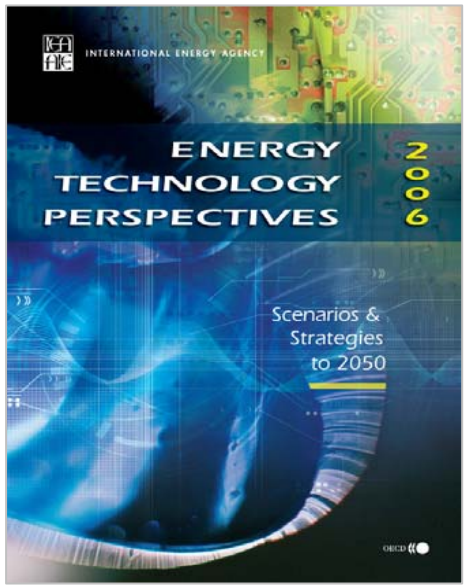
Energy Technology Perspectives 2006

Results, Technologies and R&D Needs



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RD&D Workshop, 15-16 February 2007

Structure of this Presentation

- Technology development
- ETP2006 scenarios
- Technologies
- R&D needs

Technology Development

- Technological change is a slow process
- Limited by:
  - Time for RD&D
  - Rate of product stock turnover
  - Competing existing technologies
- Typical time from invention to 50% of market 10-30 years
- Technology RD&D should be finished by 2025 in order to have a significant impact by 2050

Technology Life Cycle

R&D

Technologies in need for R&D to overcome technical barriers and to reduce costs. The outcome is still uncertain, especially in the early stages of development.

Demonstration

Demonstration of the technology. Often government funding is needed to finance part or all of the costs of the demonstration.

Deployment

Successful technical operation, but in need of support to overcome cost barriers. With increasing deployment learning-by-doing effects will result in gradually decreasing costs.

Competitive

Technology is cost competitive in some or all markets, but some technologies may require sustained incentives to value CO_2 emission reduction or other benefits.

Technology Development Criteria

- A technology should function adequately
- It should be cost-effective
- It should have no significant external effects
- It should have scope for widespread application
- It should be acceptable from a supply security and CO2 reduction viewpoint

ETP2006 scenarios

The Scenario Background

- The six IEA Energy Technology Perspectives2006 scenarios complement the two IEA World Energy Outlook (WEO) scenarios
- The WEO scenarios for 2030 show that current trends are not sustainable
- The ETP Baseline Scenario corresponds with the WEO Reference Scenario
- The ETP scenarios show how CO_2 emissions can be stabilized and how supply security can be enhanced between now and 2050
- The emphasis is on the role that energy technologies can play
- A radical technology change needed

Scenario Scope

- 2050 time horizon
- Analysis based on a technology-rich partial equilibrium model (MARKAL based)
- Renewables analysis GIS-based
- Fed by spreadsheet analysis for end-use sectors

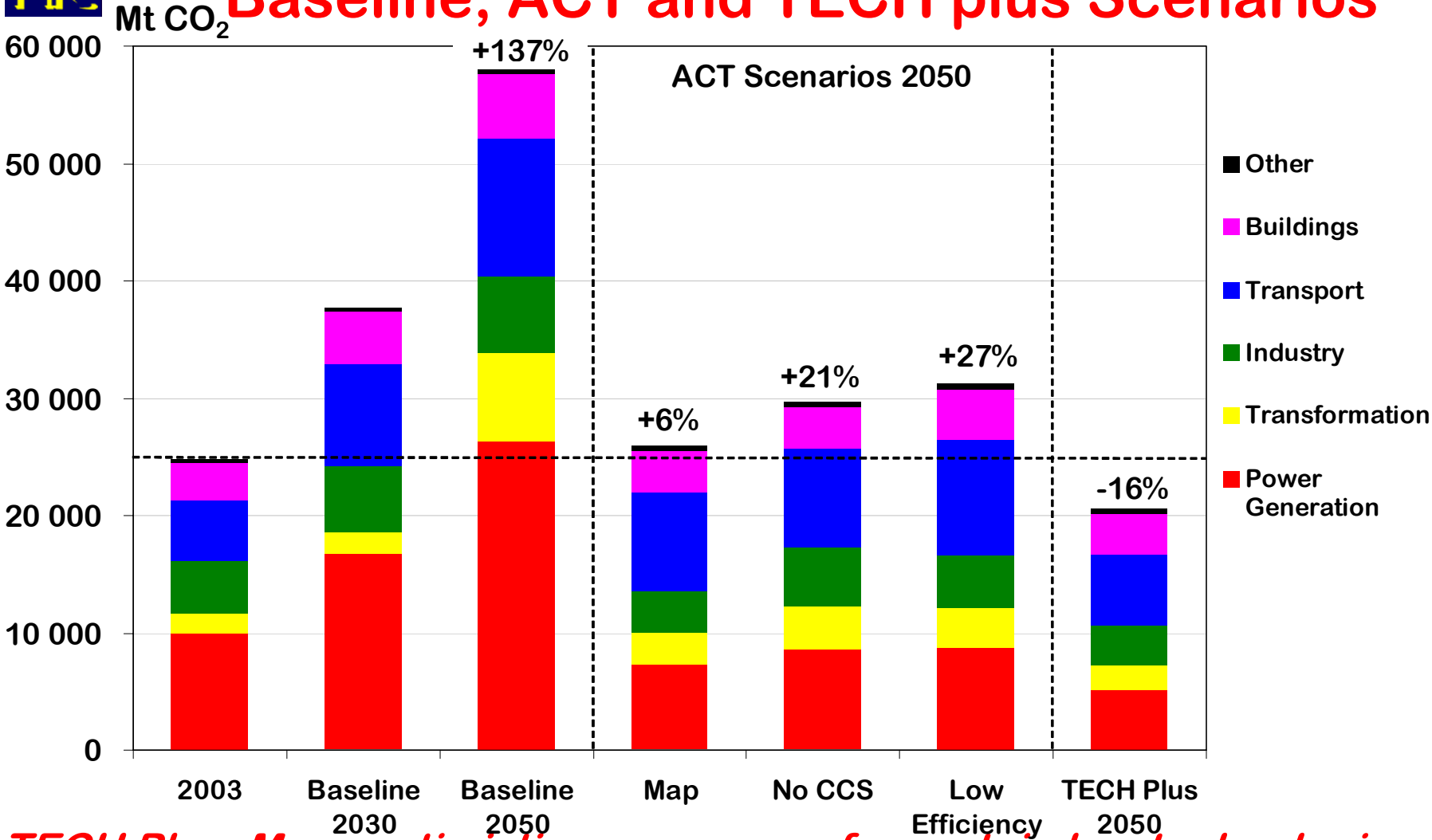
ETP2006 Scenarios

- 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 $/tonne CO_2 for low-carbon technologies implemented world-wide from 2030 and on
  - Individual scenarios differ in terms of assumptions for key technology areas

Technology Assumptions

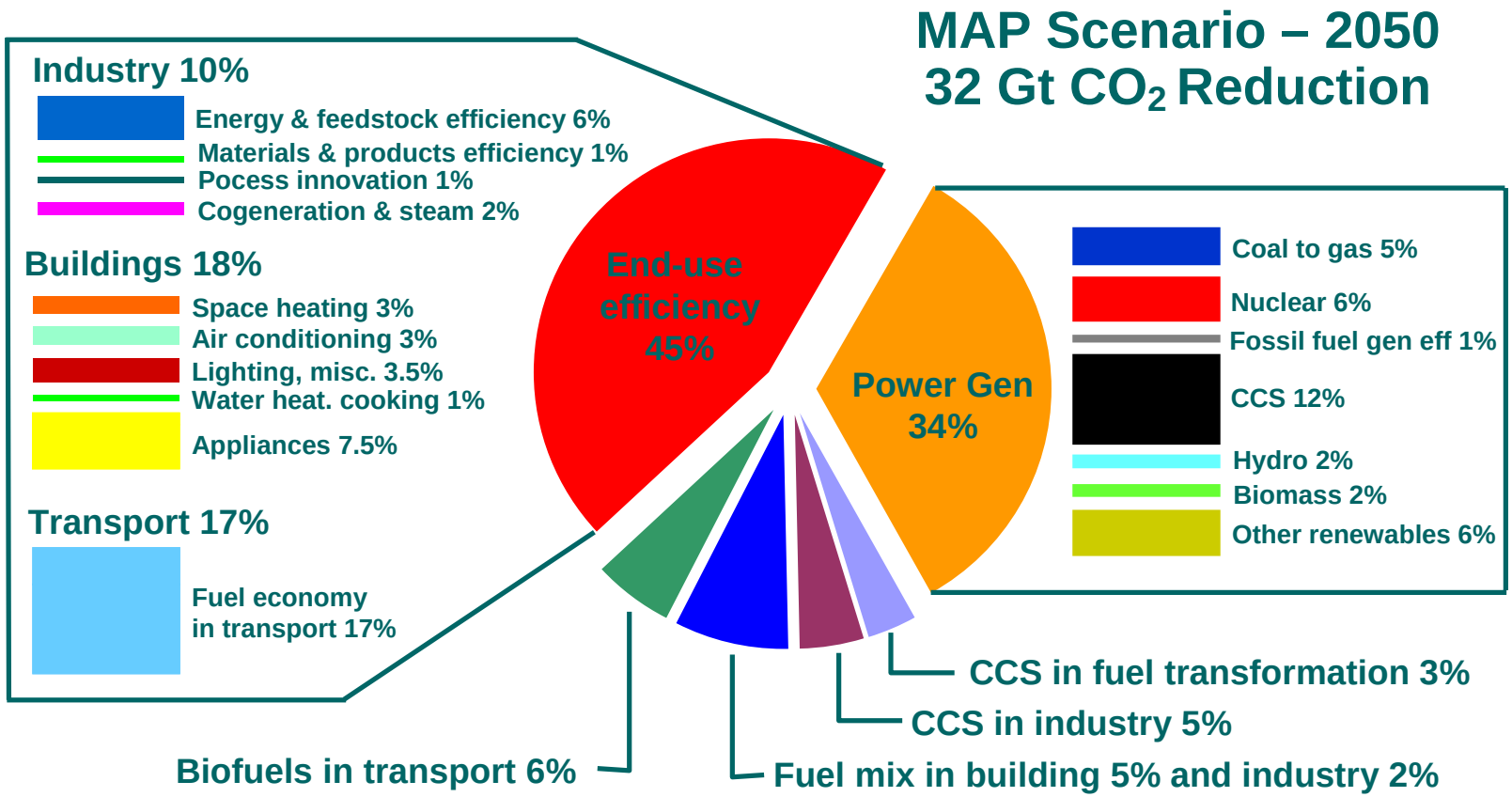
Scenario	Renewables	Nuclear	CCS	H_2 fuel cells	Advanced biofuels	End-use efficiency
ACT Map	Relatively optimistic across all technology areas					2.0 % p.a. global improvement
ACT Low Renewables	Slower cost reductions					
ACT Low Nuclear		Lower public acceptance				
ACT No CCS			No CCS			
ACT Low Efficiency						1.7 % p.a. global improvement
TECH Plus	Stronger cost reductions	Stronger cost reductions & technology improvements		Break-through for FC	Stronger cost reductions & improved feedstock availability	

Global CO_2 Emissions 2003-2050
Baseline, ACT and TECH plus Scenarios



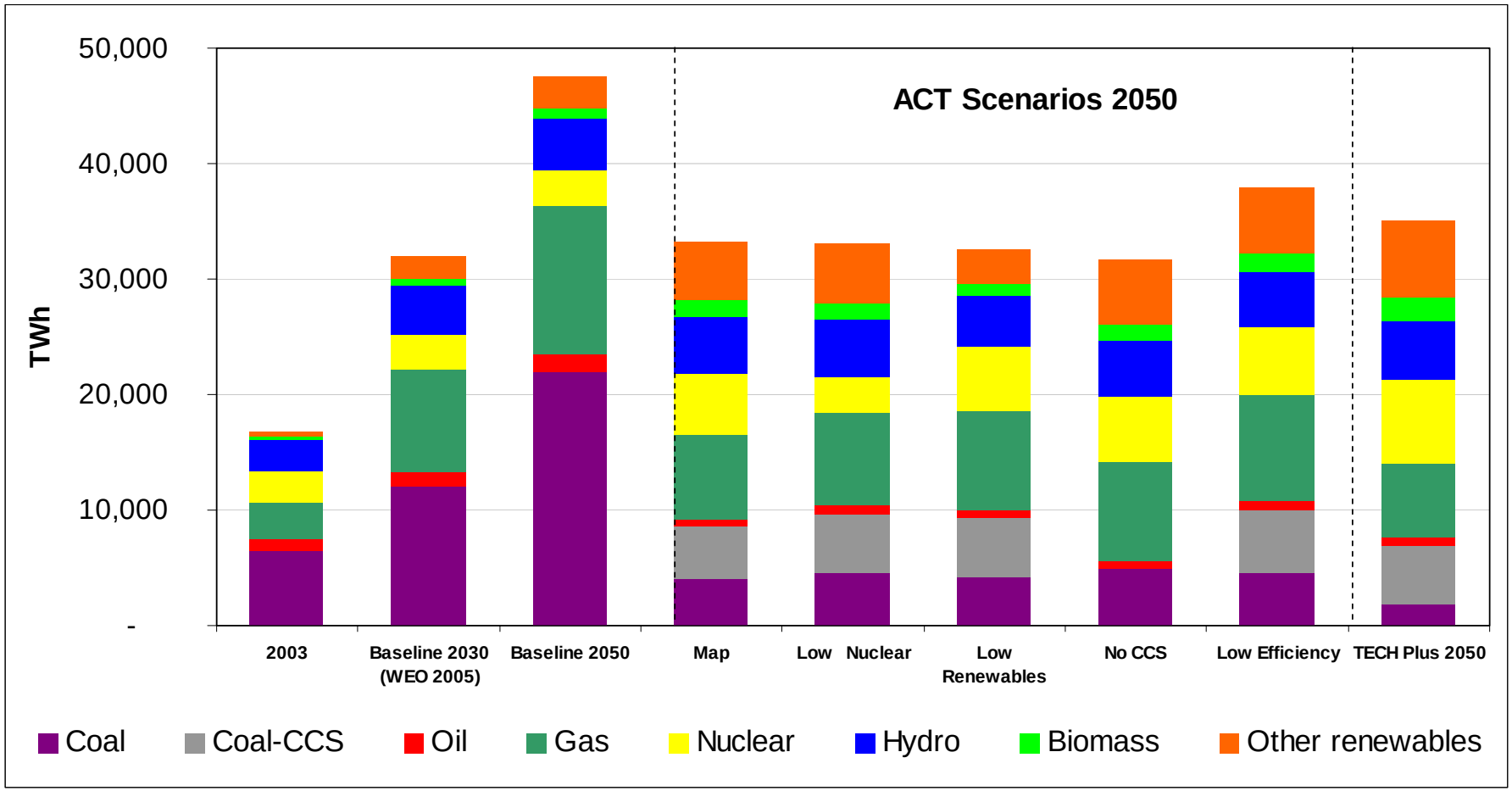
TECH Plus: More optimistic on progress for certain key technologies

Emission Reduction by Technology Area
ACT Map Scenario

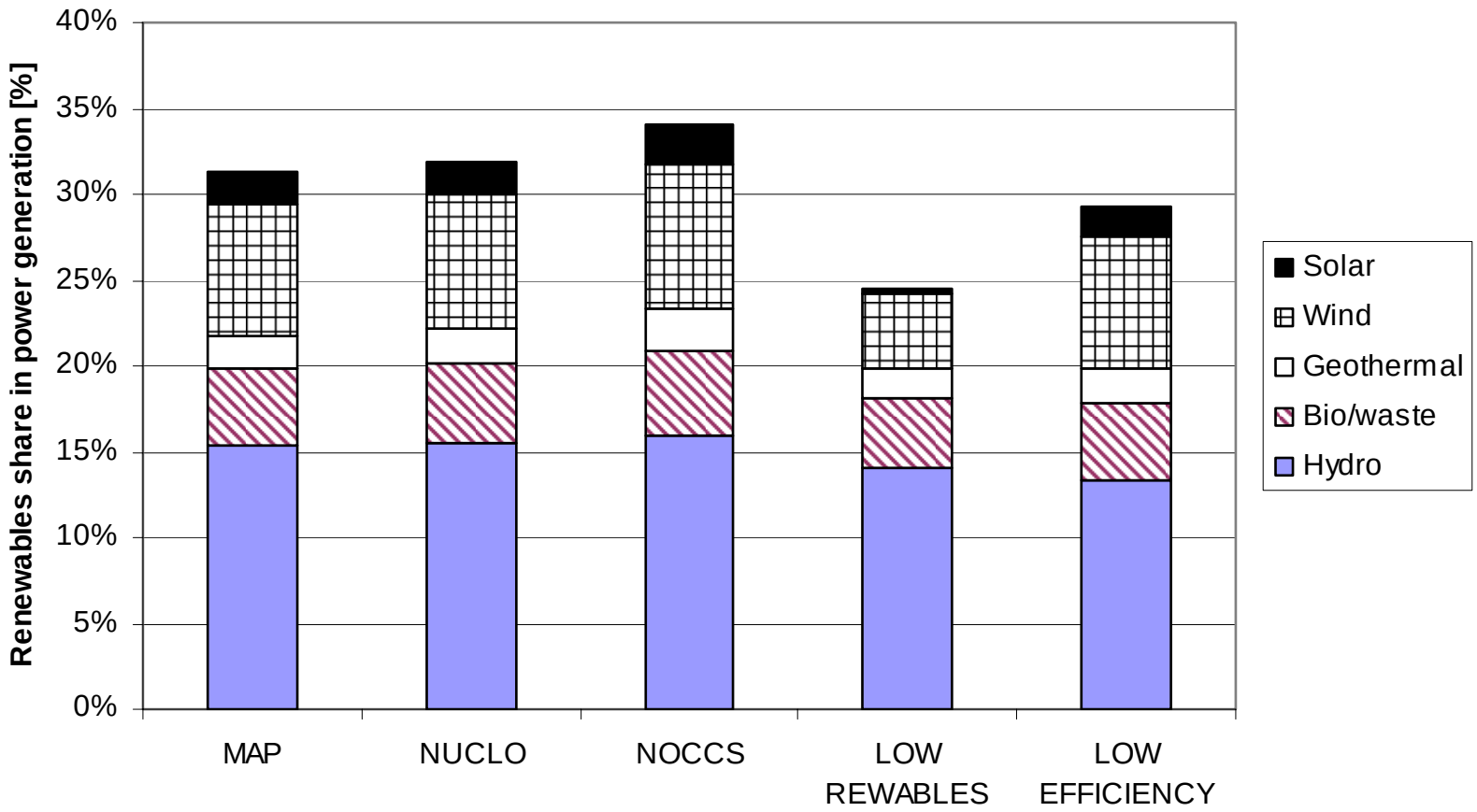


Improved energy efficiency most important contributor to reduced emissions

Power Generation



Renewables Power Generation



Renewables analysis

- Detailed GIS systems for wind, solar and geothermal
- Constraints considered (resource quality, distance to population centres, population density)
- 30 categories for wind, 20 for solar
- 15 world regions

Renewables analysis (contd.)

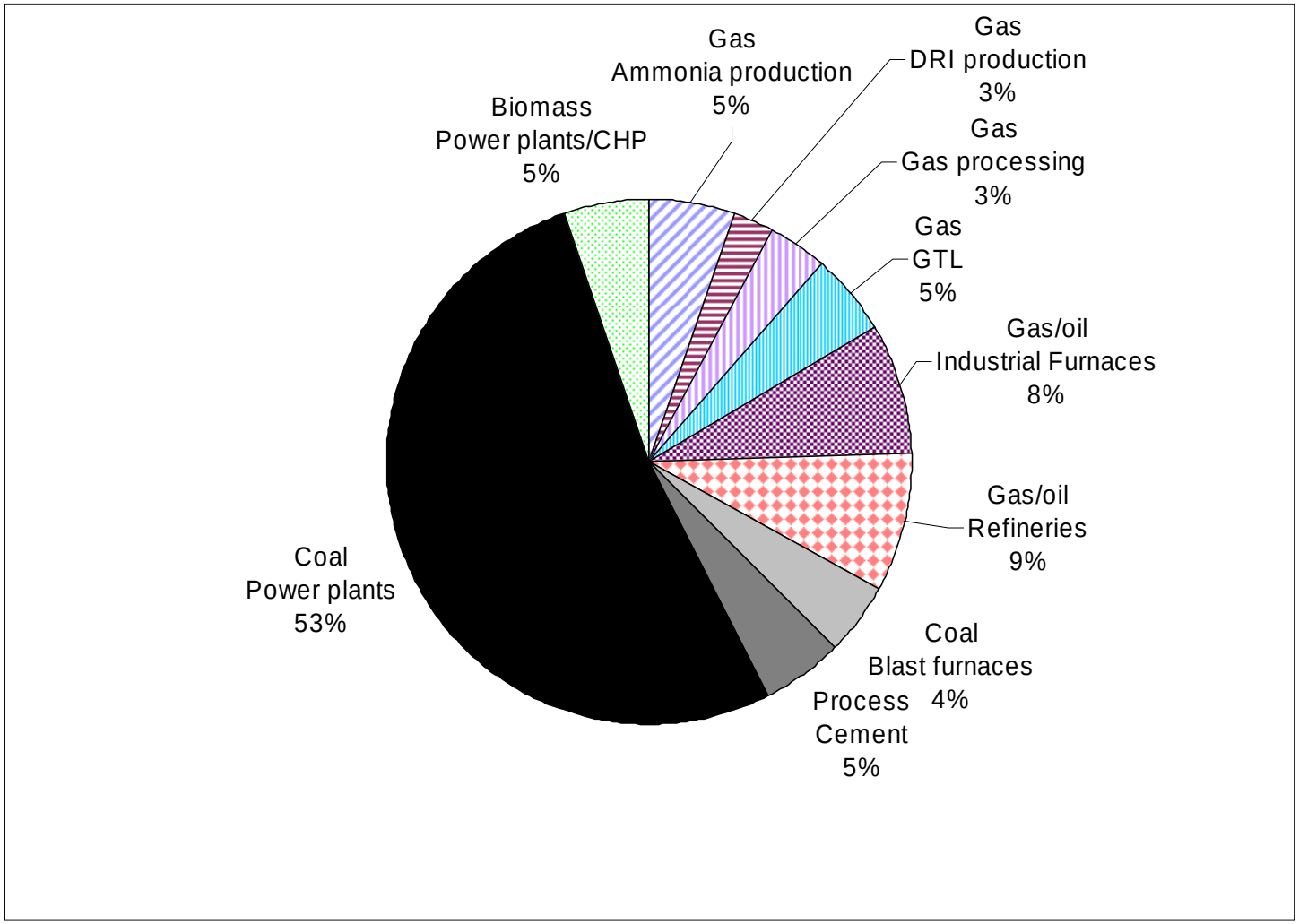
- Cost reductions are a function of investments (global technology learning)
- Low learning rates
- Intermittency, intra-regional grid connections and maximum rate of expansion constrain maximum renewable power generation
- If these constraints are removed, more renewable power generation would be possible
- This is a key technology issue

Electricity Generation

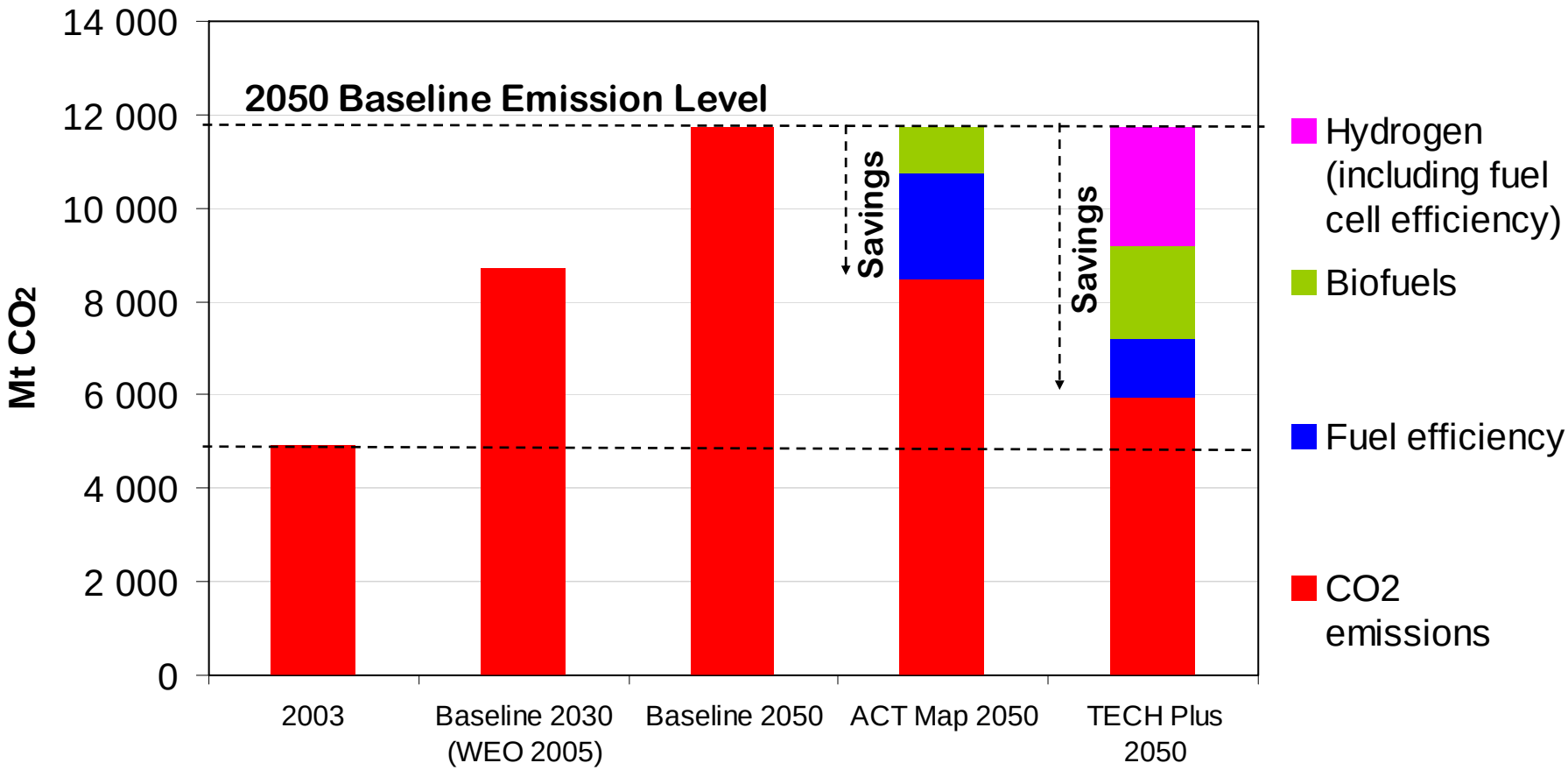
CO_2 Capture and Storage a Key Option

- CCS is crucial for the role coal can play in a CO_2 constrained world – without CCS coal-fired generation in 2050 drops below today's level
- By 2050 more than 5 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 countries where it is acceptable

CCS also in Industry and for Other Parts of the Energy Supply



Transport CO_2 Emissions by Scenario



Map Scenario: Two-thirds of CO_2 emissions reduction is from improved fuel efficiency and one-third from biofuels

Key New Technologies

- This workshop
  - CCS
  - Wind
  - Biomass for electricity and CHP
  - Solar PV & CSP
  - IVth generation Nuclear
- Another workshop
  - Large-scale electricity storage (scale hours/weeks)
  - 2nd generation biofuels (lignocellulosic ethanol, new biodiesel options)
  - Better car batteries/H2-FCVs

Key Targets

	2005	2050	2005	2020	2050	Growth rate 2020-2050
	[US$/kW]	[US$/kW]	[GW]	[GW]	[GW]	
CCS USCSC	2000	1600	0	10	250	10%
CCS IGCC	2200	1600	0	10	250	10%
Wind onshore	900-1100	750-900	47	200	1000	5%
Wind offshore	1500-2500	1400-1800	1	30	250	7%
Biomass IGCC	2500	1800	<1	10	150	8%
Solar PV	3750-3850	1000-1100	4	10	200	10%
Solar CSP	2000-2300	1700-1900	0.4	5	200	12%
Nuclear	2000	1700	370	420	750	2%

RD&D Needs

- 2050 stabilisation does not require more basic R&D
- Longer term emission reductions will require breakthroughs in the transportation sector
- More funding needed for applied R&D (technology deployment)
- Unclear if increased funding alone will be sufficient
- Unclear if reallocation of funding is needed
- Unclear of more international collaboration is needed
- Unclear what should be the role of governments and industry

A DRAFT summary of RD&D needs
Is such a table really feasible ?

	R&D [bln USD]	Demonstration [bln USD]	2007-2020 [bln USD]	2020-2030 [bln USD]
Ultra supercritical steam cycle 4 demo plants 700 C	0.1	2	2.0	
IGCC 5 demo plants		5	5.0	
15 CCS coal fired power plants (add-on cost)		7.5	5.0	2.5
Small scale hydropower & reservoir management	0.1	0.5	0.6	
Hot dry rock geothermal 25 demo projects		1	0.5	0.5
Biomass IGCC 10 demo projects		0.5	0.4	0.1
Black liquor gasifier 5 demo plants		1	1.0	
Solar Thin Film PV	1	5	2.0	4.0
Solar CSP 10 demo projects		1	0.5	0.5
Nuclear generation IV 5 demo reactors		5	3.0	2.0
Grid integration & load management	0.2		0.2	
Improved Li-ion batteries for plug-in hybrids	1		1.0	
Hydrogen economy	5	10	7.5	7.5
Lignocellulosic ethanol 5 demo plants	0.1	0.5	0.4	0.2
FT-biodiesel/jet fuel 5 demo plants		0.5	0.3	0.2
Zero-emission buildings 10,000 demo		1	0.5	0.5
Seasonal heat & cold storage 10,000 demo		1	0.5	0.5
3 CCS blast furnaces		0.5	0.4	0.1
3 CCS cement kilns		0.3	0.2	0.1
3 CCS black liquor IGCC		0.5	0.4	0.1
New waste separation technologies	0.5	1	1.0	0.5
Total			32.4	19.3
Annual			2.5	1.9

Thank You

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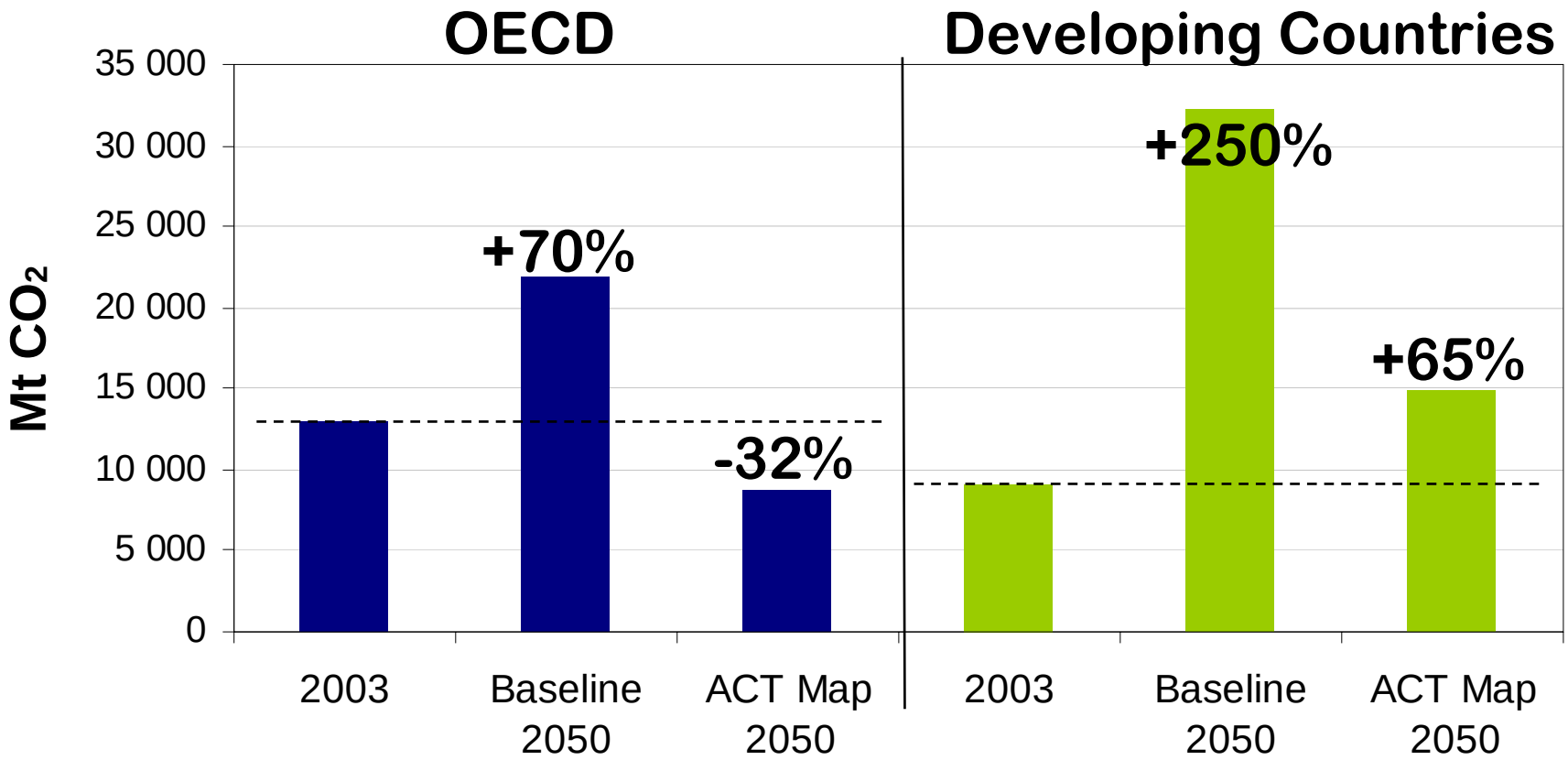
CO_2 Emissions Baseline and Map Scenarios



Map: OECD Emissions 32% below 2003 level, while emissions in Developing Countries are 65% higher

Primary Energy Supply

[mtoe/yr]		Baseline	ACT Map
	2004	2050	2050
Coal	2,451	7,532	2,912
Oil	3,574	5,988	4,780
Gas	2,221	5,349	3,746
Nuclear	710	810	1,394
Hydro	**241**	**380**	**421**
Other Renewables	**1,211**	**2,053**	**3,508**
TPES	10,624	22,112	16,762