Vattenfall's Global Climate Impact Abatement Map

IEA, Paris 2007-02-15

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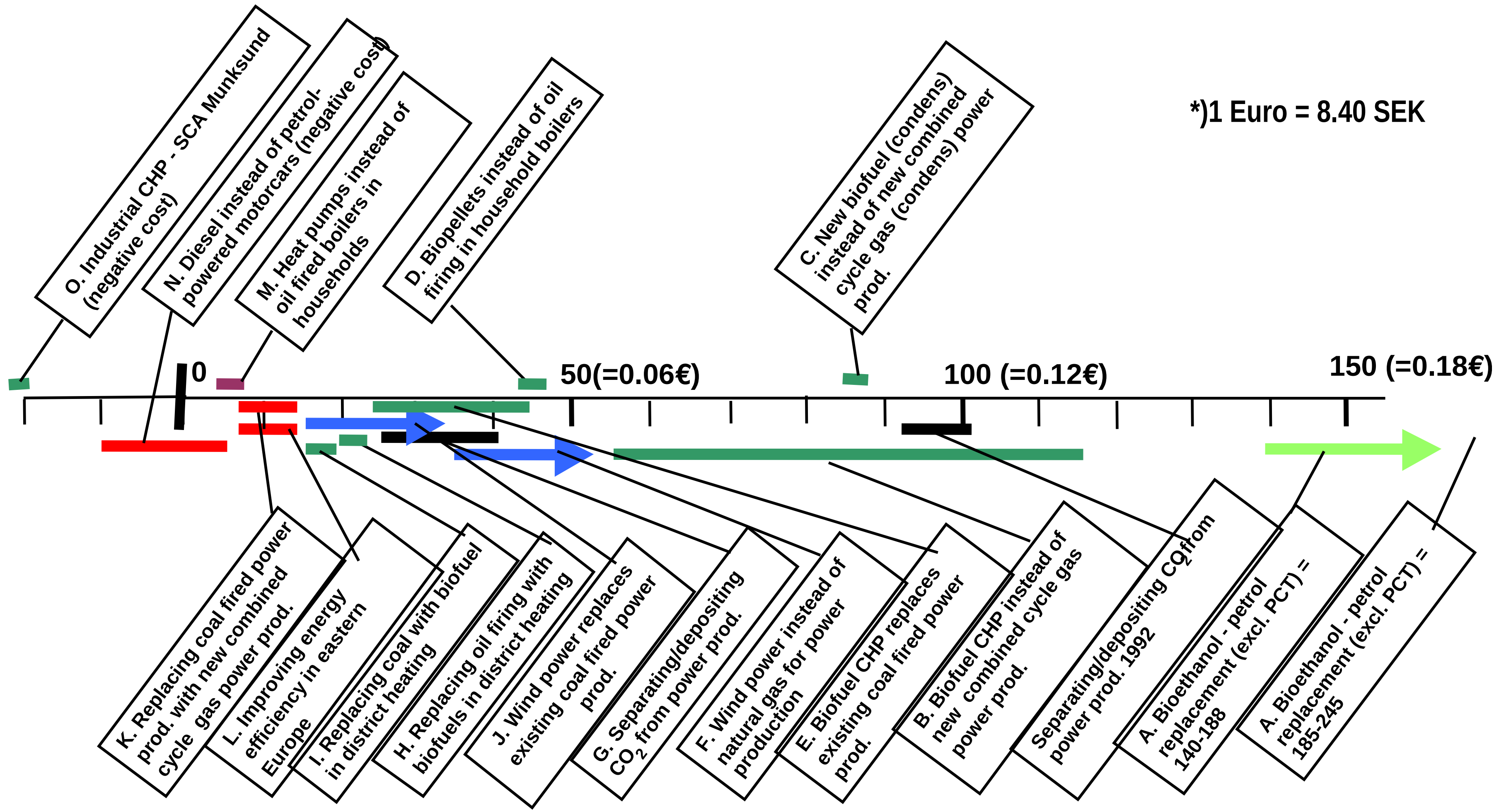
Vattenfall

SPECIFIC COSTS OF MEASURES TO REDUCE CO_2 EMISSIONS, ÖRE*/KG CO_2



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ABATEMENT ALTERNATIVES FOR CO_2 POTENTIALS*, MTON CO_2 /YR

	In Sweden	In the EU	Cost, Euro/kg CO_2
Diesel vehicles instead of petrol vehicles	< 3	?	0
Replacement of oil fired boilers with heat pumps in houses	< 3	?	
Improving energy efficiency (eastern Europe)	-	Great, in the 100s	
Replacement of existing coal fired plants with modern natural gas fired plants	-	Great, in the 100s	
Replacement of coal with biofuel in district heating	insignificant	~~Unexploited potential~~	
Replacement of oil firing with biofuel in district heating	limited	Unexploited potential	
New wind power replaces existing coal fired power production	-	Great ~~(pure question of cost~~)	
Separating/storing CO_2 from power production	uncertain	Still uncertain but promising	0,10
New wind power instead of new nat. gas combined cycle power prod.	< 5-10	Not used until after coal replacement alternatives	
New bio CHP replaces existing coal fired power prod.	-	Unexploited potential	
Replacement of oil with biofuel pellets in household boilers	< 3	?	
New bio CHP instead of new nat. gas combined cycle power prod.	< 3	?(Depends on biofuel supplement)	
Biofuel instead of natural gas for power production	< 1	Not used until after coal replacement alternatives	0,20
Bioethanol – petrol replacement	Insignificant saving of CO_2	Insignificant saving of CO_2	

*) Att.: Caution when adding potentias due to overlap

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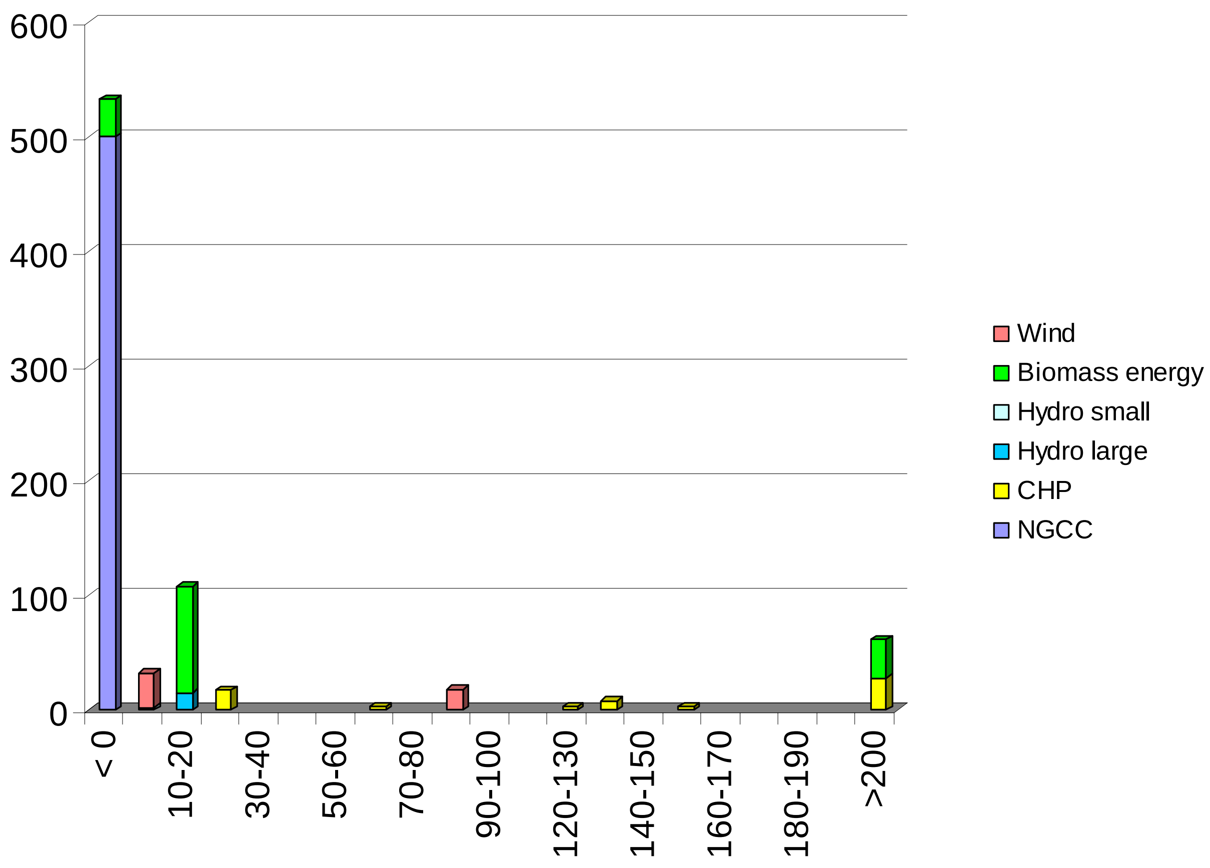
Heat pump - replacement for Oil in households
Energy Efficiency Improvement (Eastern Europe)
Natural gas fired plants - replacement for Coal fired pow er plants
Wind pow er - replacement for Coal pow er prod.
Biofuel - replacement for Coal in district heating
Biofuel - replacement for Oil in district heating
Separating/depositing CO2 from pow er prod.
Wind pow er - replacment for Natural gas in pow er prod.
Biofuel CHP - replacement for Coal fired pow er prod.
Biofuel pellets in households boilers - replacement for oil boilers
Biofuels - replacement for Natural gas in pow er prod.
Biofuel CHP - replacement for Natural gas fired CHP
0
2
4
6
8
10
12
14
US cents/ kg CO2

ABATEMENT COSTS OF CO_2 EMISSION REDUCTION - EU
EU-study 2001*, öre/kg CO2



*)ECCP. Economic Evaluation of Emission Reduction of Greenhouse Gases in the Energy Suppl. Sector in the EU-Bottom up Analysis, Report to DG Environment Jan 2001

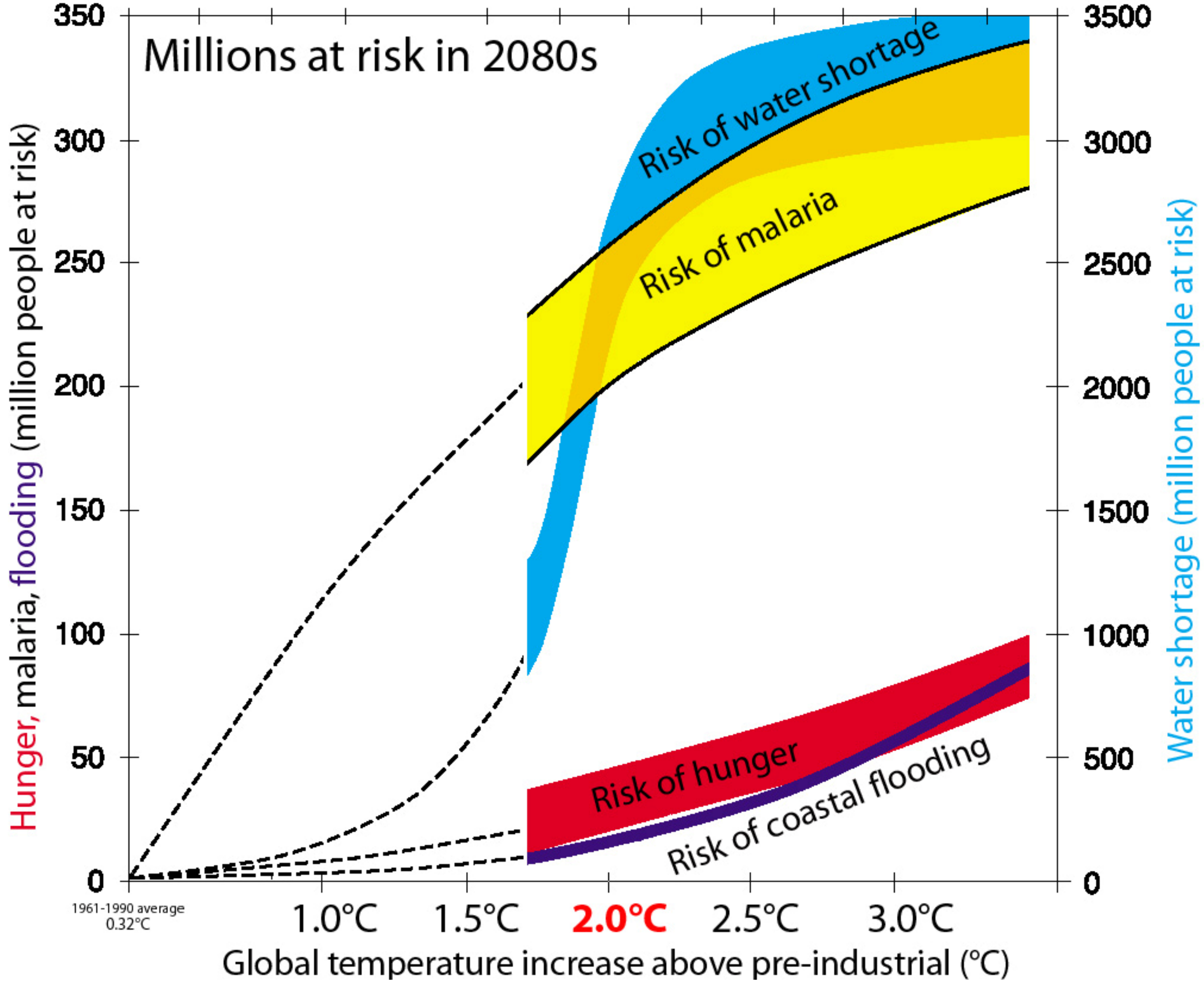
A “16th Century map” of abatement opportunities

Global cost curve model of GHG abatement opportunities:

- 6 sectors: power, industry (focus on steel and cement), transportation, buildings, forestry, agriculture
- 6 regions: North America, Western Europe, Eastern Europe incl. Russia, other industrialized countries, China, Rest of World
- 3 time frames: 2010, 2020, 2030

The report studies abatement *potentials*, not *forecasts*

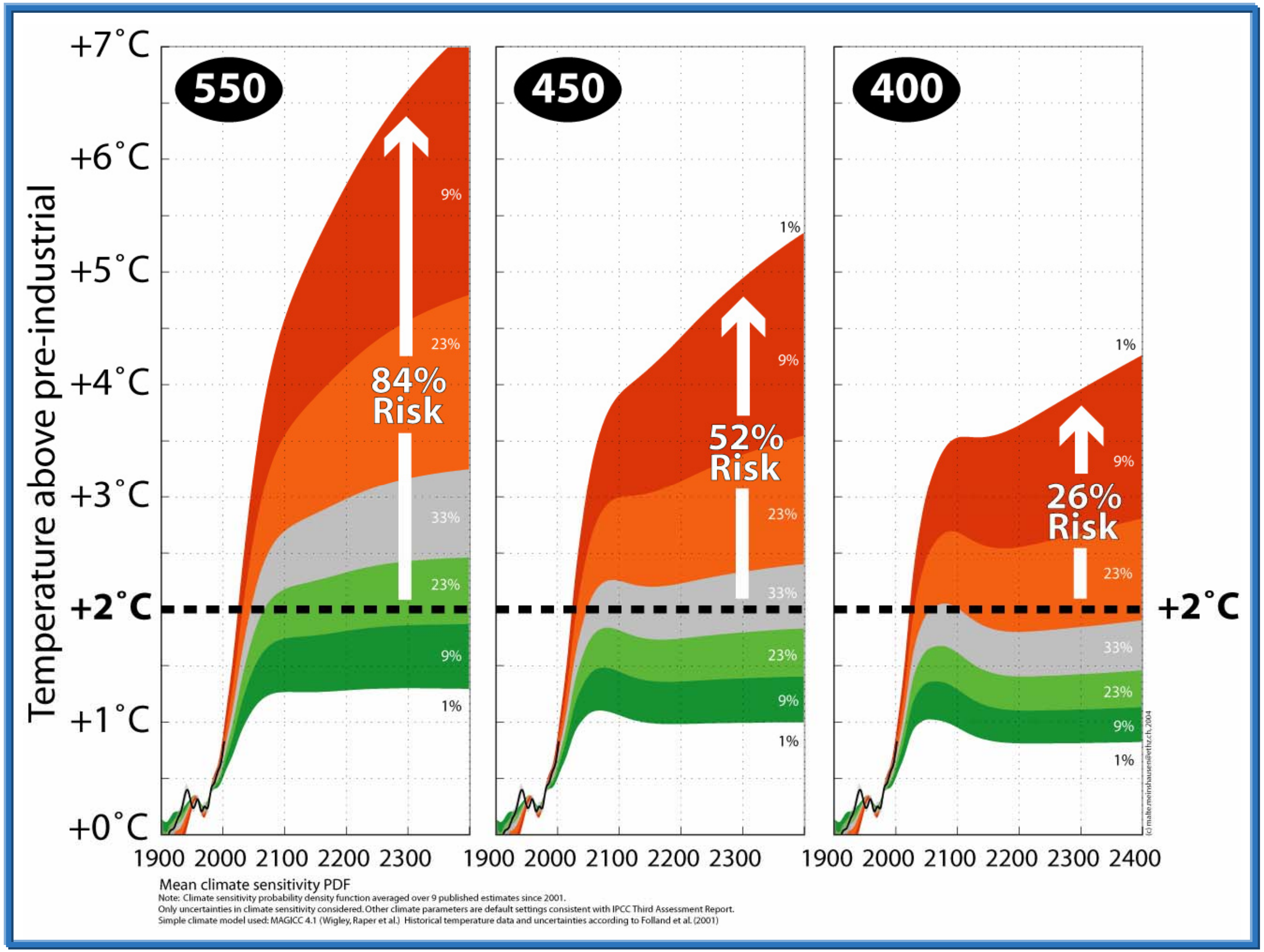
Global warming – millions at risk in 2080s



The EU has decided on 2ºC as the maximum prudent global warming level

Source: Parry (2001)

The 2ºC warming target - risks at different CO2e concentration levels



Source: Meinshausen (2004); European Environment Agency

Overall methodology

1. Focus on abatement opportunities (“supply”) – no independent research into how much abatement is needed (“demand”)

2. IEA and EPA forecasts through 2030 used as business-as-usual emission projections

3. Abatement cost defined as the additional cost* of a low-emission technology/ opportunity compared to the business-as-usual, measured as EUR/ton of avoided CO_2e emissions. Focus have been on measures with a cost below 40 EUR/ton

4. Abatement volumes are “realistic potentials”, based on assumptions of realistic deployment rates of GHG-efficient technologies/measures per region and over time

5. Abatement opportunities documented in cost curve model, to be able to assess relative economic attractiveness of different abatement options

6. Cooperation with Academic Review Panel consisting of Professors Socolow, Pacala, and Williams from Princeton, Professor Anderson from Imperial College, and Professor Bergman from Stockholm School of Economics

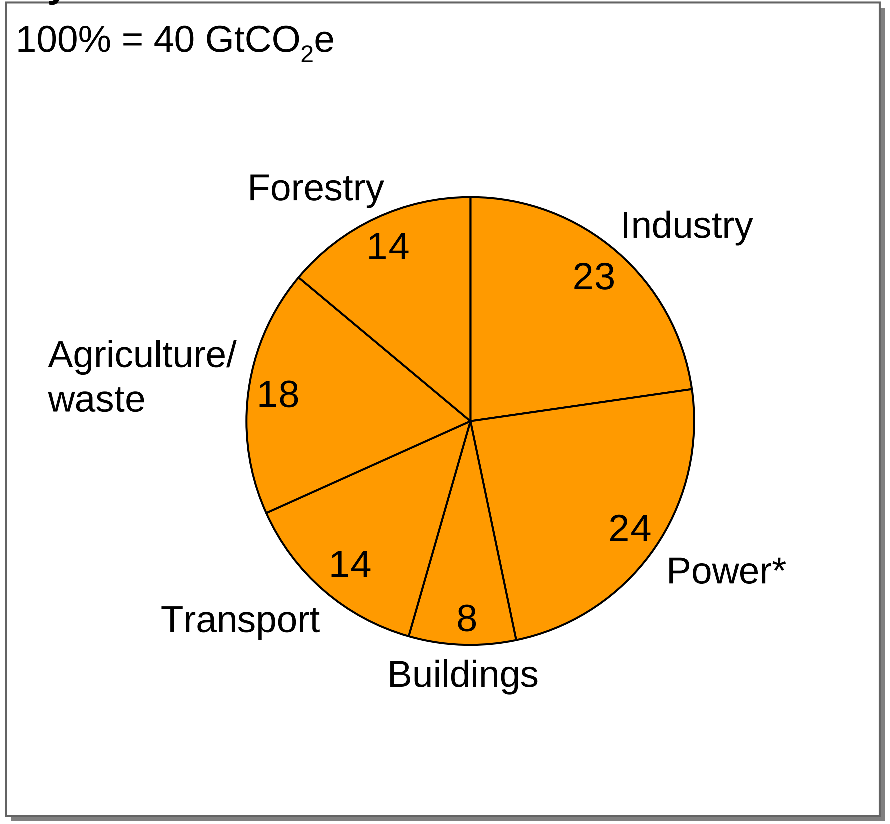
* Operational cost + depreciation

Current sources of greenhouse gas emissions

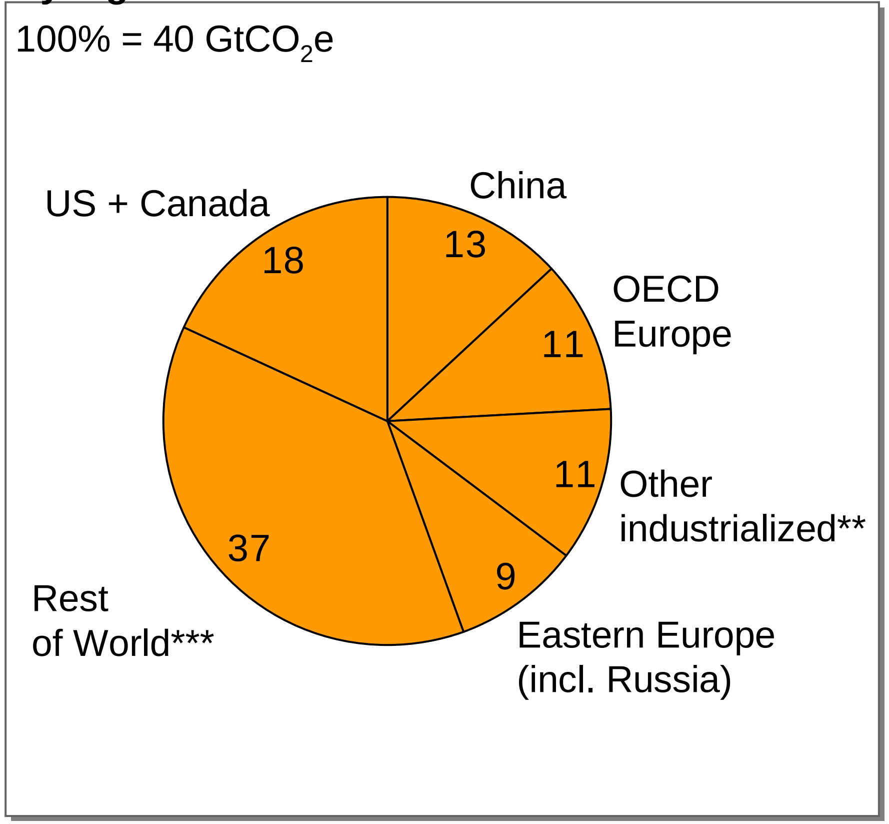
2002; Percent

BACKUP

By sector



By region



* 45% of electricity consumption in the industry sector and 55% in buildings
** Australia, New Zealand, Japan, Singapore, South Korea, Taiwan, UAE, Saudi Arabia, Qatar, Oman, Kuwait, Israel, Bahrain, Mexico
*** Africa, South and Central America excl. Mexico, Asia excl. China and countries included in “Other industrialized” (see previous note)

Source: IEA World Energy Outlook 2004; EPA

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Vattenfall's Global Climate Impact Abatement Map

Abatement cost = additional cost of a low emission technology/ opportunity compared to business-as-usual (operational cost + depreciation)

- 6 sectors: power, industry, transportation, buildings, forestry, agriculture
- 6 regions: North America, Western Europe, Eastern Europe incl. Russia, other industrialized countries, China, Rest of World
- 3 time frames: 2010, 2020, 2030

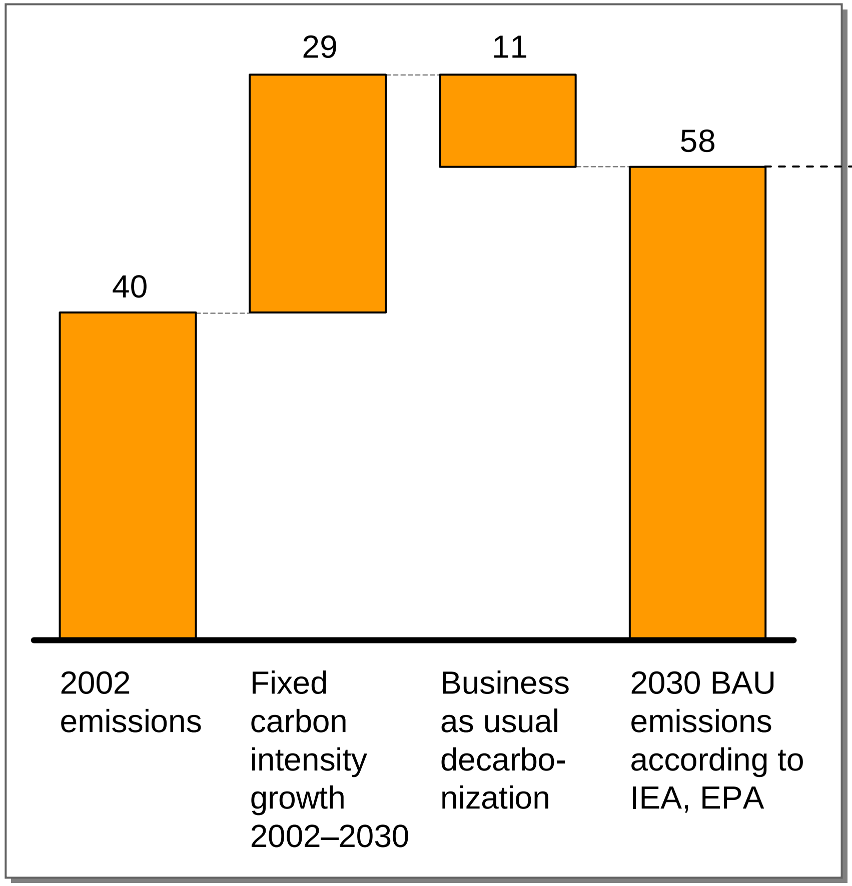
The report shows realistic abatement *potentials*, not *forecasts!*

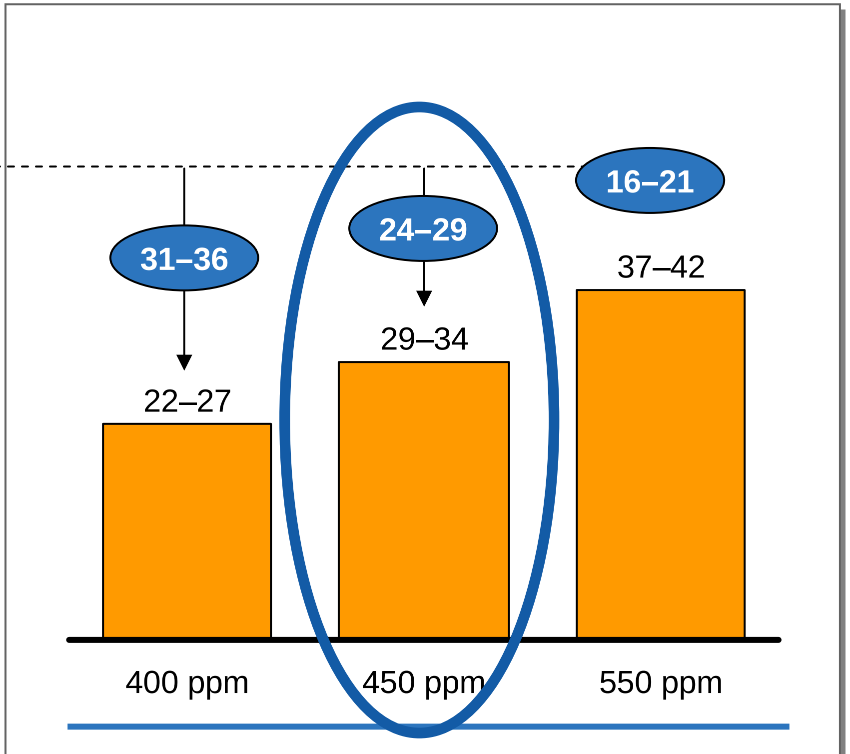
What's needed by 2030 to contain global warming below 2°C?

CO_2e emissions per year, Gton

Abatement required by 2030 compared to the BAU

Emissions growth through 2030 in the business as usual forecast

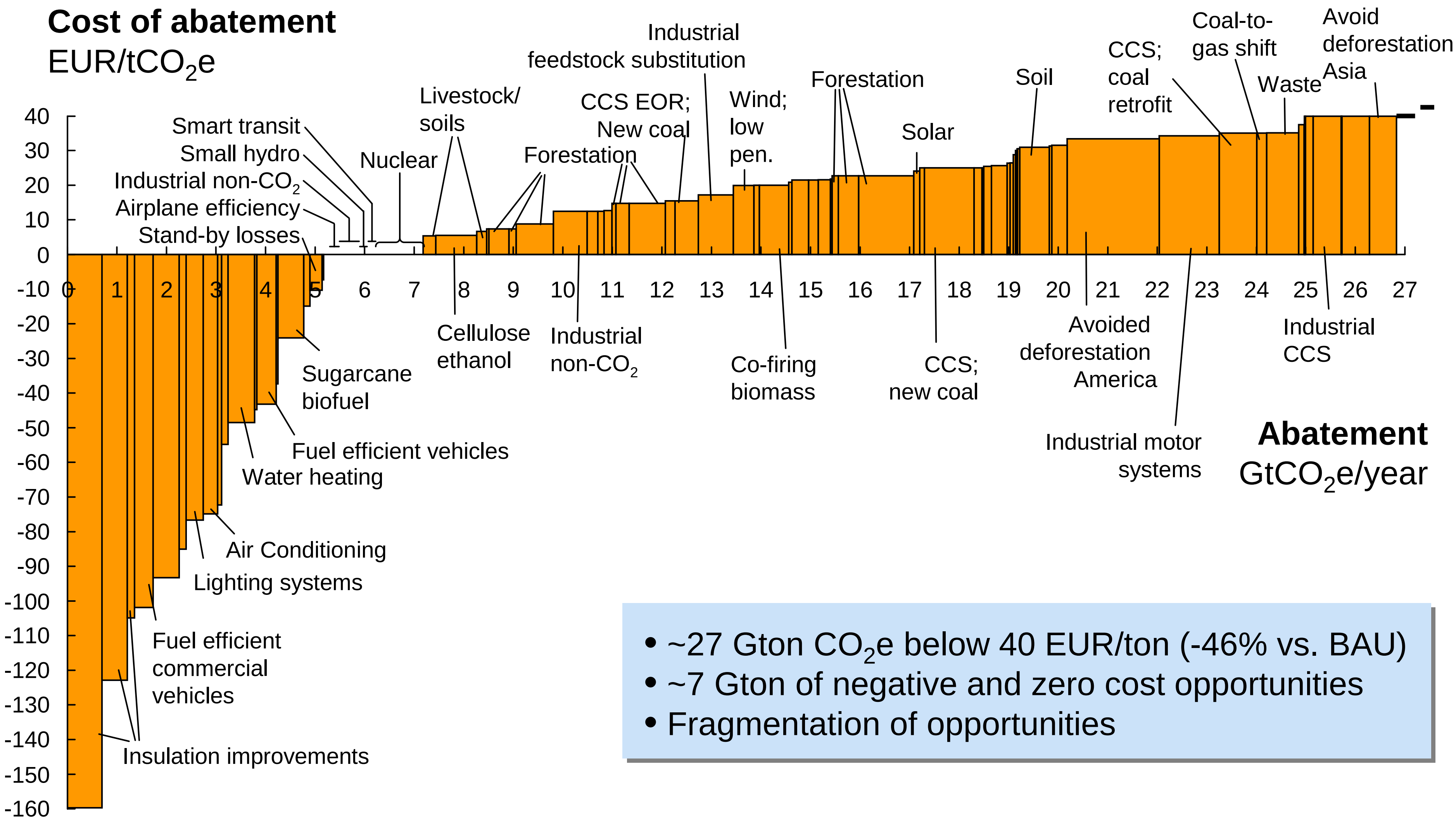




Alternative risk levels to keep global warming below 2°C – required CO_2e concentration

Global cost curve of GHG abatement opportunities beyond business as usual

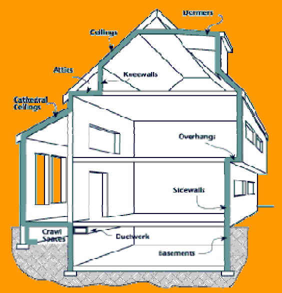
2030



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

Examples of negative cost abatement opportunities

	Opportunity	Barriers
Improved insulation	• 25% less energy for heating versus BAU • 60% lower lifecycle heating cost* • Average abatement cost: -130 EUR/t CO_2e • Total abatement opportunity: 1.6 $GtCO_2$e	**Misaligned incentives:** • Builders minimize upfront building costs – not life-cycle cost • Buyers typically not involved in specifying insulation levels
Compact Fluorescent Lamp	• 80% reduced energy consumption • 41% lower lifecycle cost for consumer • Average abatement cost: -90 EUR/t CO_2e • Total abatement opportunity: 0.2 $GtCO_2$e	**End-user behavior:** • Lacking awareness of opportunities • Savings low compared to total household budget • Require very short payback times

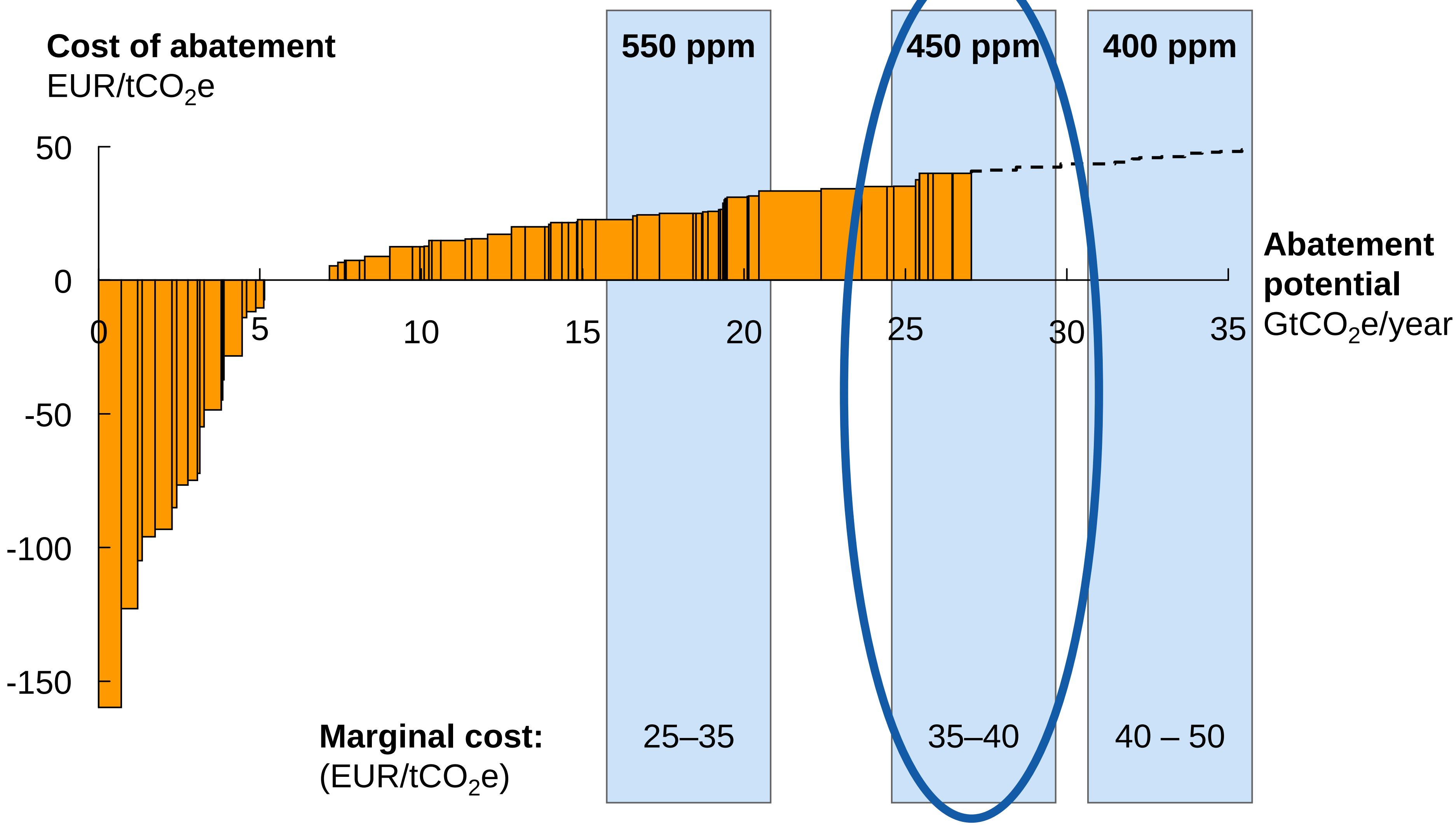


* Example for typical house in mild region with electrical heating

Examples of abatement cost calculations – power sector

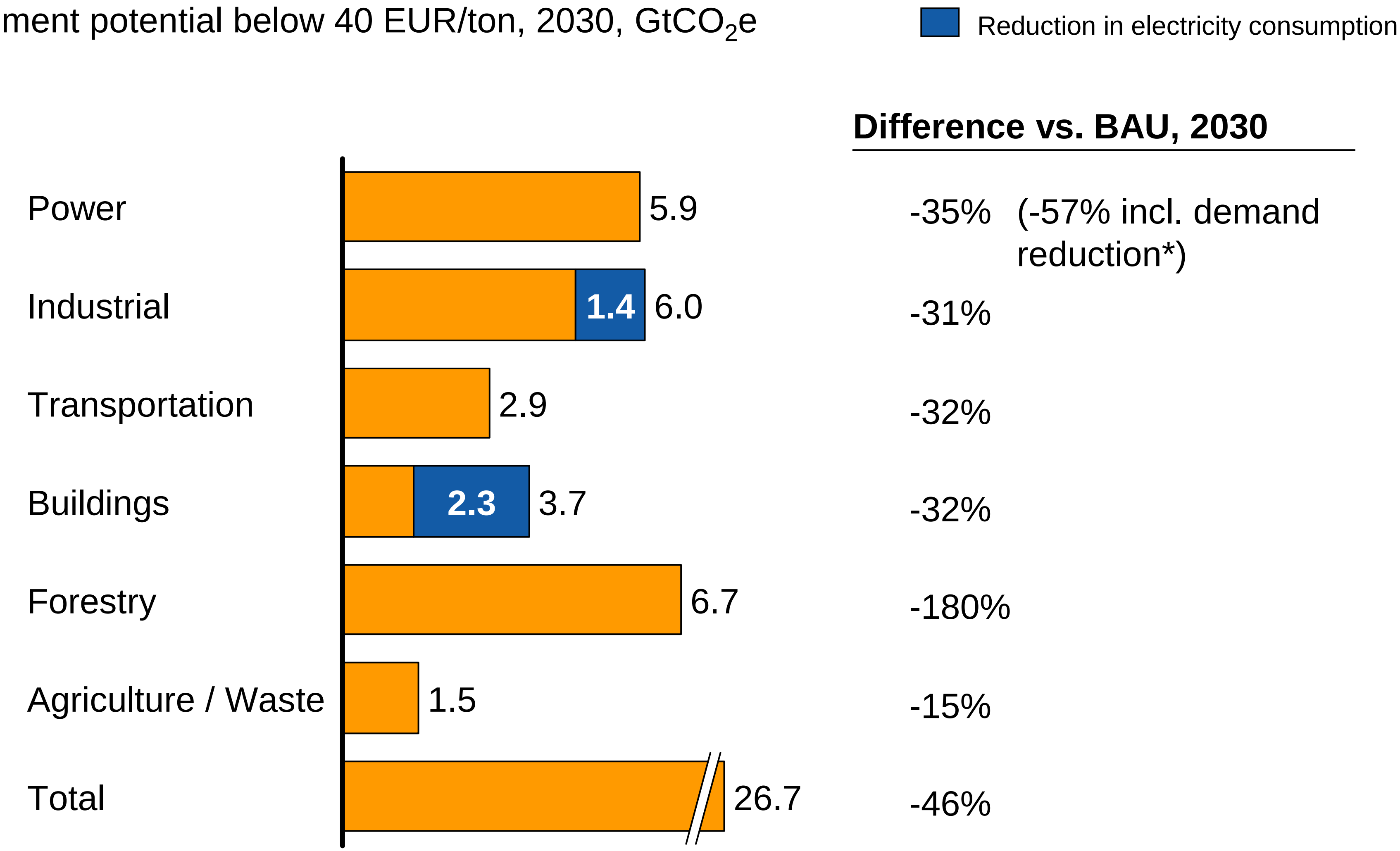
	Opportunity	Barriers
Wind power 	• Average abatement cost: – 21 EUR / tCO2e – Of which 5 EUR / tCO2e is cost induced by the high penetration • Total abatement opportunity: 0.5 $GtCO_2e$	**Environmental impact:** • Wind mill sites are often perceived as obstacles • At higher penetration rates, intermittency becomes a costly issue
Carbon capture & storage 	• Potentially installed on 55% of all coal plants by 2030 • Abatement cost: 20 – 30 EUR/tCO_2e in 2030 • Total abatement opportunity: 3.1 $GtCO_2e$	**Storage:** • Storage alternatives still need to be tested and approved **Technological development:** • Technology currently existing but needs to be proven at scale in integrated solutions

Marginal abatement cost in the different demand scenarios 2030



Abatement potential per sector

Abatement potential below 40 EUR/ton, 2030, $GtCO_2e$



Difference vs. BAU, 2030

	Difference vs. BAU, 2030
Power	-35% (-57% incl. demand reduction*)
Industrial	-31%
Transportation	-32%
Buildings	-32%
Forestry	-180%
Agriculture / Waste	-15%
Total	-46%

*I.e. 35% reduction through measures in the power sector itself (reducing emissions per MWh produced), and a total 57% including also the indirect effect of reduced electricity demand versus BAU due to energy efficiency measures in the industry and buildings sectors

Three different types of sectors

	2030 abatement potential		
	$GtCO_2e$	EUR/tCO_2e	**Key characteristics**
Power and industry 	11.9	15–40	• Mainly industrialized countries • Small numbre of large, rational emitters • High cost • Minor consumer implications • Competitive distortion issues
Transpor-tation and buildings 	6.6	<5 (often negative)	• Mainly industrialized countries • Billions of small emitters • Low/negative cost • High consumer implications
Forestry , agriculture, waste 	8.2	10–40	• 60+% developing countries • Billions of small emitters • Medium/high cost • Big social implications • Hard to measure & monitor
TOTAL	**26.7**		

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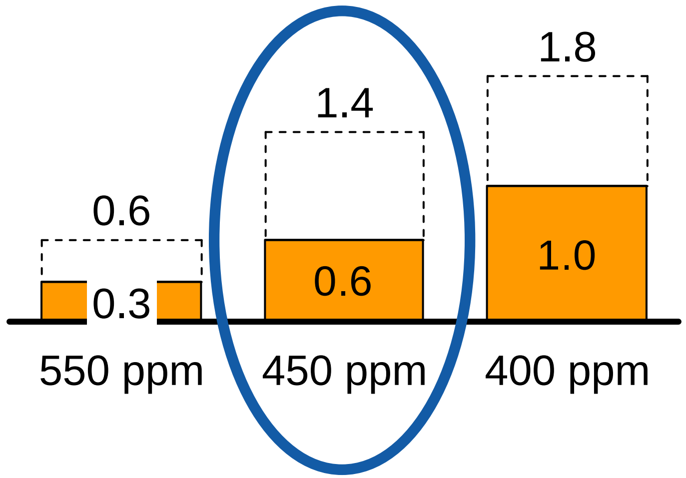
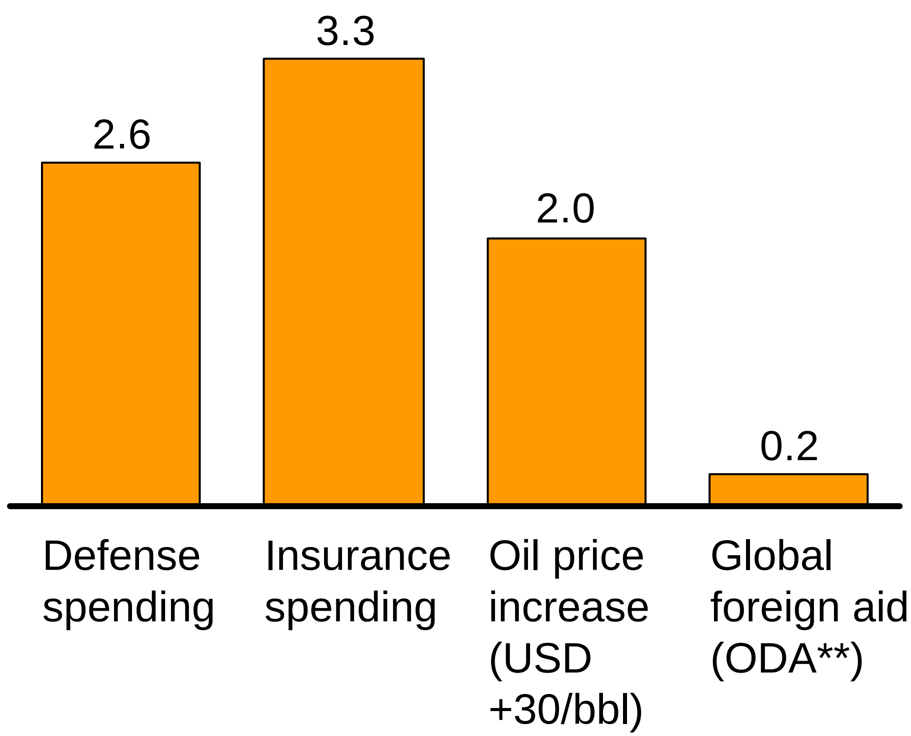
Estimates of total global cost for society

Estimates of total abatement cost for the global society*
% of global GDP 2030



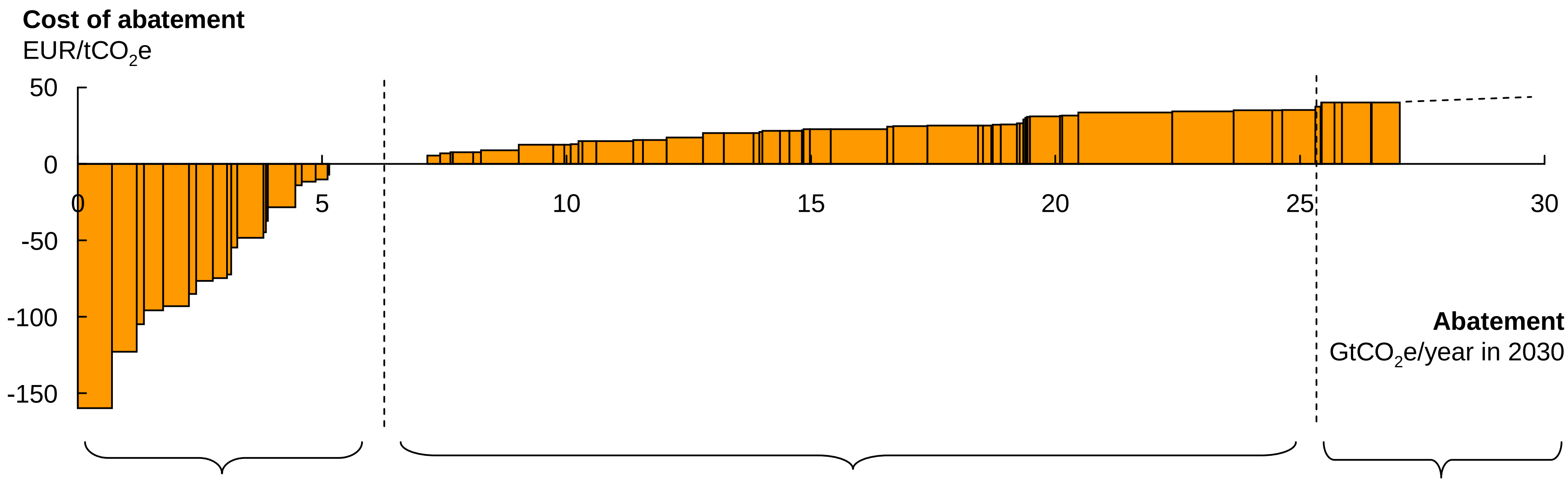
Comparables
% of global GDP 2005



* Lower boundary: Opportunities addressed in order of increasing cost and negative costs are set to zero; upper boundary: Average cost EUR 40/ton

** Official Development Assistance from OECD countries; does not include humanitarian aid or private donations

Key regulatory mechanisms identified in the abatement investigation



A **Policies/ standards for buildings and transportation, or a certificate system**

B **Long-term stable international system for power and industry**

D **International system for agriculture and deforestation**, linked to the overall developing world agenda

C **Mechanism to drive selected key technologies down the learning curve**

Conclusions

- Emissions can be reduced substantially
- The abatement potential is well distributed over sectors and regions
- Global cooperation needed to realize potentials
- Price signals are of crucial importance
- “Lubricating measures” needed in some sectors
- Total cost limited
- Speed up learning curves

Key sources of uncertainty

	Description	Examples
1. Baseline uncertainty	• Macroeconomic factors	• GDP development, population growth
2. Assessment of realistic abatement volumes/ deployment rates	• Estimate of realistic realization rates considering political, social and technical barriers	• Forestry, agriculture, nuclear, bio fuels, CO_2 storage, etc
3. Development of abatement cost	• Technology progress and learning rates • Fuel price development	• CCS, Hybrids, Biofuels, Solar PV • Biomass, fossil fuels, uranium, etc
4. Overall rate of innovation	• Development of unforeseen new technologies • Introduction of unforeseen, original “entrepreneurial solutions” driven by individual initiative and market opportunities	• Iron-seeding of oceans, aerosols, reducing warming, etc. • Compare with NO_x reduction case (several unexpected solutions introduced)

Key sources used

	Business as usual trends	Abatement
Power	• IEA World Energy Outlook 2004 • UDI for plant vintages	• IEA World Energy Outlook
Industry	• IEA World Energy Outlook 2004 • IEA for process CO_2 (Dolf Gielen) • USEPA (2006), Global Mitigation of Non-CO2 Greenhouse Gases	• IEA (Dolf Gielen) • USEPA (2006) for non-CO_2 • Japan Cement Association • Ecofys • Awrence Berkeley Lab (Lynn Price) • Institute of Technical Information for Building Materials Industry of China
Buildings	• IEA World Energy Outlook 2004 • US Energy Information Agency for residential/commercial split • MGI for breakdown by end-use	• IEA Light's Labour's Lost • IEA Annual Energy Outlook • MGI buildings models • Dolf Gielen, IEA • Ecofys
Transport	• IEA World Energy Outlook 2004 • IEA / WBSCSD transport model	• McKinsey (DRIVE initiative, Automotive Practice, Biofuels initiative, MGI) • WRI (Rob Bradley, Lee Schipper, Liz Marshall) • NRDC (Nathanael Greene, Dale Bryk) • Rocky Mountain Institute (Amory Lovins) • Princeton (Rob Socolow, Bob Williams, Eric Larson) • USEPA (Ben Ellies)
Agriculture/Waste	• USEPA (2006)	• USEPA (2006) and (Deborah Ottinger, Ben DeAngelo, Christa Clapp) • Steve Pacala, Princeton • NCAR (Jeff Fiedler) • Texas A&M University (Bruce McCarl)
Forestry	• Princeton (Steve Pacala)	• Princeton (Steve Pacala) • IPCC (Dr. N.H.Ravindranath) • Lawrence Berkeley National Laboratory (Dr. Sathaye) • Woods Hole Research Centre (Dr. Houghton) • Nature Conservancy (Zoe Kant) • Environmental Defence (Stephan Schwartzman) • Ecofys (Dr. Niklas Hohne) • Forest Stewardship Council (Daniel Arancibia) • Max Planck Institute (Annette Freibauer) • IPAM (Paulo Moutinho)

Academic review panel

Name	Institution
Prof. Dennis Anderson	• Imperial college
Prof. Lars Bergman	• Stockholm School of Economics
Prof. Steve Pacala	• Princeton University
Prof. Robert Socolow	• Princeton University
Prof. Robert Williams	• Princeton University

Fuel price assumptions used

Real 2002 prices - assumed constant through period

Fuel	Price assumptions		Comment
Crude oil	40 19.6	USD / bbl EUR / MWh th	
Heavy fuel oil	250 17.6	USD / ton EUR / MWh th	• Typical price LSFO FOB Cgo Rotterdam
Natural gas	7 19.9	USD / mbtu EUR / MWh th	• Price delivered to plant
Average coal	2.8 8.0	USD / mbtu EUR / MWh th	• Price delivered to plant
Biomass*	5 14.2	USD / mbtu EUR / MWh th	• IEA BAU assumption; imported biomass assumed to be long-term price setting
Uranium	80 3.1	USD / kg EUR / MWh th	• Historical average

Note: 1 bbl crude = 5.8 mbtu; 1 ton HFO = 40.4 mbtu; 1 kg 235U = 77 TJ; 1 EUR = 1.2 USD
* Reflects EU market prices; assumed to be 20% lower in Eastern Europe, China, and other industrials, 60% lower in developing countries

Economic development in IEA reference case (BAU)

Annual growth rate, percent

	Development 2002 - 2030	
Macro economic driver	**Globally**	**OECD**
GDP	3.2 % p.a.	2.2 % p.a.
Population	1.0 % p.a.	0.4 % p.a.
Energy demand	1.6 % p.a.	1.1 % p.a.
Energy related emissions	1.7 % p.a.	0.9 % p.a.

Source: IEA World Energy Outlook 2004

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Source: All of the presented figures represent possible future scenarios, based on certain assumptions regarding global population and GDP development.