Future sustainable power systems towards decarbonization

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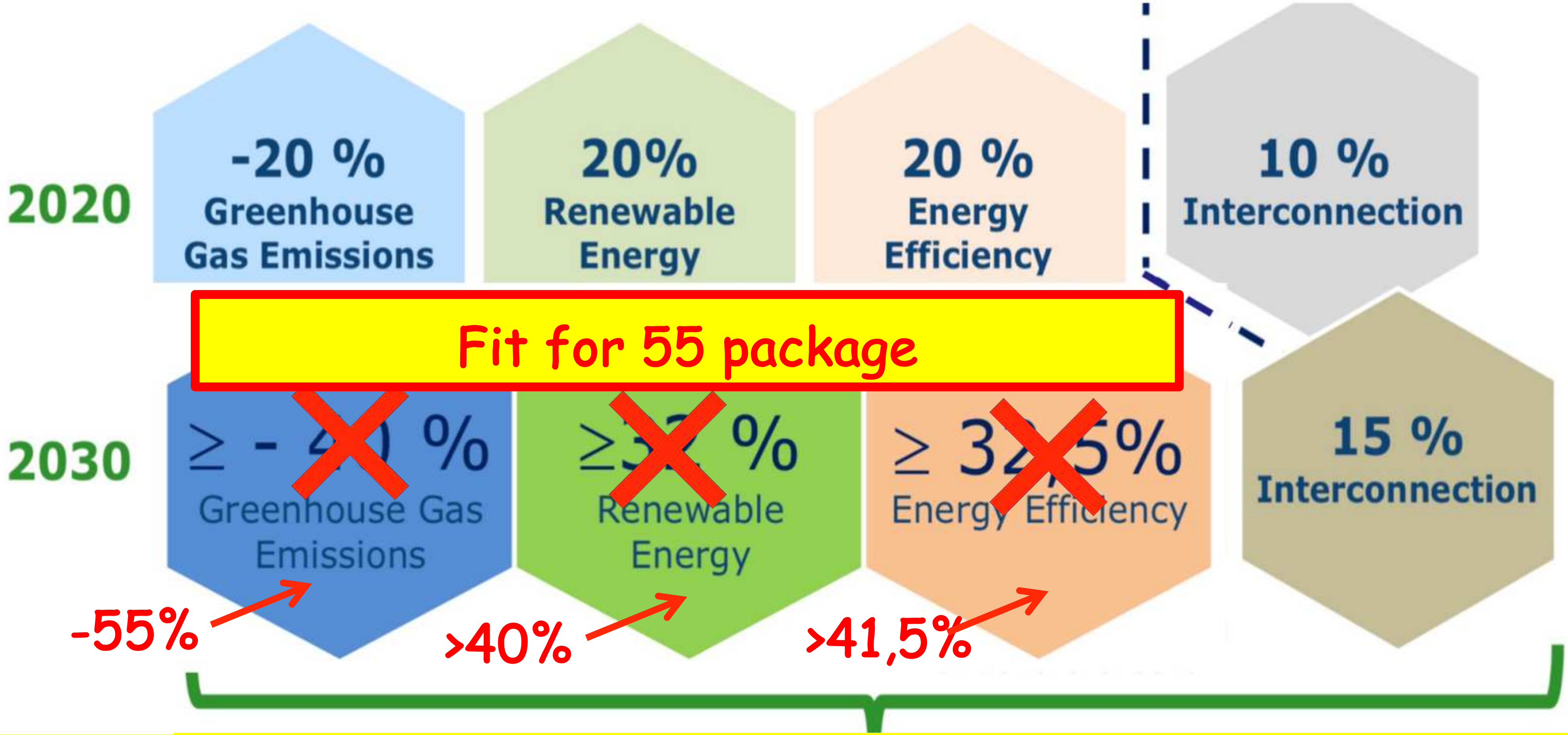
Contents

- **EU energy strategy** – **towards 2050**
- **Cyprus current electricity system** – **system characteristics**
- **Energy transition for island systems** – **solutions to isolated systems**
- **Medium to long term challenges** – **large scale integration of RES, the role of interconnections and hydrogen**

EU energy strategy

towards 2050

EU medium and long term targets

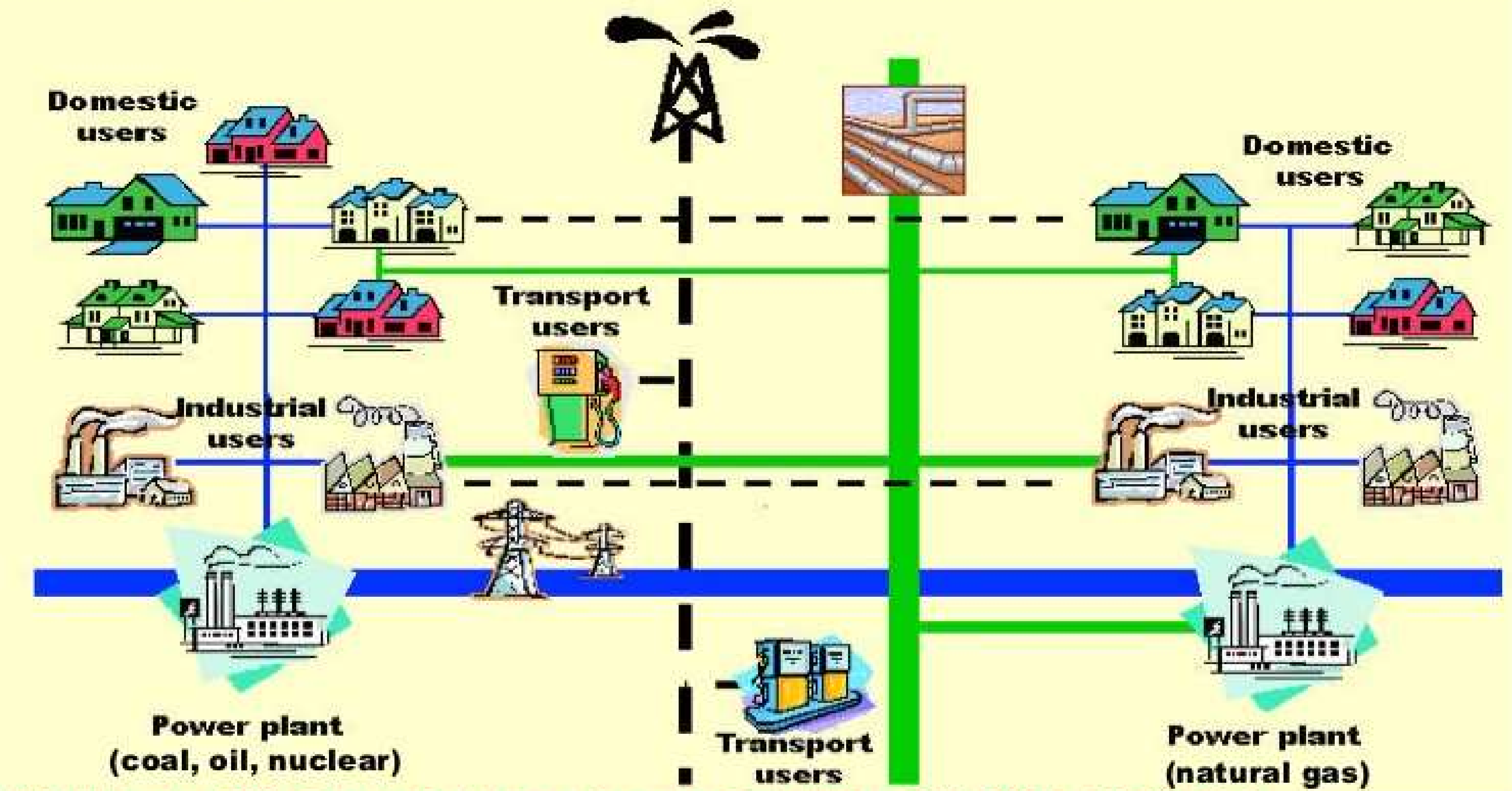


2050 **Climate-Neutral**

(an economy with net-zero greenhouse gas emissions)

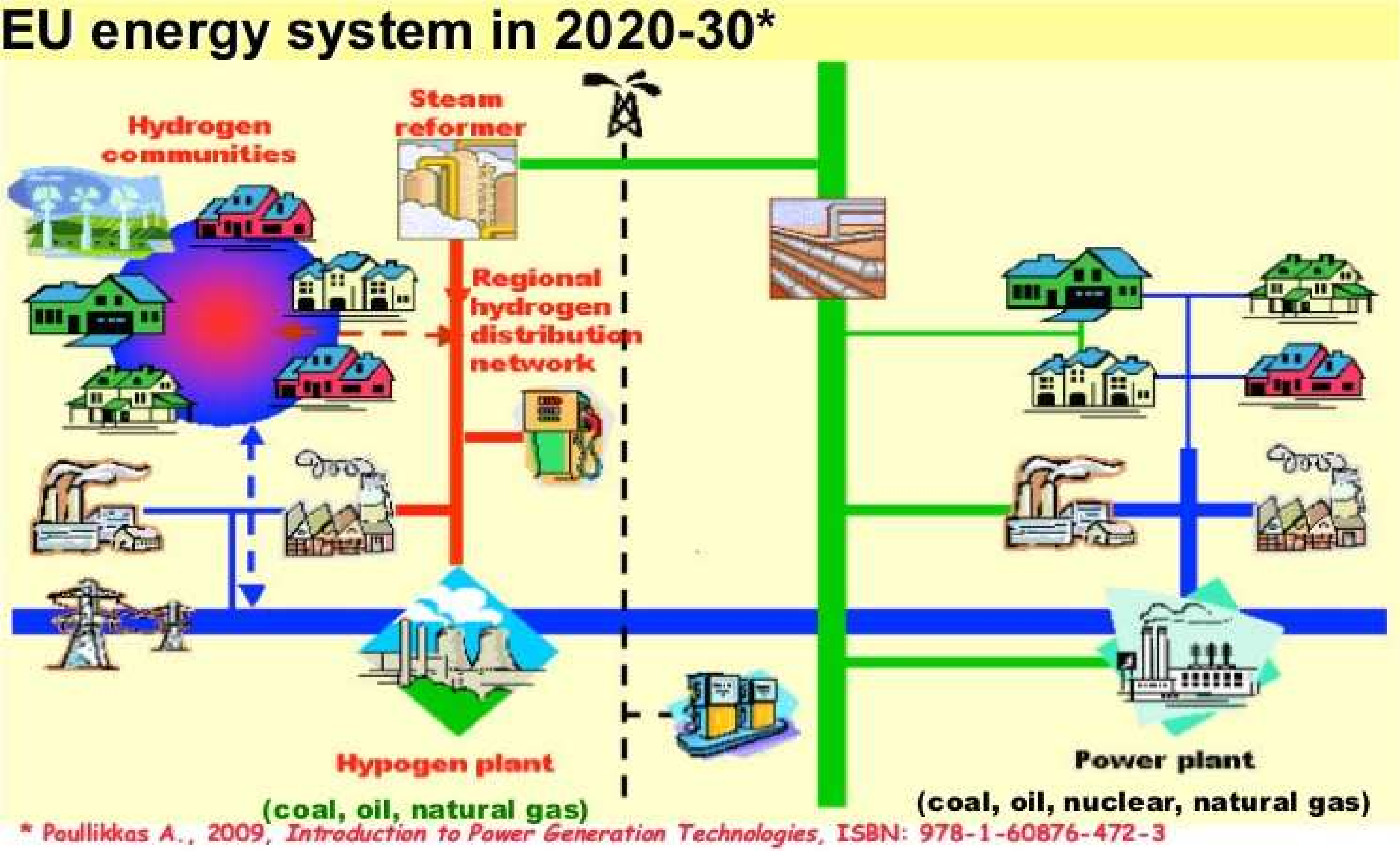
Energy system in 2010

EU energy system in 2010*

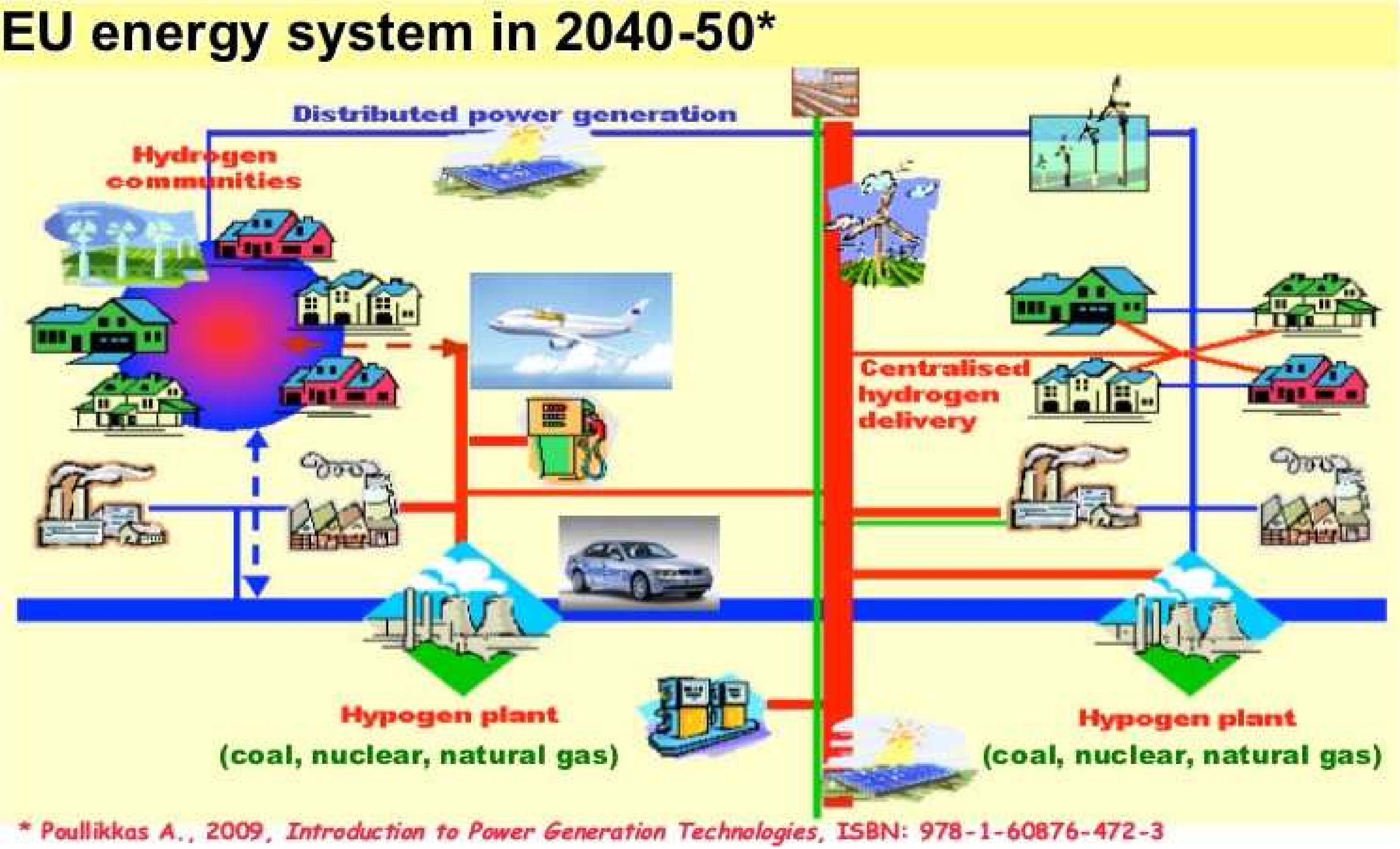


* Poullikkos A., 2009, *Introduction to Power Generation Technologies*, ISBN: 978-1-60876-472-3

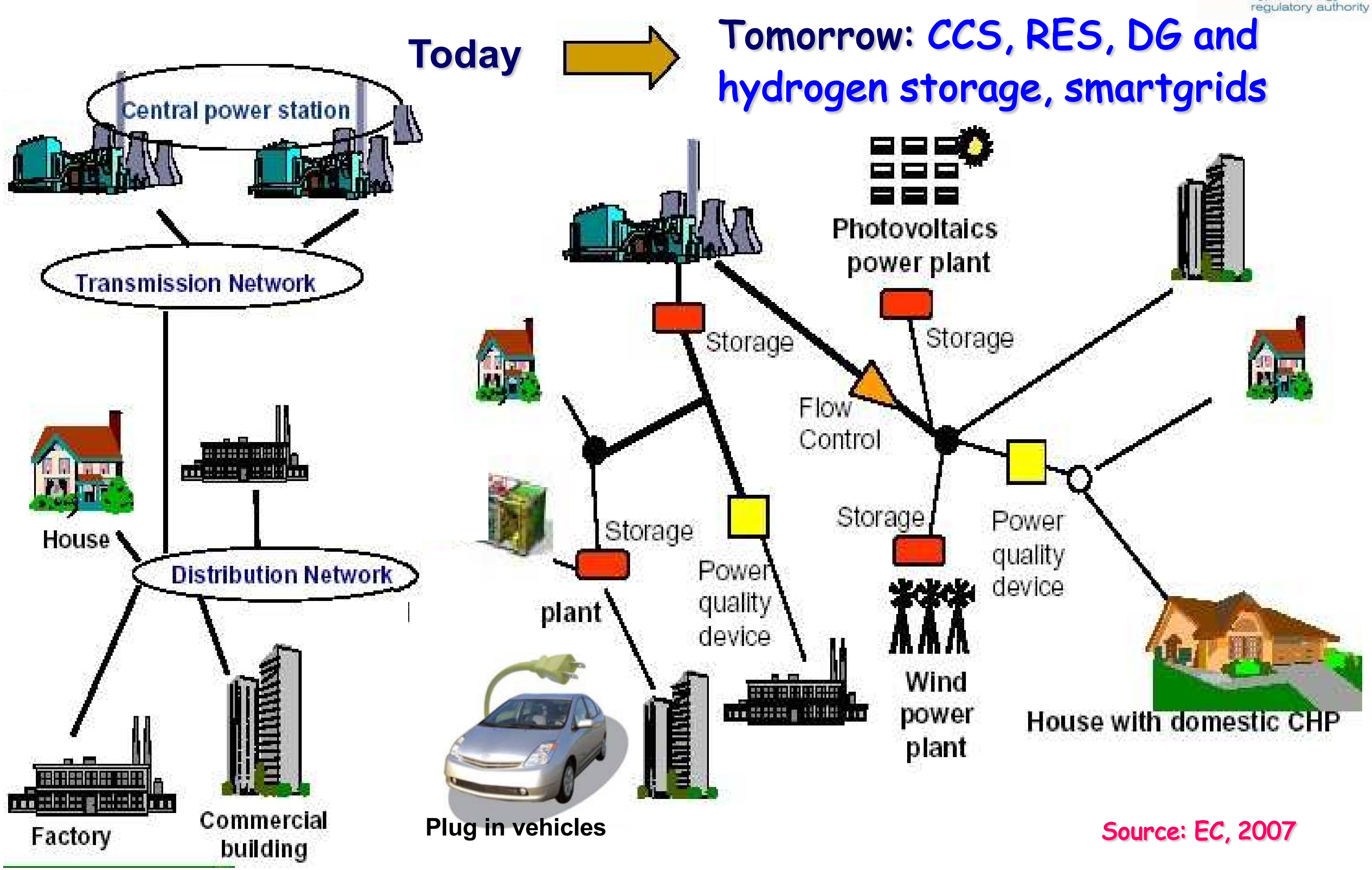
Future energy systems (optimistic scenario)



Future energy systems (optimistic scenario)

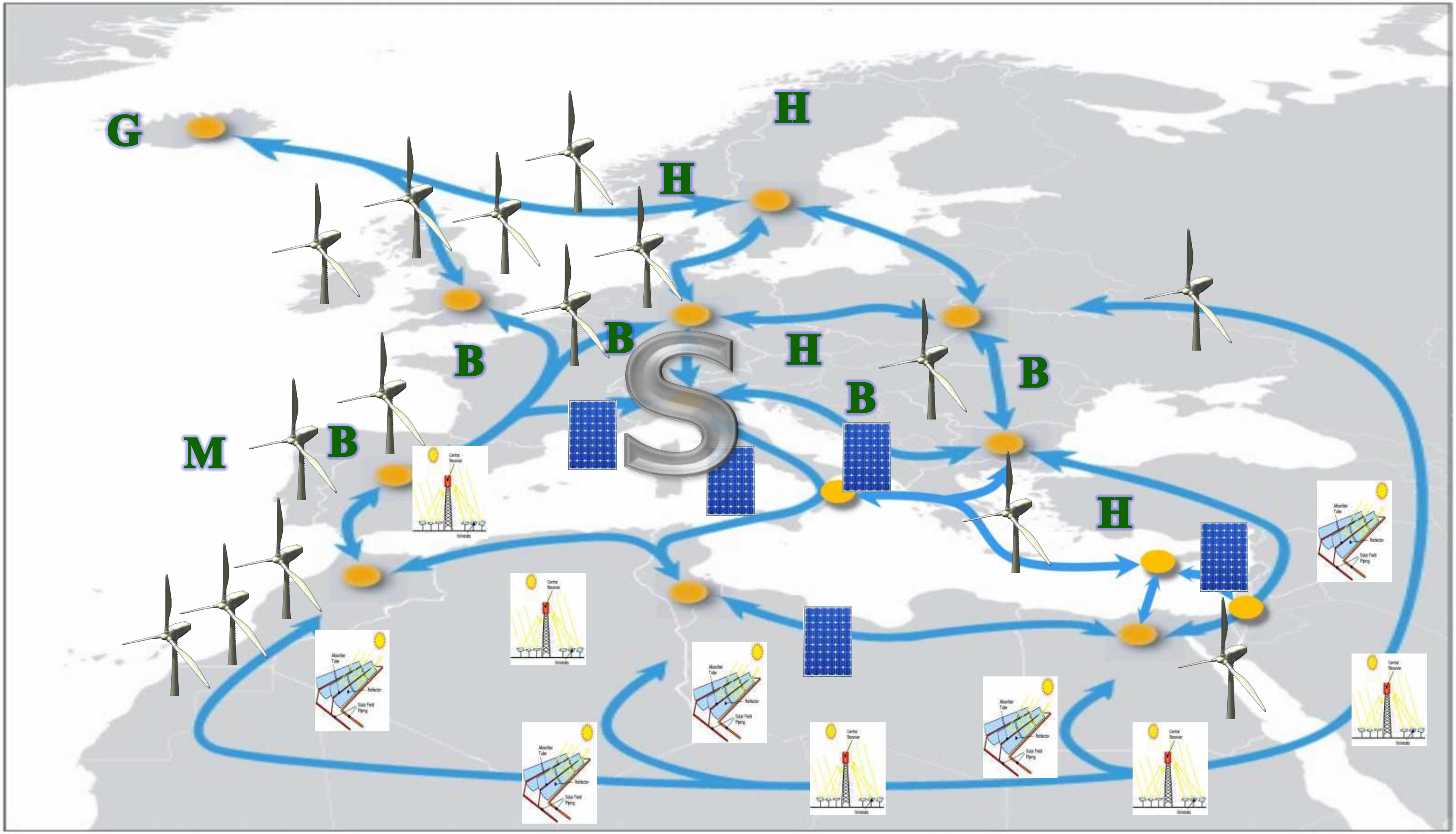


Future power systems



Source: EC, 2007

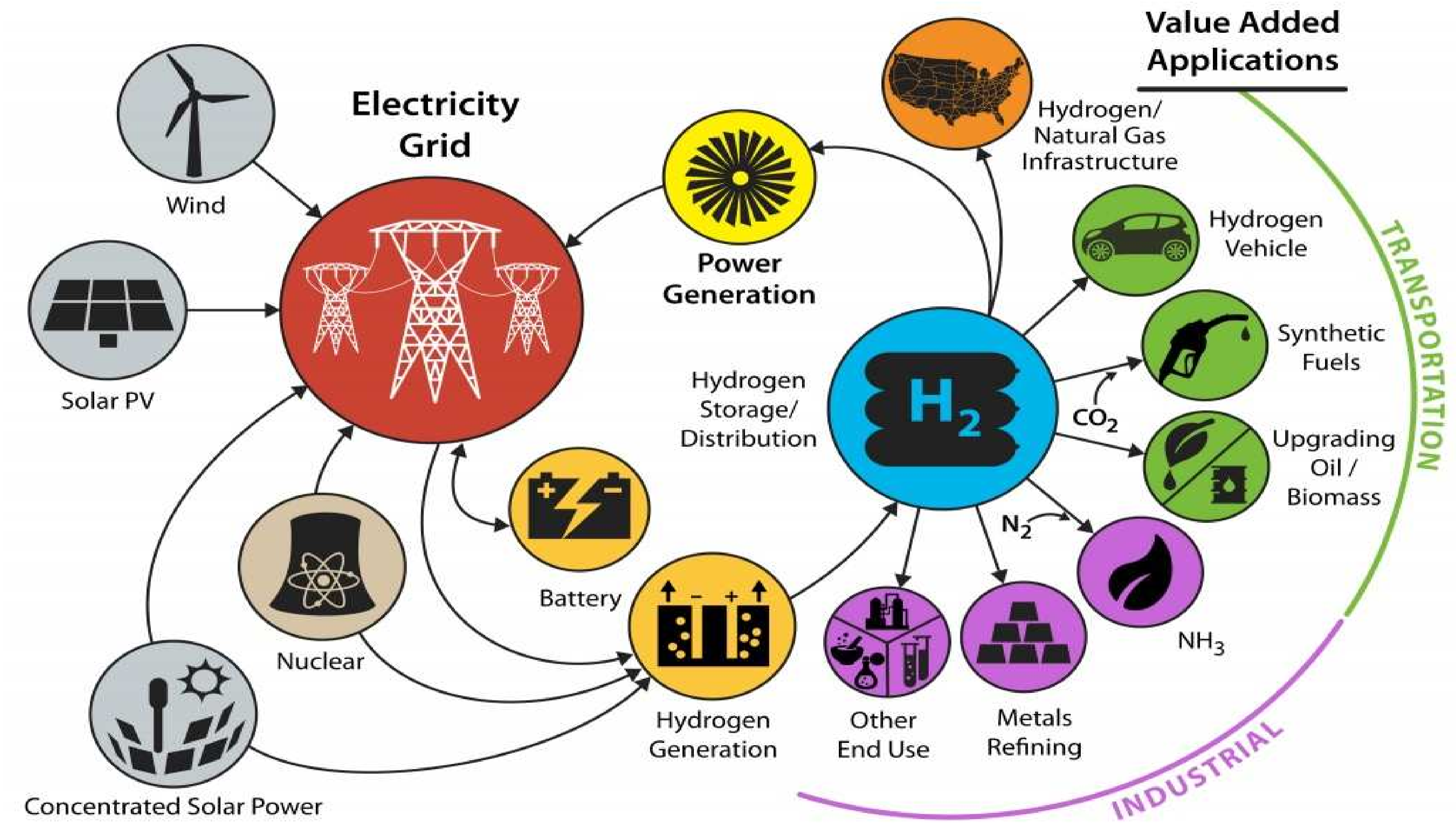
The Super Smart Grid after 2050*
(may allow for 100% RES)



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

Long term scenarios in Europe

Moving from Carbon economy to Hydrogen economy

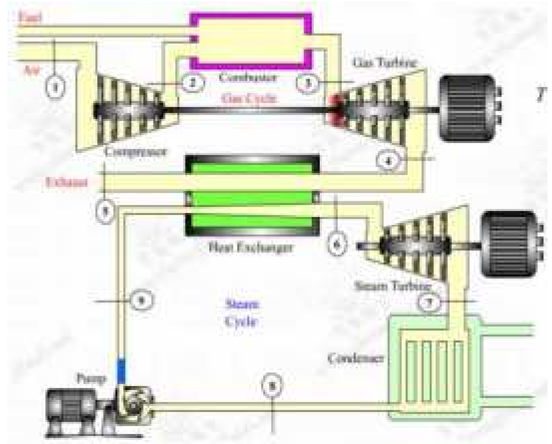


Cyprus current electricity system

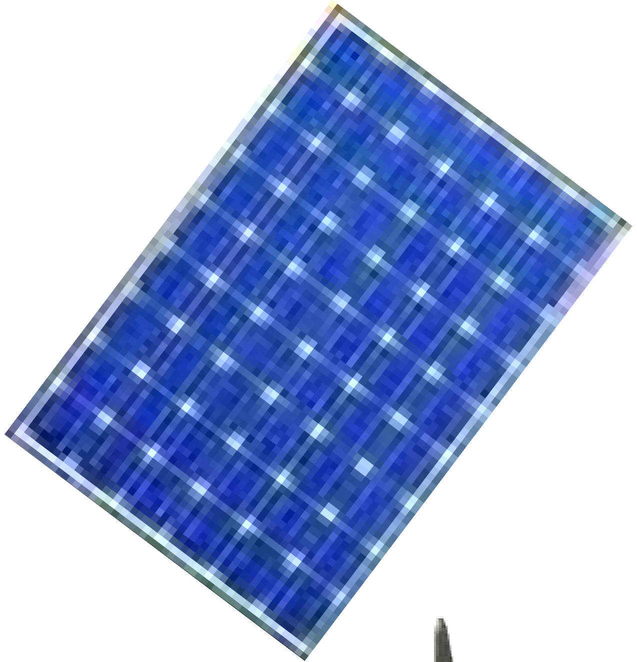
System characteristics

Existing power generation system

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



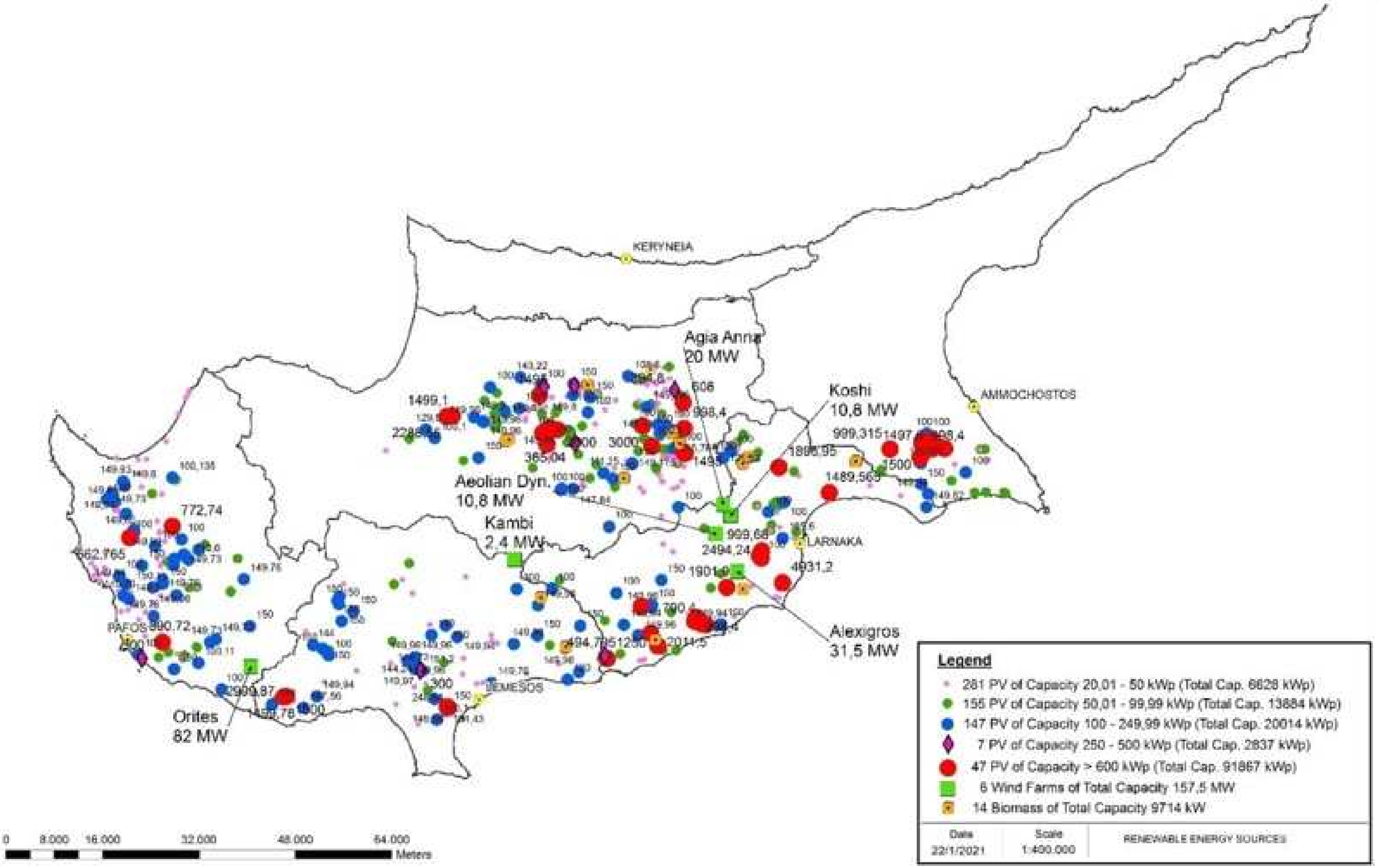
Existing power generation system (cont.)



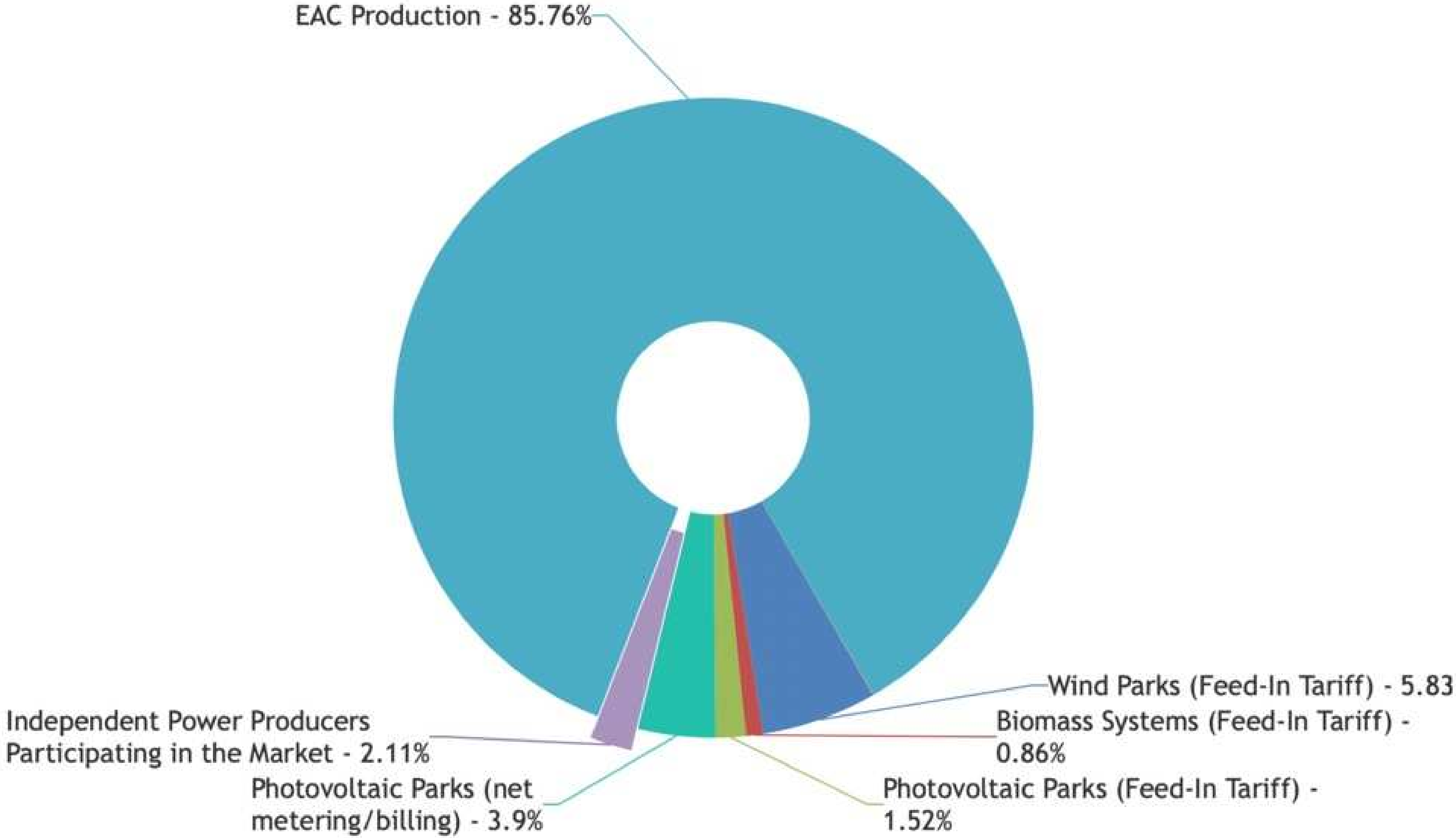
- **Renewables**
  - PVs: 335MWe
  - Wind: 157MWe
  - Biomass: 13MWe

- **Total installed capacity:**
  - Conventional: 1483MWe
  - Renewables: 505MWe

Distribution of RES-E

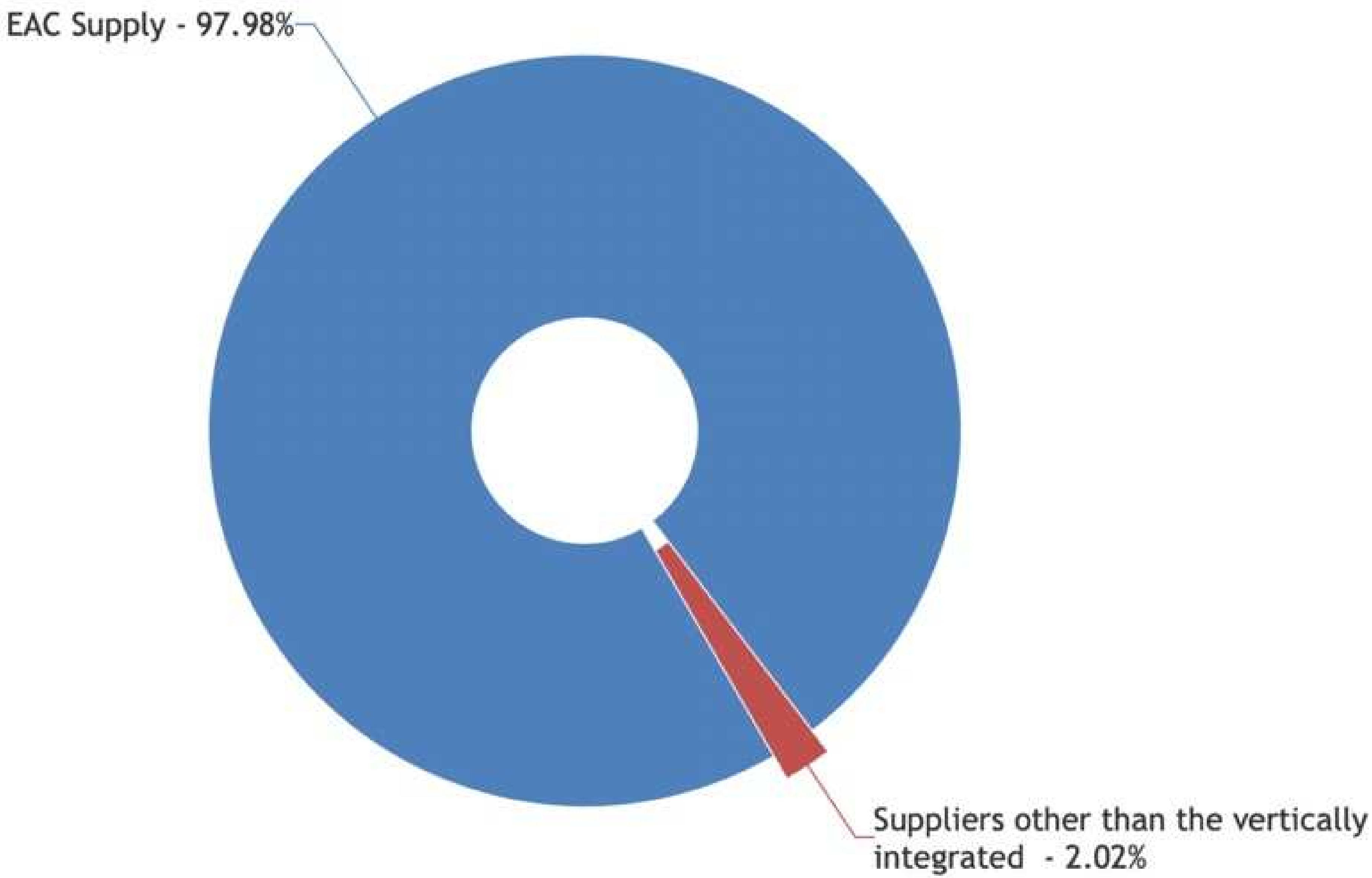


Wholesale market share* (Dec 2021)



* www.cera.org.cy

Retail market share* (Dec 2021)



* www.cera.org.cy

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

Versailles Declaration (10-11 Mar 2022)

- **Phase out EU dependency on Russian gas, oil and coal imports**
  - accelerating the reduction of overall reliance on fossil fuels
  - diversifying supplies through the use of LNG
  - further developing a hydrogen market for Europe
  - speeding up the development of renewables
  - completing and improving the interconnection of European gas and electricity networks and fully synchronising power grids throughout the EU
  - monitoring and optimising the functioning of the electricity market
  - RePowerEU plan by May 2022
  - …

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**

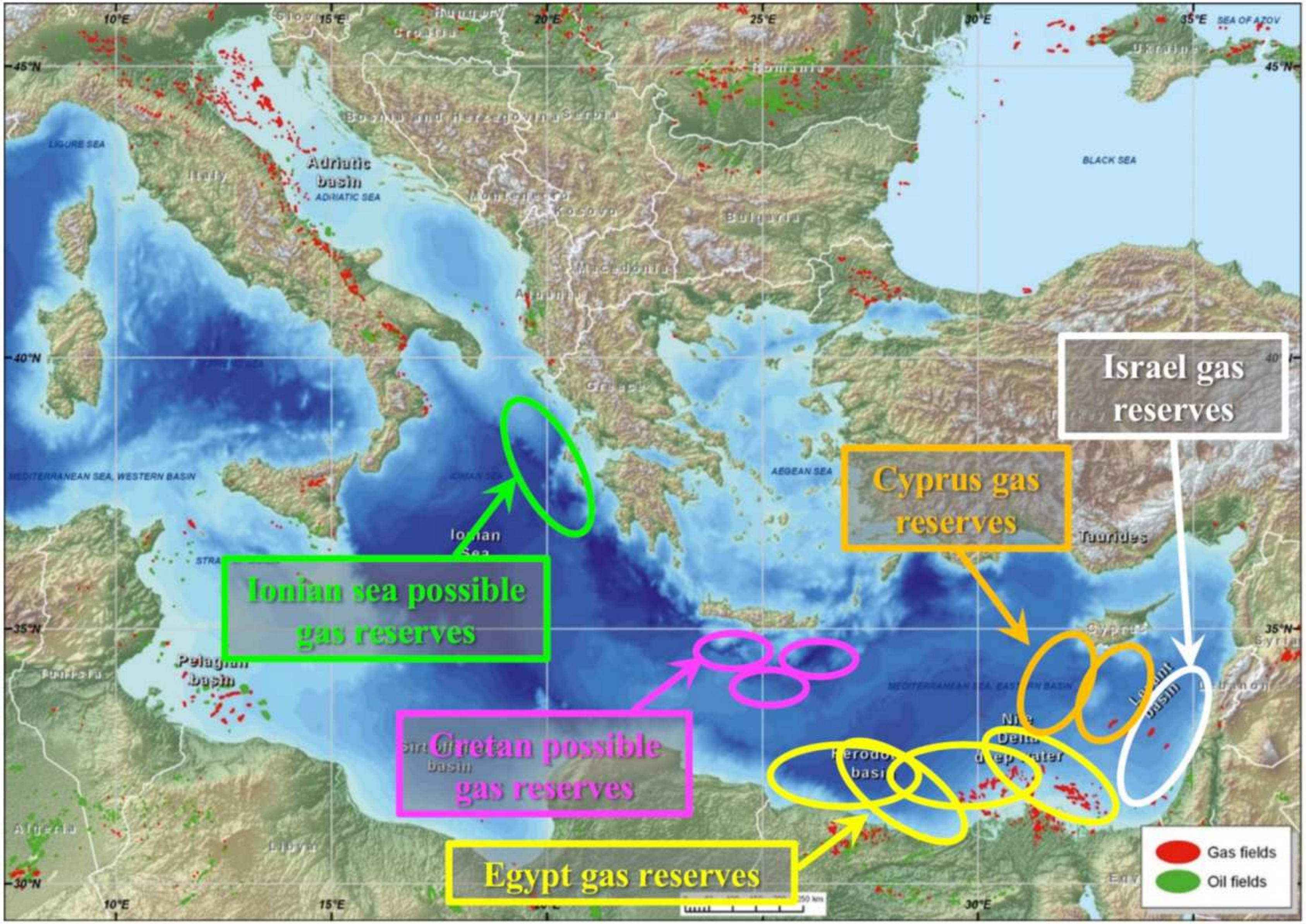
Medium to long term challenges

Large scale integration of RES, the role of interconnections and hydrogen

Regional primary energy sources

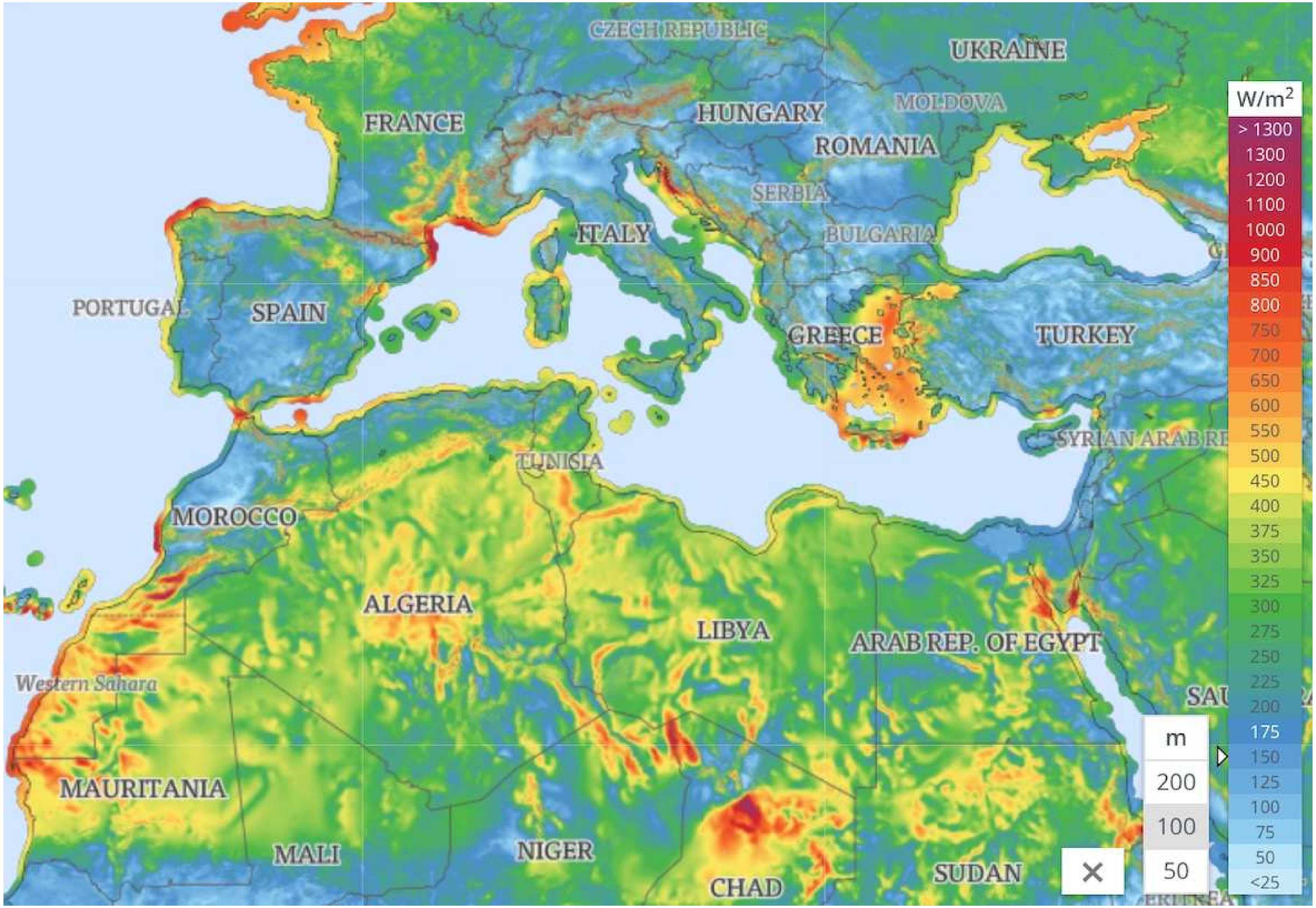
Indigenous energy sources

Gas reserves in SE Mediterranean region*



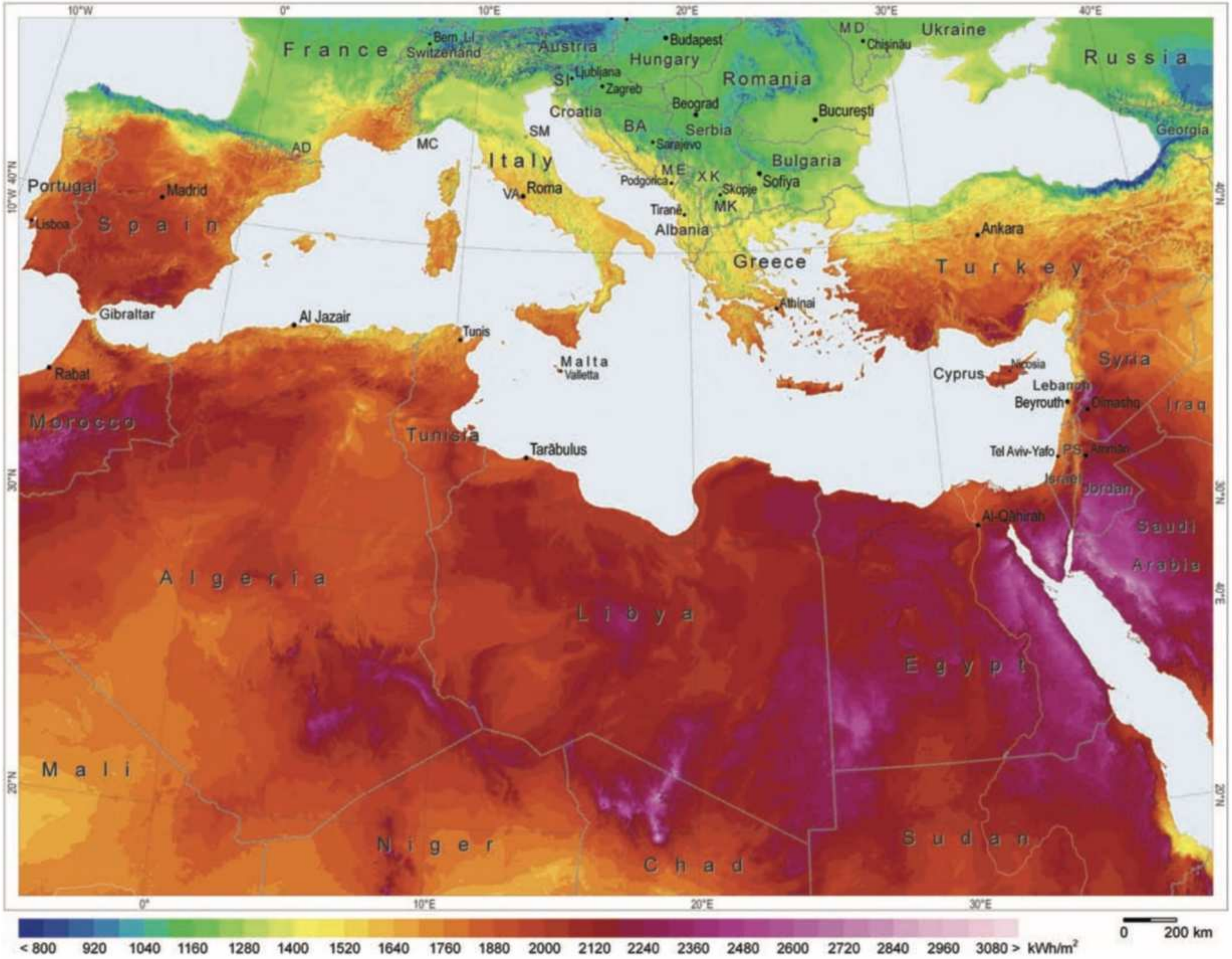
* A. Belopolsky, *et al.*, 2012, "New and emerging plays in the Eastern Mediterranean", *Petroleum Geoscience*

Wind potential in SE Mediterranean region*



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

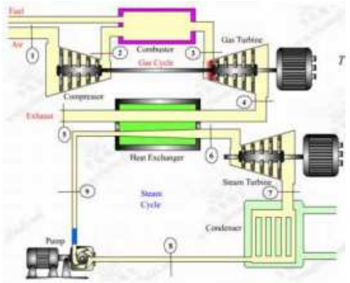
Solar potential in SE Mediterranean region*



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

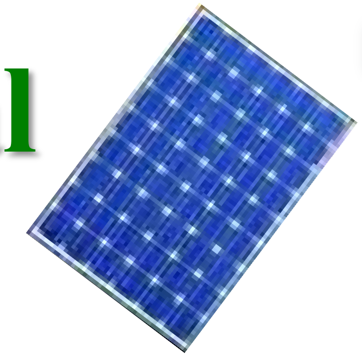
Main indigenous energy sources in SE Mediterranean region

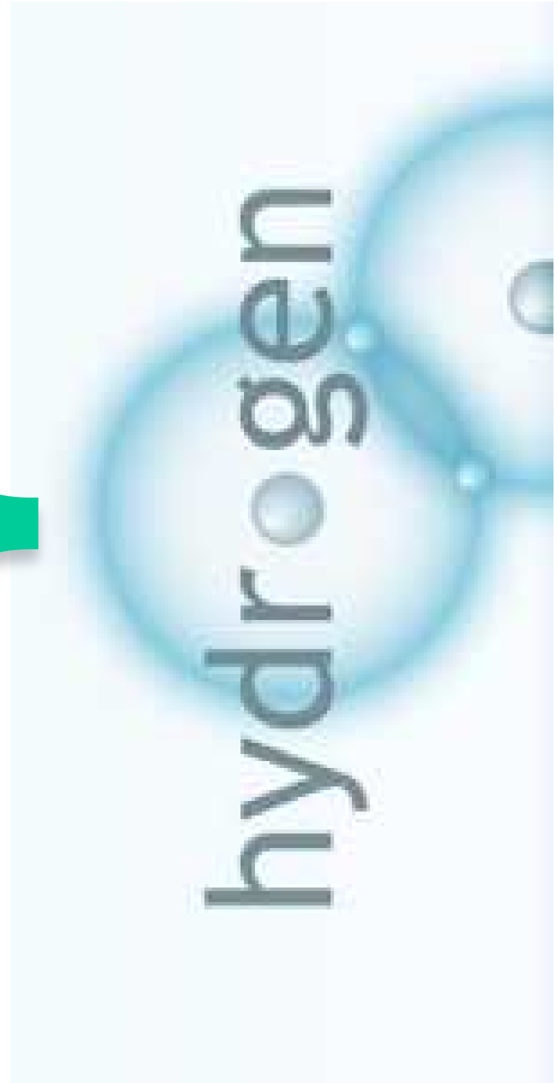
- **Natural gas**



- **Wind potential**

- **Solar potential**





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

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**

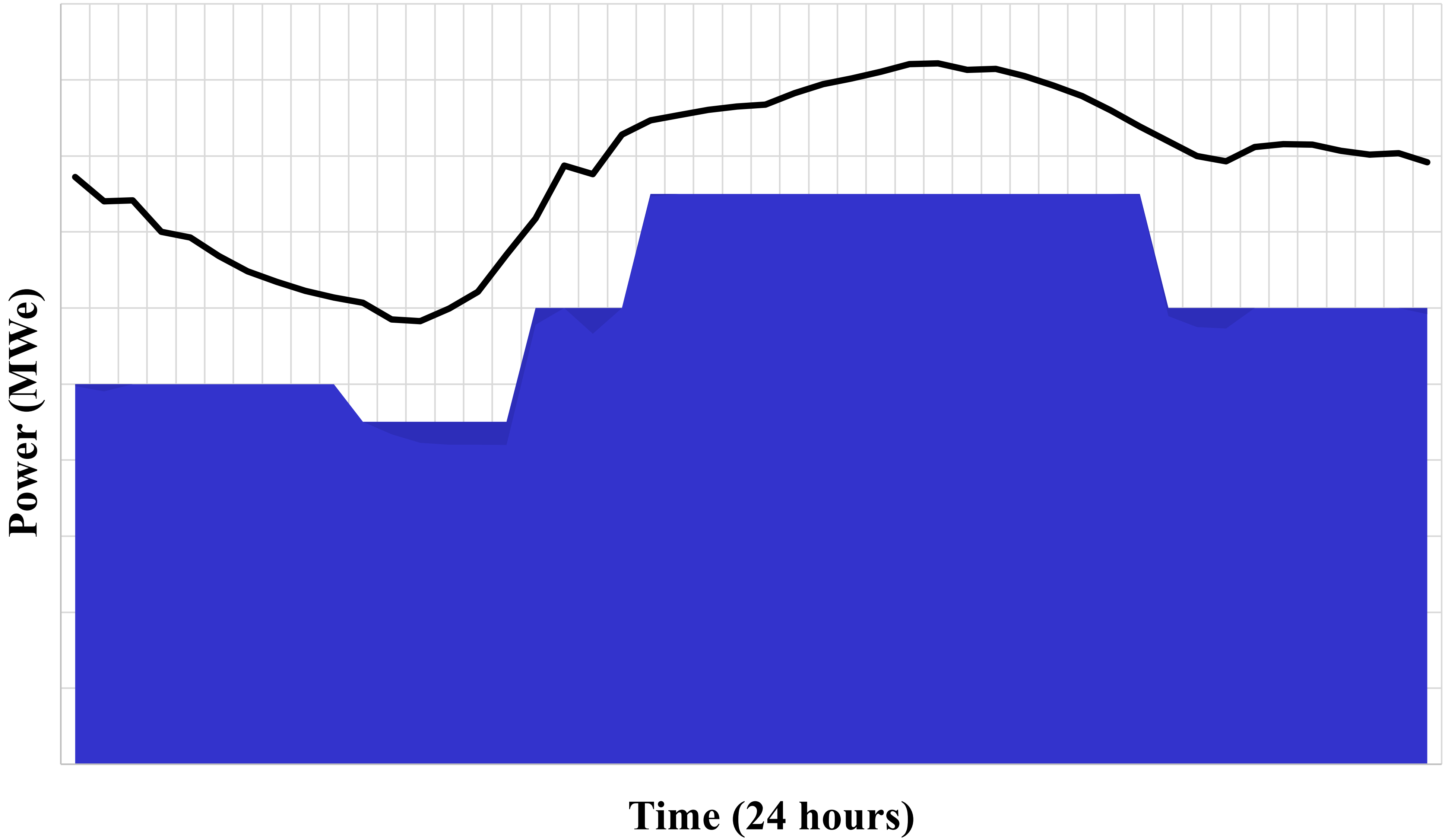
Additional Slides

Electricity market operation

EU target model

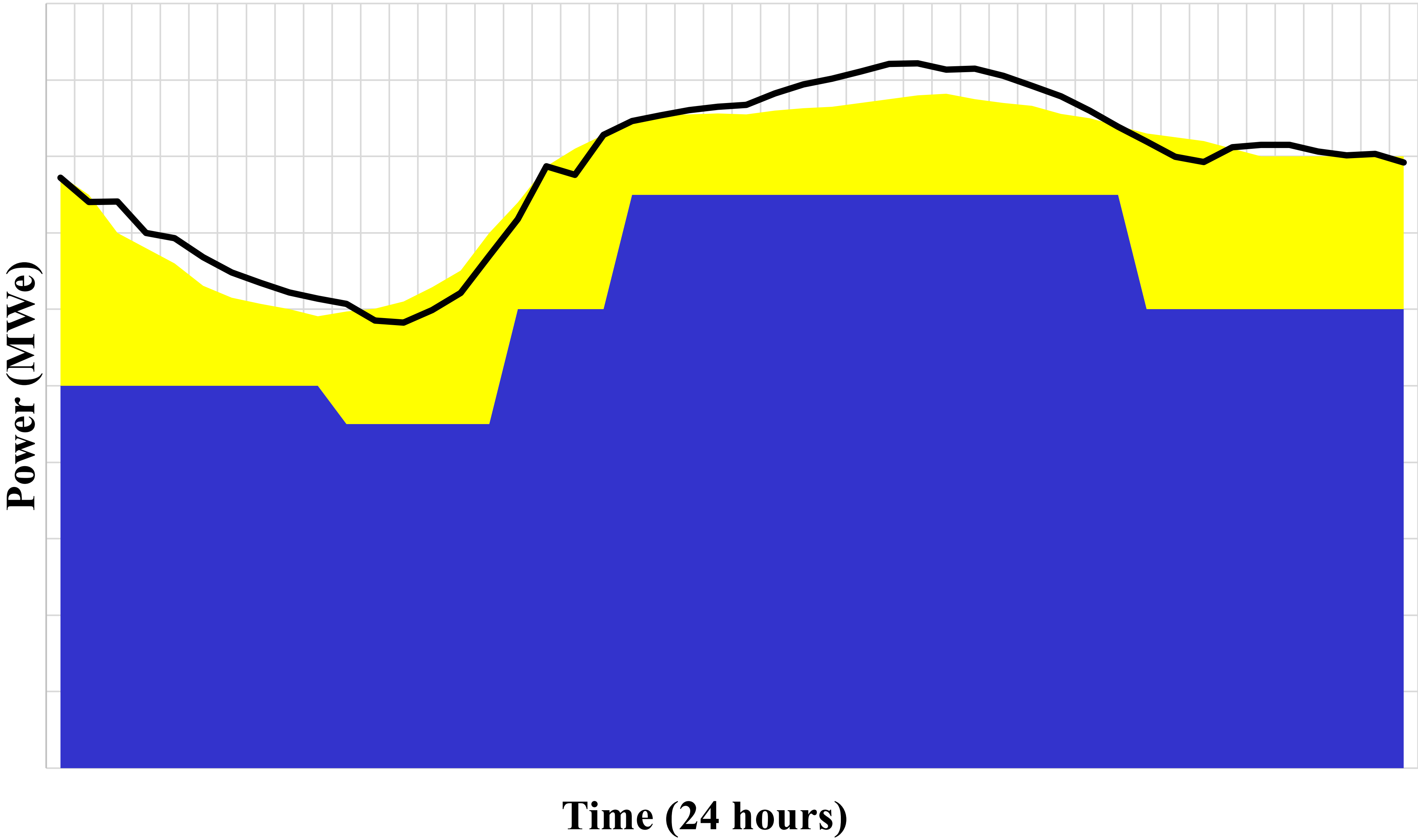
Electricity market operation

- **Forward market**



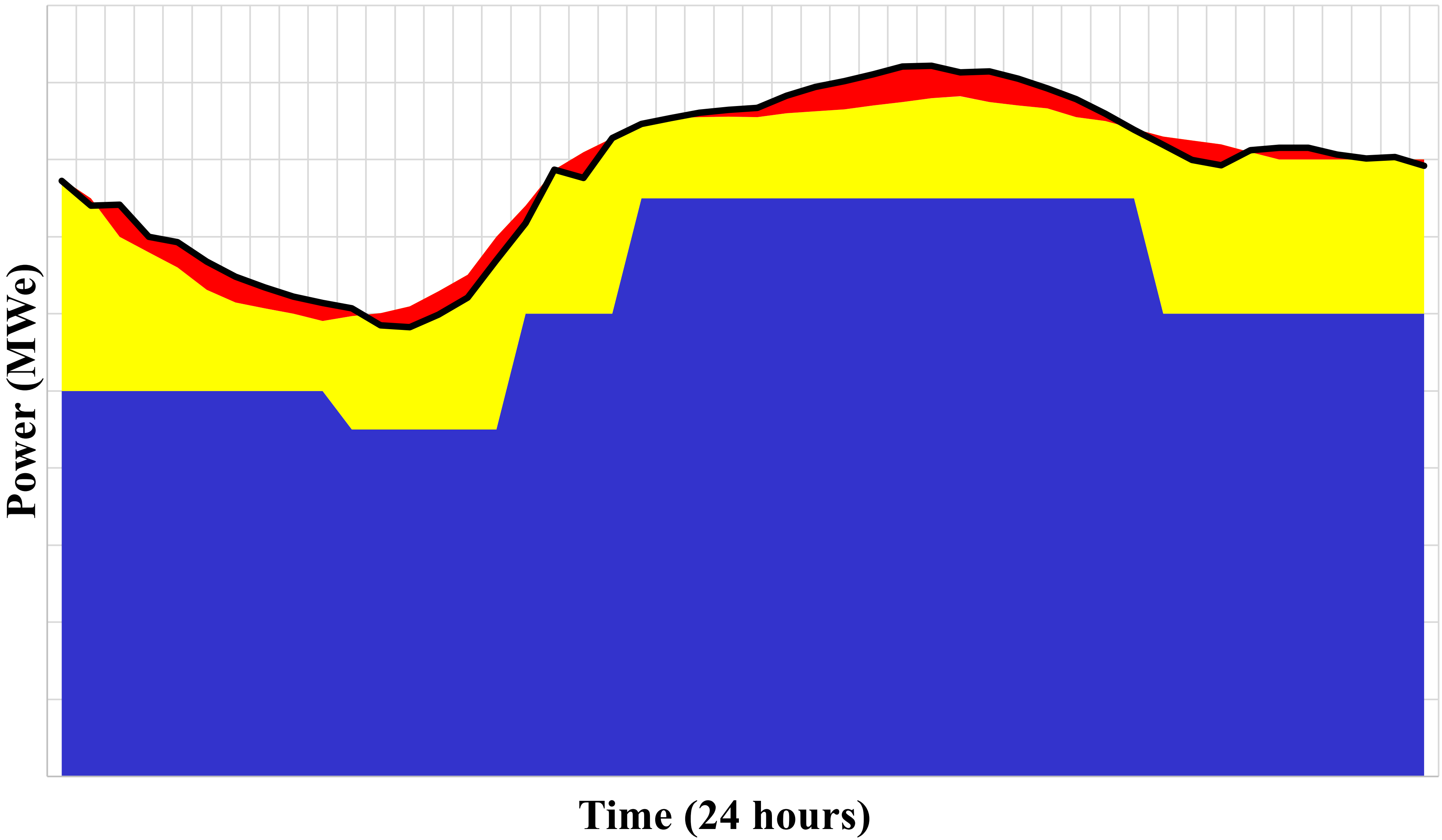
Electricity market operation

- **Forward market + Day ahead market**

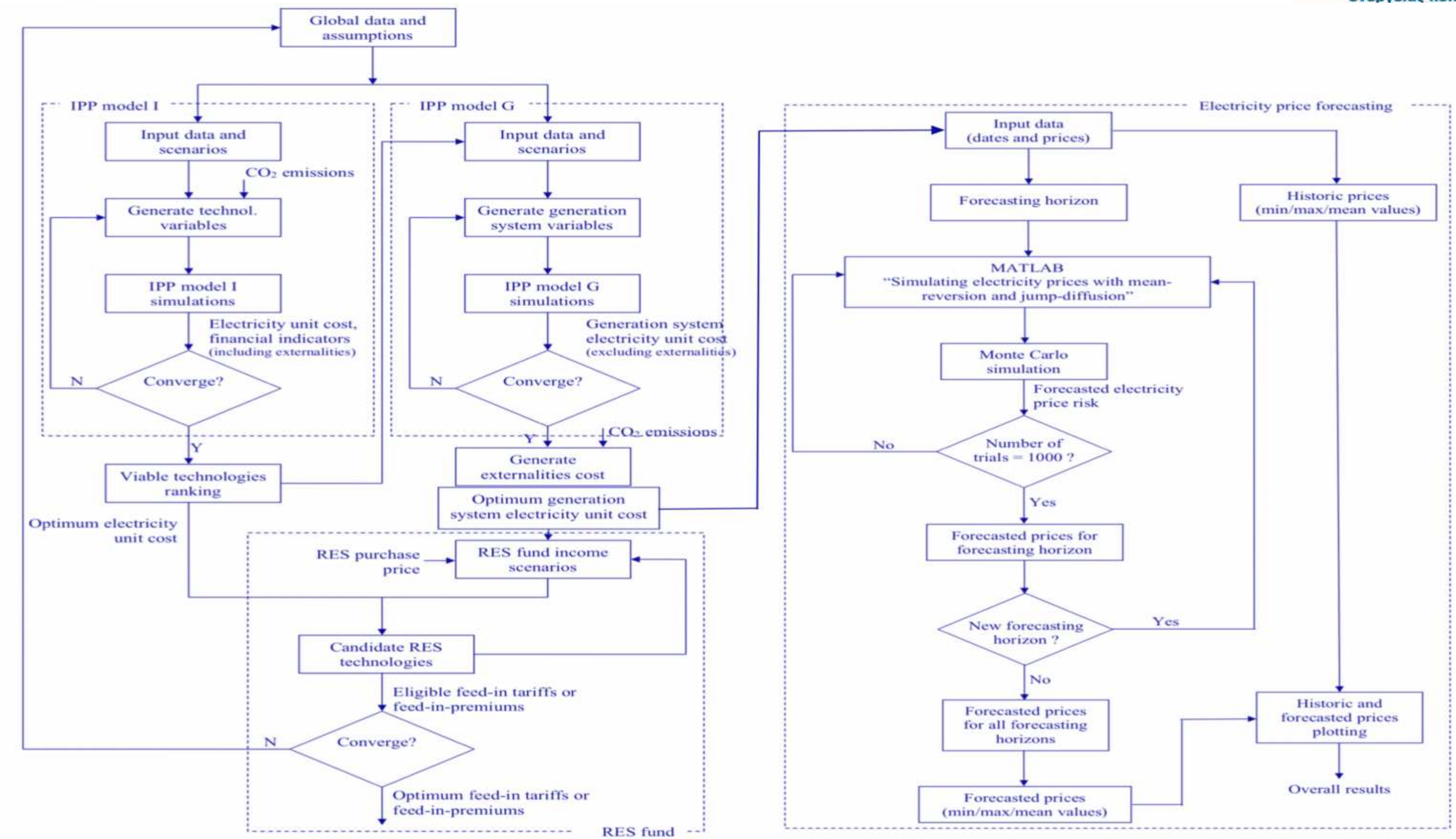


Electricity market operation

- Forward market + Day ahead market + Balancing market



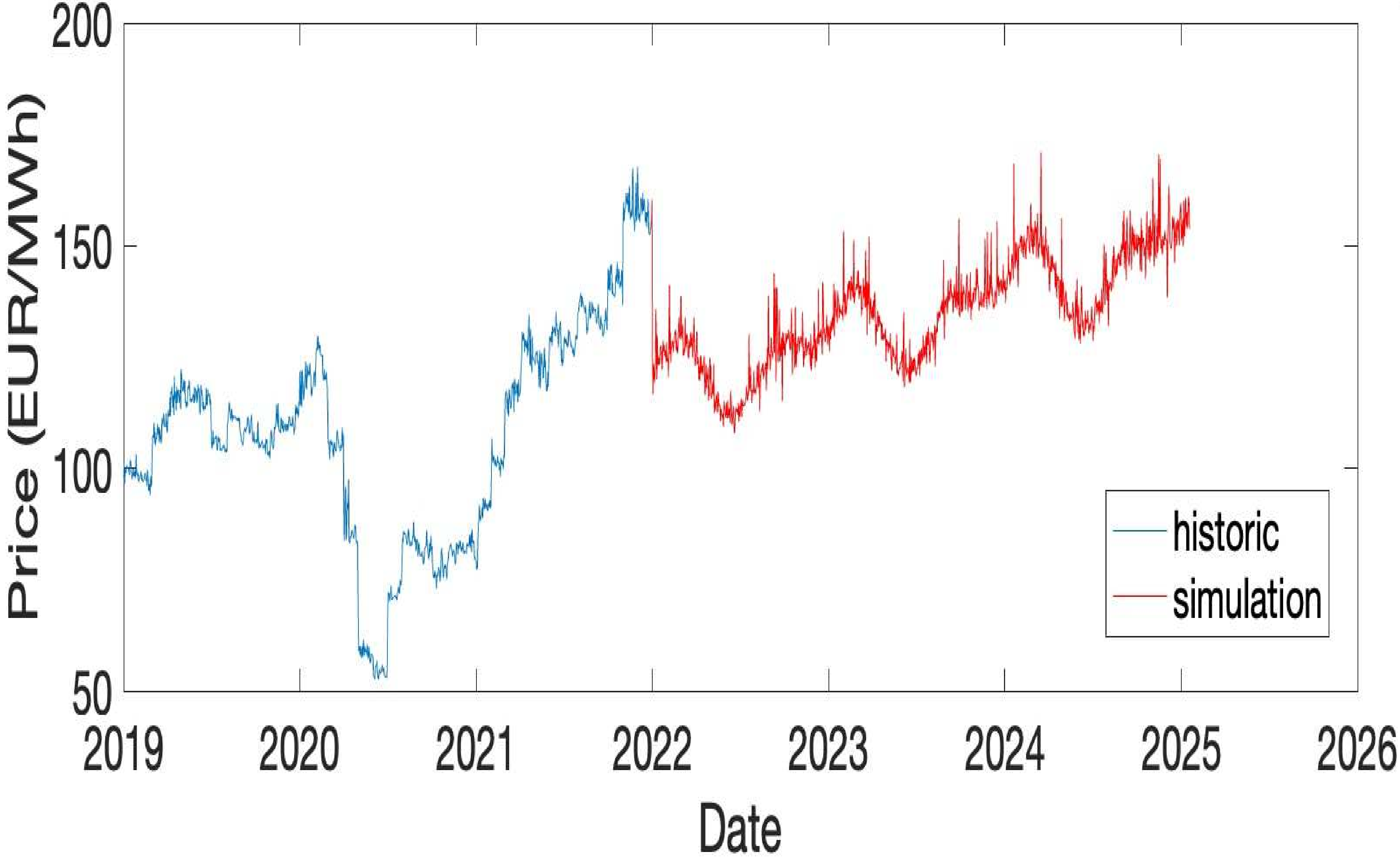
Optimization model*,**



- Poullikkas A., 2009, "A decouple optimization method for power technology selection in competitive markets", *Energy Sources*.

** Poullikkas A., 2018, "An adaptive longterm electricity price risk modelling using Monte Carlo simulation", *Journal of Power Technologies*

Actual and simulated prices*



* Poullikkas A., 2018, "An adaptive longterm electricity price risk modelling using Monte Carlo simulation", *Journal of Power Technologies*