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Climate Change Mitigation in the Buildings Sector

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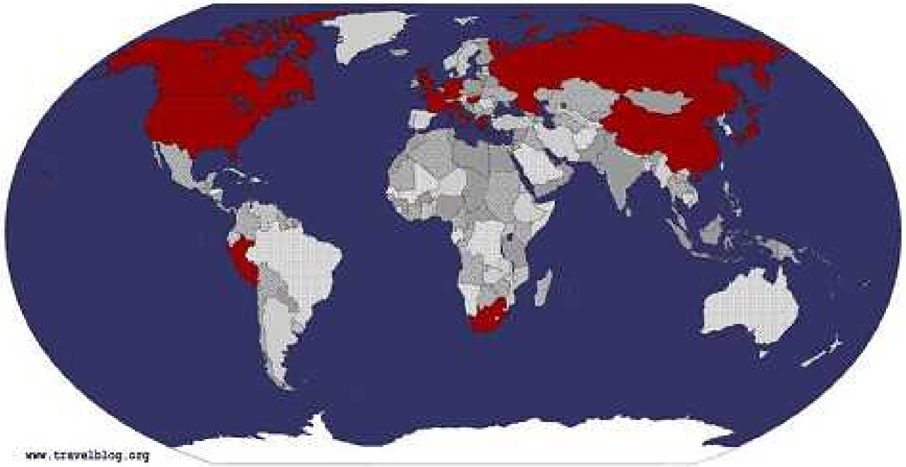
Acknowledgements: authors of Chapter 6



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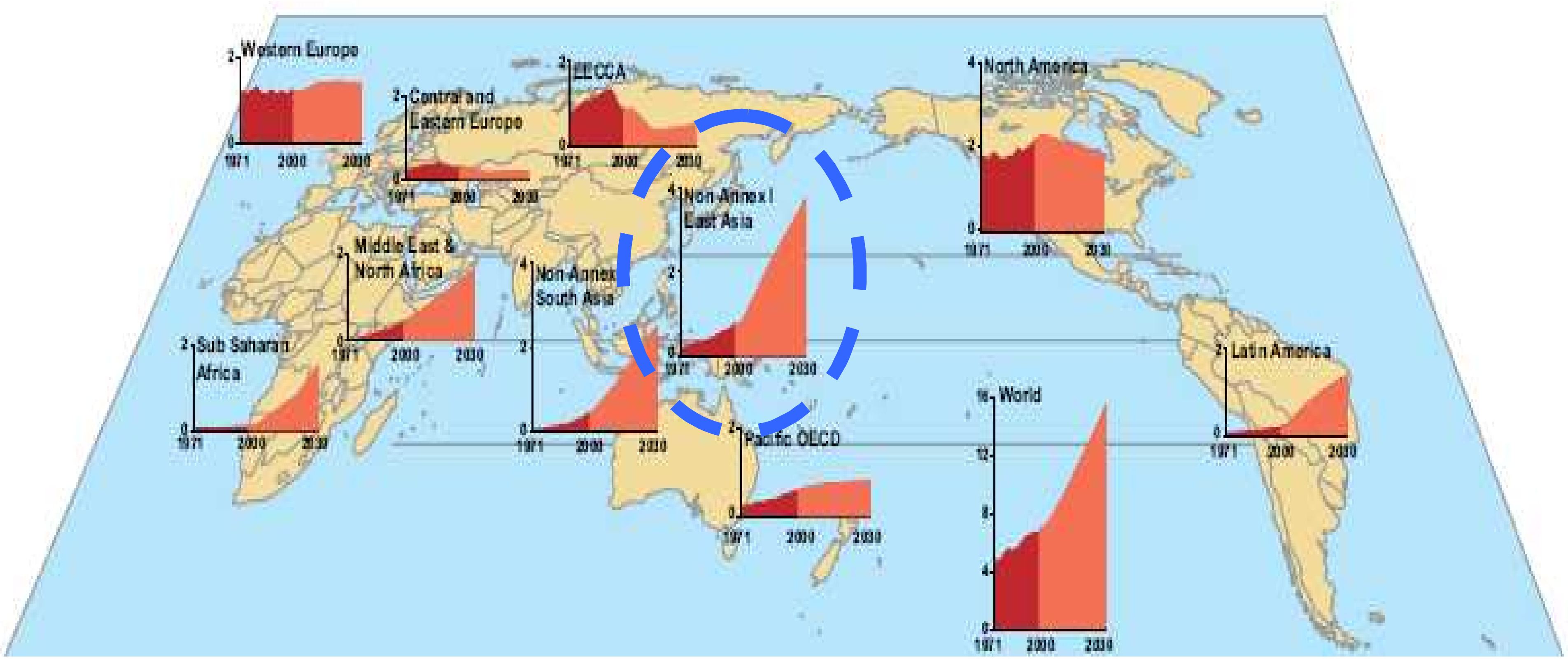
Outline

- ❖ Mitigation in the buildings sector: global and regional importance
- ❖ Potential and costs of GHG mitigation in buildings
- ❖ Co-benefits of GHG mitigation in bldgs
- ❖ Policies to foster carbon-efficiency buildings
- ❖ Conclusions

Buildings sector: global and regional importance

- In 2004, in Buildings were responsible for app. 1/3 of global CO_2 emissions



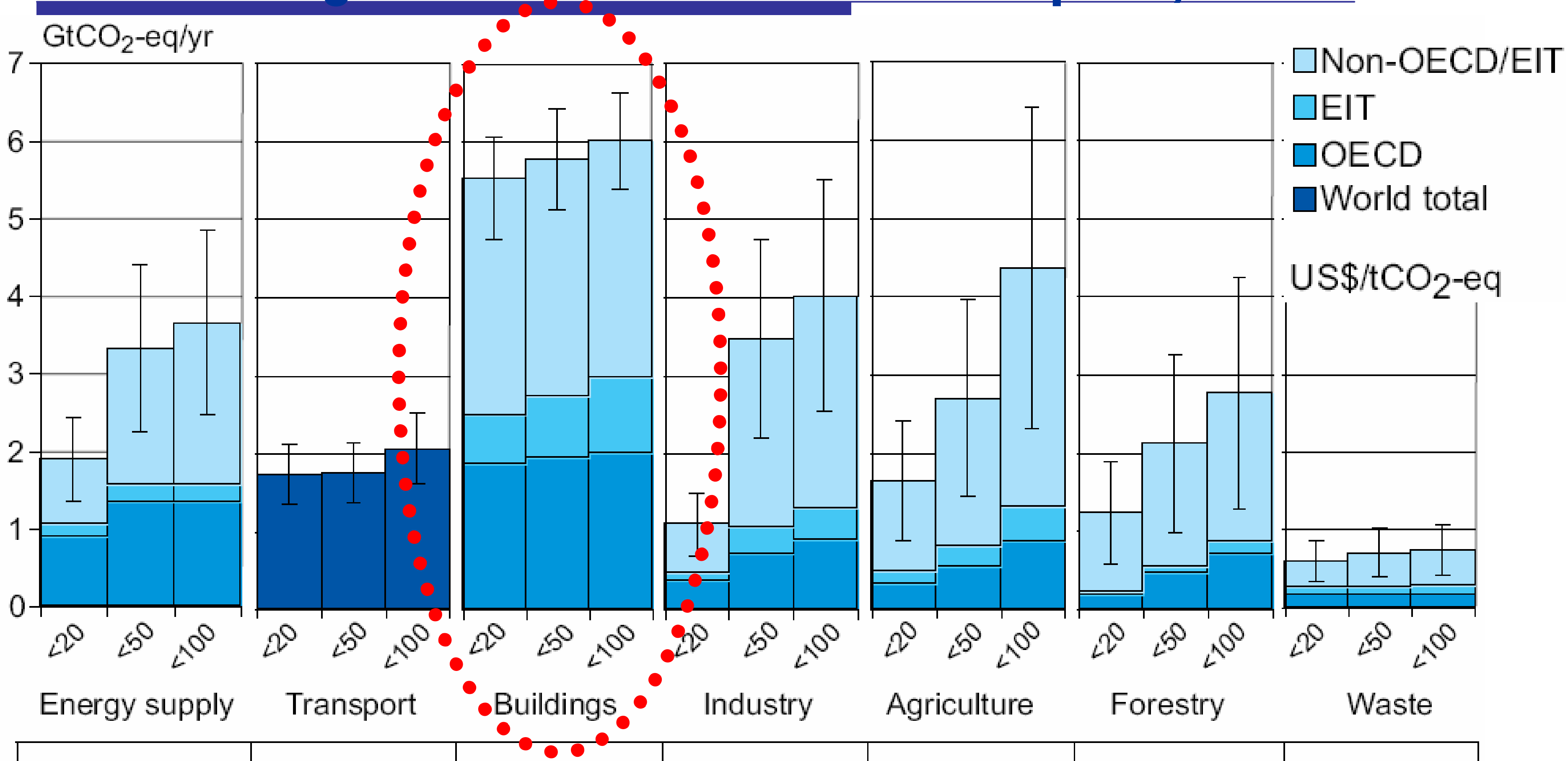
CO2 emissions including through the use of electricity
A1B scenario

Potential and costs of GHG mitigation in buildings

The importance of improved energy efficiency in GHG mitigation

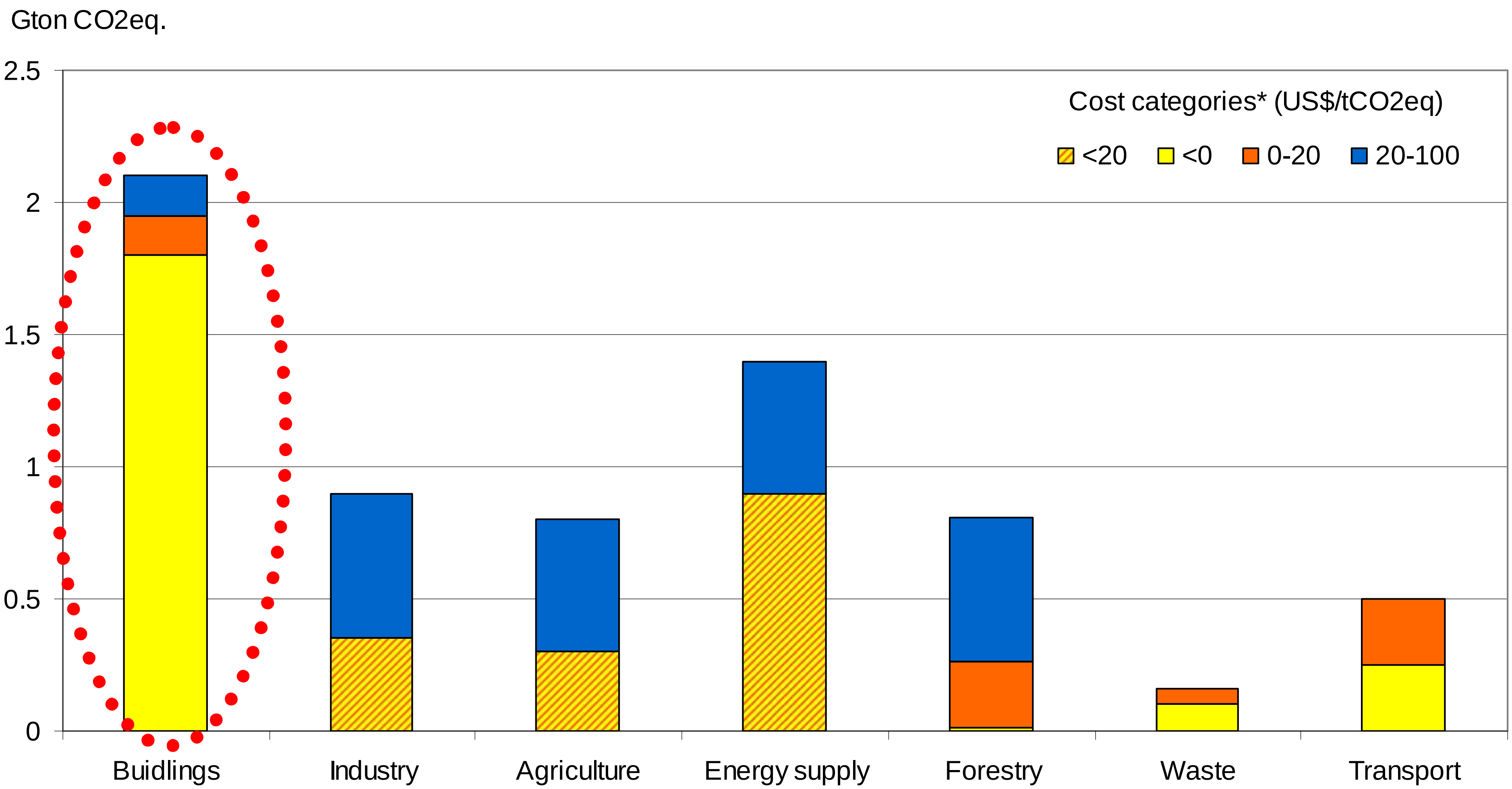
- Energy efficiency is one of the most important options to reduce GHG emissions worldwide in the short- to mid-term
- If costs are taken into account, improved building efficiency becomes the most important instrument in our mitigation portfolio in the short- to mid-term

Sectoral economic potential for global mitigation for different regions as a function of carbon price, 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 , developed countries



* 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.

Source: constructed based on the IPCC (2007)

Mitigation potential by country/region

(exert from Table 6.2)

Country/ region	Reference	Type of potential	Description of mitigation scenarios	Potential		Measures with lowest costs	Measures with highest potential	Notes
				Million tCO_2	Baseline (%)			
South Africa	De Villiers and Matibe, 2000 De Villiers, 2000	Technical	21 options: light practices; new & retrofits HVAC; stoves, thermal envelope; fuel switch in heaters; standards & labelling; for hot water: improved insulation, heat pumps, efficient use; solar heating.	41	23%	1. Energy star equipment; 2. Lighting retrofit; 3. New lighting systems.	1. Hybrid solar water heaters; 2. New building thermal design; 3. New HVAC systems.	[1] 6%; [4] Fr-ef.; [5] BY 2001; TY 2030.
		Economic		37	20%			
Croatia	UNFCCC NC1 of Croatia, 2001	Market	Electricity savings for not heating purposes (low energy bulbs, more efficient appliances, improved motors), solar energy use increase, thermal insulation improvement.	2	14%	1. Bulbs & appliances; 2. Solar energy use increase; 3. Insulation improvement	1. Insulation improvement; 2. Solar energy use increase; 3. Bulbs & appliances.	[1] n.a.
Studies providing information about both supply and demand-side options not separating them								
New EU Member States[a]	Lechtenboh-mer et al., 2005	Economic	Improvement in space and water heating, appliances and lighting, cooling/freezing, air-conditioning, cooking, motors, process heat, renewable energies, reduced emissions from electricity generation.	81	37%	n.a. (not listed in the study)	R: 1.Insulation; 2.Heating systems, fuel switch, DH&CHP; C: 1. Energy efficiency, 2. Renewables.	[1] 3-5%; [5] BY 2005; [7] C includes agriculture.
USA	Koomey et al., 2001	Market	Voluntary labelling, deployment programmes, building codes, new efficiency standards, government procurement, implementation of tax credits, expansion of cost-shared federal R&D expenditures.	898	37%	n.a. (The study did not examine a GHG potential supply cost curve).	1. Lighting; 2. Space cooling; 3.Space heating.	[1] 7%; [5] BY 1997.
Japan	Murakami et al., 2006	Technical	15 options: new and retrofit insulation, double glazing window, home appliances (water & space heating/cooling, lighting, cooking), PVs, solar heating, shift to energy efficient living style, low-carbon electricity generation.	46	28%	n.a. (not listed in the study)	1. Water heater; 2. Space heater; 3. Home appliances.	[1] n.a.; [7] R only.
Germany	Martinsen et al., 2002	Technical	Two options: fuel switch from coal and oil to natural gas and biomass and heat insulation.	31	26%	n.a. (not listed in the study)	1.Heat insulation; 2.Fuel switch from coal & oil to gas & biomass.	[1] n.a.; [5] BY 2002; [7] R only.

The importance of improved energy efficiency in GHG mitigation

- Energy efficiency is one of the most important options to reduce GHG emissions worldwide in the short- to mid-term
- If costs are taken into account, improved building efficiency becomes the most important instrument in our portfolio in the short- to mid-term
- Capturing *only the cost-effective potential in buildings* can supply app. 38% of total reduction needed in 2030 to keep us on a trajectory capping warming at 3°C
- New buildings can achieve the largest savings
  - As much as 80% of the operational costs of standard new buildings can be saved through integrated design principles
  - Often at no or little extra cost
  - Hi-efficiency renovation is more costly, but possible
- The majority of technologies and know-how are widely available

Applicability of energy efficiency technologies in different regions 1.

Selected illustrative technologies, emphasis on advanced systems, the rating of which is different between countries

Energy efficiency or emission reduction technology	Developing countries						OECD						Economies in transition, Continental		
	Cold climate			Warm climate			Cold climate			Warm climate					
	Technology stage	Cost/ effectiveness	Appropri-ateness	Technology stage	Cost/ effectiveness	Appropri-ateness	Technology stage	Cost/ effectiveness	Appropri-ateness	Technology stage	Cost/ effectiveness	Appropri-ateness	Technology stage	Cost/ effectiveness	Appropri-ateness
Structural insulation panels	⬤	⬤	⬤	●	●	•	⬤	●	●	●	●	●	●	⬤	⬤
Multiple glazing layers	⬤	⬤	⬤	⬤	●	• [1] ● [2]	~	⬤	⬤	⬤	⬤	●	⬤	⬤	⬤
Passive solar heating	⬤	●	●	⬤	●	•	⬤	●	⬤	⬤	●	●	⬤	●	⬤
Heat pumps	● [3]	•	•	● ⬤ [4]	• [5] ● [6]	• [7] ● [8]	⬤ [9]	●	●	~ [10] ⬤ [11]	● [12] ⬤ [13]	● [14] ⬤ [15]	⬤ [16]	●	●
Biomass derived liquid fuel stove	⬤	●	⬤	●	•	•	~	●	⬤	~	●	•	~	⬤	⬤
High-reflectivity bldg. materials	•	•	•	●	⬤	●	⬤	●	●	~	●	⬤	⬤	●	●
Thermal mass to minimize daytime interior temperature peaks	~	⬤	●	~	⬤	• [17] ⬤ [18]	~	⬤	●	~	⬤	• [19] ⬤ [20]	~	⬤	⬤
Direct evaporative cooler	•	•	•	~	⬤	• [21] ⬤ [22]	•	•	•	~	⬤	• [23] ⬤ [24]	•	•	•
Solar thermal water heater	~	⬤	⬤	⬤	⬤	⬤	~	⬤	⬤	~	⬤	⬤	~	⬤	⬤

Visual representation	Stage of technology	Cost/Effectiveness	Appropriateness
•	Research phase (including laboratory and development) [R]	Expensive/Not effective [$$/-]	Not appropriate {-}
●	Demonstration phase [D]	Expensive/Effective [$$/+]	Appropriate {+}
⬤	Economically feasible under specific conditions [E]	Cheap/Effective [$/+]	Highly appropriate {++}
~	Mature Market (widespread commercially available without specific governmental support) {M}	'~' Not available	'~' Not available
µ	No Mature Market (not necessarily available/not necessarily mature market)		

Applicability of energy efficiency technologies in different regions 2.

Selected illustrative technologies, emphasis on advanced systems, the rating of which is different between countries

Energy efficiency or emission reduction technology	Developing countries						OECD						Economies in transition, Continental		
	Cold climate			Warm climate			Cold climate			Warm climate					
	Technology stage	Cost/ effectiveness	Appropri-ateness	Technology stage	Cost/ effectiveness	Appropri-ateness	Technology stage	Cost/ effectiveness	Appropri-ateness	Technology stage	Cost/ effectiveness	Appropri-ateness	Technology stage	Cost/ effectiveness	Appropri-ateness
Cogeneration	●	•	•	•	·	·	~	•	●	~	•	•	●	•	●
District heating & cooling system	●	•	•	·	·	·	~	•	●	●	•	•	●	•	●
PV	●	•	•	·	·	·	~	•	●	●	•	•	●	•	•
Air to air heat exchanger	●	•	●	●	•	●	●	●	●	●	●	●	●	•	●
High efficiency lightning (FL)	~	•	●	~	•	●	μ	·	●	μ	·	●	●	•	●
High efficiency lightning (LED)	~	·	●	~	·	●	·	·	●	·	·	●	·	•	●
HC-based domestic refridgerator	•	•	●	•	•	●	~	●	●	●	•	·[25] ●[26]	●	•	●
HC or CO_2 air conditioners	·	~	μ	·	~	μ	·	•	•	·	·	μ[27] •[28]	·	~	•
Advance supermarket technologies	·	●	●	·	●	●	~	●	●	•	●	●	•	●	●
Variable speed drives for pumps and fans	~	•	•	~	•	•	~	•	•	~	•	•	~	•	•
Advanced control system based on BEMS	●	•	•	●	•	•	●	•	•	●	•	•	●	•	•

Notes:
[1] For heat block type; [2] For Low-E; [3] Limited to ground heat source etc.; [4] For air conditioning; [5] For hot water; [6] For cooling; [7] For hot water; [8] For cooling; [9] Limited to ground heat source, etc.; [10] For cooling; [11] For hot water; [12] For hot water; [13] For cooling; [14] For hot water; [15] For cooling; [16] Limited to ground heat source, etc.; [17] In high humidity region; [18] In arid region; [19] In high humidity region; [20] In arid region; [21] In high humidity region; [22] In arid region; [23] In high humidity region; [24] In arid region; [25] United States; [26] South European Union; [27] United States; [28] South European Union.

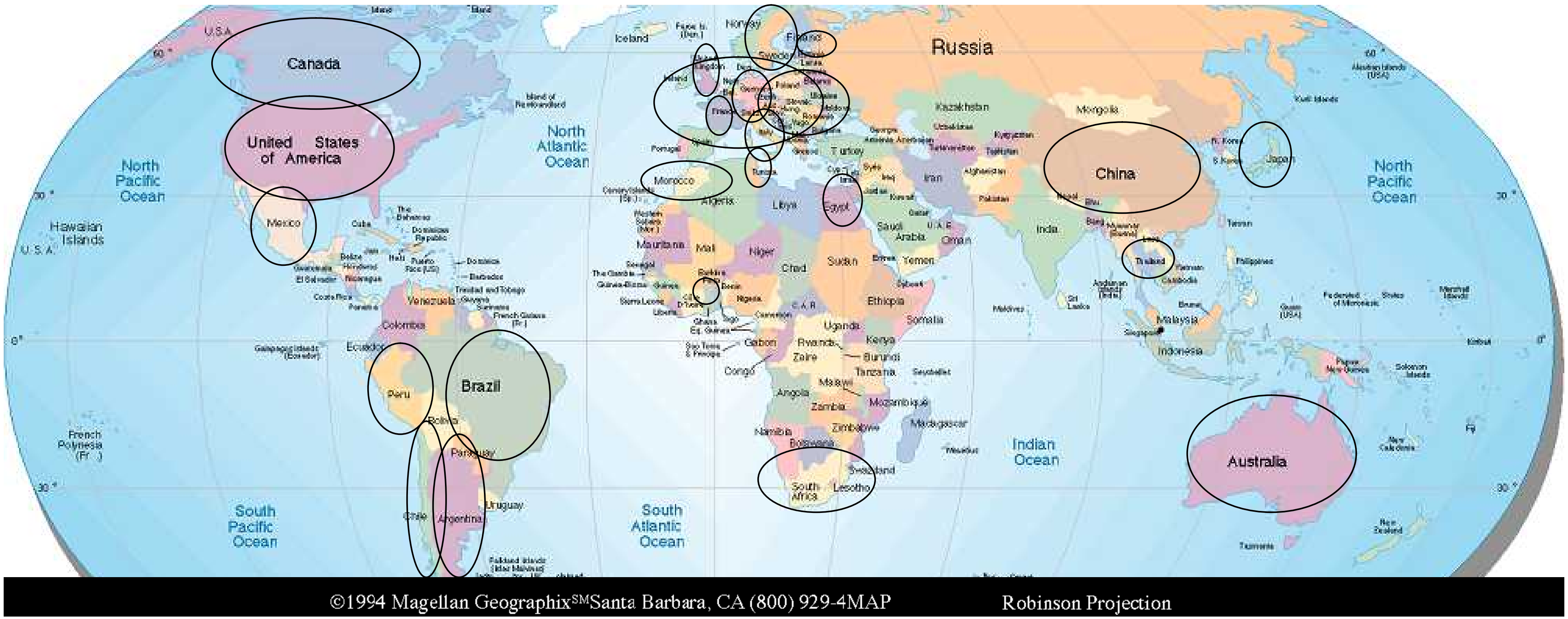
Co-benefits of improved energy-efficiency in buildings

- co-benefits are especially abundant and strong in the buildings sector
- Co-benefits are often not quantified, monetized, or even identified by the decision-makers
- The overall financial value of co-benefits may be higher than the value of the energy savings benefits
- Selected co-benefits include:
    - Employment creation
    - new business opportunities
    - improved competitiveness and productivity
    - Improved energy security
    - reduced burden of constrained energy generation capacities
    - Increased value for real estate
    - Improved social welfare, reduced fuel poverty
    - Improved air quality (both indoor and outdoor)

Policies to foster GHG mitigation in buildings

Background: case studies reviewed

- Which policies achieve high energy savings and GHG reductions? Which are very cost-effective? What are the success factors?
- Over 80 studies were reviewed from over 52 countries



The impact and effectiveness of various policy instruments
Part 1: Control and regulatory mechanisms- normative instruments

Policy instrument	Country examples	Effec-tiveness	Energy or emission reductions for selected best practices	Cost-effectiveness	Cost of GHG emission reduction for selected best practices	Special conditions for success, major strengths and limitations, co-benefits
Appliance standards	EU, US, JP, AUS, Br, Cn	**High**	Jp: 31 M tCO_2 in 2010; Cn: 250 Mt CO_2 in 10 yrs US: 1990-1997: 108 Mt CO2eq, in 2000: 65MtCO_2 = 2.5% of el.use, Can: 8 MtCO_2 in total by 2010, Br: 0.38 MtCO_2/year AUS: 7.9 MtCO_2 by 2010	**High**	AUS: -52 \$/tCO_2 in 2020, US: -65 \$/tCO_2 in 2020; EU: -194 \$/tCO_2 in 2020 Mar: 0.008 \$/kWh	Factors for success: periodical update of standards, independent control, information, communication and education
Building codes	SG, Phil, Alg, Egy, US, UK, Cn, EU	**High**	HkG: 1% of total el.saved US: 79.6 M tCO_2 in 2000; EU: 35-45 MtCO_2, up to 60% savings for new bdgs UK: 2.88 MtCO_2 by 2010, 7% less en use in houses 14% with grants& labelling Cn: 15-20% of energy saved in urban regions	**Medium**	NL: from -189 \$/tCO_2 to -5 \$/tCO_2 for endusers, 46-109 \$/tCO_2 for Society	No incentive to improve beyond target. Only effective if enforced
Procurement regulations	US, EU, Cn, Mex, Kor, Jp	**High**	Mex: 4 cities saved 3.3 ktCO_2eq. in 1 year Ch: 3.6Mt CO_2 expected EU: 20-44MtCO_2 potential US:9-31Mt CO_2 in 2010	**High/ Medium**	Mex: \$1Million in purchases saves \$726,000/year; EU: <21\$/tCO_2	Factors for success: Enabling legislation, energy efficiency labelling and testing. Energy efficiency specifications need to be ambitious.
Energy efficiency obligations and quotas	UK, Be, Fr, I, Dk, Ir	**High**	UK: 2.6 M tCO_2/yr	**High**	Flanders: -216\$/tCO_2 for households, -60 \$/tCO_2 for other sector in 2003. UK: -139 \$ /tCO_2	Continuous improvements necessary: new energy efficiency measures, short term incentives to transform markets

The impact and effectiveness of various policy instruments
Part 2: Regulatory- informative instruments

Policy instrument	Country examples	Effec-tiveness	Energy or emission reductions for selected best practices	Cost-effectiveness	Cost of GHG emission reduction for selected best practices	Special conditions for success, major strengths and limitations, co-benefits
Mandatory labelling and certification programs	US, Jp, CAN, Cn, AUS, Cr, EU, Mex, SA	**High**	AUS: 5 Mt CO_2 savings 1992-2000, 81Mt CO_2 2000-2015, SA: 480kt/yr Dk: 3.568Mt CO_2	**High**	AUS:-30$/t CO_2 abated	Effectiveness can be boosted by combination with other instrument, and regular updates.
Mandatory audit programs	US; Fr, NZL, Egy, AUS, Cz	**High, variable**	US: Weatherisation program: 22% saved in weatherized households after audits (30% according to IEA)	**Medium/ High**	US Weatherisation program: BC-ratio: 2.4	Most effective if combined with other measures such as financial incentives, regular updates, Stakeholder involvement in supervisory systems
Utility demand-side management programs	US, Sw, Dk, Nl, De, Aut	**High**	US : 36.7 MtCO2in 2000, Jamaica: 13 GWh/ year, 4.9% less el use = 10.8 ktCO2 Dk: 0.8 MtCO2 Tha: 5.2 % of annual el sales 1996-2006	**High**	EU: - 255$/tCO2 Dk: -209.3 $/tCO2 US: Average costs app. -35 $/tCO2 Tha: 0.013 $/kWh	More cost-effective in the commercial sector than in residences, success factors: combination with regulatory incentives, adaptation to local needs & market research, clear objectives

The impact and effectiveness of various policy instruments
Part 3: Economic and market-based instruments

Policy instrument	Country examples	Effec-tiveness	Energy or emission reductions for selected best practices	Cost-effectiveness	Cost of GHG emission reduction for selected best practices	Special conditions for success, major strengths and limitations, co-benefits
Energy performance contracting/ ESCO support	De, Aut, Fr, Swe, Fi, US, Jp, Hu	**High**	Fr, S, US, Fi: 20-40% of buildings energy saved; EU:40-55MtCO_2 by 2010 US: 3.2 MtCO_2/yr Cn: 34 MtCO_2	**Medium / High**	EU: mostly at no cost, rest at <22$/t$CO_2$; US: Public sector: B/C ratio 1.6, Priv. sector: 2.1	Strength: no need for public spending or market intervention, co-benefit of improved competitiveness.
Cooperative/ technology procurement	De, It, Sk, UK, Swe, Aut, Ir, US,Jp	**High/Medium**	US: 96 ktCO_2 German telecom company: up to 60% energy savings for specific units	**Medium /High**	US: - 118 $/ t$CO_2$ Swe: 0.11$/kWh (BELOK)	Combination with standards and labelling, choose products with technical and market potential
Energy efficiency certificate schemes	It, Fr	**High**	I: 1.3 MtCO_2 in 2006, 3.64 Mt CO_2 eq by 2009 expected	**High**	Fr: 0.011 $/t$CO_2$ estimated	No long-term experience. Transaction costs can be high. Adv. Institutional structures needed. Profound inter-actions with existing policies. Benefits for employment.
Kyoto Protocol flexible mechanisms	Cn, Tha, CEE (JI &AIJ)	**Low**	CEE: 220 K tCO2 in 2000 Estonia: 3.8-4.6 kt CO_2 (3 projects) Latvia: 830-1430 tCO_2	**Low**	CEE: 63 $/t$CO_2$ Estonia: 41-57$/t$CO_2$ Latvia: -10$/t$CO_2$	So far limited number of CDM &JI projects in buildings. Success factors: Project bundling, Information & awareness campaigns, link to GIS

The impact and effectiveness of various policy instruments
Part 4: Fiscal instruments and incentives

Policy instrument	Country examples	Effec-tiveness	Energy or emission reductions for selected best practices	Cost-effectiveness	Cost of GHG emission reduction for selected best practices	Special conditions for success, major strengths and limitations, co-benefits
Taxation (on CO2 or household fuels)	Nor, De UK, NL, Dk, Sw	**Low/Medium**	De: household consumption reduced by 0.9 % 2003: 1.5 MtCO2 in total Nor: 0.1-0.5% 1987-1991 NL:0.5-0.7 MtCO2 in 2000 Swe: 5% 1991-2005, 3MtCO2	**Low**		Effect depends on price elasticity. Revenues can be earmarked for further efficiency. More effective when combined with other tools.
Tax exemptions/ reductions	US, Fr, Nl, Kor	**High**	US: 88 MtCO2 in 2006 FR: 1Mt CO2 in 2002	**High**	US: B/C ratio commercial buildings: 5.4 New homes: 1.6	If properly structured, stimulate introduction of highly efficient equipment and new buildings.
Public benefit charges	BE, Dk, Fr, Nl, US states	**Medium/ Low**	US: 0.1-0.8% of total el. sales saved /yr, 1.3 ktCO2 savings in 12 states NL: 7.4TWh in 1996 = 2.5 Mt CO2 Br: 1954 GWh	**High in reported cases**	US: From -53$/tCO2 to - 17$/tCO2	Success factors: Independent administration of funds, involvement of all stakeholders, regular evaluation/ monitoring& feedback, simple and clear progr. design, multi-year progrs
Capital subsidies, grants, subsidised loans	Jp, Svn, NL, De, Sw, US, Cn, UK, Ro	**High/Medium**	Svn: up to 24% energy savings for buildings, BR: 169ktCO2 UK: 6.48 MtCO2 /year, 100.8 MtCO2 in total Ro: 126 ktCO2/yr	**Low sometimes High**	Dk: – 20$/ tCO2 UK:29$/tCO2 for soc, NL: 41-105$/tCO2 for society	Positive for low-income households, risk of free-riders, may induce pioneering investments

The impact and effectiveness of various policy instruments
Part 5: Support, information and voluntary action (to be cont.)

Policy instrument	Country examples	Effec-tiveness	Energy or emission reductions for selected best practices	Cost-effectiveness	Cost of GHG emission reduction for selected best practices	Special conditions for success, major strengths and limitations, co-benefits
Voluntary certification and labelling	De, Sw, US, Tha, Fr, Br	**Medium/ high**	Br: 6.5-12.2 MtCO2 1986-2005, US: 13.2 MtCO2 in 2004, 884 MtCO2eq in total by 2012, Tha: 192 tCO2	**High**	US: from -53 to - 53 $/tCO2 Br: 20 $ Million saved	Effective with financial incentives, voluntary agreements and regulations, adaptation to local market is important.
Voluntary & negotiated agreements	Mainly Western Europe, Jp, US	**Medium/ High**	US: 88 MtCO2eq /yr US: 66.45 MtCO2eq in 2000 EU: 50 ktCO2, 100 GWh/yr (300 buildings) UK: 14.4Mt CO2, in 2004	**Medium**	Swe: 0.0166 $/kWh	Can be effective when regulations are difficult to enforce. Effective if combined with financial incentives, and threat of regulation. Inclusion of most important manufacturers, and all stakeholders, clear targets, effective monitoring important
Public leadership programs	NZL, Mex, US, Phil, Arg, Br, Ecu, SA, De Ghana	**Medium/ High**	De: 25% public sector CO2 reduction in 15 yrs US: 2.3 ktCO2/yr Br: 6.5-12.2 MtCO2/ year Ghana: 27 MWh = 5tCO2 (14% of baseline) Mex:9.6 ktCO2/year (13% of baseline), 200 GWh/yr	**High/ Medium**	US DOE/FEMP estimates $4 savings for every $1 invested, EU: 13.5 billion $ savings by 2020 SA: 0.06$/kWh= 25$/tCO2 Br: -0.07= -125 $/tCO2	Can be used to demonstrate new technologies and practices. Mandatory programs have higher potential than voluntary ones. Clearly state, communicate and monitor, adequate funding and staff, involve building managers and experts

The impact and effectiveness of various policy instruments
Part 5: Support, information and voluntary action (cont.)

Policy instrument	Country examples	Effec-tiveness	Energy or emission reductions for selected best practices	Cost-effectiveness	Cost of GHG emission reduction for selected best practices	Special conditions for success, major strengths and limitations, co-benefits
Awareness, education, information	Dk, US, UK, Fr, CAN, Br, Jp, Swe	**Low/ Medium**	UK: 10.4ktCO_2 annually Arg: 25% in 04/05, 355 ktep Fr: 40tCO_2/ year Br: 2.23kt/yr, 6.5-12.2 MtCO_2/ year with voluntary labeling 1986-2005 Swe: 3ktCO_2/ year	**Medium / High**	Br: -66$/t$CO_2$; UK: 8$/tCO_2 (for all programs of Energy Trust)/ Swe: 0.018$/kWh	More applicable in residential sector than commercial. Deliver understandable message and adapt to local audience.
Detailed billing & disclosure programs	Ontario, It, Swe, Fin, Jp, Nor, Aus, Cal, Can	**Medium**	Max.20% energy savings in households concerned, usually app. 5-10% savings UK: 3% Nor: 8-10 %	**Medium**		Success conditions: combination with other measures and periodic evaluation. Comparability with other households is positive.

Country name abbreviations: Alg - Algeria, Arg- Argentina, AUS - Australia, Aut - Austria, Be - Belgium, Br - Brazil, Cal - California, Can - Canada, CEE - Central and Eastern Europe, Cn - China, Cr - Costa Rica, Cz - Czech Republic, De - Germany, Ecu - Ecuador, Egy - Egypt, EU - European Union, Fin - Finland, GB-Great Britain, Hkg -Hong Kong, Hu - Hungary, Ind - India, Irl - Ireland, It - Italy, JP - Japan, Kor - Korea (South), Mar- Morocco, Mex - Mexiko, NL - Netherlands, Nor - Norway, Nzl – New Zealand, Phil - Philippines, Pol - Poland, Ro- Romania, SA- South Africa, SG - Singapore, Sk - Slovakia, Svn - Slovenia, Sw - Switzerland, Swe - Sweden, Tha - Thailand, US - United States.

Conclusion

- Improved energy-efficiency could contribute the largest share in our mitigation task in the short- and mid-term
- Capturing the economic potential in buildings alone can contribute app. 38% of reduction needs in 2030 for a 3°C-capped emission trajectory
- In addition to climate change benefits, improved energy-efficiency can advance several development goals as well as strategic economic targets
  - E.g. energy security, business opportunities and job creation
- However, due to the numerous barriers public policies are needed to unlock the potentials and to kick-start or catalise markets
- Several instruments have already been achieving large emission reductions at large net societal benefits, often at double or triple negative digit cost figures all over the world
- However, each new building constructed in an energy-wasting manner will lock us into high climate-footprint future buildings – action now is important

Why is immediate action important?

Table 11.17: *Observed and estimated lifetimes of major GHG-related capital stock*

Typical lifetime of capital stock			**Structures with influence > 100 years**
Less than 30 years	30-60 years	60-100 years	
Domestic appliances Water heating and HVAC systems Lighting Vehicles	Agriculture Mining Construction Food Paper Bulk chemicals Primary aluminium Other manufacturing	Glass manufacturing Cement manufacturing Steel manufacturing Metals-based durables	Roads Urban infrastructure Some buildings

Thank you for your attention

"All I'm saying is **NOW** is the time to develop the technology to deflect an asteroid"

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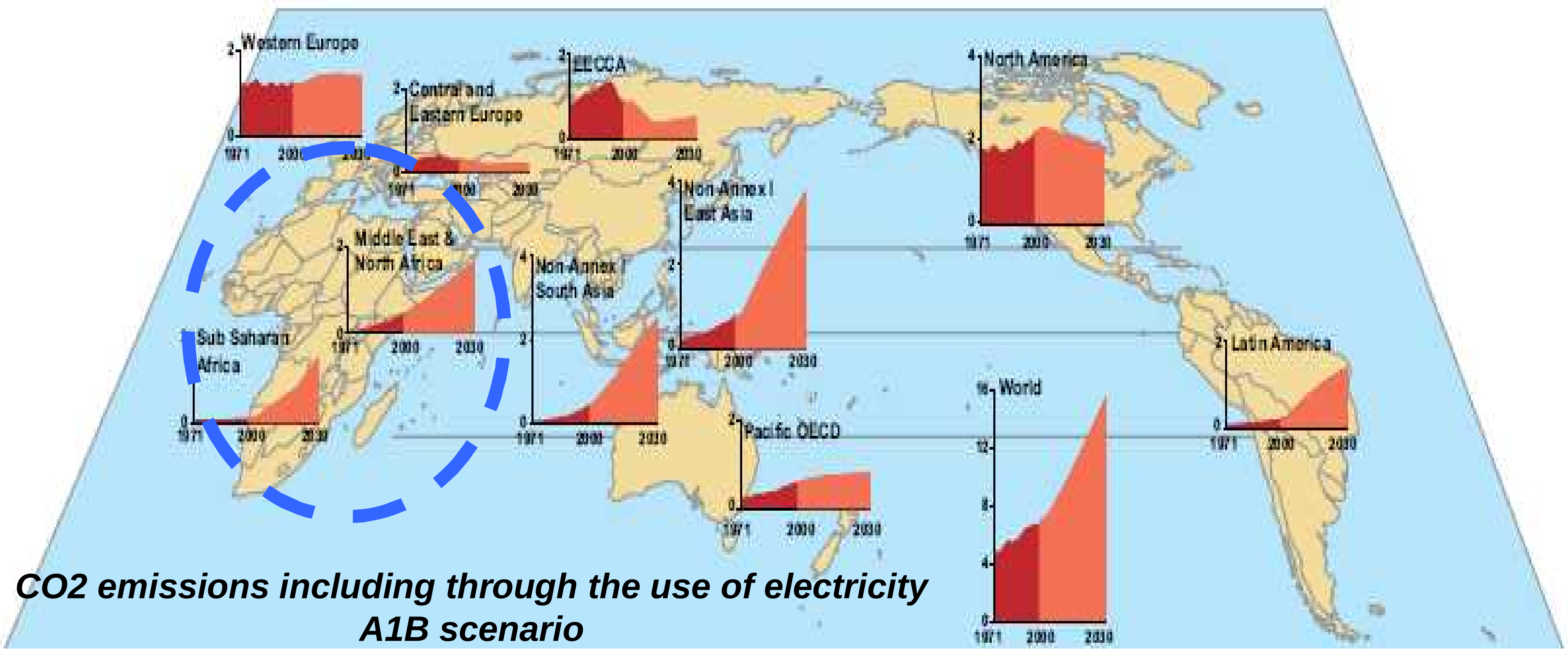
Supplementary slides

References

- Due to the large number of references, please consult:
  - Chapter 6 of the AR 4 of the IPCC (Levine, M., D. Ürge-Vorsatz, K. Blok, L. Geng, D. Harvey, S. Lang, G. Levermore, A. Mongameli Mehlwana, S. Mirasgedis, A. Novikova, J. Rilling, H. Yoshino, 2007: Residential and commercial buildings. In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA)
  - Koeppel, S. and Ürge-Vorsatz, 2007. Assessment of Policy Instruments for Reducing Greenhouse Gas Emissions from Buildings. Report for the UNEP-Sustainable Buildings and Construction Initiative

Buildings sector: global and regional importance

- In 2004, in Buildings were responsible for app. 1/3 of global CO_2 emissions
- This is app. 8.6 $GtCO_2$, 0.1 $GtCO_2eq$ N_2O, 0.4 $GtCO_2eq$ CH_4 and 1.5 $GtCO_2eq$ halocarbons (direct and indirect emissions)
- 2030: energy use in buildings will release to the atmosphere 11.8 to 15.6 Gt CO_2eq. in 2030; the largest increase in developing countries



CO2 emissions including through the use of electricity
A1B scenario

Methodology for the regional and global estimates

- Based on app. 80 recent studies from 36 countries and 11 country groups, spanning five continents
- The world was split into 7 regions (picture below)

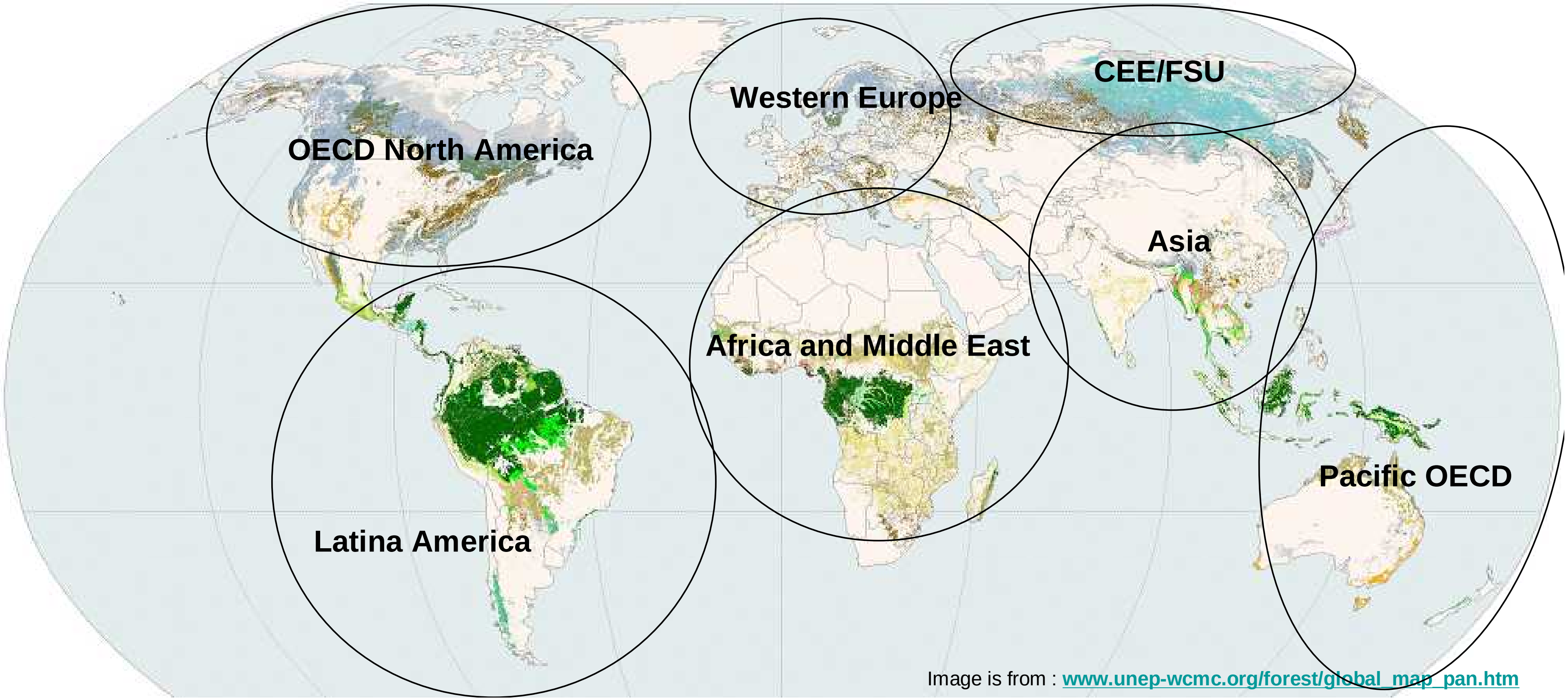


Image is from : www.unep-wcmc.org/forest/global_map_pan.htm

CO2 reduction potential for buildings in 2020 and review of measures(1)

Country groups	Countries/ country groups reviewed	Potential as bldgs BL %(2)	Measures covering the largest potential	Measures providing the cheapest mitigation options
Developed countries	USA, EU-15, Canada, Greece, Australia, Republic of Korea, UK, Germany, Japan	Technical: 21%-54%[1] Economic: 12%-25%[2] Market: 15%-37%	1. Shell retrofit, inc. insulation, esp. windows and walls; 2. Space heating systems and standards for them; 3. Efficient lights, esp. shift to CFLs and efficient ballasts.	1. Appliances such as efficient TVs and peripheries (both on-mode and standby), refrigerators and freezers, followed by ventilators and AC; 2. Water heating equipment; 3. Lighting best practices.
Economies in Transition	Hungary, Poland, Russia, Croatia, as a group: Lithuania, Malta Latvia, Estonia, Cyprus, Slovakia, Slovenia, Hungary, Poland, the Czech Repubilc	Technical: 26%-47%[3] Economic: 13%[4]-37% Market: 14%	1. Pre- and post- insulation and replacement of building components, esp. windows; 2. Efficient lighting, esp. shift to CFLs; 3. Efficient appliances such as refrigerators and water heaters.	1. Efficient lighting and its controls; 2. Water and space heating control systems; 3. Retrofit and replacement of building components, esp. windows.
Developing countries	Myanmar, India, Indonesia, Argentine, Brazil, China, Ecuador, Thailand, Pakistan, South Africa	Technical: 18%-41% Economic: 13%-52%[5] Market: 23%	1. Efficient lights, esp. shift to CFLs, light retrofit, and kerosene lamps; 2. Various types of improved cook stoves, esp. biomass stoves, followed by LPG&kerosene stoves; 3. Efficient appliances such as air-conditioners and refrigerators.	1. Improved lights, esp. shift to CFLs light retrofit,& efficient kerosene lamps; 2. Various types of improved cook stoves, esp. biomass based, followed by kerosene stoves; 3. Efficient electric appliances such as refrigerators and air-conditioners.

(1) Except for EU-15, Greece, Canada, India, and Russia, for which the target year (TY) was 2010; Hungary, Ecuador, and South Africa with TY 2030; and as a country group of Latvia, Lithuania, Estonia, Slovakia, Slovenia, Hungary, Malta, Cyprus, Poland, the Czech Republic with TY 2015.
(2) The fact that the market potential is higher than the economic potential for developed countries is explained by limitation of studies considering only one type of potential so information for some studies likely having higher economic potential is missing.

[1] Both for 2010, if suggested extrapolation formula is applied, this interval would be 38%-79%; [2] Both for 2010, if suggested extrapolation formula is used, this interval would be 22%-44%; [3] The last figure is for 2010, corresponds to 72% in 2020 if the extrapolation formula is used; [4] The first figure corresponds to 24% in 2020 if the extrapolation formula is used; [5] The last figure is for 2030, corresponds to 38% in 2020 if the suggested extrapolation formula is applied to derive the intermediate potential.

Potential estimates

Regions	CO2 Baseline in 2020	Potential as the share in the total regional baseline CO2 emissions in cost categories (USD/tCO2) in 2020, millions tons CO2				Potential as the share in the total regional baseline CO2 emissions in cost categories (USD/tCO2) in 2020, million tons CO2			
	Million tons CO2	<0	0;20	20;100	Total	<0	0;20	20;100	Total
GLOBAL TOTAL	11.1	29%	3%	4%	36%	3.2	0.4	0.5	4.0
Developed countries	4.8	27%	3%	2%	32%	1.3	0.1	0.1	1.6
Developing countries	**5.0**	**30%**	**2%**	**1%**	**32%**	**1.5**	**0.1**	**0.0**	**1.6**
Transition Economies (CEE & FSU)	1.3	29%	12%	23%	64%	0.38	0.2	0.3	0.85

Solutions 1: Training ; Information

- Lack of knowledge on energy saving construction techniques among architects is a major barrier to energy efficiency, even in most developed countries in Europe
- It is esp. important due more developing construction rates
- Information campaigns should be adopted to auditoria due to the lack of trust to new issues
  - Ex.: Lebanon has started campaign using different types of media whereby the media do not charge the government for give advice on how to save energy
- Trust and awareness can be raised through pilot projects administered and financed by international organizations or bilateral donor agencies or through demonstration projects in the public sector
  - The MED-ENEC initiative in the Mediterranean region aims for instance at promoting energy efficiency through the exchange of best practices, a number of demonstration programs and regional cooperation
  - Demonstration programs at all levels (capital, villages and cities) such as the “Green Buildings for Africa” program in South Africa prove the advantages of energy efficiency to every citizen, independent of the education level
  - Especially in rural areas, characterized by relatively high levels of illiteracy, communication and learning often take place via informal channels such as learning from neighbors; hence the importance of demonstration projects

Solutions 2: Financial assistance

- High cost of energy efficient technologies hamper their penetration, especially if the technologies are imported
- Especially poorer consumers need investment support or affordable loans from bilateral and international donor agencies, governmental funding or through ESCO financing
- Some countries of Africa have sufficient level of economic development to raise money on their own through:
  - Public benefit charges or taxes
  - The tax revenues are collected in a fund and are used for supporting energy efficiency projects
- In South Africa, the government also introduced a public benefit charge which is used to finance energy efficiency improvements
- It is important that such funds are managed by independent agencies or institutions to avoid political influence
- CDM projects may offer carbon finance for energy efficiency projects, but only few CDM projects in the buildings sector due to high transaction costs, and other barriers

Solutions 3: Adaptation in local circumstances

- Numerous programs have already failed because they were just copying programs from other countries
- Situation analyses are very important before any decision is taken
  - Ex.: In Brazil, in some regions, electric showers are the second most important electricity consumers in households and therefore require labelling whereas fridges are more important in other regions

Solutions 4: Institutionalization

- Developing countries with successful energy efficiency policies have usually started with the adoption of an Energy Efficiency law or an Energy Efficiency Strategy
- In order to assist public sector building managers, but also private persons to get the information, the creation of energy agencies is usually very helpful
  - Thailand, South Africa and Mexico also have energy agencies
  - Numerous Arab states are currently introducing such agencies, often with external assistance

Summary: Dominating policy instruments

- Many developing countries enacted legislation on energy efficiency in buildings
  - Thailand, India, China, South Africa, Egypt, Bahrain, Tunisia, Morocco, Mexico, Brazil, Argentina, Chile, Colombia, Peru
- A number of others are currently introducing the mechanisms:
  - Kenya, Uganda and the United Arab Emirates
- The most commonly applied measures in these countries:
  - Voluntary and mandatory labeling,
  - Appliance standards,
  - Public leadership programs,
  - Awareness raising campaigns
- Only very few evaluations of instruments operating in these instruments in developing countries are available

Enabling factors: Cost-reflecting E prices, energy or capacity shortages

- The differences in energy prices explain why certain governments in the Mediterranean region such as Tunisia and Morocco are interested in energy efficiency while others, especially oil producing countries such as Algeria, are not or are less interested
- However, increase of energy prices would lead
  - Higher fuel poverty
  - Other negative social effects
- Lifting energy subsidies can help
  - The revenues from lower energy price subsidies can be rechannelled into rebates for energy efficient programs, loans, special assistance for low-income households
- In South Africa, large energy shortages in 2006 have driven the government, and utilities to create an energy agency, public procurement regulations, and DSM programs, for instance the free distribution of CFLs

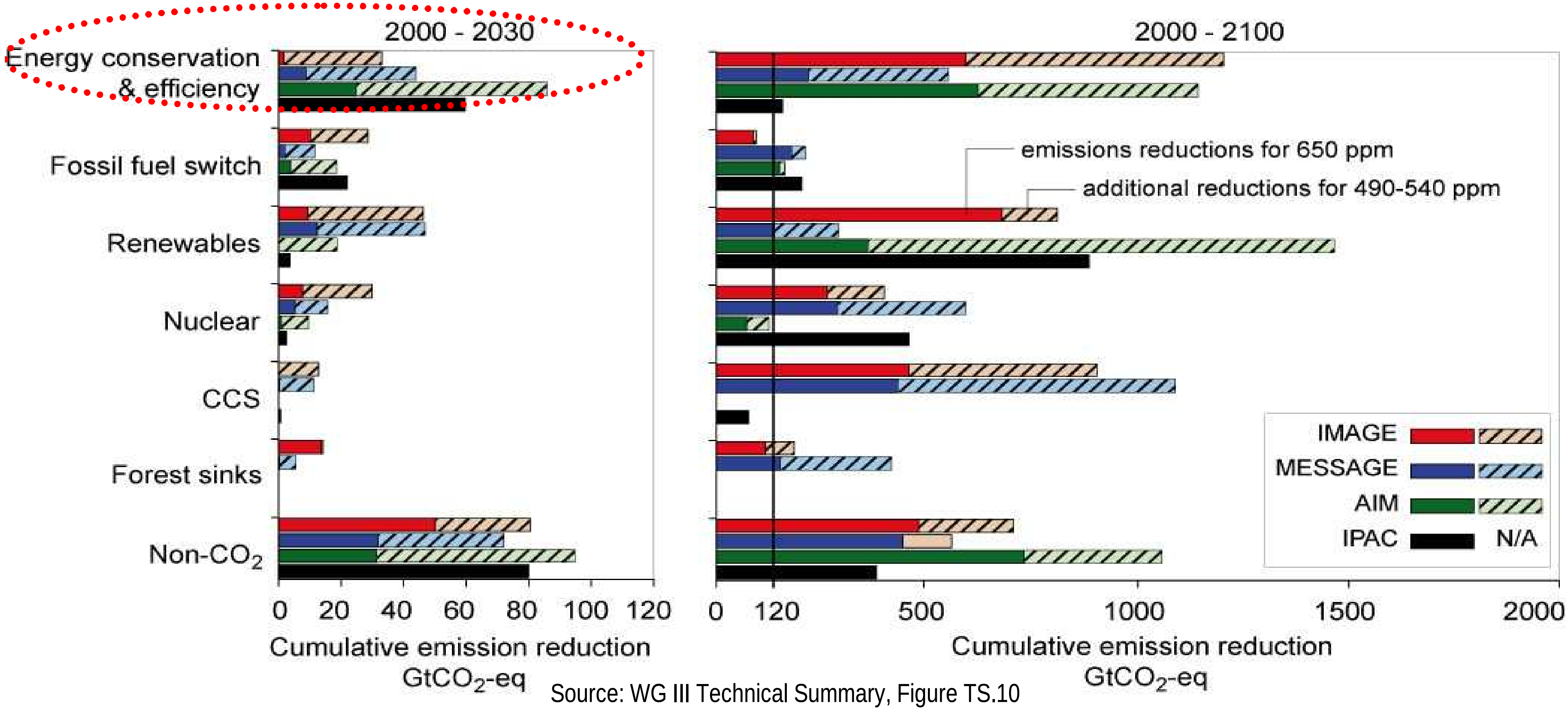
Conclusion 2

- The most commonly applied measures in these countries:
  - Voluntary and mandatory labeling,
  - Appliance standards,
  - Public leadership programs,
  - Awareness raising campaigns
- No single instrument can capture the entire, or even the large share of the economic and low-cost mitigation potential in the sector alone
- Due to the especially numerous and diverse barriers in the buildings sector, a portfolio of instruments is necessary to overcome several barriers to take advantage of synergistic effects
- In addition, developing countries especially require technical and financial assistance, demonstration and information programs and training
- Other success factors:
  - Institutionalization of energy efficiency within the government structure,
  - Regular monitoring and evaluation or adaptation to local circumstances

Cumulative emission reductions for alternative mitigation measures for 2000–2030 and for 2000–2100

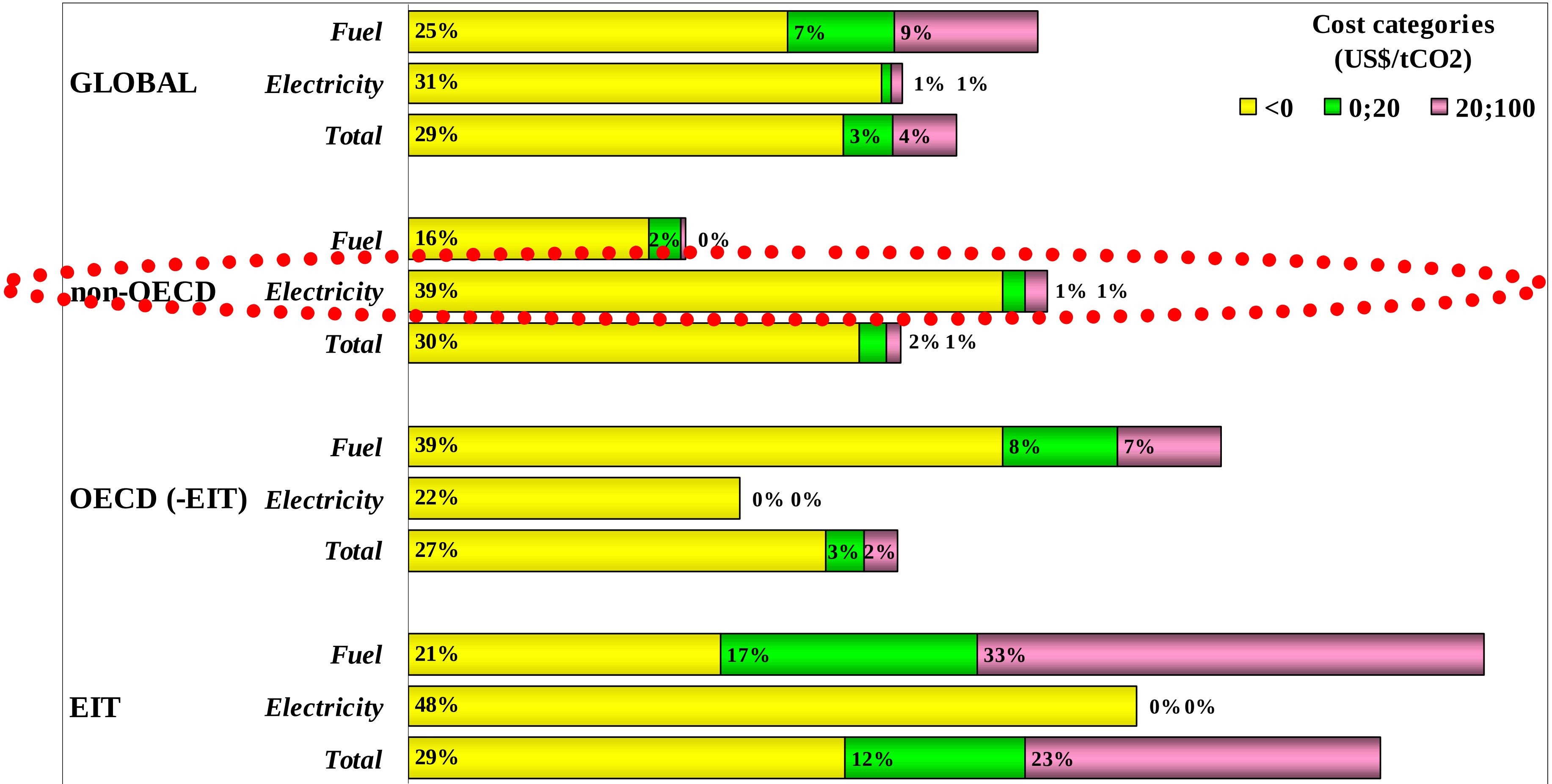
- ❖Different stabilization scenarios reflect different contribution of mitigation measures
- ❖Scenarios concur that 60-80% of reductions should come from energy and industry

Illustrative scenarios from AIM, IMAGE, IPAC and MESSAGE aiming at the stabilization at 490–540 ppm CO2-eq (light bars) and at 650 ppm CO2-eq (dark bars)



Source: WG III Technical Summary, Figure TS.10

Potential related to electric and fuel end-uses, 2020 (as shares of respective fuel- and electricity associated baseline CO2 emissions)

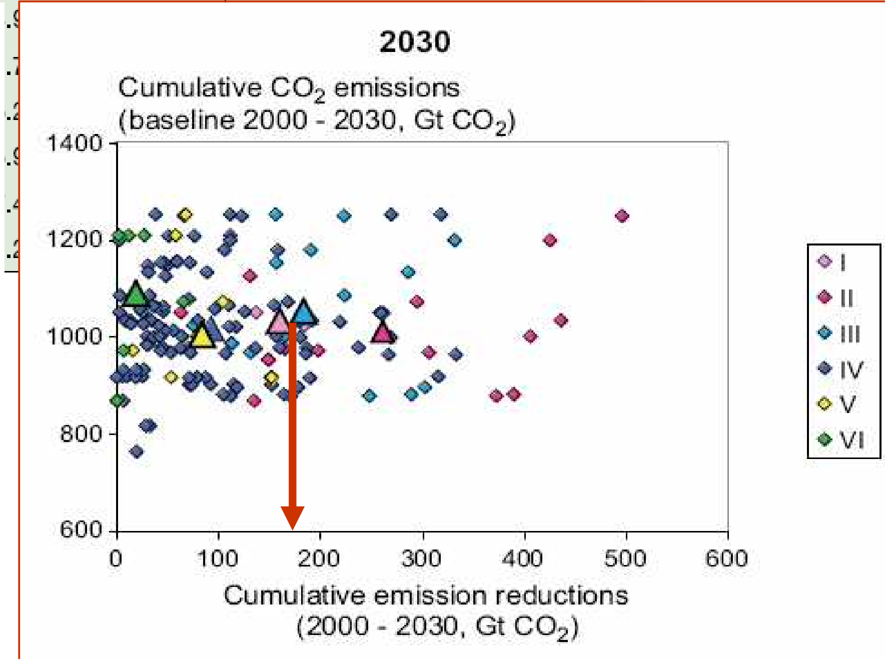


	Baseline Billion tons CO_2	Absolute values of potential in cost categories, Billion tons CO_2 (in US$/t$CO_2$)			
		<0	0-20	20-100	Total <100
Global	11.1	3.2	0.35	0.45	4.0
Non-OECD	5.0	1.5	0.10	0.05	1.6
OECD (-IET)	4.8	1.3	0.10	0.10	1.6
EIT	1.3	0.40	0.15	0.30	0.85

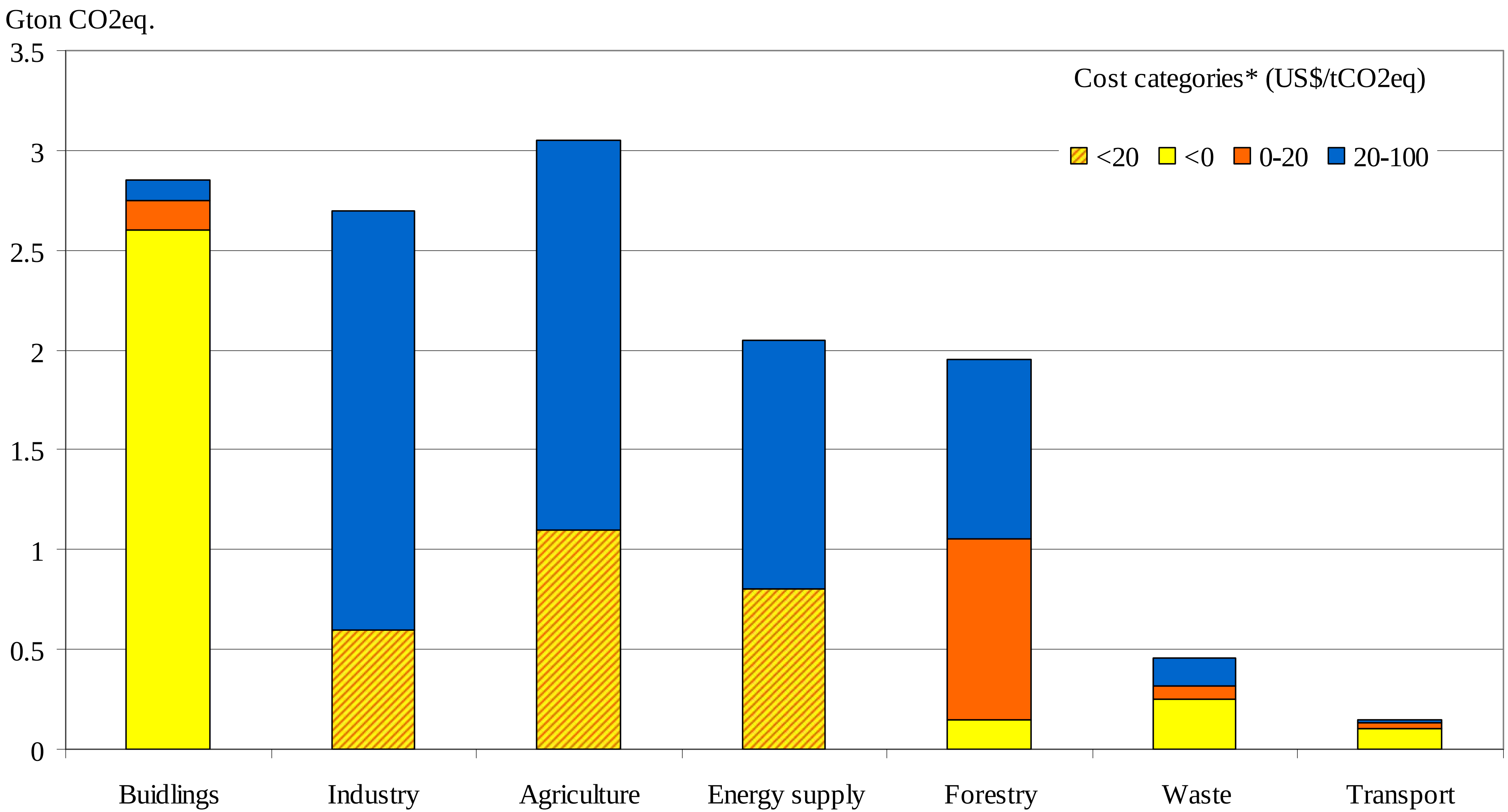
Category	Additional radiative forcing	CO_2 concentration	CO_2-eq concentration	Peaking year for CO_2 emissions[a]	Change in global emissions in 2050 (% of 2000 emissions)[1]	No. of scenarios
	W/m²	ppm	ppm	year	%	
I	2.5-3.0	350-400	445-490	2000-2015	-85 to -50	6
II	3.0-3.5	400-440	490-535	2000-2020	-60 to -30	18
III	3.5-4.0	440-485	535-590	2010-2030	-30 to +5	21
IV	4.0-5.0	485-570	590-710	2020-2060	+10 to +60	118

Equilibrium temperature increase in °C above pre-industrial temperature	CO_2-eq concentration and radiative forcing corresponding to best estimate of climate sensitivity for warming level in column 1[1,2]		CO_2-eq concentration that would be expected to limit warming below level in column 1 with an estimated likelihood of about 80% [3]
	CO_2-equivalent (ppm)	*Radiative forcing (W/m²)*	
0.6	319	0.7	305
1.6	402	2.0	356
2.0	441	2.5	378
2.6	507	3.2	415
3.0	556	3.7	441
3.6	639	4.5	484

- III Group of scenarios (stabilization level of 535-590 ppm or a T increase of 3°C ->
- Cumulative reduction need over 2000 – 2030 is app. 180 $GtCO_2$ -> Emission reduction need is 12 Gt in 2030 ->
- Cost-effective potential of buildings in 2030 is 4.5 Gt which is app. 37.5% of the reduction need



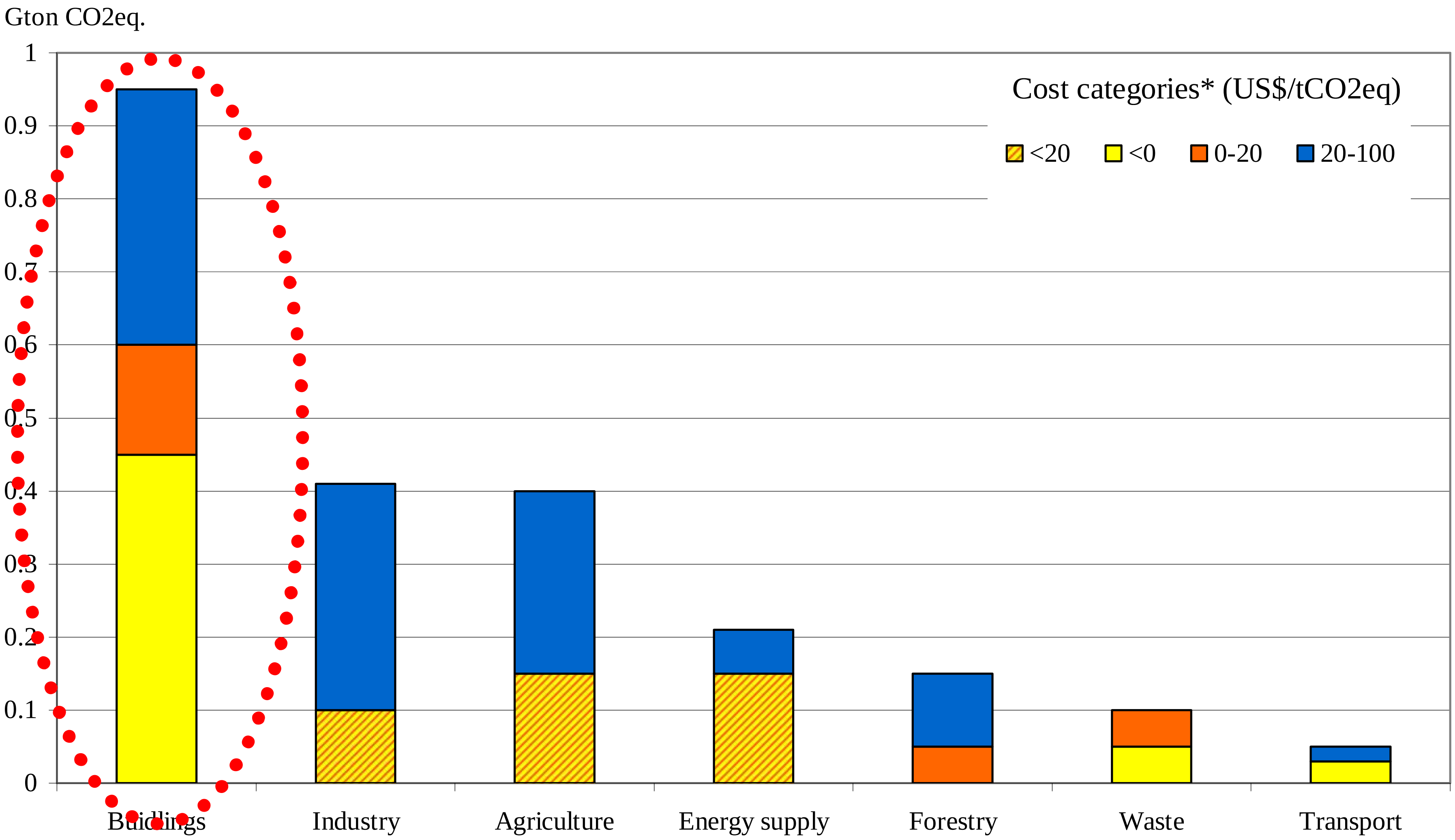
Estimated potential for GHG mitigation at a sectoral level in 2030 in different cost categories in developing countries



* 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.

Constructed based on Chapter 11 results

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.

Source: constructed based on the IPCC (2007)