



Challenges towards carbon neutral energy systems

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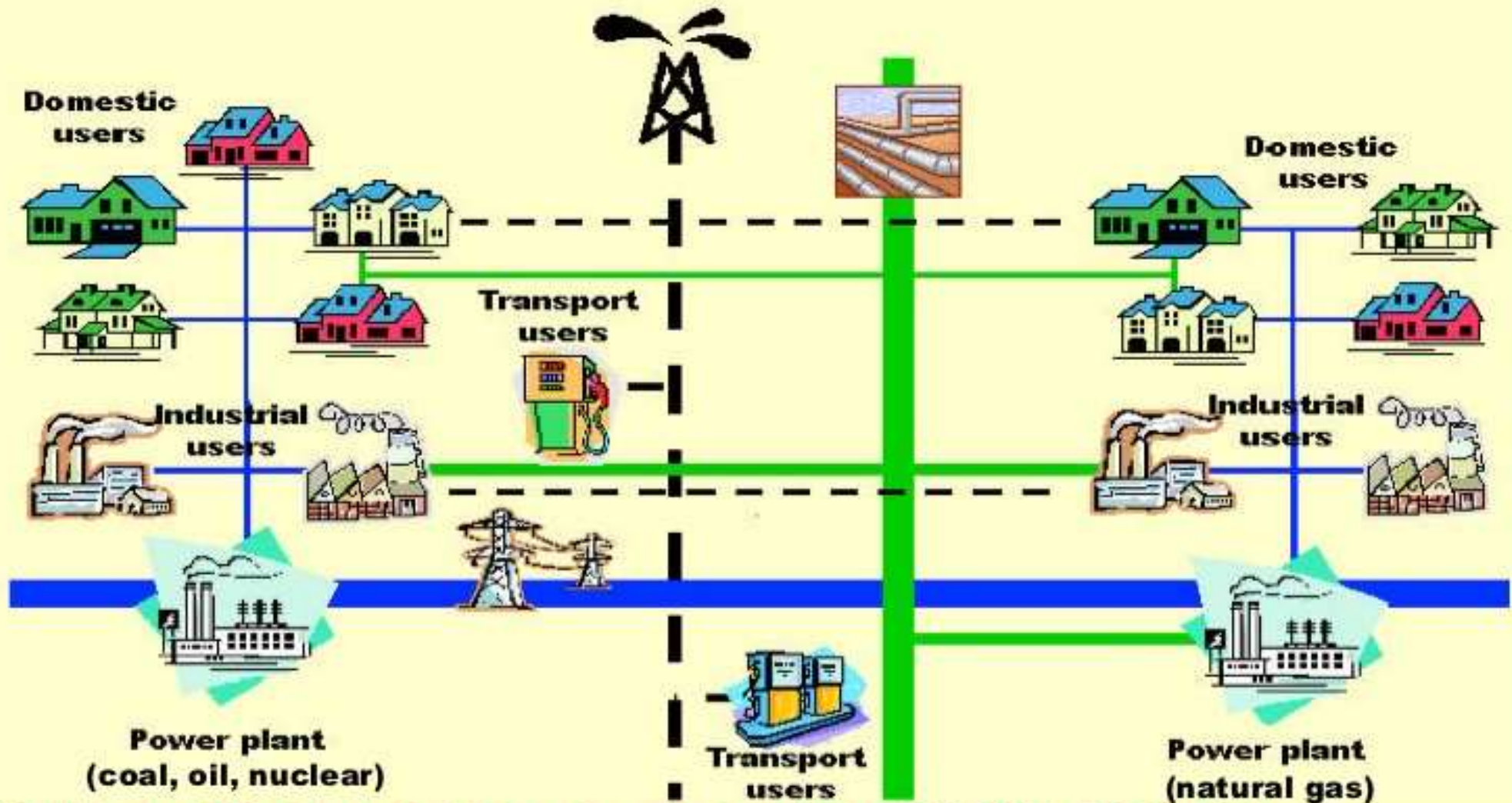
Contents

- **EU energy strategy** – towards 2050
- **Energy transition for island systems** – solutions to isolated systems
- **Short to medium term challenges** – large scale integration of RES
- **Medium to long term challenges** – the role of interconnections and hydrogen

EU energy strategy towards 2050

Current energy system

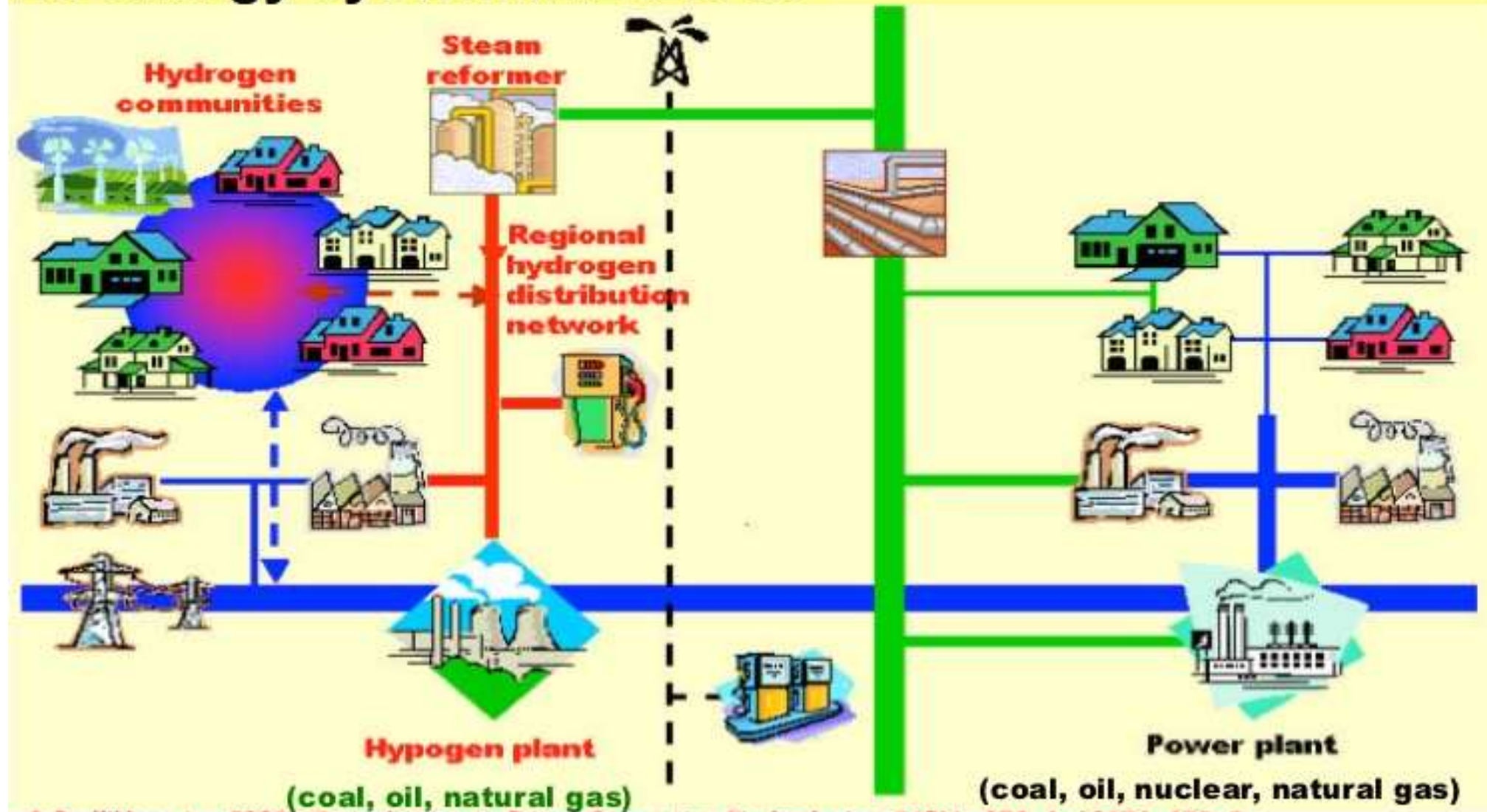
EU energy system today*



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

Future energy systems (optimistic scenario)

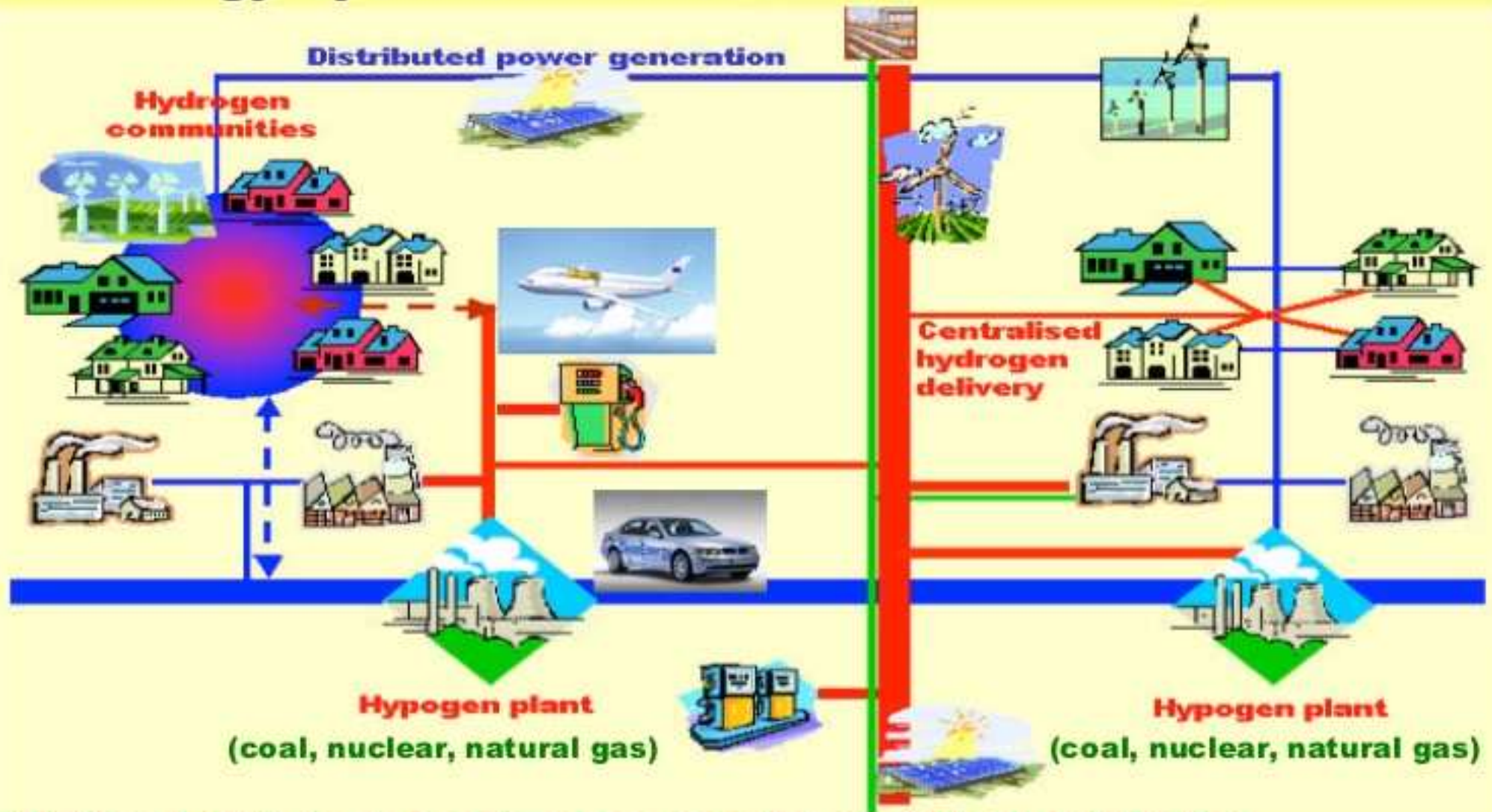
EU energy system in 2020-30*



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

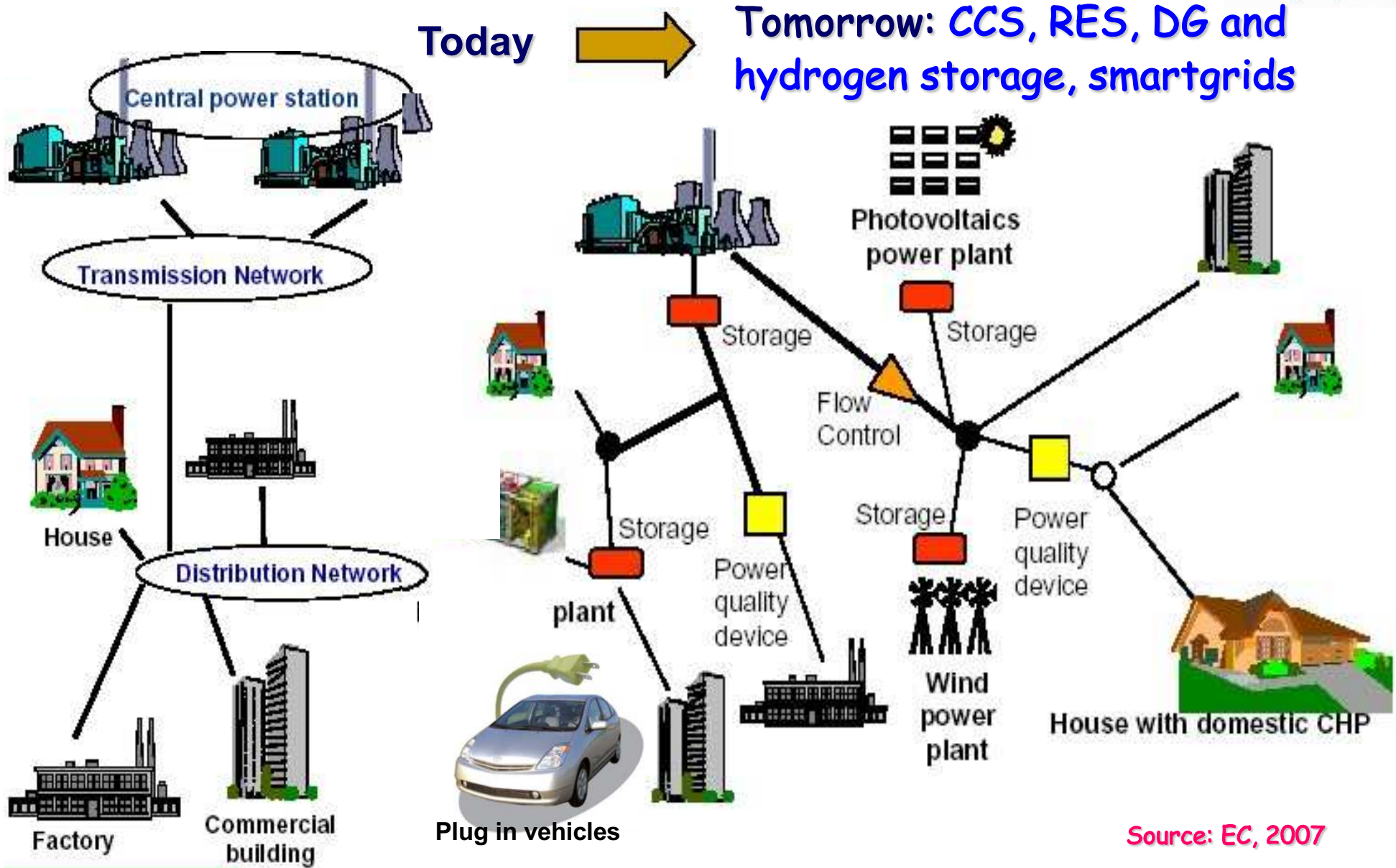
Future energy systems (optimistic scenario)

EU energy system in 2040-50*



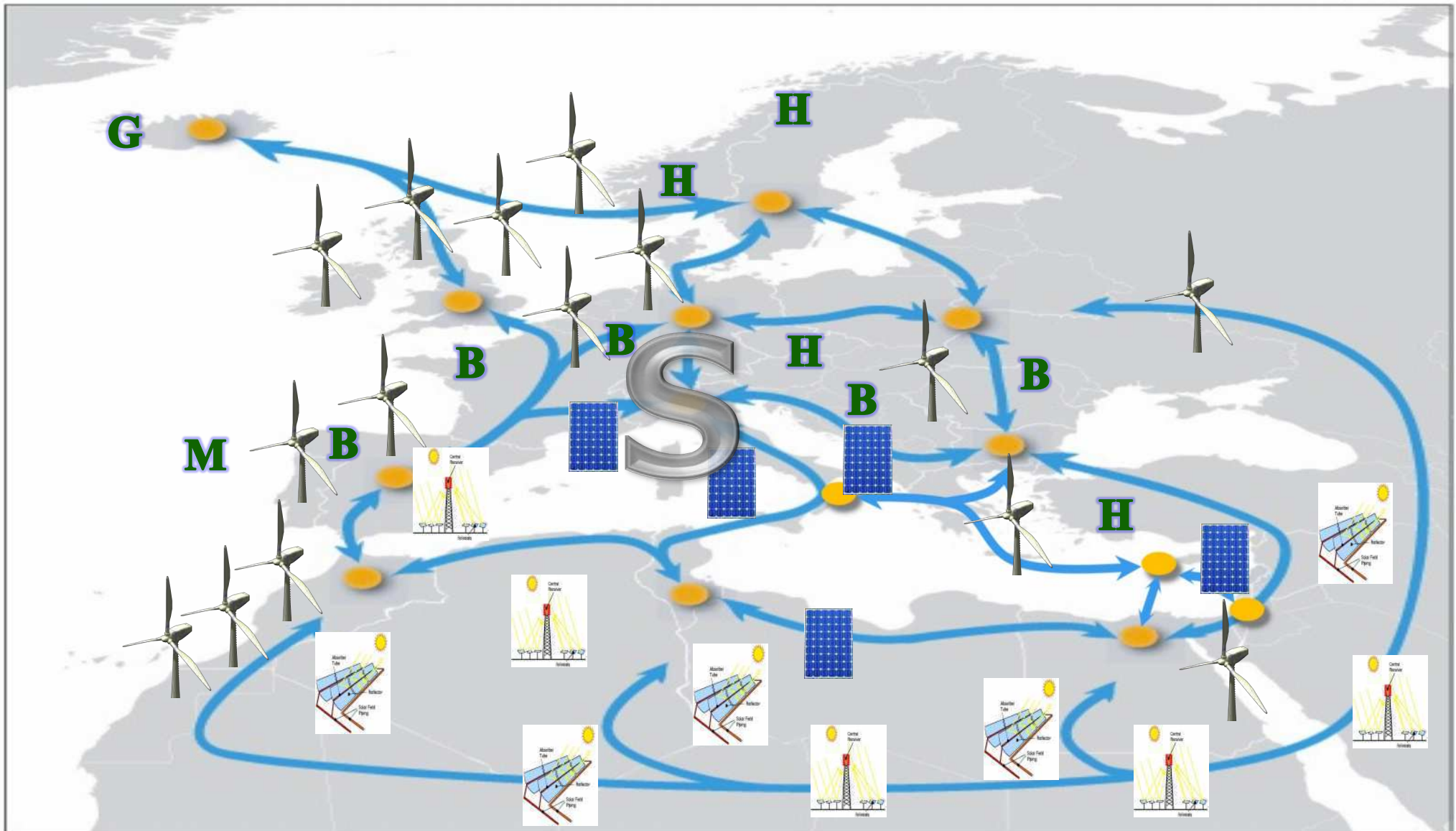
* Poullikkas A., 2009, *Introduction to Power Generation Technologies*, ISBN: 978-1-60876-472-3

Future power systems



Source: EC, 2007

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

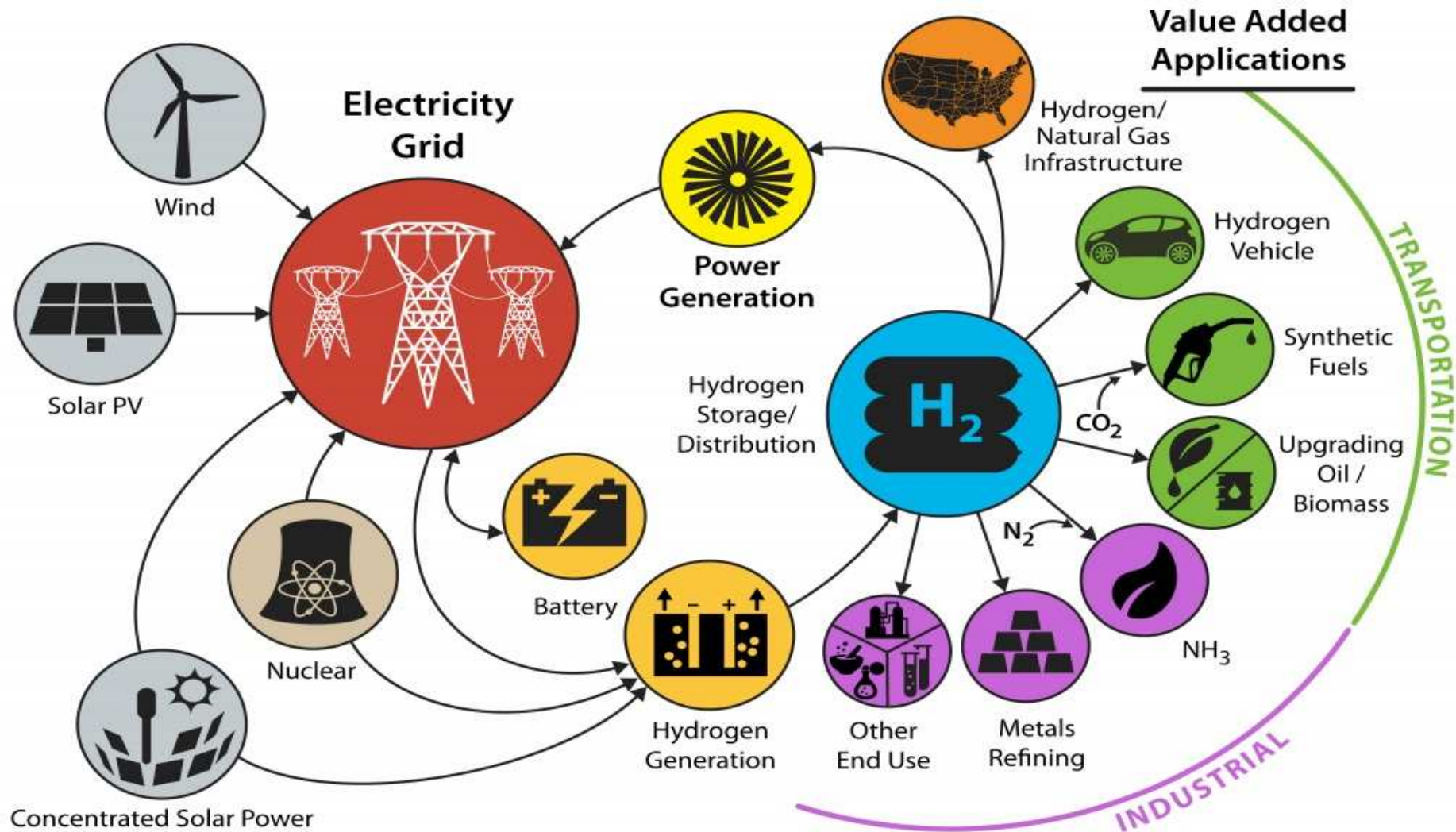


* Poullikkas A., 2013, *Sustainable Energy Development for Cyprus*, ISBN: 978-9963-7355-3-2

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Θεσσαλονίκη, Ελλάδα, 15 Σεπτεμβρίου 2021

Long term scenarios in Europe

Moving from **Carbon** economy to **Hydrogen** economy



Energy transition for island systems

Solutions for isolated systems

Characteristics of isolated electricity systems*



- **High fuel costs**
 - ~ use of oil derivatives
- **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

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

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

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

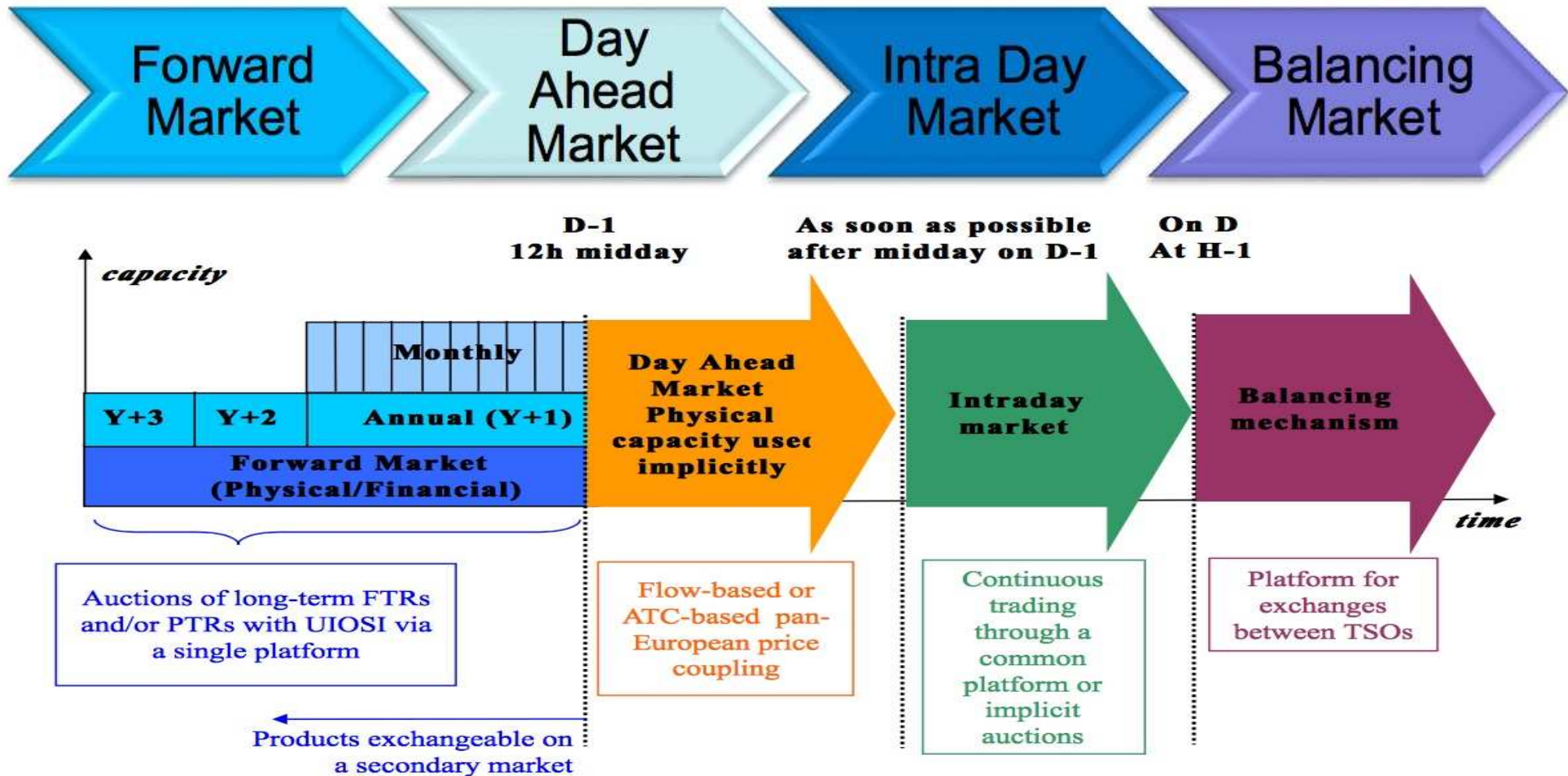
CEEA Energy Transition Regulatory Decisions

- **Regulatory Decision 01/2017 (ΚΑΠ 34/2017):** A detailed schedule for the implementation of EU electricity market target model
- **Regulatory Decision 02/2018 (ΚΑΠ 259/2018):** The mass installation of an Advanced Metering Infrastructure including smartmeters to all electricity consumers
- **Regulatory Decision 02/2019 (ΚΑΠ 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 (ΚΑΠ 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

Short to medium term challenges

Large scale integration of RES

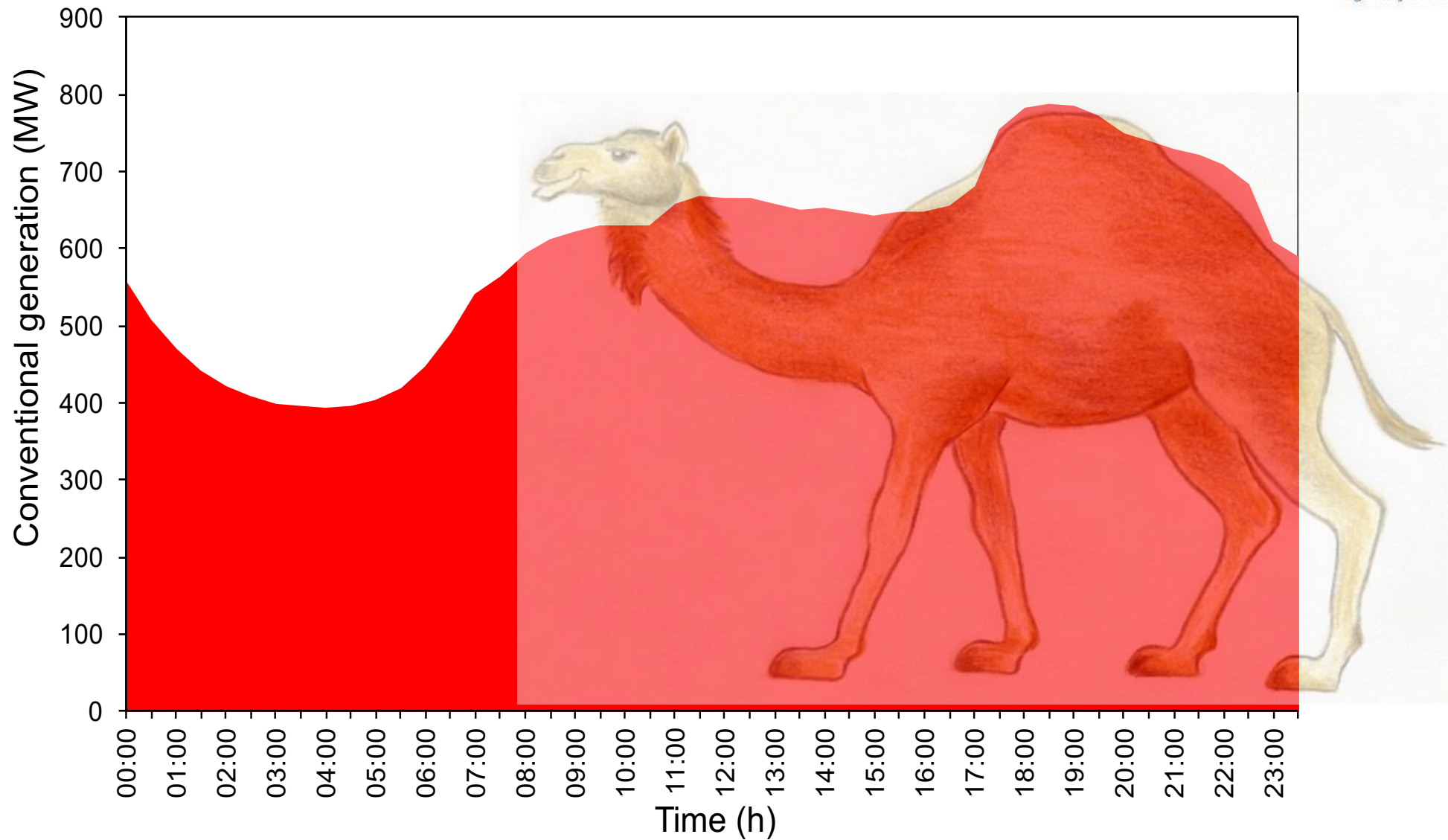
EU electricity market target model



Integration of RES*: LCOE vs Reliability

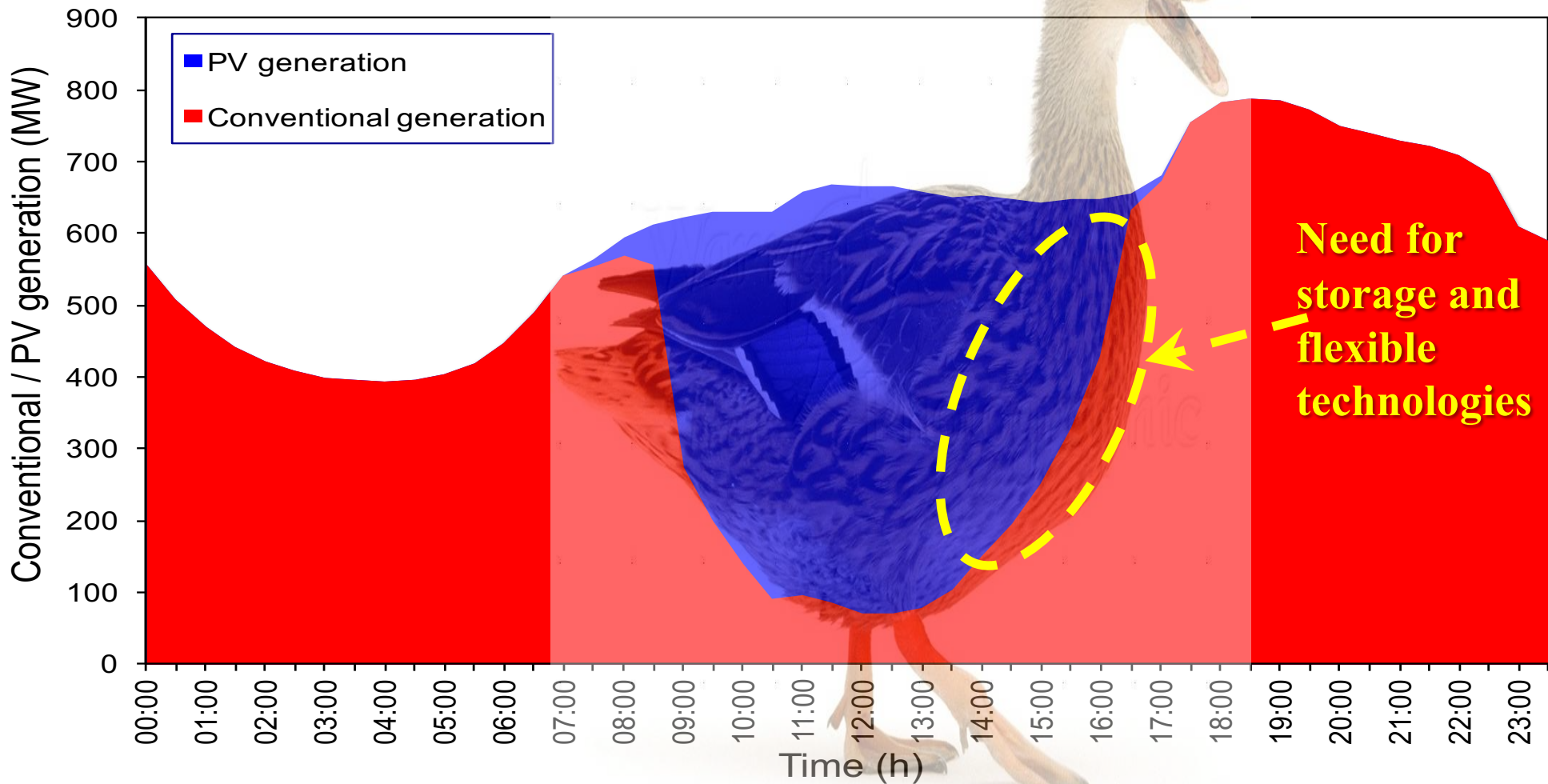
* Nicolaidis P., Chatzis S., Poullikkas A., 2018, "Renewable energy integration through optimal unit commitment and electricity storage in weak power networks", *International Journal of Sustainable Energy*

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')*



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

Medium to long term challenges

The role of interconnections and hydrogen

Regional primary energy sources

Indigenous energy sources

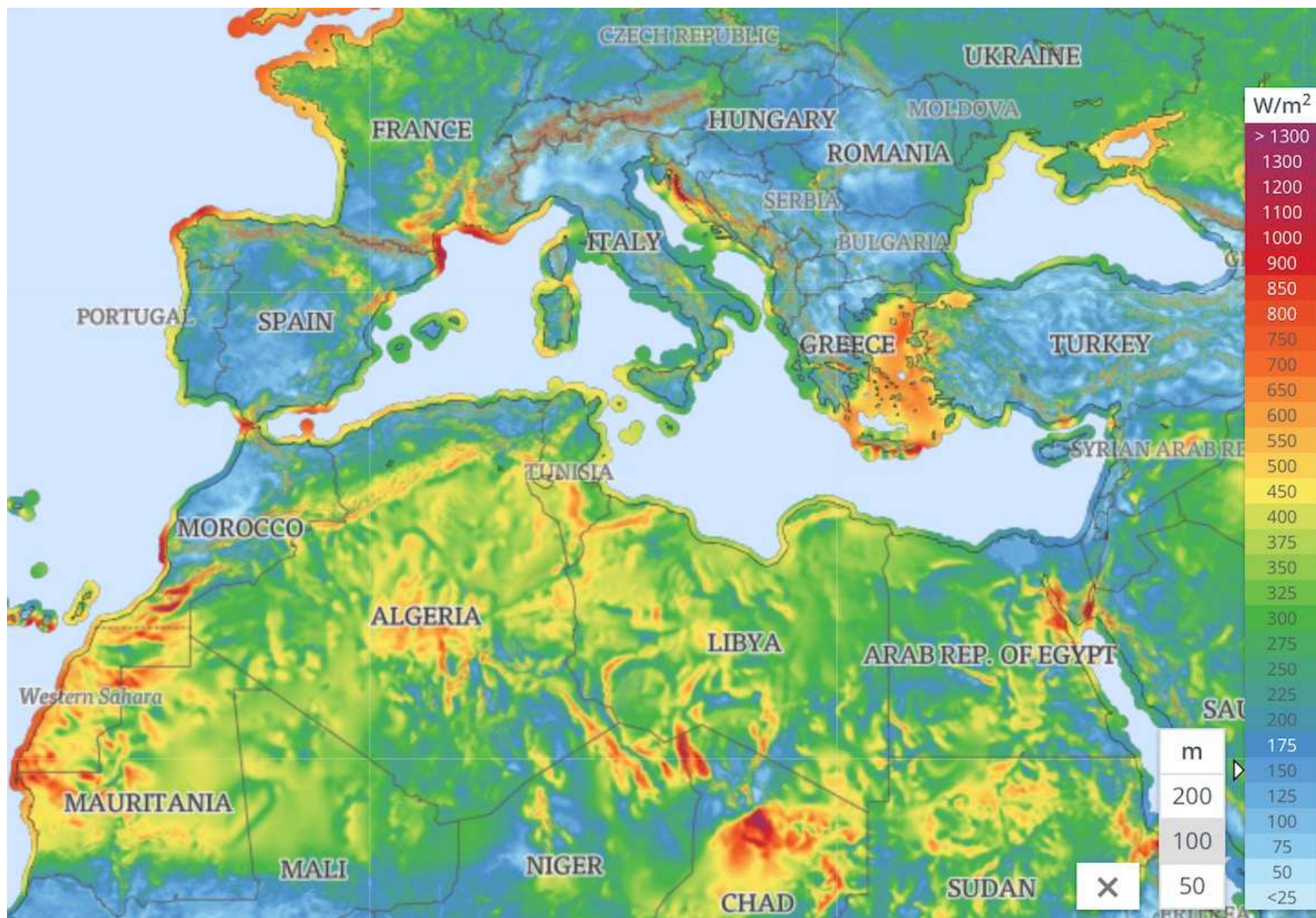


Gas reserves in SE Mediterranean region*



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

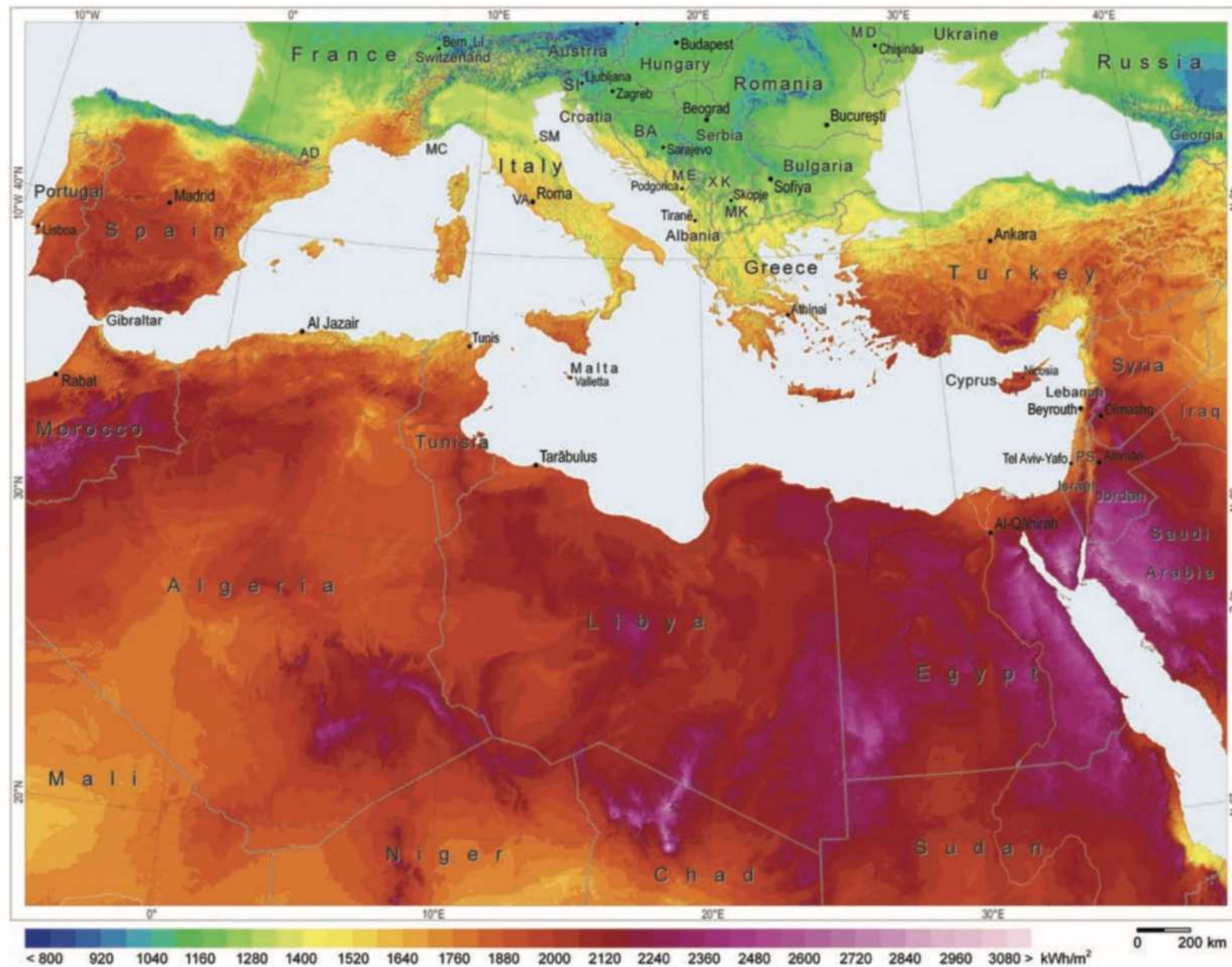
Wind potential in SE Mediterranean region*



* The Global Wind Atlas (<https://globalwindatlas.com>)

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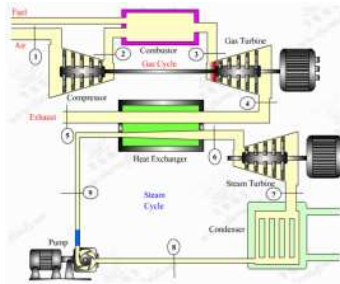
Solar potential in SE Mediterranean region*



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

Main indigenous energy sources in SE Mediterranean region

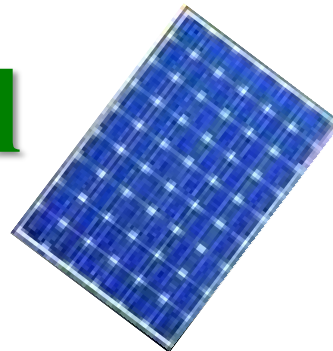
- **Natural gas**



- **Wind potential**

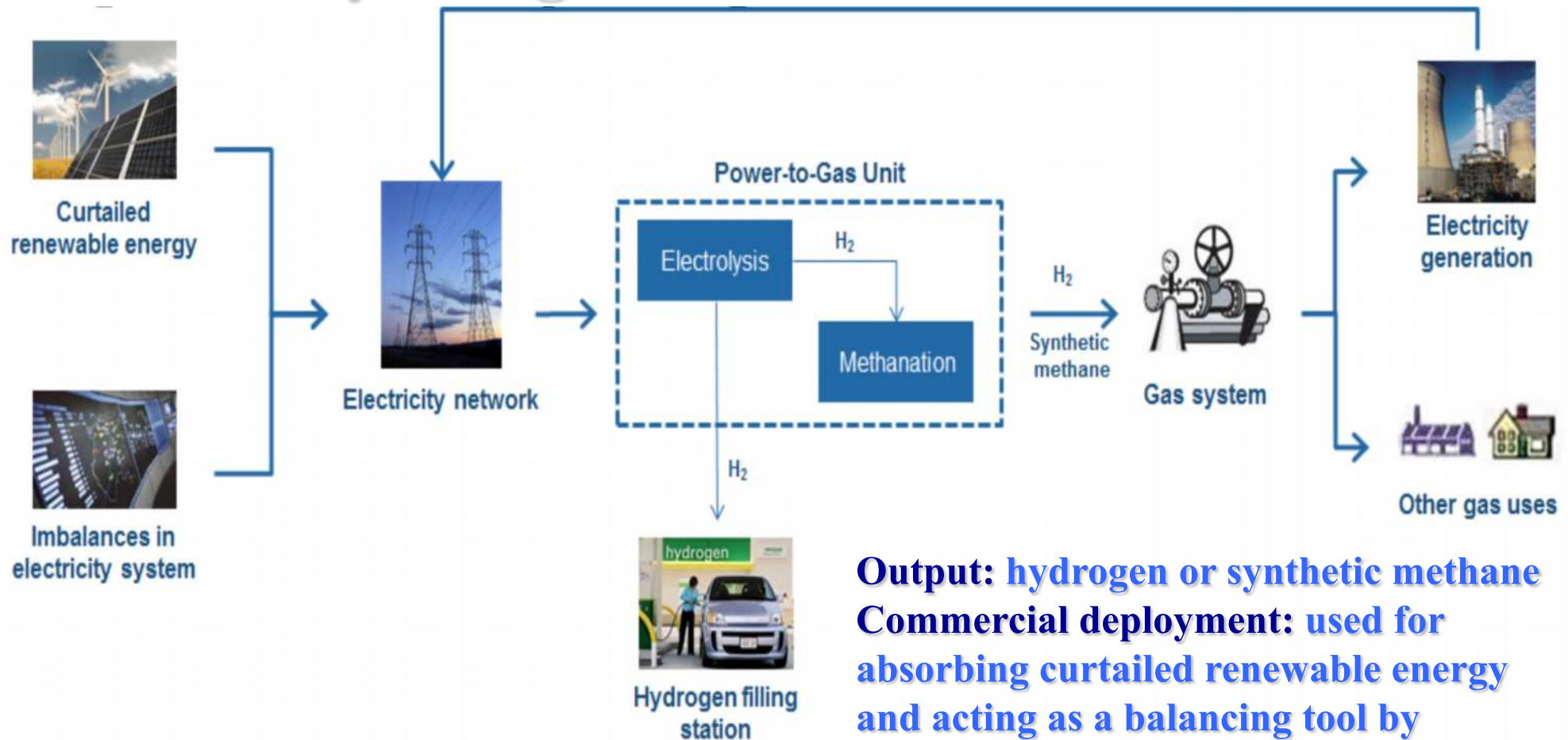


- **Solar potential**



Power-to-Gas (P2G)*

- energy storage technology linking the electricity and gas infrastructure



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

Target-setting for Cyprus' transition to hydrogen economy*

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

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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**

