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Joint ICTP-IAEA School on Nuclear Energy Management

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World Energy Demand and Supply Recent Trends

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World Energy Demand and Supply
Recent Trends

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Outline

1. Challenges and issues
2. Energy system
3. Current situation
4. Drivers of energy demand
5. Resources & technology
6. Future outlook

Challenges and issues

- Energy security
  - Eradicating energy poverty (energy for meeting MDGs)
  - Access and affordability
  - Reliability
- Economic competitiveness
  - Market structures
  - Subsidies
- Environment protection and climate change
- Resources & technology
- Demand growth
- Sustainability calls for energy system transformation
- Finance

Challenges for 21st Century Energy Supplies

- Energy is central to achieving sustainable development goals including the Millennium Development Goals (MDGs)
- Economic development translates into growing demand for energy services
- Demand is compounded by continued population growth
- Some 1.3 billion people without access to modern energy services
- Poverty eradication calls for affordable energy services
- Need to minimize of health and environmental impacts
- Energy security
- Sustainability calls for energy system transformation

Worrisome trends

- Economic concerns have focused attention on short-term energy security to the detriment of longer term sustainable development objectives
- Post-Fukushima, a bumpy road ahead for nuclear
- MENA turmoil raised questions about region's investment plans
- Some key trends are pointing in worrying directions:
  - *CO_2 emissions rebounded to a record high (2012)*
  - *Energy efficiency of global economy worsened for 2^{nd} straight year (2011)*
  - *Spending on oil imports is near record highs*
  - *Financial & economic crises*

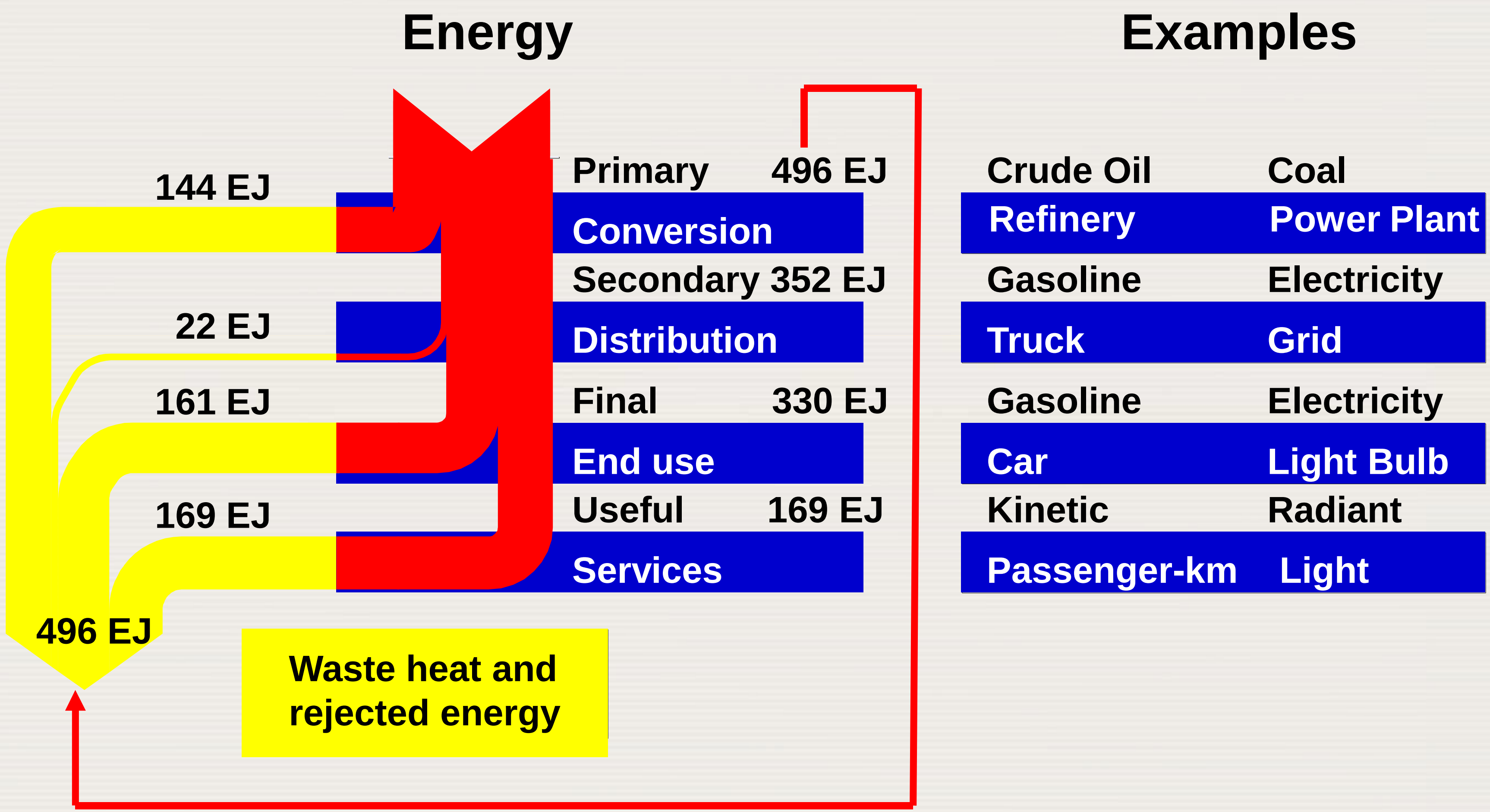
Architecture of the Energy System

Sources	**coal oil natural gas sunlight uranium wind biomass**	**What Nature Provides**
Extraction Treatment	coal mine, hydro dam, oil rig, cleaning, separation, benefication, liquef-action, gasifi-cation	
Conversion Technologies	**hydro station, thermal power plant, oil refinery, nuclear generating station, photovoltaic cell, wind converter**	**Energy Sector**
Currencies (fuels)	**electricity gasoline methanol methane hydrogen heat**	
Distribution	electricity grid, gas grid, truck, dewar, railway, district heat grid	
Service Technologies	**automobile, light bulb, telephone, furnace, microwave oven, aircraft, PC**	**Efficiency & Infrastructure**
Services	**transportation, communication, keeping warm/cold, food, potable water, health care, security, consumer goods**	**What People Want**

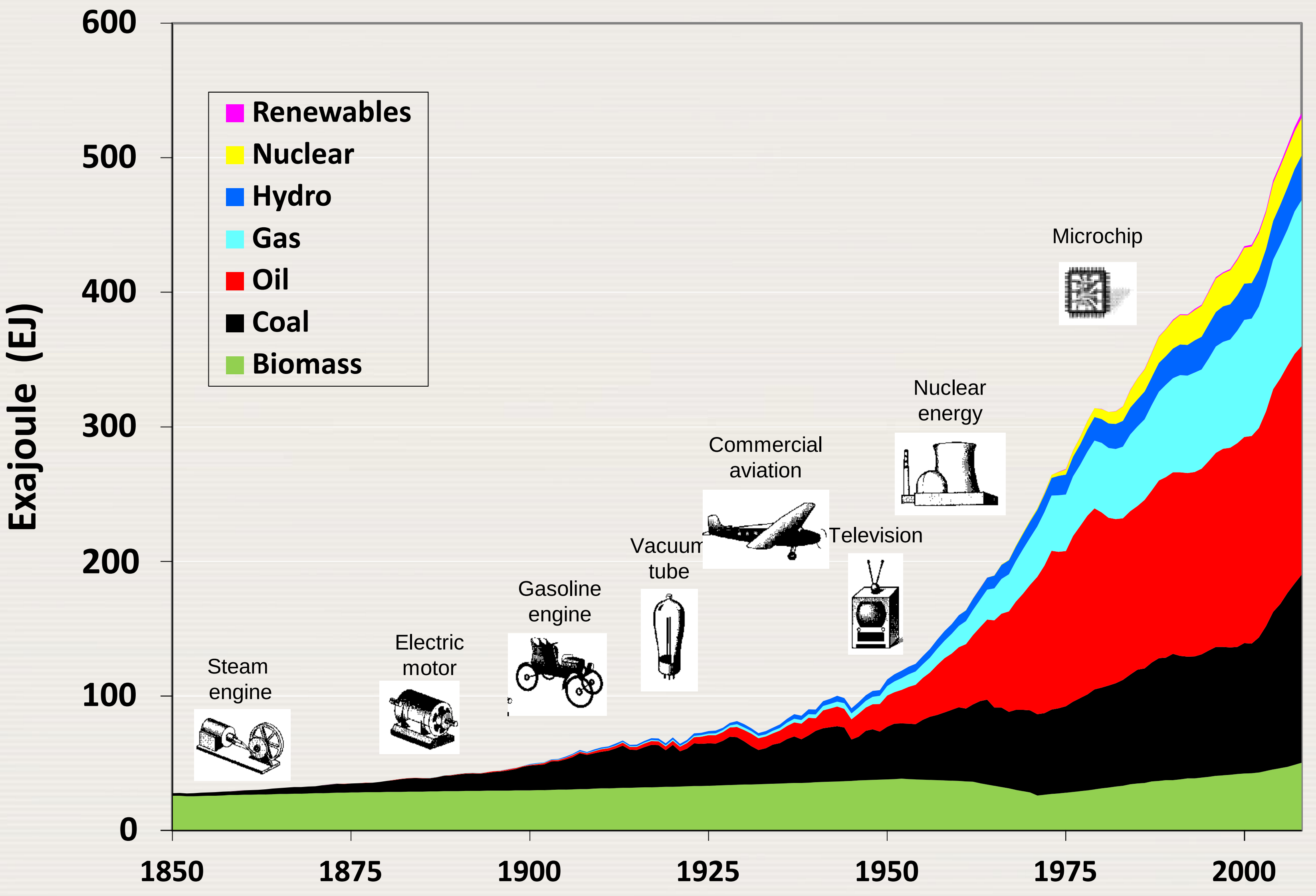
Architecture of the Energy System

Sources	**coal oil natural gas sunlight uranium wind biomass**	**Primary energy**
Extraction Treatment	coal mine, hydro dam, oil rig, cleaning, separation, benefication, liquef-action, gasifi-cation	
Conversion Technologies	**hydro station, thermal power plant, oil refinery, nuclear generating station, photovoltaic cell, wind converter**	**Secondary energy**
Currencies (fuels)	**electricity gasoline methanol methane hydrogen heat**	
Distribution	electricity grid, gas grid, truck, dewar, railway, district heat grid	
Service Technologies	**automobile, light bulb, telephone, furnace, microwave oven, aircraft, PC**	**Final energy**
Services	**transportation communication keeping warm/cold food potable water health care security consumer goods**	**Energy services**

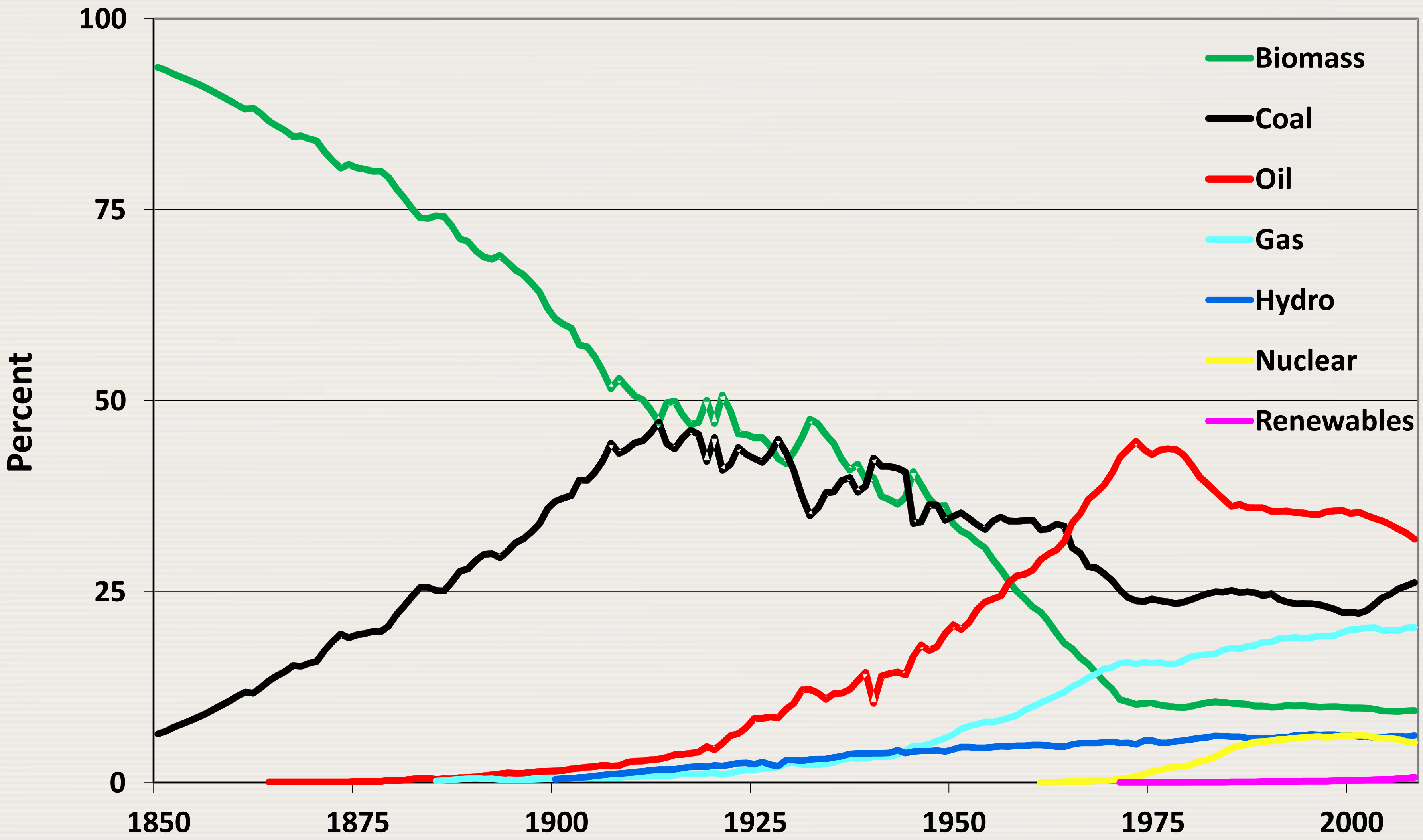
First Law of Thermodynamics: Energy conservation



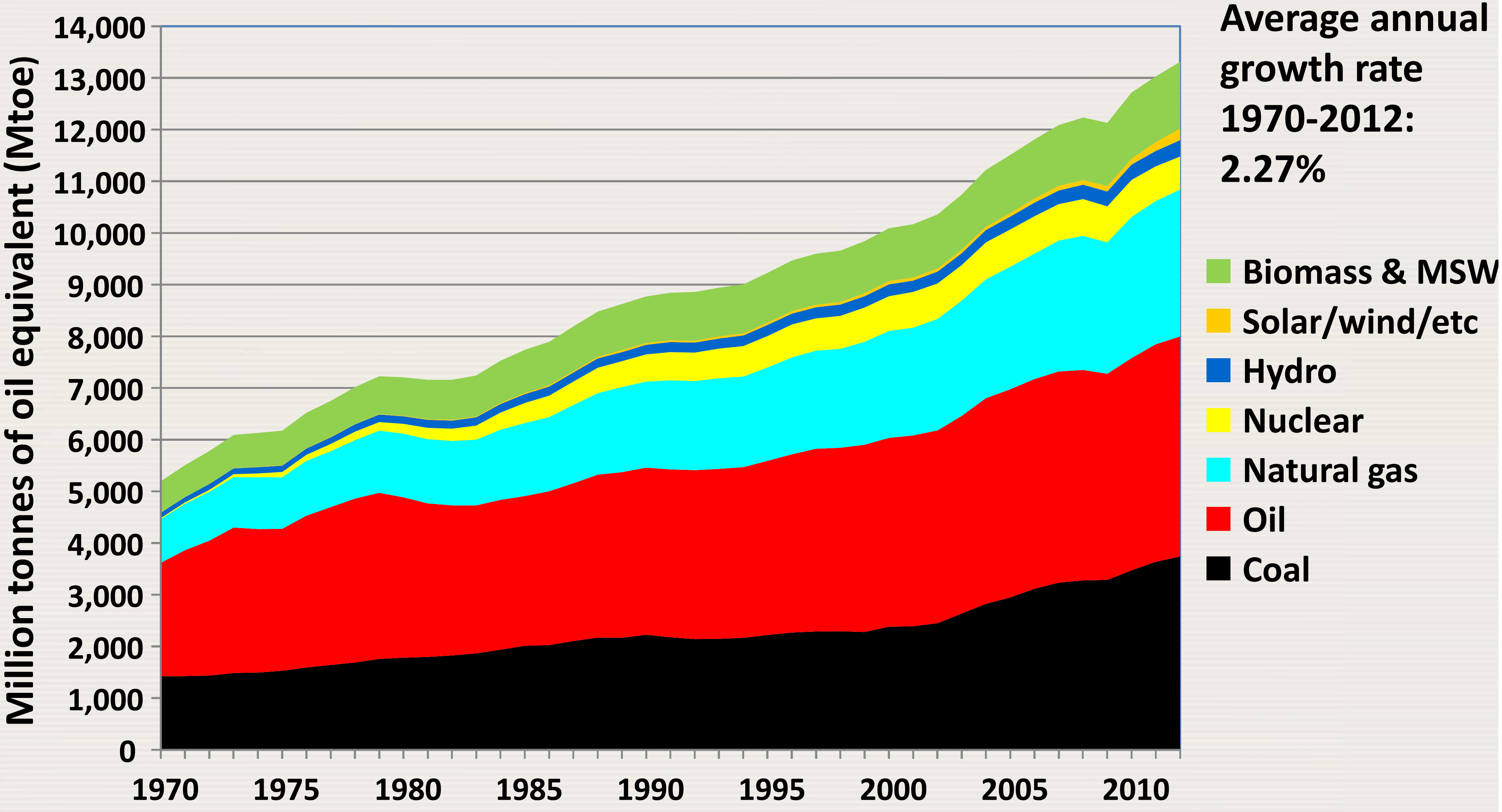
Global primary energy supply, 1850 -2010



Shares of primary energy



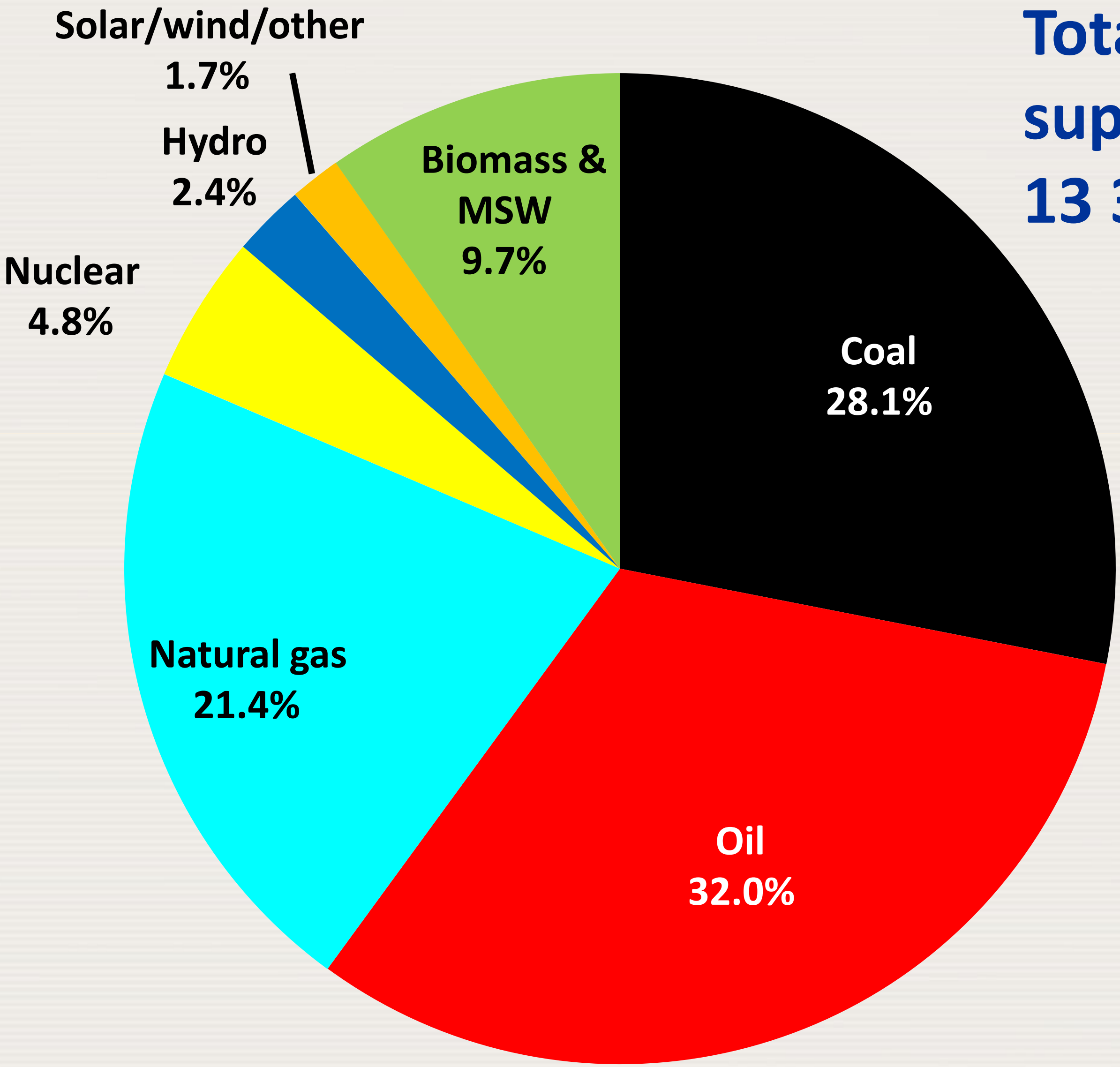
Global primary energy supply, 1970-2012



Average annual growth rate 1970-2012: 2.27%

Source: Adapted from OECD/IEA Statistics and BP

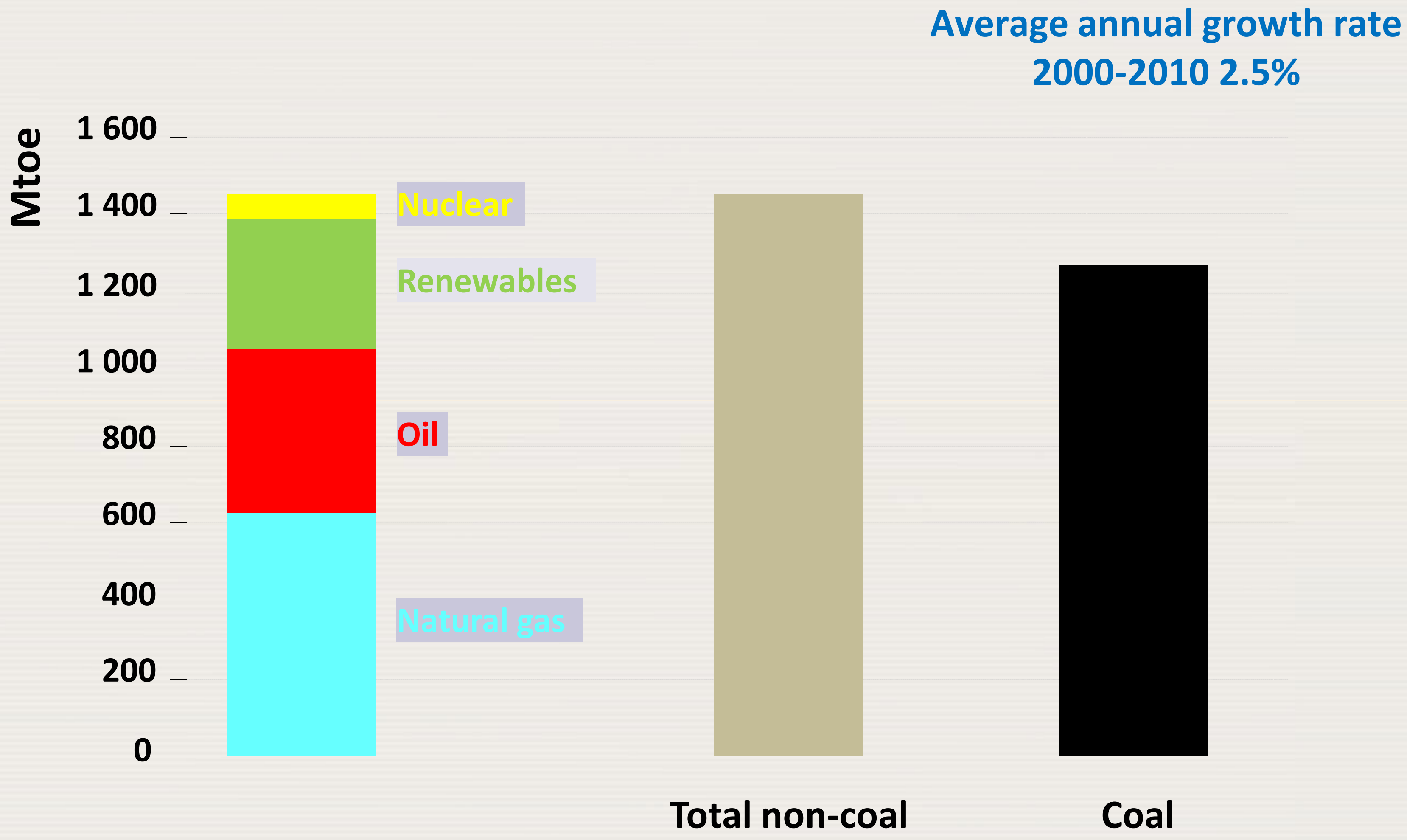
Structure of global primary energy supply



Total primary energy supply (TPES) in 2012: 13 310 Mtoe

Source: Adapted from OECD/IEA Statistics and BP

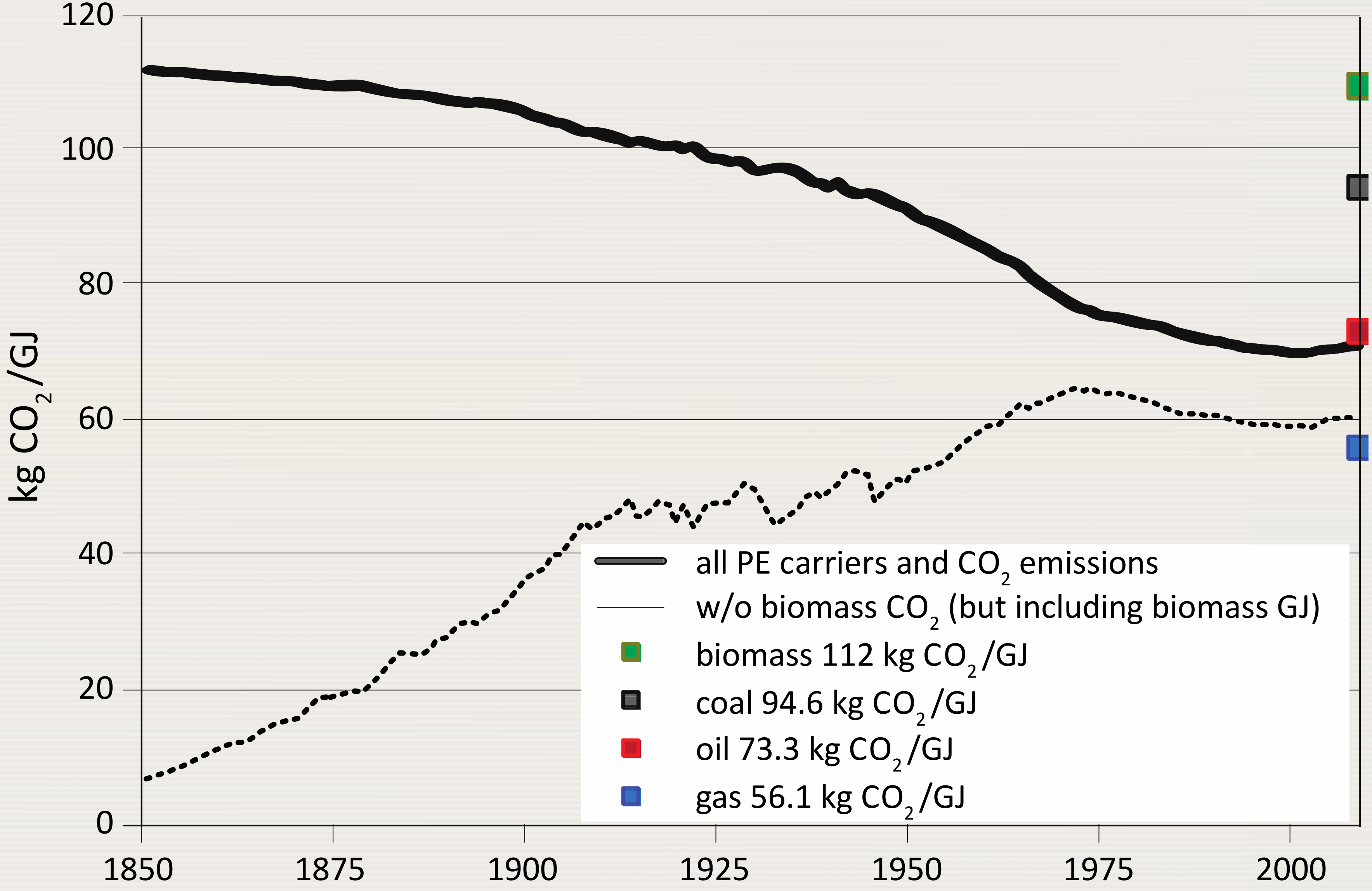
Coal won the energy race in the first decade of the 21st century



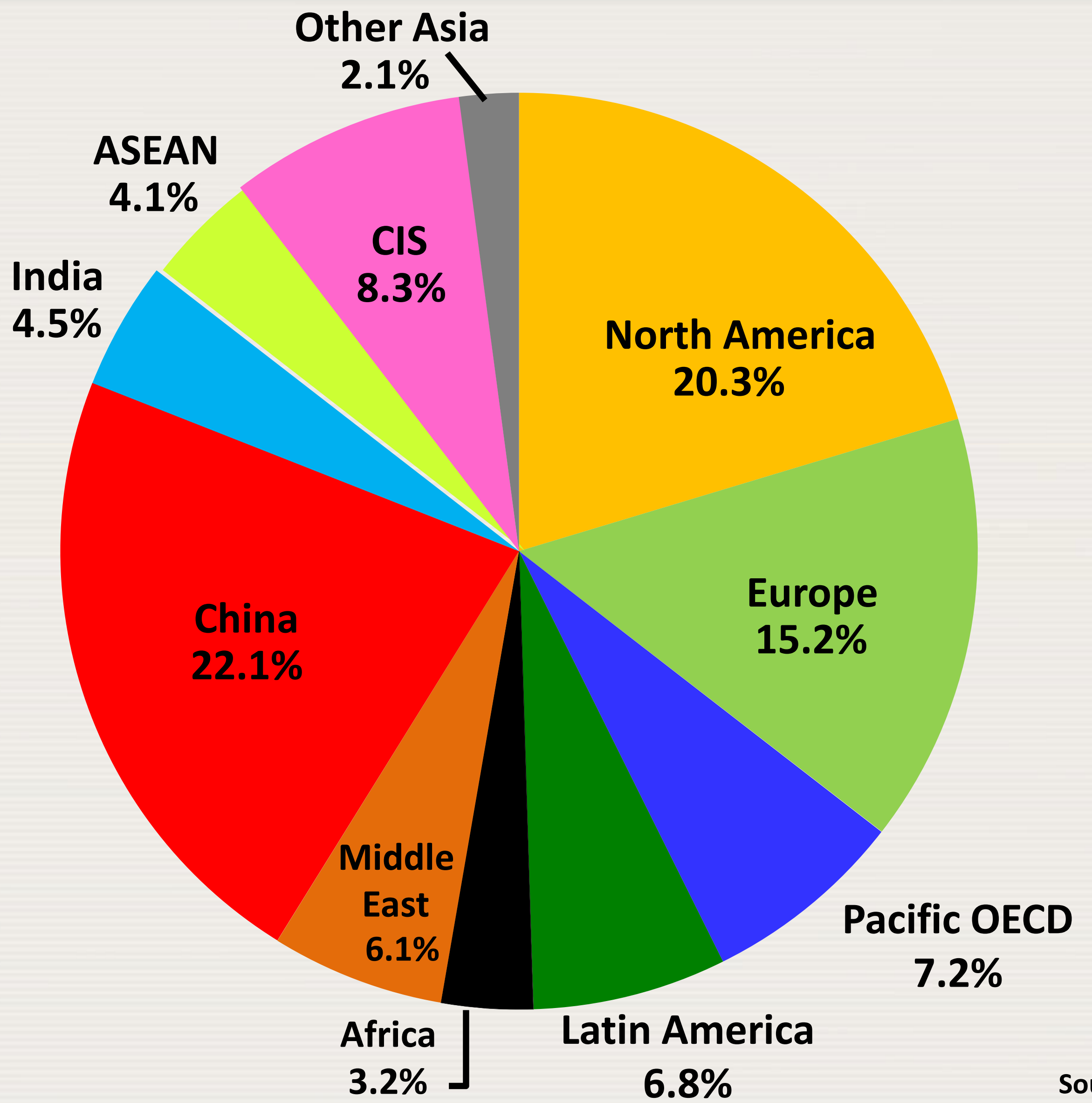
Coal accounted for nearly half of the increase in global energy use over the past decade, with the bulk of the growth coming from the power sector in emerging economies

Source: OECD/IEA - World Energy Outlook 2011

Historical carbon intensity of energy supplies



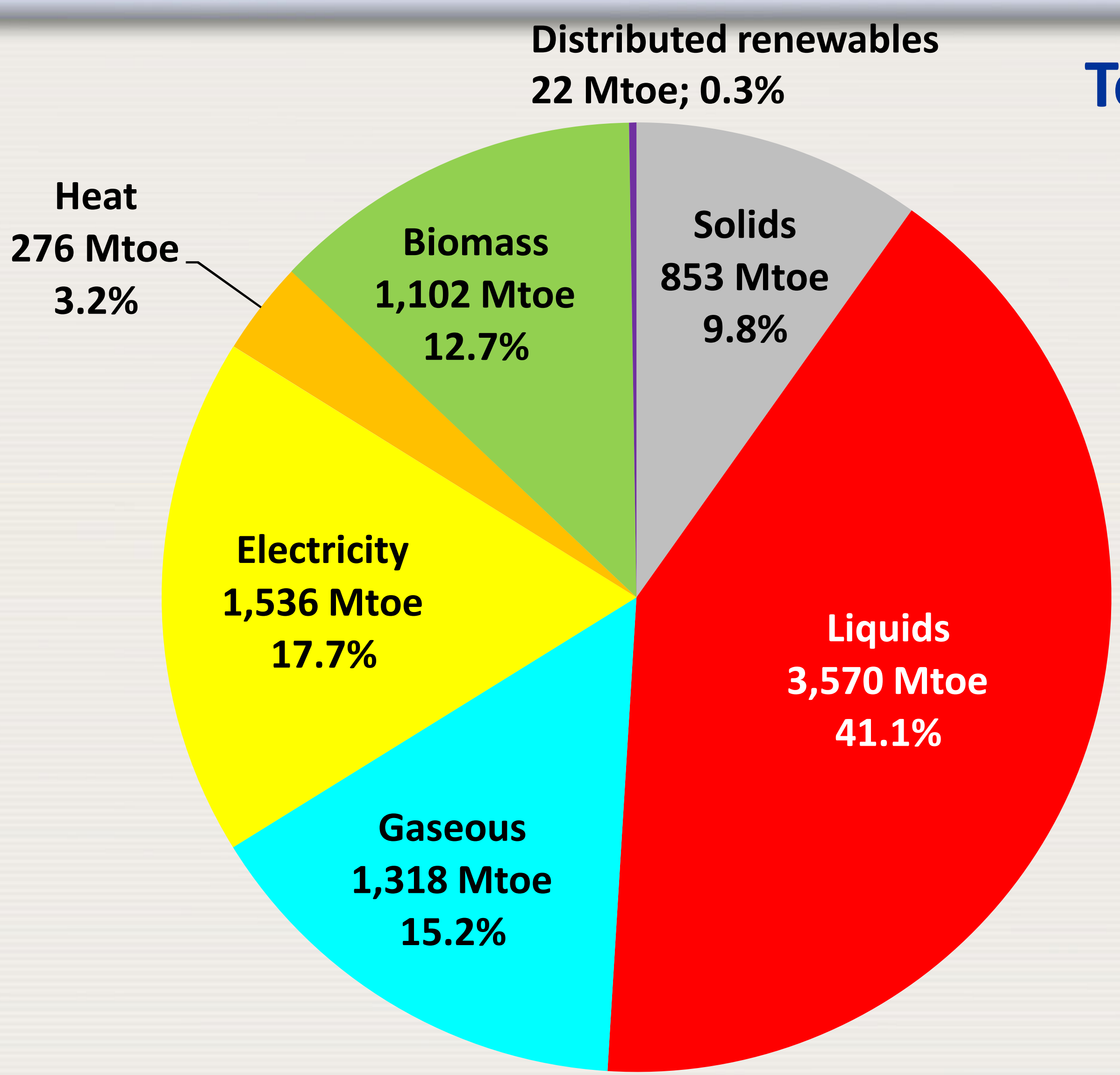
Regional TPES



Total global primary energy in 2012: 13 310 Mtoe

Source: Adapted from OECD/IEA & BP Statistics

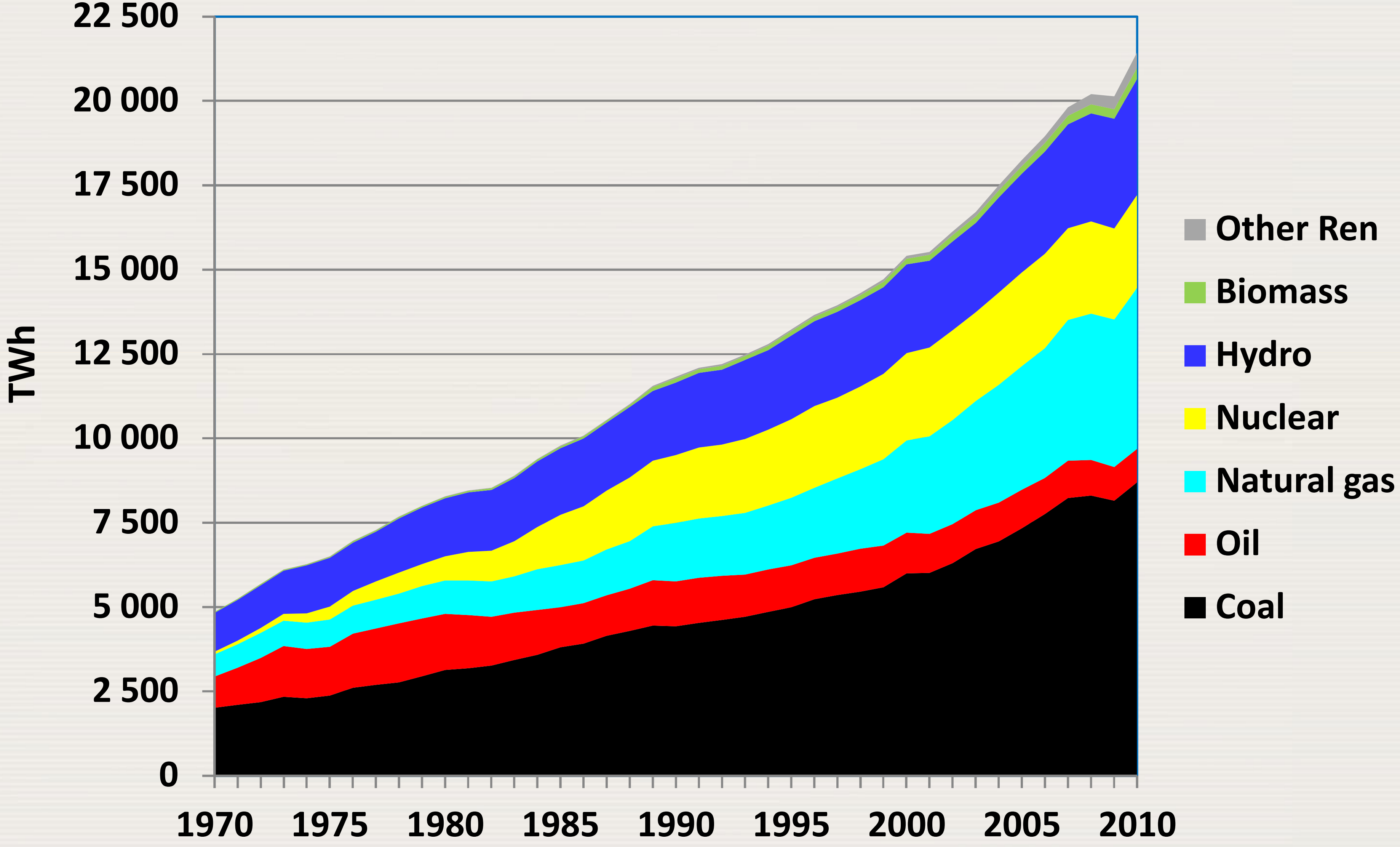
Structure of global final energy use, 2010



Total final energy: 8 677 Mtoe

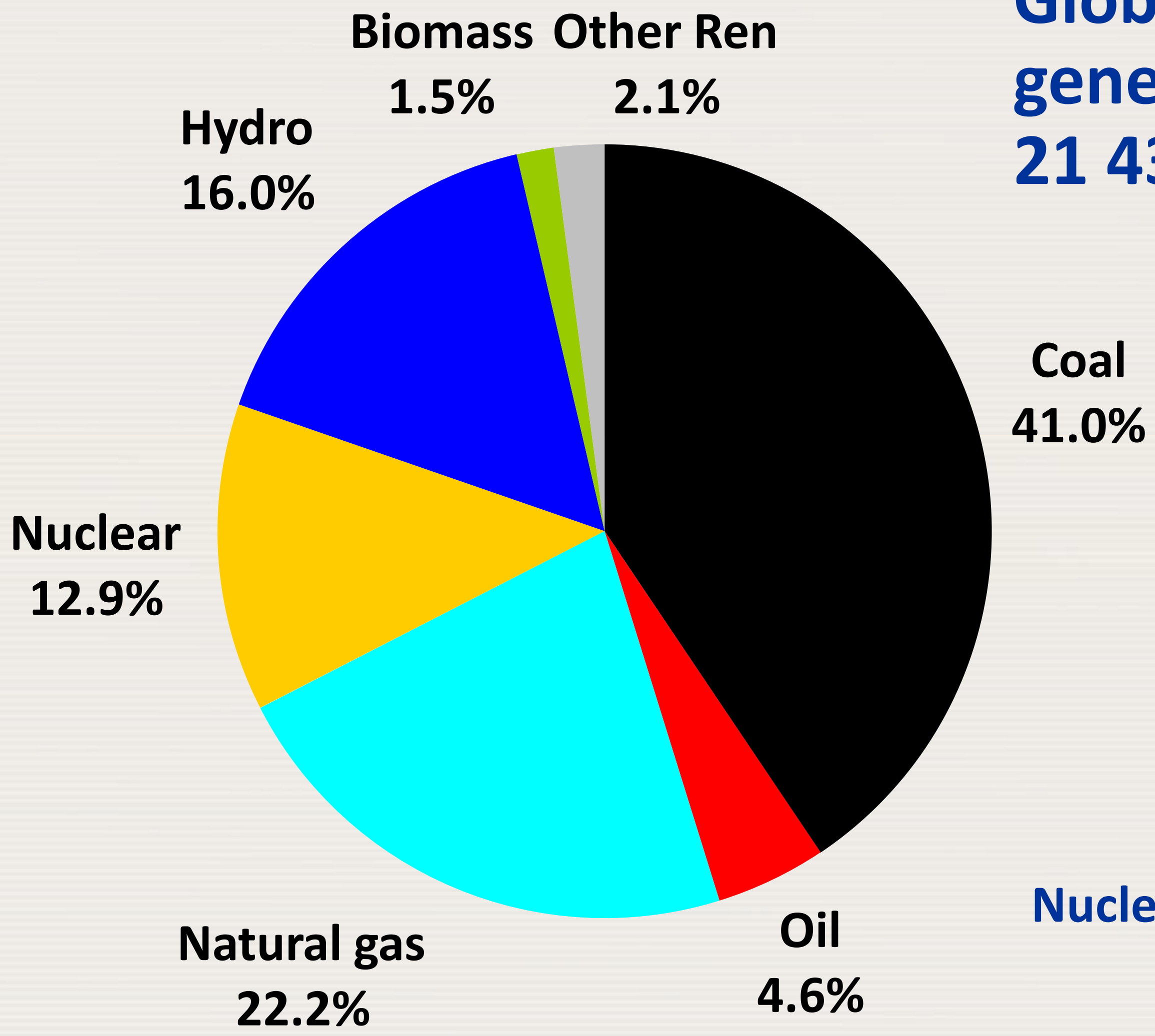
Source: Adapted from OECD/IEA Statistics

Historical development of global electricity generation, 1970 - 2010



Source: Adapted from OECD/IEA Statistics

Structure of global electricity supply

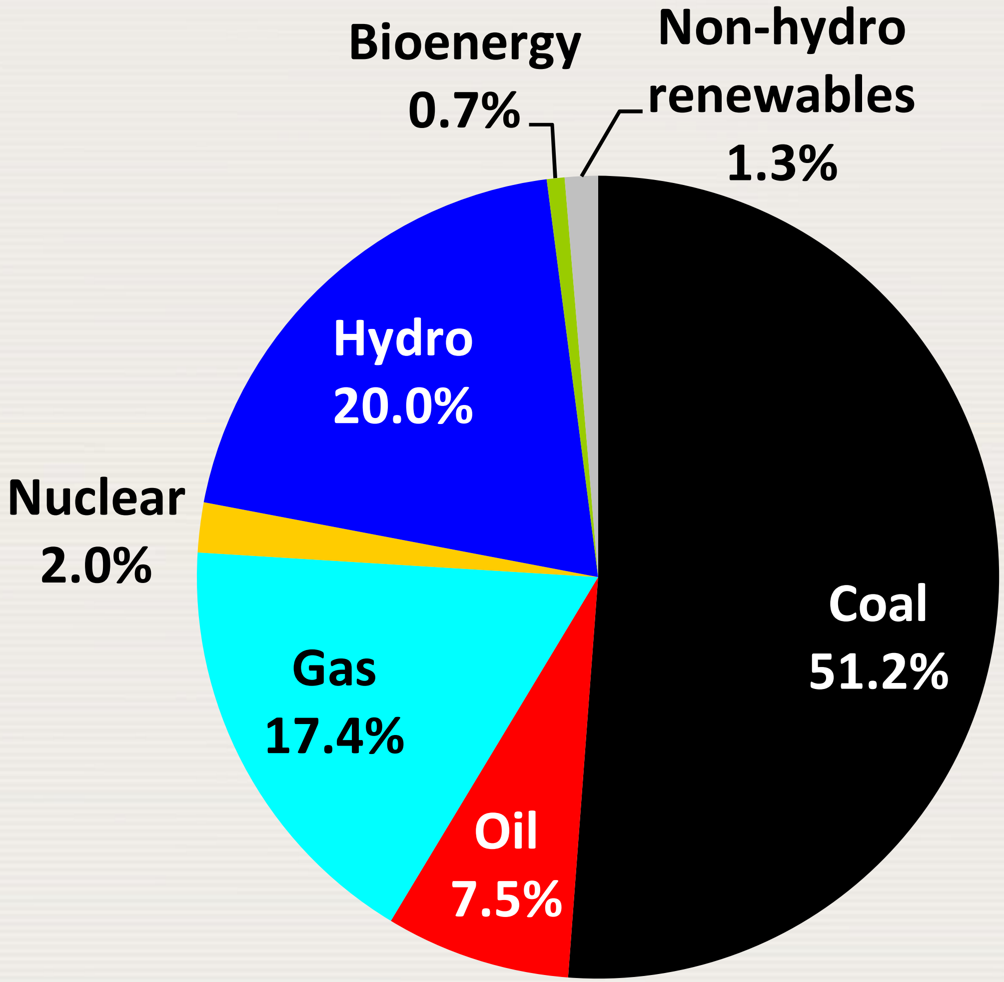


Global electricity generation in 2010: 21 430 TWh

Nuclear capacity share: 7.1%

Source: Adapted from OECD/IEA Statistics

Structure of electricity supply – Developing countries

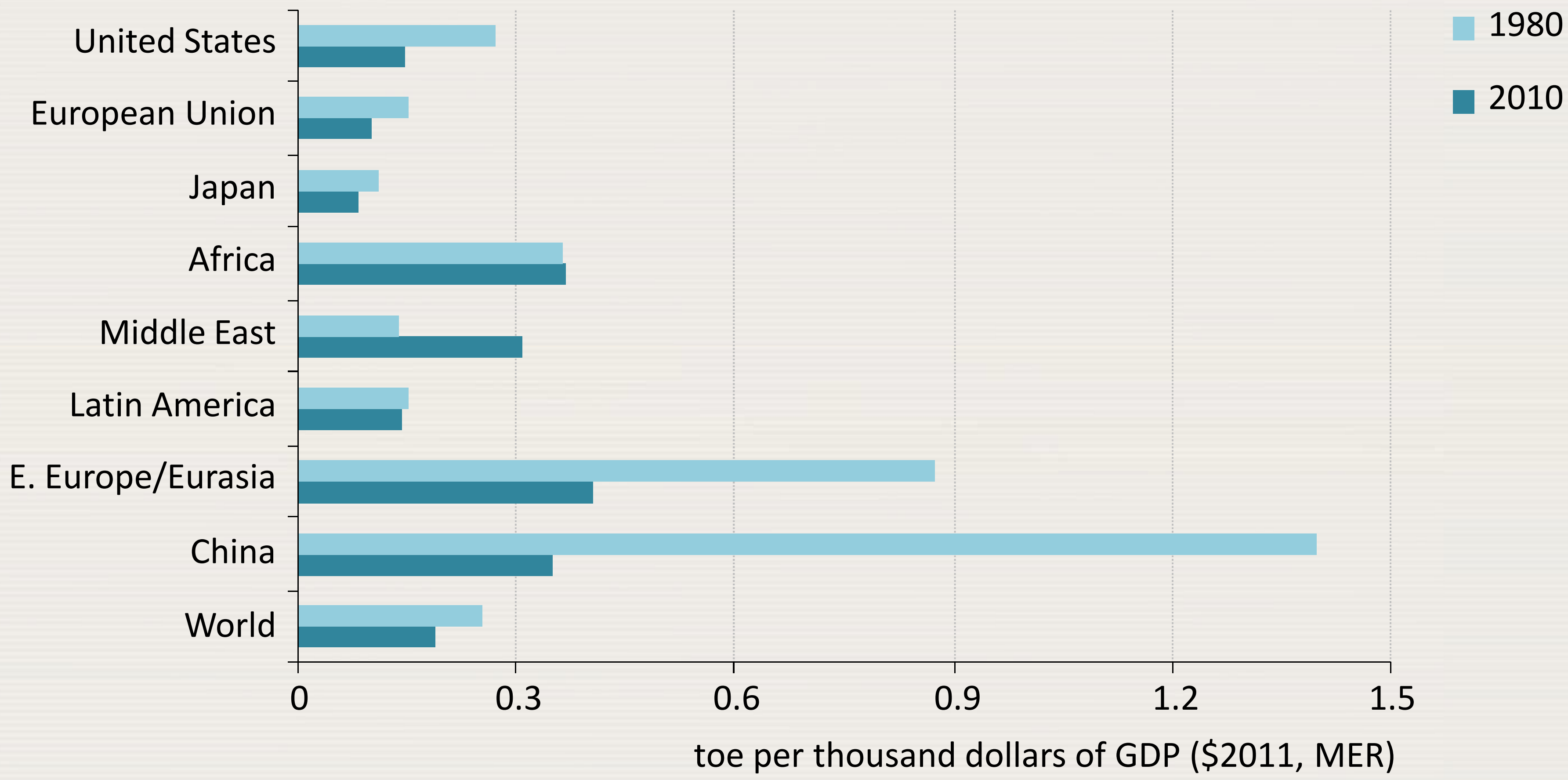


Total electricity generation in 2010: 8 880 TWh

Nuclear capacity share: 1.3%

Source: Adapted from OECD/IEA Statistics

Energy intensities by regions



Energy intensities are converging: the ratio among the highest & lowest values has declined from a factor of nine in the 1980s to just under five currently

Source: IEA World Energy Outlook 2012

The drivers of carbon emissions

KAYA identity which finds its origin in IPAT or
Impact = population × affluence × technology

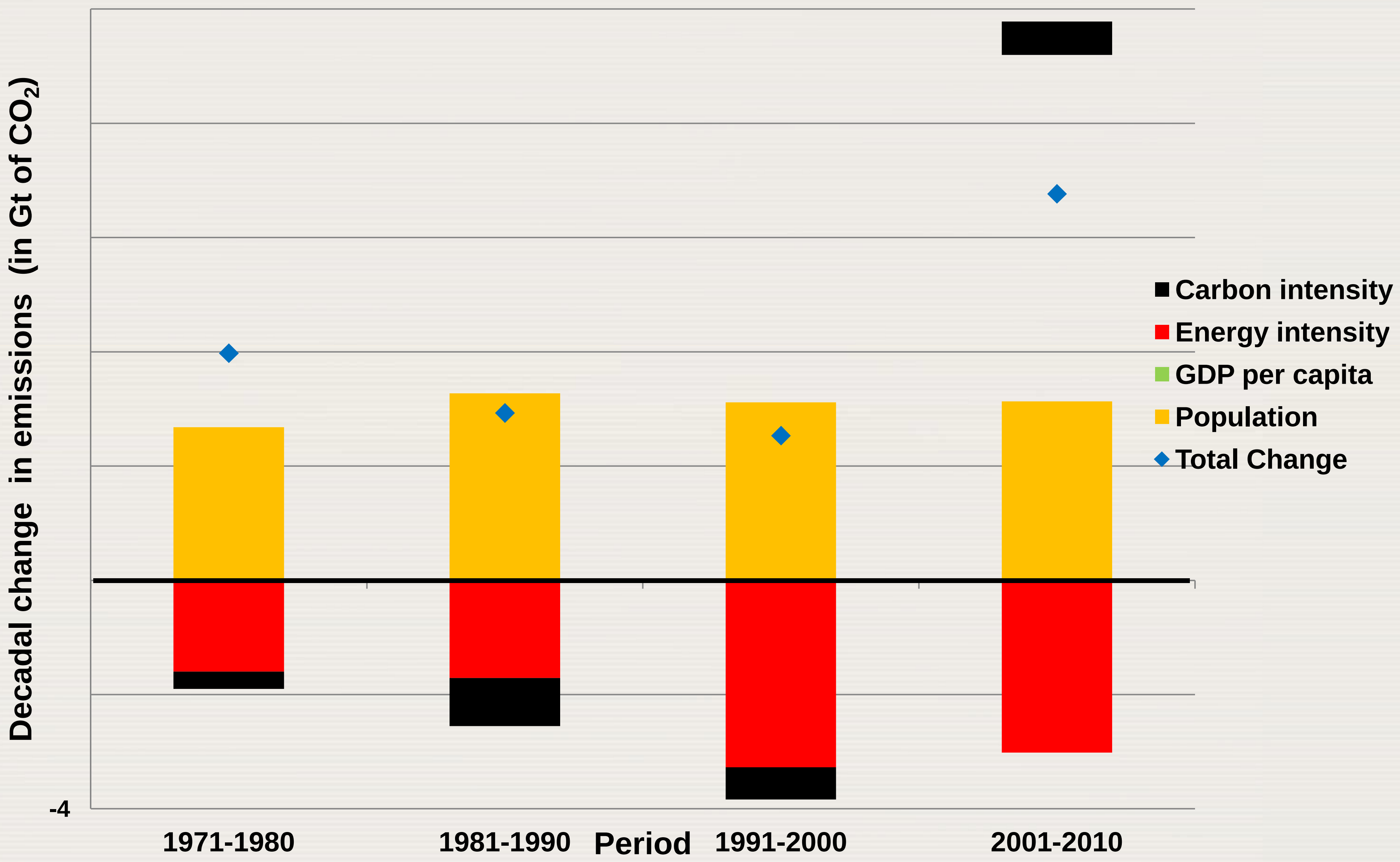
Total emissions = population × per capita income × energy intensity × carbon intensity

Total emissions = population × (GDP/population) × (energy/GDP) × (emissions/energy)

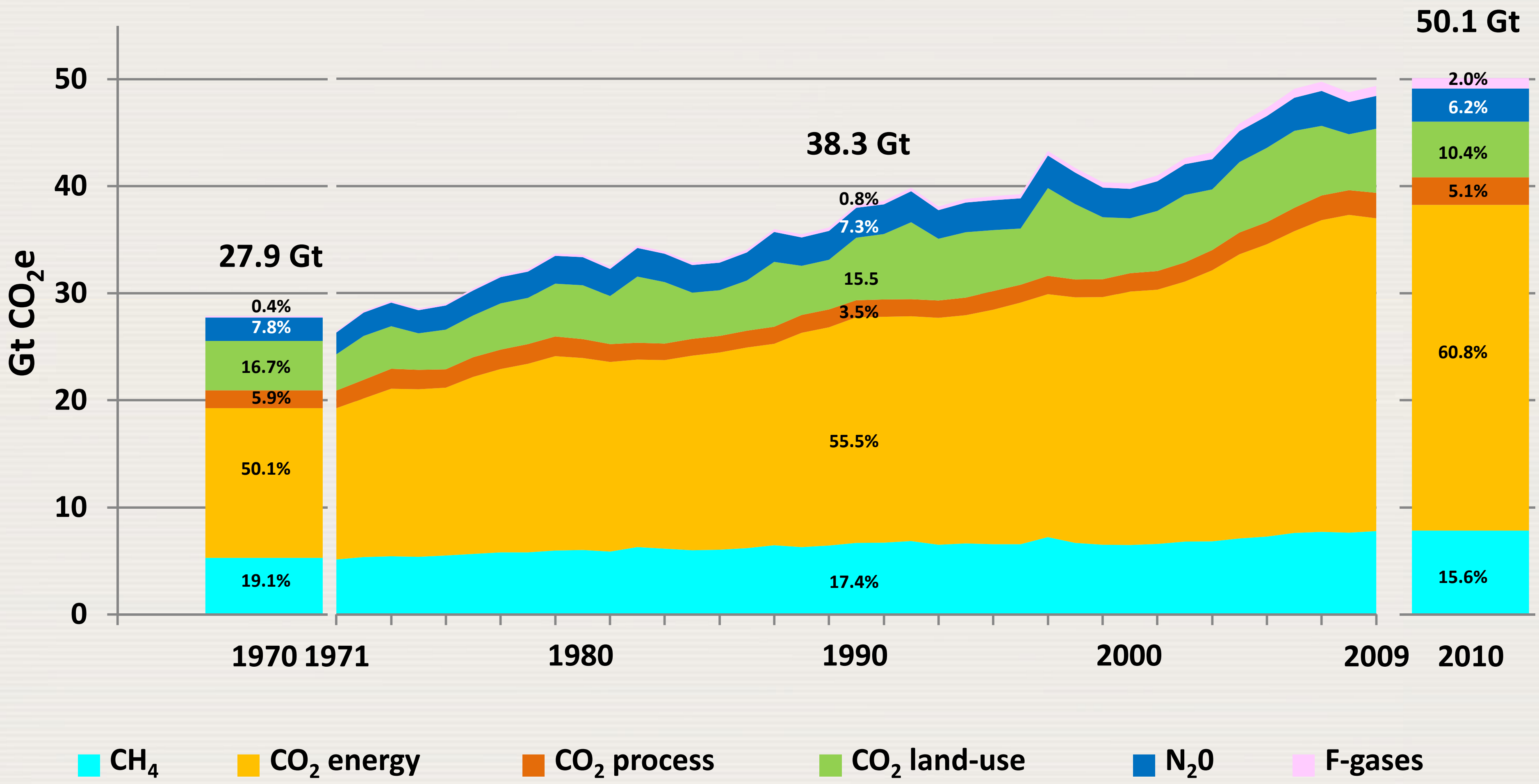
Total emissions = Pop × (GDP/pop) × (E/GDP) × (CO_2/E)

Total emissions = Pop × ($/pop) × (MJ/$) × (CO_2/MJ)

“Kaya Identity” components and their effect on total energy related CO_2 emissions levels

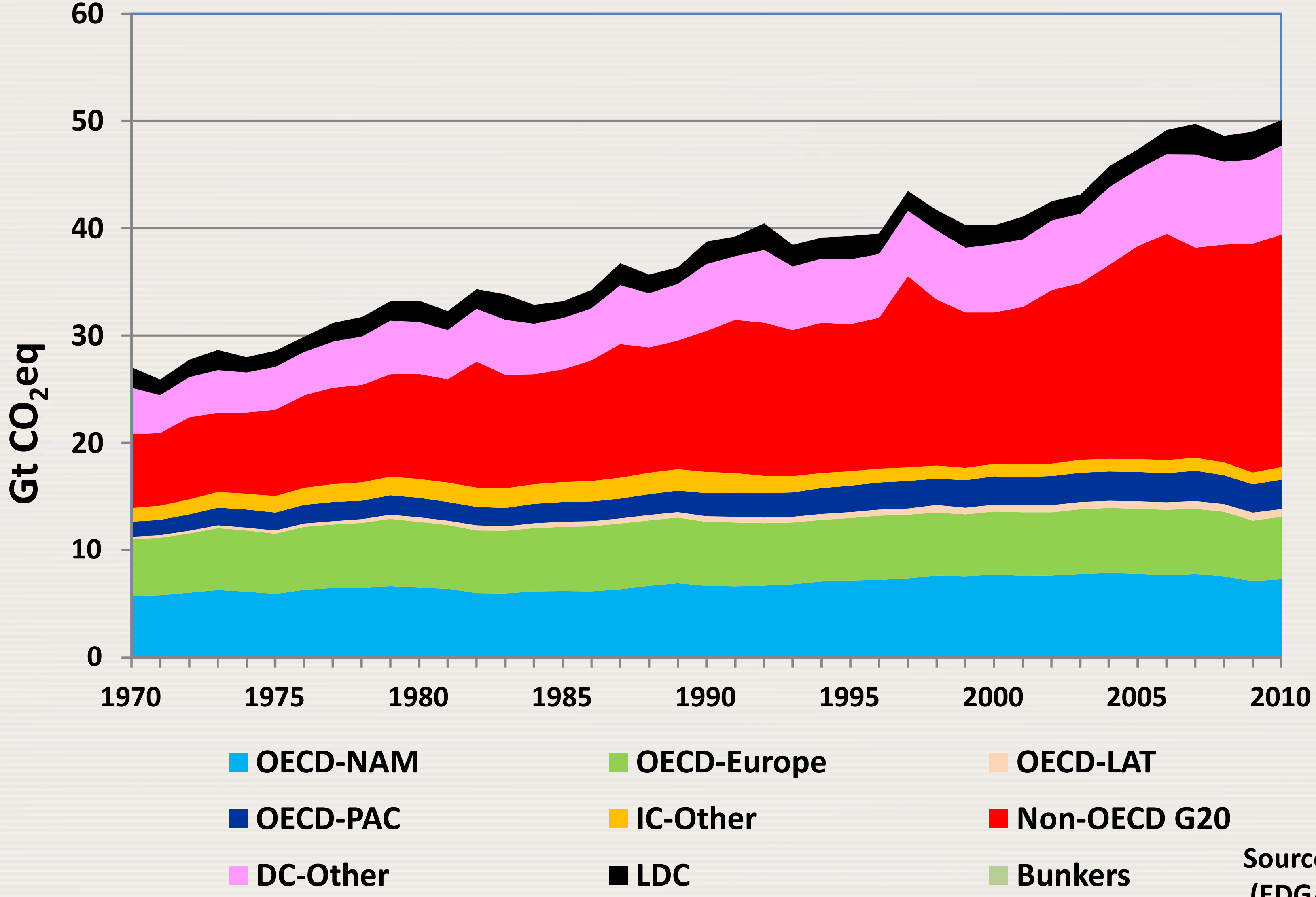


Historical GHG emissions (Kyoto gases)



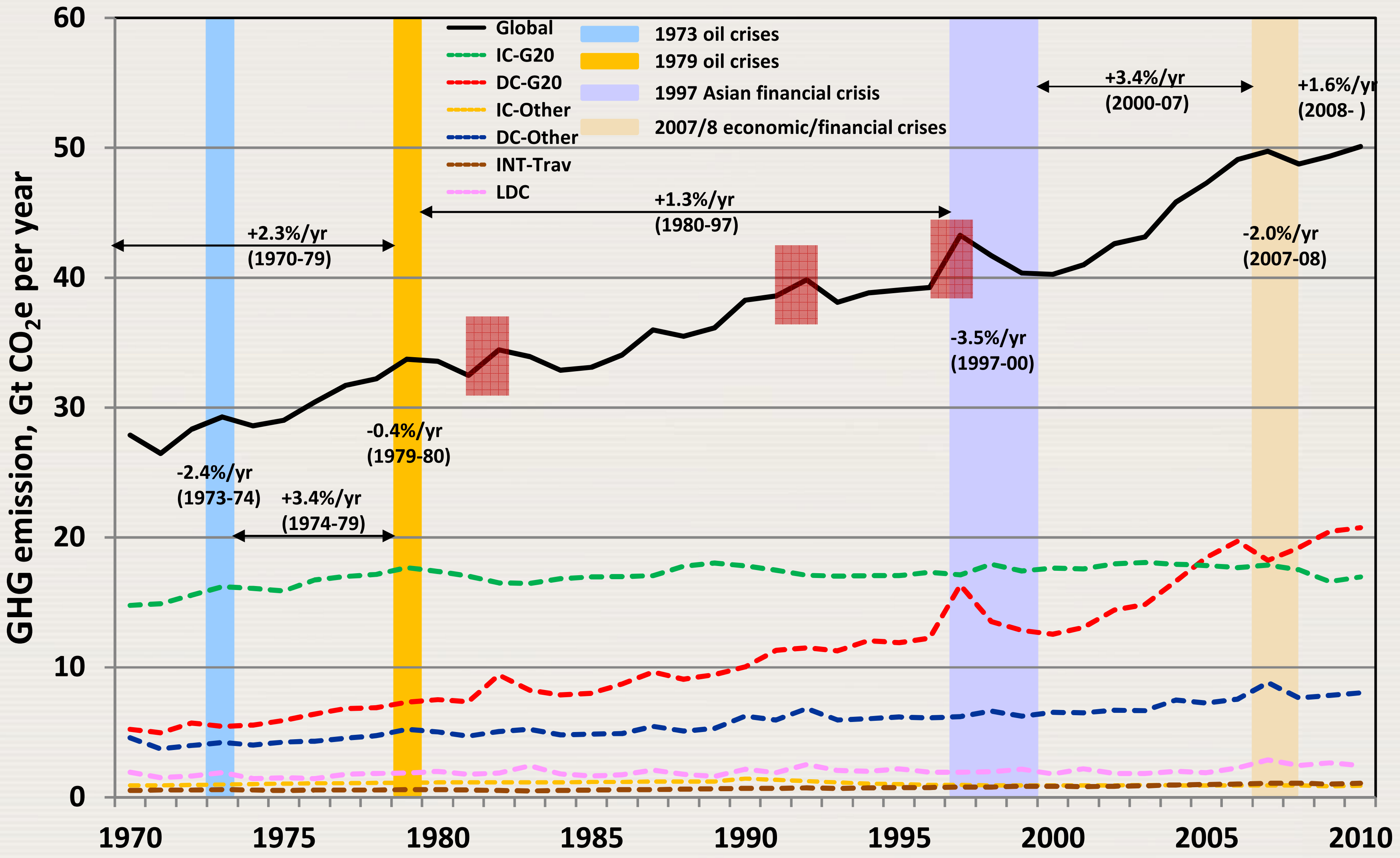
Source: JRC/PBL (2012) (EDGAR 4.2 FT2010)

Global GHG emissions by major region
– all six Kyoto gases



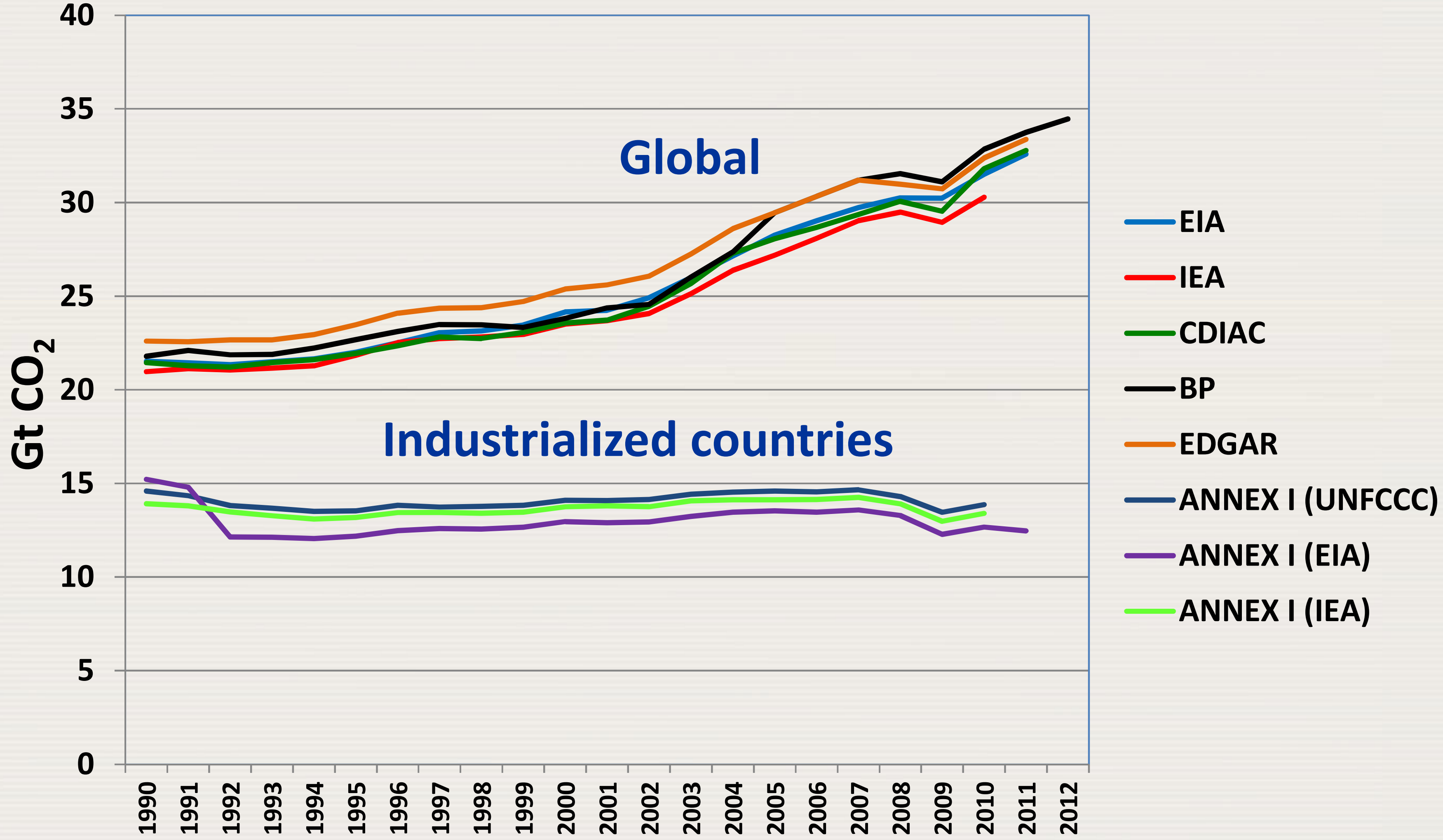
Source: JRC/PBL (2012) (EDGAR 4.2 FT2010)

Global GHG emissions, major economic recessions and El-Ninos

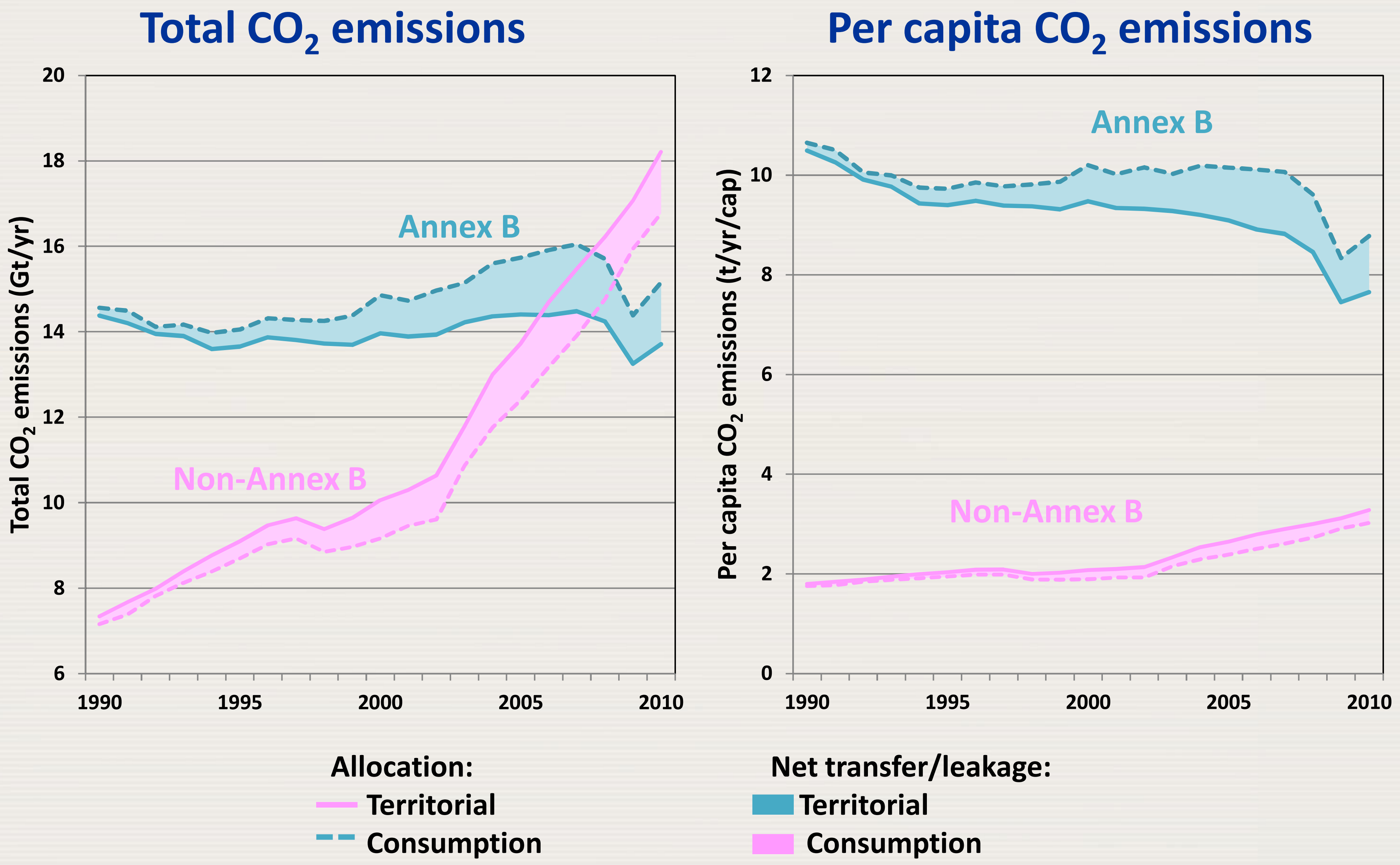


Source: JRC/PBL (2012) (EDGAR 4.2 FT2010)

CO_2 emissions – World and Annex I



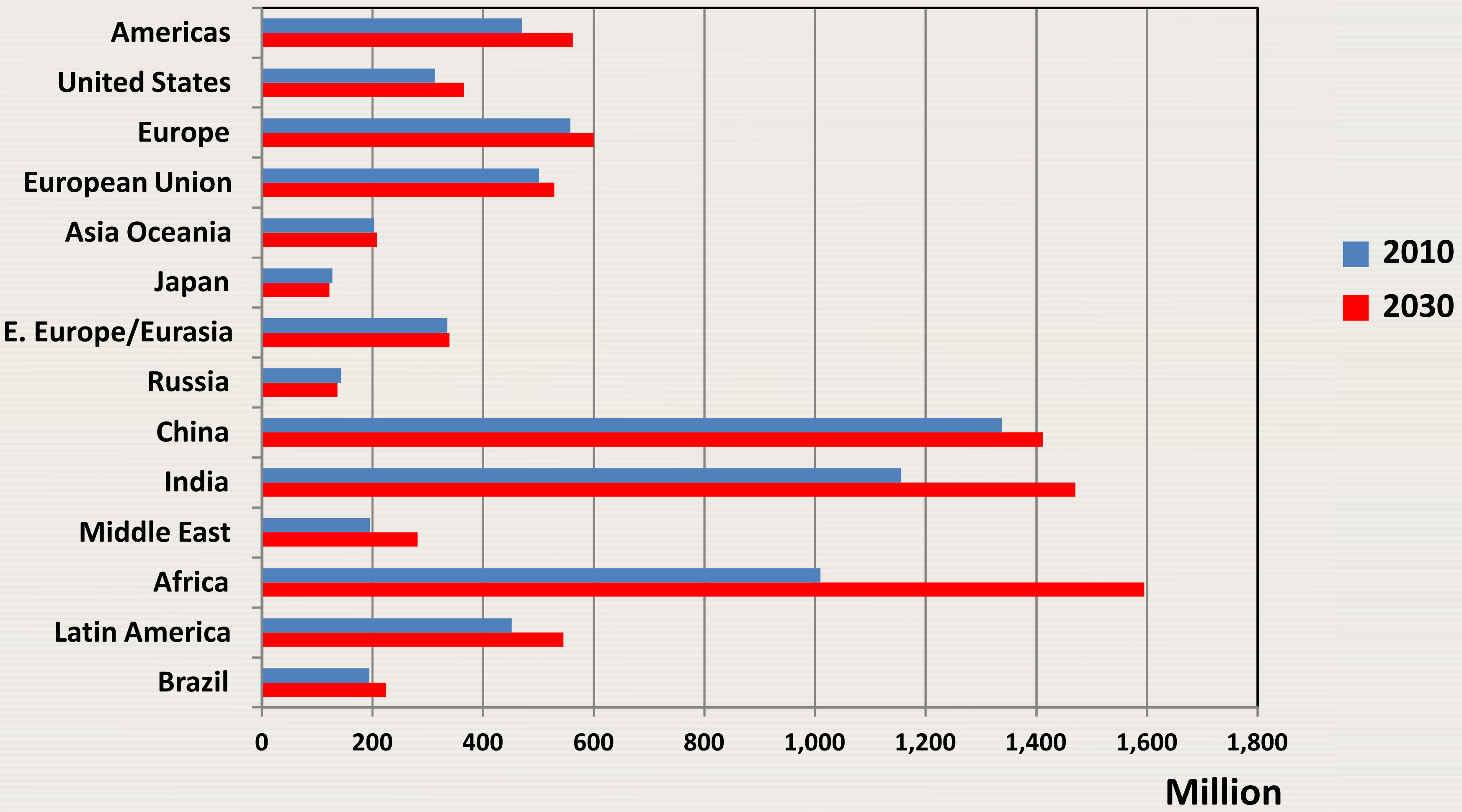
Emissions allocated on the basis of territory (solid lines) and final consumption (dotted lines)



Drivers of future demand for energy services

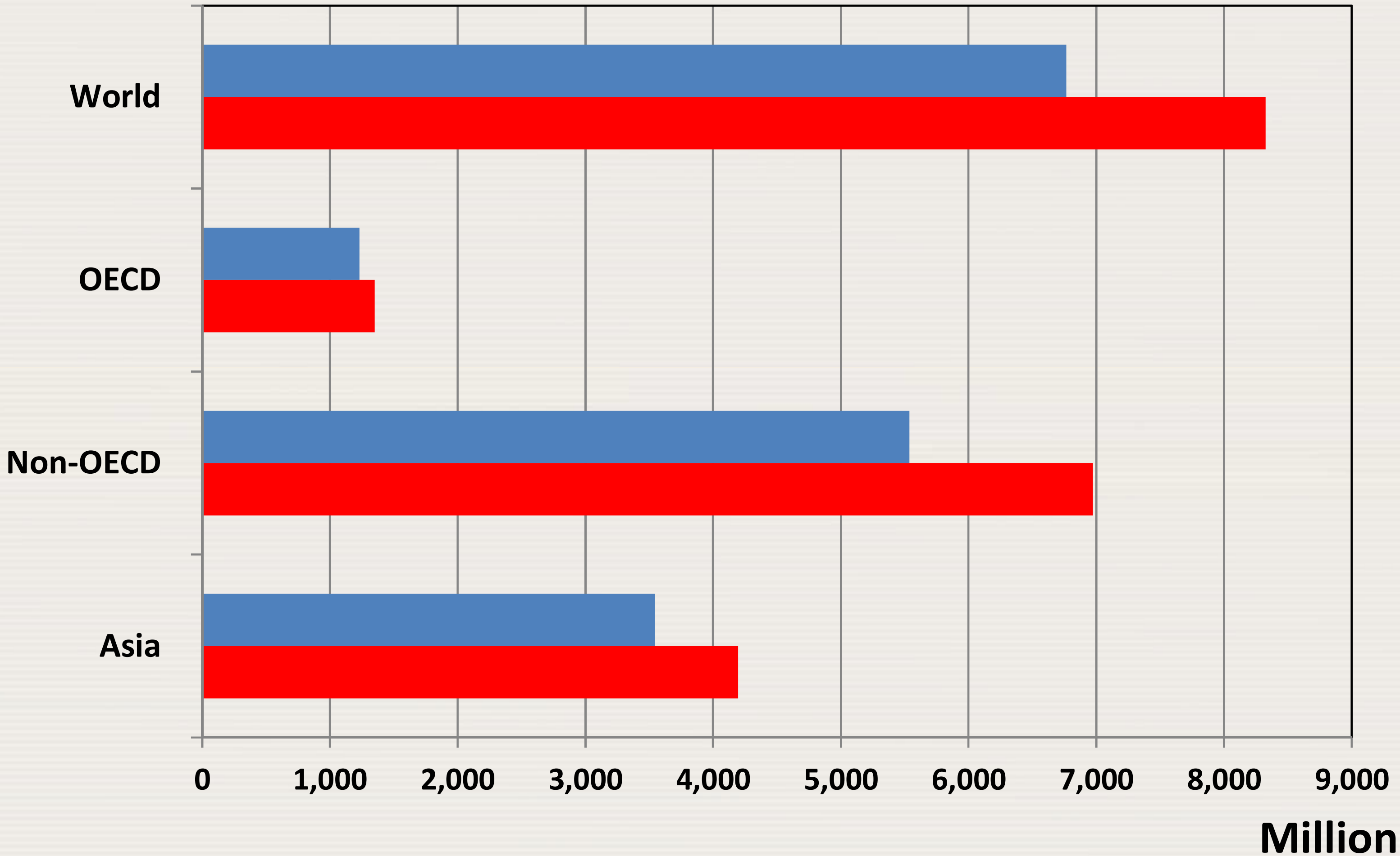
- Demographic development
- Economic development
- Technology
- Environmental policy

Population by major country/region



Source: OECD/IEA - World Energy Outlook 2011/12

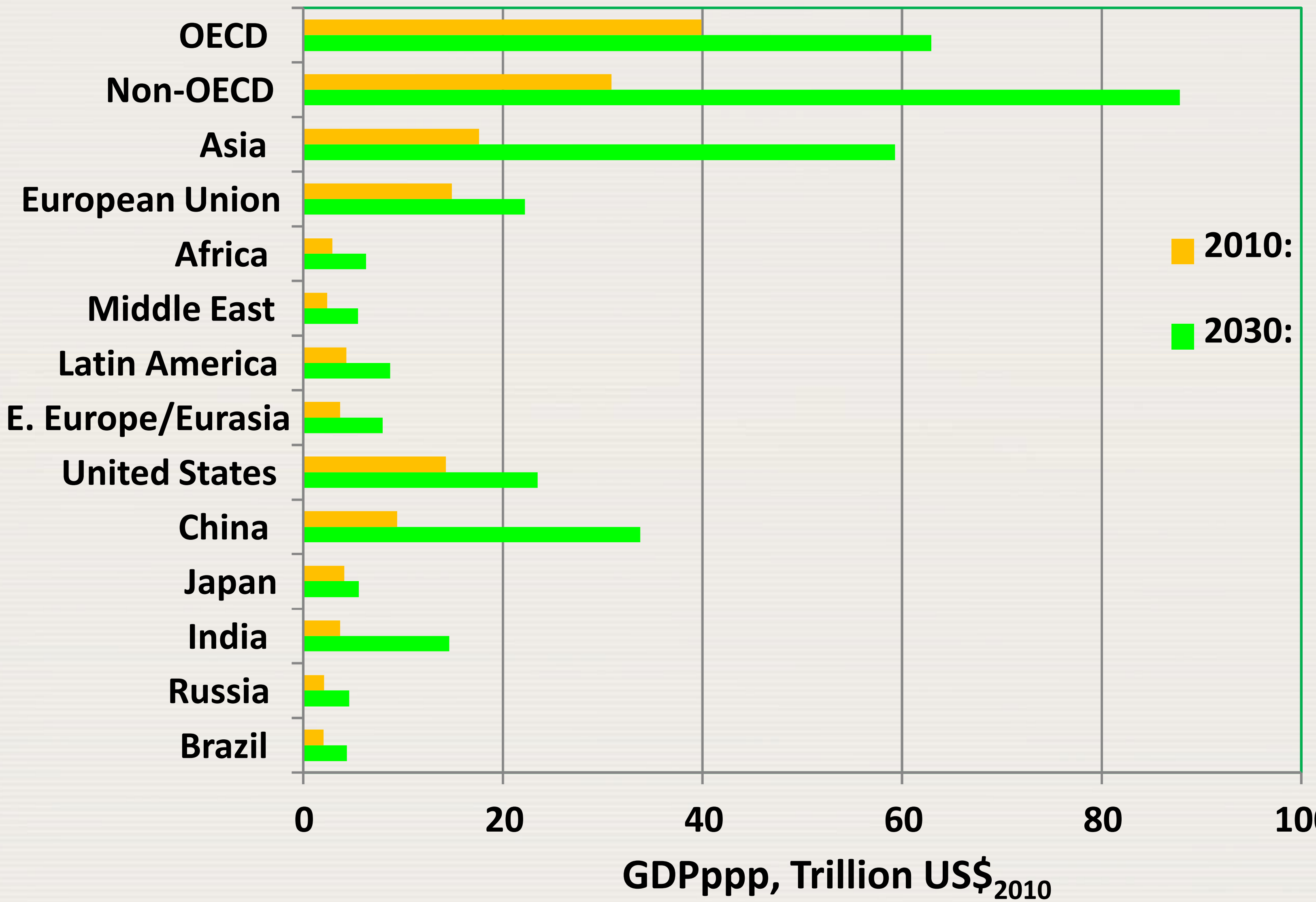
Population by major region



Global population – an important driver of energy needs – is projected to grow by 1% per year on average, from an estimated 6.8 billion in 2010 to 8.3 billion in 2030

Source: OECD/IEA - World Energy Outlook 2011/12

GDP development 2010 – 2030



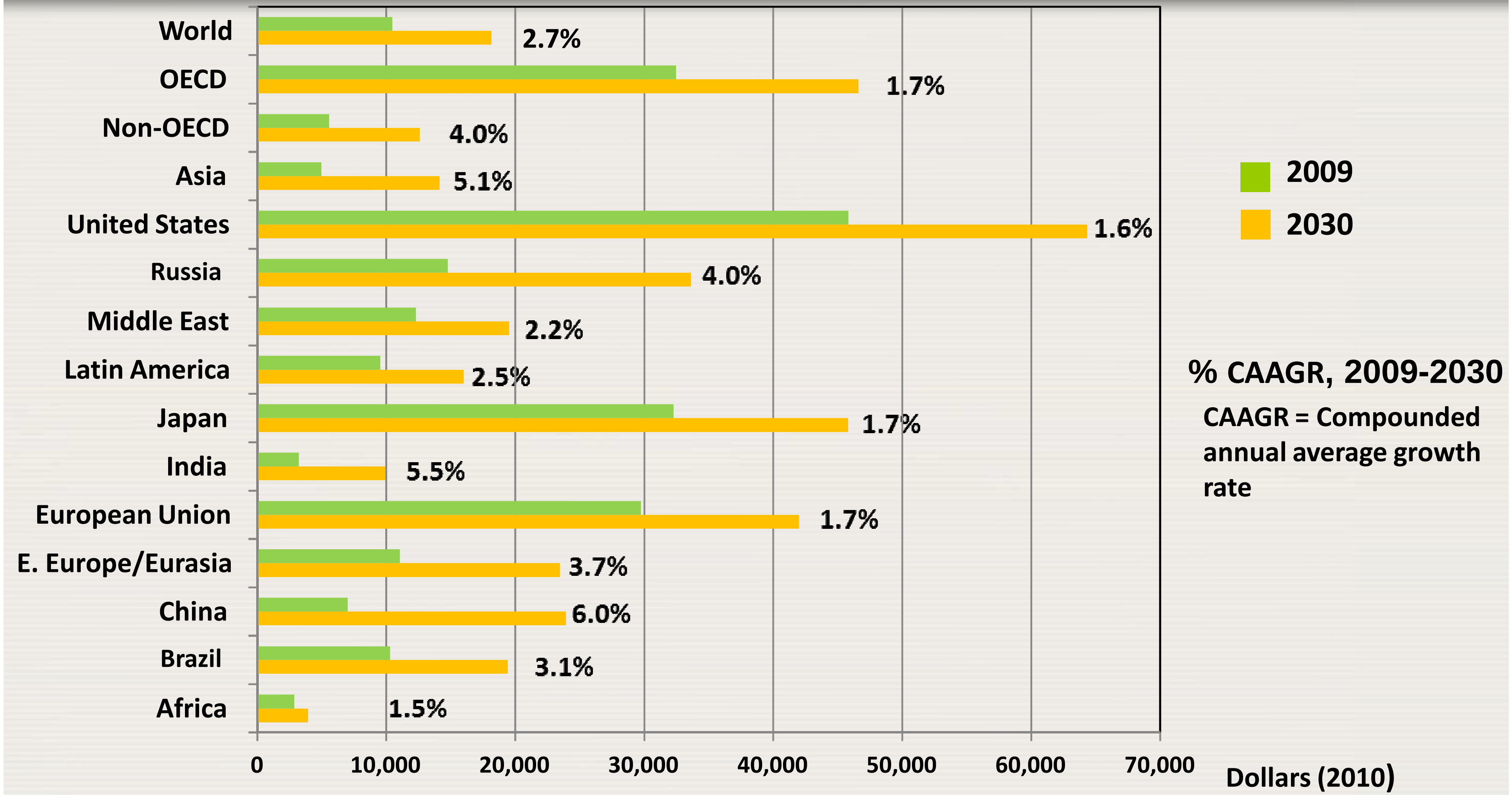
World GDP
Trillion US$ppp
at 2010 prices
and exchange
rates

2010: 70.8

2030: 151.1

Source: OECD/IEA - World Energy Outlook 2011

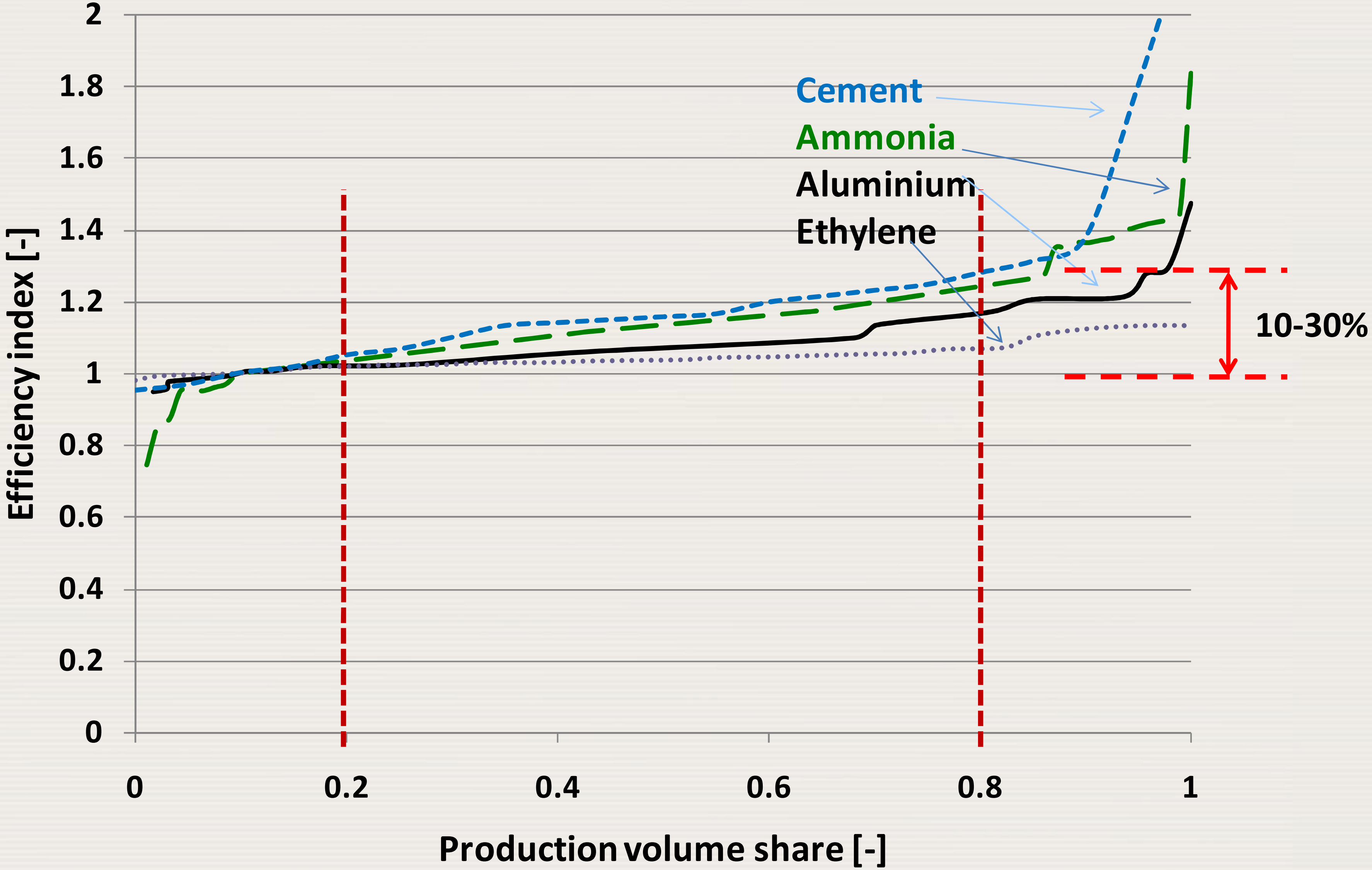
Per-capita income by selected regions



China is assumed to experience the fastest rate of growth in per-capita incomes, but the income gap with OECD countries remains wide in 2030

Source: Adapted from OECD/IEA - World Energy Outlook 2011

Efficiency improvements industrial processes



Technology: Example of energy demand reduction through retrofitting

Before retrofitting

Retrofitting according to the passive house principle

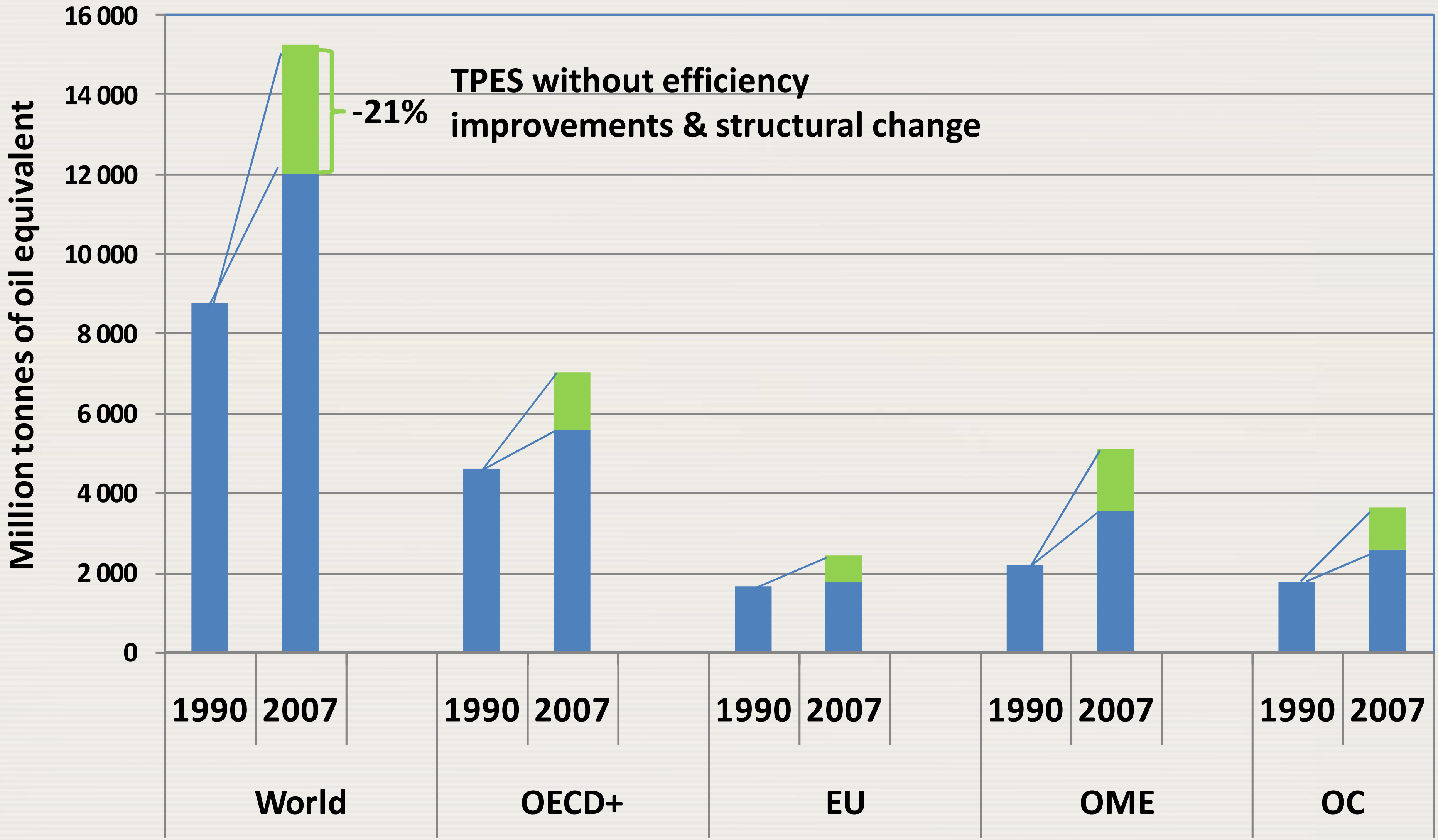
over 150 kWh/(m²a)

-90%

15 kWh/(m²a)

Source: Jan Barta, Center for Passive Buildings, www.pasivnidomy.cz, EEBW2006

Technology & structural change



Innovation: Nuclear power generation

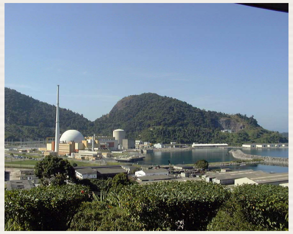
Generation I

Early prototype reactors

- Shippingport
- Dresden, Fermi I
- Magnox

Generation II

Commercial power reactors



- LWR-PWR, BWR
- CANDU
- VVER/RBMK

Generation III

Advanced LWRs & HWRs

- AP1000, ABWR, System 80+
- ACR
- EPR

Generation III+

Evolutionary designs with improved economics and safety for near-term deployment

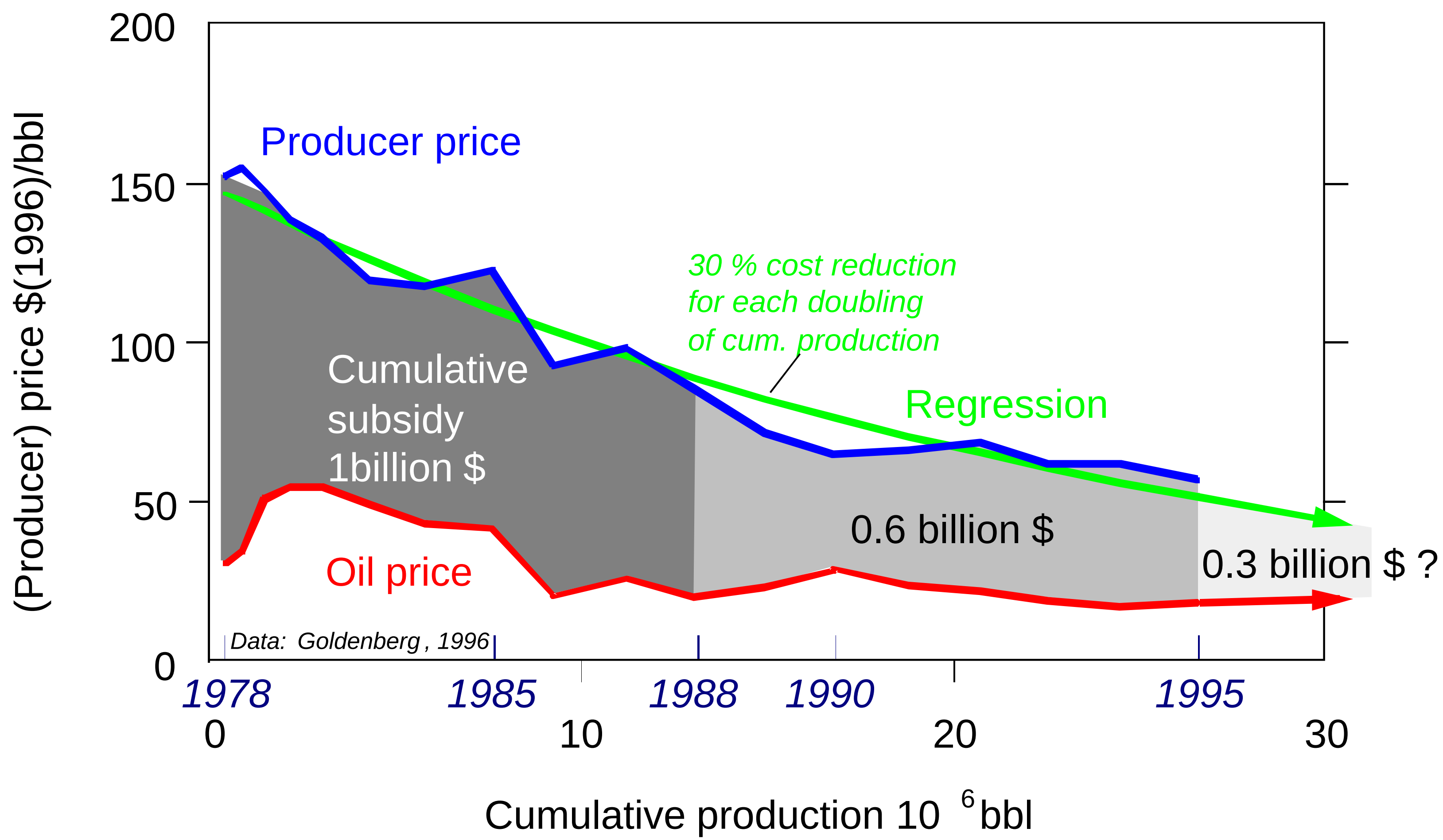
Generation IV

- Highly economical
- Enhanced safety
- Minimal waste
- Proliferation resistant

Gen III | Gen III+ | Gen IV

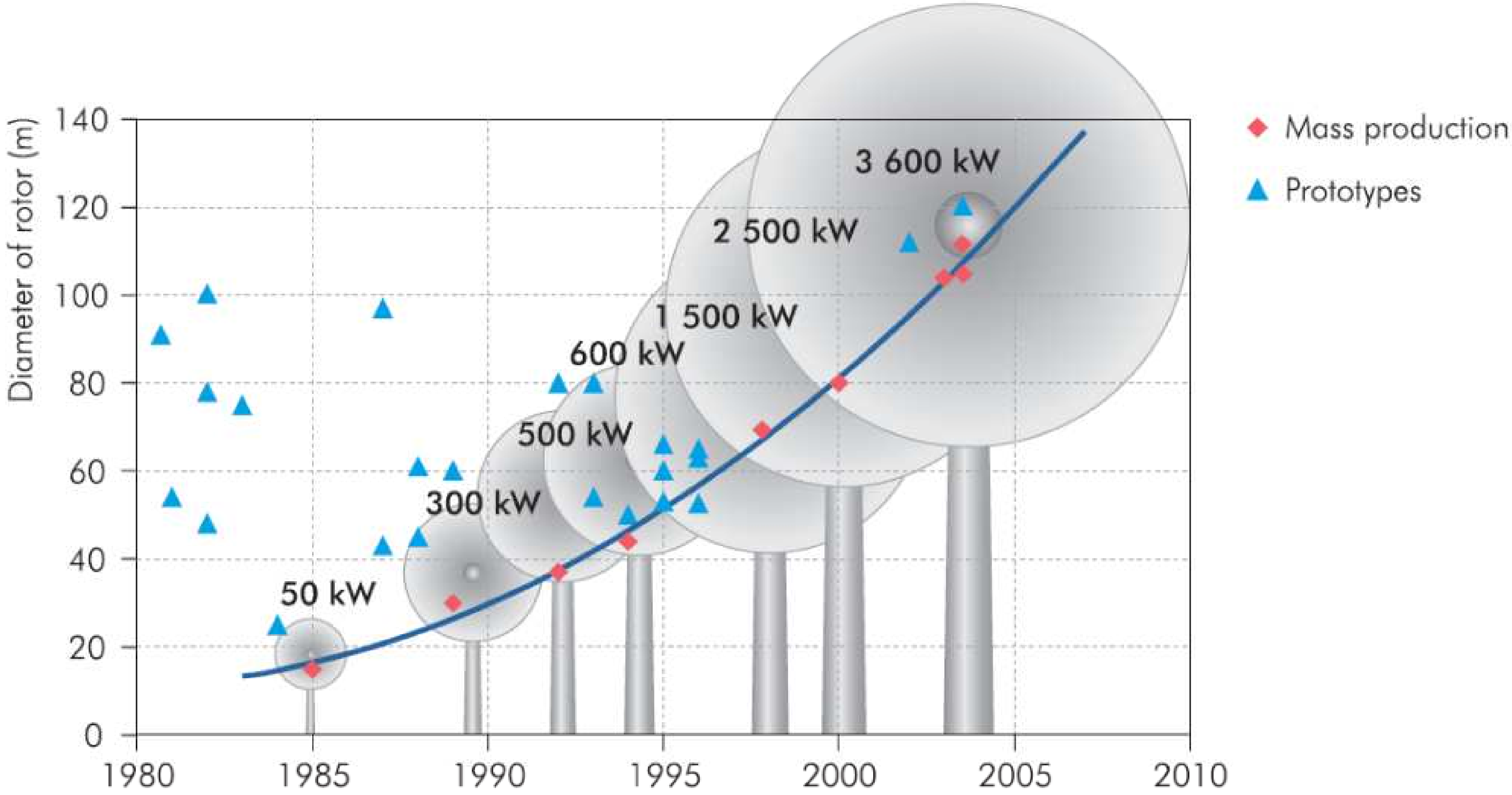
1950 1960 1970 1980 1990 2000 2010 2020 2030

Brazil – Ethanol Learning Curve



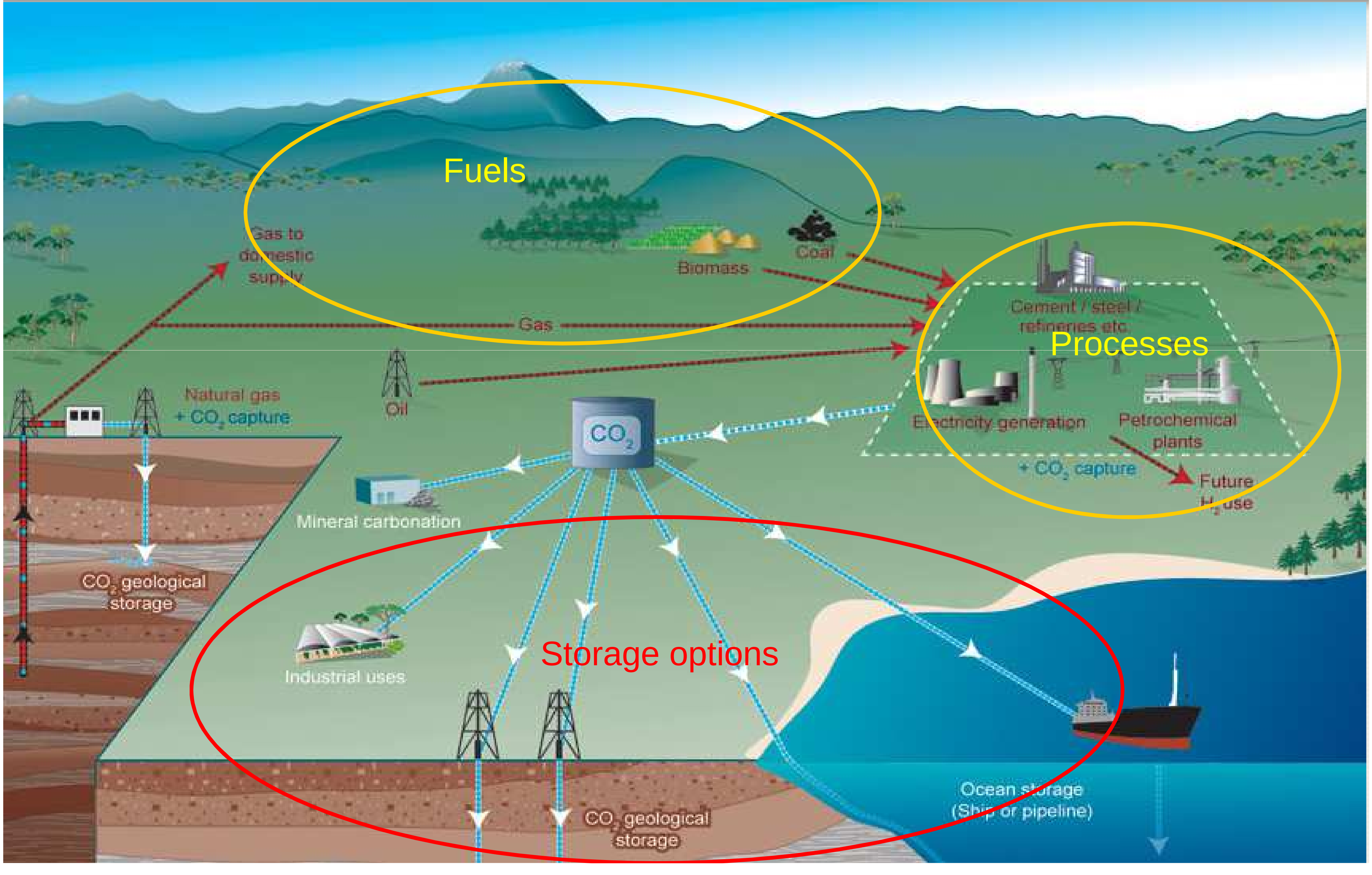
Source: IIASA

Innovation: Wind turbines

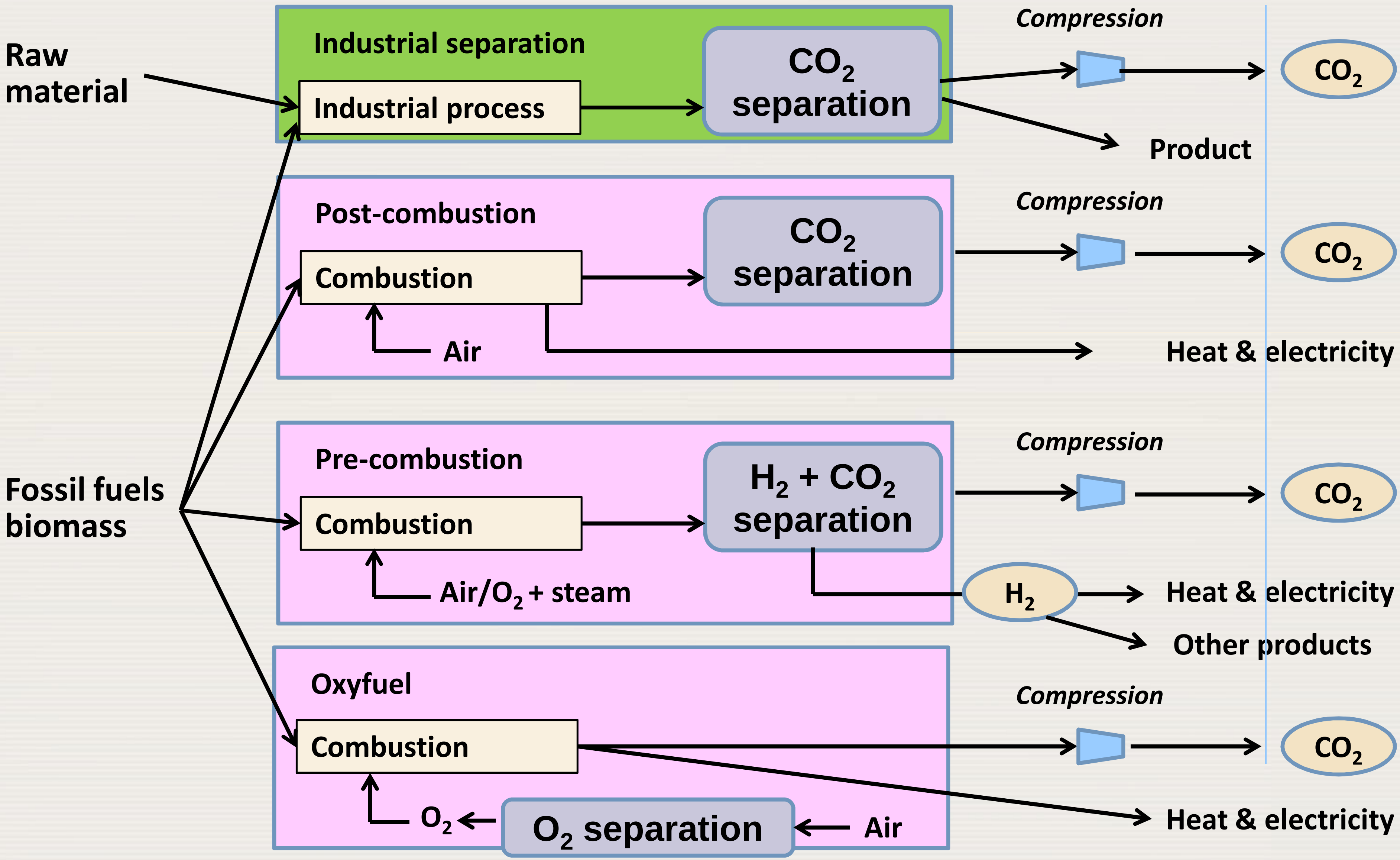


Source: German Wind Energy Institute (DEWI), 2004.

CO_2 capture and storage system

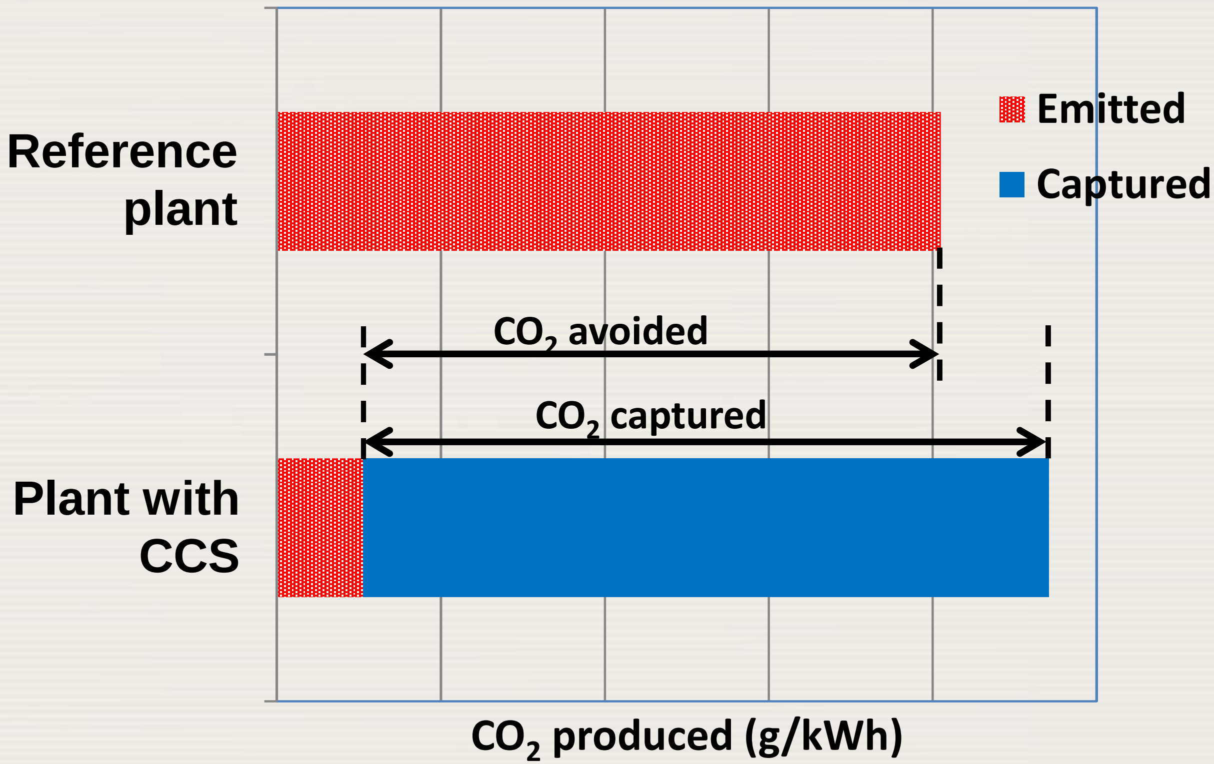


Capture of CO_2



Difference between CO_2 captured and CO_2 emissions avoided

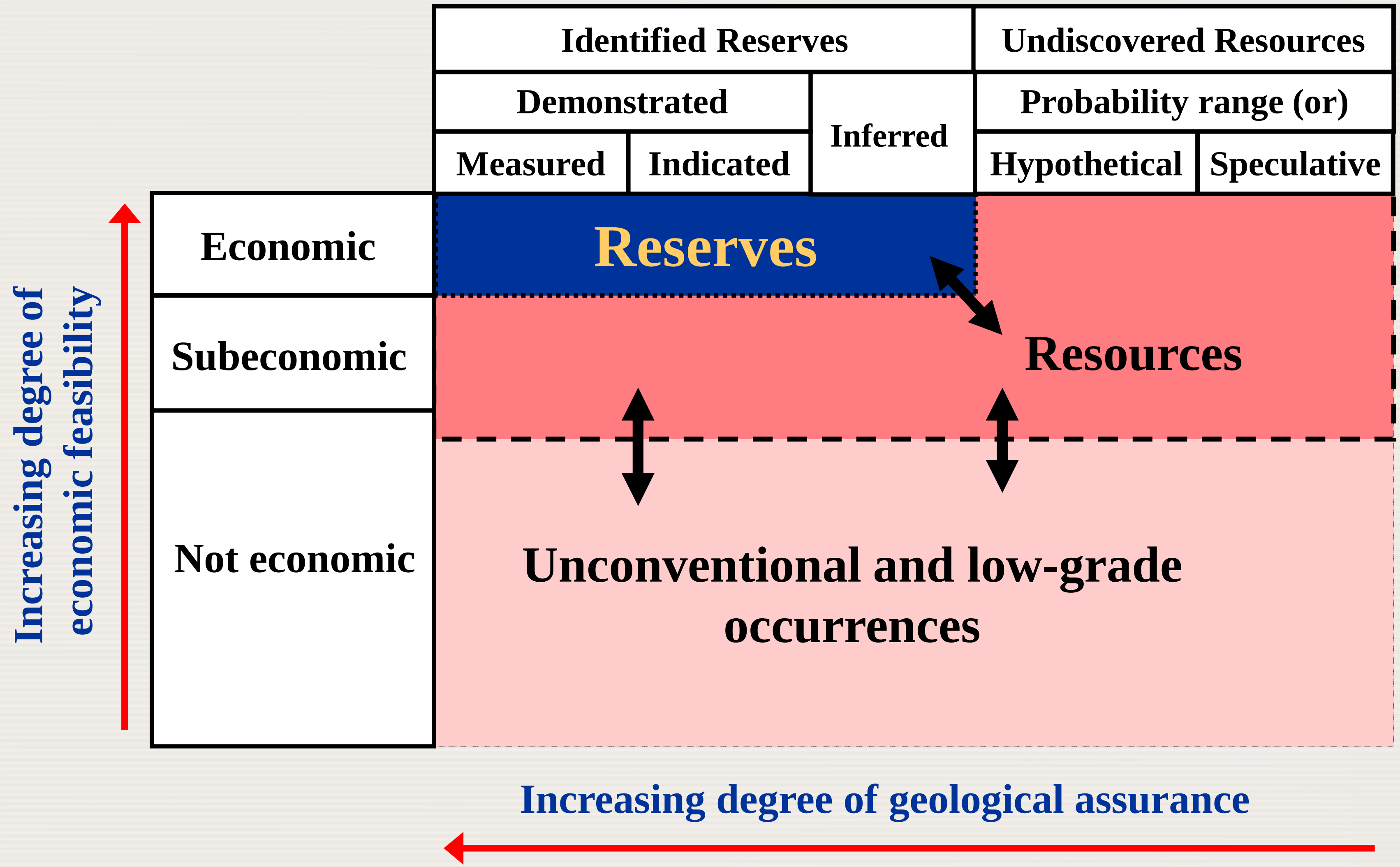
- Additional fuel use of 10 - 40% (for same output)
- Capture efficiency: 85 - 95%
- Net CO2 reduction: 80 - 90%
- Assuming safe storage



A Primer on Exhaustible Resources

- Economists maintain: There are no exhaustible resources really.
- Reserve/resource assessments are efforts of estimating the economic portion of an unknown total.
- What exists in the Earth's crust is "neutral stuff".
- Demand for a resource "creates" it - without demand the resource remains "neutral stuff".
- If production costs become too expensive, alternative solutions will be sought.
- Innovation and advancements of knowledge push the resource frontier of "exhaustible" resources.

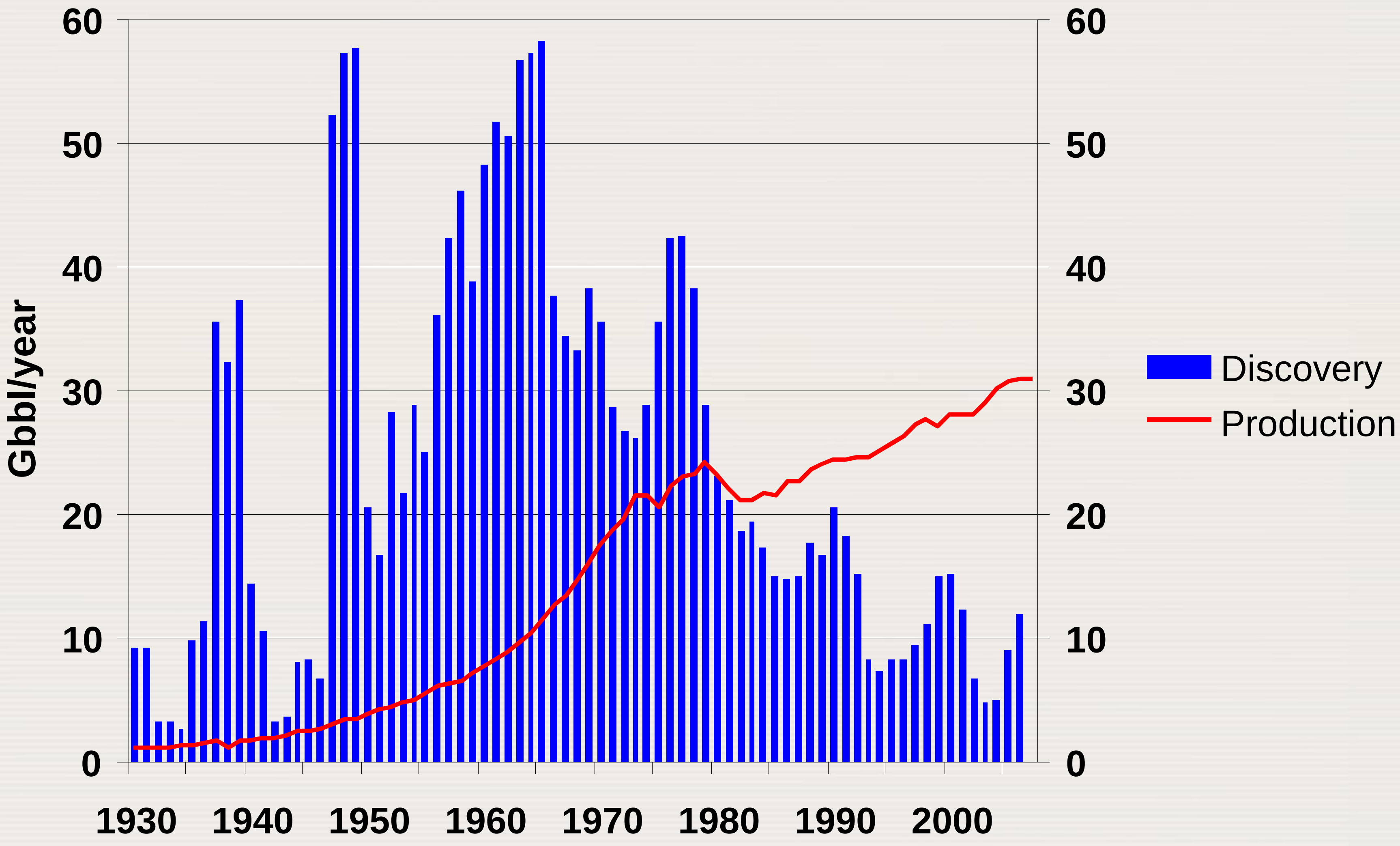
Resource Classification: The McKelvey Box



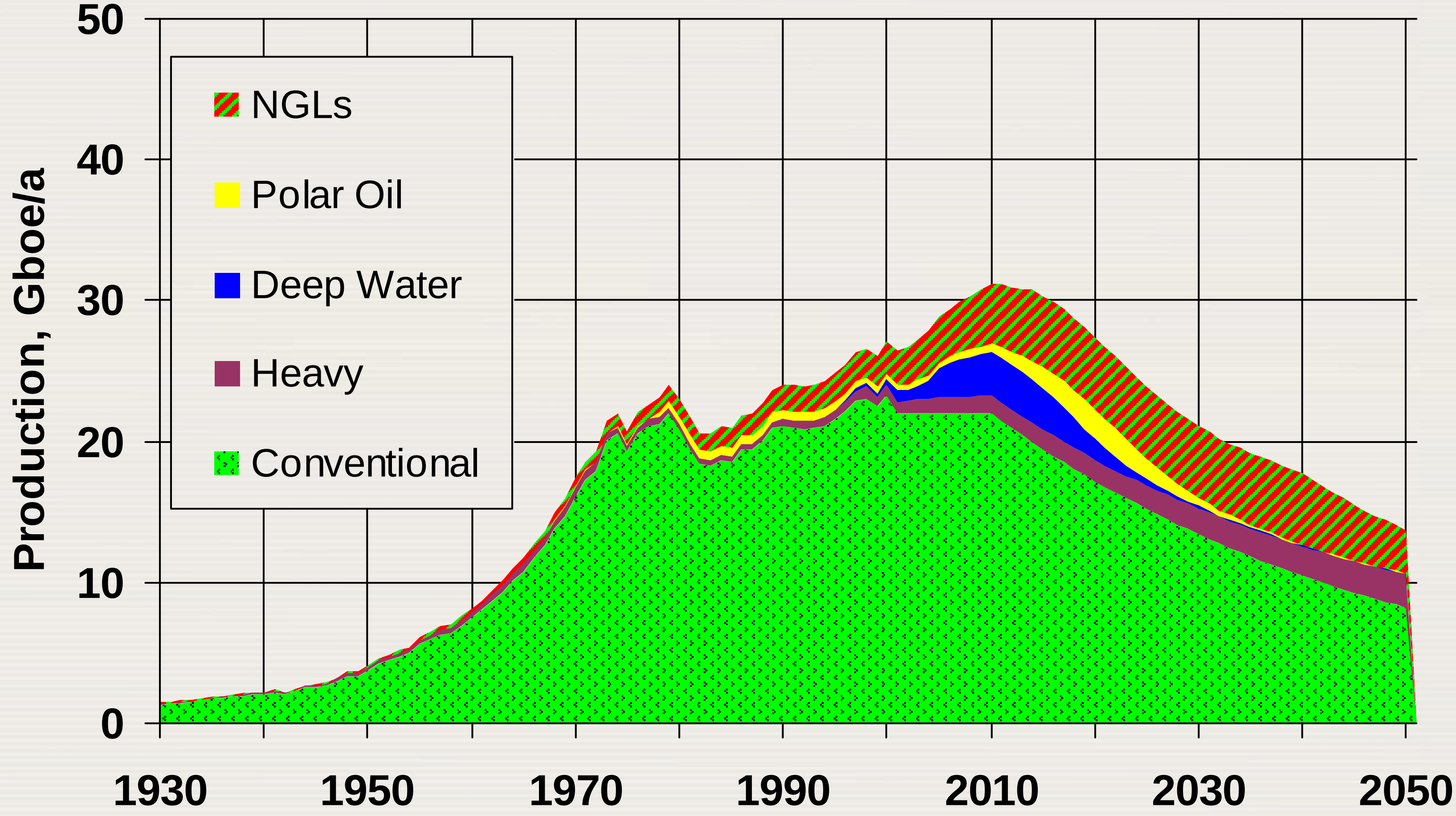
A Primer on Exhaustible Resources

- **The future availability of 'exhaustible resources' must be set in the context of**
  - **Anticipated demand;**
  - **Market prices;**
  - **Alternative fuel cycle options;**
  - **Knowledge; and**
  - **Technology change/innovation.**

Peak oil: Discovery matters



Peak Oil

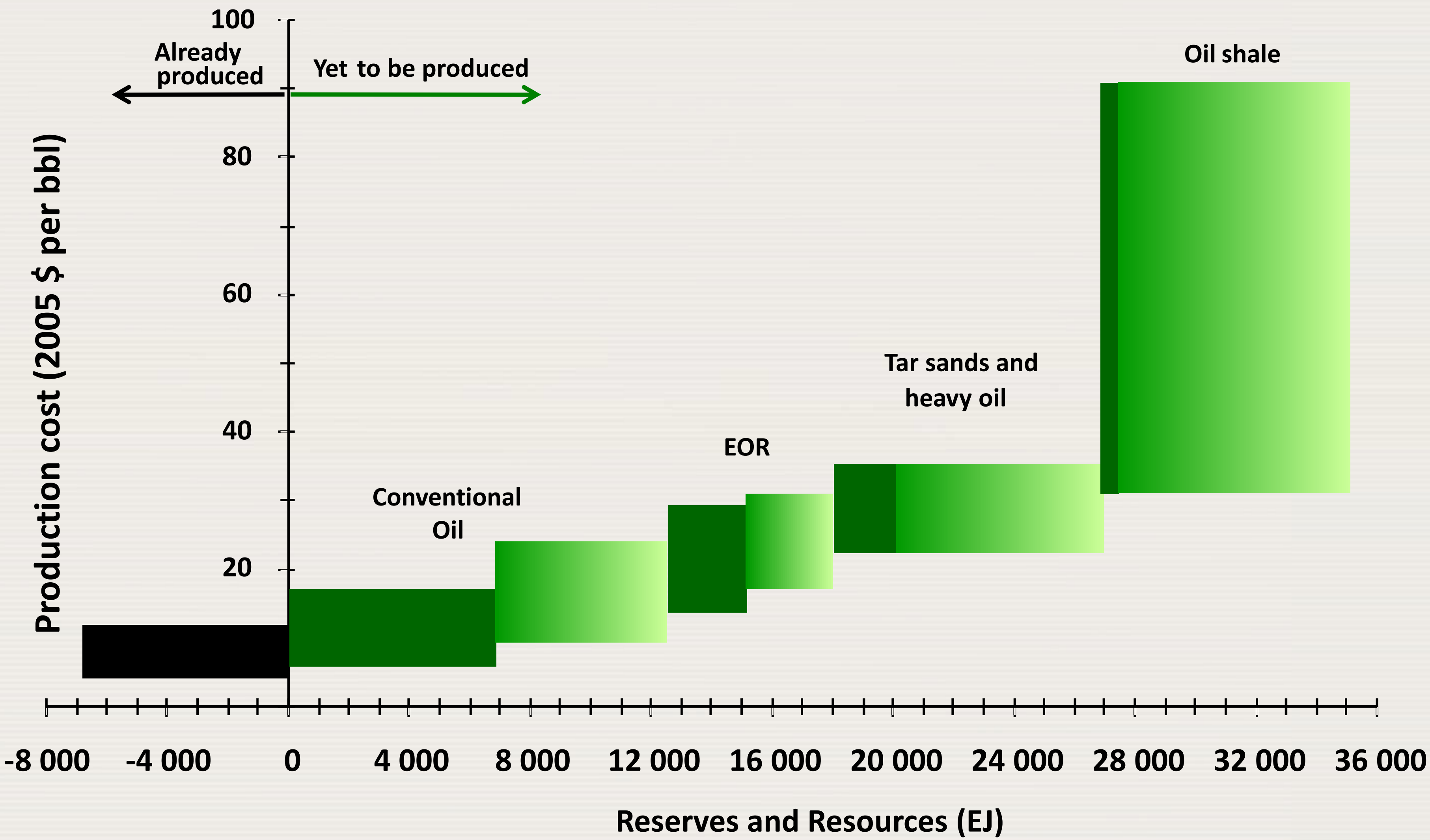


50
40
30
20
10
0
Production, Gboe/a
NGLs
Polar Oil
Deep Water
Heavy
Conventional
1930
1950
1970
1990
2010
2030
2050

Peak oil: Boundaries matter

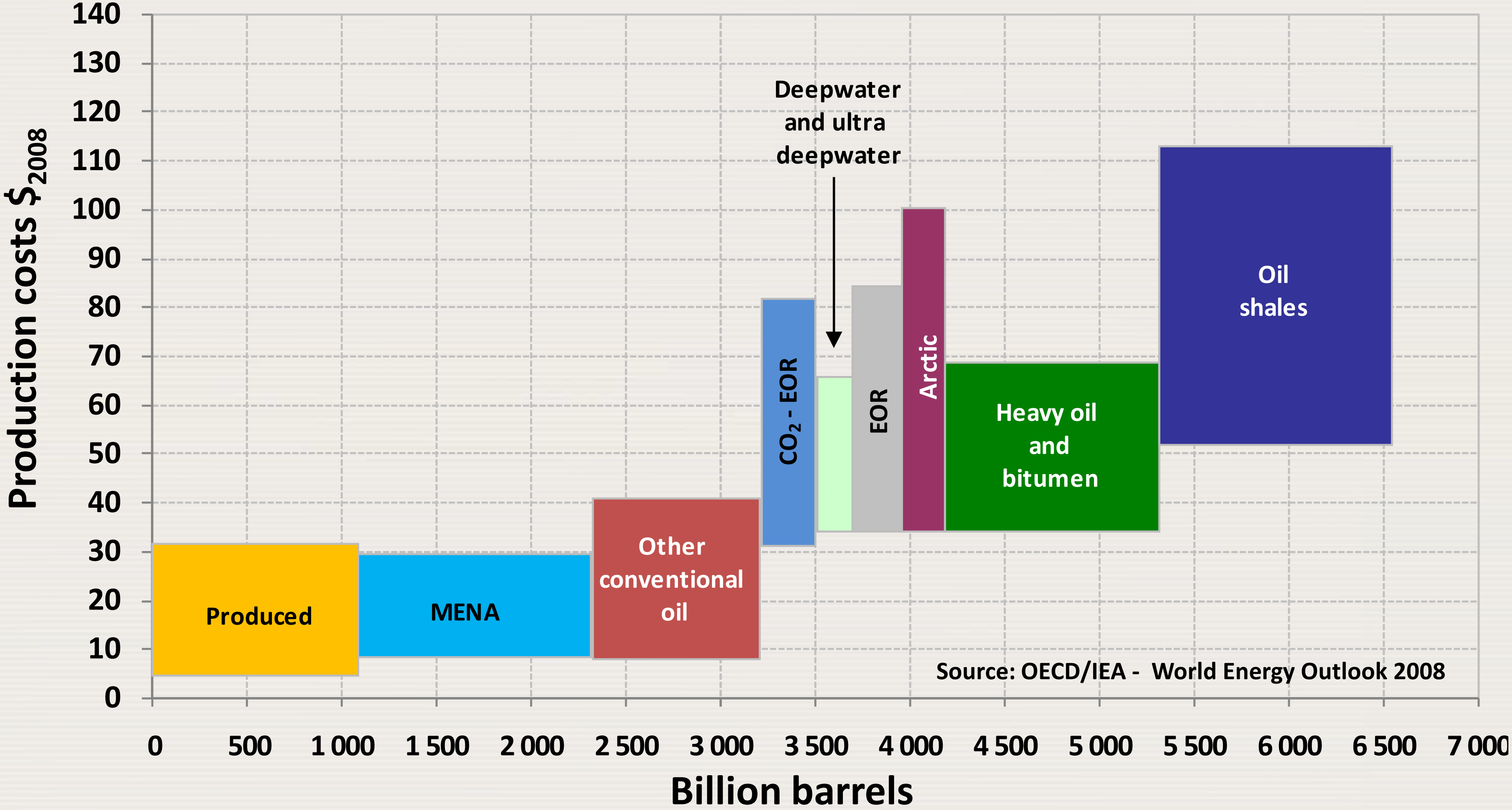
- McKelvey Box
- Economic frontier (demand, technology, prices)
- Static vs dynamic approach
- Conventional vs unconventional oil
- Environmental frontiers
- Social preferences

Global long-term oil-supply cost curve



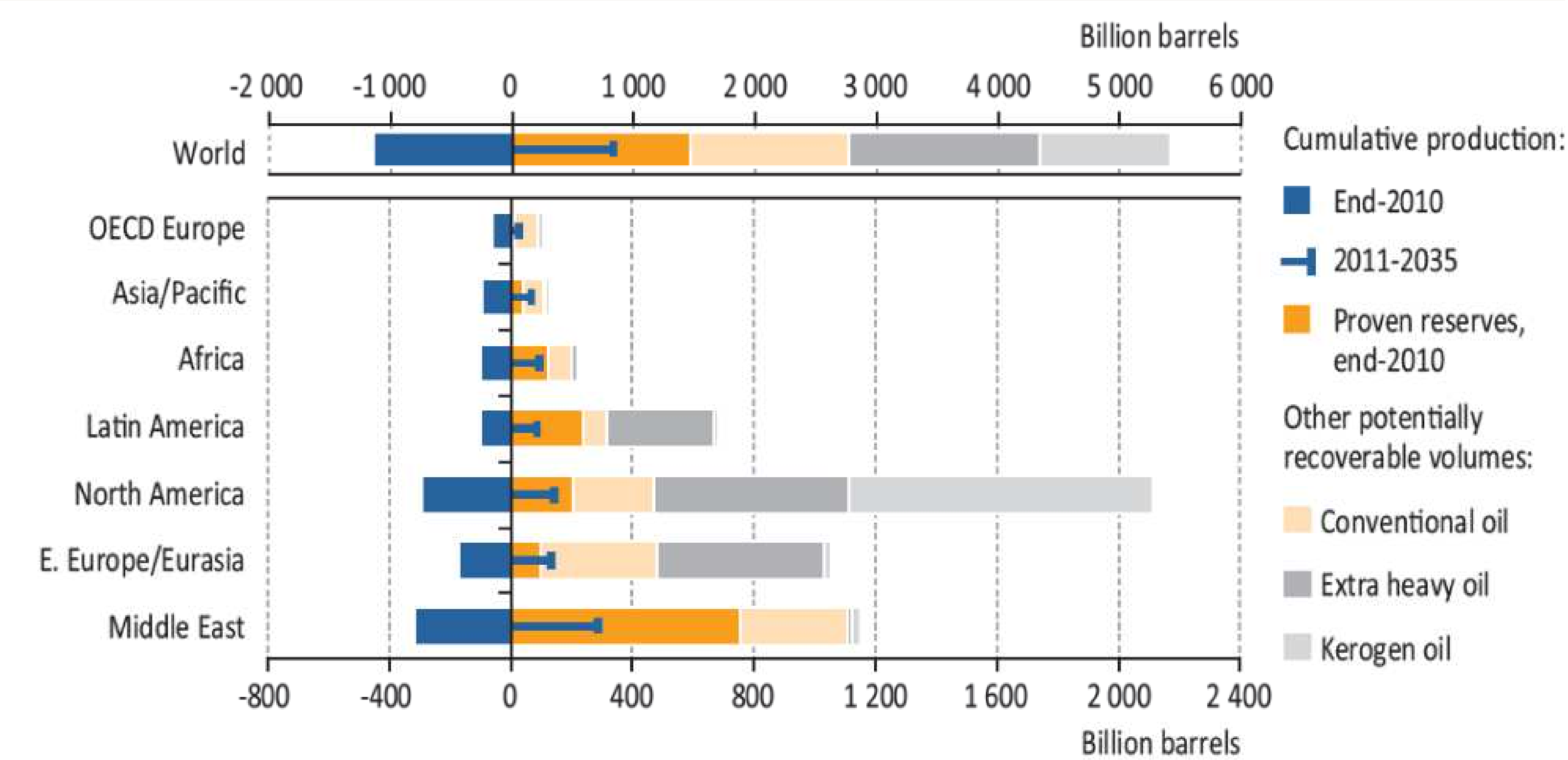
. Source: adapted from Farrell, 2008.

Long-term oil-supply cost curve



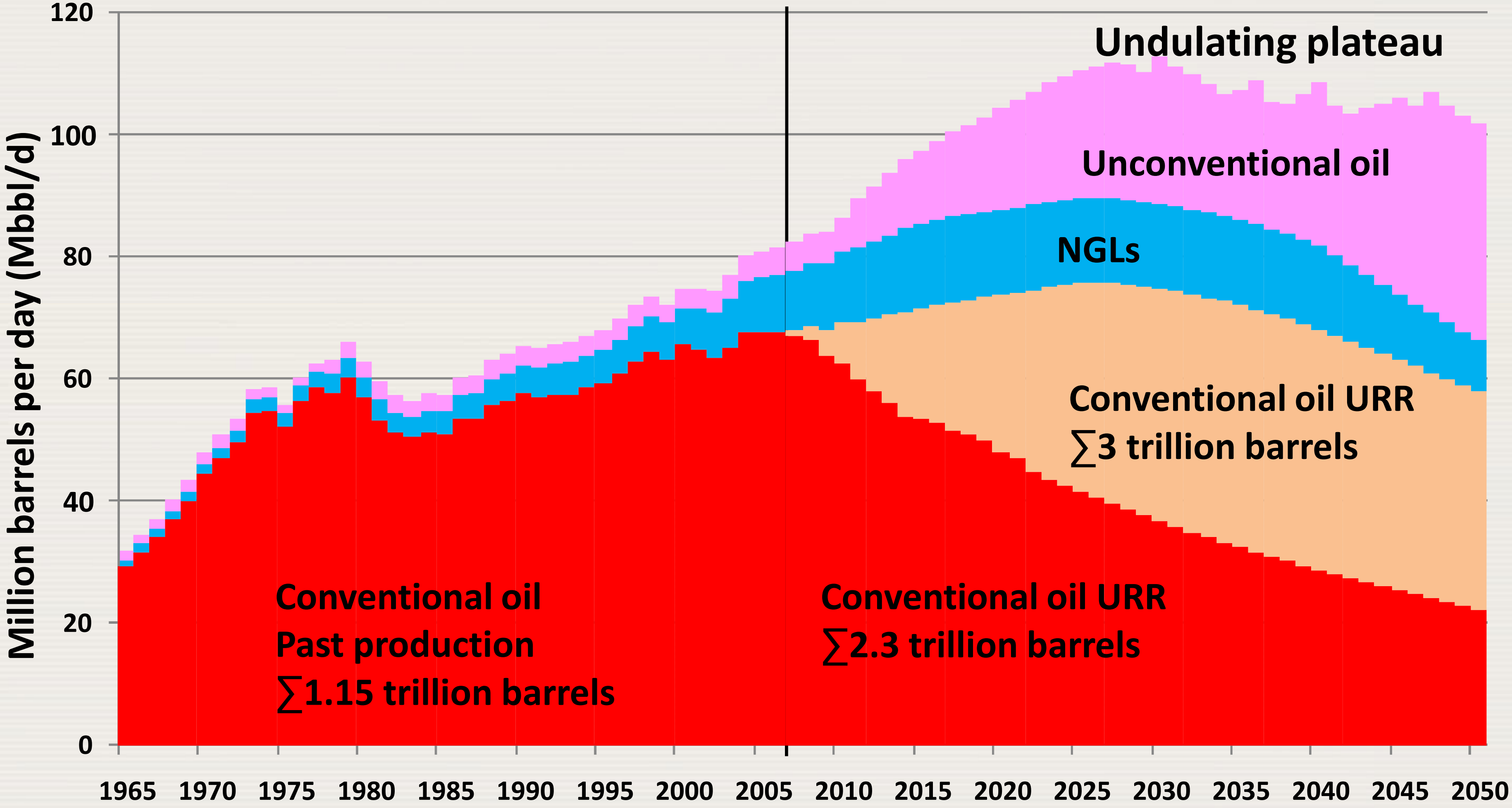
The total recoverable oil-resource base is estimated at 6.5 trillion barrels of which we have so far produced 1.1 Tb

Recoverable oil resources and production by region and type in the New Policies Scenario



Source: OECD/IEA - World Energy Outlook 2011

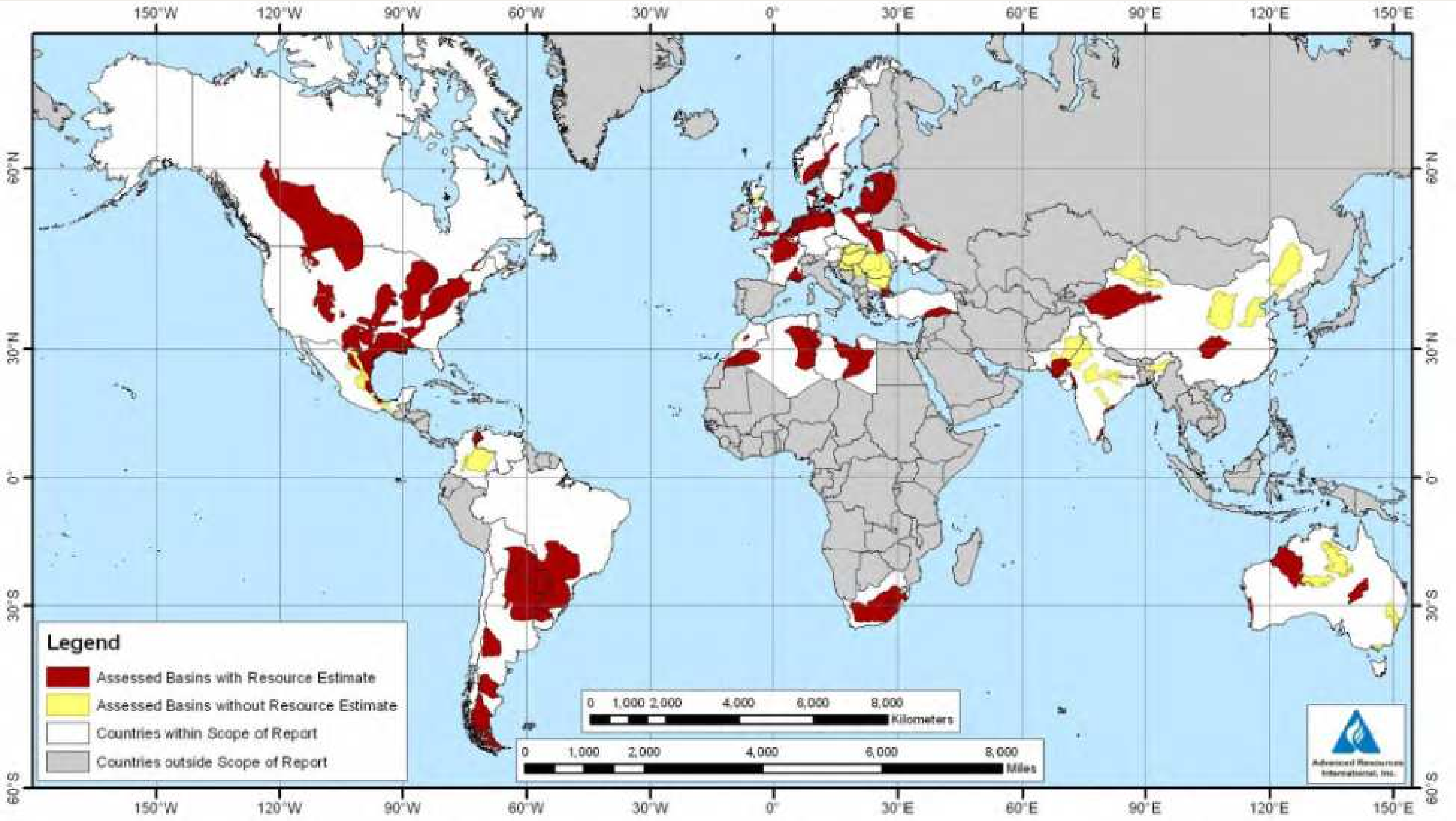
Peak oil or undulating plateau?



Shale gas – another player on the scene?

- Existence known for quite some time but no technology solution for economic extraction
- Hydraulic fracturing key to mobilizing the methane
- Major impact on the NA gas market
- Analogies sought elsewhere
- Low carbon contents

Map of 48 major shale gas basins in 32 countries

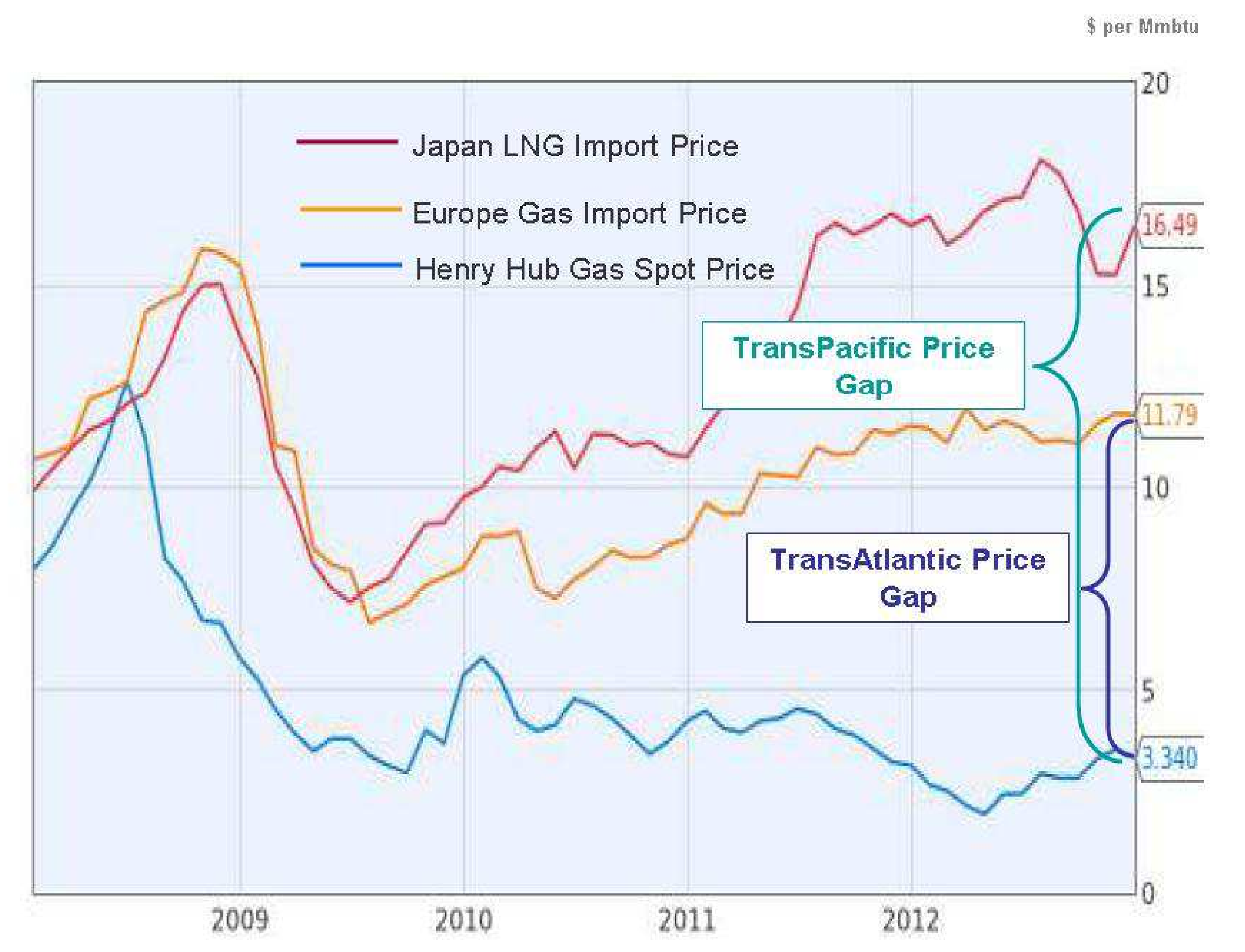


Source: USDOE EIA, 2011

Issues & challenges

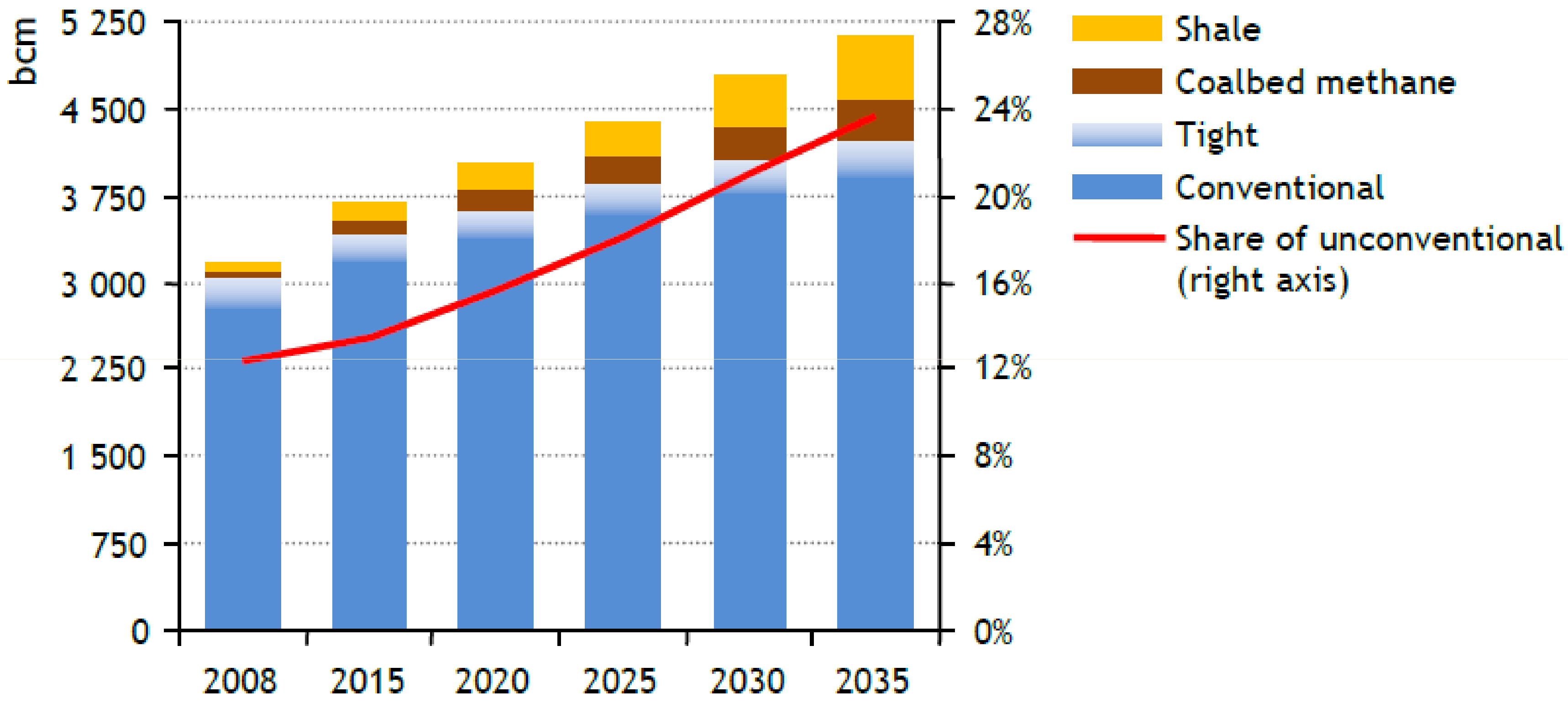
- Most regions outside NA with limited or no resources (not to speak of reserve) assessments and poor understanding of production costs
- Share of economically producible quantities (recovery rates) yet to be determined
  - Initially reserves are a small sub-set of resources but are dynamically changing
  - Reserves take years of development drilling and lots of $ before turning into supplies
  - Known reserves may never be developed
- Traps versus ‘continuous‘ basins’
- Current prices in the US are not sustainable unless cost reductions through technology progress
- Prices elsewhere should be a stimulus

Interregional gas price gaps



Source: Alboran Research

Natural gas production by type in the IEA GAS Scenario



Source: Are we entering a golden age of gas? IEA, 2011

Estimates of conventional natural gas reserves

Region	OGJ (2007) [TCF]	EIA (2008) [TCF]	Cedigaz (2009) [TCF]	BP (2010) [TCF]	BGR (2010) [TCF]	OPEC (2008) [TCF]	USGS (2000) [TCF]
Europe	172	176	193	154	185	220	274
CIS	2,015	2,137	1,939	2,074	2,244	2,052	1,657
Africa	490	501	522	521	521	513	338
Middle East	2,549	2,555	2,654	2,688	2,661	2,597	1,604
Asia	415	498	535	574	569	536	409
North America	283	287	335	307	329	283	222
Latin America	262	242	264	301	268	266	255
World	6,186	6,395	6,441	6,618	6,776	6,468	4,759

Risked gas in-place and technically recoverable shale gas resources

Continent	Risked Gas In-Place (Tcf)	Risked Technically Recoverable (Tcf)
U.S.	3,760	940
Other North America	3,856	1,069
South America	4,569	1,225
Europe	2,587	624
Africa	3,962	1,042
Asia	5,661	1,404
Australia	1,381	396
Total	**25,776**	**6,700**

Advanced Resources International, Inc.

Global Energy Assessment (GEA) Rogner 1997

Resource Potential
14,900 EJ or
14,100 Tcf
16,100 Tcf

Reserves
6,300 EJ or
5,970 Tcf

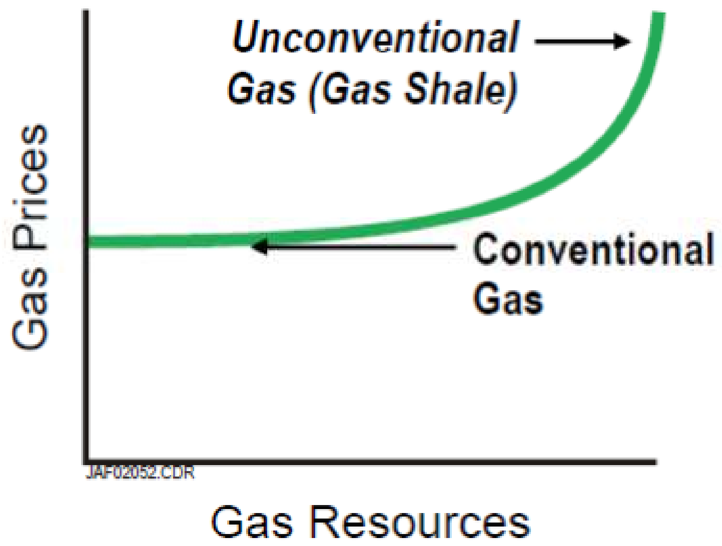
Success/Risk Factors

- The resource values for each basin have been risked for:
- the probability that the shale gas formation will (or will not) have sufficiently attractive gas flow rates to become developed; and
- an expectation of how much of the prospective area will be developed in the foreseeable future

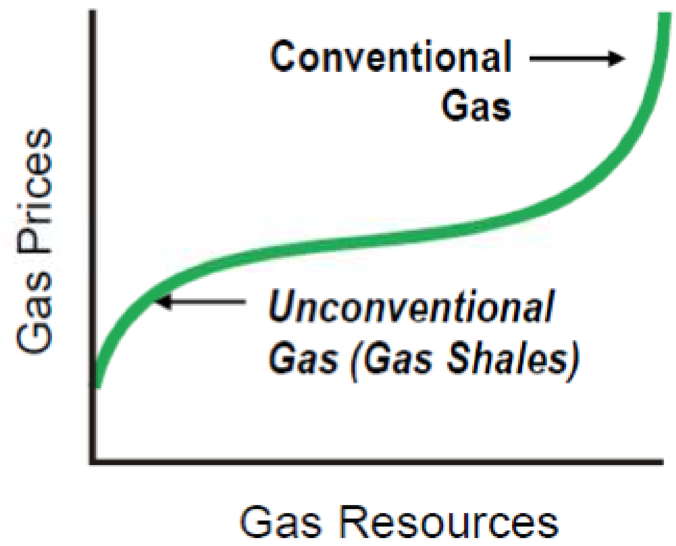
Shale gas impact on natural gas prices

Unconventional gas (particularly the higher quality gas shales) is today the low cost portion of the natural gas price/supply curve.

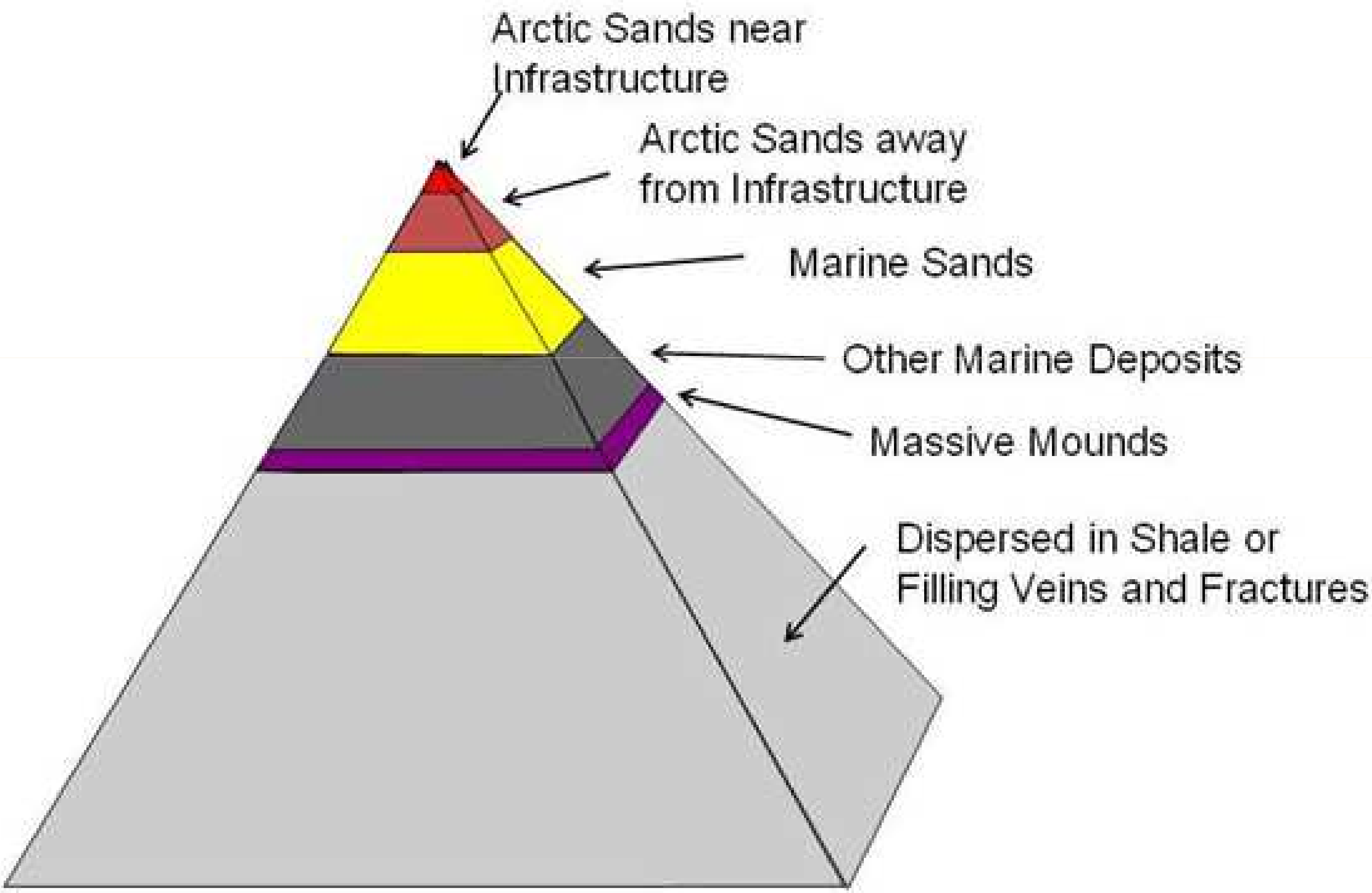
Prior Perception



New Understanding



Magnitude of gas hydrate potential by type of deposit



~ 2,7000,000 EJ

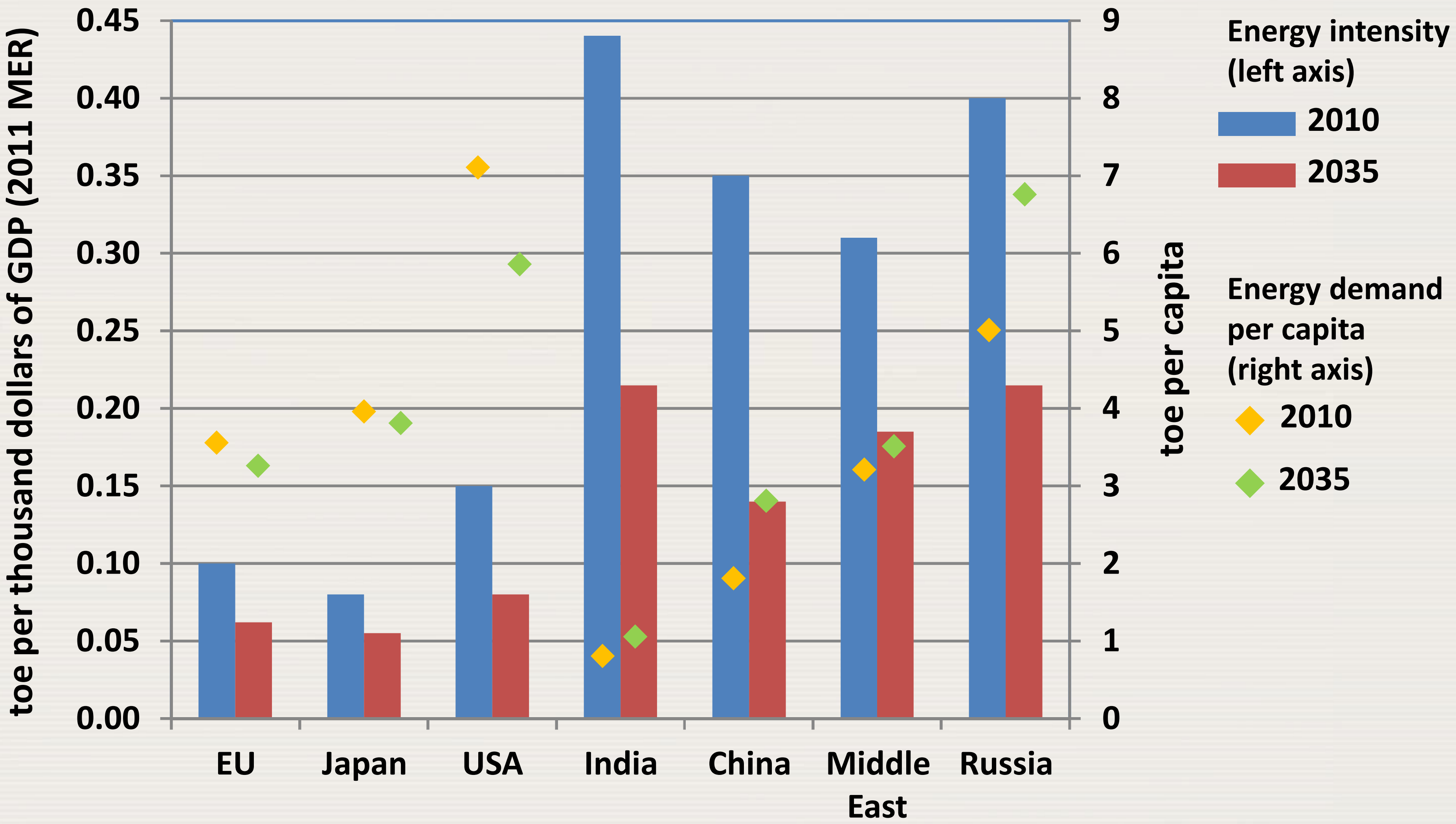
Fossil and uranium occurrences

TPES in 2010: ~500 EJ	Historical production through 2010	Production 2010	Reserves	Resources	Additional occurrences
	[EJ]	[EJ]	[EJ]	[EJ]	[EJ]
Conventional oil	6 788	141.2	4 900 - 7 610	4 170 - 6 150	
Unconventional oil	629	22.7	3 750 - 5 600	11 280 - 21 000	> 40 000
Conventional gas	3 572	105.5	5 000 - 7 100	7 200 - 10 650	
Unconventional gas	173	15.1	20 100 - 67 100	40 200 - 121 900	> 1 000 000
Coal	7 426	156.2	17 300 - 21 000	291 000 - 435 000	
Conventional uranium	1,484	31.6	2 400	7 400	
Unconventional uranium	34			7 100	> 2 600 000
Conventional oil (Gbbl)	1 188	24.7	860 - 1 333	730 - 1 080	
Unconventional oil (Gbbl)	110	4.0	660 - 980	1 970 - 3 690	> 7 000
Conventional gas (Tcm)	96	2.8	134 - 190	193 - 287	
Unconventional gas (Tcm)	5	0.4	540 - 1 800	1 080 - 3 200	> 25 000
Coal (Gtce)	253	5.3	590 - 720	9 930 - 14 800	
Conventional uranium (kt	2 519	54	4,076	12,645	
Unconventional uranium	58			12,016	4,500,000

Renewable energy flows

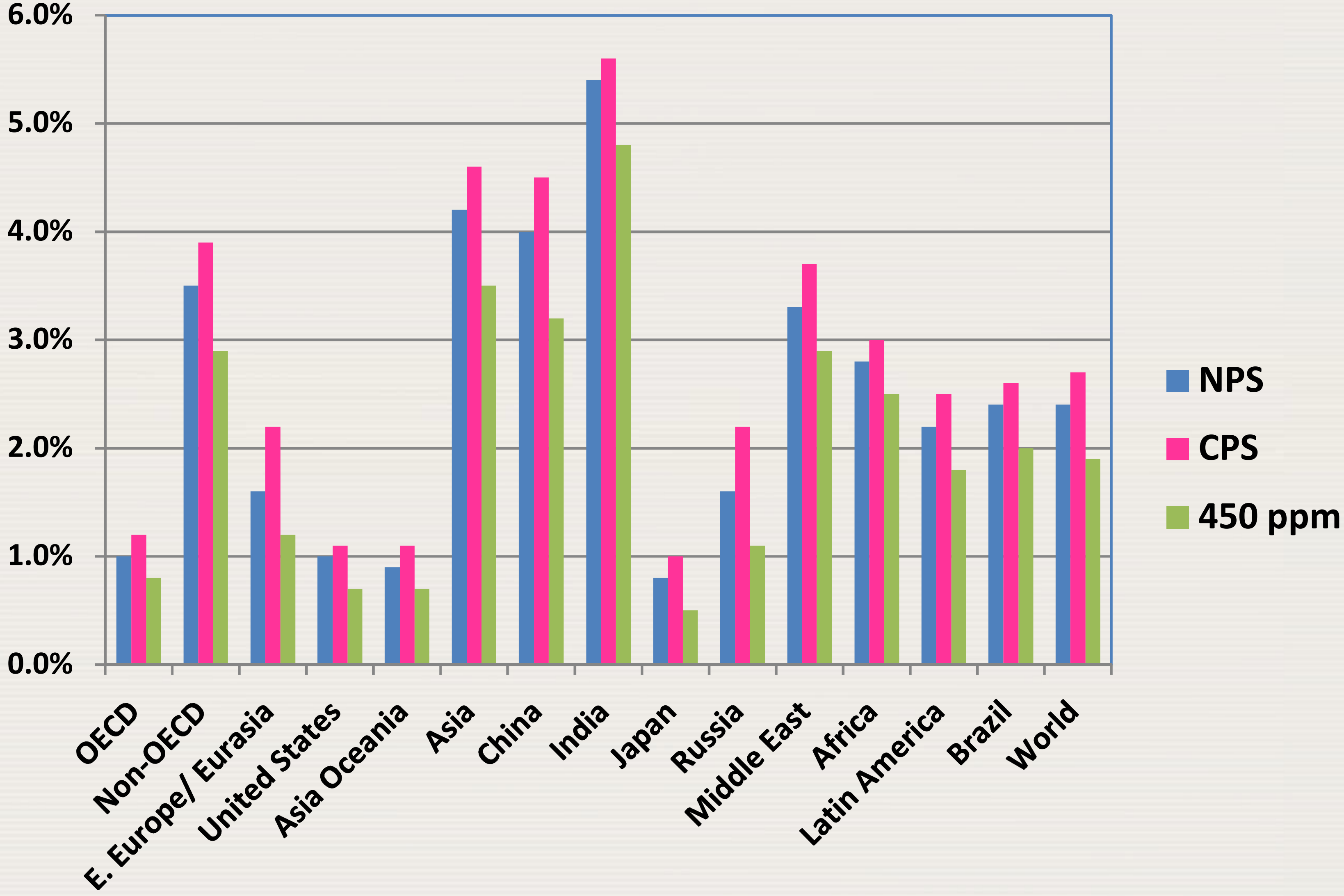
	Utilization 2010	Theoretical potential	Technical potential	Economic potential
	[EJ]	[EJ/a]	[EJ/a]	[EJ/a]
Biomass	53.5	2 400	800	44 -130
Geothermal	2.5	1 500	720	75
Hydro	13.7	504 000	160	30 - 47
Solar	0.6	3 900 000	280 000	40 – 200
Wind	1.5	110 000	1 700	72 - 350
Crop residues, MSW, etc.			70 - 106	0.78 - 1.8

Primary energy intensity and energy per capita (selected regions and countries) - NPS



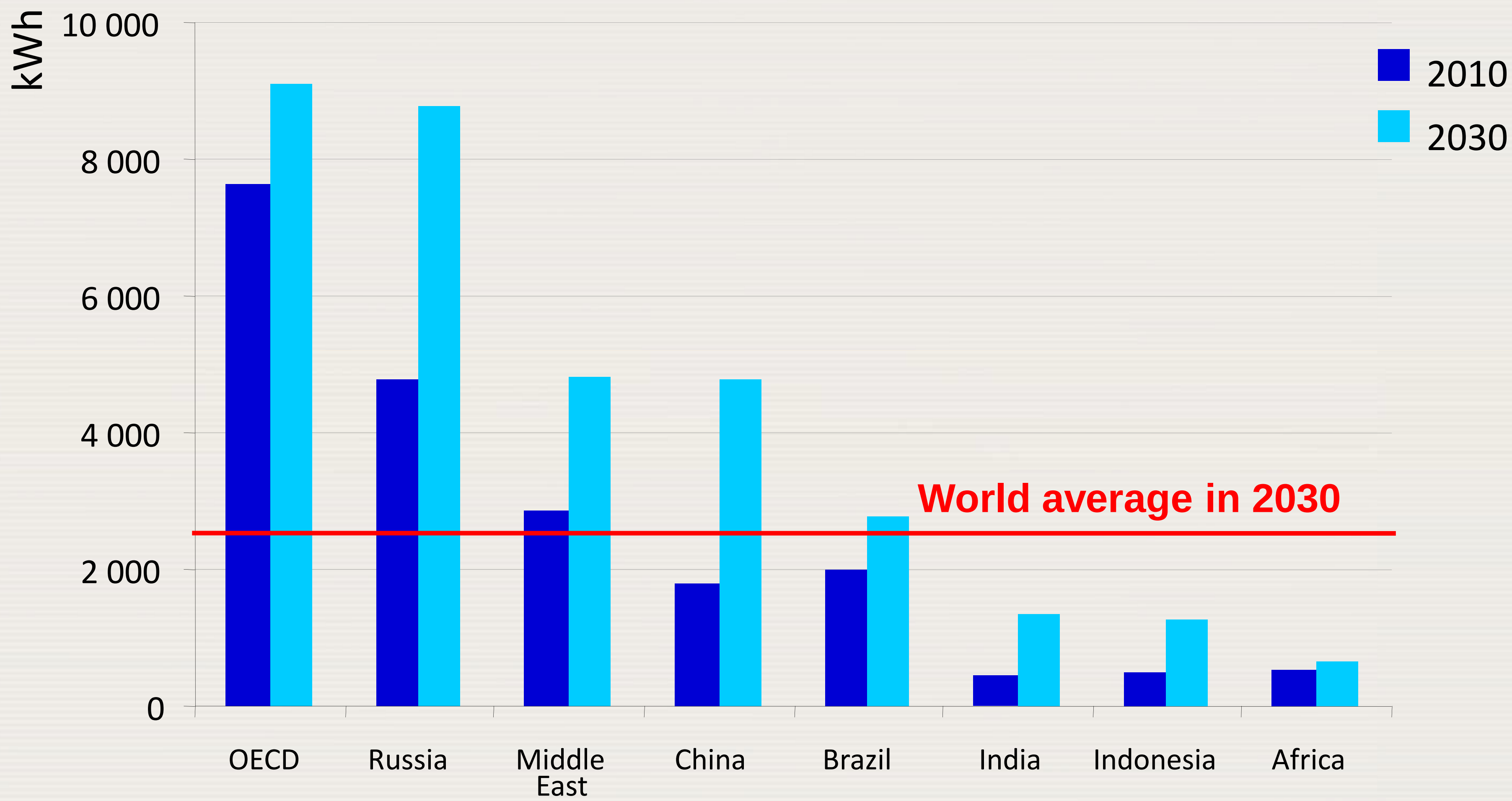
Source: OECD/IEA - World Energy Outlook 2012

Electricity Demand Annual Growth Rates



Source: OECD/IEA - World Energy Outlook 2011

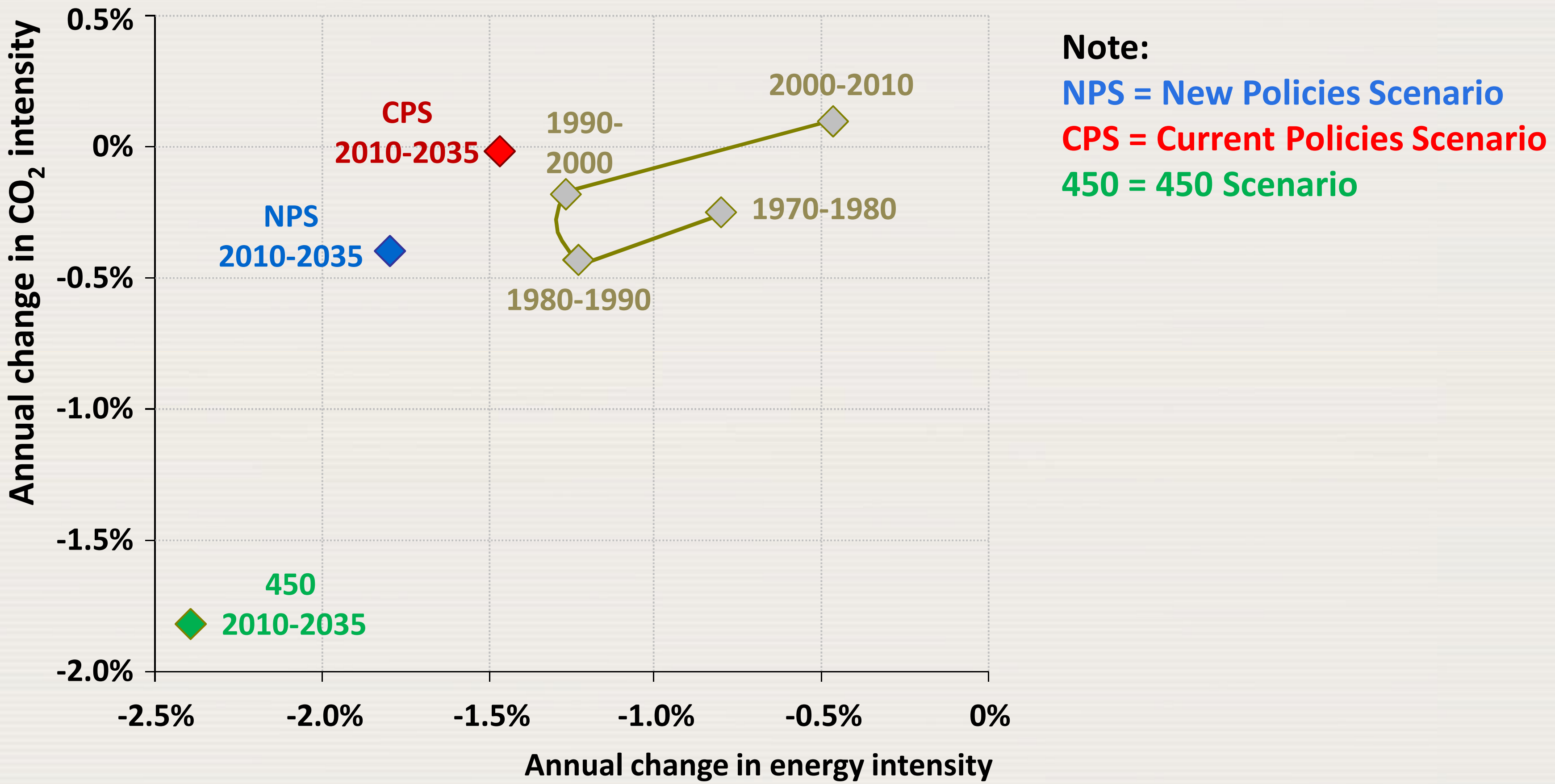
Per-capita Electricity Demand



Per-capita electricity use in non-OECD countries doubles by 2030, reaching 2 400 kWh, but remains well below even the current OECD average of 7 640 kWh

Source: OECD/IEA - World Energy Outlook 2011

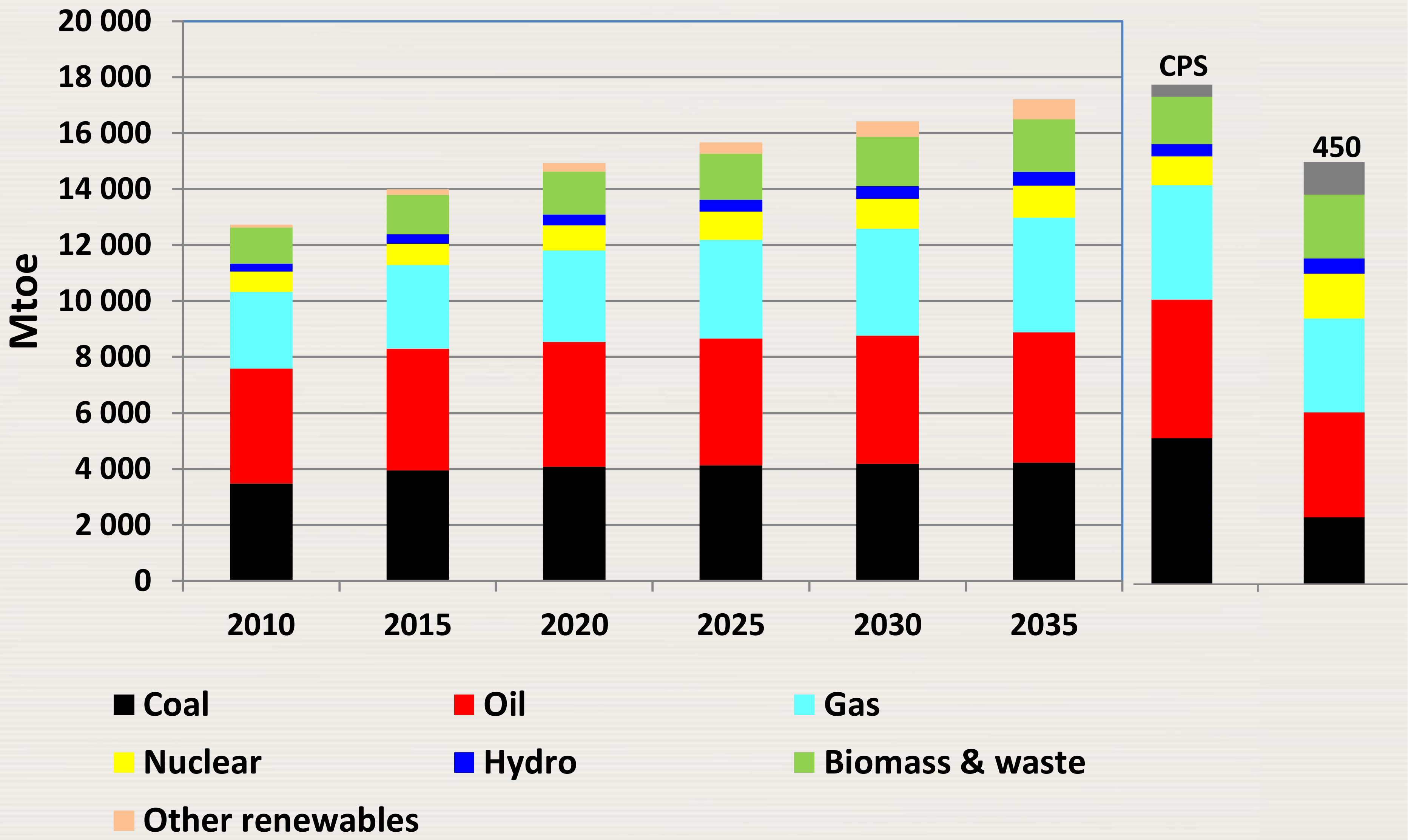
Trends in energy & CO_2 intensity, historical & by scenario



Renewables subsidies, carbon pricing & coal to gas switching in the power sector underpin a decline in carbon intensity of 0.4% per year in the New Policies Scenario

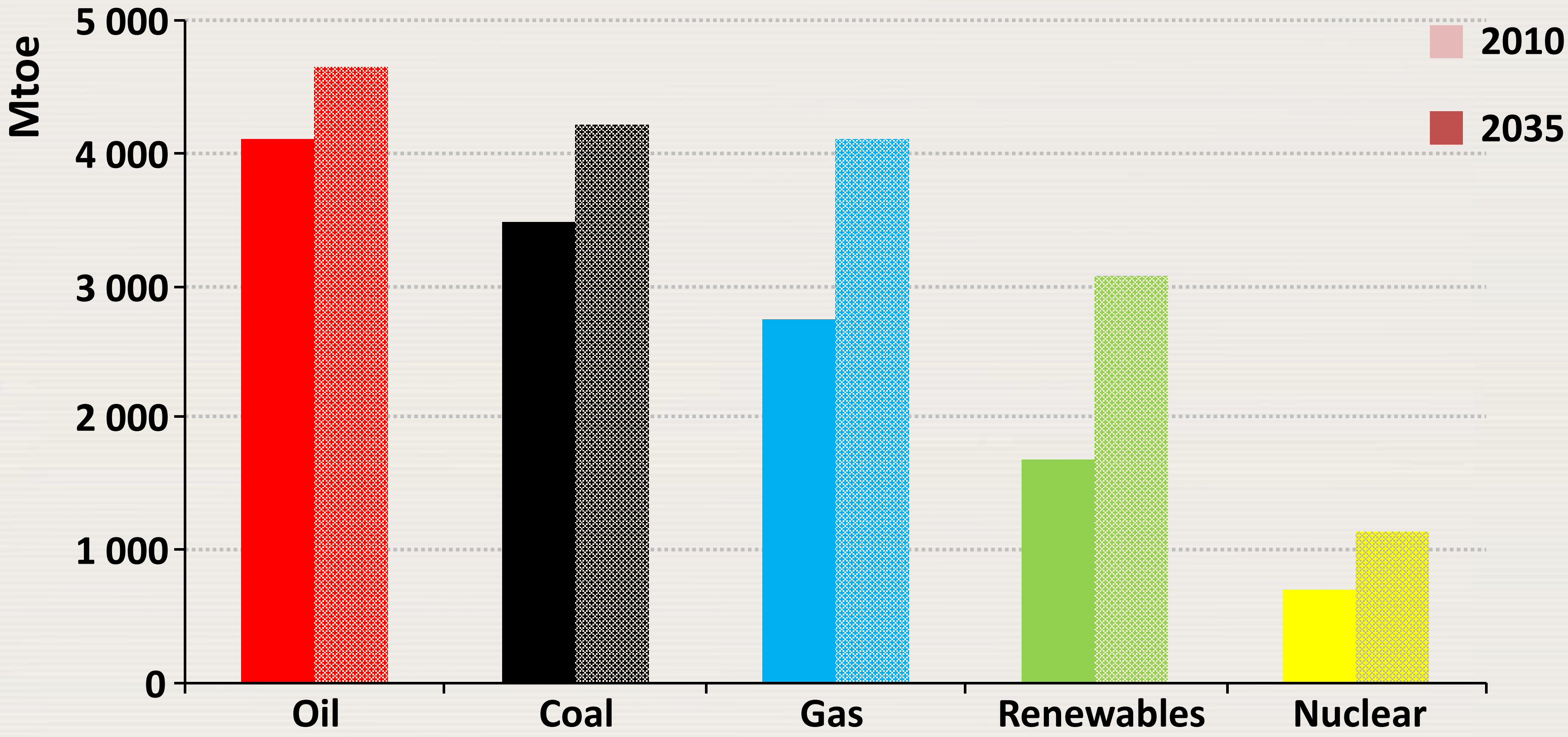
Source: OECD/IEA - World Energy Outlook 2012

Total primary energy demand – New Policy Scenario(NPS)



Source: OECD/IEA - World Energy Outlook 2012

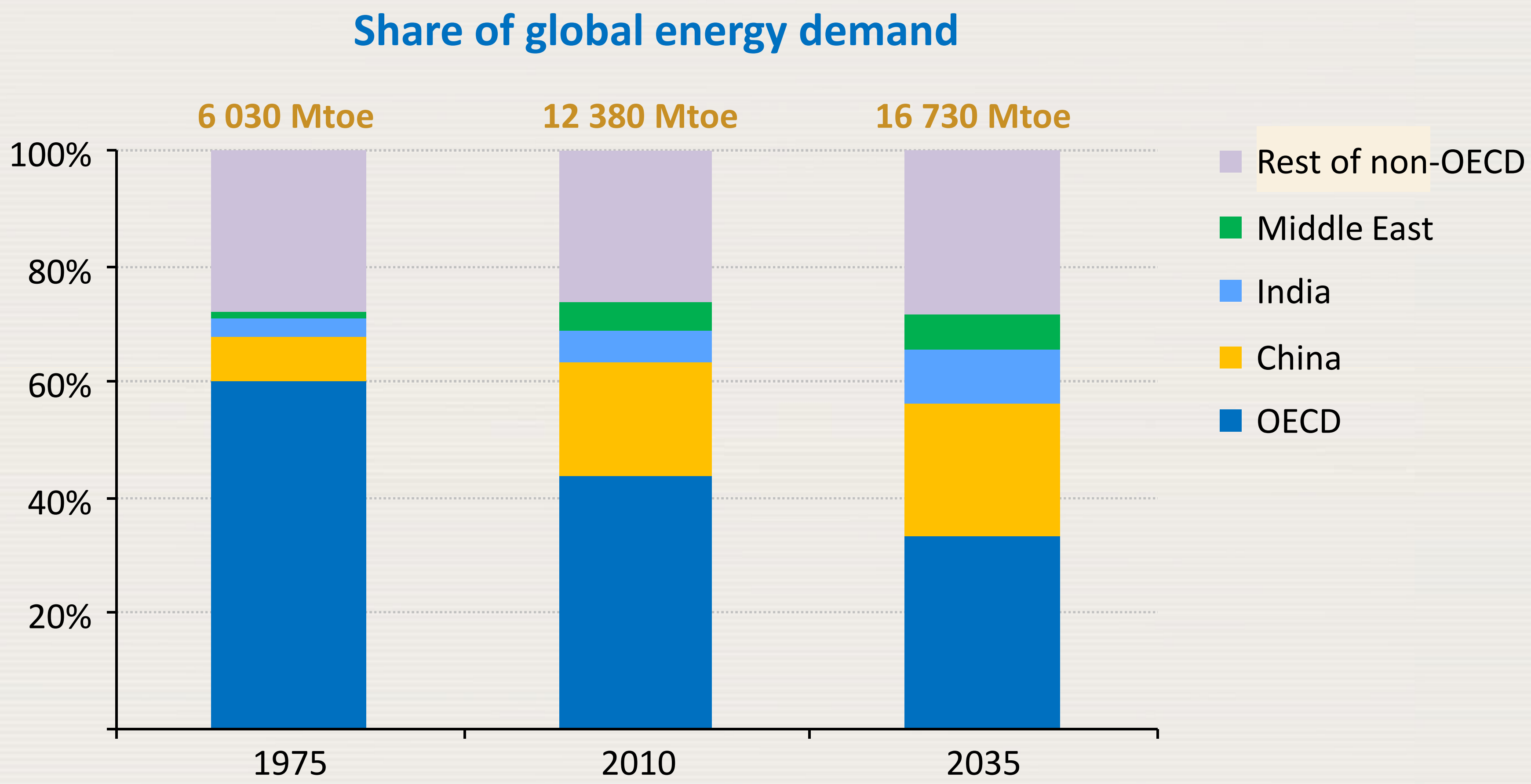
World primary energy demand by fuel



Fossil fuels account for 60% of the overall increase in demand, remaining the principal sources of energy worldwide

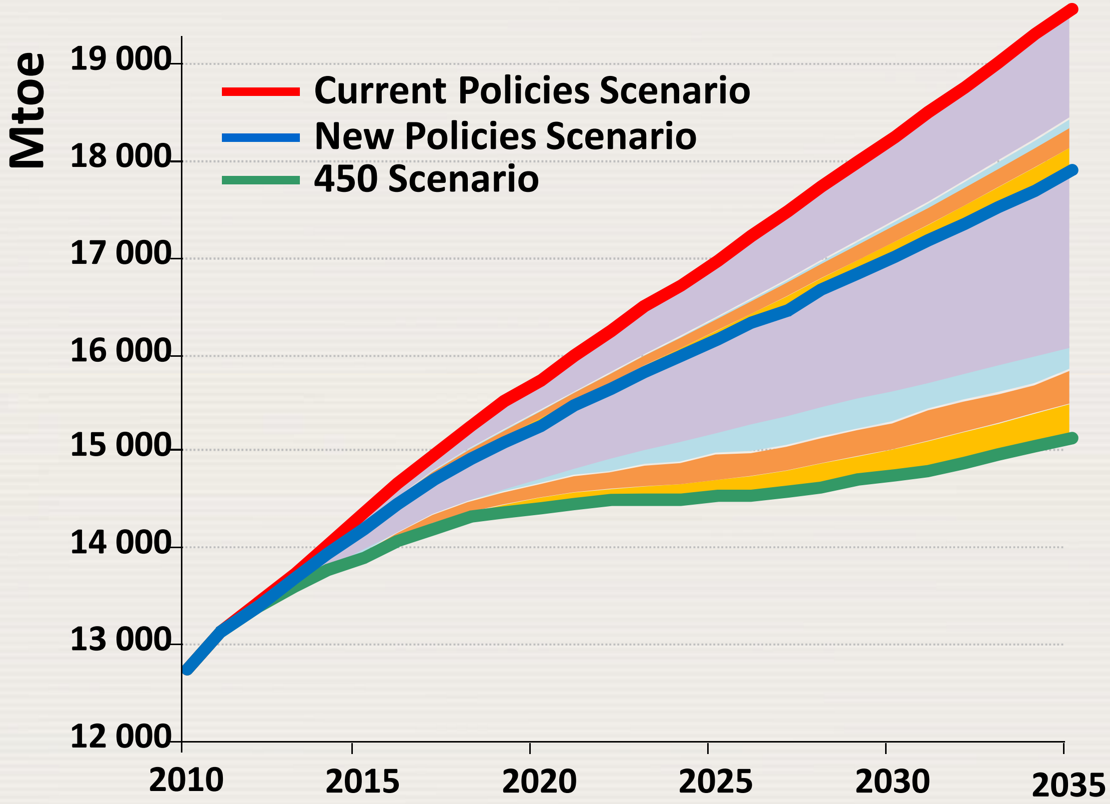
Source: OECD/IEA - World Energy Outlook 2012

Emerging economies steer energy markets



Global energy demand rises by over one-third in the period to 2035, underpinned by rising living standards in China, India & the Middle East

Change in global primary energy demand by measure & by scenario

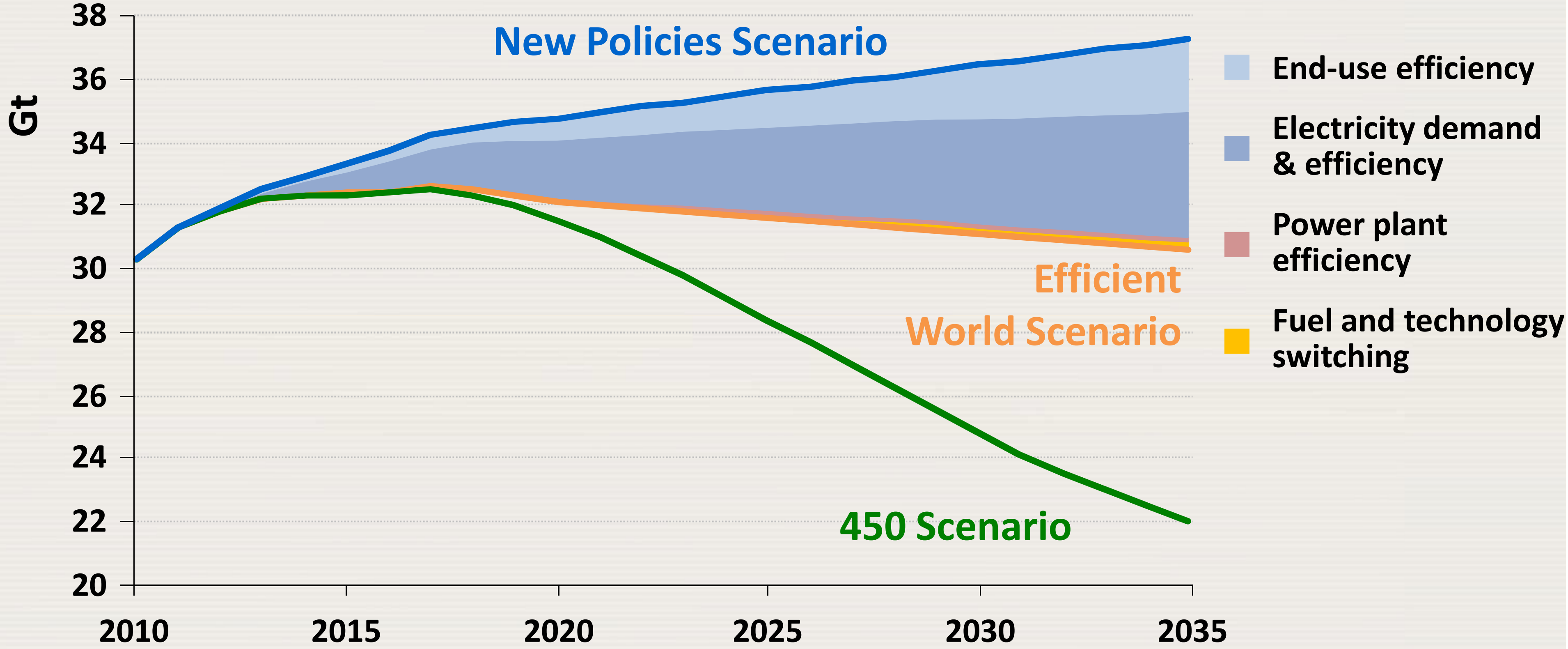


Energy demand reduction in 2035	CPS to NPS	NPS to 450
Efficiency in end-uses	67%	66%
Efficiency in energy supply	5%	8%
Fuel & technology switching	12%	12%
Activity	16%	14%
Total (Mtoe)	1 479	2 404

Note: CPS = Current Policies Scenario; NPS = New Policies Scenario; 450 = 450 Scenario.

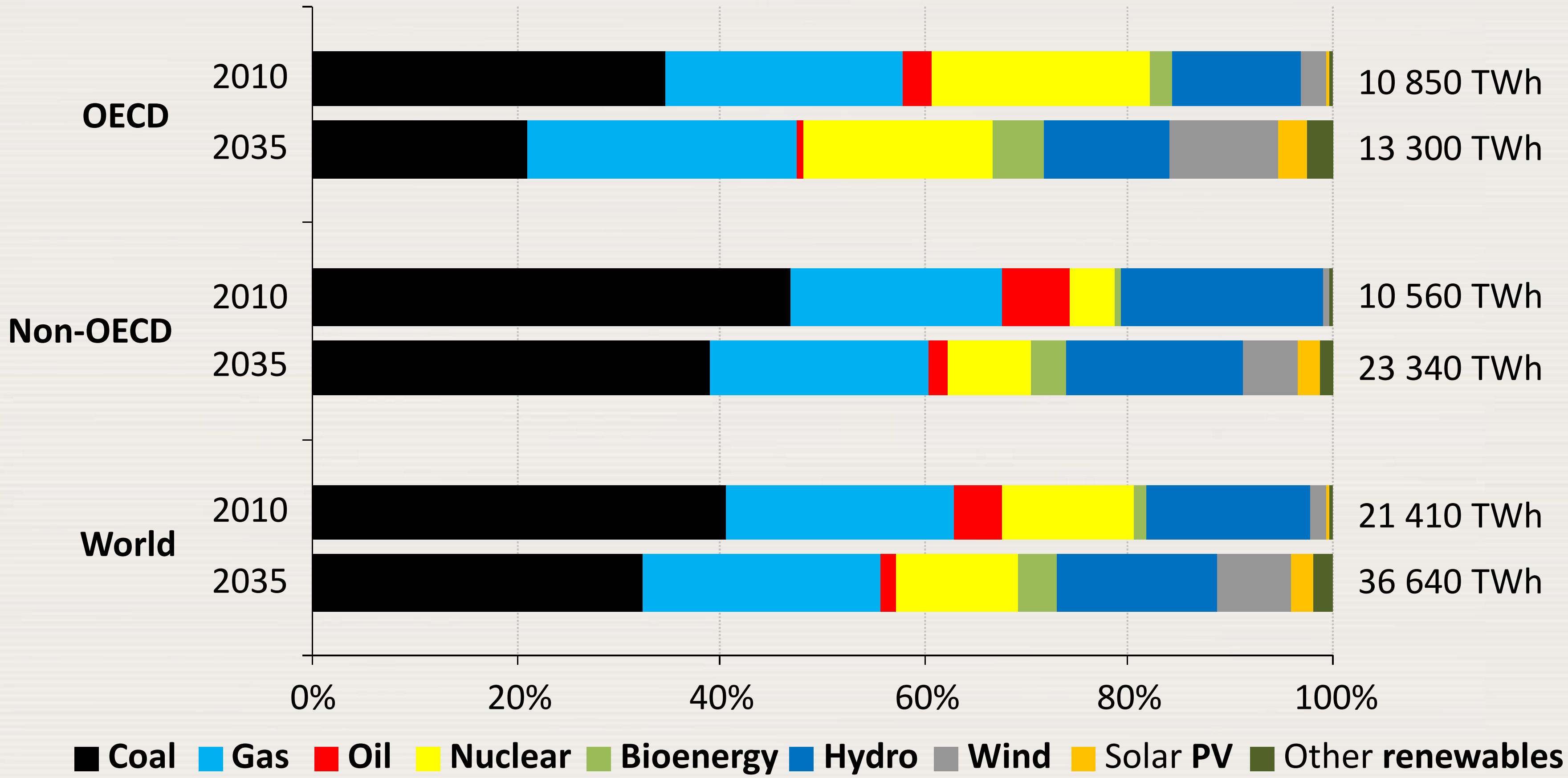
Efficiency is the single largest contributor to energy savings in achieving the New Policies Scenario & in moving beyond it, reflecting its large economic potential

Energy-related CO_2 emissions by scenario & abatement measures



CO_2 emissions in the Efficient World Scenario peak before 2020 & then decline to 30.5 Gt in 2035. Emissions are 6.5 Gt lower than in the New Policies Scenario in 2035.

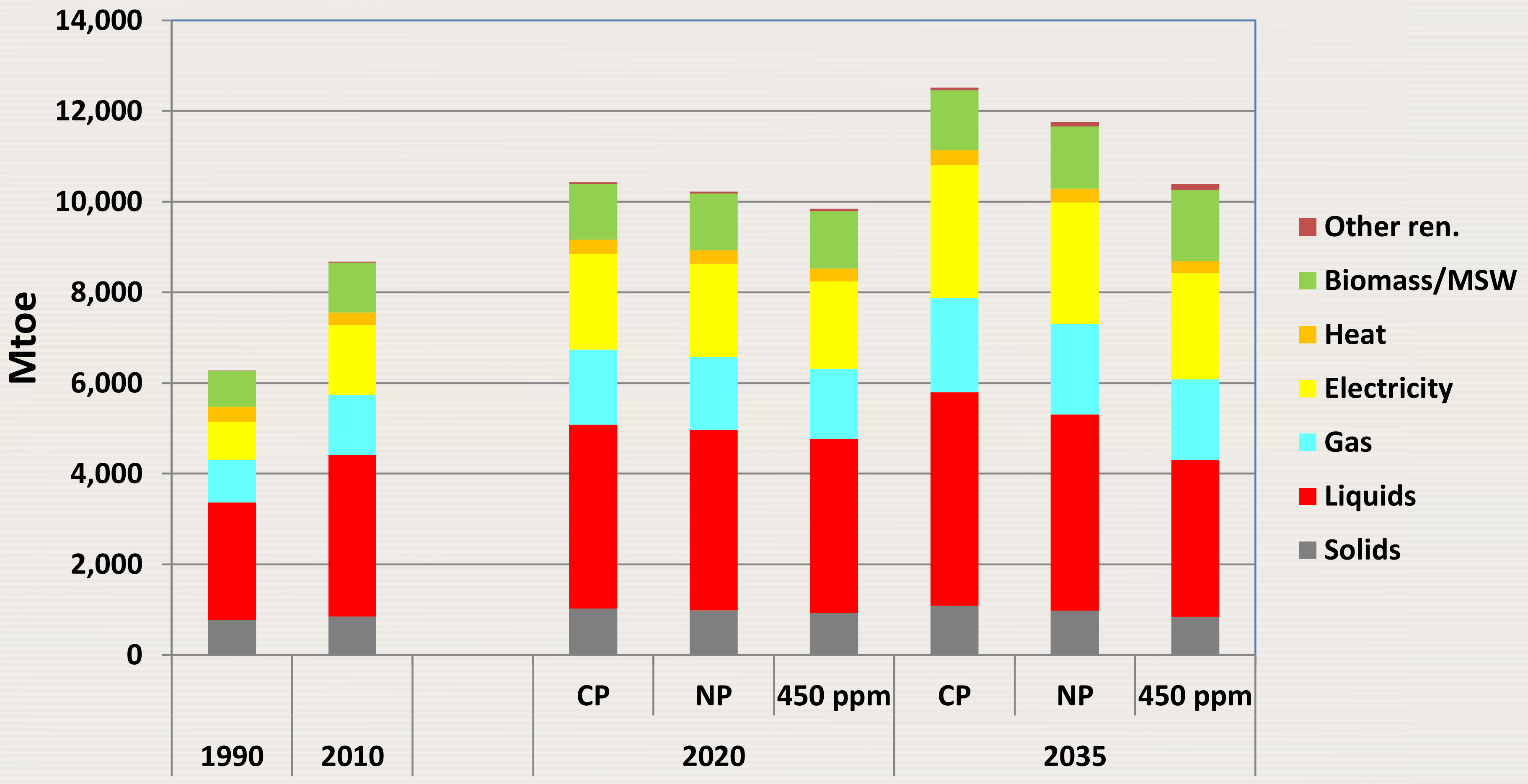
Share of electricity generation by source & region



Despite fuel mix differences, trend of greater diversity is common to OECD & non-OECD countries. Policies drive renewables up & coal down in OECD countries

Source: OECD/IEA - World Energy Outlook 2012

Global final energy demand by fuel

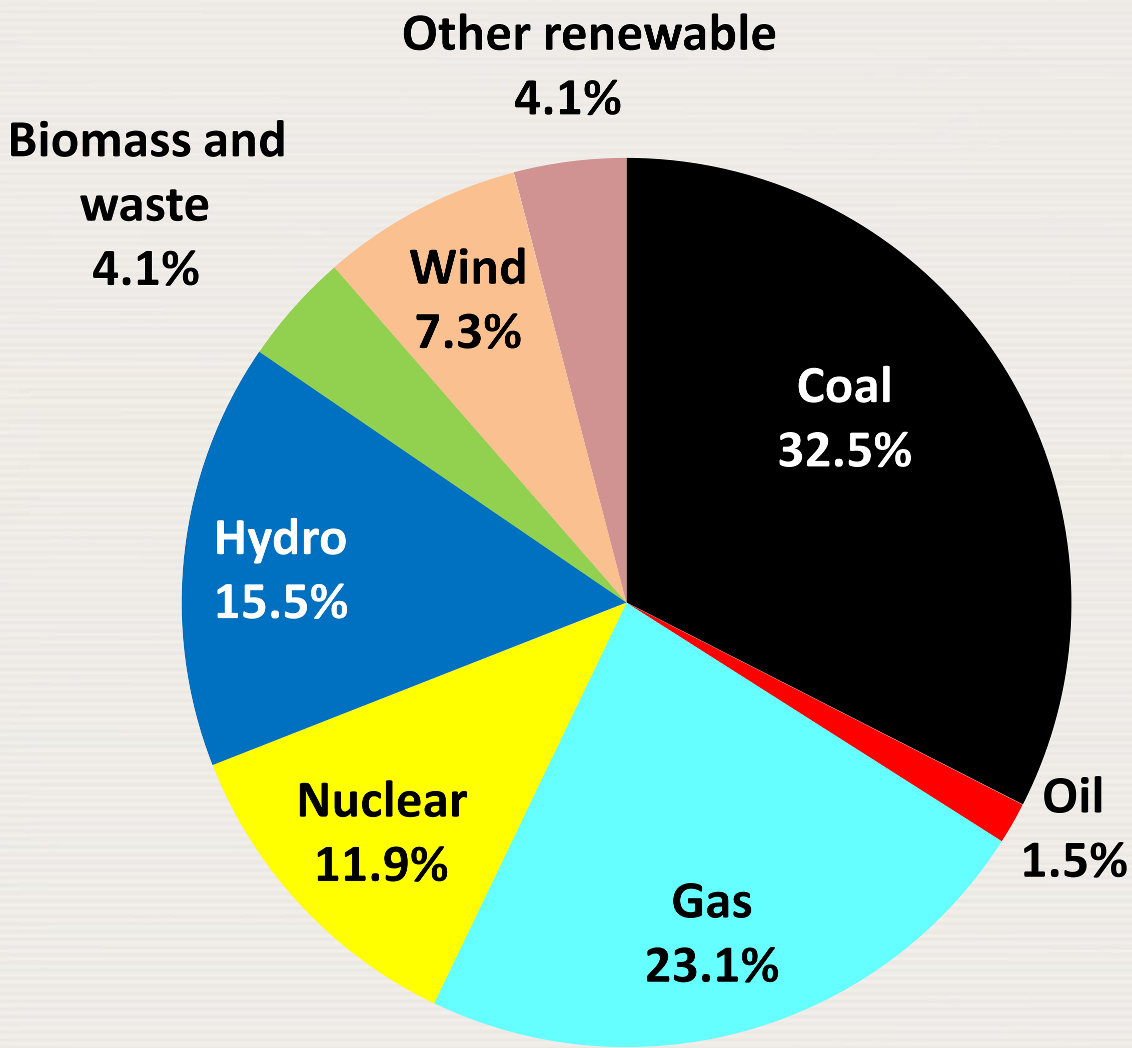


CP = Current Policies; NP = New Policies

Source: OECD/IEA - World Energy Outlook 2012

Structure of global electricity supply, 2030

Source: IEA 2012 World Energy Outlook (New Policies Scenario)



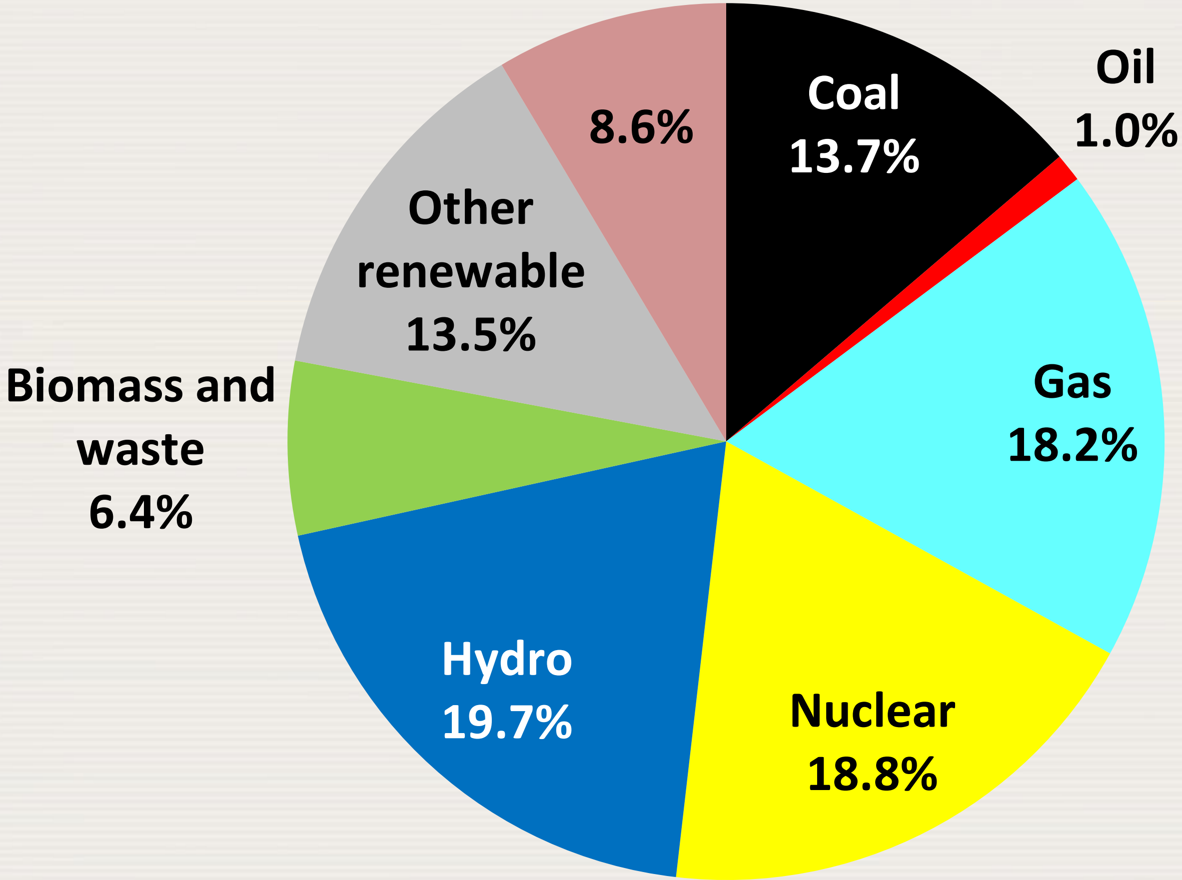
Global electricity generation in 2035: 36 640 TWh

2010 Structure:

Coal:	40.6%
Oil:	4.7%
Gas:	22.2%
Nuclear:	12.9%
Hydro:	16.0%
Biomass:	1.5%
Wind:	1.4%
Other Ren:	2.1%

Structure of global electricity supply, 2030

Source: IEA 2012 World Energy Outlook (450 ppm Scenario)

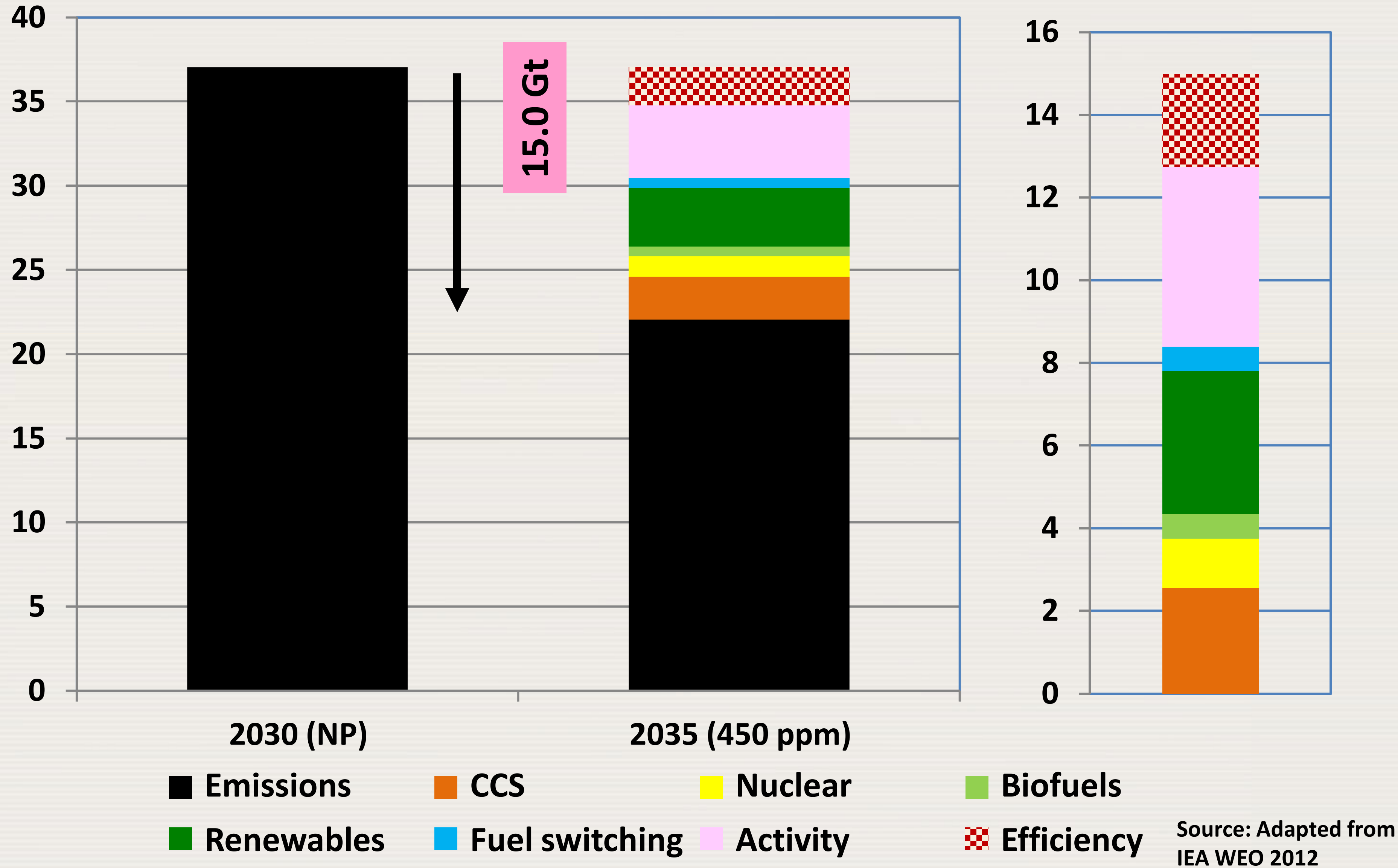


Global electricity generation in 2035: 31 750 TWh

2010 Structure:

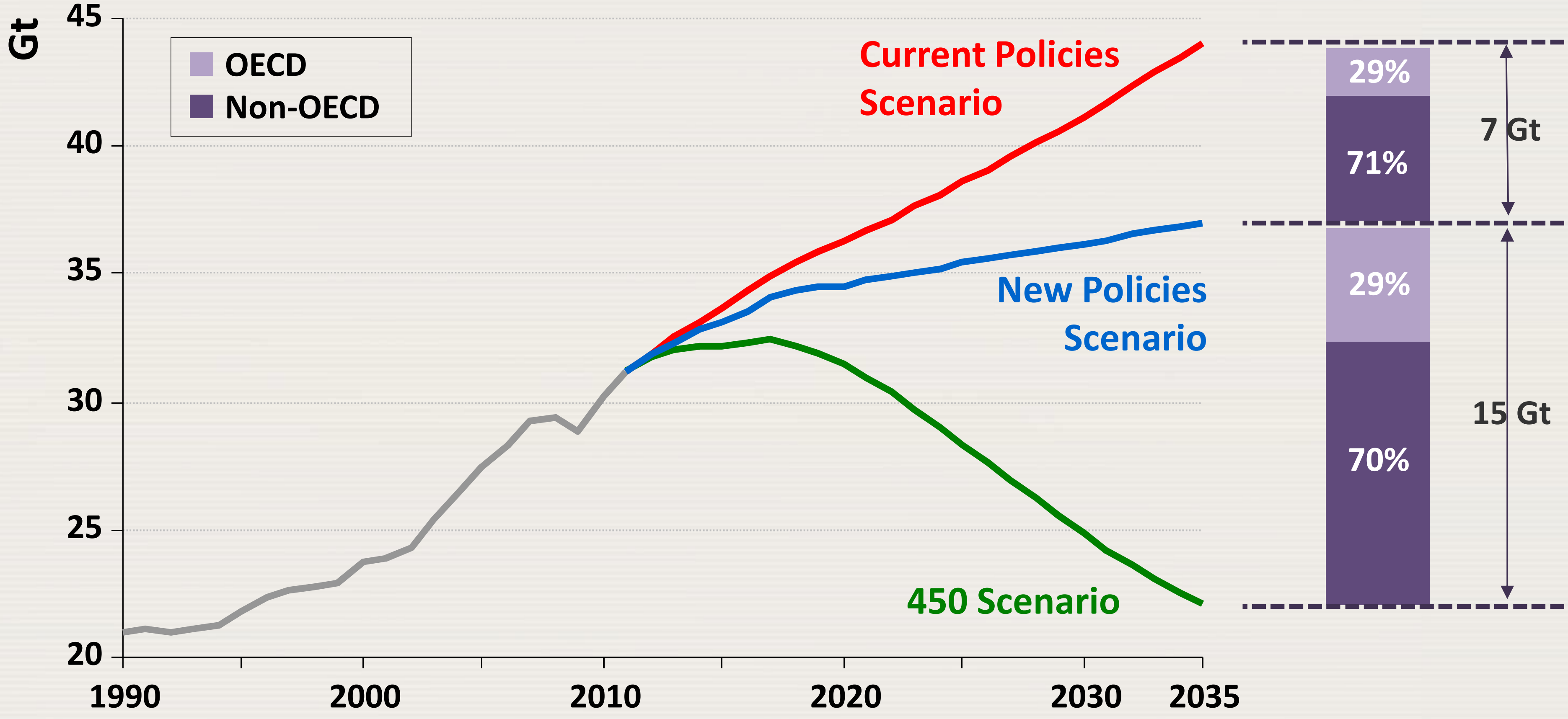
Coal:	40.6%
Oil:	4.7%
Gas:	22.2%
Nuclear:	12.9%
Hydro:	16.0%
Biomass:	1.5%
Wind:	1.4%
Other Ren:	2.1%

Avoidance of CO2 emissions in a 450 ppm scenario



Source: Adapted from IEA WEO 2012

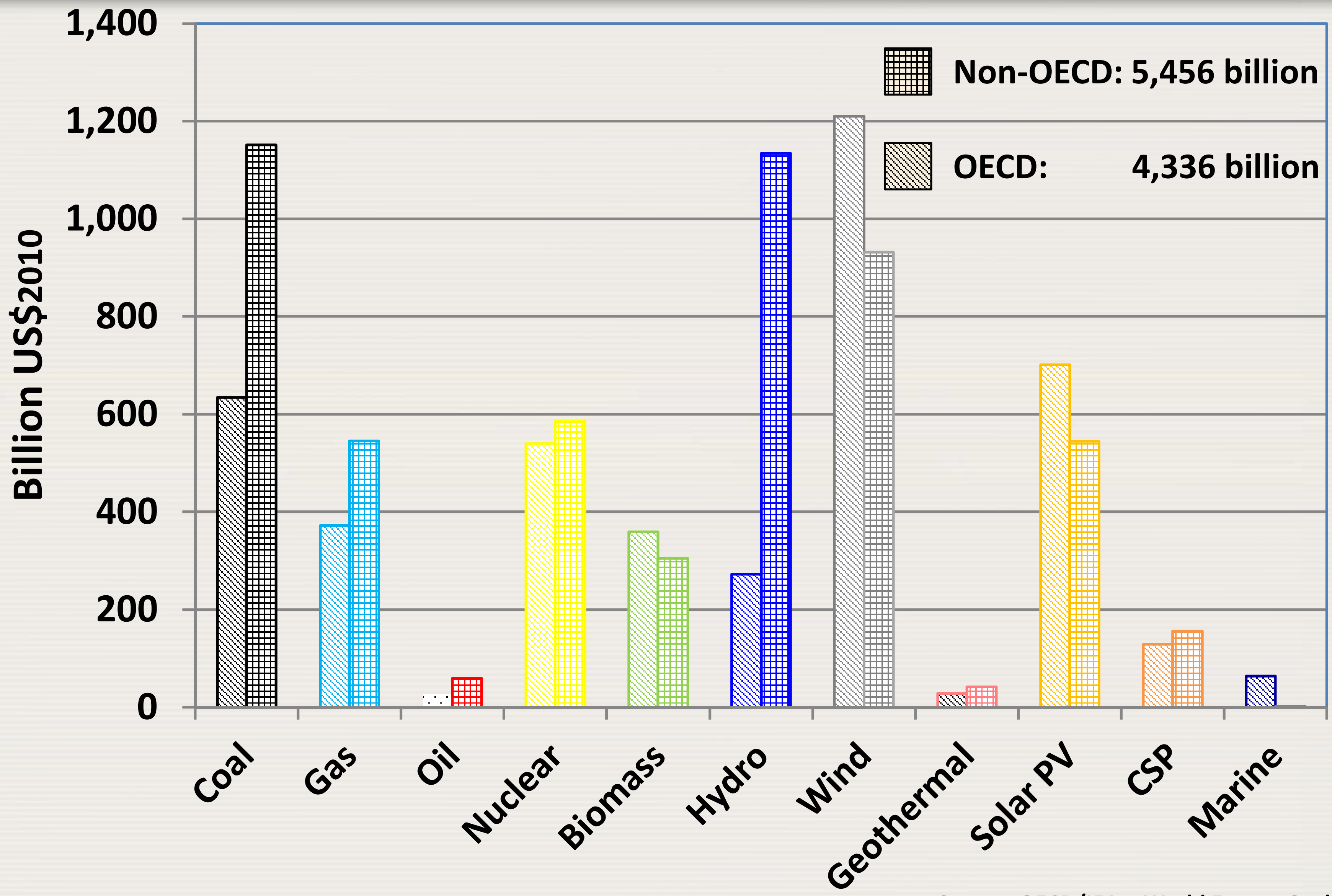
Global energy-related CO_2 emissions by scenario



CO_2 emissions rise to 44.1 Gt in CPS & 37 Gt in NPS and 22.1 Gt in 450 ppm by by 2035

Source: OECD/IEA - World Energy Outlook 2012

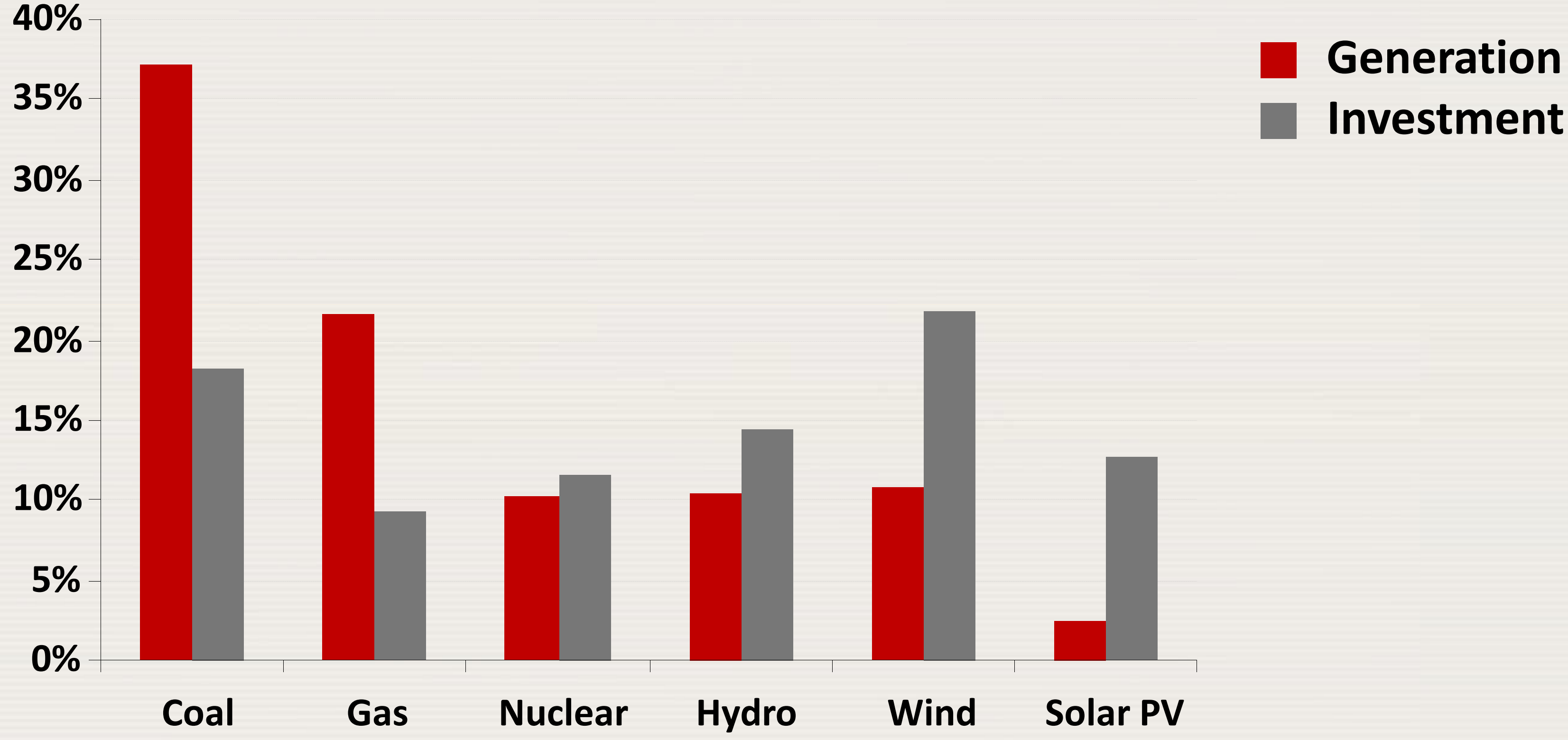
Investment in new power plants: New Policies Scenario, 2011-2035



Source: OECD/IEA - World Energy Outlook 2011

Electricity investment focuses on low-carbon technologies

Share of new power generation and investment, 2011-2035

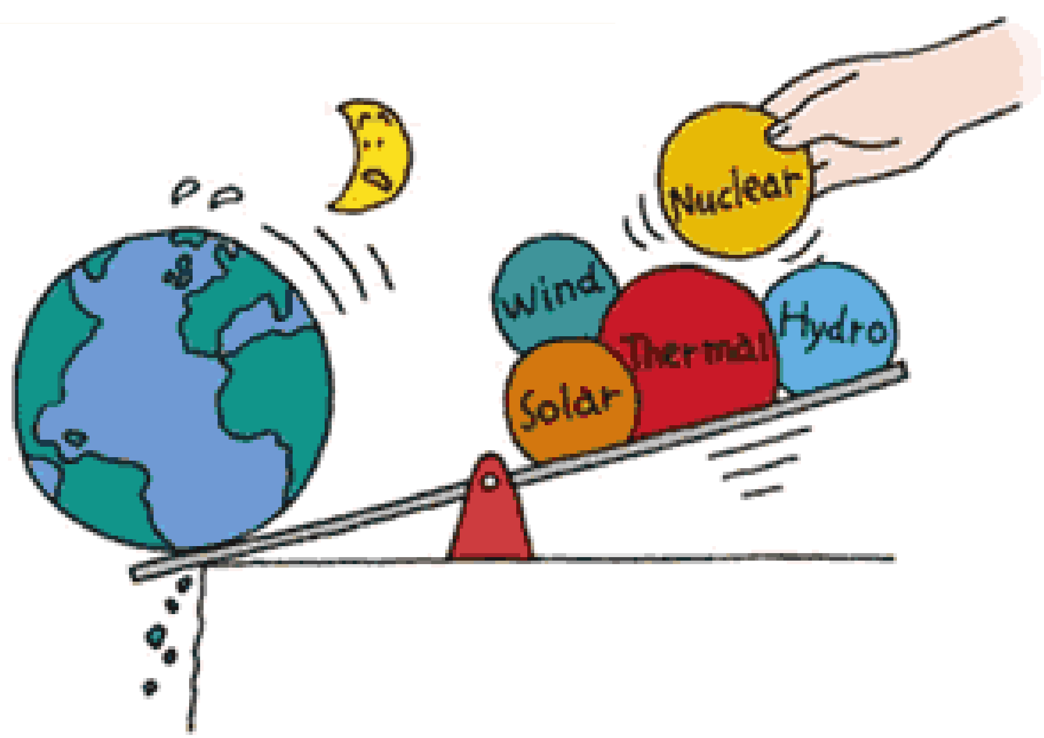


Renewables supply 25% of additional generation but account for 50% of investment

Source: OECD/IEA - World Energy Outlook 2011

Renaissance of interest before 11 March 2011

- Continued strong growth in global energy demand
- Price volatility of fossil fuels along a rising trajectory
- Draining export revenues
- Energy security concerns
- Environment protection and climate change
- Renewables progressing but still too costly
- Need for stable and reliable base-load electricity
- U resources plentiful

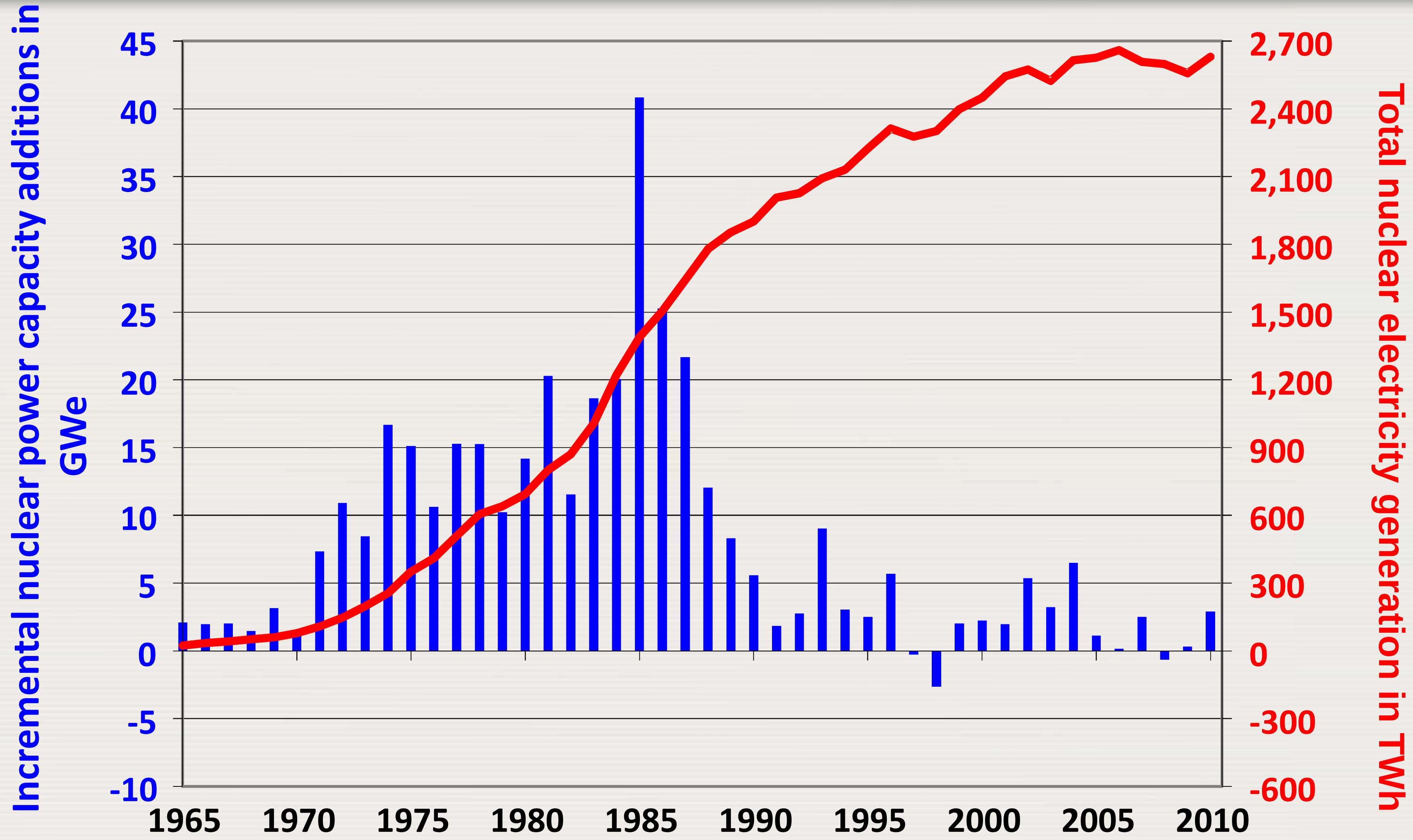


The renaissance in interest – NP related factors

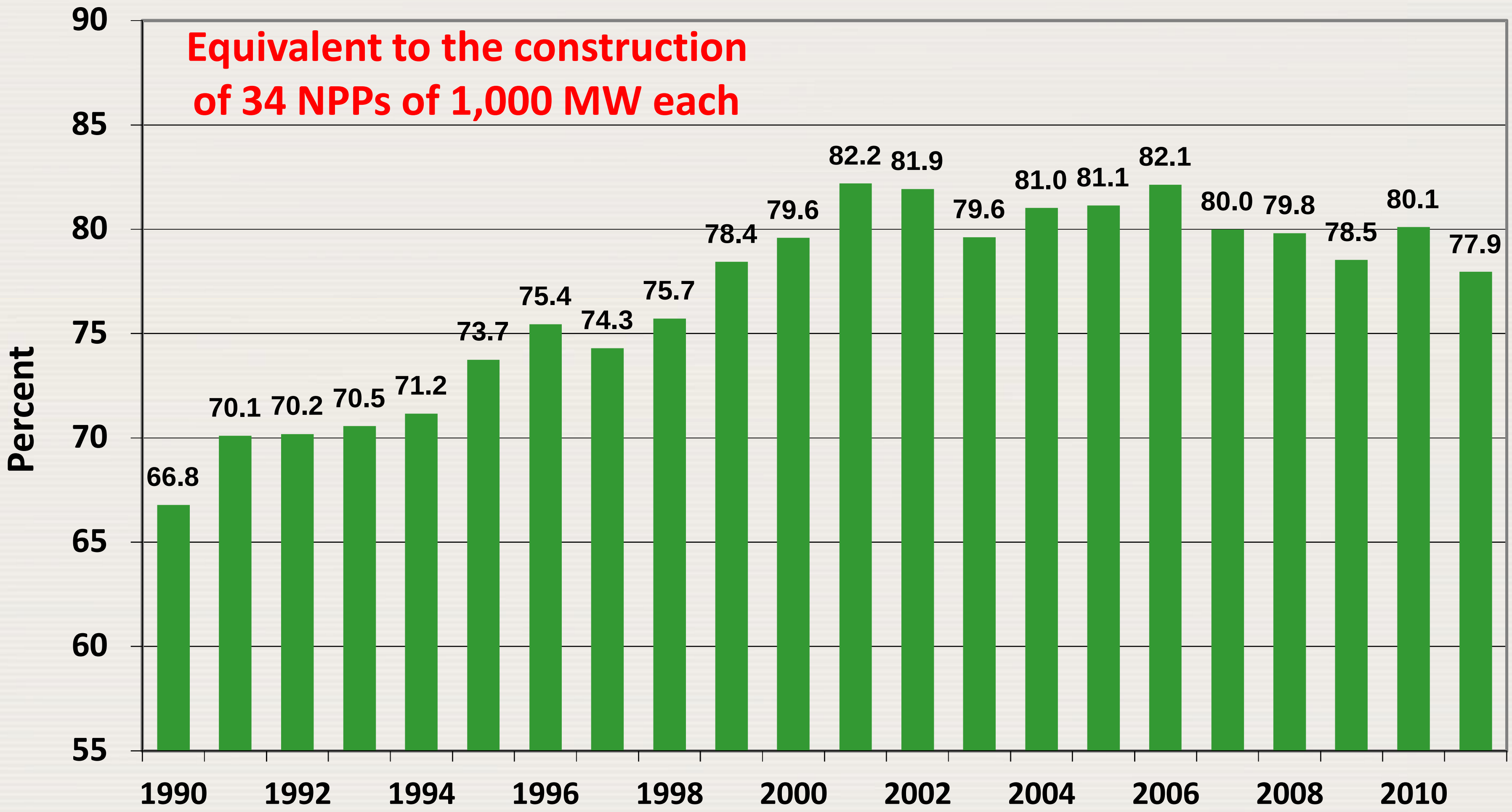
- Dramatic improvement in operating performance has transformed economics between 1990 and 2005

- Higher capacity factors
- Power up-rates
- Licence extensions
- Excellent safety record
- Market in "used" reactors
- Money printing machines
- Previous "hopes/fears" that NPPs would be victims of electricity liberalization have not materialized!

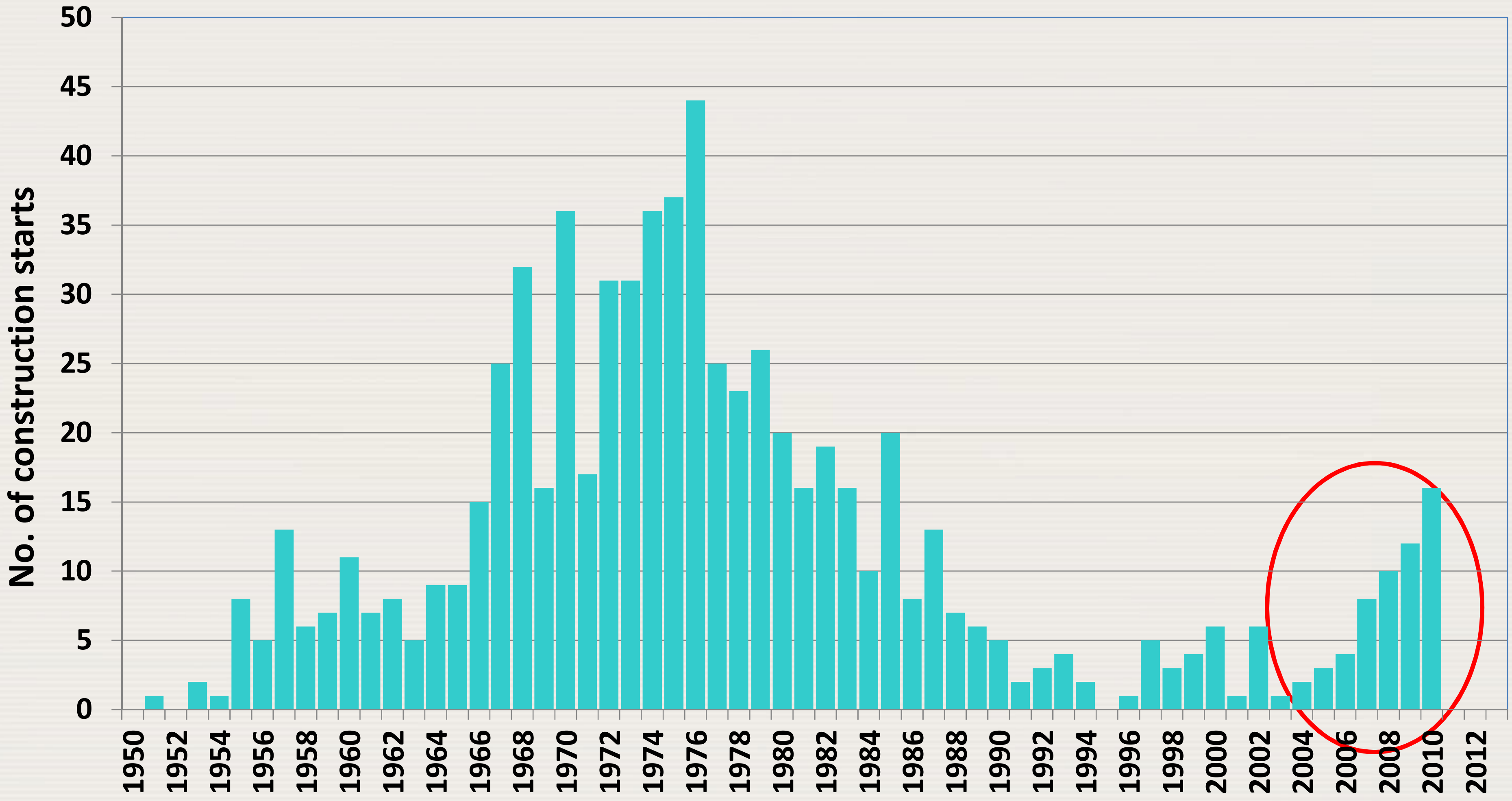
Annual Incremental Nuclear Capacity Additions and Total Nuclear Electricity Generation



Load factor: Global fleet of nuclear reactors



Construction starts until 11 March 2013



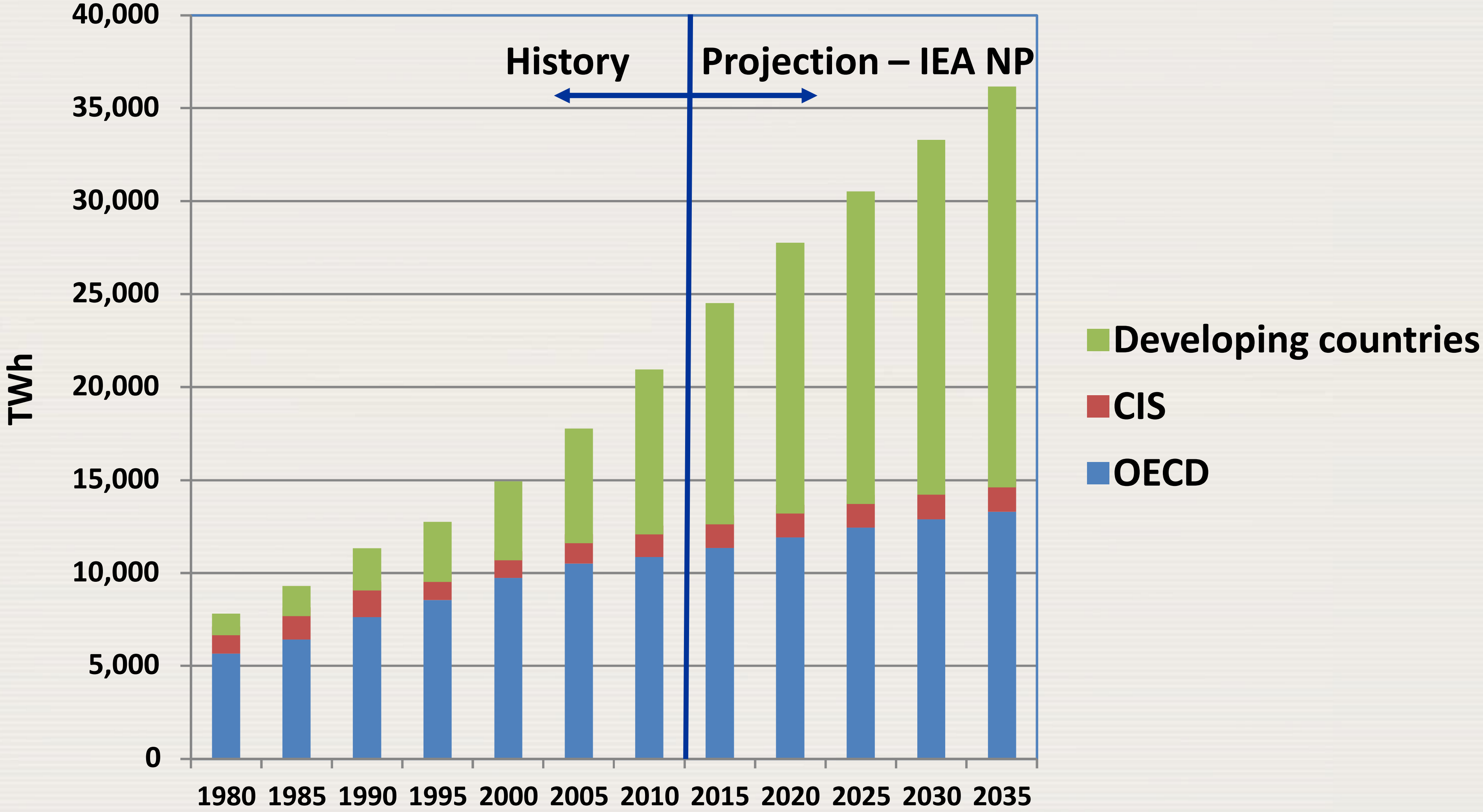
Fukushima impact to date

Belgium, Germany, Switzerland	Nuclear phase out – no new build
Taiwan	Nuclear phased out intentions announced but new plant construction continues
Japan	All construction suspended, decommissioning of Fukushima 1-4, remaining 50 plants successively shut down by 5 May 2012. Two restarts in July 2012. Phase out intentions by late 2030s
China	Initially new construction licenses suspended – lifted in October 2012
Belarus, Turkey	First plants ordered
UAE, USA	Construction starts: UAE - 2 plants; USA - First new nuclear build in more than 30 yrs
Chile, Indonesia, Malaysia, Morocco, Thailand, Saudi Arabia	Active preparation continues with final decision delayed or no final decision
Bangladesh, Vietnam, Egypt, Jordan, Nigeria, Poland	Continue preparing infrastructure
Italy, Kuwait, Senegal, Venezuela	Plans of introducing NP cancelled
Many Member States carried out national safety assessment reviews in 2011 and commitments were made to implement necessary corrective action	

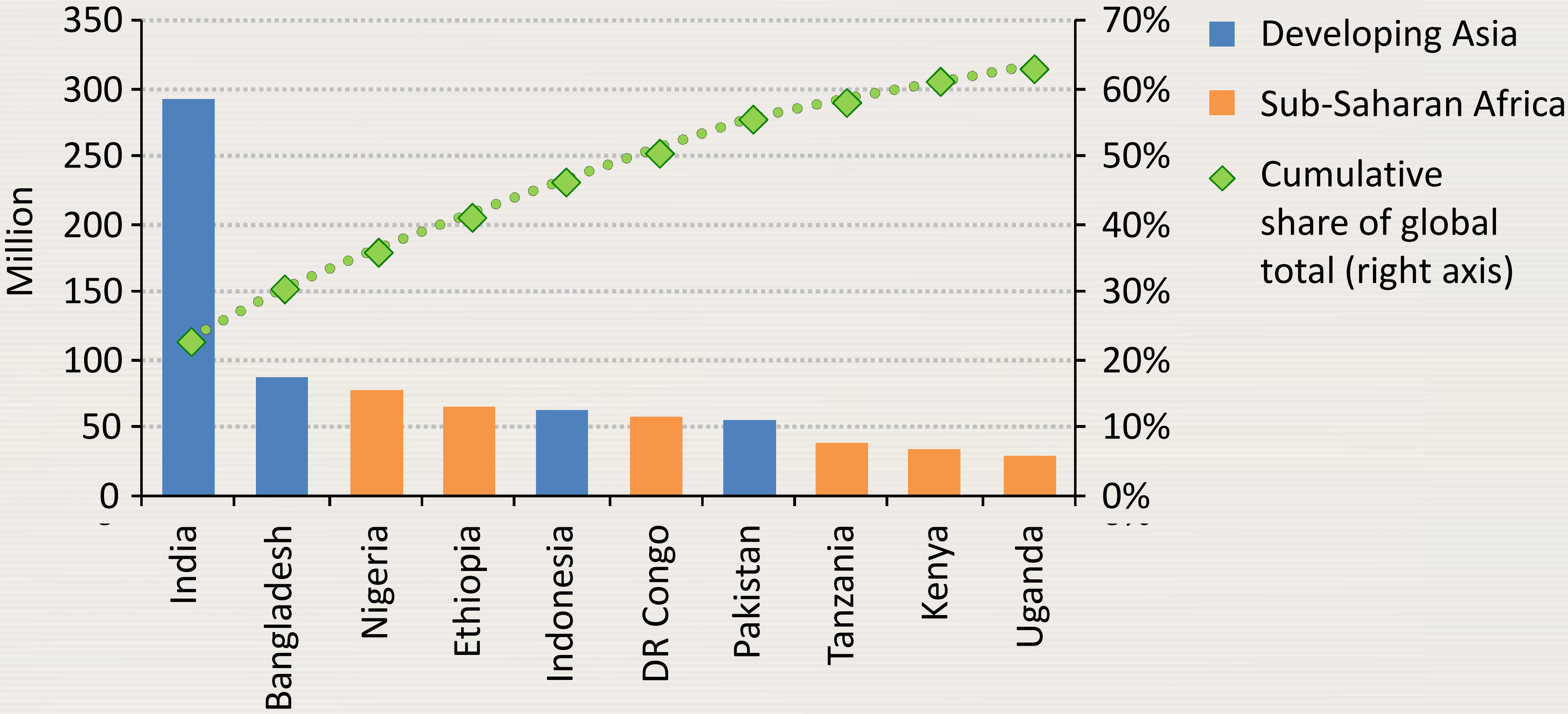
Drivers for nuclear power

- **Global energy demand is set to grow ➡ *Nuclear power expands supply options***

Electricity demand



Countries with the largest population without access to electricity, 2010



Some 1 260 million people have no access to electricity

Over 95% of those without electricity are in developing Asia or sub-Saharan Africa & nearly two-thirds are in just ten countries

Link between poverty and electricity access

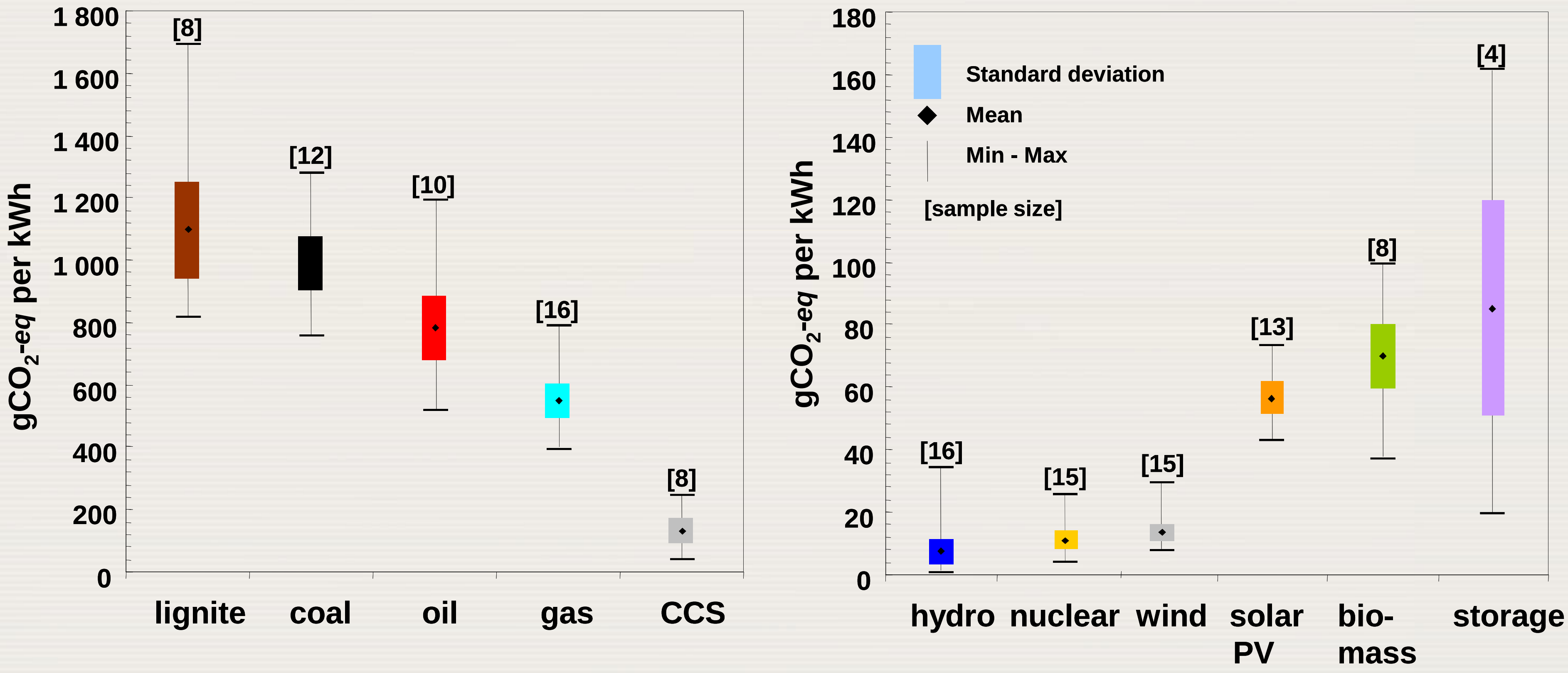
Source: UNDP – Human Development Report 2007/8

Drivers for nuclear power

- **Global energy demand is set to grow** ➡
  Nuclear power expands supply options
- **Environmental pressures are rising** ➡
  Nuclear power has low life-cycle GHG emissions

Mitigation – Role of nuclear power

Life cycle GHG emissions of different electricity generating options



Nuclear power: Very low lifetime GHG emissions make the technology a potent climate change mitigation option

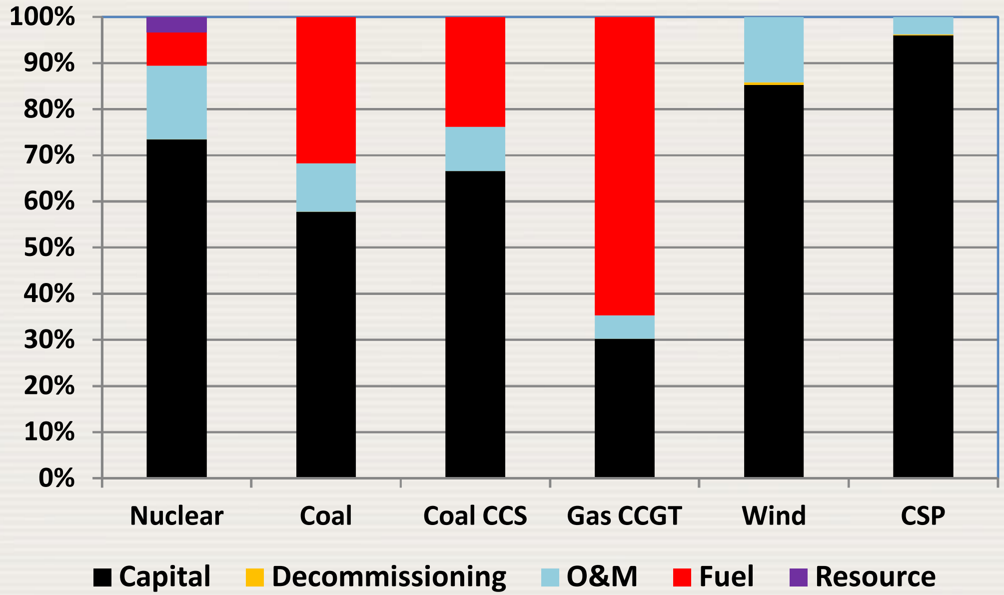
Drivers for nuclear power

- **Global energy demand is set to grow** ➡
  Nuclear power expands supply options
- **Environmental pressures are rising** ➡
  Nuclear power has low life-cycle GHG emissions
- **Energy supply security back on the political agenda** ➡
  Nuclear power contributes to energy security

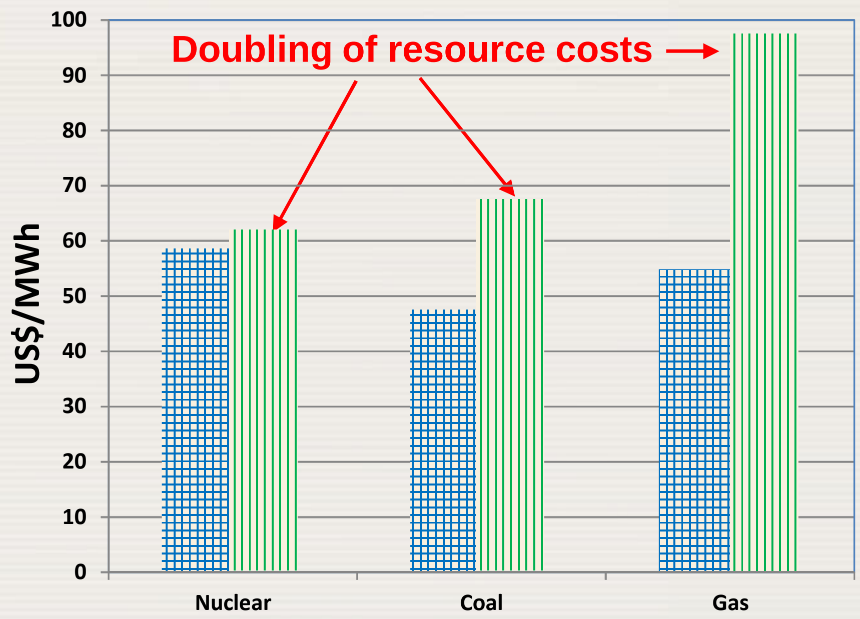
Nuclear power and energy security

- Small fuel volumes
- Long refueling cycles
- Resource a small share in generating costs
- Resource are plentiful
- Base load technology

Cost components in total generating costs at a 10% discount rate



Doubling of resource costs

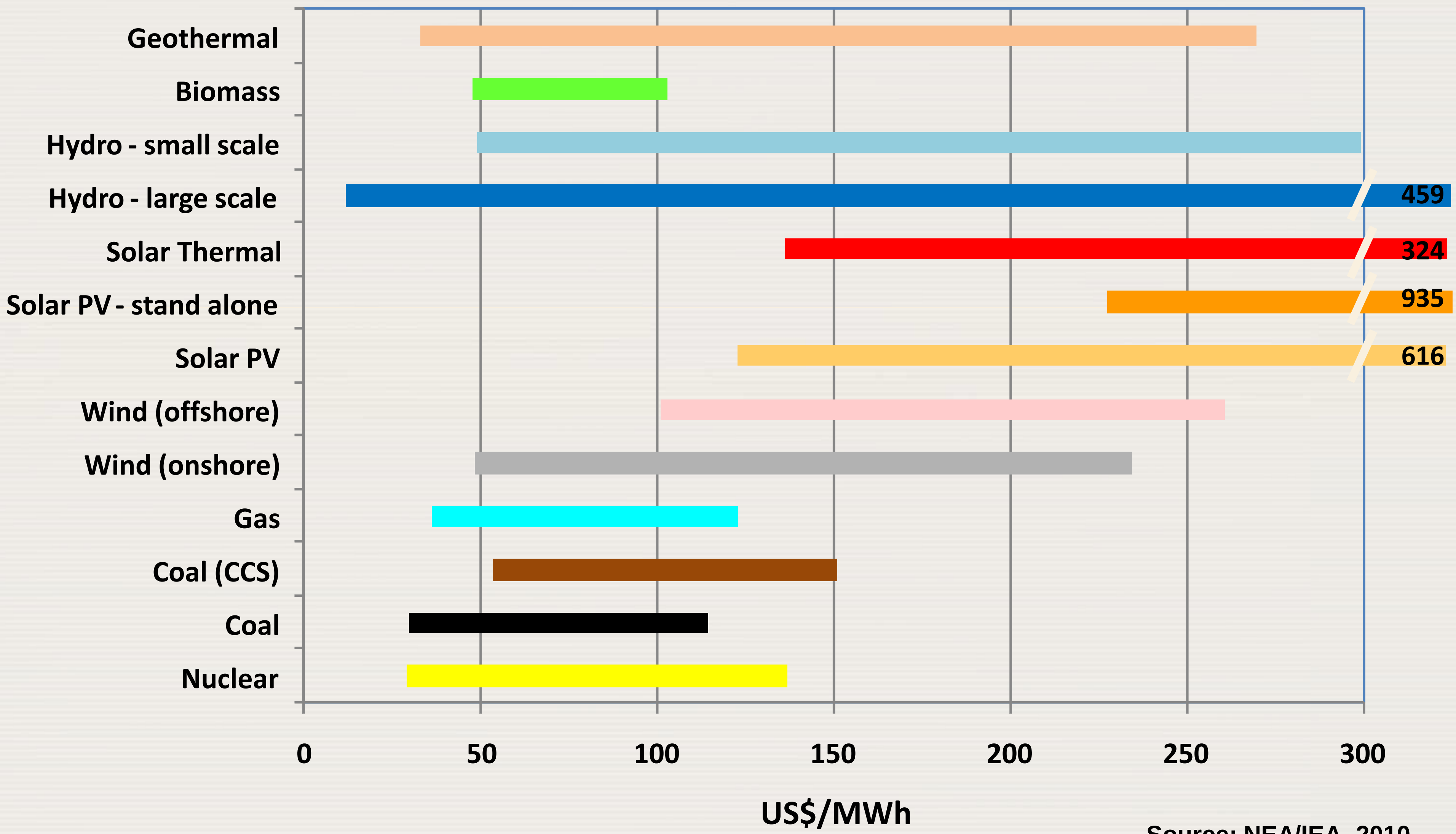


Adapted from IEA/NEA 2010 and NEA 2003

Post Fukushima: Unchanged drivers behind the renaissance in the interest in nuclear power

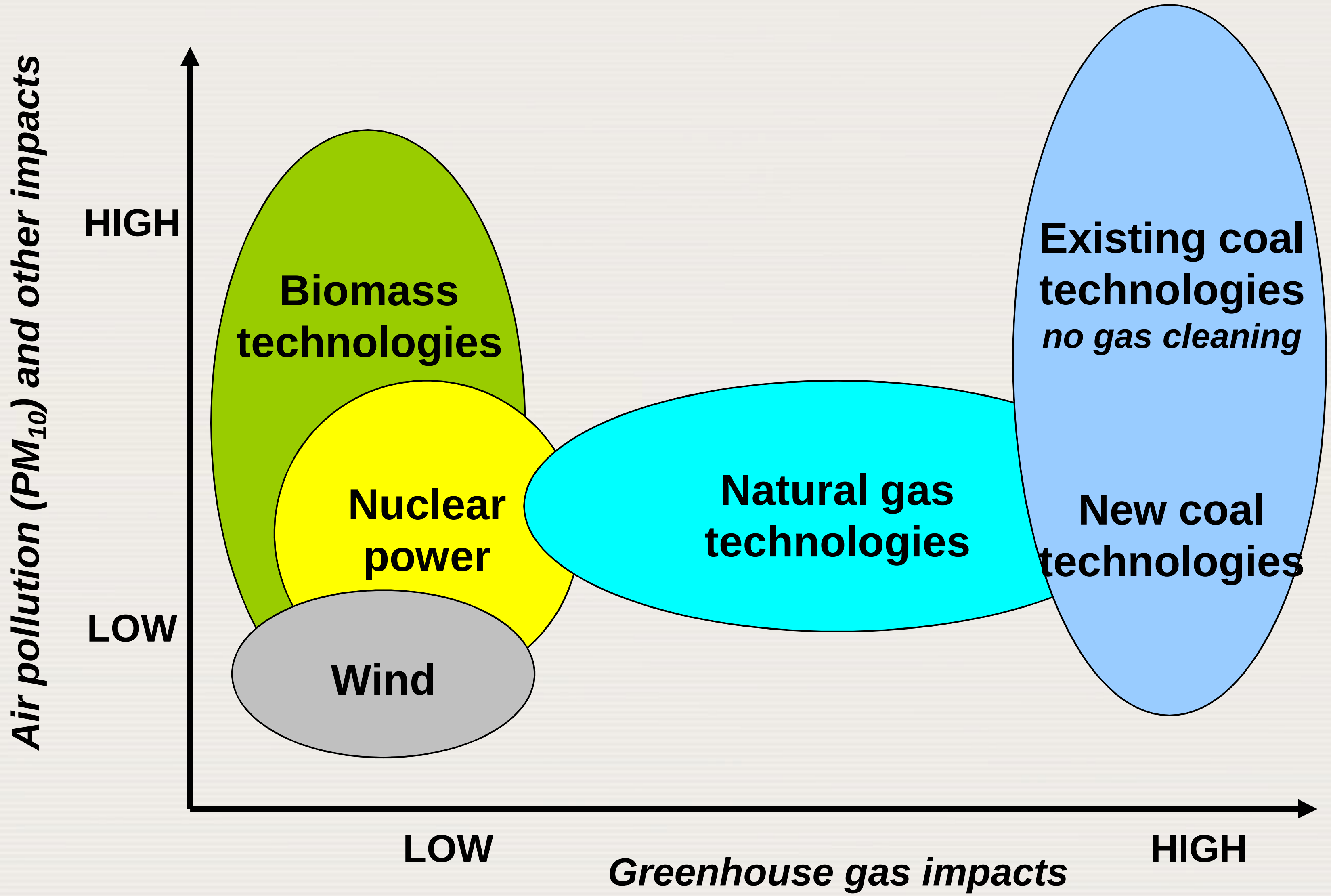
- **Global energy demand is set to grow** ➡
  Nuclear power expands supply options
- **Environmental pressures are rising** ➡
  Nuclear power has low life-cycle GHG emissions
- **Energy supply security back on the political agenda** ➡
  Nuclear power contributes to energy security
- **Reliable base load electricity at predictable and affordable costs for meeting MDGs** ➡
  Nuclear power offers stable and predictable generation costs based on low resource costs

Range of levelized generating costs of new electricity generating capacities



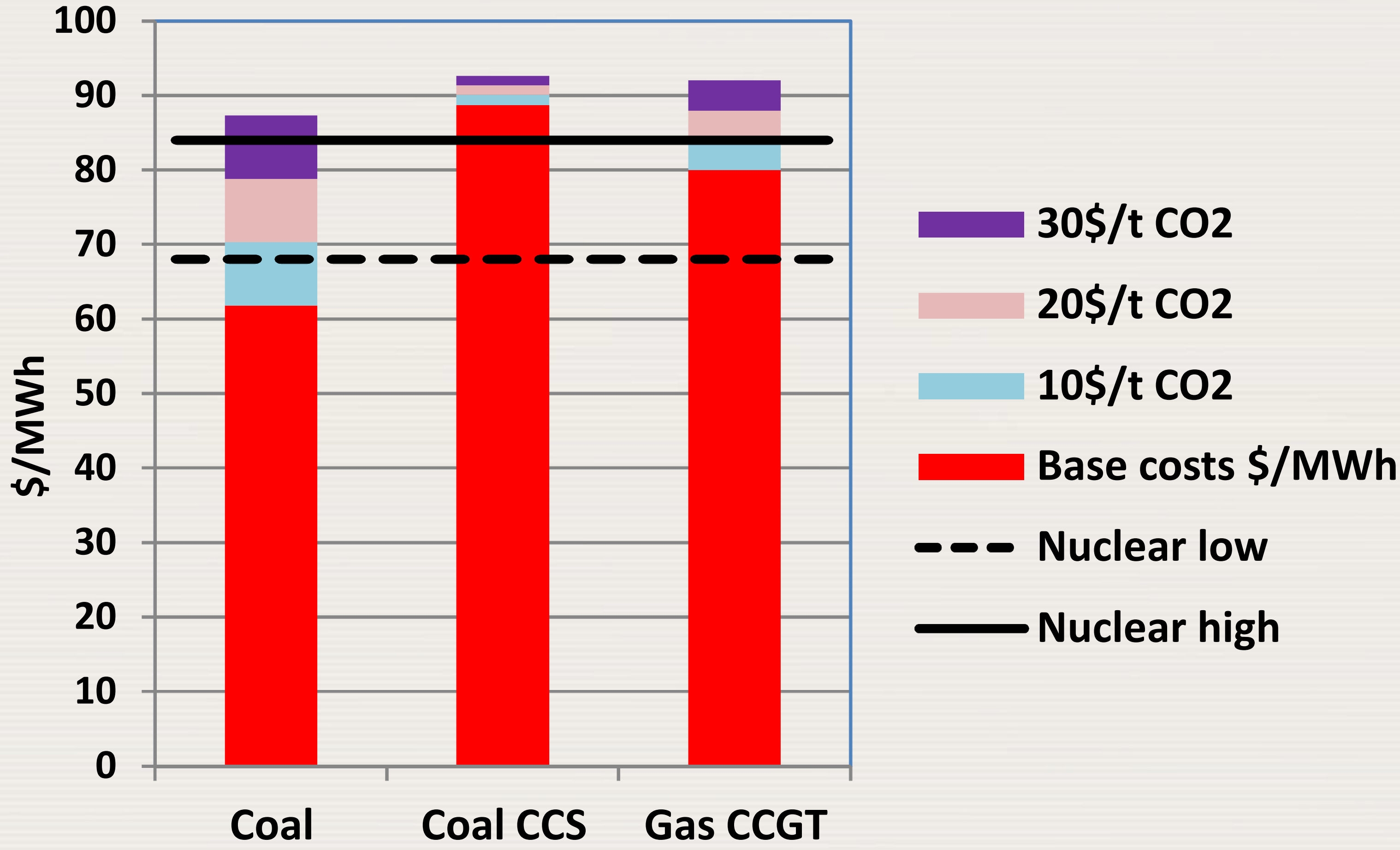
Source: NEA/IEA, 2010

Externalities of different electricity generating options



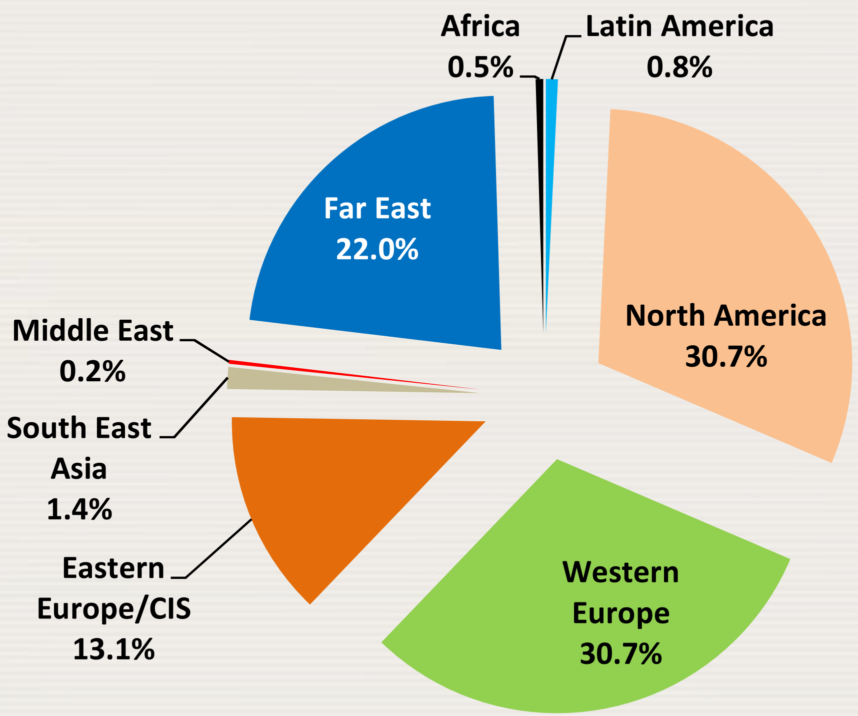
Source: EU-EUR 20198, 2003

Impact of carbon prices

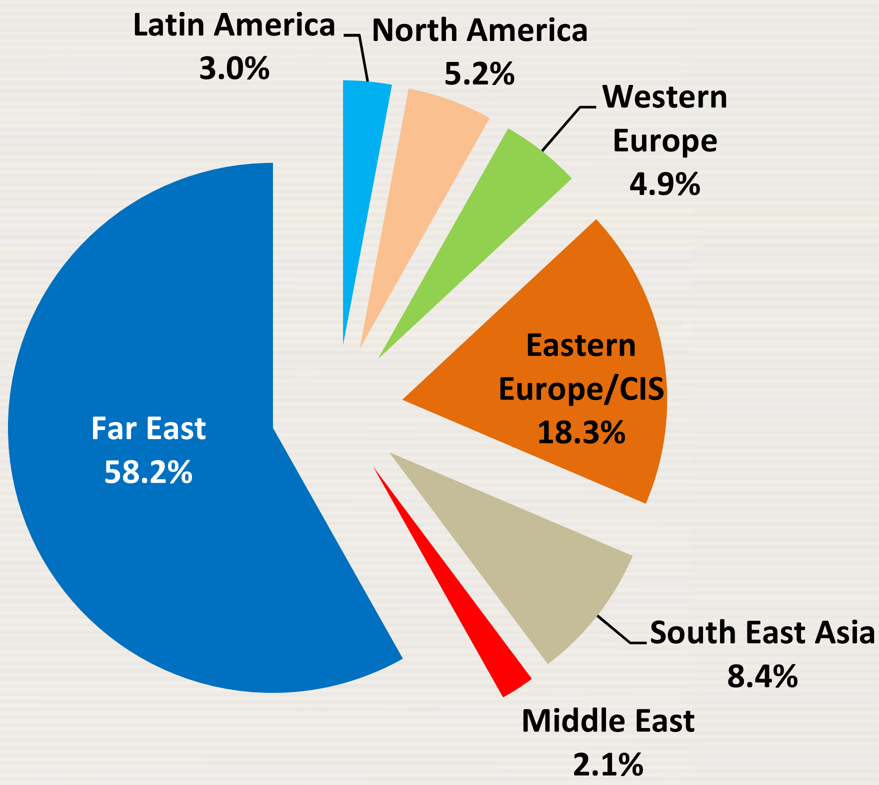


Status global nuclear power today

Units in Operation: 434
370.5 GWe

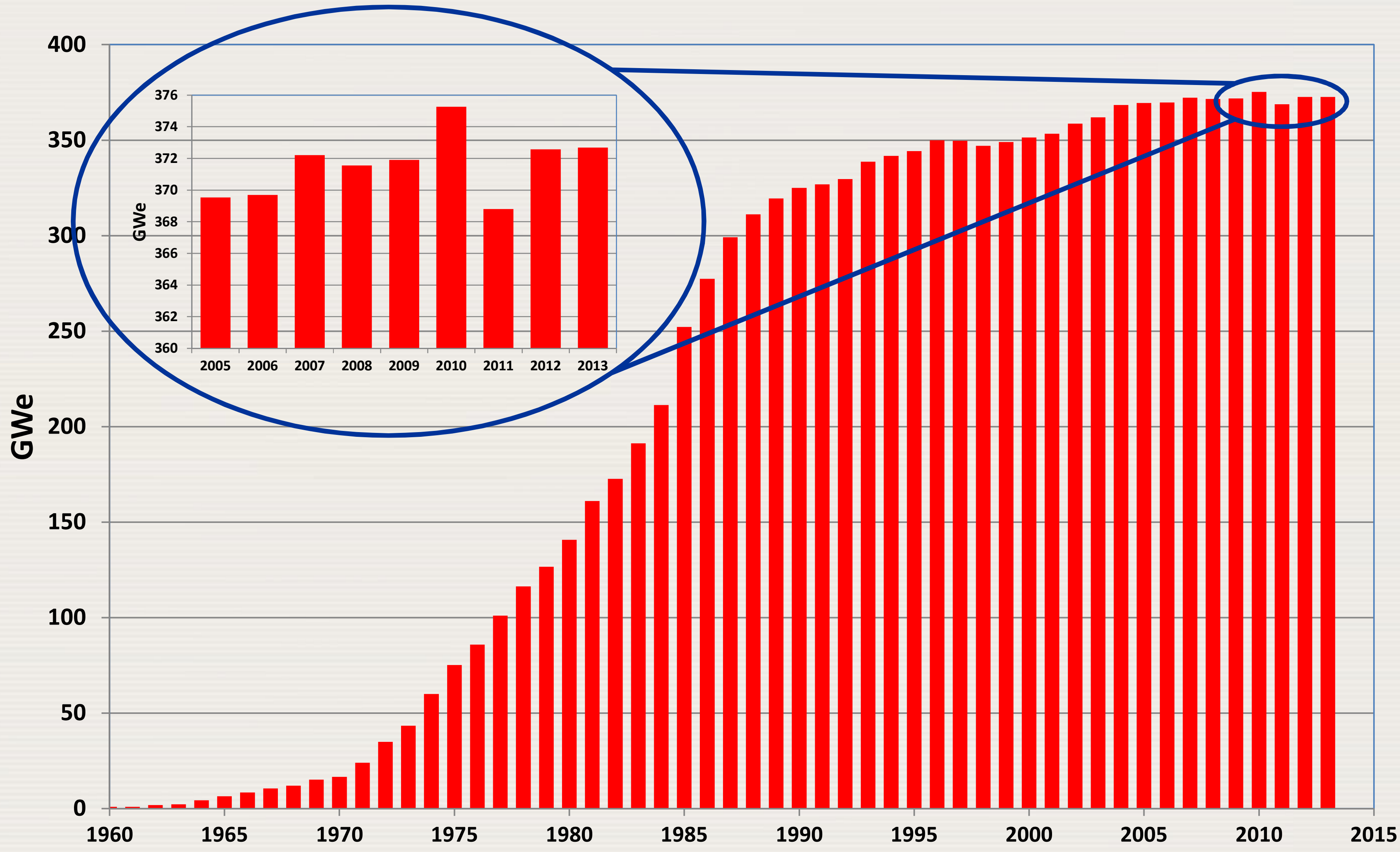


Units under construction: 69
65.3 GWe



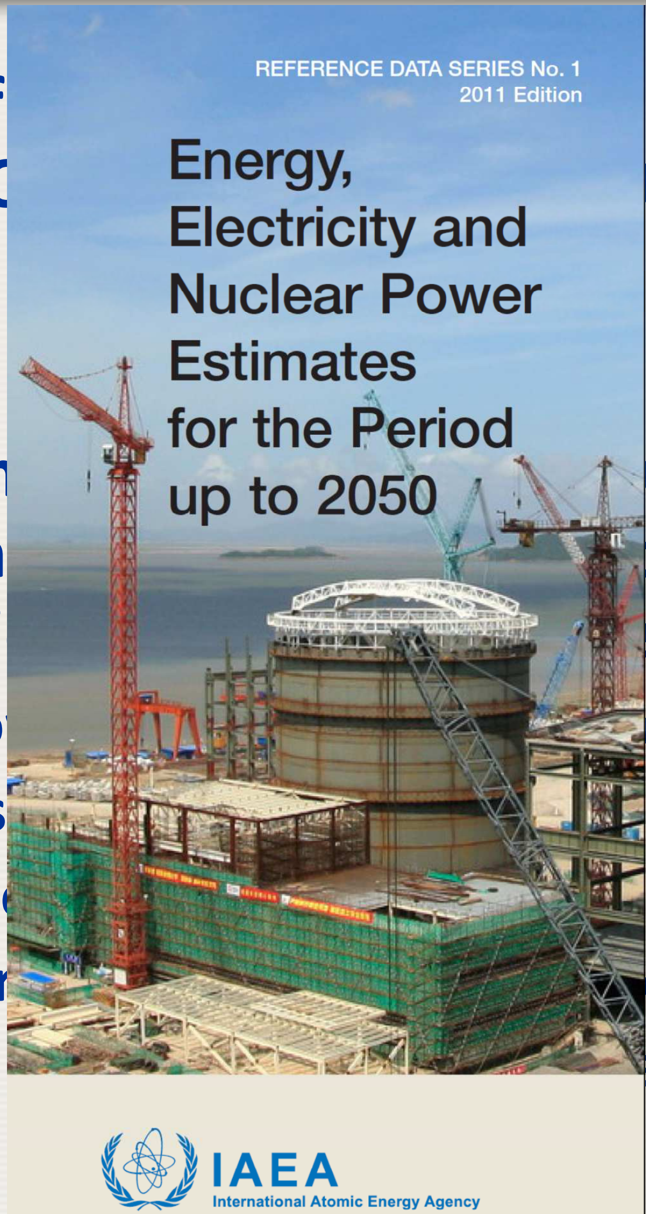
Status 15 July 2013

Nuclear power generating capacity
(as 31 May 2013)



IAEA nuclear power projections (RDS-1)

- Projections of f power are presented as LC tes
- Projections are
- The RDS-1 estin ved as very general growth ty must be constantly subj ew
  - Economic gro omic change
  - Energy intens
  - Technology p
  - Energy resour e fuel prices
  - Energy policy ental and economic constraints.



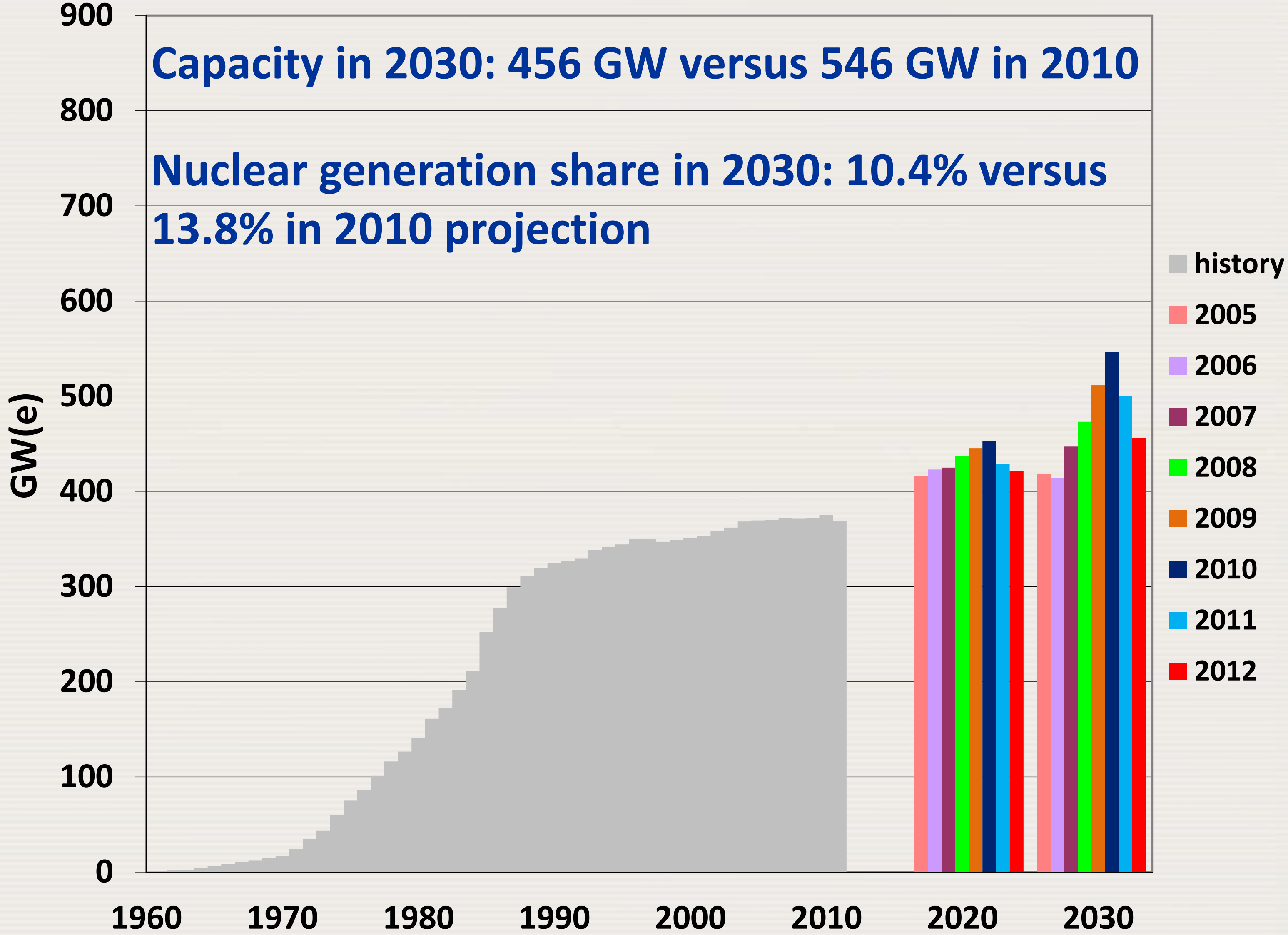
Predictions are difficult, especially about the future (Niels Bohr)

- Projections of future role of nuclear power are presented as LOW and HIGH estimates
- Projections are NOT predictions
- The RDS-1 estimates should be viewed as very general growth trends whose validity must be constantly subjected to critical review
  - Economic growth and structural economic change
  - Energy intensity
  - Technology performance and costs
  - Energy resource availability and future fuel prices
  - Energy policy and physical, environmental and economic constraints.

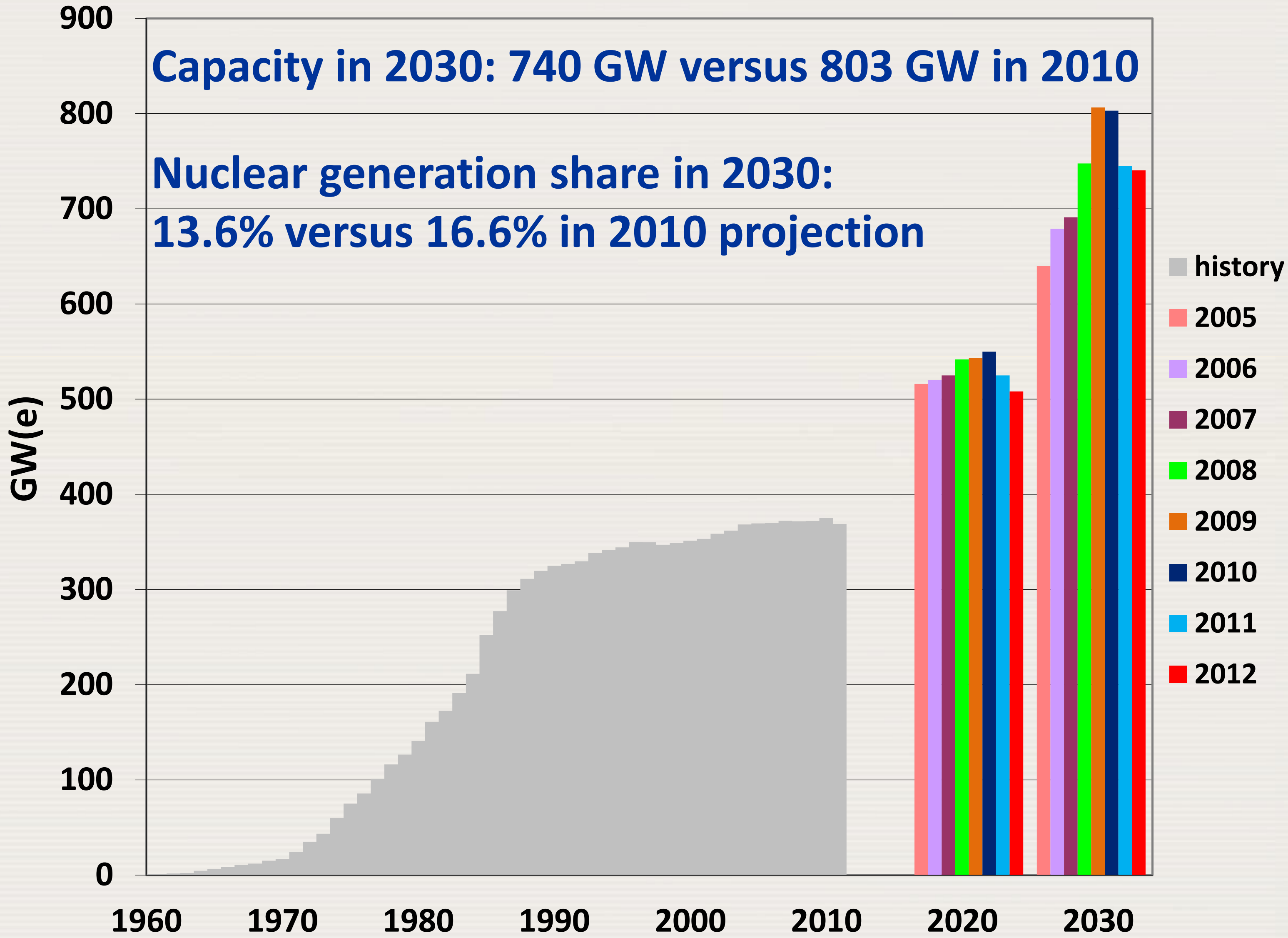
Key assumptions

- LOW reflects a continuation current trends and changes in policies affecting nuclear power other than those already in the pipeline
- HIGH is much more optimistic, but still plausible and technically feasible and assumes that
  - the Fukushima Daiichi accident does not lead to a long-term retraction of nuclear power programmes globally
  - the current financial and economic crises will be overcome in the not so distant future
  - past rates of economic growth and electricity demand, especially in the Far East, would essentially resume
  - the implementation of stringent policies globally targeted at mitigating climate change

IAEA – LOW projection



IAEA – HIGH projection



Concluding remarks

- Rising incomes & population will accelerate the demand for energy services
- Oil supply diversity is diminishing, while new options are opening up for natural gas
- Globally, energy resources are plentiful and pose no limiting constraint – but timely investment required
- Less nuclear would lead to higher CO_2 emissions, increased energy prices and growing energy import bills
- Energy conversion technologies will become increasingly capital intensive
- Despite steps in the right direction, the door to 2°C is closing