Counting good: Quantifying the co-benefits of improved efficiency in buildings

CENTER FOR CLIMATE CHANGE AND SUSTAINABLE ENERGY POLICY

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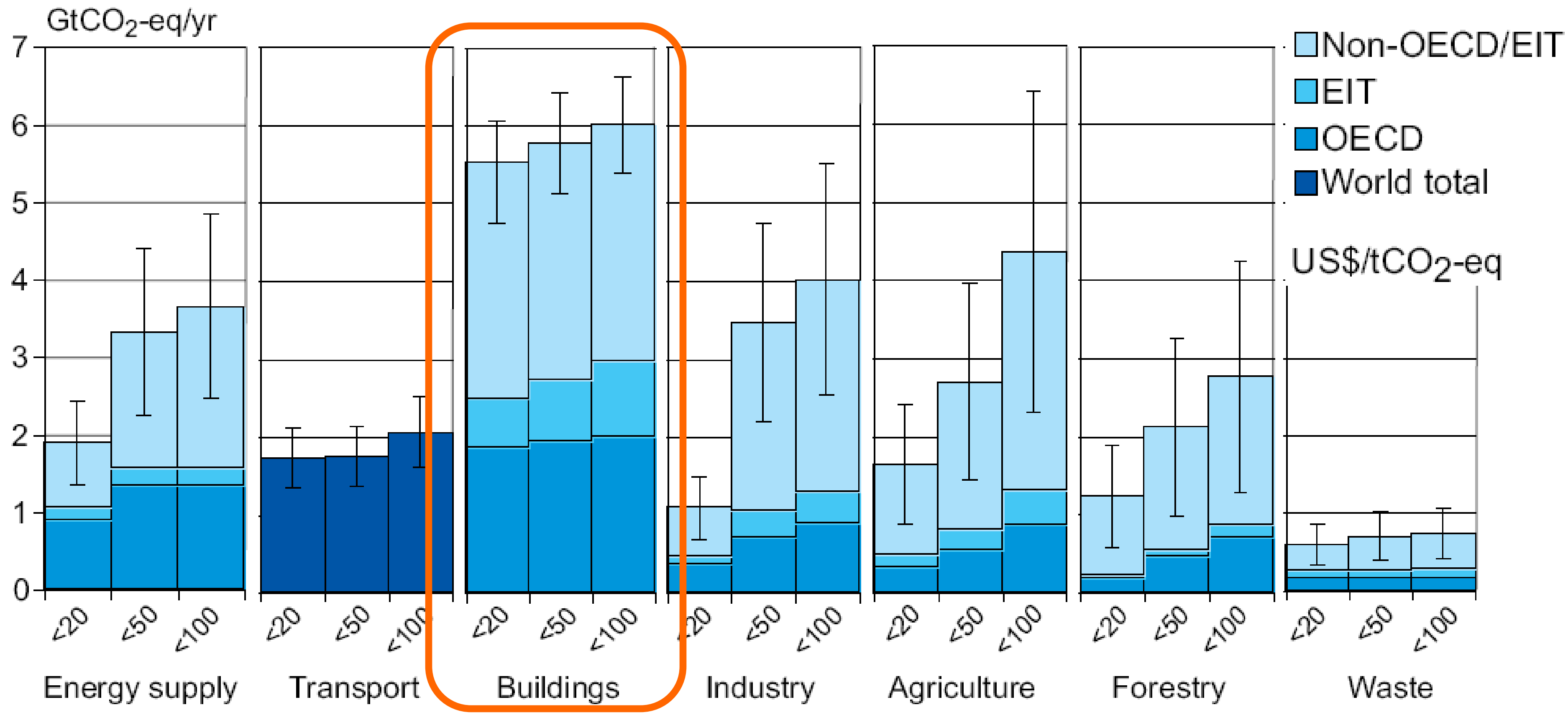
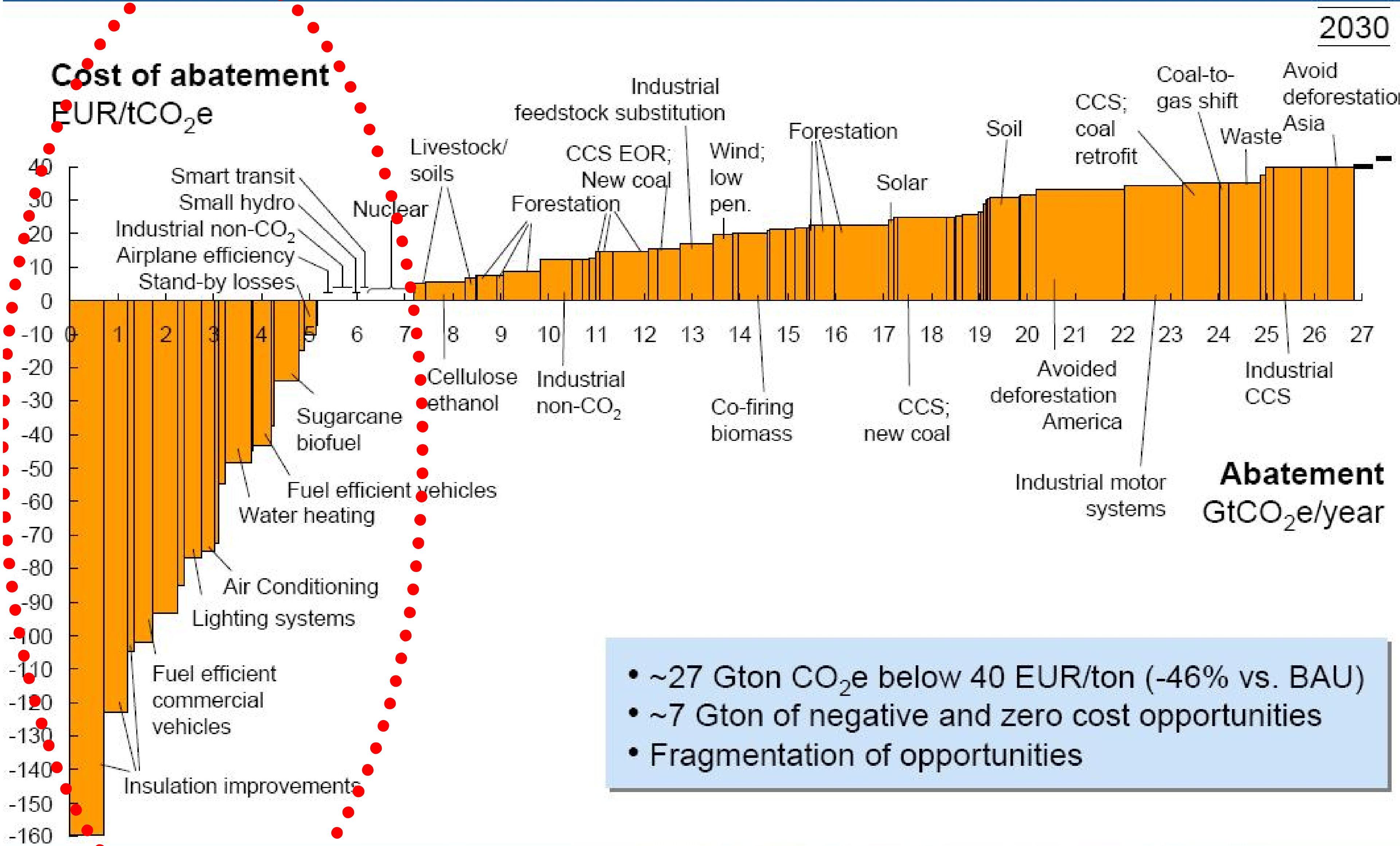
IPCC: The buildings sector offers the largest low-cost potential in all world regions by 2030



(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)*

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

Introduction and motivation

- EE investments can yield benefits beyond the value of saved energy and reduced emissions
- Total value of NEBs may exceed direct energy benefits in many cases
- However NEBs are rarely included in CBA of EE and CC mitigation projects
- Therefore, there is a need to quantify/monetize the NEBs, to enable their introduction into a more realistic energy- and climate-related decision-making

Outline

- Introduction and motivation
- Typologies of NEBs
- Review of worldwide case studies to quantify NEBs of building efficiency programs
- Suggested methodology for aggregation of NEBs
- Conclusions

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Typologies of NEBs

- Co-benefits vs. ancillary benefits (IPCC 2001, IPCC 2007)
- Very few explicit classifications of the NEBs exist
  - Davis et al. (2000): three categories - health, ecological, and economical co-benefits
  - IPCC (2007): similar to Davis et al., but also adding improved social welfare and poverty alleviation
- We suggest the following detailed typology for the NEBs:

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Suggested typology for non-energy benefits energy efficiency investments in buildings (1/3)

Category	Non-energy benefit subcategory	Examples of concrete benefits, and potential indicators for its quantification
Health effects[1]	Reduced mortality	Higher employment, more working days due to reduced mortality. Mortality is reduced through improved indoor and outdoor air pollution, and through reduced thermal stress in better buildings (hot and cold).
	Reduced morbidity	Avoided hospital admissions, medicines prescribed, restricted activity days, productivity loss. Morbidity is reduced through the impacts above, as well as through better lighting, mold abatement, thoughtful ergonomics etc.
	Reduced physiological effects	Learning and productivity benefits due to better concentration, savings due to avoided "sick building syndrome".
Ecological effects[2]	Reduction of indoor air pollution	Similar to reduced morbidity. Indoor air quality improves through the reduction of incompletely combusted fossil fuels and biomass, through better ventilation that eliminates gaseous wastes and toxic fumes from buildings materials and activities.
	Reduction of outdoor air pollution	Similar to reduced morbidity but this category is broader including, for instance, avoided damage to building constructions. Outdoor air pollution is brought down through reduced fossil fuel burning, the minimization of the heat island effect in warm periods through reduced local energy consumption, etc.
	Construction and demolition (C&D) waste reduction benefits	Waste rate reduced due to such a vital part of "green buildings" initiative as C&D waste management that includes carefully planned "reduction, reusing, and recycling waste generated from building construction, renovation, deconstruction, and demolition" as defined by the US Environmental Protection Agency.
	Increased urban vegetation	In the case of green roofs and walls.

Category	Non-energy benefit subcategory	Examples of concrete benefits, and potential indicators for its quantification
Economic effects	Lower energy prices[3]	Decrease in fuel and energy prices due to reduced energy demand driven by energy efficient measures implemented.
	Decreased energy bill payments	Lower energy consumption, on average, results in decreased payments for consumed energy.
	Higher lifetime earnings[4]	Higher salaries and, as a consequence, higher living standards.
	New business opportunities	New market niches for energy service companies (ESCOs) resulting in higher GDP growth.
	Employment creation	Reduced unemployment through hiring workers for ESCOs (as a consequence, reduced dole payments).
	Rate subsidies avoided[5]	Decrease in the number of subsidized units of energy sold. In most developing countries energy for the population is subsidized heavily. If energy is used more efficiently, substantial subsidies can be avoided.
	Lower bad debt write-off[6]	A decrease in the average size of bad debt written off and a decline in the number of such accounts due to reduced energy bills that become affordable for more households.
	Enhanced ability to rent out or sell energy-efficient space, higher price of real estate.	Higher real estate and rental prices due to the fact that a weatherized unit becomes more appealing with regard to its environmental and economic performance.
	Improved energy security	Reduced dependence on imported energy; reduced military spendings related to the securing of energy import sources.
	Avoided costs to support the human health, working environment, and building facilities[7]	Avoided costs of mortality, hospital admissions, medicines prescribed, restricted activity days, insurance costs, productivity loss, building maintenance.
	Improved productivity	GDP/income/profit generated as a consequence of new business opportunities and employment creation (see above).

Suggested typology for non-energy benefits energy efficiency investments in buildings (3/3)

Category	Non-energy benefit subcategory	Examples of concrete benefits, and potential indicators for its quantification
Service provision benefits	Transmission and distribution loss reduction[8]	Lower energy consumption caused by energy efficiency measures results in a smaller amount of energy (e.g,, electricity, gas) transported to the household; hence the elimination of energy losses.
	Fewer emergency (gas) service calls	Saving staff time and resources necessary for attending the emergency calls due to installation newer and more energy-efficient and reliable gas appliances.
	Utilities' insurance savings[9]	Decrease in the insurance costs of utility companies as a result of fewer gas leakages and faulty appliances (Schweitzer and Tonn 2002).
Social / political effects	Improved social welfare and fuel poverty alleviation[10]	Reduced expenditures on fuel and electricity; level of reduced fuel / electricity debt; changed number of inadequate energy service level related damages such as excess winter (or summer) deaths.
	Safety increase: fewer fires	Reduced number of fires and fire calls due to the renovation of HVAC – heating, ventilation and air-conditioning systems (fewer gas leaks, short circuits, etc.).
	Increased comfort	Normalizing of humidity and temperature indicators; air purity; reduced heat stress through reduced heat islands (less local energy consumption and evapotranspiration from urban greenery in case of green walls and roofs)
	Increased awareness	(Conscious) reductions in energy consumption resulting from installation of real-time pricing meters as a part of a "green building"; higher demand for energy efficiency measures due to a possible "keeping-up-with-the-Joneses" effect.
	Increased political popularity	Political leadership introducing wide-scale energy-efficiency measures benefiting the population have reportedly gained popularity and votes
	Benefits to disadvantaged social groups	With high-efficiency and clean cooking, African women and children can save the average of 8 km walking and several hours a day that they spend on firewood collection (Goldemberg 2000). Instead, children can go to school or women enter the workforce

Review of literature on NEBs (1)

- Over two dozen studies on NEB appraisal identified
- Typically physical impacts of emission reduction and EE are, first, quantified, and then the NEB is monetized
- We collected both values since assumptions for translating physical impacts into monetary ones vary with research method and geographic location; and can be controversial (e.g. value of life)

Review of literature on NEBs (2)

- Most extensively studied:
  - avoided morbidity and mortality
  - reduction of air pollution
  - productivity gains
- Under-researched:
  - improved energy security
  - induced technological change
- Few regions subject to quantitative research on CO2 mitigation co-benefits (USA, EU)
- Least researched NEBs - in developing countries and transitional economies

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General findings: co-benefits counted

- *Individual* co-benefits were often evaluated to amount to as much as 20 – 43% of energy savings
- The total value of NEBs (if estimated) often exceed the value of energy savings
- Katz (2005, 2006), O'Conor (2004), Platts Research and Consulting (2004), Hanushek (2005), Buckley et al. (2005), Paladino and Company (2005), Clinch and Healy (2001), Schweitzer and Tonn (2002), Fisk (2000a, 2000b), Heschong Mahone Group (1999), Menzies (1997), Federspiel (2002), Pape (1998), Shades of Green (2002) and others monetized these benefits in the range of **several million euros** and US$ in different countries, attaining **several percent of their national GDPs**

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

Suggested potential methodology for aggregation of NEBs

- Supply curve method might be used as follows
  - average cost of conserved energy:

$$AC_{it} = \frac{I_i \times a_i - \sum_{j=1}^{n} B_{itj}}{\Delta E_{it}} \qquad a_i = \frac{(1+DR)^{n_i} \times DR}{(1+DR)^{n_i} - 1}$$

where a_i is the annuity factor.

Quantifying co-benefits

$$B_{itj} = \Delta E_{ti} \cdot \alpha_{ij} \cdot P_{jt}$$

ΔE_{it} energy conserved in year t due to application of technology i

α_{ij} energy elasticity of co-benefit j due to application of technology i

P_{jt} a monetary estimate associated with a unit of co-benefit j in year t

- Example 1: co-benefit of CO2 savings

$$B_{i,CO_2,t} = \Delta E_{ti} \cdot EF_{i,CO_2} \cdot P_{CO_2,t}$$

$\Delta E_{i,CO2}$ – emission factor of fuel saved

$P_{CO2,t}$ – price of CO_2 in year t

- Example 2: co-benefit of reduced mortality

$$B_{i,Reduced\ Mortality,t} = \Delta E_{ti} \cdot \alpha_{i,Reduced\ Mortality} \cdot P_{Reduced\ Mortality,t}$$

$\alpha_{i,Reduced\ Mortality}$ – mortality avoided due to application of technology i per unit of energy saved

$P_{Value\ of\ Statistical\ Life,t}$ – estimated value of statistical life in year t

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Limitations

- Often not possible to entirely compartmentalise co-benefits
- Some overlap; sometimes one is the result of another (e.g., reduced air pollution and improved health), thus care is needed to avoid double-counting
- Monetising physical indicators of certain benefits (e.g., value of life, health, and comfort) is controversial as translational coefficients vary widely
- While the co-benefits are universal, their values are case- and geographic location-specific => hard to derive general regional, national or global policy-related conclusions

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Conclusions

- Many individual co-benefits amount to 20-43% of saved energy costs
- Largest financial value of NEBs as compared to the direct benefits – economic benefits estimated over the lifetime of a complex weatherization measures
- At least 9 groups of researchers monetize the value of single NEBs in the range of tens – hundreds of million EUR/yr in different countries, occasionally reaching billions
- corresponding to a few % of national GDPs
- A simplified methodology has been proposed for a zero-order incorporation of NEBs into CBA

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Thank you for your attention

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Some of these issues are also covered and updated in upcoming climate change special issue of “Energy Efficiency” journal





Additional slides

Center for Climate Change
and Sustainable Energy Policy

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Health co-benefits

- Might be considered the most important NEB at the global level for buildings related mitiation
- Include avoided morbidity and mortality, their influence on productivity and, consequently, on GDP growth
- A wealth of research on this NEB
- Examples:
  - in Ireland total mortality benefit of a 10-year proposed EE program estimated as US$ 2 billion undiscounted (Clinch and Healy 2000)

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Ecological co-benefits

- Often impact on cleaner indoor/outdoor air inseparable from health co-benefits (estimated mainly from two perspectives: better ventilation and clean-burning, more efficient stoves)
- Examples:
  - NPV of reduction in waste water and sewage over the lifetime of installed EE measures was up to $US 657 per participating hh (Schweitzer and Tonn 2002)

Service provision co-benefits

- EE improvement and emission reduction might provide some services at a higher quality:
  - transmission&distribution (T&D) loss reduction
  - fewer emergency (gas) service calls
  - utilities' insurance savings
- Examples:
  - T&D loss reduction ranges from US$ 33 to US$ 80 per participating hh (Schweitzer and Tonn 2002)
  - bill-related calls became less frequent, which amounts to savings about US$ 21.1/yr. and accounts for ca 7% of total annual energy savings (Stoecklein and Scumatz 2007)

Social/political effects

- Include improved social welfare and fuel poverty alleviation, safety increase (fewer fires), increased comfort, better awareness, increased political popularity, benefits to disadvantaged social groups
- Available estimations significantly vary in scope and size
- Examples:
  - cost-effective improvements in EE could cut utility costs by US$ 270-1,360/hh-yr (European Commission 2005)
  - after implementing a weatherization program comfort benefit amounts to ca US$ 140/hh-yr; accounting for 43% of total annual energy savings (Stoecklein and Scumatz 2007)

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