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Towards Sustainable Energy Systems

Dr. Andreas Poullikkas
Chairman, Cyprus Energy Regulatory Authority
Chairman, Cyprus Energy Strategy Council
apoullikkas@cera.org.cy

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- **Long term energy strategy (2050)**
- **Energy cost**
- **Energy Union (2030)**

Long term energy strategy

Future energy systems

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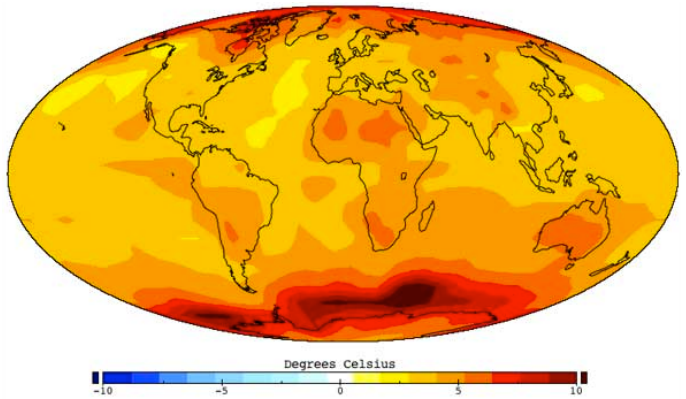
- **Climate change**



- **Third industrial revolution**

- **Future energy economics**

Global energy related CO_2 emissions

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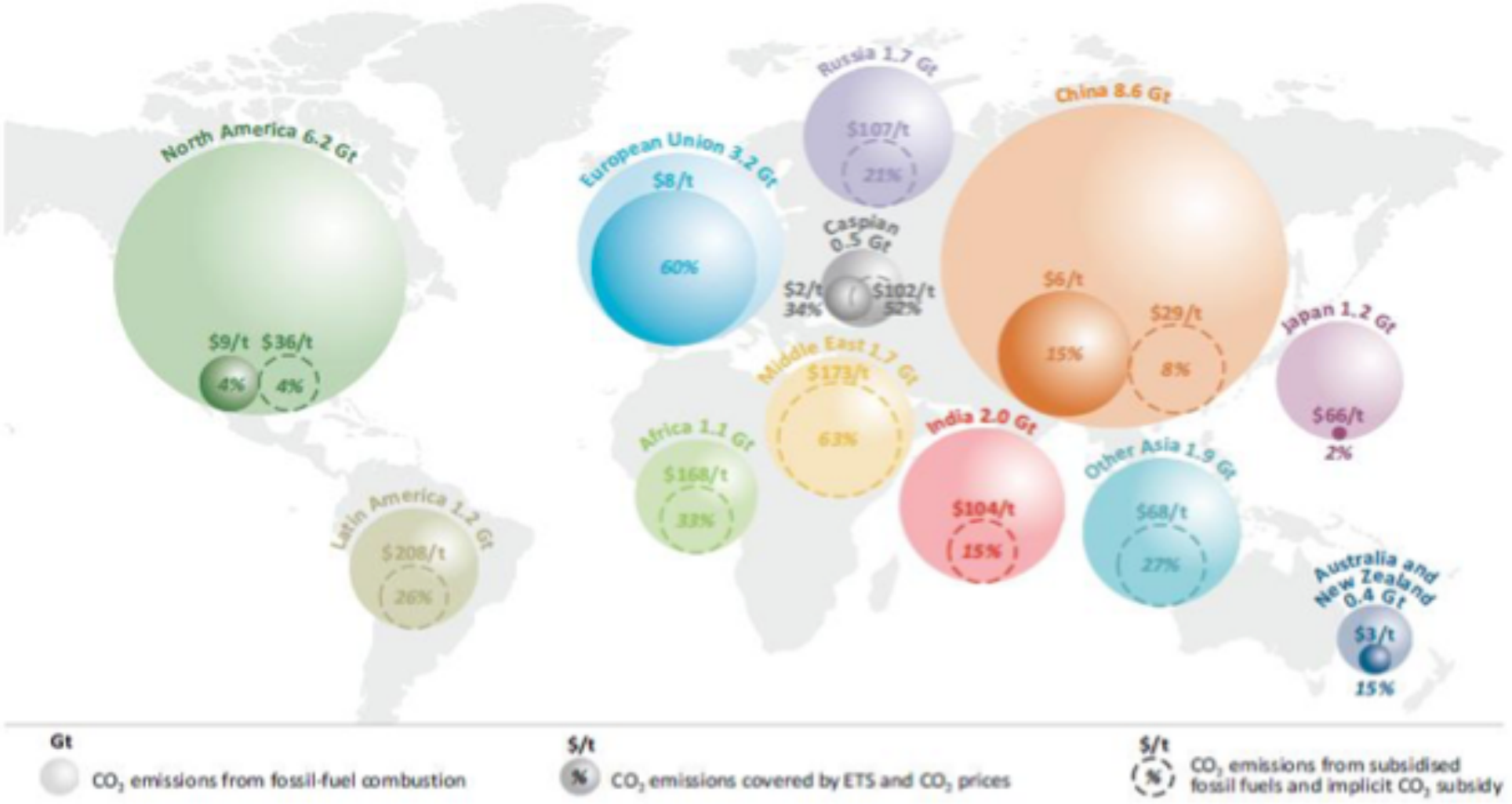
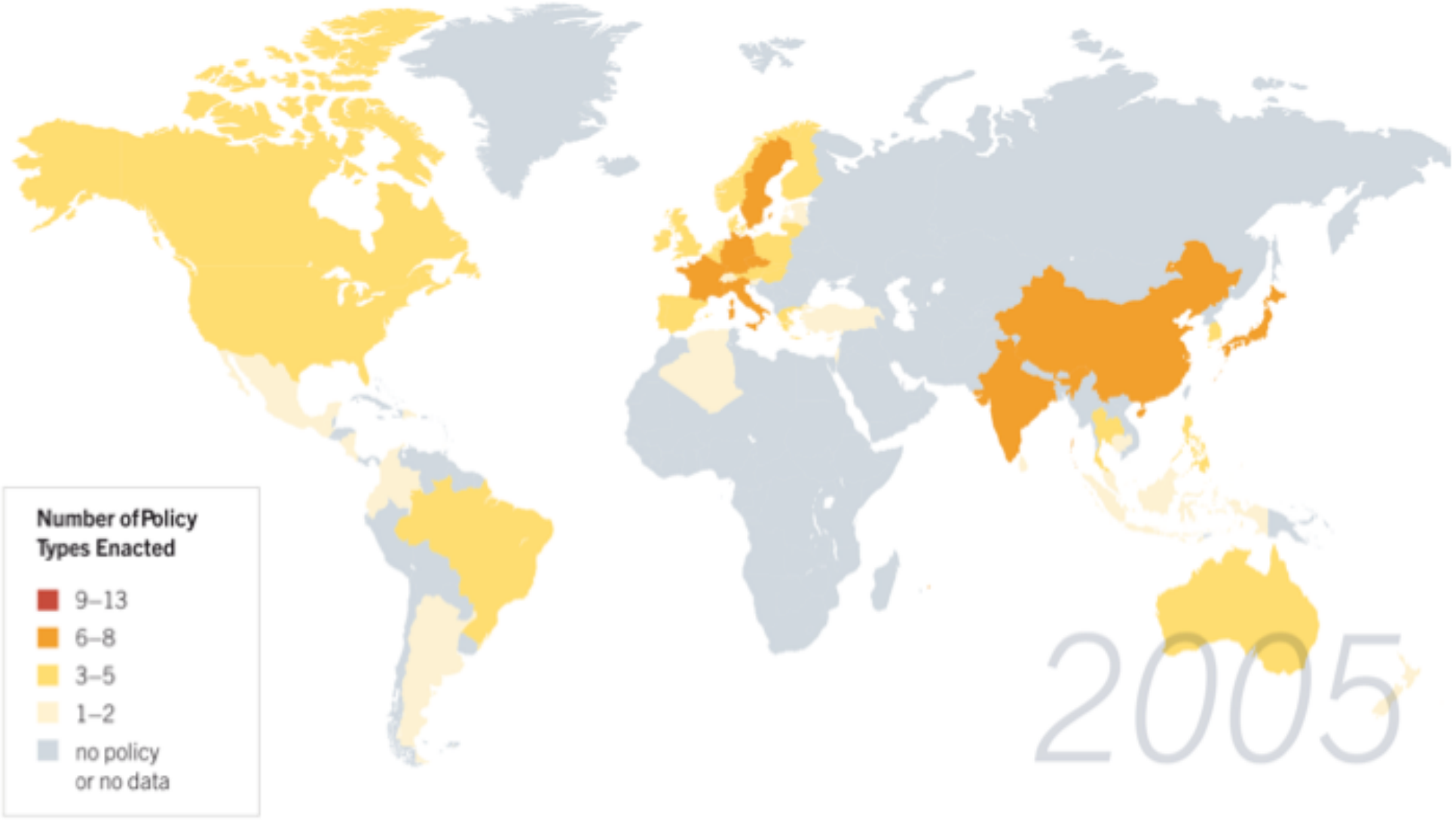


Notes: The implicit CO_2 subsidy is calculated as the ratio of the economic value of those subsidies to the CO_2 emissions released from subsidised energy consumption. ETS = emissions trading scheme.

Source: IEA World Energy Outlook special report on climate, 2014

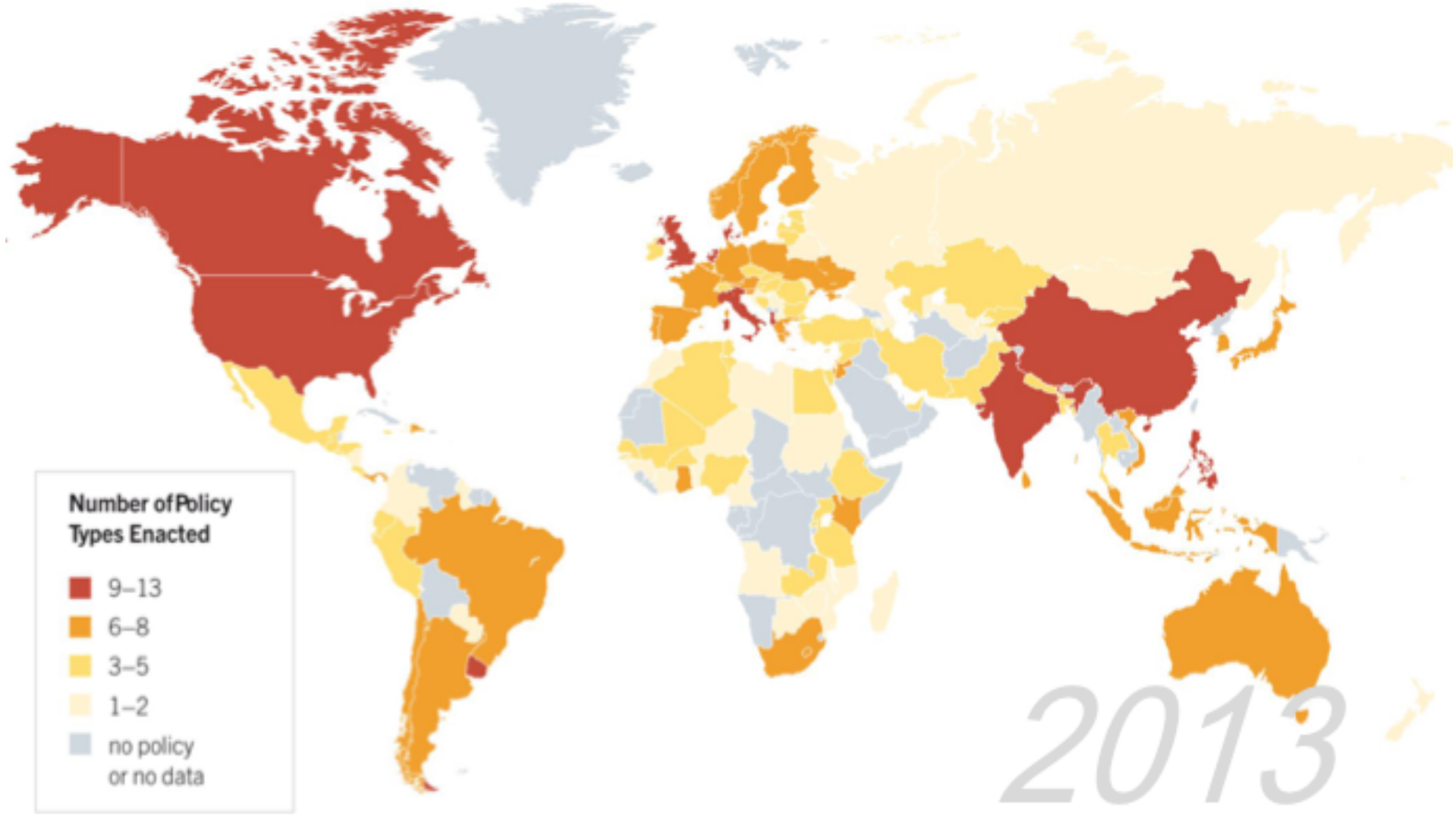
Countries with Renewables policies in 2005



Source: REN21

Energy Developments and Lessons for Cyprus
University of Nicosia, Nicosia,, 5 December 2016

Countries with Renewables policies in 2013



Source: REN21

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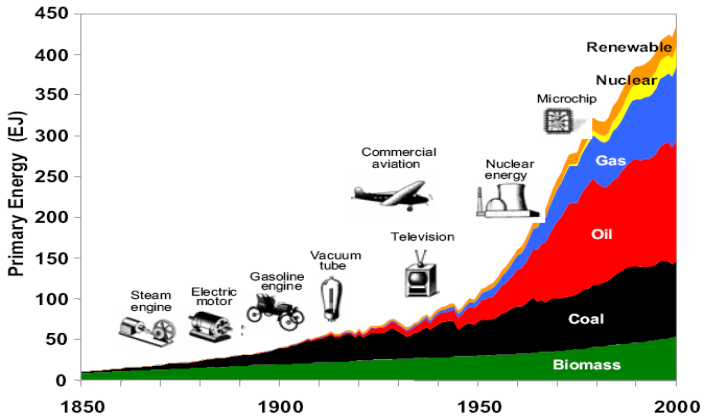
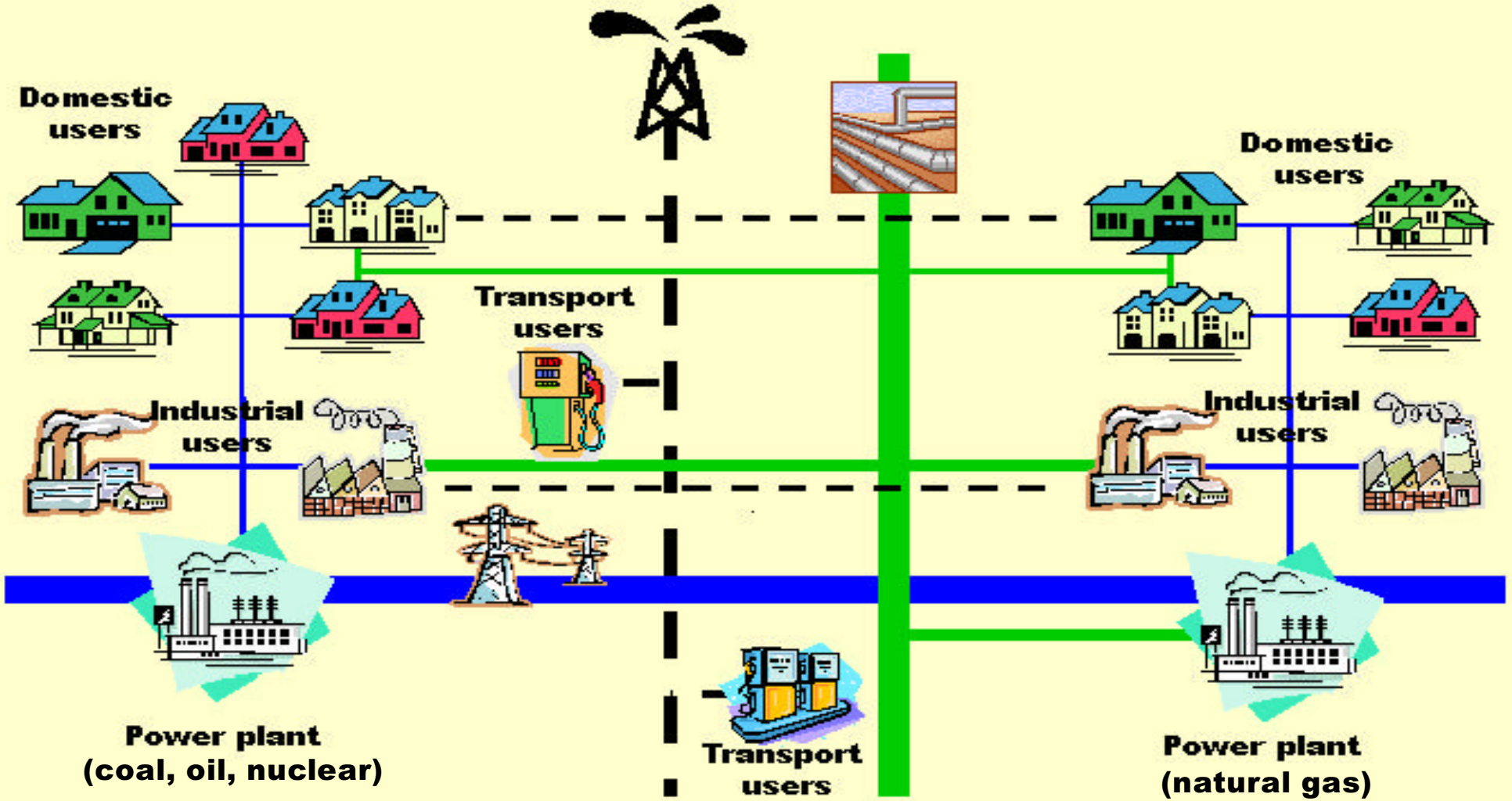
EU energy objectives

- greenhouse gas reduction
- sustainable production and consumption
- competition in electricity and natural gas markets
- security of supply



Future energy systems

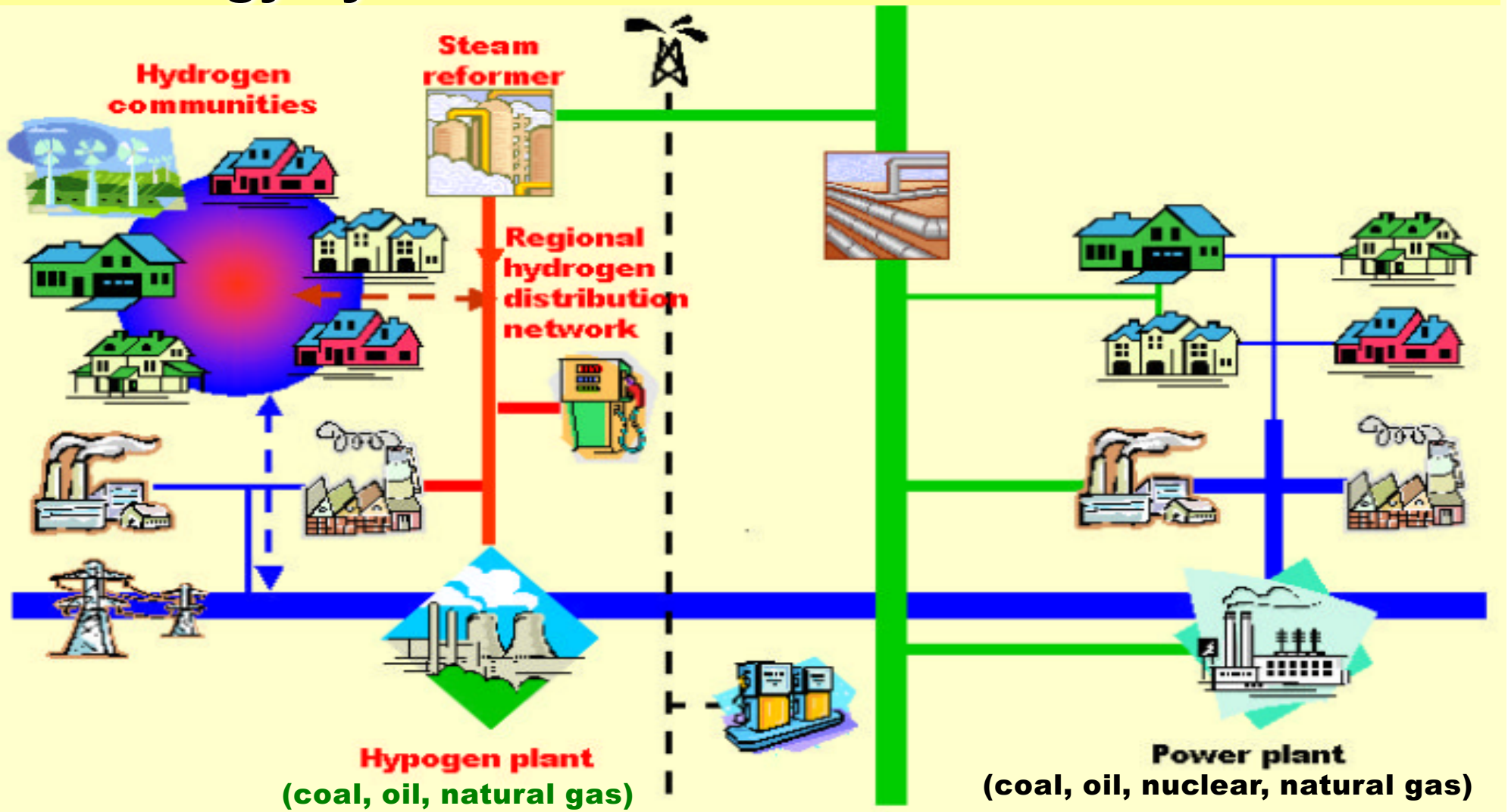
EU energy system today*



* Poullikkas A., 2009, *Introduction to Power Generation Technologies*, ISBN: 978-1-60876-472-3

Future energy systems

EU energy system in 2020-30*



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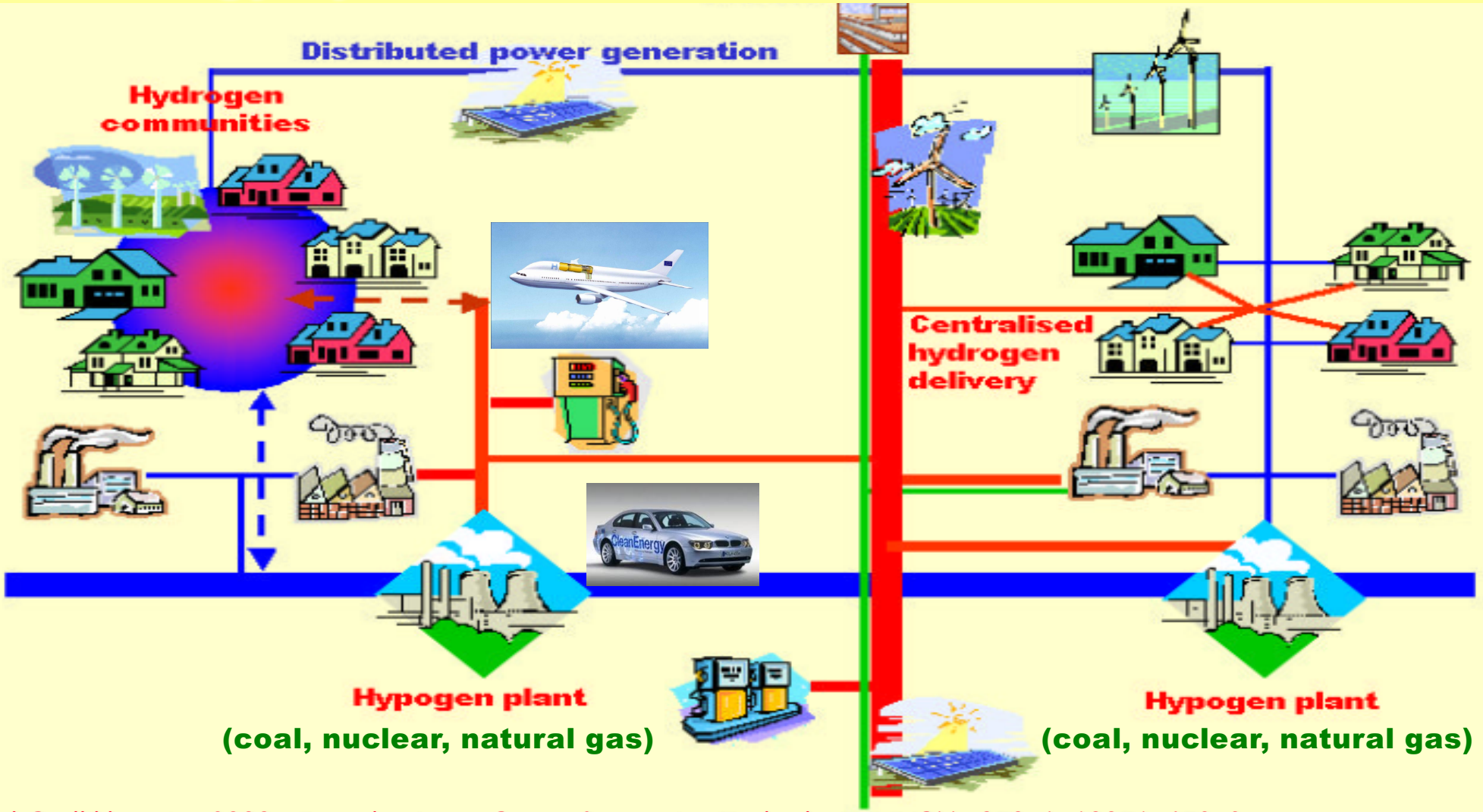
Future energy systems

EU energy system in 2040-50*



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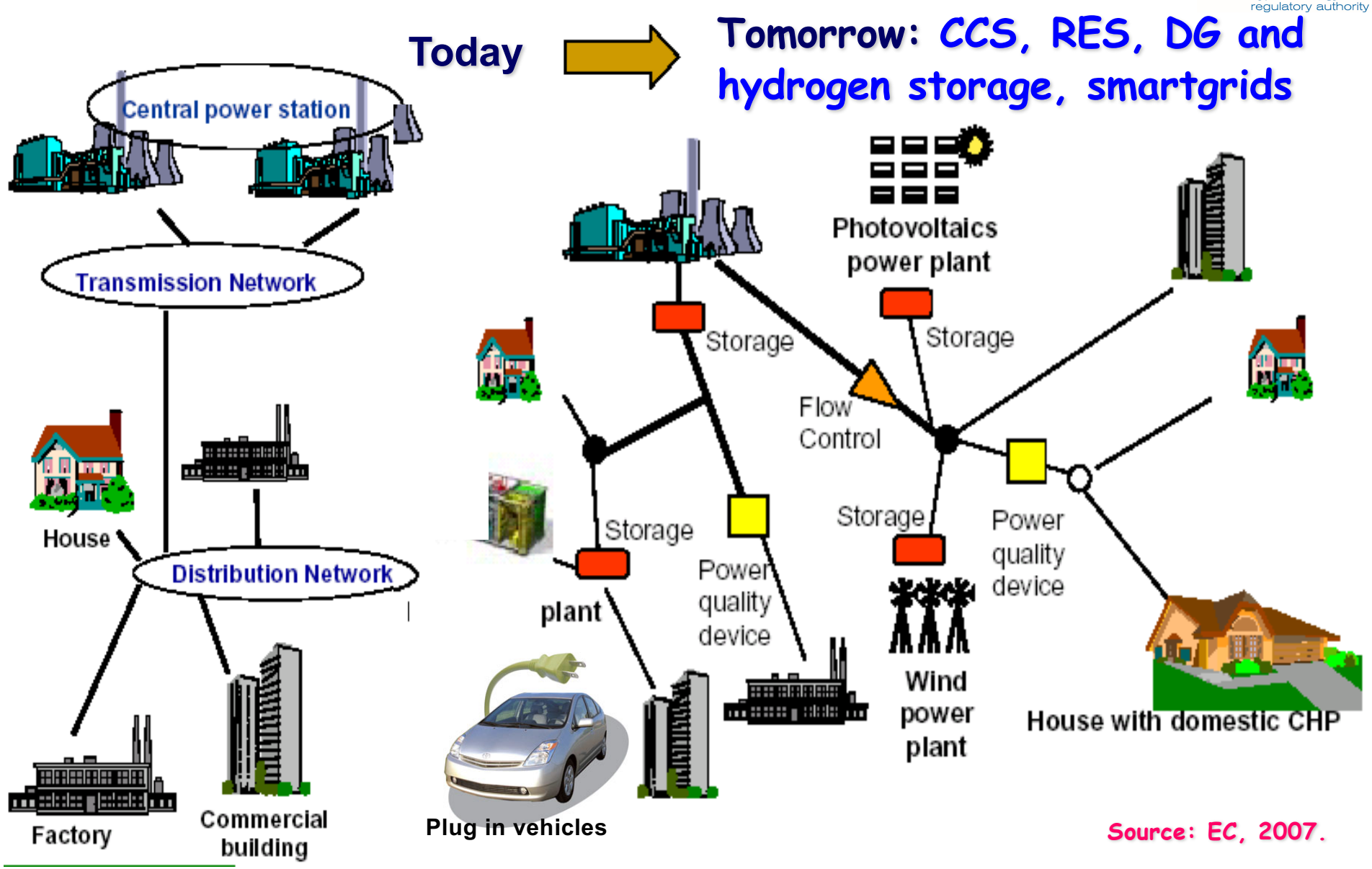
Future power systems



The Super Smart Grid after 2050
(may allow for 100% RES)

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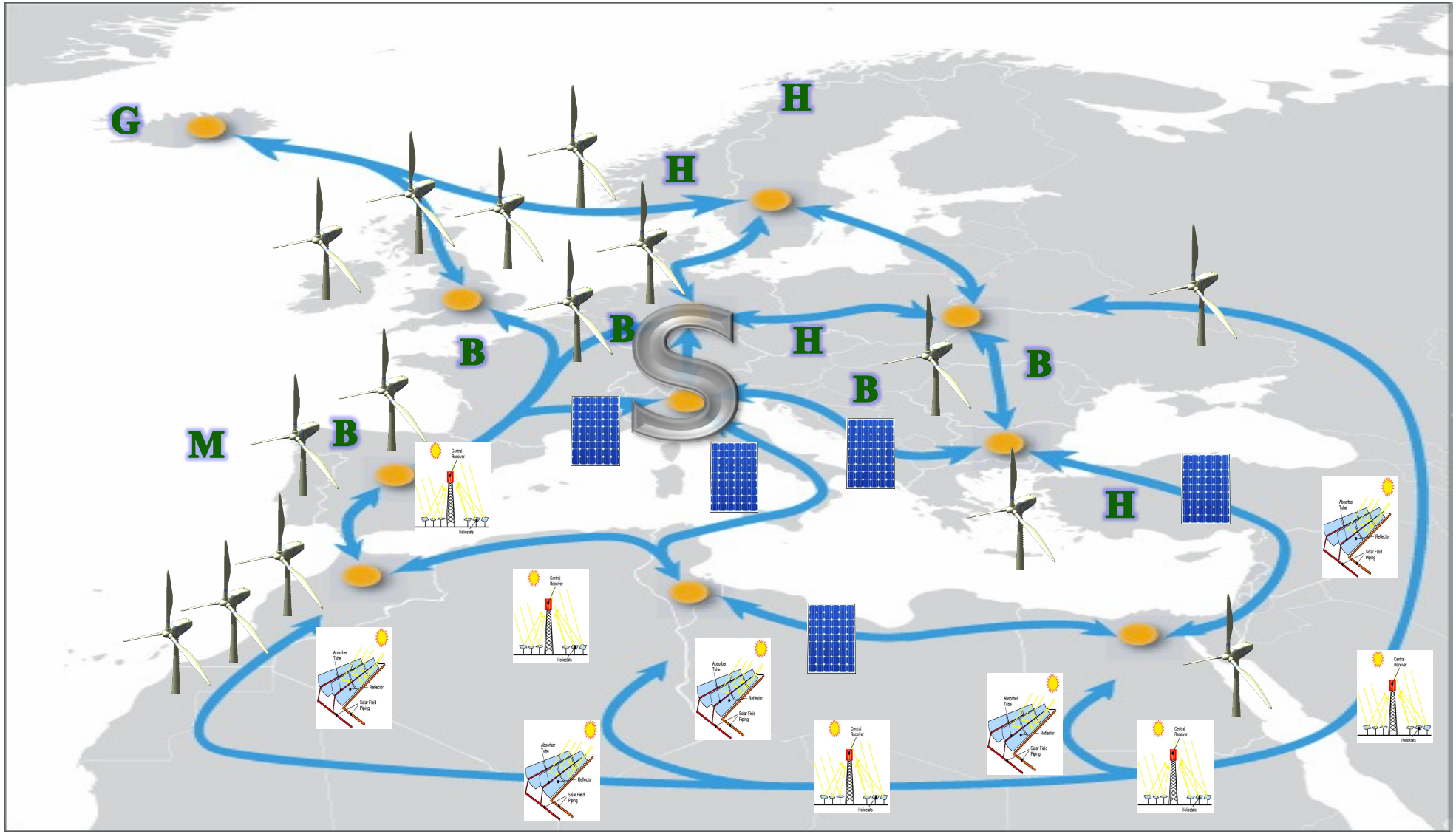

Main ingredients of future sustainable electric systems

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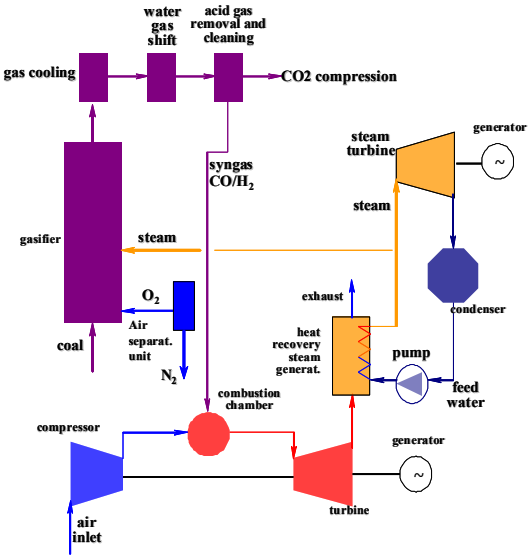
- Large scale integration of renewable energy sources
- Distributed generation
- Carbon capture and storage
- Smartgrids
- Electric vehicles
- Storage devices
- Hydrogen



Development of new sustainable technologies and infrastructure

Towards hydrogen economy in 2050

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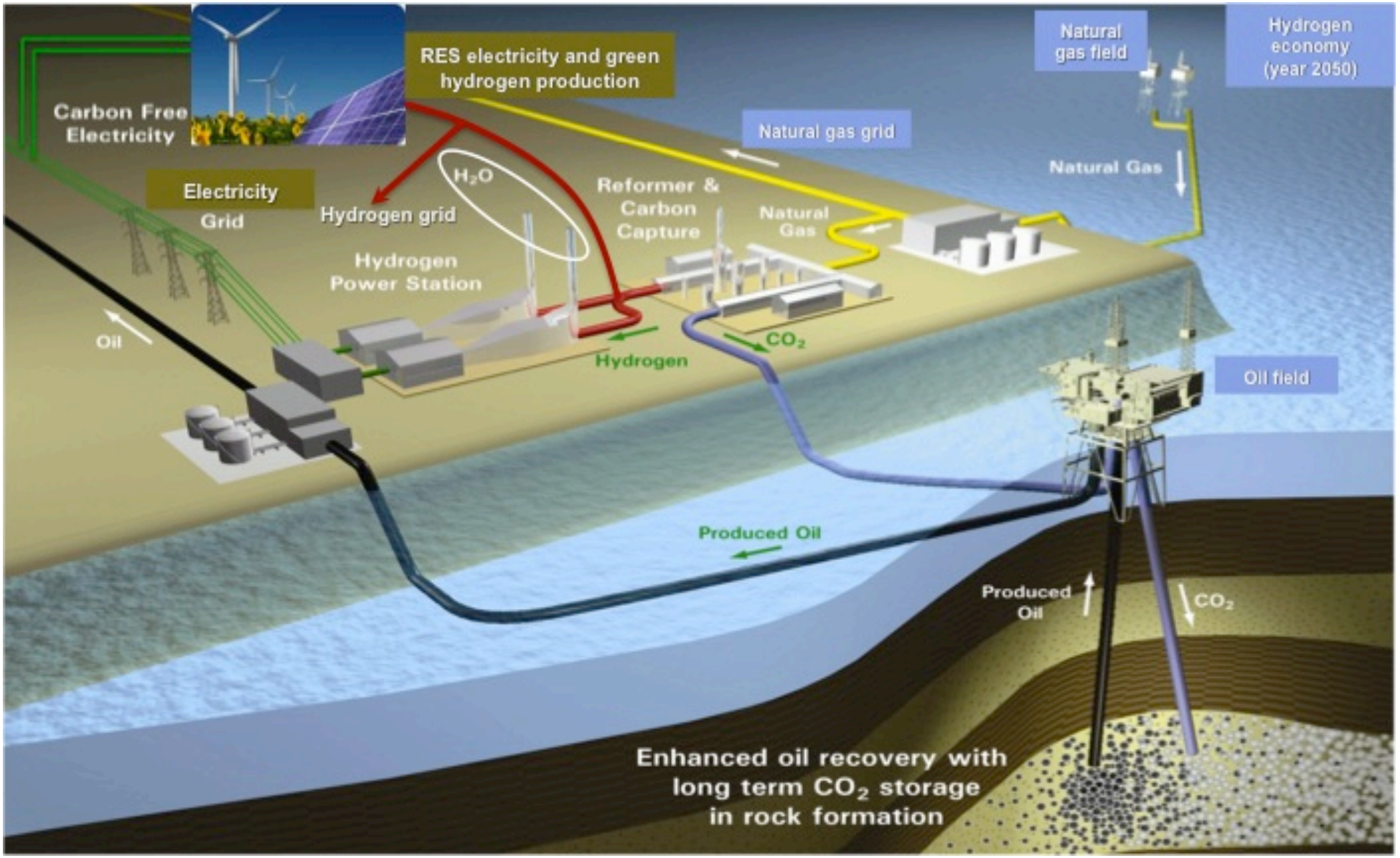
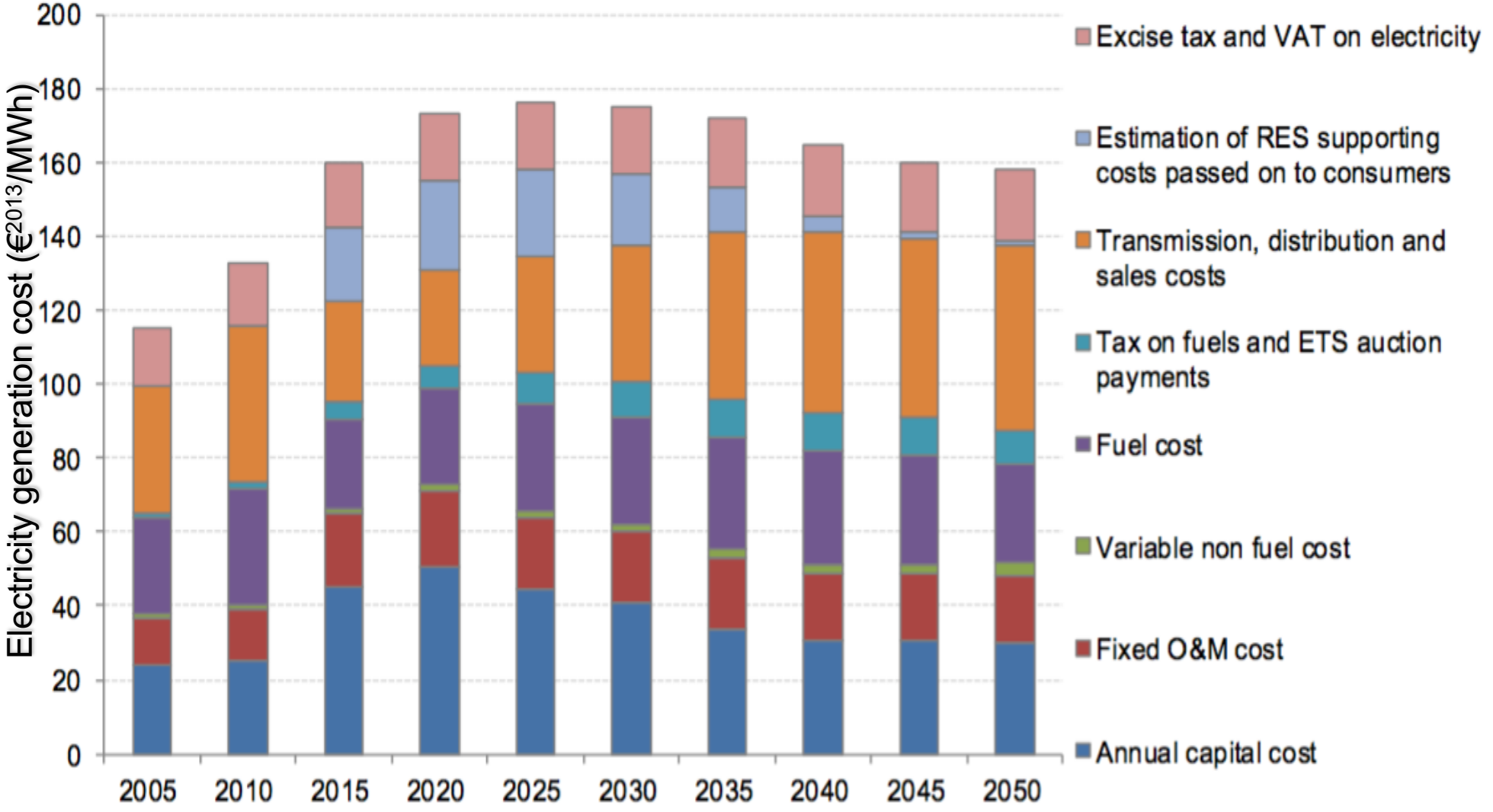


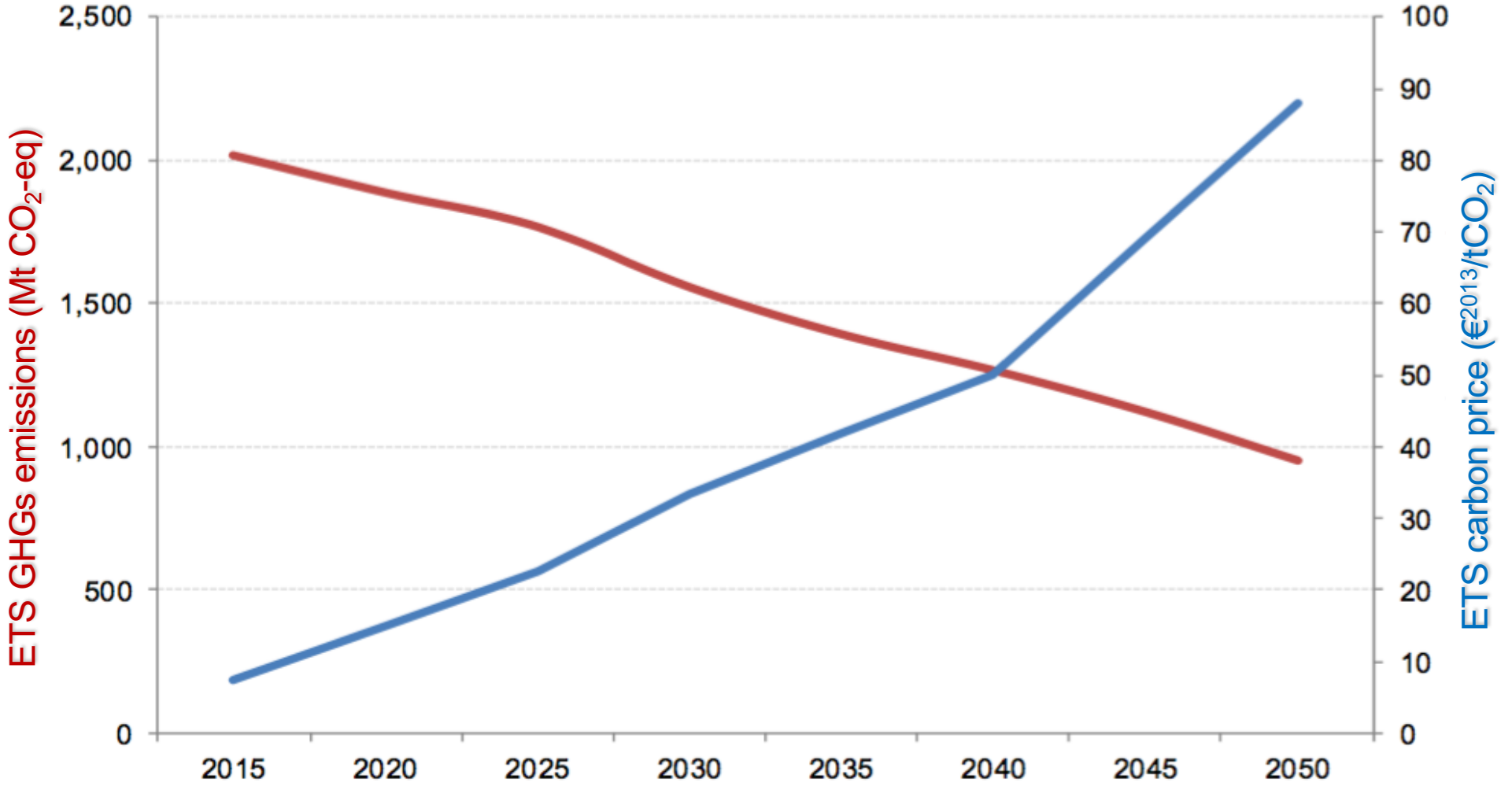
Energy cost

EU reference scenario 2016



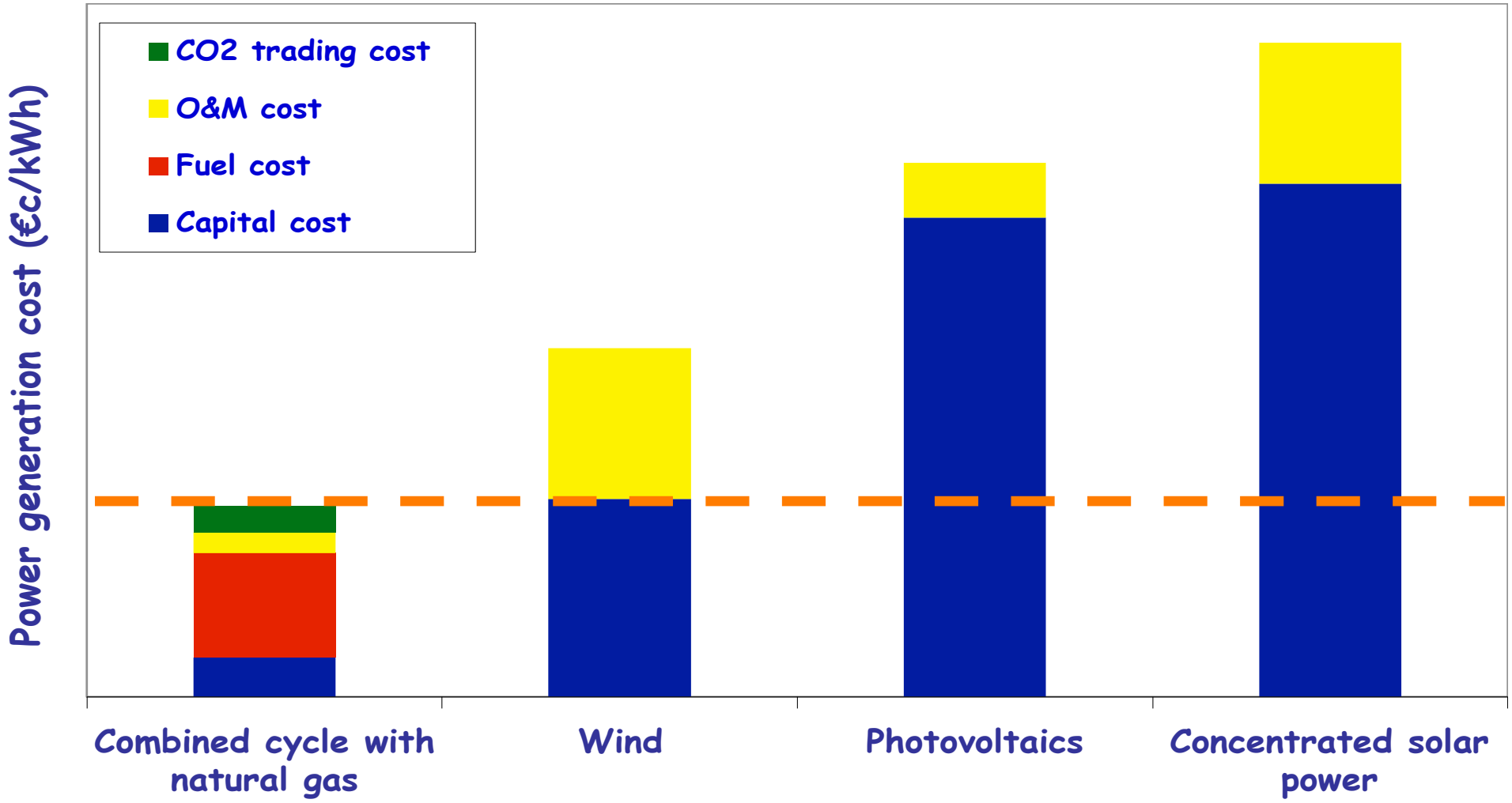
Source: PRIMES

EU reference scenario 2016



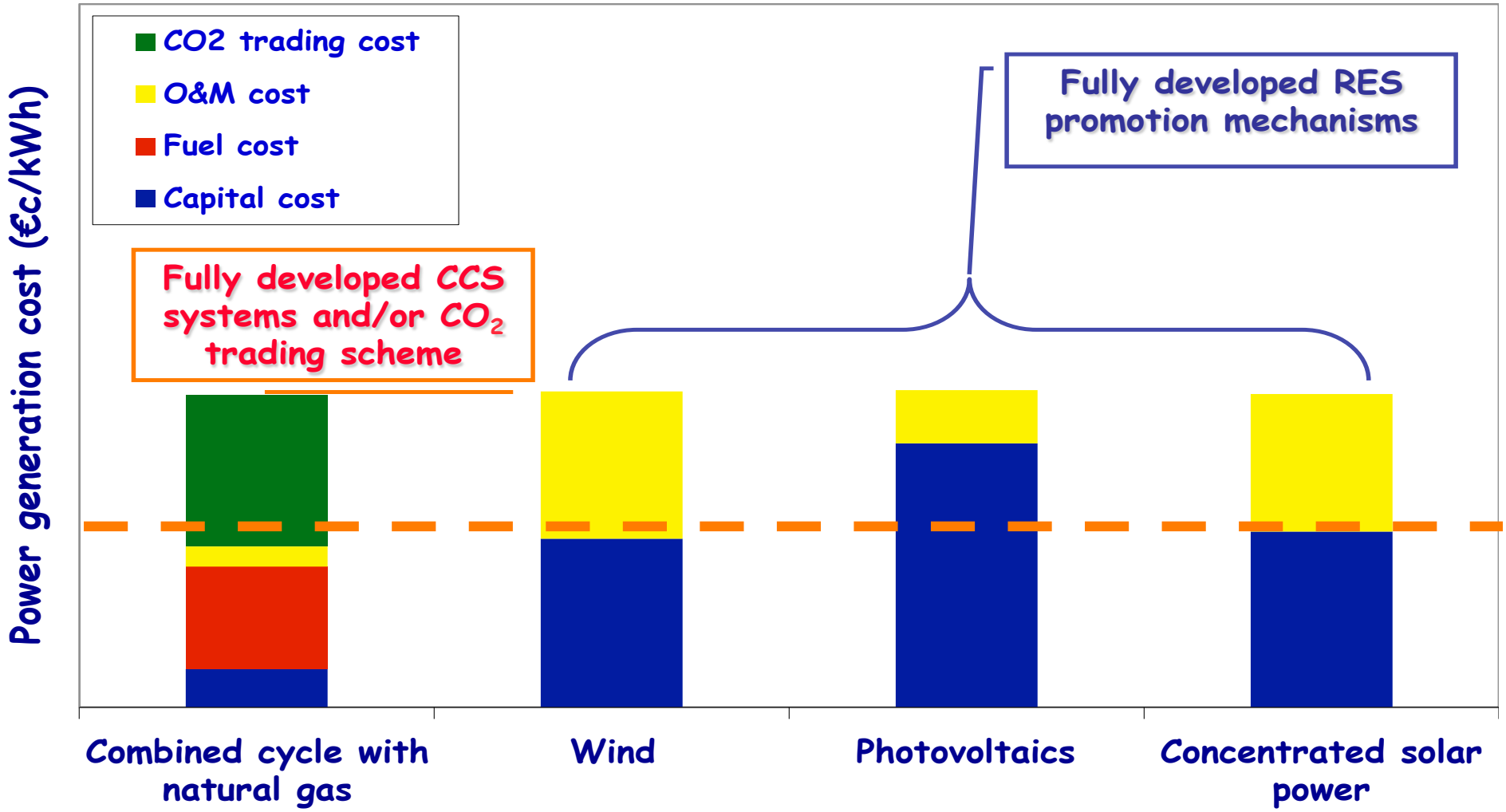
Source: PRIMES, GAINS

Power generation cost (year 2010)*



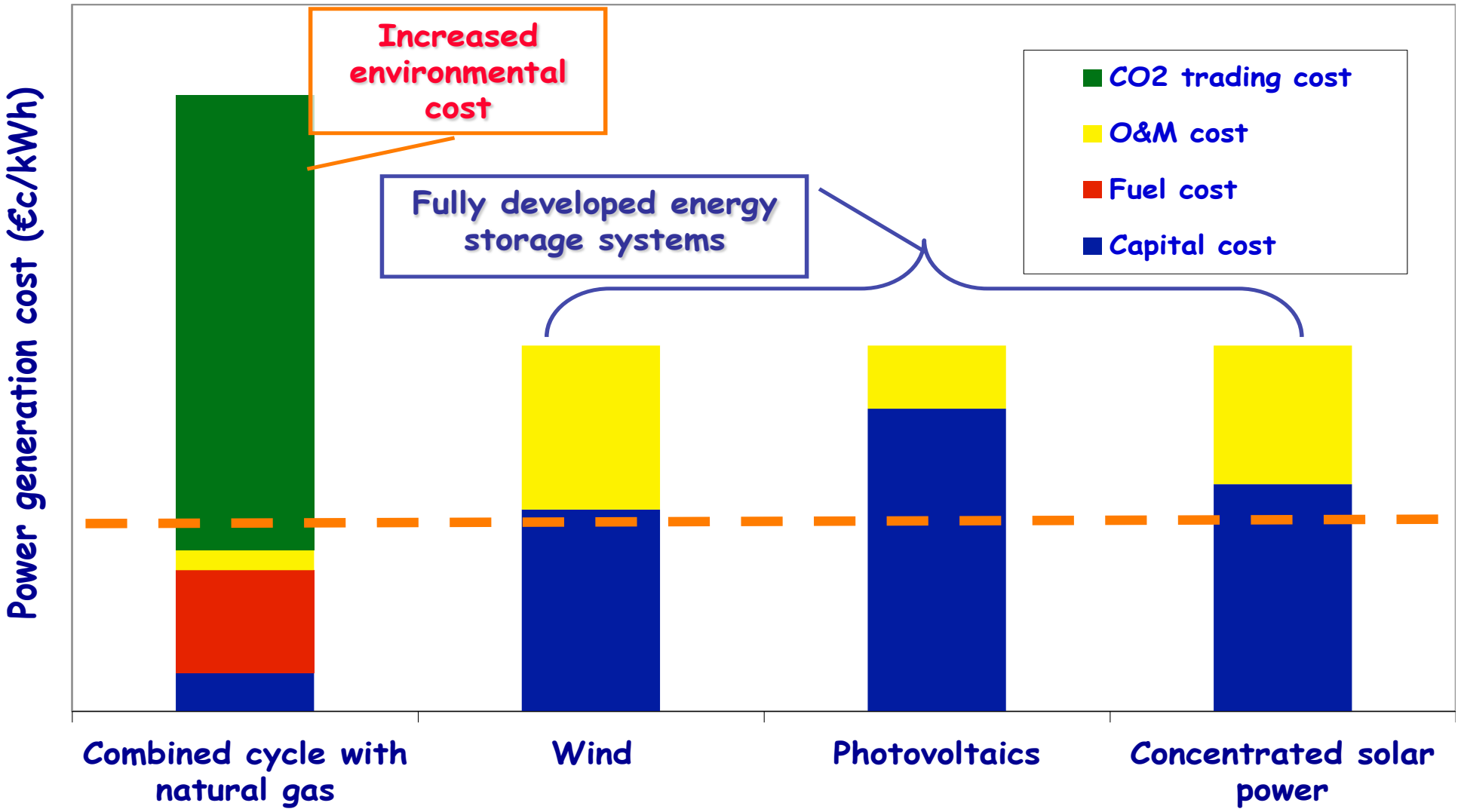
* Poullikkas A., 2010, "The cost of integration of renewable energy sources", *Accountancy*

Power generation cost (year 2020-30)*



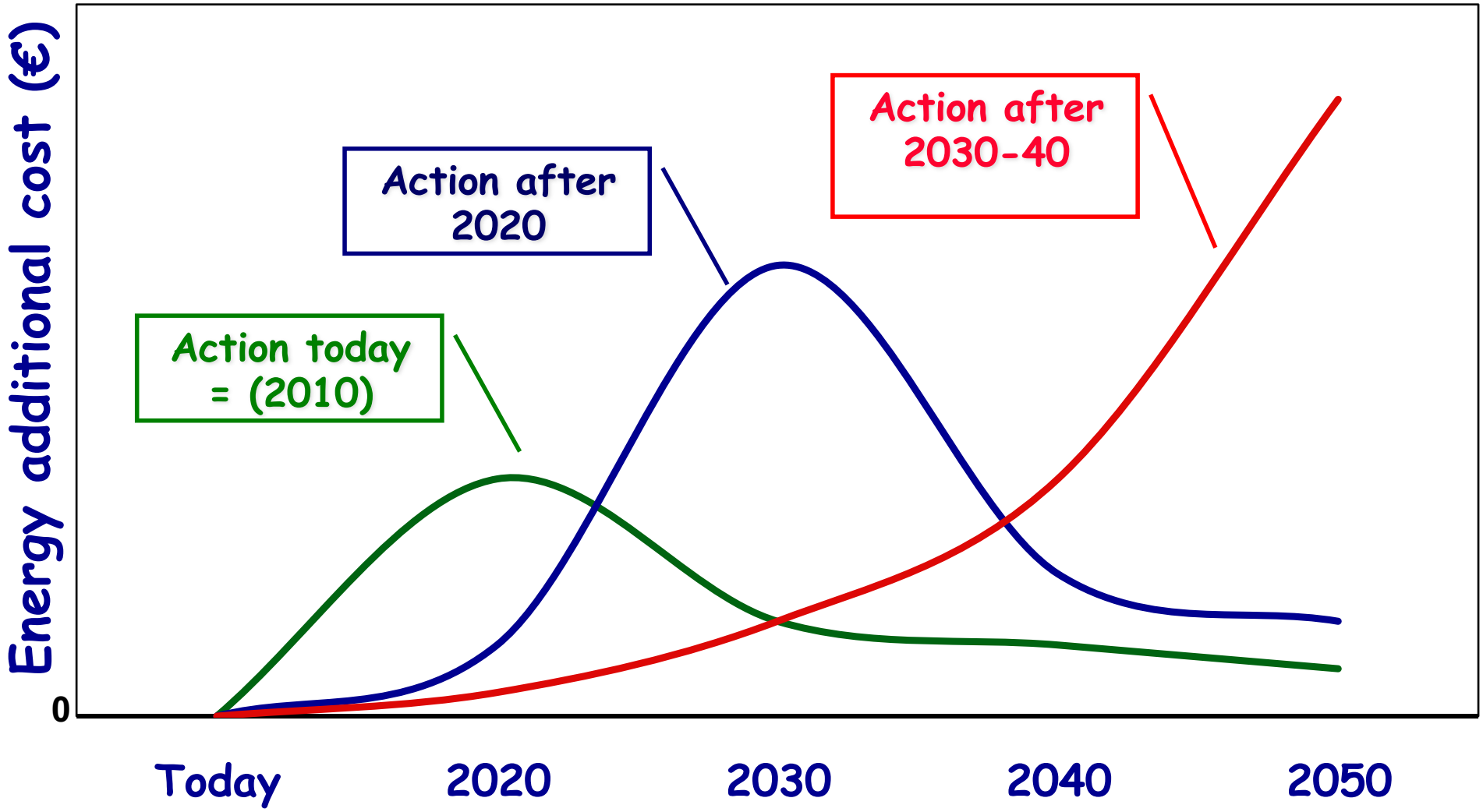
* Poullikkas A., 2010, "The cost of integration of renewable energy sources", *Accountancy*

Power generation cost (year 2040-50)*



* Poullikkas A., 2010, "The cost of integration of renewable energy sources", *Accountancy*

Future energy cost* (for EU only)



* Poullikkas A., 2010, "The cost of integration of renewable energy sources", *Accountancy*

European Union

Energy Union

- a binding EU target of at least 40% less greenhouse gas emissions by 2030, compared to 1990
- a binding target of at least 27% of renewable energy use at EU level
- an energy efficiency increase of at least 27%
- the completion of the internal energy market by reaching an electricity interconnection target of 15%
- increase energy security (natural gas South Corridor)

Connecting electricity markets

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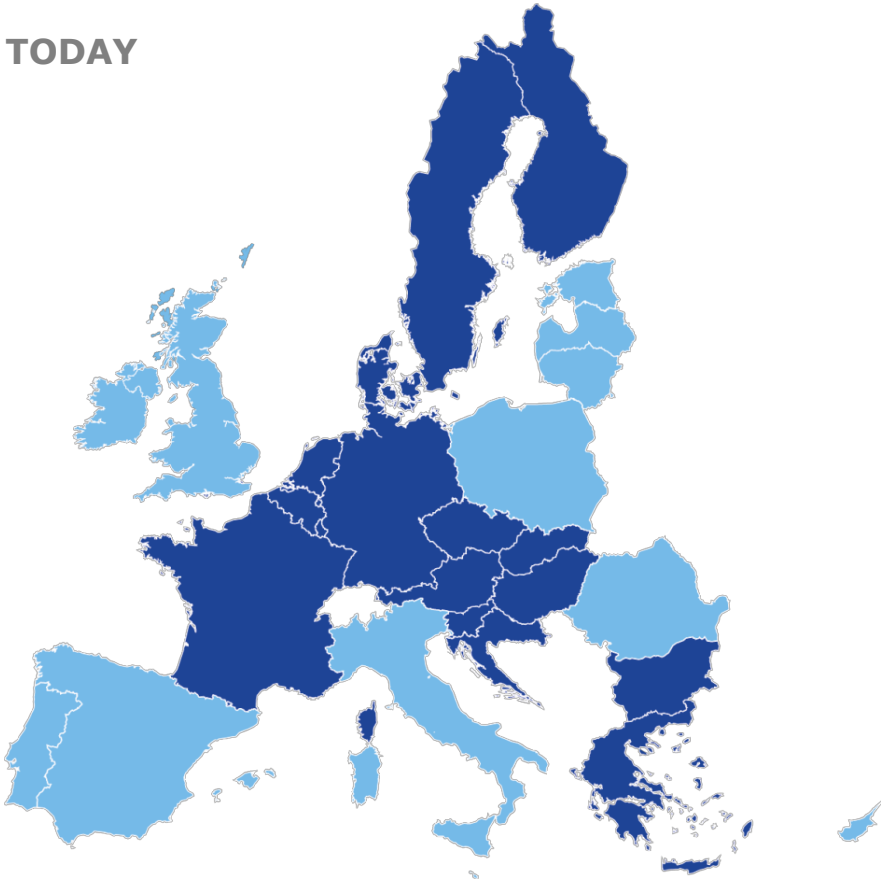
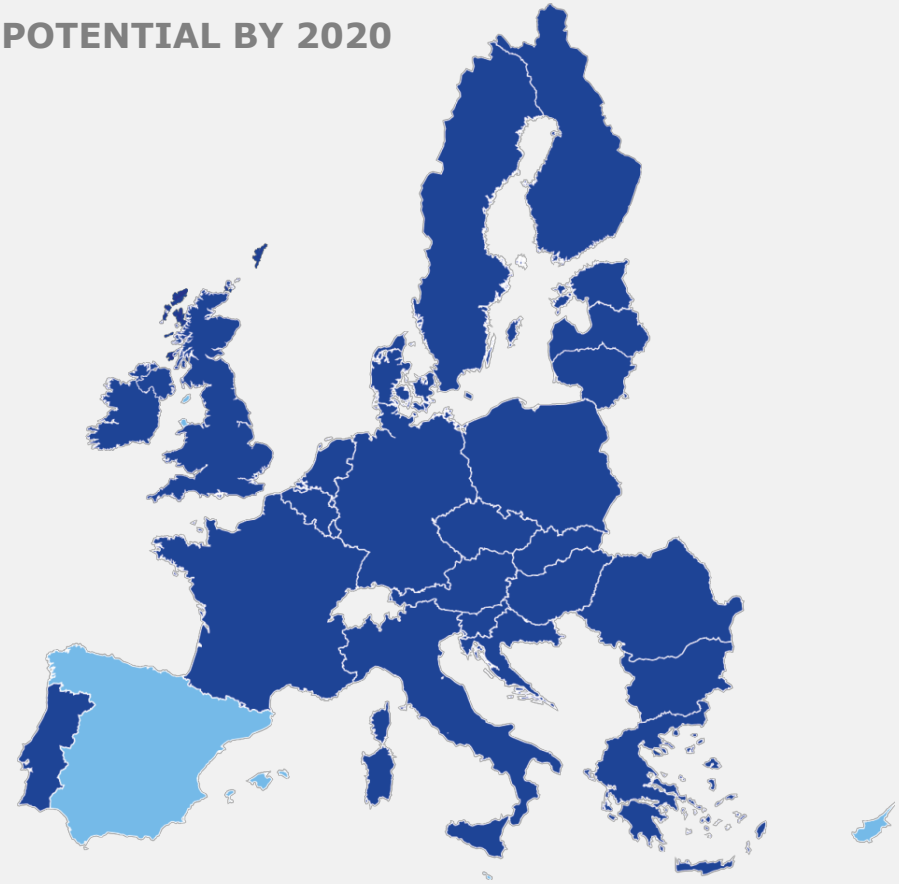
TODAY



Countries meeting the 10% **interconnection** target

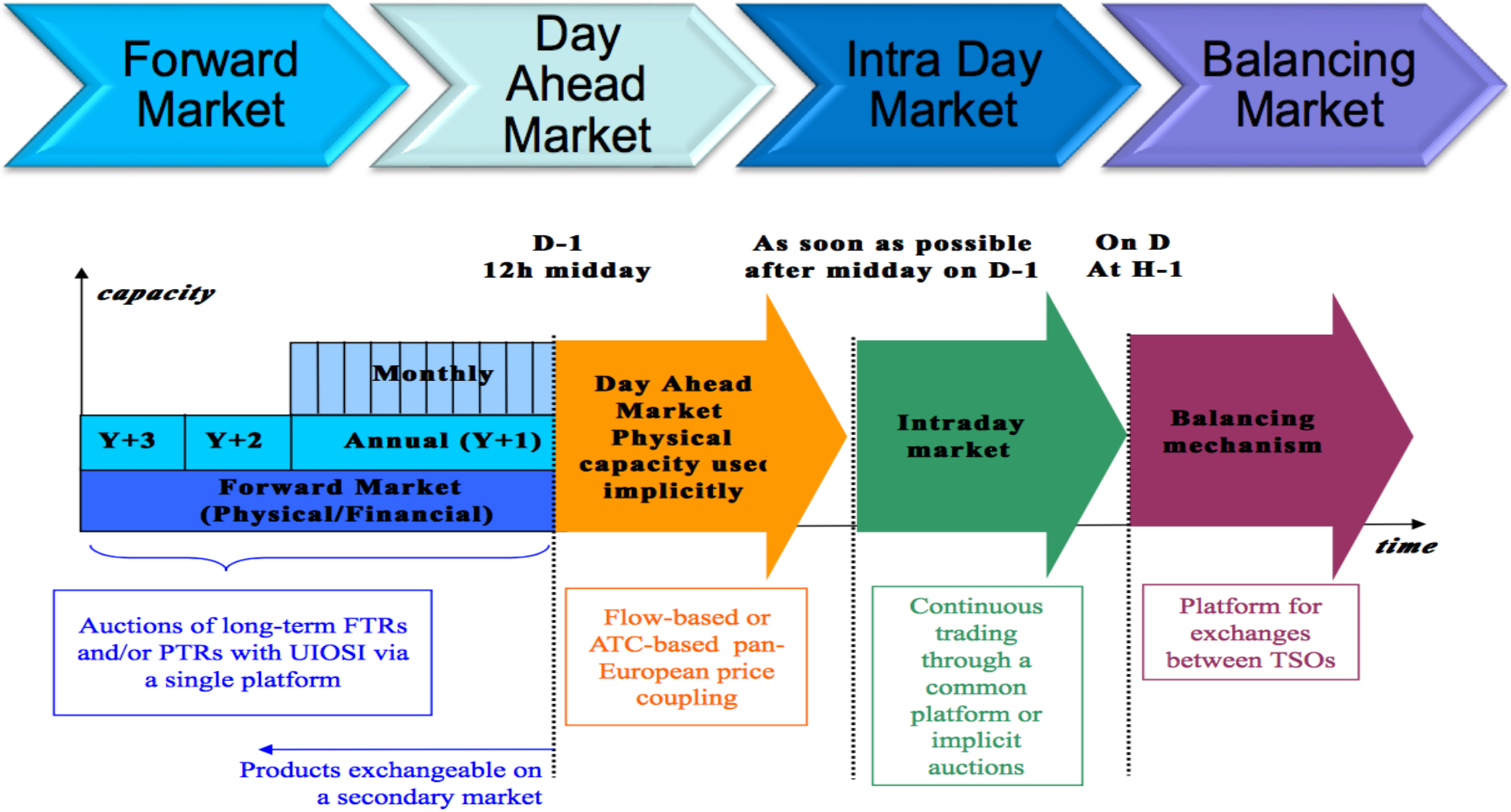
Countries not meeting the 10% **interconnection** target

POTENTIAL BY 2020

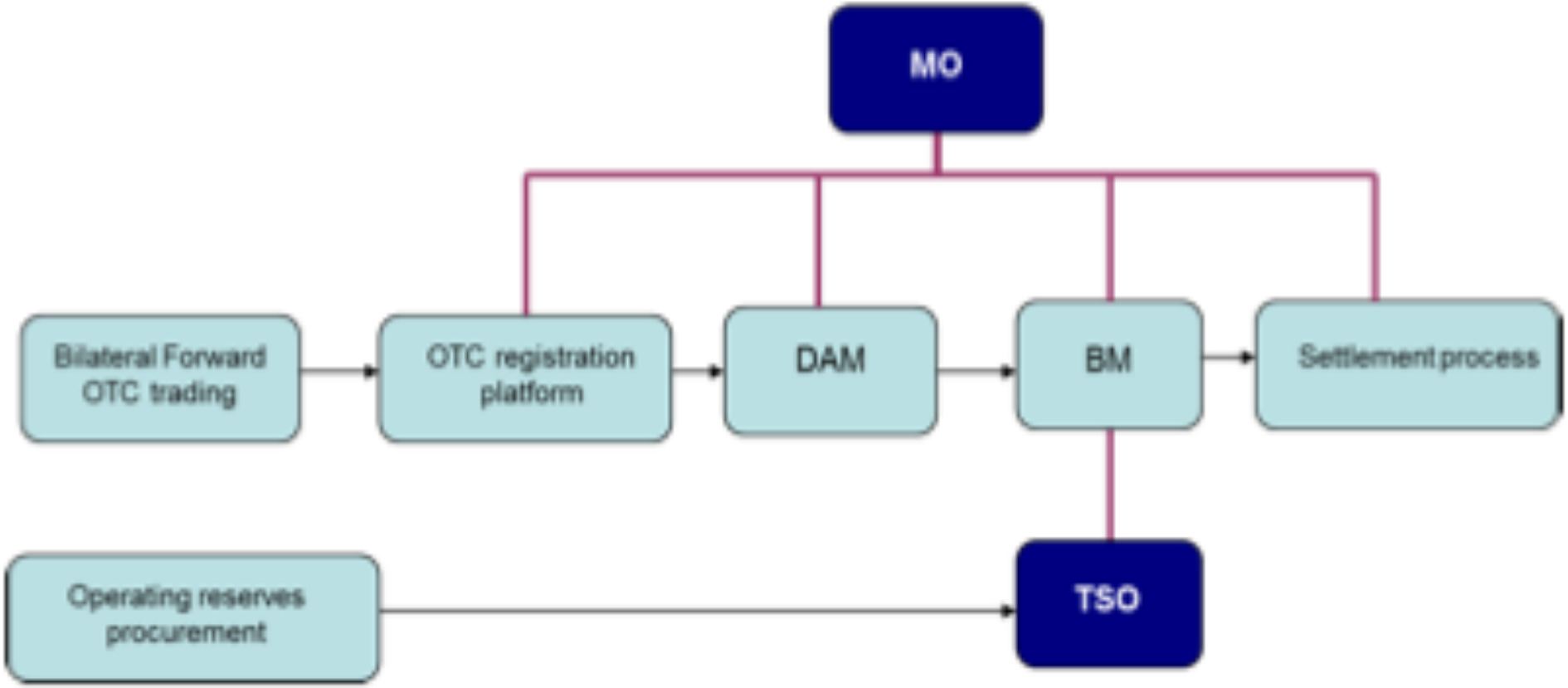


Efforts need to be stepped up for those below the 10% target by 2020, mainly Spain and Cyprus, and in view of achieving the 15% target by 2030.

EU electricity target model



The Net-Pool model



- **Central dispatch**
- **Market regulation:** CERA
- **Market participants:** TSO, MO, DSO, Generators, Aggregators, Suppliers (wholesale or retail markets), etc.

Storage is the missing link

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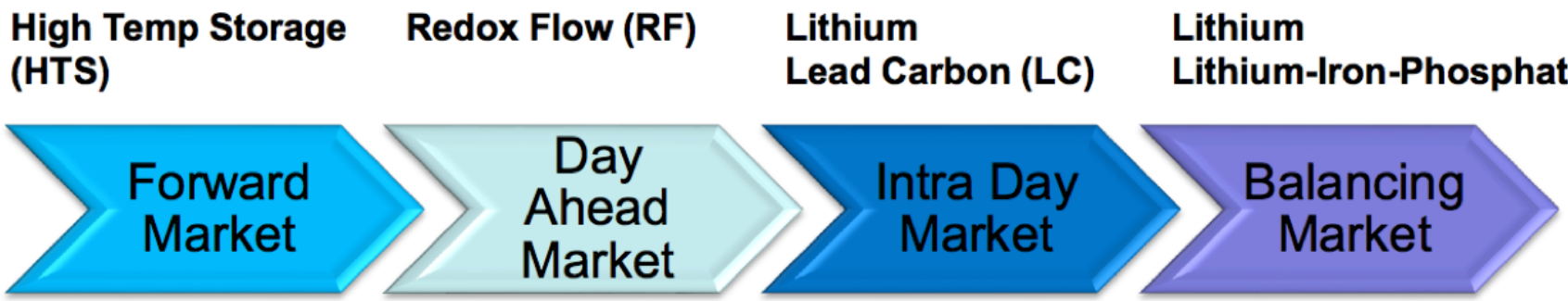

Advantage HTS:
- Very large storage
- 80% DOD
- Electricity, heat and AC generation
- Lowest Cost
- Minimum space
- 50 years LT

Disadvantage:
No fast response
E-Efficiency 40%
H-Efficiency 40%

Size: 3 - 50MWh

Advantage RF:
- Large storage
- 50-70% DOD
- High Power
- Lower cost
- No memory effect
- 15 to 20 years LT

Disadvantage:
Low Energy Density
No fast response
Efficiency < 80%

Size: 1 - 10MWh

Advantage LC:
- Large storage
- 50-70% DOD
- High power
- Lower cost
- Efficiency > 85%
- 10-15 years LT

Disadvantage:
Medium Energy Density
High Weight
Efficiency 80%

Size: 0,1 - 10MWh

Advantage Lithium:
- Fast response
- Quick Service
- 80% DOD
- High Power
- Efficiency > 95%
- No Memory effect
- Highest energy density
- 15 to 20 years LT

Disadvantage:
High Cost

Size: 0,1 - 10MWh