

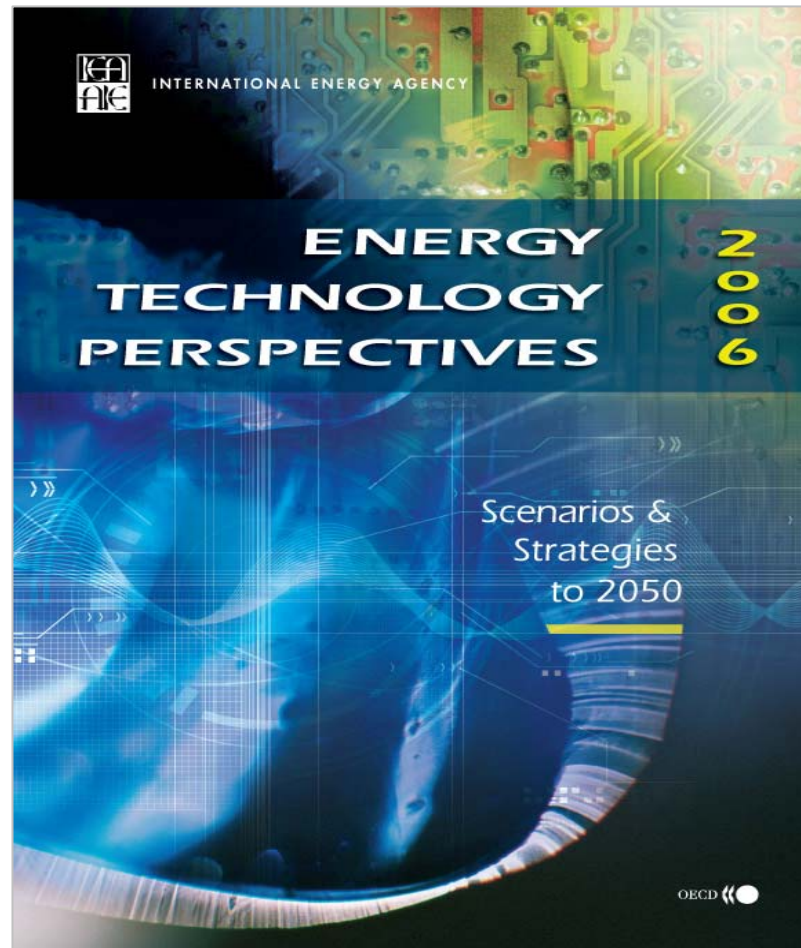
Energy Technology Perspectives Scenarios and Strategies to 2050



ENERGY
TECHNOLOGY
PERSPECTIVES

2006

Scenarios & Strategies
to 2050



Fridtjof Unander
International Energy Agency



G8 GLENEAGLES 2005



“We will act with resolve and urgency to meet our shared multiple objectives of reducing greenhouse gas emissions, improving the global environment, enhancing energy security and cutting air pollution in conjunction with our vigorous efforts to reduce poverty“

-- from “G8 Gleneagles Communiqué”



IEA and the G8 – Gleneagles Plan of Action

“IEA will advise on alternative energy scenarios and strategies aimed at a clean, clever and competitive energy future”

Take part in dialogue, including developing countries

14 international programmes focussed on energy efficiency (buildings, appliances, industry, transport), clean coal, renewables and R&D collaboration

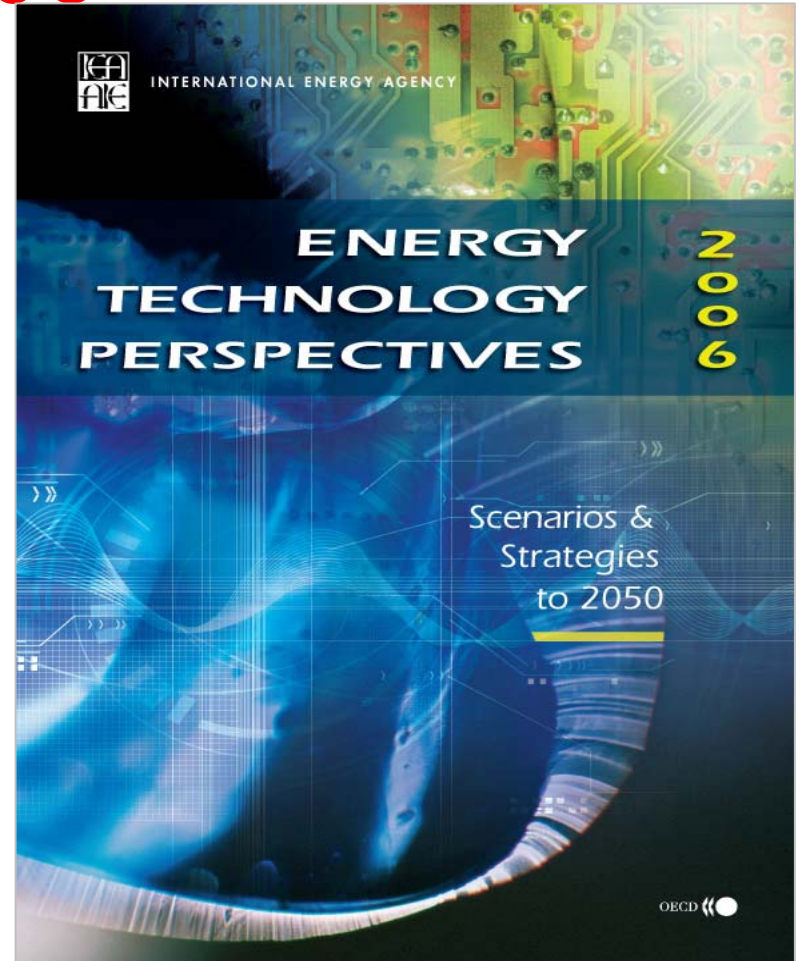
Reports to Japanese G8 Presidency in 2008



Energy Technology Perspectives 2006

ETP 2006 provides part of IEA's "advice on scenarios and strategies"

ETP 2006 presents a groundbreaking review of technologies across all sectors and assess how they together can make a difference

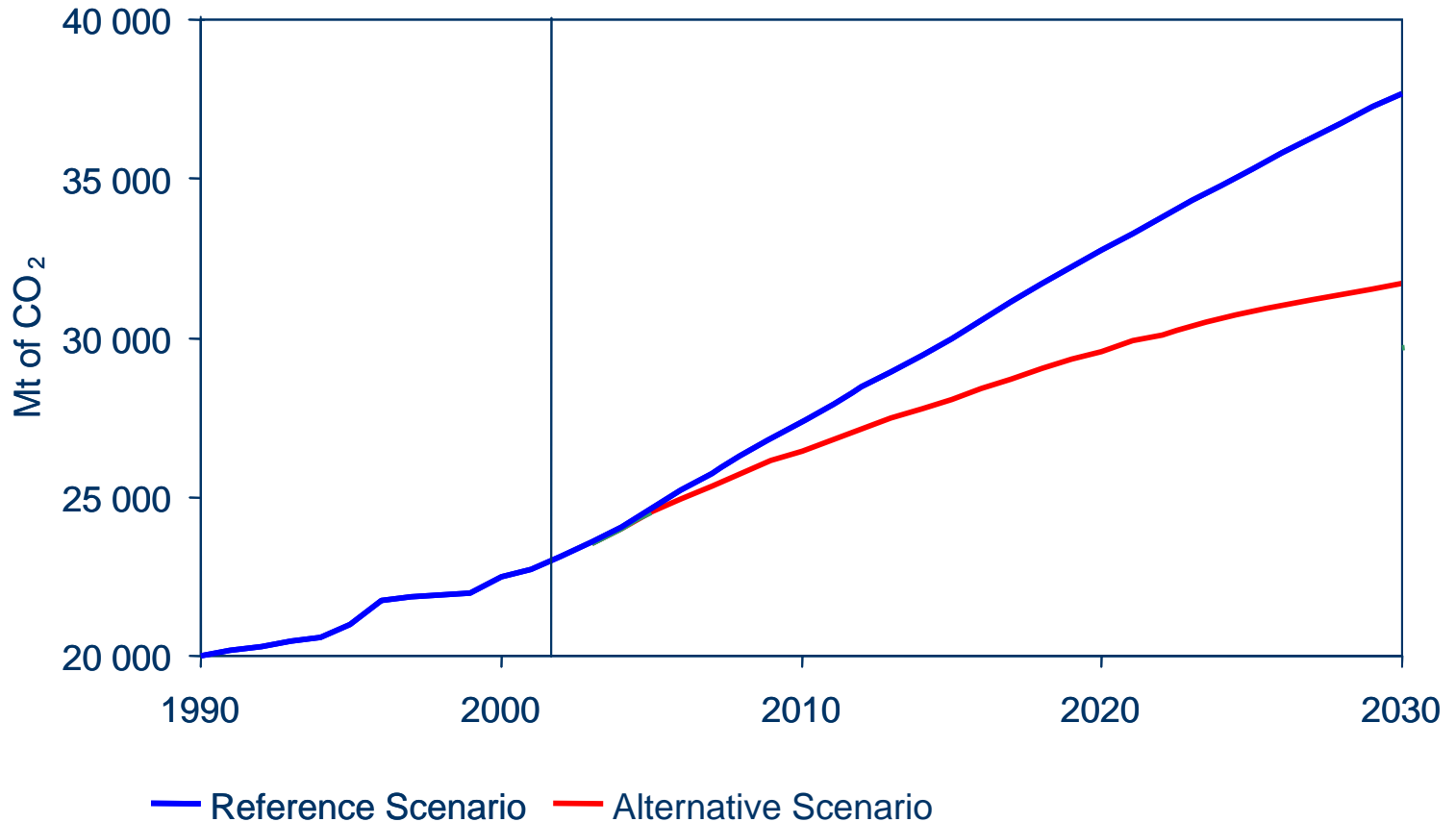




INTERNATIONAL
ENERGY AGENCY

WORLD
ENERGY
OUTLOOK
2004

Global CO₂ Emissions Reference & Alternative Scenarios



CO₂ emissions are 16% less in the AS in 2030 but still up more than 50% from 1990-levels



Energy Technology Perspectives Presents

- Status and perspectives for key energy technologies in:
 - ◆ Power Generation
 - ◆ Transport
 - ◆ Buildings and Appliances
 - ◆ Industry
- Global scenarios to illustrate potentials for different technologies under accelerated policies
- Strategies for helping key technologies make a difference



What ETP builds on

- IEA's multi-year project to develop a 15-region global energy model with associated databases
- Past work to develop IEA World Energy Outlook Alternative Scenarios
- Extensive information base from IEA's Energy Technology Network
- Substantial input from a long list of national experts



Results from the Scenario Analysis



Scenario Analysis

- Scenarios analysed:
 - ◆ Baseline Scenario
 - ◆ Accelerated Technology Scenarios (ACT)
 - ◆ TECH Plus scenario
- ACT and TECH Plus scenarios:
 - ◆ Analyse the impact from R&D, Demonstration and Deployment measures
 - ◆ Incentives equivalent to 25 USD/tonne CO₂ for low-carbon technologies implemented world-wide from 2030 and on
 - ◆ Individual scenarios differ in terms of assumptions for key technology areas



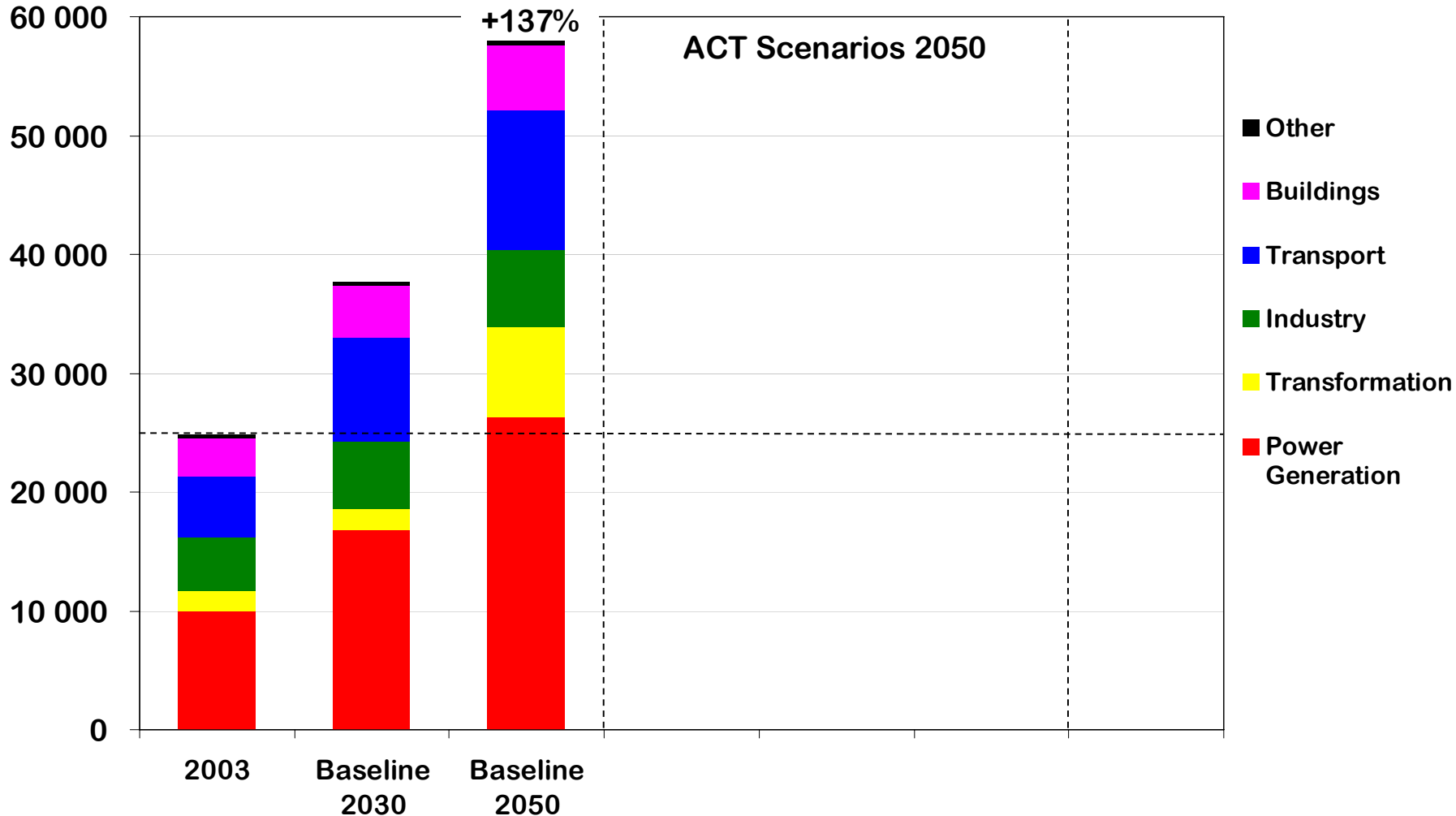
Technology Assumptions

Scenario	Renewables	Nuclear	CCS	H ₂ fuel cells	Advanced biofuels	End-use efficiency
ACT Map	Relatively optimistic across all technology areas					
ACT Low Renewables	Slower cost reductions					
ACT Low Nuclear		Lower public acceptance				
ACT No CCS			No CCS			
ACT Low Efficiency						0.3% p.a. lower global improvement
TECH Plus	Stronger cost reductions	Stronger cost reductions & technology improvement		Break-through for FC	Stronger cost reductions & improved feedstock availability	



Global CO₂ Emissions 2003-2050

Baseline Scenario

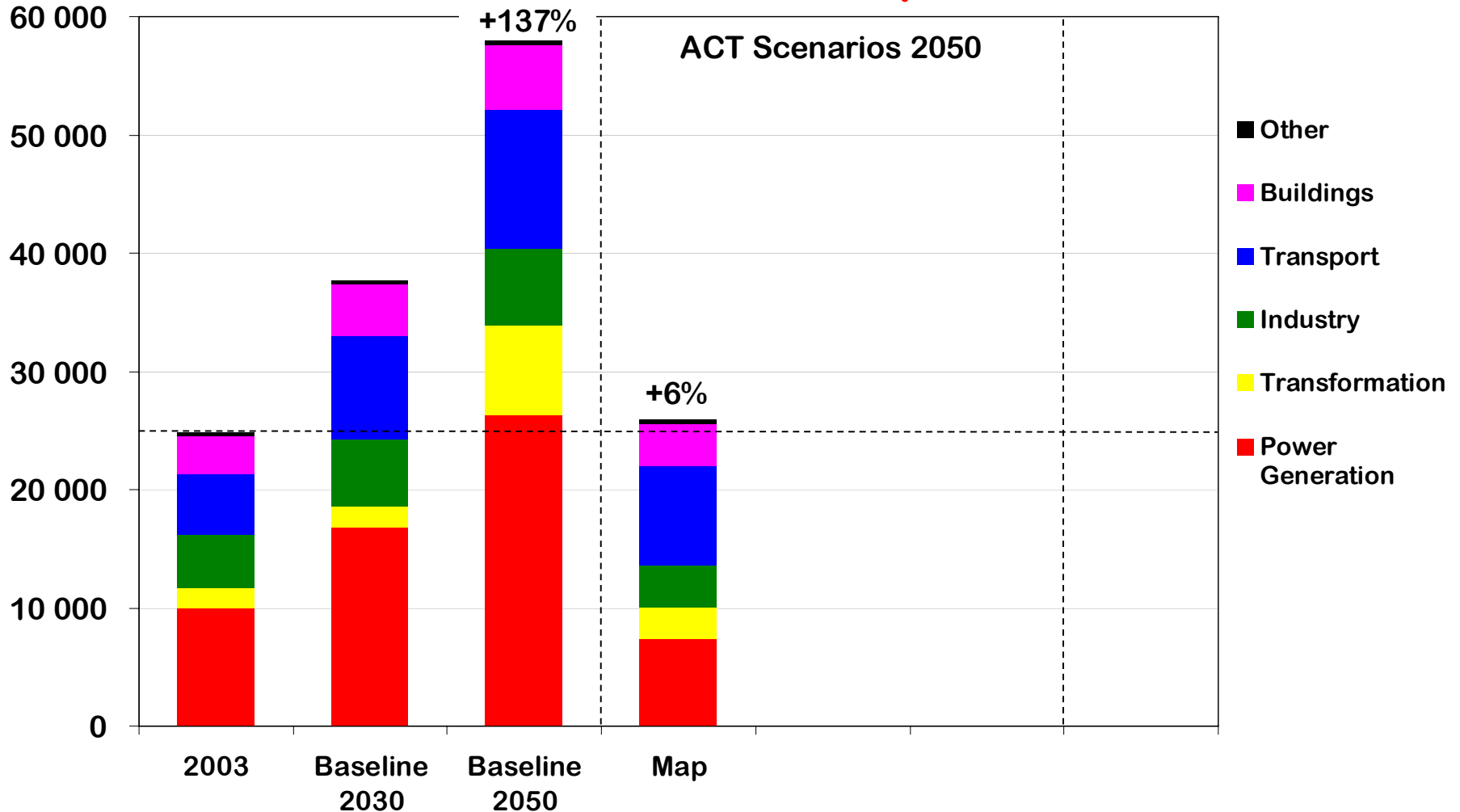


Emissions increase 137% from today's level



Global CO₂ Emissions 2003-2050

Baseline and Map Scenario

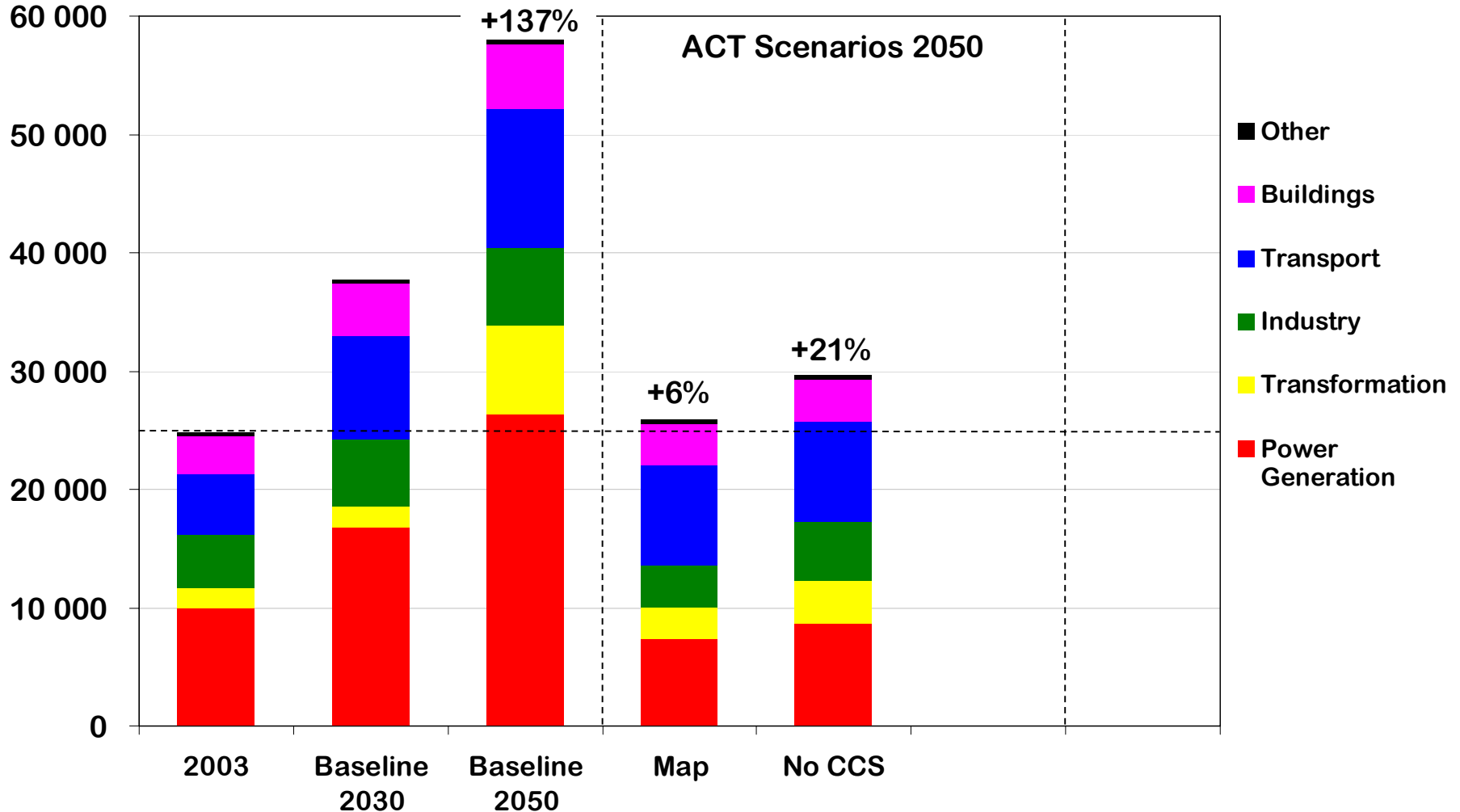


Map Scenario: Emissions returned towards today's level



Global CO₂ Emissions 2003-2050

Baseline and ACT Scenarios

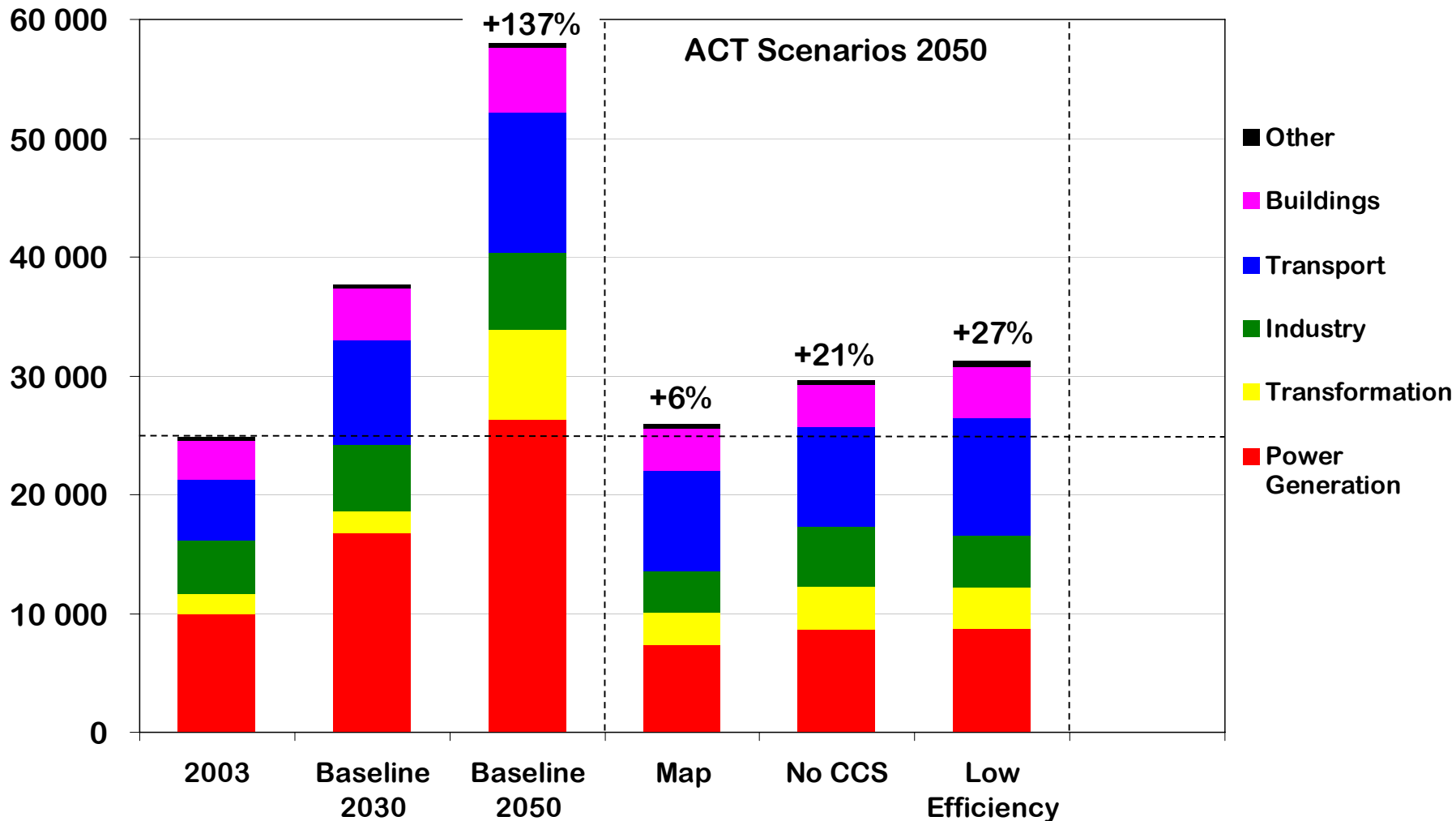


Impact of not having CCS available



Global CO₂ Emissions 2003-2050

Baseline and ACT Scenarios

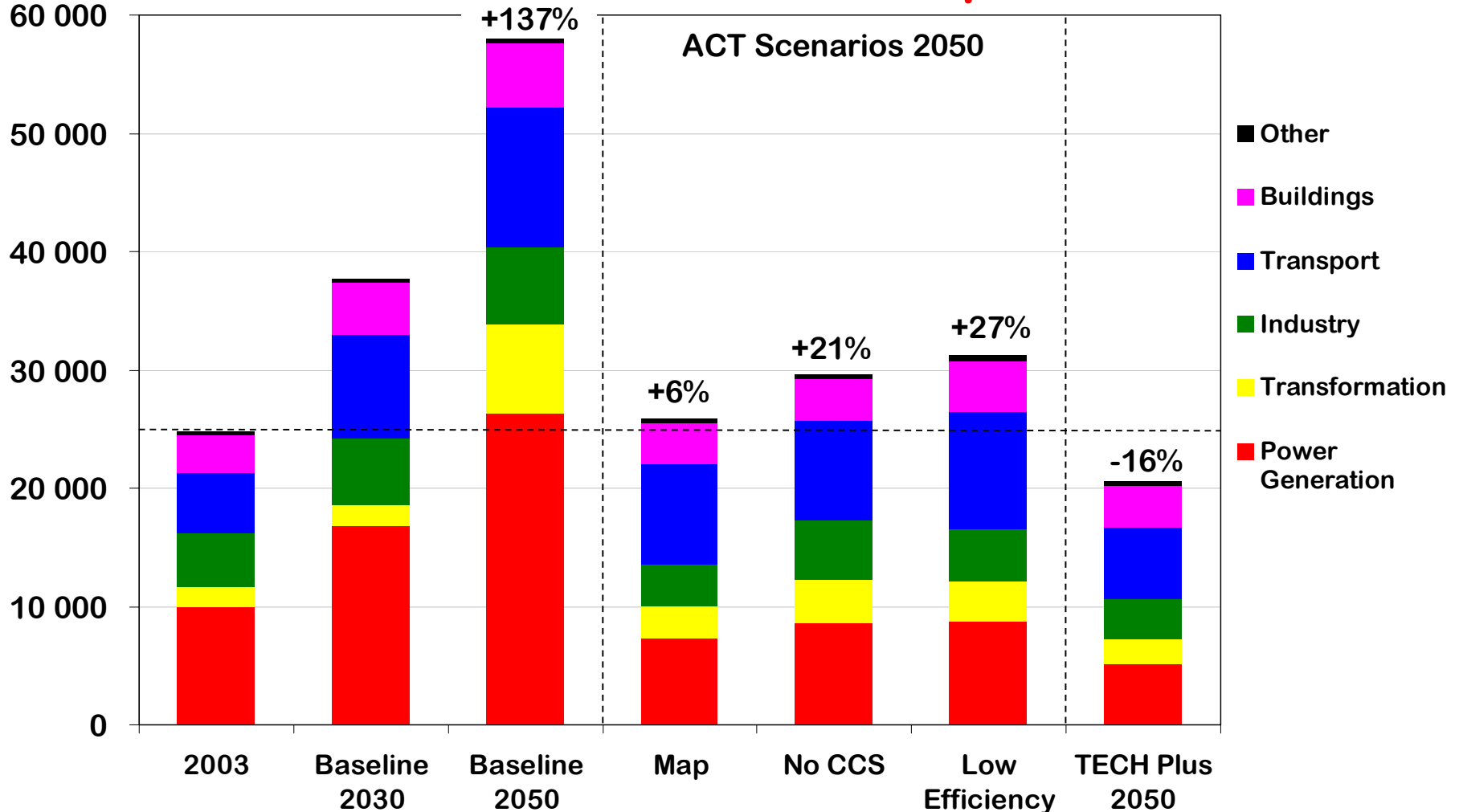


Impact of less efficiency progress



Global CO₂ Emissions 2003-2050

Baseline, ACT and TECH plus Scenarios

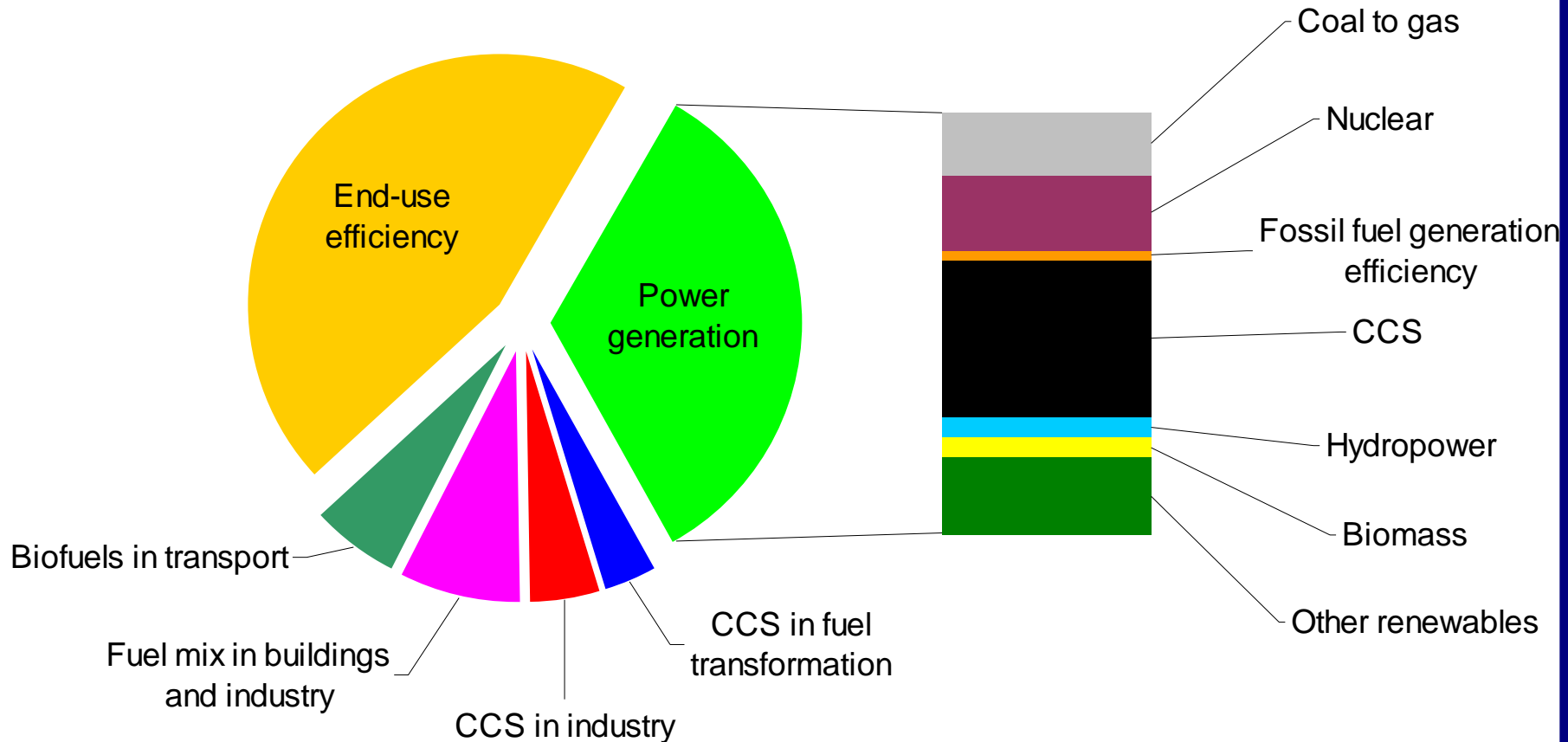


TECH Plus: More optimistic on progress for certain key technologies



Emission Reduction by Technology Area

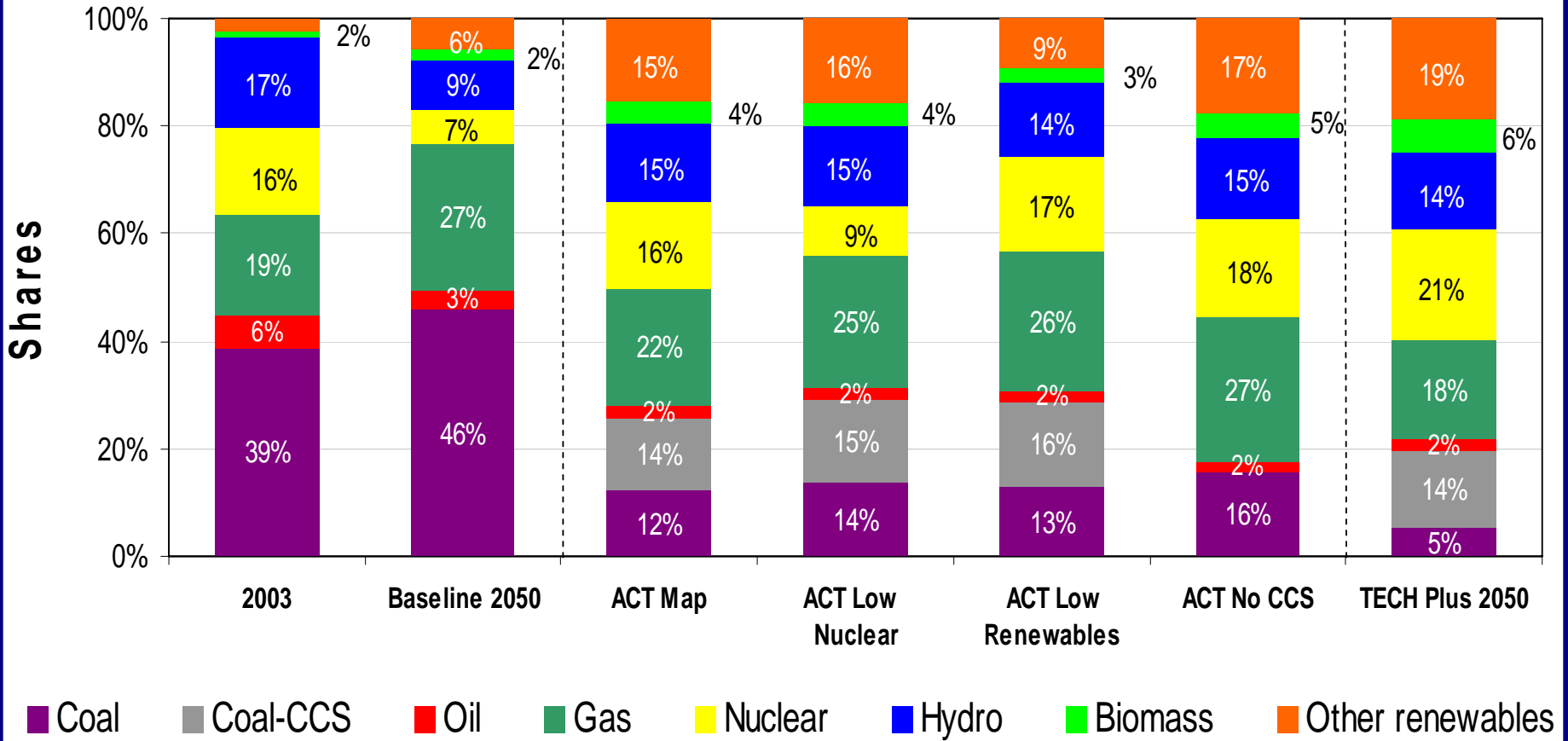
ACT Map Scenario



Improved energy efficiency most important contributor to reduced emissions



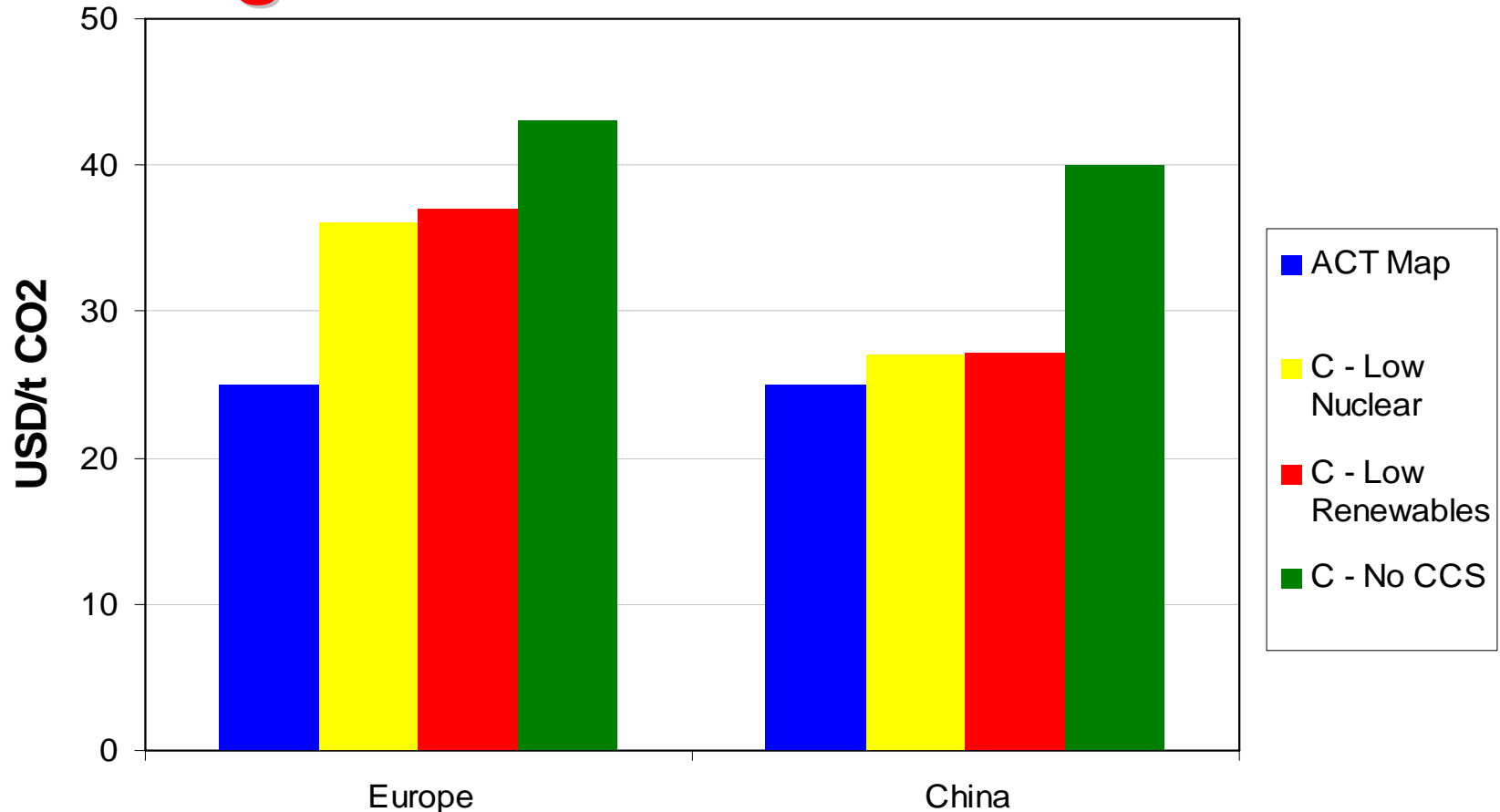
Global Electricity Generation by Fuel



ACT Scenarios: Important role for CCS and strong growth in the shares for renewables and nuclear



Impact of Technology Assumptions on Marginal Emission Abatement Costs



Absence of CCS significantly increases marginal cost of CO₂ emissions reduction



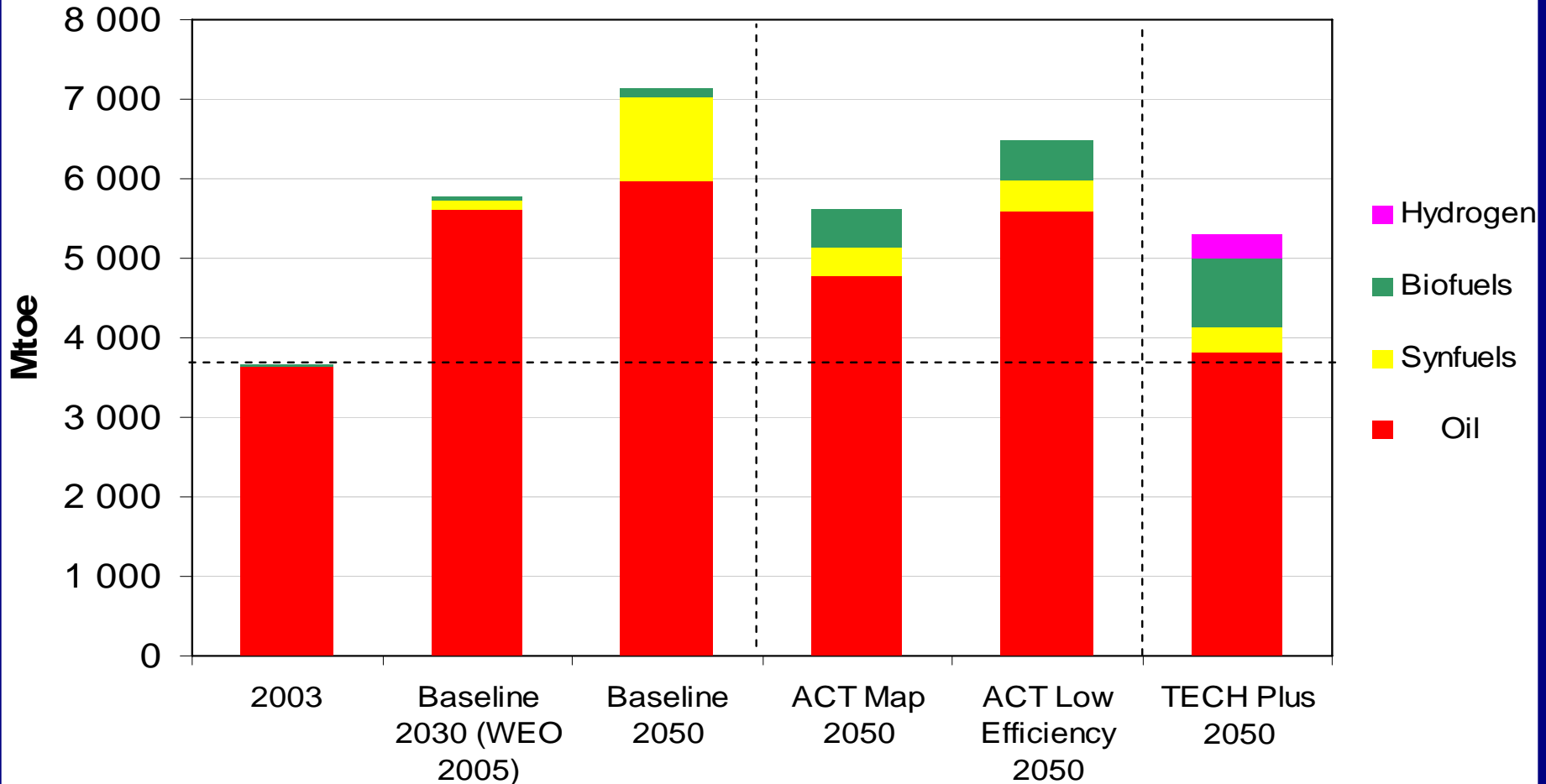
Table 2.5 ▶ **Cumulative increase in power generation investment in the Map scenario, 2005 to 2050**
(increase over the Baseline Scenario)

Power plants	Additional investment cost (USD trillion)
Wind	3.6
Solar	0.9
Geothermal	1.1
Nuclear	1.4
CCS*	0.9
<hr/>	
Total additional investment in renewables, nuclear and CCS	7.9
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Reduced investment in fossil fuel power plants	-4.5
- of which due to lower electricity demand	-2.9
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Total	3.4
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*Only the CCS costs, excluding the power plant.



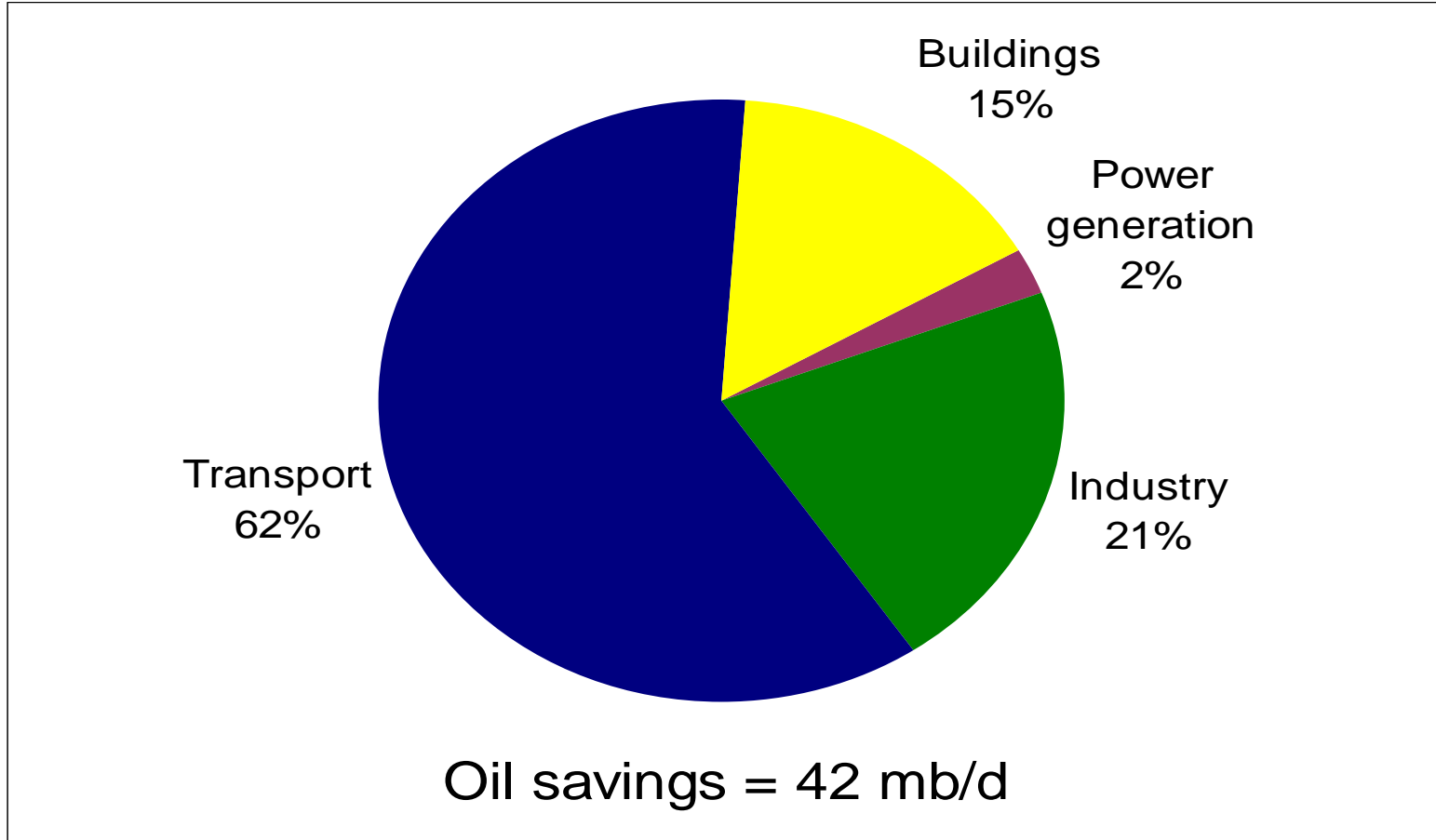
World Liquid Fuel Supply by Scenario 2003-2050



Primary oil demand is below 2030 baseline level, and is returned to about today's level in TECH Plus



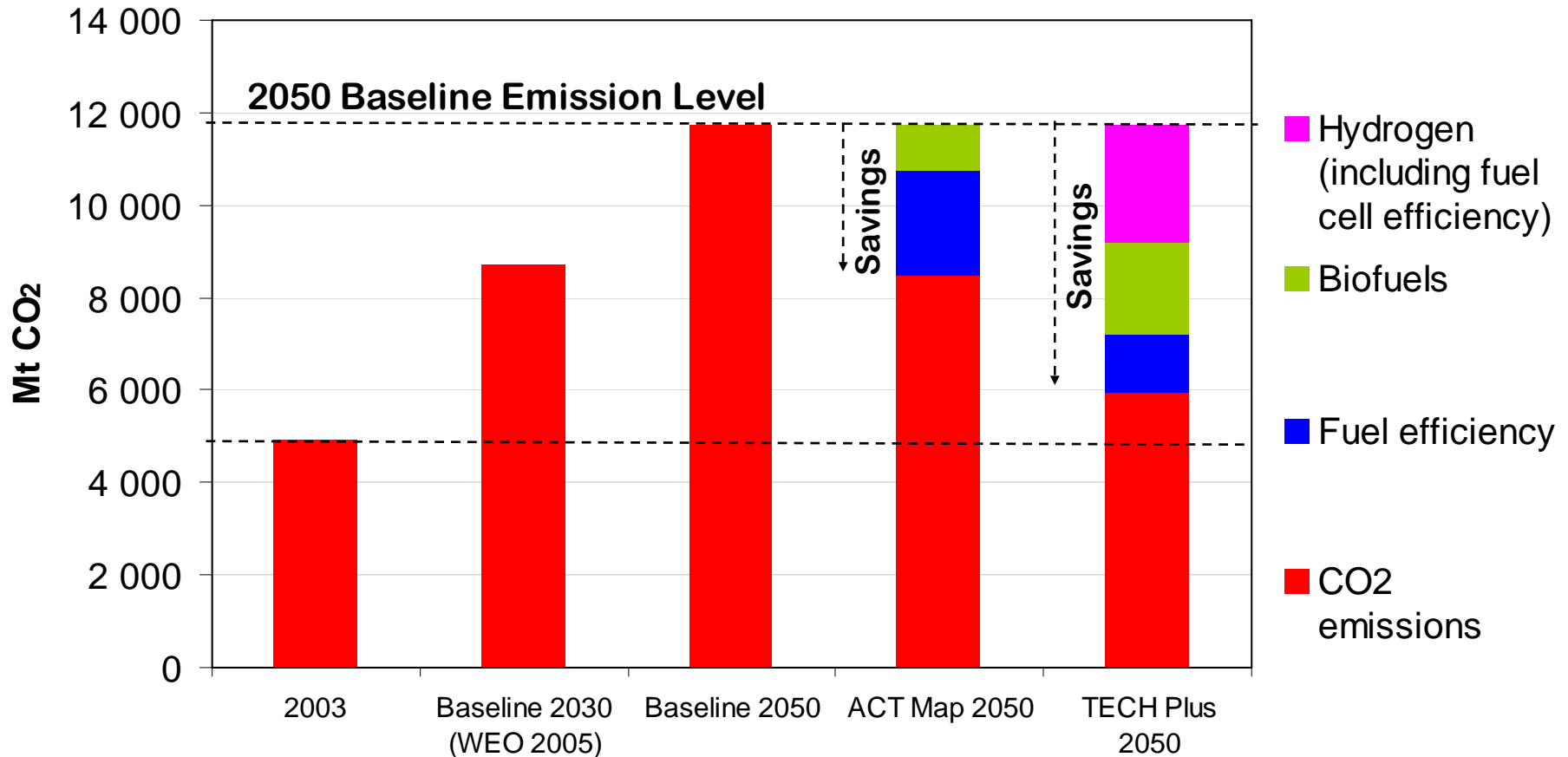
Reduction in Oil demand in the Map Scenario



Oil savings by 2050 are around half of today's total oil demand



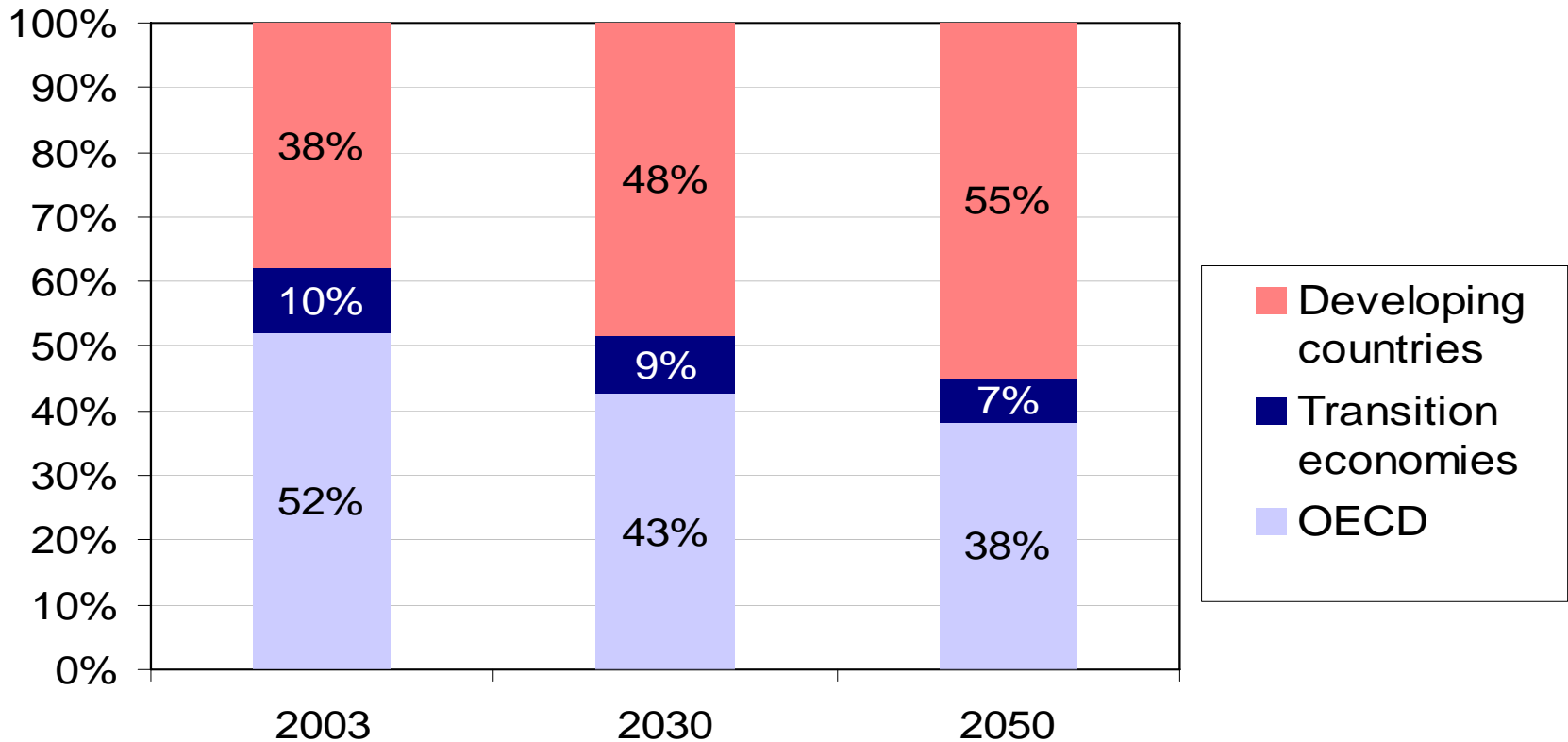
Transport CO₂ Emissions by Scenario



Map Scenario: Two-thirds of CO₂ emissions reduction is from improved fuel efficiency and one-third from biofuels



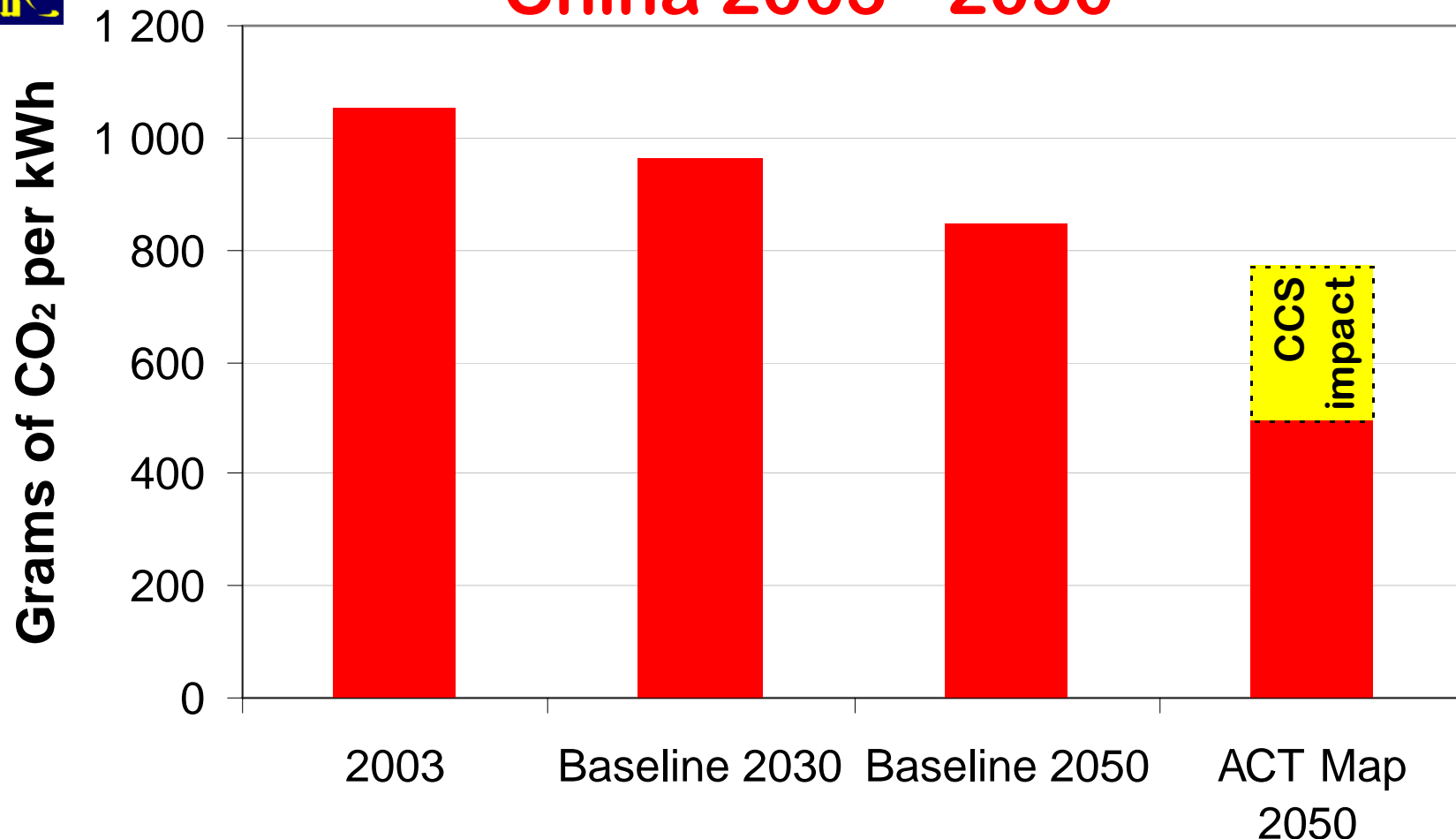
Primary Energy Demand by Region Baseline Scenario



By 2050 developing countries account for 55% of global energy demand



CO₂ Intensity Coal Fired Power Generation China 2003 - 2050



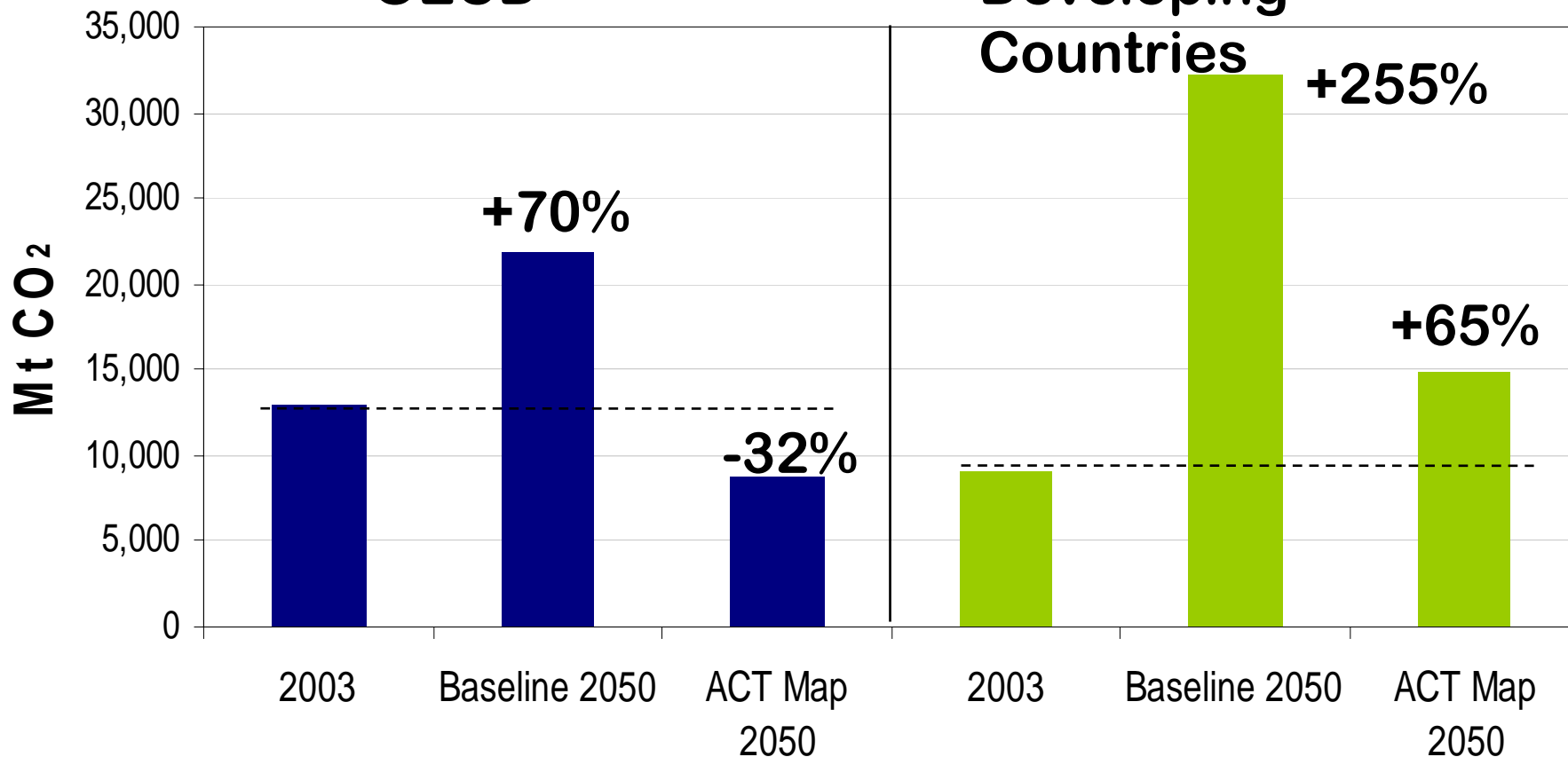
More than 50% reduction in CO₂ intensity due to improved generation efficiency and CCS



CO₂ Emissions Baseline and Map Scenarios

OECD

Developing
Countries



Map: OECD Emissions one-third below 2003 level, while emissions in Developing Countries are two-thirds higher



Insights from the Scenario Analysis



Scenario Analysis

Key Findings

- Most energy still comes from fossil fuels in 2050
- Global CO₂ emissions can be returned towards today's level by 2050
- Growth in global oil and electricity demand can be halved
- Power generation can be substantially de-carbonised by 2050
- De-carbonising transport will take longer but must be achieved in the second half of the century



Energy Efficiency - A top Priority

- Improved energy efficiency saves about 15 Gt CO₂ by 2050 – equivalent to 60% of current emissions
- Improved efficiency halves expected growth in electricity demand and reduces the need for generation capacity by a third
- In a scenario with less progress in efficiency, CO₂ emissions increase more than 20%
- Lower efficiency progress increases supply-side investments and costs of reducing CO₂ emissions



Electricity Generation

CO₂ Capture and Storage a Key Option

- CCS is crucial for the role coal can play in a CO₂ constrained world – without CCS coal-fired generation in 2050 drops below today's level
- By 2050 more than 5000 TWh electricity globally can be produced by coal-plants equipped with CCS
- There is an urgent need for more R&D and for full-scale CCS demonstration plants
- Generation from renewables can quadruple by 2050
- Nuclear can gain a much more important role in



Transport

Key to Reduce Growth in Oil Demand

- Share of biofuels by 2050 is 13% and average 2050 vehicle is almost 50% more efficient than today
 - ◆ Reduce expected growth in transport oil demand by almost 50%
- Transport accounts for 62% of the 42 mbpd total oil savings by 2050, which more than halves the expected growth in total oil demand
- Hydrogen and Fuel Cells can reduce transport oil demand and CO₂ emissions even further and can be crucial for long-term sustainability



Key Technologies

- A technology portfolio will be needed
- Improving energy efficiency is top priority
- CCS is key for a sustainable energy future
- Other important technologies:
 - Renewables, including biofuels
 - Nuclear
 - Efficient use of natural gas
 - In time and with effort, hydrogen and fuel cells



Costs

- None of the technologies have higher incremental costs than 25 USD/tonne CO₂
- Significant transitional costs for RD&D and deployment programs
- Improved energy efficiency substantially reduce need for supply side investments and fuel imports
 - ◆ Electricity sector: demand side savings offset most of the additional investment costs for power generation
- Progress in efficiency and CCS key to keep mitigation costs down

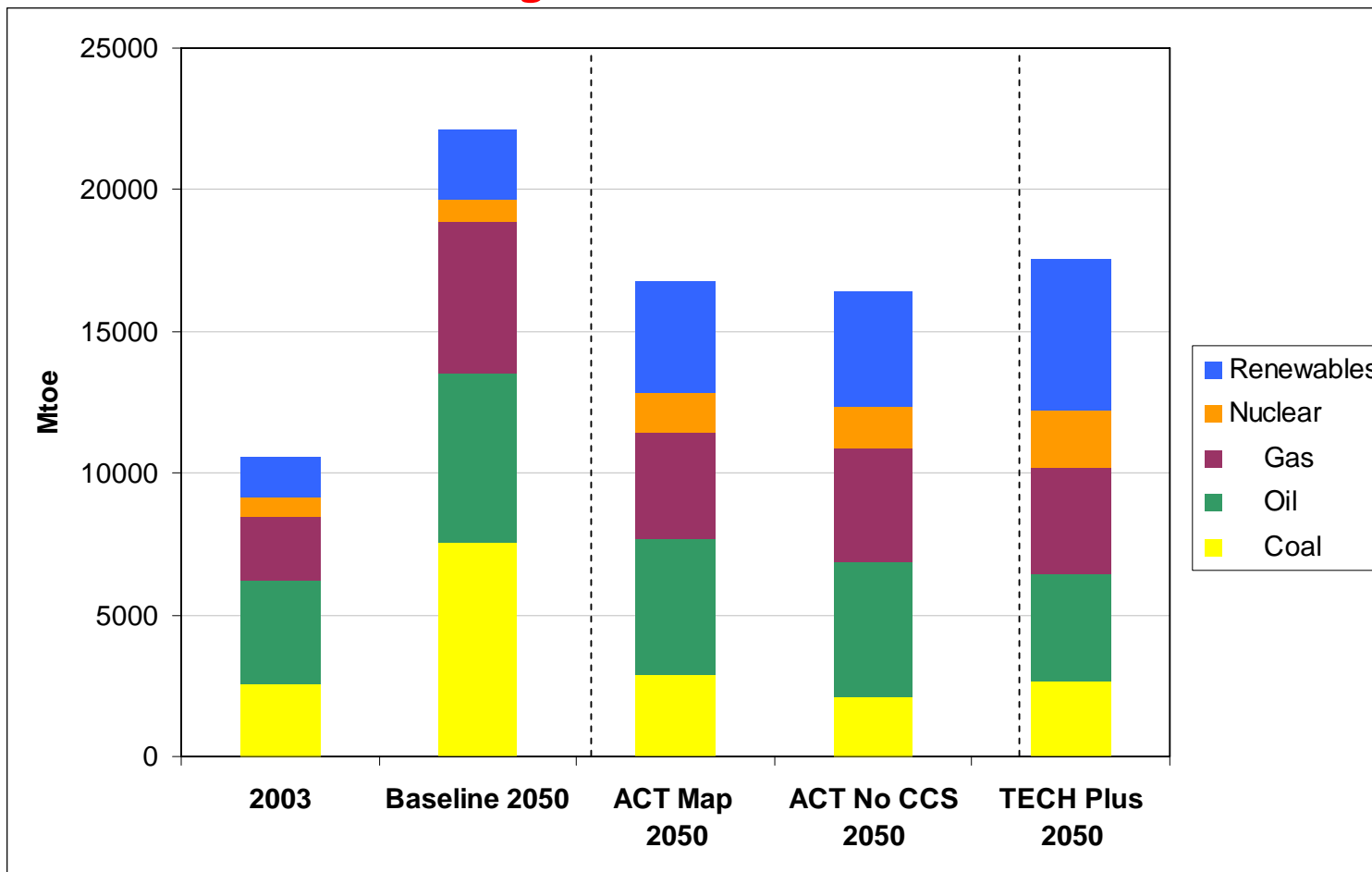


Policy Implications

- A more sustainable energy future is possible with known technology
- The costs are not out of reach
- But urgent action is needed in public and private sectors:
 - ◆ Overcome barriers for adoption of energy efficient technologies
 - ◆ Enhance R&D
 - ◆ Accelerate demonstration and deployment
 - ◆ Provide clear and predictable incentives
- Collaboration between developed and developing countries essential



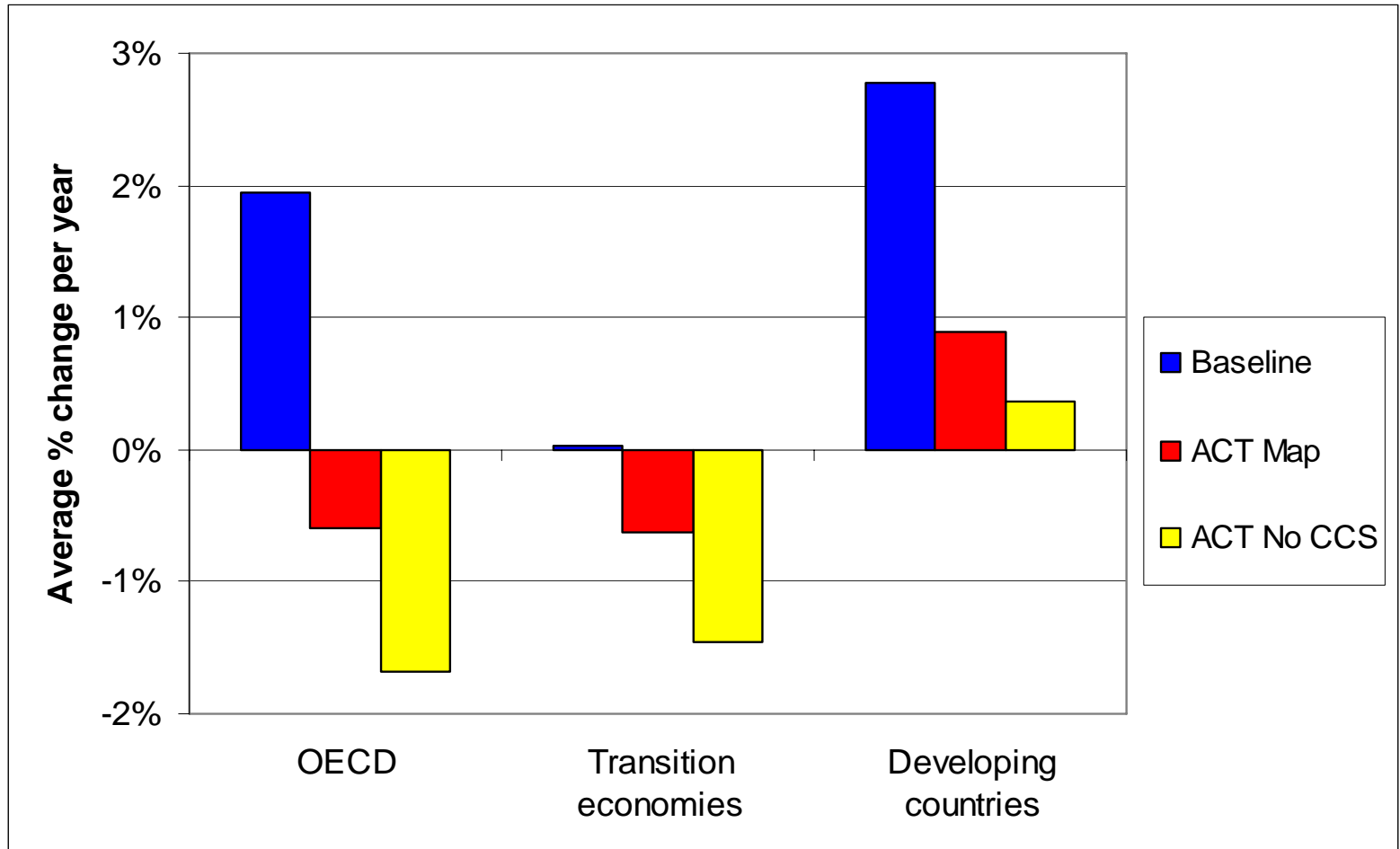
TPES by Fuel and Scenario



In the Map scenario fossil fuel use is 39% lower in 2050.



Changes in Coal Demand by Region and Scenario



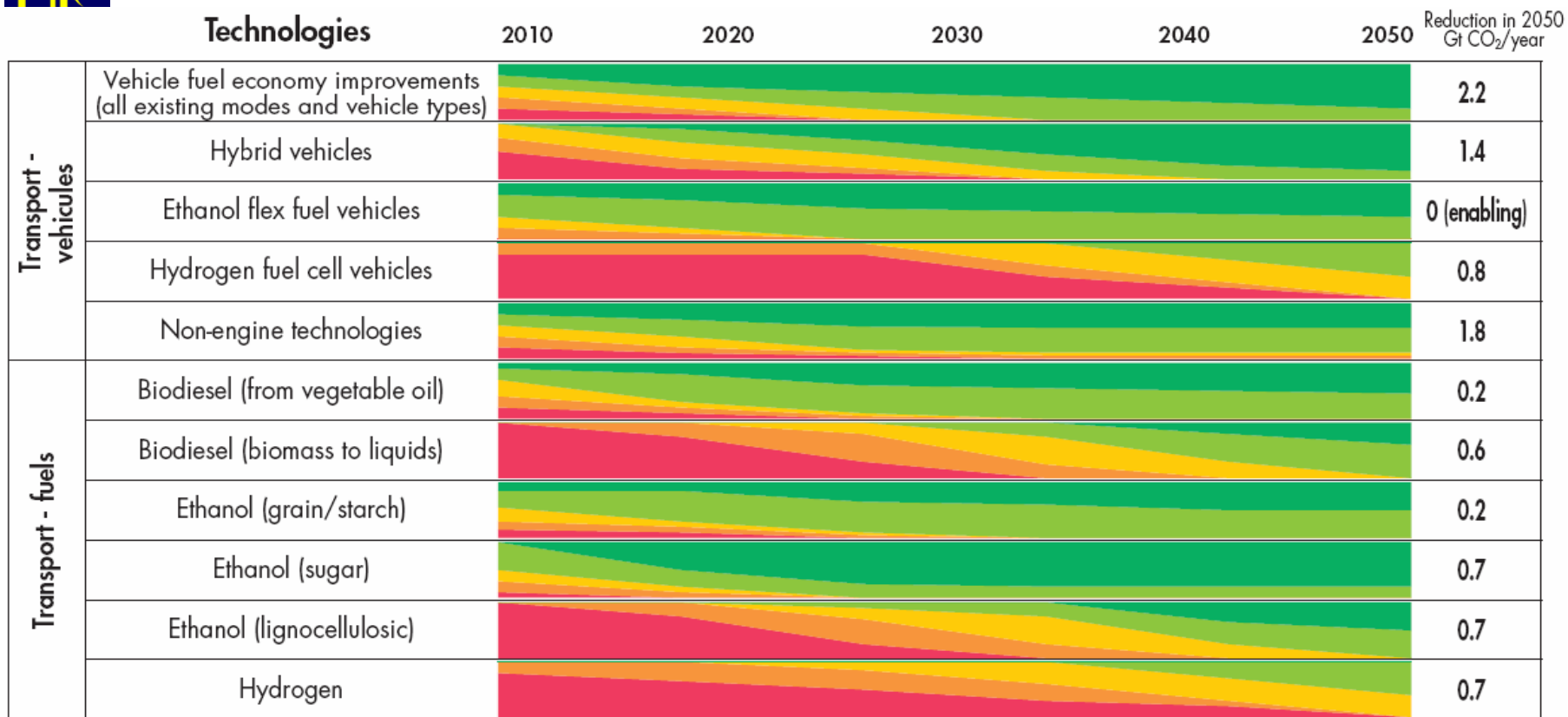
Outside of developing countries, coal demand declines in the ACT Scenarios



Technologies		2015	2030	2050	Gt CO ₂ /year
Transport – vehicles	Vehicle fuel economy improvements (all existing modes and vehicle types)	★★	★★★★	★★★★	2.2
	Hybrid vehicles	★★	★★★★	★★★★	1.4
	Ethanol flex fuel vehicles				0 (enabling)
	Hydrogen fuel cell vehicles		★	★★★★	0.8
	Non-engine technologies	★★	★★★★	★★★★	1.8
Transport - fuels	Biodiesel (from vegetable oil)	★	★★	★★	0.2
	Biodiesel (biomass to liquids)		★	★★★★	0.6
	Ethanol (grain/starch)	★	★★	★★	0.2
	Ethanol (sugar)	★★	★★★★	★★★★	0.7
	Ethanol (lignocellulosic)		★★	★★★★	0.7
	Hydrogen		★	★★★★	0.7



Figure 3.10 ▶ Pathways towards cost-competitiveness for transport technologies



the stage when the technology is cost-competitive without specific CO₂ reduction incentives

the stage where the technology is cost-competitive with CO₂ reduction incentives

the government support for deployment

the demonstration stage

the R&D stage