Free lunch we are paid to eat or mission impossible?

The role of the buildings sector in controlling climate change

Center for Climate Change
and Sustainable Energy Policy

Central European University

Diana Ürge-Vorsatz

director

Talk for the Energy Policy Research Group

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Overview

- Introduction: the CC mitigation challenge
- The global and regional importance of the buildings sector in CC – the free lunch
- How far can buildings take us?
- The risk of the lock-in effect
- Co-benefits: the free lunch we are paid to eat
- Key barriers: mission impossible?
- Lessons for policy and financing

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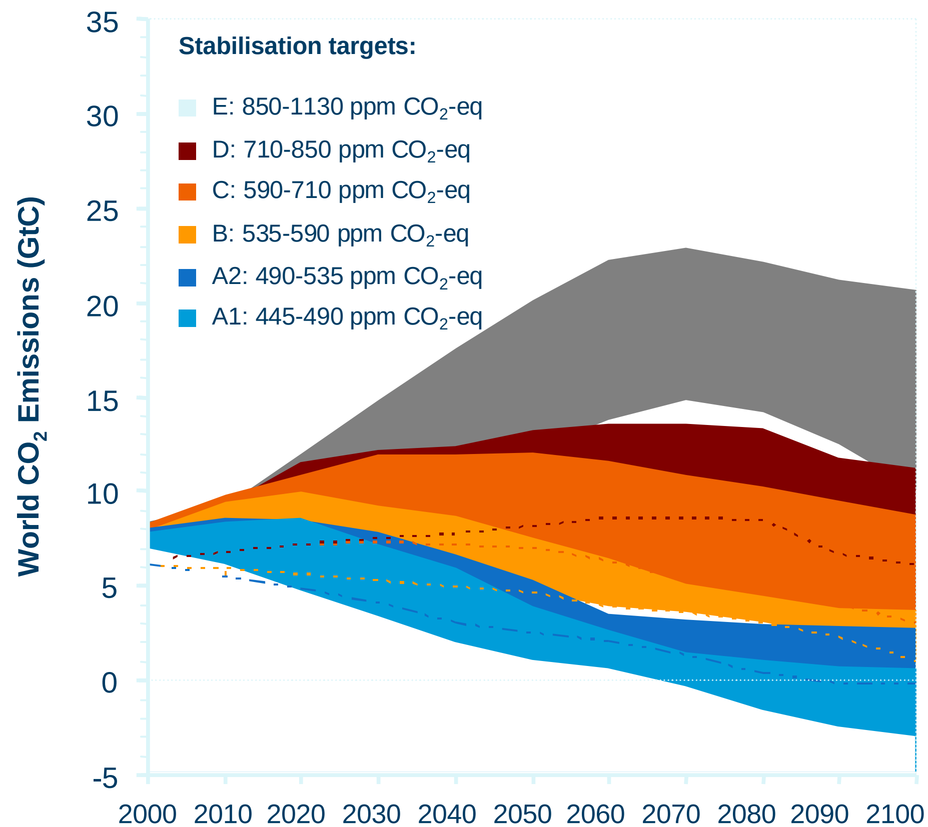
The climate change mitigation challenge

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.

Based on SPM 7, WG III. Emission pathways to mitigation scenarios



Multigas and CO_2 only studies combined

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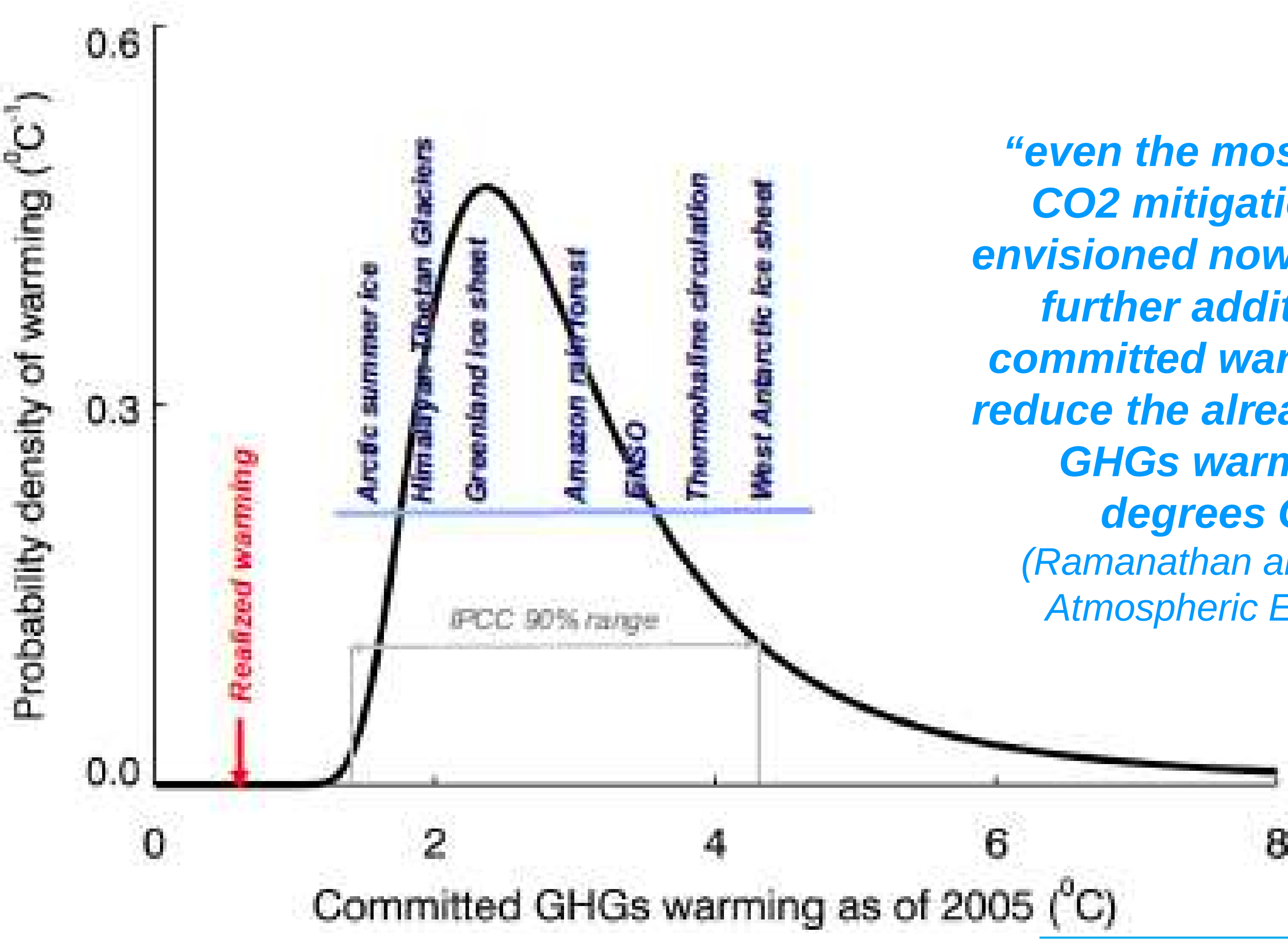
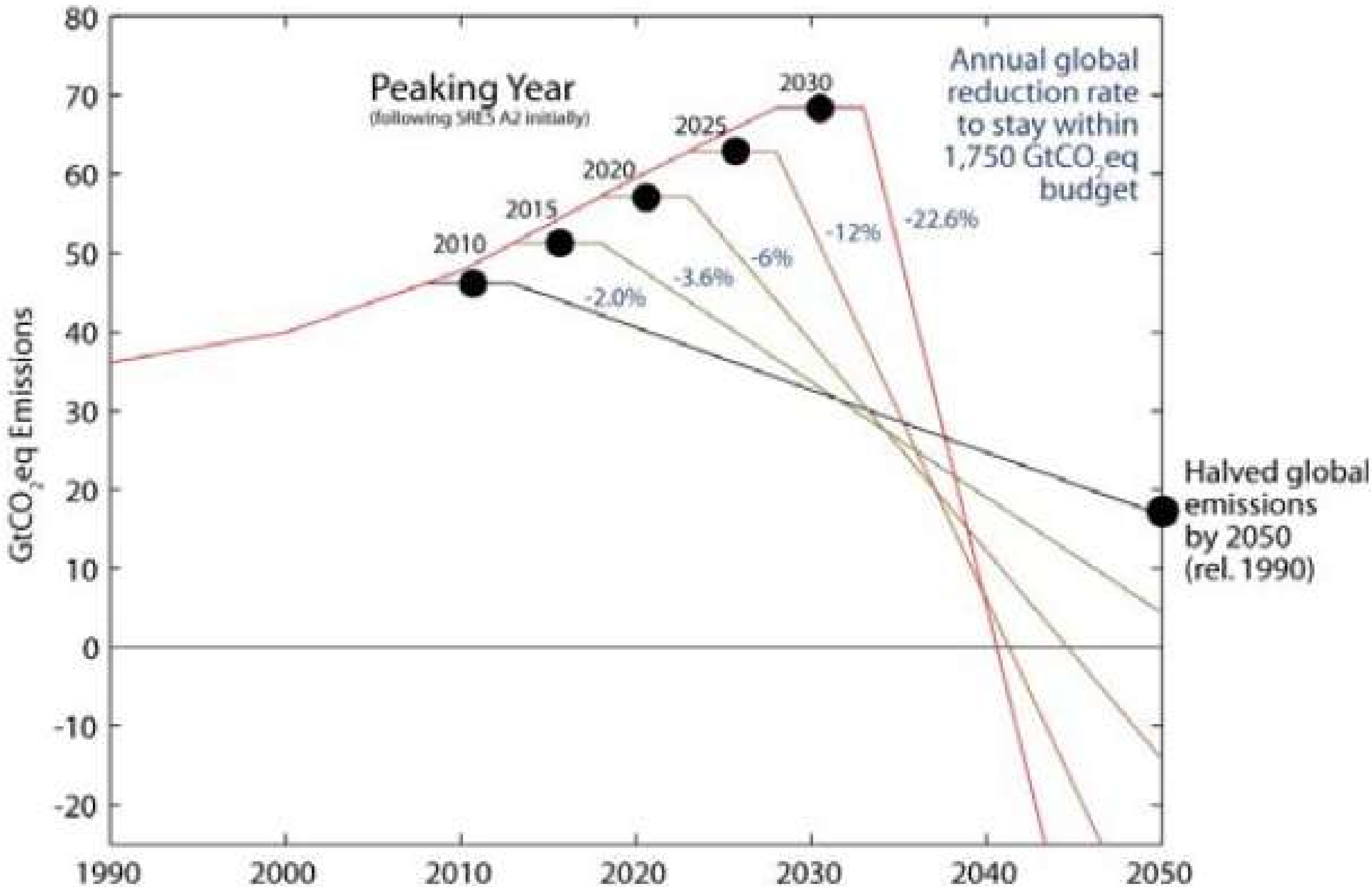
Probability distribution for the committed warming by GHGs between 1750 and 2005. Shown are climate tipping elements and the temperature threshold range.



"even the most aggressive CO2 mitigation steps as envisioned now can only limit further additions to the committed warming, but not reduce the already committed GHGs warming of 2.4 degrees Celsius"

(Ramanathan and Feng 2008, Atmospheric Environment).

The later emissions peak, the more ambitious reductions needed



***Source**: Meinshausen et al 2009*

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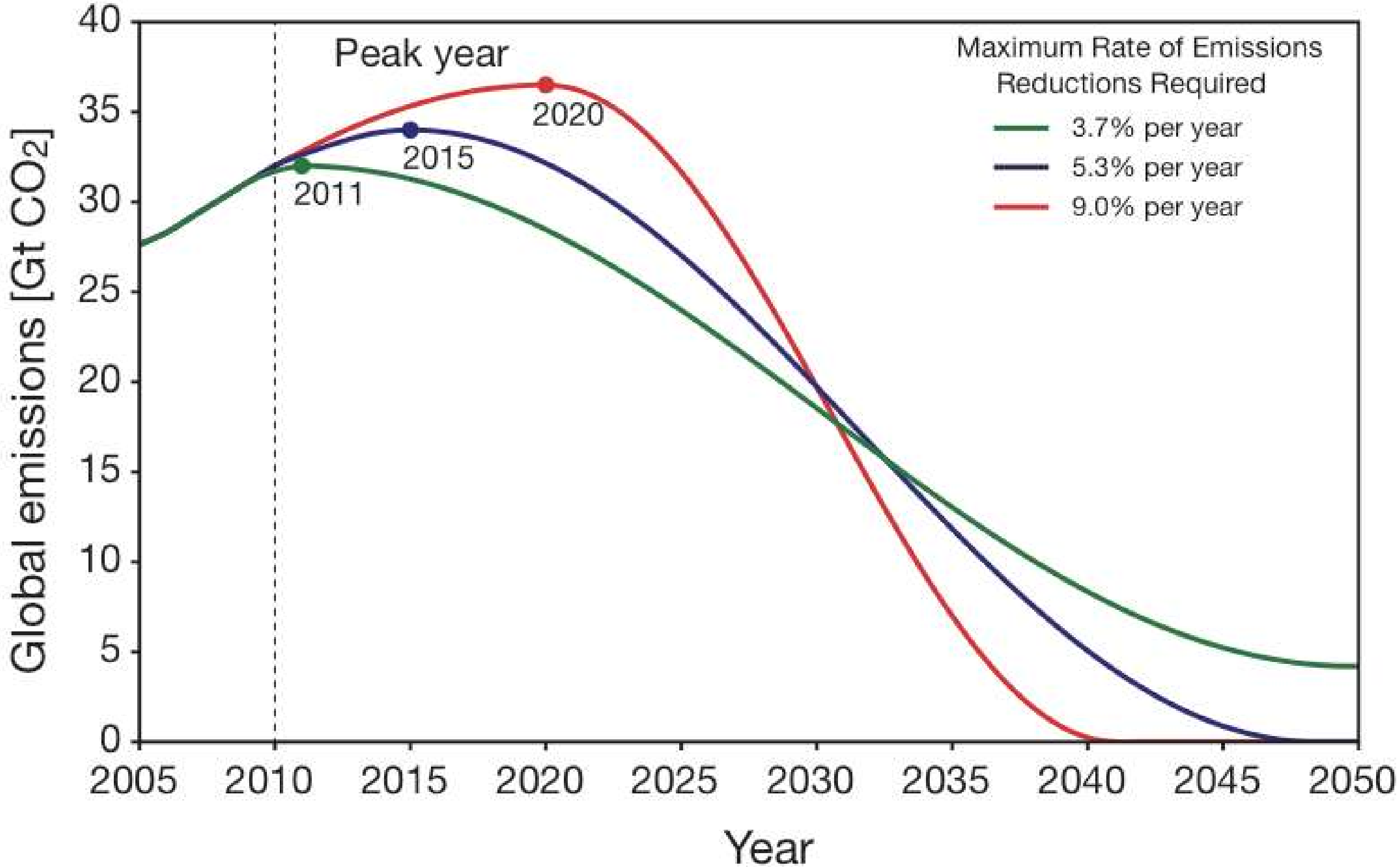
The later emissions peak, the more ambitious reductions are needed

The Copenhagen Diagnosis
Updating the World on the Latest Climate Science

http://www.copenhagendiagnosis.com/



Emissions pathways to give 75% chance of limiting global warming to 2ºC

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The role of the buildings sector in CC mitigation: global and regional importance

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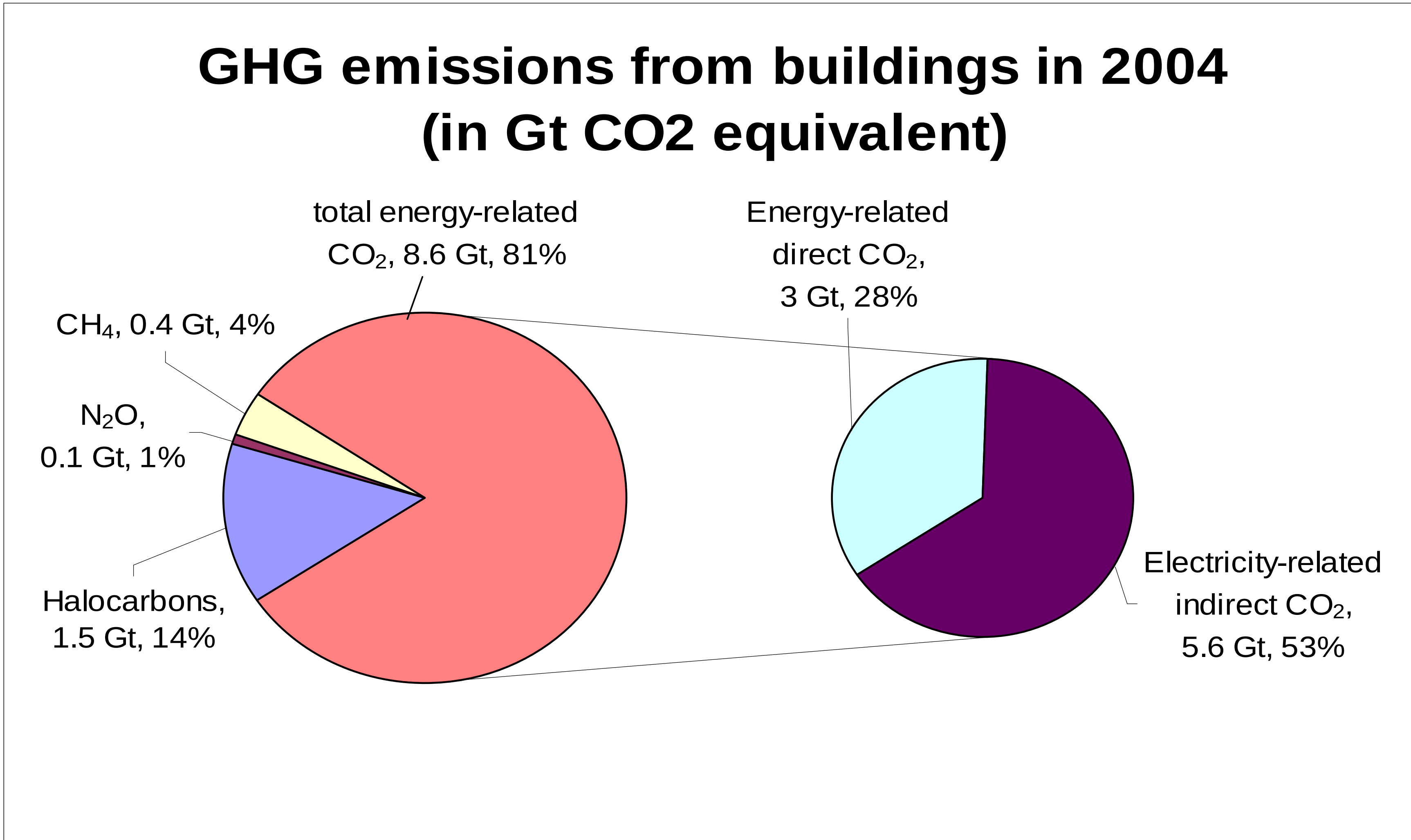
Building sector: global importance

In 2004, in buildings were responsible for app. 1/3 of global energy-related CO_2 (incl. indirect) and 2/3 of halocarbon emissions



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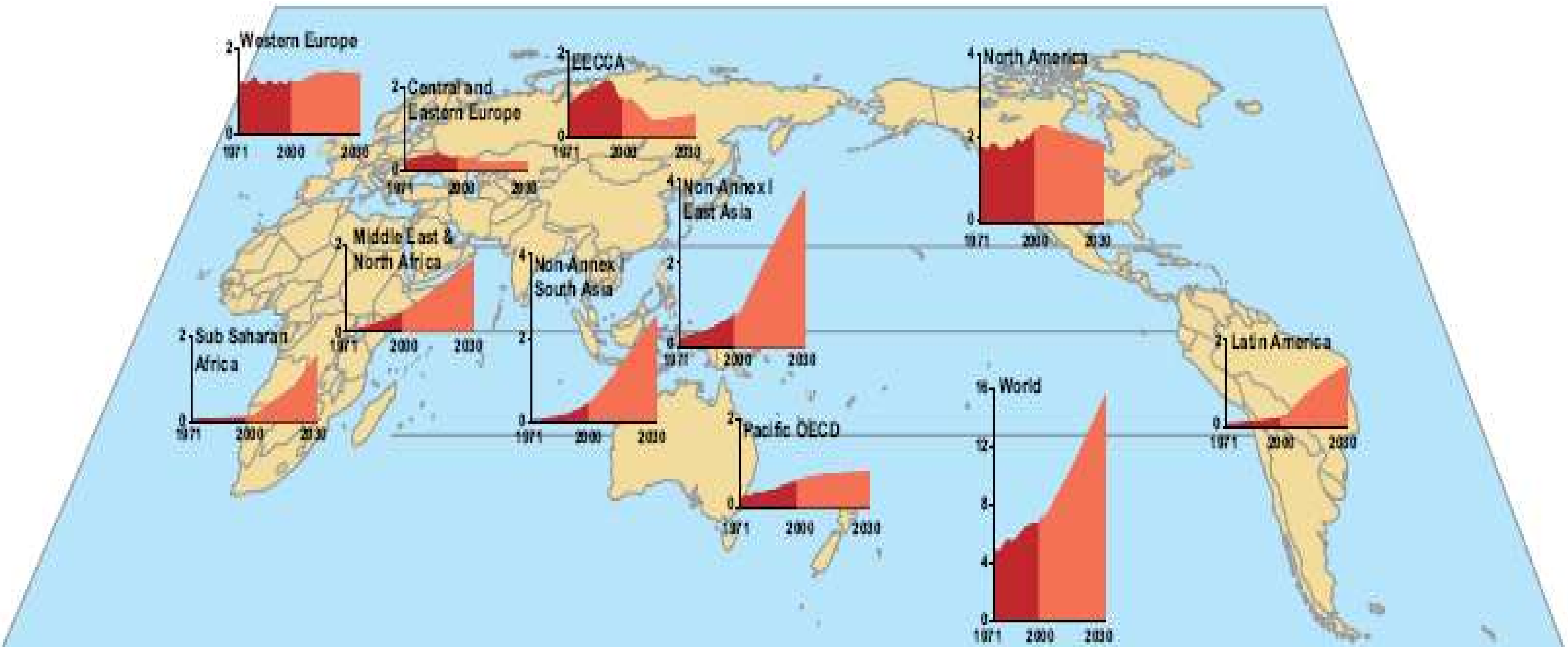
Buildings sector: regional importance

In 2030: the share of building-related emissions in global will stay at approximately 1/3 of energy-related CO2



CO2 emissions including through the use of electricity, A1B scenario

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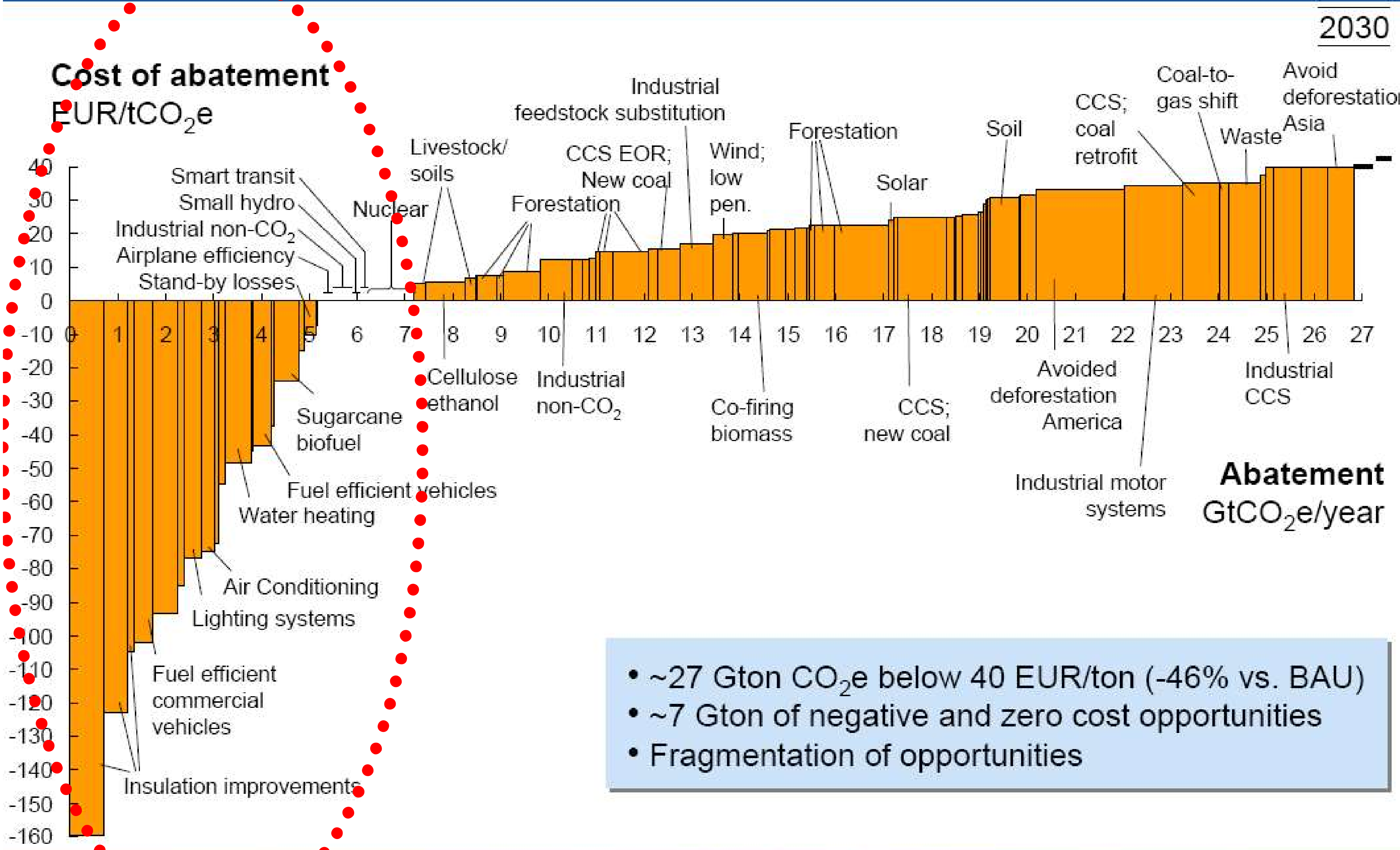
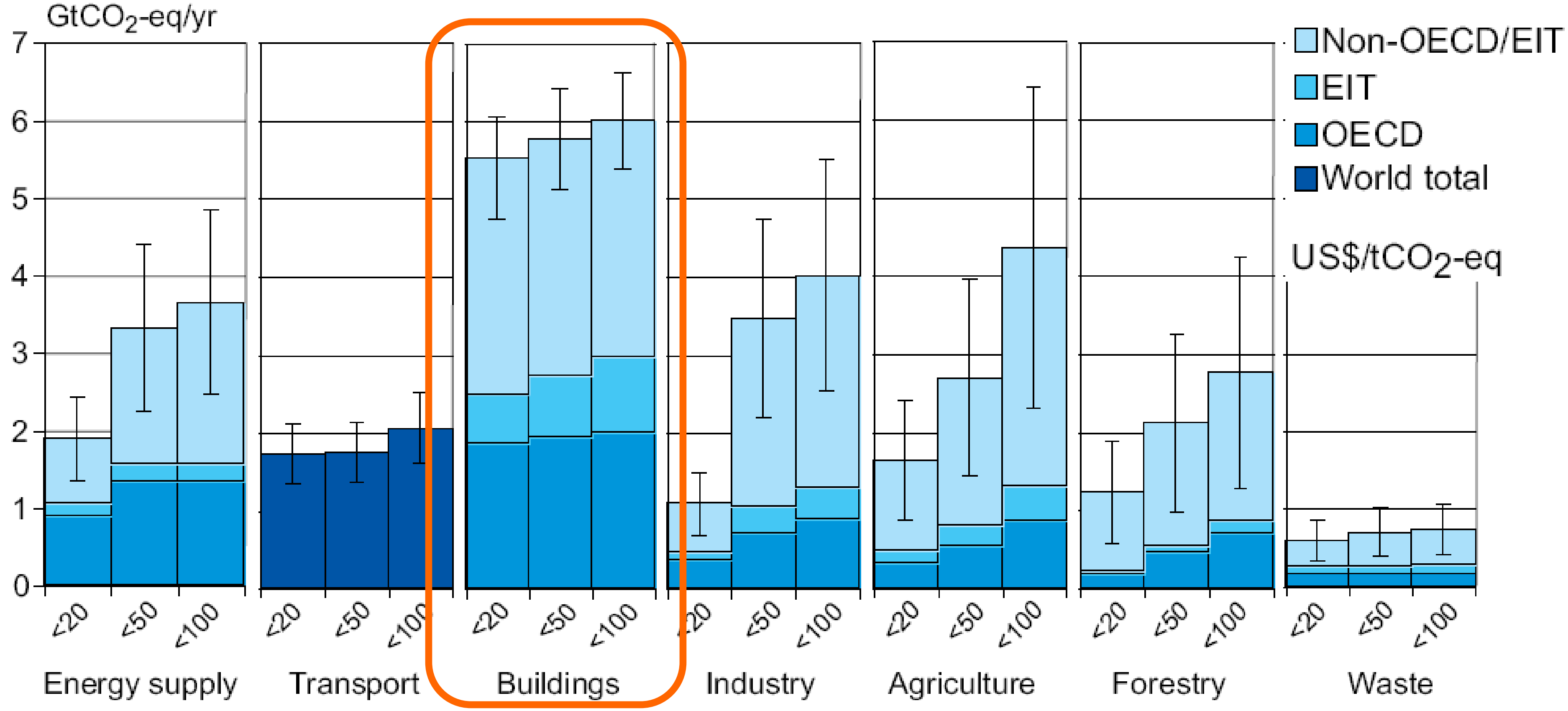
Global cost curve of GHG abatement opportunities beyond business as usual



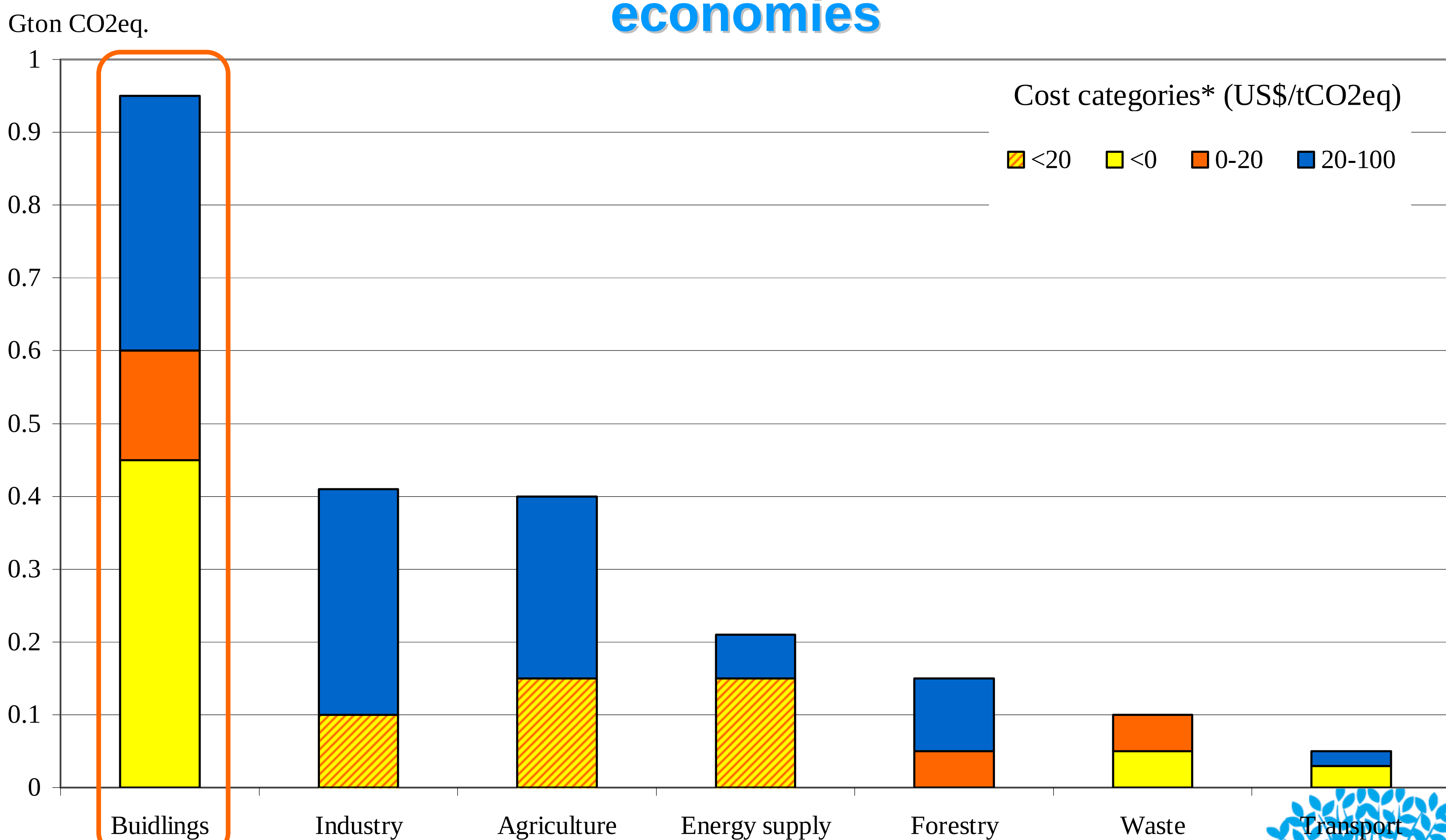
- ~27 Gton CO_2e below 40 EUR/ton (-46% vs. BAU)
- ~7 Gton of negative and zero cost opportunities
- Fragmentation of opportunities

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)*

Estimated potential for GHG mitigation at a sectoral level in 2030 in different cost categories , transition economies



* For the buildings, forestry, waste and transport sectors, the potential is split into three cost categories: at net negative costs, at 0-20 US$/tCO2, and 20-100 US$/tCO2. For the industrial, forestry, and energy suppy sectors, the potential is split into two categories: at costs below 20 US$/tCO2 and at 20-100 US$/tCO2.

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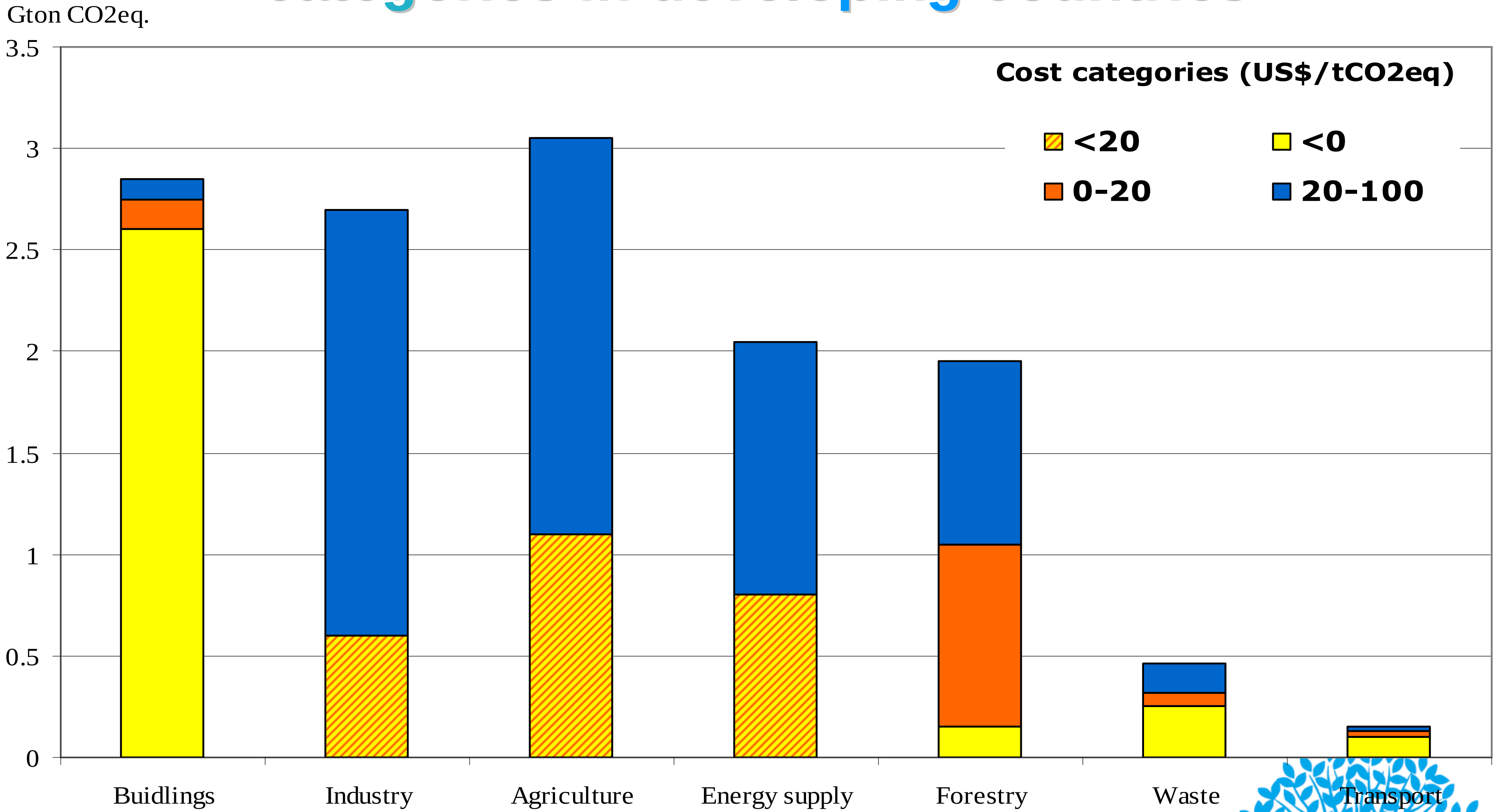
Estimated potential for GHG mitigation at a sectoral level in 2030 in different cost categories in developing countries

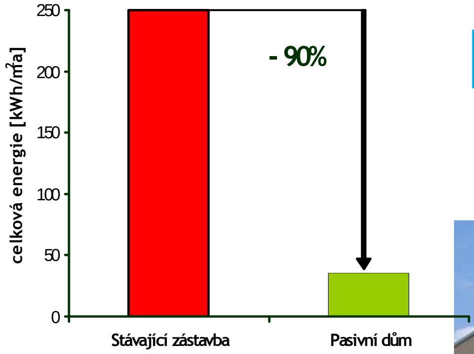


Constructed based on Chapter 11 results

How far can buildings take us?

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")



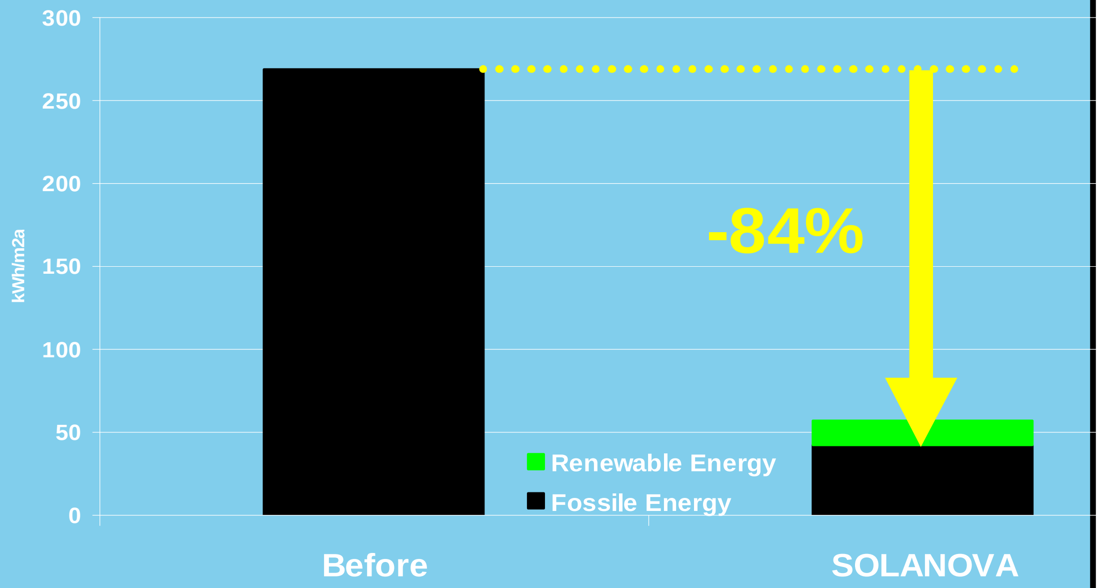






Source: Jan Barta, Center for Passive Buildings, www.pasivnidomy.cz

“EU buildings – a goldmine
for CO2 reductions, energy security, job creation and addressing low income population problems”



Source: Claude Turmes (MEP), Amsterdam Forum, 2006

More on Solanova: www.solanova.eu

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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)
- 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, led by the CEU, with co-funding from UNEP SBCI, reflect this new approach

Photos from Gunter Lang

The Global Energy Assessment: Background and purpose

- The Global Energy Assessment aims at providing (a) blueprint(s) for the world how energy-related social, environmental, geopolitical and other challenges can be addressed this century
- We all know that buildings are the key pillar to such a future, but **how much?**
- GEA constructs new scenarios (complementing IPCC-type scenarios) that attempt to take advantage of the really large and novel opportunities in buildings, hard-to-model by existing modeling frameworks

Main philosophy and assumptions

- Assumes that the world's building stock will transform over to today's known (and built) cutting edge in architecture
  - At the most affordable cost
  - At the natural rate of building construction and retrofit
  - Taking into account capacity and other limitations, but assuming ambitious and supportive (not financially but legally) policy environment.
- The main pillars of the model are existing best practices
  - Best practice from and energy and INVESTMENT COST perspective as well
- The world's building stock is broken down by regions, climate zones and 3 building types
- Model eradicates energy poverty well before 2050, i.e. everyone has appropriate thermal comfort energy services by 2050
- several scenarios planned:
  - Very high efficiency with different modalities; +building-integrated renewables; +behavioural change

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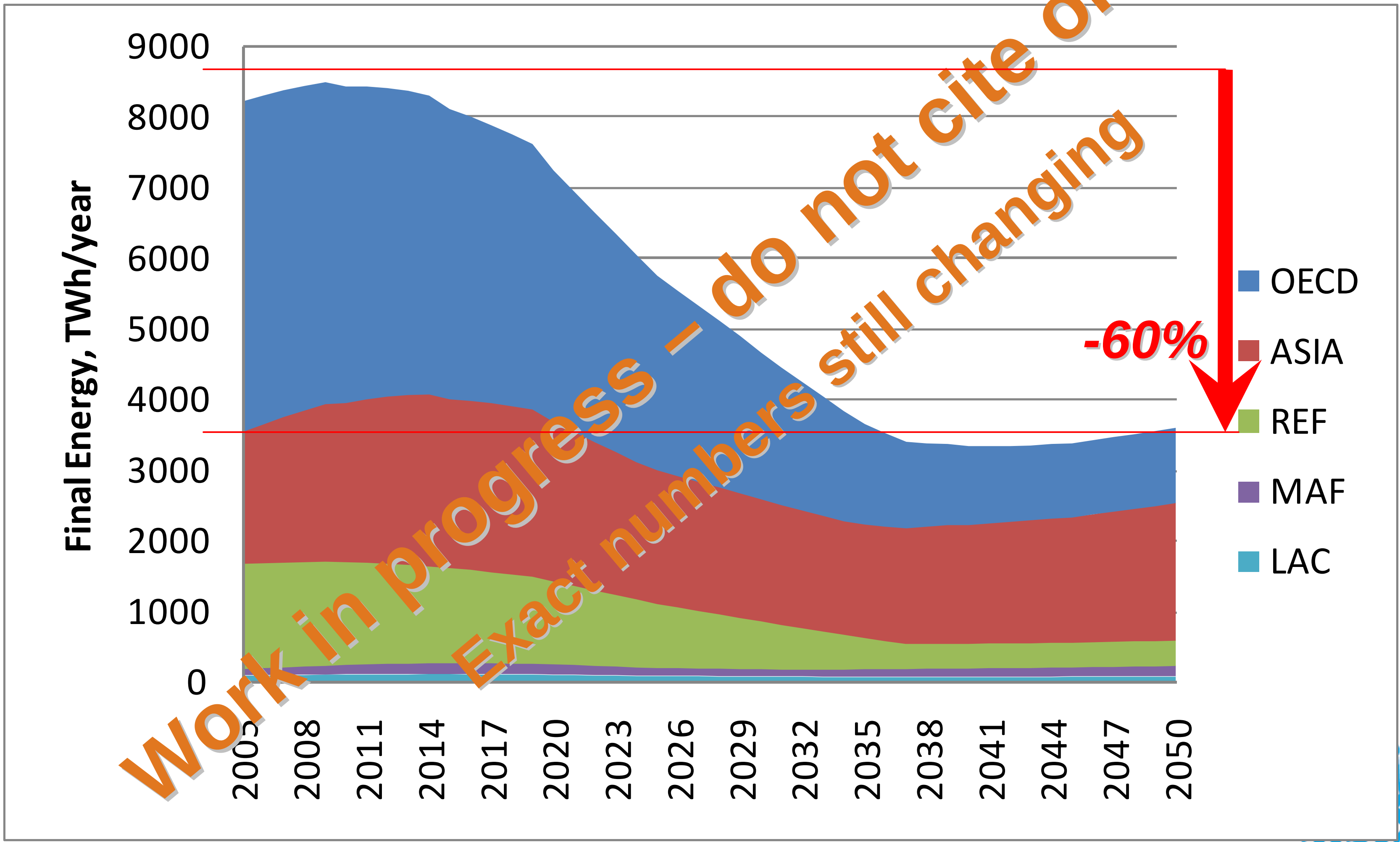
Final thermal energy consumption in the world's buildings, 2005-2050

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



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Opportunity or risk?

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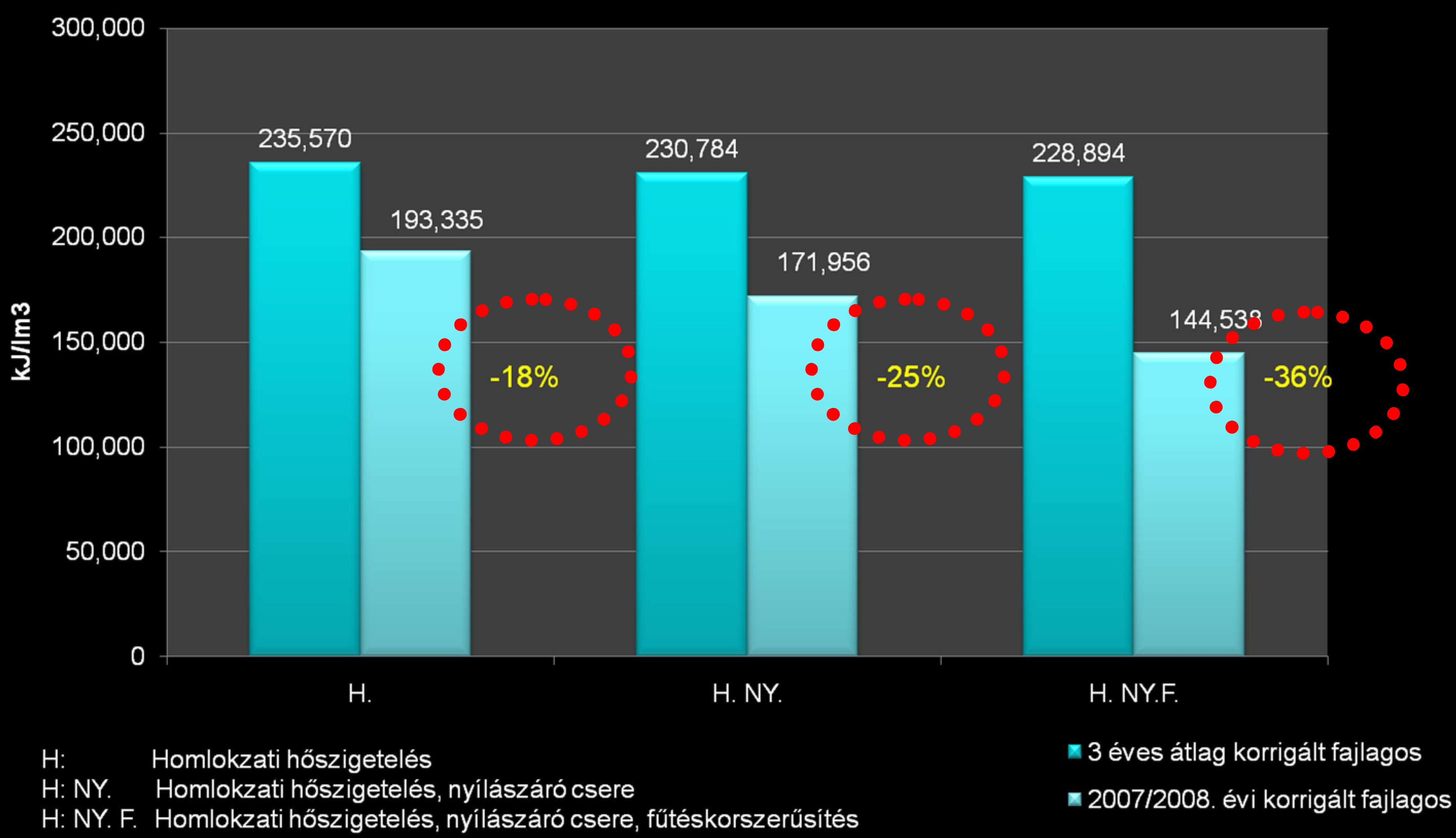
The size of the potential lock-in effect


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 Székesfehérvár



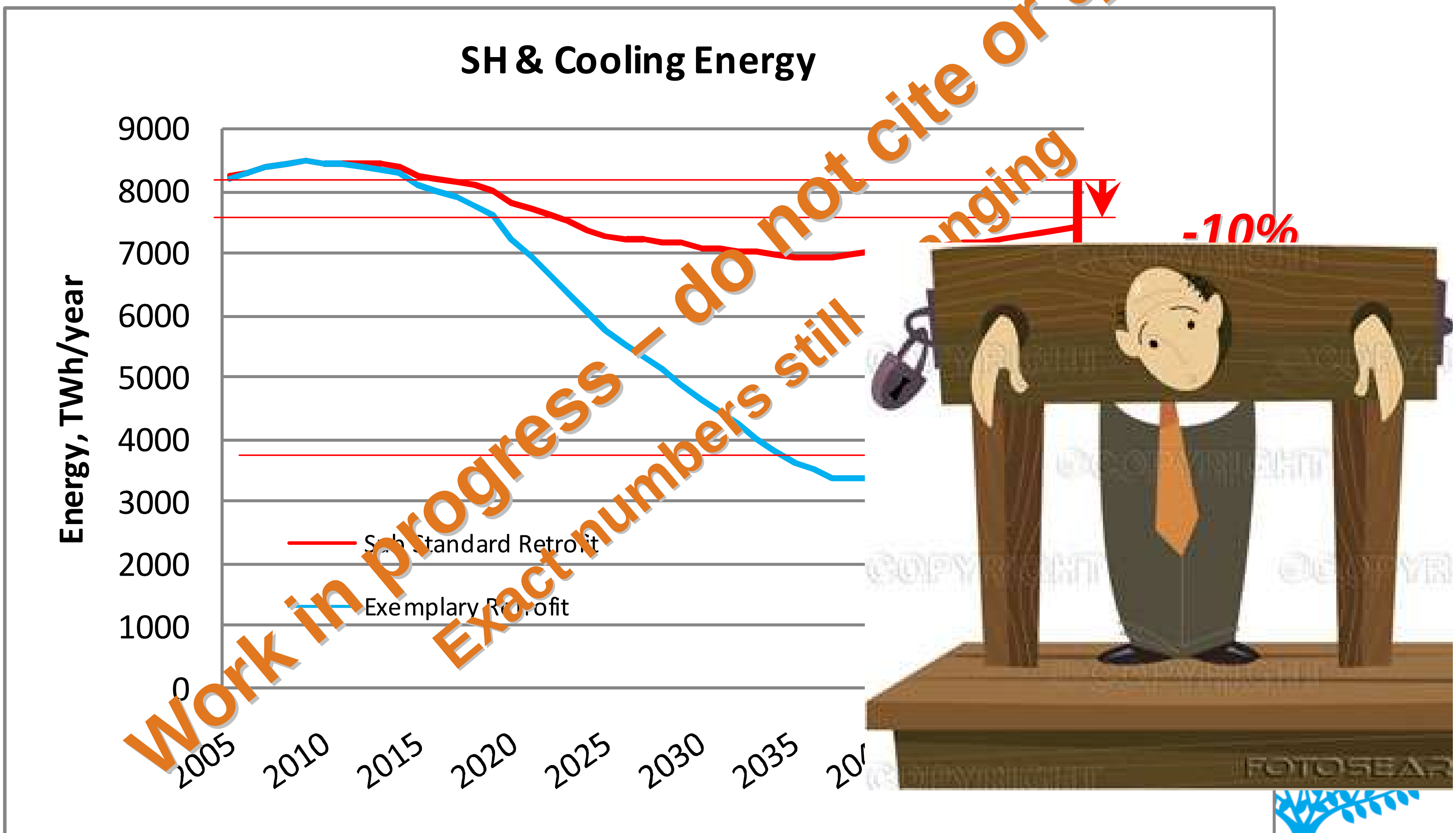
H: Homlokzati hőszigetelés
H: NY. Homlokzati hőszigetelés, nyílászáró csere
H: NY. F. Homlokzati hőszigetelés, nyílászáró csere, fűtéskorszerűsítés

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

UNEP SBCI
Sustainable Buildings & Climate Initiative

The lock-in effect

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



G E A

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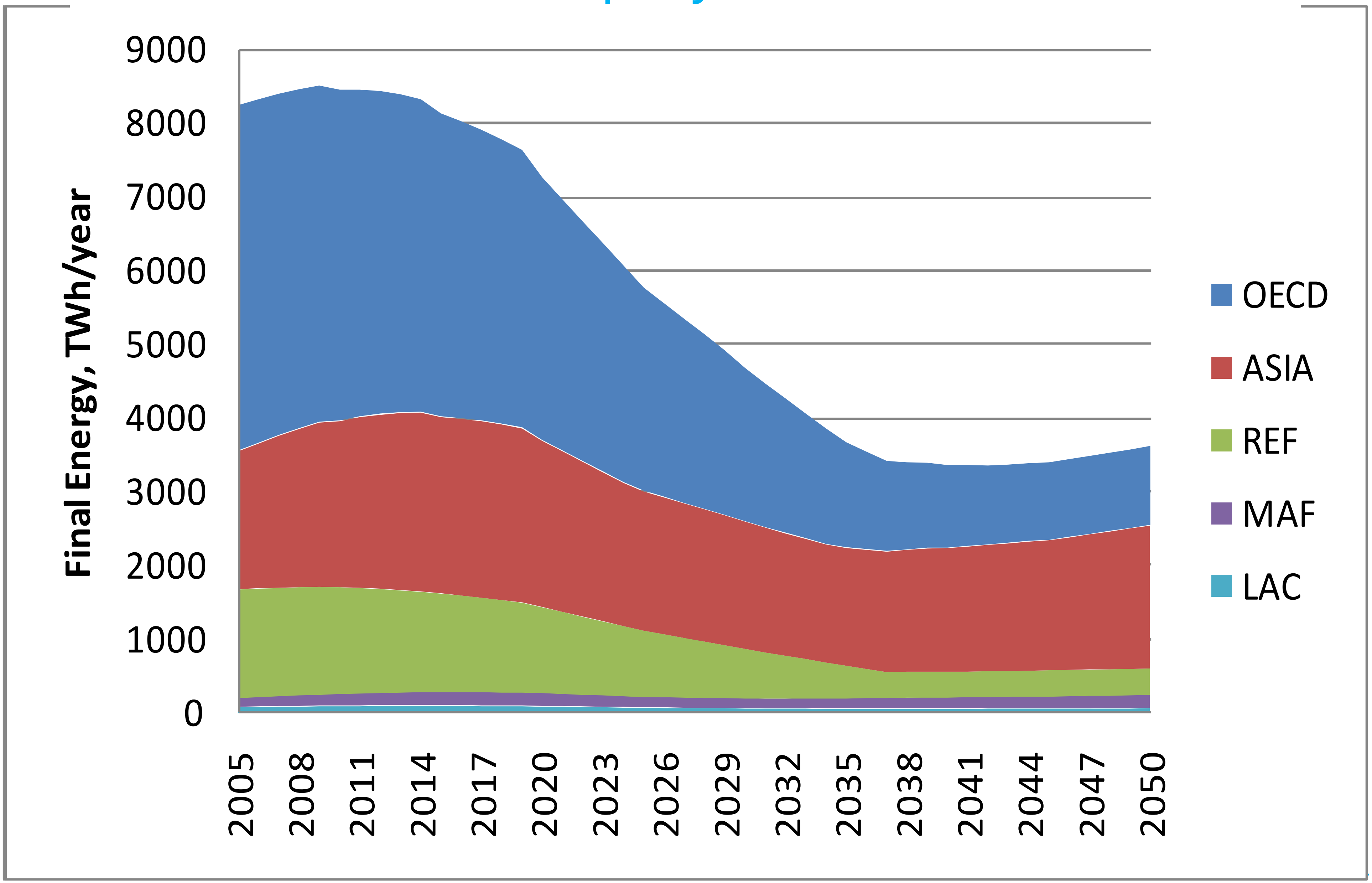
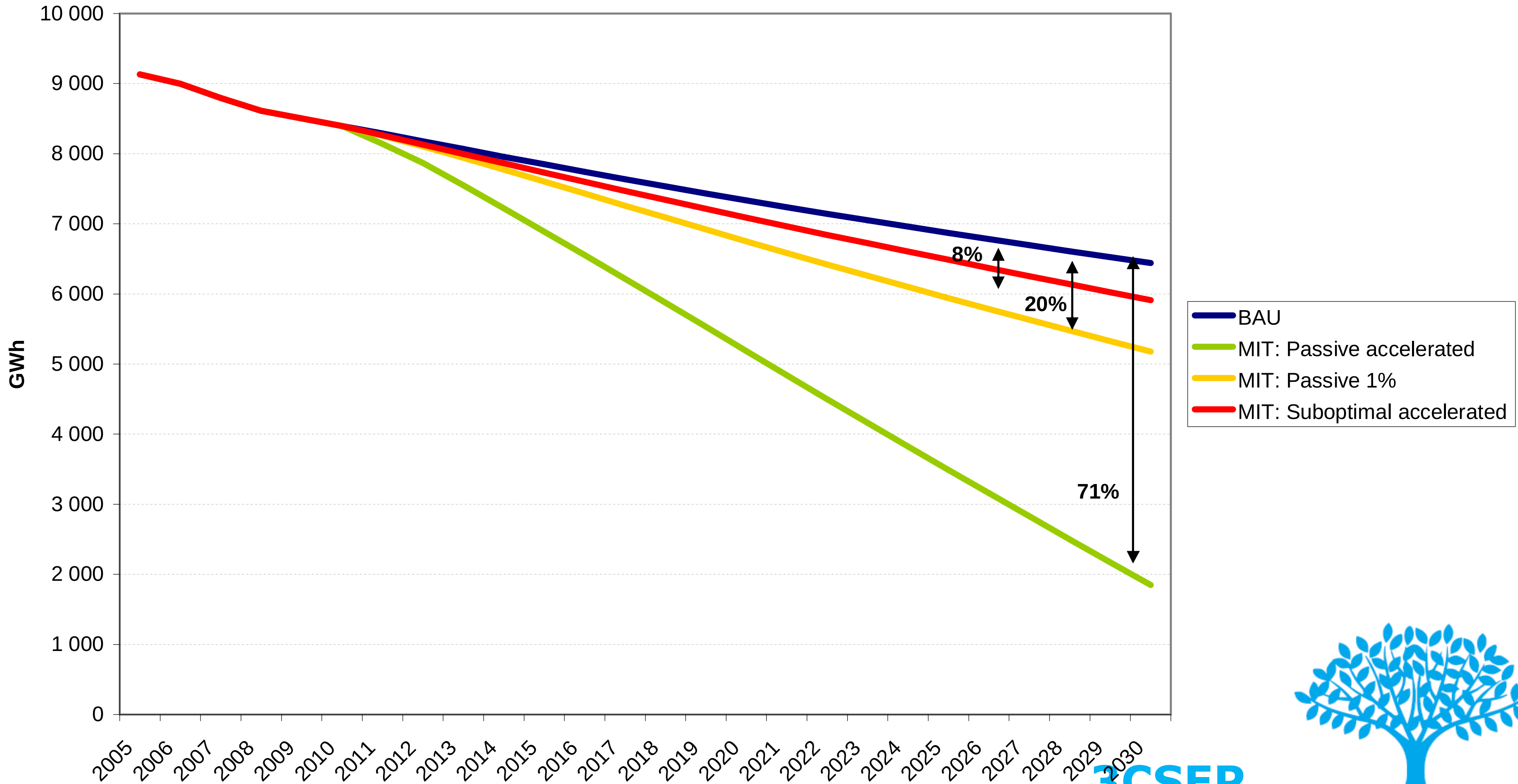
World Space Heating and Cooling Final Energy Exemplary Retrofit



The lock-in effect, case study

Heating energy use in Hungarian public buildings

Source: Katarina Korytarova, draft dissertation, 2009



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The free lunch we are paid to eat…

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Co-benefits of energy-efficient buildings

Investment needs vs. energy savings, realising mitigation potentials in the Hungarian residential sector

CO_2 mitigation cost category, EUR/tCO_2	Cumulative CO_2 mitigation potential		Investment needs 2008 – 2025, billion EUR	Saved energy costs 2008 – 2025, billion EUR
	% compared to baseline scenario	million tCO_2/yr		
< *0*	29,4%	5,1	9,6	17,1
0 – 20	33,4%	5,8	13,6	19,0

Forrás: CEU – KVVM 2008, Novikova and Urge-Vorsatz,
http://www.kvvm.hu/cimg/documents/Klimapolitika_tanulmany.pdf

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Perhaps the largest co-benefits among mitigation options

selected highlights

- (local) job creation: Danish study finds twice higher employment intensity than for other mitigation options
- Health: up to 2 million die due to poor indoor air quality
- Health: better buildings reduce flu by up to 20%, resulting in EUR 10 bln/yr savings in US alone

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Co-benefits of GHG mitigation through improved efficiency

- Co-benefits are often not quantified, monetized, or identified
- Overall value of co-benefits may be higher than value of energy savings
- A wide range of co-benefits, including:
- Improved energy security
  - “Cost effective EE measures in EU buildings like better insulation, glazing and more efficient lighting could deliver savings equivalent to 500 million cubic meters of gas per day.” [Eurima 2009] This is app. 5 times more than Nabucco will provide.
  - E.g. Nabucco’s €8 bln, South Stream > €10 bln. This could be sufficient to perform high-efficiency refurbishment of 2/3 of all buildings in Hu/Sk/Slo/Cz (@50% financing). [Eurima/Ecofy 2007]

Further key co-benefits (continued)

- **Improved social welfare**
  - “the direct cost of our inability to use energy efficiently amounts to more than 100 billion euros annually” [EC2006]
  - Fuel poverty: In the UK, about 20% of all households live in fuel poverty. The number of annual excess winter deaths is estimated at around 30 thousand”.
  - Energy-efficient household equipment and low-energy building design helps households cope with increasing energy tariffs
- **Employment creation**
  - “producing” energy through energy efficiency or renewables is more employment intensive than through traditional ways
  - a 20% reduction in EU energy consumption by 2020 can potentially create 1 mil new jobs in Europe
- **new business opportunities**
  - for developed countries a market opportunity of € 5–10 billion in energy service markets in Europe
- **Others:**
  - Improved productivity, improved competitiveness, reduced burden of constrained generation capacities, Increased value for real estate, Improved energy services (lighting, thermal comfort, etc) can improve productivity, Improved outdoor air quality, reduced congestion

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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

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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/m² 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/m² if ~214 m²/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/m²-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.

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: Physical indicator	Impact of CO_2 emission reduction: Monetary indicator	References
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 84% 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.

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Why isn't everyone eating the free lunches we are paid to eat?

1. You need to pre-pay for all your free lunches in the next ~20 years to get the money back
2. While benefits are also (one of the) most significant, the barriers to capturing these potentials are equally (most) significant
   - Split incentives (principle/agent barrier); mispriced energy and subsidies distorting a level playing field; lack of information/awareness/training/capacity; lack of (access to) financing; low priority; fragmented industry and decision-making processes; transaction costs
3. Without public policies creating a level playing field and making the financing available, the free lunches will remain uneaten – significant polic policy effort is needed to unlock the high potentials

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Challenges to realising the massive potentials

- Financial crisis: diversified energy options rely on high upfront investments and little (no) fuel costs -> financing is bigger challenge than for conventional systems
  - Obtaining financing for the average and low-income HHs is especially challenging
- However, energy infrastructure investments are expected to total > 20 trillion US$ globally until 2030. Redirecting some of these capital flows towards the demand-side could bring substantially higher economic benefits and cheaper mitigation
- Requires paradigm change in energy systems
  - Incremental improvements will not suffice
  - Shift from the supply-side to the demand-side
  - Reconceptualising energy as a service vs. a commodity
  - New business models are needed

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Financial crisis: show-stopper or opportunity? (cont'd)

- Crisis: (was) opportunity to rethink fundamentals of economy – incl. our energy systems
- Efficiency is the best public investment to invigorate economy and mitigate social impacts
- Many companies & residents rethink their own consumption patterns and cut wasteful practices
- May trigger the refocusing of corporations on new business models and fundamentally different business directions

Lessons for policy and financing

- Accessing the free lunch takes money (cover charge in the restaurant?)
- Significant investments are needed in the next few decades (could be as high as 1% GDP for 30 yrs)
  - but significant investments are planned on the supply side, too – is that the right target?
  - and the benefits outweigh the costs
- The payback/discount rate gap needs to be bridged by public money, esp. for the poor
- Are we spending EU money on the right thing?
  - Only 1.6% of EU Structural and Cohesion funds btwn 2000 – 2006 on efficiency

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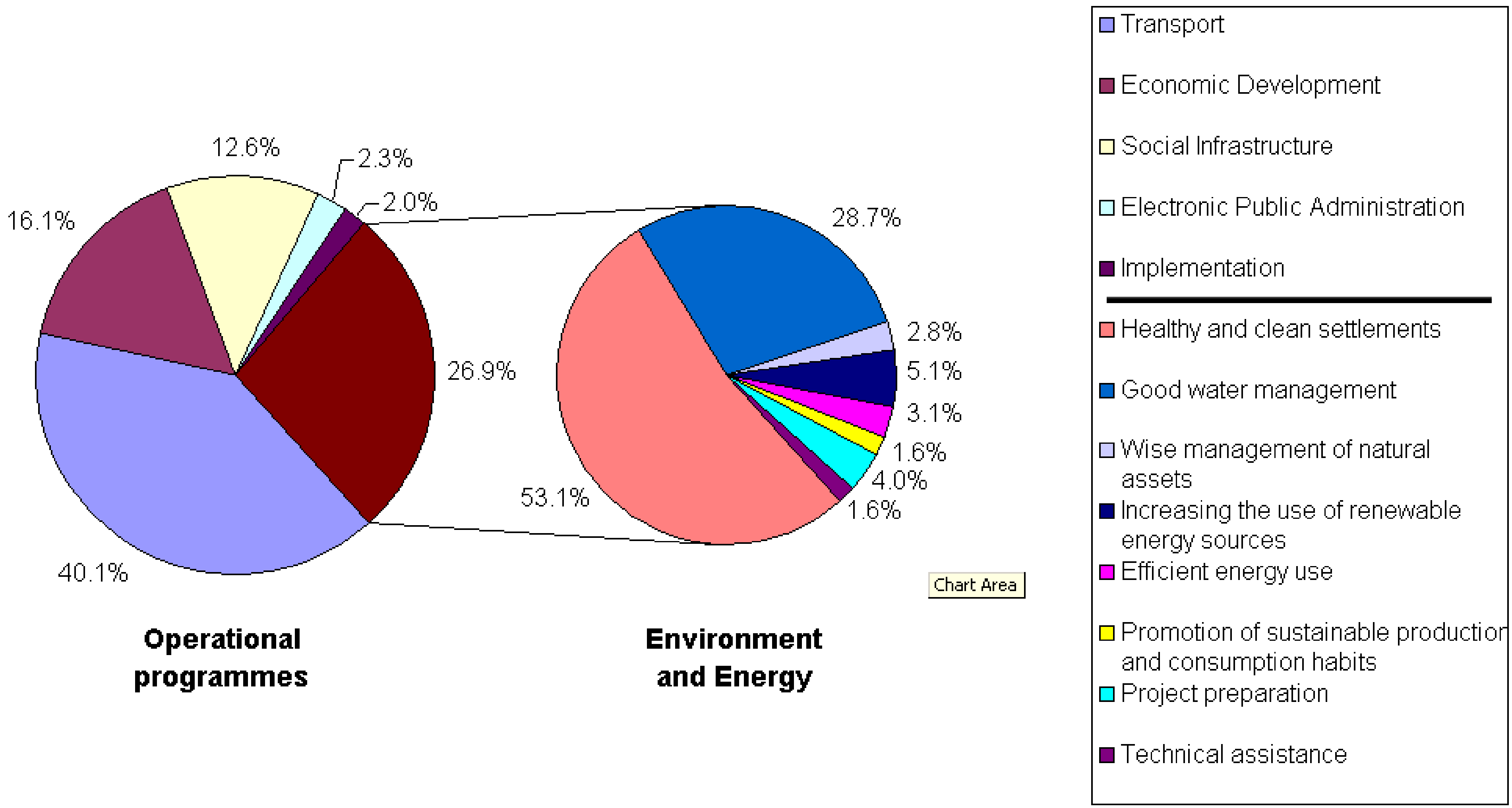
Distribution of Funding among Operational Programmes and among priorities within "Environment and Energy"



Lessons for policy and financing

- Accessing the free lunch takes money (cover charge in the restaurant?)
- Significant investments are needed in the next few decades (could be as high as 1% GDP for 30 yrs)
- The payback/discount rate gap needs to be bridged by public money, esp. for the poor
- Are we spending EU money on the right thing?
  - Only 1.6% of EU Structural and Cohesion funds btwn 2000 – 2006 on efficiency
  - Even in 2007 – 2013 it cannot exceed 4%
- One way or another, significantly more financing is needed to mobilise the major profits and unlock CO_2 potentials
- A fundamental reconceptualisation of energy from commodity to services maybe necessary to avoid global environmental catastrophies

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Conclusions

- Very low-energy buildings (retrofitted and new) are key to low-temperature climate stabilisation
- However, there is a significant lock-in risk with the present even advanced policies and trends
- There are significant co-benefits to mitigation through energy-efficient buildings
- However, there are also significant barriers, and thus the high potentials for these unique opportunities will not be unlocked without aggressive, concerted and cohesive public policies

“From today, each new building constructed in an energy-wasting manner or retrofited to a suboptimal level will lock us into a high climate-footprint future”

Thank you for your attention

CENTER FOR CLIMATE CHANGE
AND SUSTAINABLE ENERGY POLICY

CENTRAL EUROPEAN UNIVERSITY

Diana Ürge-Vorsatz Diana

Center for Climate Change and Sustainable Energy Policy (3CSEP), CEU

http://3csep.ceu.hu   www.globalenergyassessment.org

Email: vorsatzd@ceu.hu