WORLD ENERGY OUTLOOK 2011

This study was prepared by the Office of the Chief Economist (OCE) of the International Energy Agency in co-operation with other offices of the Agency. It was designed and directed by **Fatih Birol, Chief Economist of the IEA**

Comments and questions are welcome and should be addressed to:

Dr. Fatih Birol
Chief Economist
Director, Office of the Chief Economist
International Energy Agency
9, rue de la Fédération
75739 Paris Cedex 15
France
Telephone: (33-1) 4057 6670
Fax: (33-1) 4057 6509
Email: weo@iea.org

More information about the *World Energy Outlook is available at* www.worldenergyoutlook.org.

Selected items

- Energy market
- Energy projection to **2035**
- Oil market
- Natural gas market
- Power and renewables
- Climate change and **450** scenario
- Coal demand prospect
- Implication of less nuclear
- Energy for all
- Subsidies
- In short…

Energy market

- About GDP
- The three scenarios
- Energy prices
- Technology

About GDP

- The world GDP is assumed to average 3.6% per year over the period 2009 ($ 70.8 E12) to 2035 ($ 176.2 E12)
- Non-OECD countries account for over 70% of the increase in global economic output, pushing their share of global GDP from almost 45% today to over 60% in 2035.
- China alone makes up 31% of the increase in global GDP to 2035 and India a further 15%.

- Population growth will continue to underpin rising energy demand
- The world's population is assumed to increase by 26%, from 6.8 billion in 2009 to 8.6 billion in 2035, with over 90% of the increase in non-OECD regions
- The annual increase in the world's population slows progressively, from 78 million in 2010 to 56 million in 2035.

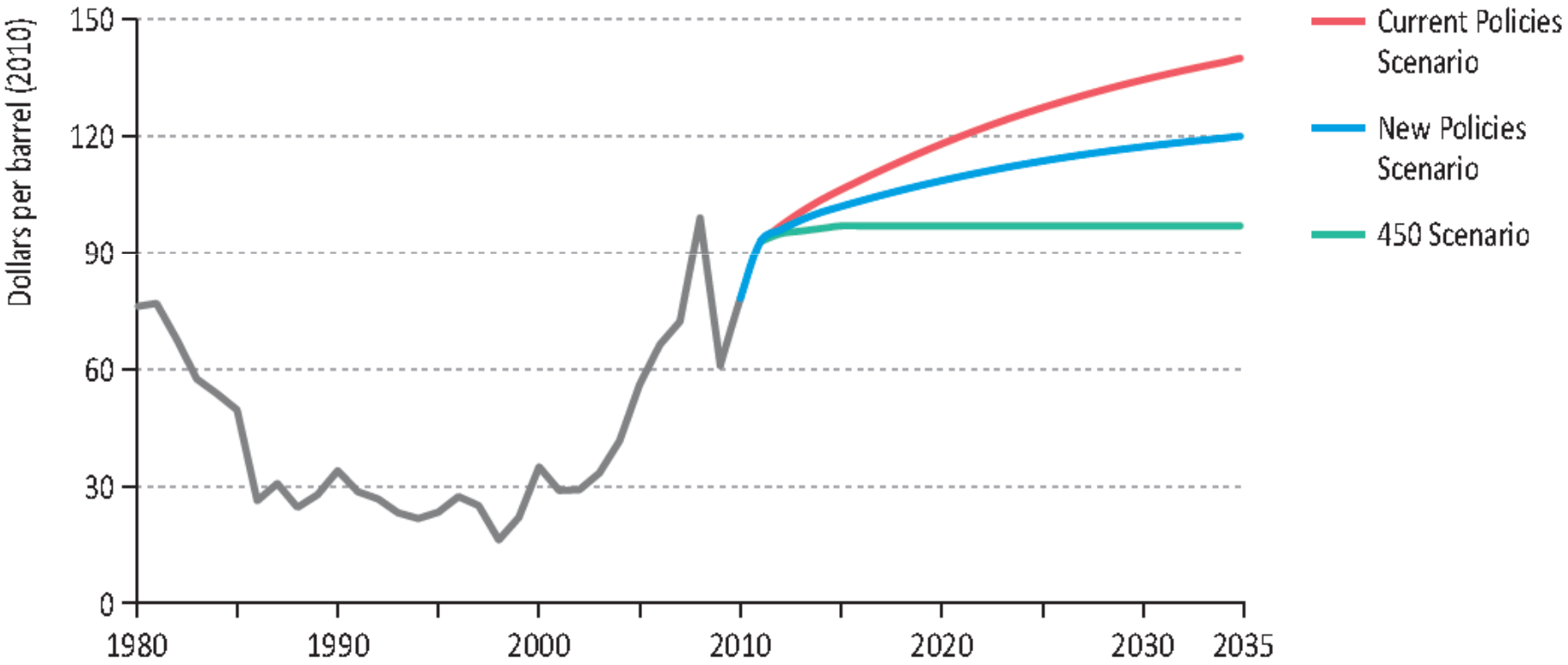
The three scenarios

- "**New Policies**" (central scenario in this *Outlook): takes into account recently announced commitments and* plans, even if they are yet to be formally adopted and implemented
- "**Current Policies**": takes account only of those policies that had been enacted by mid-2011
- "**450**": illustrative energy pathway consistent with 50% chance of limiting the increase in average global temperature to 2°C.

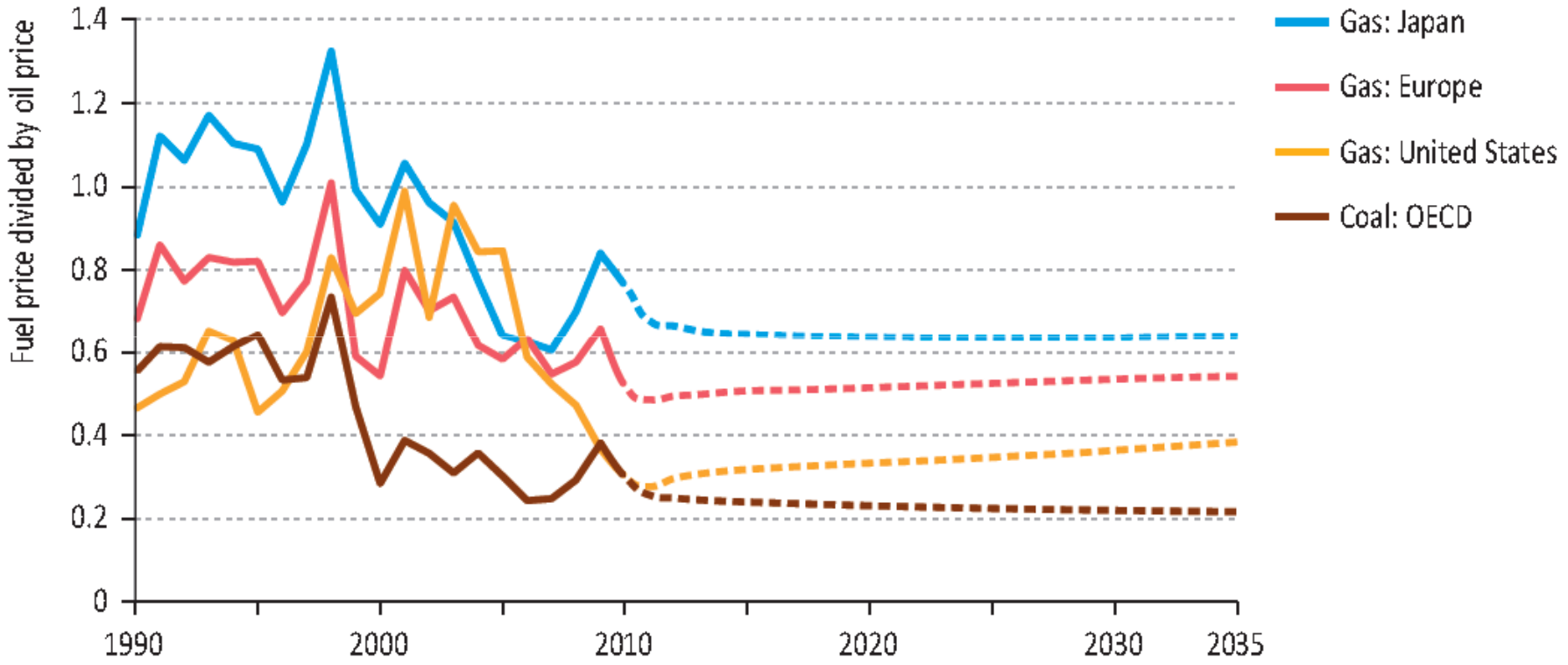
Energy prices

- Oil
- Gas
- Coal
- CO2

Average IEA crude oil import price



Ratio of average natural gas and coal import prices to crude oil prices in the New Policies Scenario



Note: Calculated on an energy-equivalent basis.

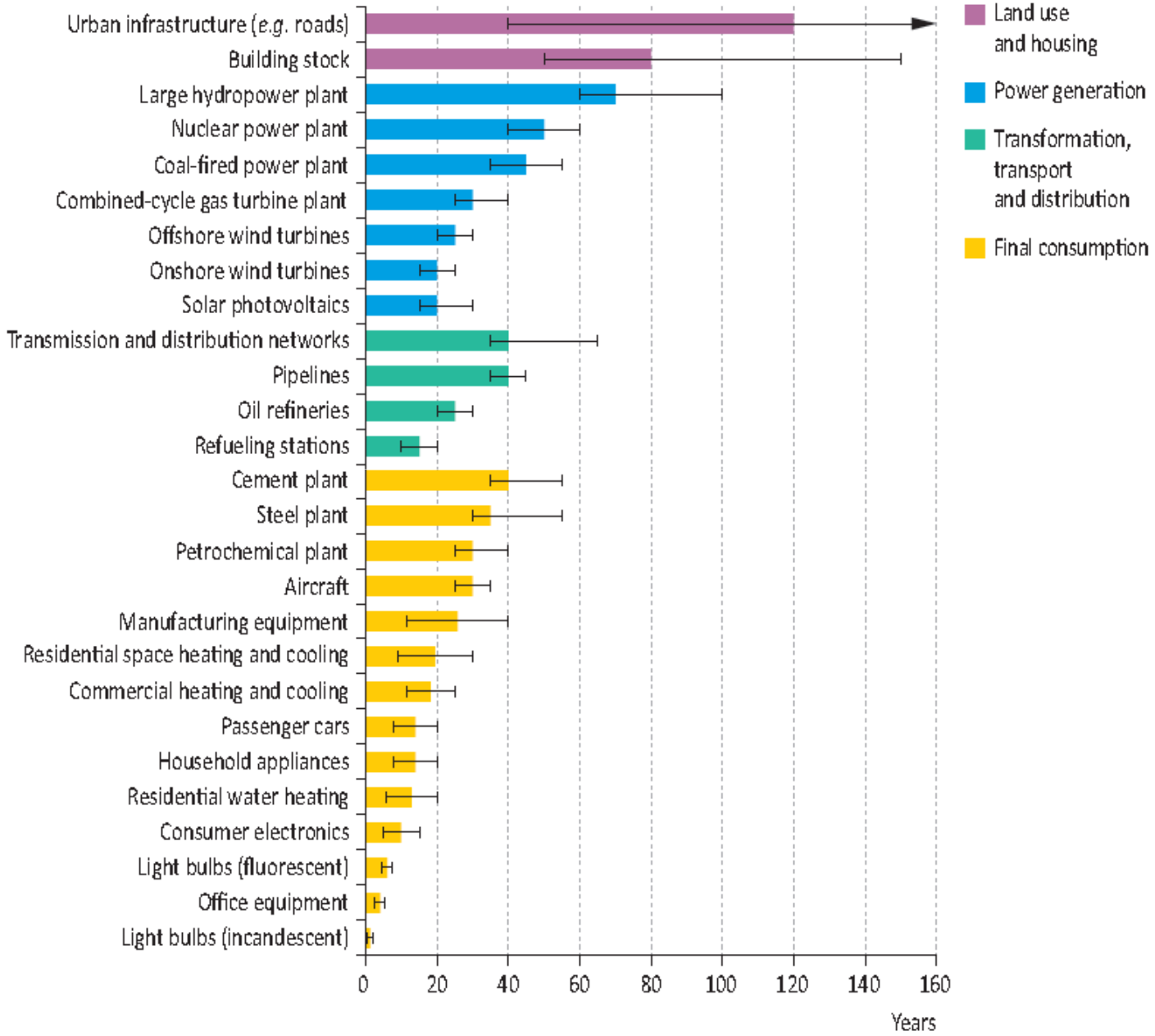
CO2 price assumptions in selected regions by scenario

($2010 per tonne)

	Region	Sectors	2020	2030	2035
Current Policies Scenario	European Union	Power, industry and aviation	30	40	45
New Policies Scenario	European Union	Power, industry and aviation	30	40	45
	Korea	Power and industry	18	36	45
	Australia, New Zealand	All	30	40	45
	China	All	10	23	30
450 Scenario	United States, Canada	Power and industry	20	87	120
	European Union	Power, industry and aviation	45	95	120
	Japan, Korea, Australia, New Zealand	Power and industry *	35	90	120
	China, Russia, Brazil, South Africa	Power and industry**	10	65	95

*All sectors in Australia and New Zealand. **All sectors in China.

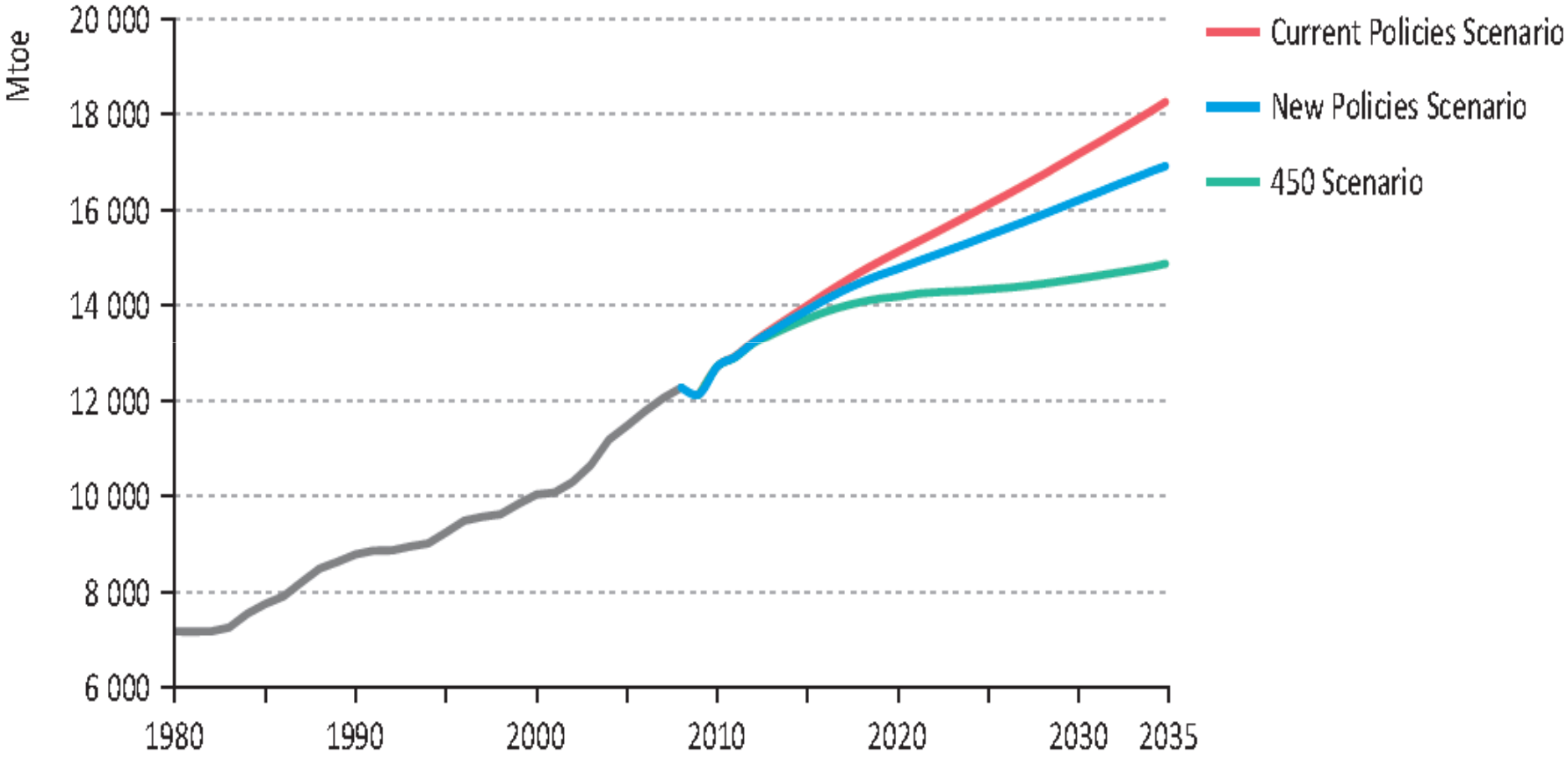
Technology: Typical lifetimes



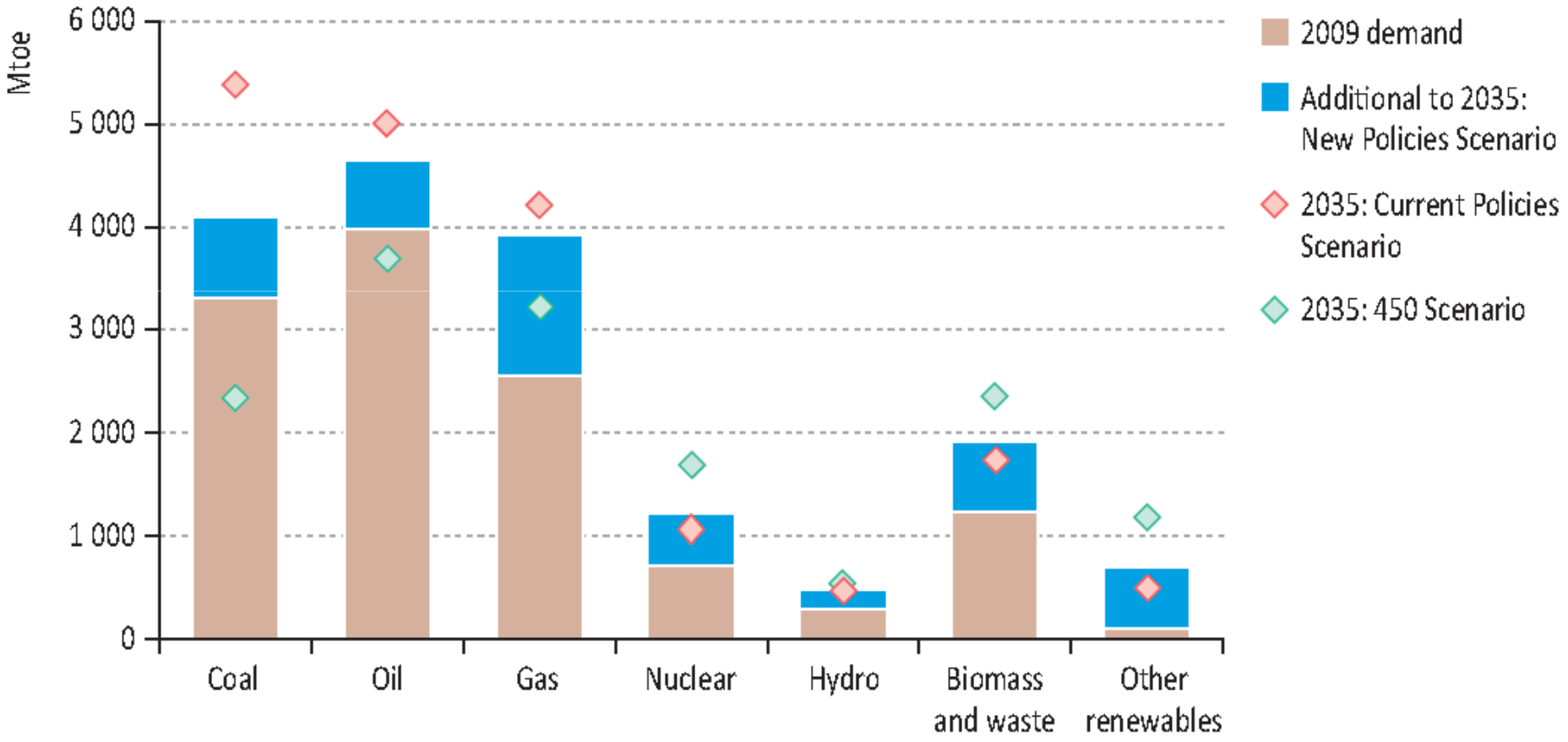
ENERGY PROJECTIONS TO 2035

- Energy trends in the three scenarios
- New policies scenario
- Energy related emissions

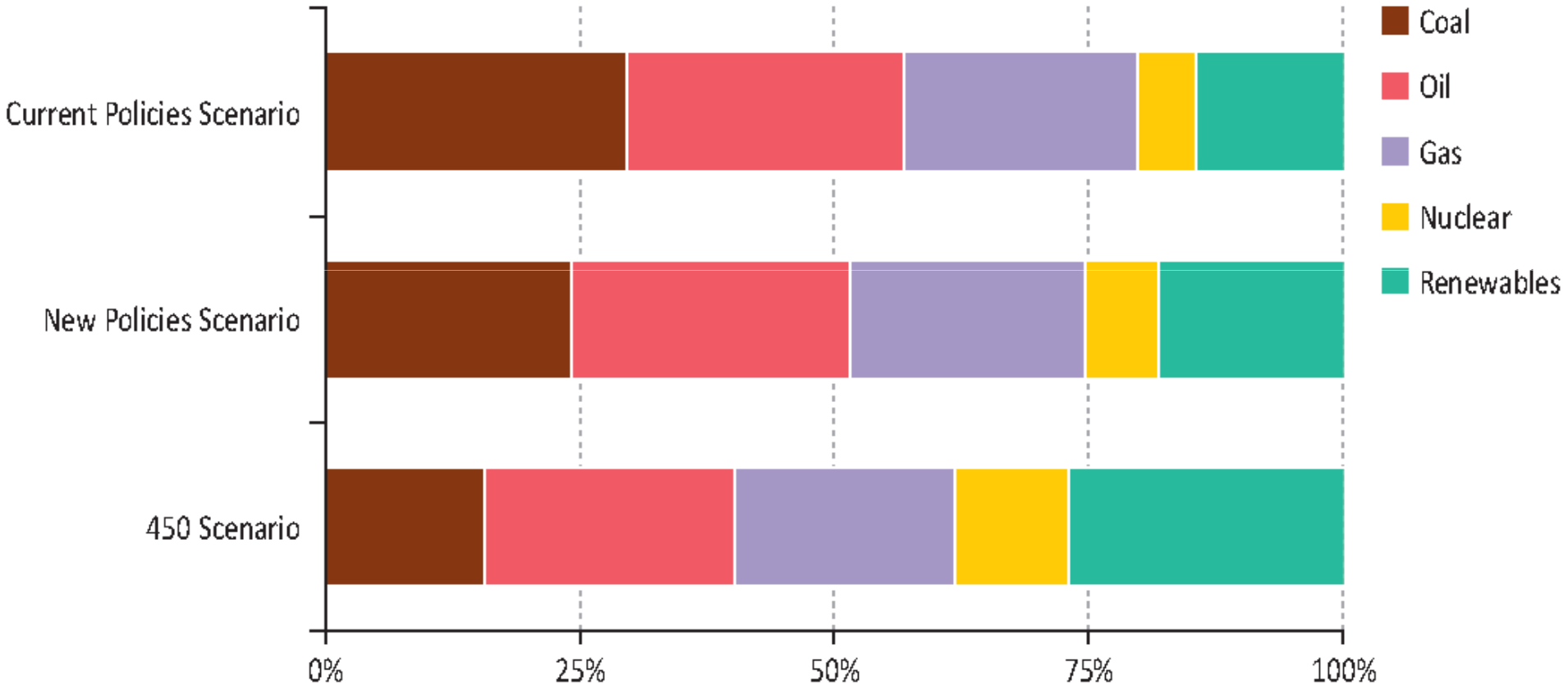
World primary energy demand by scenario



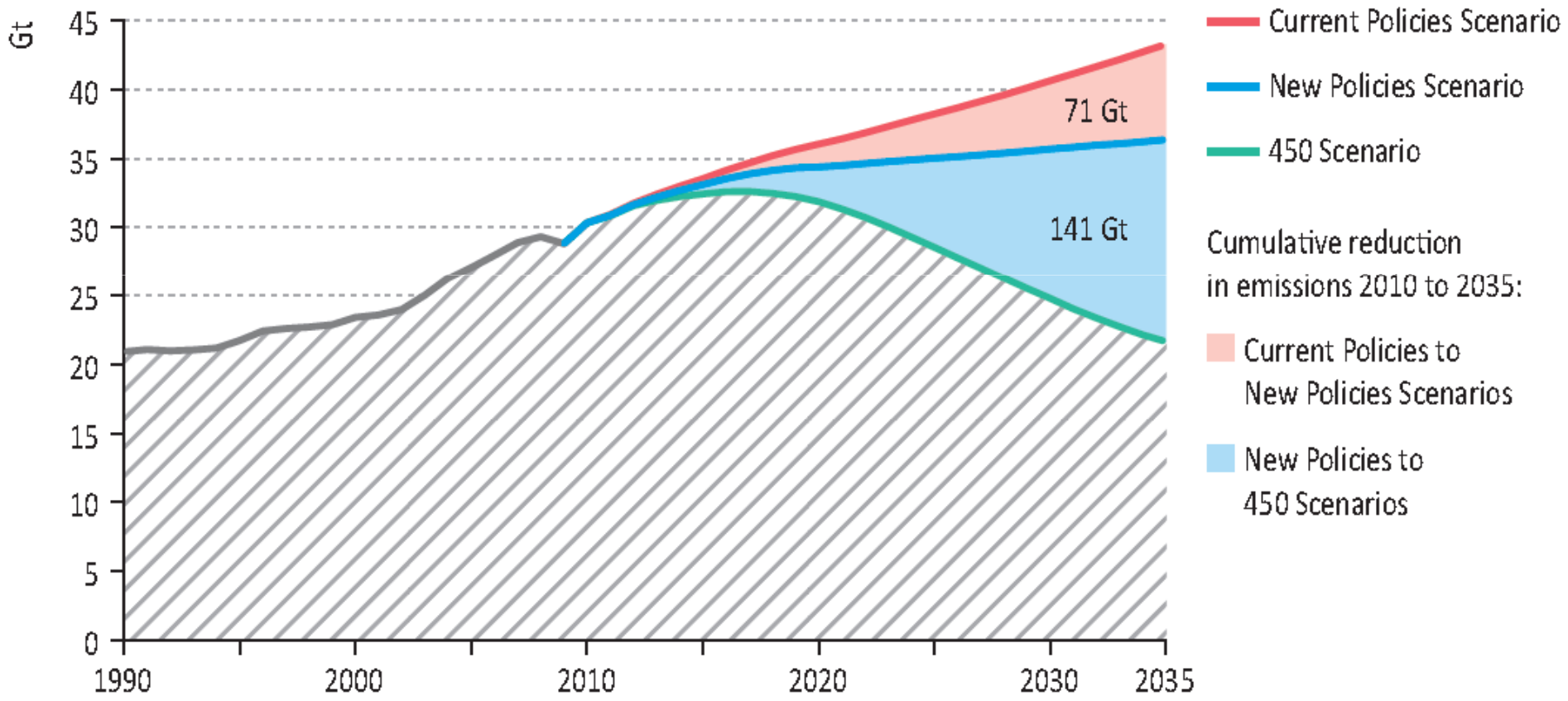
World primary energy demand by fuel and scenario, 2009 and 2035 (Mtoe)



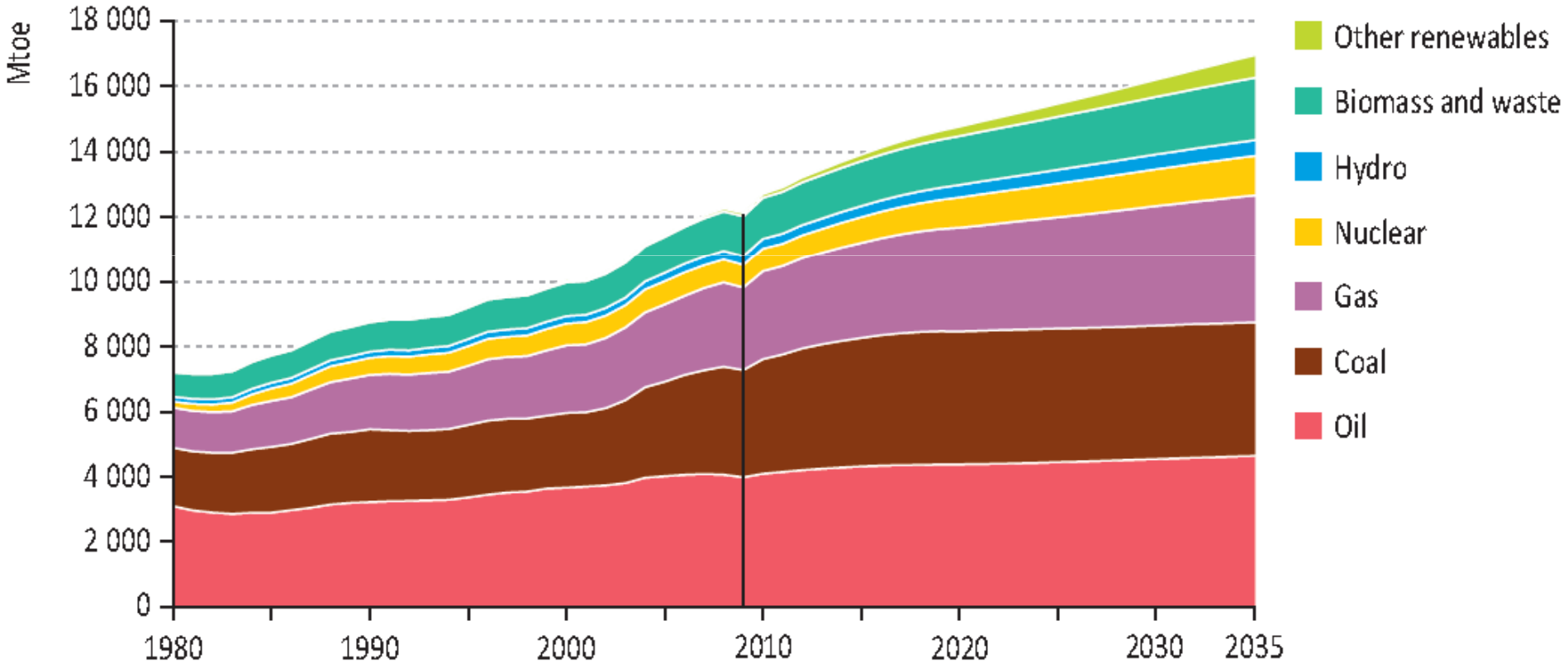
Shares of energy sources in world primary demand 2035



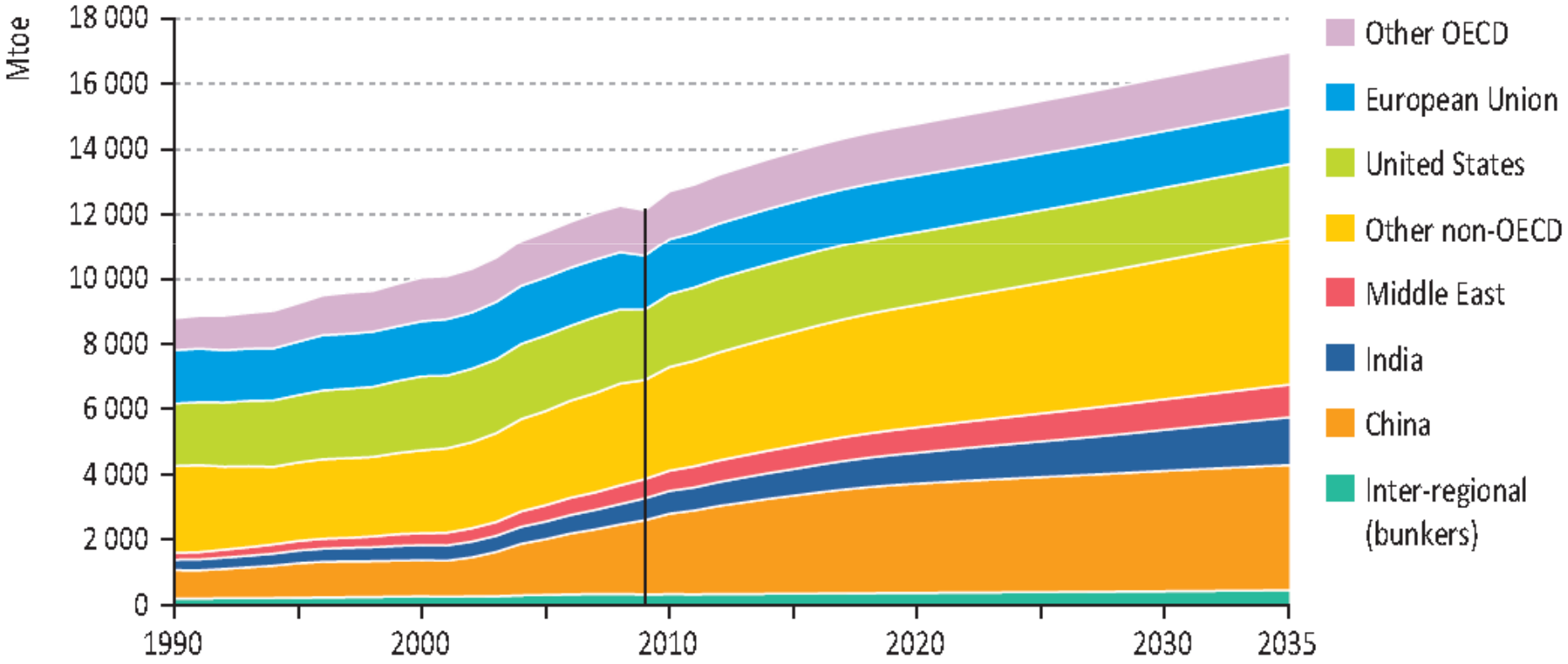
World energy-related CO2 emissions



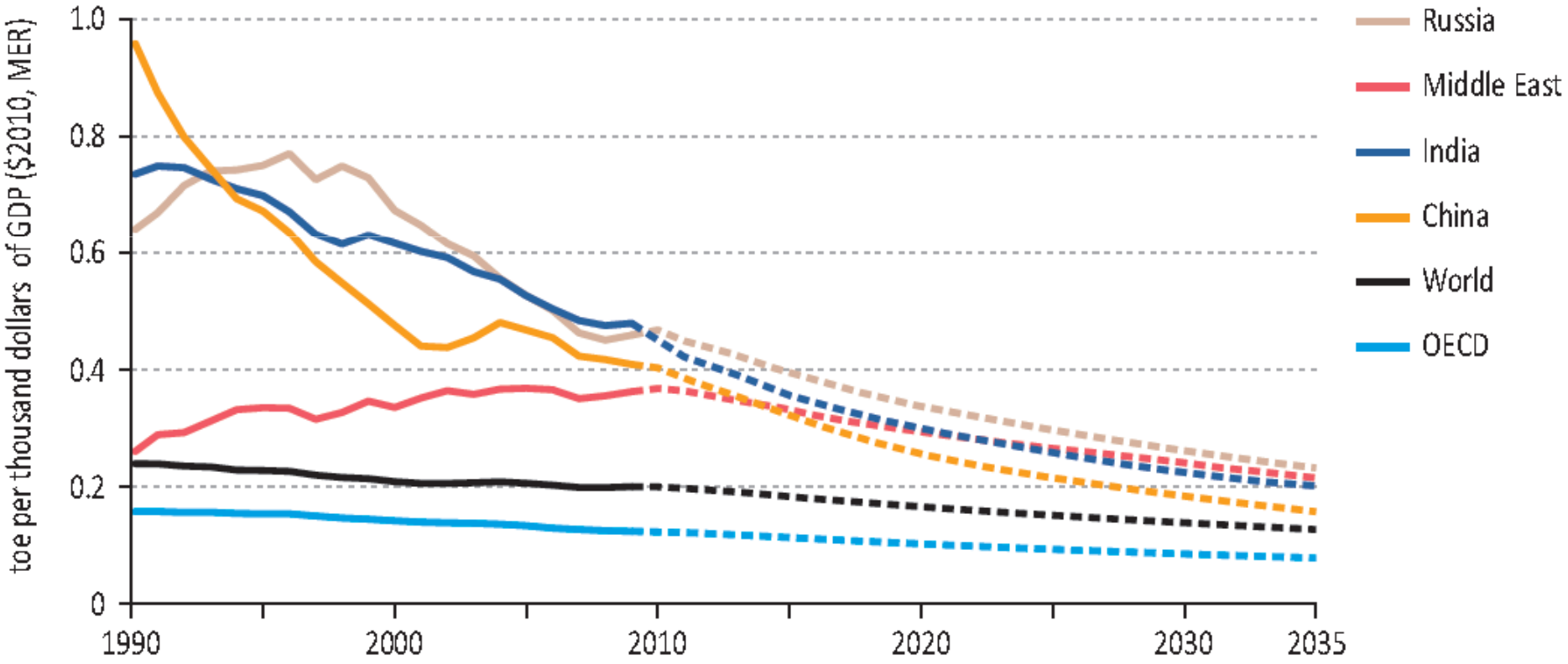
World primary energy demand by fuel in the New Policies Scenario



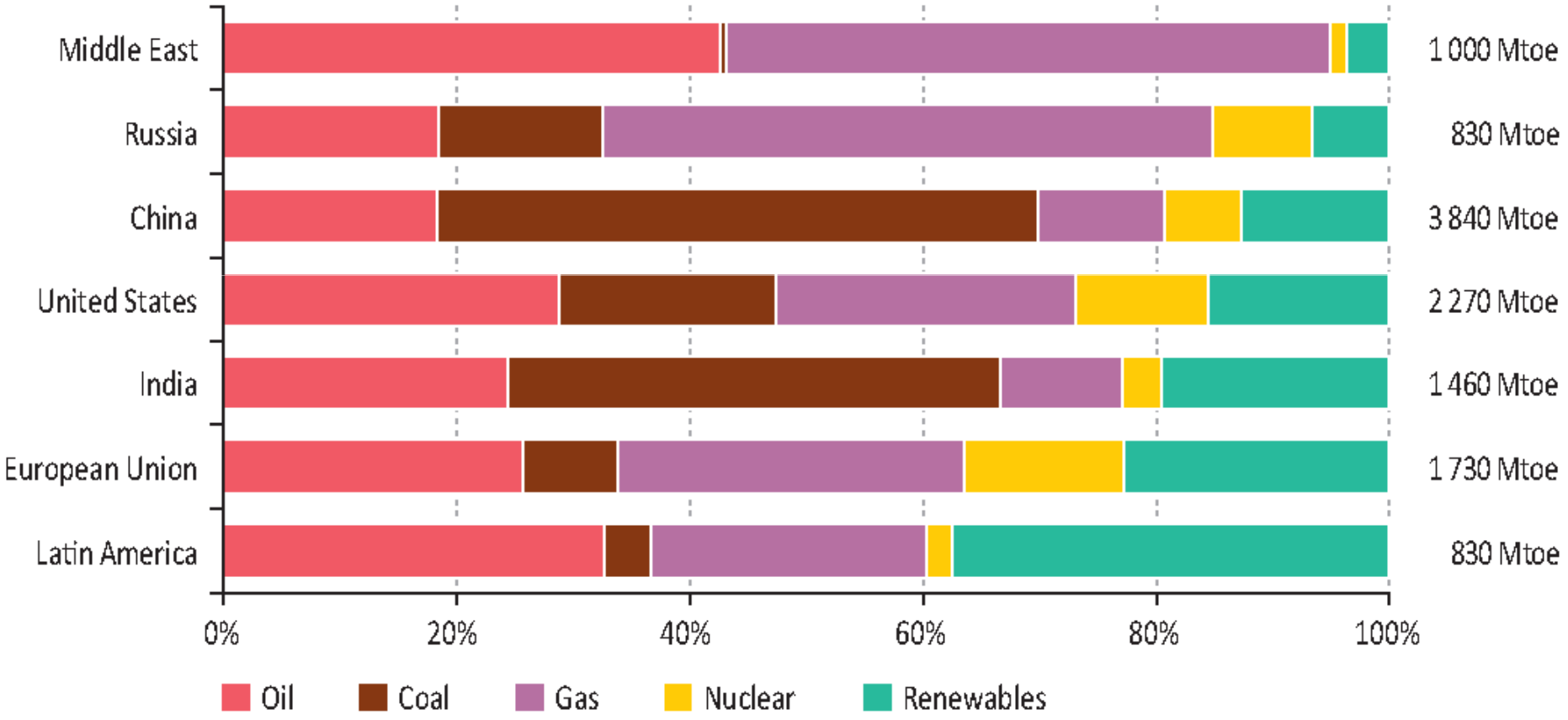
Demand by region in the New Policies Scenario



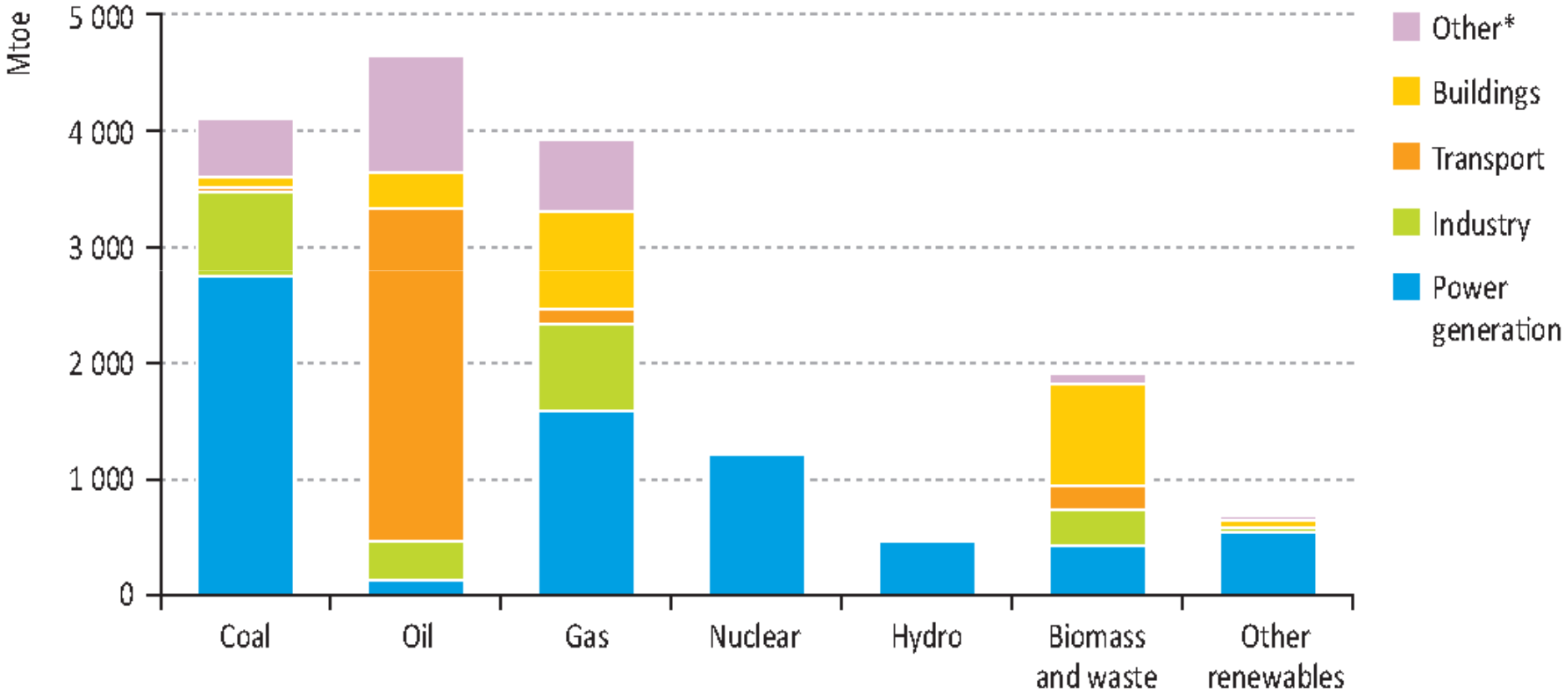
Energy intensity in the New Policies Scenario



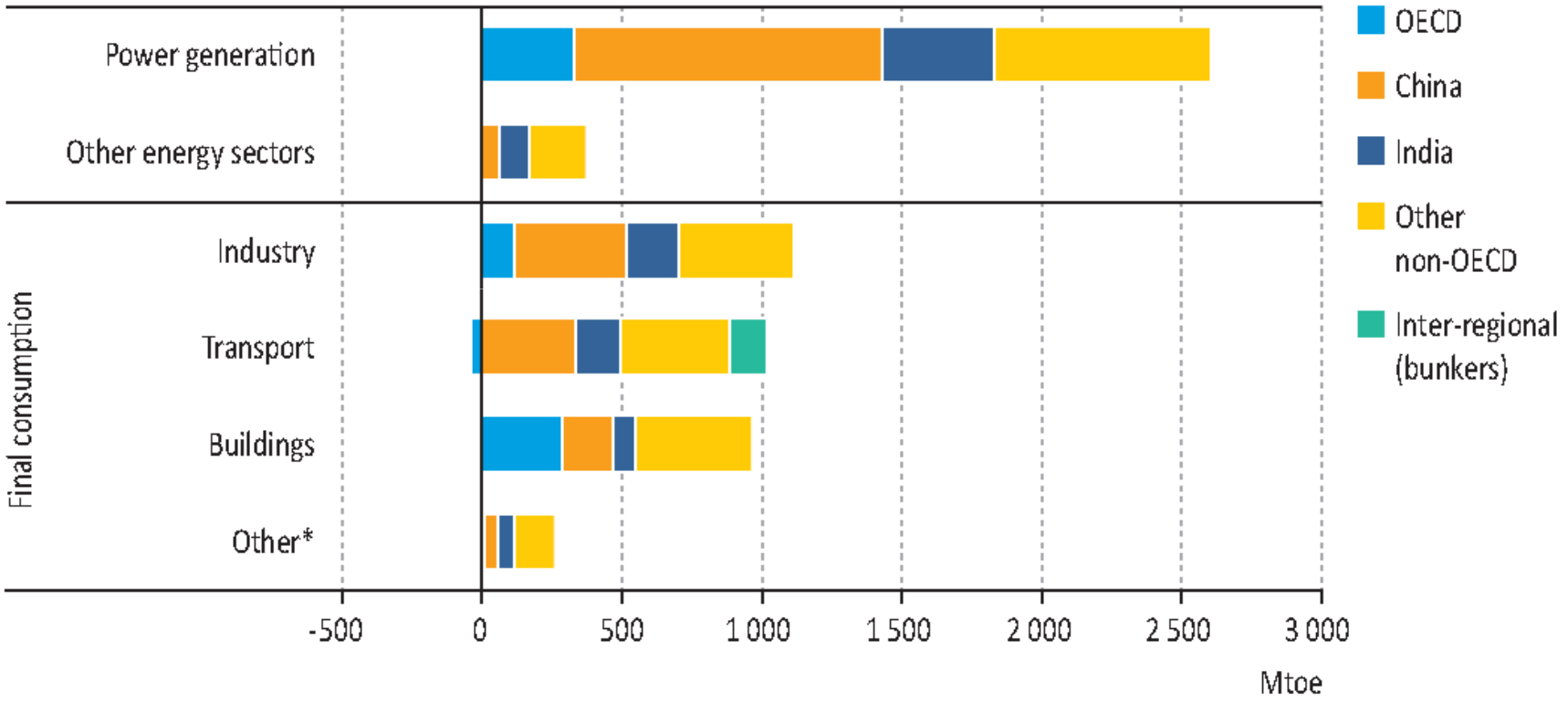
Energy mix in the New Policies Scenario, 2035



Demand by fuel and sector in the New Policies Scenario, 2035

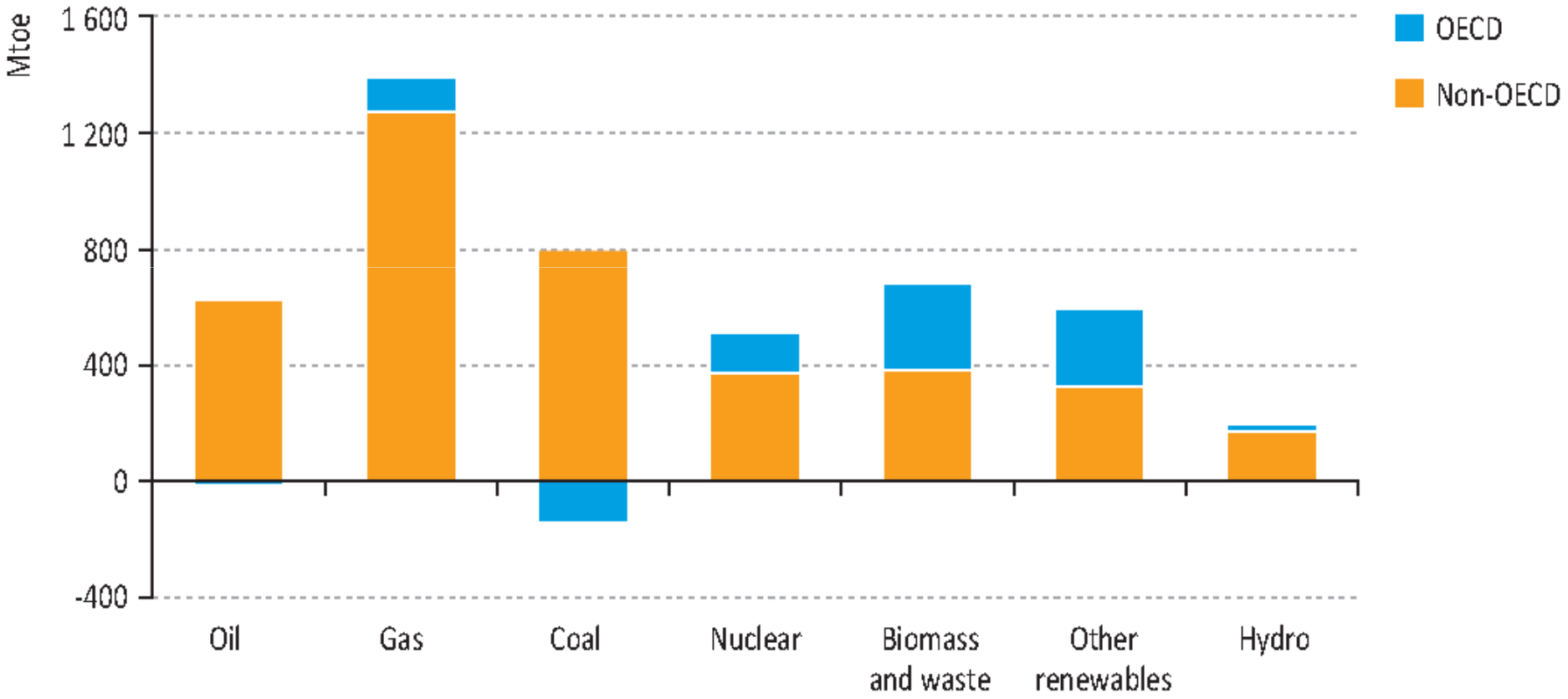


Incremental 2009-2035

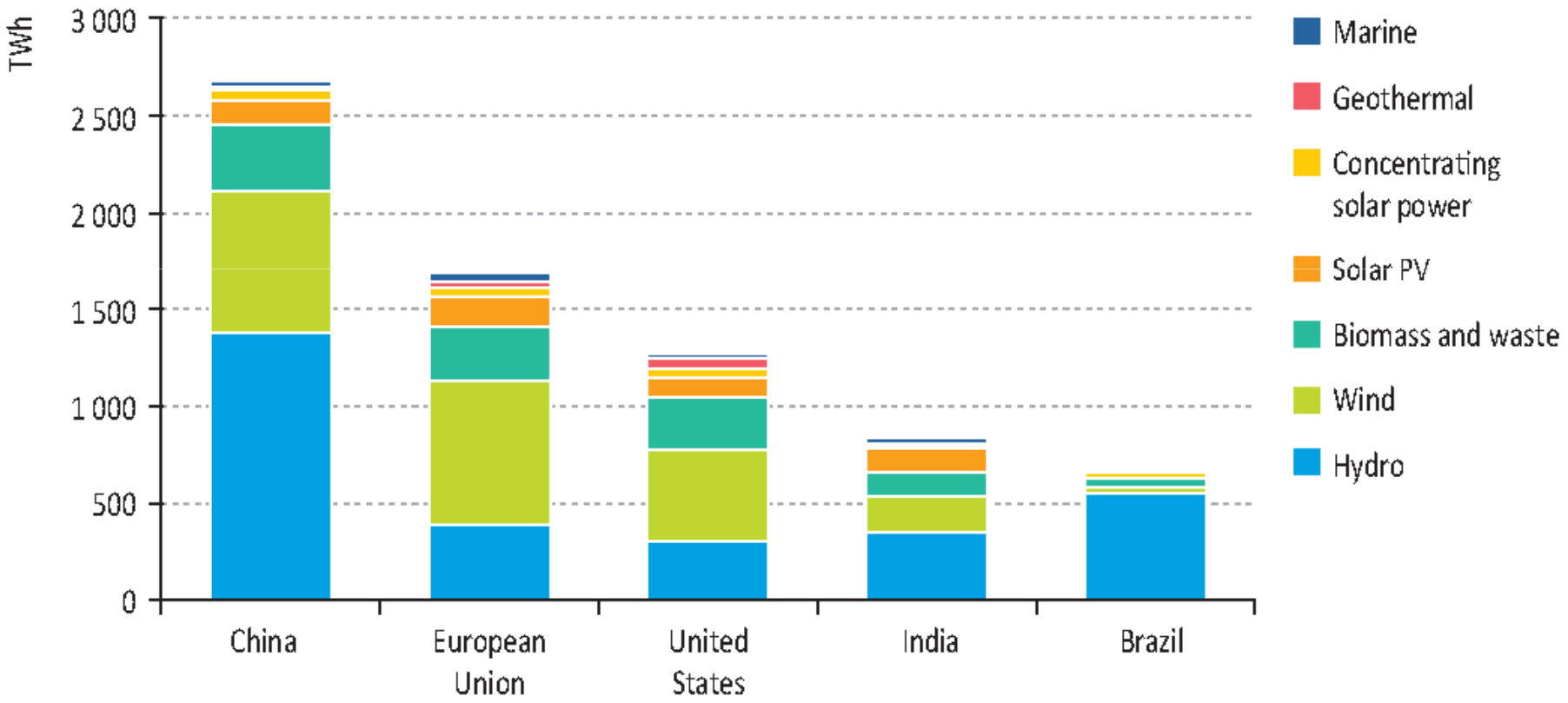


* Includes agriculture and non-energy use.

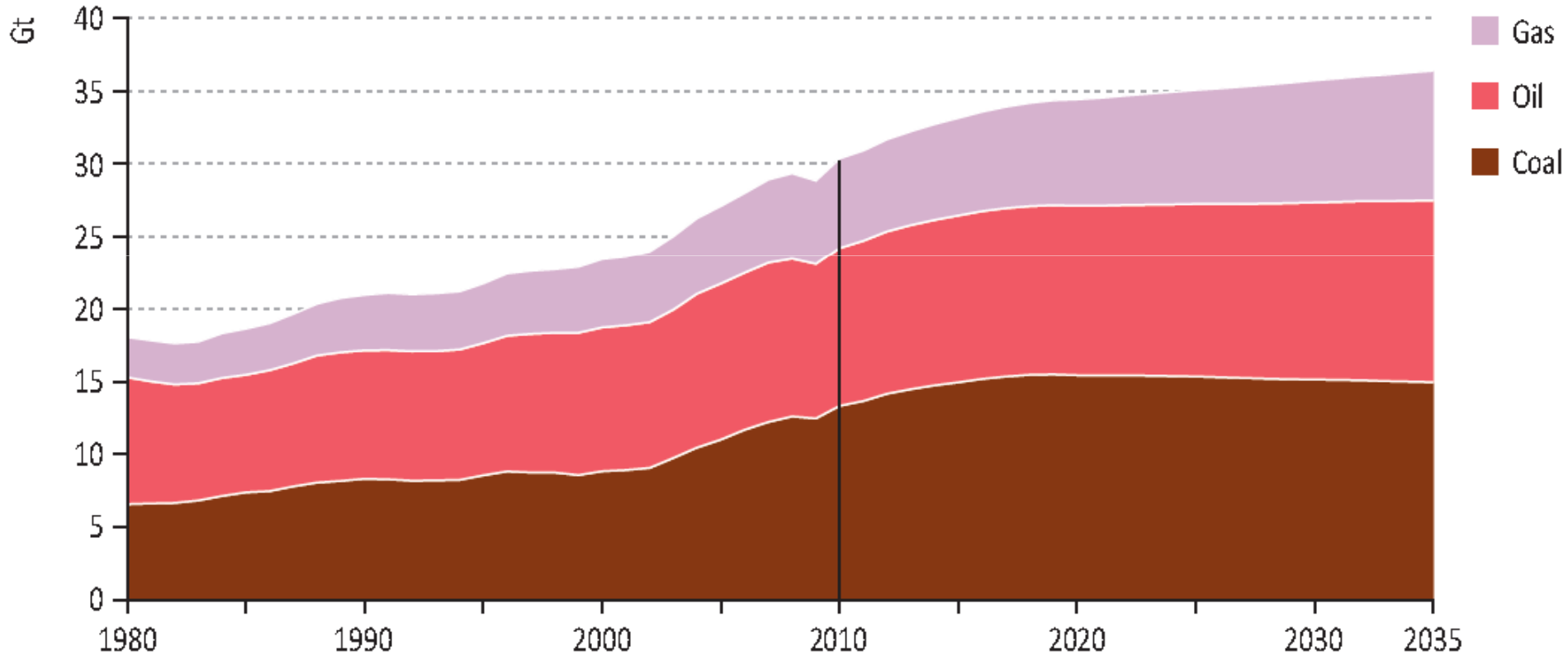
Incremental by fuel



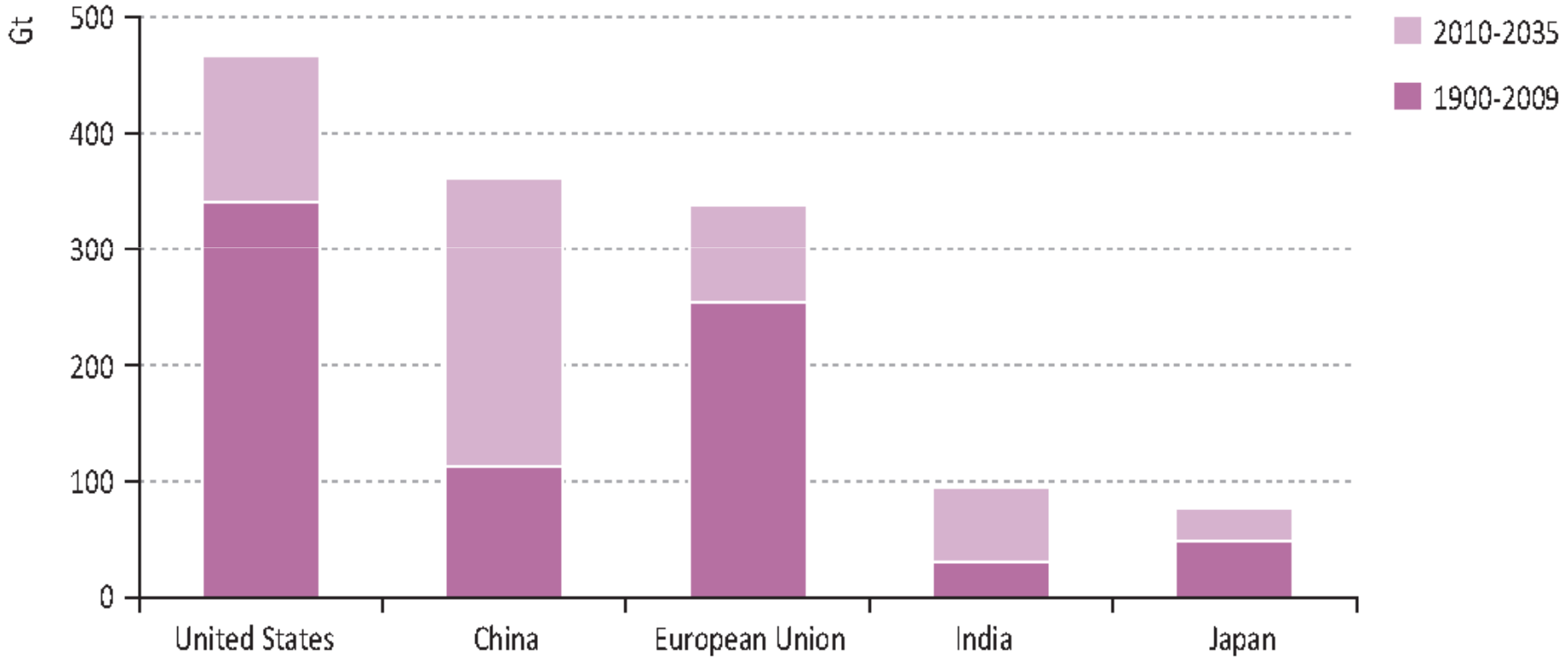
Largest producers of electricity from renewables, 2035



Energy-related CO2 emissions by fuel



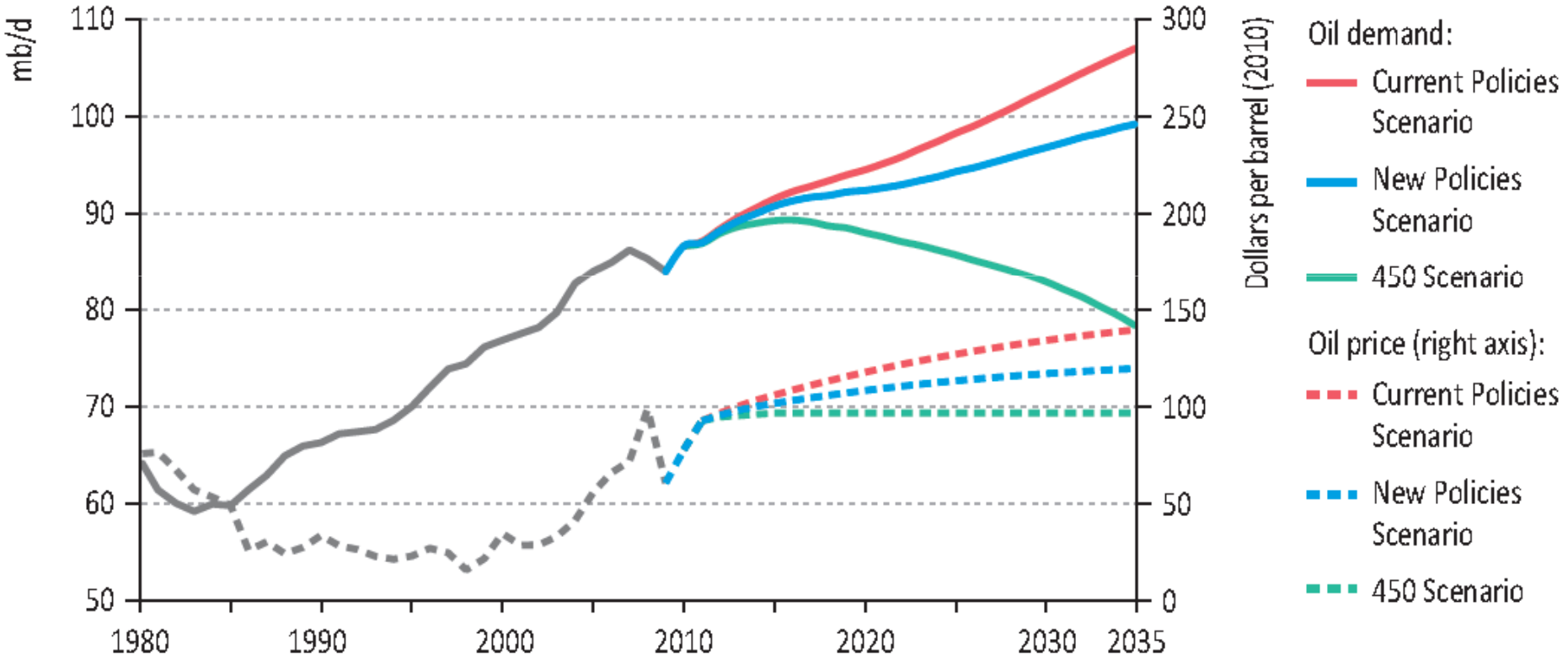
Cumulative energy-related CO2 emissions



OIL MARKET

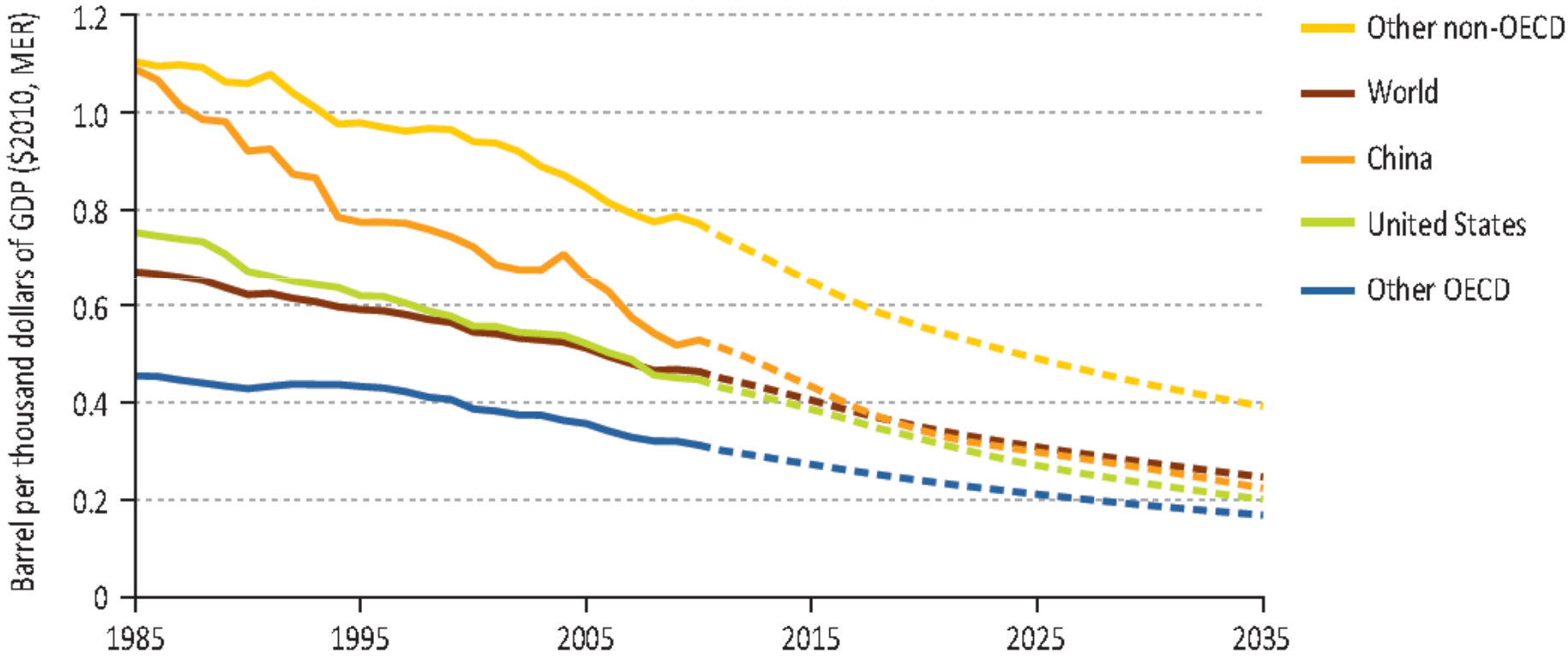
- Demand
- Production

World primary oil demand and oil price by scenario*



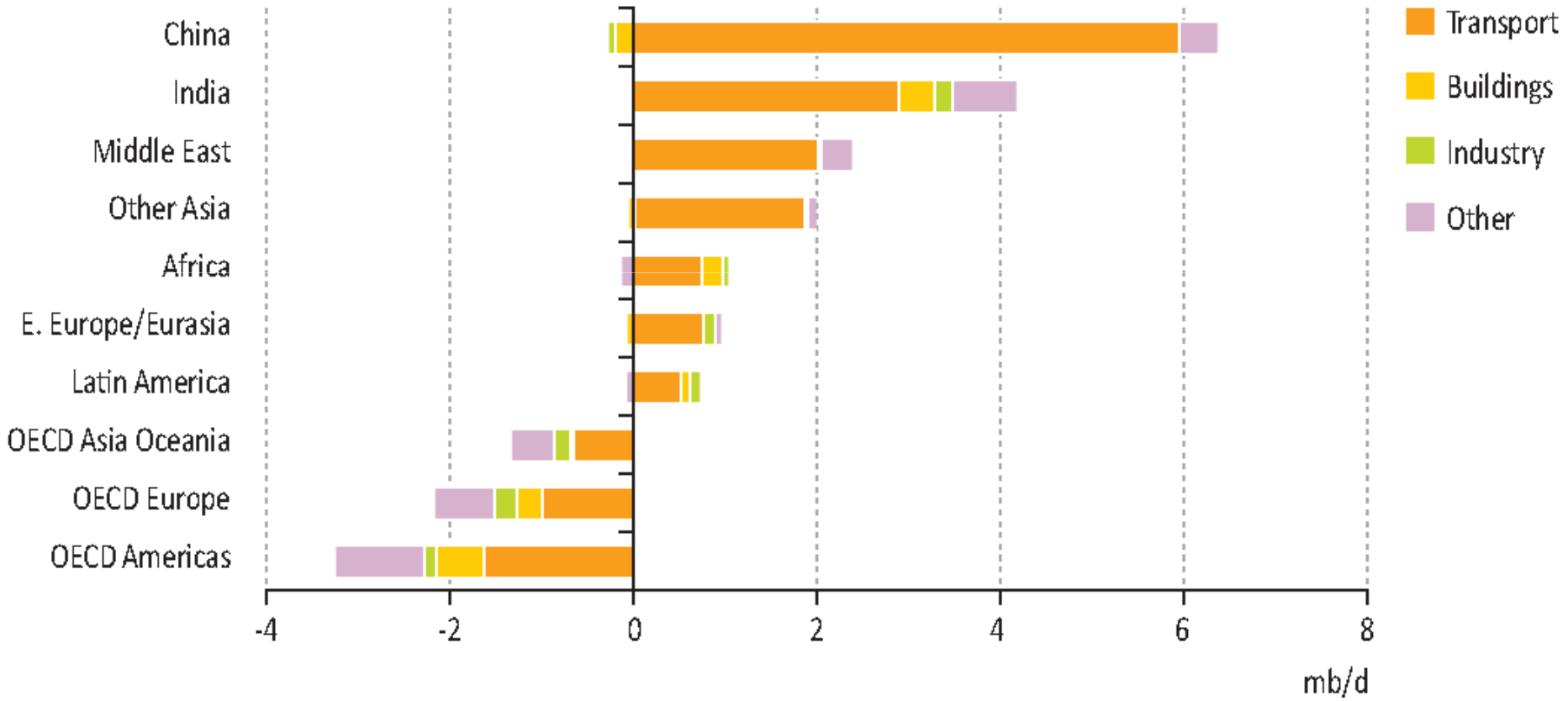
* Average IEA crude oil import price.

Primary oil intensity by region in the New Policies Scenario*

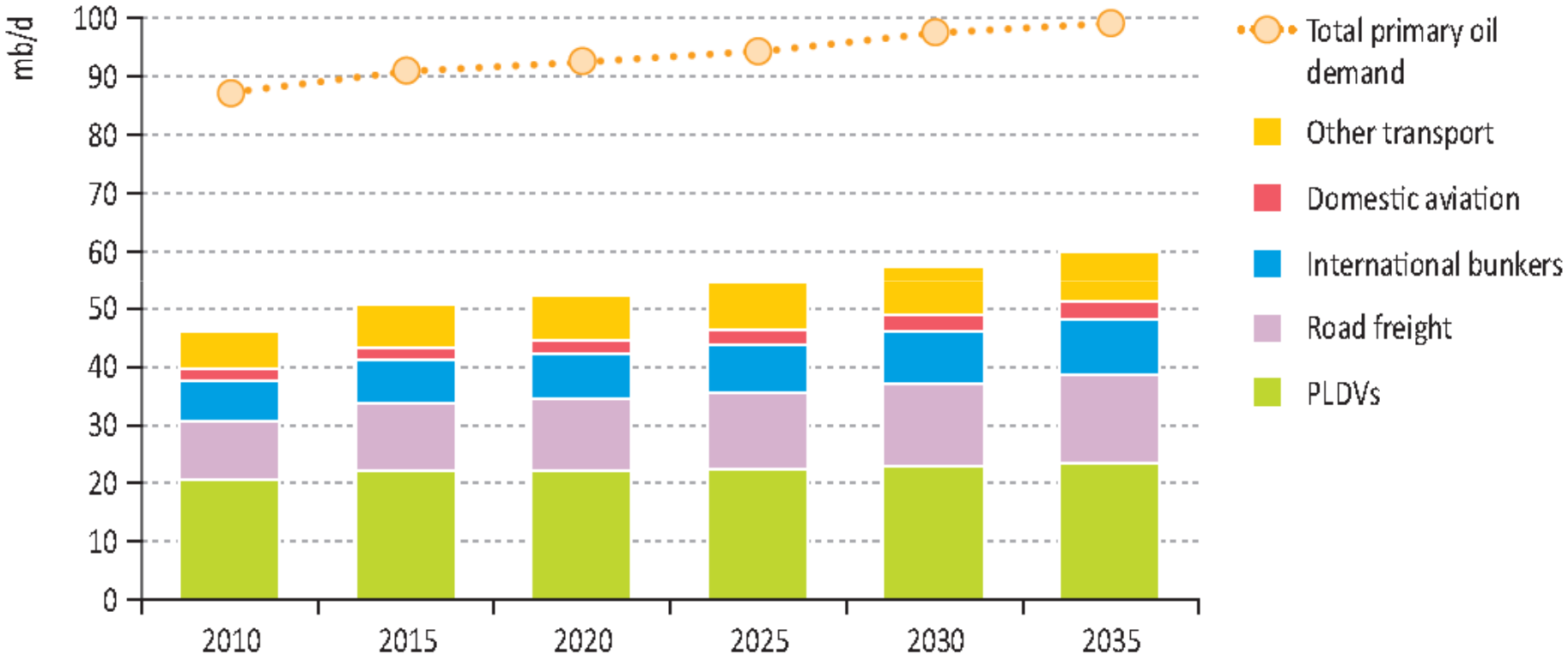


*Oil demand per unit of GDP at market exchange rates (MER). World excludes international marine and aviation bunkers.

Change in primary oil demand in the New Policies Scenario, 2010-2035

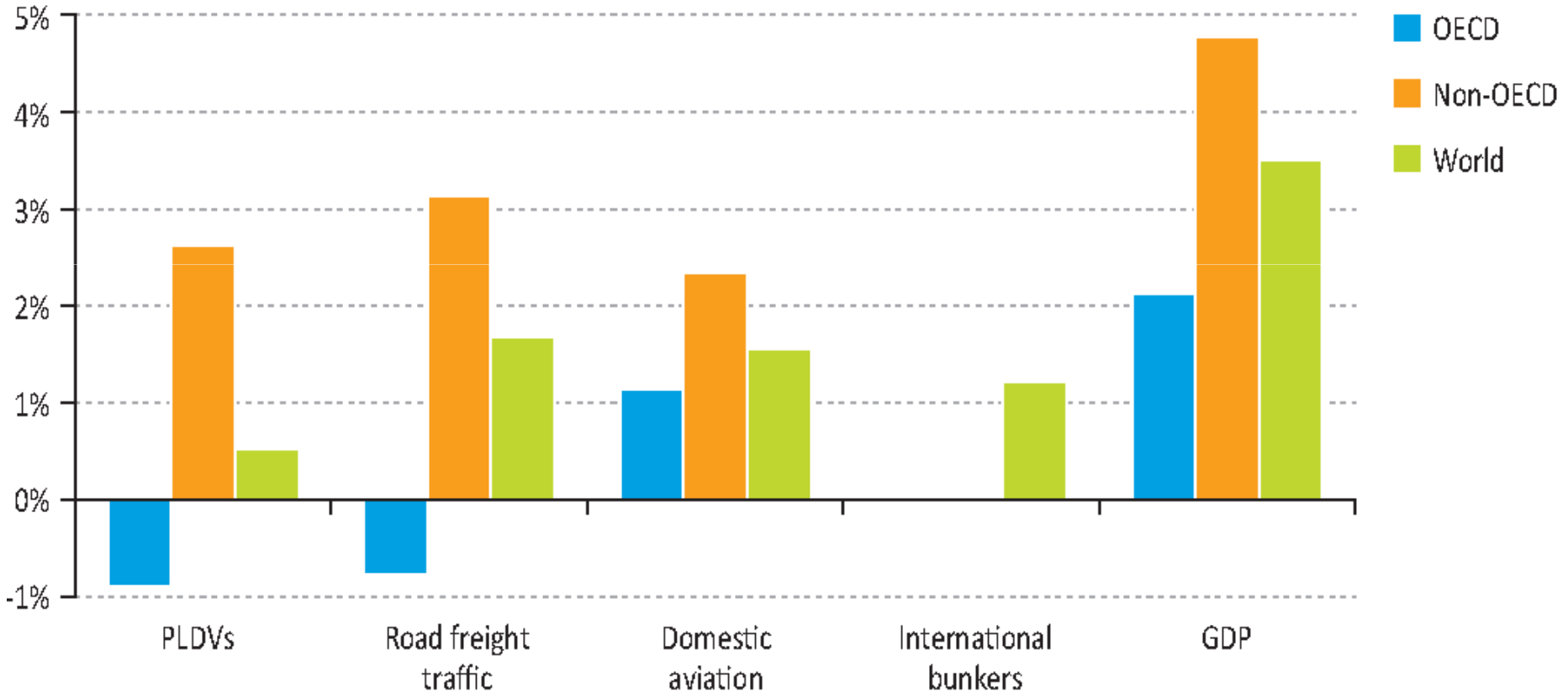


World transportation oil demand in the New Policies Scenario

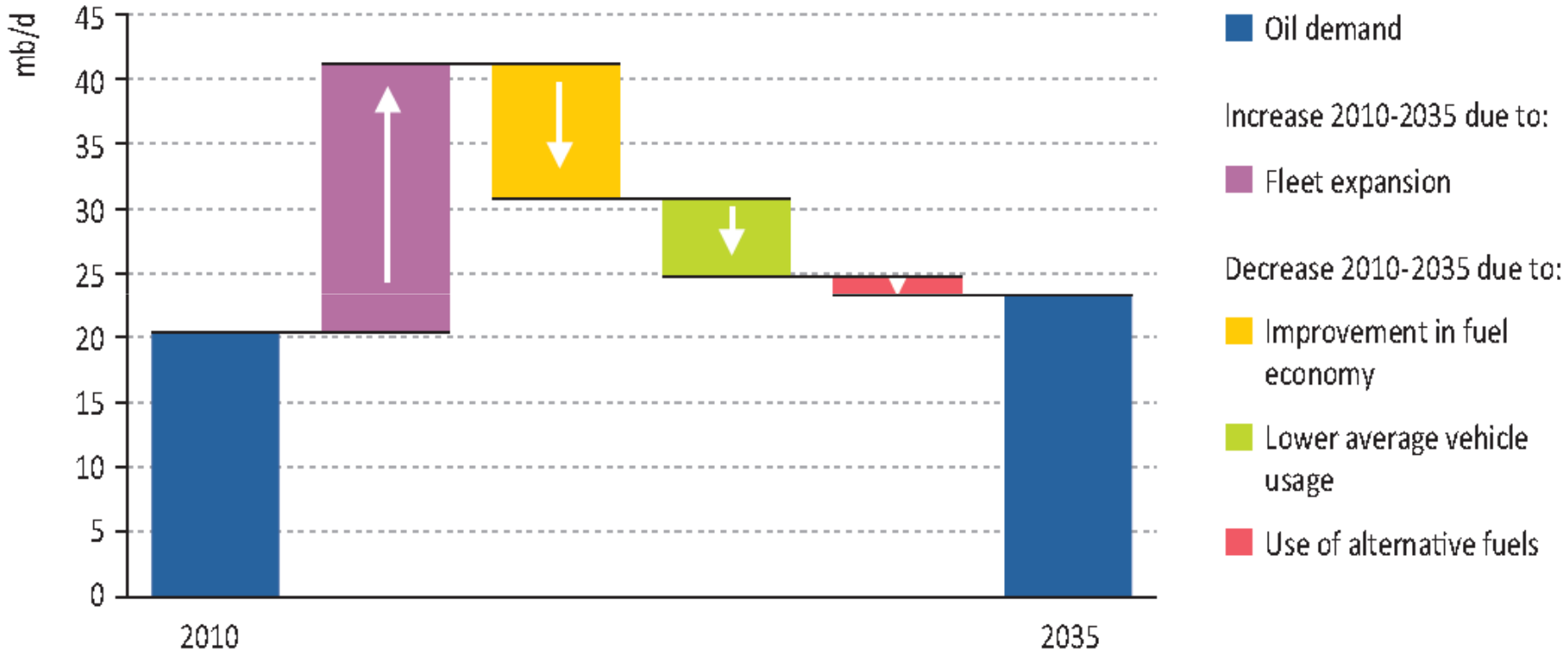


Note: PLDVs are passenger light-duty vehicles comprising passenger cars, sports utility vehicles and pick-up trucks.

Average annual change in transport oil demand and GDP, 2010-2035

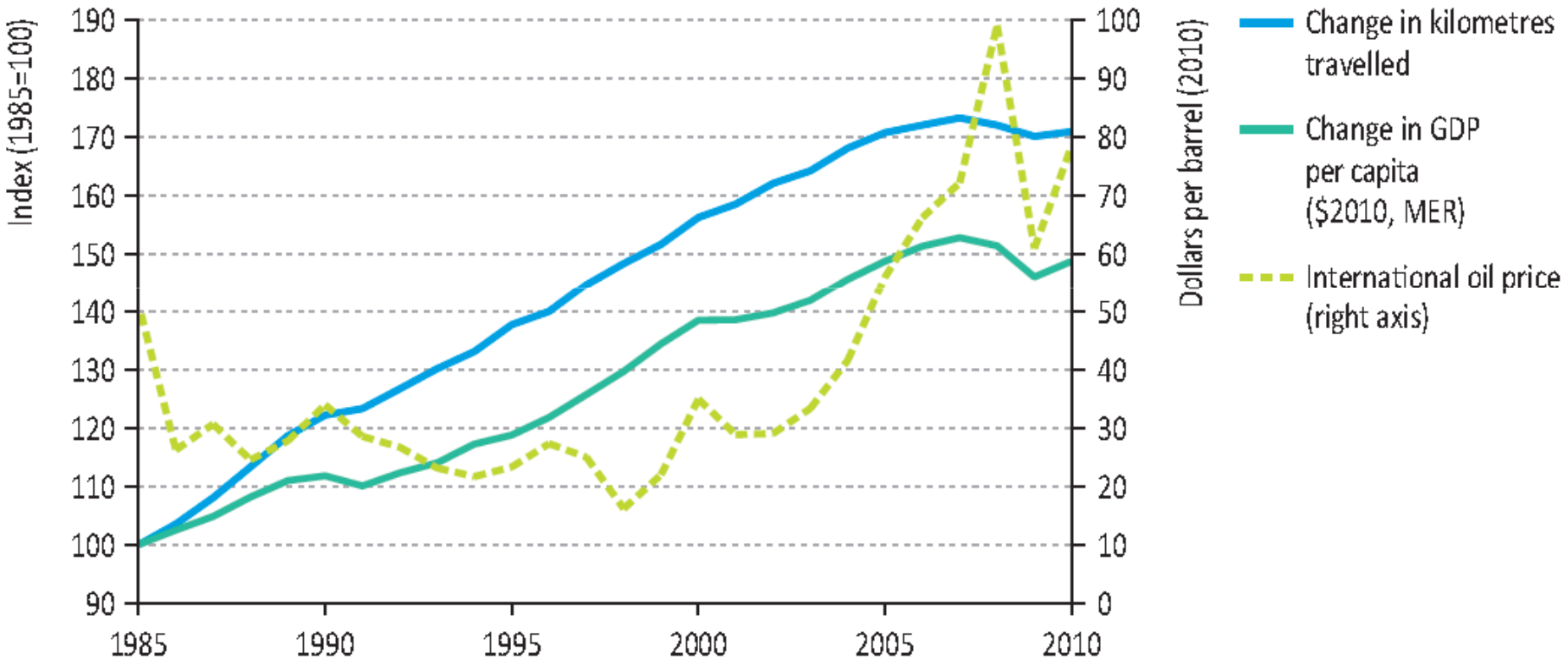


World PLDV oil demand in the New Policies Scenario



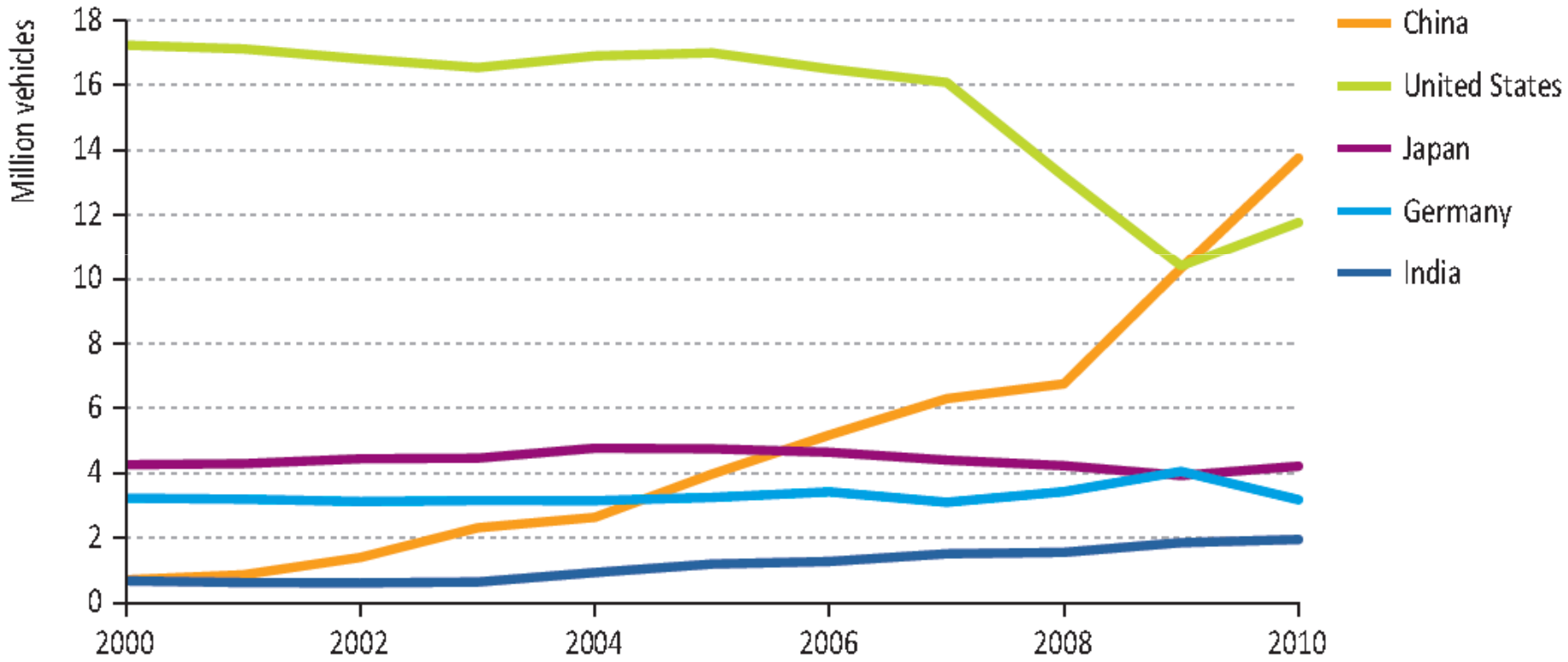
Note: The theoretical increase in oil use caused by fleet expansion assumes no change in the fuel mix, the vehicle fuel efficiency and the average vehicle-distance travelled.

Change in road vehicle travel in relation to changes in GDPper capita and oil price in the US

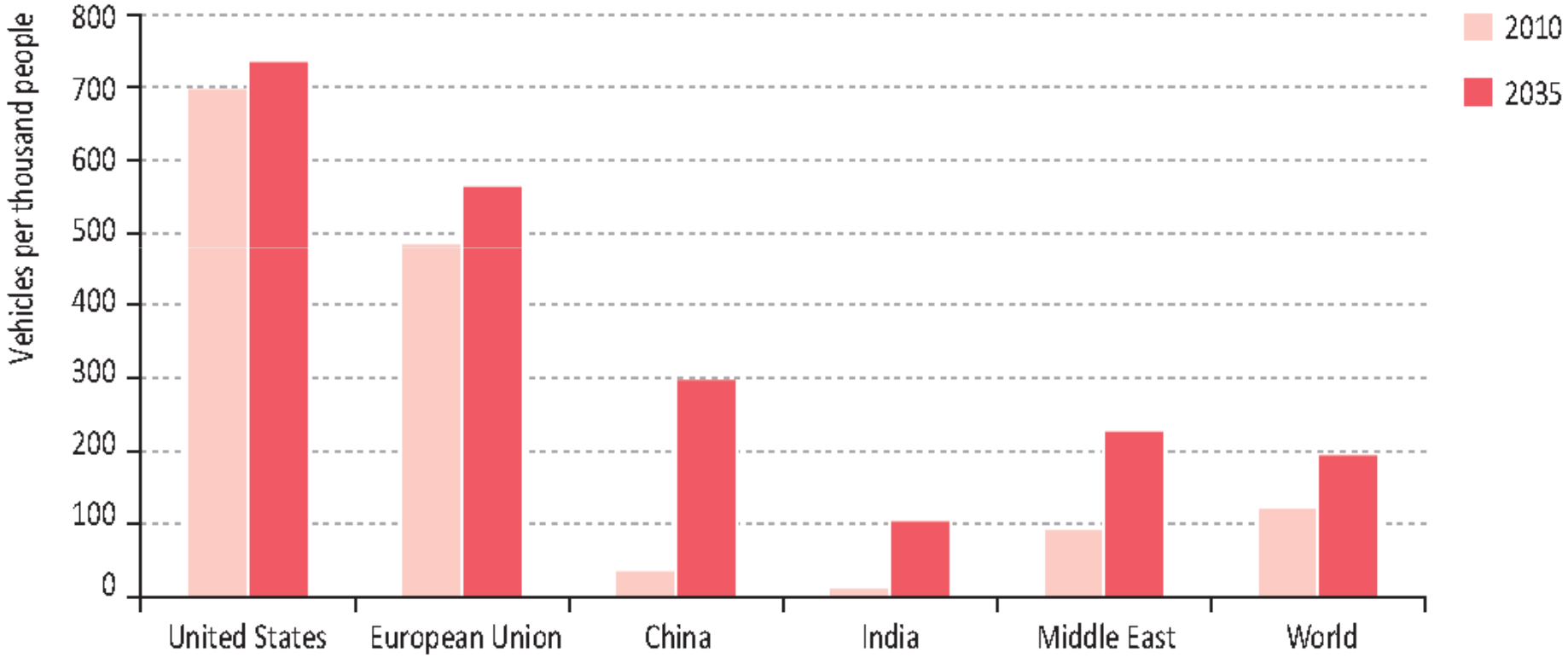


Note: MER = market exchange rate.

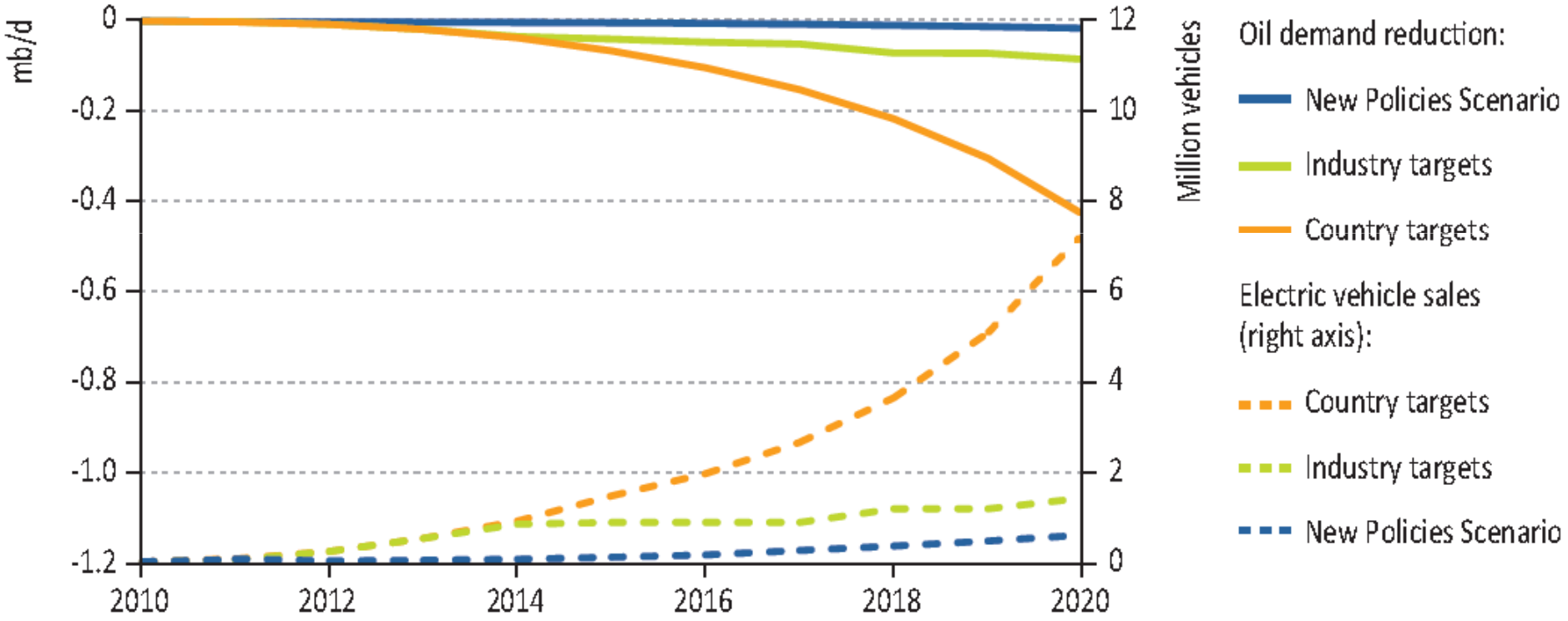
PLDV sales, 2000-2010



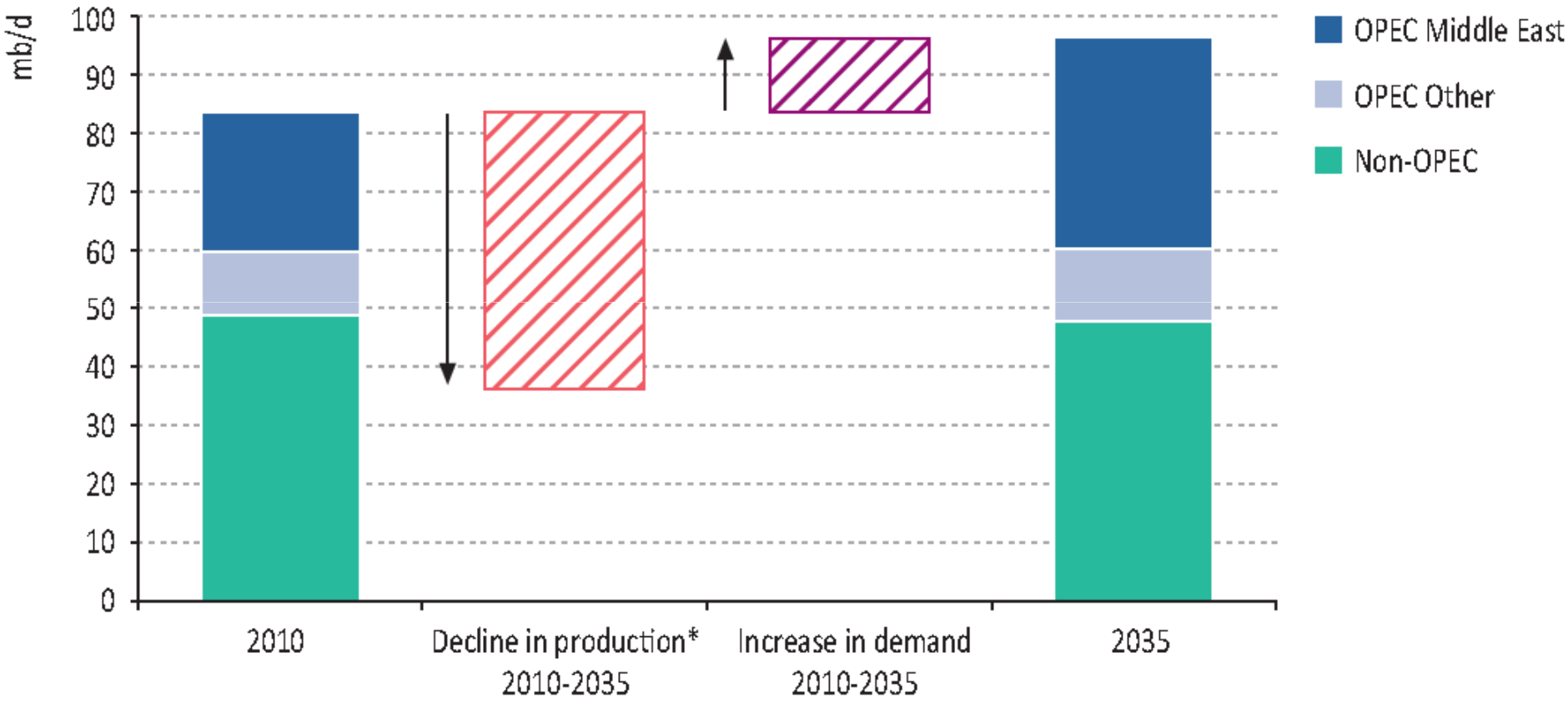
PLDV ownership in the New Policies Scenario



Oil savings through electric vehicle sales

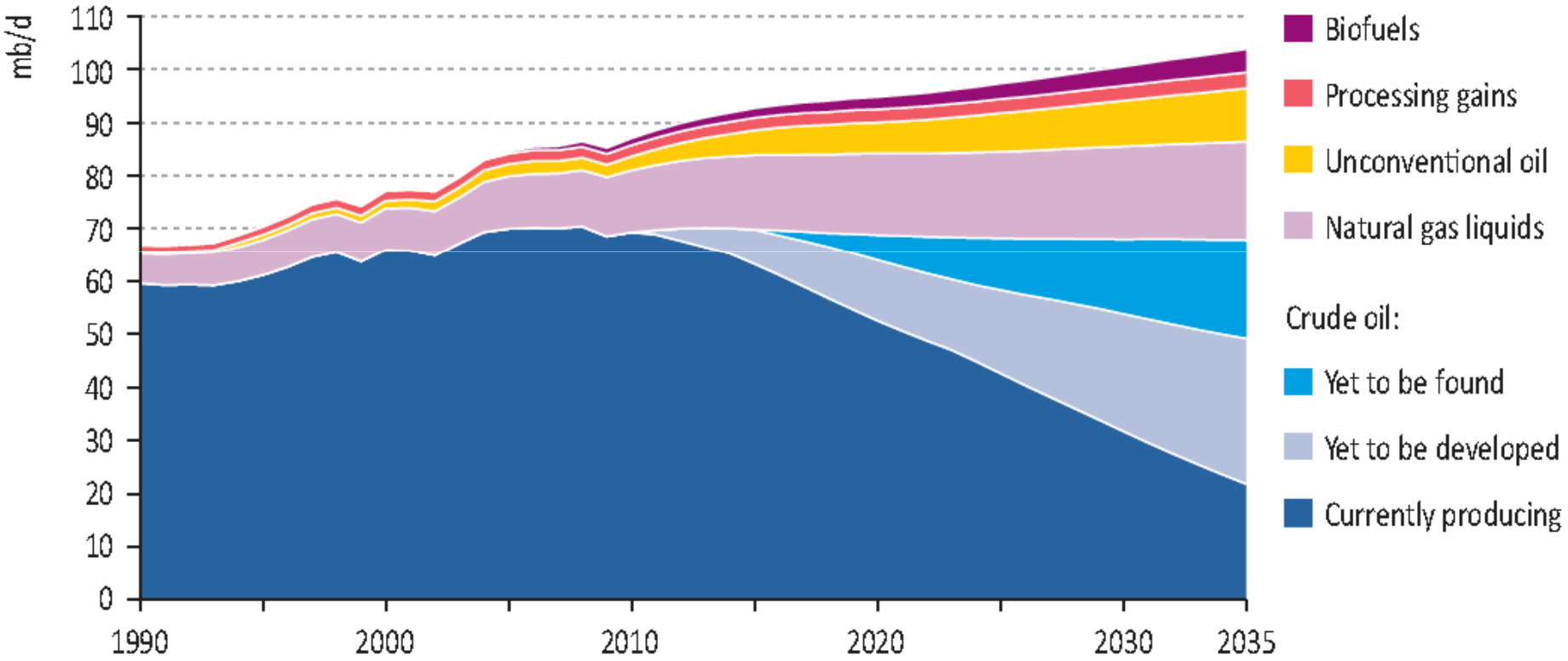


World oil production in the New Policies Scenario, 2010 and 2035



*Of oil fields producing in 2010.

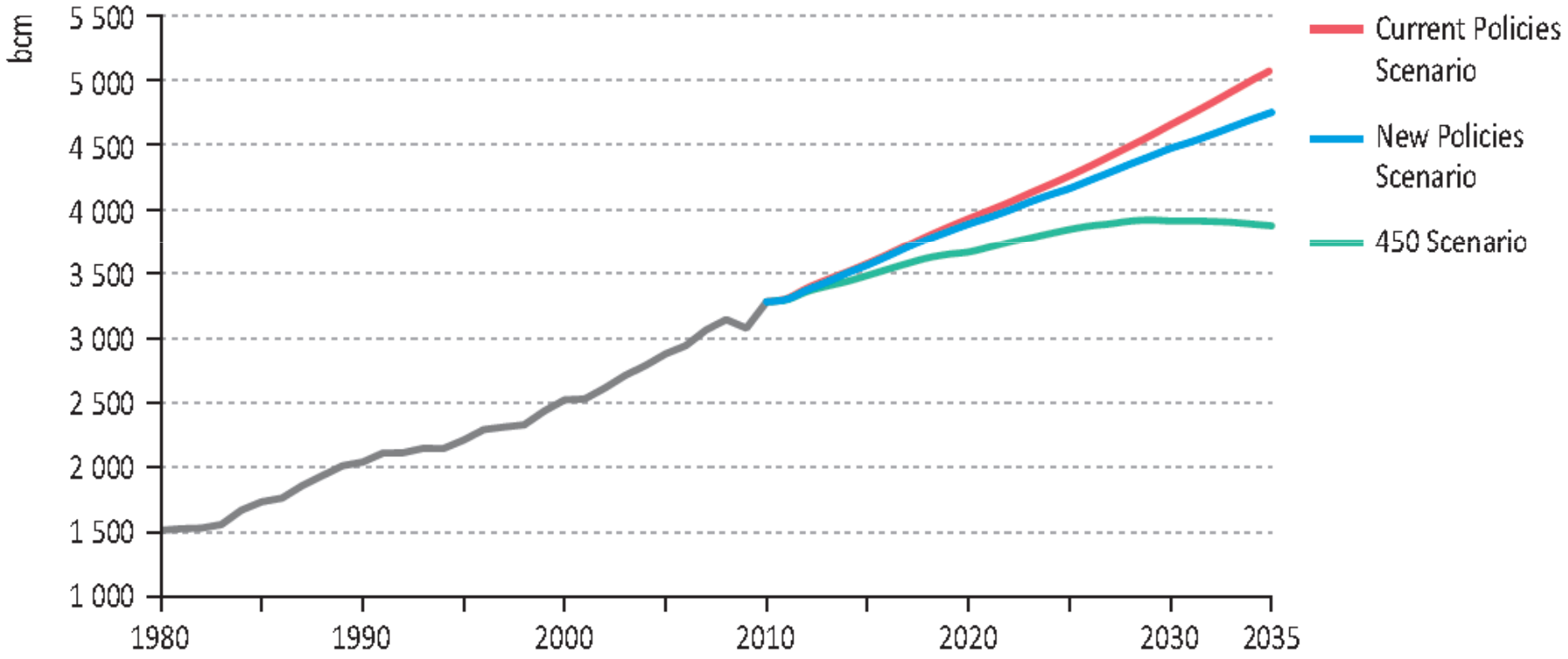
World liquids supply in the New Policies Scenario



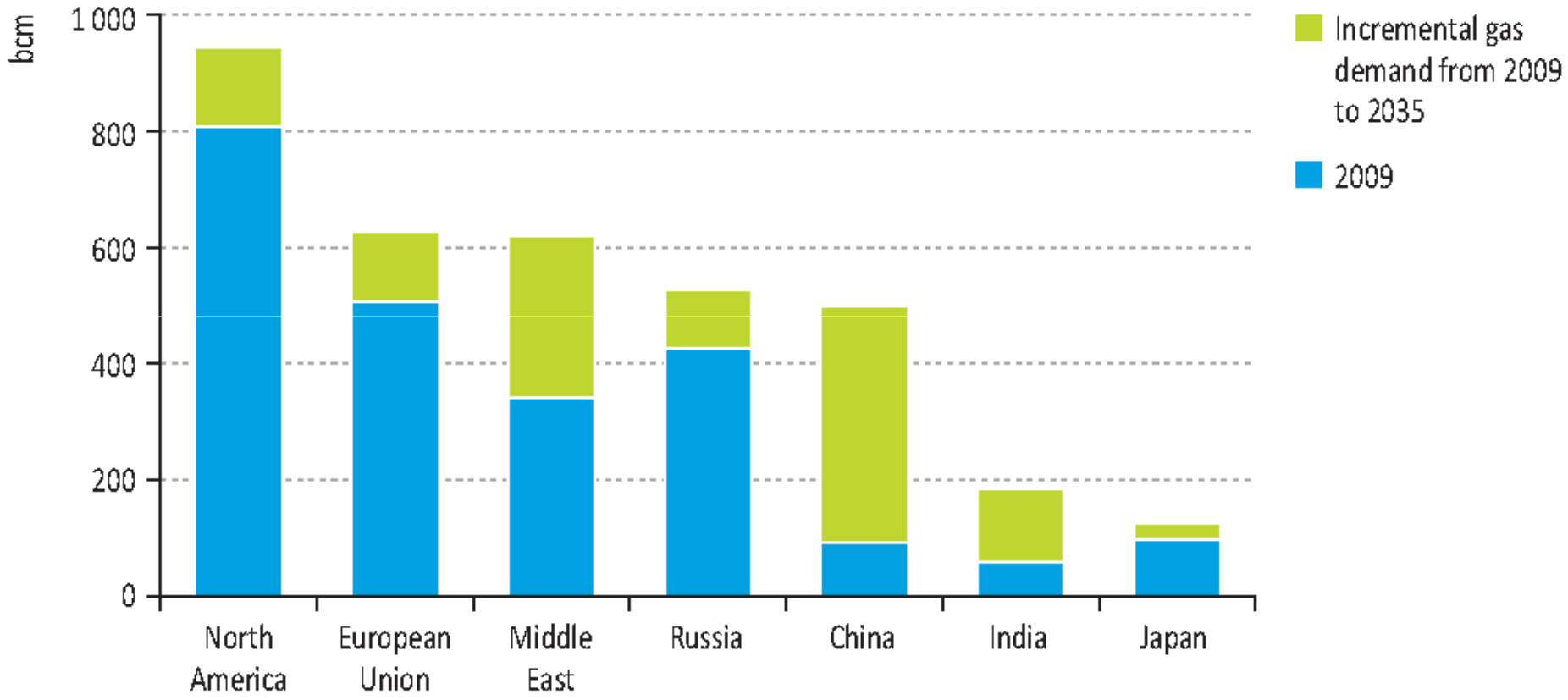
NATURAL GAS MARKET

- Demand
- Supply

World primary natural gas demand

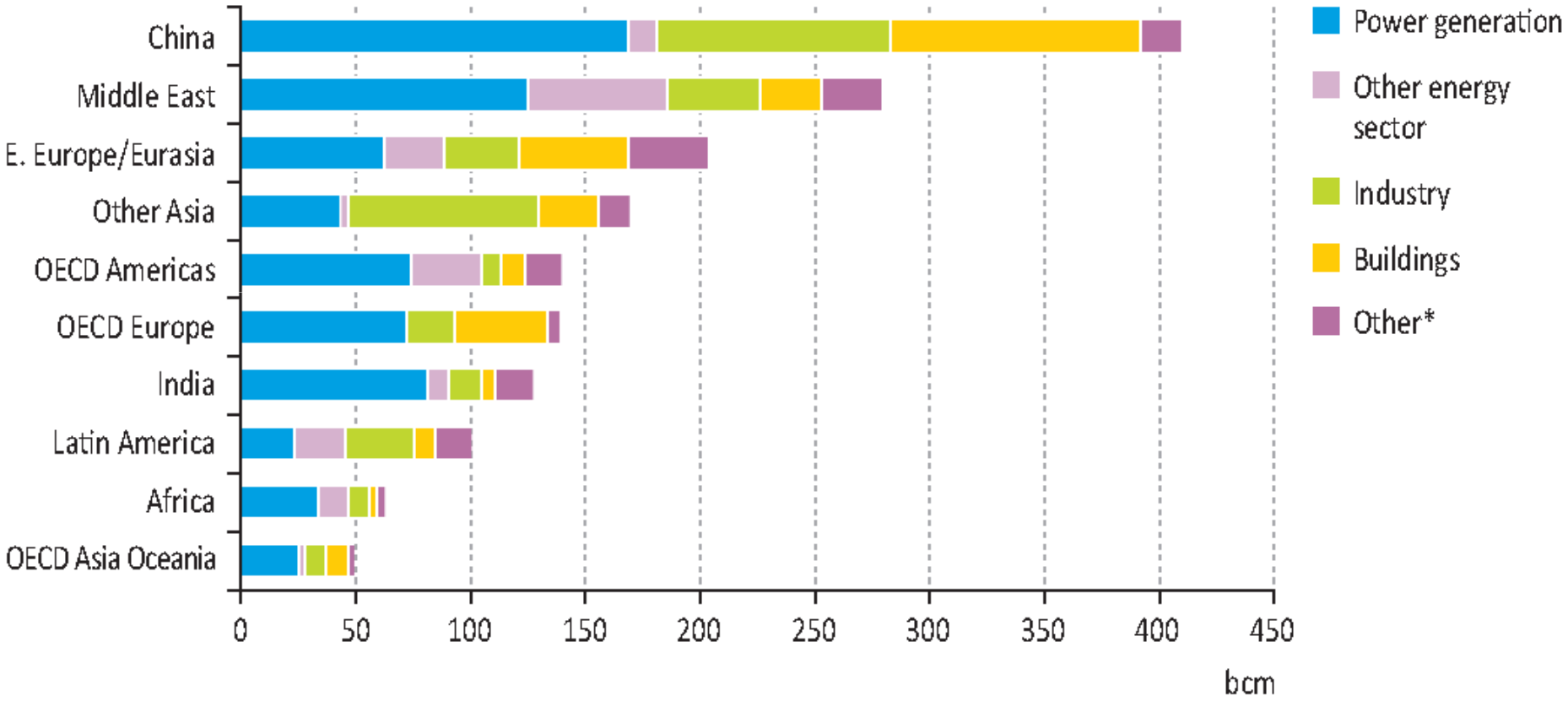


Natural gas demand in the New Policies Scenario, 2009 and 2035



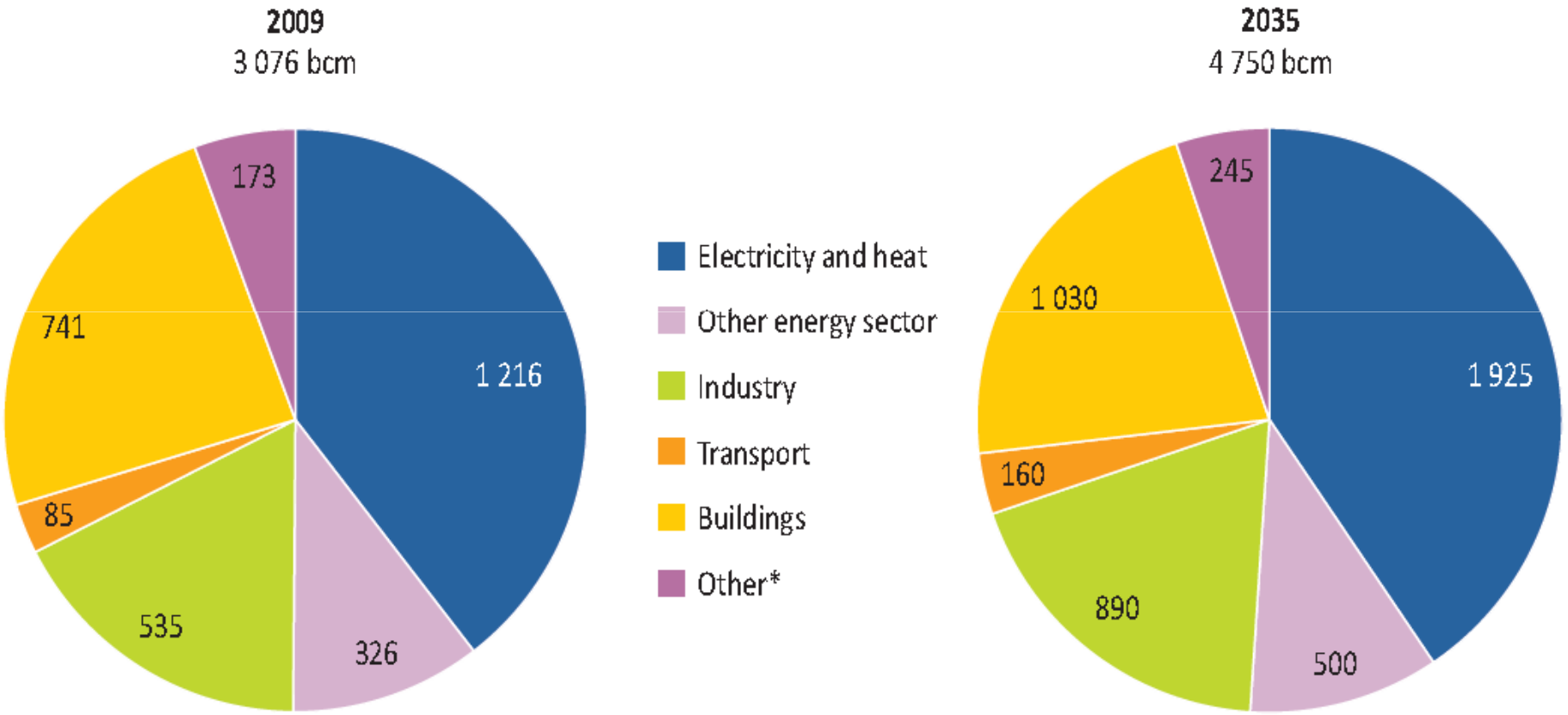
Notes: 2009 is the base year for gas projections. Rates of growth would be lower if 2010 figures were used as base year due to the impact of the economic crisis on gas demand in 2009.

Incremental primary natural gas demand, 2009-2035



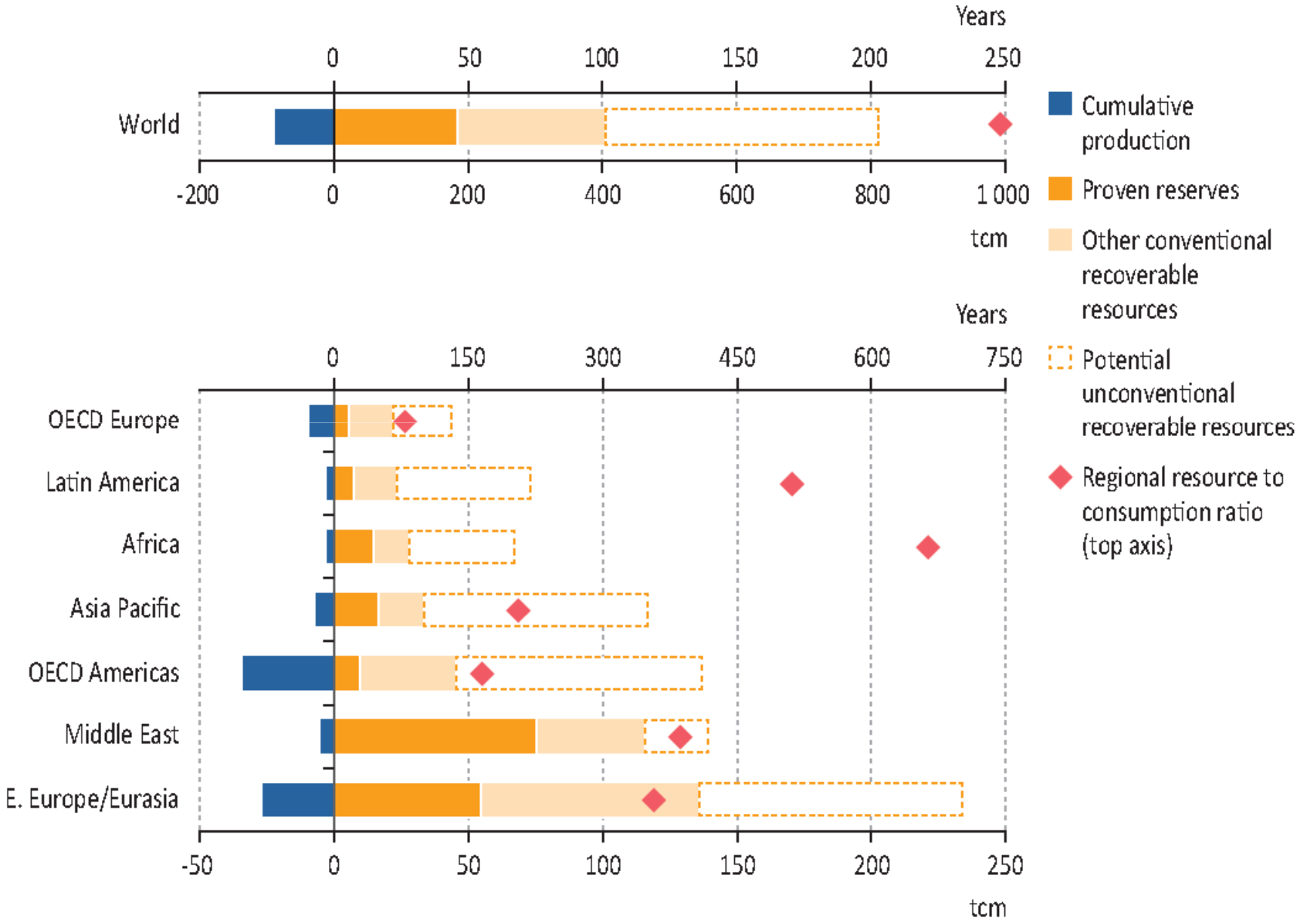
*Includes agriculture, transport and non-energy use.

Primary natural gas demand by sector, 2009 and 2035

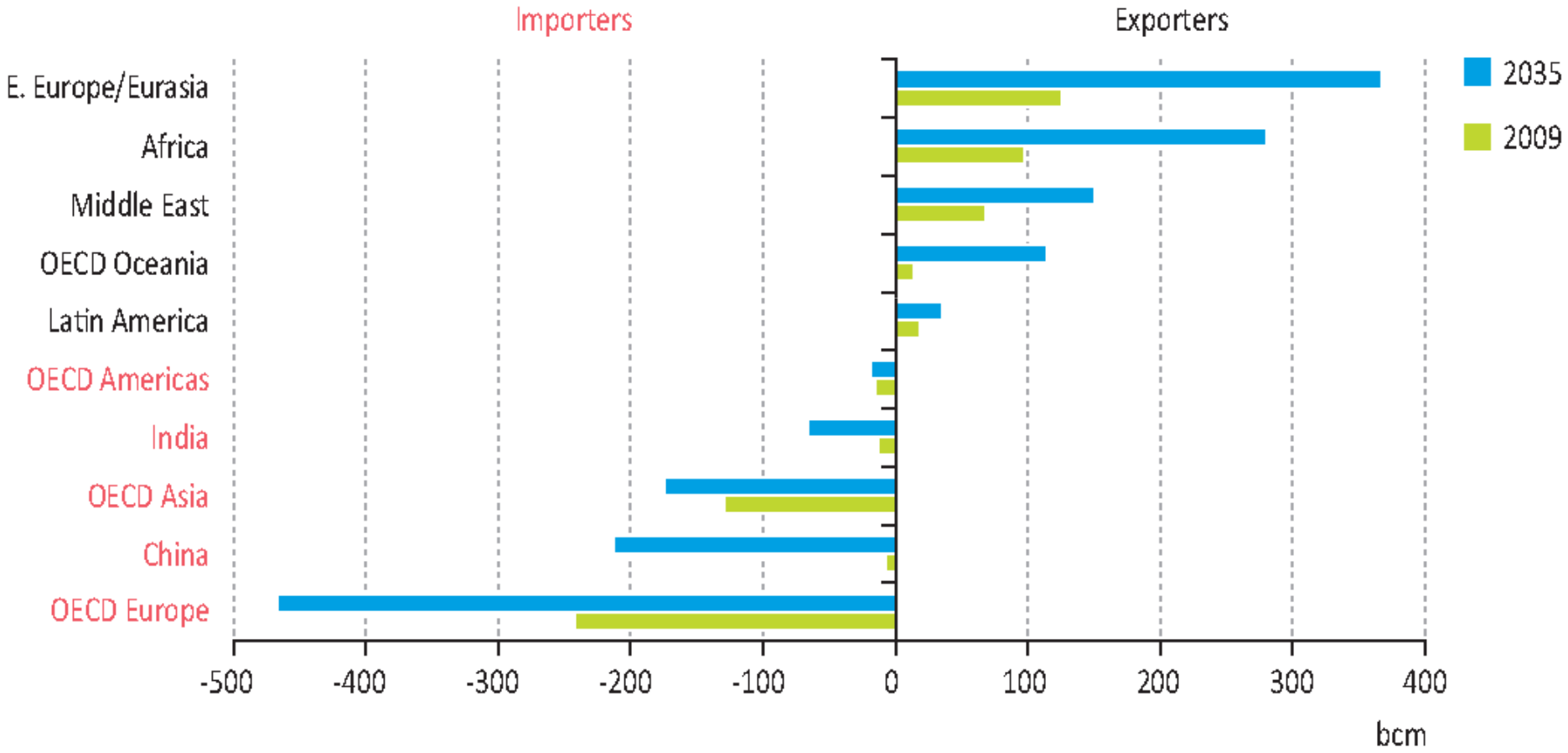


*Includes agriculture and non-energy use.

Recoverable gas resources and production, end-2010



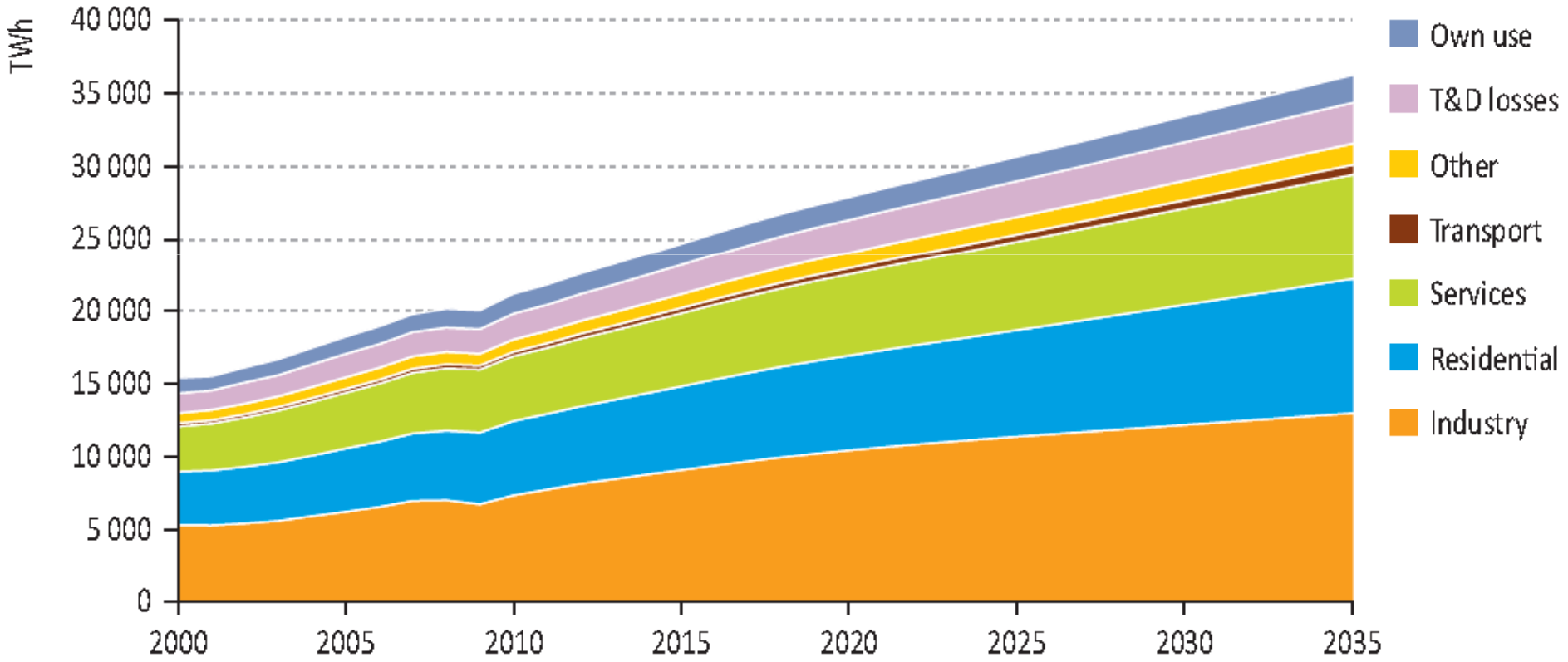
Net gas trade in the New Policies Scenario



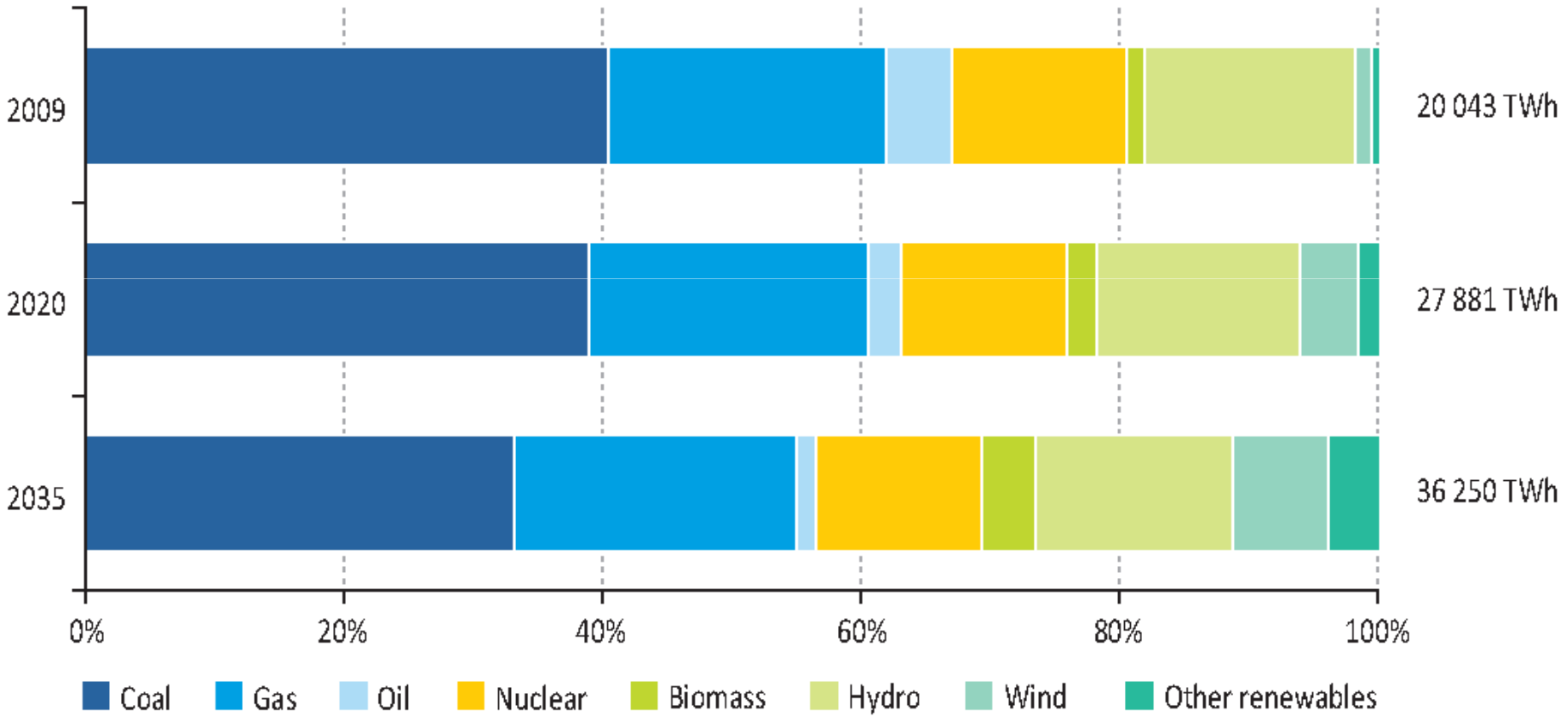
POWER AND RENEWABLES

- Electricity demand
- Supply
- Costs
- Investments

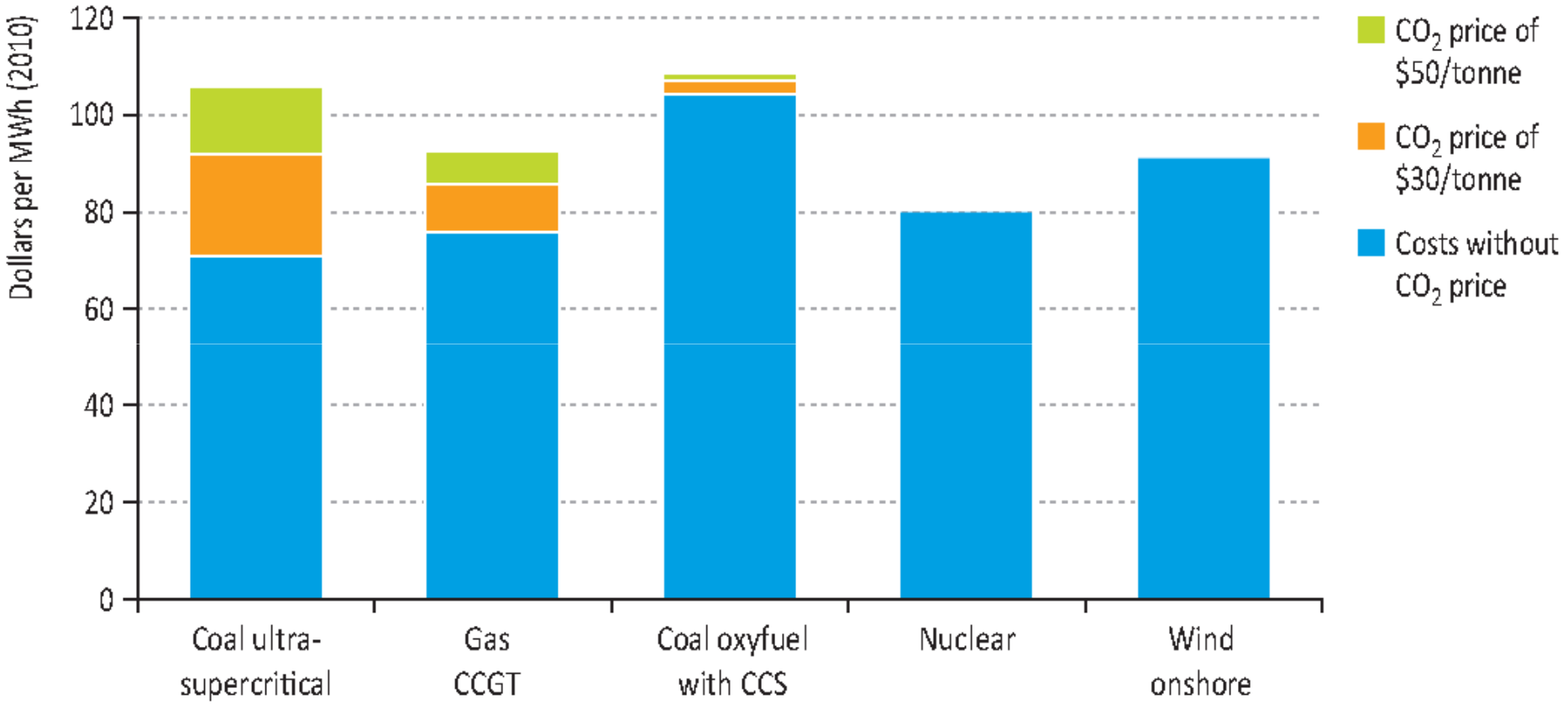
World electricity demand in the New Policies Scenario



Share of world electricity generation by fuel
New Policies Scenario

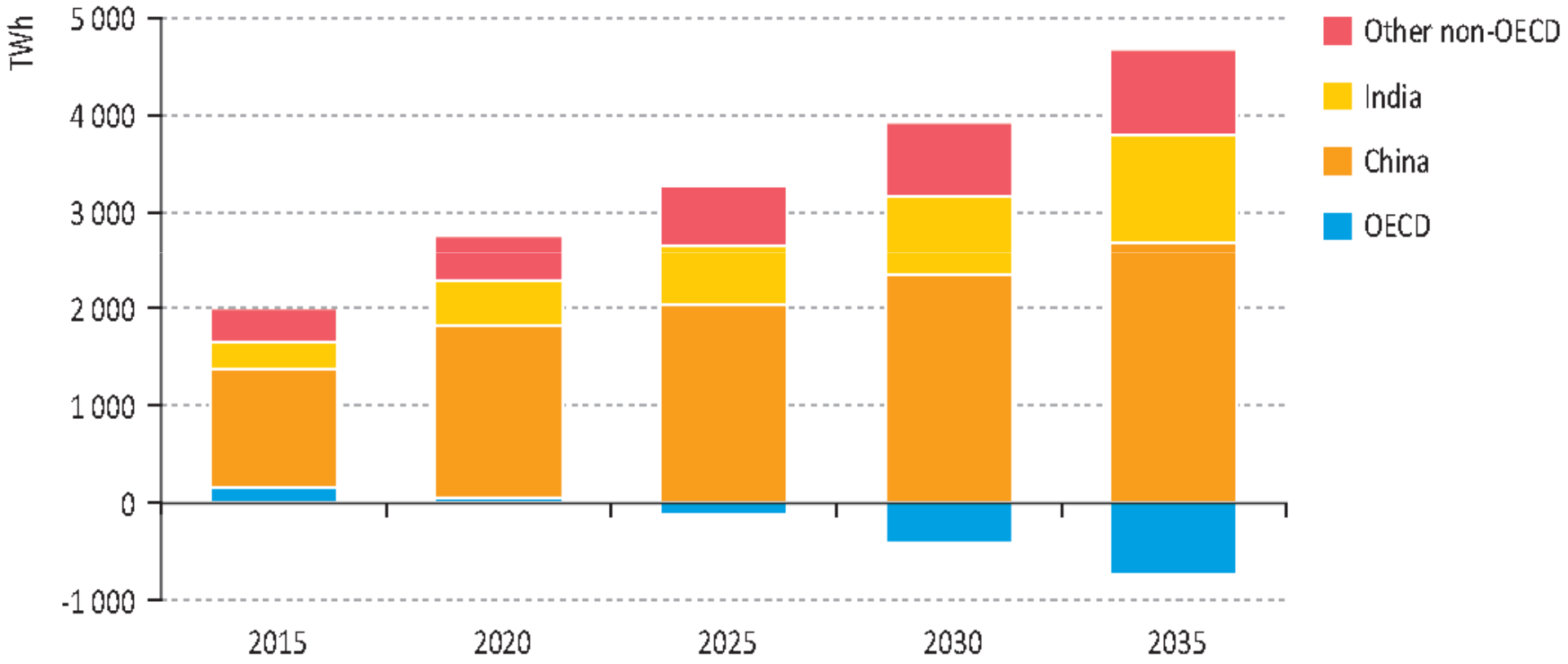


Typical levelised cost by plant type and carbon price in the OECD in the New Policies Scenario, 2020*

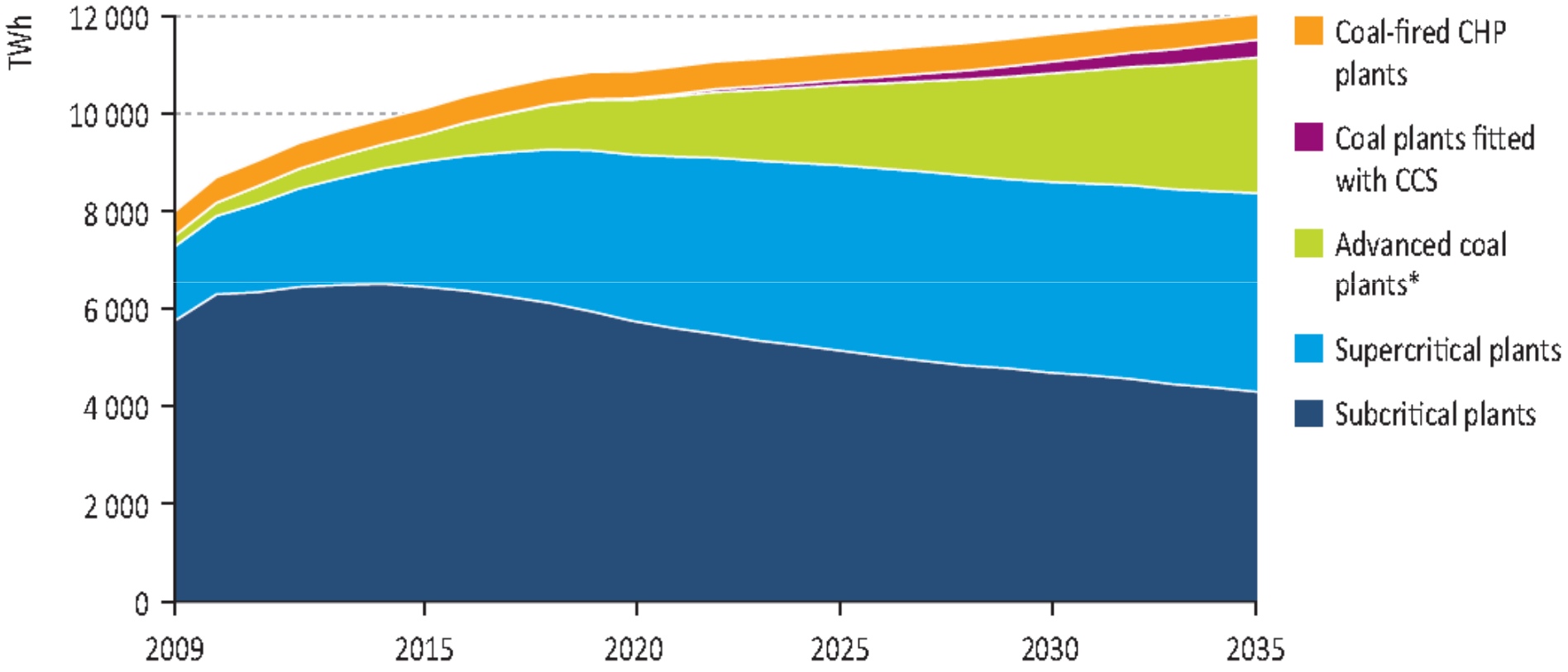


*Levelised cost is cost per unit of electricity generation, taking into account all the costs over the lifetime of the asset, including construction, operation and maintenance, fuel inputs and the cost of capital. In the New Policies Scenario, CO_2 prices range from zero to $30/tonne.

Incremental global coal-fired electricity generation relative to 2009 by region in the New Policies Scenario

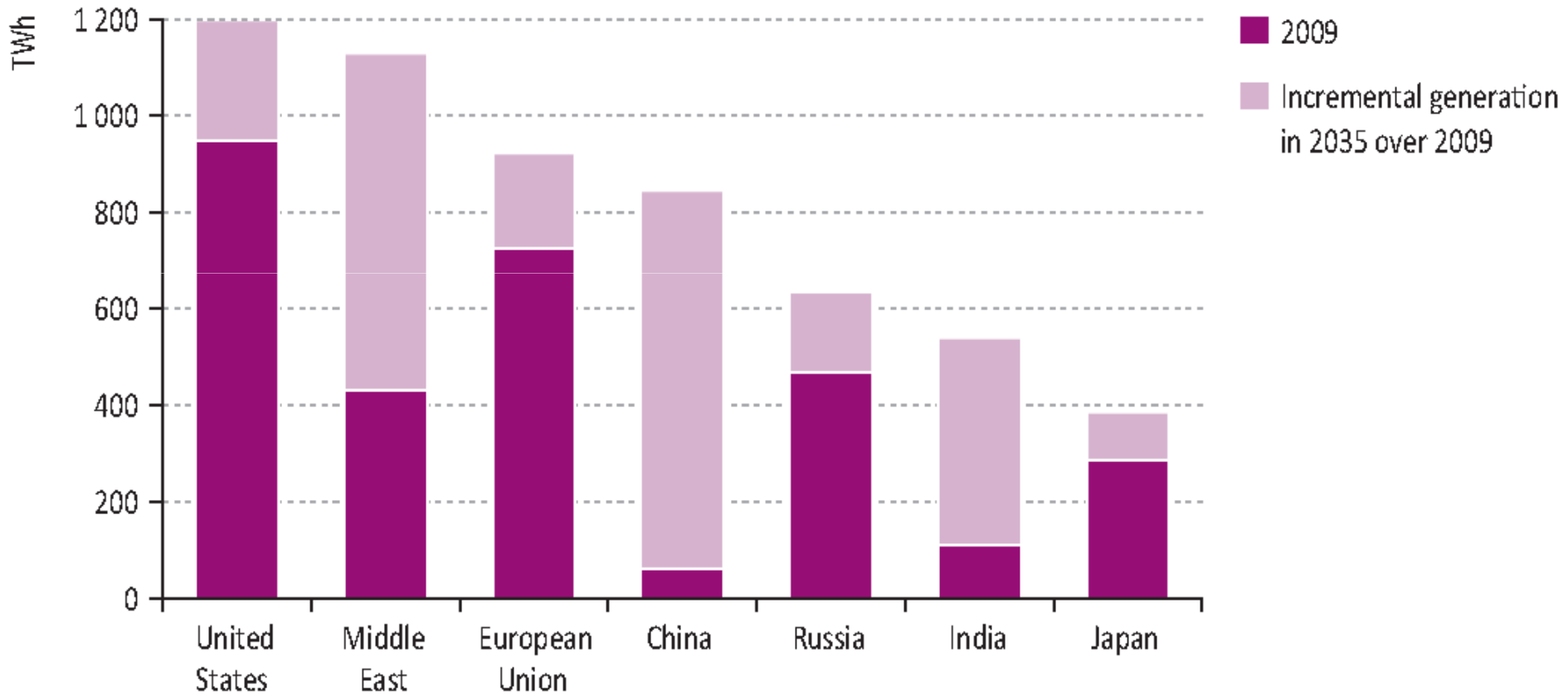


World coal-fired electricity generation by plant type in the New Policies Scenario

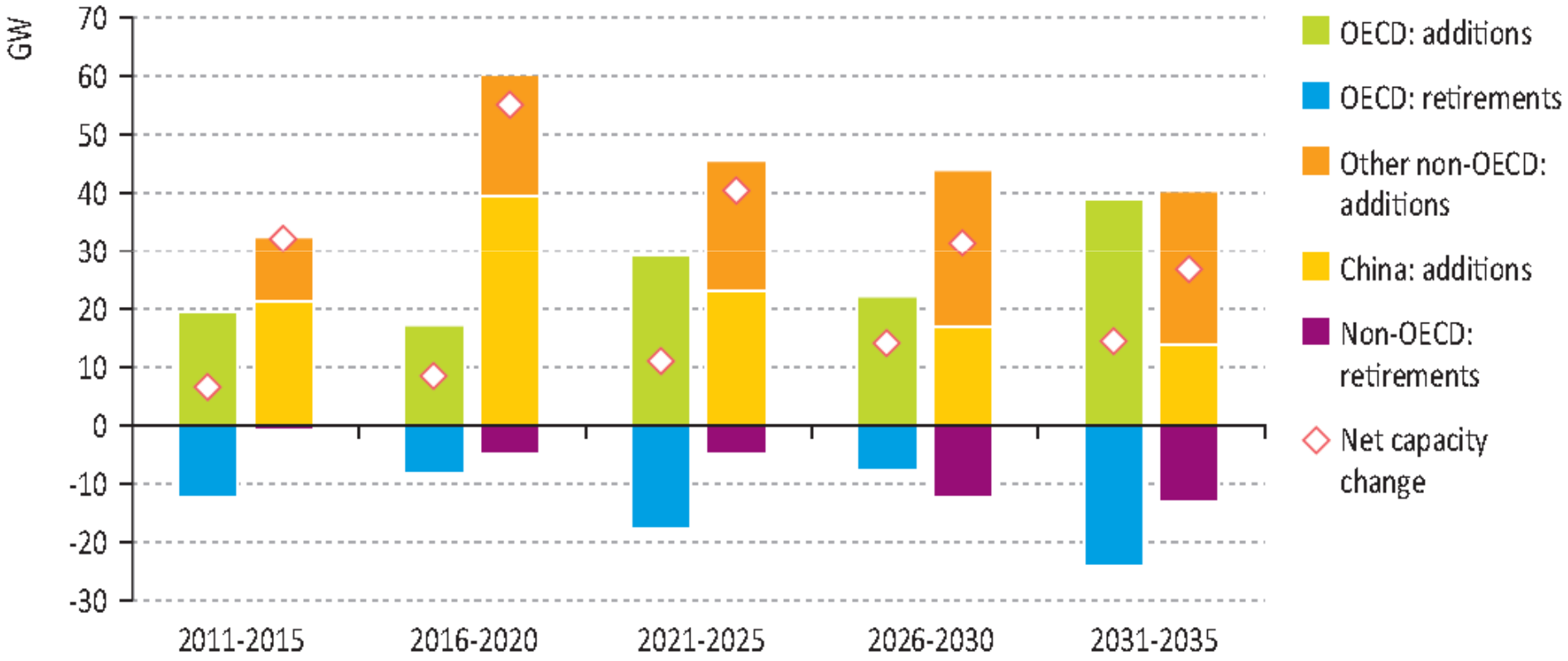


*Advanced coal plants include ultra-supercritical and IGCC plants.

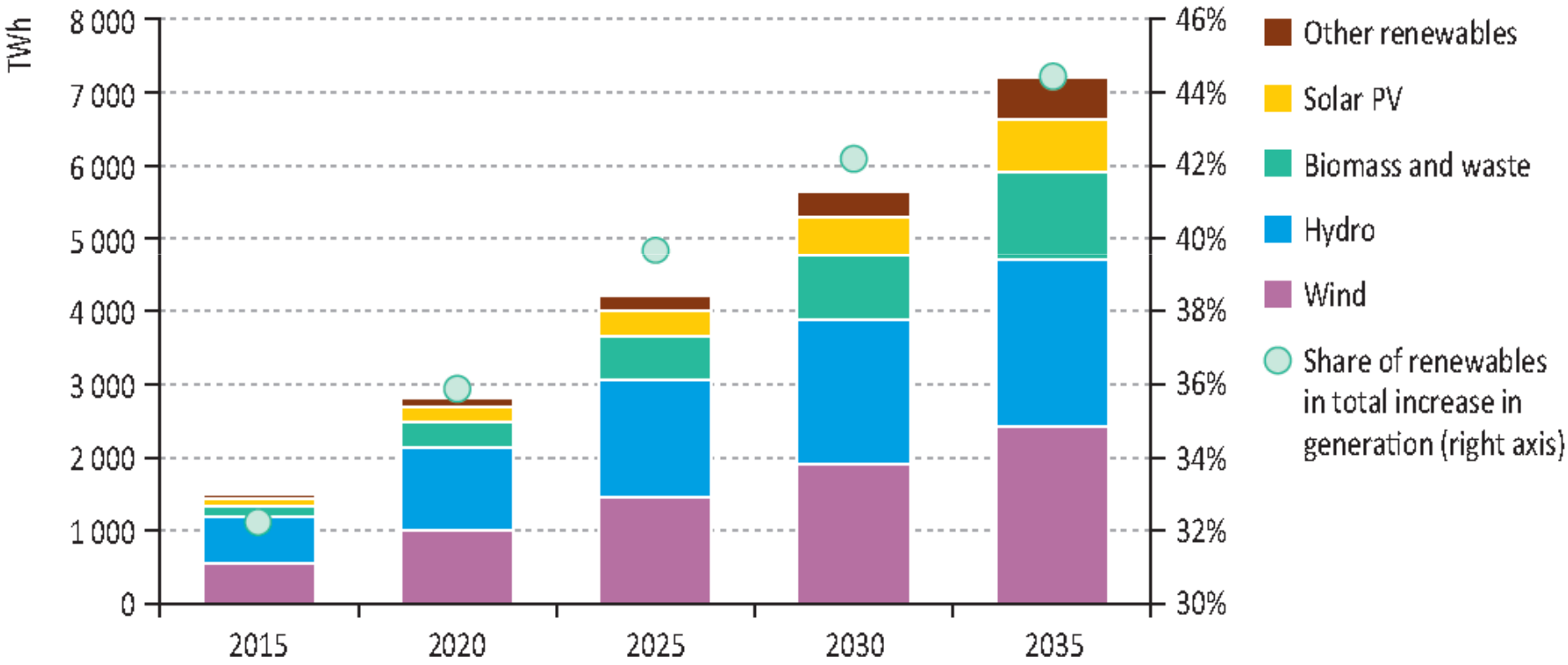
Gas-fired electricity generation
New Policies Scenario



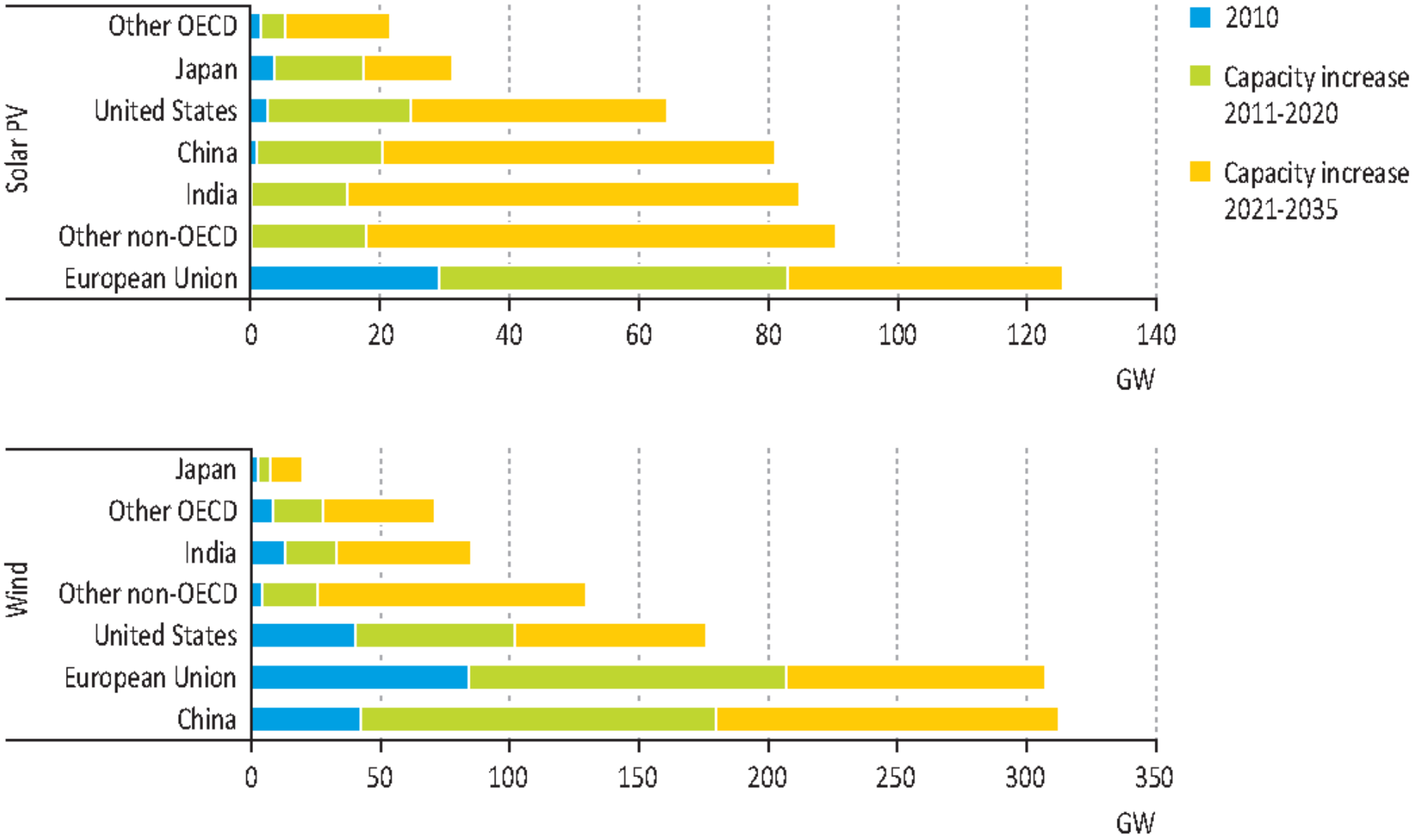
Additions and retirements of nuclear power capacity in the New Policies Scenario



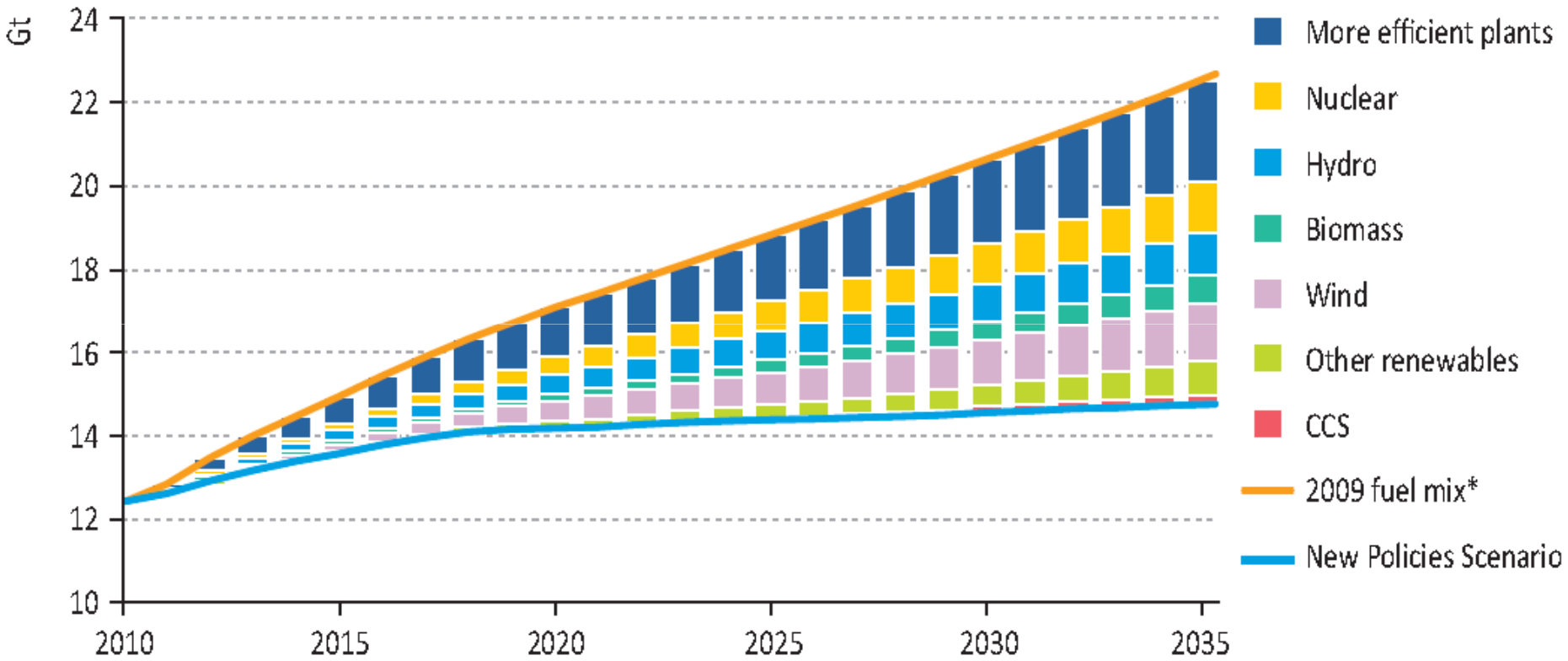
Incremental global renewables-based electricity generation relative to 2009 (New Policies Scenario)



Solar PV and wind power capacity
New Policies Scenario

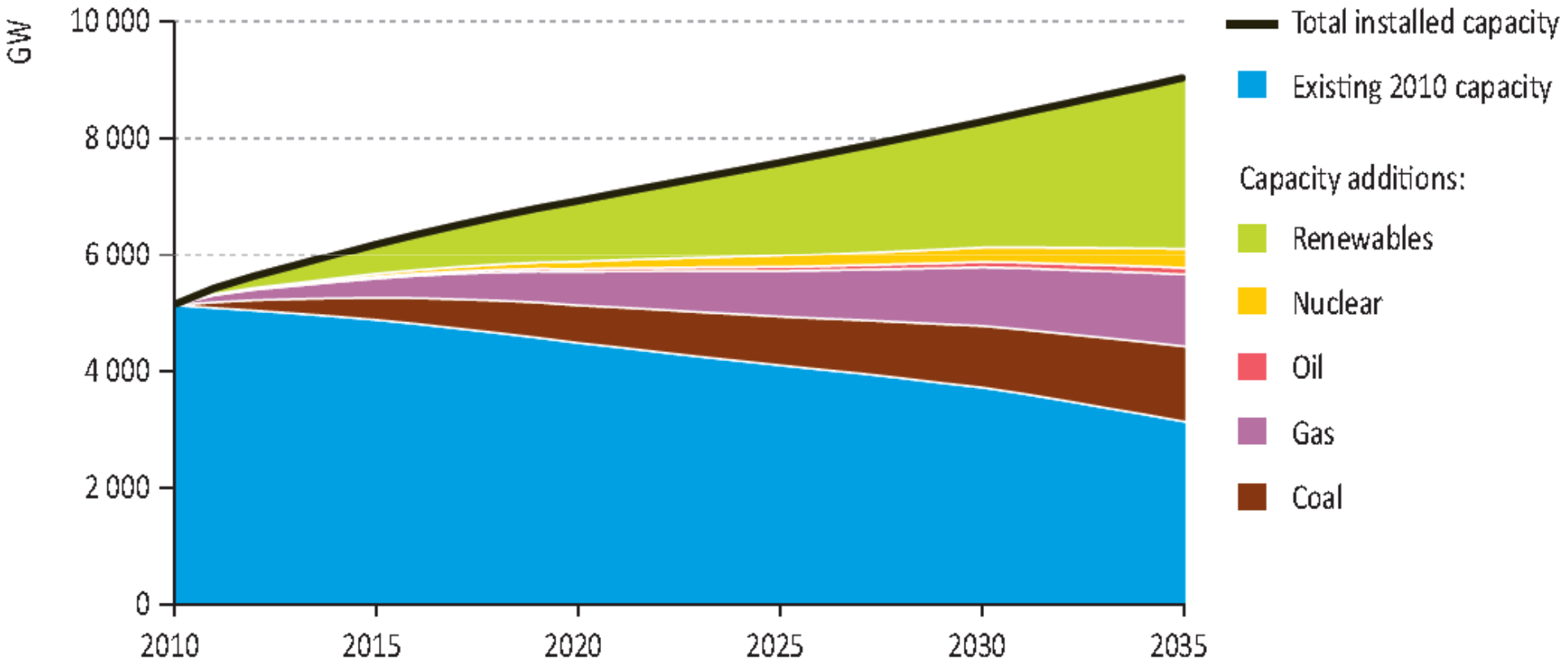


*Global CO2 emission savings in power generation relative to the 2009 fuel mix**



*The emissions savings compared with the emissions that would have been generated for the projected level of electricity generation were there no change in the mix of fuels and technologies, and no change in the efficiency of thermal generating plants after 2009.

Global installed power generation capacity and additions in the New Policies Scenario



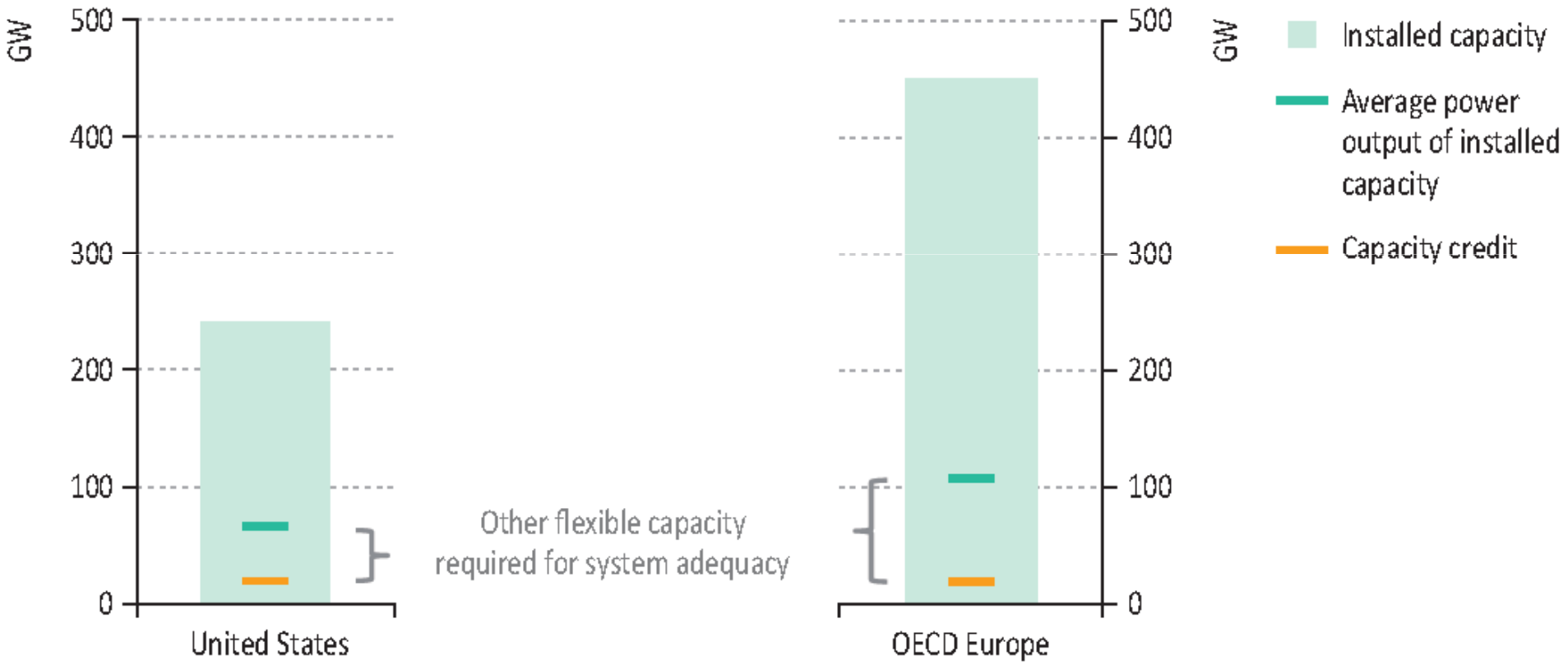
Globally, the share of renewables in capacity additions has
steadily increased in recent years, reaching about 50% of total additions in 2010. However, as renewables often generate less electricity per unit of capacity installed each year than thermal plants, their contribution to incremental electricity output has been less than their share of incremental capacity.

For every 5 MW of variable renewable capacity installed, about 1 MW of other (flexible) capacity is needed to maintain system adequacy.

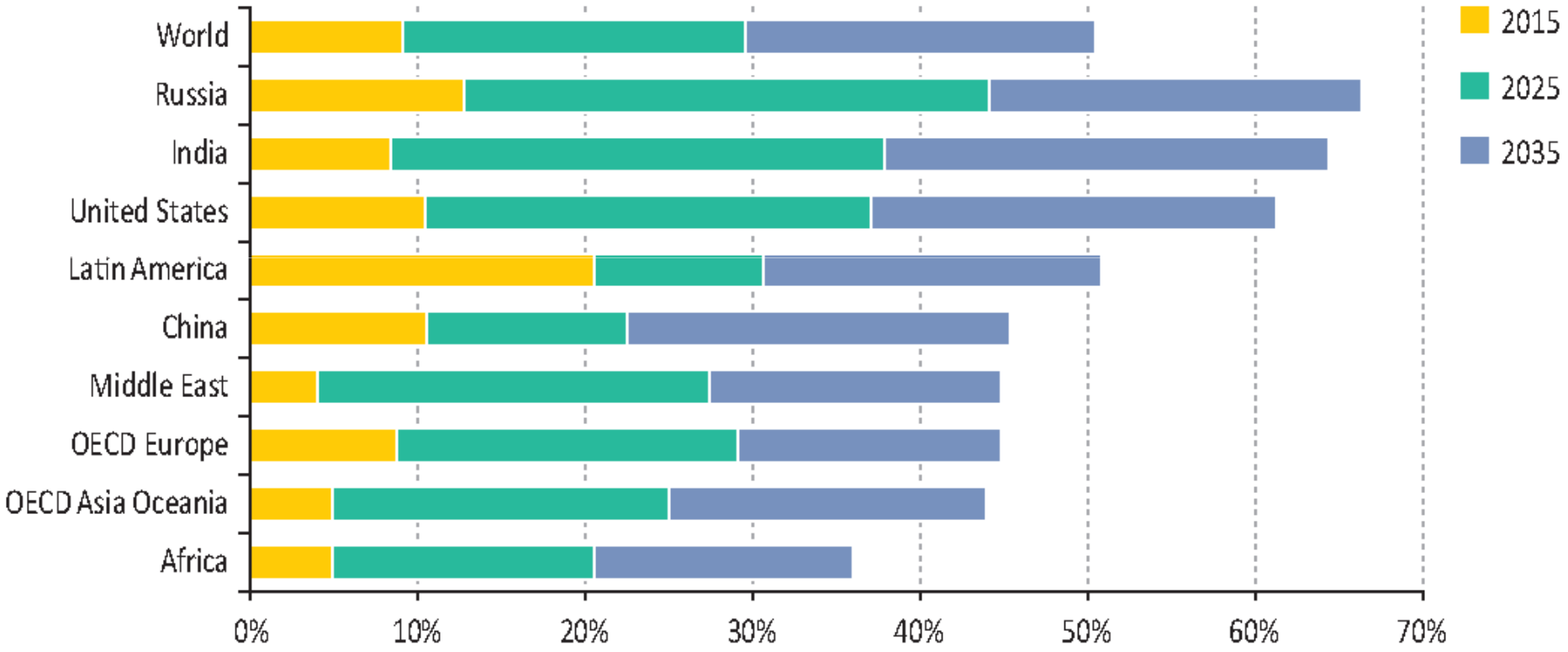
Costs of integrating variable renewables into the electricity system

- Adequacy (additional capacity): 3 to 5 $/MWh
- Balancing (flexibility): 1 to 7 $/MWh
- Grid integration (TD reinforcement): 2 to 13 $/MWh
- Total for integration: 5 to 25 $/MWh

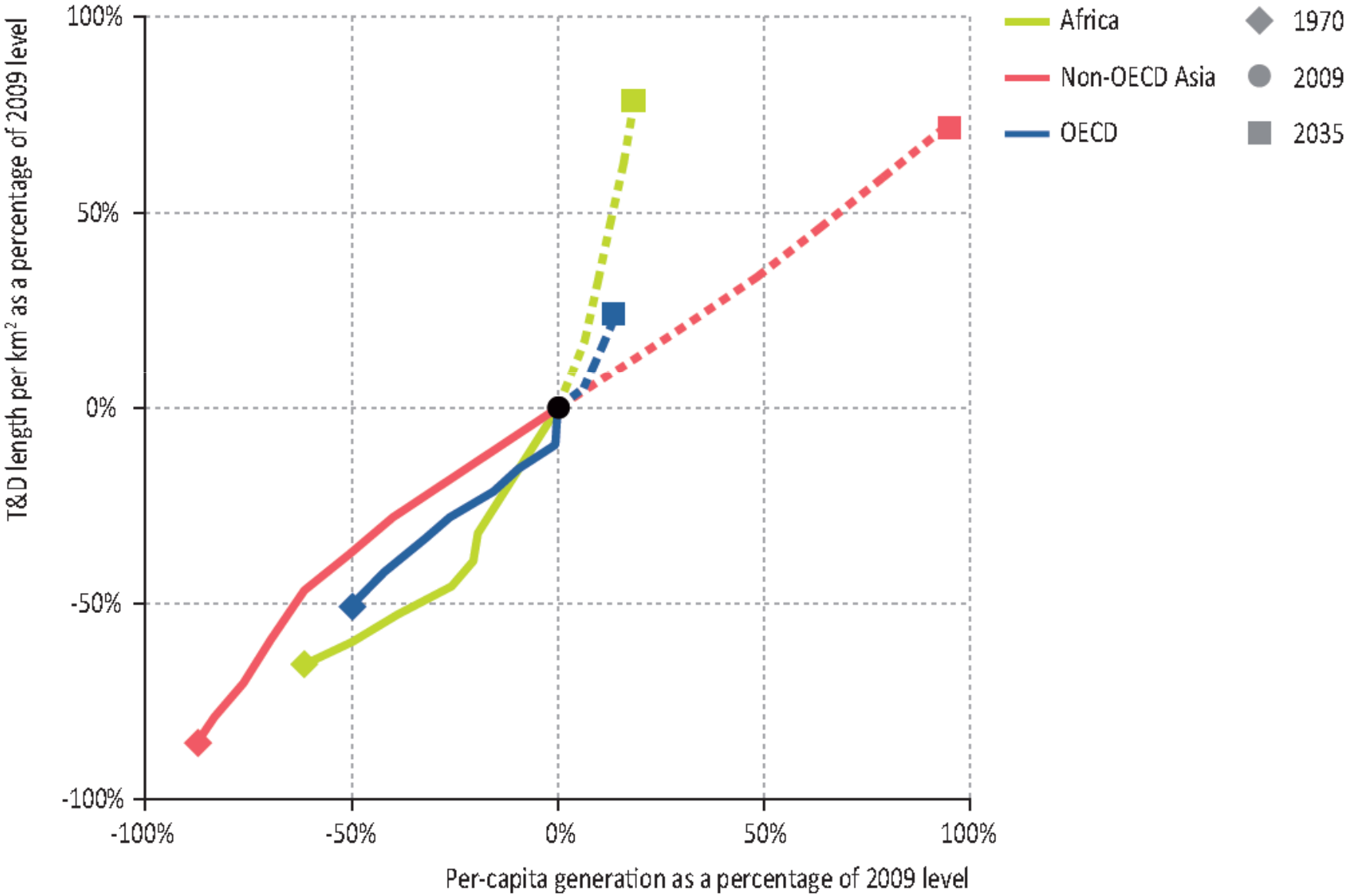
Capacity of wind and solar PV and their system effects for the United States and OECD Europe, 2035



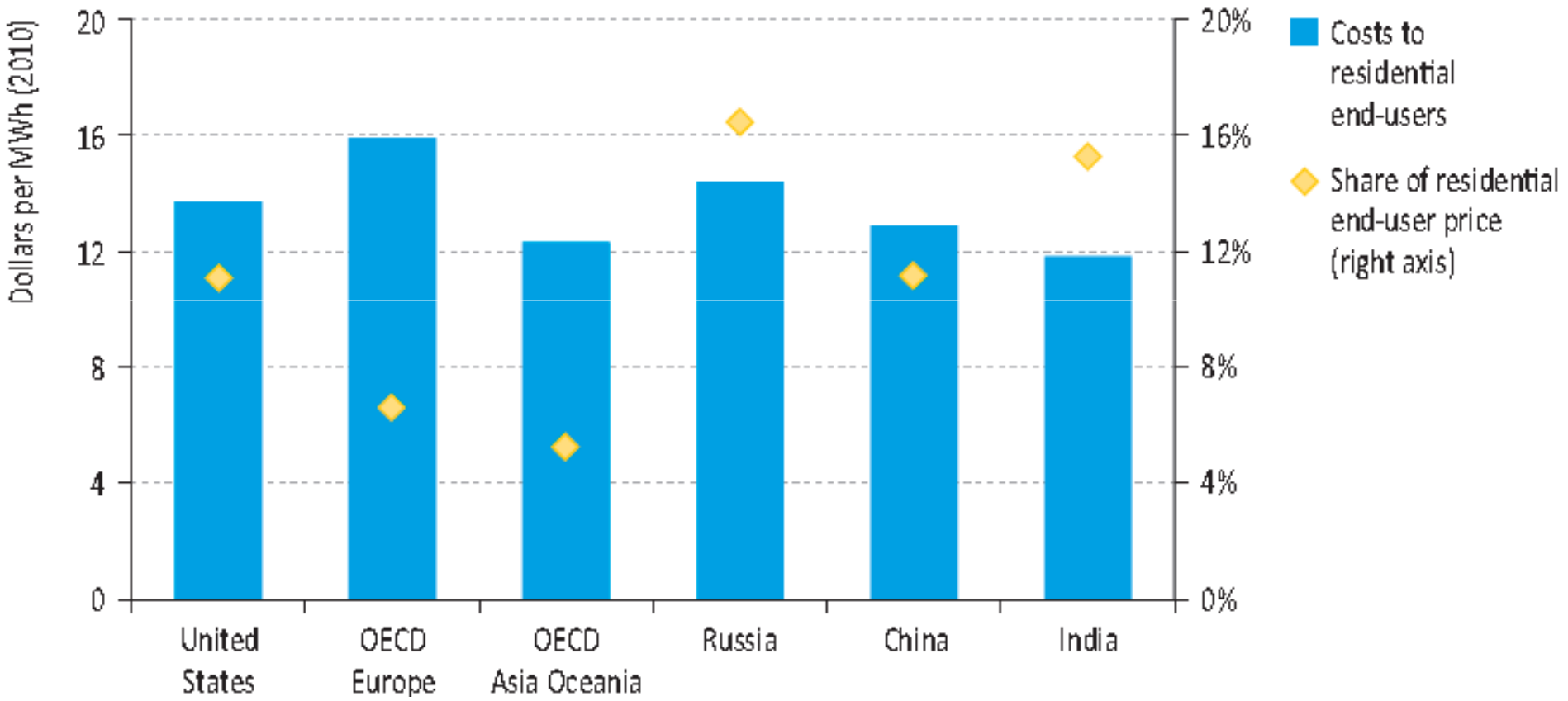
Share of T&D infrastructure in place in 2009 reaching 40 years of age



T&D grid length and per-capita generation
New Policies Scenario



T&D infrastructure costs as a share of residential end-user price in the New Policies Scenario, 2035



- Regulations are a key determinant in the efficiency and reliability of T&D infrastructure.
- Additionally, planning and building new transmission and distribution can take up to ten years or longer and often exceeds the time to build new power plants.
- Therefore, providing a stable investment framework for grid operators is an important task for regulators.

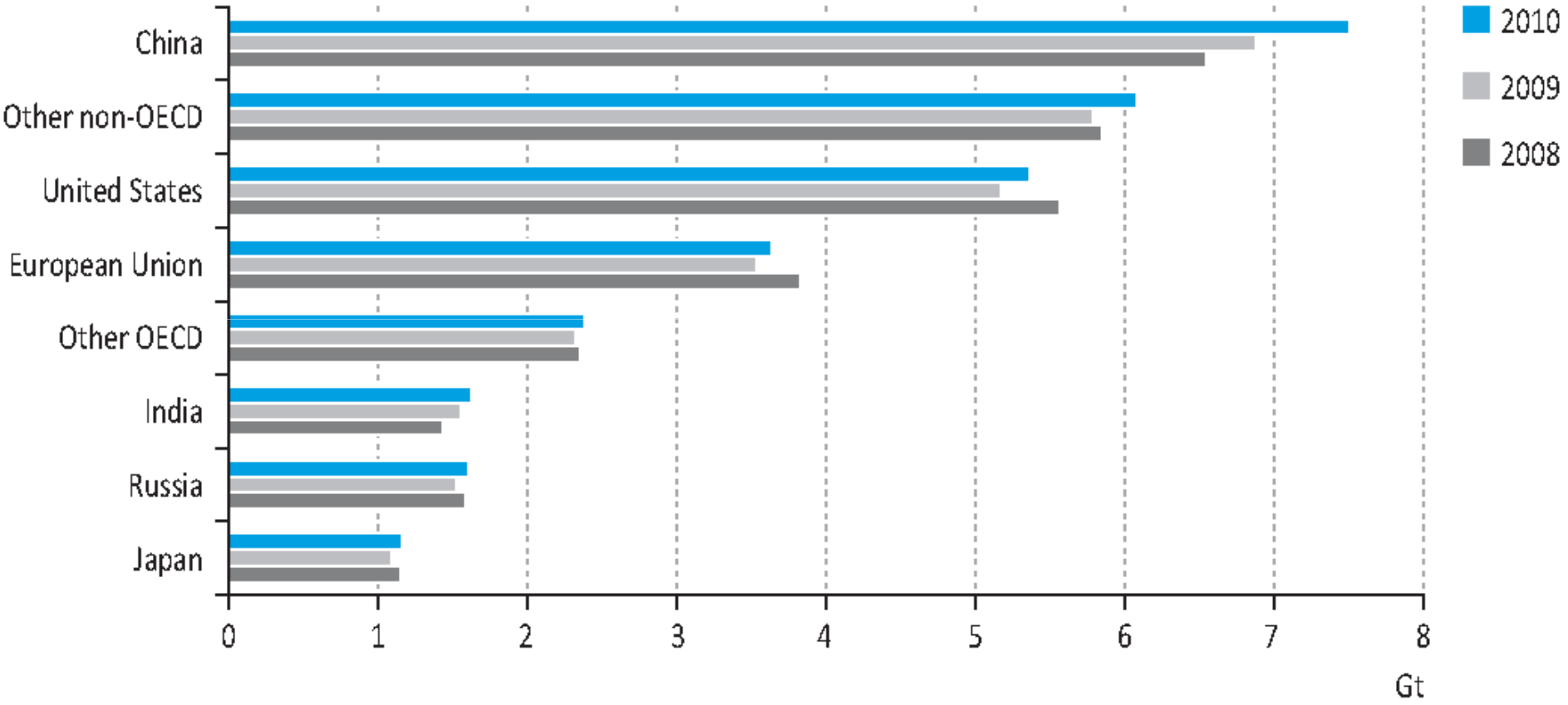
CLIMATE CHANGE AND THE 450 SCENARIO

- ***What is special about 2°C?***
- ***Recent developments***
- ***Demand***
- ***Emissions***
- ***Implication of delayed actions***
- ***What if CCS does not deliver?***

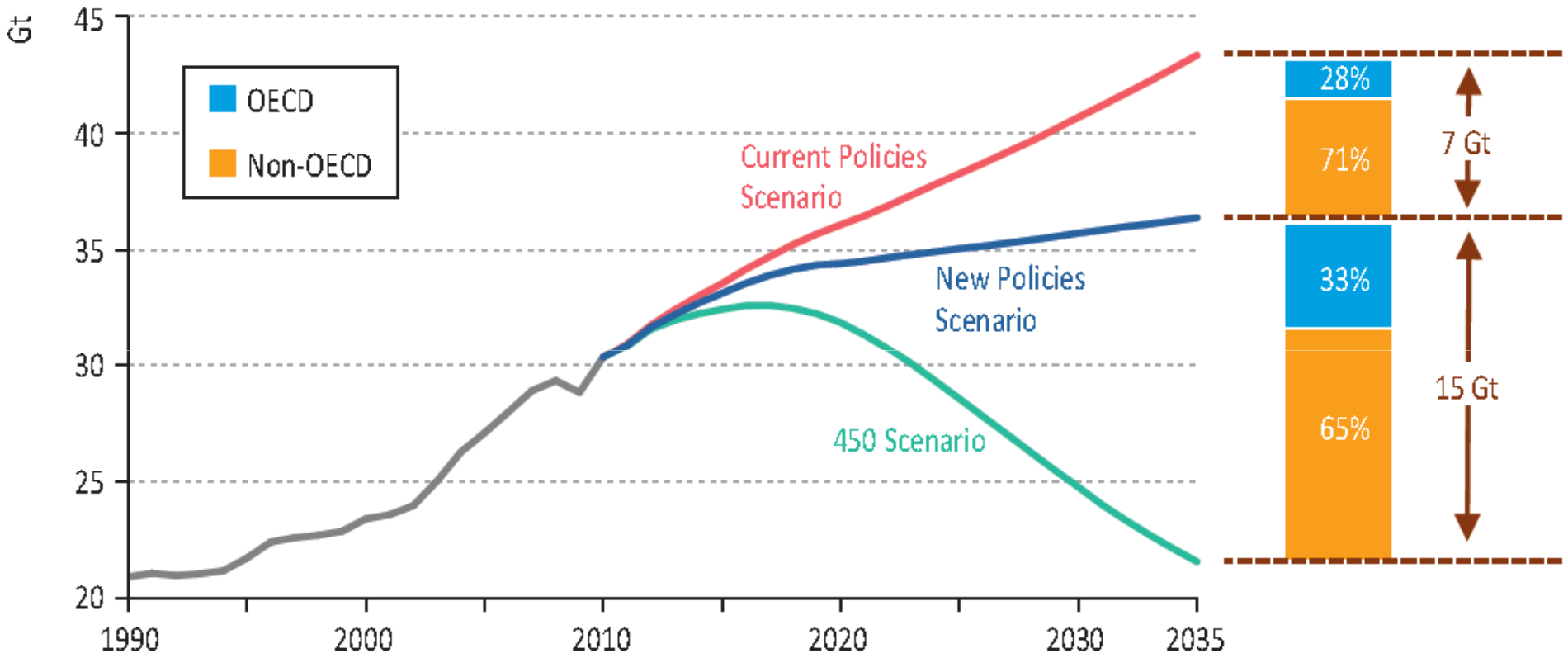
What is special about 2°C?

- Expected warming of more than 3.5°C in the New Policies Scenario would have too severe consequences
- The 450 Scenario, by definition, achieves a long-term atmospheric concentration of 450 ppm CO2-eq (resulting in average warming of 2°C)
- But even keeping the temperature rise to 2°C may risk dangerous climate change…
- Although the difficulty of achieving 450ppm stabilisation is increasing sharply with every passing year, so too are the predicted consequences of failing to do so…

Energy-related CO2 emissions by country, 2008-2010



World energy-related CO2 emissions



Note: There is also some abatement of inter-regional (bunker) emissions which, at less than 2% of the difference between scenarios, is not visible in the 2035 shares.

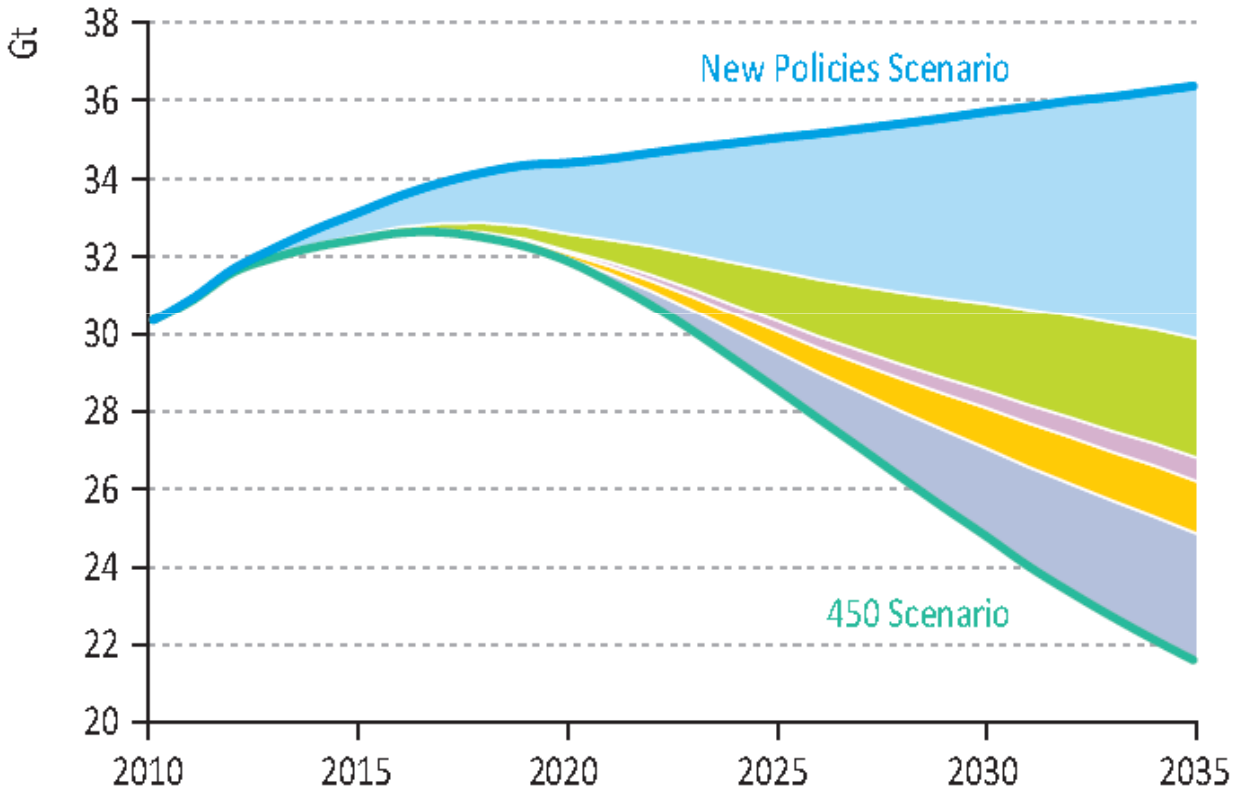
World anthropogenic greenhouse-gas emissions by scenario *(Gt CO2-eq)*

		New Policies Scenario		Current Policies Scenario		450 Scenario	
	2009	2020	2035	2020	2035	2020	2035
CO_2-energy	28.8	34.4	36.4	36.1	43.3	31.9	21.6
CO_2-other	1.4	1.2	1.1	1.7	1.9	1.0	0.8
CH_4	7.7	7.2	7.1	9.3	10.7	6.4	5.1
N_2O	3.2	3.2	3.2	3.8	4.2	3.0	2.7
F-gases	0.7	0.7	0.9	1.4	2.3	0.5	0.5
LULUCF[3]	5.2	4.3	1.9	4.3	1.9	4.3	1.9
Total	**47.1**	**50.9**	**50.6**	**56.5**	**64.4**	**47.1**	**32.6**

Notes: F-gases include hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) from several sectors, mainly industry. CO_2-other = CO_2 from industrial processes; LULUCF = land use, land-use change and forestry. Peat emissions are not included.

Source: IEA-OECD analysis using OECD Env-Linkages model.

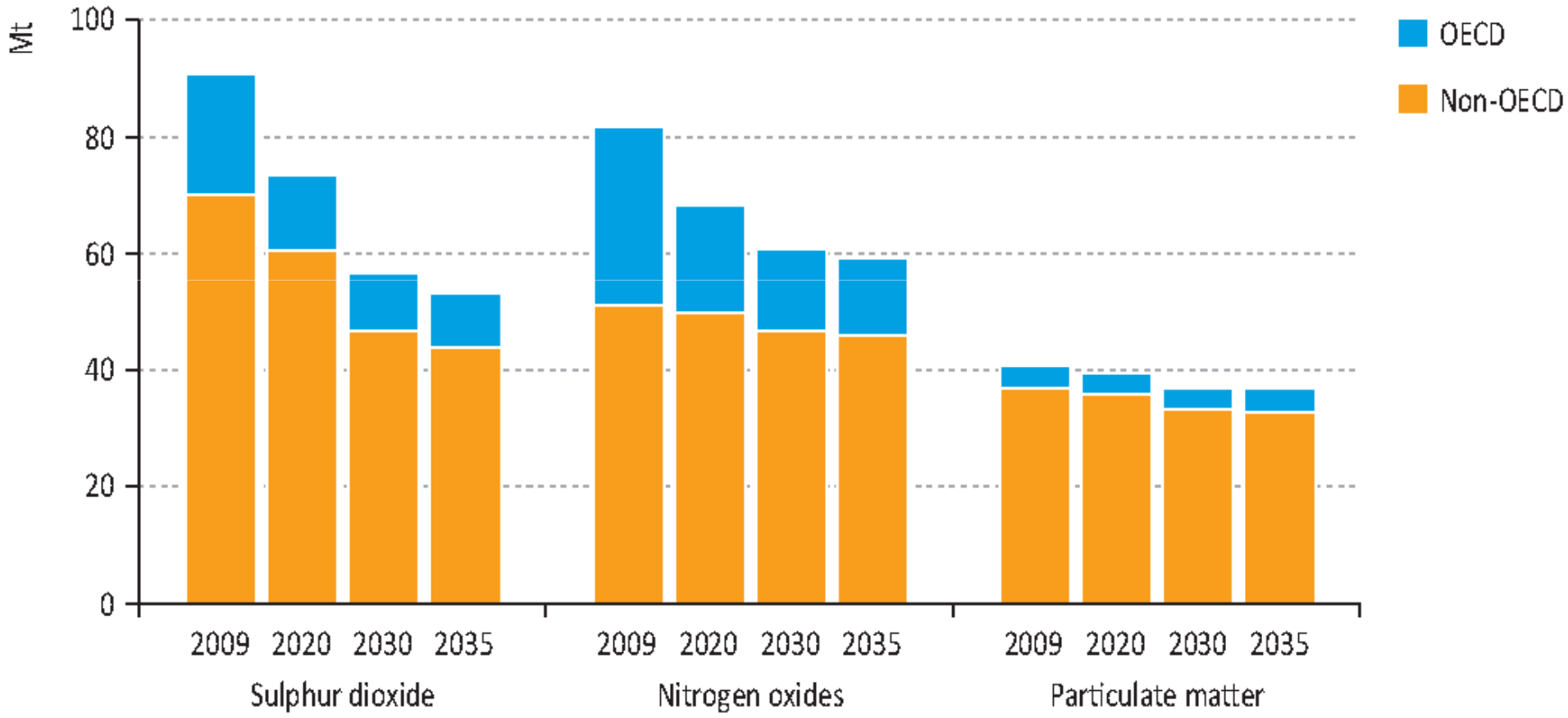
World energy-related CO2 emissions abatement in the 450 Scenario relative to the New Policies Scenario



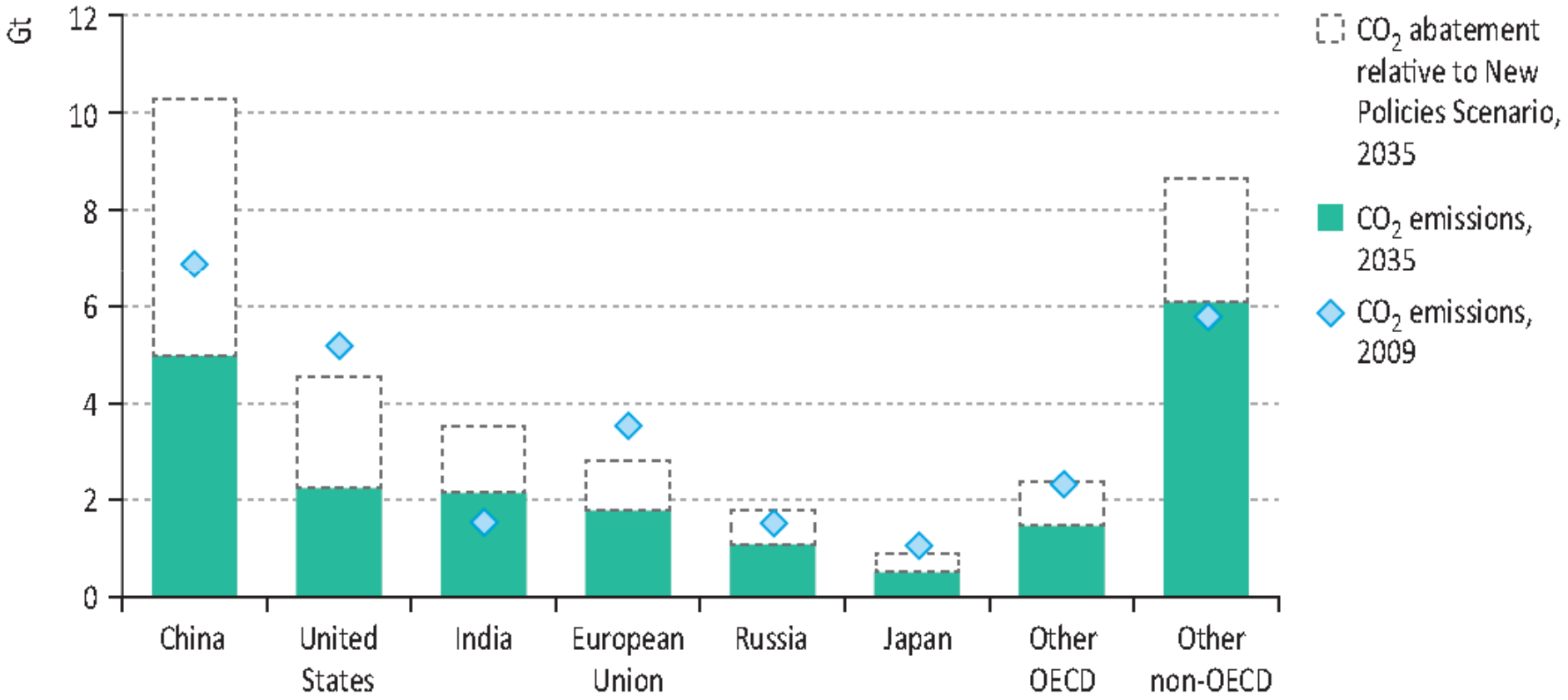
	Abatement	
	2020	2035
Efficiency	72%	44%
Renewables	17%	21%
Biofuels	2%	4%
Nuclear	5%	9%
CCS	3%	22%
Total (Gt CO_2)	2.5	14.8

- Energy efficiency measures have associated benefits, in terms of energy security and reduced local pollution. Despite this, and their sound economic rationale, energy efficiency measures are more difficult to implement than one might suppose…

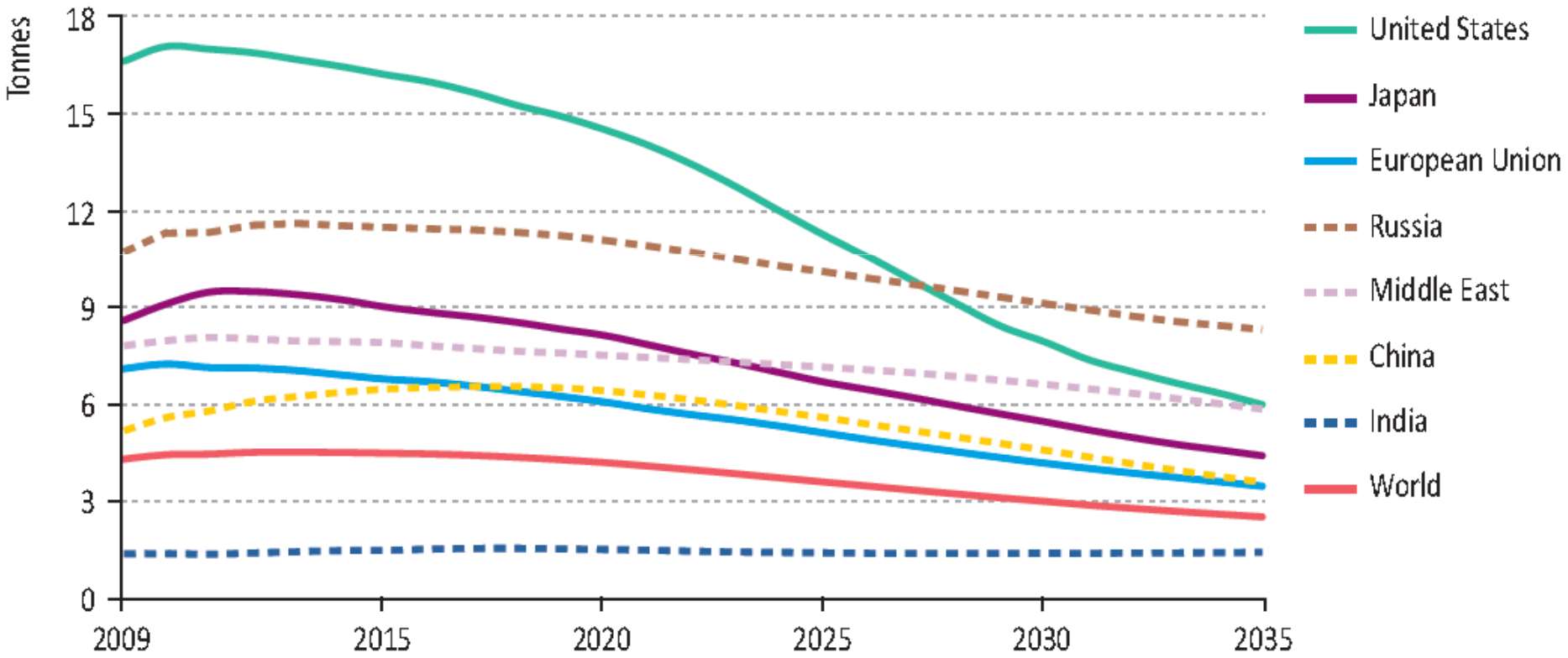
Emissions of major air pollutants by region in the 450 Scenario



Energy-related CO2 emissions in the 450 Scenario and abatement relative to the New Policies Scenario, 2009 and 2035



Energy-related CO2 emissions per capita in the 450 Scenario



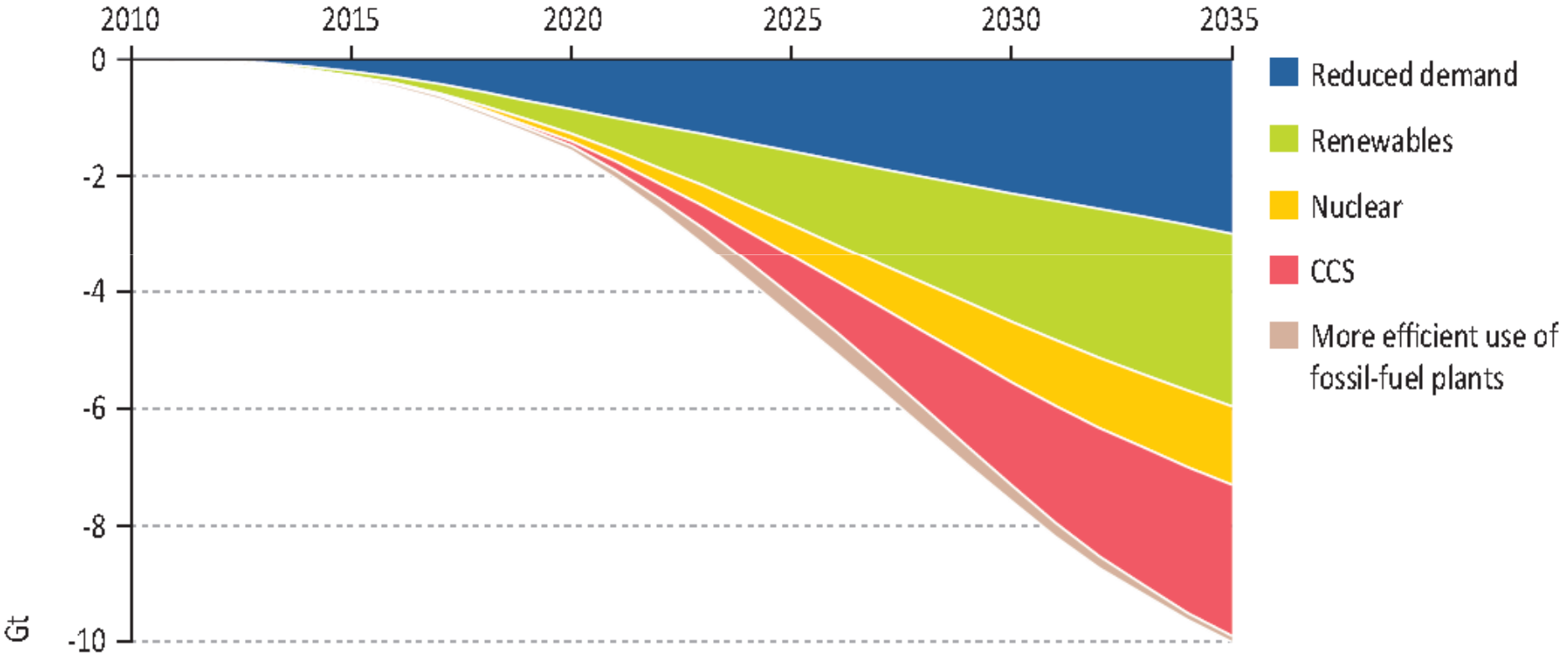
In Europe…

- Biomass represents 60% of renewables use in the European Union in 2035, being widely used for heating, power generation and transport.
- By 2035, wind represents the largest single share of installed electricity generating capacity, 29% higher than that of natural gas.
- CO2 emissions from new PLDVs reach on-road levels of 50 gCO2/km in 2035, 70% below current levels.

The International Year of Sustainable Energy for All: can universal access be achieved without increasing CO2 emissions?

- Today 1.3 billion people,lack access to electricity, 84% of whom live in rural areas.
- It is unrealistic to assume all new electrification would come entirely from low-carbon options due to the high cost.
- It is also unnecessary, as climate goals can be achieved through abatement in countries other than the poorest…

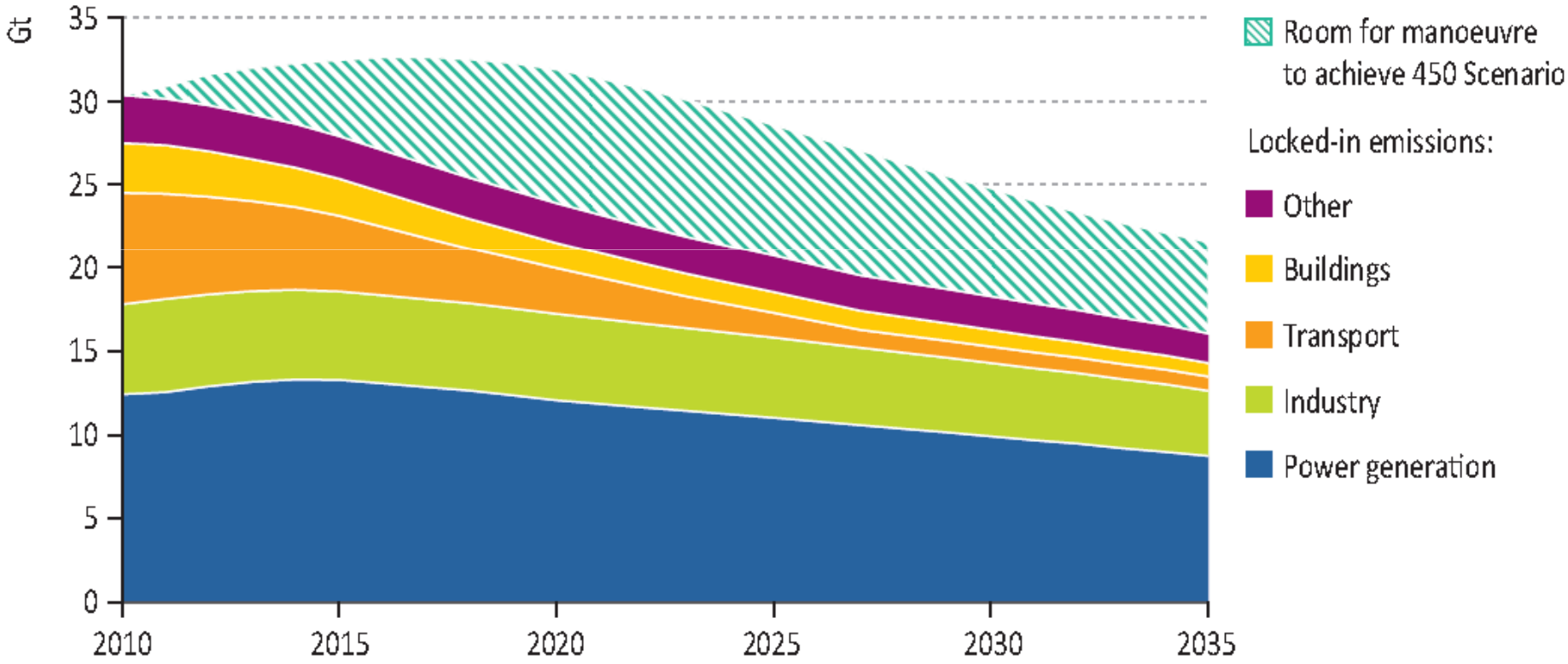
Change in world energy-related CO2 emissions from the power generation sector in the 450 Scenario compared with the New Policies Scenario



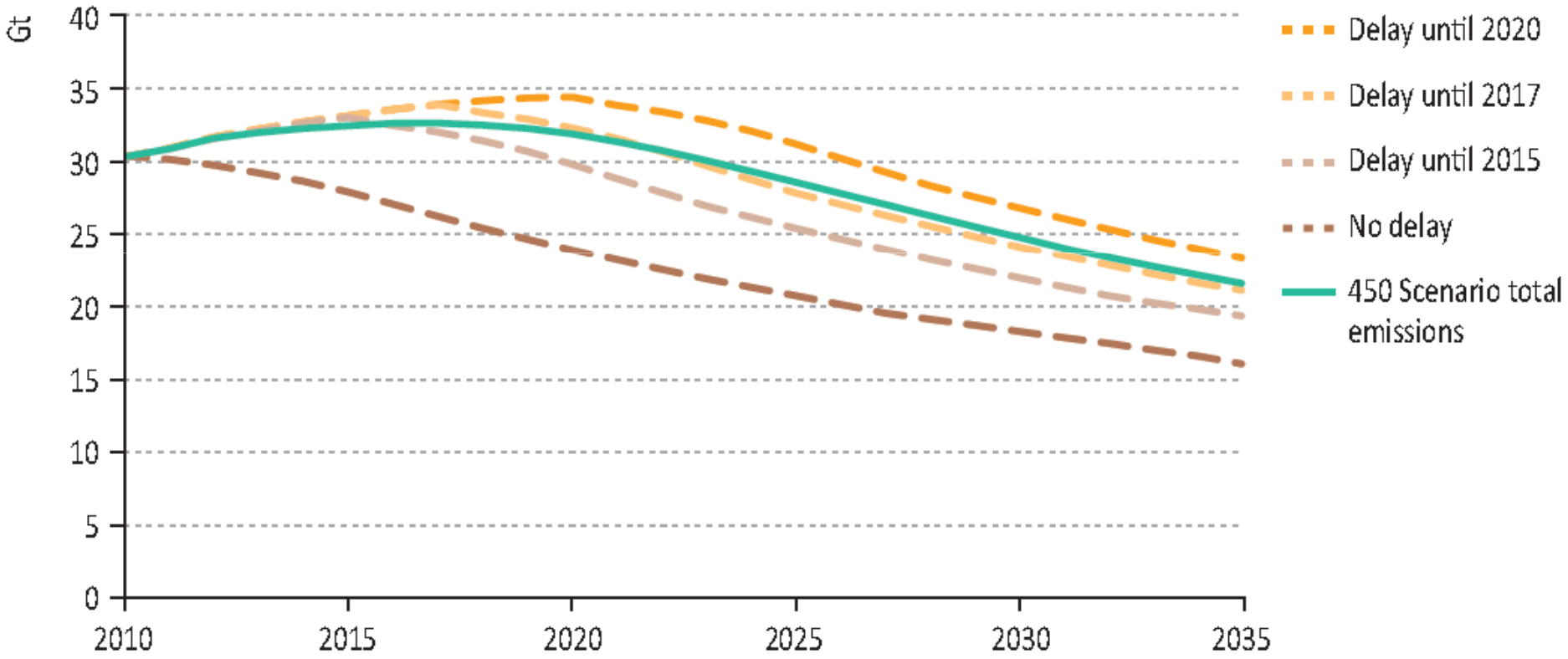
Implications of delayed action

- ***Lock-in in the energy sector***

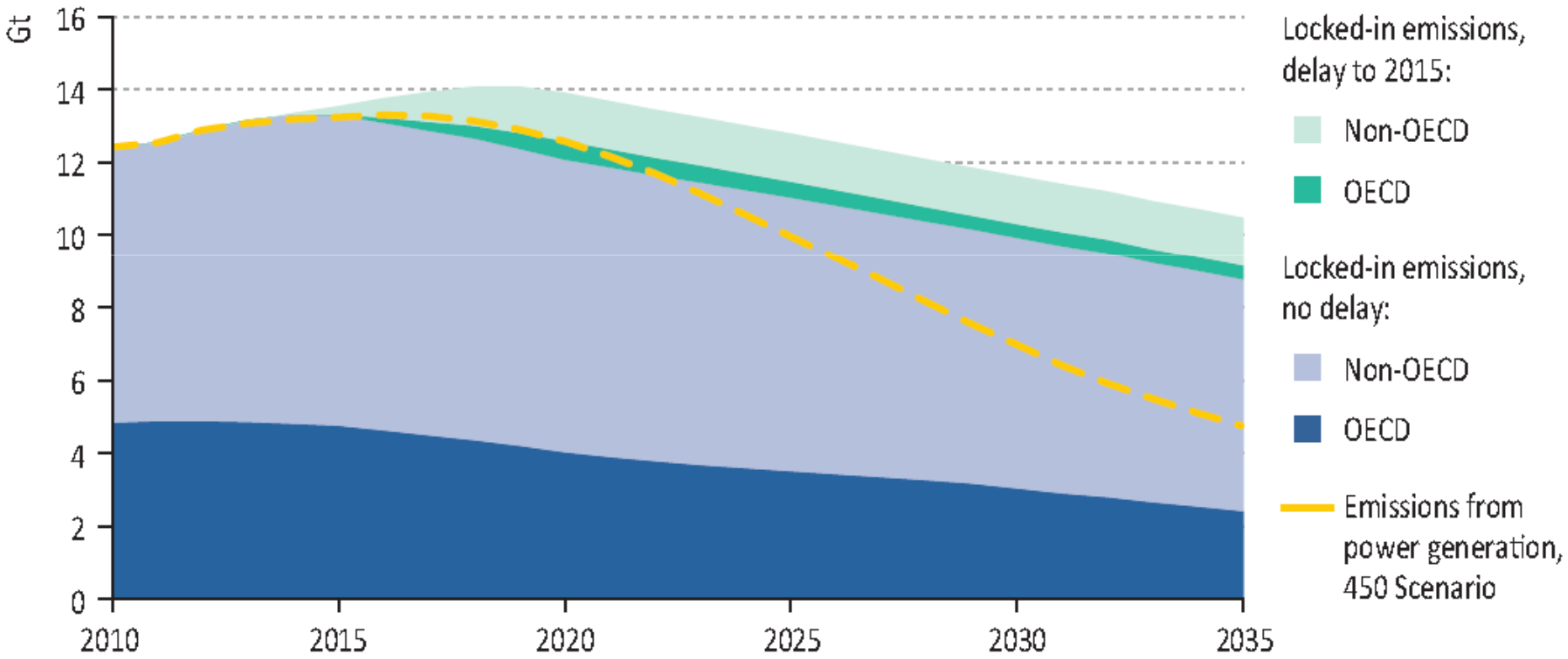
World energy-related CO2 emissions from locked-in infrastructure in 2010 and room for manoeuvre to achieve the 450 Scenario



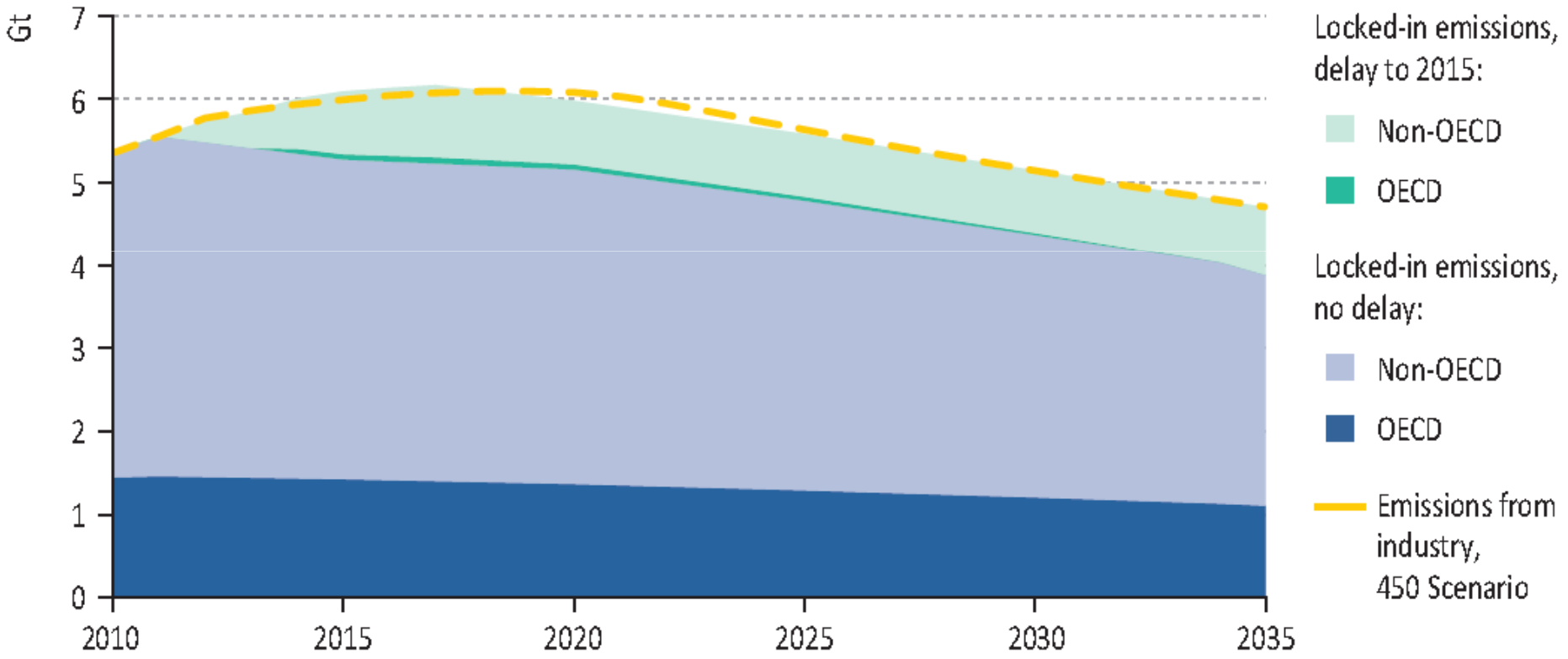
World energy-related CO2 emissions in the 450 Scenario and from locked-in infrastructure in 2010 and with delay



World energy-related CO2 emissions in the 450 Scenario and from locked-in infrastructure in 2010 and with delay to 2015 in the power sector

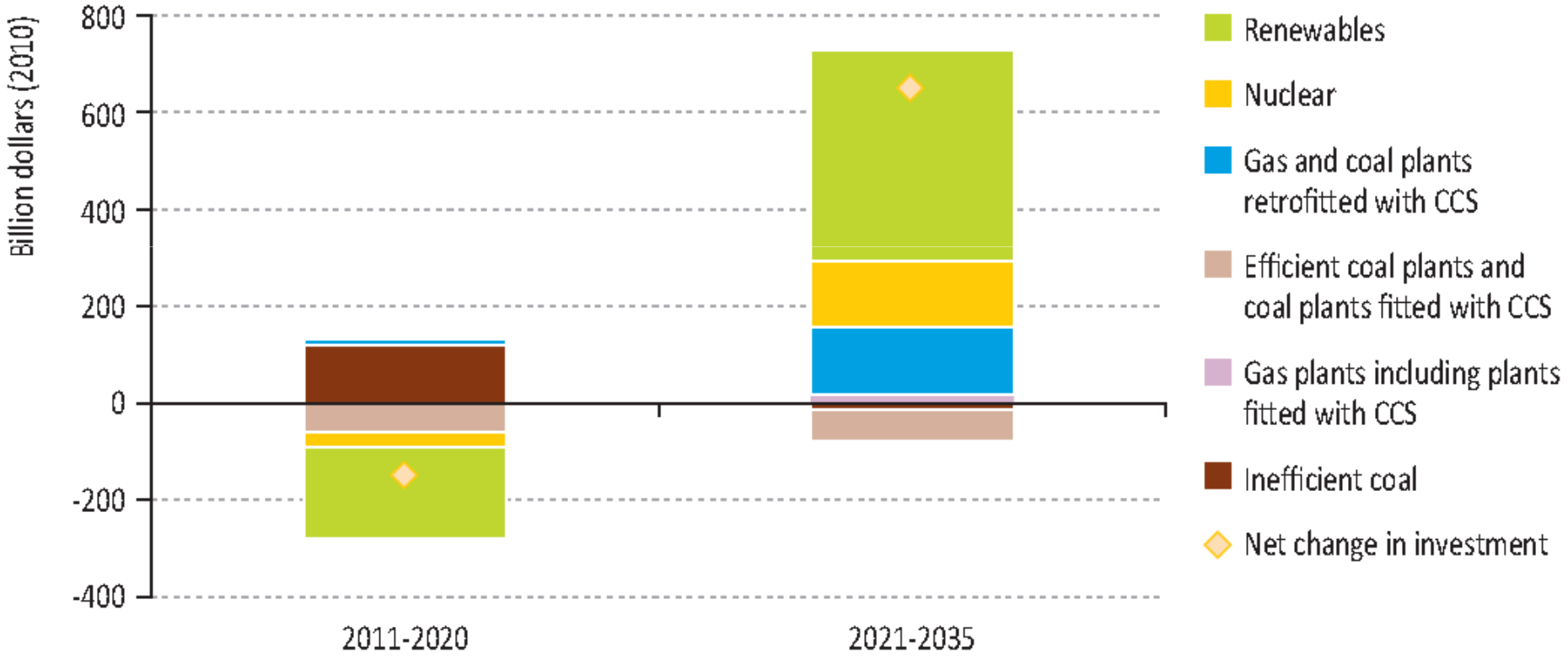


World energy-related CO2 emissions in the 450 Scenario and from locked-in infrastructure in 2010 and with delay to 2015 in industry



- Since the global location of industrial activities is relatively flexible, the consequence of exhausting the national “budget” of emissions from this sector could well be that activities would simply be switched to countries without CO2 restrictions.
- This points to the need for a global sectoral approach when addressing the issue of emissions control in the industry sector.

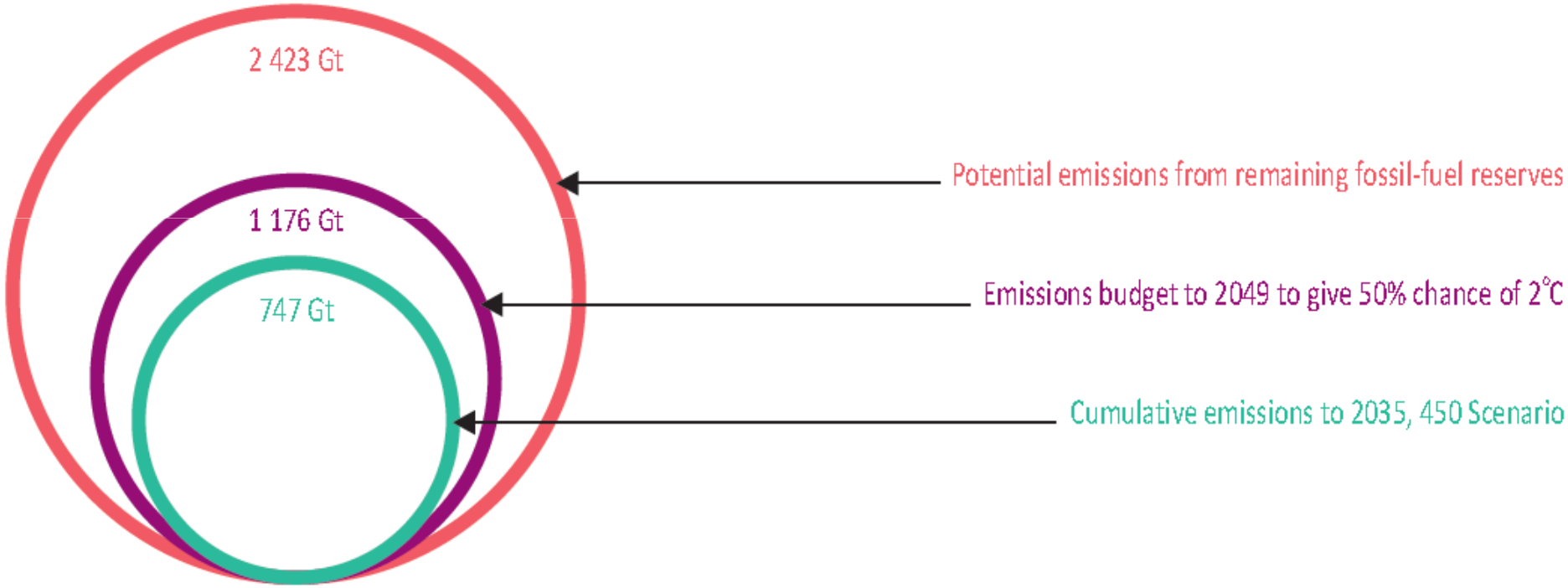
Change in investment in power generation in the Delayed 450 Case, relative to the 450 Scenario



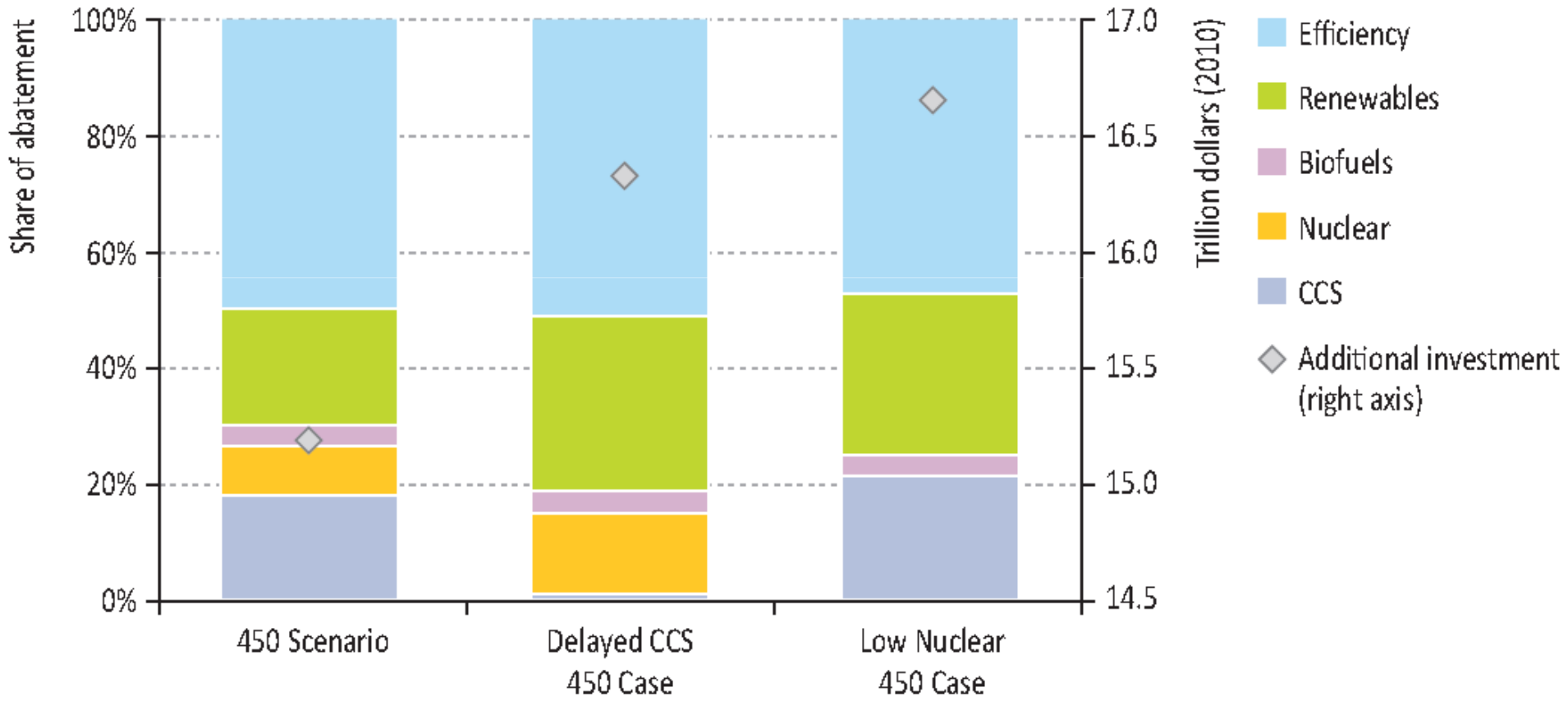
What if CCS does not deliver?

- A budget of a cumulative 1 000 Gt of CO2 emitted between 2000 and 2049 would, if respected, give a 75% chance of keeping the global average temperature increase to 2°C or less (Meinshausen *et al., 2009).*
- *In the 450 Scenario,* this budget is exceeded by 2035.
- Reducing the probability of success to 50% increases the budget to 1 440 Gt.
- Since a total of 264 Gt of emissions have already been emitted between 2000 and 2009, 1 176 Gt more can be emitted from2010 to 2049.

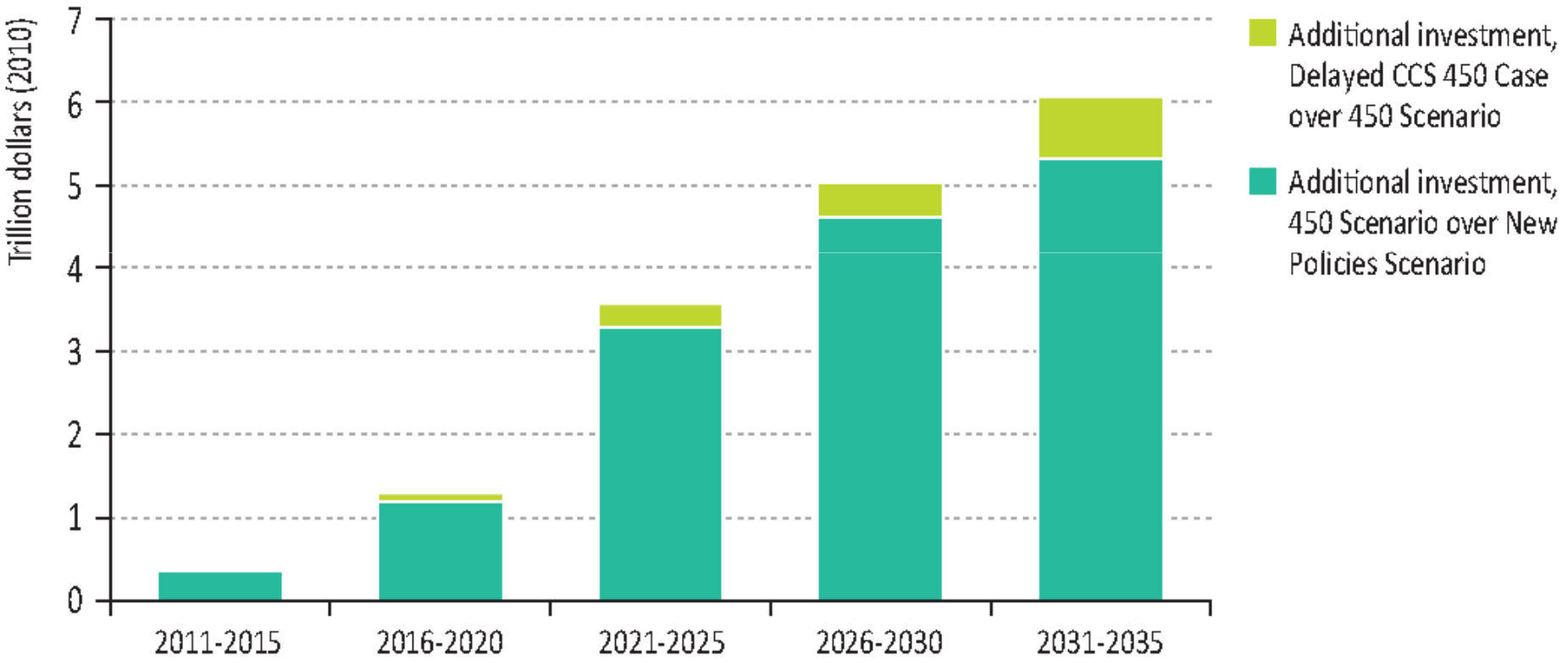
Potential CO2 emissions from remaining fossil-fuel reserves and in the 450 Scenario, compared with the emissions budget to achieve 2°C



Cumulative share of abatement relative to the New Policies Scenario in the 450 Scenario, Delayed CCS 450 Case and Low Nuclear 450 Case



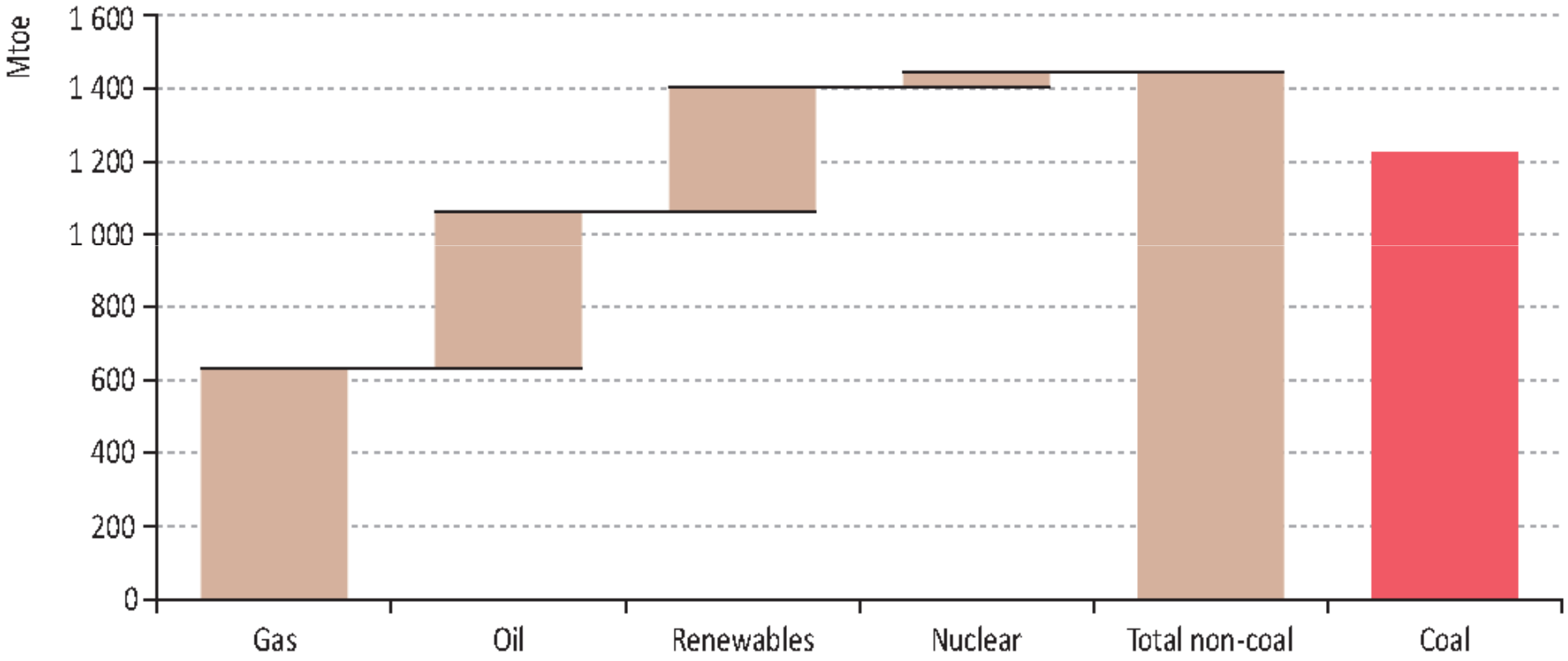
Additional investment in the Delayed CCS 450 Case



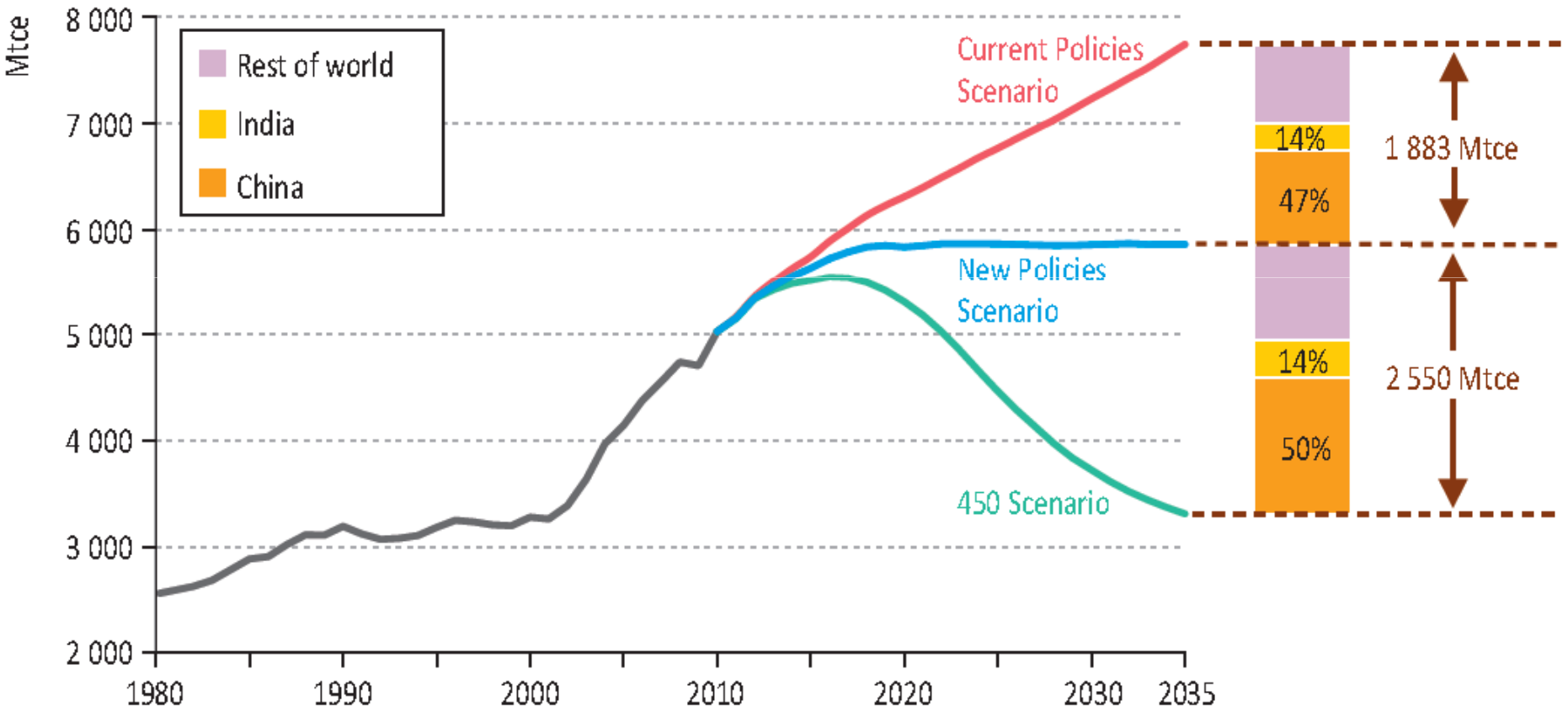
COAL DEMAND PROSPECTS

- Demand
- Environmental impact
- Technological innovation

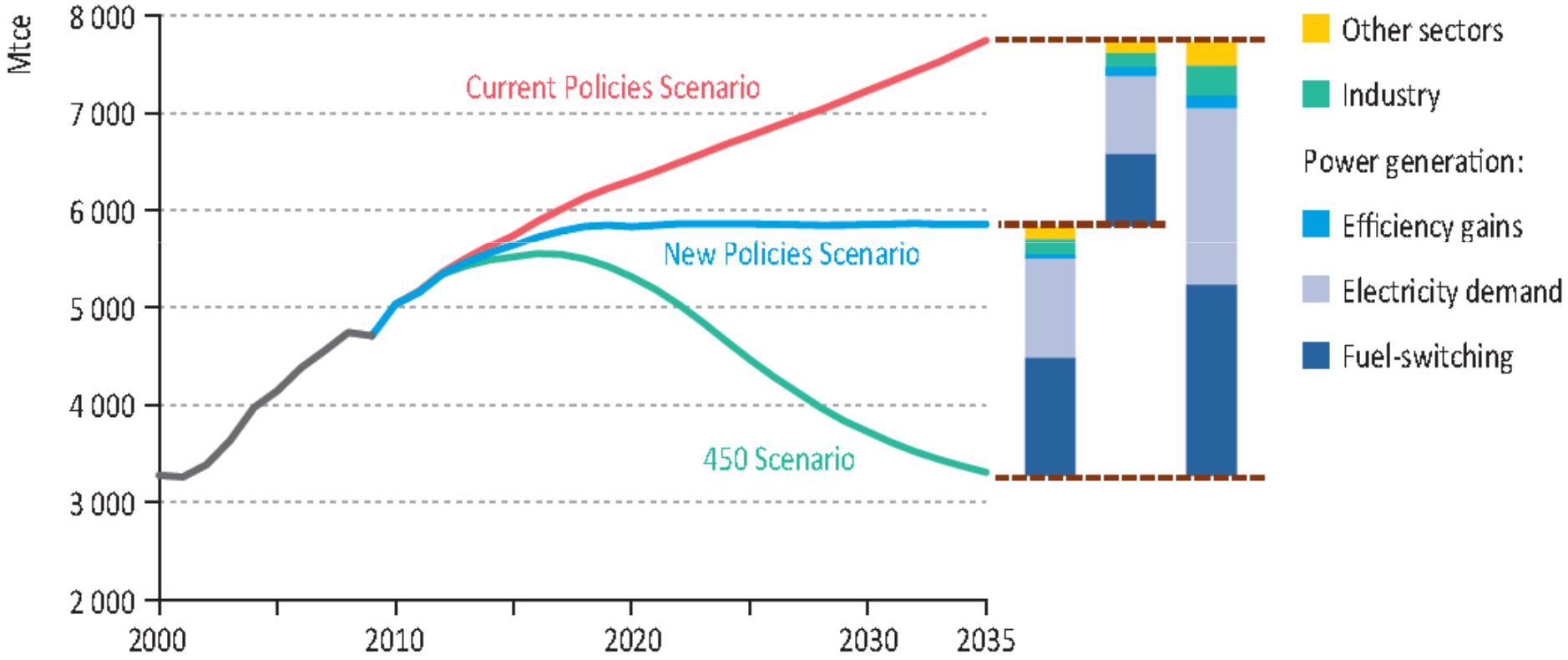
Incremental world primary energy demand by fuel, 2000-2010



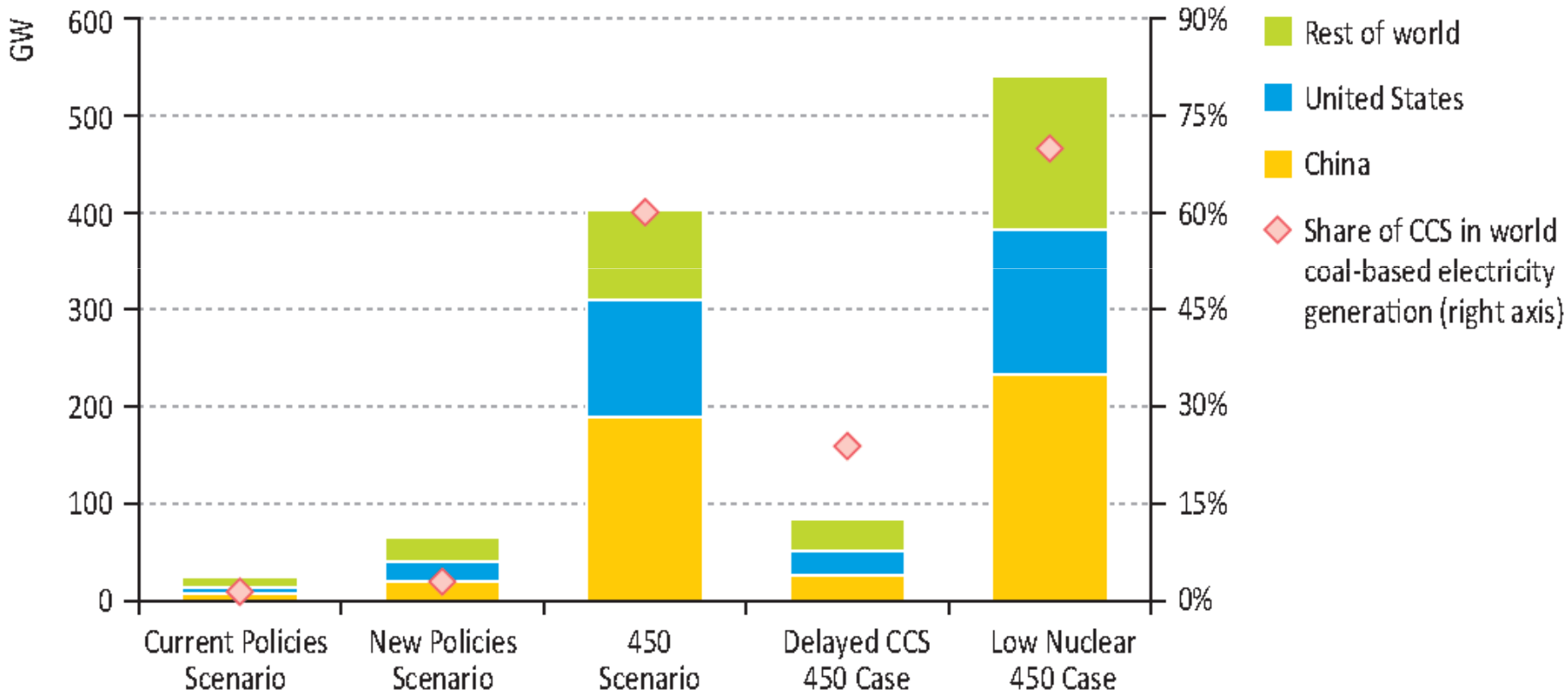
World primary coal demand



Reduction in world primary coal demand by sector and scenario



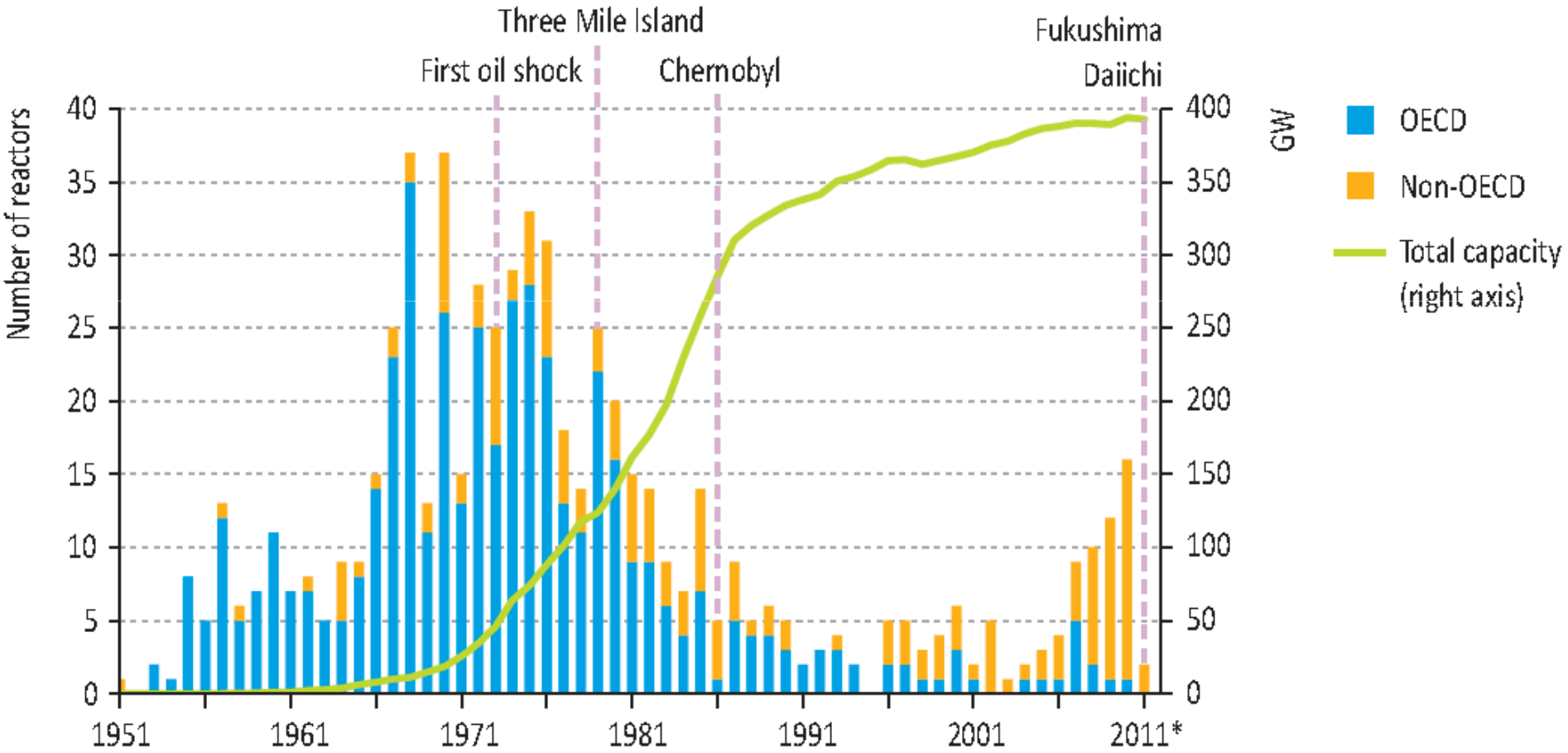
Coal-fired generating capacity equipped with CCS, 2035



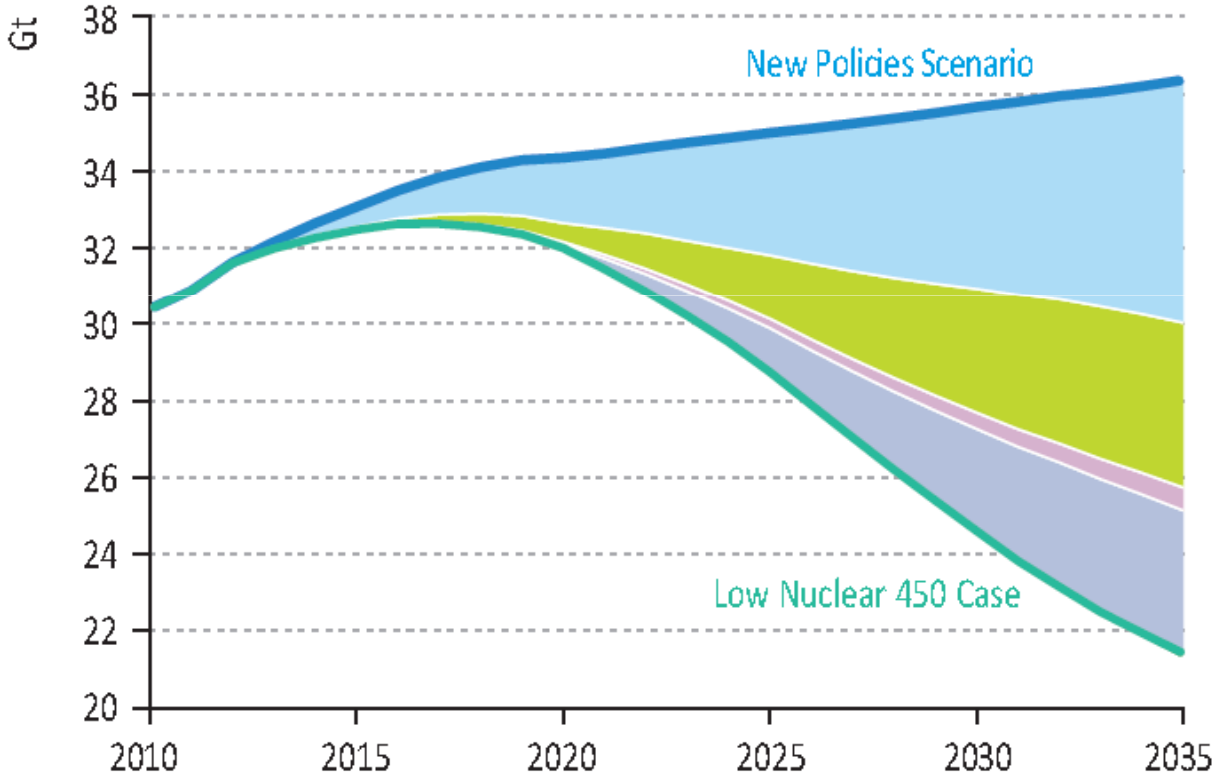
THE IMPLICATIONS OF LESS NUCLEAR POWER

- ***How would it affect energy markets and climate trends?***

Nuclear reactor construction starts, 1951-2011



World energy-related CO2 emissions abatement in Low Nuclear 450 Case relative to New Policies Scenario



	Abatement	
	2020	2035
Efficiency	72%	42%
Renewables	21%	29%
Biofuels	2%	4%
CCS	4%	25%
Total (Gt CO_2)	2.4	15.0

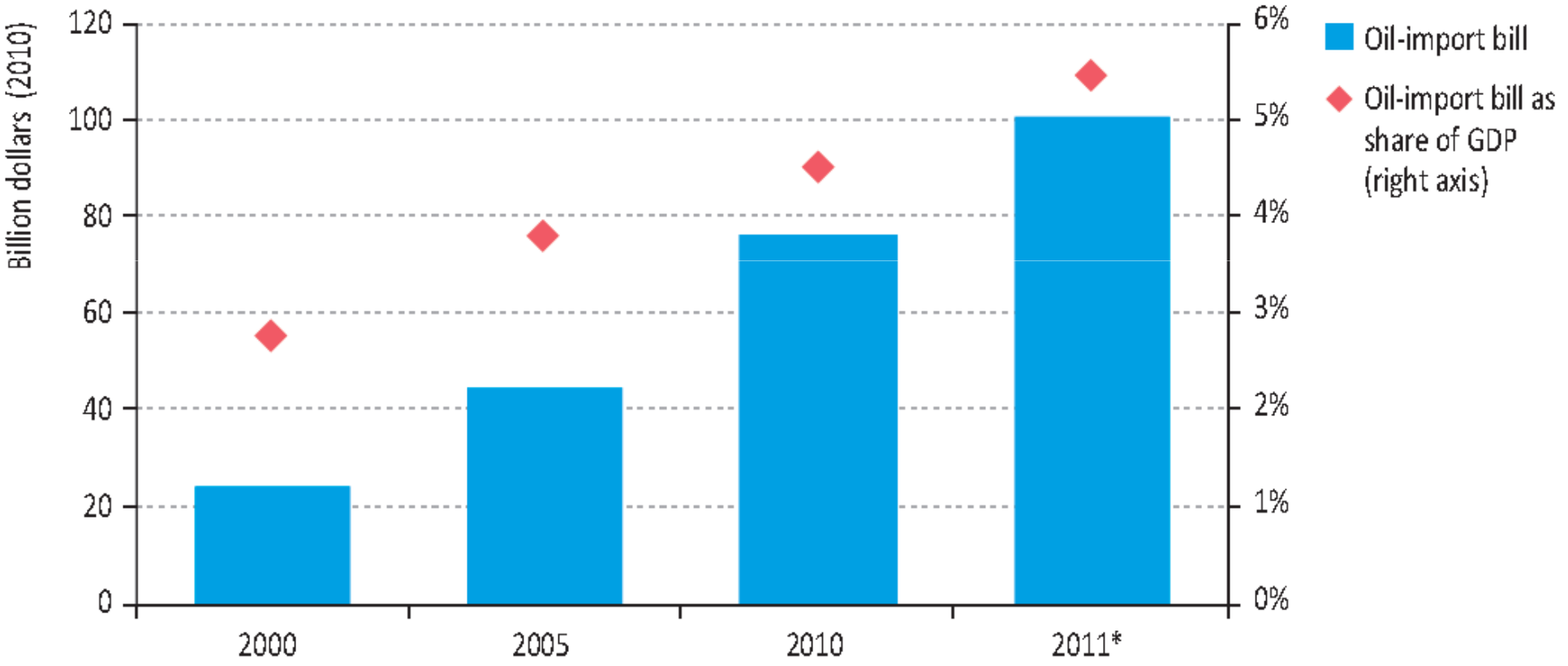
- In the Low Nuclear 450 Case, as in the 450 Scenario, energy efficiency measures are the largest source of emissions abatement, accounting for about 47% of the cumulative emissions savings over the period 2011 to 2035 and underlining the importance of very vigorous policy action in this area!

ENERGY FOR ALL

- Modern energy services are crucial to human well-being and to a country's economic development; and yet over 1.3 billion people are without access to electricity and 2.7 billion people are without clean cooking facilities. More than 95% of these people are either in sub-Saharan Africa or developing Asia and 84% are in rural areas.

- Achieving universal access by 2030 would increase global electricity generation by 2.5%.
- Demand for fossil fuels would grow by 0.8% and CO2 emissions go up by 0.7%, both figures being trivial in relation to concerns about energy security or climate change.
- The prize would be a major contribution to social and economic development, and helping to avoid the premature death of 1.5 million people per year.

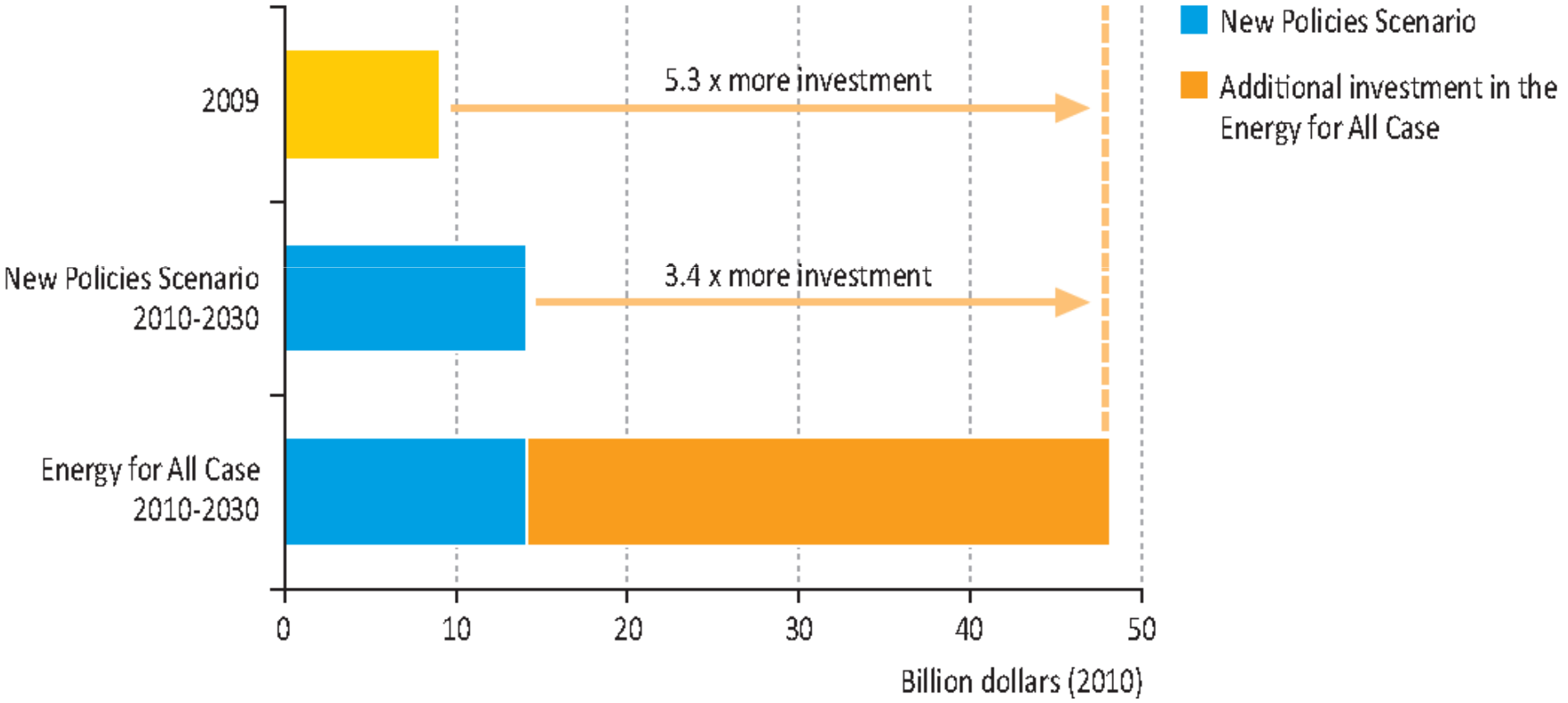
Oil-import bills in net-importing less developed countries



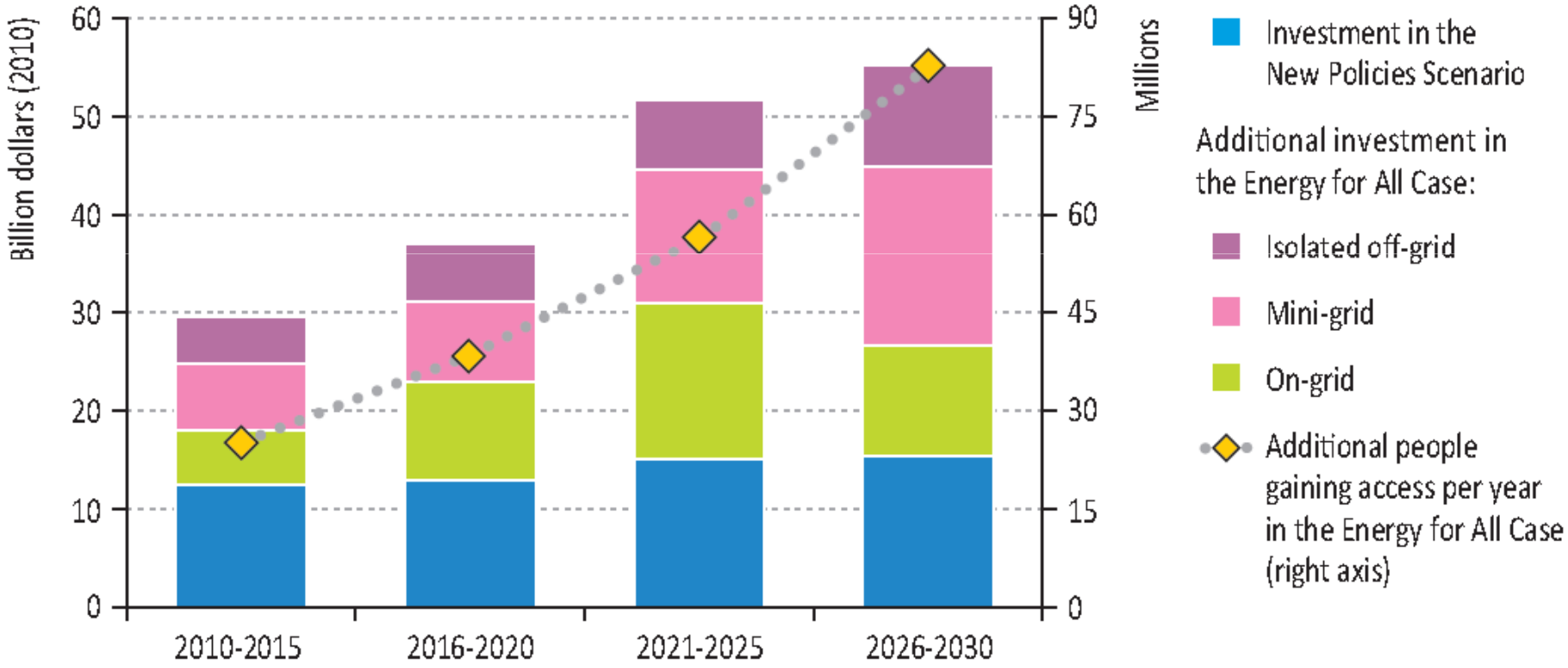
- The initial threshold level of electricity consumption for rural households is assumed to be 250 kilowatt-hours (kWh) per year and for urban households it is 500 kWh per year.
- In rural areas, this level of consumption could, for example, provide for the use of a floor fan, a mobile telephone and two compact fluorescent light bulbs for about five hours per day.
- In urban areas, consumption might also include an efficient refrigerator, a second mobile telephone per household and another appliance, such as a small television or a computer.

- This definition of energy access also includes provision of cooking facilities which can be used without harm to the health of those in the household and which are more environmentally sustainable and energy efficient than the average biomass cook stove currently used in developing countries.

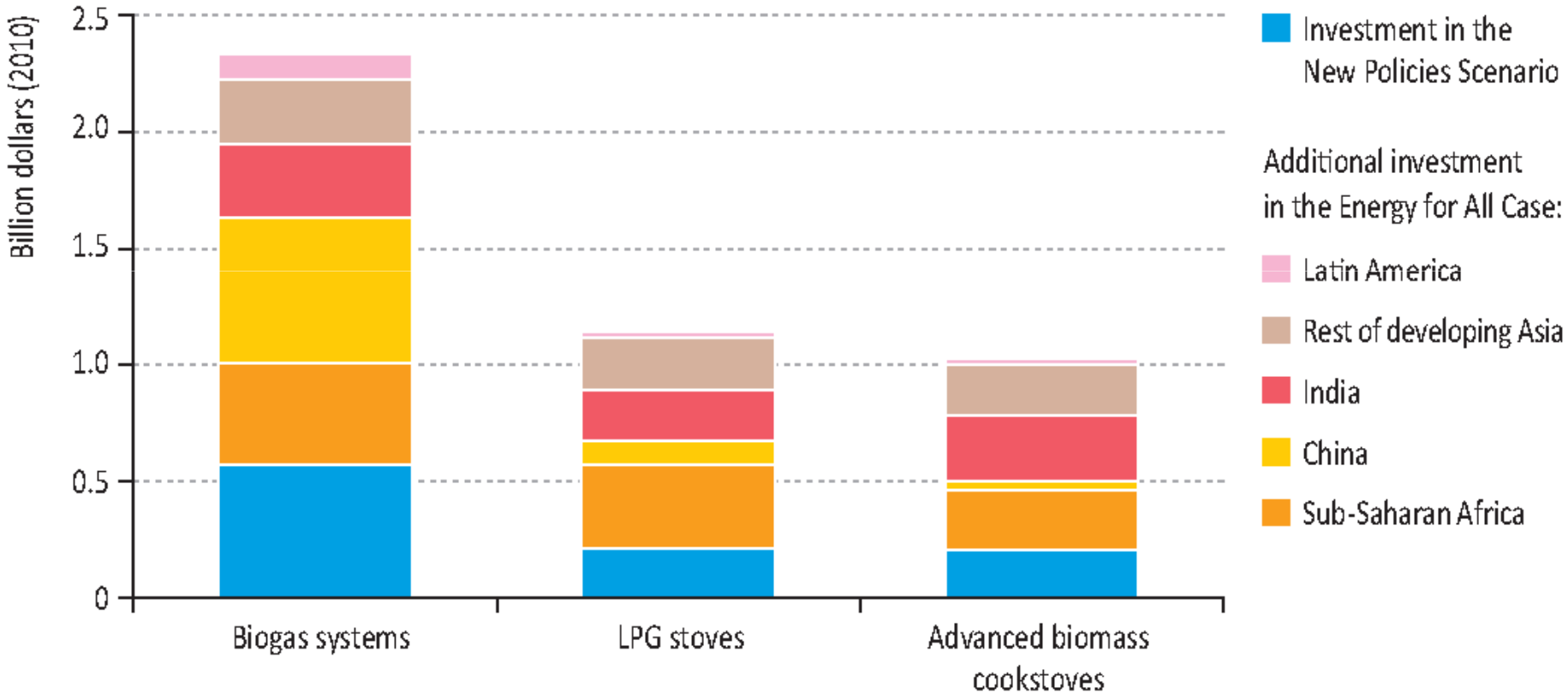
Average annual investment in modern energy access by scenario



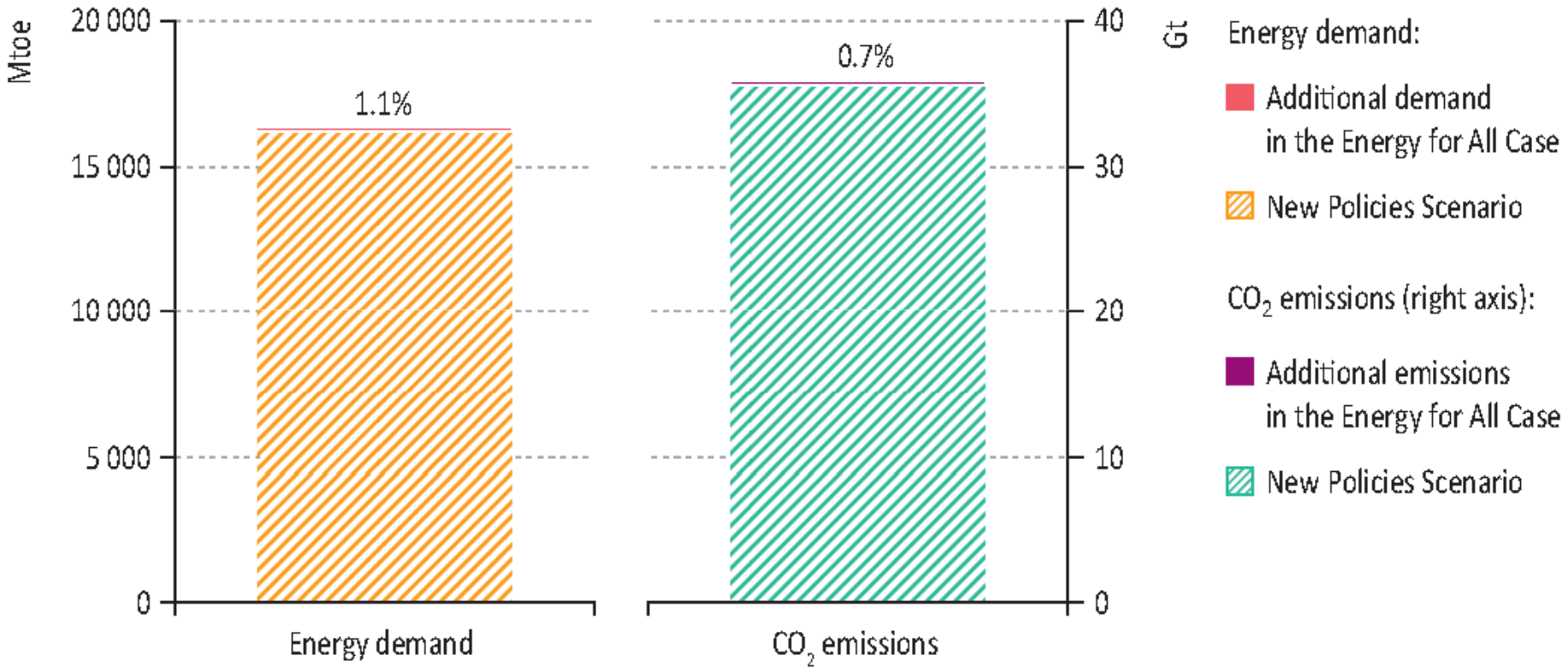
Average annual investment in access to electricity by type and number of people connected in the Energy for All Case



Average annual investment in access to clean cooking facilities by type and region, 2010-2030

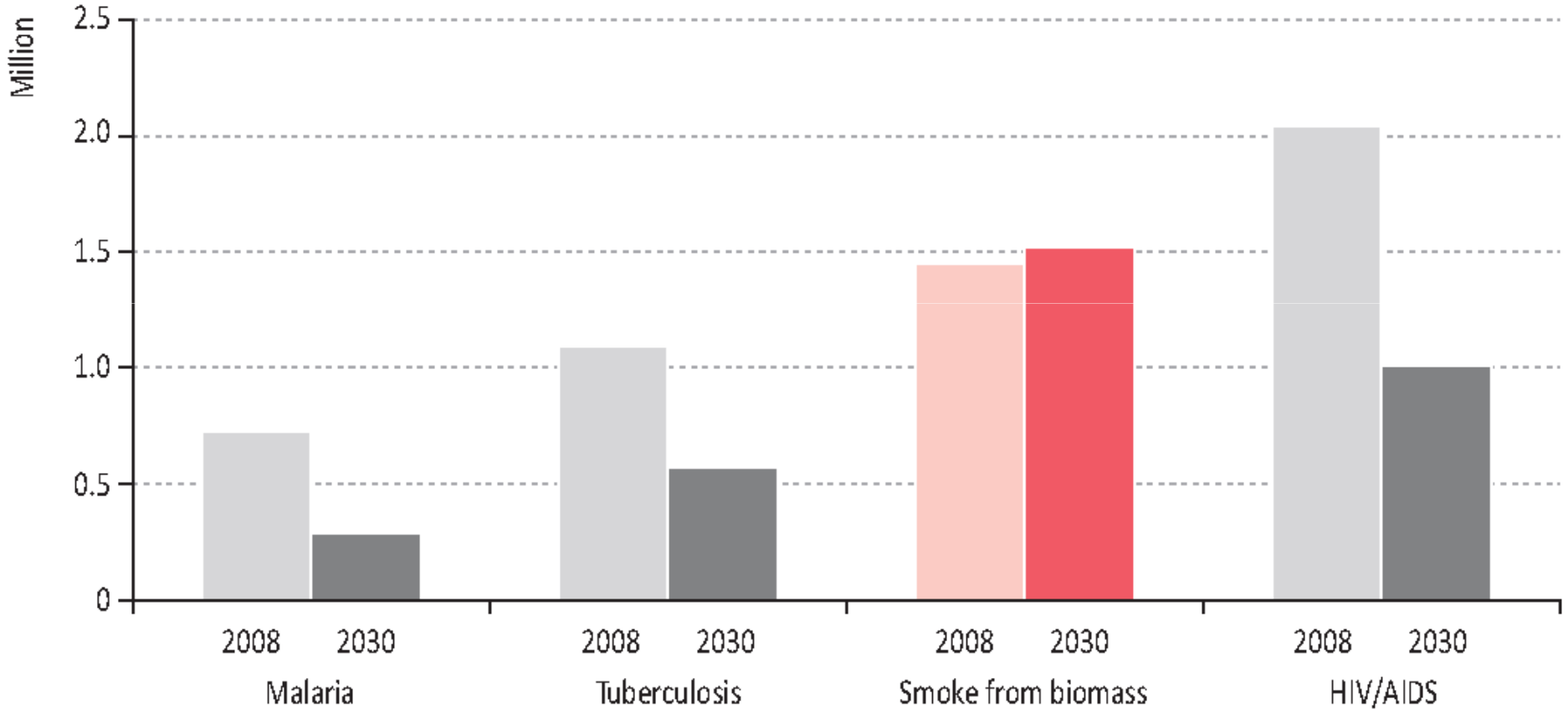


Additional global energy demand and CO2 emissions in the Energy for All Case compared with the New Policies Scenario, 2030



Notes: Percentages are calculated as a share of the total energy demand or CO_2 emissions respectively in 2030. Gt = gigatonnes.

Premature annual deaths from household air pollution and selected diseases in the New Policies Scenario



Note: 2008 is the latest available data in WHO database.

DEVELOPMENTS IN ENERGY SUBSIDIES

- ***The good, the bad and the ugly?***

Fossil-fuel subsidies and the poor

- One common justification for fossil-fuel subsidies is that they are needed to help the poor gain or maintain access to energy services essential to basic living standards, but…
- Poor households may not have access to subsidised energy directly, lacking a connection to electricity or natural gas and owning no vehicle.

- Without precise targeting, fossil fuel subsidies are often an inefficient means of assisting the poor.
- Out of the $409 billion spent on fossil-fuel consumption subsidies in 2010, only $35 billion, or 8% of the total, reached the poorest income group (the bottom 20%).
- In general, social welfare programmes are a more effective and less distortionary way of helping the poor than energy subsidies…

- Subsidisation may not be the most cost-effective means of making renewable energy more competitive or to meet broader policy objectives.
- Internalising the cost of certain externalities, for example by instituting more widespread or higher CO2 prices, may represent a more economically efficient approach, although there are political hurdles to be overcome.

Estimated costs of renewable-electricity subsidies

- Subsidies to renewables-based electricity – wind, solar PV in buildings, geothermal and biomass-based technologies – totalled $44 billion in 2010, an increase of 12% over 2009.
- Much of the renewable electricity capacity deployed throughout the year actually generated little output.

- Total subsidies to wind were highest in absolute terms, at $18 billion, receiving, on average, $53 per megawatt-hour (MWh) of output.
- Solar PV, which produces electricity at a higher cost, benefitted from $425/MWh on average.
- As a result, solar PV received 28% of total renewable-electricity subsidies in 2010, despite accounting for only 4% of subsidised renewable electricity generation.

In short…

- *“If we don’t change direction soon, we’ll end up where we’re heading”*
- *Short-term uncertainty does little to alter the longer-term picture*
- *Steps in the right direction, but the door to 2°C is closing*
- *Rising transport demand and upstream costs reconfirm the end of cheap oil*
- *Golden prospects for natural gas*

- ***Renewables are pushed towards centre stage***
- ***Treading water or full steam ahead for coal?***
- ***Second thoughts on nuclear would have far-reaching consequences***
- ***Achieving energy for all will not cost the earth***