INTERNATIONAL ENERGY AGENCY

Energy Technology Perspectives 2008

Neil Hirst

Washington, 23-24 June 2008

International Energy Agency

Created in 1973; currently 27 Member Countries

Goals:

- energy security
- environmental protection
- economic growth

Activities:

- co-ordinates efforts to ensure energy security
- compiles energy statistics
- conducts policy analysis
- reviews energy policies & programs
- convenes, mobilizes science & technology experts

G8 - Gleneagles Communiqué July 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 onjunction with our vigorous efforts to reduce poverty."

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

In support of the G8 Plan of Action

ENERGY TECHNOLOGY PERSPECTIVES 2008

Scenarios & Strategies to 2050

INTERNATIONAL ENERGY AGENCY

Energy Technology Perspectives 2008

- In support of the G8 Plan of Action
  - Launch June 6th, Japan (G8 energy ministers meeting)
- This is a study about the role of technology
- It will result in key technology roadmaps that specify development needs
- It can be a basis for an international technology cooperation framework
- It is *not* meant for country target setting in a post-Kyoto framework
- It is *not* a study about climate policy instruments

ENERGY TECHNOLOGY PERSPECTIVES 2008

Scenarios & Strategies to 2050

INTERNATIONAL ENERGY AGENCY

Energy Technology Perspectives Publication 2008

- **Scenario analysis 2005-2050**
  - **Baseline WEO2007 Reference Scenario**
  - **Global stabilization by 2050 (ACT)**
  - **Global 50% reduction by 2050 (BLUE) – *consistent with WEO2007 450 ppm case***
- **How to get there**
  - **Short and medium term technology policy needs**
  - **Special attention for technology roadmaps**
- **Technology chapters:**
  - **Power sector**
  - **End-use sectors**

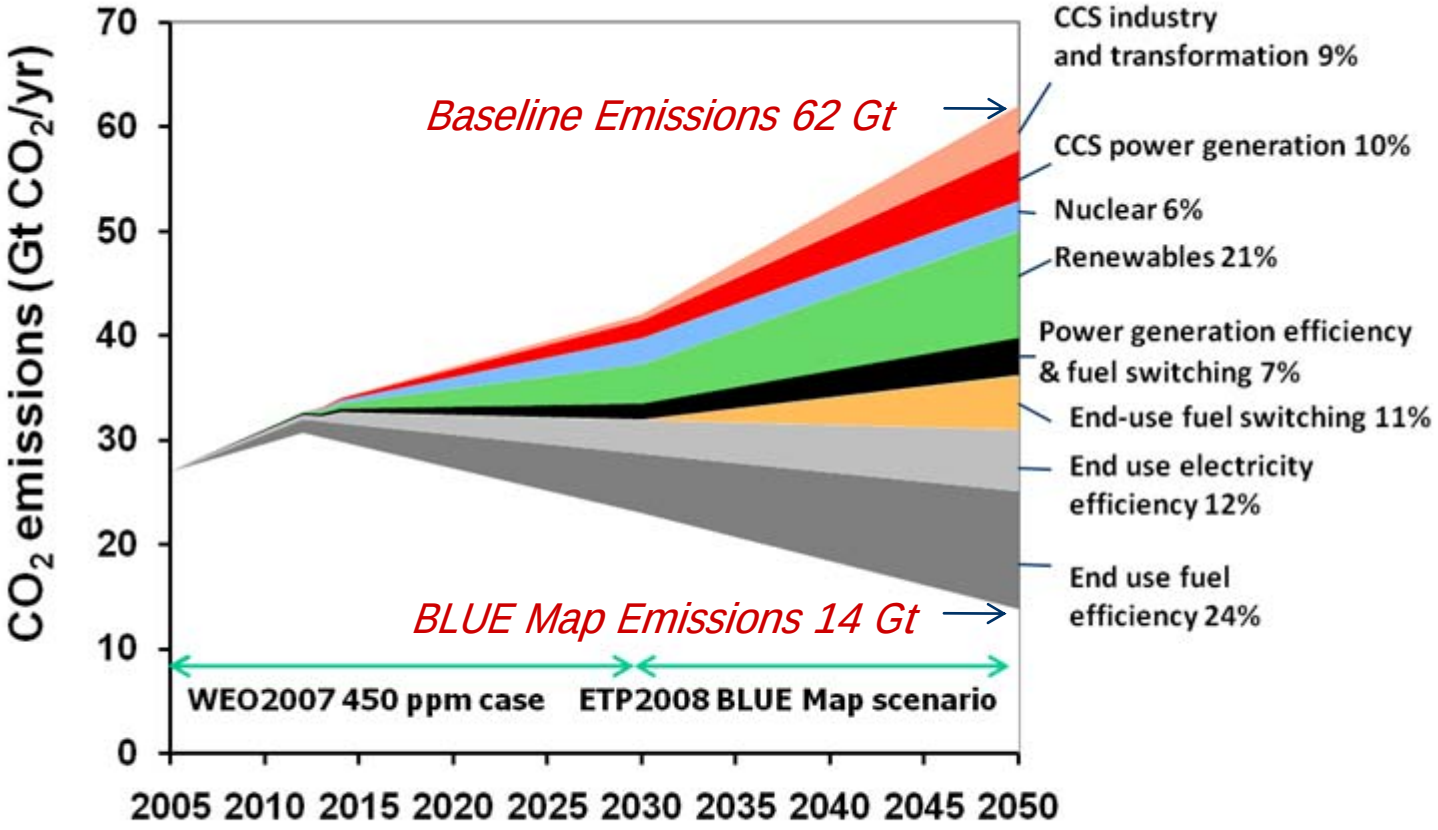
In support of the G8 Plan of Action

ENERGY TECHNOLOGY PERSPECTIVES 2008

Scenarios & Strategies to 2050

INTERNATIONAL ENERGY AGENCY

A New Energy Revolution: Cutting Energy Related CO_2 Emissions



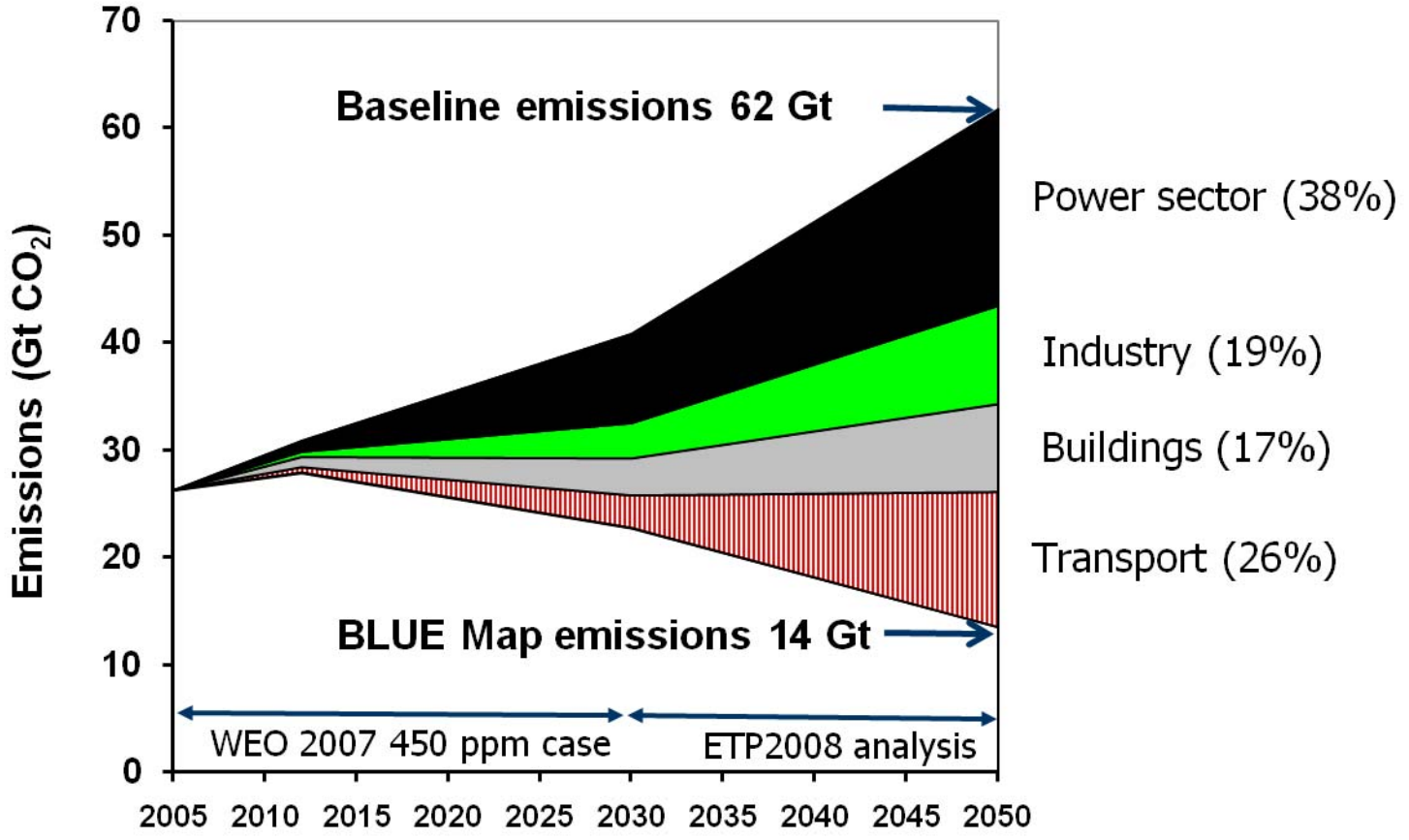
ENERGY TECHNOLOGY PERSPECTIVES 2008

Scenarios & Strategies to 2050

INTERNATIONAL ENERGY AGENCY

In support of the G8 Plan of Action

Sector Contributions



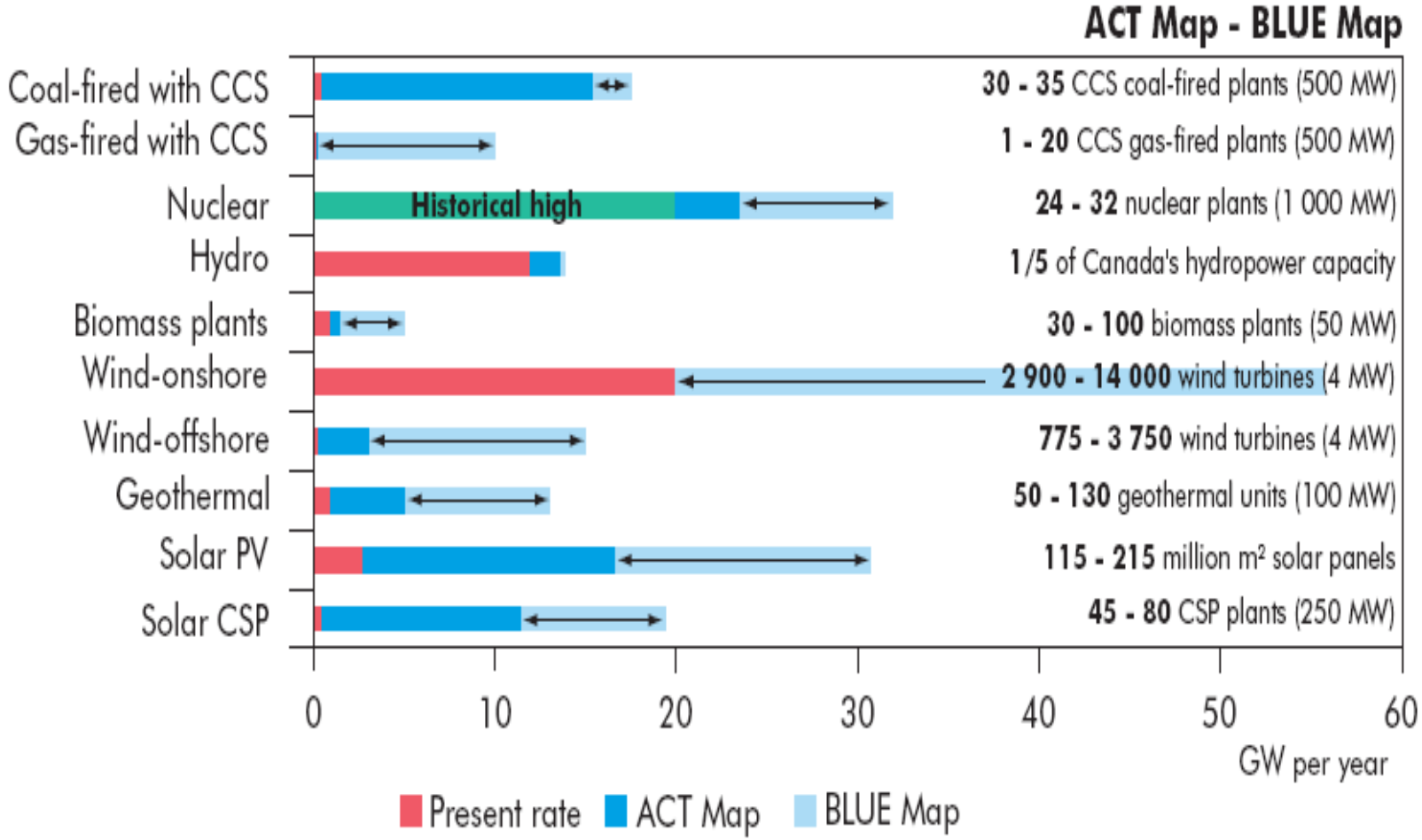
ENERGY TECHNOLOGY PERSPECTIVES 2008

Scenarios & Strategies to 2050

INTERNATIONAL ENERGY AGENCY

In support of the G8 Plan of Action

Average Annual Power Generation Capacity Additions, 2010 – 2050
An Energy Revolution



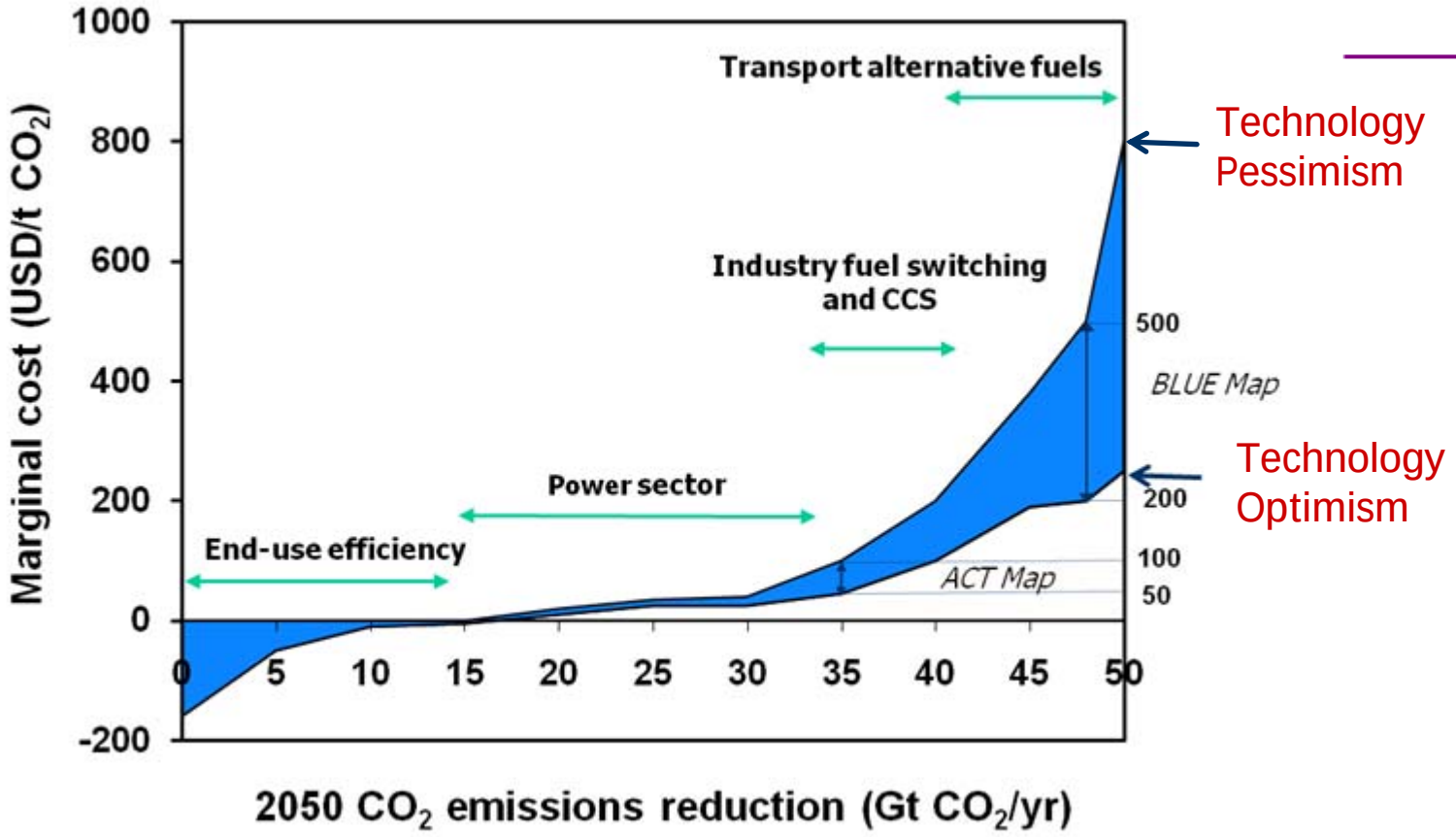
ENERGY TECHNOLOGY PERSPECTIVES 2008

Scenarios & Strategies to 2050

INTERNATIONAL ENERGY AGENCY

In support of the G8 Plan of Action

Cost of Emissions Reductions



To bring emissions back to current levels by 2050 options with a cost up to USD 50/t are needed. Reducing emissions by 50% would require options with a cost up to USD 200/t, possibly even up to USD 500/t CO_2

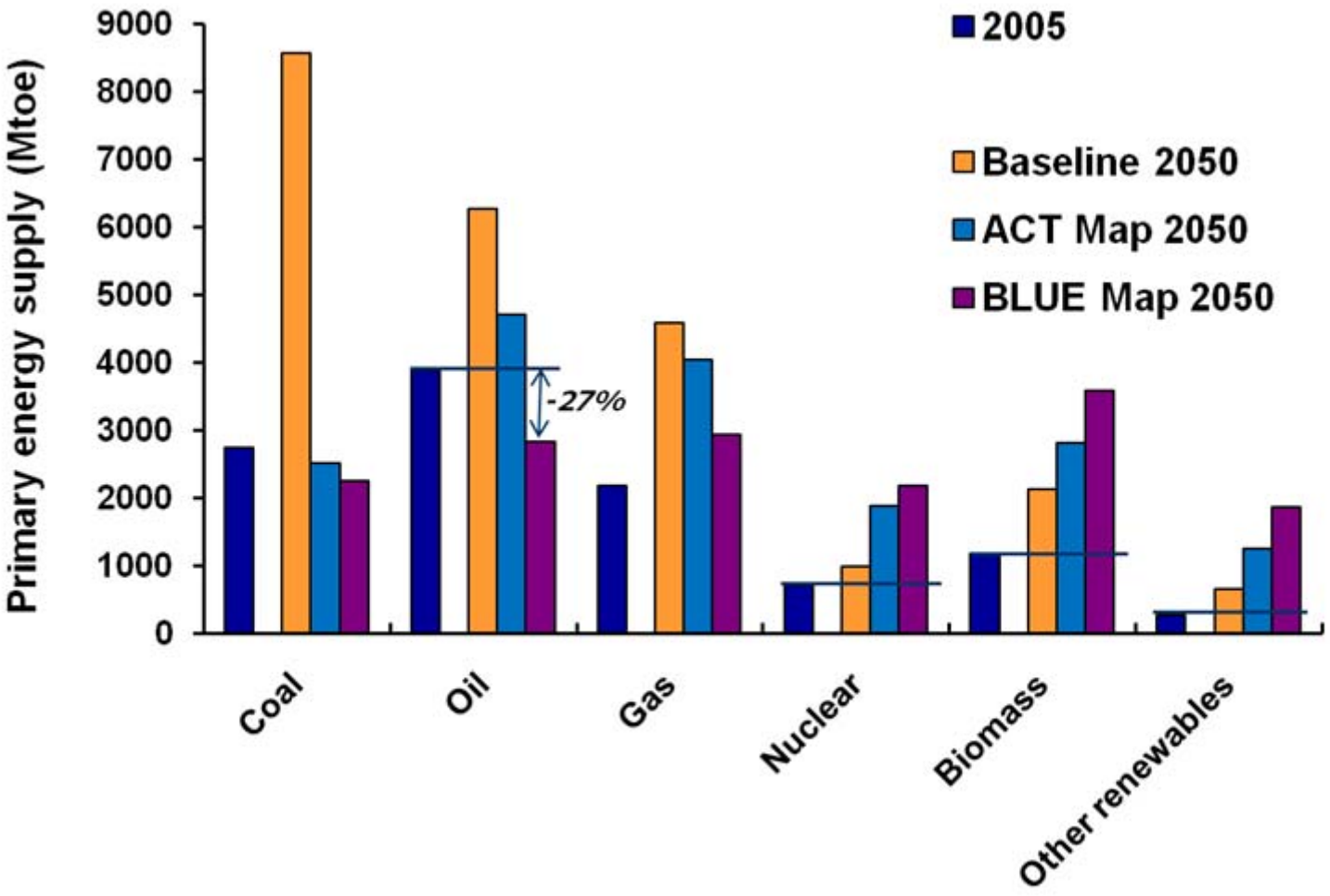
ENERGY TECHNOLOGY PERSPECTIVES 2008

Scenarios & Strategies to 2050

INTERNATIONAL ENERGY AGENCY

Primary Energy Demand

Important supply security benefits



Transport sector accounts for 78% of oil savings

ENERGY TECHNOLOGY PERSPECTIVES
2008
Scenarios & Strategies to 2050
INTERNATIONAL ENERGY AGENCY

Key Technology Options (Roadmaps)

- **Supply side**
  - CCS power generation
  - Nuclear III + IV
  - Wind
  - Biomass – IGCC & co-combustion
  - Solar – PV
  - Solar – CSP
  - Coal – IGCC
  - Coal – USCSC
  - 2nd generation biofuels
- **Demand side**
  - Energy efficiency in buildings
  - Heat pumps
  - Solar space and water heating
  - Energy efficiency in transport
  - Electric and plug-in vehicles
  - Fuel cell vehicles
  - CCS in industry
  - Industrial motor systems

ENERGY TECHNOLOGY PERSPECTIVES 2008

Scenarios & Strategies to 2050

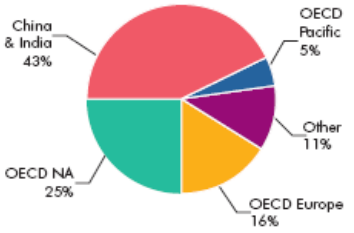
INTERNATIONAL ENERGY AGENCY

Roadmaps – Example CCS

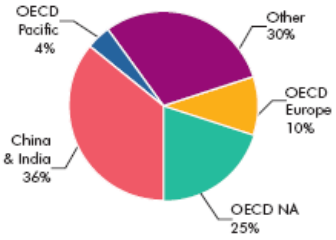
10 % of CO_2 reduction potential in BLUE Map

CO_2 Capture and Storage - Fossil-Fuel Power Generation

ACT 2.89 Gt savings 2050



Blue 4.9 Gt savings 2050



Other developing Asia, Middle East and Transition Economies

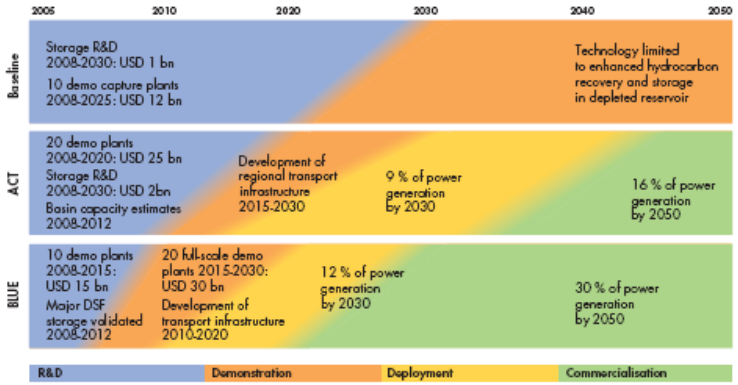
	Global Deployment Share 2030	RDD&D Inv. Cost USD bn 2005-2030	Commercial Inv. Cost* USD bn 2030-2050
OECD NA	35%	25-30	160-180
OECD Europe	35%	25-30	100-120
OECD Pacific	10%	7-8	30-40
China & India	15%	10-12	280-300
Other	5%	3-4	60-70

	Global Deployment Share 2030	RDD&D Inv. Cost USD bn 2005-2030	Commercial Inv. Cost* USD bn 2030-2050
OECD NA	35%	30-35	350-400
OECD Europe	35%	30-35	150-200
OECD Pacific	10%	10-12	70-80
China & India	15%	12-14	450-500
Other	5%	4-5	300-350

Technology Targets

	ACT: Emissions Stabilisation	BLUE: 50% Emissions reduction
RD&D		
Capture technologies for three main options (post-combustion, pre-combustion, and oxy-fuelling)	Technologies tested in small- and large-scale plants. Cost of CO_2 avoided around 50 USD/t by 2020. Chemical looping tested	
Demonstration targets	20 large-scale demo plants with a range of CCS options, including fuel type (coal/gas/biomass) by 2020	30 large-scale demo plants with a range of CCS options, including fuel type (coal/gas/biomass) by 2020
New gas-separation technologies: membranes & solid adsorption	New capture concepts: next-generation processes, such as membranes, solid absorbers and new thermal processes	
Technology transfer	Technology transfer to China and India	Technology transfer to all transition and developing countries
Deployment		
Regional pipeline infrastructure for CO_2 transport	Major transportation pipeline networks developed and CO_2 maritime shipping	
Deployment targets	Early commercial large-scale plants by 2015 (ZEP, ZeroGen, GreenGen)	30% of electricity generated from CCS power plant

Technology Timeline



Key Actions Needed

- Develop and enable legal and regulatory frameworks for CCS at the national and international levels, including long-term liability regimes and classification of CO_2.
- Incorporate CCS into emission trading schemes and clean development mechanisms.
- RD&D to reduce capture cost and improve overall system efficiencies.
- RD&D for storage integrity and monitoring. Validation of major storage sites. Monitor and valuation methods for site review, injection & closure periods.
- Raise public awareness and education on CCS.
- Assessment of storage capacity using Carbon Sequestration Leadership Forum methodology at the national, basin and field levels.
- New power plants built after 2020 to have CCS.
- New power plants to be "capture-ready" after 2015.

Key Areas for International Collaboration

- Development and sharing of legal and regulatory frameworks.
- Develop international, regional and national instruments for CO_2 pricing, including CDM and ETS.
- Raise public awareness and education.
- Sharing best practices and lessons learnt from demonstration projects (pilot and large-scale).
- Joint funding of large-scale plants in developing countries by multi-lateral lending institutions, industry and governments.
- Development of standards for national and basin storage estimates and their application.
- Organizations: CSLF, IEA GHG, IEA CCC, IPCC.

ENERGY TECHNOLOGY PERSPECTIVES 2008

Scenarios & Strategies to 2050

INTERNATIONAL ENERGY AGENCY

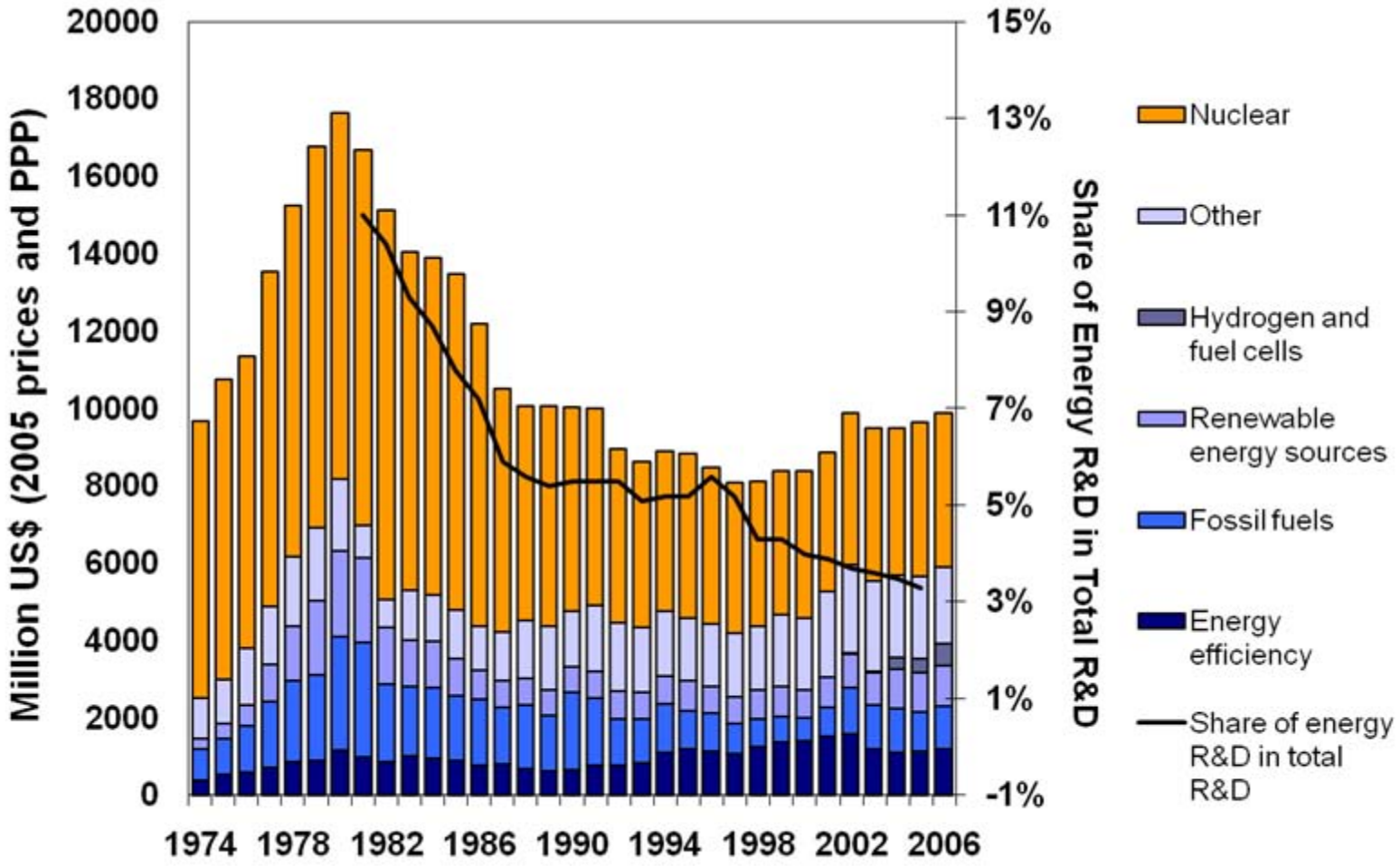
In support of the G8 Plan of Action

Financing Needs *on top of Baseline*

- **BLUE USD 45 trillion (1.1% of GDP); ACT USD 17 trillion**
- **Demand side investments dominate (80%)**
- **Undiscounted fuel savings BLUE USD 51 trillion (2010-2050)**
  - **However valuation at market prices is debatable**
- **The problem for BLUE is not the cost but the burden sharing**
- **Financing needs**
  - **USD +10 to +100 bln/yr RD&D (short to mid-term)**
  - **USD +100 to +200 bln/yr learning investments (short to mid-term)**
  - **USD +1000 to +2000 bln/yr commercial investments (mid-long term)**

ENERGY TECHNOLOGY PERSPECTIVES
2008
Scenarios & Strategies to 2050
INTERNATIONAL ENERGY AGENCY

Public Sector Energy R&D in IEA Countries – USD 10 bln/yr



ENERGY TECHNOLOGY PERSPECTIVES 2008

Scenarios & Strategies to 2050

INTERNATIONAL ENERGY AGENCY

In support of the G8 Plan of Action

Emission Reductions by Industry Sector

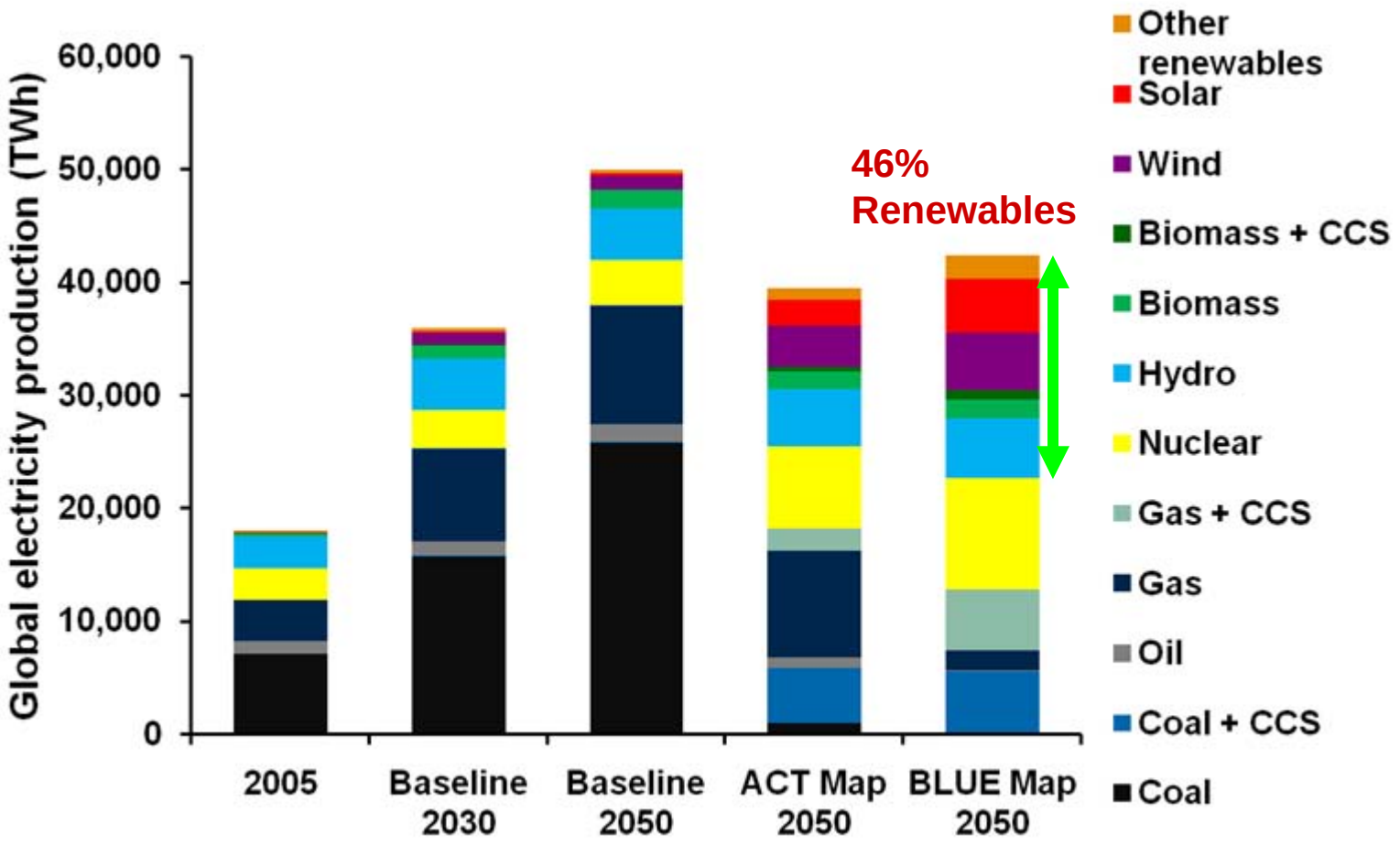
Reference	ACT Map Baseline 2050 [%]	BLUE Map Baseline 2050 [%]	ACT Map 2005 [%]	BLUE Map 2005 [%]
Iron and Steel	-20	-65	71	-26
Cement	-22	-68	38	-44
Chemicals and petrochemicals	-2	-53	101	-5
Pulp and paper	-36	-97	83	-91
Nonferrous Metals	-9	-24	258	200
Other	-11	-48	54	-10
Total	-16	-61	66	-22

ENERGY TECHNOLOGY PERSPECTIVES 2008

Scenarios & Strategies to 2050

INTERNATIONAL ENERGY AGENCY

Power Generation Mix



¼ nuclear and fossil + CCS, nearly half renewables

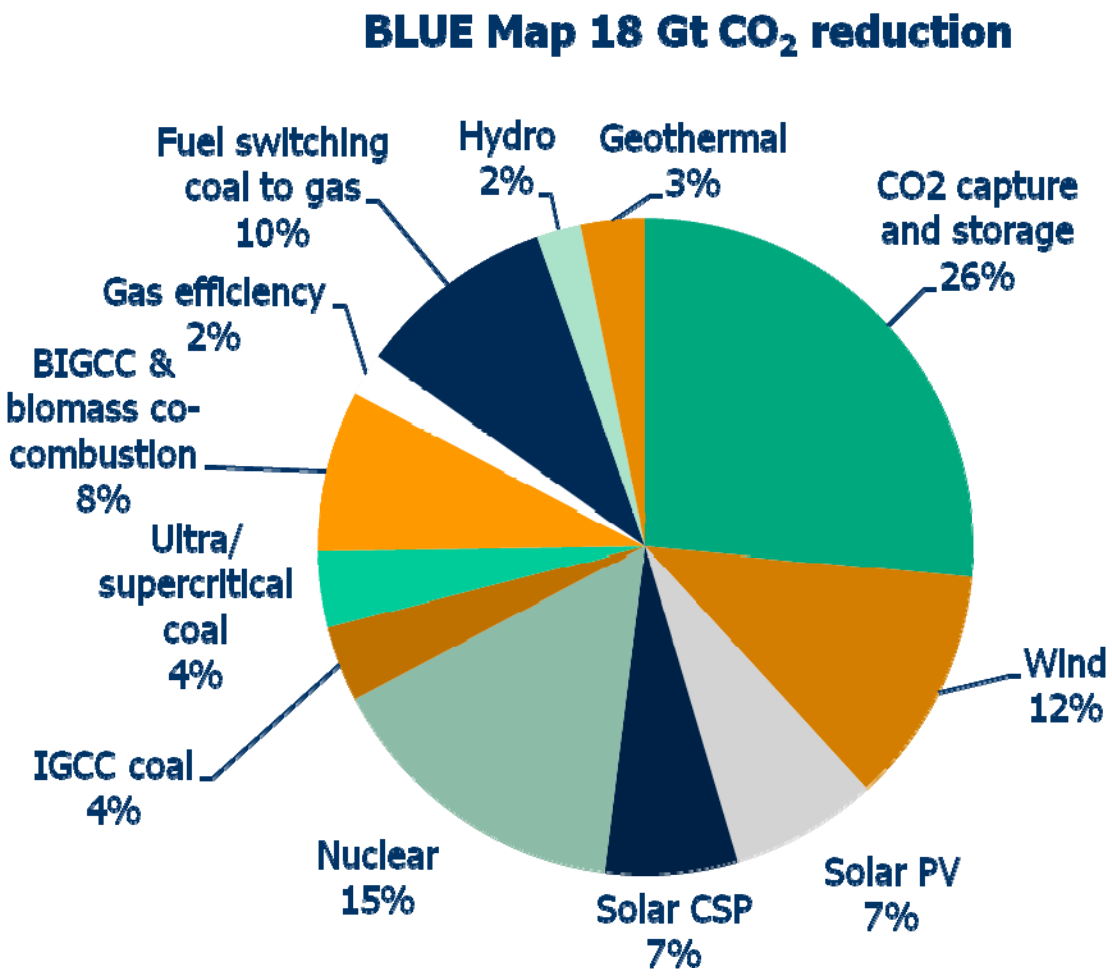
ENERGY TECHNOLOGY PERSPECTIVES 2008

Scenarios & Strategies to 2050

INTERNATIONAL ENERGY AGENCY

In support of the G8 Plan of Action

Power sector CO_2 reductions



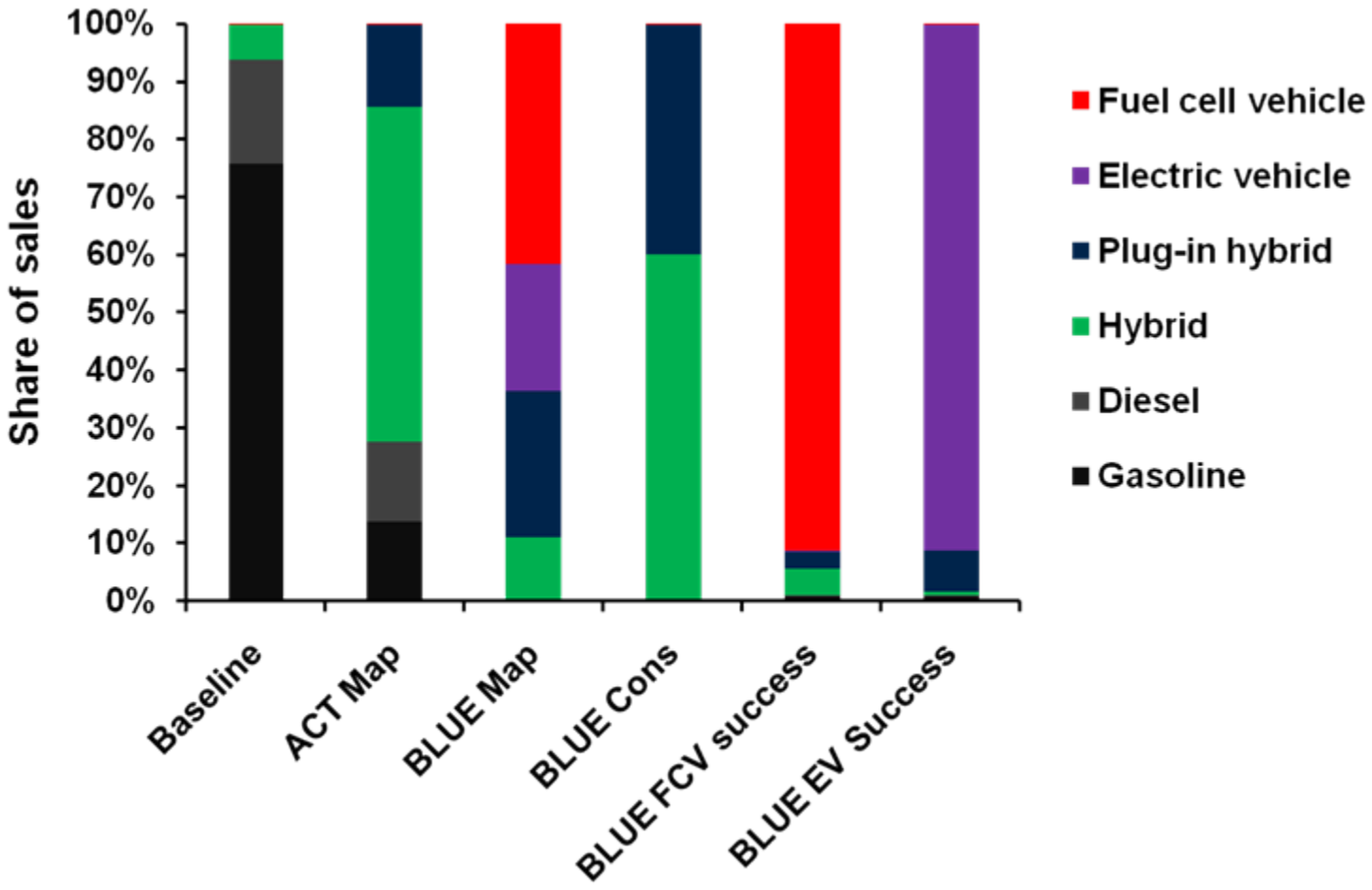
ENERGY TECHNOLOGY PERSPECTIVES 2008

Scenarios & Strategies to 2050

INTERNATIONAL ENERGY AGENCY

In support of the G8 Plan of Action

Vehicle Market Share in 2050, by Scenario and Variant



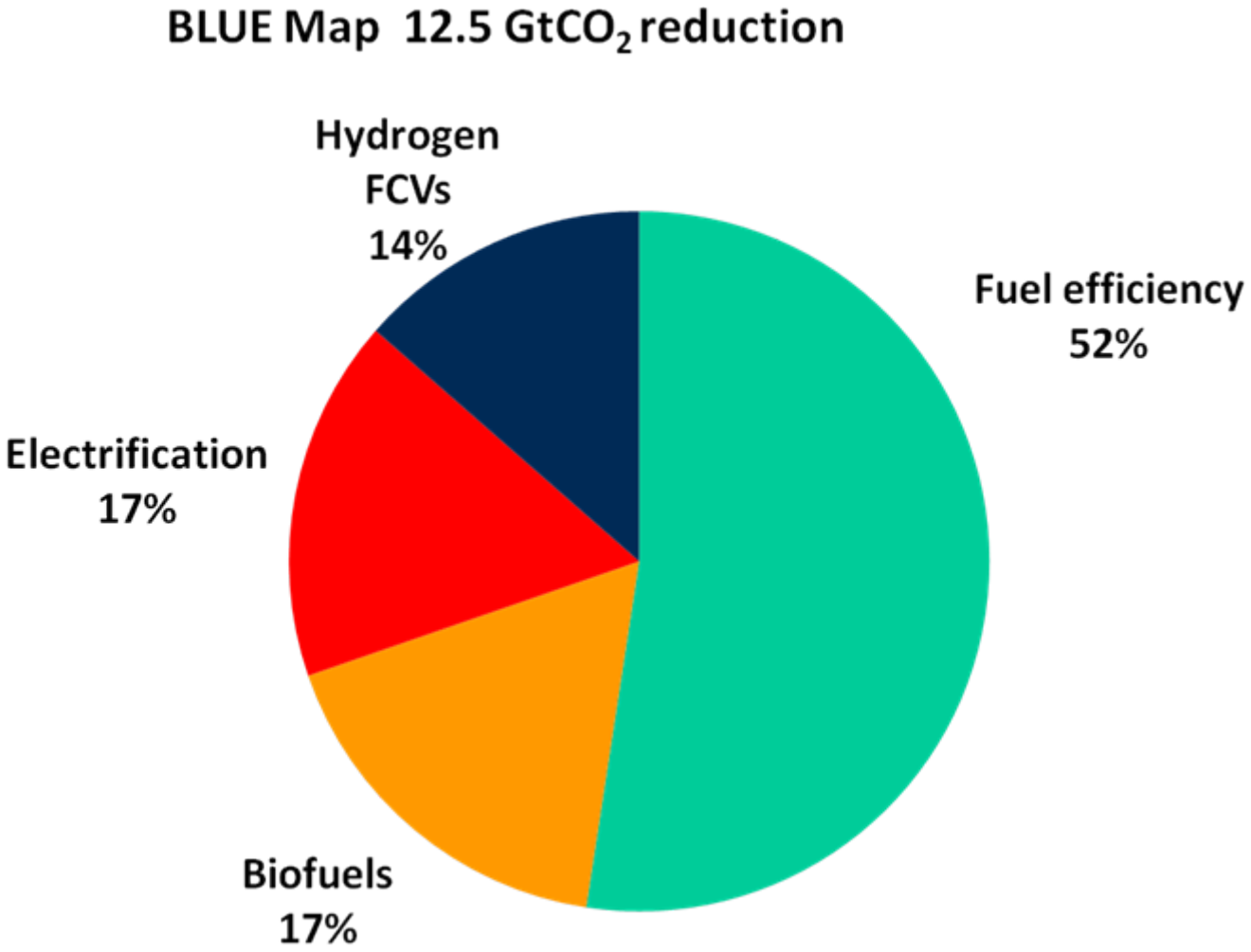
ENERGY TECHNOLOGY PERSPECTIVES 2008

Scenarios & Strategies to 2050

INTERNATIONAL ENERGY AGENCY

In support of the G8 Plan of Action

Transport Sector Emissions Reductions



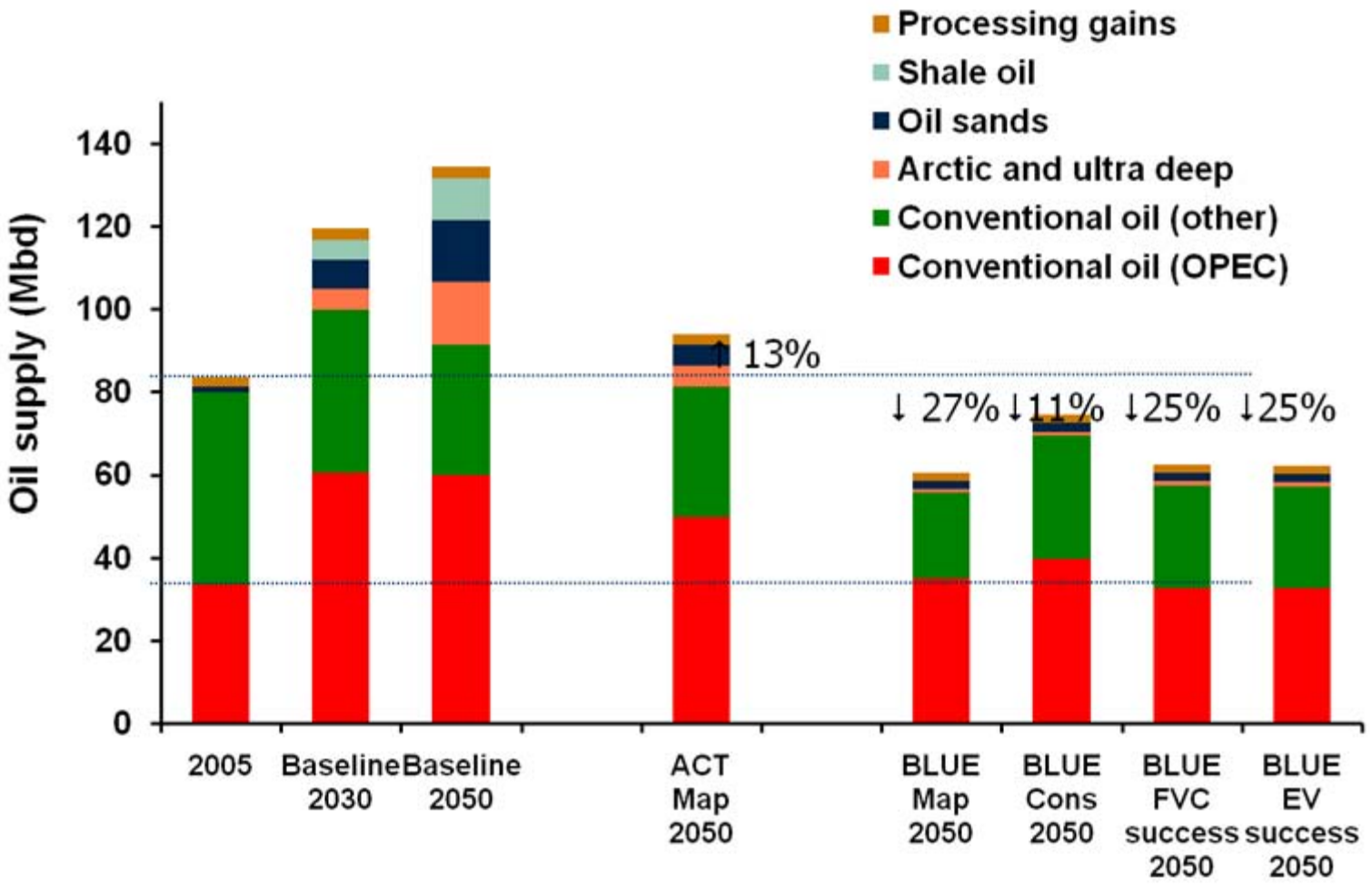
ENERGY TECHNOLOGY PERSPECTIVES 2008

Scenarios & Strategies to 2050

INTERNATIONAL ENERGY AGENCY

In support of the G8 Plan of Action

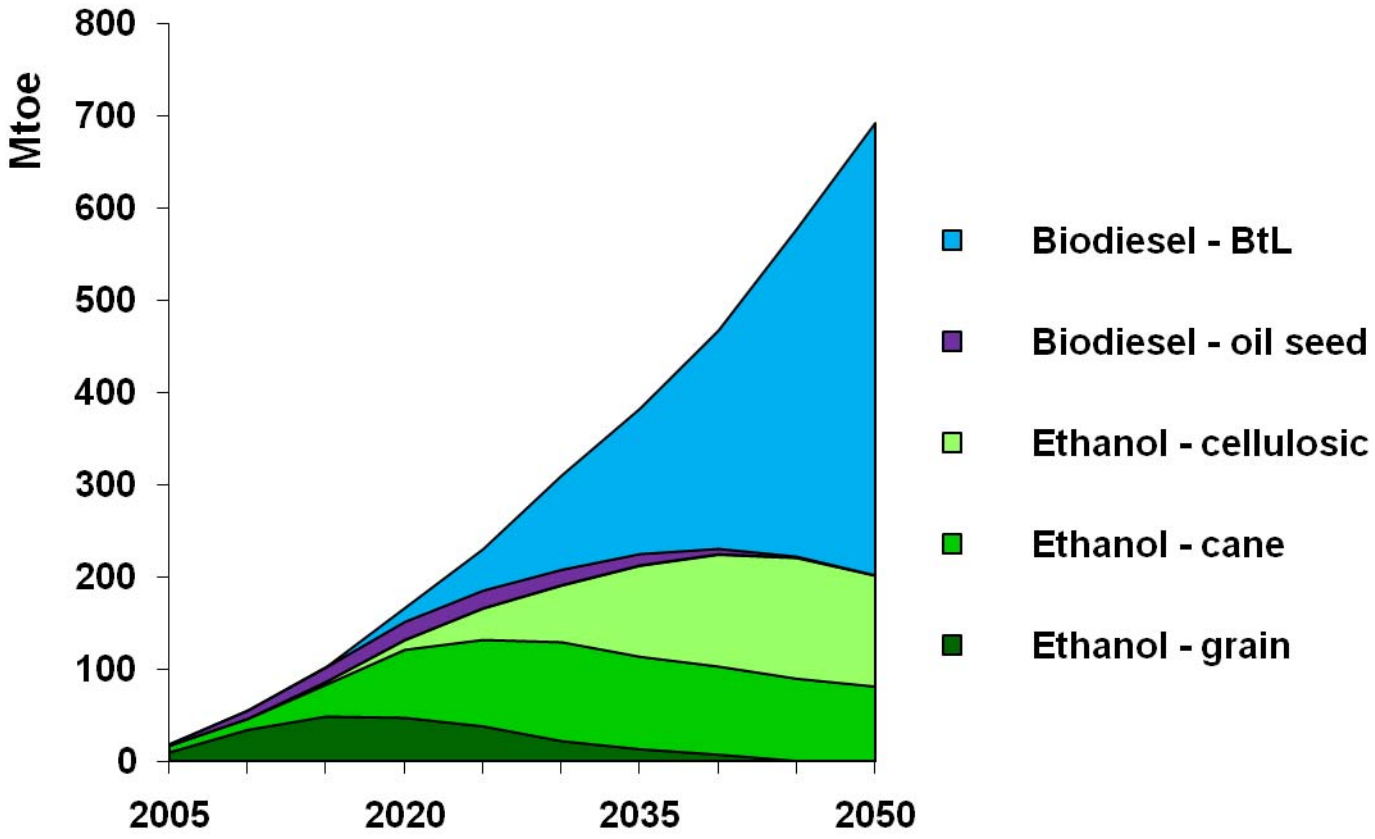
Oil Supply Projections



In support of the G8 Plan of Action

INTERNATIONAL ENERGY AGENCY

Biofuels Use in BLUE Map
26% of Transport Fuel Use in 2050



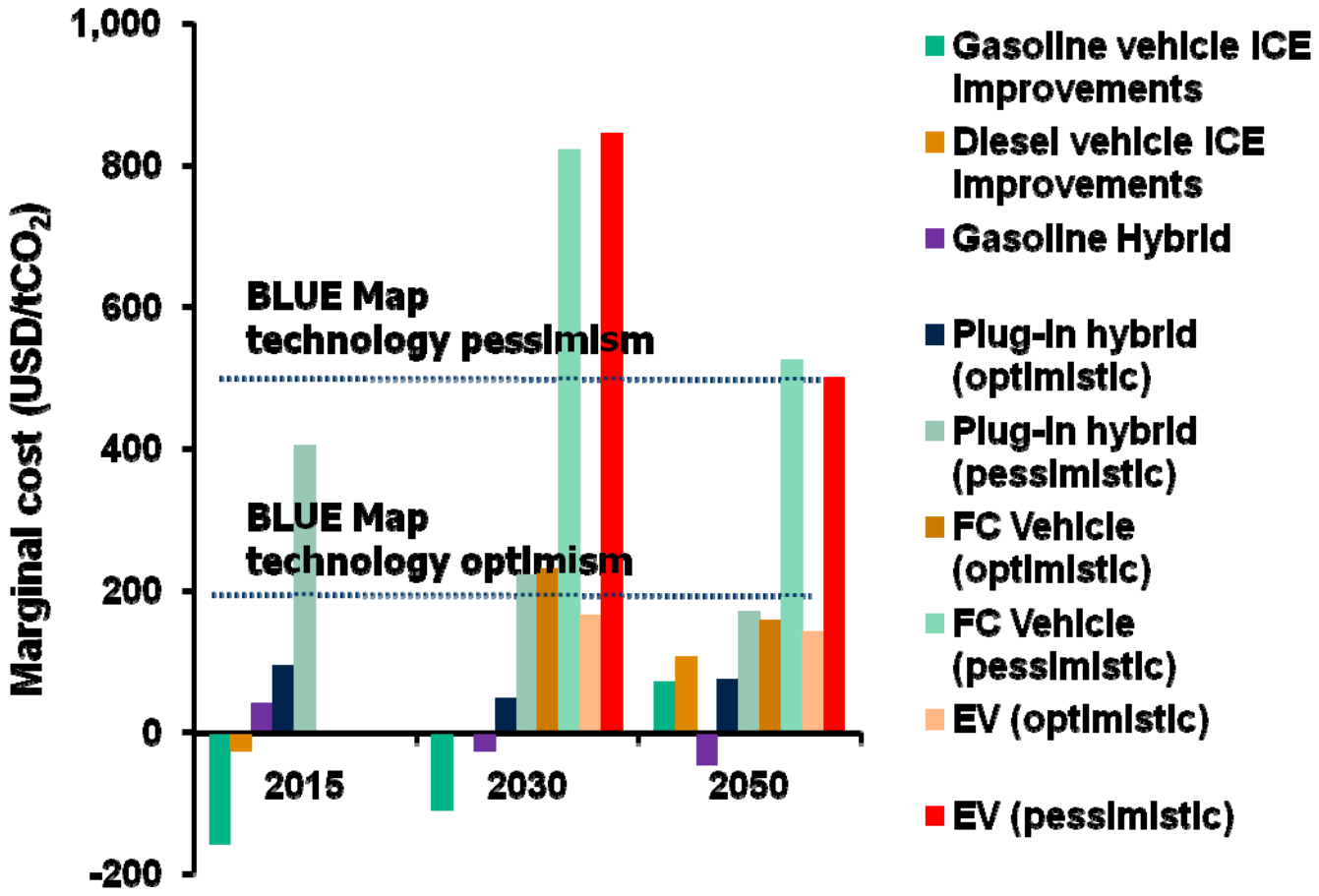
ENERGY TECHNOLOGY PERSPECTIVES 2008

Scenarios & Strategies to 2050

INTERNATIONAL ENERGY AGENCY

In support of the G8 Plan of Action

LDV Technology Costs
Cost per tonne CO2



ENERGY TECHNOLOGY PERSPECTIVES 2008

Scenarios & Strategies to 2050

INTERNATIONAL ENERGY AGENCY

In support of the G8 Plan of Action

Key Messages

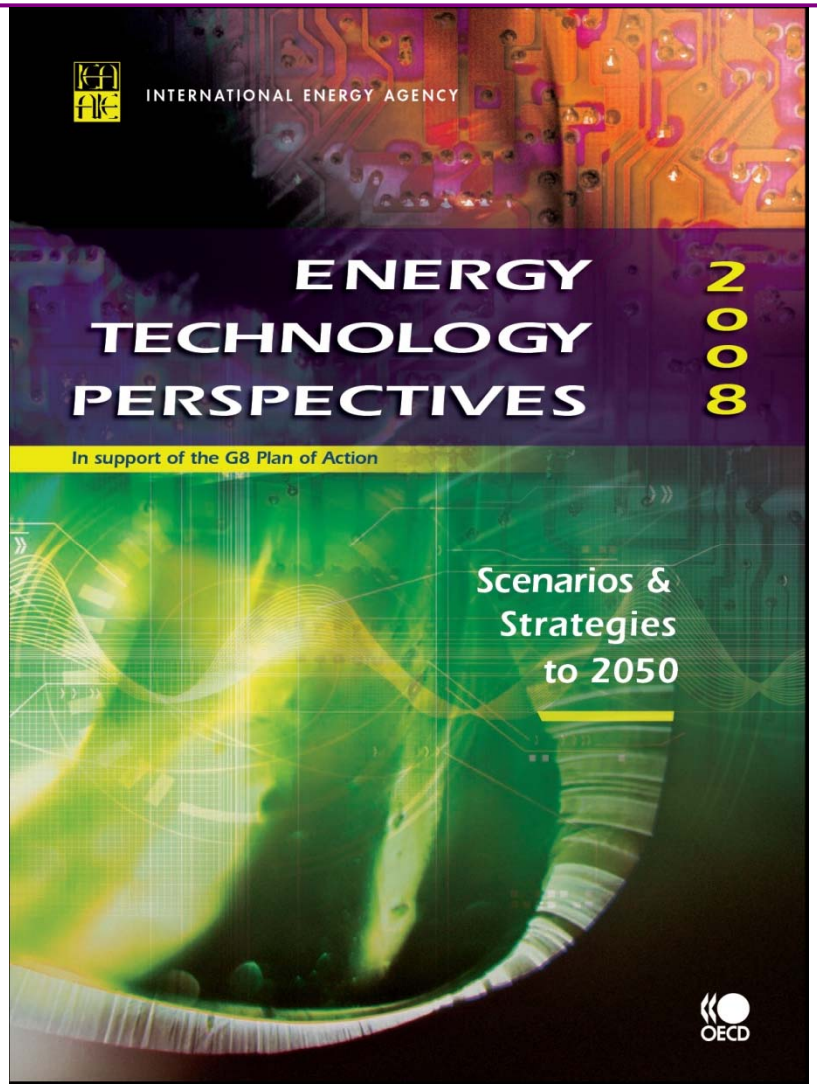
- We are facing an urgent challenge in the energy sector and we need a global solution
- Emissions stabilization – mainly energy efficiency and power sector measures (ACT scenarios)
- Halving emissions by 2050 implies deep cuts for transport and industry (BLUE scenarios)
- Marginal cost ACT USD 50/t; BLUE USD 200/t (optimistic technology estimates)
  - The cost uncertainty increases with ambition level
- USD 45 trillion additional investment cost for BLUE (1% of GDP)
- Important supply security benefits
- We need a steep change in government policies, with closer international collaboration
- The roadmaps can provide a focus for this

ENERGY TECHNOLOGY PERSPECTIVES 2008

Scenarios & Strategies to 2050

INTERNATIONAL ENERGY AGENCY

Thank You !



www.iea.org

ENERGY TECHNOLOGY PERSPECTIVES 2008

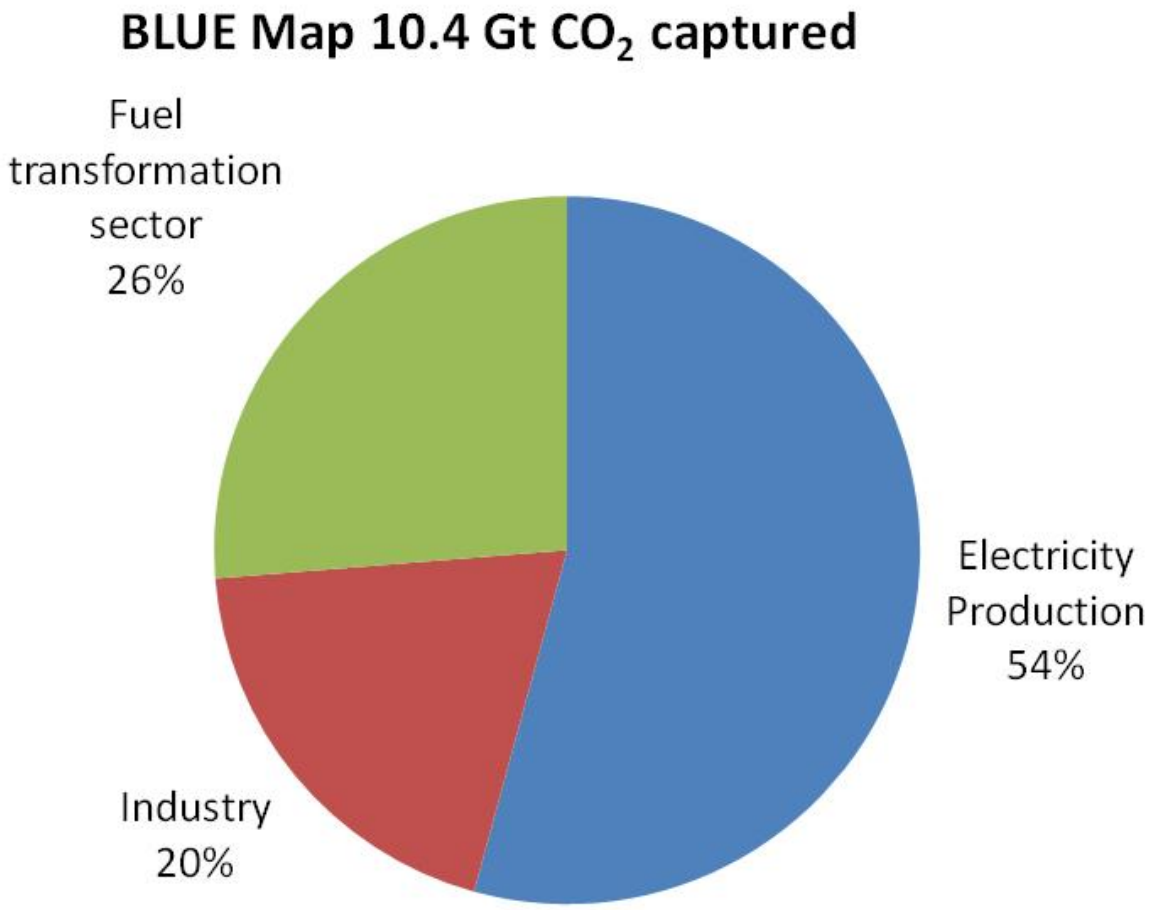
Scenarios & Strategies to 2050

INTERNATIONAL ENERGY AGENCY

INTERNATIONAL ENERGY AGENCY

Extra slides

CO_2 Capture and Storage Use in BLUE Map



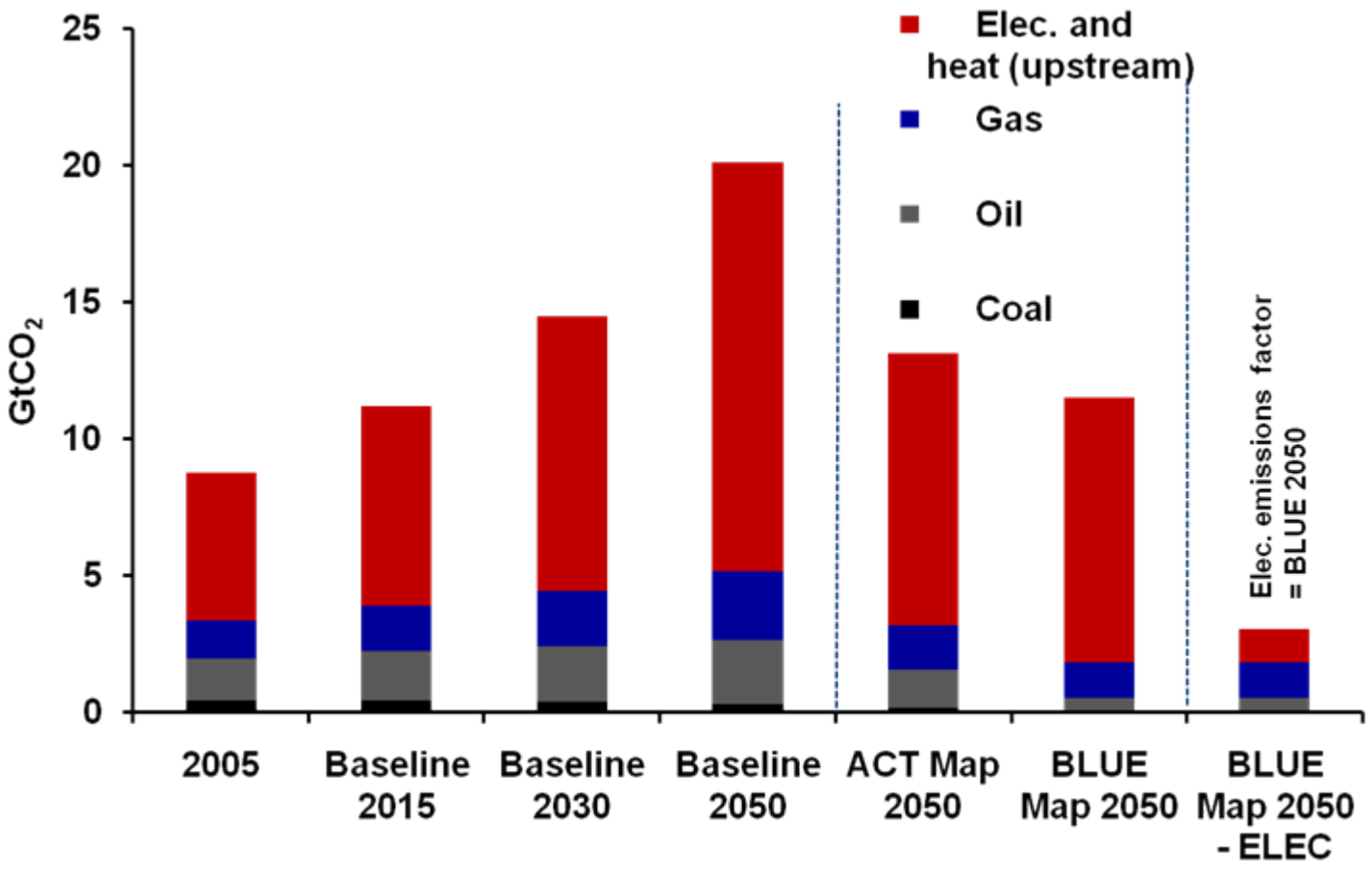
ENERGY TECHNOLOGY PERSPECTIVES 2008

Scenarios & Strategies to 2050

INTERNATIONAL ENERGY AGENCY

In support of the G8 Plan of Action

Buildings Sector CO_2 Emissions by Scenario



ENERGY TECHNOLOGY PERSPECTIVES 2008

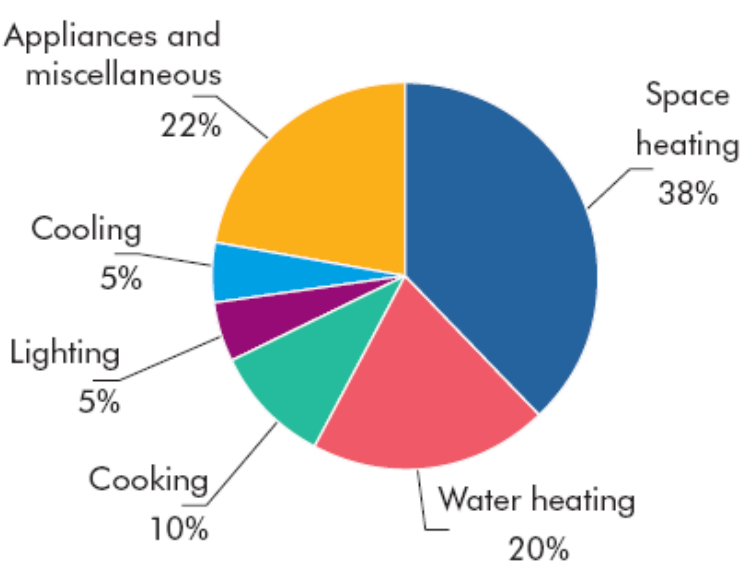
Scenarios & Strategies to 2050

INTERNATIONAL ENERGY AGENCY

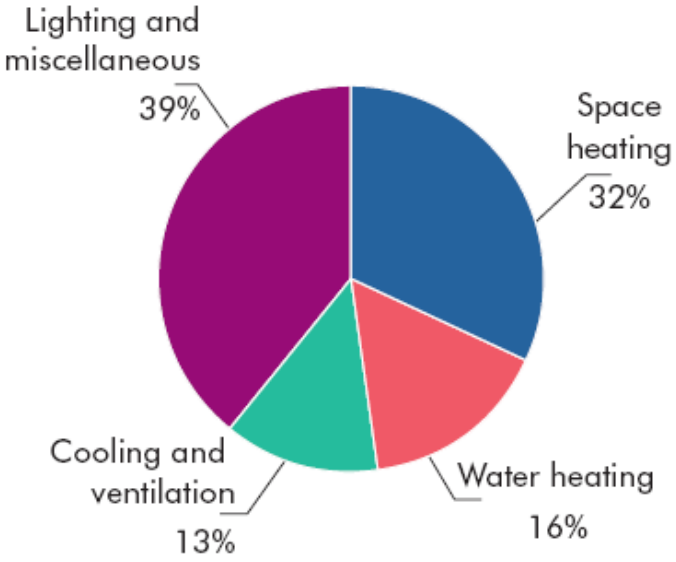
In support of the G8 Plan of Action

Buildings Sector Savings by Sector and End-use in BLUE Map

Residential sector: 1267 Mtoe savings



Service sector: 684 Mtoe savings



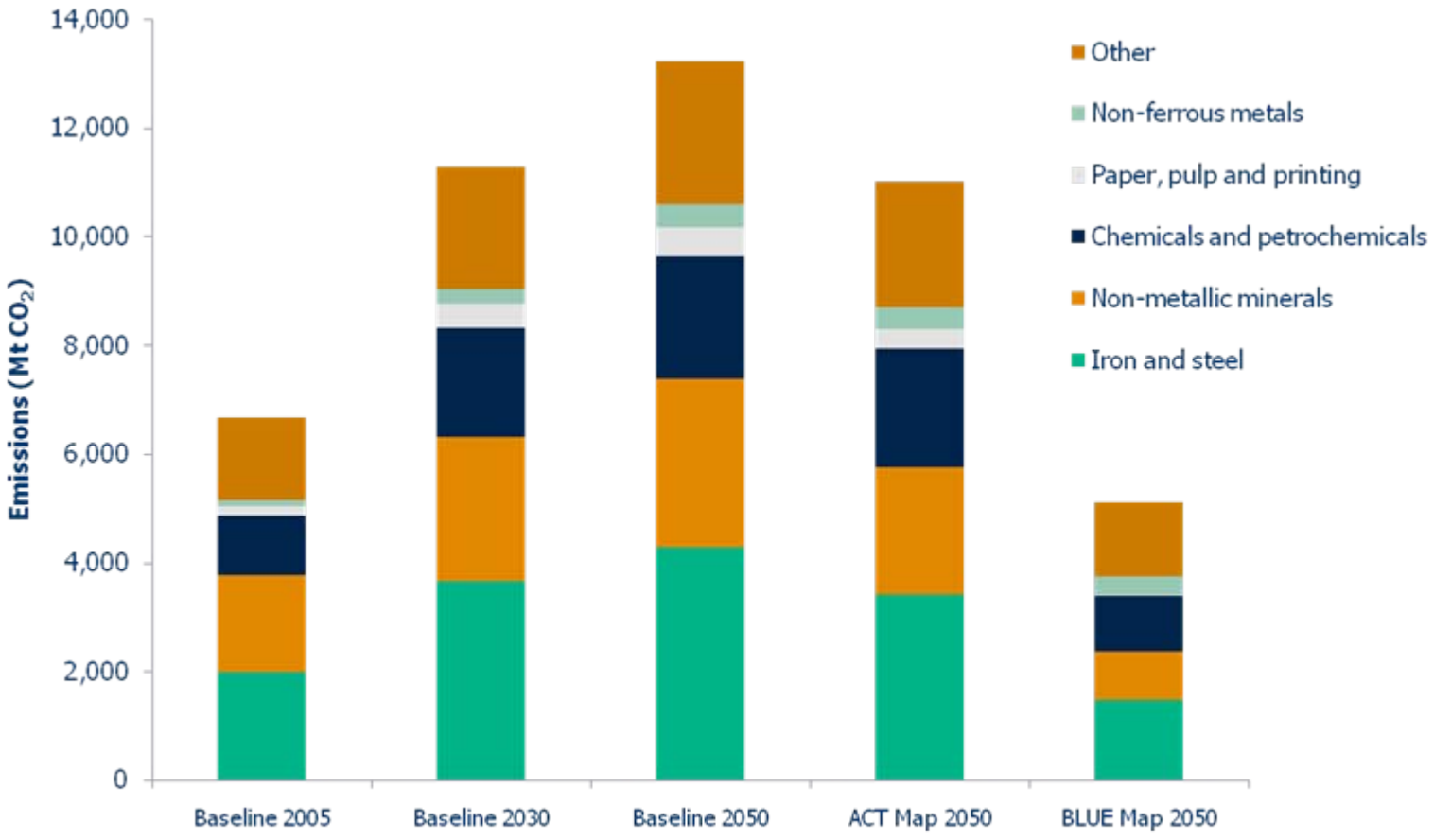
ENERGY TECHNOLOGY PERSPECTIVES 2008

Scenarios & Strategies to 2050

INTERNATIONAL ENERGY AGENCY

In support of the G8 Plan of Action

Industrial CO_2 Emissions by Scenario



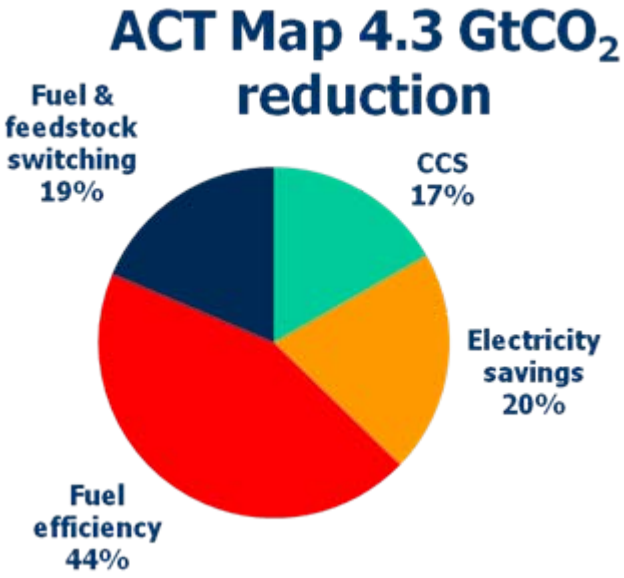
ENERGY TECHNOLOGY PERSPECTIVES 2008

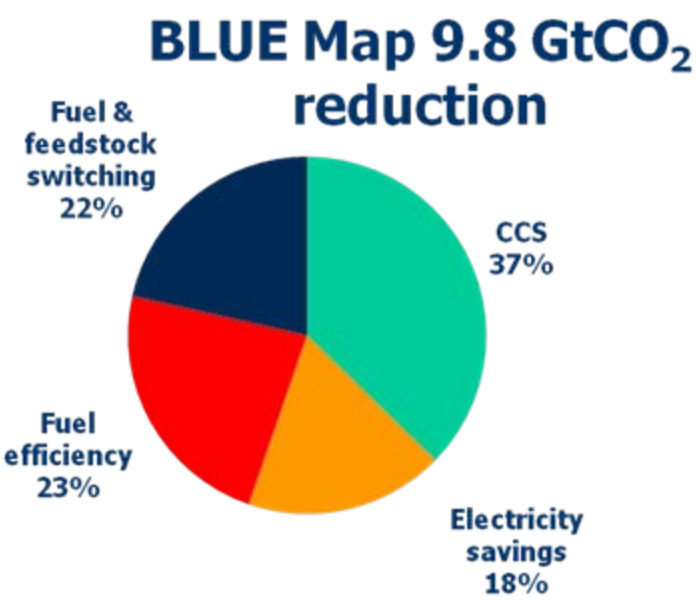
Scenarios & Strategies to 2050

INTERNATIONAL ENERGY AGENCY

In support of the G8 Plan of Action

Industrial Emissions Reduction





CCS can play a key role

ENERGY TECHNOLOGY PERSPECTIVES 2008

Scenarios & Strategies to 2050

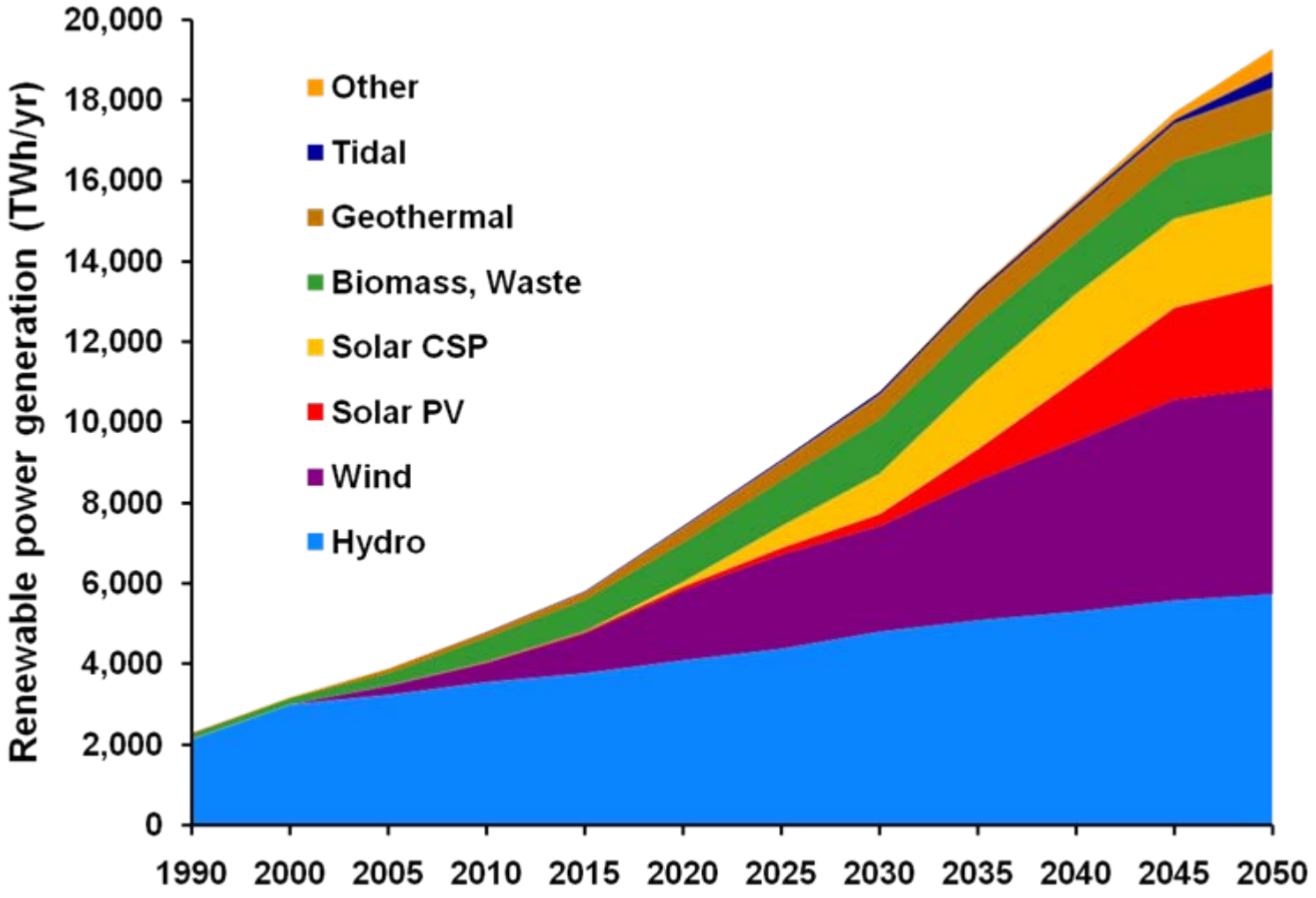
INTERNATIONAL ENERGY AGENCY

In support of the G8 Plan of Action

INTERNATIONAL ENERGY AGENCY

Power Sector

Growth of Renewables in BLUE Map



ENERGY TECHNOLOGY PERSPECTIVES 2008

Scenarios & Strategies to 2050

INTERNATIONAL ENERGY AGENCY

In support of the G8 Plan of Action

Scenario Variants
Some room for choice

	ACT			BLUE		
	Emissions 2050 [Gt CO2/yr]	Additional Investment needs 2050 [trln USD/yr]	Marginal cost 2050 [USD/t CO2]	Emissions 2050 [Gt CO2]	Additional Investment needs 2050 [trln USD/yr]	Marginal cost 2050 [USD/t CO2]
Map	27		50	14		200
NoCCS	31.3	0.215	76	20.4	1.28	394
HiNUC	25.6	-0.07	41	13.4	-0.12	182
LoREN	27.6	0.03	54	14.2	0.04	206
LoEFF	29.3	0.12	64	15	0.2	230

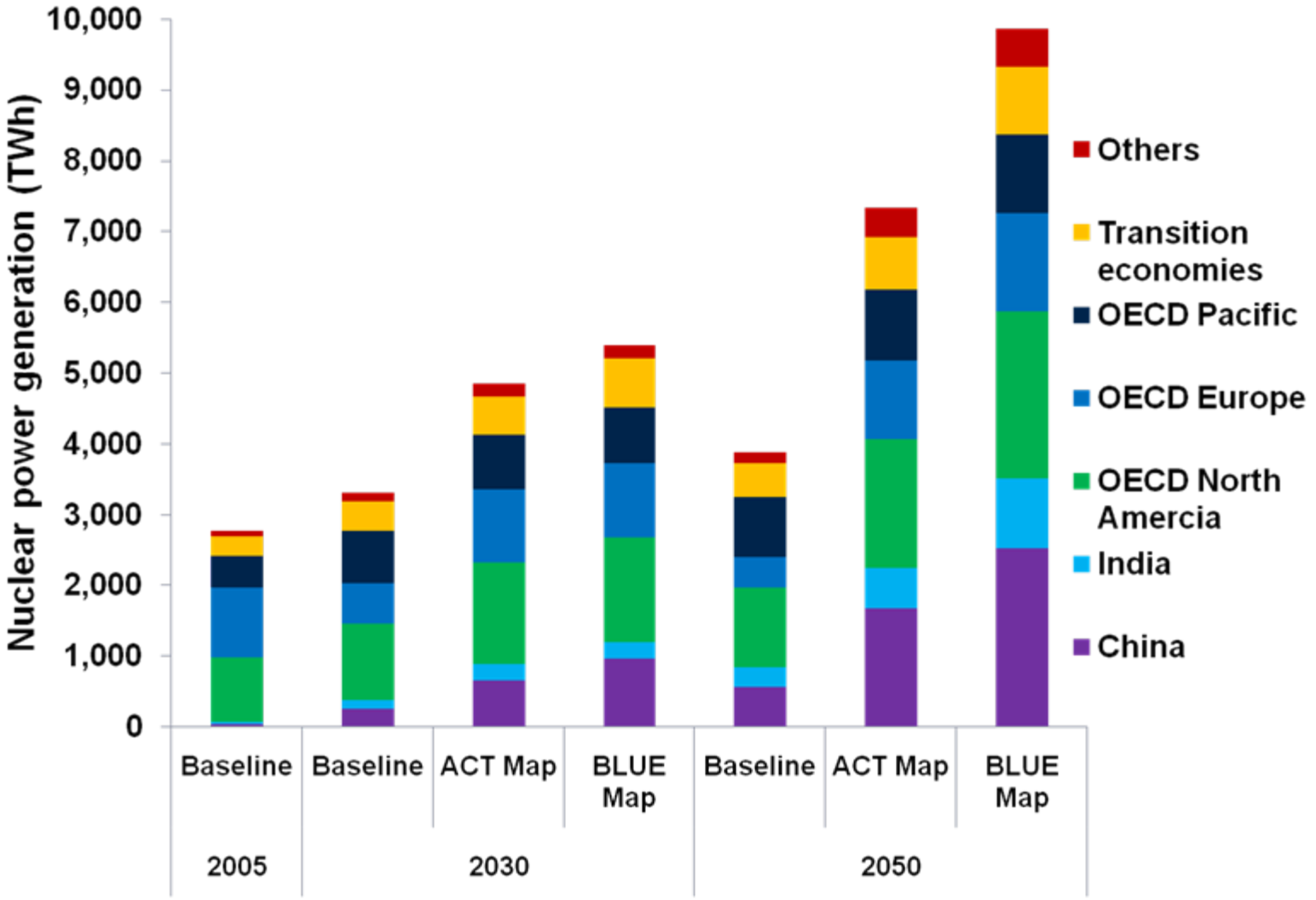
ENERGY TECHNOLOGY PERSPECTIVES 2008

Scenarios & Strategies to 2050

INTERNATIONAL ENERGY AGENCY

In support of the G8 Plan of Action

Nuclear Power Generation Projections



In support of the G8 Plan of Action

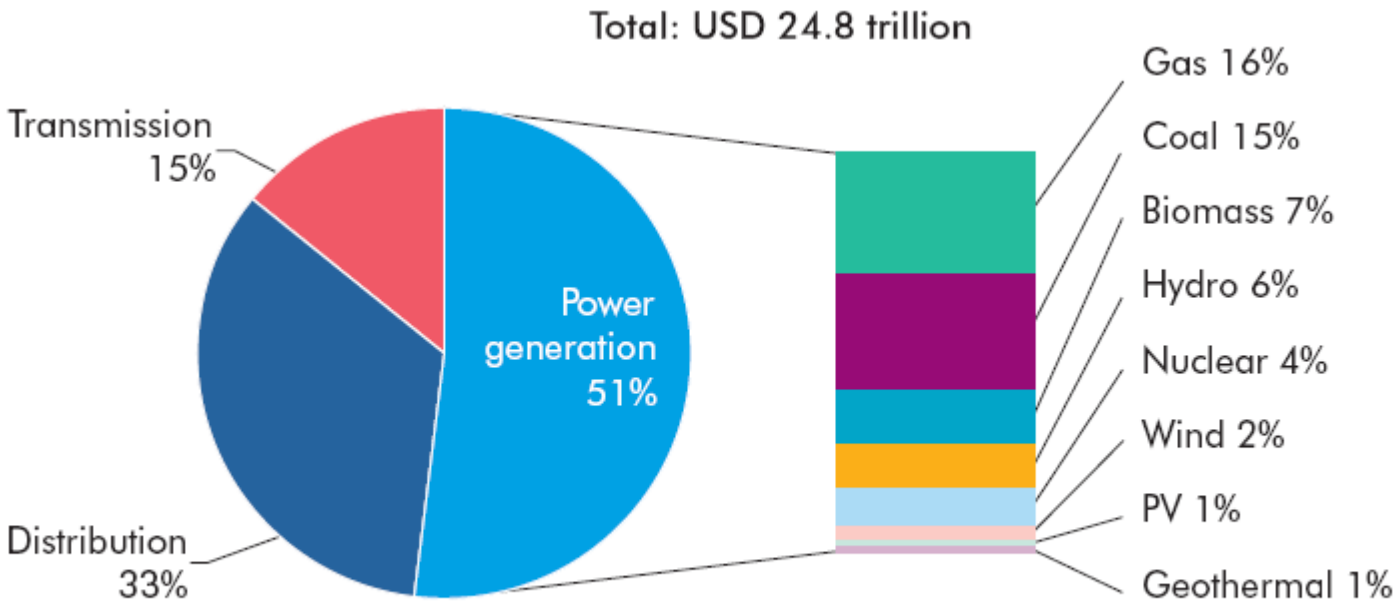
ENERGY TECHNOLOGY PERSPECTIVES

2008

Scenarios & Strategies to 2050

INTERNATIONAL ENERGY AGENCY

Baseline Electricity Sector Investment (cumulative, 2005-2050)



ENERGY TECHNOLOGY PERSPECTIVES 2008

Scenarios & Strategies to 2050

INTERNATIONAL ENERGY AGENCY

In support of the G8 Plan of Action

Investment Patterns Over Time: Electricity Plant Additions (GW/yr)

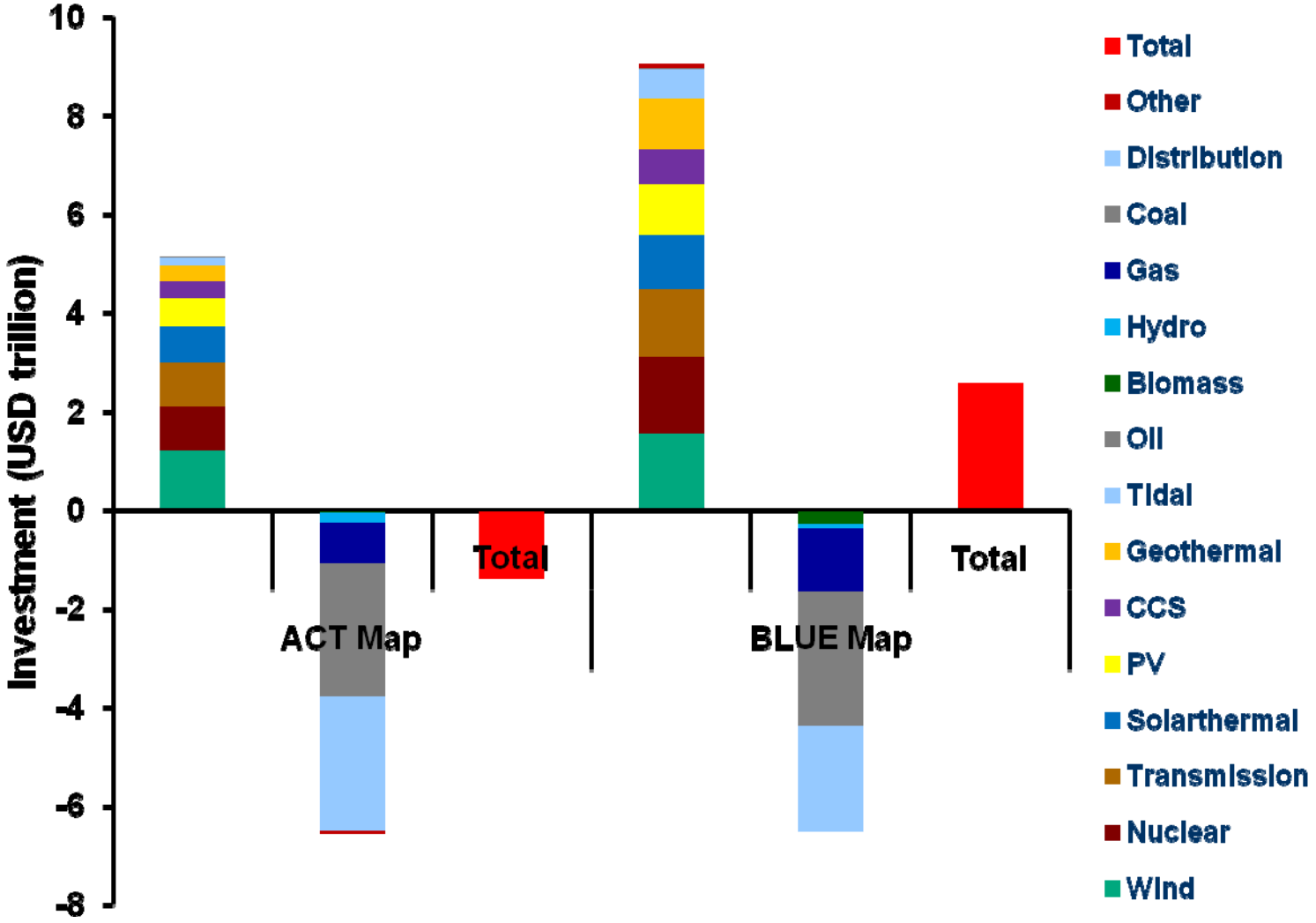
	2005-2015	2015-2025	2025-2035	2035-2050
Gas + CCS	0	5	17	18
Coal + CCS (including retrofit)	0	1	26	43
Nuclear	16	18	24	46
Wind	29	53	60	94
PV	2	6	28	58
Solar CSP	0	14	37	18
Biomass (including co-combustion)	8	12	20	25
Geothermal	2	10	11	19
Hydro	12	15	16	8
Total	**68**	**134**	**239**	**330**

ENERGY TECHNOLOGY PERSPECTIVES 2008

Scenarios & Strategies to 2050

INTERNATIONAL ENERGY AGENCY

Cumulative Additional Investment in the Electricity Sector (2005-2050)



ENERGY TECHNOLOGY PERSPECTIVES 2008

Scenarios & Strategies to 2050

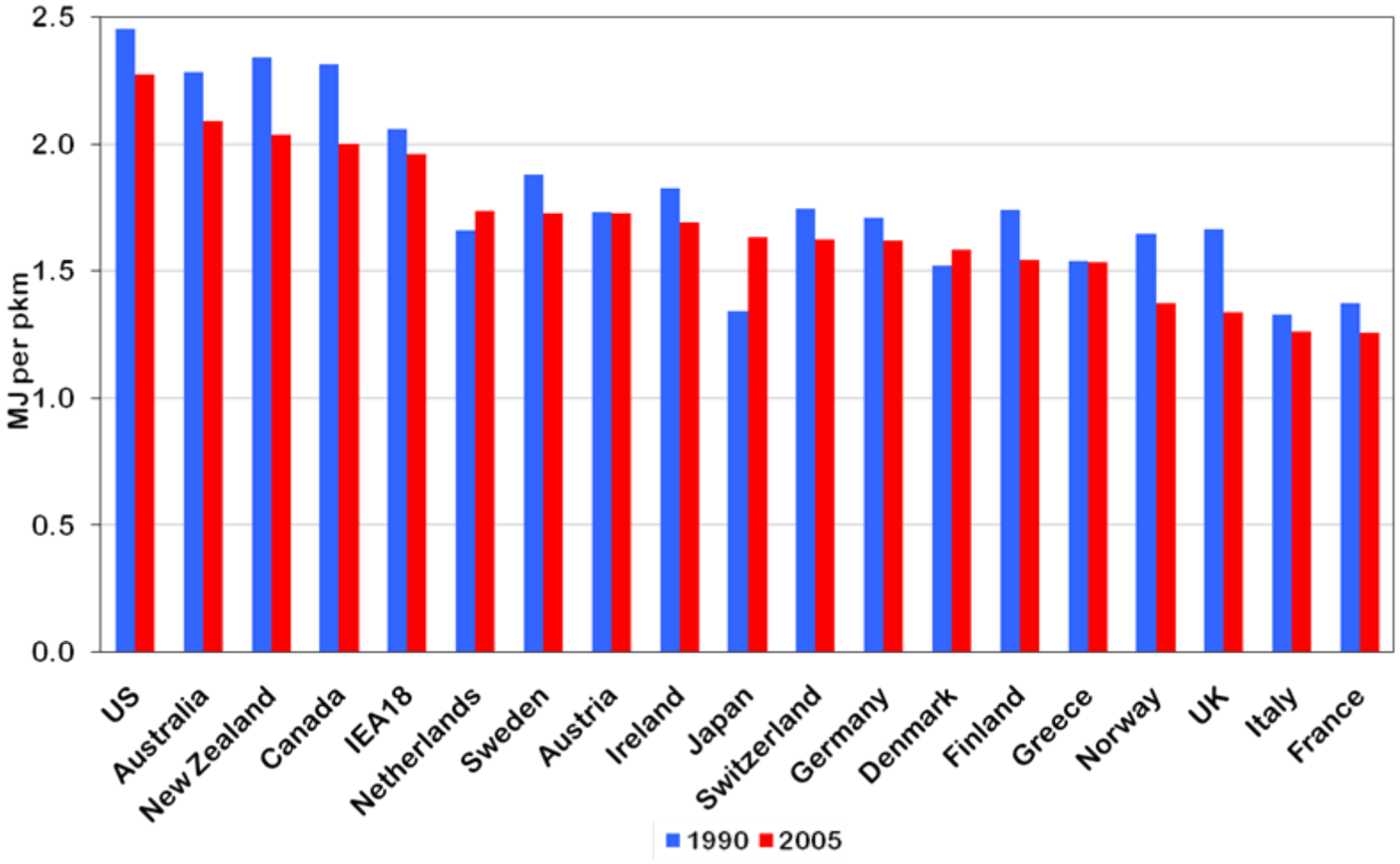
INTERNATIONAL ENERGY AGENCY

In support of the G8 Plan of Action

INTERNATIONAL ENERGY AGENCY

Transport

Energy Use per Passenger-Km



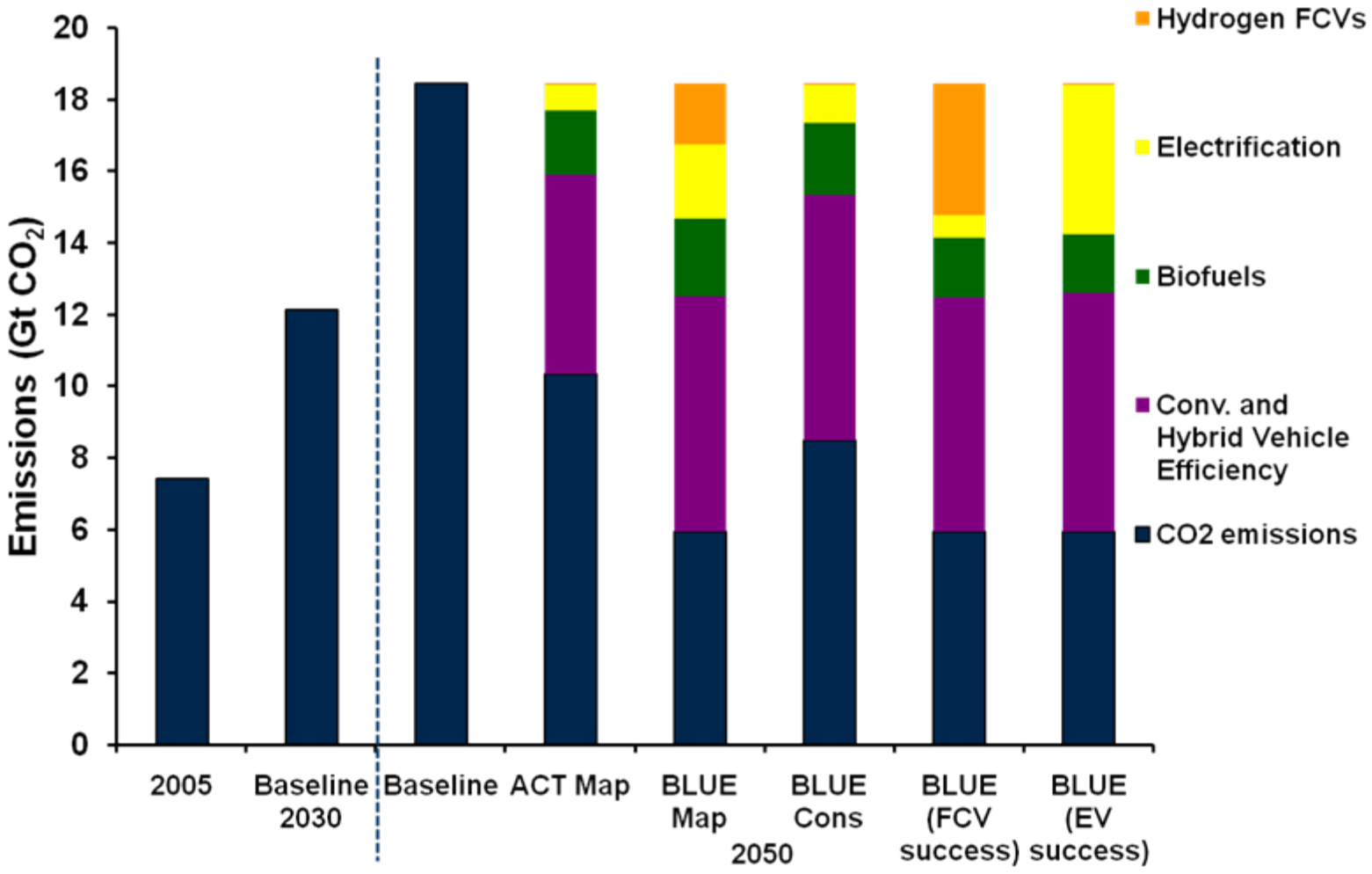
ENERGY TECHNOLOGY PERSPECTIVES 2008

Scenarios & Strategies to 2050

INTERNATIONAL ENERGY AGENCY

In support of the G8 Plan of Action

Transport



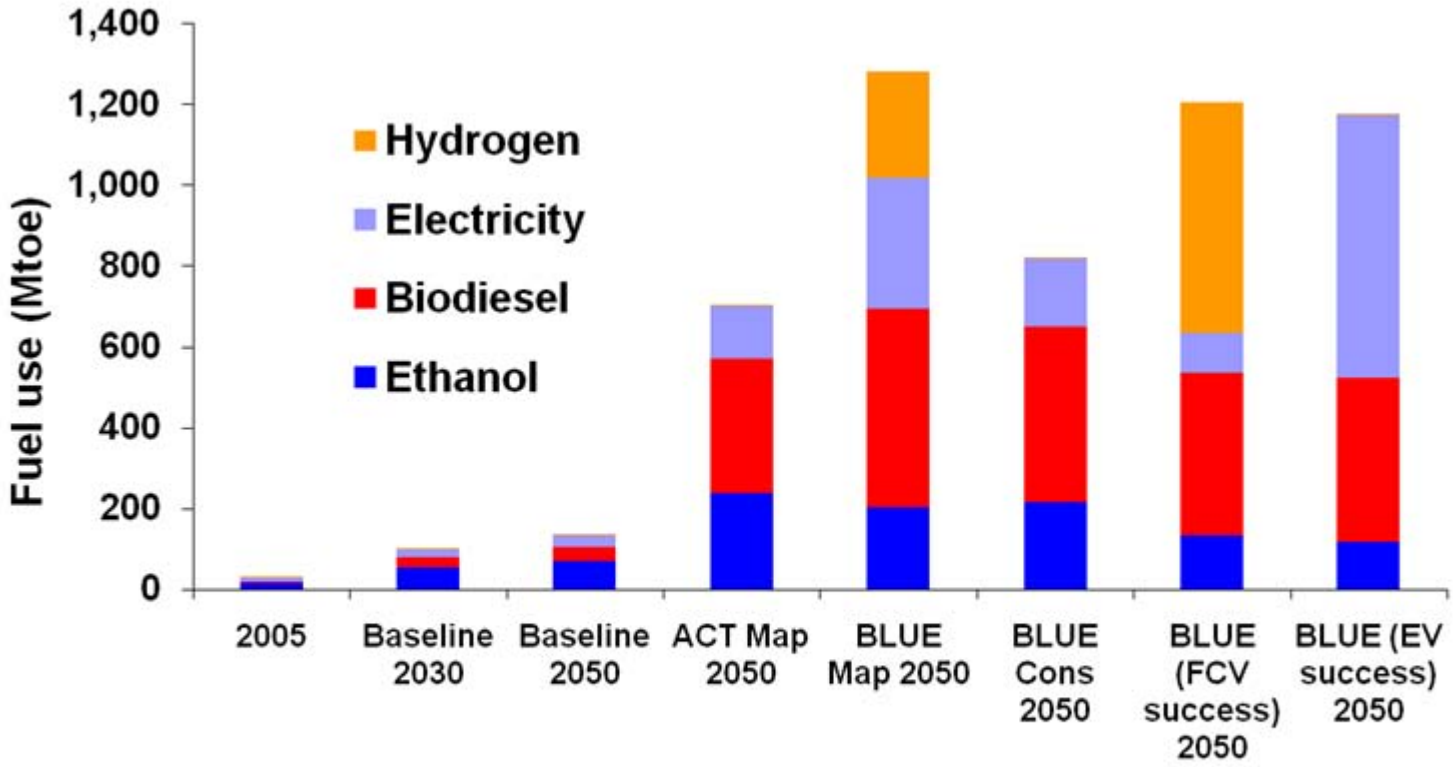
ENERGY TECHNOLOGY PERSPECTIVES 2008

Scenarios & Strategies to 2050

INTERNATIONAL ENERGY AGENCY

In support of the G8 Plan of Action

Alternative Fuel Use



ENERGY TECHNOLOGY PERSPECTIVES 2008

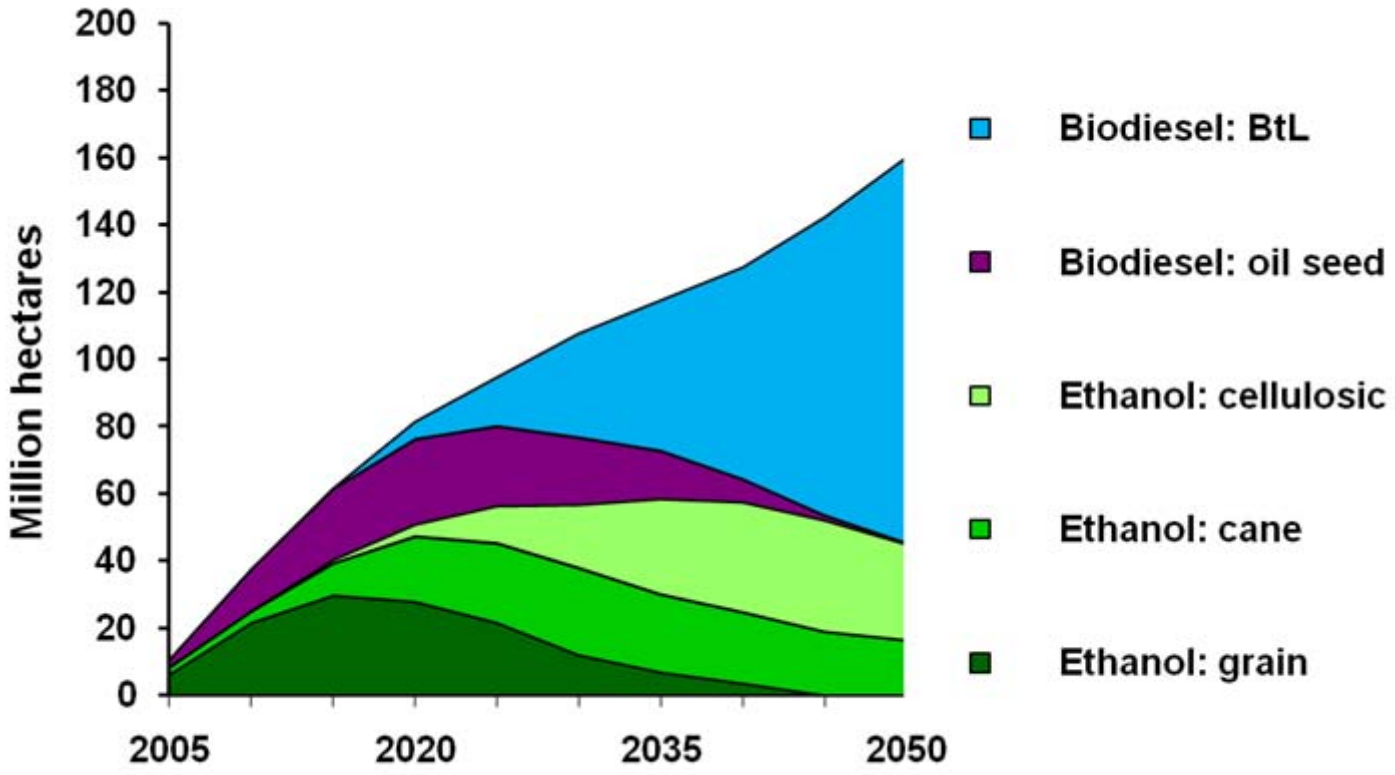
Scenarios & Strategies to 2050

INTERNATIONAL ENERGY AGENCY

In support of the G8 Plan of Action

Biofuels Land Use in Blue

Perhaps about 150 million hectares worldwide



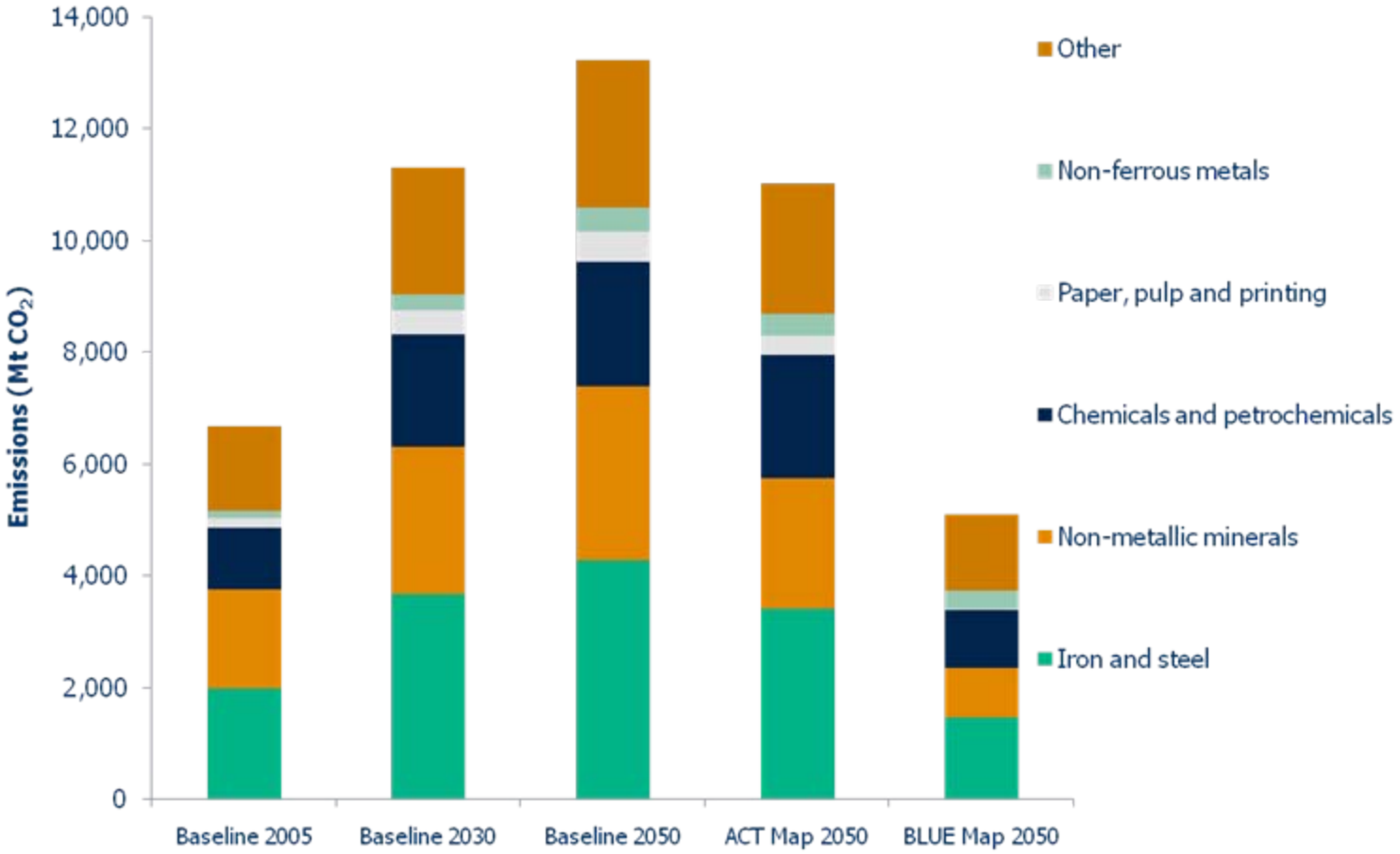
Based on yields for different feedstocks reported in literature; assumes 100% from agricultural/forest crops; other sources like residues would reduce land requirement.

ENERGY TECHNOLOGY PERSPECTIVES
2008
Scenarios & Strategies to 2050
INTERNATIONAL ENERGY AGENCY

INTERNATIONAL ENERGY AGENCY

Industry

Industrial CO_2 Emissions by sector and scenario



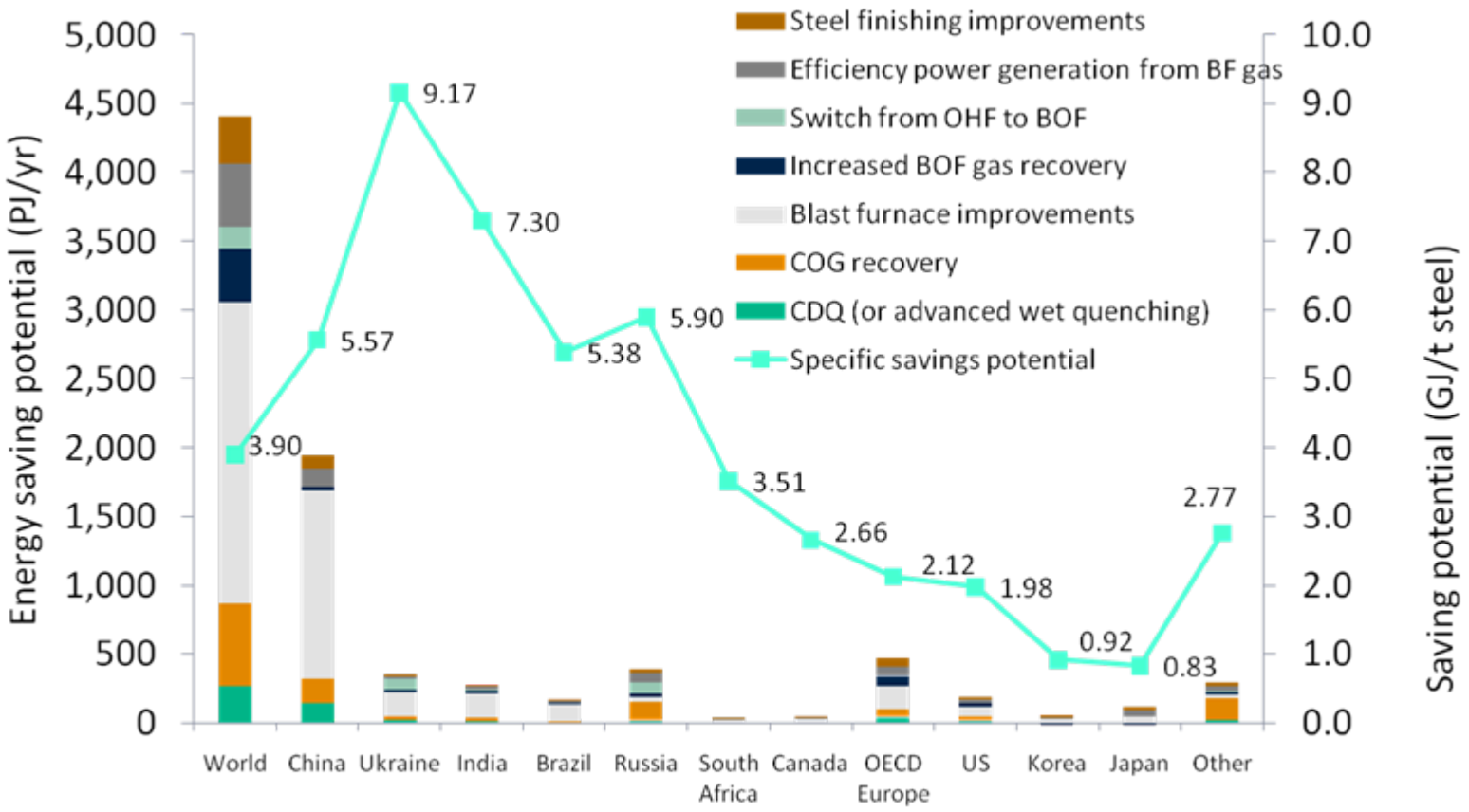
ENERGY TECHNOLOGY PERSPECTIVES 2008

Scenarios & Strategies to 2050

INTERNATIONAL ENERGY AGENCY

In support of the G8 Plan of Action

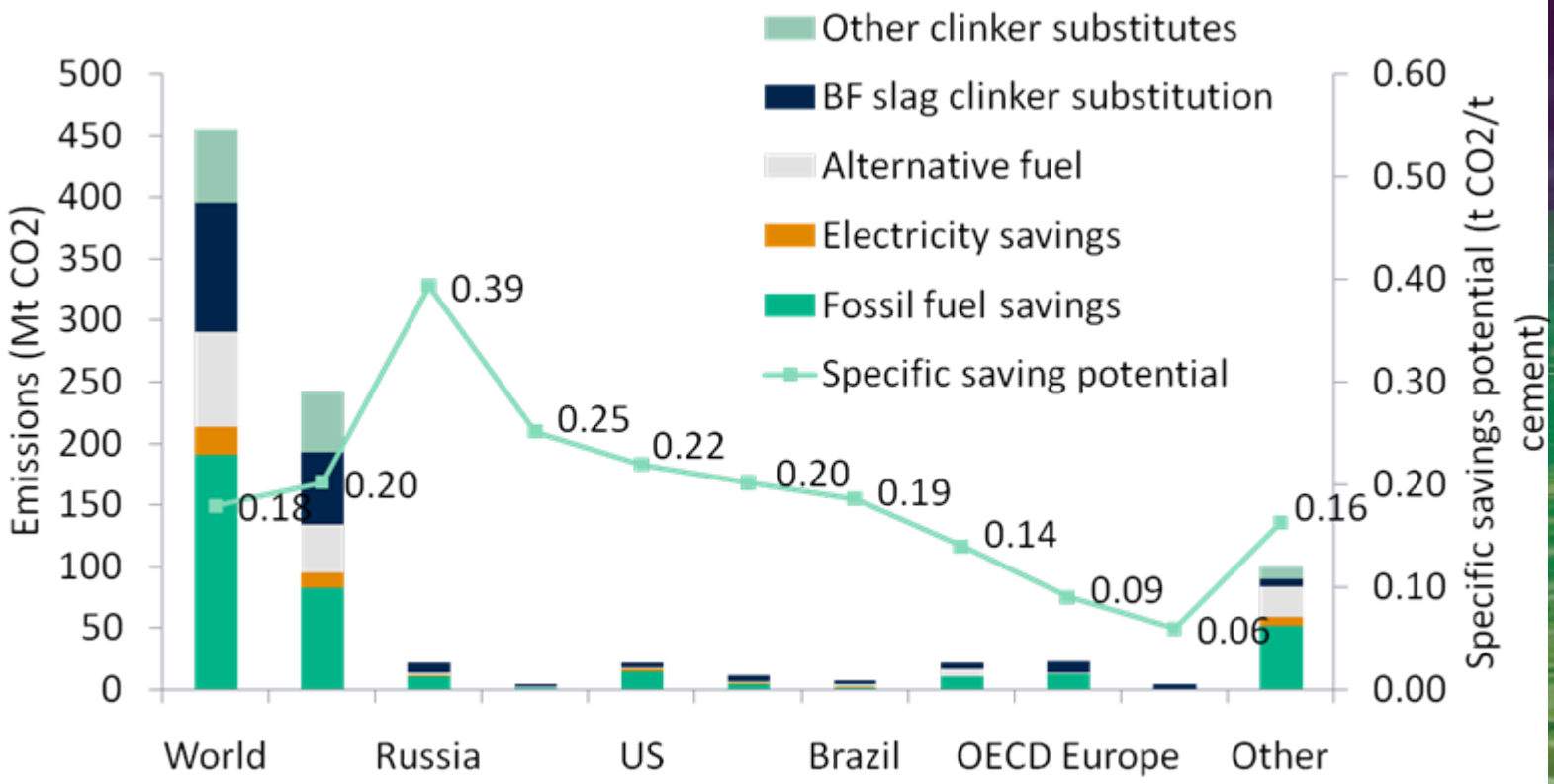
Steel Energy Efficiency Potentials, 2005 (revised)



Includes only BAT options

ENERGY TECHNOLOGY PERSPECTIVES
2008
Scenarios & Strategies to 2050
INTERNATIONAL ENERGY AGENCY

Cement CO_2 Reduction Potentials (revised)



Includes only BAT options

In support of the G8 Plan of Action

ENERGY TECHNOLOGY PERSPECTIVES 2008

Scenarios & Strategies to 2050

INTERNATIONAL ENERGY AGENCY