Η ρύθμιση των ενεργειακών αγορών και η ενσωμάτωση των αειφόρων τεχνολογιών στο ρυθμιστικό πλαίσιο

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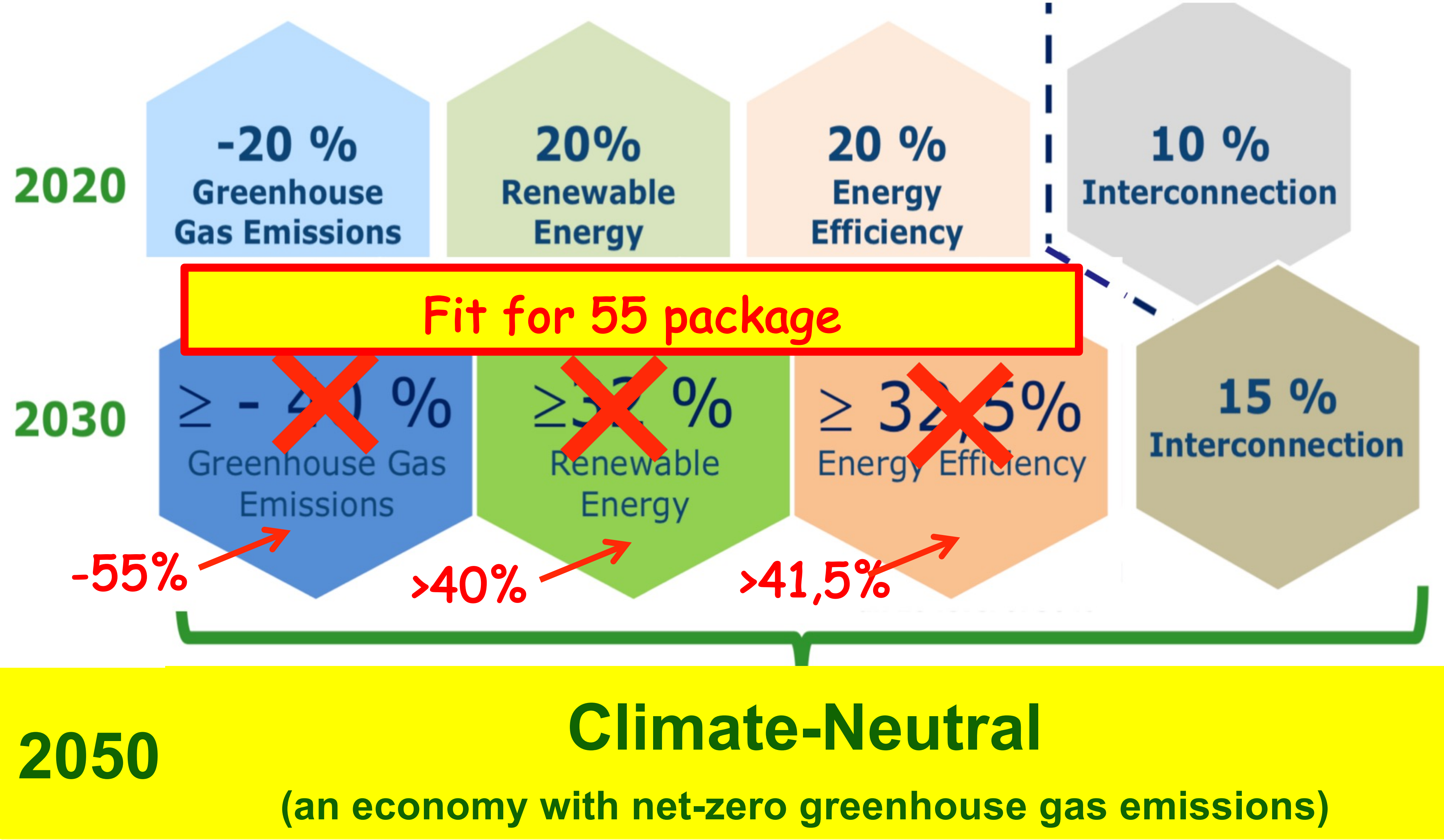
EU energy strategy

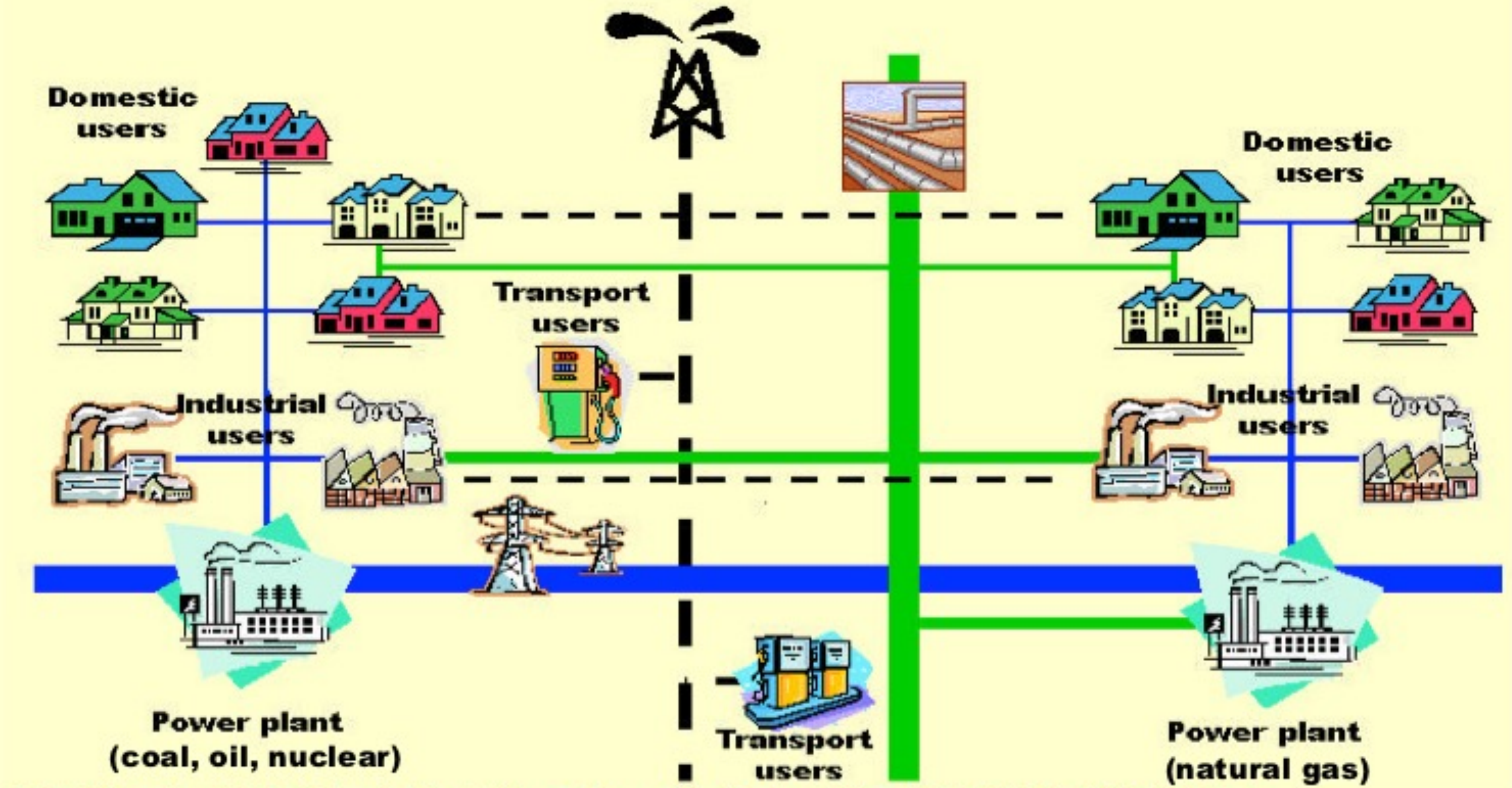
towards 2050

EU medium and long term targets



Energy system in 2010

EU energy system in 2010*



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

Future energy systems (optimistic scenario)

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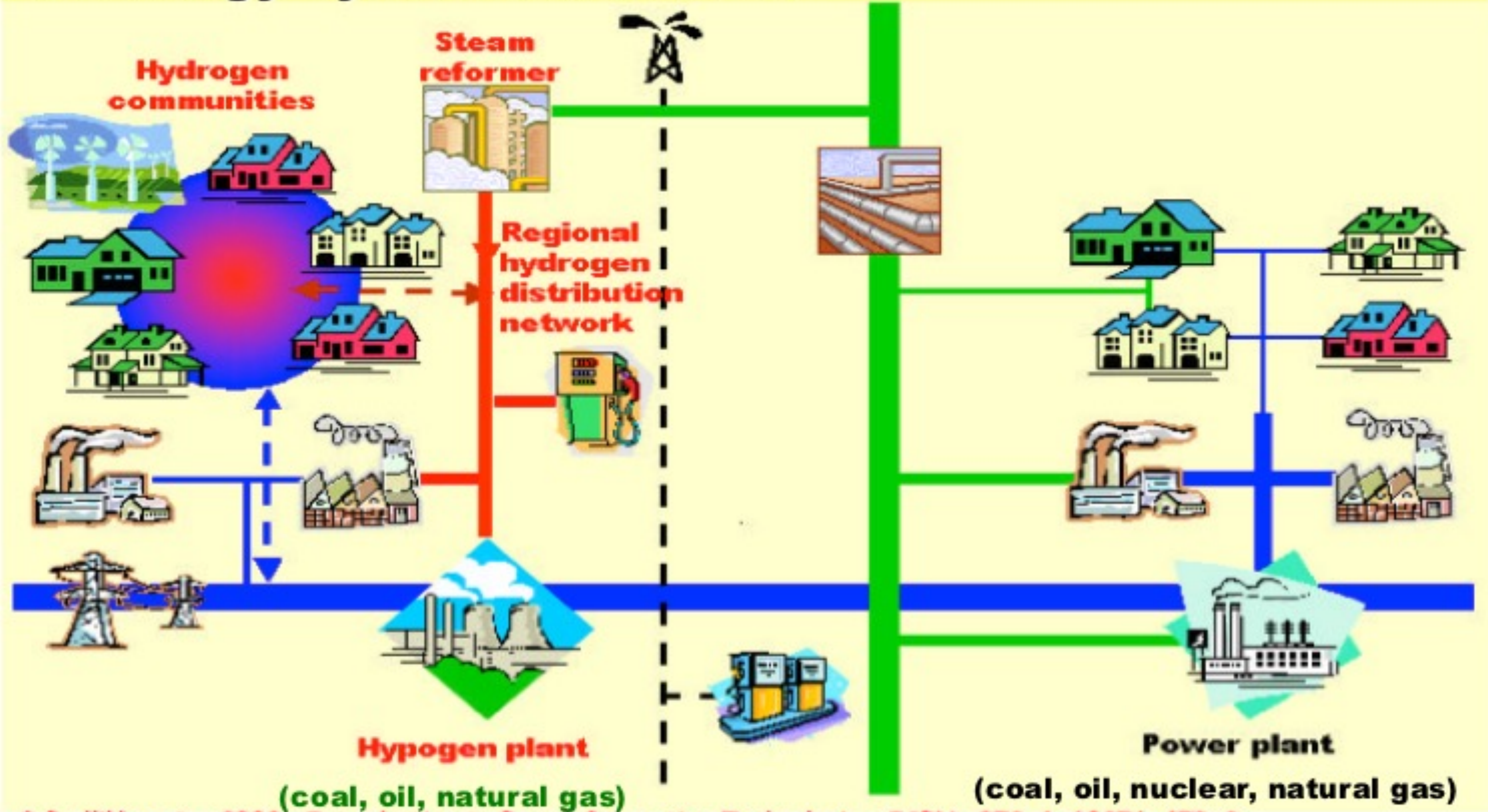
EU energy system in 2020-30*



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Future energy systems (optimistic scenario)

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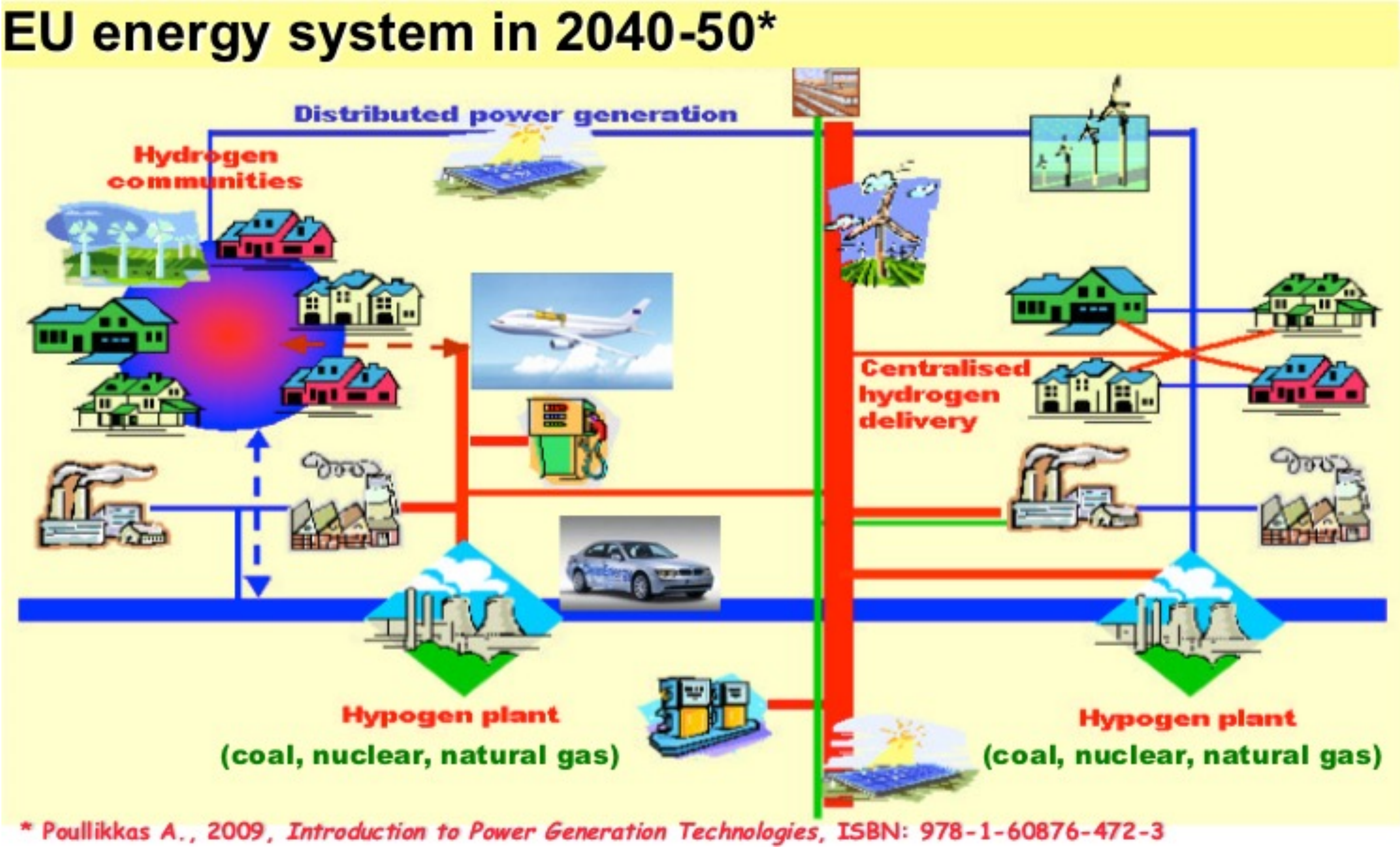
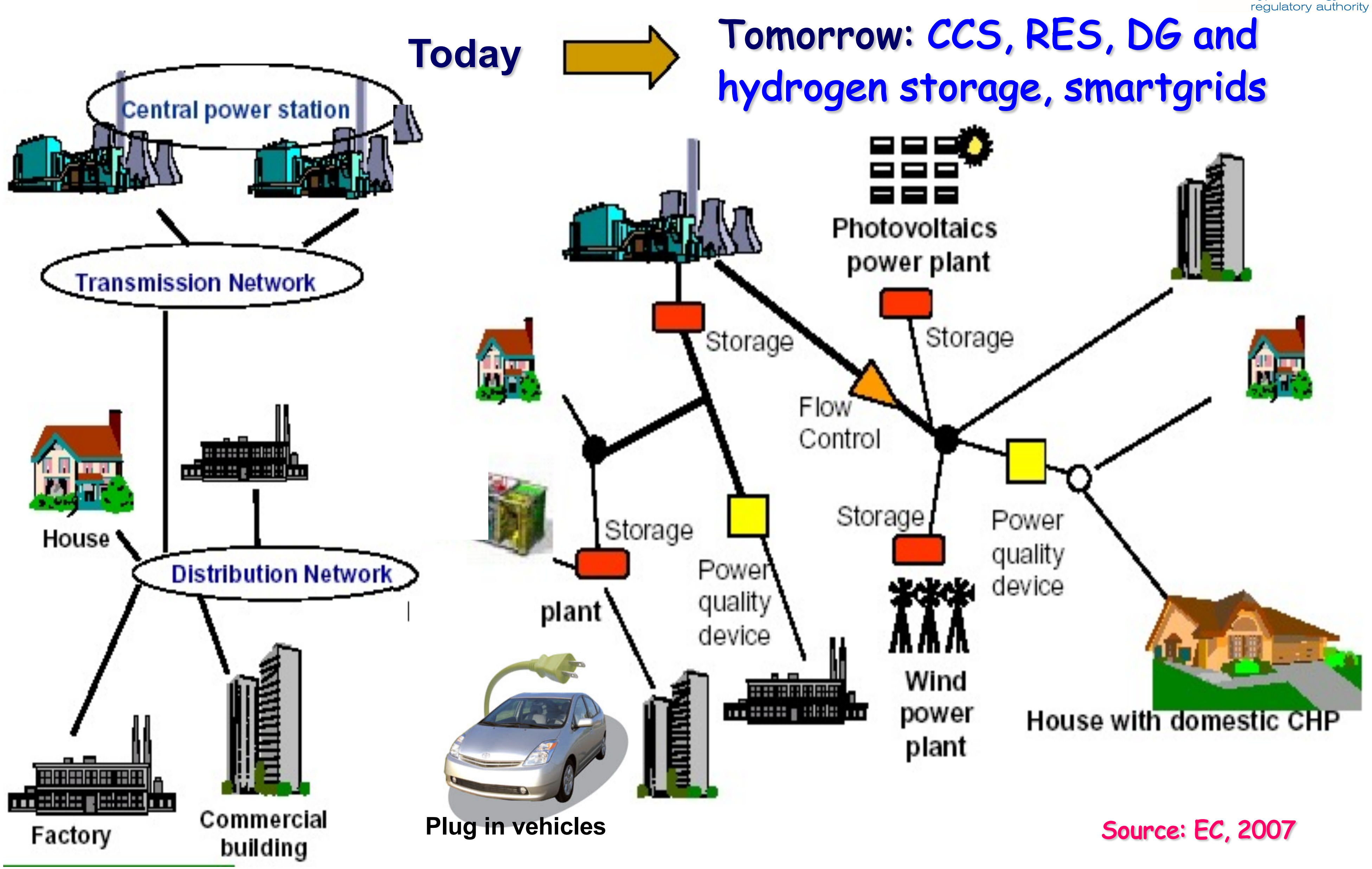


Future power systems



Source: EC, 2007

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

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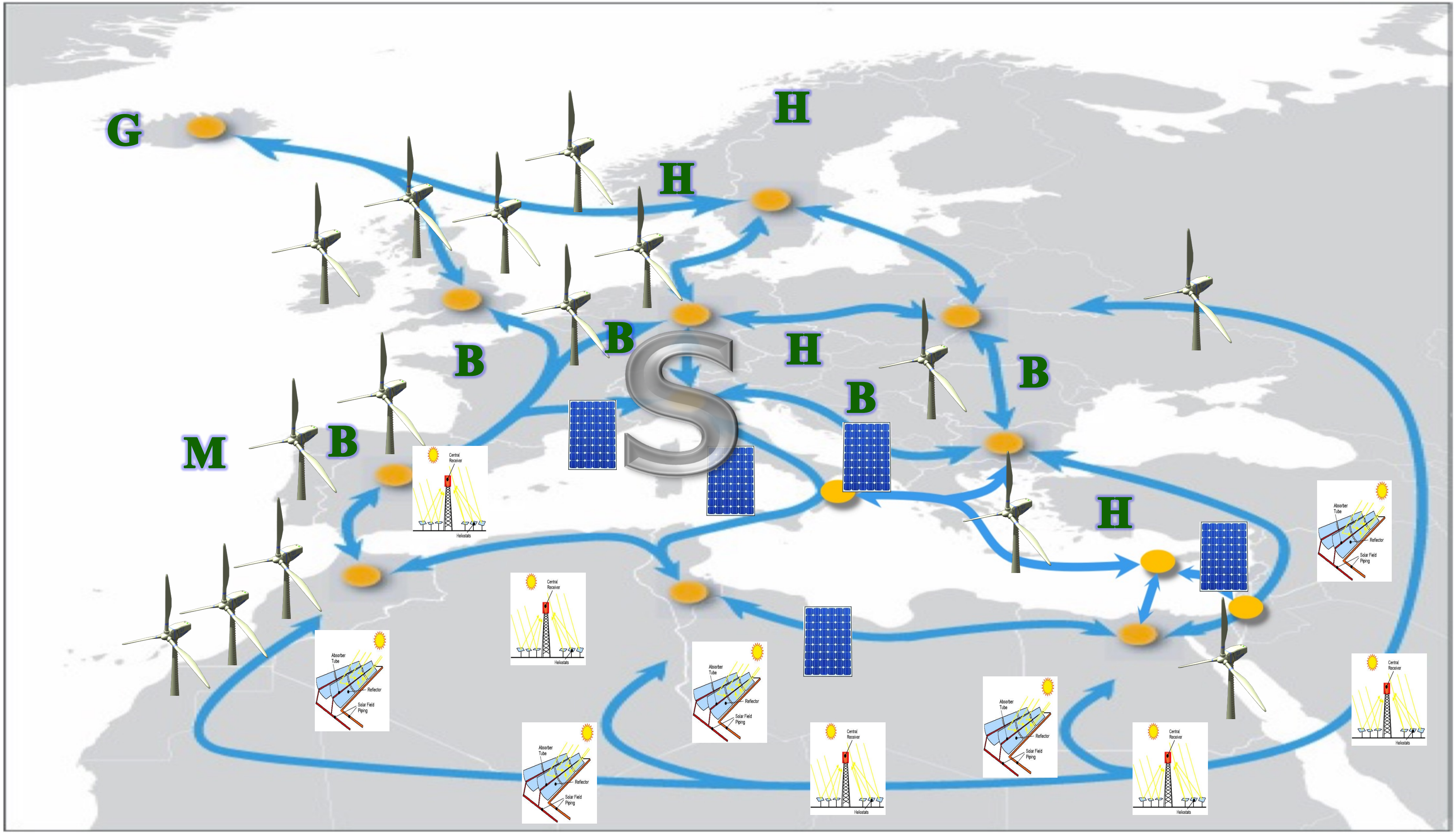

* Poullikkas A., 2013, *Sustainable Energy Development for Cyprus*, ISBN: 978-9963-7355-3-2

Long term scenarios in Europe

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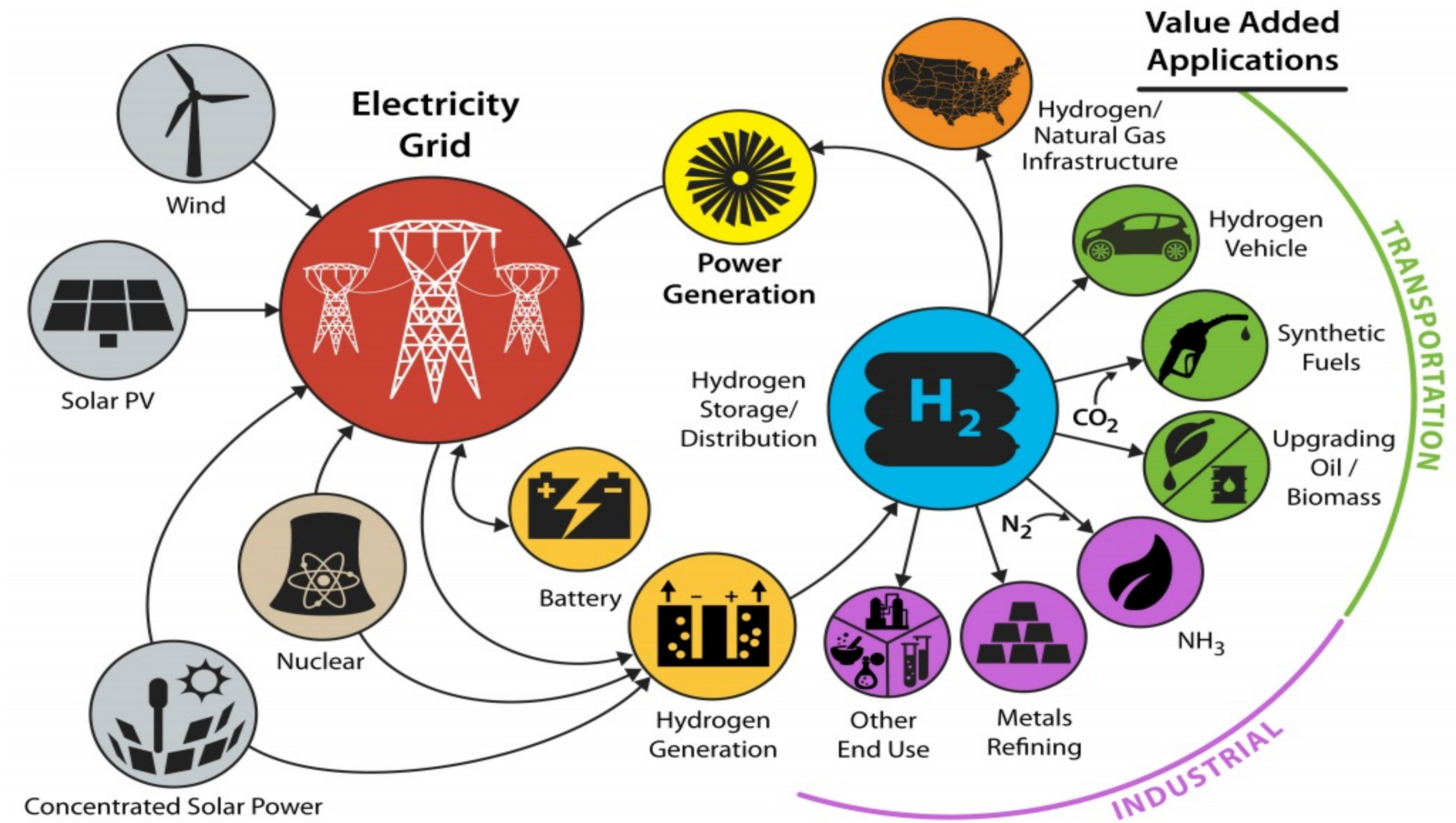
Moving from Carbon economy to Hydrogen economy



Saudi Arabia $5bn Helios H2 project

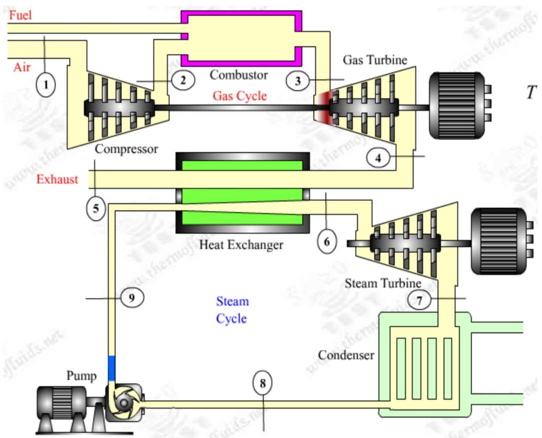
- Desert area = Belgium
- 4GW of Wind and PVs
- Production of 650t/day of H_2
- Reduce of H_2 production from 5US$/kg to 1.5US$/kg
- Long-term: Saudi Arabia to become H_2 exporter

Cyprus current electricity and NG systems

Systems characteristics

Existing power generation system

- **Steam turbine units (HFO)**
  - Dhekelia power station 6x60MWe
  - Vasilikos power station 3x130MWe
- **Combined cycles (Diesel)**
  - Vasilikos power station 2x220MWe
- **Gas turbine units (Diesel)**
  - Moni power station 4x37,5MWe
  - Vasilikos power station 1x38MWe
- **Internal combustion engines**
  - Dhekelia power station 6x17.5MWe (HFO)

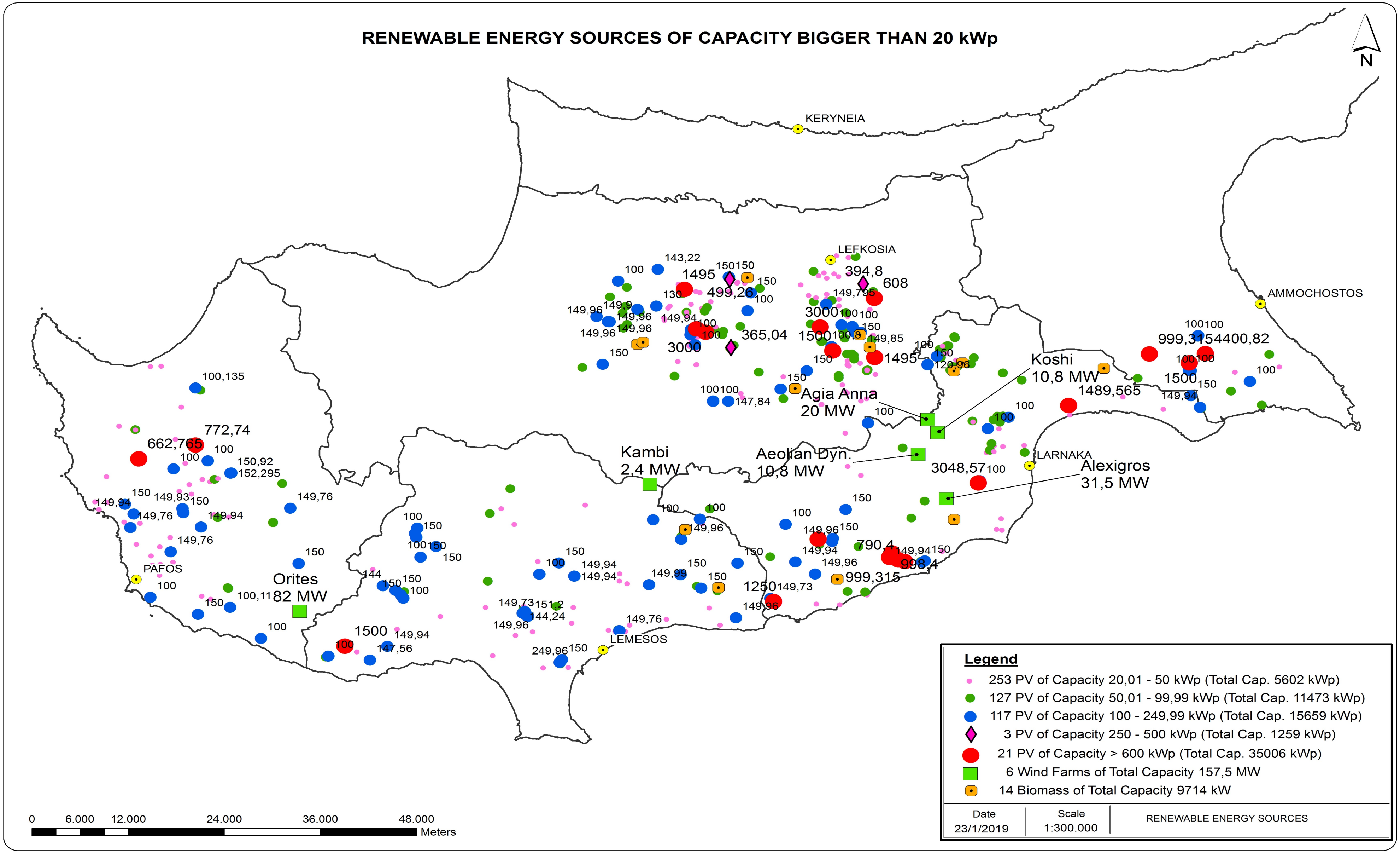


Existing power generation system (cont.)

- **Renewables**
  - PVs: 293MWe
  - Wind: 157MWe
  - Biomass: 13MWe

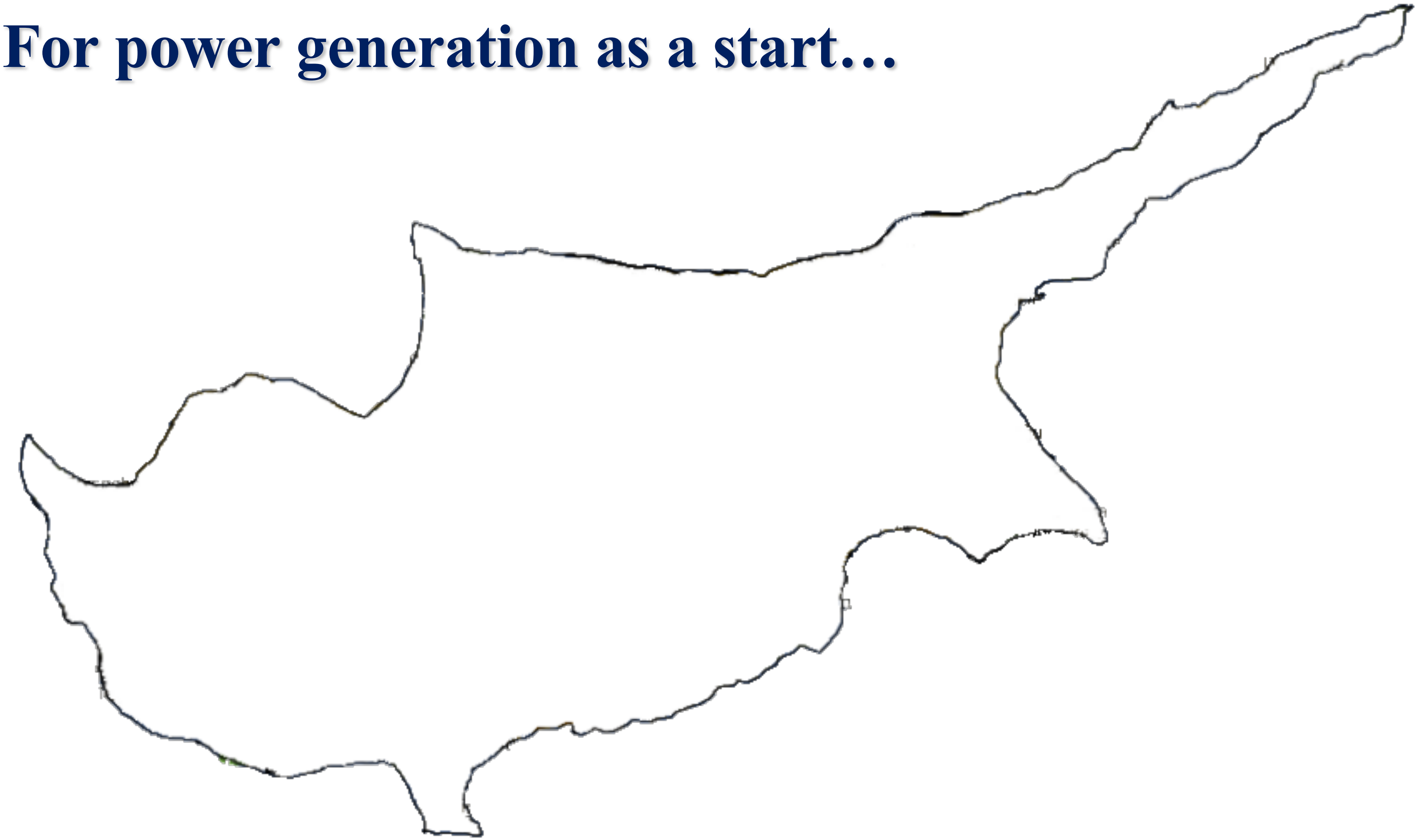
- **Total installed capacity:**
  - Conventional: 1483MWe
  - Renewables: 463MWe

Distribution of RES-E



Existing natural gas system

- Under development !
- For power generation as a start…



Energy transition for island systems

Solutions for isolated systems

Characteristics of isolated electricity systems*

- **High fuel costs**
  - ~ use of oil derivatives
  - ~ high CO_2 emissions (additional cost)
- **Economies of scale cannot be adequately exploited**
  - ~ generation units cannot exceed a certain size since the loss of a unit would mean the loss of a high percentage of the entire system
- **Need to maintain high reserve capacity to ensure power system reliability**

The smaller the electrical system size, the more the expenses will be

* Poullikkas A., 2015, *Sustainable Energy Policy for Cyprus*, ISBN: 978-9963-7355-6-3

Energy transition for non-interconnected islands*

Need to:

- **Reduce cost of security of supply**
- **Achieve market integration**
- **Increase socio-economic welfare benefits**

* Poullikkas A., 2013, *Renewable Energy: Economics, Emerging Technologies and Global Practices*, ISBN: 978-1-62618-231-8

The solution*

- **Increase system flexibility**
  - ~ integrate RES into electricity market
  - ~ use natural gas, storage and RES for power generation
  - ~ promote e-mobility (V2G technology - bidirectional flow of electricity between the electric car and the grid)
- **Establish electricity interconnections**
  - ~ with EU internal electricity market (the island of Cyprus is the only non-interconnected Member State)
- **Production of hydrogen** (energy carrier)
  - ~ from RES and natural gas

* Poullikkas A., 2016, *Fundamentals of Energy Regulation*, ISBN: 978-9963-7355-8-7

CERA Energy Transition Regulatory Decisions

- Regulatory Decision 01/2017 (ΚΔΠ 34/2017): A detailed schedule for the implementation of EU electricity market target model
- Regulatory Decision 02/2018 (ΚΔΠ 259/2018): The mass installation of an Advanced Metering Infrastructure including smartmeters to all electricity consumers
- Regulatory Decision 02/2019 (ΚΔΠ 204/2019): The establishment of basic principles of a regulatory framework for the operation of electricity storage systems in the wholesale electricity market
- Regulatory Decision 03/2019 (ΚΔΠ 224/2019): The redesign of the power grid to become smart and bi-directional in order to allow integration of large quantities of renewable energy sources in combination with energy storage systems

ACER key regulatory requirements for energy transition (Dec 2021)

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1. Adopt a gradual and flexible regulatory approach to facilitate the emergence of competitive hydrogen markets, by defining core market and regulatory principles, guaranteeing a level playing field, ownership unbundling, third party access, transparency and regulatory oversight
2. Monitor hydrogen markets periodically to identify their development and whether more regulation is needed
3. Apply cost reflectivity and beneficiary-pays principles to hydrogen networks, avoiding cross-subsidies between energy carriers
4. Ensure an integrated, liquid and interoperable EU internal gas market, also by foreseeing a more flexible approach to the application of relevant network codes with respect to specific cross-border charges
5. Adopt a more integrated approach to infrastructure development, both in relation to different levels of the supply chain (vertical), and to the various energy carriers (horizontal), consistent with the revised TEN-E Regulation
6. Guarantee consumer rights regardless of energy carrier
7. Embed robust consumer protection, future innovation, technology developments and new market trends in the decarbonisation policies, recognising the specificities of gas markets
8. Ensure cost efficiency and affordability to safeguard inclusiveness and a just transition, including by promoting and facilitating energy efficiency measures and information
9. Provide consumers with clear and reliable information and support, as well as ensure effective enforcement of their rights and consumer-centric digitalisation rules to enhance their empowerment and trust in the energy transition

Hydrogen market (items 1–3)

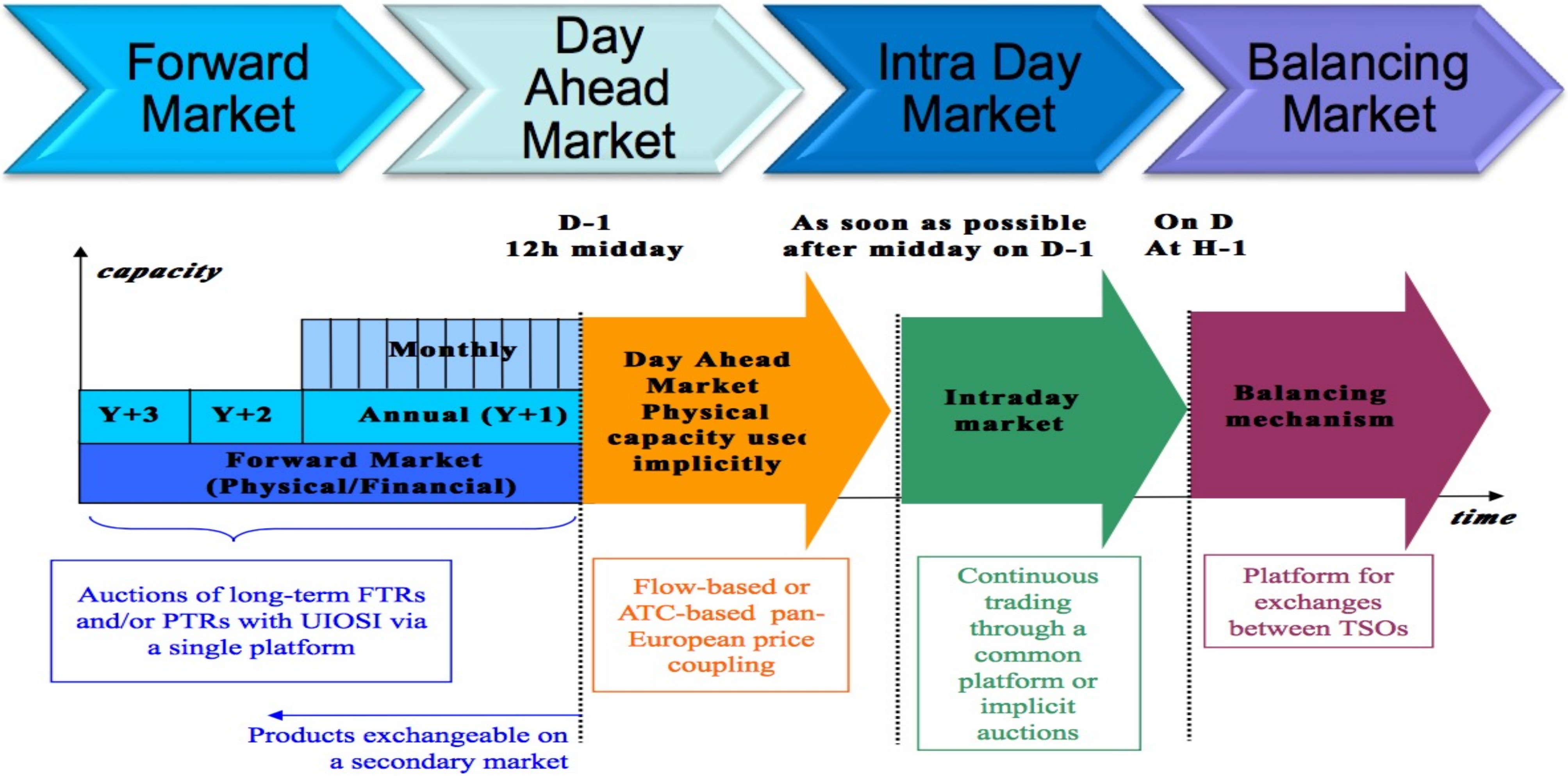
Infrastructure (items 4–5)

Consumers rights (items 6–9)

Short to medium term challenges

Large scale integration of RES

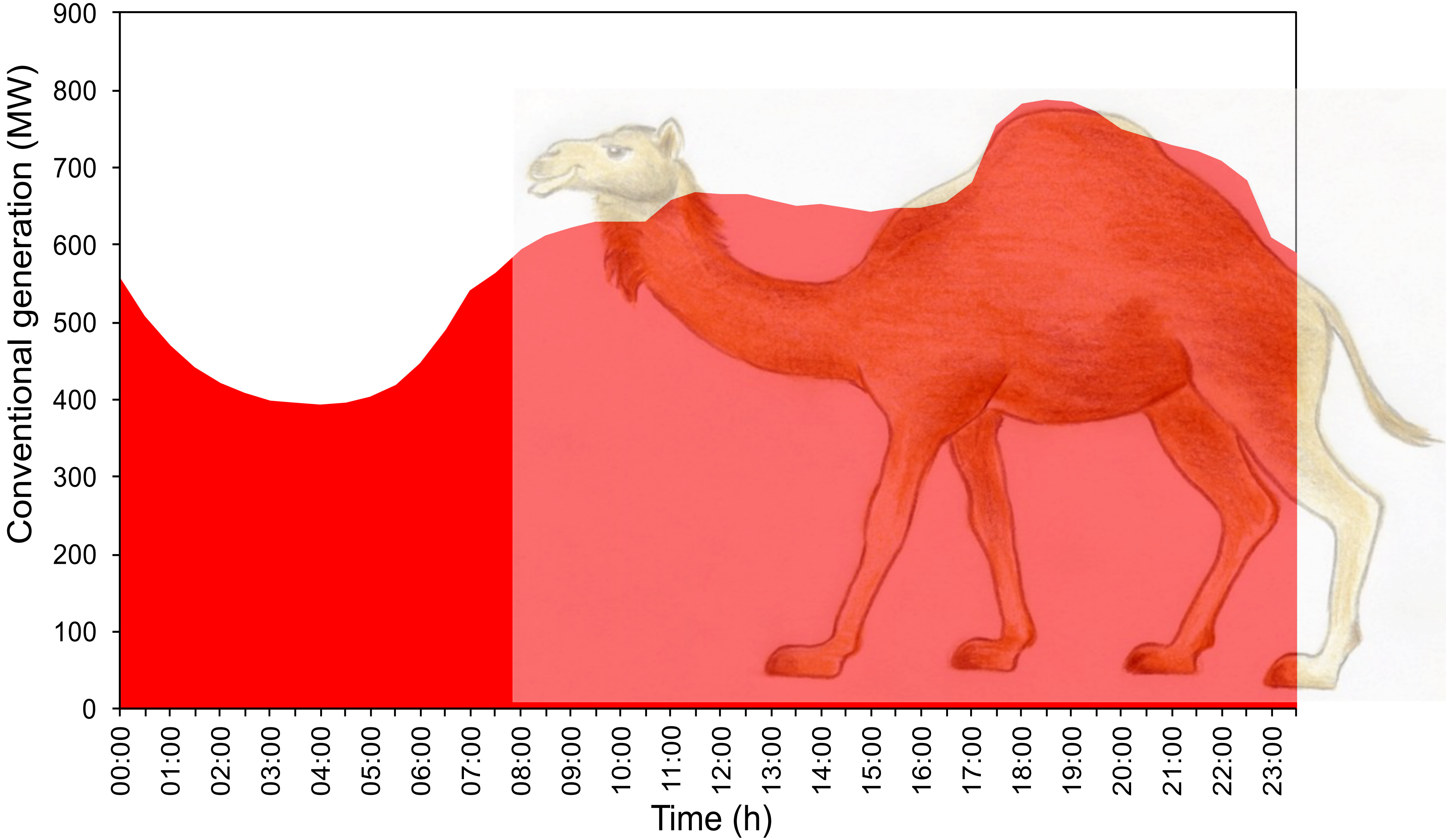
EU electricity market target model



Integration of RES*: LCOE *vs* Reliability

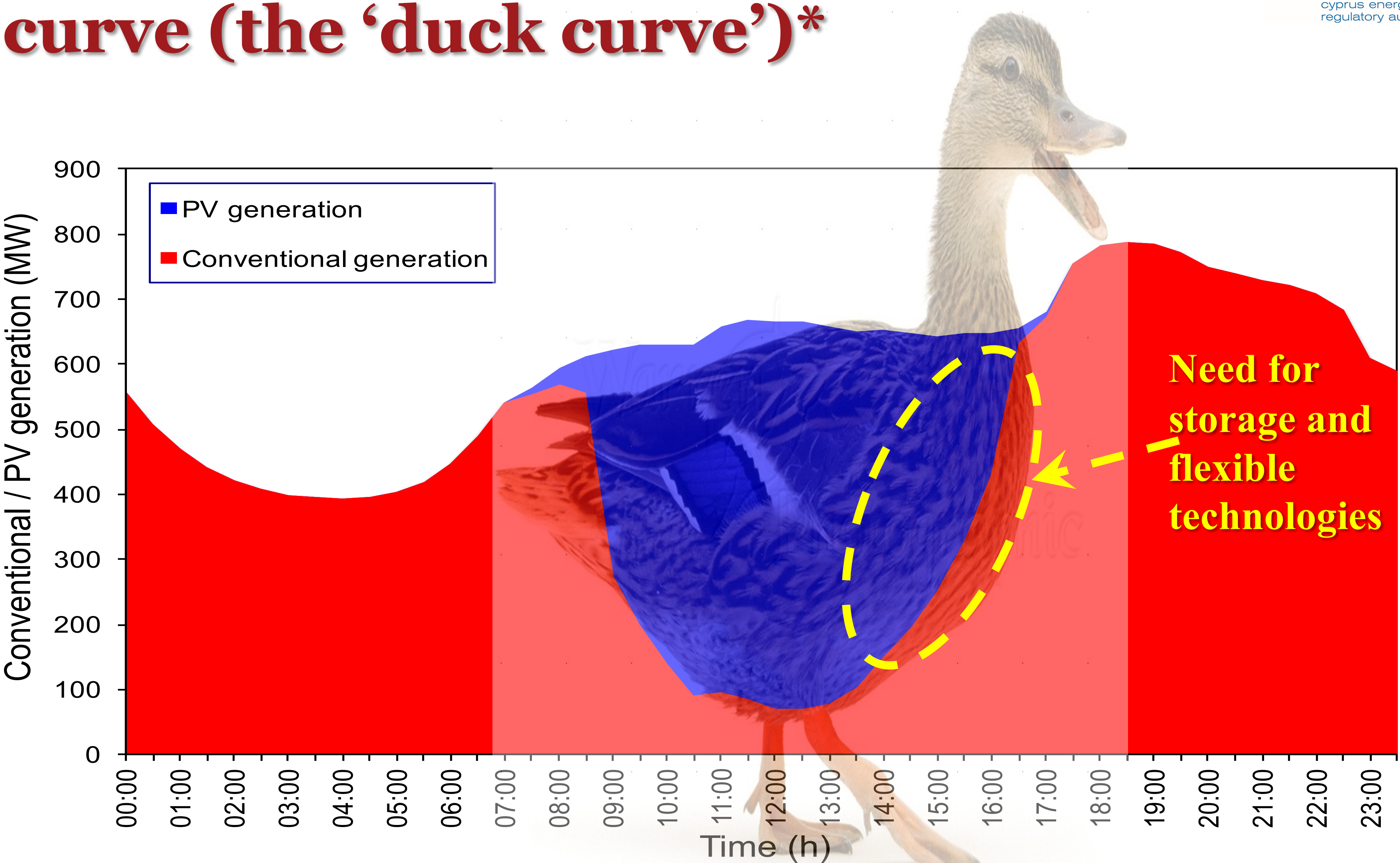
* Nicolaidis P., Chatzis S., Poullikkas A., 2018, "Renewable energy integration through optimal unit commitment and electricity storage in weak power networks", *International Journal of Sustainable Energy*

Daily load curve (the 'camel curve')*



* **Poullikkas A., 2016, "From the 'camel curve' to the 'duck curve' on electric systems with increasing solar power", *Accountancy***

Effect of PV generation on load curve (the 'duck curve')*



* **Poullikkas A., 2016, "From the 'camel curve' to the 'duck curve' on electric systems with increasing solar power", *Accountancy***

Storage and flexible technologies are the missing links

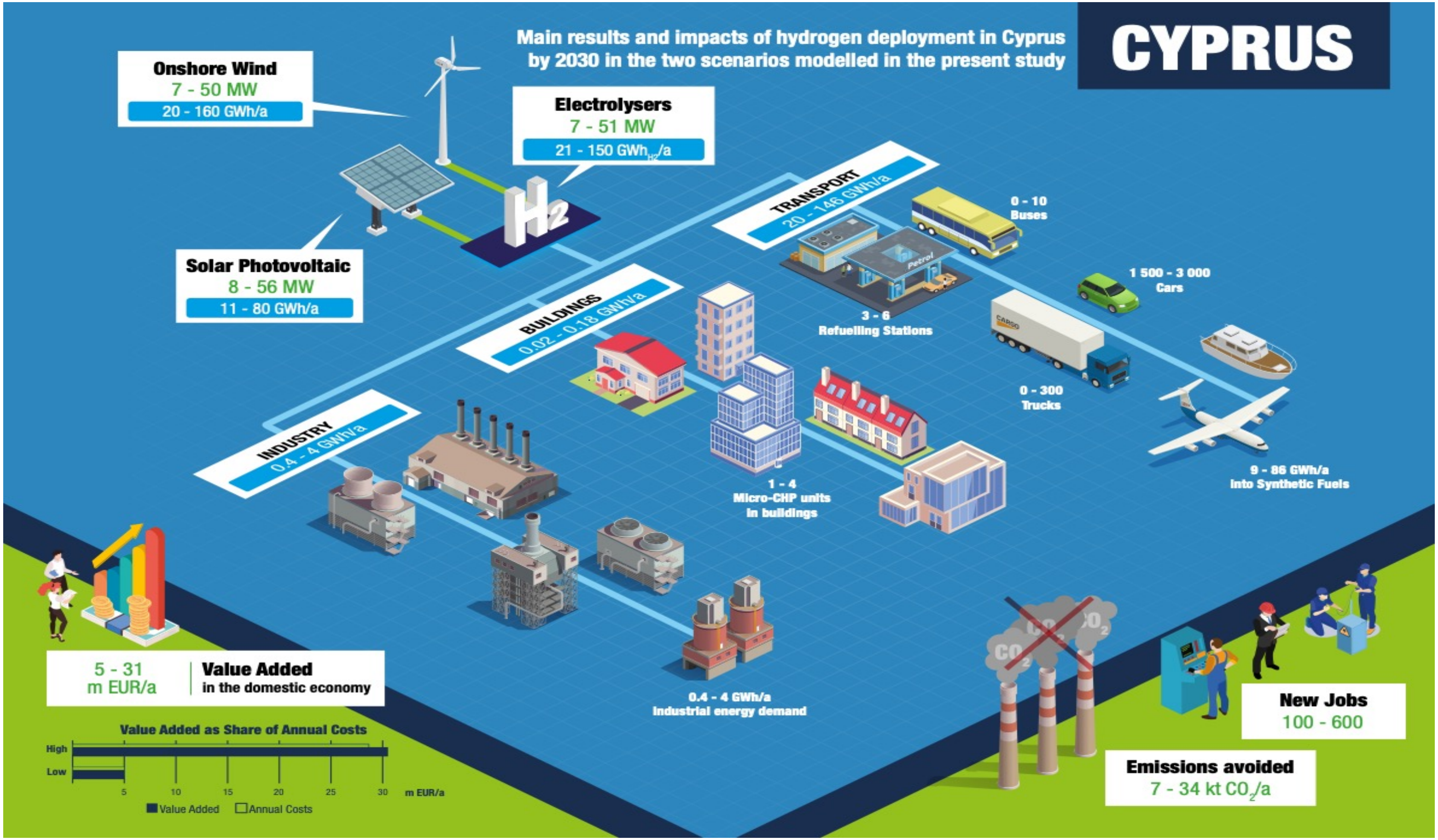
Energy storage

Flexible technologies

Hydrogen technologies

CERA
Storage, Flexible Technologies and Hydrogen Regulatory Frameworks

Introduction of H2 in Cyprus's by 2030*



* FCH, EU, 2020

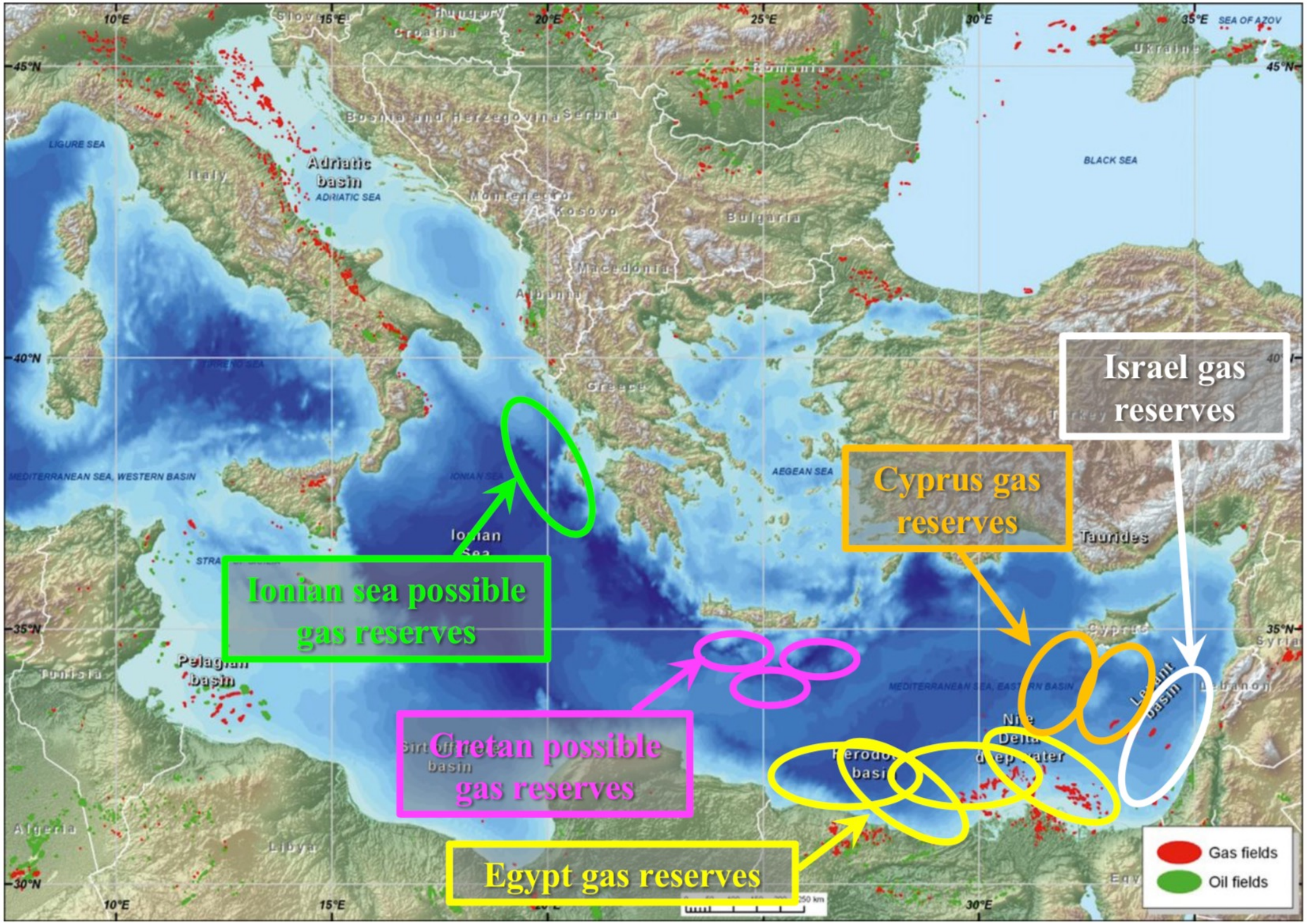
Medium to long term challenges

The role of interconnections and hydrogen

Regional primary energy sources

Indigenous energy sources

Gas reserves in SE Mediterranean region*



* A. Belopolsky, *et al.*, 2012, "New and emerging plays in the Eastern Mediterranean", *Petroleum Geoscience*

Wind potential in SE Mediterranean region*

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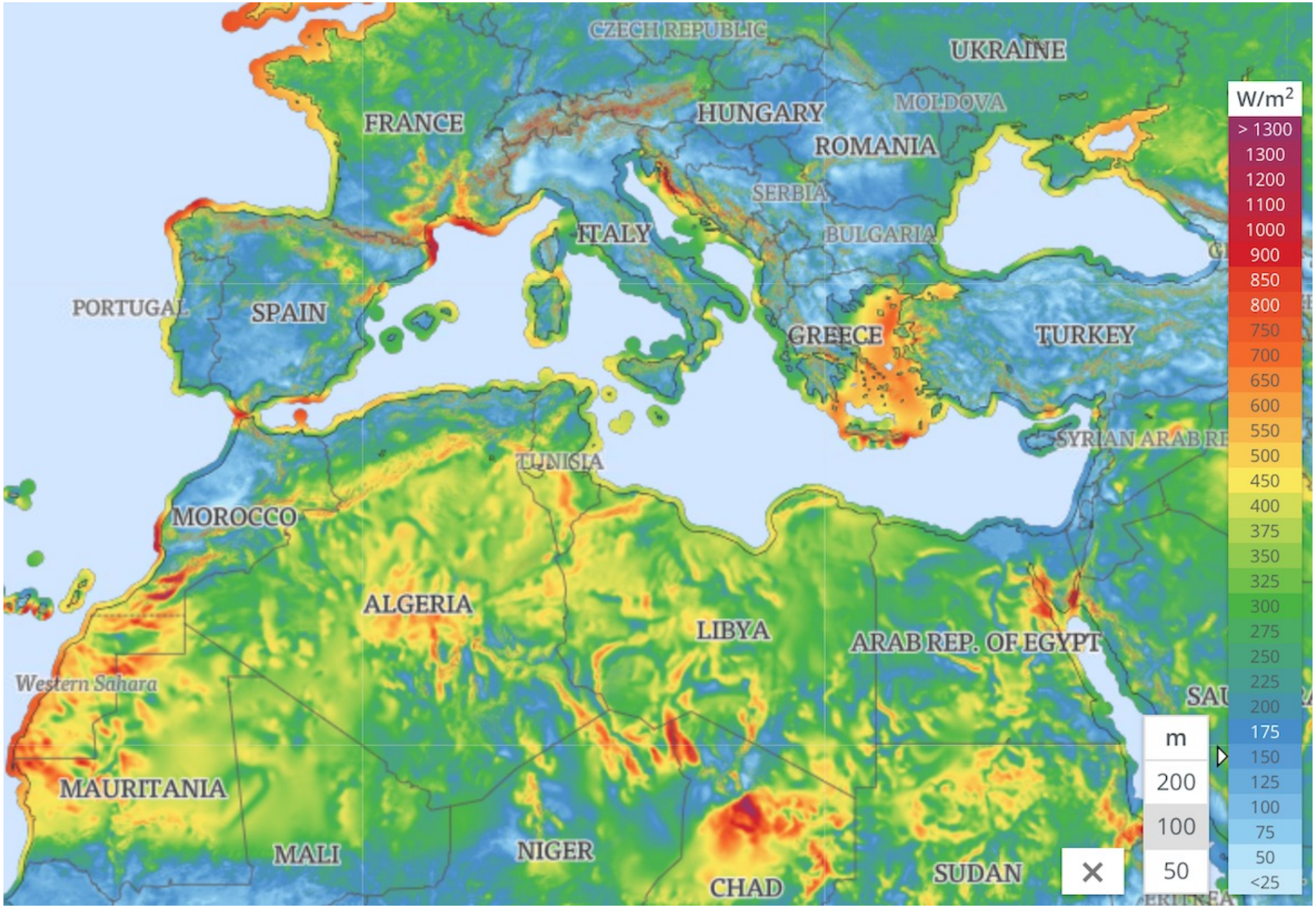
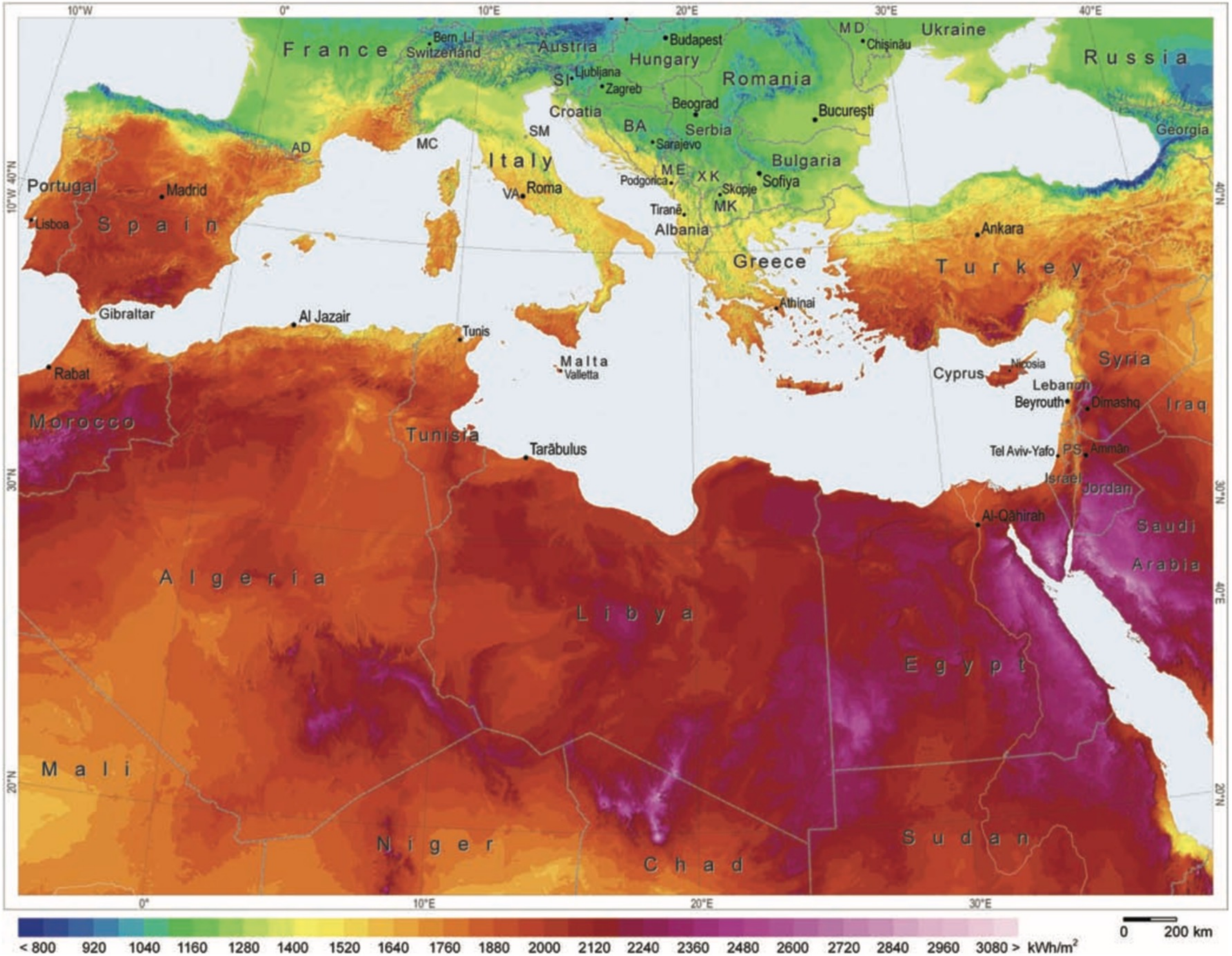


* The Global Wind Atlas (https://globalwindatlas)

Solar potential in SE Mediterranean region*



* Easac & Pihl, Erik. (2011). Concentrating Solar Power: Its potential contribution to a sustainable energy future

Main indigenous energy sources in SE Mediterranean region

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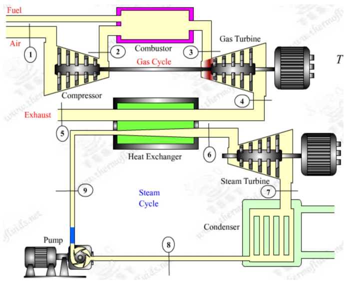
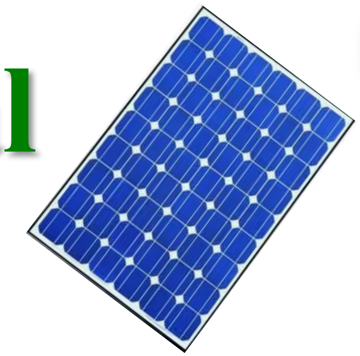
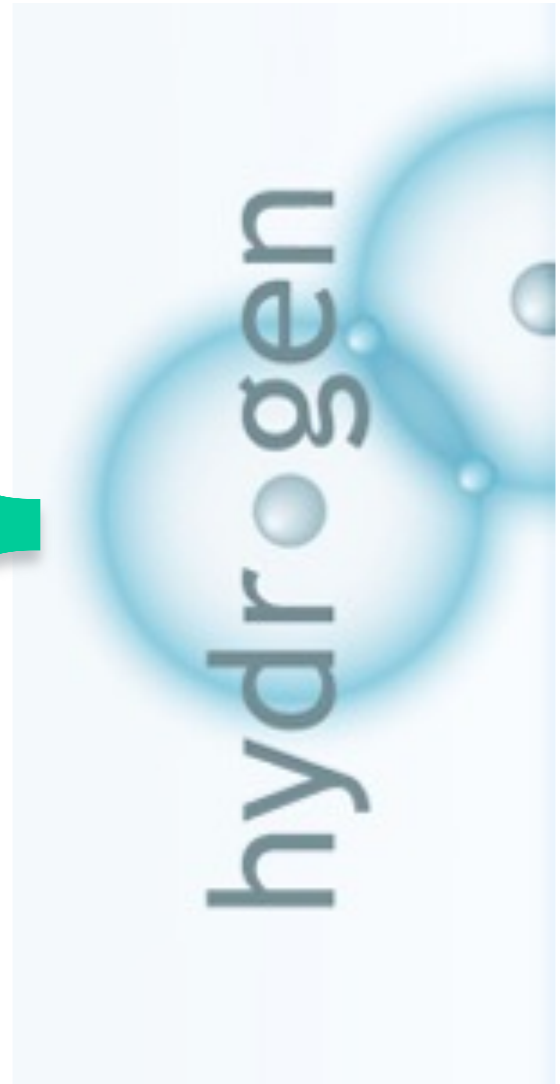
- **Natural gas**



- **Wind potential**

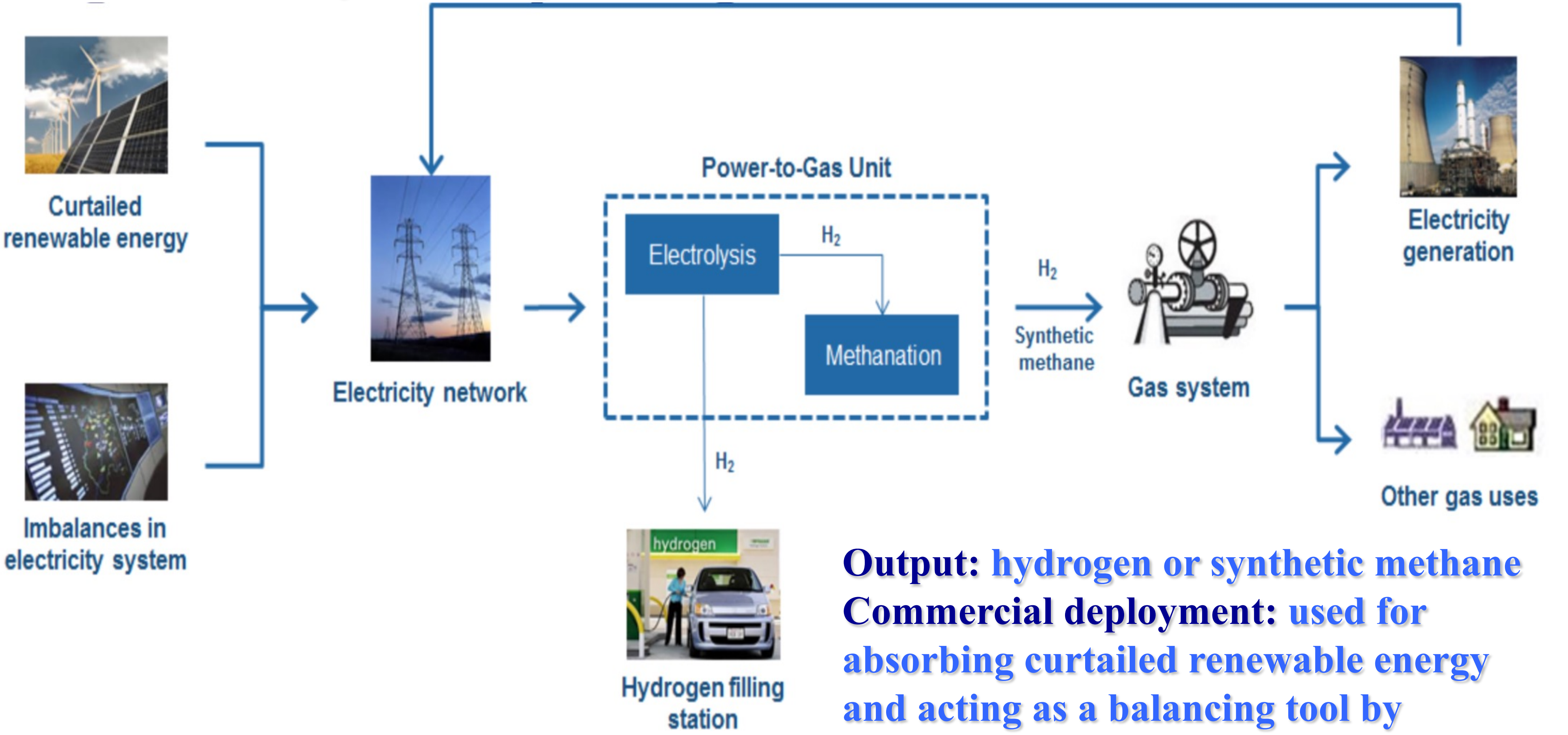
- **Solar potential**





Power-to-Gas (P2G)*

- **energy storage technology linking the electricity and gas infrastructure**



Output: hydrogen or synthetic methane
Commercial deployment: used for absorbing curtailed renewable energy and acting as a balancing tool by electricity TSOs

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

Target-setting for Cyprus' transition to hydrogen economy*

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Target	Year		
	2030	2040	2050
Greenhouse gases	-30%	-75%	-100%
Renewable energy sources	30%	75%	100%
Electrical interconnections	50%	65%	80%

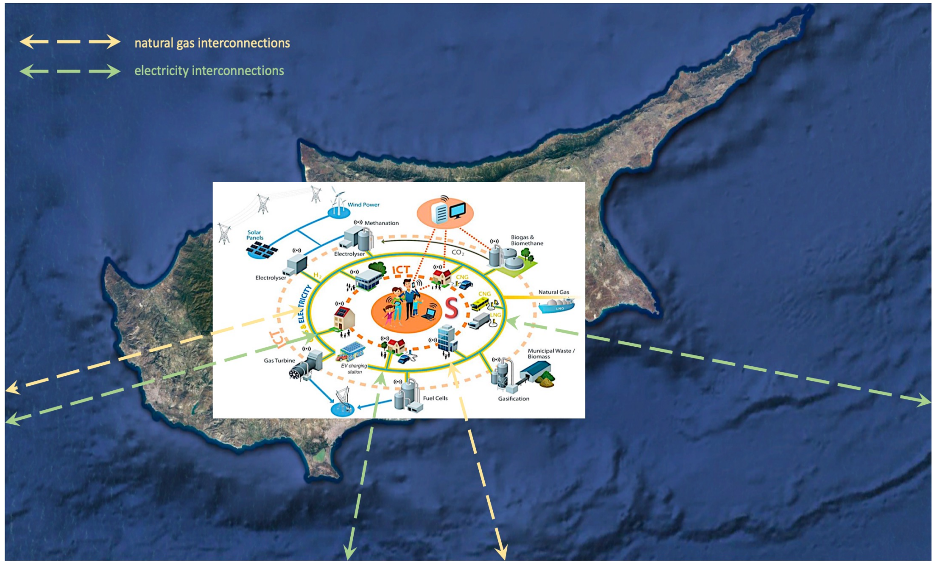
Cyprus could set a long-term goal of reducing greenhouse gas emissions by 100% by 2050 !

* Poullikkas A., 2020, *Long-term Sustainable Energy Strategy: Cyprus' Energy Transition to Hydrogen Economy*, ISBN: 978-9925-7710-0-4

Energy transition by 2050

Cyprus' energy system:

- smart and digitised
- flexible
- decentralised
- electrically interconnected
- interconnected gas and/or hydrogen pipelines



Integration:

- hydrogen in all energy sectors
- renewable energy sources
- storage energy systems
- electric mobility

Transition of Cyprus from the current carbon economy to hydrogen economy by the year 2050

Development of regional energy strategy ?

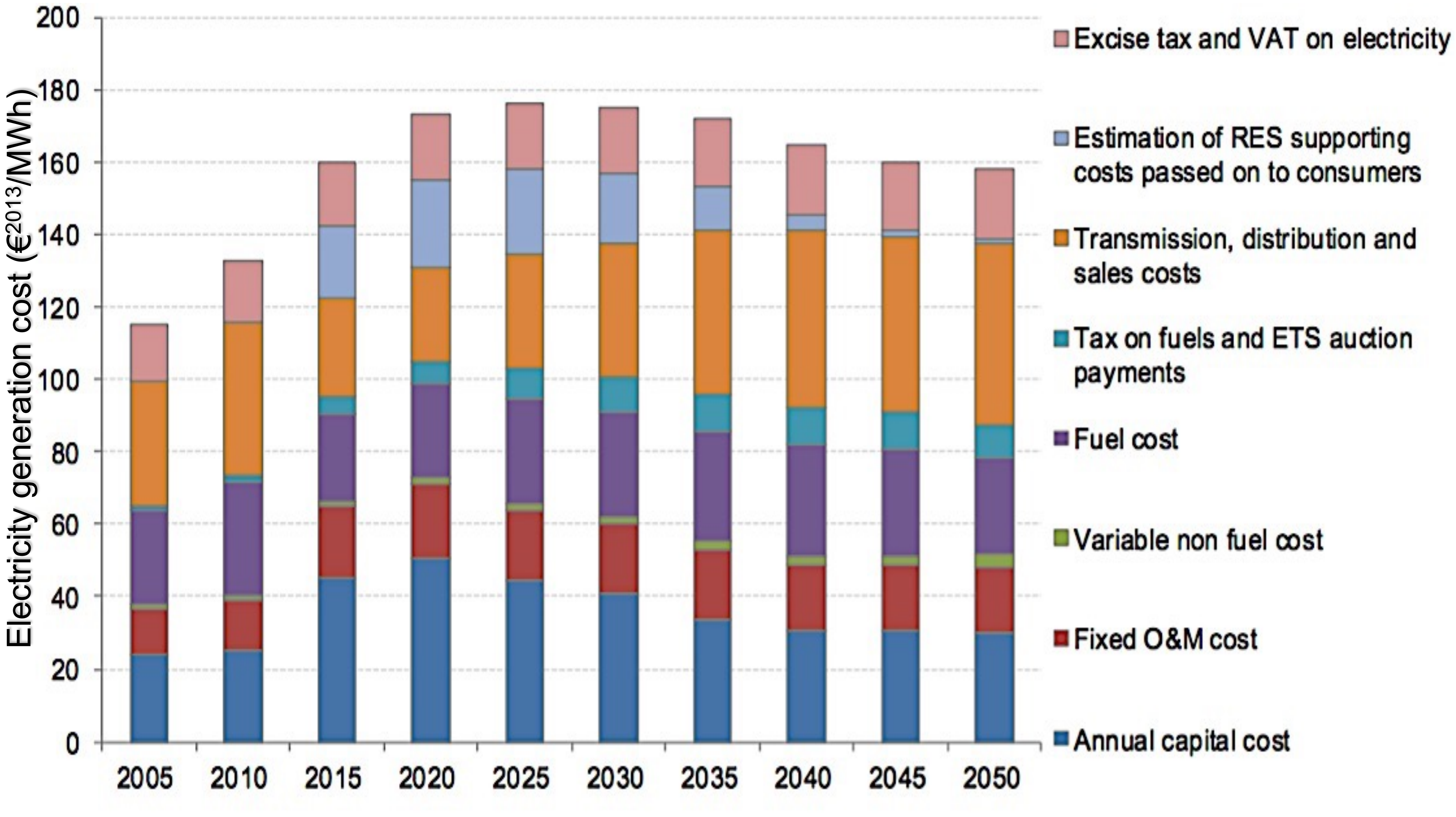
- **Horizon up to 2060**
- **Development of strategic plan for SE Med region:**
  - ~ **Electrical interconnections**
  - ~ **Pipeline interconnections (or virtual pipelines)**
  - ~ **Integration of sustainable technologies and storage**
  - ~ **Use of hydrogen after 2030**
  - ~ **Hydrogen production**
    - **From natural gas**
    - **From renewables**
- **Energy exporters to EU**

Additional Slides

The energy transition cost

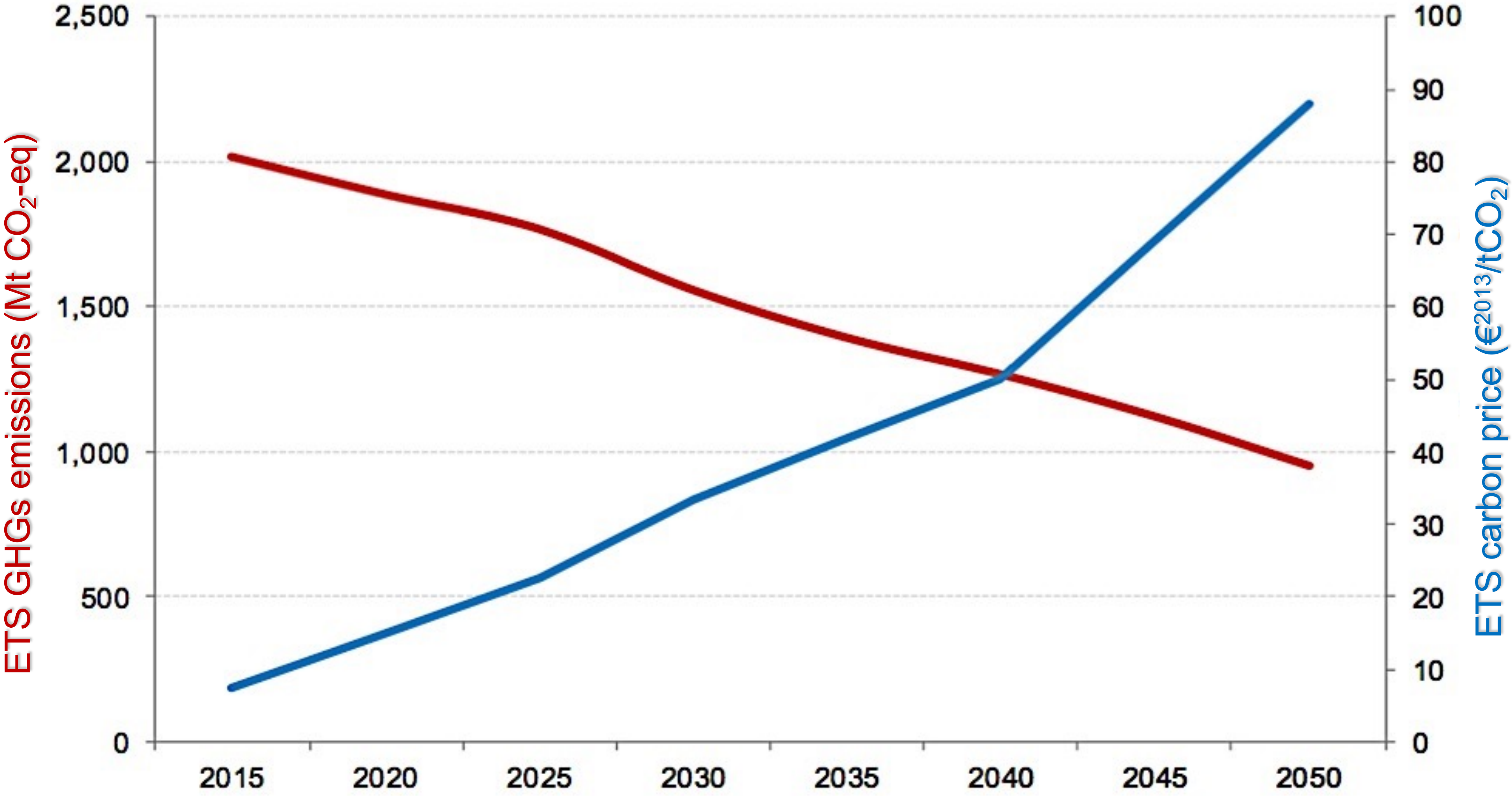
Towards 2050

EU reference scenario 2016



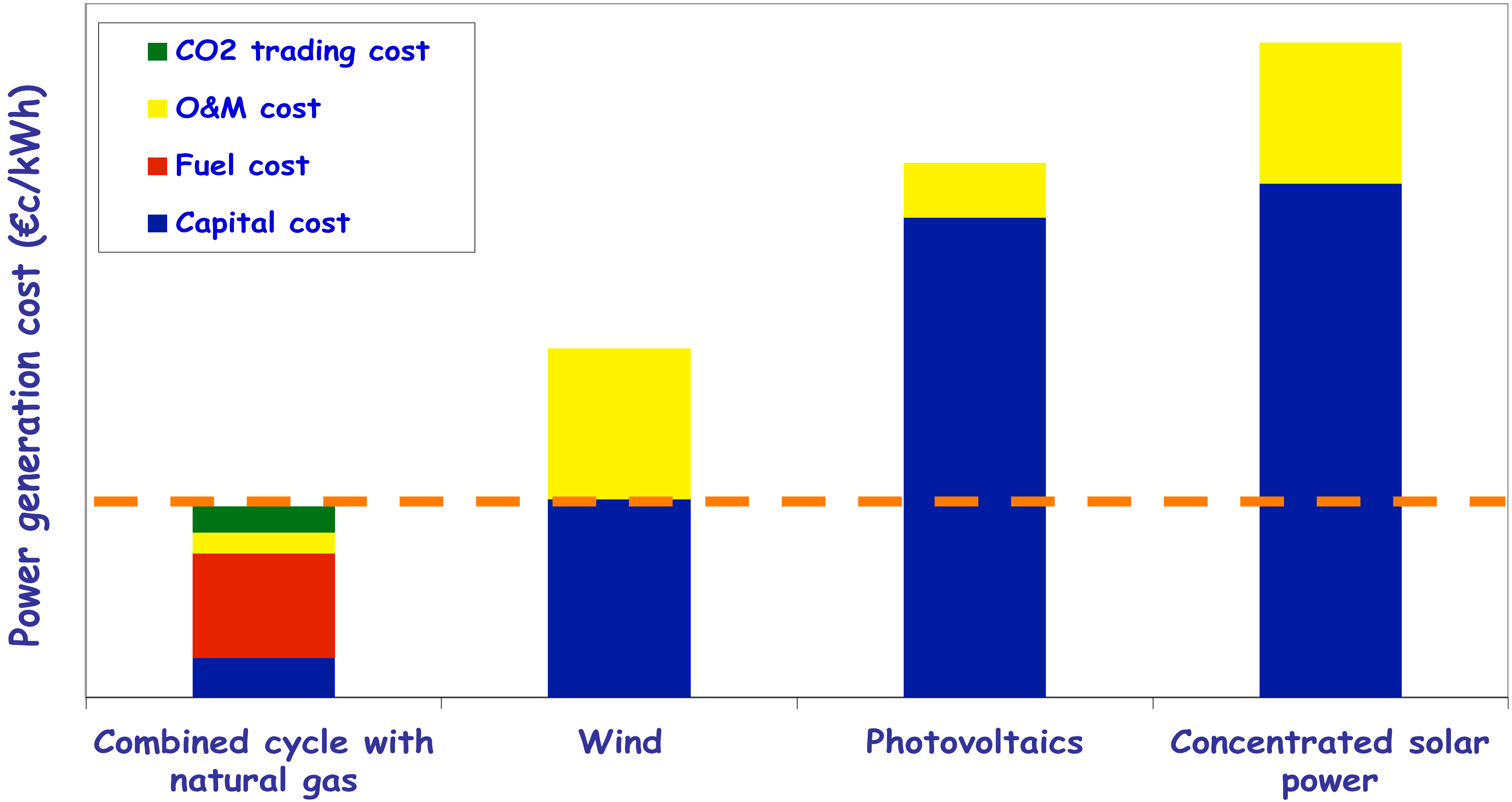
Source: PRIMES

EU reference scenario 2016



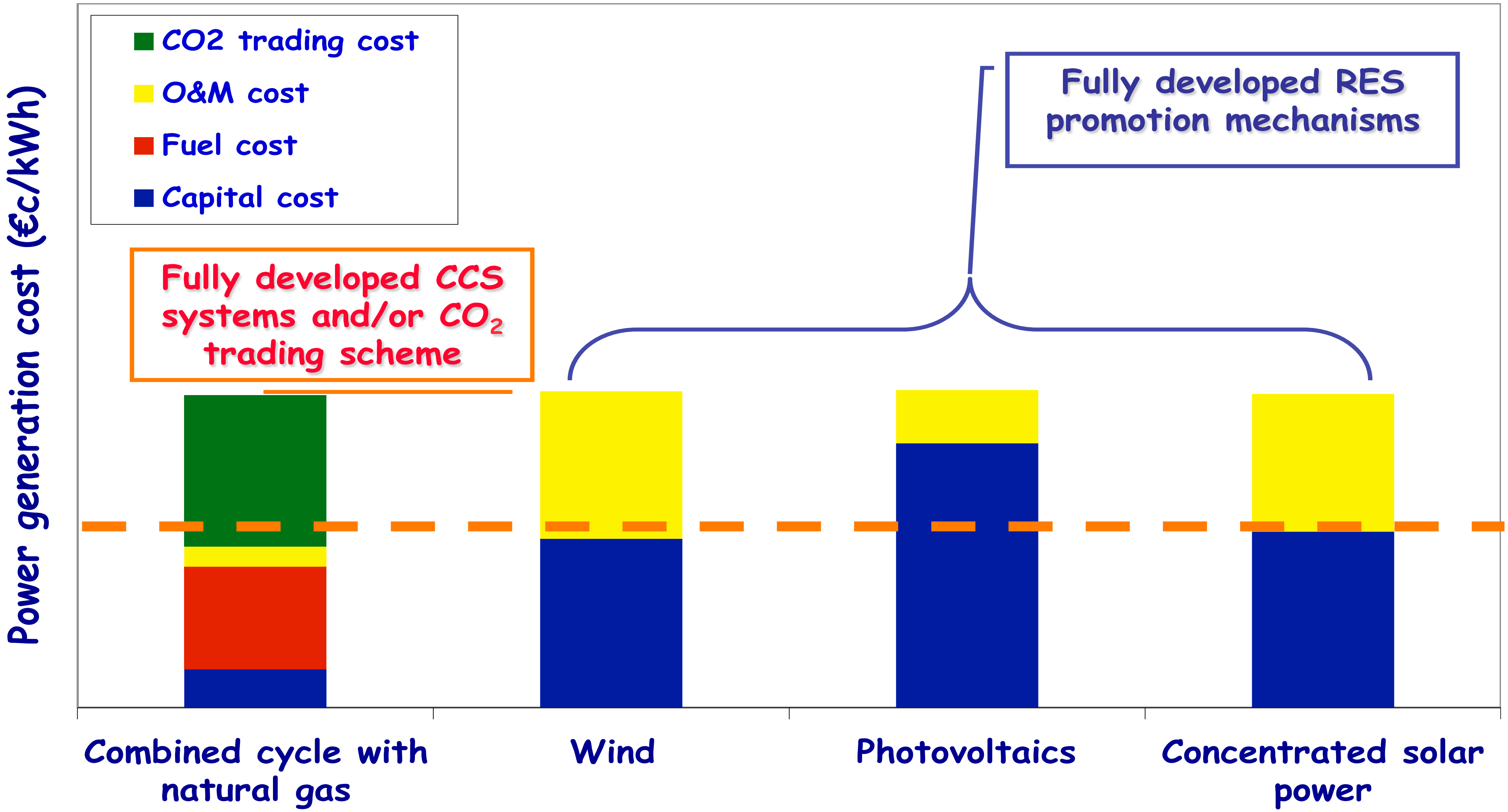
Source: PRIMES, GAINS

Power generation cost (year 2010)*



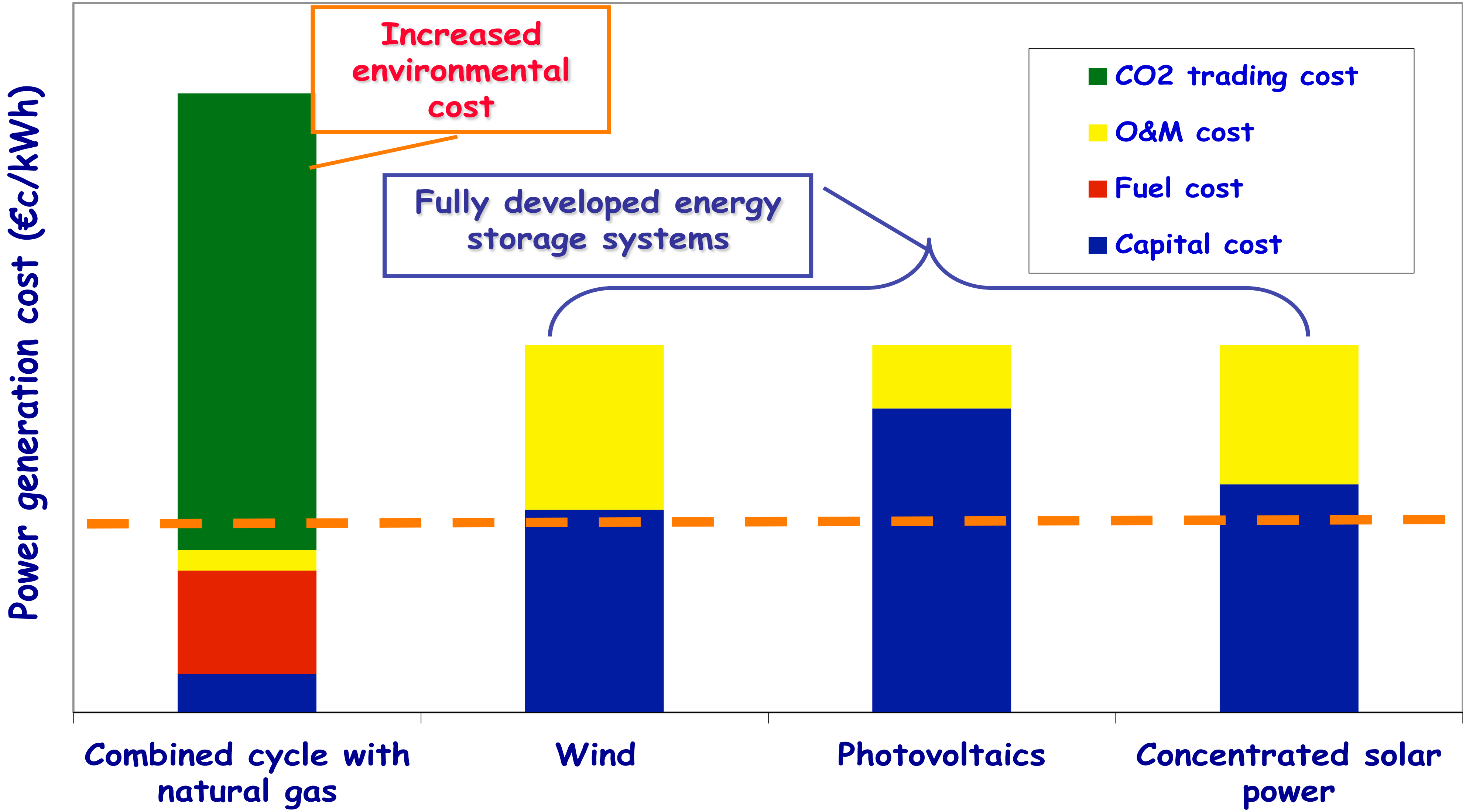
* Poullikkas A., 2010, "The cost of integration of renewable energy sources", *Accountancy*

Power generation cost (year 2020-30)*



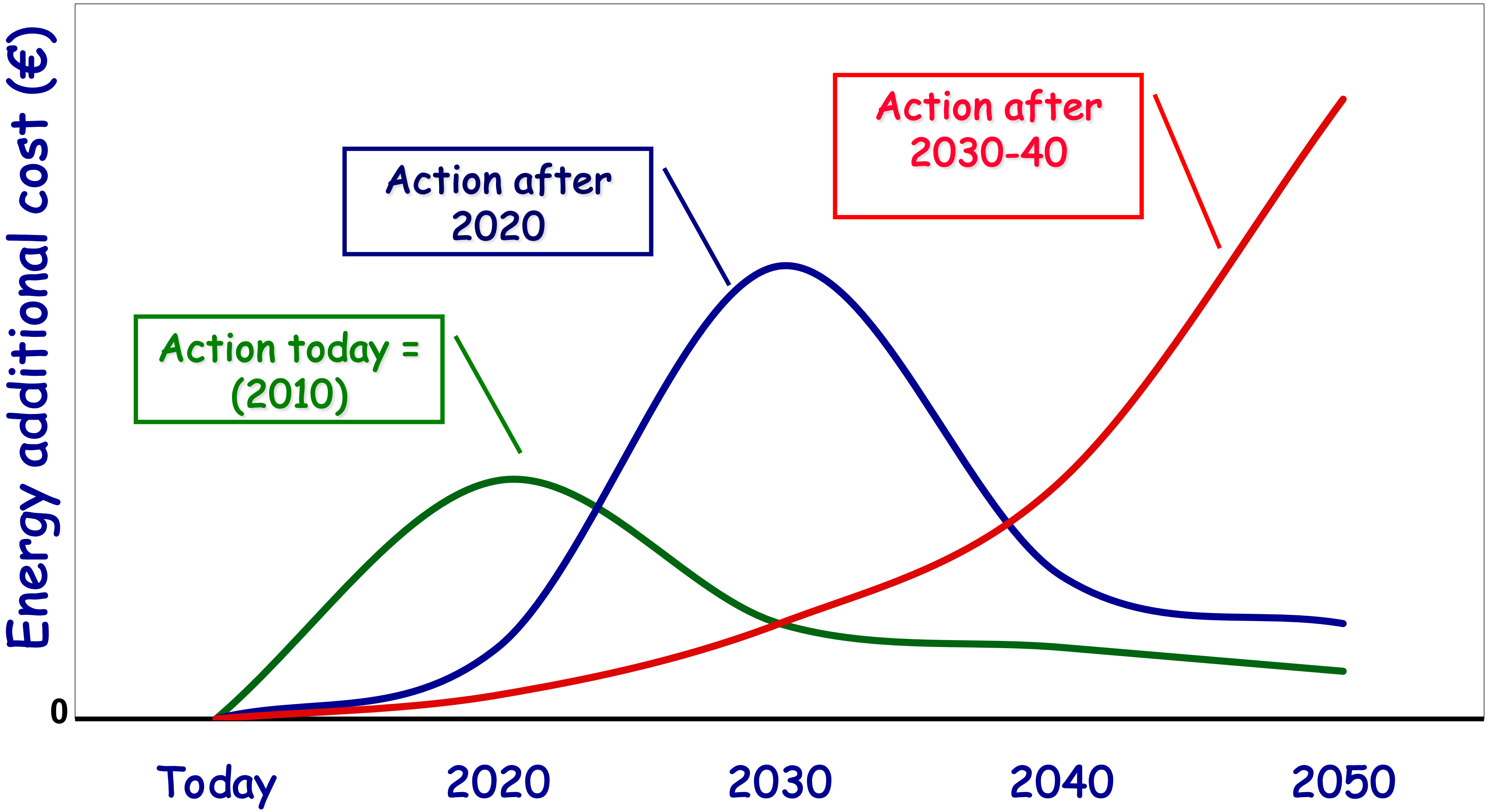
* Poullikkas A., 2010, "The cost of integration of renewable energy sources", *Accountancy*

Power generation cost (year 2040-50)*



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

Future energy cost* (for EU only)



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