Energy efficiency in buildings: how far can they take us in mitigating climate change?

CENTER FOR CLIMATE CHANGE
AND SUSTAINABLE ENERGY POLICY

CENTRAL EUROPEAN UNIVERSITY

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Key messages

- Buildings are (the?) key to reaching ambitious mitigation targets…
- …but they can also lock us into high(er) GHG concentration levels for many decades
  - Suboptimal retrofits and new construction are a major climate risk
- EE in buildings may also have the largest co-benefits among mitigation options
- But - since efficiency is unsexy and intangible, measuring and convincingly documenting its performance is crucial for to unlocking its potential
- We need to go much further: A suggested evaluation progress agenda

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EE in buildings is key to climate change mitigation

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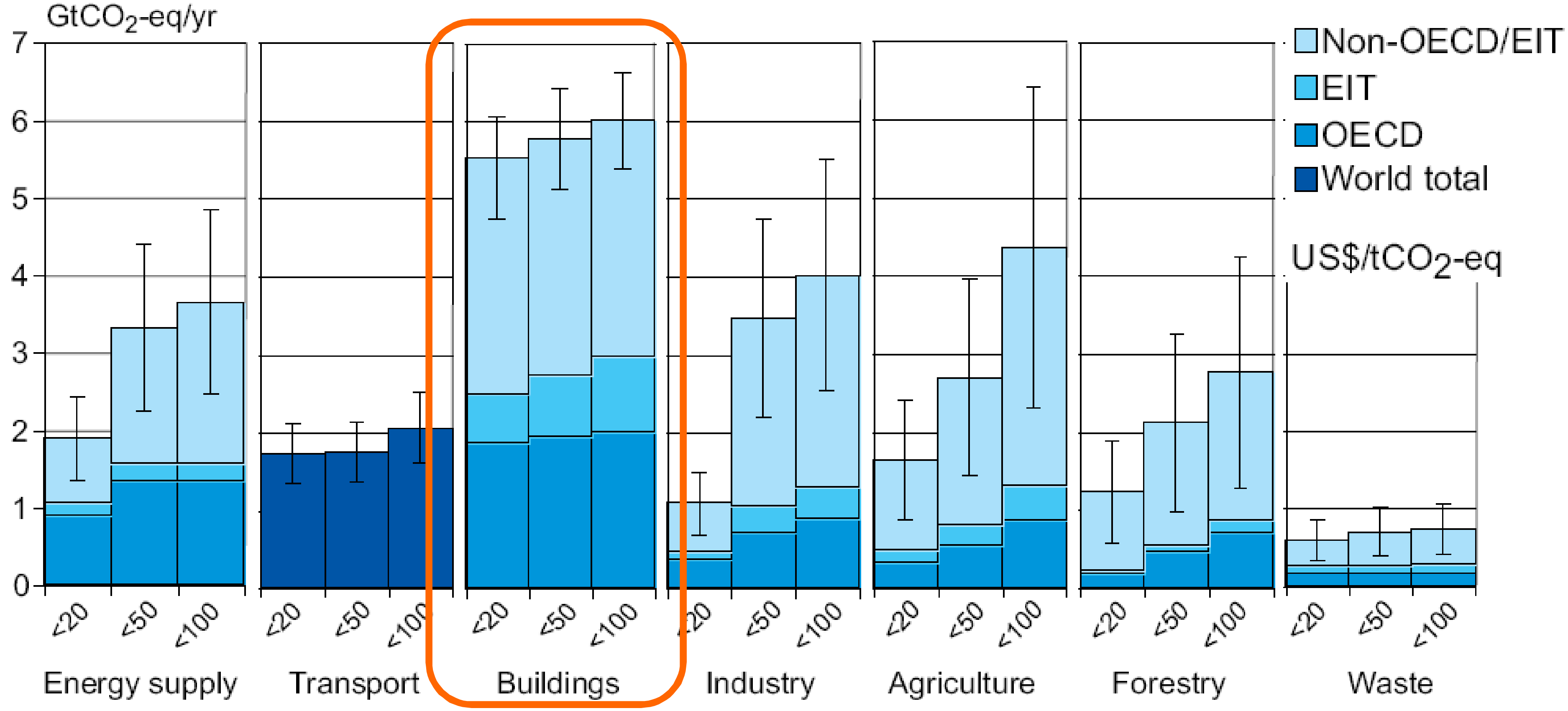
The buildings sector offers the largest low-cost potential in all world regions by 2030



(potential at <US$100/ tCO_2-eq: 2.4 - 4.7 Gt CO_2-eq/yr)	*(potential at <US$100/ tCO_2-eq: 1.6 - 2.5 Gt CO_2-eq/yr)*	*(potential at <US$100/ tCO_2-eq: 5.3 -6.7 Gt CO_2-eq/yr)*	*(potential at <US$100/ tCO_2-eq: 2.5 - 5.5 Gt CO_2-eq/yr)*	*(potential at <US$100/ tCO_2-eq: 2.3 -6.4 Gt CO_2-eq/yr)*	*(potential at <US$100/ tCO_2-eq: 1.3 - 4.2 Gt CO_2-eq/yr)*	*(potential at <US$100/ tCO_2-eq: 0.4 - 1 Gt CO_2-eq/yr)*

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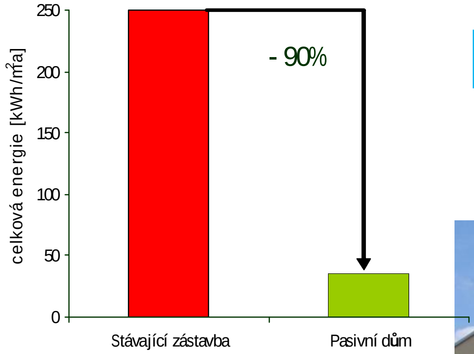
Few sectors can deliver the magnitude of emission reduction needed

- know-how has recently developed that we can build and retrofit buildings to achieve 60 – 90% savings as compared to standard practice in all climate zones (providing similar or increased service levels)



Buildings utilising passive solar construction (“PassivHaus”)

Source: Jan Barta, Center for Passive Buildings, www.pasivnidomy.cz

Few sectors can deliver the magnitude of emission reduction needed

- know-how has recently developed that we can build and retrofit buildings to achieve 60 – 90% savings as compared to standard practice in all climate zones (providing similar or increased service levels)
- Novel methods developed for mitigation potential assessment that considers buildings as complex systems rather than independent sums of components
- New scenarios are constructed under the Global Energy Assessment, with co-funding from UNEP SBCI, that reflect this new approach

Final thermal energy consumption in the world's buildings, 2005-2050

Using state-of-the-art and cost-effective construction know-how

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Final heating and cooling energy consumption 2005 – 2050, Europe

Western Europe **Eastern Europe**

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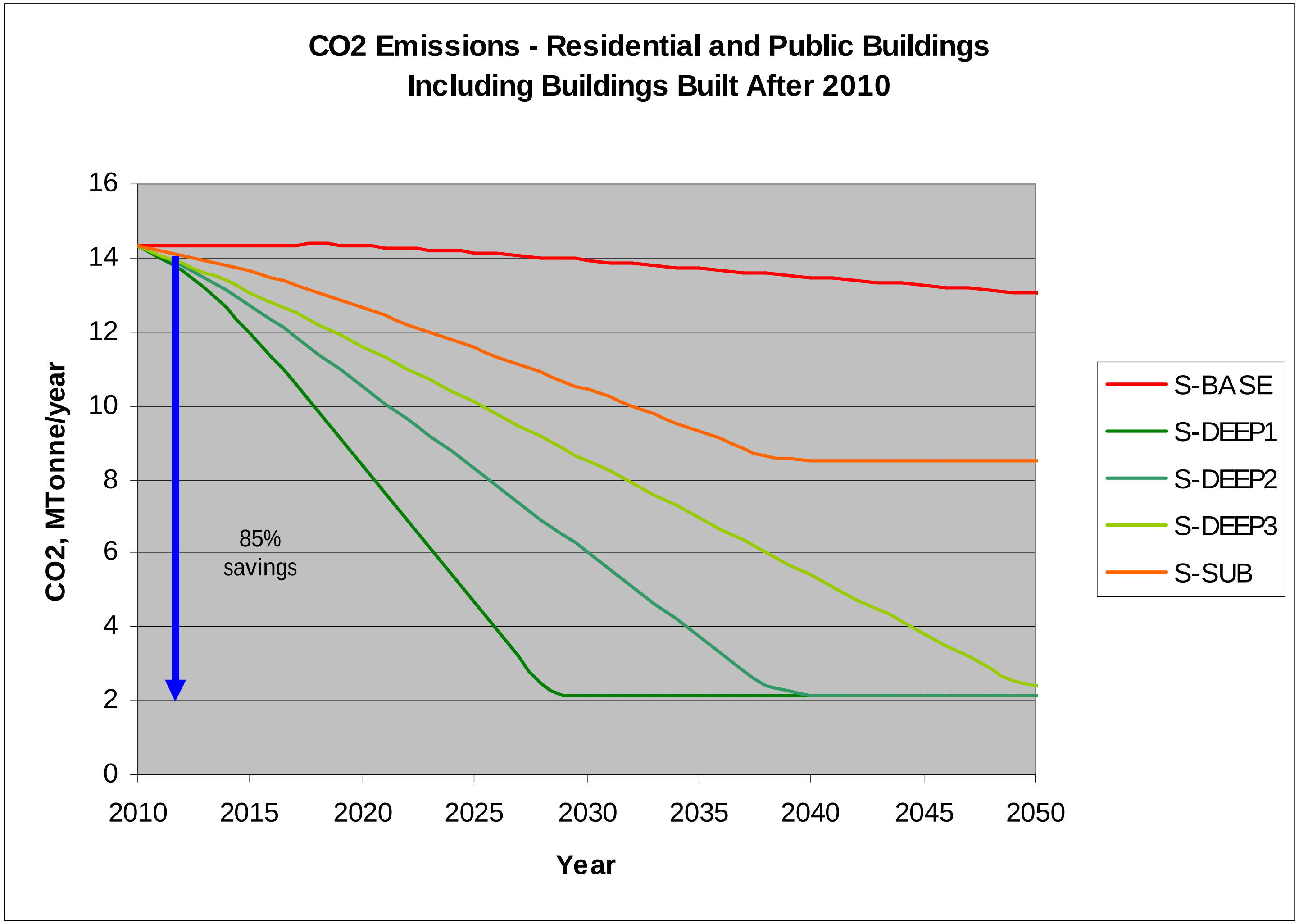
CO2 emission reductions until 2050
Heating and cooling, Hungary



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Opportunity or risk?

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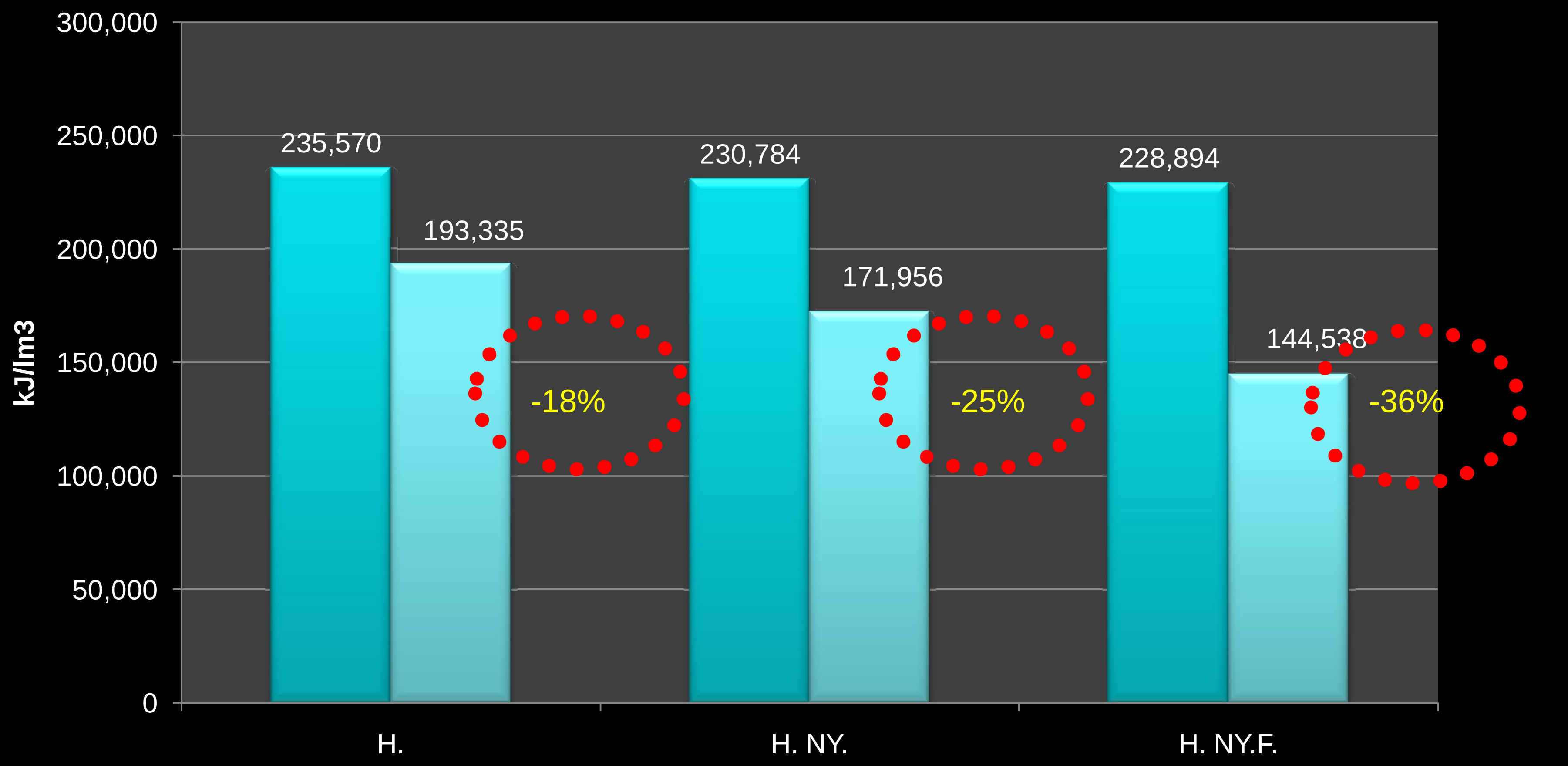
The size of the potential lock-in effect


300
250
200
150
100
50
0
kWh/m2a
-84%
Renewable Energy
Fossile Energy
Before
SOLANOVA

Panelfelújítási programban részt vevő épületek fűtési fajlagos hőfelhasználásának alakulása (city of Sz in Hungary)



H: Homlokzati hőszigetelés
H: NY. Homlokzati hőszigetelés, nyílászáró csere
H: NY. F. Homlokzati hőszigetelés, nyílászáró csere, fűtéskorszerűsítés

Source: Pájer Sándor, SZÉPHŐ Zrt., KLÍMAVÁLTOZÁS - ENERGIATUDATOSSÁG –ENERGIAHATÉKONYSÁG. V. Nemzetközi Konferencia, SZEGED, 2009. április 16-17.

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The lock-in effect

Final world thermal energy consumption
State-of-the-art vs. suboptimal retrofits

GEA

Work in progress – not yet publishable

Watch out for the Global Energy Assessment release in 2011…

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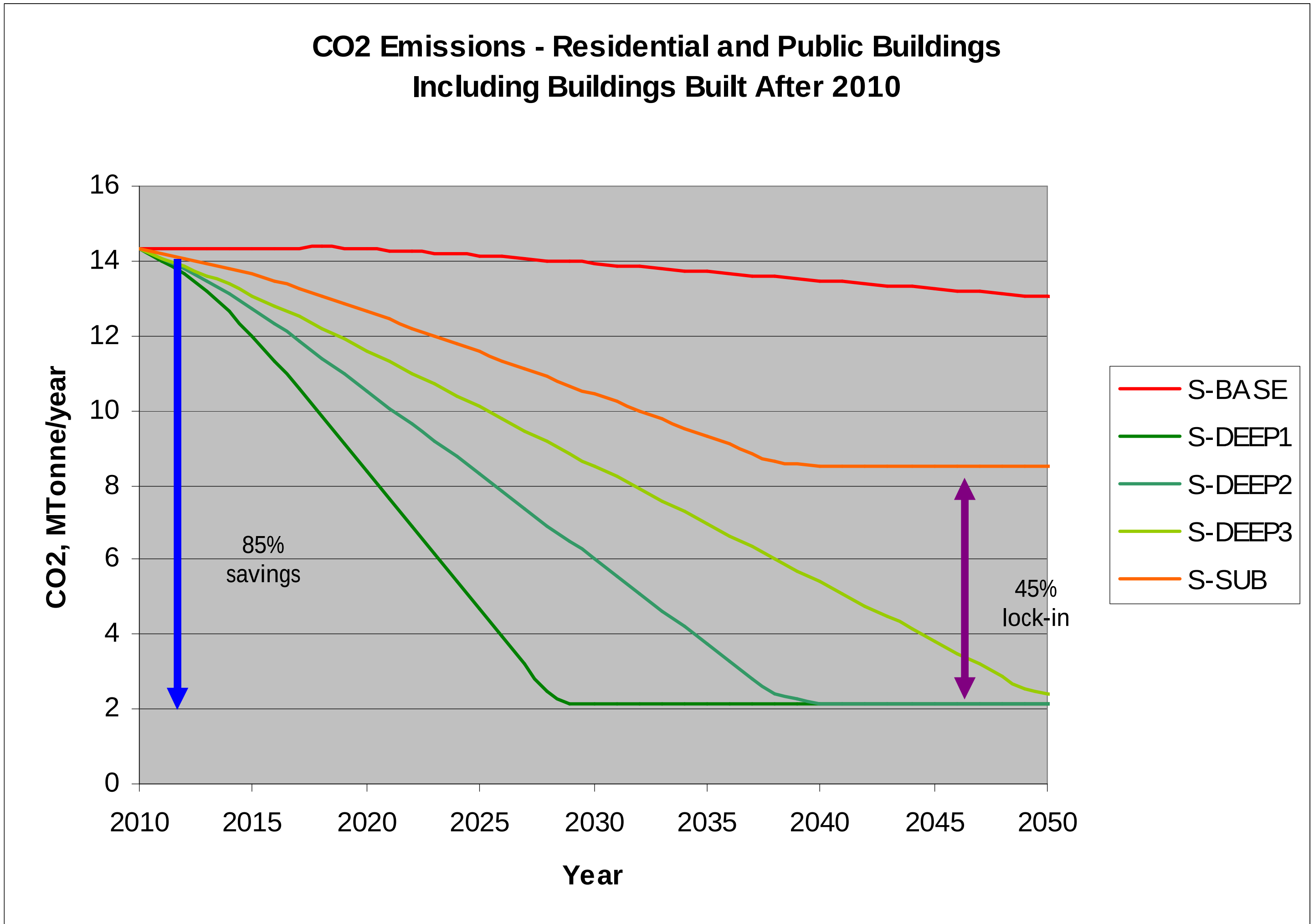
CO2 emission reductions until 2050
Heating and cooling final energy use, Hungary



- 85% of emissions are saved in deep scenarios
- 45% of emissions remain locked-in by the suboptimal scenario

Final heating and cooling energy consumption 2005 – 2050, Western Europe

State-of-the-Art Scenario **Sub-Optimal Scenario**

Work in progress – not yet publishable

Watch out for the Global Energy Assessment release in 2011…

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Co-benefits - the entry points to policy-making?

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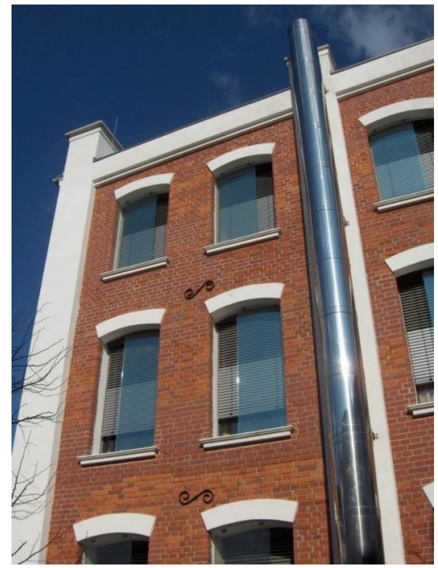

Co-benefits of energy-efficiency in buildings

Quantified non-energy benefits of building energy-efficiency programs (1/5)

Co-benefits	Country/ region	Methodology	Impact of CO_2 emission reduction		References
			Physical indicator	Monetary indicator	
Quantifiable health effects					
Morbidity reduction	USA, New Zealand, Denmark	• A double-blind, multiple crossover intervention • Initial self-completed background questionnaires; then shorter weekly questionnaires assessing the outcomes • Environmental measurements • Statistical analysis • Cost-benefit analysis • Literature review • Authors' adjustment/estimates	USA: A drop of concentration of the smallest airborne particles by 94% resulted a decrease of confusion scale by 3.7%, fatigue scale by 2.5%, the feeling of "stuffy" air 5.3%, of "too humid" by 7.0%, of "too cold" by 5.5% and "too warm" by 3.5%. USA: Cooler temperatures within the recommended comfort range resulted in a decrease of the chest tightness by 23.4% per each 1°C decrease. Denmark: Better thermal air quality led to better concentration of 15% of respondents and a 34% decrease "sick building syndrome*" cases.	USA: Improved ventilation may result in net savings of EUR 302/employee-yr. that on a national scale represents productivity gain of EUR 17 billion/yr. USA: NPV** over the lifetime of improved ventilation can reach as hight as EUR 1,652/hh… USA: Better ventilation and indoor air quality reduce influenza and cold by 9-20% (ca 16-37 million cases) that translates into savings of EUR 4.5-10.6 billion/yr. New Zealand: Health benefits due to a weatherization program amount to EUR 35/hh-yr. or 18.5% of the total annual energy savings of a household.	Mendell et al. 2002; Milton et al. 2000; Schweitzer and Tonn 2002; Wyon 1994; Stoecklein and Scumatz 2007; Fisk 1999; Fisk 2000a
Mortality reduction	Hungary; USA, Ireland, Norway	• Bottom-up study (with Monte Carlo simulation) • Statistic time-series analysis: semi-parametric log-linear model, a weighted 2-stage regression • Analysis of mortality statistics with a population of a similar country as the control group	USA: Every 10 g/m^3 increase in ambient particulate matter (the day before deaths occur) brings a 0.5% increase in the overall mortality. Ireland, Norway: The share of excess winter mortality attributable to poor thermal housing standards is 50% for cardiovascular disease and 57% for respiratory disease.	Hungary: Energy saving program resulted in the total health benefit of EUR 489 million/yr. due to a decrease of chronic respiratory diseases and premature mortality. Ireland, Norway: A total mortality benefit of a hypothetical thermal-improving program is EUR 1.5 billion (undiscounted) for a study in the left column.	Aunan et al. 2000; Samet et al. 2000; Clinch and Healy 1999

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Quantified non-energy benefits of building energy-efficiency programs (2/5)

Co-benefits	Country/ region	Methodology	Impact of CO_2 emission reduction		References
			Physical indicator	Monetary indicator	
Environmental (ecological) co-benefits					
General environmental benefits	New Zealand	• Direct computation • Willingness to pay/to accept, contingent valuation, other survey-based methods	NZ: Benefits to the environment gained after the weatherization program amount to EUR 44/hh.-yr. in 2007 that accounts for around 18.7% of the total annual energy expenditures saved		Stoecklein and Scumatz 2007
Cleaner indoor air	USA	• Literature review • Data analysis	US: A sample considered a reduction of concentration of the smallest airborne particles by 94% US: The reduction in the emission/yr. of a green school as compared to the average practice: - 1,200 pounds of NOx - a principal component of smog - 1,300 pounds of SO2 - a principal cause of acid rain - 585,000 pounds of CO2 - GHG and the principal product of combustion - 150 pounds of coarse particulate matter (PM10) – a principal cause of respiratory illness and an important contributor to smog.		Mendell et al. 2002; Kats 2005
Fish impingement	USA	• Literature review • Authors' adjustment/estimates	USA: NPV of reduction in fish impingement over the lifetime of weatherization measures is EUR 17.6/hh.		Schweitzer and Tonn 2002.
Waste water and sewage	USA	• Literature review • Authors' adjustment/estimates	USA: NPV of reduction in waste water and sewage over the lifetime of weatherization measures is EUR 2.6 – 495.3/hh.		Schweitzer and Tonn 2002
Construction and demolition waste benefits	USA	• Statistical analysis • NPV analysis with a 7% DR over 20 years	USA: Construction and demolition diversion rates are 50-75% lower in green buildings (with the maximum of 99% in some projects) as compared to an average practice USA: A sample of 21 green buildings submitted for certification, 81% of such buildings reduced construction waste by at lease 50%, 38% of such buildings reduced construction waste by 75% or more		SBTF 2001; Kats 2005
Reduction in air pollution (indoor + outdoor)	USA	• Literature review • Authors' adjustment/estimates • Statistical analysis	USA: A green school emits 544 kg of NO_x , 590 kg of SO_2, 265 tonnes of CO_2, 68 kg of coarse particulate matter (PM10) less in comparison with the average practice	USA: The study in the left column results in NPV EUR 0.4/ft^2 (~EUR 0.037/m^2) over 20 yr. USA: NPV of air emission reduction (CO_2, SO_x, NO_x, CO, CH_4, PM) over lifetime of the measures is (all in thousand EUR/hh.: a) from natural gas burning 30.2 - 37.7; b) from electricity consumption EUR 118-185; c) air emissions of heavy metals is 0.75-12.8	Schweitzer and Tonn 2002; Kats 2005; Kats 2006

Quantified non-energy benefits of building energy-efficiency programs (3/5)

Co-benefits	Country/ region	Methodology	Impact of CO_2 emission reduction		References
			Physical indicator	Monetary indicator	
Economic co-benefits and ancillary financial impacts					
Indirect secondary impact from reduced overall market demand and resulting lower energy prices market-wide	USA	• NPV analysis with a 7% DR over 20 years • Literature review • Simplified quantification of the effect of renewable energy/energy efficiency on gas prices and bills • Using a range of plausible inverse elasticity estimates	USA: Efficiency-driven reductions in demand results in a in long-term energy price decrease equal to 100% to 200% of direct energy savings; assuming the indirect price impact of 50% over 20 years from an efficient school design, the impact of indirect energy cost reduction for new and retrofitted schools has NPV EUR 0.21/m^2 USA: 1% decrease of the national natural gas demand through energy efficiency and renewable energy measures leads to a long-term wellhead price reduction of 0.8% - 2%; the indirect monetary savings from this price decrease amounted to 90% of the direct monetary savings that it EUR 14.6 million for all customers (cumulative 5-year impact, 1998-2002, over June-September peak hours) USA: 1% reduction in natural gas demand result in a 0.75-2.5% reduction in the long-term wellhead prices.		Kats 2006; Wiser et al. 2005; O'Connor 2004; Platts Research &Consulting 2004
Enhanced learning in 'greened' buildings	USA	• Review of the financial benefits of education	Better environmental condition lead to enhanced learning abilities; a 3-5% improvement in learning and test scores is equivalent to a 1.4% lifetime annual earnings increase; an increase in test scores from 50% to 84% is associated with a 12% increase in annual earnings.		Hanushek 2005
Employees' retention: avoided reduced-activity days	USA, The State of Washington, Ireland	• Statistical analysis • Literature review • Bottom-up model • NPV analysis with a 7% DR over 20 years • A walk-through assessment of schools • Survey	USA: The improved quality of schools increases teacher retention by 3% USA/The State of Washington: "Greening" schools could bring 5%/yr. of improvement in teacher retention	USA : if the cost of teacher loss is 50% of salary, the left column tops study equals to a saving of EUR 0.28/m^2 if ~214 m^2/teacher is assumed USA/The State of Washington (left column): Savings of USD 160 thousand/yr. during 20 years (not discounted) Ireland: The annual value of the morbidity benefits of the energy efficiency program is EUR 58 million excl. reduced-activity days and EUR 66.6 million incl. them	Buckley et al. 2005; Kats 2005; Paladino & Company 2005; Clinch and Healy 2001
Improved productivity	USA	• Case studies on documented productivity gains • Empirical measurements • Computer-based literature searches, reviews of conference proceedings, and discussions with researchers • Multivariate linear regression	USA: In well day-lighted buildings: labor productivity rises by about 6–16%, students' test scores shows ~20–26% faster learning, retail sales rise 40%. USA: Students with the most day-lighting show 20% - 26% better results than those with the least day-lighting USA: The ventilation rates less than 100%	USA: The productivity can improve by 7.1%, 1.8%, and 1.2% with lighting, ventilation, and thermal control by a tenant; an average workforce productivity increase is 0.5% - 34%/each control type. A 1% increase in productivity (~ ca 5 minutes/day) is equal to EUR 452 – 528/employee-yr. or EUR 0.21/m^2-yr.; a 1.5 % increase in productivity (~ ca 7	Lovins 2005; Fisk 2000a; Fisk 2000b; Heschong Mahone Group 1999; Federspiel 2002; Menzies

Quantified non-energy benefits of building energy-efficiency programs (4/5)

Co-benefits	Country/ region	Methodology	Impact of CO_2 emission reduction		References
			Physical indicator	Monetary indicator	
		analysis of student perfromance data • Log-linear regression model • Statistical analysis • Questionnaire • NPV analysis with a 7% DR over 20 years	outdoor air and temperature higher than 25.4°C result in lower work performance Canada: A new ventilation system improved the productivity of co-workers by 11% versus reduced productivity by 4% in a control group USA: After building retrofitting, absenteeism rates dropped by 40% and productivity increased by more than 5%; after moving to a retrofitted facility two business units monitored 83% and 57% reductions in voluntary terminations versus a c control group with 11% reduction in voluntary termination of employment	minutes/day) is equal to ~EUR 754/employee-yr. or EUR 0.35/m^2-yr. USA: More comfortable temperature and lighting results in productivity increase by 0.5% - 5%; considering only U.S. office workers, such a change translates into an annual productivity increase of roughly EUR 15 – 121 billion.	1997; Kats 2003; Pape 1998; Shades of Green 2002
Avoided unemployment	USA	• Literature review • Authors' adjustment and calculations	NPV of avoided unemployment over the lifetime of weatherization measures is EUR 0 – 137.9/hh.		Schweitzer and Tonn 2002
Lower bad debt write-off	USA	• Literature review • Authors' adjustment/estimates	NPV of lower bad debt write-off over the lifetime of weatherization measures is EUR 11.3 – 2,610 /hh.		Schweitzer and Tonn 2002
Employment creation	USA	• NPV analysis with a 7% DR over 20 years • Literature review • Authors' adjustment/estimates • Statistical assessment of the 5- year the energy efficiency programs	USA: Green schools create more jobs than conventional schools: the long-term employment impact of increased energy efficiency may provide EUR 0.21/m^2 of benefits USA: NPV of direct and indirect employment creation over the lifetime of the measures is EUR 86.7 – 3.2 thousand/hh. (note: this benefit occurs only one time in year weatherization is performed) USA: Energy efficiency investment of EUR 85.2 million in the Massachusetts economy in 2002 created 1780 new short-term jobs; in addition, lowered energy bills for participants and for Massachusetts resulted in additional spending, creating 315 new long-term jobs; energy efficiency jobs added EUR 104.8 million to the gross state product, including EUR 48.2 million in disposable income (in 2002 in Massachusetts)		Kats 2005; Schweitzer and Tonn 2002; O'Connor 2004; Kats 2005
Rate subsidies avoided	USA	• Literature review • Authors' adjustment/estimates	NPV of avoided rate-subsidies over the lifetime of weatherization measures is EUR 4.5 – 52.8 /hh.		Schweitzer and Tonn 2002
National energy security	USA	• Literature review • Authors' adjustment/estimates	NPV of enhanced national energy security over the lifetime of weatherization measures is EUR 56.5 – 2,488/hh.		Schweitzer and Tonn 2002

Quantified non-energy benefits of building energy-efficiency programs (5/5)

Co-benefits	Country/ region	Methodology	Impact of CO_2 emission reduction		References
			Physical indicator	Monetary indicator	
Service provision benefits					
Transmission and distribution loss reduction	USA	• Literature review • Authors' adjustment/estimates	USA: NPV over the lifetime of weatherization measures installed ranges EUR 24.9 – 60.3/hh.		Schweitzer and Tonn 2002
Fewer emergency gas service calls	USA	• Literature review • Authors' adjustment/estimates	USA: NPV of fewer emergency gas service calls over the lifetime of weatherization measures is EUR 29.4 – 151.5/hh.		Schweitzer and Tonn 2002
Utilities' insurance savings	USA	• Literature review • Authors' adjustment/estimates	USA: NPV of utilities insurance cost reduction over the lifetime of weatherization measures is EUR 0 – 1.5/hh.		Schweitzer and Tonn 2002
Decreased number of bill-related calls	New Zealand	• Direct computation • Willingness to pay, willingness to accept, contingent valuation and other survey-based methods	Bill-related calls became less frequent after the implementation of weatherization program, which amounted savings of NZ$30 (~EUR 15.9/hh-yr.) that is 7% of the total saved energy costs		Stoecklein and Scumatz 2007
Social co-benefits					
Improved social welfare and poverty alleviation	UK	• Survey monitoring the impact of energy company schemes which were set up to fuel poverty	UK: Energy efficiency schemes applied to 6 million households in January-December 2003 resulted in the average benefit of EUR 12.7/hh-yr.		DEFRA 2005
Safety increase: fewer fires	USA	• Literature review • Authors' adjustment/estimates	USA: NPV over the lifetime of the measures installed is EUR 0 - 418 /hh.		Schweitzer and Tonn 2002
Increased comfort	Ireland; New Zealand	• A computer-simulation energy-assessment model • Direct computation • Willingness to pay, willingness to accept, contingent valuation and other survey-based methods	Ireland: A household temperature once the energy efficiency program has been completed increased from 14 to 17.7 °C. The analysis showed that comfort benefits peak at year 7 and then decline gradually until year 20.	Ireland: The total comfort benefits of the program for households (described in the left column) amount to EUR 473 million discounted at 5% over 20 years; New Zealand: Comfort (incl. noise reduction) benefits after the weatherization program estimated as EUR 103/hh.-yr. that is 43% of the saved energy costs	Clinch and Healy 2003; Stoecklein and Scumatz 2007.

In many countries, high-performance buildings are not primarily a green, but a social and economic agenda


ENERGIASZEGÉNYSÉG MAGYARORSZÁGON

ELSŐ ÉRTÉKELÉS

Sergio Tirado Herrero

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Éghajlatváltozási és Fenntartható Energiapolitikai Központ (3CSEP)
Közép-európai Egyetem (CEU)

Együttműködésben a Környezeti Igazságosság Munkacsoporttal
VÉDEGYLET – Protect the Future

VÉDEGYLET

- a wide-scale renovation program can create app. 130,000 net jobs in Hu alone (vs. the "1 million" estimated for the whole EU for the 20/20/20 target)
- …and save **59%** of Hungary's **peak** (January) **natural gas import needs** Fuel poverty is a rising problem in Europe
- According to a new study, app. 2500 lives are lost in Hungary alone each year
- By the UK definition, over 80% of Hungarian households are fuel poor
- A widespread deep (!) building energy retrofit program can **eliminate fuel poverty**

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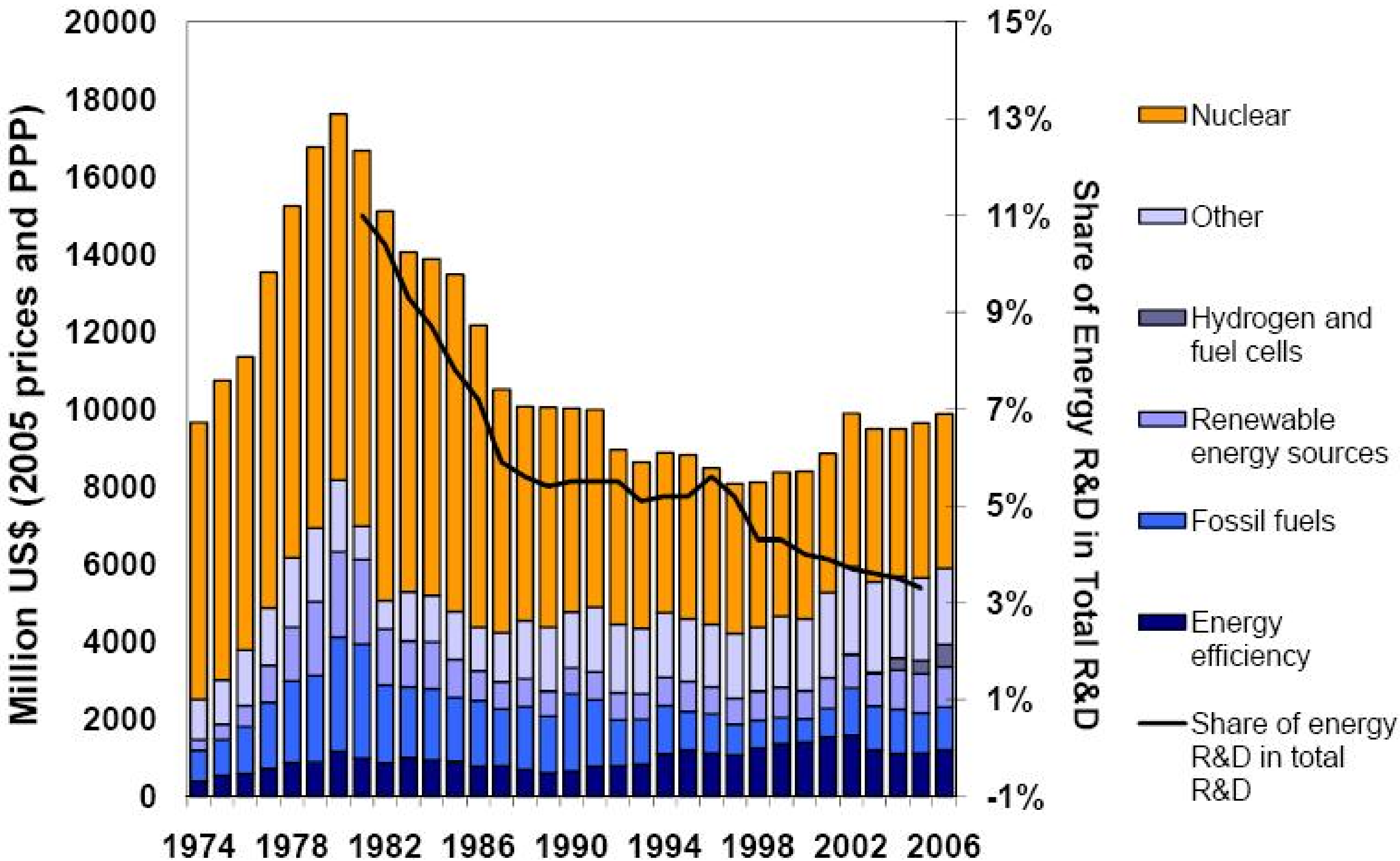
However, hard facts, robust numbers needed on ex-post evaluations: energy efficiency has worked!

- while efficiency is often first in rhetoric, it is far from being first when it comes to action

Public Sector Energy R&D in IEA Countries – USD 10 bln/yr



However, hard facts, robust numbers needed on ex-post evaluations: energy efficiency works!

- while efficiency is often first in rhetoric, it is far from being first when it comes to action
- Efficiency is not “sexy”, photogenic
- For efficiency to become a market-compatible commodity, standardised MRV is needed
- *…just doing it is not enough…*

A long-term agenda for progress in energy (program) evaluation

- be honest about ex-post results vs. expected savings (ex-ante)
- Ex-ante: evaluate the **lock-in risk**
- We need to go beyond measuring direct costs and benefits (savings)
  - quantify/monetise **non-energy benefits**
    - Ex-post
  - Quantify/monetise transaction costs and other **indirect costs**/hassles
- Ideally, evaluations should be conducted on a lifecycle basis – going beyond the operational phase
  - If GHGs measured, non-CO2 should also be included
    - (app. 2/3 of F-gas emissions are related to buildings!)

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Thank you for your attention

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