

Co-benefits quantified: employment, energy security and fuel poverty implications of the large-scale, deep retrofitting of the Hungarian building stock

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Abstract

Co-benefits can often be more attractive entry points for energy-efficiency measures to policy-making than climate change or other environmental benefits. However, they are seldom quantified and thus rarely can be effectively entered into the decision-making process. This paper presents the key results of a research that has analysed and quantified the co-benefits of a concrete case where co-benefits have a strong chance to drive policy-making: deep energy-efficient retrofits of buildings in Hungary. In this country, buildings are responsible for half of the energy-related CO₂ emissions, are one of the least energy-efficient in the EU, and contain the largest potential for cost-effective mitigation among the different end-use sectors. At the same time, Hungary has the second lowest employment rate of the EU and the OECD, is highly dependent on natural gas imports and a substantial part of its population lives in fuel poverty. Deep energy-efficient retrofitting of the building stock offers a (partial) solution to most of these problems. The main focus of the research was on employment benefits, for which a novel combination of Input-Output analysis with detailed bottom-up estimates was applied. Our findings indicate that if Hungary's residential and public buildings are deep-retrofitted, up to 2030: i) 85 % of its heating-related energy consumed and CO₂ emitted in 2010 will be avoided; ii) up to 59 % of the January net gas imports will be avoided; and iii) as much as 180,000 net additional jobs can be created, with this figure getting lower in time and depending on the renovation dynamic. At the same time, if suboptimal retrofits continue to dominate, 45 % of the 2010 heating-related CO₂ emissions will be *locked-*

in, with also energy security and employment benefits significantly lower than in deep renovation scenarios. The paper also offers a discussion on the qualitative aspects of the forecasted employment effects in the Hungarian labour market, including its geographic and skill level distribution, as well as recommendations stemming from an overall macroeconomic assessment of such a program. The significance of the study is that a few weeks after its release the Hungarian government announced its commitment to a comprehensive, deep retrofit program of its building stock.

Introduction

While climate change is often low in the political agendas of medium welfare economies, other policy targets, especially if presented in an integrated manner, may provide strategic entry points to policy-making for important climate change mitigation priorities. Previous research (Levine et al., 2007; Ürge-Vorsatz et al., 2009a; 2009b) has demonstrated that many energy-efficiency measures have significant co-benefits; often larger in value than the direct benefits related to the energy-saving, thus an integrated cost-efficiency assessment may result in very different feasibility assessment outcome than only if direct benefits are considered. At the same time, though numerous co-benefits of climate policies and energy efficiency in buildings have been described (Pearce, 2000; Krupnick et al., 2000; Schweitzer and Tonn, 2002; Levine et al., 2007; Ürge-Vorsatz et al., 2009a; 2009b; Skumatz et al., 2009), they are seldom quantified, or even identified, and thus rarely enter the decision-making processes.

These notions particularly apply for the case for the refurbishment of inefficient building stocks, often hampered by

strong market barriers, and, while cost-effective, its typically long payback times make it unattractive for single policy goals such as climate change mitigation. The goal of this paper is thus to present a case where selected co-benefits were quantified in a robust manner to allow their serious consideration in a policy-making process. The concrete case was the deep renovation of the Hungarian building stock; and, as described later, the results of the study have in the end entered important decision-making processes in this country.

In Hungary, climate policies have so far had only relative importance because of the large decrease in GHG emissions following the political and economic changes occurred in the 1990s. In this land-locked Central European country with a population of 10 million (70 % living in cities), buildings are key to the mitigation challenge: they contribute approximately half of its energy-related CO₂ emissions, and are regarded as a central element of any policy aimed at reducing the nation's energy consumption and/or emissions (Novikova, 2008). This is related to the inefficiency of the Hungarian building stock, which ranks among the top-ten EU27 countries in terms of specific dwelling energy consumption scaled to EU average (ODYSSEE, 2010) and makes the its households sector as the one with the largest cost-effective mitigation potential (Eichhammer et al., 2009).

Other relevant social and energy-related challenges have also close links with the building sector: Hungary has one of the highest gas dependences of IEA member countries (OECD/IEA, 2007) and indicators evidence the incidence of fuel poverty in the country (Tirado Herrero and Ürge-Vorsatz, 2009). Additionally, Hungary's employment rate (61.9 %) is the second lowest in the EU (EUROSTAT, 2010) and in the OECD, which has a number of negative effects for the inactive and the society as a whole – increased poverty, erosion of knowledge and skills, deteriorating health conditions and life expectancy, poor socialisation, risks to the long-term sustainability of the social security systems, etc. (Csere-Gergely et al., 2009).

Though previous research (Novikova, 2008; Korytarova and Ürge-Vorsatz, 2010) has assessed the energy and carbon savings potential of reducing Hungary's residential and public buildings energy use for space heating, this was done by following a component-based approach based on upgrading of specific parts of the building structure. Holistic approaches that aim at an overall, substantial reduction in the energy use of the building for heating such as the passive-house concept have not been usually considered. Besides, estimates of co-benefits in the Central and Eastern European region (and in Hungary in particular) are practically non-existent.

The paper is thus organized as follows. A methodology section first presents the main assumptions, approaches and data sources used in the combined building stock and employment model. The results section follows, where energy savings and carbon reductions plus the forecasted net job creation, energy independency reduction and fuel poverty alleviation effects for the four different scenarios defined are reported. Finally, a shorter qualitative revision of selected aspects and a conclusions section discuss the key findings of the research.

Methodology

OVERVIEW

This study presents two worth-mentioning methodological aspects. First, it has applied a joint building stock and employment model that goes all the way from characterising Hungary's buildings and estimating energy and carbon savings and annual financial costs and benefits to forecasting the employment effects of the proposed intervention. Second, a novel combination of Input-Output analysis with detailed bottom-up estimates was applied for estimating employment effects. This mixed approach was chosen because applying the construction sector labour intensity as employment multiplier to building renovation activities was considered imprecise. In fact, case studies have shown that energy-efficiency retrofit activities are notably more labour intensive than general construction activities.

THE BUILDING STOCK MODEL

A building stock model was first assembled in order to estimate the energy savings, carbon emission reductions and annual investment costs and energy saving benefits of various building renovation scenarios intended to reduce the energy use for space heating of Hungary's 4.4 million dwellings and more than 32,000 public buildings. A summary of the main characteristics and assumptions of the model contains the following elements:

- Six residential and public building typologies – from historical and protected buildings to single and multi-family homes built in different periods – make up the stock subject to renovation. Public building categories have been made have been made equivalent (in terms of energy use before and after retrofit, renovation costs, etc.) to residential types on the basis of their similarities in terms of shape factors, age, and construction practices. Data on the size, characteristics and energy use of each building typology was obtained from Novikova (2008), Korytarova (2010) and consultation with national experts.
- Five renovation scenarios characterised by different depths of renovation – from non-energy efficiency-oriented (S-BASE) to sub-optimal (S-SUB) and deep renovations (S-DEEP) that bring specific energy use for space heating as realistically and economically feasible close to passive-house standards (i.e., from 25 to 35 kWh m⁻² year⁻¹) – and rates of renovation are analysed (see Table 1). Sub-optimal differ from deep renovations in that the former are component-based (i.e., replacement of selected building elements such as walls insulation, windows or heating systems) and the latter are performance-based (i.e., comprehensive retrofits that combine various measures – thick wall insulation, ensured airtightness, advanced heat recovery ventilation systems, etc. – following the passive house approach). Both approaches accept on-site renewable energy generation.
- A 5-year ramp-up period is applied for the renovation industry to learn technologies and acquire the resources. In this period, the floor area renovated increases linearly until reaching the each scenario's target retrofit rate.

Table 1. Summary of renovation scenarios.

Scenario	Description	Average energy savings (% previous consump.)	Target retrofit rate (units per year)	Forecasted completion
S-BASE	Baseline scenario: no intervention. <i>Business-as-usual</i> retrofits	10%	1.3% of total floor area 4.5 million m ²	77 years
S-SUB	Suboptimal retrofit with medium implementation rate	40%	3.4% of total floor area 12 million m ²	28 years
S-DEEP1	Deep retrofit with fast implementation rate	85%	5.4% of total floor area 20 million m ²	18 years
S-DEEP2	Deep retrofit with medium implementation rate	85%	3.4% of total floor area 12 million m ²	28 years
S-DEEP3	Deep retrofit with slow implementation rate	85%	2.3% of total floor area 8 million m ²	41 years

- The cost per square metre of base (45 to 80 €₂₀₀₅ m², depending on the building typology) and suboptimal renovations (75 to 146 €₂₀₀₅ m²) are assumed to remain stable for the whole modelling period. Deep renovation costs, which for 2010 are in the 250–550 €₂₀₀₅ m² range, are allowed to decrease in order to reflect the effects of mass production and learning. The rate of decrease of deep renovation costs (8 % per year in the first year) progressively slows down until the cost is twice the price of base renovation by 2040. Renovation costs were retrieved from a extensive review of case studies in Hungary and abroad and consultation with national experts.
- Real energy prices – ranging from 0.021 €₂₀₀₅ kWh⁻¹ for solid fuels to 0.145 €₂₀₀₅ kWh⁻¹ for electricity – are assumed to increase throughout the modelling period at a progressively decreasing rate starting at 2 % to 3.5 % per year (depending on the fuel considered). Data on real prices and price-increase rates were retrieved from Petersdorff et al. (2005), Euroheat & Power (2007), OECD/IEA (2009a), the Hungarian Central Statistical Office (KSH, 2010a) and Demecs Lászlóné (pers.comm.).
- Constant CO₂ emission factors – ranging from 202 gCO₂ kWh⁻¹ for natural gas to 366 gCO₂ kWh⁻¹ for electricity – were obtained from IPCC (2006), Novikova (2008) and Euroheat & Power (2007).

THE EMPLOYMENT IMPACTS MODEL

Typologies of employment impacts assessed

Typically, three employment (positive and negative) effects of investment programmes have been described (Weber, 1998; Geller et al., 1998; Bailie et al., 2001). For the case of building retrofits, these are described as:

- Direct employment effects, which happen as a result of a change in the demand of goods and services directly related to the actual improvement of the energy performance of buildings (i.e., construction and energy supply).
- Indirect employment effects result from the changes in the demand of goods and services produced by sectors that supply those directly involved in the intervention (e.g., transport, catering, construction materials, etc).
- Induced employment effects derive from households re-spending the additional income generated by the investment. In previous studies, these are usually the wages en-

joyed by the new workers hired by the intervening sectors (Pollin and Garrett-Peltier, 2009a). In this case, another source of additional income to the households is the energy expenditure savings generated by the intervention.

Methodological approaches identified in the literature

Four main methodological approaches are usually applied on the estimation of employment effects of investments.

The scaling-up of case studies is a bottom-up approach that uses recorded job creation figures from completed projects (Wade et al., 2000; Jeeninga et al., 1999; Blanco and Rodrigues, 2009; Bezdek, 2009) and applies them to the level of the proposed intervention (see Wei et al., 2010). Known also as analytical method, it usually accounts only for direct effects, disregarding multiplier effects and thus underestimating net impacts (Kammen et al., 2004).

Input-Output (I/O) analysis is the most often applied methodology for top-down forecasting of the employment impacts of medium- and large-sized investments, including energy efficiency interventions (Pollin and Garrett-Peltier, 2009a; 2009b; 2009c; Tourkolias et al., 2009; Caldes, et al., 2009). It has been criticised because of the number of implicit assumptions underlying the calculations (Kammen et al., 2004).

Computable general equilibrium models (CGEM) are capable of exploring the relationship between sectors, consumers and the government and of modelling the more complex dynamic effects of climate policies on a variety of macroeconomic parameters, including employment (Kremers et al., 2002).

Finally, the results transfer approach, which applies the results of previous studies obtained in better studied locations to cases, markets or scales where little data is available (see Greenpeace, 2009). Such transfers are associated with significant limitations due to differences in economic and market environments.

A combination of case studies (bottom-up) and I/O analysis

Scaling-up of case studies: direct impacts on the construction sector

In order to produce a case study-base estimate of the direct employment effects, the research first gathered data from more than 50 energy-efficient renovation case studies in Hungary and Austria (mostly for passive retrofits). The case studies, where possible, contained detailed data on: i) man-months involved in each renovation, divided by skill level (architects and professionals, skilled and unskilled labourers); ii) building

Table 2. Crew composition for the three renovation depths considered.

Skill-level	Base renovations	Suboptimal renovations	Deep renovations
Professionals /architects	5%	10%	30%
Skilled workers	65%	77%	47%
Unskilled workers	30%	13%	23%
Total	100%	100%	100%

Source: own estimations based on case studies.

type and specific energy consumption for space heating before and after the renovation; and iii) total floor area and cost of the retrofit.

Depending on the completeness of the information thus collected, two alternatives were followed:

- In some cases, when data were available for a specific building type and depth of renovation, specific labour intensities by skill level (man-months per square metre renovated) were directly obtained.
- In other cases, when full information was not available, labour intensities were estimated upon the proportion of labour costs on the total costs of the renovation (conservatively assumed to be 25 % in all cases) and on the *crew composition* of the labour involved (i.e. percentage of labour coming from professionals, skilled and unskilled workers, see Table 2), as done by Sundquist (2009). These estimates came also from case studies on a selected number of building types where detailed data was available.

The man-months per square metre and skill level estimates obtained either way were then up-scaled by multiplying the floor area renovated per year and dividing by 12 (months per year). This resulted in the annual number of direct jobs created in the construction sector by each scenario.

Labour intensities: direct (negative) impacts in the energy supply sector

To calculate job losses in the energy supply sector, the labour intensity corresponding to the “Electricity, gas, steam and hot water supply” sector – 10.73 FTE per billion HUF (KSH, 2010b) has been multiplied by the annual energy saving benefits (i.e., the decrease in the yearly output of the energy supply sector) obtained for each scenario.

Input-output analysis: indirect and induced effects

Indirect and induced effects are estimated with I/O tables by applying the Leontief inverse matrix equation,

$$X = (I - A)^{-1}Y \quad (1)$$

where X is the vector of final production of every sector, Y is the vector of final demand, I is the identity matrix and A is the economy's technical coefficient matrix (Tourkolias et al., 2009). This way *Type I* and *Type II* Leontief inverse matrices were obtained for estimating the indirect employment effects in the sectors supplying the construction sector and the induced effects generated by the additional disposable income available to households.

Type I and *Type II* Leontief inverse matrices were calculated upon the latest available I/O transaction table for Hungary (2005) from the Hungarian Central Statistical Office (KSH, 2010c). Employment impacts were subsequently estimated by multiplying

changes in the outputs of economic sectors by the latest available (2006) labour intensities, extracted from KSH (2010b) and OECD (2010) for missing categories in the KSH dataset.

For the calculation of positive induced effects, additional income stemming from the wages of newly employed workers and from energy expenditure savings were considered. However, it was assumed that the renovations are financed by a pay-as-you save scheme that takes 80 % of the energy expenditure savings for the repayment of initial investment costs and leaves 20 % of those available to the household or public building manager for other uses, including additional consumption. Since KSH (2010d) data indicate that households save on average a 10 % of their net income, additional consumption was assumed to be 90 % of the extra disposable income.

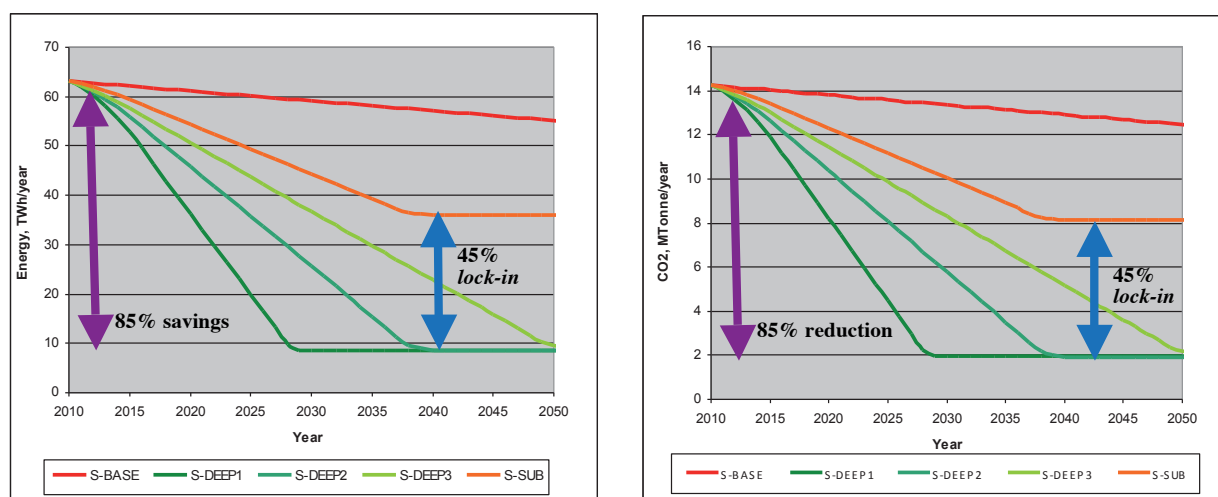
LIMITATIONS AND CAVEATS

The collection of the data needed for the bottom-up approach based on case-studies was fraught with difficulties because very scarce information proved to be available in renovation projects of any kind: man-months are rarely recorded, and the same goes for the division in skill levels of the workers involved in the projects and for the energy use reduction achieved. Because of this, direct employment estimated must be regarded with caution.

As for the I/O analysis, the usual drawbacks apply. As mentioned in Caldes et al. (2009) and Morriss (2010), a main limitation of Input-Output tables is that they offer a snapshot of the economy that does not reflect changes in the interaction between sectors or in the relative prices between production factors. It has been also noted (Scott et al., 2008) that I/O analysis assumes by default no constraints in the supply of labour or any other production factors.

A number of limitations also arise from the actual application of the I/O methodology in the context of this research:

- Additional negative employment impacts are expected if the renovation programme increases the expenditure of the government in other areas and/or reduces State revenues through, for instance, decreased energy tax collection. These elements had to be kept beyond the scope of this research not only because financing issues have purposely not been dealt with in detail, but also because they would require an analysis of the wide macroeconomic effects of the scenarios with advanced tools such as computable general equilibrium models.
- Typically, gains in the efficiency of energy consumption usually result in a reduction of the per-unit price of energy services and in additional household income, which offset part of the energy savings that would initially expected (*rebound effect*). These more complex, dynamic effects, which are likely to influence the final results, are noted but not in-



Source: own estimations.

Figure 1. Total heating energy use and CO₂ emissions of all renovation scenarios including new buildings after 2010 and indicating the size of the lock-in effect.

cluded in the quantitative analysis because of the constraints posed by the I/O methodology.

- The incidence of informal labour has an undetermined impact on the results. According to ILO estimates, some one million of workers in Hungary (25-30 % of all workers) are in some sort of irregular employment situation, with the construction and agricultural sectors being the most affected (Júhasz, 2008).

Results

ENERGY SAVINGS AND CARBON EMISSION REDUCTIONS: AVOIDING THE LOCK-IN EFFECT.

Once the whole building stock has been renovated, deep retrofits represented by *S-DEEP2* scenario deliver an 85 % reduction in the total energy use and carbon emissions versus a 40 % reduction achieved by applying suboptimal retrofits (*S-SUB*), and a negligible 10 % decrease registered for *S-BASE* scenario. This means that if suboptimal renovations are supported, this will result in a 45 % of the estimated CO₂ emissions and energy consumption in 2010 still emitted by Hungarian buildings which could have been saved (see Figure 1, which also includes new residential and public buildings added to the stock after 2010 following EPBD guidelines and implementation timeframes), thus *locking in* a substantial fraction of the savings' potential to be achieved at the end of the programme.

This is very relevant to current developments in Hungary, where State-supported retrofits reduce 5 % to 40 % of the energy demand for heating (Bencsik, 2009; Pájer, 2009; Czako, 2010) but the SOLANOVA pilot project¹ has demonstrated that reductions of up to 80 % to 90 % are feasible (Hermelink, 2007). Thus, one important conclusion to be drawn is that if suboptimal technologies keep on being applied, this will jeopardise

reaching any later ambitious mitigation targets. As space heating in buildings is a large source of carbon, and heating-related emissions are difficult to mitigate in other ways than addressing them in the buildings themselves, applying suboptimal retrofits may force Hungary to consider more expensive mitigation options (e.g., renewables or CCS) at later stages.

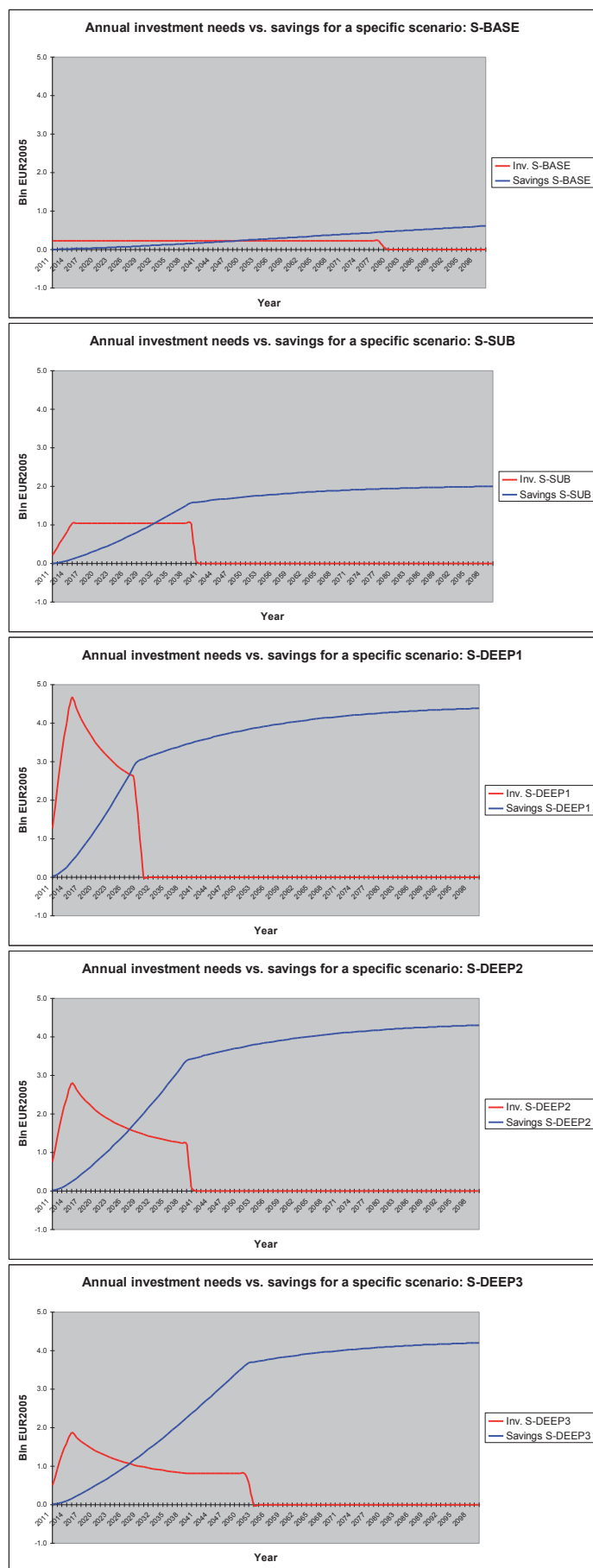
ANNUAL INVESTMENT COSTS VS. ENERGY SAVING BENEFITS

Yearly investment costs and energy saving benefits until 2100 have been obtained from applying the scenarios' renovation rates, depths and costs and forecasts of energy prices to the building stock model. Results are all expressed in €₂₀₀₅ (see Figure 2.1 to 2.5 for detailed results for each scenario) and indicate that annual total national investment needs in the renovation programmes are initially higher than the annual energy cost savings. In the middle-term, energy savings eventually outstrip the yearly investment costs by far, especially for deep renovation scenarios and when the programme is finished only benefits are accrued.

The results of *S-DEEP* renovations clearly show the effect of the learning factor in yearly investment costs: after peaking in the mid-2010s, at the end of the ramp-up period, investment costs decline reflecting the decrease in deep renovation costs per square metre described in methodology section. By scenarios, *S-DEEP1* annual investment costs range between 4.7 and 2.6 billion Euros per year, *S-DEEP2* between 2.8 and 1.2 billion Euros per year and *S-DEEP3* between 1.3 and 0.8 billion Euros per year. On the other hand, the annual aggregated investment costs of the *S-SUB* and *S-BASE* scenarios remain stable at around 1 and 0.22 billion Euros per year respectively.

Annual energy saving benefits results reproduce the projected growth in real energy prices progressively and increase the size of yearly benefits accrued throughout the modelling period. Once all buildings have been retrofitted, *S-DEEP1* scenario generates some 3.1 billion Euros per year of energy savings in 2030, whereas *S-DEEP2* and *S-DEEP3* scenarios generate 3.5 and 3.7 billion Euros per year in 2041 and 2053 respectively. The annual energy savings achieved by the suboptimal and base scenarios at the end of their implementation period are much

1. 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).



Source: own estimations.

Figures 2.1 to 2.5. Annual Investment costs vs. energy saving benefits of the different scenarios.

smaller (1.6 and 0.47 billion Euros per year each). No rebound effect-related reductions in total yearly savings are accounted for since deep retrofits are assumed to deliver the quantified reductions in heating energy use while simultaneously improving dwelling thermal comfort to sufficient levels.

ENERGY DEPENDENCY REDUCTION

Most of Hungary's consumption of natural gas in 2006-2008 (81 %) was imported from former Soviet countries, making energy security issues the main driver of Hungary's energy policy (OECD/IEA, 2007; OECD/IEA, 2009b). Since residential and commercial sectors currently take up to 80 % of the total final natural gas consumption, the highest percentage in the EU (EUROSTAT, 2009a), and it is forecasted that gas will be their main source of heat still in 2030 (OECD/IEA, 2007), buildings are key end-use for reducing the energy (gas) dependency of Hungary.

A deep retrofit programme such as the represented by *S-DEEP* scenarios will allow Hungary to reduce by 2030 between 17 % and 39 % of the natural gas imported in 2006-2008 (depending on implementation rate, see Figure 3), and would be in the same order of magnitude of Hungary's indigenous natural gas for the same period.

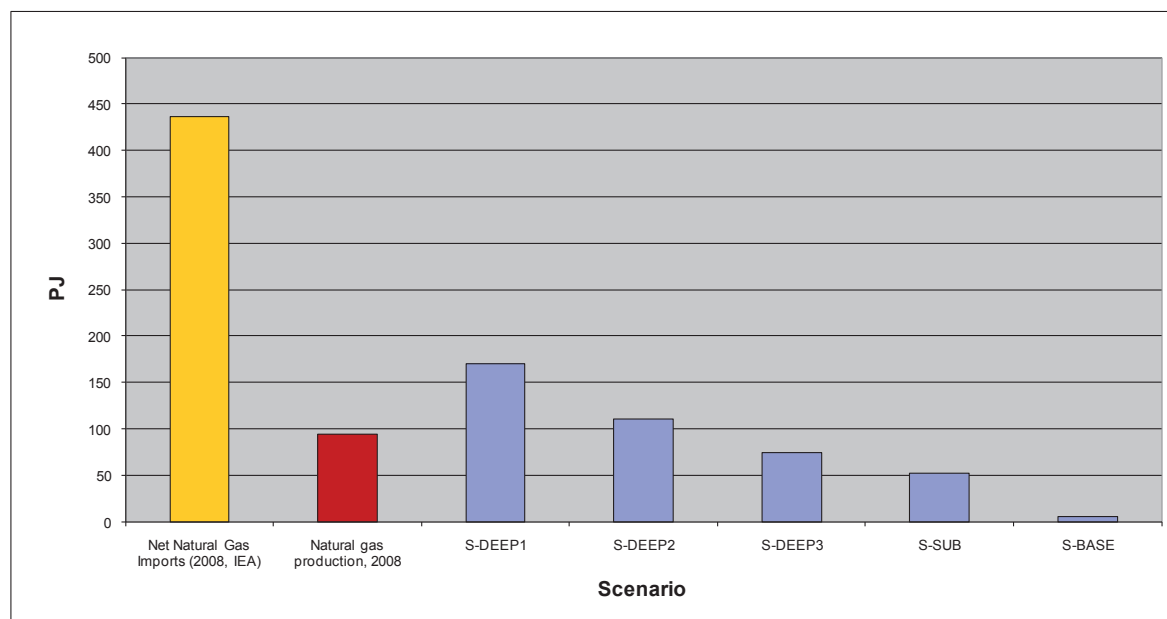
Furthermore, a preliminary seasonal analysis of natural gas consumption also based on OECD/IEA (2009b) data concluded that by 2030, the average energy savings forecasted for January – the peak month for imports, the month of highest risk for energy security – are equivalent to between 59 % (*S-DEEP1* scenario), 26 % (*S-DEEP3* scenario) and 18 % (*S-SUB* scenario) of the average natural gas imports recorded for that month in 2006-2008.

EMPLOYMENT EFFECTS

Results demonstrate that net employment impacts are positive for all scenarios. As expected, employment impacts are higher for deep renovation scenarios because of the larger investments involved (see Figures 4 and 5).

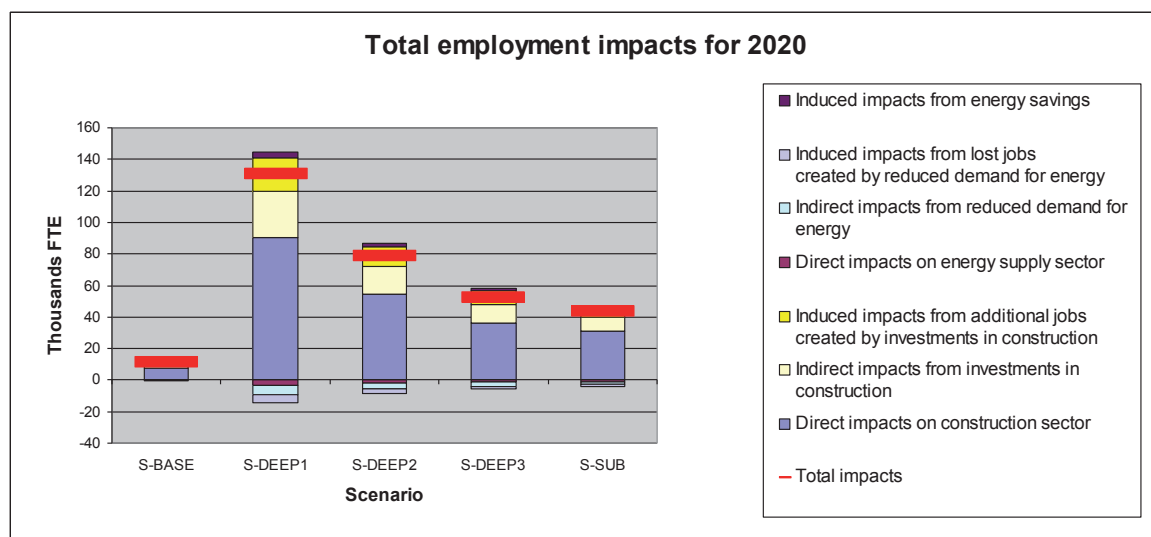
By macro-sectors, most new jobs are expected in the construction industry, where all direct positive employment is created. Other major employment benefits can be seen in community and social services (which is a very labour-intensive sector) and manufacturing (a sector expected to make a big contribution to the program through the supply of materials for the renovations). The only category where noticeable negative impacts are recorded is unsurprisingly the energy supply sector. Given the permanent nature of the energy savings generated, the forecasted decrease in employment for this sector is also permanent. However, as discussed below, these negative effects may be overestimated, and in any case it has been estimated that for every FTE unit lost in the energy supply sector, roughly 30 jobs are created in the construction sector (for *S-DEEP* scenarios).

A dynamic representation of results for the whole modelling period allows visualising the effect of certain assumptions like the ramp-up period, the decrease of deep renovation costs and the increase in real energy prices. As presented in Figure 5, the initial ramp-up period of 5 years is reflected in the steady increase of net positive job creation effects until 2015. At that point, the foreseen decrease in deep renovation costs becomes more influential, therefore making it possible to renovate the same number of dwellings at lower costs (i.e., with less workers).



Source: own estimations and OECD/IEA (2009b).

Figure 3. Annual natural gas savings forecasted for all scenarios in 2030 compared to 2006-2008 average yearly imports and indigenous production.



Note: net impact marked by the thick red crossing line. Source: own estimations.

Figure 4. Total (direct, indirect and induced) net employment impacts for all scenarios (2020).

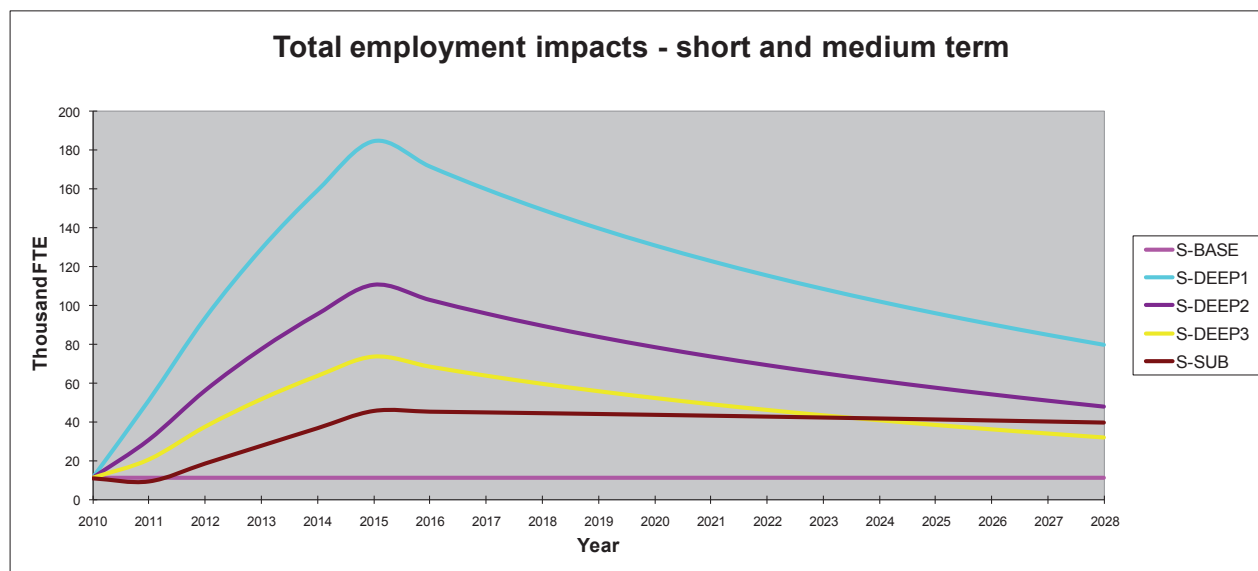
Long-term forecasts carry a higher degree of uncertainty because of the uncertainty in the evolution of many variables included the model (e.g., changes in technology and costs, energy prices, labour intensities of economic sectors involved, etc.) However, in this regard it is possible to highlight the importance of the induced jobs derived from the households' energy savings as they are the only remaining ones after all renovations are finished. They contribute to offset the permanent job losses in the energy supply sector derived from the reduced energy use.

Finally, a sensitivity analysis was performed (no results displayed) on four key assumptions and input data of the combined employment and building stock model: i) annual rate of increase of real natural gas prices; ii) initial costs of deep

renovations in 2010; iii) annual rate of decrease in deep renovation costs (technology learning); and iv) ratio of labour costs on total costs. By allowing each of the four parameters to vary in a specific interval, it was concluded that positive employment impacts are forecasted even for the most pessimistic model assumptions.

FUEL POVERTY ALLEVIATION

It has been argued that "the most sustainable way to eradicate fuel poverty is to *fuel poverty-proof* the housing stock" (DTI, 2006, p. 31). At the same time, there is evidence on fuel poverty as a distinct challenge of today's Hungary (Tirado Herrero and Ürge-Vorsatz, 2010): the average Hungarian household



Source: own estimations.

Figure 5. Total net employment impacts for all retrofit scenarios until 2028.

spends 9.7 % of its net income on energy, and 15 % of Hungarian citizens declare to be unable to afford to keep their homes adequately warm.

While a suboptimal renovation of Hungarian dwellings would reduce to a certain extent fuel poverty rates in Hungary, it can be claimed that the full completion of any of the *S-DEEP* scenarios would practically eliminate fuel poverty in the long-term. The UK experience has also pointed out the spatial overlapping between fuel poverty and high unemployment, which implies that a programme acting of fuel-poverty affected areas will benefit fuel-poor households also by providing income-earning opportunities (EST, 2000).

Qualitative discussion on selected aspects

GEOGRAPHIC DISTRIBUTION AND DURABILITY OF THE ADDITIONAL EMPLOYMENT

As supported by the literature (Wade et al., 2000; Baillie et al., 2001), a nation-wide programme of energy efficiency in the building sector is likely to have positive job creation effects widely distributed throughout the country given the geographically dispersed nature of its direct, indirect and induced effects.

The length of the programme (between 18 and 41 years) ensures the long-term character of the employment effect, which will last for two decades even in the most ambitious scenario (*S-DEEP1*). Job losses throughout the implementation period offers an additional argument for supporting low implementation rates (i.e., *S-DEEP3*).

CONSIDERATIONS ON THE ENERGY SUPPLY SECTOR

Job losses in the range of the several thousand FTE per year are expected in the energy supply sector as a result of the decrease in the turnover of energy supply companies. However, these figures may be overestimated for two reasons related to the limitations of I/O analysis: i) the largely fixed costs of the energy sector (i.e. a fixed amount of labour and capital is re-

quired regardless the amount of energy delivered) implies that the estimated reductions in the energy demand may result in a less than proportional (i.e., smaller than estimated in the model) reduction of the workforce; ii) the energy no longer needed in the domestic market might also be exported (at least the domestically produced energy).

Additionally, the rebound effect (Greening et al., 2000; Nässén and Holmberg, 2009) calls for a cautious interpretation of the results. Previous research (Roland-Host, 2008) has indicated that induced jobs stemming from increased households' consumption are created preferentially in low energy-intensity sectors.

REMARKS ON THE SUPPLY OF LABOUR IN THE CONSTRUCTION SECTOR

A large additional demand of labour in the construction industry, especially for skilled workers, is expected in deep retrofit scenarios. For instance, peak direct employment estimates in 2015 for the *S-DEEP1* scenario (120,000 FTE units per year) represent a 40 % of the total size of the Hungarian construction labour market in 2009. A question might then arise if there is a sufficient supply of workers in Hungary to satisfy the enhanced demand of labour.

Though a preliminary analysis of data retrieved from the 2009 Hungarian Labour Force Survey indicates that a large number of unemployed and inactive people with the required skills is available, some actions (i.e., training professionals and skilled workers, promoting the internal mobility of the workforce, a gradual implementation of the programme, as suggested by the 5-year ramp-up period) would help to avoid tensions on the supply side of the construction labour market. Eventually, if the additional labour demand cannot be met with the inactive and unemployed, it is likely that wages will increase as firms compete for the scarce skills, which would increase the costs of the programme but also provide higher wages and thus additional induced employment effects.

To provide some indication of the negative effects of wage increases on employment, *ad-hoc* calculations² indicate that for most relevant sectors (i.e., where the largest employment gains occur), the wage elasticity of labour demand is expected to be below -0.3 (i.e., a 10 % increase in wages would result in a 3 % reduction in the demand for labour).

REAL ESTATE

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, as analysed by hedonic pricing techniques (Jakob, 2006; Brounen and Kok, 2010). Thus, that the financial value of the building as an asset – often the household's most valuable asset – increases as a result of the intervention is important because it provides an additional incentive for households to participate and maintain the energy efficiency gains achieved. However, it has to be noted that other features like property location or the impact of exogenous factors (e.g., credit-related crisis such as the present one) are usually more important determinants of real estate prices.

FINANCING

The implementation of a large-scale, deep renovation programme is expected to be costly both to the households and the State. For instance, the peak annual financial investment costs as forecasted by the model (4.7 billion €₂₀₀₅ per year in 2015 in the *S-DEEP1* scenario represents more than 3 % of Hungary's GDP in 2009.

As discussed in methodology section, a pay-as-you-save financing formula assumes that the State provides interest-free loans allowing property owners to re-pay only the principal of the loan. To avoid an increase in government expenditure, two complementary alternatives for re-channelling existing budget allocations can be thought of: i) redirecting EU funds, which could provide up to half billion Euros per year in the short-term; ii) making a better use of the more than 800 million Euros that, according to Varró (2010), are currently subsidising energy consumption, carbon-intensive technologies and expensive mitigation alternatives. Well-tailored financing tools would be needed for allowing lower-income households to access credit and benefit from the programme.

Conclusions

KEY FINDINGS AND IMPLICATIONS

The purpose of this research was to quantify the important co-benefits of a deep retrofit program of the Hungarian building stock in a detailed, profound manner in order to demonstrate that co-benefits can play a major role in decision-making processes if adequately and robustly assessed. This paper therefore presents first the changes in the energy consumption and CO₂ emissions resulting from the implementation of *business-as-usual*, suboptimal and deep (i.e., close to passive-house standard) renovations in Hungary's residential and public building

stock. Then it offers a forecast of the net total (direct, indirect and induced) employment, energy dependency reduction and fuel poverty alleviation effects of the five renovation scenarios defined. For that, a joint building stock and employment model that, as a methodological novelty, combines case study-based estimates of direct employment effects with an Input-Output analysis of indirect and induced effects has been applied.

One first conclusion is that if Hungarian residential and public buildings are deep retrofitted substantial energy savings and emission reductions can be achieved: nearly 85 % of the final energy consumed and carbon emitted by Hungarian buildings for heating in 2010 will be offset, while suboptimal technologies would not go further than 40 % and the savings obtained in a *business-as-usual* scenario are practically negligible. The comparison between *S-DEEP* and *S-SUB* scenarios concluded that 45 % of the 2010 buildings' heating-related emissions would be *locked-in* if suboptimal technologies, such as those implemented so far by State-supported schemes, keep on being applied.

Second, as most heating in buildings is based on natural gas, deep retrofits will bring about by 2030 reductions of 39 % and 59 % of the annual and monthly (in January, the peak month from an energy security perspective) natural gas imports in 2006-2008, thus greatly reducing Hungary energy dependency from former Soviet Union suppliers.

Third, all considered scenarios have positive net employment effect mostly because the labour intensity (FTE per million Euro) of renovation activities is considerably larger than the one of the energy supply sector and also due to the induced employment derived from the additional income available to households (new wages and energy savings). Deep scenarios create more employment (from 185,000 to 75,000 FTE per year in the peak year 2017), but also entail larger investment needs (from 4.1 to 1.6 Billion Euro per year in 2017), than suboptimal (up to 45,000 FTE and 1 Billion Euros per year) and base renovations (11,000 FTE and 0.2 Billion Euro per year). However, if deep renovations are implemented at a less pushed rate (*S-DEEP3* scenario: 2.3 % of the total floor area renovated per year) the total costs of the intervention will be reduced by letting the technology learning factor act for a longer time. This less ambitious scenario provides a smaller peak amount of jobs, but also a more balanced employment-creation temporal profile with smaller job losses throughout the programme.

The length of the programme ensures that the employment created is long-term, and the fact that the whole building stock is considered for renovation implies that the new jobs are likely to be distributed throughout the country. Though some uncertainty remains on the distortions that such a large-scale programme may introduce in the labour market (especially of the construction sector), a preliminary analysis of the Hungary's unemployed and inactive population indicates that enough workers would be available to meet the forecasted enhanced labour demand.

Finally, it is also anticipated that deep retrofits would practically eliminate fuel poverty in the long-term, especially once the household fully appropriates the energy savings derived from the intervention. Synergies between fuel poverty and unemployment alleviation are expected assuming spatial overlapping between both social problems.

2. A comprehensive firm level dataset for the years of 2004 and 2005 was used to build dynamic labour demand equations and to set the relationship between wage changes and the employment responses of firms.

IMPACTS ON ACTUAL DECISION-MAKING IN HUNGARY

This paper has been produced in the context of a European Climate Foundation-sponsored research project developed during the period of elections and new government formation in Hungary during spring 2010. From an applied policy perspective, its main goal was to provide the incoming Hungarian government with evidence-based arguments for energy efficiency in buildings to become a higher priority in the employment and energy agendas and upgrading the existing State-supported scheme. This was preliminarily achieved in late June 2010, some three weeks after the official presentation of the study, when Mr. János Bencsik, State Secretary for Energy and Climate of the new Hungarian government, announced a new building renovation programme aimed for a 70 %-80 % energy use reduction in 100,000 residential units per year (not only apartments in panel blocks, the main focus of intervention before, but also other building typologies such as single family houses) which was expected to start by January 2011. However, at the time of finishing this paper (March 2011) the government had yet to define the depth (energy savings to be achieved) and breadth (number of units to be retrofitted per year) of the new scheme. Current developments indicate that it will be launched as part of Hungary's *Energy Strategy 2030* and that the government plans to use revenues from CO₂ quota sales in international markets plus probably other sources (e.g., revenues from taxes on energy companies) to finance its implementation. If carried out successfully, it will turn Hungary into a frontrunner of the large-scale implementation of advanced building retrofit technologies.

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