Toward a Global Climate Deal: An Integrated Science and Policy Approach for Real Impact

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TERI

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International Institute for Applied Systems Analysis

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- International, independent, interdisciplinary research on solutions to global problems
- From East-West to global coverage and South-North:

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Finland	Russia	Egypt
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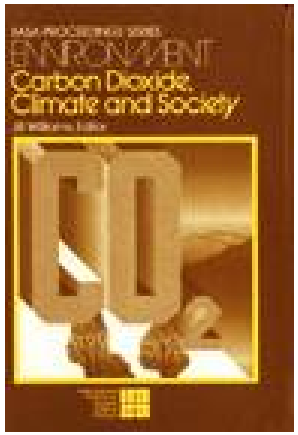
Japan	Ukraine	Pakistan
Netherlands	USA	South Africa
Norway		South Korea

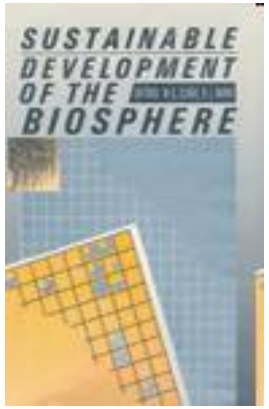
Examples of Early Research



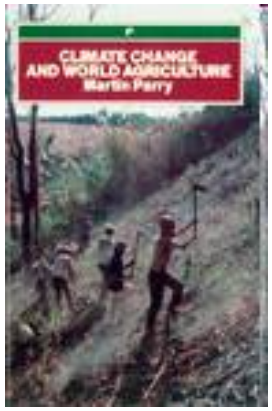
1978

1981

1983

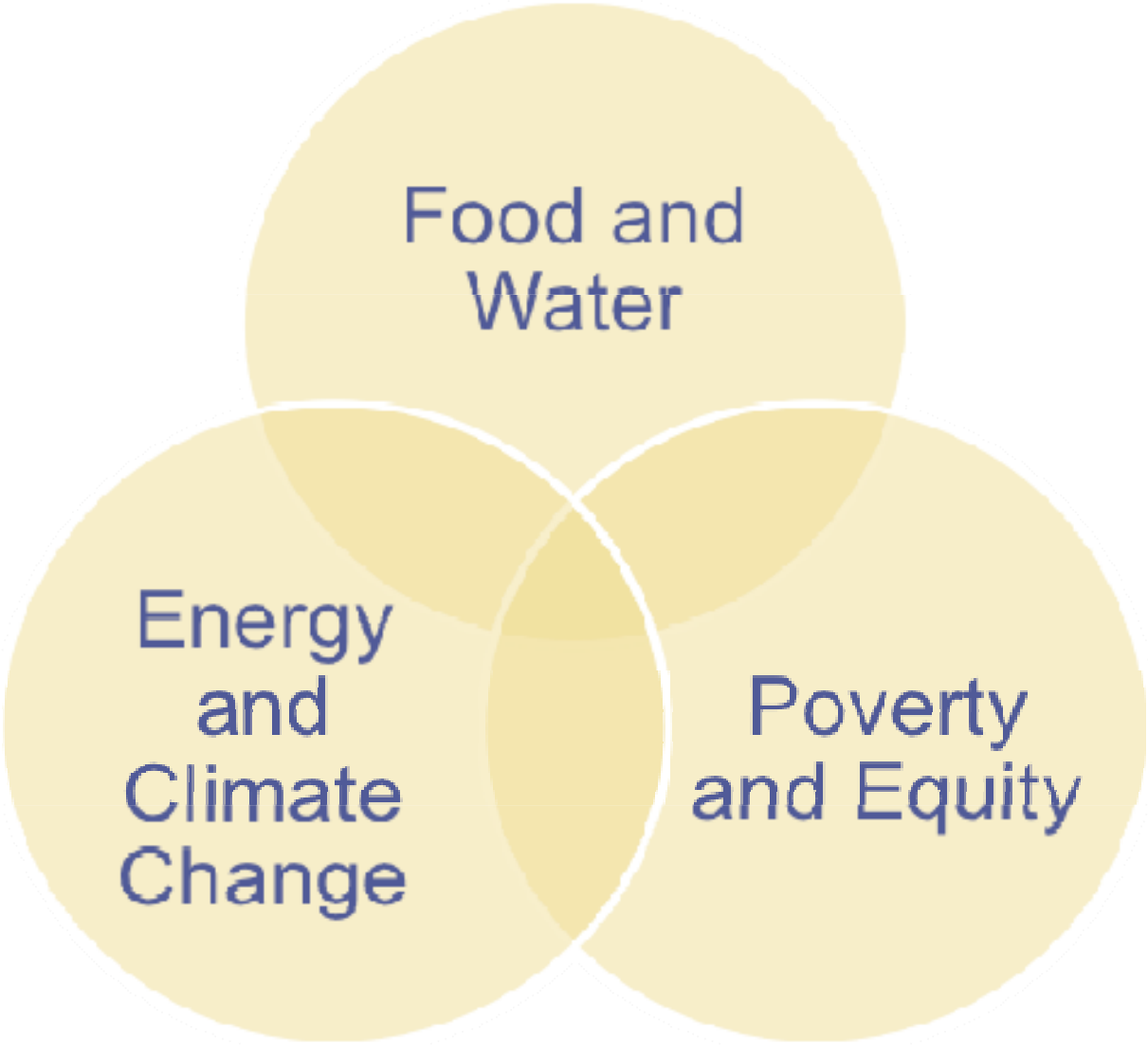


1986



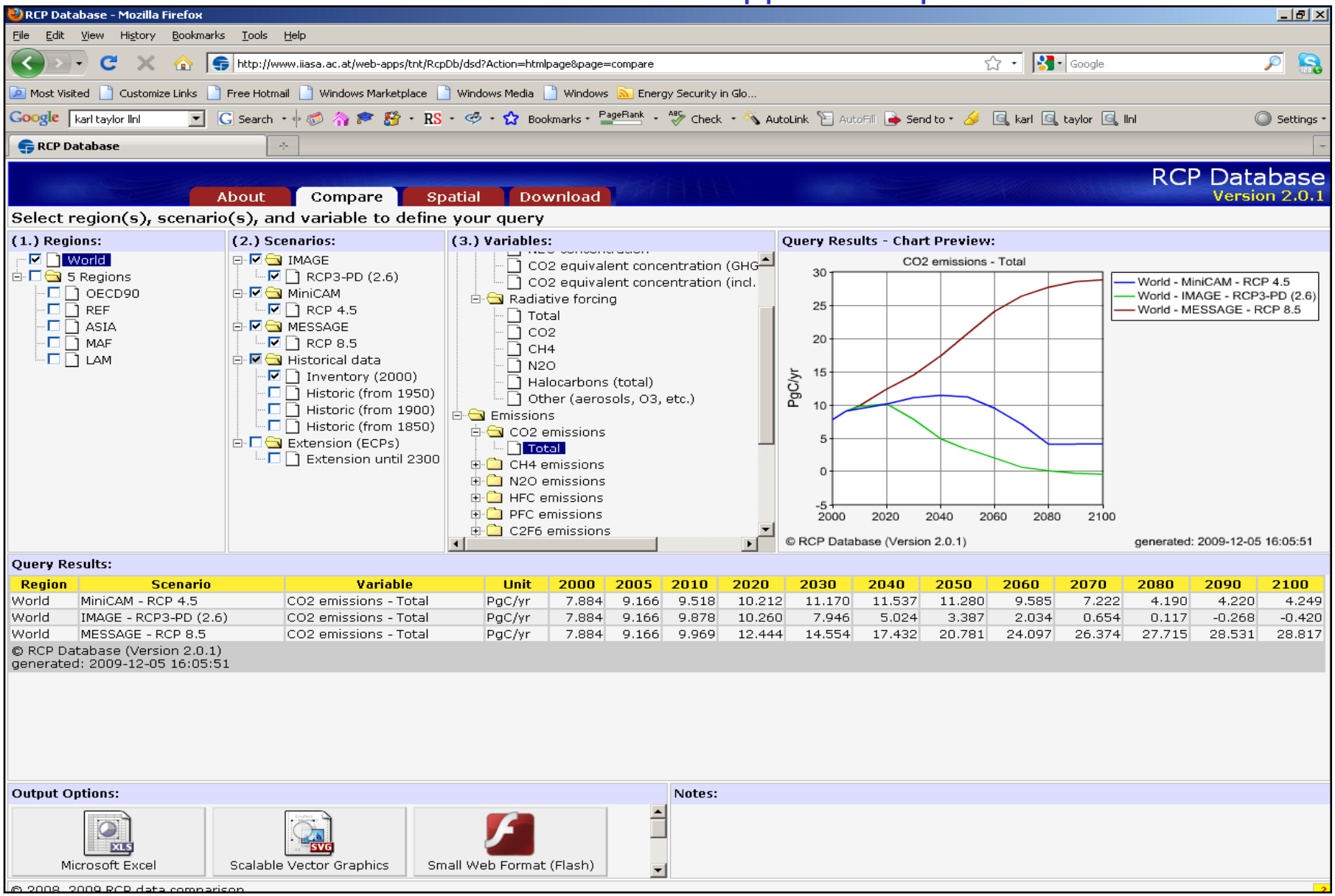
1990

Research for a Changing World



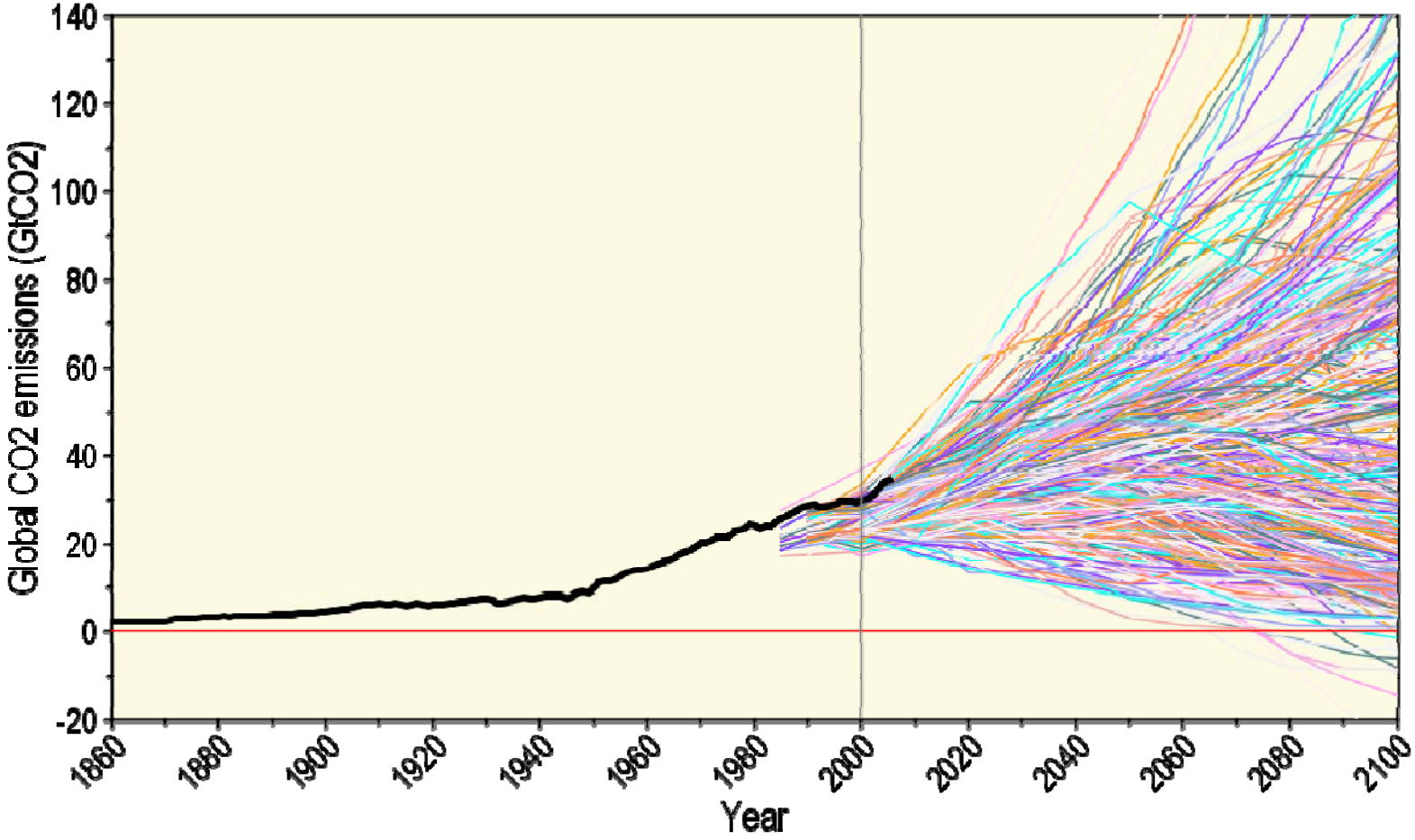
RCP Database

www.iiasa.ac.at/web-apps/tnt/RcpDb



Global Carbon Emissions

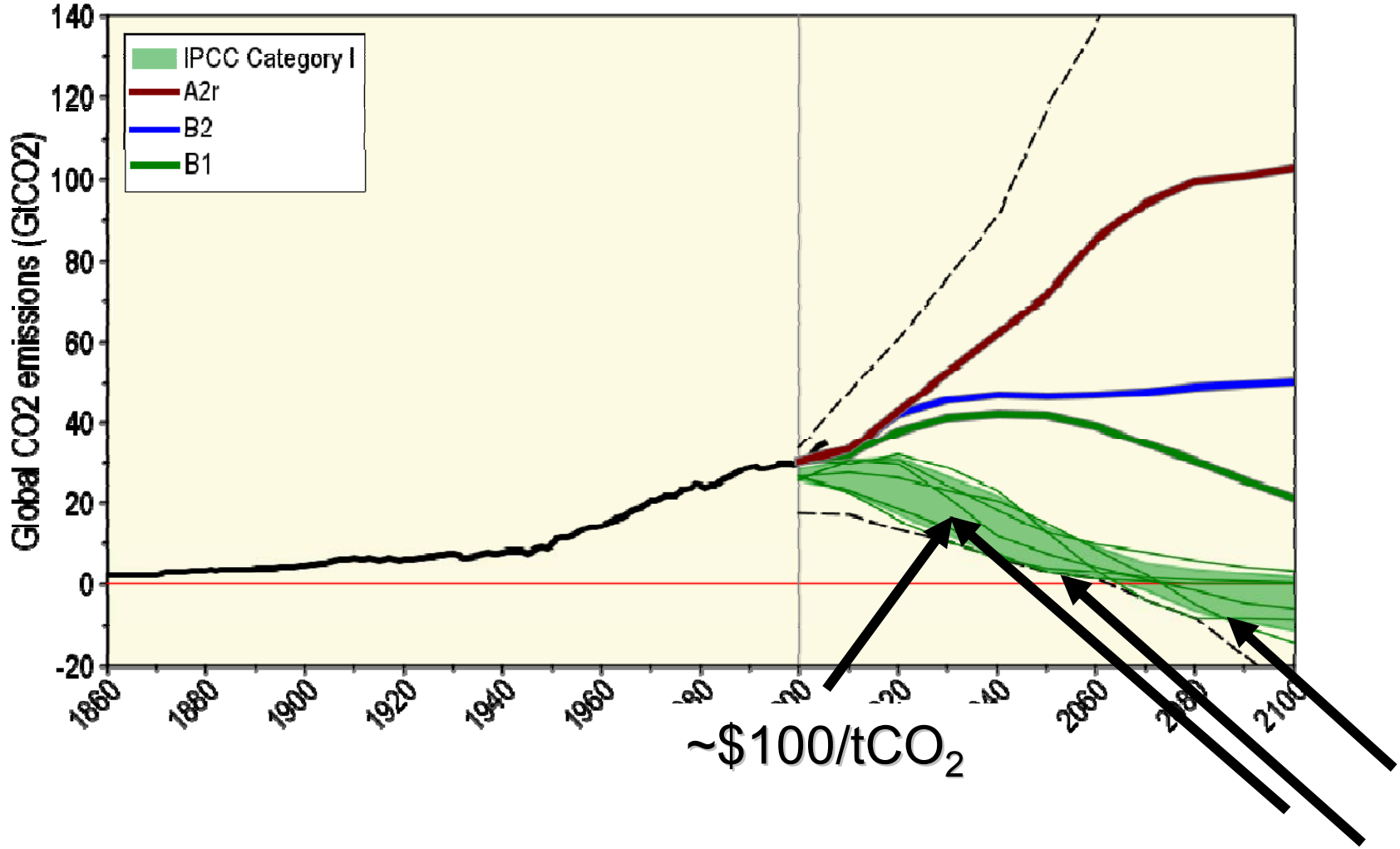
Range of All Scenarios Assessed in IPCC AR4



Source: IPCC, 2007

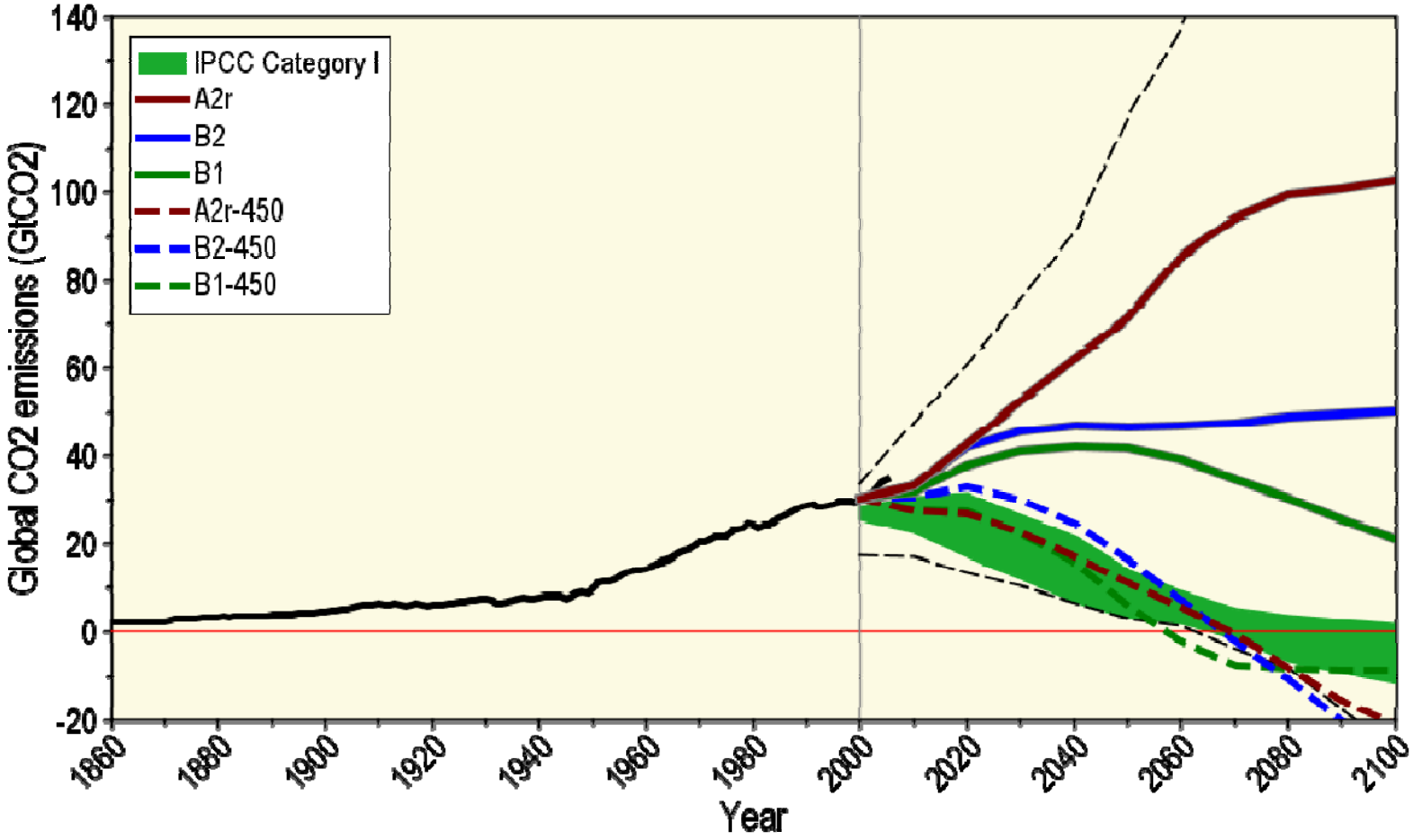
Global Carbon Emissions

Baseline-Range & Low Stabilization Scenarios



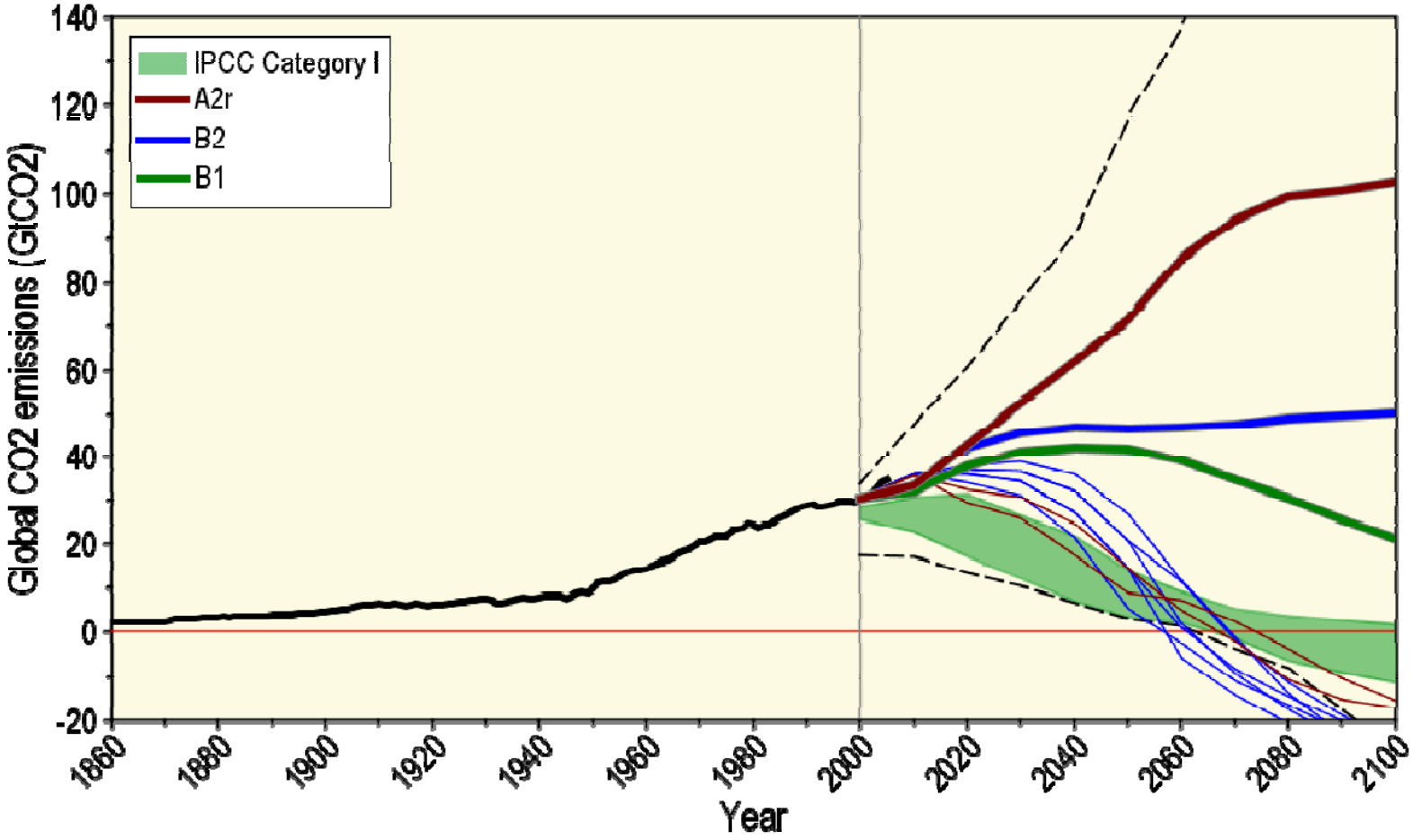
Global Carbon Emissions

Baseline-Range & Low Stabilization Scenarios



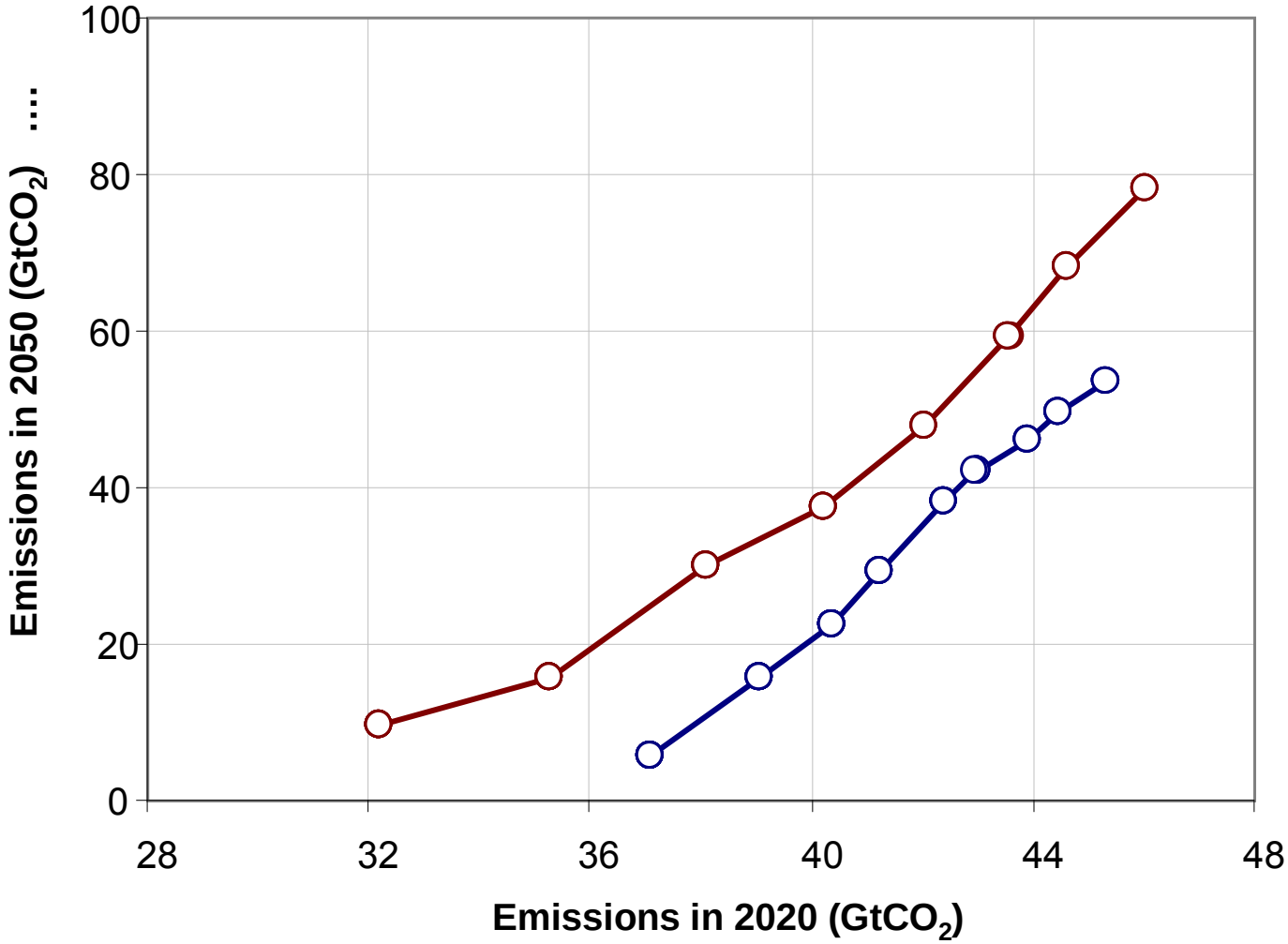
Global Carbon Emissions

Baseline-Range & low stabilization scenarios



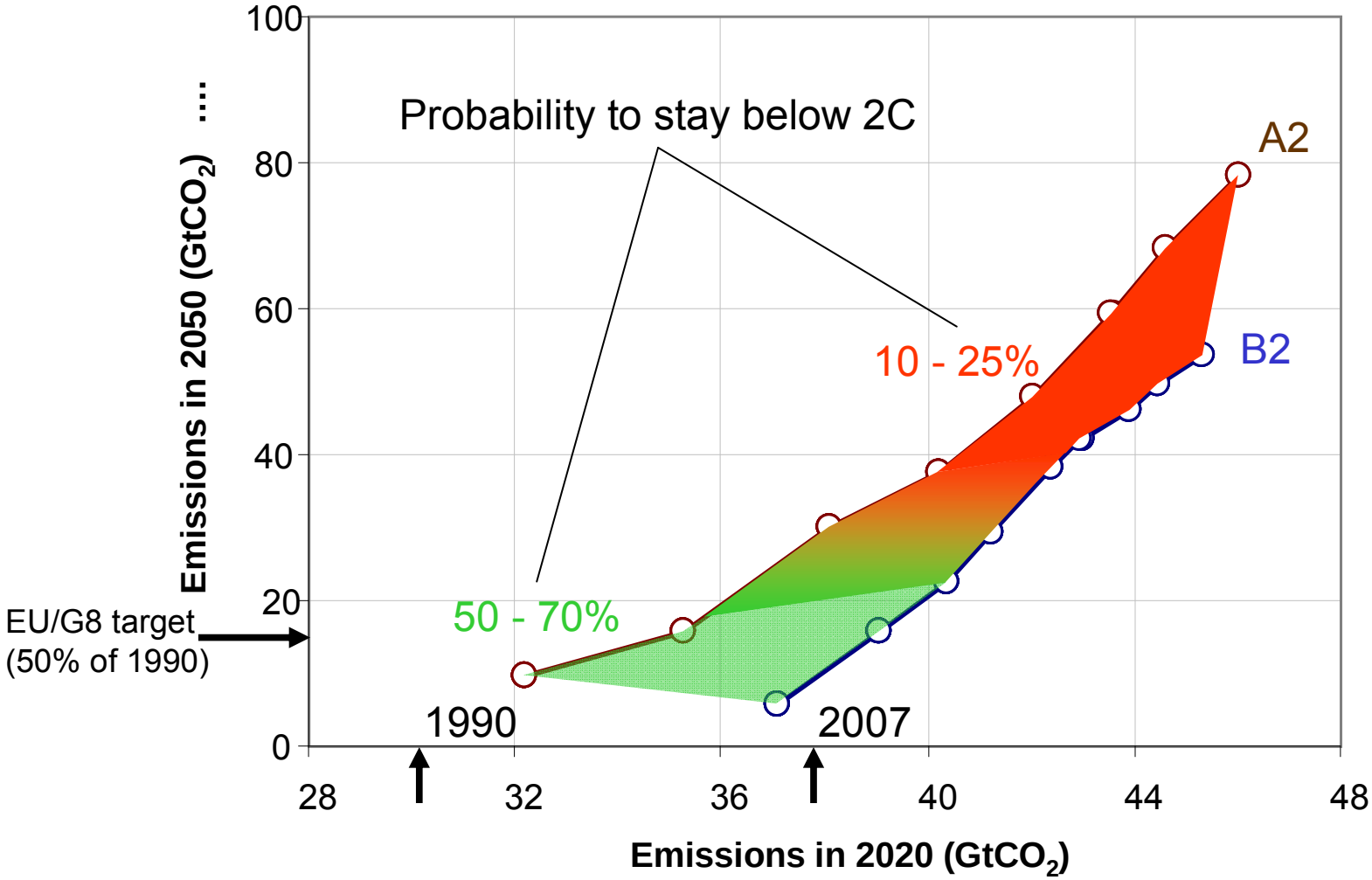
World CO_2 Emissions

2020 vs 2050



Riahi, 2009

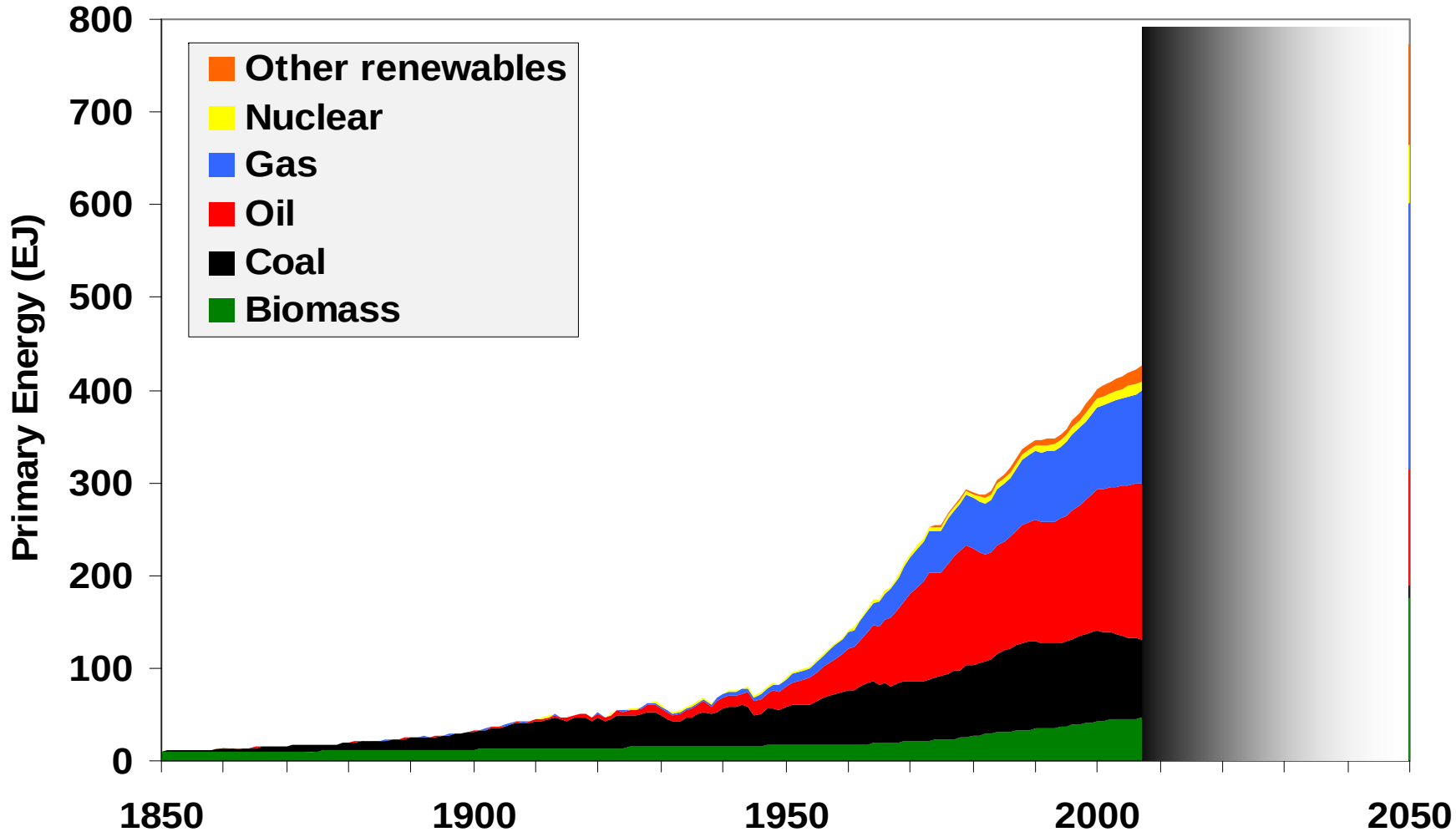
World CO_2 Emissions
2020 vs 2050



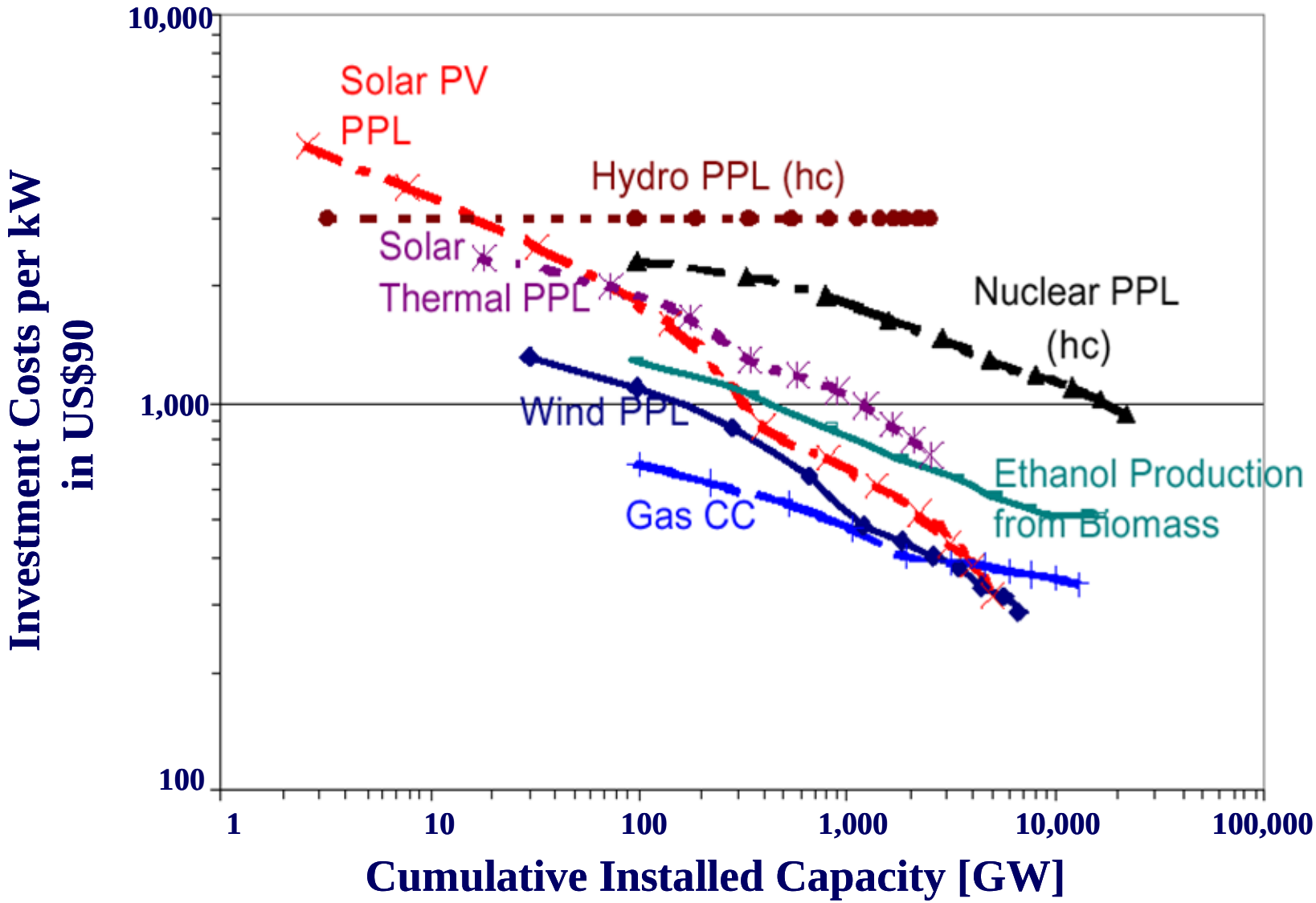
Source: Riahi, 2009

Global Primary Energy

450 ppm CO_2-equ. or 2°C



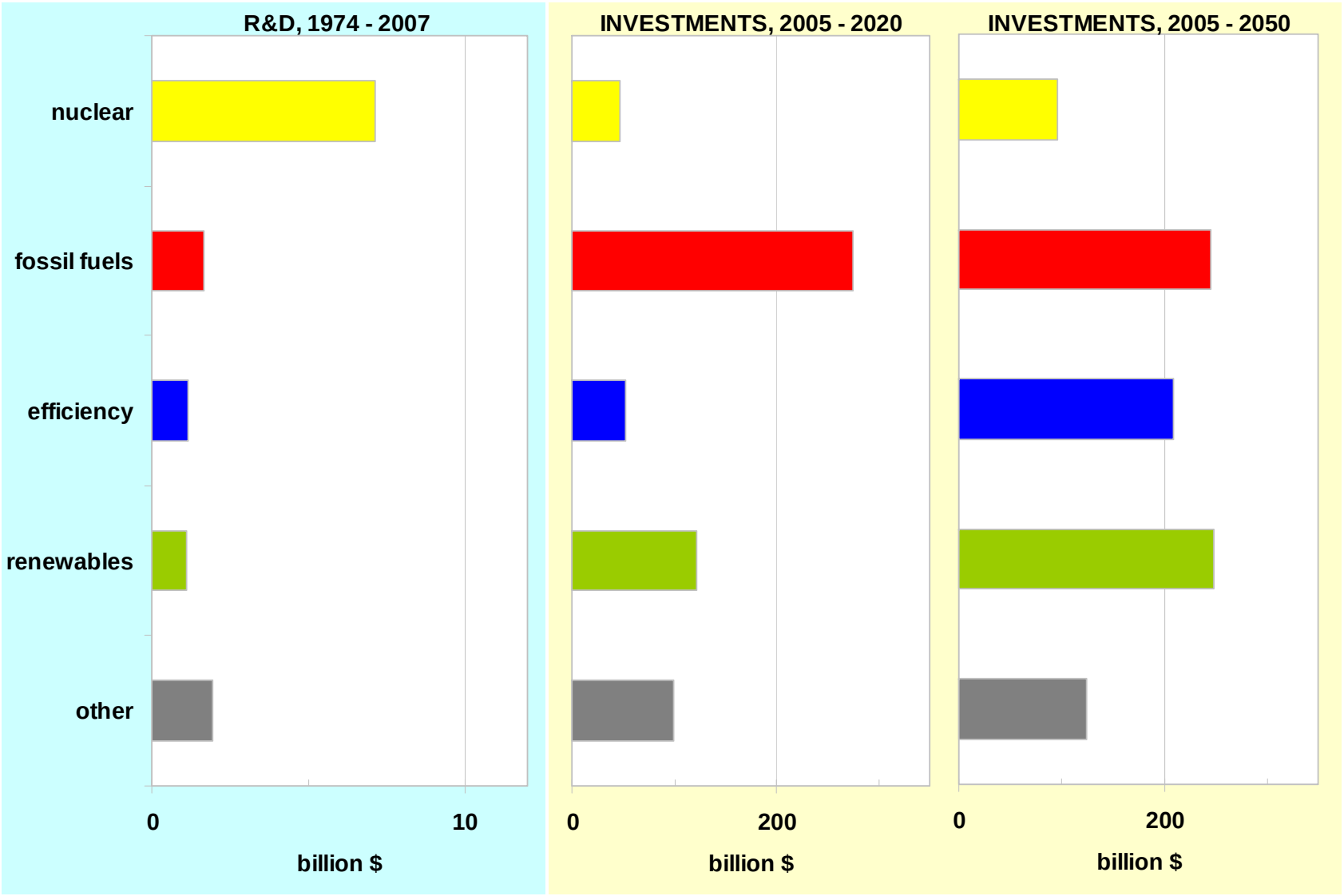
Future Technology Learning



Source: Riahi, 2009

Energy R&D & Investments

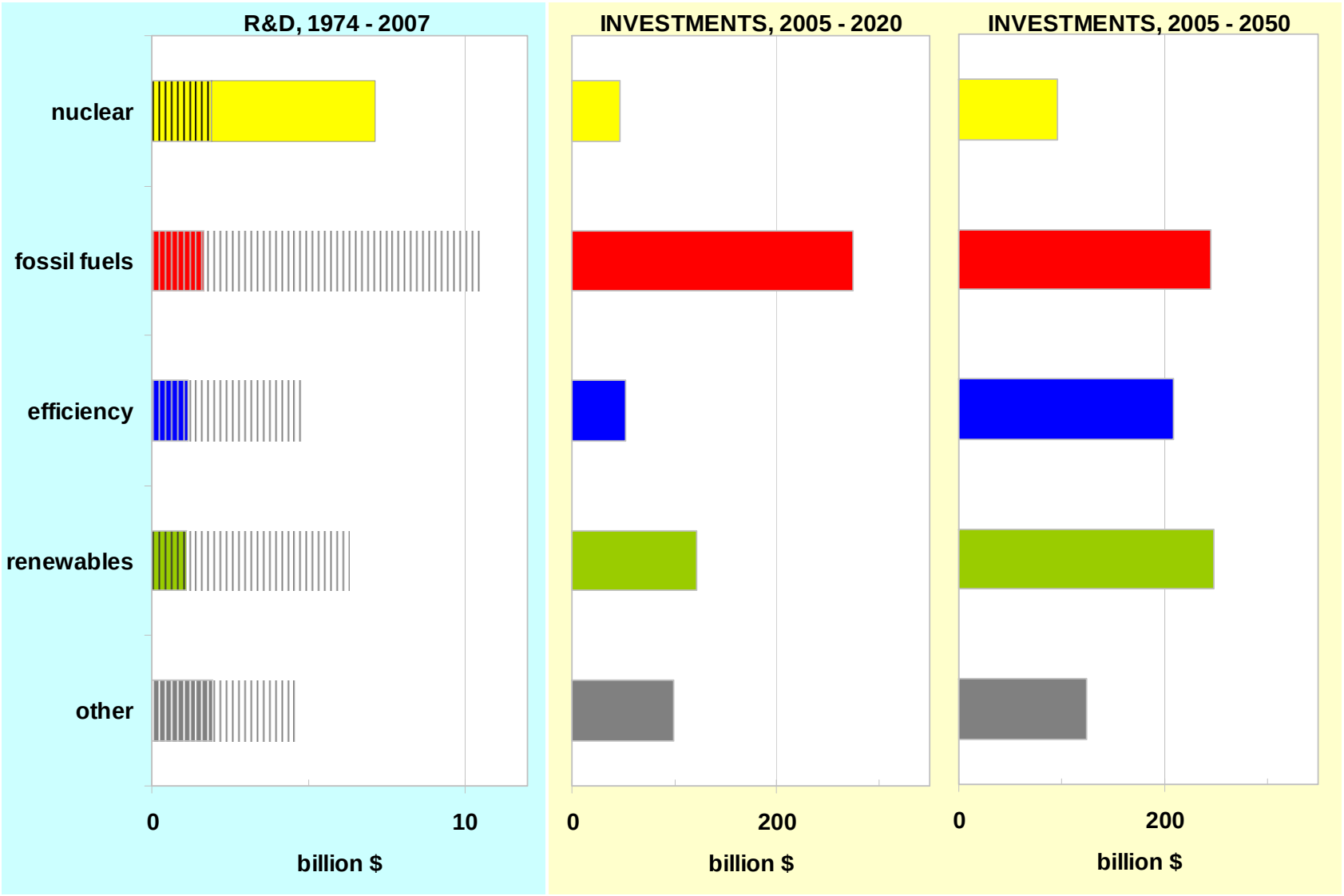
Historical R&D Efforts & Future Investment Needs



Public R&D from IEA countries

Energy R&D & Investments

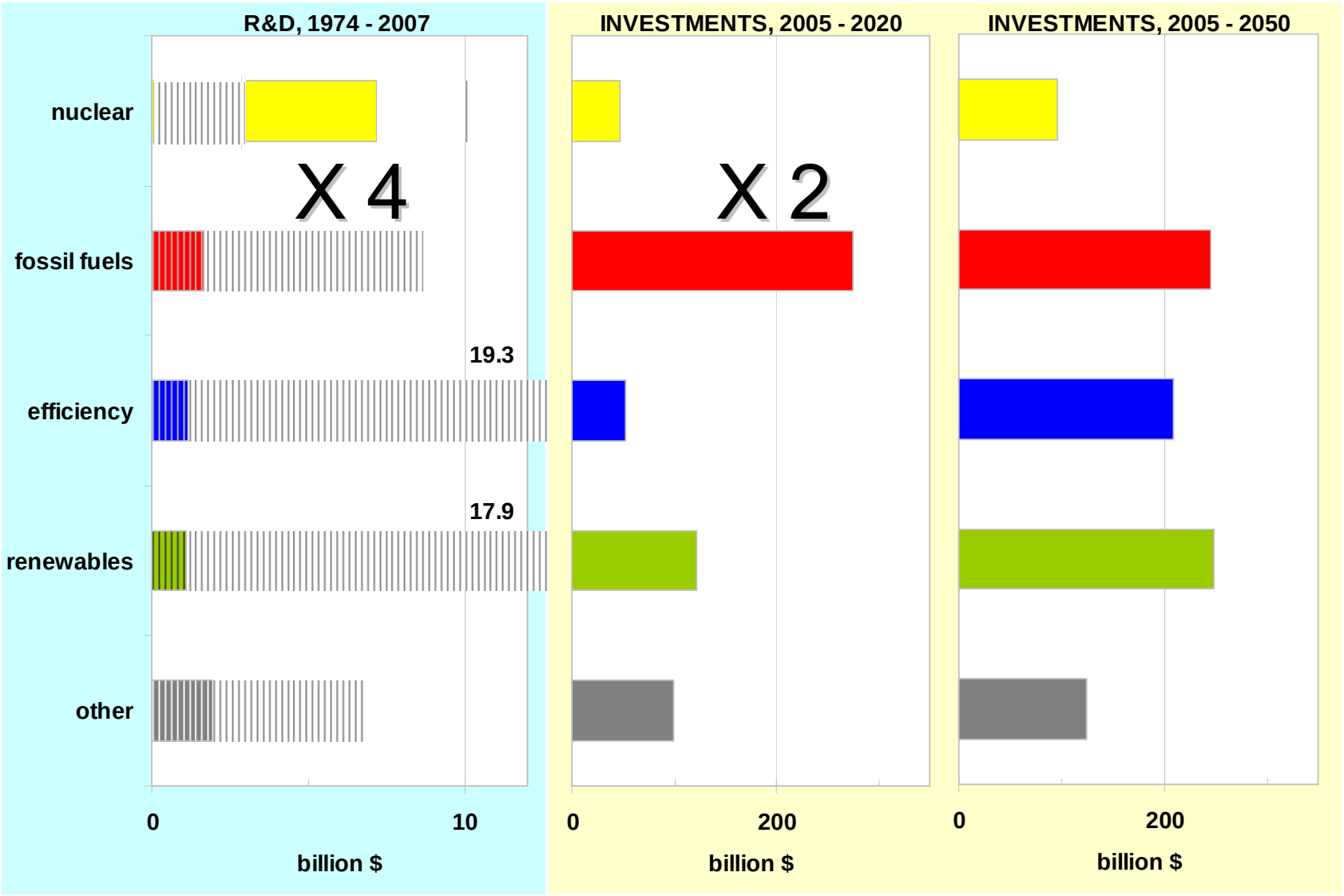
Historical & 2020 R&D & Investment Needs



Public R&D from IEA countries

Energy R&D & Investments

Historical & 2050 R&D & Investment Needs



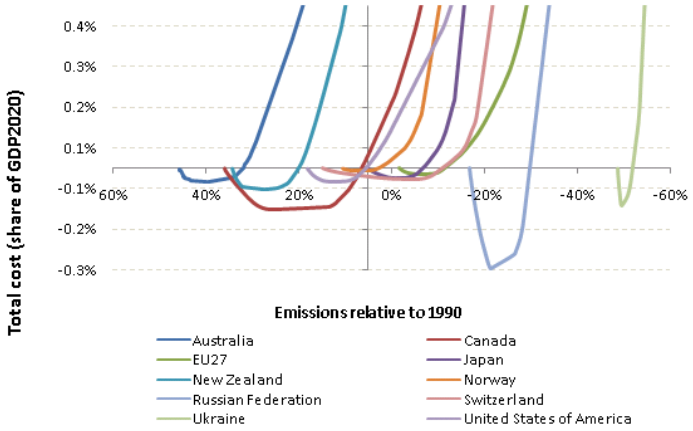
Public R&D from IEA countries

IIASA analysis of near-term mitigation potentials and costs in Annex I countries

GAINS estimates

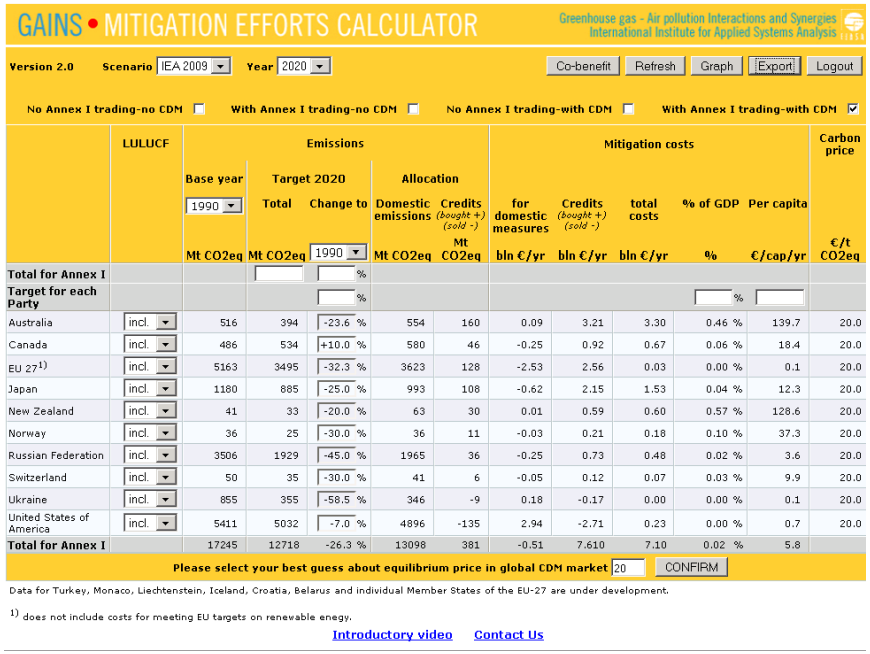
of national GHG mitigation potentials and costs

Mitigation cost curves for Annex I countries



Bottom-up estimates based on exogenous activity projections, all GHGs, 300+ measures, co-benefits on air pollution, open access to all information

An interactive calculator is freely accessible at http://gains.iiasa.ac.at



GAINS • MITIGATION EFFORTS CALCULATOR

Greenhouse gas - Air pollution Interactions and Synergies
International Institute for Applied Systems Analysis

Version 2.0 Scenario IEA 2009 Year 2020 Co-benefit Refresh Graph Export Logout

No Annex I trading-no CDM ☐ With Annex I trading-no CDM ☐ No Annex I trading-with CDM ☐ With Annex I trading-with CDM ☑

	LULUCF	Emissions					Mitigation costs					Carbon price
		Base year	Target 2020		Allocation							
		1990	Total	Change to	Domestic emissions	Credits (bought +) (sold -)	for domestic measures	Credits (bought +) (sold -)	total costs	% of GDP	Per capita	
		Mt CO2eq	Mt CO2eq	1990 %	Mt CO2eq	Mt CO2eq	bln €/yr	bln €/yr	bln €/yr	%	€/cap/yr	€/t CO2eq
Total for Annex I				%								
Target for each Party				%						%		
Australia	incl.	516	394	-23.6 %	554	160	0.09	3.21	3.30	0.46 %	139.7	20.0
Canada	incl.	486	534	+10.0 %	580	46	-0.25	0.92	0.67	0.06 %	18.4	20.0
EU 27 1)	incl.	5163	3495	-32.3 %	3623	128	-2.53	2.56	0.03	0.00 %	0.1	20.0
Japan	incl.	1180	885	-25.0 %	993	108	-0.62	2.15	1.53	0.04 %	12.3	20.0
New Zealand	incl.	41	33	-20.0 %	63	30	0.01	0.59	0.60	0.57 %	128.6	20.0
Norway	incl.	36	25	-30.0 %	36	11	-0.03	0.21	0.18	0.10 %	37.3	20.0
Russian Federation	incl.	3506	1929	-45.0 %	1965	36	-0.25	0.73	0.48	0.02 %	3.6	20.0
Switzerland	incl.	50	35	-30.0 %	41	6	-0.05	0.12	0.07	0.03 %	9.9	20.0
Ukraine	incl.	855	355	-58.5 %	346	-9	0.18	-0.17	0.00	0.00 %	0.1	20.0
United States of America	incl.	5411	5032	-7.0 %	4896	-135	2.94	-2.71	0.23	0.00 %	0.7	20.0
Total for Annex I		17245	12718	-26.3 %	13098	381	-0.51	7.610	7.10	0.02 %	5.8	

Please select your best guess about equilibrium price in global CDM market 20 CONFIRM

Data for Turkey, Monaco, Liechtenstein, Iceland, Croatia, Belarus and individual Member States of the EU-27 are under development.

1) does not include costs for meeting EU targets on renewable enegy.

Introductory video Contact Us

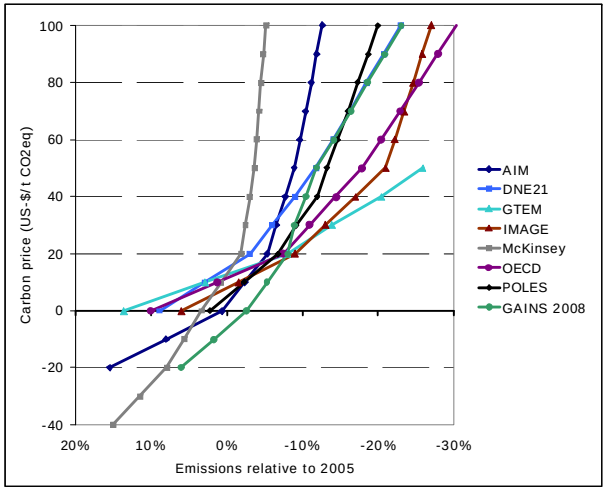
Estimates of mitigation costs for Annex I in 2020:

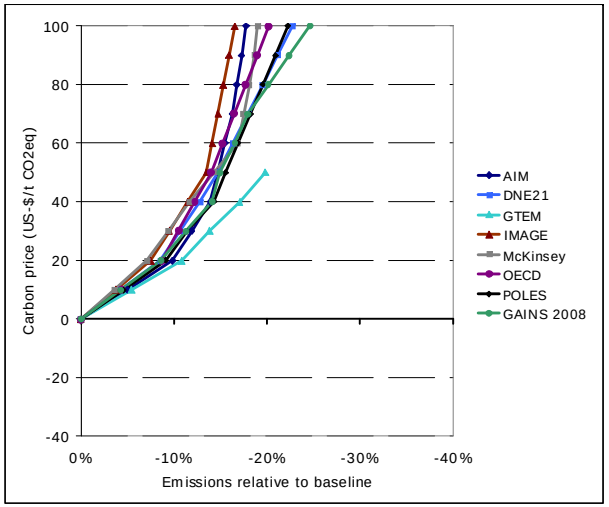
Models agree well after adjustments for different cost concepts and exogenous assumptions

IIASA comparison of 9 models:

Apparent disagreements between estimates can be resolved by adjusting for differences in:

- **Cost concepts**
  (engineering costs, private costs, social costs, with/without macro-economic feedbacks),
- **Baseline assumptions**
  (e.g., on future economic development, autonomous efficiency improvements, policy reference, etc.),
- **Assumed implementation periods**
  (models assume 5-15 years implementation time up to 2020).

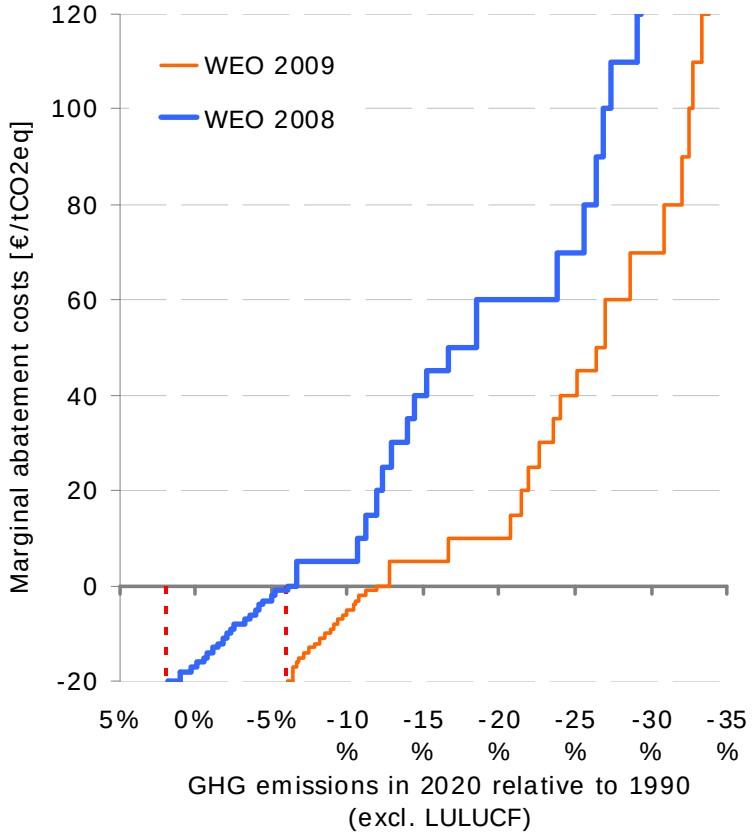




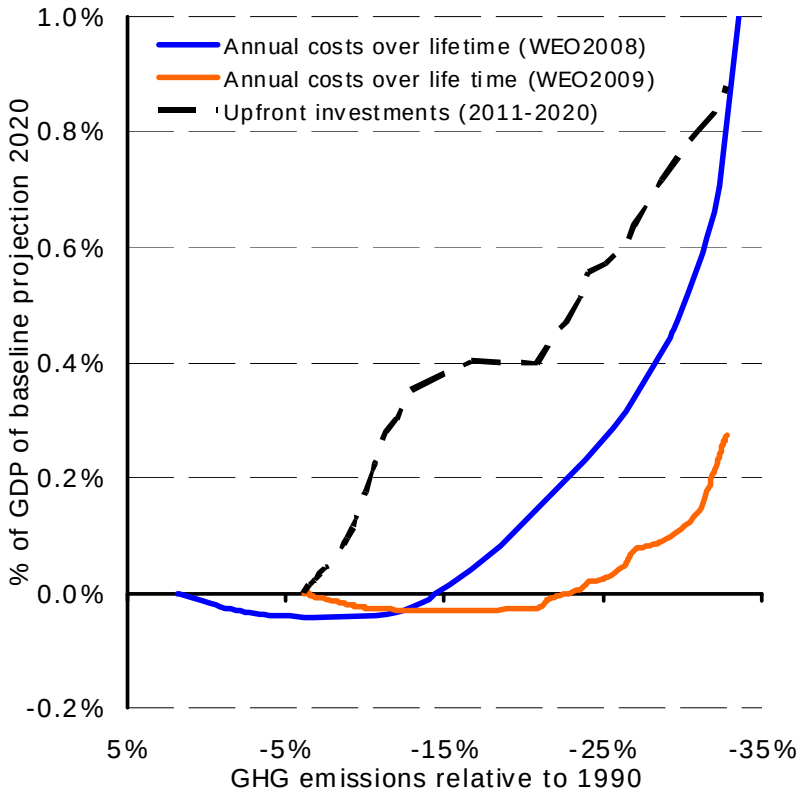
GHG mitigation cost curves of Annex I, 2020

Mitigation costs are sensitive towards assumptions on future economic development

GAINS cost curves for pre- and post-crisis projections Annex I, 2020 (excl. LULUCF)



Marginal costs/carbon prices



Total costs and up-front investments

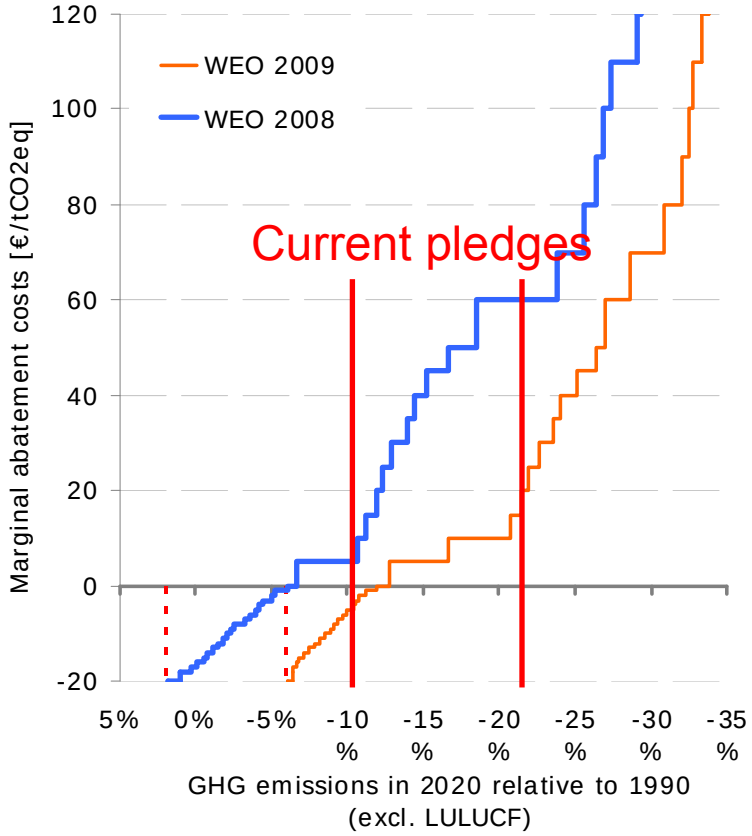
Recent pledges of Annex I

	Conservative interpretation	Optimistic interpretation	Reference year	Inclusion of LULUCF	Status
AUSTRALIA	-5%	-25% through -20% cap and trade of domestic emissions and -5% government purchases of international credits	2000	Yes	Officially announced (May 4, 2009)
CANADA	-20%	-20%	2006	t.b.d.	Officially announced
EU	-20%	-30%	1990	Not for the 20% target, t.b.d. for the 30% target	Adopted by legislation
JAPAN	-15% (relative to 2005; through domestic measures)	-25% (relative to 1990)		Not for the 15% target, t.b.d. for the 25% target	Low pledge officially announced June 10, 2009; high pledge demanded by the Democratic Party
NEW ZEALAND	-10%	-20%	1990	Yes (with current rules)	Announced in Bonn (11 August 2009)
NORWAY	-40%	-40%	1990	Yes (with current rules)	Officially announced
SWITZERLAND	-20%	-30%	1990	Yes	Switzerland announced to follow the EU
UKRAINE	-20%	-20%	1990	?	Under consideration
USA	-4%	-17% (through cap plus complementary measures)	1990	Yes	(High pledges: WRI paper 22 June 2009)
RUSSIA	-20%	-25%	1990	?	Announced by president Medvedev

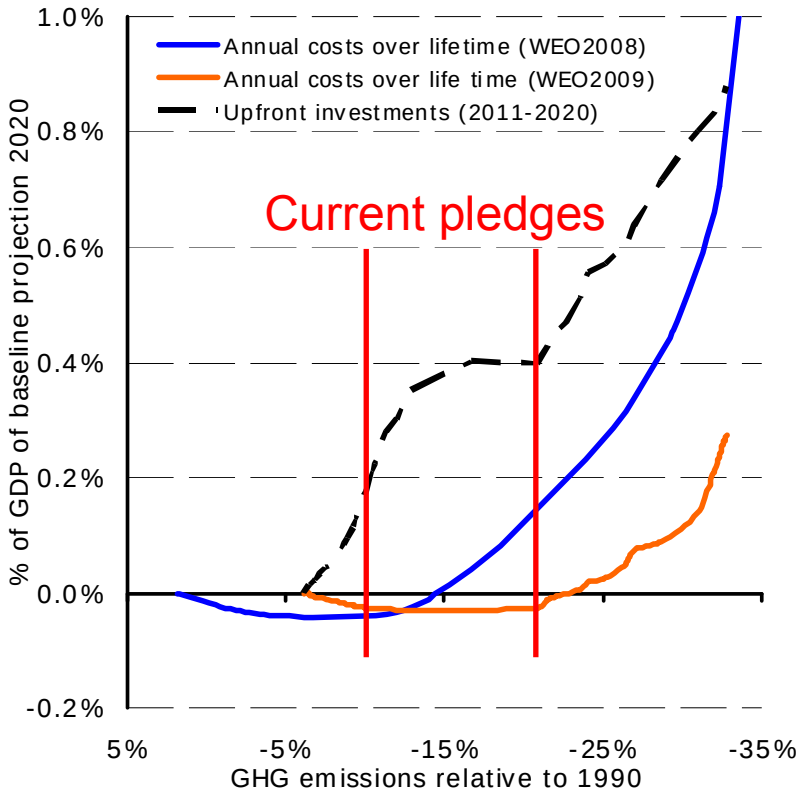
Pledges of Annex I countries for 2020

Efforts are sensitive towards assumptions on economic development

GAINS cost curves for pre- and post-crisis projections Annex I, 2020 (excl. LULUCF)



Marginal costs/carbon prices

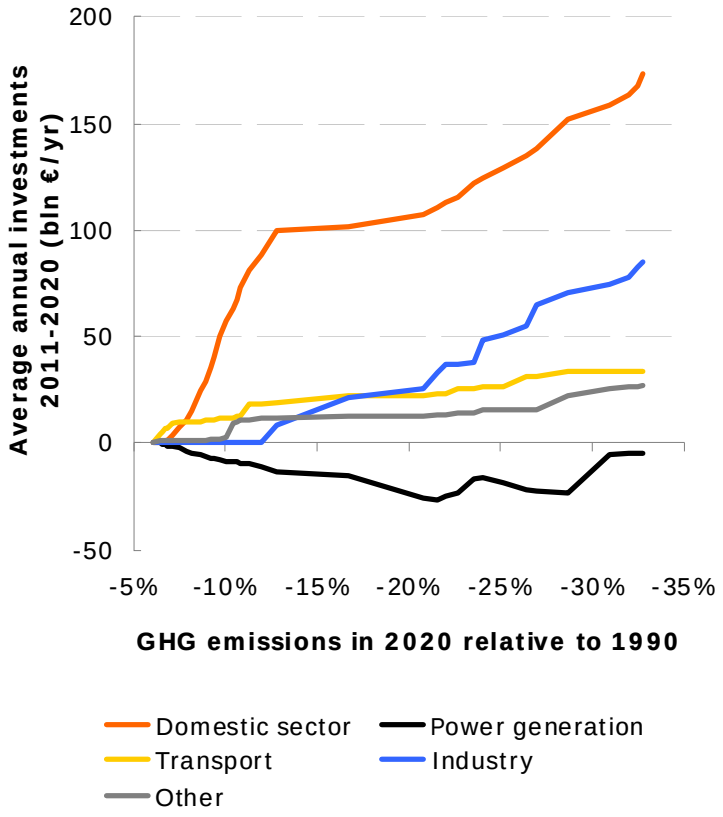


Total costs and up-front investments

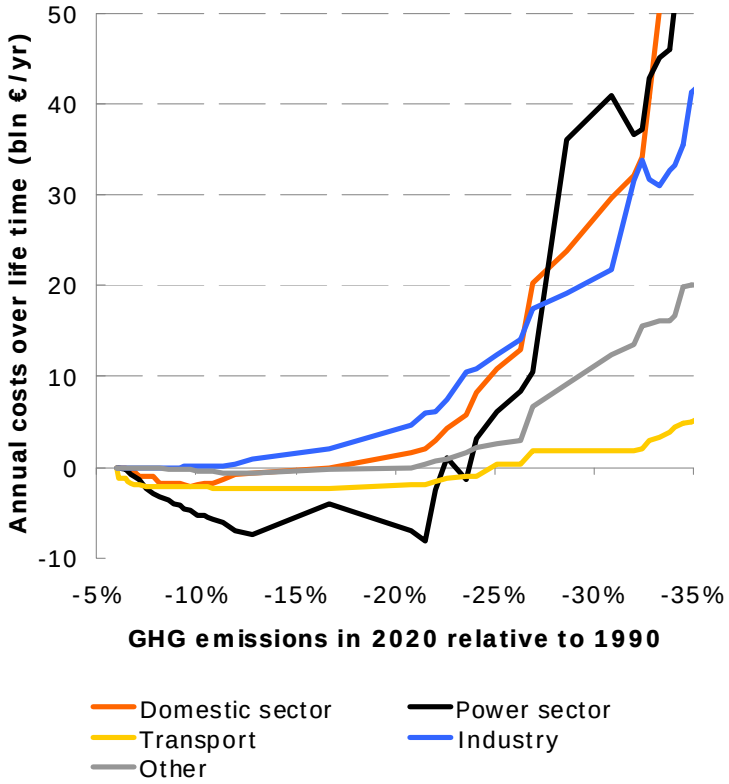
Sectoral mitigation costs and investments

Annex I, 2020

Annual investments in 2011-2020

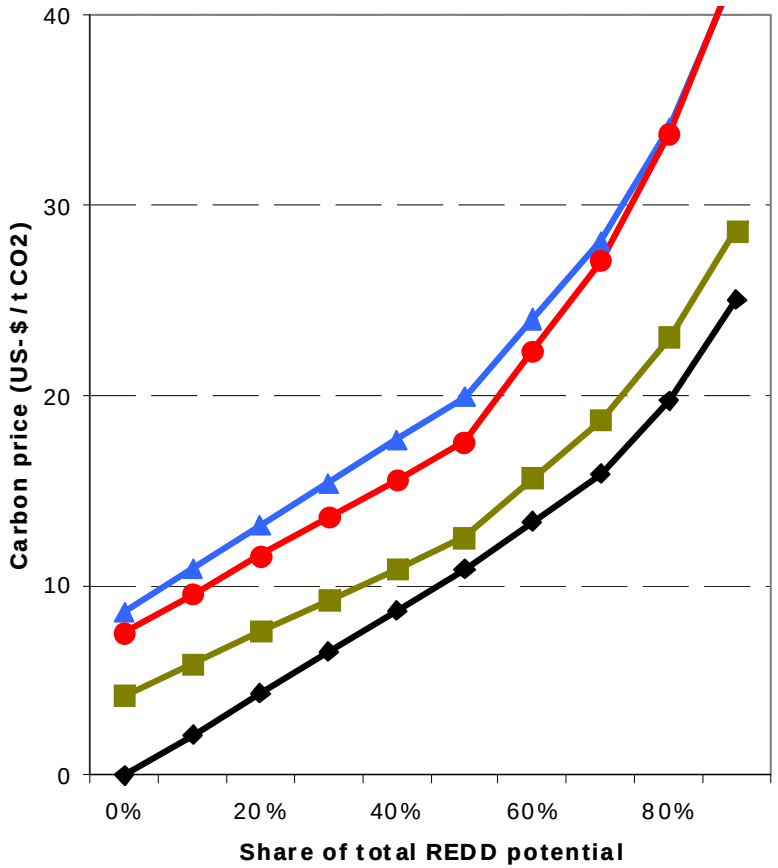


Annual costs during life time (annuities + operating costs)



Marginal supply costs of REDD permits:

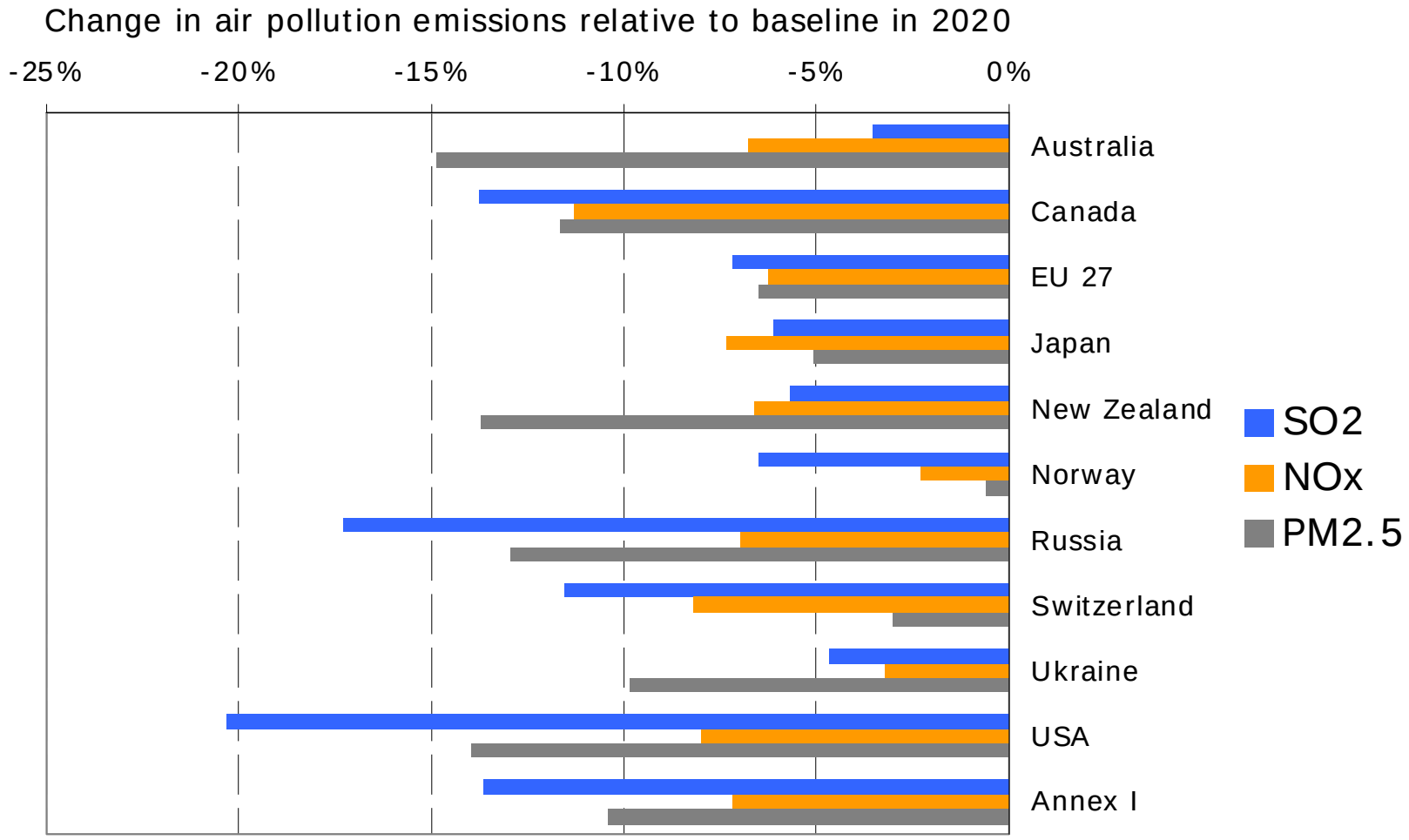
Sensitive to policies in competing sectors



Source: Obersteiner, 2009

Co-benefits on air pollution (1)

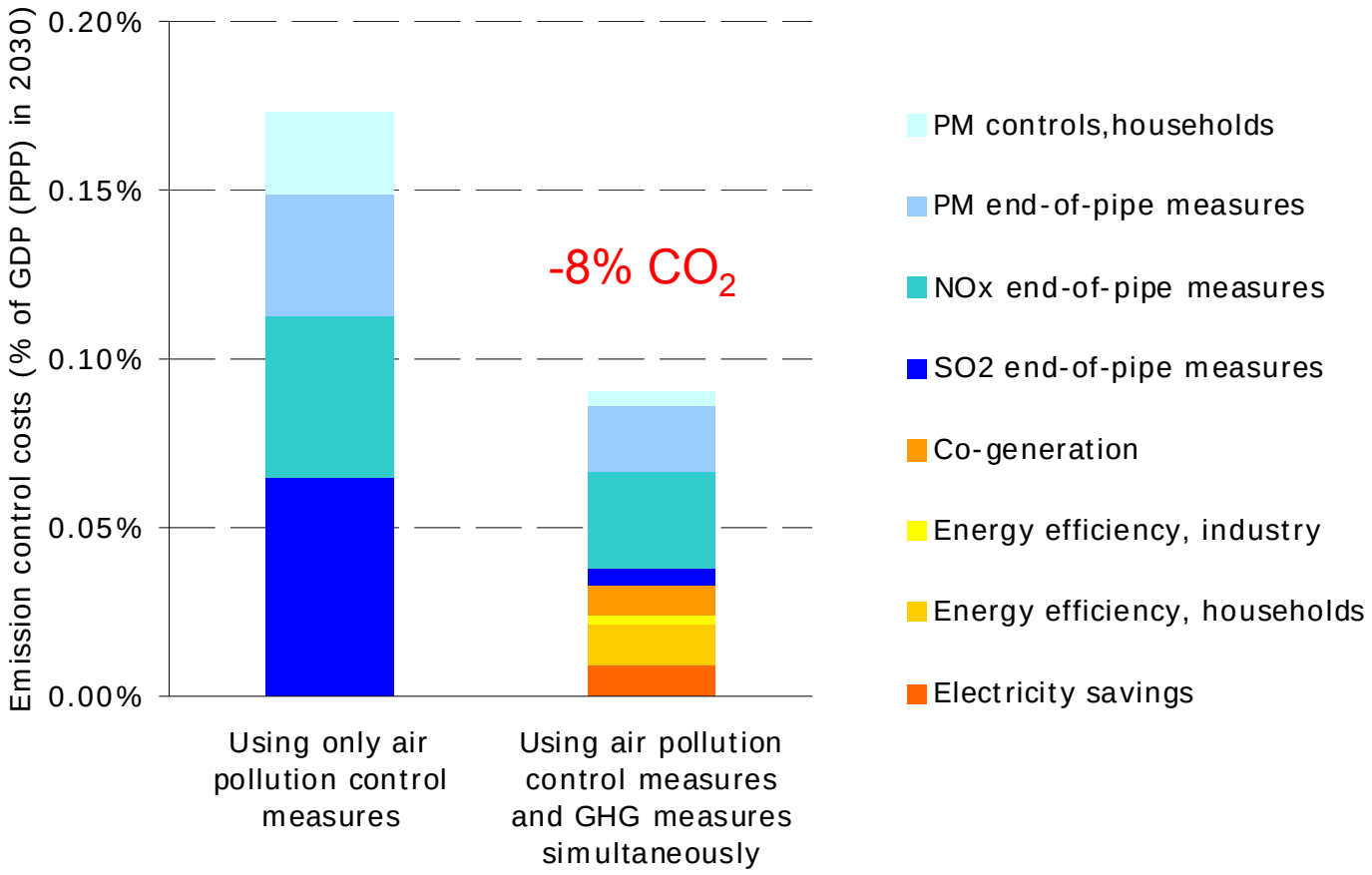
High pledges would co-control air pollutants in Annex I



Co-benefits on air pollution (2)

Well-designed air pollution control strategies can also reduce GHG emissions

Emission control costs for reducing PM health impacts in China by 50%



Conclusions

- Once corrected for obvious differences in assumptions, model estimates agree on GHG mitigation potentials and costs

- Current pledges would reduce Annex I emissions in 2020 by 11 to 21 % relative to 1990. Compared to an assumed increase of GDP by 32-42%, costs would amount to <0.15% of GDP. However, higher upfront investments (<0.4% of GDP) would be required.

- GHG mitigation has significant co-benefits on air pollution in Annex I and developing countries

More information: http://gains.iiasa.ac.at

Toward a Global Climate Deal: An Integrated Science & Policy Approach for Real Impact

2 deg Guardrail

- The agreement at the MEF forum (L'Aquila) in 2009 to contain global temperature increase to not more than 2 degrees celsius above pre-industrial levels created a new momentum
- Scientists responded by estimating the carbon budget that would ensure meeting this goal at different levels of probability
- How could this overarching goal translate into options for a country like India?

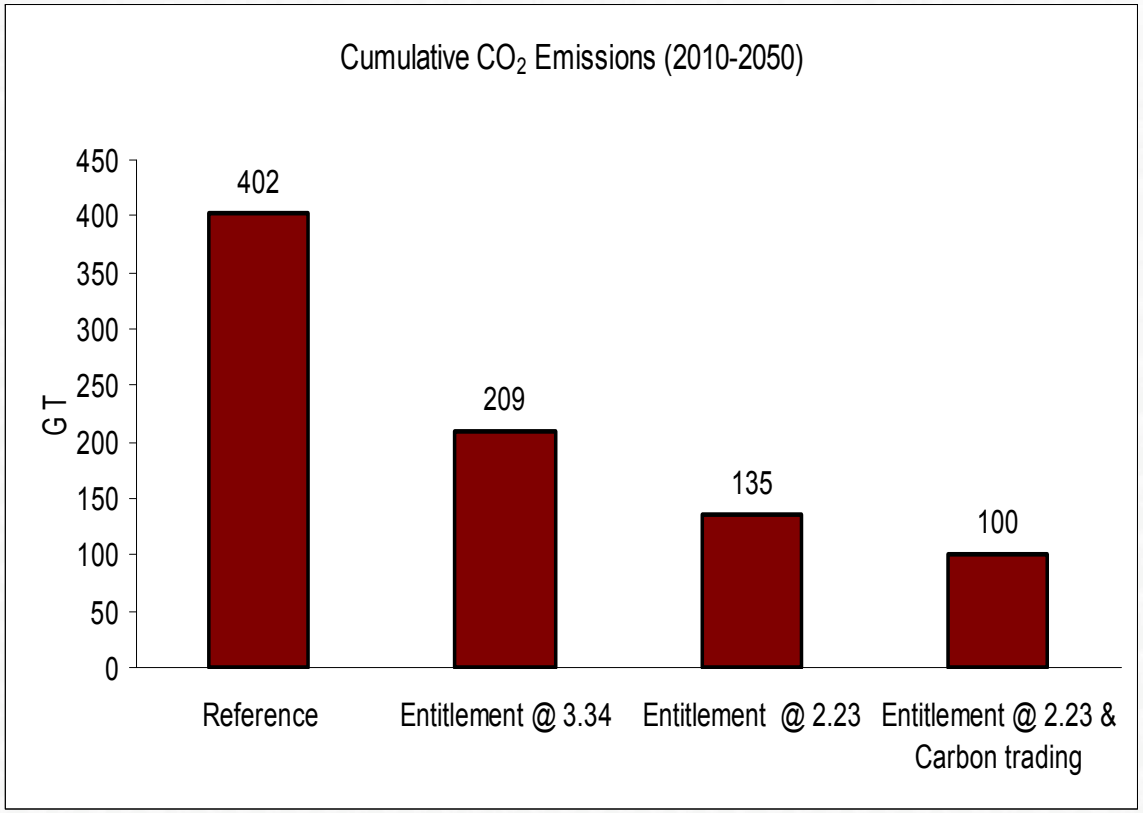
Methodology

- Using the MARKAL model – results of which were presented at Poznan last year – the baseline scenario was extended to 2050
- Moved away from defining per capita emissions targets to the carbon budget approach
- Allows greater flexibility to define pathways and identify peaking periods
- Identify short and medium term transitions required
- Implications for technology and finance would also be revealed

India's Carbon Budget

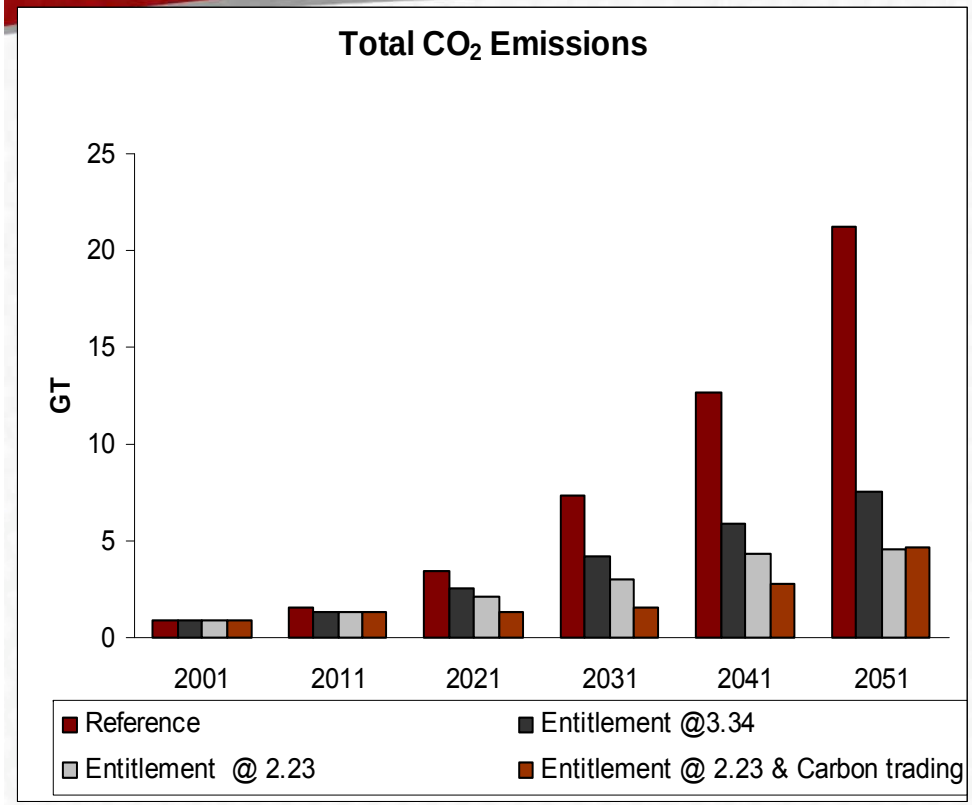
- At a 2/3 probability and a 3/4 probability of achieving the 2 deg C guardrail, the global carbon budget has been estimated to be 750 GT and 600 GT respectively
- Accepting the argument of equal per capita rights from 2010 onwards, India's carbon budget for the period 2010 to 2050 is ~ 135 GT
- It must be noted that in a fully fair and just world India's carbon budget, not accounting for its past under-utilisation, would be ~ 209 GT

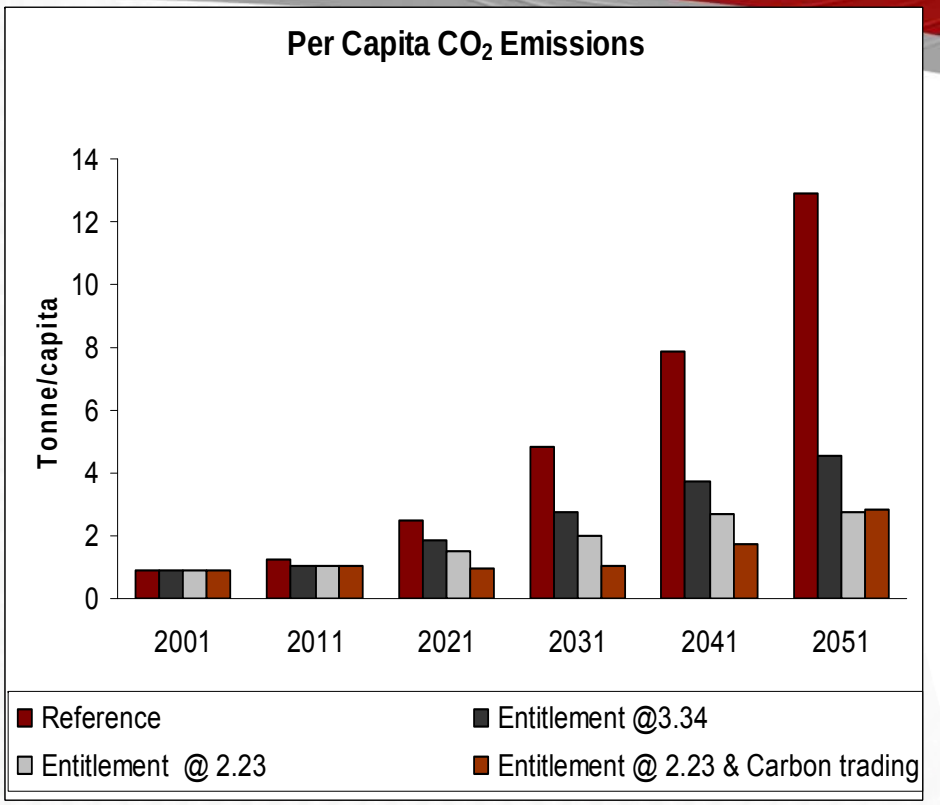
Cumulative CO_2 Emissions Under Reference and Carbon Budget Scenarios



- Reduction from Reference Case
  - Entitlement @3.34: 48%
  - Entitlement @2.23: 66%
  - Entitlement @ 2.23 & CO_2 trading (35 GT): 75%

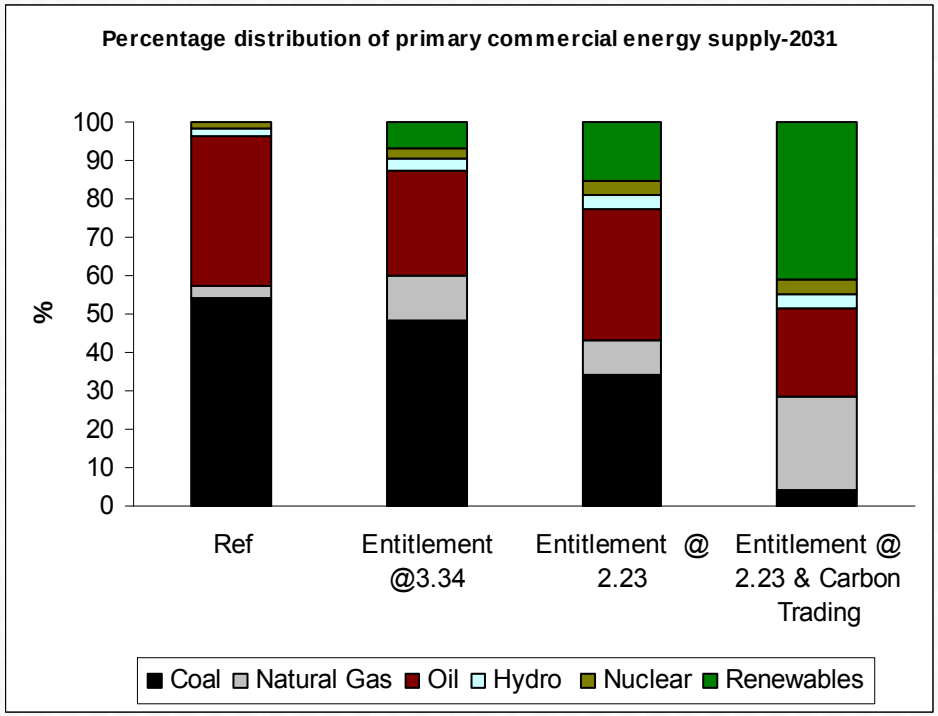
Projected Trend of Total and Per Capita CO_2 Emissions

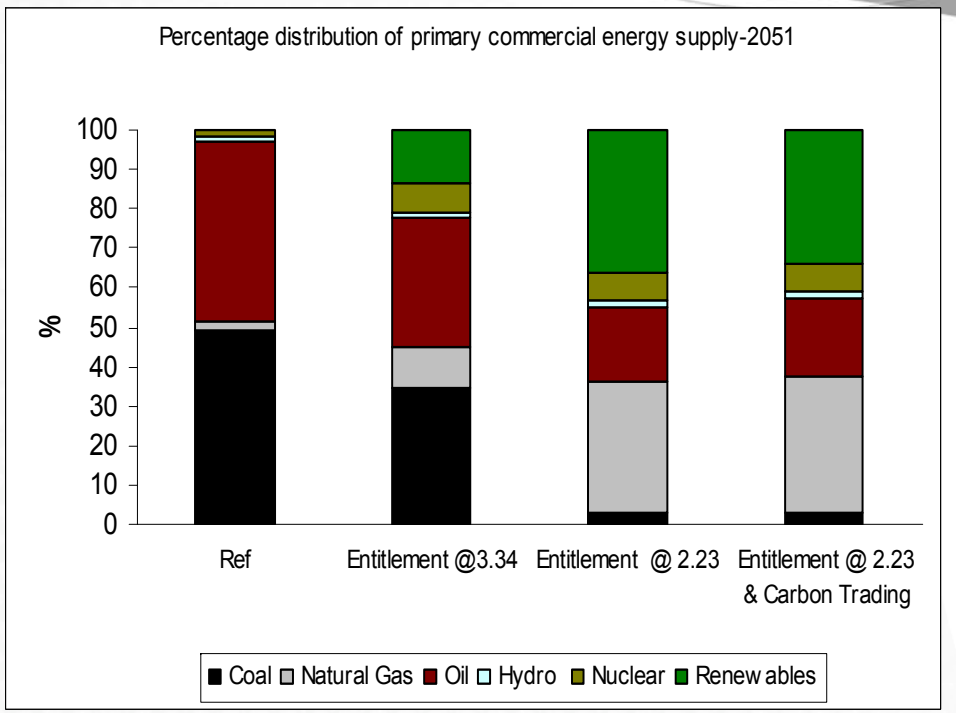




- Large deviation required from reference scenario but no peaking till 2051
- Per capita CO2 emission in 2051
  - Reference: 12.9 tonnes; Scenario @ 3.34: 4.6 tonnes; Scenario @ 2.23: 2.8 tonnes; Scenario @2.33& trading: 2.8 tonnes

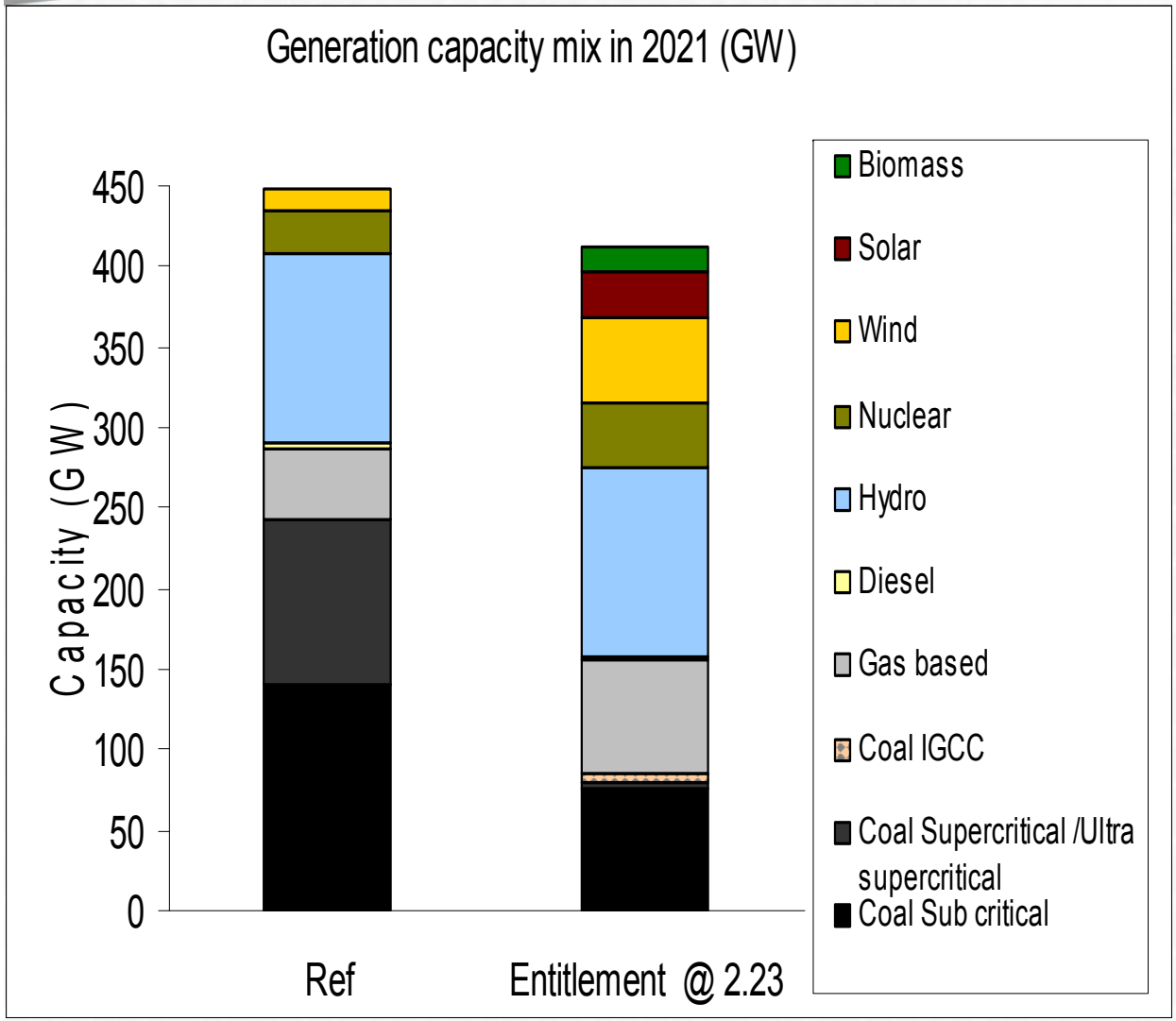
Fuel Mix in 2031 & 2051





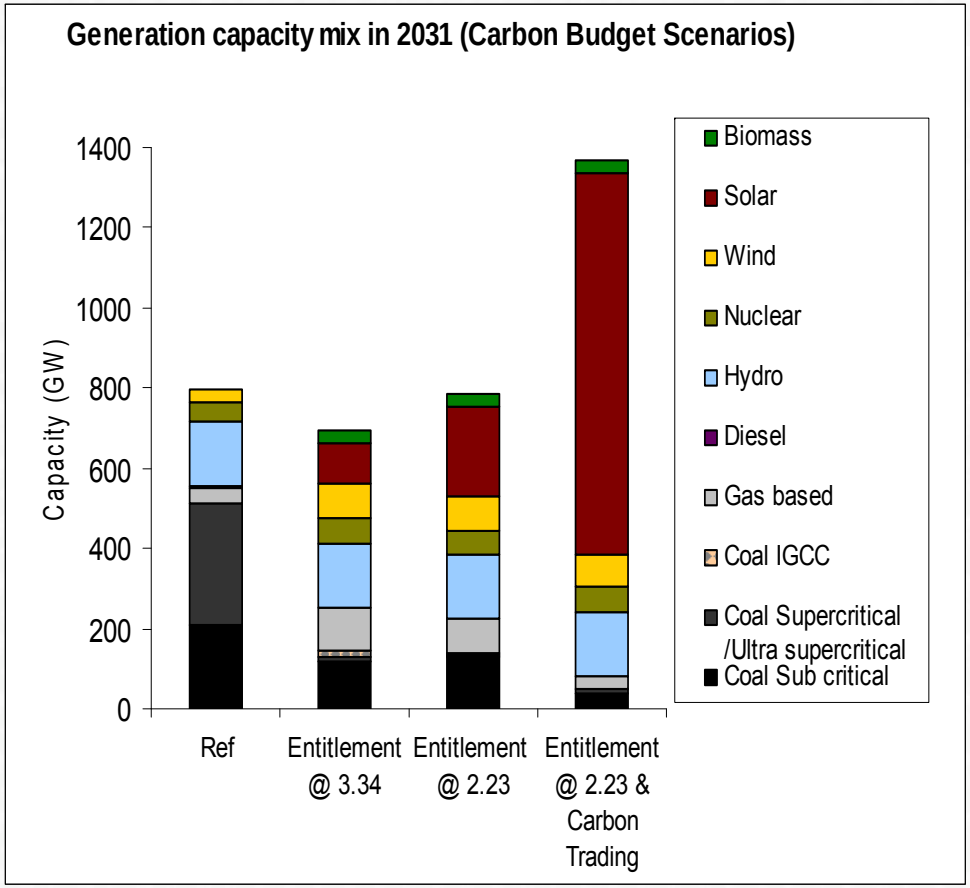
- Substantial shifts are required to achieve the desired level
- Significant capacities would need to be forcibly retired towards the end
- Move away from coal in longer time frame with stringent carbon constraint
- Renewable is the key for achieving low carbon growth in longer term along with energy efficiency and advance technologies

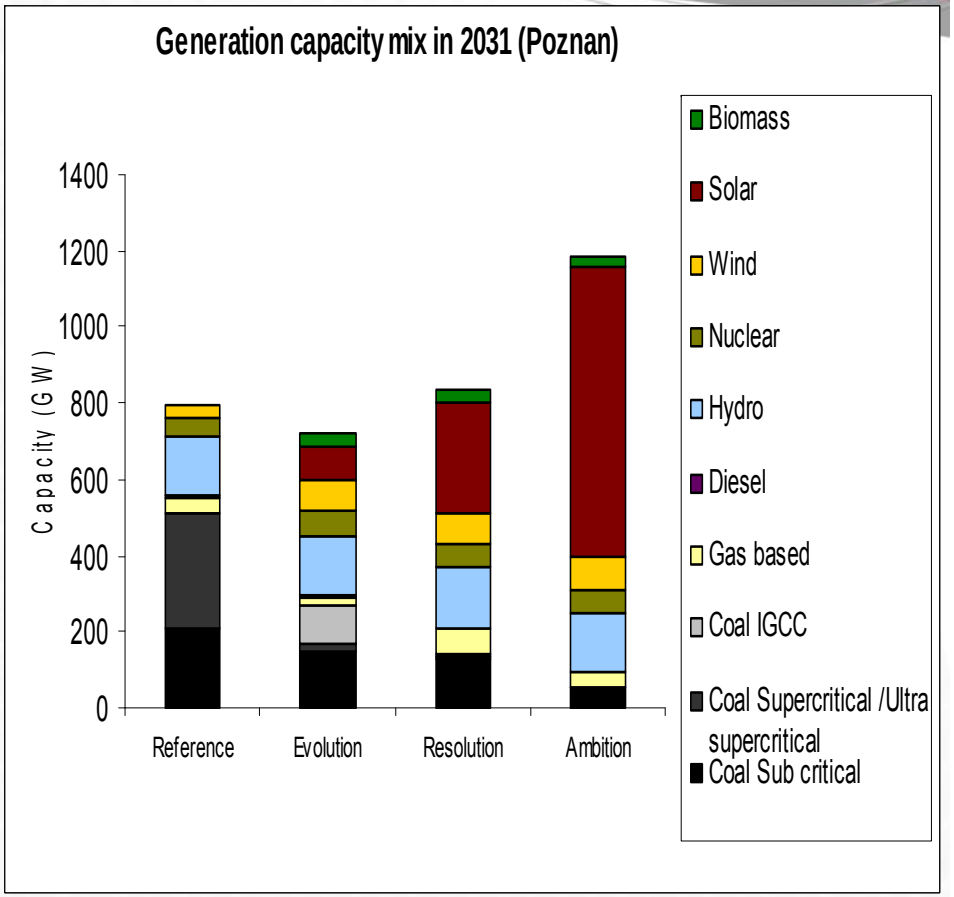
Power Generation Technology in Medium Term



- Reduction in power generation capacity due to energy efficiency improvement at end uses
- Move away from coal to renewable and nuclear (even clean coal technology)
- In 2021 Alt scenario
  - Wind : 53 GW
  - Solar: 28 GW
  - Biomass: 16 GW
  - Nuclear: 40 GW
- Additional investment requirement : US$ 54 Billion (2011-2021)

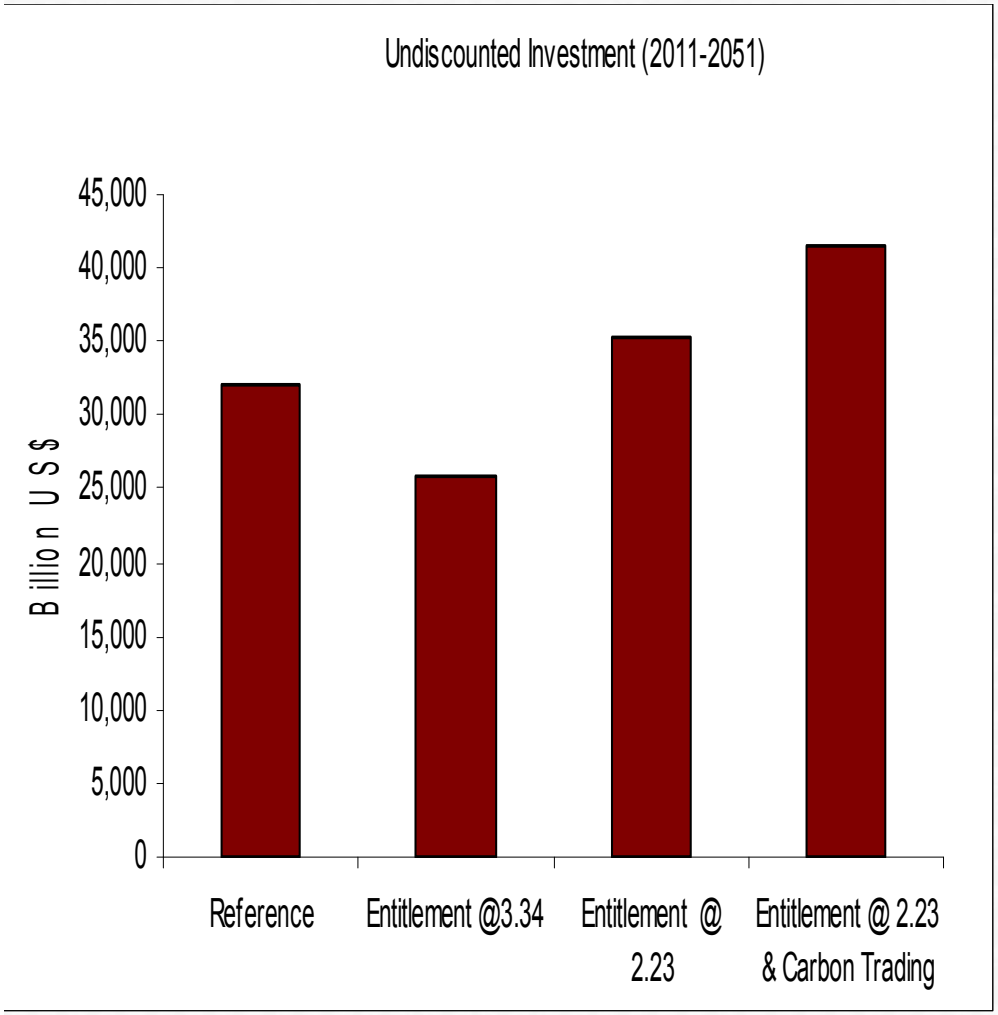
Comparison with Poznan Scenarios





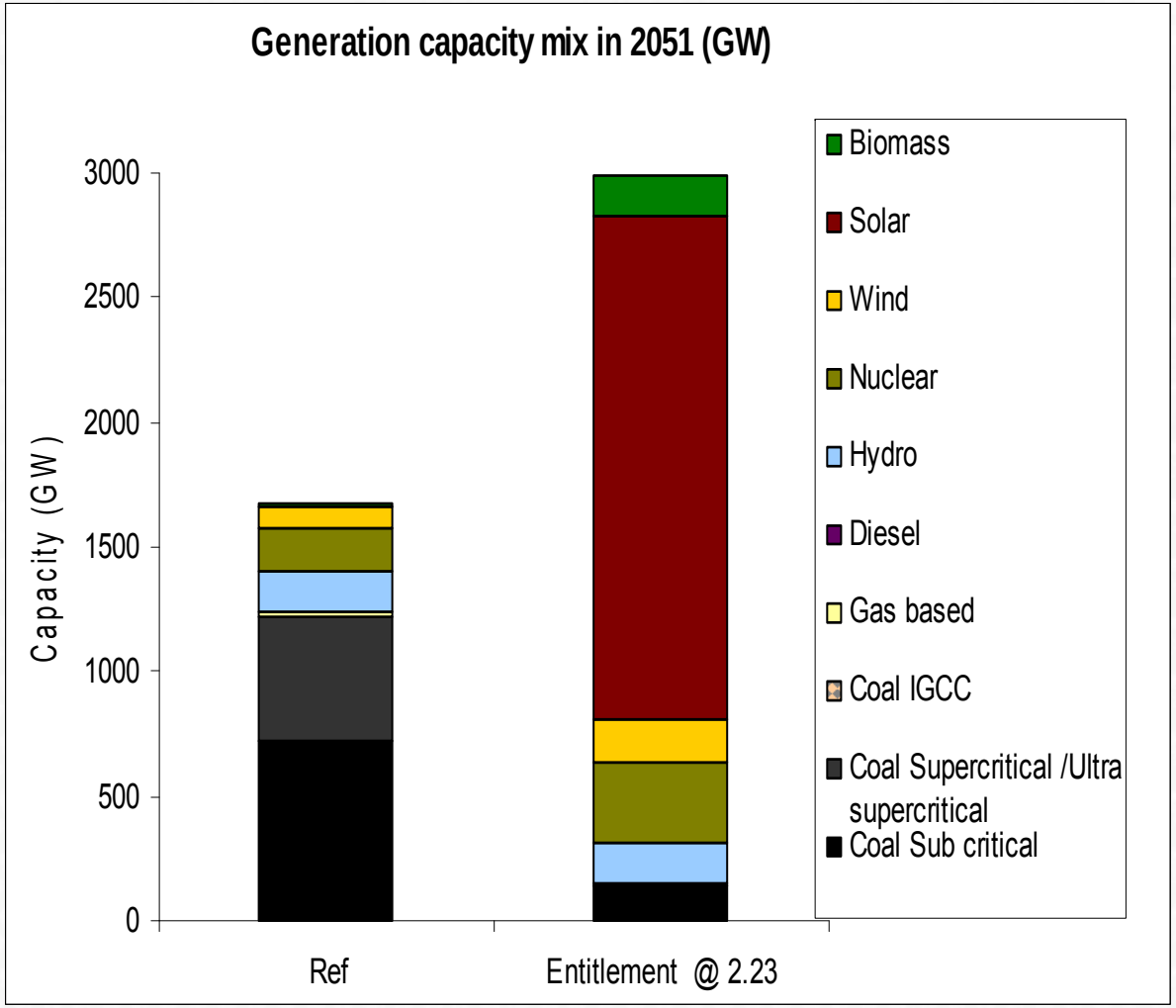
•In medium term Entitlement @ 3.34 scenario is inline with Evolution Scenario; Entitlement @ 2.23 scenario is comparable with Resolution scenario; carbon trading scenario is even more stringent than Ambition scenario

Long Term Investment Requirement (2011-51)



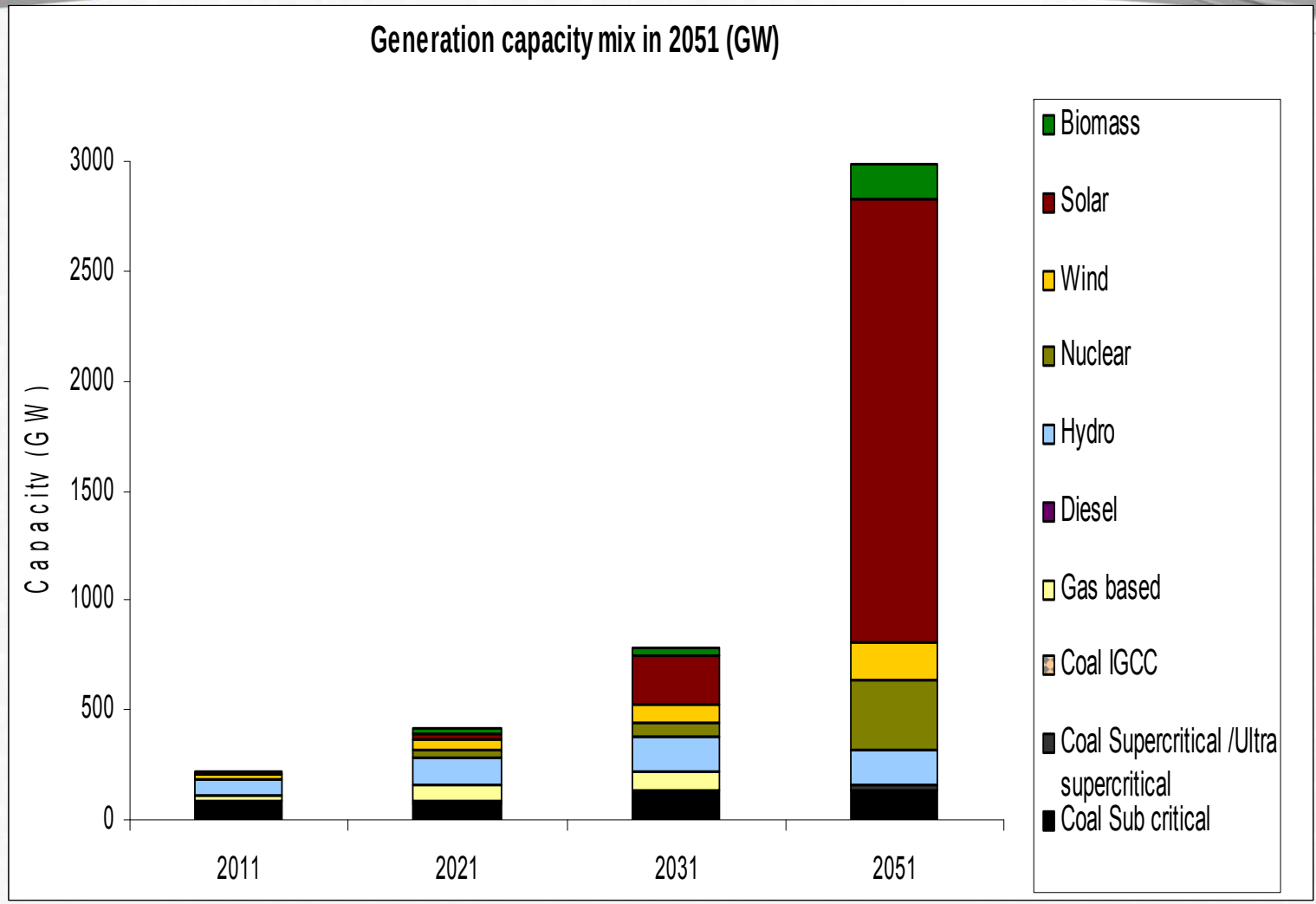
- Additional investment of US$ 3.14 Trillion is required to move towards Entitlement @ 2.23 Scenario in next Forty years (~ US$ 79 Billion per Year)
- Much higher additional public finance would be required:
  - Power sector: Additional investment requirement: US$ 13 Trillion (in Entitlement @ 2.23 scenario over the reference case)
  - Public transportation facilities (Metro, high speed rail, dedicated freight corridor, good quality bus, etc) would require additional investment of US$ 1.13 trillion (in Entitlement @ 2.23 scenario over the reference case)

Power Generation Capacity in 2051

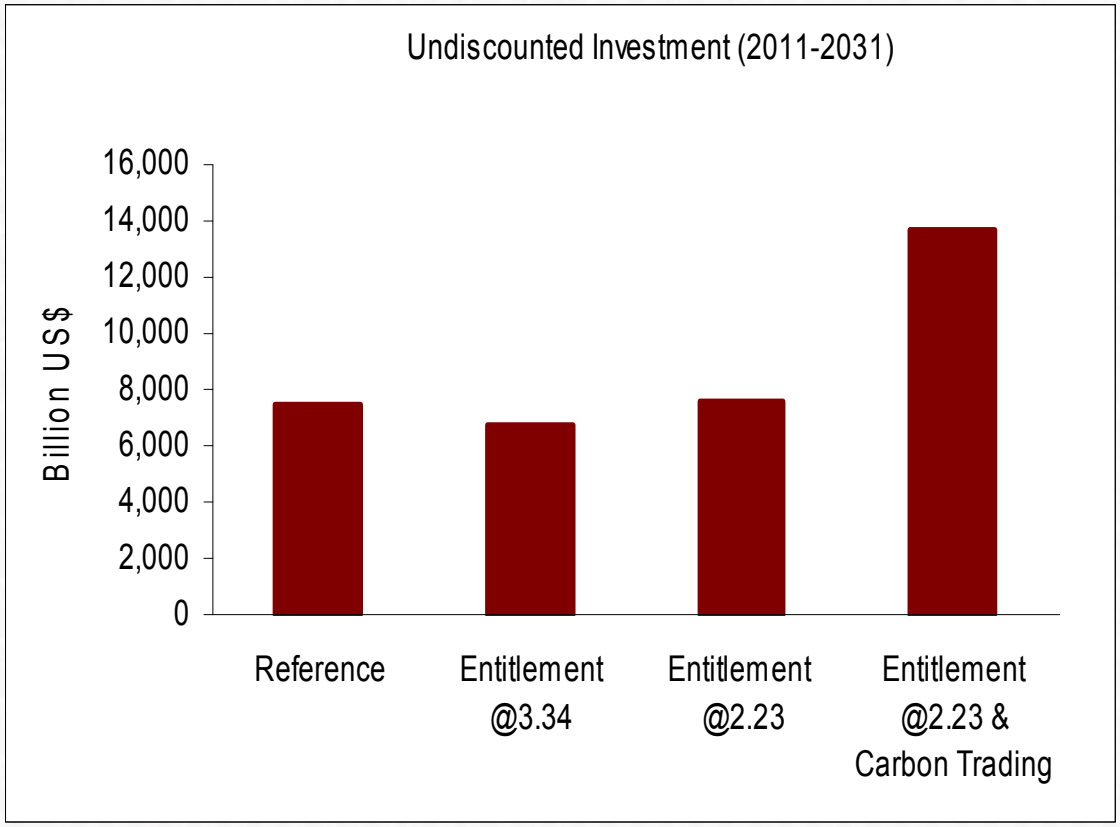


- Total capacity requirement in increases from 1700 GW to 3000 GW due to large share of renewable and their lower availability factor
- ***In 2051***
- Solar :
  - ~2000 GW (@ 2.23)
  - ~negligible (reference)
- Nuclear :
  - 325 GW (@ 2.23)
  - 169 GW (reference)
- Wind:
  - 175 GW (@ 2.23)
  - 83 GW (reference)
- Additional investment requirements US$ 13 Trillion (2011-2051)

Power Generation Capacity in Entitlement @ 2.23 Scenario 2011-2051



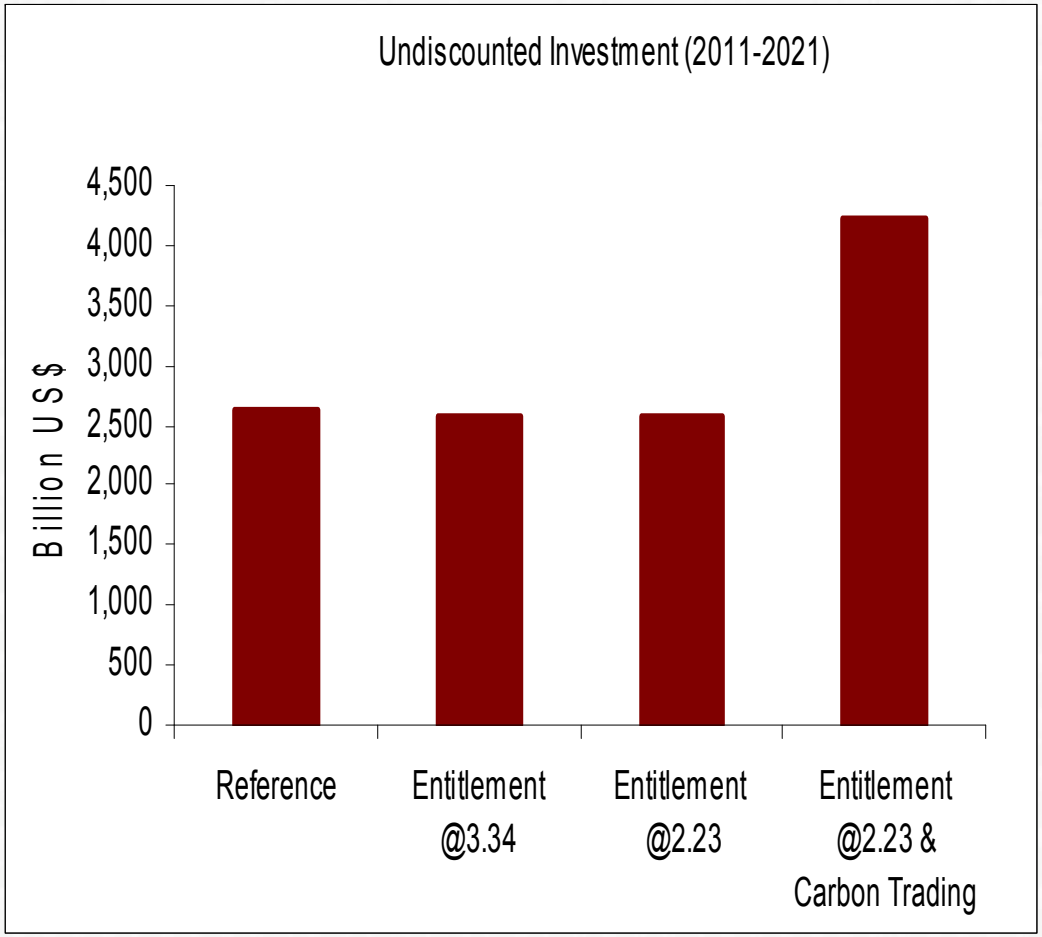
Medium Term Investment Requirement (2011-2031)



Some sectors will have avoided investment on other hand some sector will require much higher investment

- Additional investment of US$ 198 Billion would be required during (2011-2031) to move towards entitlement @ 2.23 scenario from reference
- Power generation will require much more investment in the tune of US$ 1 trillion of these 20 years (~US$ 53 Billion per year)
- Additional public finance required for public transportation would be US$ 651 Billion (~US$ 33 Billion/year)

Short Term Investment (2011-2021)



- Only carbon trading scenario requires additional investment of US$ 1.5 Trillion
  - much higher level of solar energy (244 GW in 2021)
- Additional investment that accrued in implementation of high cost options are lesser than the avoided investment in low cost low carbon option (public transportation, autonomous energy efficiency, demand side management etc)
- However, significant additional public finance would be required for moving towards @2.23 scenario over the reference case
  - Power generation capacity: US$ 54 billion (~ US$ 5.4 Billion per year)
  - Public transportation facility: US$ 240 billion (US$ 24 billion per year)

Transport Sector

- Share of public modes in movement of passengers by road remains at the level of 76% (2001-2051)
  - *(Reference: decreases from 76% in 2001 to 34% in 2051)*
- Share of rail in freight movement increases from 42% in 2001 to 60% by 2036 & remaining constant at 60% till 2056
  - *(Reference: reduces to 16% in 2051)*
- Share of rail in passenger movement increases from 23% in 2001 to 50% by 2036 & remaining constant at 50% till 2056
  - *Reference: remaining constant at 23% (2001 – 2051)*
- Hybrid vehicles in intermediate and long term
  - By 2021 onwards in all alternative scenario
- Battery operated vehicle in longer term (two wheelers and three wheelers)
  - @ 3.34 Scenario: by 2056; @2.23 Scenario: by 2041; Carbon trading: by 2021
- Rapid electrification of rail with stringent emissions level
- Continuous efficiency improvement in transport vehicle (1% per annum till 2051)
- Reference case no improvement after 2011

Residential & Commercial Sector

- Improved lighting devices 100% penetration of CFL by 2036
  - Reference case only around 1% till 2051
- Greater penetration of efficient appliances: Refrigeration, Space conditioning , Air conditioning, water heating etc
  - Enforcement of energy labeling programme
  - 100% penetration by 2036
  - Autonomous energy efficiency improvement over time
- Increased share of solar water heater upto 100% by 2046)

Agriculture Sector

- 20% reduction in water pumping demand due to better irrigation practices
  - Reduced water losses (no additional investment assumed)
  - Only in alternative scenarios
- Complete electrification of irrigation pumpsets by 2026
  - Reference case- 2001: 71%; 2051: 81%
- 100% penetration of efficient pumps by 2036
  - Remaining constant at 40% in the reference case (2001-56)

Industry Sector

- Higher autonomous energy efficiency improvement in small and medium scale industry
- Shift away from coal to gas
  - Much earlier with more stringent carbon constraint
  - Only natural gas based urea plants
- Scrapping of old plants
  - High cost more efficient plants are preferred over retrofitting of old plant
  - Scraping of plants much earlier than useful life
- Increased share of blended cement

Thank You