International Energy Agency

WORLD ENERGY OUTLOOK

The World Energy Outlook 2013 and Power sector modelling in the World Energy Model

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Seoul, 14 November 2013

The world energy scene today

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- **Some long-held tenets of the energy sector are being rewritten**
  - *Countries are switching roles: importers are becoming exporters…*
  - *… and exporters are among the major sources of growing demand*
  - *New supply options reshape ideas about distribution of resources*
- **But long-term solutions to global challenges remain scarce**
  - *Renewed focus on energy efficiency, but CO_2 emissions continue to rise*
  - *Fossil-fuel subsidies increased to $544 billion in 2012*
  - *1.3 billion people lack electricity, 2.6 billion lack clean cooking facilities*
- **Energy prices add to the pressure on policymakers**
  - *Sustained period of high oil prices without parallel in market history*
  - *Large, persistent regional price differences for gas & electricity*

The engine of energy demand growth moves to South Asia

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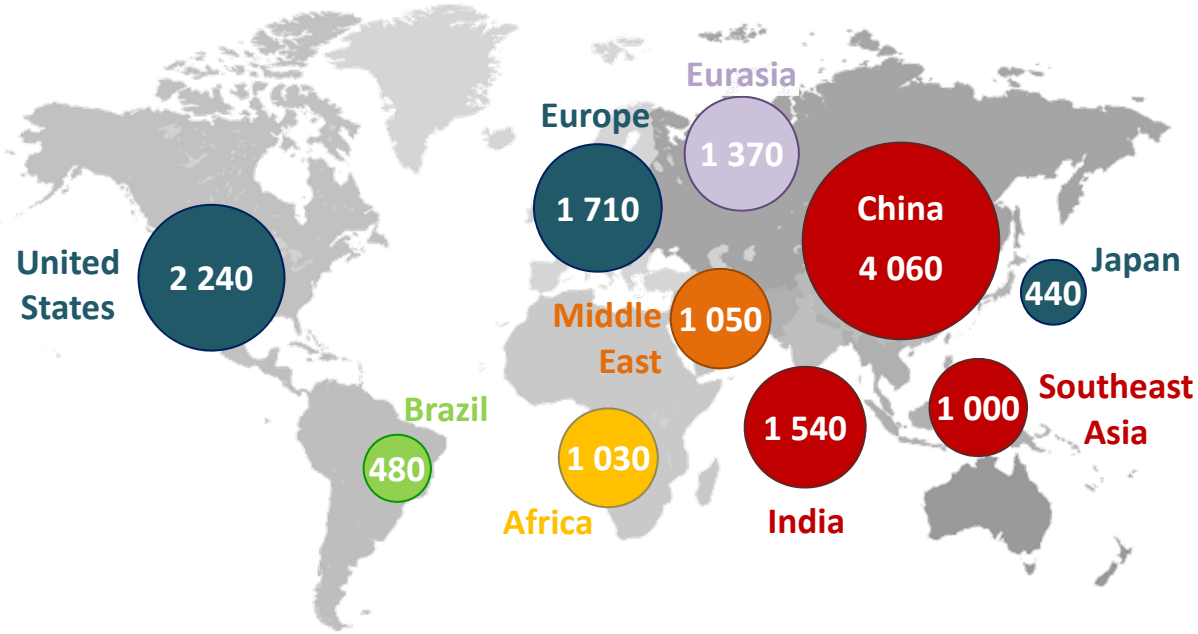
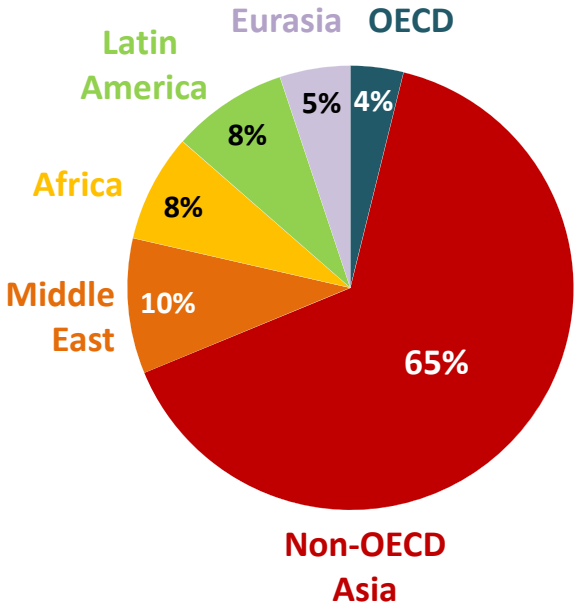
Primary energy demand, 2035 (Mtoe)



Share of global growth 2012-2035



China is the main driver of increasing energy demand in the current decade, but India takes over in the 2020s as the principal source of growth

A mix that is slow to change

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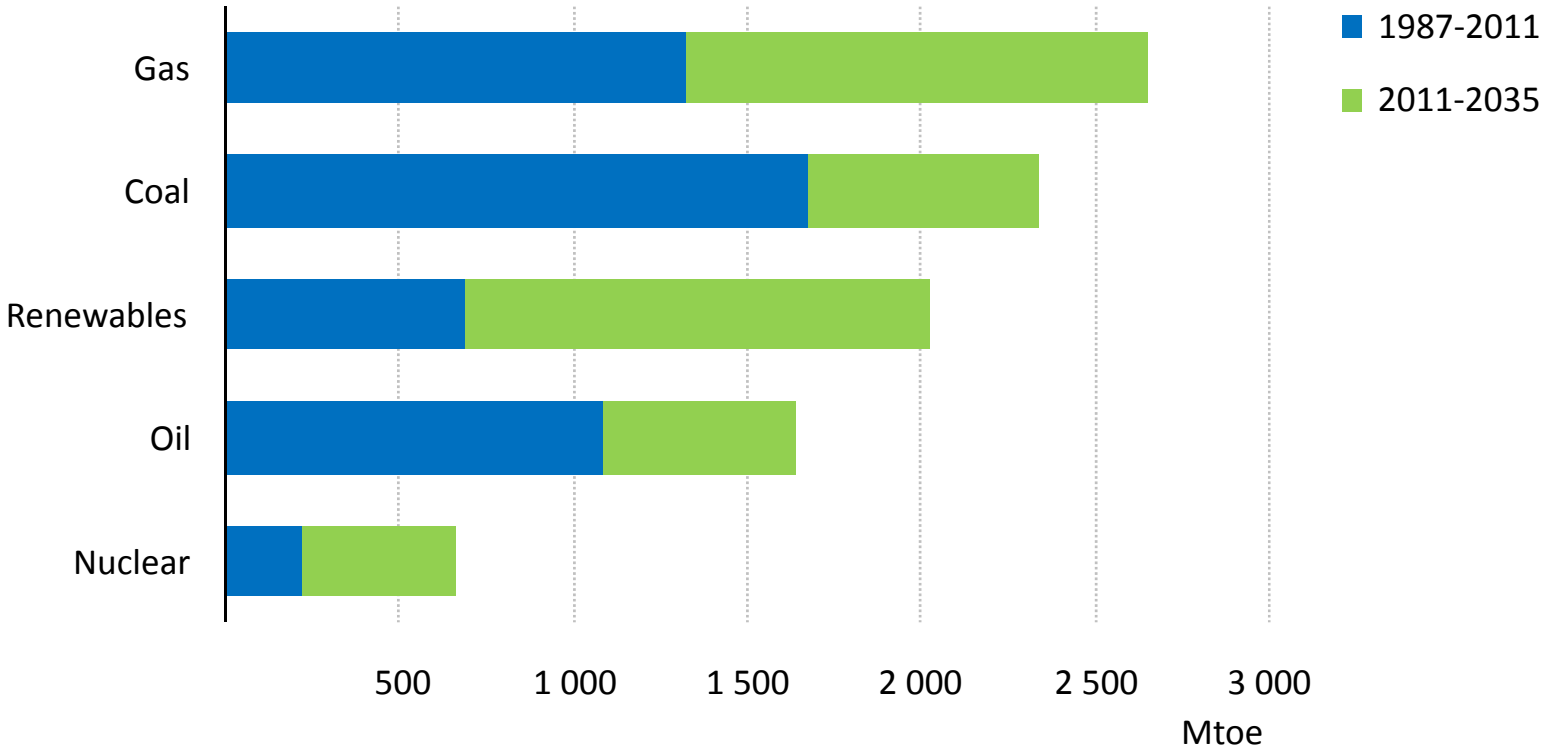
Growth in total primary energy demand



Today's share of fossil fuels in the global mix, at 82%, is the same as it was 25 years ago; the strong rise of renewables only reduces this to around 75% in 2035

The global energy system, 2011 (Mtoe)

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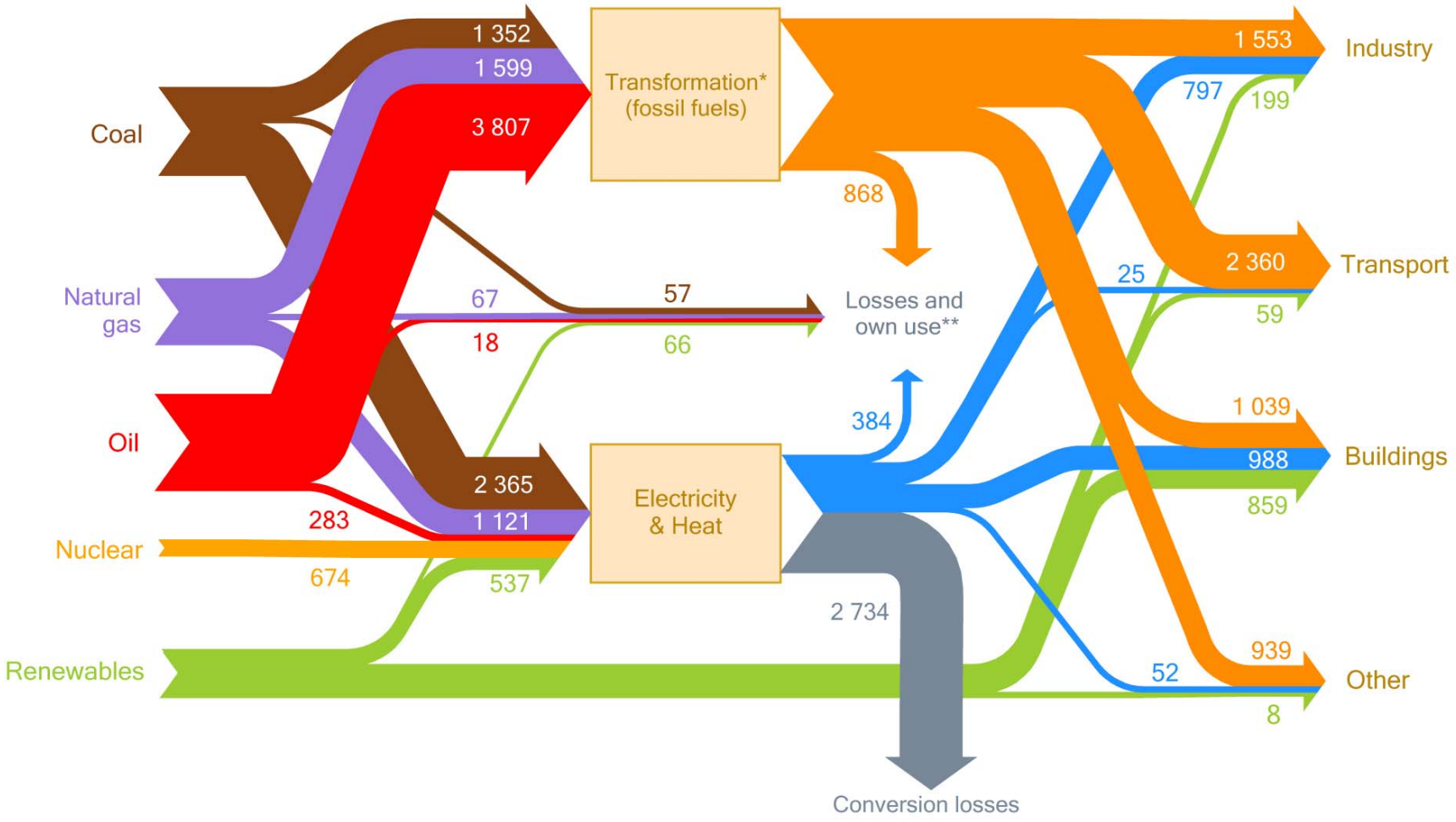

A complex energy world requires a well integrated model to capture all the interactions among markets, sectors, fuels and countries

World primary energy demand and related CO_2 emissions by scenario

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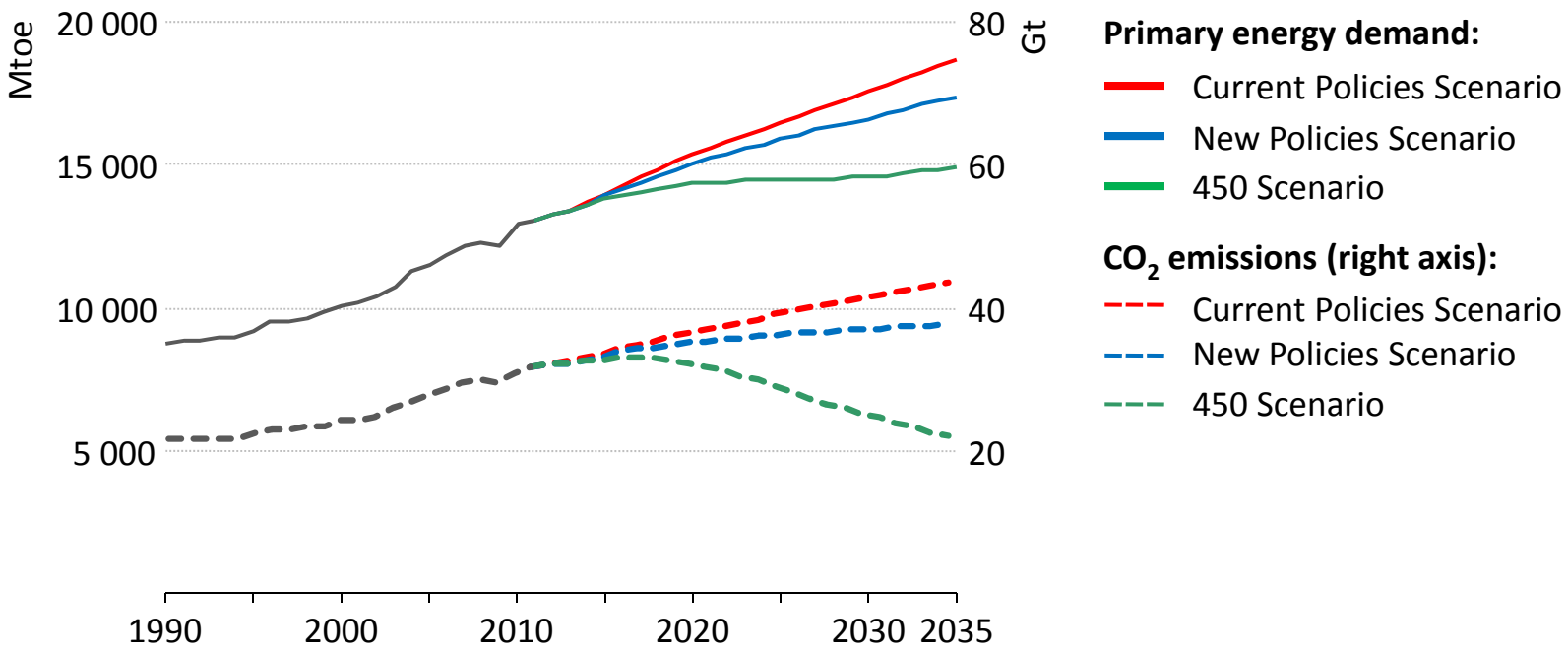

In the New Policies Scenario, global primary energy demand increases by one-third and CO_2 emissions by one-fifth between 2011 and 2035

World Energy Model (WEM)

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- ***Partial equilibrium model that allows scenario analysis***
  - *Detailed sectoral and regional energy demand balances*
  - *Regional supply of all fuels and trade matrixes*
  - *CO_2 emissions from fuel combustion*
  - *Investment needs in the supply and end-use technologies*
- ***Time horizon to 2035, with annual data***
  - *complete update every year (e.g. in WEO 2013 the last complete data set was 2011, but many data available for 2012 are integrated)*
- ***Regional resolution: 25 regional models***
  - *of which 12 country models, including US, China, India, Japan, Korea, Russia, Brazil…*
- ***Three main modules***
  - ***Final Energy Consumption*** *– Industry, Transport, Residential, Services, Agriculture, Non-Energy Use*
  - ***Energy Transformation*** *– Power Generation, Heat Production, Refinery/Petrochemicals, Other Transformation*
  - ***Supply and Trade*** *– Coal, Oil, Gas and Biomass*

http://www.worldenergyoutlook.org/weomodel/

World Energy Model (WEM) overview

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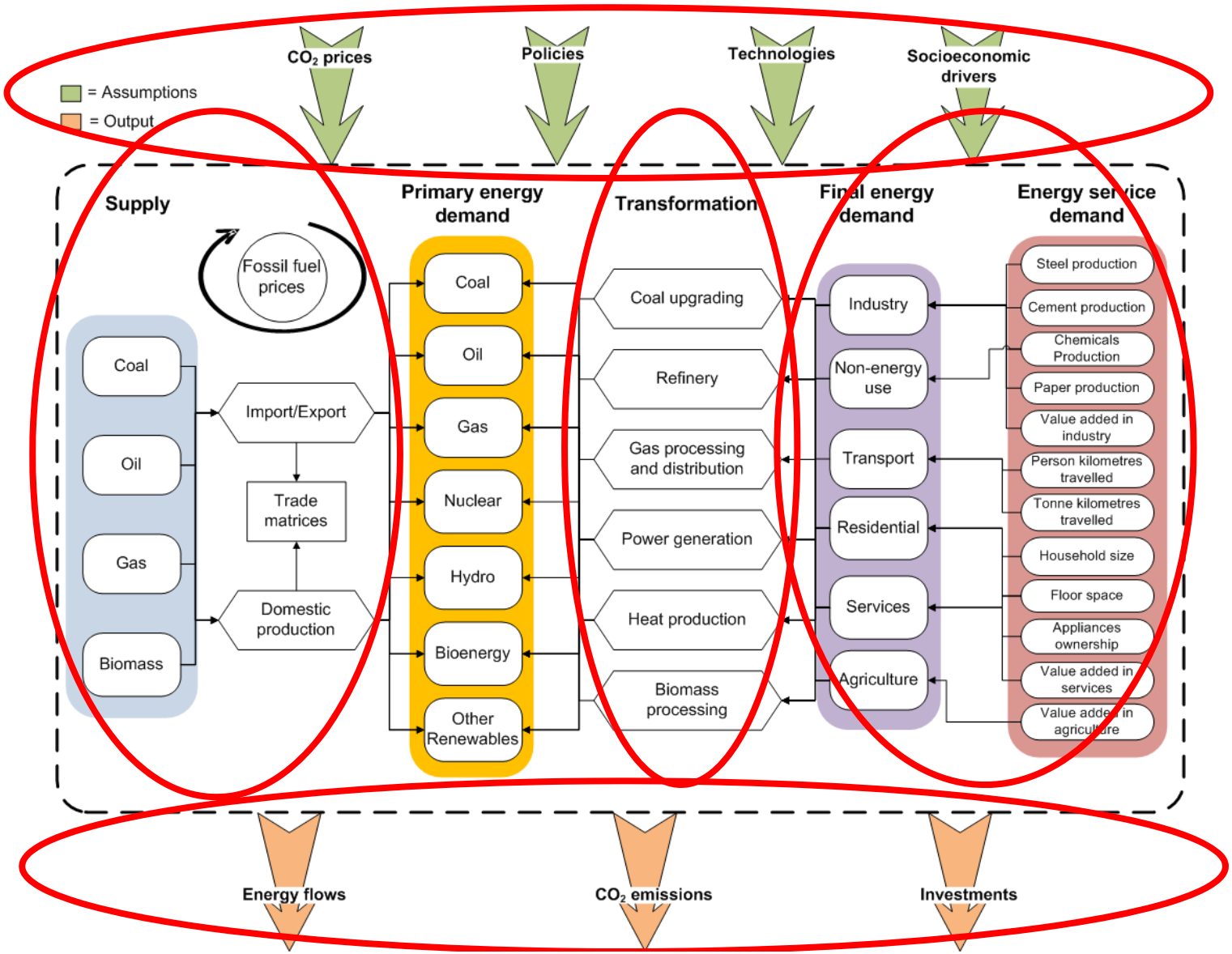

World Energy Model (WEM) overview

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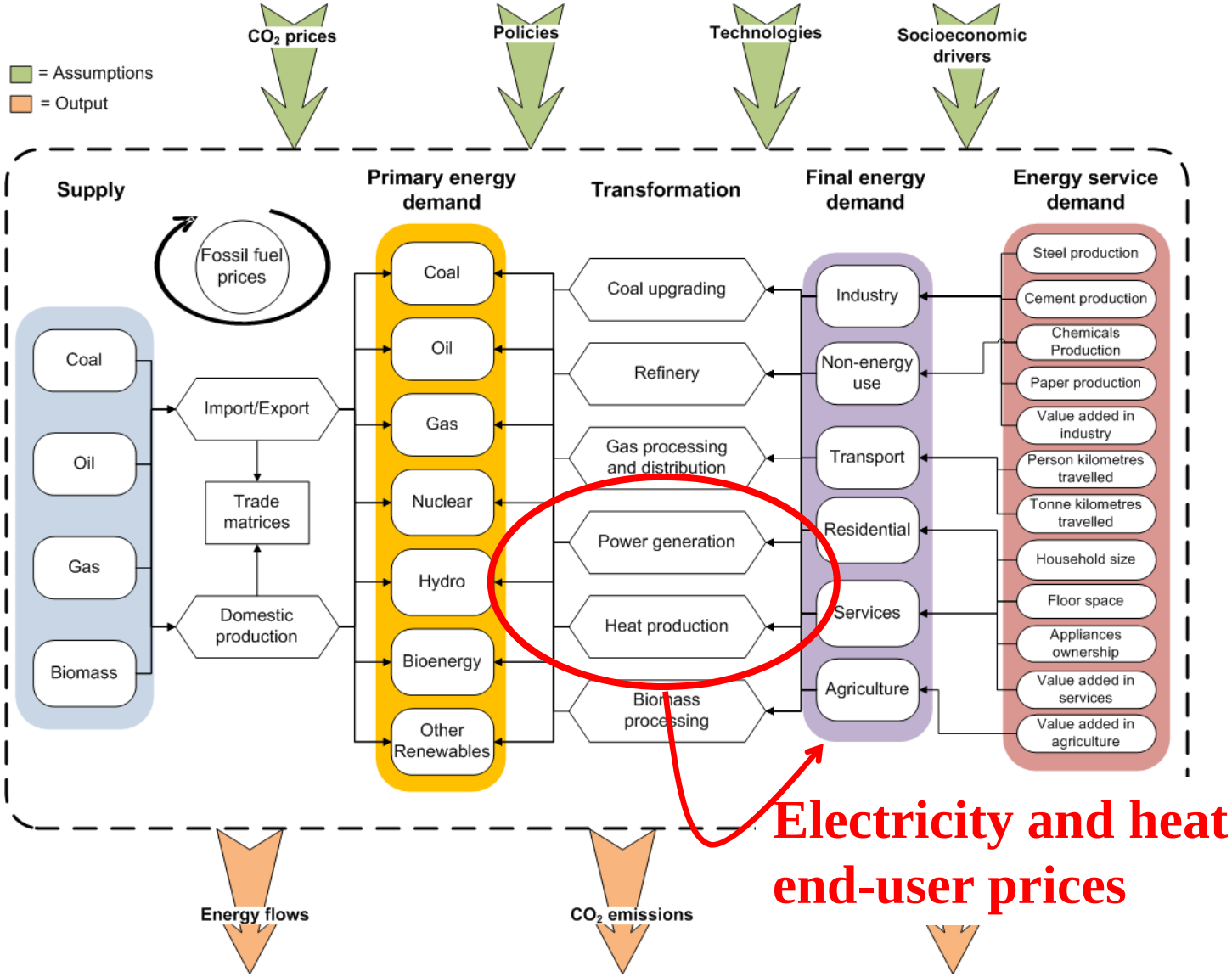

Power generation sub-modules

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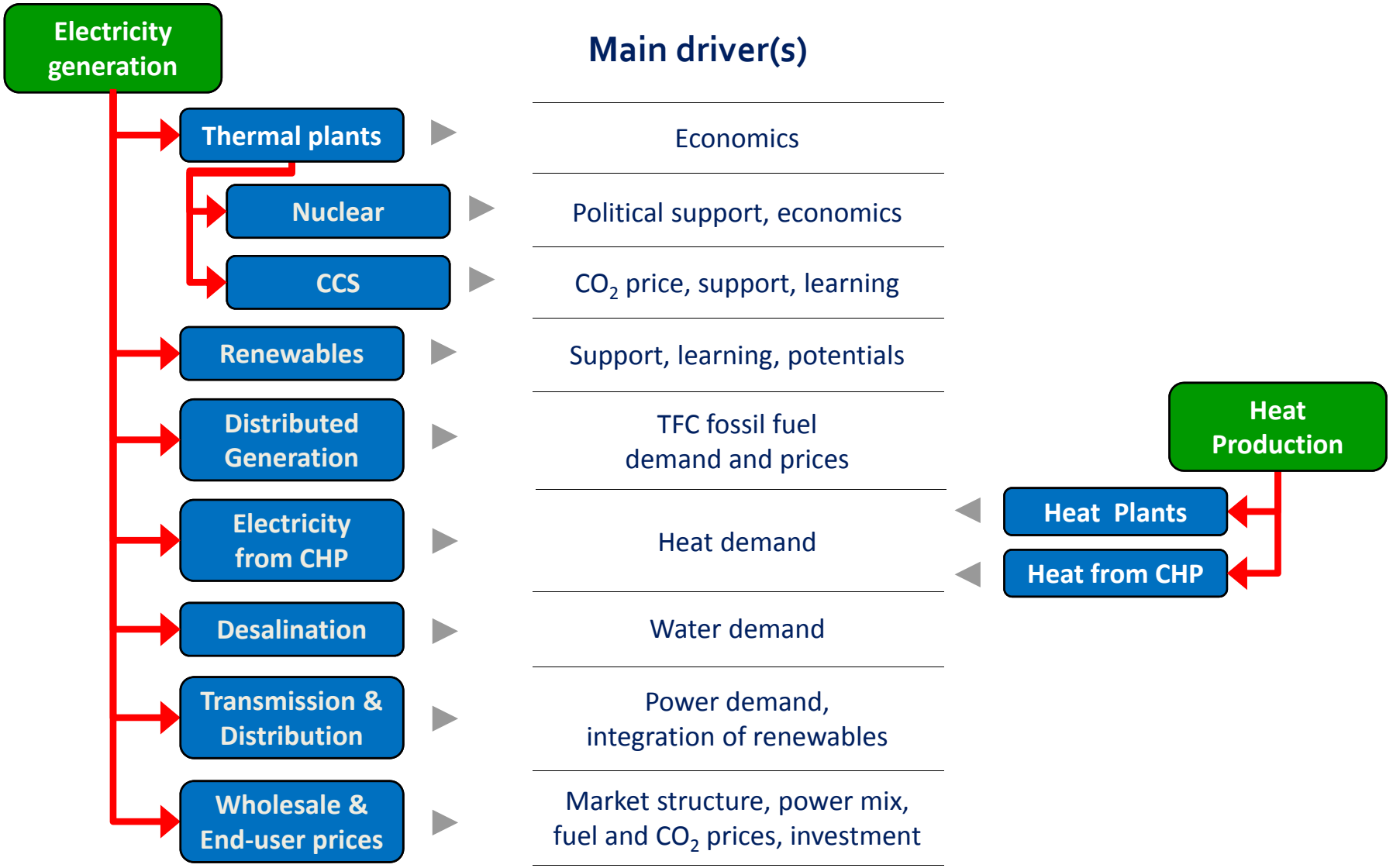

The module determines which plants are added and how they operate

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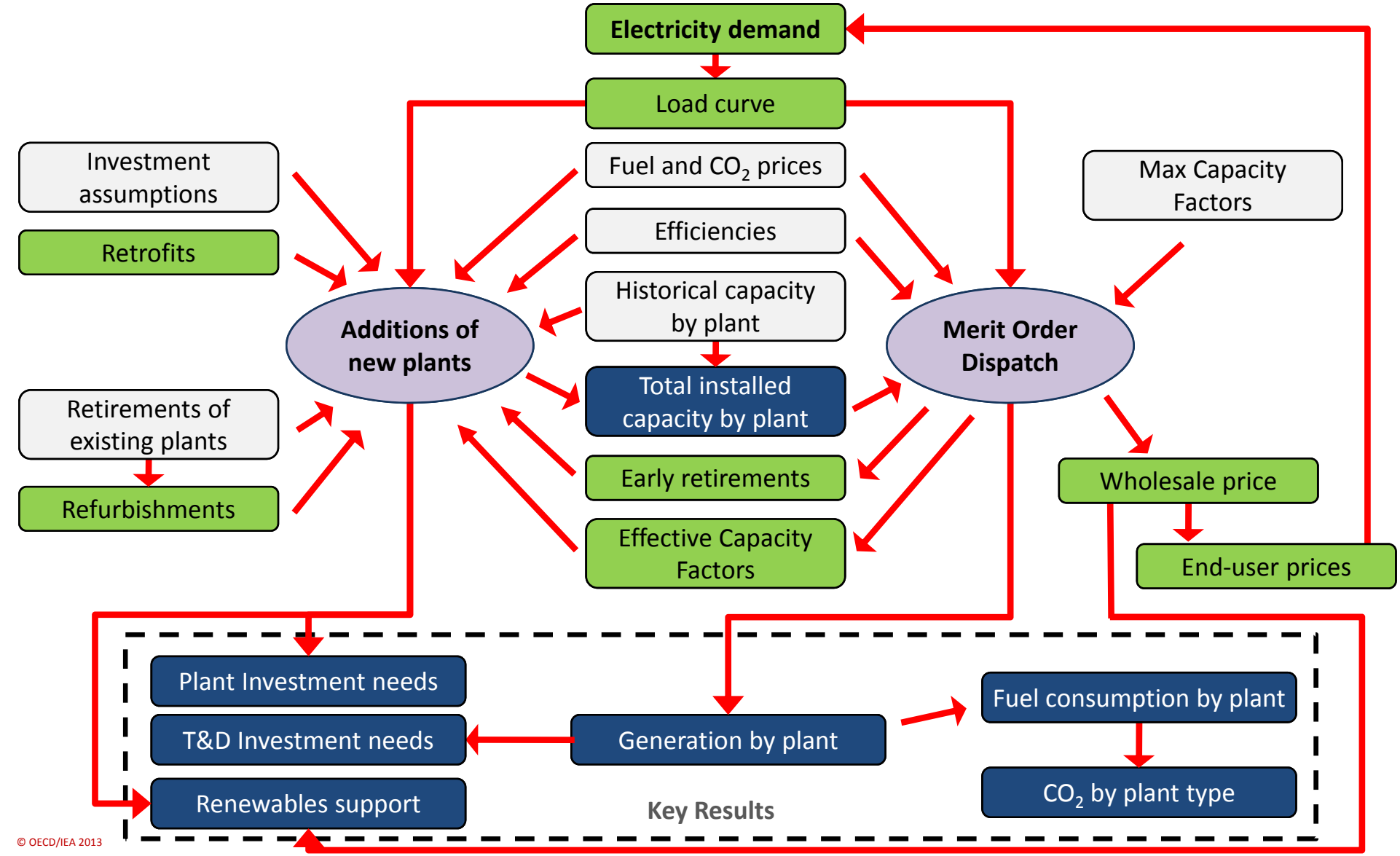

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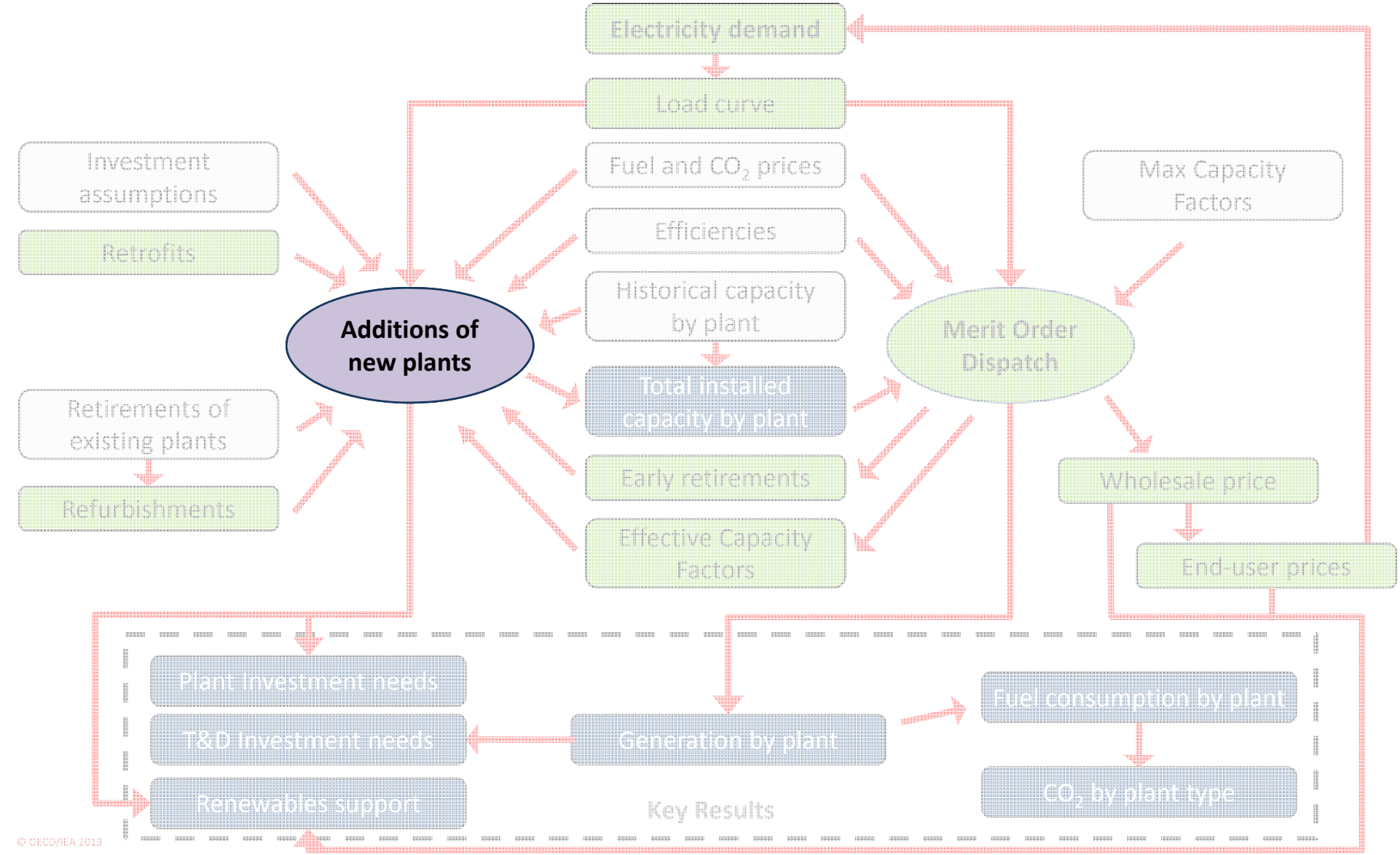

Capacity additions mechanism

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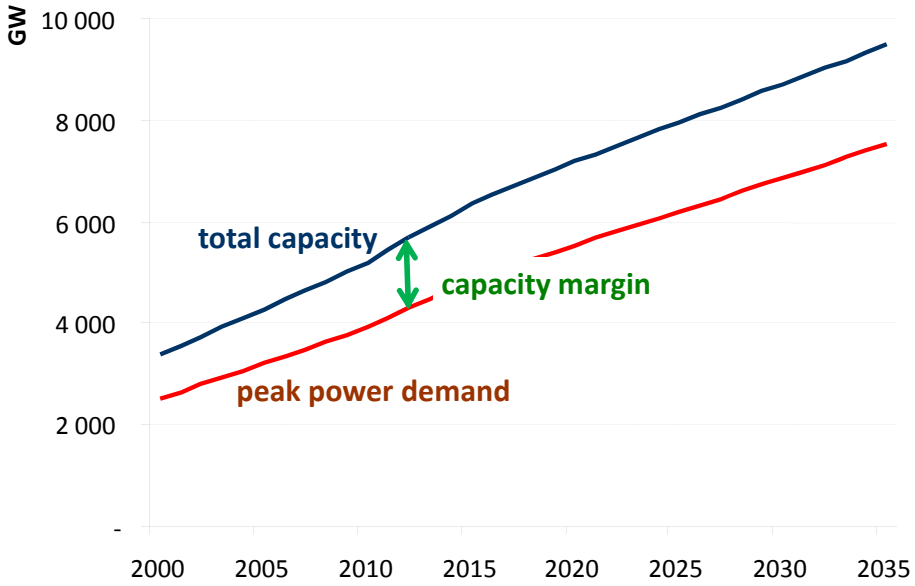
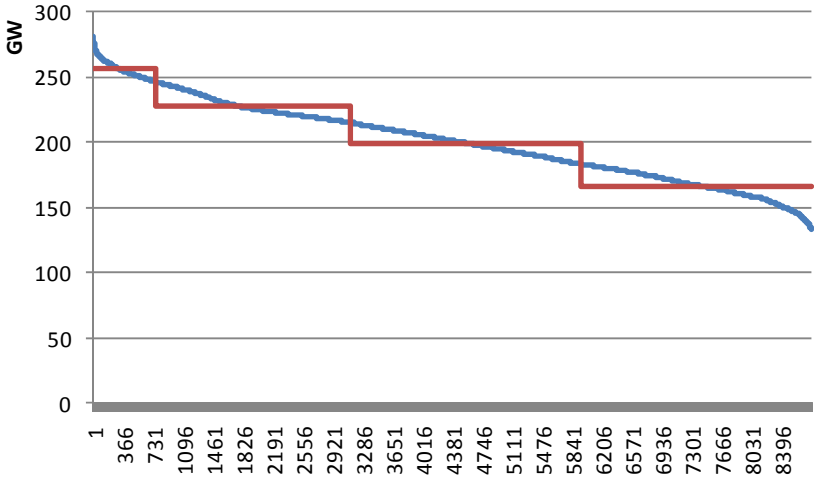


- Installed capacity is greater than peak demand to allow system to cope with maintenance and unexpected outages ⇒ Capacity Margin
- Plants are added each year based on demand growth, maintaining the capacity margin, replacement of retiring plants

- Annual data is not enough
  - *Need for greater granularity in the year*
  - *Split the load duration curve (hourly demand ordered from biggest to smallest) in 4 blocks*
    - *Peak load*
    - *Mid load 1 and 2*
    - *Base load*



Long Run Marginal Cost (LRMC)
(also referred to as 'Levelised Cost of Electricity')

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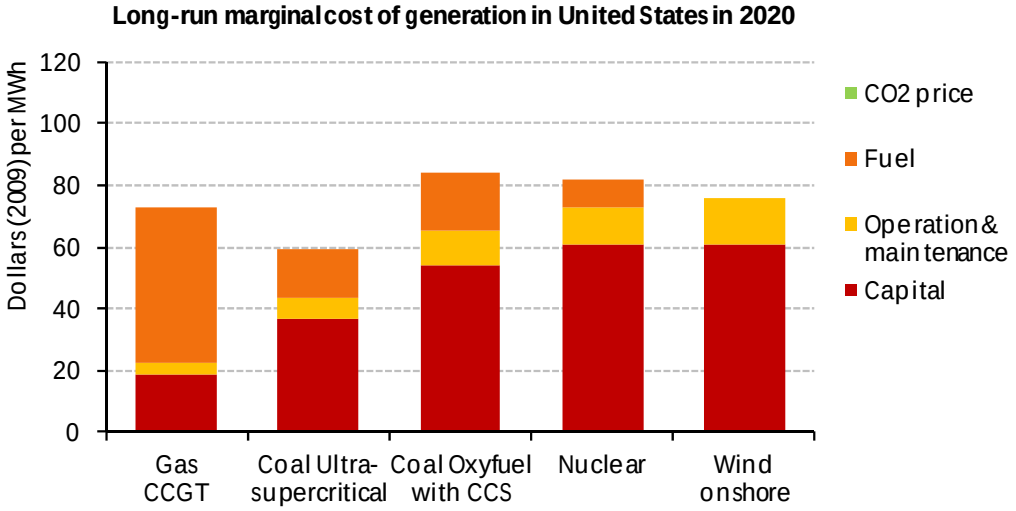

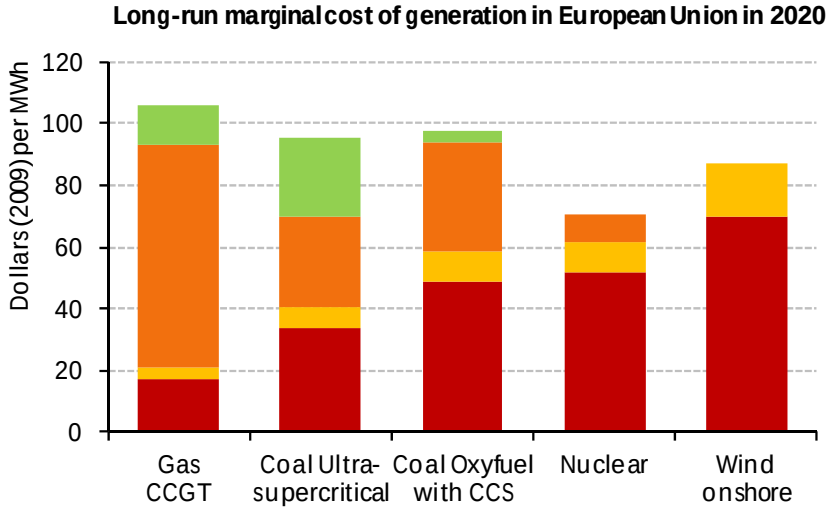

- Plants are added on a least-cost basis, with a portfolio approach
- Competition depends on several factors (fuel prices, CO_2 prices, efficiency, investment cost, construction time, WACC, economic lifetime) and is very much time-dependent

$$LRMC = \frac{fuel\ cost + CO_2\ price \times emission\ factor + VOM}{efficiency} + \frac{Inv.cost \times prepayment\ coefficient / \left(\sum_{t=1}^{n} \frac{1}{(1+i)^t}\right) + FOM}{capacity\ factor \times \frac{8760}{1000}}$$

How much each plant generates in a year is determined by the merit order

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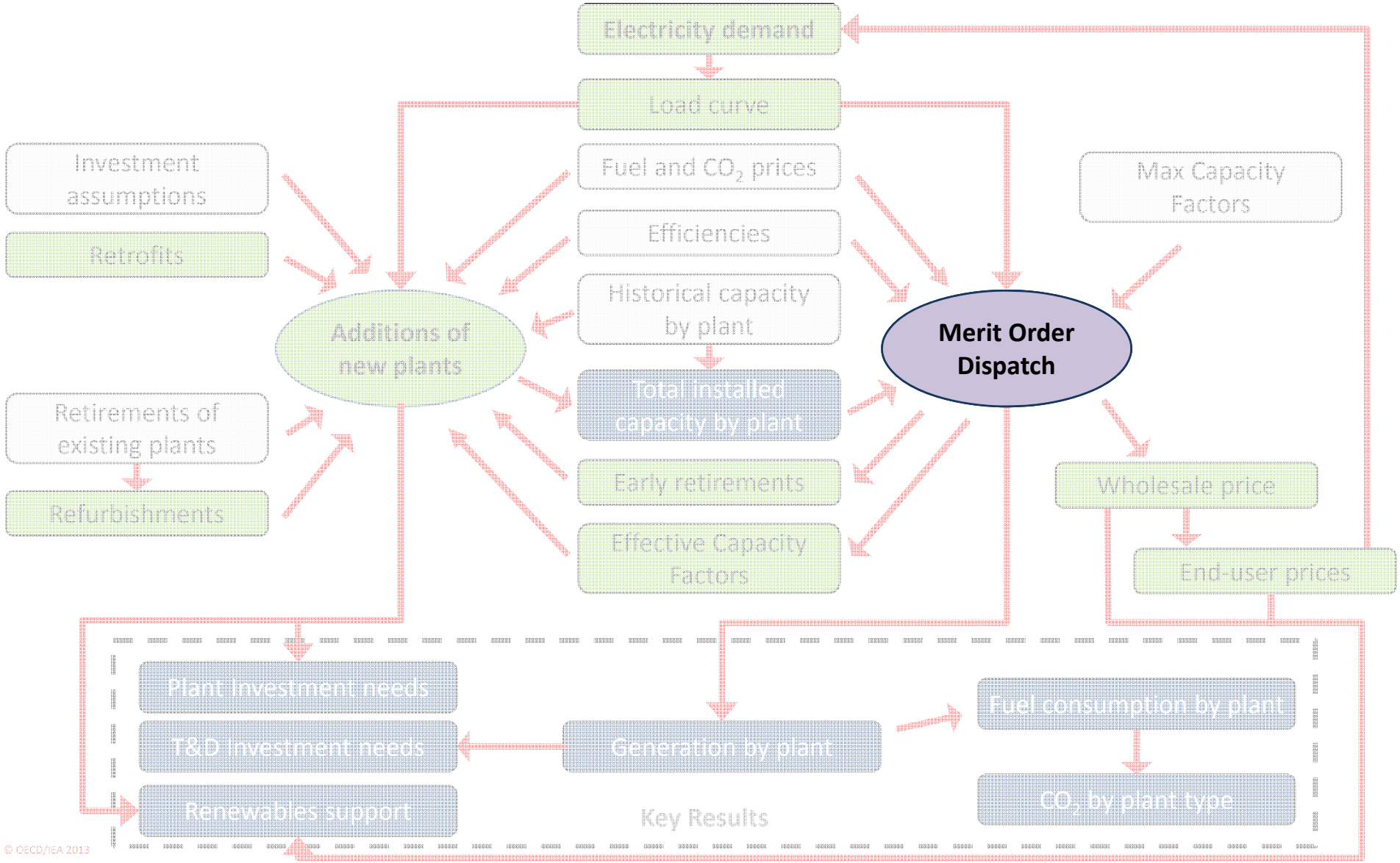

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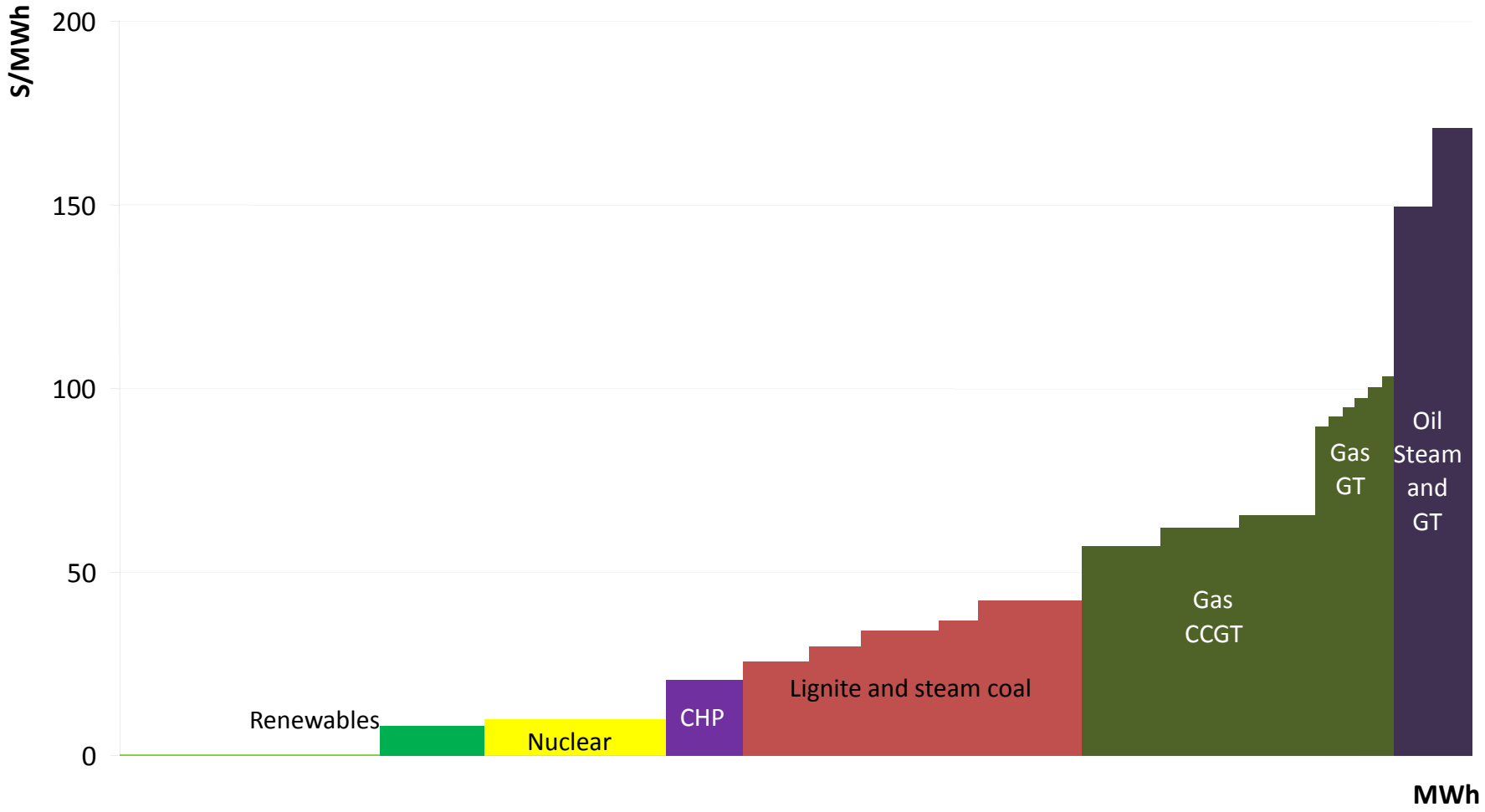

Fuel cost, efficiency, and CO_2 prices determine a plant's position in the merit order

Electricity generation in non-OECD countries has only begun to rise

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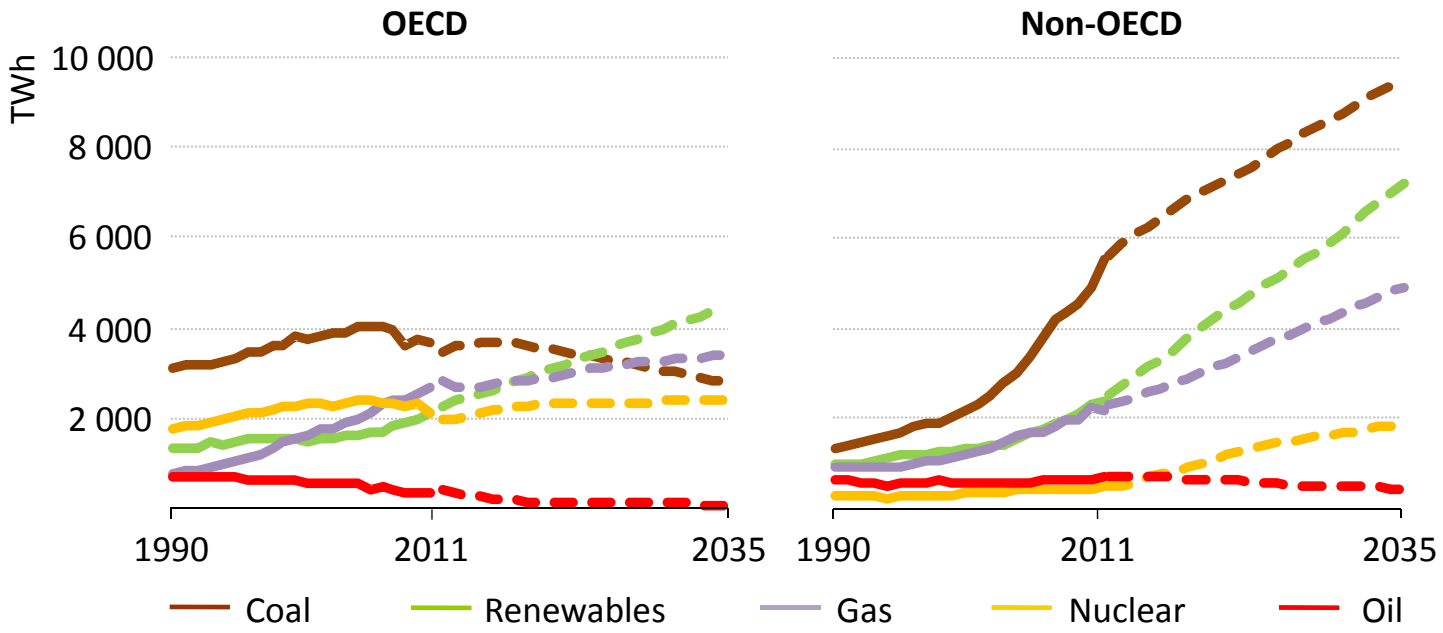
Electricity generation by source in the New Policies Scenario



Non-OECD countries make up an ever-increasing share of global generation, with coal steadily rising and more than outweighing the decrease in the OECD

Capacity to change?

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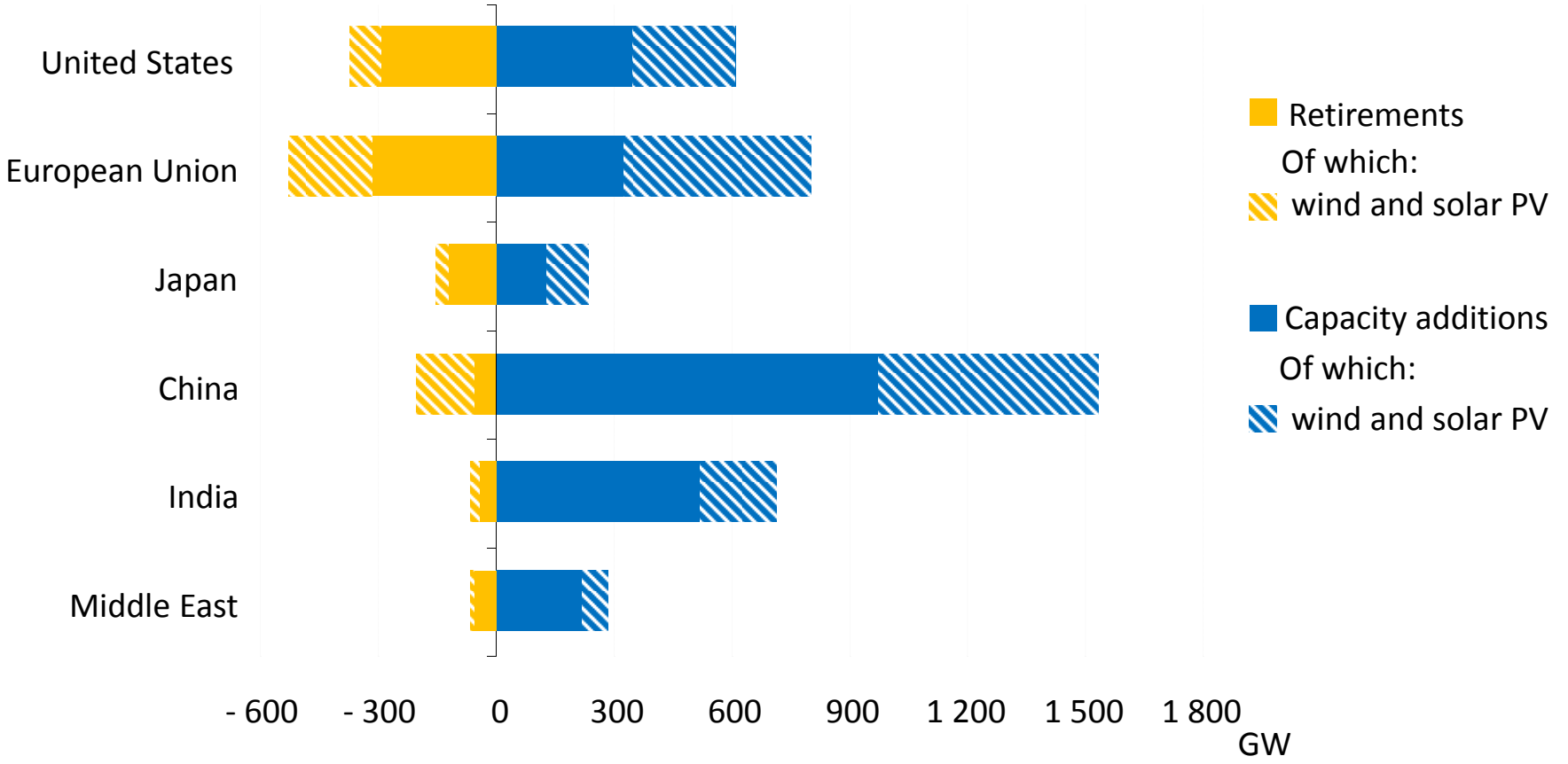
Capacity additions and retirements by selected region, 2013-2035



China & India together build almost 40% of the world's new capacity; one-third of global additions come from wind&solar, with profound implications in some markets

Renewables power up around the world

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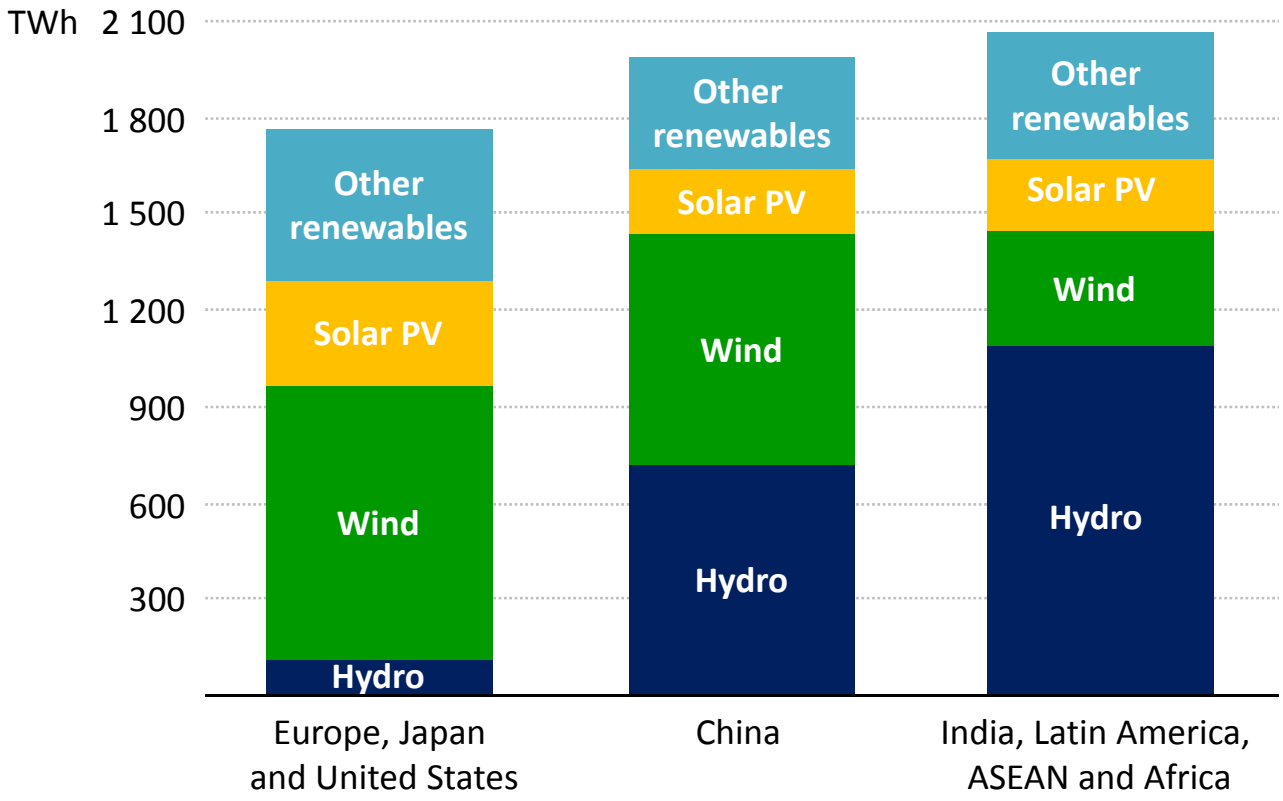
Growth in electricity generation from renewable sources, 2011-2035



The expansion of non-hydro renewables depends on subsidies that more than double to 2035; additions of wind & solar have implications for power market design & costs

Components of the end-user price of electricity

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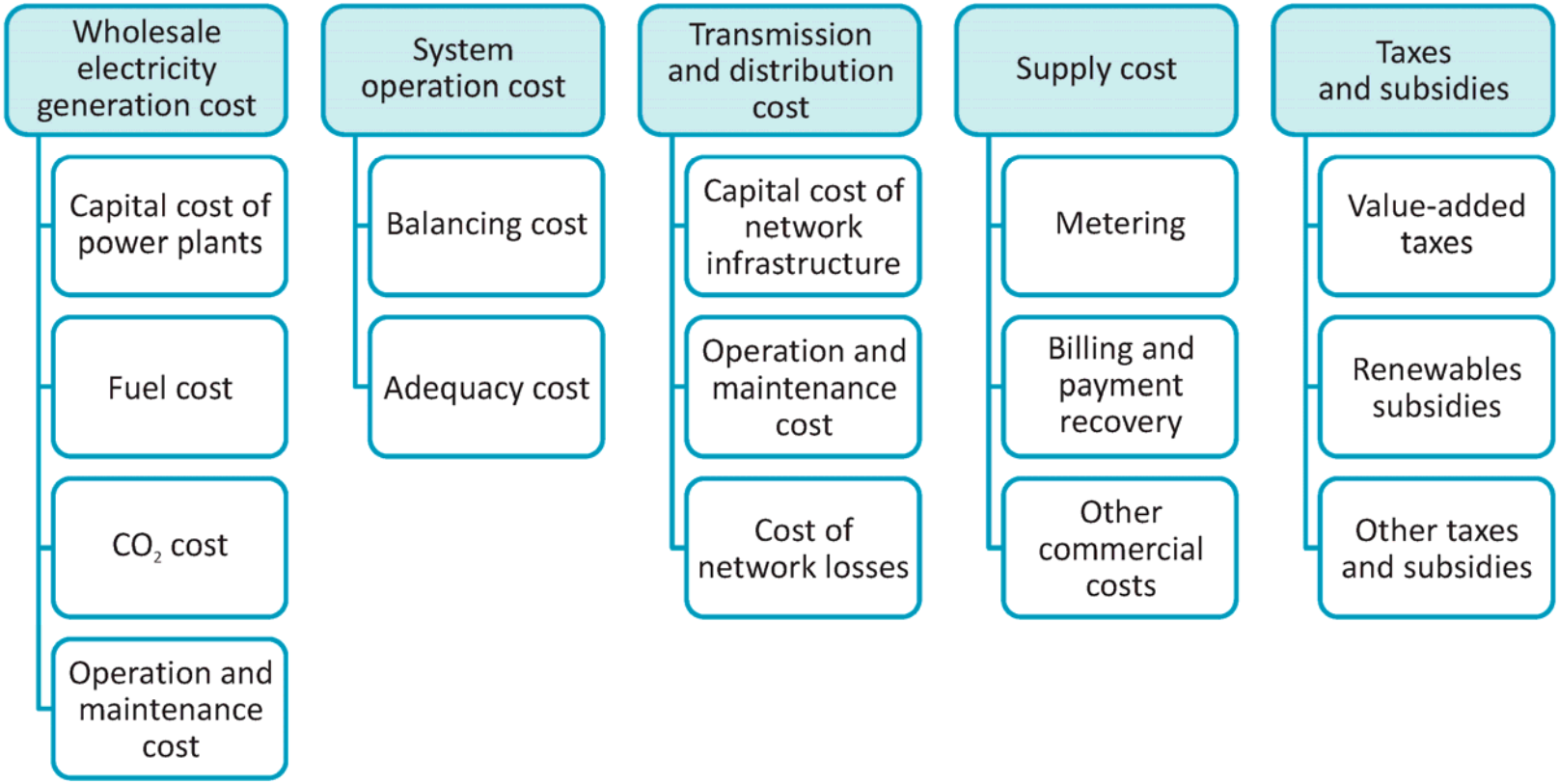

Who has the energy to compete?

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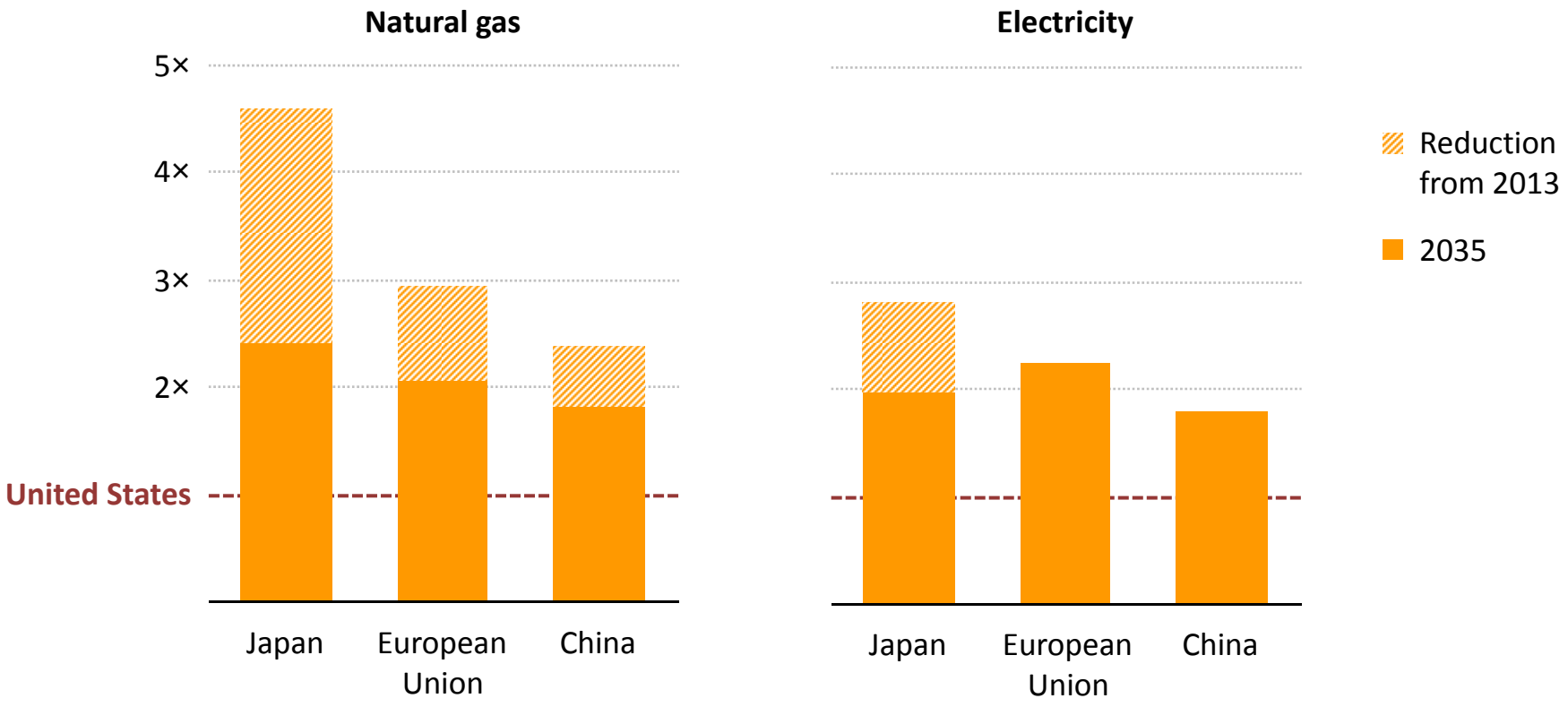
Ratio of industrial energy prices relative to the United States



Regional differences in natural gas prices narrow from today's very high levels but remain large through to 2035; electricity price differentials also persist

Electricity prices are set to increase in most regions

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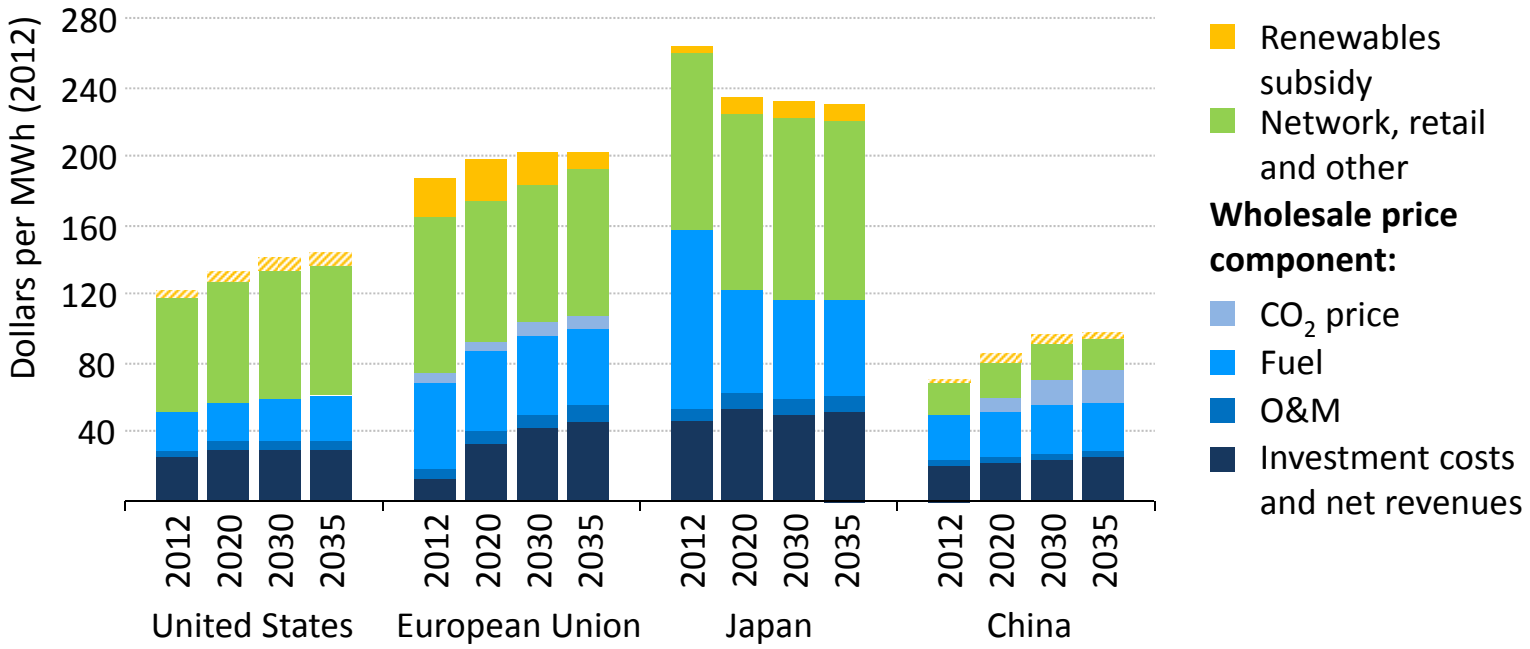
Average residential electricity prices (excluding taxes) by region and cost component in the New Policies Scenario



Electricity bills increase along with rising electricity prices and demand per capita in most regions, though economic growth outpaces these trends

Policy implications

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- *Impact of policies under consideration on global energy trends*
- *Role of emerging economies on global energy demand and supply*
- *Implications of technological developments of carbon-free technologies*
- *Exploitation of the economic energy efficiency potential, its costs and benefits*
- *Environmental impact of energy use and the effect of policies to limit it*
- *Competitiveness within the energy sector and among countries*