The Role of Carbon Capture and Storage (CCS) in Tackling Climate Change

Nick Mabey, E3G

September 2008

Outline

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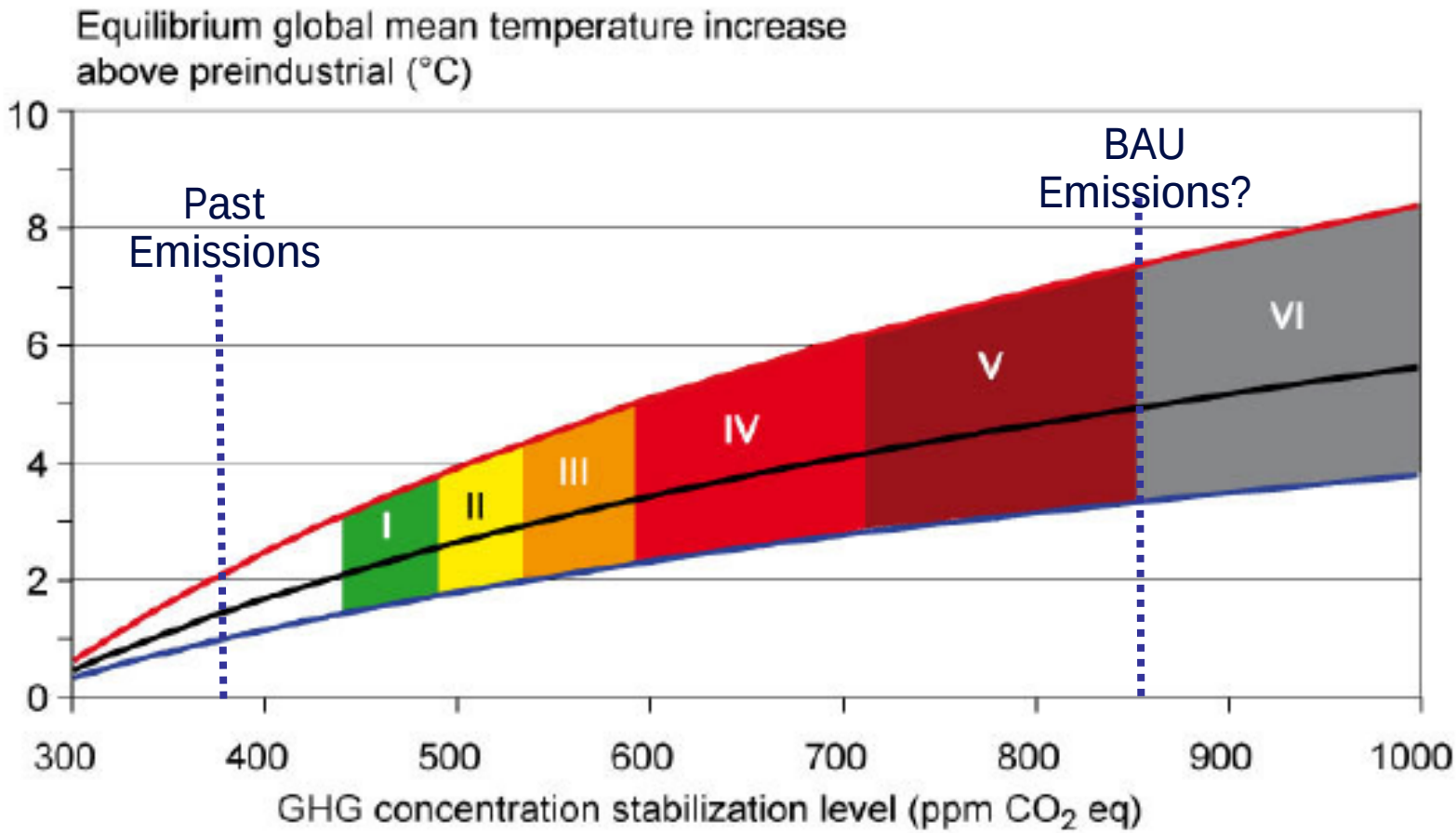
- Delivering Climate Security

- The Economics of Transformation

- Managing Climate Risks
  - Avoiding high carbon lock-in
  - Delivering energy and climate security
  - Managing policy failure

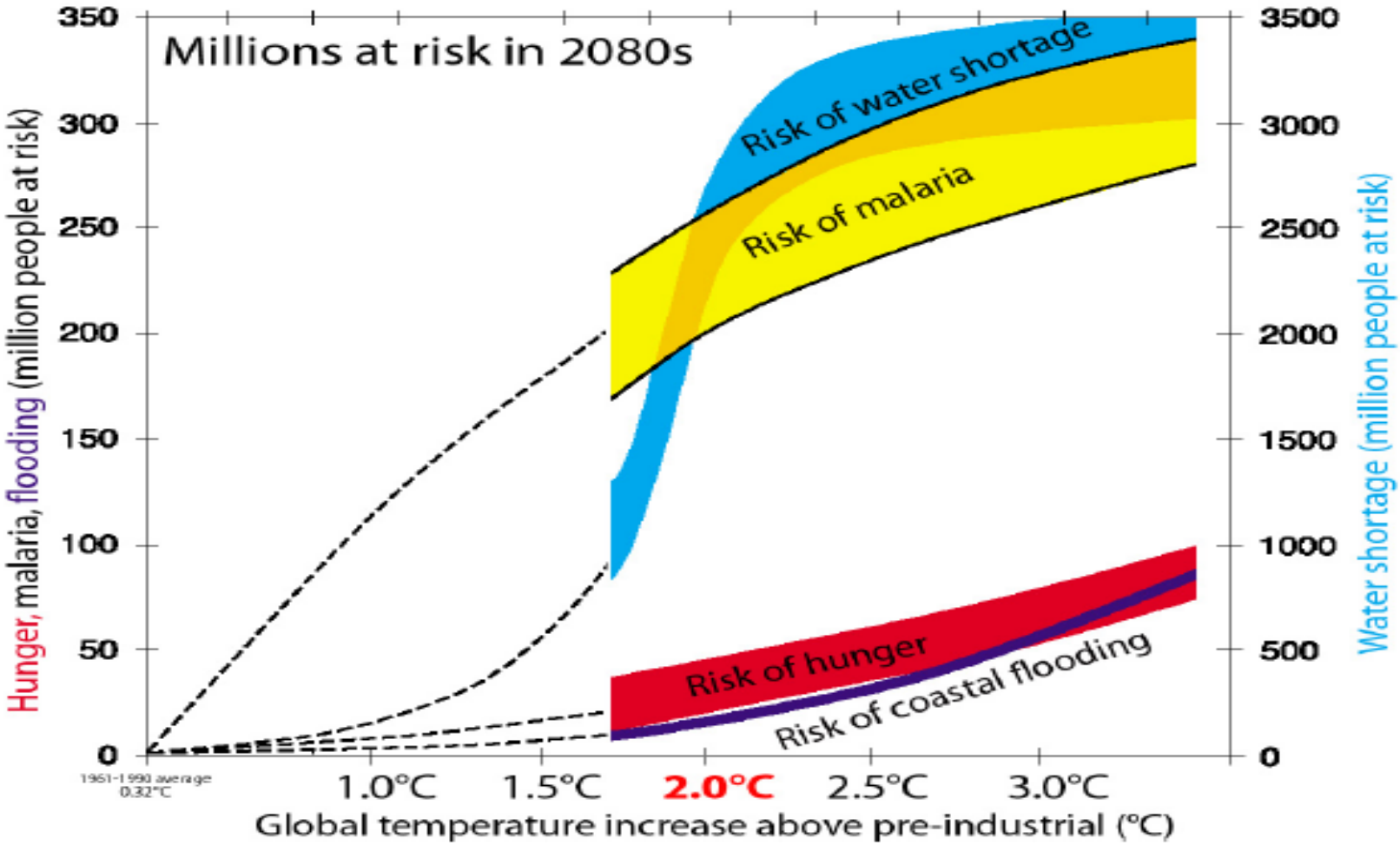
- Developing CCS as a critical low carbon option

Past GHG emissions will result in 1.6C warming. Business as Usual will result in a rise of up to 6.5C by 2100



Source: IPCC (2007)

Global temperature rise above 2^{0}C has been seen as a threshold for greatly increased damages



Source: Vattenfall (2007); IPCC WG II (2007)

IPCC AR4 Finds Greater Risks

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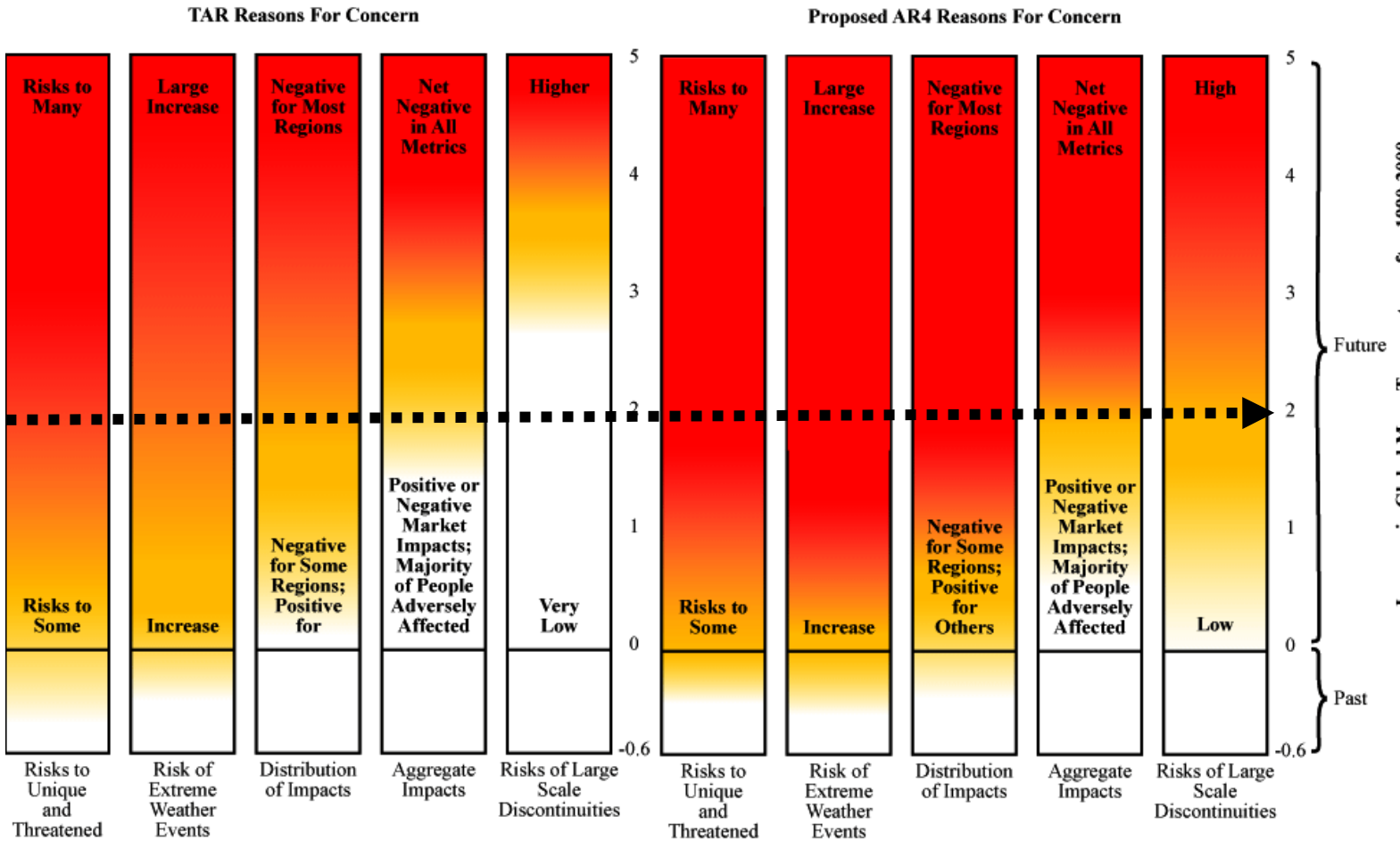

Dangerous Climate Change: An Update of the IPCC Reasons for Concern, December 30, 2007: Joel B. Smitha, Stephen H. Schneiderb, Michael Oppenheimerc, Gary W. Yohed, William Haree, Anand Patwardhanf, Michael D. Mastrandreag, Ian Burtonh, Jan Corfee-Morloti, C. H. D. Magadzaj, Hans-Martin Füsselk, A. Barrie Pittockl, A. Rahman,m A. Suarezn, and Jean-Pascal van Yperseleo

Preserving climate security means avoiding climate tipping points

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IPCC/Stern analysis did not include many of the most extreme impacts of climate change

- High impact scenarios: Atlantic conveyor slowdown; increased storm activity; monsoon variation;
- Cost of social instability and conflict
- Irreversible impacts (all accelerating): glacial melting; icesheet melting rates; ocean acidification
- Runaway climate change: Amazon forest dieback; tundra melt; release of methane hydrates;

Stern acknowledges he underestimated the cost of climate change. Real issue is how we avoid passing these tipping points

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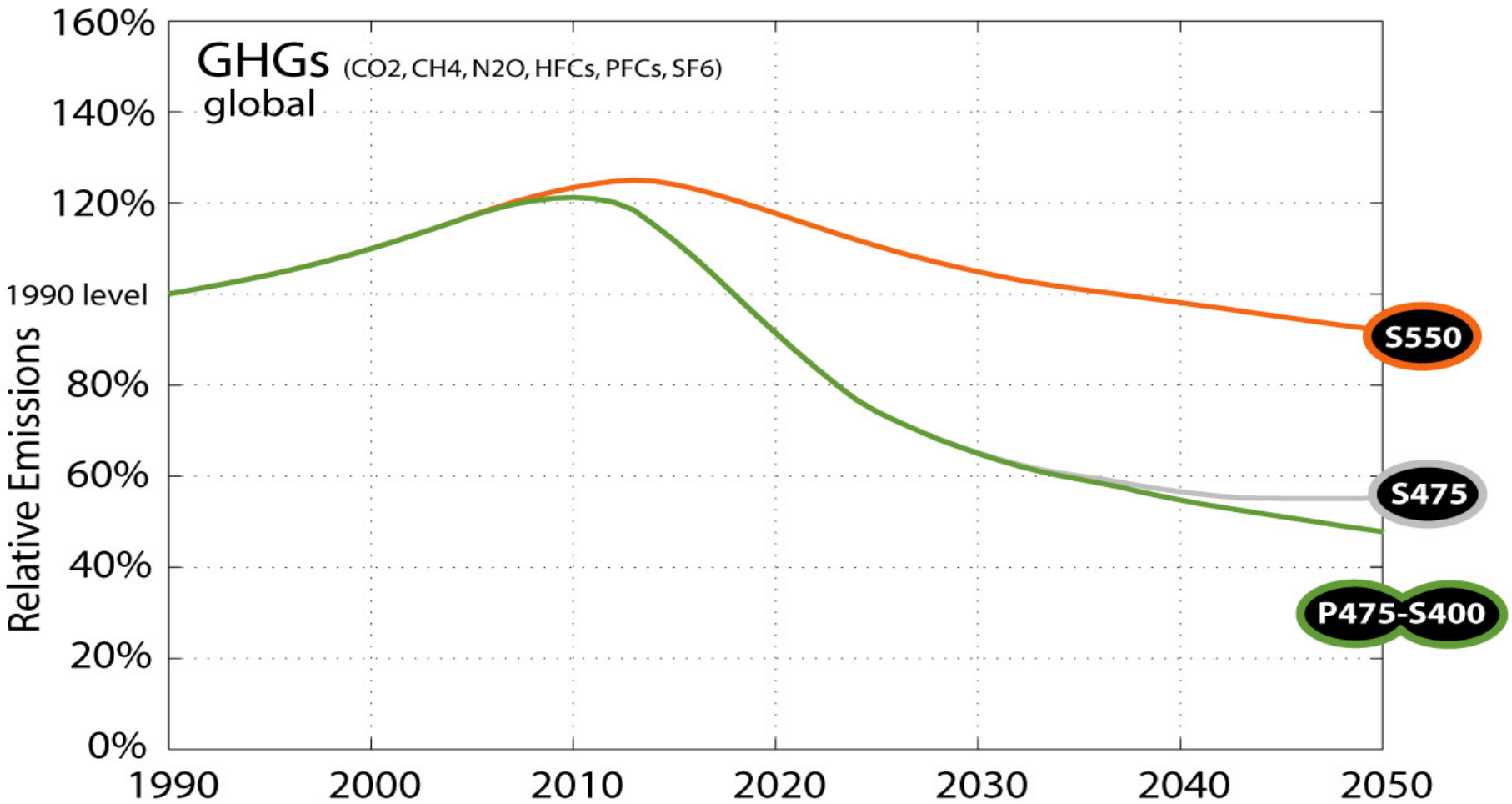
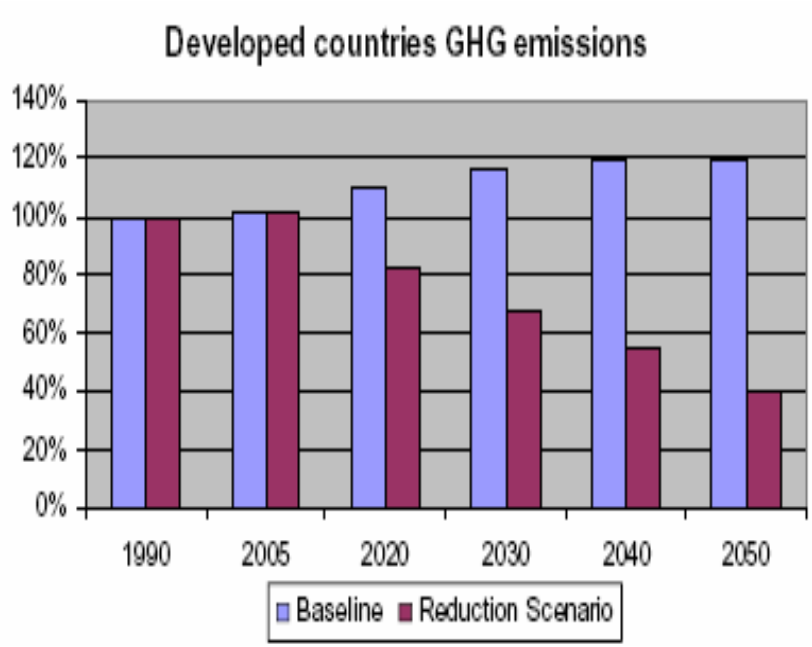
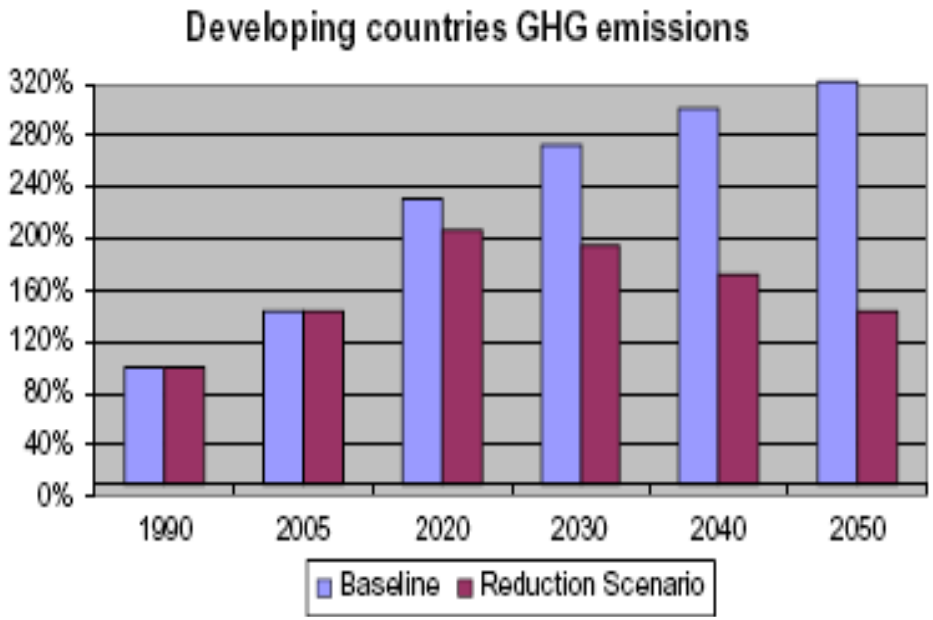
There is less time to avoid disastrous climate change: peak in global emissions in next 10 years



(M. Meinshausen, PIK)

A 2C future means Developed Countries emissions falling 20-30% by 2020 and 60-80% by 2050



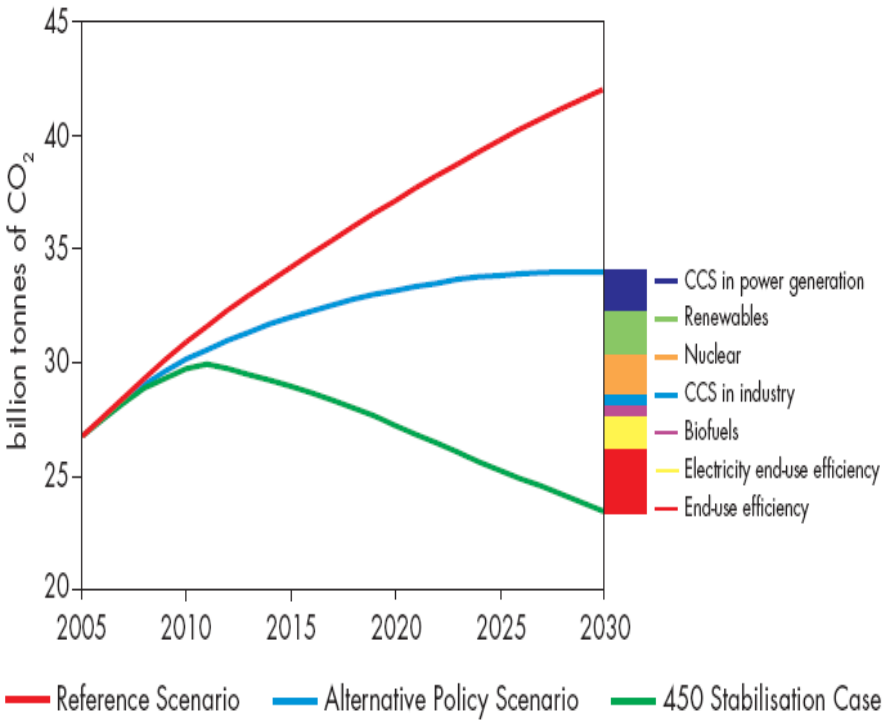


Source: European Commission EPRG January 2007

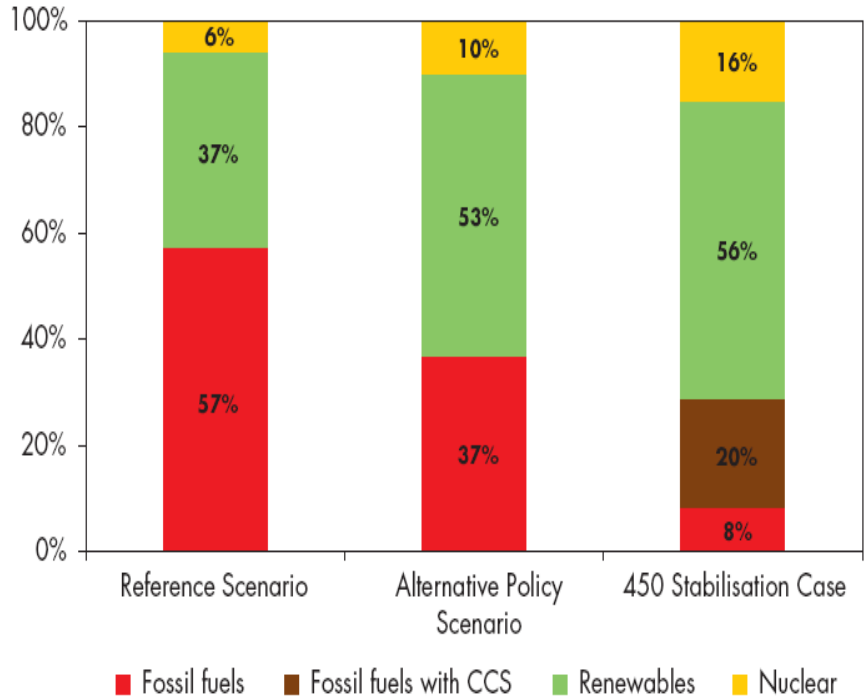
This aggressive scenario gives a 50% chance of avoiding a 2C temperature rise

This requires delivery of a lot of efficiency and new low carbon generation in the next 20 years

CO2 Emissions in the 450 Stabilisation Case

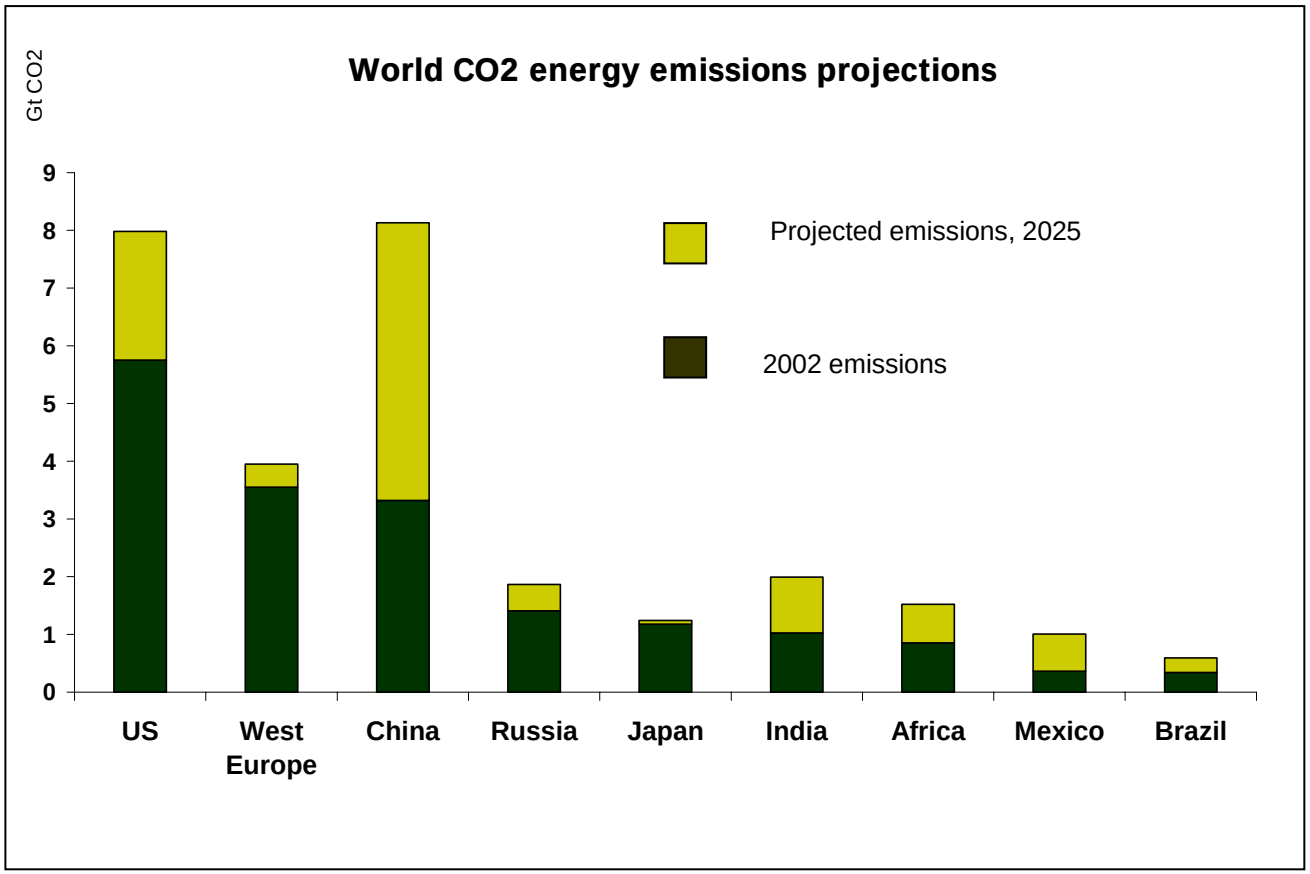


Share of Cumulative Power-Generation Investment by Technology, 2006-2030



Source: IEA, WEO (2007)

Transformation needed in a small number of large developed and developing country emitters



Twenty-five countries (counting the EU as one) are responsible for 83% of global greenhouse gas emissions

Source:WRI CAIT Energy Information Administration Reference Scenario, Energy emissions only

The implied investment shifts in these scenarios are very dramatic

	Annual Intervention (from 2013)	**Net Intervention 2030**	**Net Installed Energy 2030 (GW)**
Nuclear	30 nuclear reactors of 1000MW each	510 reactors	510
Fossil Fuel with CCS	22 CCS coal-fired plants of 800MW each and 20 CCS gas-fired plants of 500 MW each	374 coal fired plants and 340 gas fired plants	469.2
Renewables	400 CHP plants of 40 MW and 17000 wind turbines of 3MW each	6800 CHP plants and 289000 wind turbines	1139
Hydro	2 three georges dam of 22500 MW each	34 three georges dams	1530

Source:Adapted from IEA WEO 2007 by Froggatt and Viswanath, 2008

Creating an Economics of Transformation

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Climate Change is unique challenge to drive global change in markets and technology towards a public good goal inside a specific timescale (outside WWII and Cold War).

Post 2012 framework needs to target three core activities:

- **Investment**: consistent signals to investors to move on-going energy system investment towards low carbon alternatives.
- **Innovation**: produce sufficient "market pull" to generate radical investment in innovation in the next generation of low carbon technologies, services and businesses.
- **Institutions**: redesign the market, regulatory and business models currently shaping the energy system so they efficiently and effectively drive low carbon investment, and are increasingly sensitive to carbon price signals.

Very weak understanding of what is a robust system of incentives and institutions to drive the transition to a low carbon economy

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Managing Climate Change Risk

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- High risk of catastrophic climate change if miss low emission paths
- Large simultaneous shift to high efficiency and low carbon power needed in developed and major developing countries
- Mechanisms and technologies for achieving this transformation very underdeveloped

Need to develop a risk management approach to climate change - not a cost-optimisation frame

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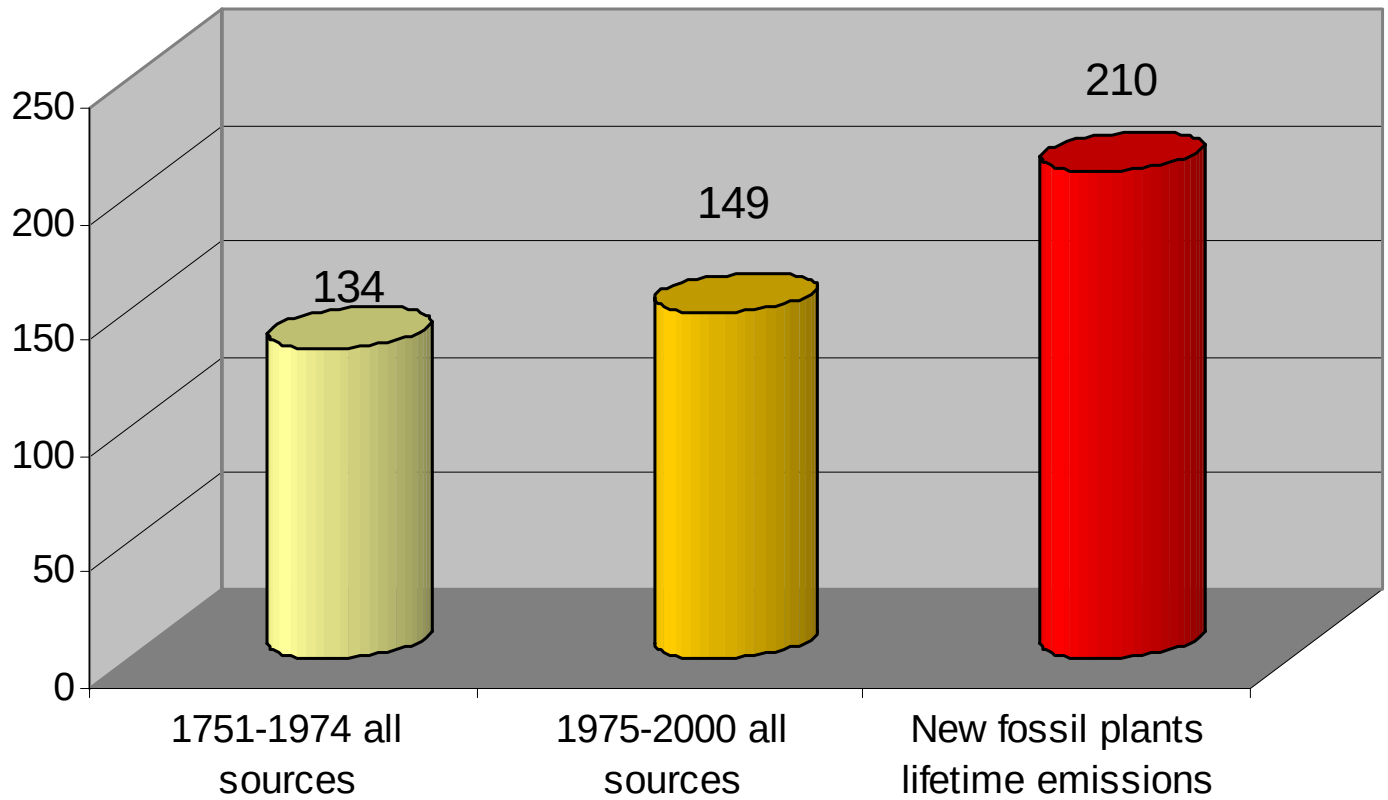
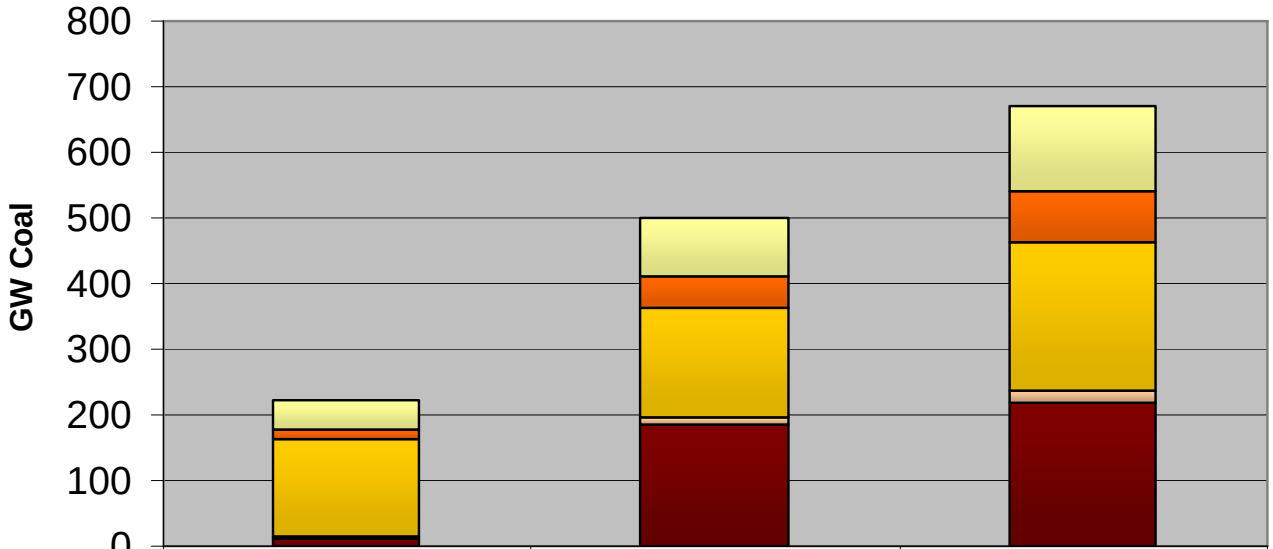
Lifetime emissions just from fossil power plants planned in next 30 years preclude a 2C world



(Billion tonnes carbon)

Source: ORNL, CDIAC; IEA, WEO 2004

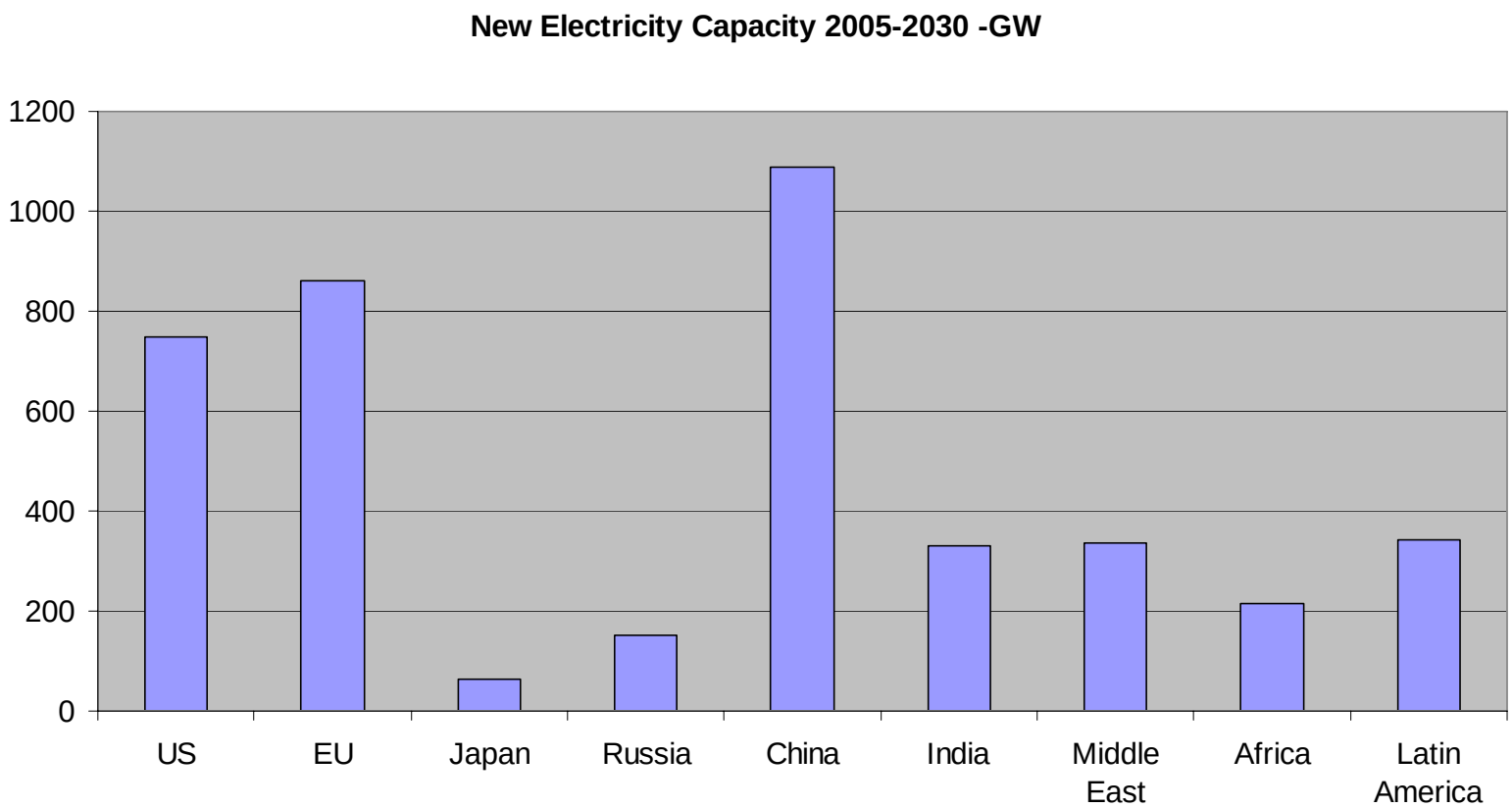
Developing countries are investing first and fastest in coal capacity but OECD close behind



	2003-2010	2011-2020	2021-2030
Other Developing	43	90	128
India	16	48	79
China	150	168	226
Transition	1	11	19
OECD	12	184	218

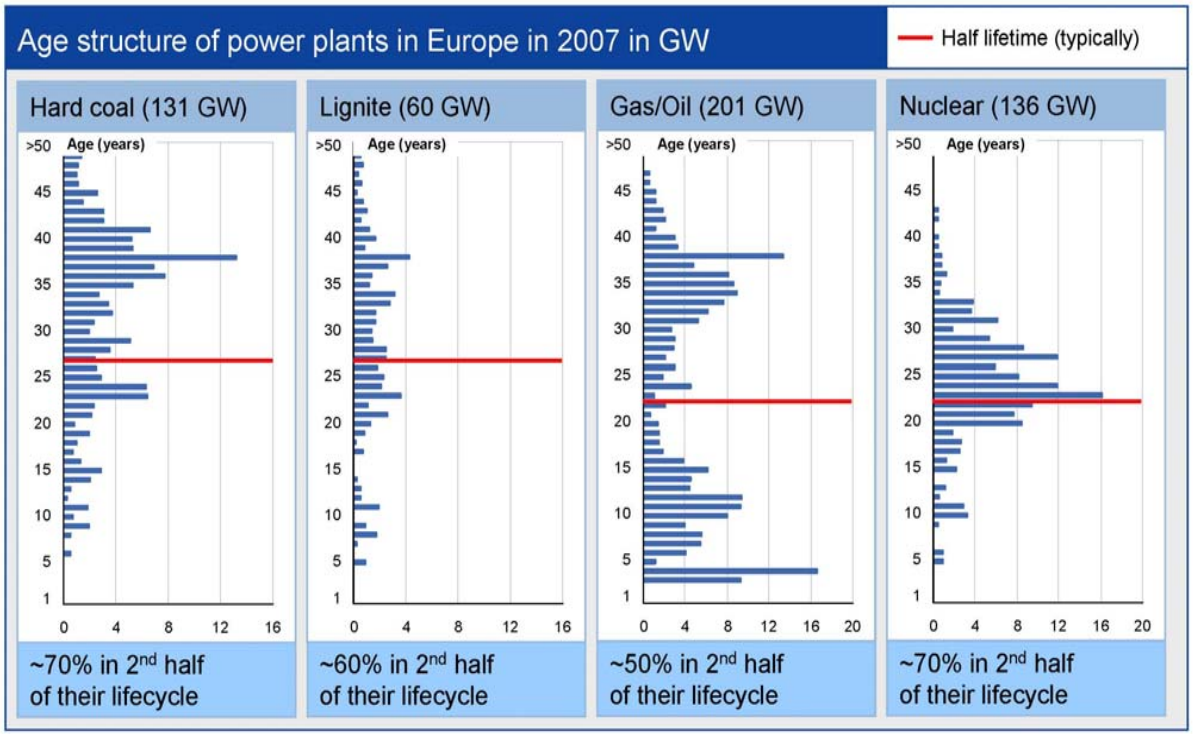
Source: IEA, WEO 2004

Aging infrastructure means significant new energy investment



Source: IEA, 2006; Euroelectric 2007

Even in Europe more than half of current generation capacity will need to be replaced by 2030



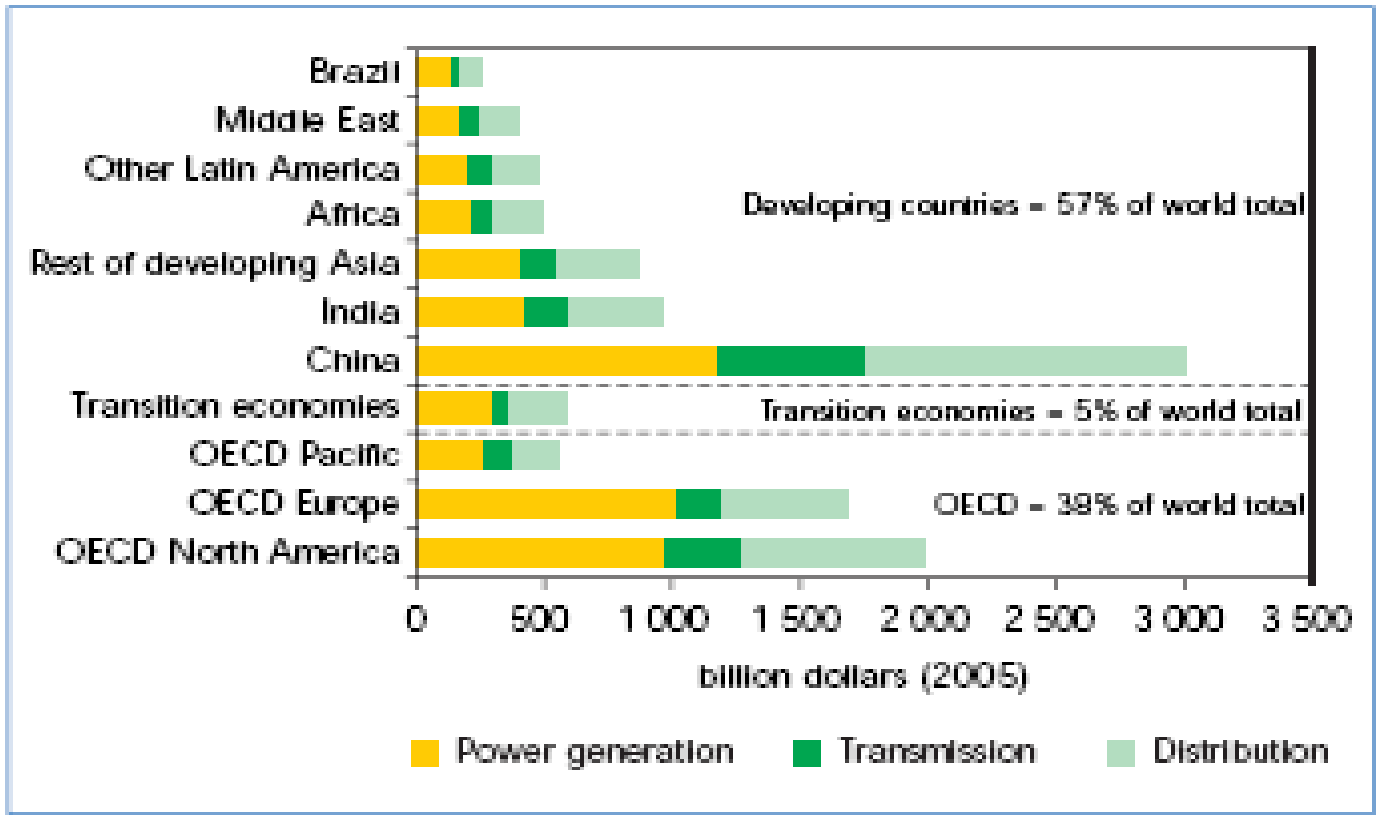
Sources: BCG, RWE

Source: Euroelctric (2007)

- IEA 2005-2030 the total new capacity in EU will be 862 GW, additional installed capacity is 395 GW; 61% of current capacity.
- Eurelectric 822 GW of new power stations replacement of old capacity (439 GW).
- In 2030-2050 new investment is estimated at 605 TW and decommissioning at 470 GW

Developing countries are also investing in major power infrastructure

Cumulative Power-Sector Investment by Region in the Reference Scenario, 2005-2030



- **China alone needs to invest about $3.7 trillion – 18% of the world total. Russia and other transition economies account for 9% of total world**

Source: IEA, WEO 2006

Lock-in of unabated coal power and standard power infrastructure

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- Business as usual development would see lock-in to a new generation of coal and conventional power infrastructure

- Even with CCS unless power systems are made truly CCS-compatible now – location; technologies; supply chains – retrofit is highly unlikely

- Lowest risk to climate security would be to have a moratorium on new coal generation without CCS; first impact would be to drive a global dash to gas.

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Energy and Climate Security are public goods; markets will not automatically give right signals to shift major investment

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- Recent fossil fuel price increases dwarf equilibrium carbon price in Stern Review/IEA etc but are not leading to carbon-free economy

- Price rises and energy security are driving investment in climate instability:
  - rapid rise in coal power investment - outside US
  - coal to liquids investment in US and China
  - large increase in carbon inefficient biofuels

- Impact on energy efficiency of high energy prices has been very slow, even in transport sector

Need coherent, clear and effective policy signals to drive investment to deliver energy and climate security together

Most major countries have good reasons for using indigenous coal and avoiding gas

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- **Europe**: fear of dependency on Russia and North Africa/Iran; Georgia effect!
- **India**: Pakistan/US block to Iranian gas; tensions with Myanmar/Bangladesh/Nepal on gas and hydro access
- **China**: reluctance to rely on Russia –limited supplies from Central Asia and Myanmar.
- **US**: major gas supplies from Canada plus indigenous sources

Any credible strategy must deliver energy and climate security

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- In the short term energy security will always trump climate security
- Strong policy on coal moratorium is good for investment in CCS and other alternatives, but raises fears of gas dependence
- Without advances in solar technology countries such as China and India have few alternatives
- “Carbon Catch 22” biases towards existing technologies as policy makers find it hard to give credible incentives for alternatives at scale.

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All current 450ppm scenarios depend on delivering high levels of energy efficiency

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Cumulative CO2 reduction in BLUE Scenario, 2008-2050

End-use fuel efficiency	**24%**
Electricity end-use efficiency	**12%**
Electrification	**6%**
Total renewables	**21%**
CCS power	**10%**
CCS industry and transformation	**9%**
Nuclear	**6%**
Power fossil fuel and switching efficiency	**7%**
End-use fuel switching	**1%**
Hydrogen FCVs	**4%**

43% reduction through energy efficiency; 19% from CCS

Source:Adapted from IEA ETP 2008 by Froggatt and Viswanath, 2008

Risk to these scenarios are high and hedging strategies are needed

- Efficiency is notoriously hard to deliver at pace in all countries without punitive price signals
- Demand growth may be higher – especially in Asian transport markets
- Lack of delivery on alternative biofuels would place more pressure on low carbon power generation

Need to plan for policy failure leading to higher demands for low carbon electricity

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The case for developing the CCS option as quickly as possible

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- Need to have a high probability for avoiding climate change tipping points and have hedges against policy failures
- Investment dynamics and energy security imperatives mean that large scale new coal build is very likely globally
- Without CCS as a viable power option soon these investments will lock-in climate instability into the future; must avoid “CCS Ready” camoflage
- All radical abatement trajectories assume early deployment of CCS. If CCS is not technically, geologically or economically feasible at large scale need to know quickly in order to develop “Plan B”

Climate risks are too high not to take CCS seriously

Constructing a CCS strategy

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- Whether you “believe” in CCS or not – it is critical to have an early answer to CCS feasibility and costs.
- First step to is avoid lock-in to unabated coal: moratorium in developed countries; carbon capture compatible in developing countries
- Second step is global demonstration programme of at least 20 full scale plants by 2015. Public funded to ensure technology and geographic spread – and public IPR generation.
- Third step is regulatory and financial incentives for technology diffusion and deployment from 2015 onwards

Aim is not to pick winners- but to ensure there are enough winners available to avoid catastrophic climate change