making level. Solutions so far have remained disconnected. They have consisted of more or less untargeted support (e.g., price subsidies, VAT rebate, etc.) mainly benefitting users of gas and DH, shallow energy efficiency retrofits mostly concentrated in one building typology (panelbuildings), and an upgrading of the country's strategic gas storage capacity. And as practically all other EU Member States, Hungary does not have a fuel poverty strategy. Yet the UK experience, where the policy goal of eradicating fuel poverty by 2016/2018 will be missed by a large margin (Boardman, 2010), shows that official government recognition is not any guarantee of success.

But given that Hungary faces the need for a substantial restructuring of its energy systems, a real opportunity exists if a consistent policy approach for reducing the residential energy demand is put in place. As argued by this dissertation, a stable investment framework aimed at improving the energy efficiency of residential buildings would result in Hungary having a better chance to meet its long-term (by 2050) mitigation targets, reducing its energy (gas) dependency, and alleviating or even eradicating fuel poverty.

Consequently, 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. In fact, even when the global positive effects of climate change mitigation are disregarded, *national* welfare gains experienced by Hungarians (i.e., improved comfort and air quality, reduced domestic energy costs and fuel poverty-related mortality, additional earnings for the sale of surplus emission permits) outweigh the costs incurred with the retrofits.

The implications of this economic assessment of residential energy efficiency scenarios in Hungary extend beyond its borders. Several key 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. Such interventions are often part of mitigation policies and are aimed at ensuring some level of climatic stability to future generations. Understanding that they also have substantial short-term welfare effects puts the intergenerational conflict implicit in climate policies (interests of 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. This dissertation contributes to this methodological challenge by presenting several approaches to the quantification and valuation of the co-benefits of residential energy efficiency (especially of fuel poverty alleviation co-benefits) that can be replicated in other contexts.

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 turmoilin 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, more capital-demanding 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 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.

9.2.2. Implications for policy design and implementation

The relationship between income, energy supply, domestic energy efficiency and the role of institutions is complex and multi-faceted. While domestic energy price increases have clear negative impacts in terms of fuel poverty and reduced consumption or savings, they also provide incentives for improving energy efficiency. Thus it could be argued that a positive side effect of the on-going increase of natural gas prices is that it creates the conditions for energy efficiency investments to occur.

However, a household's decision to invest in energy efficiency will not occur automatically. It is influenced by factors like the household's availability of own savings, access to credit, willingness to take a loan, expectations about the evolution of energy prices, availability of information, reluctance to put up with the trouble of going through the renovation, etc. Precisely because these aspects act as barriers (especially for lower-income households, the ones more likely to be in fuel poverty), the public sector needs to be involved to provide the conditions and mechanisms that increase the likelihood of such investments. Otherwise they will not occur, or at least not to the extent required by the magnitude of the climate change and fuel poverty challenges.

Taking Hungary as a representative case study for Central and Eastern Europe, the conclusions of this dissertation translate into a series of recommendations:

- Currently existing policies and measures should be reassessed in order to prioritise those targeting underlying causes (i.e., energy inefficiency of residential buildings) rather than symptoms (e.g., price subsidies to alleviate the effects of fuel poverty; strategic storage for buffering the impact supply disruptions). The bottom line is that residential energy efficiency can tackle three key priorities of Hungary's social, energy and climate policies: fuel poverty, energy (gas) dependency and GHG emission mitigation targets. Such proposal could be operationalized as a fuel poverty-specific policy that explicitly acknowledges its alleviation or eradication as a goal.

- The results of the social cost-benefit analysis recommend retrofitting Hungary's residential dwellings to deep energy efficiency levels (i.e., based on the passive house design and delivering savings in the range of 79 to 90% of current energy use for space heating). A programme like this should be aimed at upgrading the whole residential stock in order to maximise emission reduction, minimise energy imports and effectively eradicate fuel poverty.
- However, a country-wide, deep energy efficiency programme like that (DEEP scenario) requires long implementation periods – at 100,000 units per year, 44 years for retrofitting the whole stock existing in 2010. For this reason, an improved, better-targeted version of the existibng palliative measures (e.g., income transfers, price support schemes) are required by the fuel poor during the transition to a low-carbon residential stock.
- Perhaps the largest obstacle to the proposed large scale upgrade of Hungary's residential stock is the financing of the initial investment costs of the retrofit. For this, this research suggests preliminarily a *pay-as-you-save*scheme (retrofits costs repaid with energy savings) combined with State grants that subsidise to a certain extent the investment costs of the retrofit.These grants would be progressively reduced in parallel to the reduction of retrofit costs and the forecast increase in energy prices.
- Along this line, the dissertation suggests an improved implementation path acting first on building typologies with a better benefit-to-cost ratio (single-family homes built before 1992, traditional multi-family homes and panel buildings). It would reduce the

programme’s total implementation costs and increase energy saving benefits in the first years or decades. These building categories are also suspected to accommodate most of Hungary’s fuel poor households.

- Given that the expected energy savings are the only income source for the repayment of retrofit costs, quality controls are necessary to ensure that retrofits deliver the expected savings for its expected lifetime. Equally, a careful control is needed to check whether the expected learning-curve reduction of high efficiency retrofit costs (DEEP scenario) effectively occurs. In fact, for the learning curve assumption to hold, the programme needs deliver a large number of retrofits per year retrofits for a long period of time, which requires a stable policy and investment framework during decades (until around 2050).
- State grants and programme management costs would demand a substantial amount of government resources, especially during the first years or decades. A very initial estimate indicates than in the peak year the burden to the government may reach up to 1.5% of the Hungarian GDP or 3% of the Hungarian government total expenditure in 2010. This could be covered by the reallocation of existing budget items (e.g., EU funds, cost-inefficient subsidies in the energy sector) or additional sources of revenues (e.g., sale of CO_2emission permits).
- These resources would be primarily targeted to priority groups (e.g., low-income older people living in single-family homes), for various reasons. They are more likely to be in fuel poverty, have less capital (as evidenced by the low savings rate of the Hungarian population) and also restricted access to credit; they also have less information about the advantages and possibilities of the retrofits. For them, government support is required in the form of information campaigns, financing schemes, technical advice, etc. in order to remove the many transaction costs they face. In the case of higher income population, a careful analysis would be required for avoiding subsidies to result in allocative

inefficiencies or free-riding. Equally, the government should be also concerned about the possibility of subsidy-related inflation in retrofit costs.

- In the case of dwellings supplied with district heating, energy efficiency investments must be 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 ensuring the right to disconnect are recommended.
- The situation of poor Roma households in rural areas needs to be addressed comprehensively; for this segment of the population, fuel poverty is just one more piece of a much wider and more complex picture of deprivation and social exclusion. Thus it is likely that the solution proposed for the average Hungarian household – subsidising the initial costs of the retrofit with a State grant – would not be feasible. For them, a specific approach that combines quality housing with complementary measures aimed at improving their income-earning capacity can be suggested.

9.3. ORIGINAL CONTRIBUTIONS

In the author's view, this dissertation has produced the following original contributions in the research fields of fuel poverty and the co-benefits of climate change mitigation.

In terms of the geographical coverage of the research fields considered, the dissertation offers:

- An estimate of fuel poverty incidence rates in Hungary following both the self-reported/consensual and expenditure-based approaches. No attempt to estimate the incidence of fuel poverty in Hungary had been done previously.

- An assessment of the causes of fuel poverty in Hungary based on three main (and usually considered) contributing factors: domestic energy prices, household income and energy efficiency of residential buildings.
- Evidence for a broader understanding of fuel poverty in Europe, given that most of the literature comes from Western Europe and evidence from Central and Eastern Europe is still lacking.
- The first ever comprehensive economic assessment of the co-benefits (emphasising fuel poverty alleviation effects) of a nationwide residential energy efficiency programme in Central and Eastern Europe.

In terms of the methodologies involved, it offers:

- One of the few available comparisons of fuel poverty rates obtained by the self-reported/consensual and expenditure approaches, though not conducted on the same dataset.
- An indicator of fuel substitution (i.e., natural gas by firewood) as an aspect related to fuel poverty in Hungary, but probably in other contexts as well.
- A preliminary analysis of summertime fuel poverty as defined by Healy (2004) for Hungary in the EU27 context, including the proposal of an indicator for its measurement (*Percentage of dwellings not being comfortably cool during summer time*) based on the self-reported approach and on data retrieved from the 2007 *ad-hoc* EU-SILC module on housing conditions (EC, 2009). No attempts to measure rates of summertime fuel poverty had been done previously for any country.
- A first ever economic assessment of advanced residential energy efficiency solutions based on the passive house standard (deep retrofits) in a social cost-benefit analysis framework.

- An example of how to incorporate programme management costs (as transaction costs) in a social cost-benefit analysis. Transaction costs are usually disregarded or underestimated in the economic assessment of climate investments.
- A proposal to deal with the lifetime of retrofits (as well as of the need to maintain the quality of retrofits)in long-term cost and benefit calculations – the so called *2nd round retrofits*.
- A methodology for the economic valuation of two comfort benefits related to fuel poverty alleviation: increase in the percentage of floor area heated and elimination of inconvenient firewood-based heating.

In terms of the current knowledge about the issues addressed, and of the concepts and theories employed, it offers:

- A description of two typologies of fuel poverty present in Central and Eastern Europe that defies the traditional understanding of the phenomenon coming from the UK and Ireland: fuel poverty in in prefabricated (*panel*)blocksconnected to district heating and fuel poverty among poor Roma households in rural areas.
- A comprehensive review of coping strategies displayed by households experiencing energy affordability problems which is representative of Hungary but also of other countries in Europe.
- Further evidence about the relevance of co-benefits for the assessment and redefinition of climate investments.

9.4. AVENUES FOR FUTURE RESEARCH

Finally, the following items are suggested as a priority for further research:

- The reliability and comparability of fuel poverty rates based either on expenditure-based or on self-reported/consensual indicators remains an open question.
- Expenditure-based fuel poverty rates should be based on required (and not actual) energy consumption for ensuring a certain level of thermal comfort. However, these data need to be obtained through fuel poverty-specific sources such as the UK's Household Condition Surveys. However, Household Budget Surveys (HBS) are readily available in EU countries as they are used for inflation and GDP calculations. If a reliable methodology for the calculation of fuel poverty rates could be devised based on HBS methodologies, it would allow a cross-country comparison of fuel poverty rates making an efficient use of already existing data sources.
- Additional indicators exploring further aspects of fuel poverty can be explored i.e., fraction of the dwelling area not heated or sub-heated, rates of disconnection to utility grids, etc. They may provide valuable information to understand poorly known aspects or effects of fuel poverty.
- The relationship between domestic energy expenditure and other household expenditures on other basic needs such as housing, food and education. This dissertation has attempted (though not comprehensively) to deal with the *heat or eat dilemma* by proposing an expenditure-based fuel poverty rate according to which a household is in fuel poverty if it spends more on energy than on food. More research may help disentangle the complex relationship between energy and other domestic expenditures.
- The role of providers and suppliers, which often supply domestic energy in conditions of regulated oligopoly, remains a largely unexplored cause of fuel poverty.

- The actual effect of different types of energy efficiency retrofits is another aspect worth exploring. For instance, in the social cost-benefit analysis it was assumed that MID retrofits (40% of energy savings) avoid half of the fuel poverty-related excess winter deaths than DEEP retrofits (79 to 90% of energy savings); this is a working assumption not sustained on any real data, which is in any case non-existent.
- A comprehensive assessment of learning curve-based reduction of retrofits is recommended, for which data seem to be lacking in the literature.
- Estimation of the extent and value of health benefits associated with a reduced incidence of fuel poverty in Hungary, which could not be incorporated in the social cost-benefit analysis because of lack of readily available data.
- Valuation methodologies for energy dependency reduction benefits, which are seldom incorporated in the assessment of climate investments because of the lack of such tools.

REFERENCES

Aaheim, H.A., Aunan, K. and Seip, H.M. 1997. *Social Benefits of Energy Conservation in Hungary.An examination of alternative methods of evaluation*. Working Paper 1997:10.Center for International Climate and Environmental Research (CICERO). Oslo.

ADEME, 2009. Energy Efficiency Trends and Policies in the EU 27 Results of the ODYSSEE-MURE project. Paris: Agence de l'Environnement et de la Maîtrise de l'Energie.

Adorján, R. 2004. *The value of human life.Development of an exceptional economic issue in Hungary*.PhD dissertation.Department of Public Service.BudapestUniversity of Economics and Public Administration.

Alberini, A., Banfi, S., Ramseier, C. 2011. Energy Efficiency Investments in the Home: Swiss Homeowners and Expectations about Future Energy Prices. CEPE Working Paper No. 80. Centre for Energy Policy and Economics (CEPE). Swiss Federal Institutes of Technology.

Alberini, A., Cropper, M., Krupnick, A., Simon, N.B. 2004. Does the Value of Statistical Life Vary with Age and Health Status? Evidence from the US and Canada.*Journal of Environmental Economics and Management*48: 769-792.

Anderson, W., White, V., Finney, A. 2010. *"You just have to get by". Coping with low incomes and cold homes*. Centre for Sustainable Energy.

Andzsans-Balogh, K. (pers. comm.).Research associate at the Regional Energy Research Centre (REKK).Corvinus Univeristy of Budapest.Information exchange in June 2011.

Andzsans-Balogh, K. 2011.The Road to Hungarian Energy Security.*Journal of Energy Security* (March 2011).

Aunan, K., Pátzay, G., Asbjørn Aaheim, H. and Martin Seip, H. 1998. Health and environmental benefits from air pollution reductions in Hungary.*The Science of the Total Environment* 212: 245 – 268.

Aylward, R. 1994. *Economic evaluation of tropical forest land use options : a review of methodology and applications*. London: International institute for environment and development (IIED). Environmental economics programme.

Azqueta Oyarzun, D. 2007. *Introduccion a la economia ambiental*[Introduction to environmental economics] Madrid: McGraw-Hill / Interamericana de España.

Bann, C. 1997. *The Economic Valuation of Tropical Forest Land Use Options: A Manual for Researchers*. Economy and Environment Program for Southeast Asia. EEPSEA Research Report Series

Bari, J. (pers. comm.). Biologist.Member and advisor of *the* Sajó-menti Közösség *és Környezetfejlesztők Egyesülete* (SAKKF – E). Budapest, June 26th, 2009.

Bass.L., Ágnes, D., Zsombor, F., Zsuzsa, F. 2008.*A gyermekszegénység elleni küzdelem állása 2008-ban* [The state of the fight against child poverty in 2008].MTA KTI Gyermekprogram Iroda.

Bencsik, J. 2009. *Zöldülő* Tatabánya. Presented at the conference 'Opportunities for Climate Change and Energy Efficiency Action in an Economic Crisis: Catalysing a Green Recovery'. October 20, 2009. CentralEuropeanUniversity (CEU), Budapest.

Benzie, M., Havery, A., Burningham, K., Hodgson, N., Siddiqi, A., 2011.*Vulnerability to heatwaves and drought. Case studies of adaptation to climate change in south-west England*. Joseph Rowntree Foundation.

Bhattacharya J., Deleire, T., Haider, S. and Currie, J. 2003. Heat or Eat? Cold-Weather Shocks and Nutrition in Poor American Families.*American Journal of Public Health* 93 (7): 1149-1154.

Bird, S., Hernandez, D. 2012. Policy options for the split incentive: Increasing energyefficiency for low-income renters. *Energy Policy* 48 (2012) 506–514.

Birol, F. 2007. Energy Economics: A Place for Energy Poverty in the Agenda? *The Energy Journal* 28(3), 1–6.

Boardman, B. (pers. comm.) Emeritus Fellow.Environmental Change Institute.University of Oxford. Discussion at the international workshop "Mapping the European energy poverty research landscape: towards common action and co-operation". September 30th, 2010, Brussels, Belgium.

Boardman, B. 1991.*Fuel Poverty: from Cold Homes to Affordable Warmth*. London: Belhaven Press.

Boardman, B. 2010.*FixingFuel Poverty*. London: Earthscan.

Boardman, B. 2011. Participant benefits and quality of life: the challenge of hard to measure benefits. Presented at the IEA workshop "Evaluating the Co-Benefits of Low-Income Weatherisation Programmes".January 27-28, 2011, Dublin, Ireland.

Boross, N. (pers. comm.). Director of communication and corporate strategy of the Budapesti Elektromos Művek (ELMŰ) Nyrt. Budapest, June 25th, 2009.

Borsani, C., M. Salvi, 2003.*Analysebericht zum Minergie-Standard*. Memorandum of Züricher Kantonalbank (ZKB) to CEPE-Team. Zurich, Switzerland.

Bouzarovski, S. 2010. Entangled boundaries, scales and trajectories of change: post-communist energy reforms in critical perspective.*European Urban and Regional Studies* 17, 167-182.

Brophy, V., Clinch, J.P., Convery, F.J., Healy, J.D., King, C. and Lewis, J.O. 1999.*Homes for the 21st Century – the Costs and Benefits of Comfortable Housing for Ireland*. Report prepared for Energy Action Ltd. by the Energy Research Group and Environmental Institute. Dublin: UniversityCollegeDublin.

Brounen, D., N. Kok, 2010.*On the Economics of EU Energy Labels in the Housing Market*. RICS Research, Erasmus University and Maastricht University, the Netherlands.

Brunner, K.-M., Spitzer, M., Christanell, A. 2011.*Fuel poverty.A case study of vulnerable households in Vienna/Austria*.Proceedings of the ECEEE Summer Study 2011. 6-11 June 201. Belambra Presqu'île de Giens,France.

Burkholder, P., Anderson, C. 2005. Be Cool: Natural Systems to Beat the Heat. *Home Power* 108: 20-25.

Buzar, S. 2007a. *Energy poverty in Eastern Europe*.Aldershot: Ashgate.

Buzar, S. 2007b. When homes become prisons: the relational spaces of postsocialist energy poverty.*Environment and Planning A*(39): 1908–1925.

Buzar, S. 2007c. The 'hidden' geographies of energy poverty in post-socialism: between institutions and households. *Geoforum* 38: 224–240.

Buzar, S. 2011. *Energy poverty in the EU: a review of the evidence*.Workshop and Conference "Cohesion policy investing in energy efficiency in buildings". Brussels November 29-30 2011.

Buzar, S. Lecturer in Human Geography. University of Birmingham. Discussion at the at the international workshop "Mapping the European energy poverty research landscape: towards common action and co-operation". September 30th, 2010, Brussels, Belgium.

Cahn C. 2007. *The Unseen Powers: Perception, Stigma and Roma Rights*. European Roma Rigths Centre (ERRC)

Callicoat, E.A. 2010.*Mapping Energy Poverty in Huntington, West Virginia*. MarshallUniversity, Theses and Dissertations, Paper 32. URL: http://mds.marshall.edu/etd/32

Capros, P., Mantzos, L., Tasios, N., De Vita, A., Kouvaritakis, N. 2009. EU energy trends to 2030 — UPDATE 2009.European Commission.Directorate-General for Energy in collaboration with Climate Action DG and Mobility and Transport DG.

Chapman, R., Howden-Chapman, P., Viggers, H., O'Dea, D. and Kennedy, M. 2009. Retrofitting houses with insulation: a cost–benefit analysis of a randomised community trial. Journal of Epidemiology and Community Health 63: 271–277.

Checchi, A., Behrens, A., Egenhofer, C. 2009 *Long-Term Energy Security Risks for Europe: A Sector-Specific Approach*. CEPS Working Document No. 309/January 2009. Centre for European Policy Studies.

Chichilnisky, G. 1996.An axiomatic approach to sustainable development.*Social Choice and Welfare* 13: 219–248.

Clinch, J.P. and Healy, J.D. 2001. Cost-benefit analysis of domestic energy efficiency.*Energy Policy* 29: 113–124.

Collins, J.K. 1986. Low indoor temperatures and morbidity in the elders.*Age and Ageing* 15 (4): 212-220.

Conniffe, D. 2000. *Household energy expenditures: policy relevant information from the household budget survey*. ESRI Policy Research Series No. 37. Cited in Scott, S. Lyons, S., Keane, C., McCarthy, D., and Tol, R.S.J. 2008. *Fuel Poverty in Ireland: Extent, Affected Groups and Policy Issues*. Working Paper No. 262.Dublin: Economic and Social Research Institute (ESRI).

Cropper, M., Hammitt, J.K., Robinson, L.A. 2011.*Valuing Mortality Risk Reductions.Progress and Challenges*.Discussion paper 11-10.Resources for the Future, Washington.

Csagoly, P., 1999. Post-com pre-fab.*Central Europe Review* 1(24).

Csoknyai, 2010.Personal communication with T. Csoknyai, BudapestTechnicalUniversity. February 22, 2010.

Czakó, V. 2010.*Energy efficiency programs in the residential buildings sector: the Hungarian experience*. Presentation at the Department of Environmental Sciences and Policy, CentralEuropeanUniversity (CEU).Budapest, Hungary, January 20, 2010. URL:http://3csep.ceu.hu/sites/default/files/field_attachment/page/node-3234/eeprogshuvczako.pdf

Czakó, V. 2011. Evolution of Hungarian residential energy efficiency support programmes: road to and operation under the Green Investment Scheme. *Energy Efficiency* (2012) 5:163–178.

Damigos, D., Tourkolias, C., Diakoulaki, D. 2009. Households' willingness to pay for safeguarding security of natural gas supply in electricity generation.*Energy Policy* 37: 2008–2017.

Dániel, Z. 1996. A bérlakás-privatizáció paradoxona [*The paradox of the privatisation of the tenement apartment*] *Közgazdasági Szemle* 43:3. pp.204–230. Cited in Kocsis, J. 2004.The Housing Poor in Budapest, Hungary: Situation and Perspectives. In Fearn (ed.). *Too poor to move, too poor to stay.A Report on Housing in the CzechRepublic, Hungary and Serbia*.Local Government and Public Service Reform Initiative.Budapest: Open Society Institute.

Danish Energy Authority (2005).*Heat Supply in Denmark - Who What Where and Why*.Copenhaguen, Denmark.

Day R. 2010. Environmental justice and older age: consideration of a qualitative neighbourhood-based study.*Environment and Planning A*42(11) 2658–2673.

de Garbino J. P. (editor-in-chief), 2004: Children's health and the environment.A global perspective.A resource manual for the health sector.Geneva: World Health Organization.

Deloitte, 2011.GES NewsFlash.Hungary – Changes to the personal income tax and social security rules for 2012. Deloitte Tax LLP Global Employer Services.

Department Energy and Climate Change (DECC) 2009. *The UK Fuel Poverty Strategy.7th Annual Progress Report 2009*.Department Energy and Climate Change.

Department Energy and Climate Change (DECC) 2010.*The Green Deal.A summary of the Government's proposals*.

Department Energy and Climate Change (DECC) 2012.*Annual Report on Fuel Poverty Statistics 2012*. UK National Statistics.

Department Energy and Climate Change (DECC) 2012. *European Energy Efficiency.Analysis of ODYSSEE indicators*.Energy Efficiency Deployment Office.

Department for Business Enterprise and Regulatory Reform (BERR) 2001.*UK Fuel Poverty Strategy*.Department for Business Enterprise and Regulatory Reform.UK.

Department of Environment, Food and Rural Affairs / Department of Business Entreprise & Regulatory Reform (DEFRA/BERR), 2008.*The UK Fuel Poverty Strategy 6th Annual Progress Report*.Department of Environment, Food and Rural Affairs.Department of Business Entreprise & Regulatory Reform.UK.

Department of Transport and Industry (DTI) 2006.*Energy – its impact on the environment and society*.

Desaigues, B., Ami, D., Bartczak, A., Braun-Kohlová, M., Chilton, S., Czajkowski, M., Farreras, V., Hunt, A., Hutchison, M., Jeanrenaud, C., Kaderjak, P., Máca, V., Markiewicz, O., Markowska, A., Metcalf, H., Navrud, S., Nielsen, J.S., Ortiz, R., Pellegrini, S., Rabl, A., Riera, R., Scasny,M., Stoeckel,M.-E., Szántó, R., Urban, J. 2011. Economic valuation of air pollution mortality: A 9-country contingent valuation survey of value of a life year (VOLY). *Ecological Indicators* 11:902-910.

Desaigues, B., Rabl,A., Ami D., Kene, B.M.Y., Masson, S. 2007.Monetary Value of a Life Expectancy Gain due to Reduced Air Pollution Lessons from a contingent valuation in France.*Revue d'économie politique* 117(5): 675-698-

Dibáczi, Z., Hujber, D., Lipcsik, M., Simon, T. 2010. *Study on Biomass Trade In Hungary*. Energy Centre-Energy Efficiency, Environment and Energy Information Agency Non-profit Limited Company (Hungary).

Downing, T., Anthoff, D., Butterfield, R., Ceronsky, M., Grubb, M., Guo, J., Hepburn, C.,Hope, C. and co-authors 2005.*Social cost of carbon: a closer look at uncertainty*. Final Report.Defra.

Duncan, J., 2005. *From Budapest to Bishkek: Mapping the Root of Poverty Housing*. Habitat for Humanity Europe and Central Asia.

E.On Földgaz 2008. *The new Gas Act. A straight path into the future?*Földgáz magazin 2008/3.

Eaga Partnership Charitable Trust 2003.*A Review of English Local Authority Fuel Poverty Reports and Strategies*.Final report presented to Eaga Partnership Charitable Trust.

Eddy, K. 2001. Wind Energy. *Business Hungary* 15(9).Published by the American Chamber of Commerce of Hungary.

Eichhammer, W., Fleiter, T., Schlomann, B., Faberi, S., Fioretto, M., Piccioni, N., Lechtenböhmer, S., Schüring, A., Resch, G., 2009.Study on the Energy Savings Potentials in EU MemberStates, Candidate Countries and EEA Countries.Final Report for the European Commission.Directorate-General Energy and Transport. EC Service Contract Number TREN/D1/239-2006/S07.66640. Karlsruhe / Grenoble / Rome / Vienna / Wuppertal.

Elek, L. (pers. comm). International project manager at the Energia Központ.Budapest, June 4th, 2010.

Elek, L. 2007. *Energy Efficiency Policies and Measures in Hungary 2006 Evaluation and Monitoring of Energy Efficiency in the New EU Member Countries and the EU-25 (EEE-NMC)*.Energia Központ / Energy Centre Hungary, Budapest.

Energia Klub, 2010. *Távhő körkép és kisokos 2* [District heating at a glance 2]. Energy Club, Budapest. URL: http://energiaklub.hu/hir/tavho-korkep-es-kisokos-2 \

Energia Klub, 2011. *Negajoules project*.Results. URL: http://www.negajoule.hu/oldal/adatok

Energia Központ 2008. *Energy Efficiency Profile: Hungary*. Mure /ODYSSEE.

Energia Központ 2009. *A haztartasok energiafogyasztasa* [The energy consumption of households].Energia Kozpont Nonprofit Kft. Budapest.

Energia Központ 2009. Energy efficiency policies and measures in Hungary.Final Report for Hungary in the „Monitoring Energy Efficiency in the EU-27" Project.MURE ODYSSEE / Intelligent Energy Europe.Energia Központ Nonprofit Kft. Budapest.

Energieinstitut Vorarlberg 2010a. EI-Education. Best practice example No 1 from Germany. Ludwigshafen. URL:http://www.energieinstitut.at/Retrofit/Dateien/BestPractice/Englisch/Bestpractice_Germany1.pdfConsulted June 17, 2010.

Energy in Central and Eastern Europe (enerCEE.net) 2011.Hungary country profile. Austrian Energy Agency [URL: http://www.enercee.net/hungary/energy-sources.html] Consulted in several dates during 2012.

Energy Information Administration (EIA) 2004.*World Energy Use and carbon Dioxide Emissions, 1980-2001*.US Department of Energy.

Enseling, A., Hinz, E. 2006.*Energetische Gebäudesanierung und Wirtschaftlichkeit – Eine Untersuchung am Beispiel des 'Brunckviertels' in Ludwigshafen*. Darmstadt, Institut Wohnen und Umselt GmbH.

Environment Protection Agency (EPA) 2012a. *Environmental Justice*. URL: http://www.epa.gov/environmentaljustice/index.html. Consulted on-line 29th October 2012.

Environment Protection Agency (EPA) 2012b.*What Is an Urban Heat Island?* URL: http://www.epa.gov/heatisld/about/index.htmConsulted on-line December 16th 2012.

Euractiv 2010.*Impoverished SE Europeans turn to wood for heating*. URL:http://www.euractiv.com/enlargement/impoverished-se-europeans-turn-w-news-494816

Euractiv 2012. Energy poverty takes toll on Balkan forests. URL:http://www.euractiv.com/climate-environment/energy-poverty-takes-toll-balkan-news-513402

Euroheat & Power 2006.*Possibilities with more district heating in Europe*. ECOHEATCOOLWork package 4. Final report.

Euroheat & Power, 2011.*District Heating in Buildings*. Prepared by Euroheat & Power Task Force Customer Installations.Brussels, Belgium.

European Bank of Reconstruction and Development (EBRD) 2003.*Can the Poor Pay for Power? The Affordability of Electricity in South East Europe*.European Bank of Reconstruction and Development.

European Commission (EC) 2007.*Poverty and social exclusion*.Special Eurobarometer 279 / Wave 67.1 – TNS Opinion & Social.

European Commission (EC) 2008a.*Guide to cost-benefit analysis of investment projects. Structural Funds, Cohesion Fund and Instrument for Pre-Accession*. Directorate General Regional Policy.

European Commission (EC) 2008b.*Poverty and social exclusion in rural areas.Executive summary*.Directorate-General for Employment, Social Affairs and Equal Opportunities , Unit E2. Manuscript completed in September 2008.

European Commission (EC) 2009.*EU-SILC module 2007 on housing conditions.Assessment of the implementation*.ESTAT F3/GRG D(2009) EUROSTAT. Directorate F: Social and information society statistics. Unit F-3: Living conditions and social protection. Luxembourg.

European Commission (EC) 2010a.*An energy policy for consumers*. Commission Staff Working Papers. Brussels, 11.11.2010.SEC(2010) 1407 final.

European Commission (EC) 2010b.*Description of target variables: Cross-sectional and Longitudinal. 2008 operation (January 2010 version)*.EU-SILC 065 (2008 operation).Directorate F: Social Statistics and Information Society. Unit F-3: Living conditions and social protection statistics. EUROSTAT.

European Commission (EC) 2010c.*Joint report on social protection and social inclusion 2010*.Directorate General for Employment, Social Affairs and Equal Opportunities Units E2 and E4.

European Commission (EC) 2012a.*The EU Climate and Energy Package*. URL: http://ec.europa.eu/clima/policies/package/index_en.htm Consulted on-line on 8th November 2012.

European Commission (EC) 2012b.*Analysis of options to move beyond 20% greenhouse gas emission reductions and assessing the risk of carbon leakage*.Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions.Brussels, 26.5.2010.COM(2010) 265 final

European Commission (EC) 2012c.*Quarterly Report on European Gas Markets*. Volume 4, Issue 4: October 2011 – December 2011 / Volume 5, Issue 1: January 2012 – March 2012. Market Observatory for Energy, DG Energy.

European Environment Agency (EEA) 2009. *EMEP/EEA air pollutant emission inventory guidebook — 2009.*

European Environment Agency (EEA) 2012 Energy efficiency and energy consumption in the household sector (ENER 022) URL: http://www.eea.europa.eu/data-and-maps/indicators/energy-efficiency-and-energy-consumption-2/assessmentConsulted on-line December 7th 2012.

European Environment Agency (EEA) 2012. *Air quality in Europe – 2012*. EEA Report No. 4 / 2012.

European Forum for Renewable Energy Sources (EUFORES) 2008.*Declaration of Budapest 2008 on the future of Europe's energy supply*.8th Inter-Parliamentary Meeting on Renewable Energy and Energy Efficiency.7th November 2008, Parliament of Hungary, Budapest.

European fuel Poverty and Energy Efficiency (EPEE) project 2009a.*Evaluation of fuel poverty in Belgium, Spain, France, Italy and the United Kingdom. WP2 - Deliverable 6*. Intelligent Energy Europe (contract EIE/06/158/SI2.447367). [URL: http://www.precarite-energetique.org/files/WP2_D6_en.pdf] Consulted on-line on August 30th, 2009.

European fuel Poverty and Energy Efficiency (EPEE) project 2009b.*Diagnosis of causes and consequences of fuel poverty in Belgium, France, Italy, Spain and United Kingdom*. WP2 - Deliverable 5. Intelligent Energy Europe (contract EIE/06/158/SI2.447367). [URL: http://www.precarite-energetique.org/files/WP2_D5_final.pdf] Consulted on-line on November 2nd, 2009.

Eurostat 2009.*What can be learned from deprivation indicators in Europe. Methodologies and working paper*s.Luxembourg: Office for Official Publications of the European Communities.

Eurostat 2012a.*Energy Statistics - Heating degree-days*.Eurostat metadata.URL: http://epp.eurostat.ec.europa.eu/cache/ITY_SDDS/EN/nrg_esdgr_esms.htmConsulted on-line April 18 2012.

Eurostat 2012b.*Glossary: Equivalised income*. URL: http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Glossary:Equivalised_incomeConsultedon-line October 15th, 2012.

Eurostat 2012c.*Glossary: Purchasing power parities (PPPs*). URL: http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Glossary:Purchasing_power_parities_(PPPs)Consultedon-line October 15th, 2012.

Eurostat 2012d.*Glossary: At-risk-of-poverty rate*. URL: http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Glossary:At-risk-of-poverty_rateConsultedon-line October 15th, 2012.

Faluház 2009.Energy Efficient Renovation Program. December 2009. URL: http://www.faluhaz.eu/ [Retrieved March 16, 2010]

Faluház/Staccatto project, unpublished.Report on the social questionnaire for the staccato building renovation project.

Fankhauser, S., and Tepic, S. 2005.*Can poor consumers pay for energy and water?An affordability analysis for transition countries*.Working paper No. 92.European Bank of Reconstruction and Development.

Feist, W., 2007.*Tasks-challenges-perspectives*.Conference proceedings of the 11th International passive House Conference 2007, Bregenz. Passive House Institute, Darmstadt, Germany, pp. 439-449.

Flyvjberg, B. 2011.*Case study*, in Norman K. Denzin and Yvonna S. Lincoln (eds.) The Sage handbook of Qualitative Research (4th edition). California: Thousand Oaks.

Forster, P., V. Ramaswamy, P. Artaxo, T. Berntsen, R. Betts, D.W. Fahey, J. Haywood, J. Lean, D.C. Lowe, G. Myhre, J. Nganga, R. Prinn, G. Raga, M. Schulz and R. Van Dorland, 2007.Changes in Atmospheric Constituents and in Radiative Forcing. In: Climate Change 2007: *The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Fülöp, O.(pers. comm.). Researcher and project manager of the *Negajoule* project at *Energia Klub*. Email exchange on May 26, 2011.

Fülöp, O. 2009.*Ösztönzött pazarlás - Lakossági energiaárak állami támogatása 2003 – 2009.Összefoglaló elemzés*.Budapest: Energia Klub.

Fülöp, O., Fellegi D. 2012.*Poverty or fuel poverty?Defining fuel poverty in Europe and Hungary*. Budapest: EnergiaKlub.

Galvin, R. 2011. Thermal upgrades of existing homes in Germany: The building code, subsidies, and economic efficiency. CSERGE Working Paper EDM 09-11.

Giraudet, L.-G., Guivarch, C., Quirion, P. 2009. A model of the French residential demand for heating energy to evaluate the impact of policy instruments.IAEE 2009 conference, Wien, Austria.

Goebbels, A.F.G., Ament, AJ.H.A, Novák, A., Veraart, CP.V.M., Severens, J.L. 2008. Estimating the implicit value of statistical life based on public interventions implemented in The Netherlands. *International Journal of Technology Assessment in Health Care* 24(4): 495-501.

Greening, L.A., Grene, D.L. and Difiglio, C. 2000.Energy efficiency and consumption –the rebound effect –a survey.*Energy Policy* 28: 389-401.

Griffiths, A. 2011.*The Health Costs of Cold dwelling*. BRE.

Gumerman, E., Marnay, C. 2004. Learning and Cost Reductions for Generating Technologies in the National Energy Modeling System (NEMS). Ernest Orlando Lawrence Berkeley National Laboratory.Environmental Energy Technologies Division.LBNL-52559.

Győri, P. 2005. *Fagyhalál*.Révészek, A BMSZKI dolgozóinak lapja. 2005.február–III.évfolyam1.szám

Hardin, G. 1968. The Tragedy of the Commons.*Science*162 (3859),1243-1248.

Harks, E. 2006. The conundrum of energy security gas in Eastern and Western Europe.*The International Spectator* 41(3): 47-58.

Harper., K., Steger, T., Filcak, R. 2009. *Environmental Justice and Roma Communities in Central and Eastern Europe*.Selected Publications of EFS Faculty, Students, and Alumni.Paper 1.

Harrington B.E., Heyman, B., Merleau-Ponty, N., Stockton, H., Ritchie, N., Heyman, A. 2005. Keeping warm and staying well: findings from the qualitative arm of the Warm Homes Project.*Health and Social Care in the Community* 13(3): 259-67.

Harrison, C. 2010. *'Because You Got to Have Heat': Energy Poverty and Weatherization in Eastern North Carolina*. MA Thesis.Department of Geography.East Carolina University.

Harvey, L.D.D. 2010.Energy and the New Reality 1.Energy Efficiency and the Demand for Energy Services. Earthscan, London.

Hassi, J. and Rytkönen, M. 2005. Climate warming and health adaptation in Finland.FINADAPT Working Paper 7.Finnish Environment Institute Mimeographs 337, Helsinki.

Healy, J.D. 2003. Excess winter mortality in Europe: a cross country analysis identifying key risk factors. *Journal of Epidemiology and Community Health* 57: 784–789.

Healy, J.D. 2004. *Housing, fuel poverty, and health: a pan-European analysis*. Aldershot: Ashgate Publishing.

Healy, J.D. and Clinch, J.P. 2002. Fuel poverty, thermal comfort and occupancy: results of a national household-survey in Ireland. *Applied Energy* 73: 329-343.

Healy, J.D., Clinch, J.P. 2004. Quantifying the severity of fuel poverty, its relationship with poor housing and reasons for non-investment in energy-saving measures in Ireland.*Energy Policy* 32: 207-220.

Hegedűs, J., 2010. *Housing affordability and inequality after transition*.Following Transition: Urban Restructuring in Eastern Europe. November 27, 2010. Corvinus University, Budapest.

Hegedűs, J., Tosics, I., Hovanyec L. 1994. Lakáspolitika a rendszerváltás után.Beszélgetés Hegedüs József és Tosics Iván szociológusokkal [*Housing policy after the change of the system.Discusion with the sociologists József Hegedüs and Iván Tosics*].*Társadalmi Szemle*: 59–66. Cited in Kocsis, J. 2004.The Housing Poor in Budapest, Hungary: Situation and Perspectives. In Fearn (ed.). *Too poor to move, too poor to stay.A Report on Housing in the Czech Republic, Hungary and Serbia*.Local Government and Public Service Reform Initiative. Budapest: Open Society Institute.

Hermelink A., 2005. *Do not forget the dwellers - Surprising insights from user surveys*. In: Proceedings of the 4th International Conference Climate Change - Energy Awareness - Energy Efficiency. June 8-10, 2005. Visegrád, Hungary. 175-182.

Hermelink A., 2006. *Reality Check: The Example SOLANOVA*, Hungary In: Proceedings of the European Conference and Cooperation Exchange 2006. Sustainable Energy Systems for Buildings - Challenges and Chances. November 15-17, 2006. Vienna, Austria.

Hermelink A., 2007. SOLANOVA.*The Real Social Housing*.Presented at the EU Sustainable Energy Week. February 1, 2007. Brussels, Belgium.

Hills, J. 2012.*Getting the measure of fuel poverty.Final Report of the Fuel Poverty Review*.CASE report 72.Center for the Analysis of Social Exclusion.

Hirado 2012.Gázártámogatás helyett lakásfenntartási támogatás szeptembertől [Household maintenance support instead of gas price support from September] URL: http://www.hirado.hu/Hirek/2011/08/25/17/Gazartamogatas_helyett_lakasfenntartasi_tamogatas_szeptembertol.aspx (Retrieved on line 31 August 2012)

Hong, S.H., Gilbertson, J., Oreszczyn T., Green, G., Ridley, I., and the Warm Front Study Group 2009. A field study of thermal comfort in low-income dwellings in England before and after energy efficient refurbishment. *Building and Environment* 44(6): 1228-1236.

Hong, W., Chiang, M.S., Shapiro, R.A., Clifford, M.L., 2007.*Building Energy Efficiency.Why Green Buildings Are Key to Asia's Future*. Asia Business Council.

Howieson, S. G. 2005.Multiple deprivation and excess winter deaths in Scotland. *The Journal of the Royal Society for the Promotion of Health* 125(1): 18–22.

Hungarian Energy Office 2011.*Annual report to the European Commission*.Magyar Energia Hívatal / Hungarian Energy Office.

ICISHeren 2012.Record-high AAU price reported in Hungary (17 April 2009). URL: http://www.icis.com/heren/articles/2009/04/17/9310977/record-high-aau-price-reported-in-hungary.html [Consulted on-line on June 29, 2012]

IEA/OECD 2009.*Co-generation and District Energy.Sustainable energy technologies for today... and tomorrow*.International Energy Agency, Paris.

IG Passivhaus Oesterreich 2010. Altbausanierung WHA Heudörfelg., Wien, 1230. URL: http://www2.igpassivhaus.at/onoff_neu.php?id=726 [Retrieved June 17, 2010]

Intergovernmental Panel on Climate Change (IPCC) 2001.*Climate Change 2001: Impacts, Adaptation, and Vulnerability*. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change.Cambridge University Press.

Intergovernmental Panel on Climate Change (IPCC) 2006.*2006 IPCC Guidelines for National Greenhouse Gas Inventories.Volume 2.Energy*. Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T., and Tanabe K. (eds).Japan: IGES.

Intergovernmental Panel on Climate Change (IPCC) 2007a. *Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Core Writing Team, Pachauri, R.K and Reisinger, A. (eds.)]. IPC., Geneva, Switzerland.

Intergovernmental Panel on Climate Change (IPCC) 2007b.*Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds.)] Cambridge and New York: Cambridge University Press.

Isherwood, B.C., Hancock, R.M. 1979. *Household expenditure on fuel: distributional aspects*. Economic Adviser's Office, DHSS, London.

Jakob, M. 2006. Marginal costs and co-benefits of energy efficiency investments.The case of the Swiss residential sector.*Energy Policy* 34: 172–187.

Jeanreanaud, C. Marti, J. 2007. The Cost of Reduced Life Expectancy Due to Air Pollution: Assessing the Value of a Life Year (VOLY) Using Contingent Valuation. Paper presented in the iHEA 6th World Congress 2007.

Jeeninga, H., Weber, C., Mäenpää, Rivero García, F. Wiltshire, V., Wade, J. 1999. Employment Impacts of Energy Conservation Schemes in the Residential Sector Calculation of direct and indirect employment effects using a dedicated input/output simulation approach. A contribution to the SAVE Employment project SAVE contract XVII/4.1031/D/97-032.

Jochem, E., Madlener, R. 2003. *The Forgotten Benefits of Climate Change Mitigation: Innovation, Technological Leapfrogging, Employment, and Sustainable Development*. OECD Workshop on the Benefits of Climate Policy: Improving Information for Policy Makers. ENV/EPOC/GSP(2003)16/FINAL.

Johnson, H., Griffiths, C. 2003.Estimating excess winter mortality in England and Wales.Health Statistics Quarterly 20: 19-24.

Jungbauer, J. 2011. *Good Practices in Metering and Billing. Reduce, Recycle, Replace. Doubling DHC now!*35th Euroheat & Power Congress. Paris, May 9th-10th, 2011.

Kats, G. 2005. *National Review of Green Schools: Costs, Benefits, and Implications for Massachusetts*. A Report for the Massachusetts Technology Collaborative. Capital E. Massachusetts.

Kaufman, B. (pers. comm.). Passivehaus Institut Darmstadt.Meeting at the EC EPBD workshop in Brussels on March 16th 2011.

Kessides, I. (ed.) 2000. *Hungary: Regulatory and Structural Review of Selected Infrastructure Sectors*. World Bank Technical paper no. 474. Europe and Central Asia Poverty Reduction and Economic Management Series.

Kocsis, J. 2004. The Housing Poor in Budapest, Hungary: Situation and Perspectives. In Fearn (ed.). *Too poor to move, too poor to stay.A Report on Housing in the Czech Republic, Hungary and Serbia*.Local Government and Public Service Reform Initiative. Budapest: Open Society Institute.

Korytarova, K. 2011. Energy efficiency potential for space heating in the Hungarian public buildings.Unpublished PhD dissertation, Department of Environmental Sciences and Policy.Central European University. Budapest.

Korytarova, K., Ürge-Vorsatz, D., 2010.*Energy savings potential in the Hungarian public buildings for space heating*.Presented at IEECB'10: Improving Energy Efficiency in Commercial Buildings. Frankfurt, 13 -14 April 2010.

Központi Statisztikai Hivatal (KSH) 2004. A háztartások lakásfenntartási kiadásai [*Expenditure of households on maintenance of dwellings*].Központi Statisztikai Hivatal - Hungarian Central Statistical Office.Living Standard and Human Resources Statistics Department. Budapest.

Központi Statisztikai Hivatal (KSH) 2006. A háztartások villamosenergia-kiadásai [*Electricity consumption of households*].Központi Statisztikai Hivatal - Hungarian Central Statistical Office.Living Standard and Human Resources Statistics Department. Budapest.

KözpontiStatisztikai Hivatal (KSH) 2008. Household incomes and consumption patterns.*Statistical Reflections*II(1).Budapest: Központi Statisztikai Hivatal – Hungarian Central Statistical Office.

Központi Statisztikai Hivatal (KSH)2009. *Consumption habits in international comparison*. *Statistical Reflections*2009/28 (Issue 28 of Volume 3). Budapest: Központi Statisztikai Hivatal / Hungarian Central Statistical Office.

Központi Statisztikai Hivatal (KSH) 2011. Level and structure of household consumption, 2010.*Statistical Reflections* 2011/20 (Issue 20 of Volume 5). Budapest: Központi Statisztikai Hivatal / Hungarian Central Statistical Office.u20 of Volume 5 2 December 2011.

Központi Statisztikai Hivatal (KSH) 2012. *Level and structure of consumption*.Metainformation/statistical domains. URL: http://www.ksh.hu/apps/meta.objektum?p_lang=EN&p_menu_id=110&p_almenu_id=101&p_ot_id=100&p_obj_id=ZHC&p_session_id=81328032Consulted on-line November 3rd, 2012.

Kremer, B. Sziklai, I., Tausz, K. 2002. The Impact of Decentralization on Social Policy in Hungary. In Tausz (ed.) *The Impact of Decentralization on Social Policy*. Budapest: LGI.

Krupnick, A. 2007. Mortality-risk Valuation and Age: Stated Preference Evidence. *Review of Environmental Economics and Policy* 1(2): 261–282.

Krupnick, A., Burtraw, D. and Markandya, A. 2000.*The ancillary benefits and costs of climate change mitigation: A conceptual framework*. Workshop on Assessing the Ancillary Benefits and Costs of Greenhouse Gas Mitigation Strategies, (Washington DC, 27-29 March 2000).OECD.

Kubitsch, R. 2011. *The status of the Hungarian District Heating and CHP regulation.Hungarian* Energy Office / ERRA Technical Exchange Programme. Budapest, 21 February, 2011.

Kuik, O., Brander, L., Tol, R.S.J. 2009.Marginal abatement costs of greenhouse gas emissions: A meta-analysis. *Energy Policy* 37: 1395–1403

Laake, K., Sverre, J.M. 1996. Winter Excess Mortality: A Comparison between Norway and England plus Wales. *Age and Ageing* 1996:25:343-348.

Lampietti, J.A., Meyer, A.S. 2003.*Coping with the Cold.Heating Strategies for Eastern Europe and Central Asia's Urban Poor*.World Bank Technical Paper: Europe & Central Asia Environmentally & Socially Sustainable Development.

Lapillone, B, Pollier, K., and Bossebouef, D. 2004. *Energy efficiency index ODEX*. SAVE-ODYSSEE Monitoring tools for energy efficiency in Europe. EU and eceee expert seminar on measurement and verification in the European Commission’s Proposal for a Directive on Energy Efficiency and Energy Services. Brussels, September 21st, 2004.

Levine, M., Ürge-Vorsatz, D., Blok, K., Geng, L., Harvey, D., Lang, S., Levermore, G., Mongameli Mehlwana, A., Mirasgedis, S., Novikova, A., Rilling, J., and Yoshino, H. 2007. *Residential and commercial buildings*. In: Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth

Assessment Report of the Intergovernmental Panel on Climate Change [Metz, B., Davidson, O.R., Bosch, P.R., Dave, R., Meyer, L.A. (eds.)]. Cambridge and New York: Cambridge University Press.

Li, J., 2008. Towards a low-carbon future in China's building sector— A review of energy and climate models forecast. *Energy Policy*, 36, 1736–1747.

Liddell, C. 2008. *The impact of Fuel Poverty on Children*.Policy Briefing. Save the Children / University of Ulster.

Liddell, C., Morris, C. 2010. Fuel poverty and human health: a review of recent evidence. Energy Policy 38: 2987–2997

Liddell, C., Morris, C., McKenzie, P., Rae, G. 2011. *Defining fuel poverty in Northern Ireland.A preliminary review*.University of Ulster.

Lindhjem, H., Navrud, S., Braathen, N.A., Biausque, V. 2011. Valuing mortality risk reductions from environmental, transport, and health policies: a global meta-analysis of stated preference studies.*Risk Analysis*31(9):1381-407.

Lloyd, B. 2006.Fuel poverty in New Zealand.*Social Policy Journal of New Zealand* (27): 142-155.

Lomax, N., Wedderburn, F. 2009. *Fuel Debt and Fuel Poverty.A case study of financial exclusion*.Friends Provident Foundation.

Mack J., Lansley, S. 1985. *Poor Britain, London*: Allen and Unwin. Cited in Eurostat. What can be learned from deprivation indicators in Europe.Methodologies and working papers. Luxembourg: Office for Official Publications of the European Communities, 2009.

Maibach, M., Schreyer, C., Sutter, D., van Essen H.P., Boon, B.H., Smokers, R., Schroten, A., Doll, C., Pawlowska, B., Bak, M. 2007. *Handbook on estimation of external cost in the transport sector*.Produced within the study Internalisation Measures and Policies for All external Cost of Transport (IMPACT).CE Delft.

Markandya, A., Hunt, A., Ortiz, R., Alberini, A. 2004. EC NewExt Research Project: Mortality Risk Valuation – Final Report – UK. Brussels, European Commission.

Markandya, A., Rübbelke, D.T.G., 2004. Ancillary benefits of climate policy.*Jahrbücher für Nationalökonomie und Statistik*, 224, 488–503.

McAvoy, H., 2007. *All-Ireland Policy Paper on Fuel Poverty and Health*.Institute of Public Health in Ireland. Dublin.

McDonald, A., Schrattenholzer, L., 2002. Learning curves and technology assessment.*International Journal of Technology Management* 23: 718–745.

Menhely Alapítvány 2005. *Hányan élnek fedél nélkül?Budapesti fedél nélkül élő emberek „népszámlálása" 2005*. Budapesti Módszertani Szociális Központ és Intézményei

Mercer, J.B. 2003. Cold—an underrated risk factor for health. *Environmental Research* 92(1): 8-13.

Microsoft 2012.Description of the PMT function. URL: http://office.microsoft.com/en-001/excel-help/pmt-function-HP010342769.aspx Consulted on line December 17, 2012.

Miller, P. 2009. Energy Conservation.*National Geographic*. March 2009.

Mills, E., Rosenfeld, A. 1996. Consumer non-energy benefits as a motivation for making energy-efficiency improvements. *Energy* 28: 707-720.

Milne, G. and Boardman, B. 2000. Making cold homes warmer: the effect of energy efficiency improvements in low-income homes A report to the Energy Action Grants Agency Charitable Trust. Energy Policy 28 (6-7): 411–424.

Ministry of Foreign Affairs 2012.*Hungary: National Social Inclusion Strategy – Deep poverty, child poverty and Roma (2011-2020*). OSCE Human Dimension Committee 9 May 2012.

Ministry of Labour and Social Affairs, 2008.*National Strategy Report on Social Protection and Social Inclusion 2006-2008*. Budapest.

Ministry of National Development 2011.*Hungarian Green Investment Scheme.Presentation for Prospective Buyers*. URL:http://zbr.kormany.hu/download/a/72/00000/Interested%20in%20buying%20AAUs%20from%20Hungary%20_EHval.pdf

Moreno-Ternero, J.D., Roemer, J.E. 2005.*Impartiality and priority. Part 1: the veil of ignorance*. Cowles Foundation Discussion Papers, no 1477A.

Morgan, E. 2008.*Energy poverty in the EU*.Socialist Group in the European Parliament.

Morris, C., Liddell, C. 2010. *Chapter 2.Seasonality of Mortality in Northern Ireland*.Northern Ireland Statistics and Research Agency.

Morrison, C., Shortt, N. 2008. Fuel poverty in Scotland: Refining spatial resolution in the Scottish Fuel Poverty Indicator using a GIS-based multiple risk index. *Health & Place* 14: 702–717.

Nabuurs, G.J., O. Masera, K. Andrasko, P. Benitez-Ponce, R. Boer, M. Dutschke, E. Elsiddig, J. Ford-Robertson, P. Frumhoff, T. Karjalainen, O. Krankina, W.A. Kurz, M. Matsumoto, W. Oyhantcabal, N.H. Ravindranath, M.J. Sanz Sanchez and X. Zhang, 2007. *Forestry*. In *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Metz, B., Davidson, O.R., Bosch, P.R., Dave, R. and Meyer, L.A. (eds)], Cambridge and New York: Cambridge University Press.

Nässén, J. and Holmberg, J. 2009. Quantifying the rebound effects of energy efficiency improvements and energy conserving behaviour in Sweden.*Energy Efficiency* 2: 221–231.

National Energy Assistance Directors' Association (NEADA). 2005. *2005 National Energy Assistance Survey. Final Report*.

Nemzeti Erőforrás Minisztérium (NEM) 2012. *Adósságkezelési szolgáltatás* [Debt managementservices].Szociális Lakossági és Tájékoztatási Osztály /SocialandConsumerInformation Department.

Népszabadság Online (NOL) 2010.Brüsszel szerint mehet a kedvezményes távhő-áfakulcs.[URL:http://nol.hu/gazdasag/brusszel_szerint_mehet_a_kedvezmenyes_tavho-afakulcs] Consulted on-line July 15th, 2010.

Nerhagen, L., Li, C-Z. 2010. Valuing statistical lives or life years? A choice experimental study.Working Paper No 2010:11. Swedish National Road & Transport Research Institute (VTI).

Nolan, B., Whelan, C. 2009.*Using Non-Monetary Deprivation Indicators to Analyse Poverty and Social Exclusion in Rich Countries: Lessons from Europe?*Presented at the conference "Measuring Poverty, Income Inequality, and Social Exclusion.Lessons from Europe".Paris (France) March 16-17, 2009.

Novikova, A. 2008.*Carbon dioxide mitigation potential in the Hungarian residential sector*.Unpublished PhD dissertation, Department of Environmental Sciences and Policy.Central European University. Budapest.

O'Neill, T., Jinks, C., Squire, A. 2006. 'Heating is more important than food': Older women's perceptions of fuel poverty. *Journal of Housing for the Elderly* 20(3): 95-108.

OECD/IEA 2004.*Coming in from the Cold.Improving District Heating Policy in Transition Economies*.Paris: International Energy Agency.

OECD/IEA 2007.*Hungary 2006 review.Energy Policies of IEA Countries*.Paris: International Energy Agency.

OECD/IEA 2009a.*Energy Prices & Taxes.Quarterly statistics.Second Quarter 2009*.IEA Statistics. Paris: International Energy Agency.

OECD/IEA 2009b.*Technology Roadmap.Wind energy*. Paris: International Energy Agency.

OECD/IEA 2010a.*Natural gas information 2010*.IEA Statistics.Paris: International Energy Agency.

OECD/IEA 2010b.*Key World Energy Statistics 2010*. Paris: International Energy Agency.

OECD/IEA 2010c.*World Energy Outlook 2009*.Paris: International Energy Agency.

OECD/IEA 2010d.*Technology Roadmap.Solar photovoltaic energy*.International Energy Agency, Paris.

OECD/IEA 2011a.*Evaluating the co-benefits of low-income energy-efficiency programmes*.Workshop report (eds. Grayson Heffner, Nina Campbell).Results of the Dublin Workshop, 27-28 January 2011. Paris: International Energy Agency.

OECD/IEA 2011b.*Energy Policies of IEA Countries*.*Hungary 2011 review*.Paris: International Energy Agency.

OECD/IEA 2012a.*Oil & Gas Security.Emergency Response of IEA Countries*. Hungary.

OECD/IEA 2012b.S*preading the net: the multiple benefits of energy efficiency improvements*.Insight series 2012.Paris: International Energy Agency.

Official Journal of the European Union (2011).*Opinion of the European Economic and Social Committee on 'Energy poverty in the context of liberalisation and the economic crisis' (exploratory opinion)*.Official Journal of the European Union 11.02.2011 (2011/C 44/09).

Official Journal of the European Union 2012. Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC. 14.11.2012 / L 315/1

Official Journal of the European Union, 2010a.*Directive 2009/72/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in electricity and repealing Directive 2003/54/EC*. 14.8.2009 / L 211/5.

Official Journal of the European Union, 2010b.*Directive 2009/73/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in electricity and repealing Directive 2003/55/EC*. 14.8.2009 / L 211/9.

Official Journal of the European Union, 2011.*Opinion of the European Economic and Social Committee on 'Energy poverty in the context of liberalisation and the economic crisis' (exploratory opinion)*. (2011/C 44/09)

Ofgem 2012.*Why are energy prices rising?* Factsheet 108 14.10.11

Organisation for Economic Co-operation and Development (OECD) 2008.*Environmental Performance Reviews. Hungary*. Organisation for Economic Co-operation and Development. Paris.

Organisation for Economic Co-operation and Development (OECD) 2009.*What are equivalence scales?* URL:http://www.oecd.org/els/socialpoliciesanddata/35411111.pdf

Organisation for Economic Co-operation and Development (OECD) 2011.*Valuing Mortality Risk Reductions in Regulatory Analysis of Environmental, Health and Transport Policies: Policy Implications*. Paris: OECD.

Ostro, B. 2004.Outdoor air pollution.Assessing the environmental burden of disease at national and local levels.Environmental Burden of Disease Series, No. 5. Geneva: Wolrd Health Organisation.

Pachauri, S. and Spreng, D. 2003.*Energy use and energy accessin relation to poverty*.CEPE Working Paper Nr. 25. Centre for Energy Policies and Economics. Zürich: Swiss Federal Institutes of Technology.

Pájer, S. 2009. *Klímaváltozás – Energiatudatosság – Energiahatékonyság.V. Nemzetközi Konferencia* [Climate Change – Energy Awareness – Energy Efficiency. V. National Conference]. April 16-17, 2009. Szeged, Hungary.

Passive House Retrofit Kit 2010.Passive house retrofit kit.URL: http://www.energieinstitut.at/retrofit/?to=1&forward=BEST_PRACTICE&id=e091b7ffd7575145d14882 5aa6587e2f&dmy=3d3ecf06336566ceee5fe0371f661de9 [Retrieved June 17, 2010]

Pearce, D. 2000. *Policy Frameworks for the Ancillary Benefits of Climate Change Policies*.Workshop on Assessing the Ancillary Benefits and Costs of Greenhouse Gas Mitigation Strategies, (Washington DC, 27-29 March 2000).OECD.

Pearce, D., Atkinson, G., Mourato, S. 2006. *Cost-benefit analysis and the environment.Recent developments*.Organisation for Economic Co-operation and Development.OECD, Paris.

Pearson, I., Zeniewski, P., Gracceva, F., Zastera, P., McGlade, C., Sorrell, S., Speirs, J., Thonhauser, G. 2012.*Unconventional Gas: Potential Energy Market Impacts in the European Union*. JRC Scientific and Policy Reports.

Persson U.,Werner S.,2011. Heat distribution and the future competitiveness of district heating.*Applied Energy*88(3): 568-576.

Peszko, G. 2009. *AAU Trade & Green Investment Schemes: Post 2012 potential. Senior Energy/Environmental Economist*.Office of the Chief Economist.European European Bank for Reconstructionand Development.2nd Meeting CEPS Task Force on the CDM and future Flexible Mechanisms Post 2012.14 January, 2009.

Pittel, K., Rübbelke, D.T.K. 2008.Climate policy and ancillary benefits: A survey and integration into the modelling of international negotiations on climate change. *Ecological Economics*68(1-2): 210–220.

PointCarbon 2009.*Carbon Market Analyst .Outlook for 2009*. PointCarbon Research.

Pollin, R. Heintz, R., Garrett-Peltier, H., 2009.*The Economic Benefits of Investing in Clean Energy. How the economic stimulus program and new legislation can boost U.S. economic growth and employment*. Department of Economics and Political Economy Research Institute (PERI).University of Massachusetts, Amherst.Center for American Progress.

Poputoaia, D., Bouzarovski, S., 2010.Regulating district heating in Romania: Legislative challenges and energy efficiency barriers.*Energy Policy* 38: 3280-3289.

Poyry Energy Consulting and AECOM, 2009.*The Potential and Costs of District Heating Networks - A report to DECC.* Poyry - Faber Maunsell/AECOM.

Preiss, P., Friedrich, R., Klotz, V. 2008. *Deliverable n° 1.1 - RS 3a "Report on the procedure and data to generate averaged/aggregated data"*. NEEDS –New Energy Externalities Developments for Sustainability

Rabl, A. 1996. Discounting of long-term costs: what would future generations prefer us to do? *Ecological Economics* 17: 137– 145.

Radian, 2010.*The Revolving Retrofit Guarantee Fund Mechanism.A sustainable and affordable financing solution to enable large scale energy efficient retrofitting of housing*.

Rawls, J. 1971. *A Theory of Justice*. Cambridge: Harvard University Press.

Rosenthal, E. 2008. No Furnaces but Heat Aplenty in 'Passive Houses'. The New York Times, December 26, 2008. URL: http://www.nytimes.com/2008/12/27/world/europe/27house.html?_r=1&ref=world&pagewanted=all [Retrieved March 16, 2010]

Sagar, A.D. 2005. Alleviating Energy Poverty for the World's Poor.*Energy Policy* 33 (11): 1367-1372.

Salamin, J., and Ménesi, E. Head of Section and Senior Statistician.Living Standard Statistics Surveys section and Senior Statistician.Living Standards and Labour Statistics Department.Hungarian Central Statistical Office.Meeting for information exchange. October 13th, 2010. Budapest.

Schelling, T.C. 1995. Intergenerational discounting.*Energy Policy*, 23: 395– 401

Schweitzer, M., Tonn., B. 2002. *Nonenergy benefits from the weatherization assistance program: A summary of findings from the recent literature*. ORNL/CON-484.Oak Ridge National Laboratory. Oak Ridge, Tennessee.

Scott, S. Lyons, S., Keane, C., McCarthy, D., and Tol, R.S.J. 2008.*Fuel Poverty in Ireland: Extent, Affected Groups and Policy Issues*. Working Paper No. 262. Dublin: Economic and Social Research Institute (ESRI).

Scott, S., 1996.*Social welfare fuel allowances… to heat the sky?*Working Paper no. 74. Dublin: The Economic and Social Research Institute (ESRI).

Seppänen, O. 2008.*Scientific basis for design of ventilation for health, productivity and good energy efficiency*.Presented in the Indoor Air Congress 2008, Copenhagen.

Sharmina, M., Úrge-Vorsatz, D., Feiler, J. 2008.*Green Investment Scheme: Case Study on Hungary*. Working Paper.Climate Strategies.

Sigmond, G. ,2009. *The Situation of District Heating, District Cooling andEnergy Supplyin Hungary*. Presented at the Conference & Business Forum "District heating and energy efficiency – the Danish example". March 30–31, 2009. Budapest.

Sigmond, Gy., Veress, Sz., Lázár, R. (pers. comm.). Representatives of the Association of Hungarian District Heating Enterprises (*MaTáSzSz*) and the Budapest District Heating Company (FőTÁV Zrt). Interview conducted on November 2011.

Socor, V. 2009.MOL, Gazprom to Build Gas Storage Site in Hungary Independent of South Stream.*Eurasia Daily Monitor* 6 (48) [March 12th, 2009]

Soliño, M. 2010. External benefits of biomass-e in Spain: An economic valuation. *Bioresource Technology* 101(6), 1992–1997.

Spiegel Online International 2009. Independence Day For European Gas. *Spiegel Online International*. July 13th, 2009.

Stasiūnas, V. 2011.*District and individual heating in Lithuania and Europe*.Lithuanian District Heating Association. Presented at an International seminar in Kaunas (Lithuania) on February 9, 2011.

Steger (ed.) 2007.*Making the Case for Environmental Justice in Central and Eastern Europe*. CEU Center for Environmental Policy and Law (CEPL), The Health and Environment Alliance (HEAL) and The Coalition for Environmental Justice

Stephens, C. Bullock, S. Scott, A. 2001. *Environmental justice. Rights and means to a healthy environment for all*. Special Briefing No. 7 November 2001. ESRC Global Environmental Change Programme, Friends of the Earth and London School of Tropical Hygiene and Medicine.

Stern, N. 2007.*The Economics of Climate Change: The Stern Review*. Cambridge and New York: Cambridge University Press.

Stoecklein, A. Scumatz, L. 2007. *Zero and low energy homes in New Zealand: The value of non-energy benefits and their use in attracting homeowners*. Proceedings of the ECEEE Summer Study 2007.

Sunikka-Bland, M., Galvin, R. 2012.Introducing the prebound effect: the gap between performance and actual energy consumption.*Building Research & Information* 40(3), 260-273.

Szajkó, G., Mezősi, A., Pató, Zs., Scúltety, O., Sugár, A., Tóth, A.I., 2009. *Erdészeti és ültetvény eredetű fás szárú energetikai biomassza Magyarországon* [Firewood energy biomass of plantation and forestry origins in Hungary]. Regionális Energiagazdasági Kutatóközpont (REKK). Budapesti Corvinus Egyetem.

Szivós, P., Bernát, A., Kőszeghy, L. 2011. Managing household debt: Hungarian country report. Tárki Social Research Institute.

Szombati, K. (pers. comm.). Sociologist and PhD student of Department of Sociology and Social Anthropology at Central European University (CEU).Project coordinator of the Polgár Alapítványaz Esélyekért (Civil Foundation for Opportunities). Budapest, June 12th, 2009.

Taylor, T.N., Lloyd, C.R 2004.*A Cost-Benefit Analysis of an Insulation Retrofit to New Zealand State Housin*g. World Renewable Energy Conference, Denver, Colorado, USA, September 2004.

The Economist 2012.*Careful what you wish for. The pros and cons of a more competitive gas market in Europ*e. URL: http://www.economist.com/node/21558433Consulted on-line October 25th, 2012.

The Eurowinter Group 1997. Cold exposure and winter mortality from ischaemic heart disease, cerebrovascular disease, respiratory disease, and all causes in warm and cold regions of Europe. *The Lancet* 349: 1341–1346.

The Government of the Republic of Hungary 2006.*The New Hungary Development Plan 2007–2013. Employment and Growth*.National Strategic Reference Framework of Hungary.Accepted by the Hungarian Government on the 25th of October, 2006.

The Marmot Review Team 2011.*The Health Impacts of Cold Homes and Fuel Poverty*.Written by the Marmot Review Team for Friends of the Earth.

Thomas, H.R., 2009. Construction Learning Curves.*Practice Periodical on Structural Design and Construction*14(1): 14-20.

Thomson, H., Snell, H. 2012. Quantifying the prevalence of fuel poverty across the European Union.*Energy Policy* 52: 563–572.

Thyholt M., Hestnes, A.G., 2008. Heat supply to low-energy buildings in district heating areas: Analyses of CO2 emissions and electricity supply security.*Energy and Buildings* 40(2): 131-139.

Tirado Herero, S. Ürge-Vorsatz, D. 2012. Trapped in the heat: a post-communist type of fuel poverty.*Energy Policy* 49: 60–68.

Tirado Herrero, S., Ürge-Vorsatz, D. 2010.*Fuel poverty in Hungary.A first assessment*. Report prepared for Védegylet – Protect the Future Society. Budapest: Center for Climate Change and Sustainable Energy Policy (3CSEP).

Tirado Herrero, S., Ürge-Vorsatz, D., Arena, D., Telegdy, A. 2011. *Co-benefits quantified: employment, energy security and fuel poverty implications of the large-scale, deep retrofitting of the Hungarian building stock*. Proceedings of the ECEEE Summer Study 2011. 6-11 June 201. Belambra Presqu'île de Giens,France.

Tirado Herrero., S. López Fernández, J.L., Martín García, P. 2012. *Pobreza energética en España, Potencial de generación de empleo directo de la pobreza derivado de la rehabilitación energética de viviendas*. [Energy poverty in Spain. Direct employment creation potential of energy efficient retrofitting of residential buildings]. Madrid: Asociación de Ciencias Ambientales.

Tol, R.S.J. 2005. The marginal damage costs of carbon dioxide emissions: an assessment of the uncertainties. *Energy Policy* 33: 2064-2074.

Townsend, P. 1979. *Poverty in the United Kingdom*. London: Penguin.

Tresó, E. 2008.Price setting for universal service of electricity in Hungary.Hungarian Energy Office.ERRA Tariff/Pricing Committee meeting. Skpje (Macedonia), September 15-16, 2008.

Tuerk, A., Frieden, D., Sharmina, M., Schreiber, H., Ürge-Vorsatz, D. 2010.Working Paper. Green Investment Schemes: First experiences and lessons learned. Joaennum Research and Center for Climate Change and Sustainable Energy Policy (3CSEP).

Turner, R.K., Pearce, D.W., Bateman, I. 1993. *Environmental economics: an elementary introduction*. John Hopkins University Press.

UK Green Building Council (UKGBC) 2009.*Pay As You Save: Financing low energy refurbishment in housing*. Campaign for a Sustainable Built Environment.UK Green Building Council.

UNDP 2004.*Stuck in the Past.Energy, Environment and Poverty in Serbia and Montenegro*.United Nations Development Programme.Country Office Serbia and Montenegro.Belgrade, Serbia and Montenegro.

UNDP/*Autonómia Alapítvány*2004.*Energiatakarékossági kísérleti programok az Encsi kistérségben* (Household energy pilot project for Roma settlements in Encs region). Budapest,AutonómiaFoundation.

United Nations Framework Convention on Climate Change (UNFCCC) 2012a. Greenhouse Gas Inventory Data – Detailed data by party (Hungary). [URL: http://unfccc.int/di/DetailedByParty/Event.do?event=go] Consulted on-line October 25th, 2012.

United Nations Framework Convention on Climate Change (UNFCCC) 2012b.Glossary of climate change acronyms.URL: http://unfccc.int/essential_background/glossary/items/3666.php#A [Consulted on-line on June 29, 2012]

Ürge-Vorsatz, D, Miladinova, G., Paizs, L. 2006. Energy in transition: from the iron curtain to the European Union. *Energy Policy* 34: 2279–2297.

Ürge-Vorsatz, D., Arena, D., Tirado Herrero, S., Butcher, A.C., 2010.*Employment Impacts of a Large-Scale Deep Building Energy Retrofit Programme in Hungary*. Prepared for the European Climate Foundation by The Center for Climate Change and Sustainable Energy Policy (3CSEP) Central European University Budapest, Hungary.

Ürge-Vorsatz, D., Novikova, A., 2008. Potentials and costs of carbon dioxide mitigation in the world's buildings.*Energy Policy* 36(2):642-661.

Ürge-Vorsatz,D., Novikova, A, Köppel, S., Boza-Kiss, B., 2009a.Bottom–up assessment of potentials and costs of CO_2 emission mitigation in the buildings sector: insights into the missing elements. Energy Efficiency 2, 293-316.

Ürge-Vorsatz, D., Novikova, A., Sharmina, M., 2009b.Counting good: quantifying the co-benefits of improved efficiency in buildings. Paper presented at ECEEE 2009 Summer Study. June 1–6, 2009. La Colle sur Loup, France.

Ürge-Vorsatz, D., Tirado Herero, S. 2012.Building synergies between climate change mitigation and energy poverty alleviation.*Energy Policy* 49: 83-90.

Ürge-Vorsatz, D., Wojck-Gront, E., Tirado Herrero, S., Foley, P.2012.*Employment Impacts of a Large-Scale Deep Building Energy Retrofit Programme in Poland*. Center for Climate Change and Sustainable Energy Policy (3CSEP), Budapest..

Vaasa ETT 2012.European Residential Energy Price Report 2012.Vaasa ETT Global Energy Think Tank.

van Vuuren, D.P., Cofala, J., Eerens, H.E., Oostenrijk, R., Heyes, C., Klimont, Z., den Elzen, M.G.J., Amann, M. 2008. Exploring the ancillary benefits of the Kyoto Protocol for air pollution in Europe.*Energy Policy* 34: 444–460.

Vandentorren, S..,Suzan, F., Medina, S., Pascal, M., Maulpoix, A, Cohen, J-C., Ledrans, M., 2004. Mortality in 13 French Cities During the August 2003 Heat Wave. *American Journal of Public Health* 94(9), 1518-1520.

Varró, L. 2010. *Megújuló energia: mit, miért, mennyiböl?*[Renewable energy: what, why, how much?]Presented in the conference Energia - másképp II.Hungarian Academy of Sciences (Budapest). March 10, 2010.

Waddams Price, C., Brazier, K., Pham, K., Mathieu, L. and Wang, W. 2006.*Identifying Fuel Poverty Using Objective and Subjective Measures*. CCP Working Paper no. 07-11. Centre for Competition Policy, University of East Anglia, UK.

Wade, J., Wiltshire, W. and Scrase, I. 2000. *National and Local Employment Impacts of Energy Efficiency Investment Programmes*. Volume 1: Summary Report. SAVE contract XVII/4.1031/D/97-032.

Walker, G., Day, R. 2012. Fuel poverty as injustice: Integrating distribution, recognition and procedure in the struggle for affordable warmth. *Energy Policy* 49, 69–75.

Wilkinson P., Landon M., Armstrong B., Stevenson S., Pattenden S., McKee M., Fletcher T. 2001.*Cold Comfort: The Social and Environmental Determinants of Excess Winter Deaths in England, 1986–96*. Bristol: The Policy Press.

Willits, M. 2006. *Measuring child poverty using material deprivation: possible approaches*.Working Paper No 28.Department for Work and Pensions, UK.

Winkler, H., Spalding Fecher, R., Tyani, L. and Matibe, K. 2000.Cost benefit analysis of energy efficiency in low-cost housing. EDRC report no EDRC/00/R. Energy & Development Research Centre. University of Cape Town. South Africa.

Wiser, R., Bolinger, M. and St. Clair, M. 2005.*Easing the Natural Gas Crisis: Reducing Natural Gas Prices through Increased Deployment of Renewable Energy and Energy Efficiency*.Lawrence Berkeley National Laboratory, California.

World Bank 2000.*Maintaining Utility Services for the Poor. Policies and Practices in Central and Eastern Europe and the Former Soviet Union*. The World Bank Group. Washington.

World Bank 2010.*Subsidies in the Energy Sector: An Overview*. Background Paper for the World Bank Group Energy Sector Strategy.

World Health Organisation (WHO) 1987.*Health Impact of Low Indoor Temperatures*. Report on a WHO Meeting. World Health Organisation, Regional Office for Europe. Copenhaguen.

World Health Organisation (WHO) 2004.*Review of evidence on housing and health. Background document.* Fourth Ministerial Conference on Environment and Health- Budapest, Hungary, 23–25 June 2004. World Health Organization.Regional Office for Europe. Copenhagen.

World Health Organisation (WHO) 2007.*Housing, energy and thermal comfort. A review of 10 countries within the WHO European Region*. World Health Organization.Regional Office for Europe. Copenhagen.

Wright, T., 1936.Factors Affecting the Cost of Airplanes.*Journal of Aeronautical Science* 4(4): 122-128.

Yeh, S., Rubien, E.S. 2012. A review of uncertainties in technology experience curves. *Energy Economics* 34, 762–771.

Yin, R. K. 2003.*Case Study Research: Design and Methods*. Applied Social Research Methods, Vol. 5.3rd Edition.

Yohe, G.W., Lasco, R.D., Ahmad, Q.K., Arnell, N.W., Cohen S.J., Hope, C., Janetos, A.C. and Perez, R.T, 2007.Perspectives on climate change and sustainability.*Climate Change 2007: Impacts, Adaptation and Vulnerability*. *Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds.. , Cambridge: Cambridge University Press.