Employment Impacts of a Large-Scale Deep Building Energy Retrofit Programme in Hungary

Presentation of results
June 08, 2010
Summary: Key findings

- **Energy use and CO2 emissions reduction**
  - Up to **85%** of Hungarian **heating energy use and the corresponding CO2 emissions can be avoided** by a consistent and wide-spread deep retrofit programme
  - **A suboptimal scenario** (saving only 40% of energy use) **locks in 45%** of 2010 building **heating-related emissions** at the end of the programme
  - This makes medium-term national emission reduction targets (75 – 85%) very difficult and expensive to achieve

- **Energy security enhancement**
  - A deep retrofit programme can reduce Hungary’s natural gas import dependence significantly (in % of 2006-2008 average NG imports):
    - Up to **39%** of annual import needs by 2030
    - Up to **59% of the January import needs** (the most critical month for energy security)
  - A suboptimal retrofit programme would lack the same strength
    - Only 10% of natural gas imports saved in 2030
    - Peak (January) savings reduced to 18%
Summary: Key findings (2)

- Employment benefits
  - Up to 131,000 net jobs created by 2020, including the losses in the energy supply sector
    - This value is 184,000 in 2015
    - 38% of this value: indirect and induced effects in other sectors than construction
  - Suboptimal scenario: 43,000 jobs

- Deep renovation activities are much more labour intensive than other economic recovery activities
  - e.g. 5 times more jobs are created than with the same investments in road construction

- The corresponding investment needs are also higher
  - For the most ambitious programme (5.7% floor area/yr):
    - 4.5 Bln EUR/year initially, and 2.8 Bln EUR/year towards the end; vs. 2 bln/year for a gradual program (2.3% floor area renovated/year), declining to 1 bln/year
    - Cumulative undiscounted investments: 59 Bln EUR, vs. 44 in a more gradual program
    - Cumulative undiscounted savings: 97 Bln EUR by 2050
Summary: Recommendations

- Recommendation: deep renovation programme with more gradual implementation
  - App. 8 million sqm per year, 2.3% of the floor area, 100,000 dwellings-equivalent
  - 52,000 jobs created by 2020
  - Initial costs peak at 2 Bln EUR per year, and are reduced to less than 1 Bln EUR in the final phases of the programme
    - Take advantage of the initial learning period
- App. 1 billion Euros public funds per year could potentially be made available
  - Partly from EU funding
  - Partly from redirecting current energy subsidies
- Pay-as-you-save schemes and other innovative financing schemes also relieve the financing burden
- More gradual implementation means less shock for the labour market
- For all scenarios:
  - Employment created is long-term
  - New jobs will be distributed across the country
- Public administration should be heavily involved
  - To the achievement of deep savings through deep renovations
  - To reduce the risks of supply bottlenecks
The climate change challenge

“How on earth do we turn it off?”
In order to limit the impacts of CC, GHG emissions have to be reduced significantly

- Stabilizing global mean temperature requires a stabilization of GHG concentrations in the atmosphere -> GHG emissions would need to peak and decline thereafter (SPM 18 WG III)
- The lower the target stabilisation level limit, the earlier global emissions have to peak.
- Limiting increase to 3.2 – 4°C requires emissions to peak within the next 55 years.
- Limiting increase to 2.8 – 3.2°C requires global emissions to peak within 25 years.
- Limiting global mean temperature increases to 2 – 2.4°C above pre-industrial levels requires global emissions to peak within 15 years and then fall to about 50 to 85% of current levels by 2050.
The later emissions peak, the more ambitious reductions needed

Source: Meinshausen et al 2009
EE as an economic/social agenda: employment and other economic benefits

- A wide range of co-benefits of energy-efficient buildings:
  - labor productivity rises by app. 6–16%;
  - students’ test scores shows ~20–26% faster learning
  - Influenza and cold rates can decrease by as much as 20%, resulting in a USD10 bln/yr savings in US alone
    - better indoor environments related with building EE save annually in the US $6 -14 bill. (reduced respiratory disease); $1 - 4 bill. (reduced allergies and asthma); $10 - 30 bill. (reduced sick building syndrome); and $20 - 160 bill. (direct improvements in worker performance unrelated to health)

- Employment: (local) job creation: Danish trade union study finds twice higher employment intensity than for other mitigation options

- This research studies the employment impacts of a wide-scale energy-efficient renovation programme in Hungary
Background

- Climate and energy challenges in Hungary
  - GHG emissions are below Kyoto targets
  - But: very high energy dependency
    - Especially from Russian gas
  - Fuel poverty
    - Over 80% of Hungarian households live in fuel poverty, according to the UK definition
    - A widespread, deep renovation program could eliminate, or at least alleviate this problem
Background

- Inefficiency of Hungarian buildings
  - Largest potential for energy consumption reduction among end-use sectors
  - Contribute 50% of energy-related emissions in Hungary
  - Only Slovenia and Latvia are less energy-efficient in residential heating

Households’ specific energy consumption (kWh/m²a) scaled to EU average climate. Hungary vs. CEE Member States. Average 2000-2007
Source: own elaboration based on data retrieved from the ODYSSEE database
Background: Hungary has the EU’s 2nd lowest employment and activity rate

Activity rate in the European Union, Q2 2009 (selected countries)

Source: Eurostat
The project in a nutshell

- **Objective**: to gauge the net employment impacts of a large-scale deep building energy-efficiency renovation programme in Hungary

- **Scope of the research**:
  - Type of buildings: residential and public buildings (no industrial or commercial)
  - Type of renovation: reduce demand for heating (no appliances)
  - Employment effects: direct, indirect and induced

- **Scenarios**: S-BASE, S-SUB, S-DEEP1, S-DEEP2, S-DEEP3

- **Expected results**:
  - Non-employment results: investments involved, reduction in energy consumption and CO2 emissions, energy cost savings
  - Net impacts on Hungarian labour market

- **Two phases**:
  - Preliminary results: 22 March 2010
  - Final report: by 31 May 2010 (revised results)
### Scenarios considered

<table>
<thead>
<tr>
<th>Name</th>
<th>Scenario</th>
<th>Retrofit rate</th>
<th>Type of retrofits</th>
<th>Forecasted completion</th>
</tr>
</thead>
<tbody>
<tr>
<td>S-BASE</td>
<td>Baseline scenario: no intervention</td>
<td>1.3% of the total building stock (around 4.5 million square metres a year, equivalent to 55,000 dwellings)</td>
<td>“Business as usual” retrofits</td>
<td>N/A</td>
</tr>
<tr>
<td>S-DEEP1</td>
<td>Deep retrofit with fast implementation rate</td>
<td>Around 20 million square metres (equivalent to 5.7% of floor area, 250,000 dwellings) per year</td>
<td>Deep retrofits</td>
<td>17-18 years</td>
</tr>
<tr>
<td>S-DEEP2</td>
<td>Deep retrofit with medium implementation rate</td>
<td>Around 12 million square metres (equivalent to 3.4% of floor area, 150,000 dwellings) per year</td>
<td>Deep retrofits</td>
<td>26-28 years</td>
</tr>
<tr>
<td>S-DEEP3</td>
<td>Deep retrofit with slow implementation rate</td>
<td>Around 8 million square metres (equivalent to 2.3% of floor area, 100,000 dwellings) per year</td>
<td>Deep retrofits</td>
<td>39-41 years</td>
</tr>
<tr>
<td>S-SUB</td>
<td>Suboptimal retrofit with medium implementation rate</td>
<td>Around 12 million square metres (equivalent to 3.4% of floor area, 150,000 dwellings) per year</td>
<td>Suboptimal retrofits</td>
<td>26-28 years</td>
</tr>
</tbody>
</table>
Employment Effects: Overview

- **Direct impacts**
  - Positive on the construction industry
  - Negative on the energy industry

- **Indirect impacts**
  - Upstream in the supply chain

- **Induced impacts**
  - Caused by the increased disposable income:
    - From new jobs (directly and indirectly generated)
    - From energy savings

- **Qualitative analysis**
  - Types of employment generated and skill levels
  - Geographical distribution
  - Durability of the jobs (short/long-term)
  - Supply of labour
Employment Effects: Overview

- **BUILDINGS RETROFITTING programme**
  - Job losses to **ENERGY gen. & distr. sector**
  - Additional disposable income to **HOUSEHOLDS**
  - Job gains to **CONSTRUCTION sector**

- **ENERGY gen. & distr. sector**
  - Job losses to **SUPPLY-CHAIN related sectors**

- **CONSTRUCTION sector**
  - Job gains to **SUPPLY-CHAIN related sectors**
  - Additional spending and job gains to **HOUSEHOLDS**

- **SUPPLY-CHAIN related sectors**
  - Job losses to **OTHER sectors**

- **OTHER sectors**
  - Job gains to **BUILDINGS RETROFITTING programme**

The diagram illustrates direct, indirect, and induced effects.
Residential Building Stock
Current Characteristics

Floor Area and Energy Consumption:
Residential Buildings

Total Heating Energy Consumption: 58 TWh/year
Public Building Stock
Current Characteristics

Total Heating Energy Consumption: 5 TWh/year
Employment effects: available methodologies

**Scaling-up of case studies**
- Bottom-up method
- Based on case-study data

**Input-Output analysis**
- Top-down method
- Based on input-output tables

**CGEM**
(Computable general equilibrium models)
- More complex
- Adds dynamics to I/O method
- Can model international exchanges

**Results transfer**
- Useful if data is lacking (e.g. developing countries)
- Subject to uncertainties
Methodology used

- Mixed: Up-scaling + Input-Output analysis

- Labour
- Up-scaling
- Direct (positive) impacts in construction
- Indirect + induced impacts
- I/O analysis
- Labour intensity
- Direct (negative) impacts in energy supply
- Investments
- Energy savings
- Renovation Case Studies

European Climate Foundation
3CSEP
Scenario results: Final energy use until 2050

- 85% of energy is saved in deep scenarios
- 45% of the savings remain locked-in by the suboptimal scenario
Scenario results: Energy savings by building category

**Final Heating Energy Use - Residential and Public Buildings**

- **S-BASE Scenario**
- **S-SUB Scenario**

The graphs illustrate the energy use over time for different building categories, including:

- New Multi Story Public after 2010
- New Single Story Public after 2010
- New Multi-Family after 2010
- New Single Family after 2010
- Modern Multi Story
- Modern Single Story
- Traditional Single Story
- Panel Multi-Story
- Traditional Single Story
- Public Historical
- Modern Multi-Family
- Modern Single Family
- Traditional Single Family
- Panel Multi-Family
- Traditional Multi-Family
- Residential Historical

The data shows a trend of decreasing energy use over the years 2010 to 2050, indicating improvements in energy efficiency.
Scenario results: Energy savings by building category
Energy Security Benefits

- Reduced import of Natural Gas
  - At the end of their implementation, the deep renovation scenarios can save up to 39% of the current natural gas imports
  - The natural gas saved in 2030 is the same order of magnitude as Hungary’s NG production (2008 levels)

![Natural gas saved (year 2030) compared to 2006-2008 imports and production](image)
In January (peak month for imports) the energy savings achieved by 2030 would be equivalent to between 59% (S-DEEP1 scenario), 26% (S-DEEP3 scenario) and 18% (S-SUB scenario) of the natural gas imports recorded for that month.

![Natural gas saved in January 2030 in the different scenarios compared to January imports (average 2006-2008)]
Scenario results: renovation costs

- Investments for renovations
  - Use of best practices to estimate the cost per sqm in every scenario, for every building type
  - SOLANOVA case study (Dunaujvaros):
    - Pilot project for deep renovation in a panel building
    - The only deep renovation project available in Hungary
    - 90% energy savings
    - 42 dwellings, 2300 sqm
    - Cost: 250€ per sqm
  - Examples abroad: Mostly in Austria and Germany
  - Transfer of results to Hungary
Evolution of investments per sqm, with learning factor

Average renovation costs for all types of buildings (with learning factor)

- Baseline and suboptimal costs remain fixed (mature technology)
- Deep renovation costs decrease until they reach double baseline renovation costs
Scenario results: annual investment needs vs. savings

- Annual savings become higher than the investment needs in 20 years
Cumulative (undiscounted) investments and savings

- Total investments needed to refurbish the whole building stock:
  - S-DEEP1: 60 Bln EUR
  - S-DEEP2: 50 Bln EUR
  - S-DEEP3: 44 Bln EUR
  - S-SUB: 28 Bln EUR

- Cumulative savings eventually outstrip the investment needs

<table>
<thead>
<tr>
<th></th>
<th>Cumulative investments (Billion Euros)</th>
<th>2025</th>
<th>2050</th>
<th>2075</th>
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<tbody>
<tr>
<td><strong>S-DEEP1</strong></td>
<td></td>
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<tr>
<td>Cumulative</td>
<td>50.47</td>
<td>59.83</td>
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<tr>
<td>Cumulative</td>
<td>14.13</td>
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<tr>
<td><strong>S-DEEP2</strong></td>
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<td>Cumulative</td>
<td>30.29</td>
<td>50.05</td>
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<tr>
<td>Cumulative</td>
<td>8.48</td>
<td>80.56</td>
<td>179.39</td>
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<tr>
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<tr>
<td><strong>S-DEEP3</strong></td>
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<tr>
<td>Cumulative</td>
<td>20.20</td>
<td>42.20</td>
<td>43.58</td>
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<tr>
<td>Cumulative</td>
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<td>59.56</td>
<td>156.06</td>
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<tr>
<td><strong>S-SUB</strong></td>
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<tr>
<td>Cumulative</td>
<td>13.53</td>
<td>28.17</td>
<td>28.17</td>
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<tr>
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<tr>
<td>Cumulative</td>
<td>3.94</td>
<td>37.43</td>
<td>83.34</td>
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<tr>
<td>savings</td>
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</table>
Total net employment impacts: snapshot in 2020

- Direct effects
  - Calculated with bottom-up method
  - Shown in the previous slides
- Indirect + induced effects
  - Application of I/O tables
  - Indirect + induced impacts have the same order of magnitude as the direct impacts

### Total employment impacts for 2020

**Scenario**
- S-BASE
- S-DEEP1
- S-DEEP2
- S-DEEP3
- S-SUB

**Thousands FTE**
- 160
- 140
- 120
- 100
- 80
- 60
- 40
- 20
- 0
- -20
- -40

**Legend**
- Induced impacts from energy savings
- Induced impacts from lost jobs created by reduced demand for energy
- Indirect impacts from reduced demand for energy
- Direct impacts on energy supply sector
- Induced impacts from additional jobs created by investments in construction
- Indirect impacts from investments in construction
- Direct impacts on construction sector
- Total impacts
Direct employment impacts in construction per skill: snapshot in 2020

- The effects on professional labour are highest in the deep renovation scenarios.
Direct employment impacts: comparison with other investments

- Labour intensity in renovations is much higher than labour intensity in many other sectors
- E.g. many more jobs would be created with these programmes than if the money was spent in building highways
Net employment impacts in construction: medium-term view

- The initial increase shows the ramp-up period
- The subsequent decrease is due to the learning factor
  - Productivity increases
  - Therefore costs and labour intensities decrease
  - There is practically no learning factor in S-BASE and S-SUB: the technologies are mature
Total employment impacts: long-term view

- After the end of the renovation programme, in certain scenarios there are negative impacts coming from the reduction of demand in energy.
  - However, realistically these negative impacts will be dampened or even cancelled
    - By additional energy consumption in other sectors
    - Reductions in energy sector cannot be linear (see qualitative discussion)
- In later years, the effects of increased consumption can be seen
  - They kick off later on because the energy savings are first used to repay the loan for the initial renovation investment
- Results for such a long term are extremely uncertain
Further issues

- Distributed geographic effects
  - The buildings are renovated throughout the country
  - Work is mainly done by small-medium enterprises
  - Induced consumption is also distributed

- Durability of effects
  - Such a programme lasts 20-30 years, effectively a worker’s lifetime

- Negative employment effects in the energy supply sector are likely to be overestimated
  - Large fixed costs in energy supply: Job losses are probably in “lumps” – e.g. power stations still need people to maintain them, even if the demand is lowered
  - Some increase in energy demand is expected from other sectors (e.g. commercial, manufacturing) which will compensate the losses from residential sector
  - Possibility to export surplus energy
Further issues (2)

❖ Supply of labour
  ❑ There is availability of labour in Hungary for all skill levels
    ❖ Entrepreneurs, professionals
    ❖ Skilled, unskilled – among unemployed and inactive
  ❑ However, these workers need to be attracted to the construction industry
    ❖ Training
    ❖ “Promotion” of the sector
    ❖ Possibly higher wages (at least in the beginning)
  ❑ Population aging
  ❑ What if there is no sufficient labour supply?
    ❖ Guest workers might be brought in
❖ Such a large-scale program is likely to raise the wage level in the country
  ❑ Increases the costs of the project
  ❑ Increases the costs of other investments (because opportunity costs are higher)
  ❑ But also increases consumption (hence more induced effects)
❖ Supply of materials
  ❑ Manufacturing must keep up with the increased demand from construction sector
Further issues (3)

- Grey labour
  - Opportunity for the State to increase the control on grey labour in construction

- Fuel poverty
  - Such a programme has the potential of eradicating fuel poverty
  - Great attention has to be put in financing, especially for the lower income households

- Real estate markets
  - The value of buildings increases
  - The lifetime of buildings is extended
Such programme will need a vast amount of financing

- E.g. in 2020:
  - S-DEEP1 – 3.5 B€\textsubscript{2005} (13% of 2009 HU budget)
  - S-DEEP2 – 2.1 B€\textsubscript{2005} (8% of 2009 HU budget)
  - S-DEEP3 – 1.4 B€\textsubscript{2005} (5% of 2009 HU budget)

The energy savings are higher than the investments, but they accrue later

However, at least part of the initial funds can come from:

- the EU (up to 400M€ per year)
- Redirecting the current energy subsidies (about 800M€ per year)
- An ESCO-type scheme of financing in which part of the savings go into repaying the investment costs
Energy subsidies in Hungary

- **Biofuel**: relatively little CO2 emission mitigation at a high cost
- **District heating VAT discount**: further decreases energy efficiency
- **Coal subsidy**: artificially increases the competitiveness of high carbon intensity energy
- **Gas subsidy**: decreases energy efficiency and competitiveness of renewable heat
- **Feed-in tariff for co-generation**: predominantly subsidy of gas based co-generation, decreases competitiveness of renewable heat

- 300 Bn HUF state investment to a new lignite plant.
- 1 Mt additional CO2 emission compared to a BAT gas turbine

Source: slides from Mr. Laszlo Varro, Strategy Director at MOL
Results compared with other investment initiatives

- The scenarios have an average FTE generated (direct + indirect + induced) per Million Euro invested much higher than the studies reviewed.

<table>
<thead>
<tr>
<th></th>
<th>FTE generated (direct + indirect + induced) per M€ invested in 2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deep renovation scenarios</td>
<td>37.3</td>
</tr>
<tr>
<td>S-DEEP</td>
<td>37.3</td>
</tr>
<tr>
<td>Studies reviewed</td>
<td></td>
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<tr>
<td>Energy efficiency/Bldgs. retrofit</td>
<td>17.07</td>
</tr>
<tr>
<td>Other mitigation</td>
<td>15.56</td>
</tr>
<tr>
<td>Non-energy related activities</td>
<td>21.64</td>
</tr>
</tbody>
</table>
Summary of results: conclusions

- Deep renovation scenarios give higher climate and energy benefits compared to suboptimal renovation scenarios
  - Deep retrofit scenarios can save 85% of energy use and relative carbon emissions
  - A suboptimal scenario locks in 45% of 2010 heating-related emissions
  - Deep retrofit scenarios can reduce up to 39% of annual natural gas needs in 2030, 59% in the critical month of January (compared to average 2006-2008 values)
  - A suboptimal scenario will reduce imports of 10% only (18% in January)
  - The construction sector has the opportunity of learning new techniques which will inevitably be state-of-the-art in a few years
- Employment impacts are highly positive in the short to medium term, especially for deep renovation scenarios
  - 131,000 jobs created in S-DEEP1, 78,000 in S-DEEP2, 52,000 in S-DEEP3, 43,000 in S-SUB
    - Around 38% are indirect and induced effects in other sectors
  - Labour intensity in deep retrofit is higher than if the money was invested in other initiatives (e.g., 5 times higher than road construction)
- The major issue is financing
  - The renovation programmes would have a high impact on the state’s budget (up to 13% for S-DEEP1, 8% for S-DEEP2, 5% for S-DEEP3)
  - However, a large amount of money (up to 1 billion Euros) can come from the EU or from redirecting current energy subsidies (e.g. to gas and district heating)
  - Part of the initial investment costs can be financed by a pay-as-you-save financing scheme
Summary of results: recommendations

- The recommendation is to promote a deep renovation scenario with a less ambitious rate of renovation
  - e.g. S-DEEP3 (2.3% of the floor area, 100,000 dwellings-equivalent)
  - 52,000 jobs created by 2020
  - Less than 2 Billion Euros of peak annual investment, app. 1 bln in later program phases
- The impacts are slightly lower but sustained: no shock in the economy and in the industry
  - The slower rate of renovation allows for a “smooth” transition period
  - Time is allowed for the firms to learn, train employees and increase production of materials
  - The learning factor ensures that the costs become lower throughout the years
    - The investment shock is reduced
    - Less money is “locked in” on renovations which could have been less expensive in following years
  - Labour supply issues and wage effects are reduced
- The public administration should be involved in planning and financing
  - To assure the achievement of deep savings through deep retrofits
  - To reduce potential supply bottlenecks
The research team

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Thank you for your attention

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Center for Climate Change and Sustainable Energy Policy

Central European University

Supplementary slides
Building sector: global importance

In 2004, in buildings were responsible for app. 1/3 of global energy-related CO₂ (incl. indirect) and 2/3 of halocarbon emissions.

GHG emissions from buildings in 2004 (in Gt CO₂ equivalent)

- Total energy-related CO₂: 8.6 Gt, 81%
- Energy-related direct CO₂: 3 Gt, 28%
- Electricity-related indirect CO₂: 5.6 Gt, 53%
- CH₄: 0.4 Gt, 4%
- N₂O: 0.1 Gt, 1%
- Halocarbons: 1.5 Gt, 14%
Co-benefits

- Co-benefits of buildings energy efficiency
- Some examples:
  - Improved air quality
  - Improved productivity
  - Noise reduction
  - Increased real estate value
  - Improved energy security
  - Reduced fuel poverty
  - Employment creation
Hungarian building stock

- **Residential (92% of floor area considered)**
  - Historical Residential Buildings
  - Traditional Multi-Family (19\textsuperscript{th} Century until 1960s)
  - Panel Multi-Family (Industrial Technology)
  - Traditional Single-Family (Built until 1992)
  - Modern Single-Family (Between 1993-2010)
  - Modern Multi-Family (Between 1993-2010)

- **Public (8% of floor area considered)**
  - Historical Public Buildings
  - Traditional Multi-Story (19\textsuperscript{th} Century until 1960s)
  - Panel Multi-Story (Industrial Technology)
  - Traditional Single-Story (Built until 1992)
  - Modern Single-Story (Between 1993-2010)
  - Modern Multi-Story (Between 1993-2010)

- **Total Energy for Space Heating and Cooling Public and Residential Buildings – 63 TWh/year**
- **Commercial buildings are not considered in this research**
Scenario variables

- **Type of retrofit**
  - “Deep” (towards Passive House standard, 15kWh/sqm/y for residential and 30 kWh/sqm/y for public buildings: 75-90% energy savings)
  - Suboptimal (saves 40% energy on average)
    - Risk of lock-in effect

- **Rates of renovation**
  - **S-DEEP1**: 20 million sqm (250k dwellings-equivalent) a year
    - Completed in 16-20 years
  - **S-DEEP2** and **S-SUB**: 12 million sqm (150k dwellings-equivalent) a year
    - Completed in 26-30 years
  - **S-DEEP3**: 8 million sqm (100k dwellings-equivalent) a year
    - Completed in 42-43 years

- **S-BASE** is the reference scenario
  - 1.3% of buildings renovated per year
  - Very little energy savings (10% assumed on average)

- **Main assumptions**
  - Ramp-Up Period: 5 Years
  - Study results:
    - In 2020 – Completion of EU2020 strategies (on climate/energy and on employment)
    - Trends of results throughout the years
  - All the financial estimates are in EUR2005
Renovation Scenarios: characteristics

### Dwellings-equivalent renovated per year

<table>
<thead>
<tr>
<th>Year</th>
<th>S-BASE</th>
<th>S-DEEP1</th>
<th>S-DEEP2</th>
<th>S-DEEP3</th>
<th>S-SUB</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2021</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>2022</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>2023</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>150</td>
</tr>
<tr>
<td>2024</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>2025</td>
<td>250</td>
<td>250</td>
<td>250</td>
<td>250</td>
<td>250</td>
</tr>
<tr>
<td>2026</td>
<td>300</td>
<td>300</td>
<td>300</td>
<td>300</td>
<td>300</td>
</tr>
</tbody>
</table>

### Evolution of the floor area renovated

<table>
<thead>
<tr>
<th>Million sqm</th>
<th>S-BASE</th>
<th>S-DEEP1</th>
<th>S-DEEP2</th>
<th>S-DEEP3</th>
<th>S-SUB</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2021</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>2022</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>2023</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>150</td>
</tr>
<tr>
<td>2024</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>2025</td>
<td>250</td>
<td>250</td>
<td>250</td>
<td>250</td>
<td>250</td>
</tr>
<tr>
<td>2026</td>
<td>300</td>
<td>300</td>
<td>300</td>
<td>300</td>
<td>300</td>
</tr>
</tbody>
</table>
Direct impacts in construction: “bottom-up”
Scaling-up of case studies

- Gather detailed information for a number of renovation projects
  - Man-months involved (divided by skill level)
  - Labour costs (multiply man-months by average salary per skill level)
  - Energy savings
  - Ideally: one or more projects for each building type and retrofit type
- Up-scale these cases to the whole building stock
Indirect and induced impacts in construction: “top-down” Input-Output analysis

Procedure:
1. Classify case studies by renovation rate and type of building
2. Estimate total costs per sqm for each case study
3. Up-scale results for each scenario to get total annual costs
4. Total annual costs are used to be entered into I-O table, which gives indirect and induced effects in demand
   - Labour intensity is then used to estimate employment impacts

![Diagram of the procedure with estimated total costs flowing into the I/O tables and generating indirect and induced impacts.](image)
Impacts from energy savings

- A similar process is followed for energy cost savings:
  1. Estimate energy savings per type of building
  2. Use fuel split to compute energy savings by type of fuel
  3. Use price estimates of fuel types to calculate energy cost savings
  4. Up-scale results for each scenario to get annual cost savings
  5. Cost savings accumulate!
  6. Total cost savings in a year are used to compute direct and indirect employment effects.
The input-output tables

- Tables that show the transactions between industries
- It is possible to “reverse” them to see how much output is generated by each industry to make 1EUR (or USD, or HUF) of product
  - The “Leontief inverse” matrix is what we use: the increase in output of construction (and the decrease in energy) are reflected in the outputs of the other industries
  - The output change is multiplied by the labour intensity to obtain the employment impacts

<table>
<thead>
<tr>
<th>Example Inverse I/O table (Leontief Inverse)</th>
<th>Energy</th>
<th>Construction</th>
<th>Transport</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>0.1</td>
<td>0.2</td>
<td>0.05</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>0.05</td>
<td>0.12</td>
<td>0.2</td>
</tr>
<tr>
<td>Energy</td>
<td>1.3</td>
<td>0.23</td>
<td>0.3</td>
</tr>
<tr>
<td>Construction</td>
<td>0.05</td>
<td>1.15</td>
<td>0.15</td>
</tr>
<tr>
<td>Transport</td>
<td>0.3</td>
<td>0.2</td>
<td>1.1</td>
</tr>
<tr>
<td>Other services</td>
<td>0.2</td>
<td>0.1</td>
<td>0.2</td>
</tr>
</tbody>
</table>
Labour intensity

- How many people are employed per output
  - FTE per million EUR
- Is assumed to be linear
- Labour intensity of sectors is very variable
  - E.g. intensity for construction much higher than energy
- Labour intensity is the inverse of labour productivity
  - It typically decreases over the years (as labour productivity increases)

<table>
<thead>
<tr>
<th>Labour intensity in Hungary</th>
<th>FTE per Million EUR (2006)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction</td>
<td>12.03</td>
</tr>
<tr>
<td>Energy</td>
<td>2.66</td>
</tr>
<tr>
<td>Average for all sectors</td>
<td>8.52</td>
</tr>
</tbody>
</table>

Source: KSH
Limitations of I/O method

- I/O method is the most widely used for calculating employment effects
- Caveats of I/O-based estimates:
  - I/O tables are a snapshot of the economy: static coefficients and prices
  - No complex analysis of dynamic effects on input prices, income, etc.
  - Better fit for estimating the effects of marginal changes
    - The proposed interventions (S-DEEP) will have a larger impact on the Hungarian economy
- For our analysis:
  - Total investment costs depend on the quality of information
    - Small amount of case studies available in Hungary, uncertainty for case study transfer from abroad
  - Labour intensity not available for the specific researched sectors (deep and sub-optimal retrofit)
  - Implications of informal labour in the construction sector
  - Rebound effect only partially considered
    - Rebound effect: offsetting of energy savings because of additional household income and lower energy prices
    - The study assumes an increase of heated floor area in dwellings after deep renovations
Scenario results: CO2 emission reductions until 2050

- 85% of emissions are saved in deep scenarios
- 45% of emissions remain locked-in by the suboptimal scenario
Scenario results: CO2 savings by building category
Scenario results: CO2 savings by building category
## Estimated investments per sqm

<table>
<thead>
<tr>
<th>Residential Building Stock: estimated investments (Euro per sqm)</th>
<th>S-BASE</th>
<th>S-DEEP</th>
<th>S-SUB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Historical and Protected Buildings</td>
<td>80</td>
<td>550</td>
<td>146</td>
</tr>
<tr>
<td>Traditional Multi-Family Homes (&lt;1960)</td>
<td>48</td>
<td>280</td>
<td>83</td>
</tr>
<tr>
<td>Multi-Family Homes - Industrial technology (Panel Buildings) to 1992</td>
<td>45</td>
<td>250</td>
<td>75</td>
</tr>
<tr>
<td>Single Family Homes to 1992</td>
<td>52</td>
<td>330</td>
<td>86</td>
</tr>
<tr>
<td>Single Family Homes 1993 -2010</td>
<td>45</td>
<td>330</td>
<td>92</td>
</tr>
<tr>
<td>Multi-Family Homes 1993-2010</td>
<td>45</td>
<td>270</td>
<td>75</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Public Building Stock: estimated investments (Euro per sqm)</th>
<th>S-BASE</th>
<th>S-DEEP</th>
<th>S-SUB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Historical and Protected Buildings</td>
<td>80</td>
<td>550</td>
<td>146</td>
</tr>
<tr>
<td>Traditional Public Buildings (similar to MF)</td>
<td>48</td>
<td>280</td>
<td>83</td>
</tr>
<tr>
<td>Panel Public Buildings (similar to MF)</td>
<td>45</td>
<td>250</td>
<td>75</td>
</tr>
<tr>
<td>Traditional Public Buildings (similar to SF)</td>
<td>52</td>
<td>330</td>
<td>86</td>
</tr>
<tr>
<td>New Public buildings (similar to SF)</td>
<td>45</td>
<td>330</td>
<td>92</td>
</tr>
<tr>
<td>New Public Buildings (similar to MF)</td>
<td>45</td>
<td>270</td>
<td>75</td>
</tr>
</tbody>
</table>

- These investments are estimated in EUR2005 for the beginning of the programme
- Due to the learning factor, the costs will decrease throughout the years for deep renovations
  - Baseline and suboptimal renovation costs do not change – the technology is mature
Scenario Results: Energy Savings

Fuel Prices and Emission Factors

<table>
<thead>
<tr>
<th>Fuel Prices and Emission Factors</th>
<th>Prices in 2010 (EUR2005/kWh)</th>
<th>Prices in 2020</th>
<th>CO2 Emission Factors (g/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Gas, Domestic Customers</td>
<td>0.034</td>
<td>0.045</td>
<td>202</td>
</tr>
<tr>
<td>Electricity, Domestic Customers</td>
<td>0.145</td>
<td>0.186</td>
<td>366</td>
</tr>
<tr>
<td>District Heating</td>
<td>0.052</td>
<td>0.069</td>
<td>255</td>
</tr>
<tr>
<td>Other (Avg. of fuels)</td>
<td>0.021</td>
<td>0.025</td>
<td>350</td>
</tr>
</tbody>
</table>

Sources: own elaborations based on data from KSH, IEA World Energy Outlook 2009, Hungarian Ministry of Water and Environment (KVVM)
Fuel Splits: Residential Buildings

![Bar chart showing fuel splits by residential building type](chart.png)
Fuel Splits: Public Buildings

Public Building Stock Fuel Splits

- Historical and Protected Buildings
- Traditional Public Buildings (similar to MF)
- Panel Public Buildings (similar to MF)
- Traditional Public Buildings (similar to SF)
- New Public buildings (similar to SF)
- New Public Buildings (similar to MF)

Fuel Split

- Other fuels
- District Heating
- Electricity
- Natural Gas
Scenario results: Investments for the programme

- Initial 5-year ramp-up period
- Subsequent decrease thanks to learning factor
Scenario results: energy cost savings

- Energy expenditure savings for an average dwelling
- Energy prices are forecasted to increase and drive up the savings

![Graph showing annual savings generated by reduction in energy consumption for an average dwelling.](image)
Scenario results: energy cost savings

- Energy savings generated each year by all retrofits implemented until that year

![Energy cost savings generated by all the retrofits implemented](chart.png)
Employment effects: literature review

- Studies reviewed show effects of 10-30 jobs per M€ invested
- The studies are mainly from Western Europe/USA
- Difficult to transfer to transition economies (e.g. Hungary)

<table>
<thead>
<tr>
<th>Resource</th>
<th>Reference</th>
<th>Year</th>
<th>Location</th>
<th>Intervention</th>
<th>Jobs/M€ invested</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU SAVE Programme</td>
<td>Wade et al., 2000</td>
<td>1995</td>
<td>European Union</td>
<td>Energy Efficiency</td>
<td>26.60</td>
</tr>
<tr>
<td>SAVE: UK Case Studies</td>
<td>EST, 2000</td>
<td>1996</td>
<td>United Kingdom</td>
<td>Energy Efficiency in Buildings</td>
<td>82.65</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>10.08</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>USA: Moderate scenario</td>
<td>11.21</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>USA: Advanced scenario</td>
<td>10.97</td>
</tr>
<tr>
<td>Investing in Clean Energy</td>
<td>Pollin, Heintz and Garrett-Peltier, 2009</td>
<td>2009</td>
<td>U.S.A.</td>
<td>Building retrofits</td>
<td>16.60</td>
</tr>
<tr>
<td>Danish Green Jobs</td>
<td>Juul, Hansen, Hansen and Ege, 2009</td>
<td>2009</td>
<td>Denmark</td>
<td>Energy renovation of poorly insulated housing</td>
<td>4.05</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Energy savings in buildings operated by local authorities</td>
<td>16.67</td>
</tr>
<tr>
<td>Rebuilding America</td>
<td>Hendricks, Goldstein, Detchon and Shickman, 2009</td>
<td>2009</td>
<td>U.S.A.</td>
<td>Building retrofits</td>
<td>17.44</td>
</tr>
</tbody>
</table>
Direct employment impacts: snapshot in 2020

- The results are calculated in 2020
  - Programme in full activity
  - 5-year ramp-up period is over

- Direct effects
  - Construction: calculated with bottom-up method
    - 17% to 48% more jobs in construction
  - Energy: calculated with labour intensity
    - Loss of 3% to 10% of jobs in energy

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Investments in construction in 2020 (M€)</th>
<th>Direct effects in construction (thousand FTE units)</th>
<th>Percentage of the FTE units working in construction (2006 data, KSH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S-BASE</td>
<td>224</td>
<td>7.6</td>
<td>4%</td>
</tr>
<tr>
<td>S-DEEP1</td>
<td>3,506</td>
<td>90.6</td>
<td>48.5%</td>
</tr>
<tr>
<td>S-DEEP2</td>
<td>2,104</td>
<td>54.3</td>
<td>29%</td>
</tr>
<tr>
<td>S-DEEP3</td>
<td>1,402</td>
<td>36.2</td>
<td>19.5%</td>
</tr>
<tr>
<td>S-SUB</td>
<td>1,040</td>
<td>31.3</td>
<td>17%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Energy savings in 2020 (M€)</th>
<th>Direct effects in energy (thousand FTE units)</th>
<th>Percentage of the FTE units working in energy (2006 data, OECD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S-BASE</td>
<td>40</td>
<td>-0.1</td>
<td>-0.3%</td>
</tr>
<tr>
<td>S-DEEP1</td>
<td>1,234</td>
<td>-3.2</td>
<td>-10.5%</td>
</tr>
<tr>
<td>S-DEEP2</td>
<td>740</td>
<td>-1.9</td>
<td>-6.5%</td>
</tr>
<tr>
<td>S-DEEP3</td>
<td>493</td>
<td>-1.3</td>
<td>-4.5%</td>
</tr>
<tr>
<td>S-SUB</td>
<td>344</td>
<td>-0.9</td>
<td>-3%</td>
</tr>
</tbody>
</table>
Direct employment impacts in construction: medium-term view (by skills)
Total net employment impacts: snapshot in 2020

- **Direct effects**
  - Calculated with bottom-up method
  - Shown in the previous slides
- **Indirect + induced effects**
  - Application of I/O tables
  - Indirect + induced impacts have the same order of magnitude as the direct impacts

### Direct Impacts

<table>
<thead>
<tr>
<th>Result</th>
<th>S-BASE</th>
<th>S-DEEP1</th>
<th>S-DEEP2</th>
<th>S-DEEP3</th>
<th>S-SUB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Million EUR invested in 2020</td>
<td>224</td>
<td>3,506</td>
<td>2,104</td>
<td>1,402</td>
<td>1,040</td>
</tr>
<tr>
<td>Direct impacts on construction sector</td>
<td>8</td>
<td>91</td>
<td>54</td>
<td>36</td>
<td>31</td>
</tr>
<tr>
<td>Direct impacts on energy supply sector</td>
<td>0</td>
<td>-3</td>
<td>-2</td>
<td>-1</td>
<td>-1</td>
</tr>
<tr>
<td>Indirect impacts from investments in construction</td>
<td>0</td>
<td>-3</td>
<td>-2</td>
<td>-1</td>
<td>-1</td>
</tr>
<tr>
<td>Induced impacts from additional jobs created by investments in construction</td>
<td>2</td>
<td>29</td>
<td>18</td>
<td>12</td>
<td>9</td>
</tr>
<tr>
<td>Indirect impacts from reduced demand for energy</td>
<td>1</td>
<td>21</td>
<td>13</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>Induced impacts from lost jobs created by reduced demand for energy</td>
<td>0</td>
<td>-5</td>
<td>-3</td>
<td>-2</td>
<td>-1</td>
</tr>
<tr>
<td>Induced impacts from energy savings</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total net employment impacts in 2020</strong></td>
<td>11</td>
<td>131</td>
<td>78</td>
<td>52</td>
<td>43</td>
</tr>
</tbody>
</table>
### Total net employment impacts divided by sector: snapshot in 2020

<table>
<thead>
<tr>
<th>Sector</th>
<th>S-BASE</th>
<th>S-DEEP1</th>
<th>S-DEEP2</th>
<th>S-DEEP3</th>
<th>S-SUB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture, hunting, forestry and fishing</td>
<td>0.1</td>
<td>0.5</td>
<td>0.3</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Mining and quarrying</td>
<td>0.0</td>
<td>0.7</td>
<td>0.4</td>
<td>0.3</td>
<td>0.2</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>0.7</td>
<td>10.5</td>
<td>6.3</td>
<td>4.2</td>
<td>3.2</td>
</tr>
<tr>
<td>Electricity, gas and water supply</td>
<td>-0.1</td>
<td>-3.1</td>
<td>-1.8</td>
<td>-1.2</td>
<td>-0.8</td>
</tr>
<tr>
<td>Construction</td>
<td>7.7</td>
<td>91.8</td>
<td>55.1</td>
<td>36.7</td>
<td>31.7</td>
</tr>
<tr>
<td>Wholesale and retail trade, restaurants and hotels</td>
<td>0.3</td>
<td>3.6</td>
<td>2.2</td>
<td>1.4</td>
<td>1.1</td>
</tr>
<tr>
<td>Transport, storage and communications</td>
<td>0.3</td>
<td>4.2</td>
<td>2.5</td>
<td>1.7</td>
<td>1.3</td>
</tr>
<tr>
<td>Finance, insurance, real estate and business services</td>
<td>0.5</td>
<td>5.8</td>
<td>3.5</td>
<td>2.3</td>
<td>1.8</td>
</tr>
<tr>
<td>Community, social and personal services</td>
<td>1.5</td>
<td>16.7</td>
<td>10.0</td>
<td>6.7</td>
<td>5.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>11.0</strong></td>
<td><strong>130.7</strong></td>
<td><strong>78.4</strong></td>
<td><strong>52.3</strong></td>
<td><strong>43.4</strong></td>
</tr>
</tbody>
</table>

### Total employment impacts per sector for a specific year: 2020

![Bar chart showing total employment impacts per sector]
Sensitivity analysis: variation of increase of energy prices

Sensitivity analysis: final impacts depending on increase of gas (and DH) price between 1.0% and 5.5% - Scenario: S-DEEP2

Year

Thousand FTE

3.50%
Sensitivity analysis: variation of learning factor

Sensitivity analysis: final impacts depending on cost variation between -2% and -18% of the estimates - Scenario: S-DEEP2
Sensitivity analysis: variation of ratio labour costs / total costs

Sensitivity analysis: final impacts depending on variation of the ratio of labour costs on total costs of a renovation - between 20% and 60% - Scenario: S-DEEP2

Year

Thousand FTE
0 25 50 75 100 125 150 175 200 225 250

25.00%
Sensitivity analysis: variation of cost estimates

Sensitivity analysis: final impacts depending on cost variation between -20% and 20% of the estimates - Scenario: S-DEEP2

Year

Thousand FTE