ρυθμιστική αρχή ενέργειας κύπρου
cyprus energy regulatory authority

Ενεργειακή μετάβαση για νησιωτικά συστήματα

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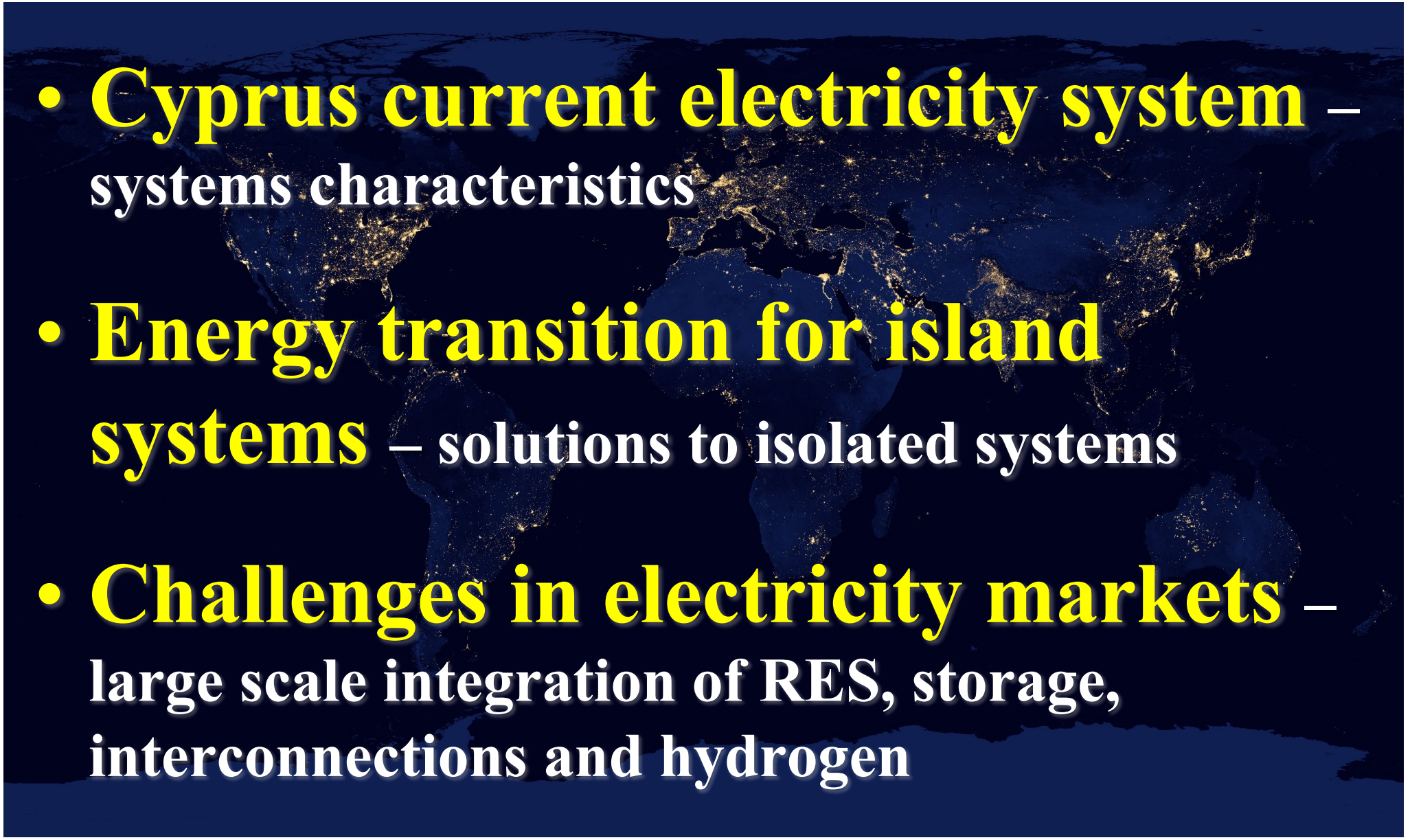


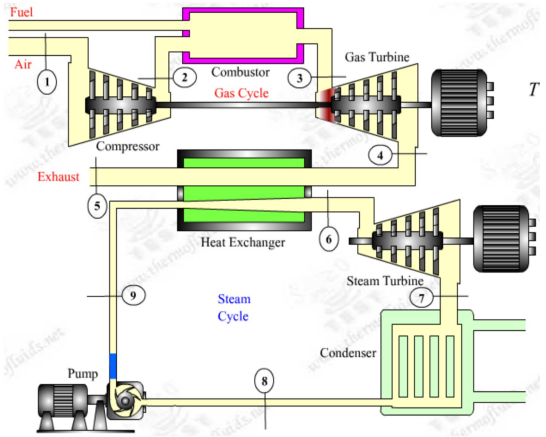
- **Cyprus current electricity system** – systems characteristics
- **Energy transition for island systems** – solutions to isolated systems
- **Challenges in electricity markets** – large scale integration of RES, storage, interconnections and hydrogen

Cyprus current electricity system

Systems 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.)

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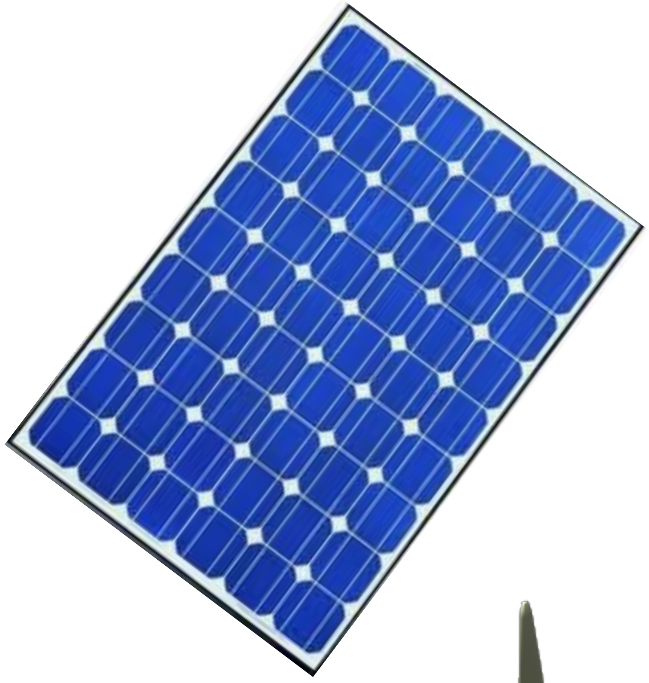
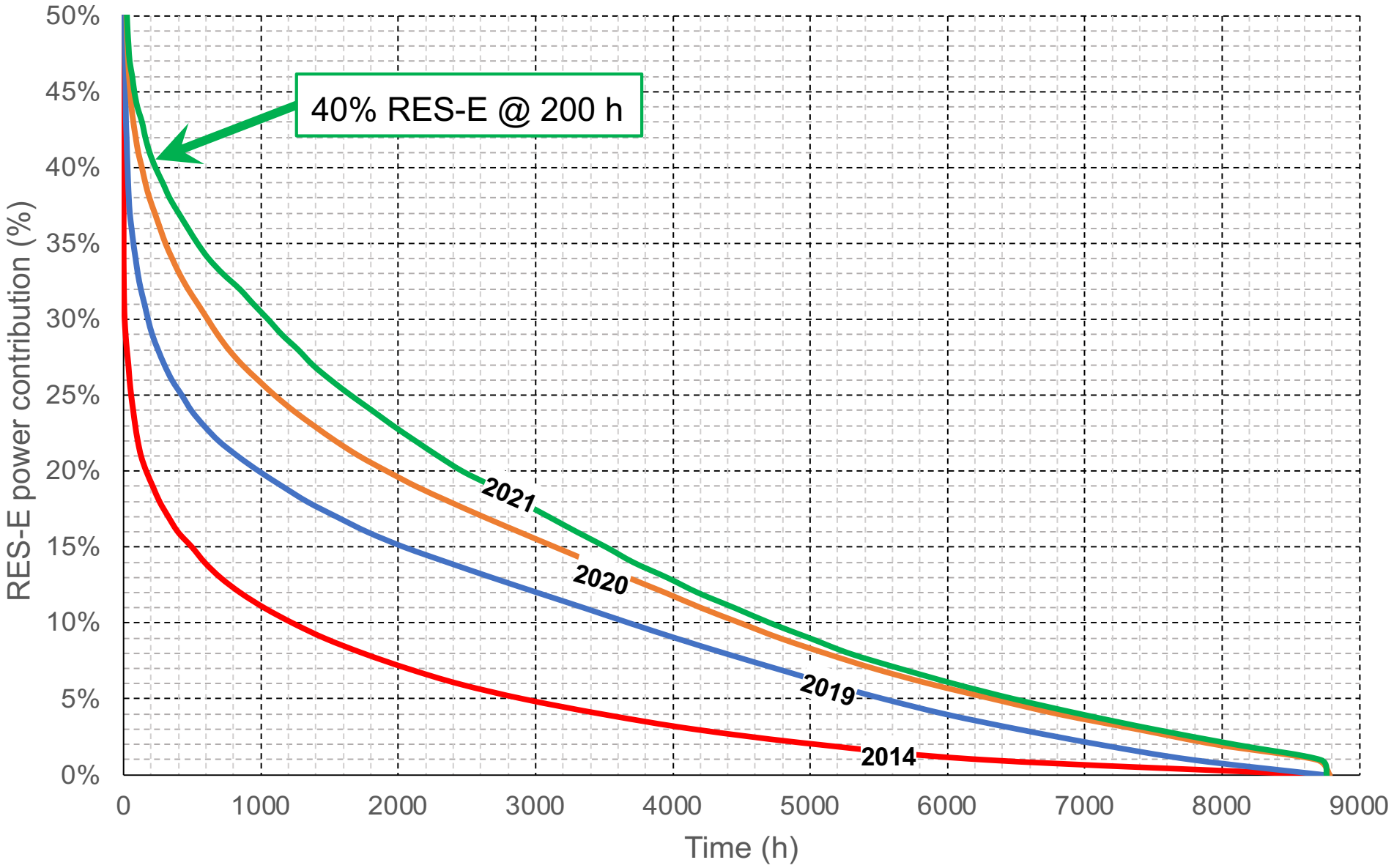
- **Renewables**
  - **PVs: 293MWe**
  - **Wind: 157MWe**
  - **Biomass: 13MWe**



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

RES-E Load Duration Curve



Wholesale market share* (Dec 2021)

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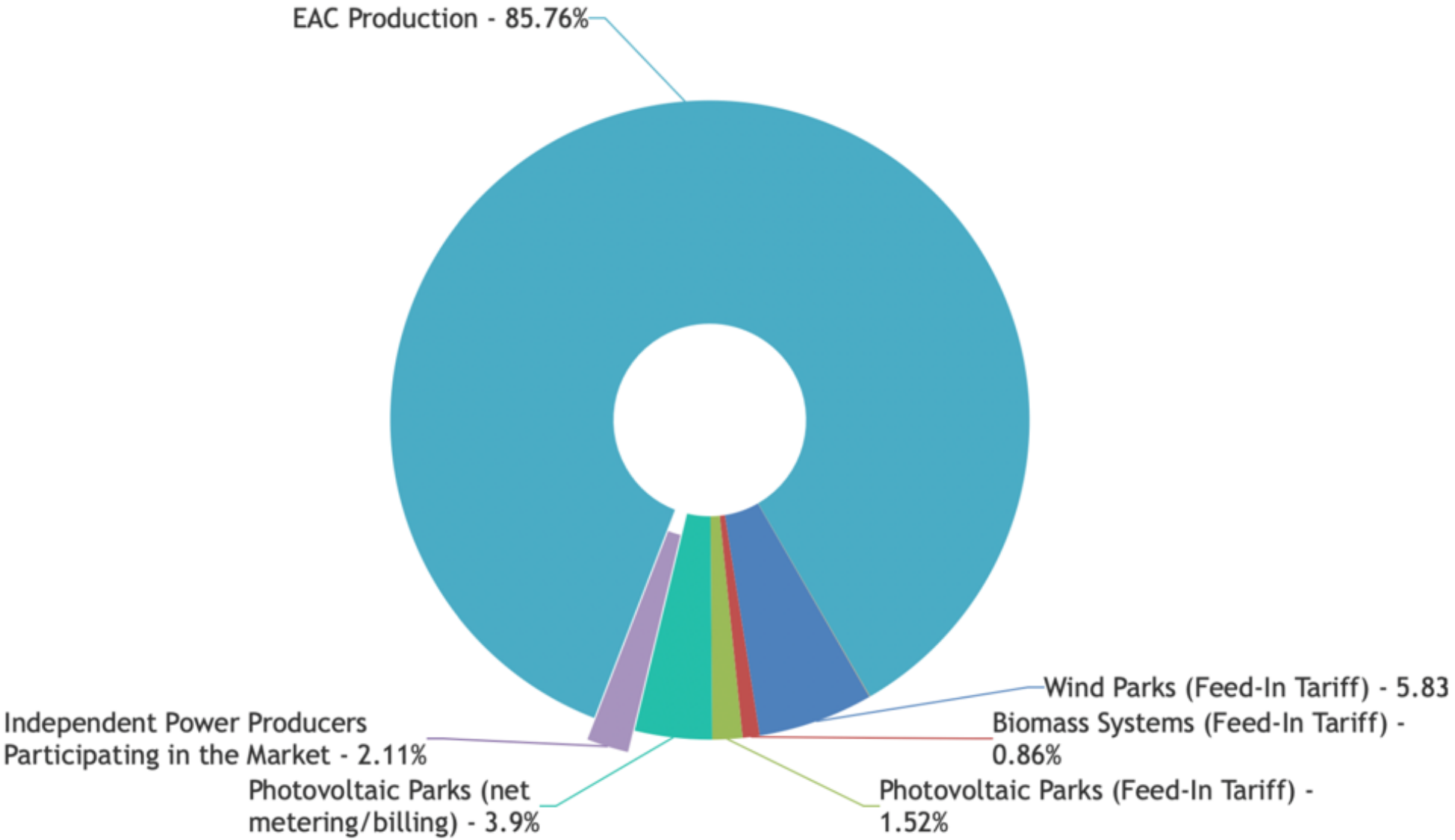
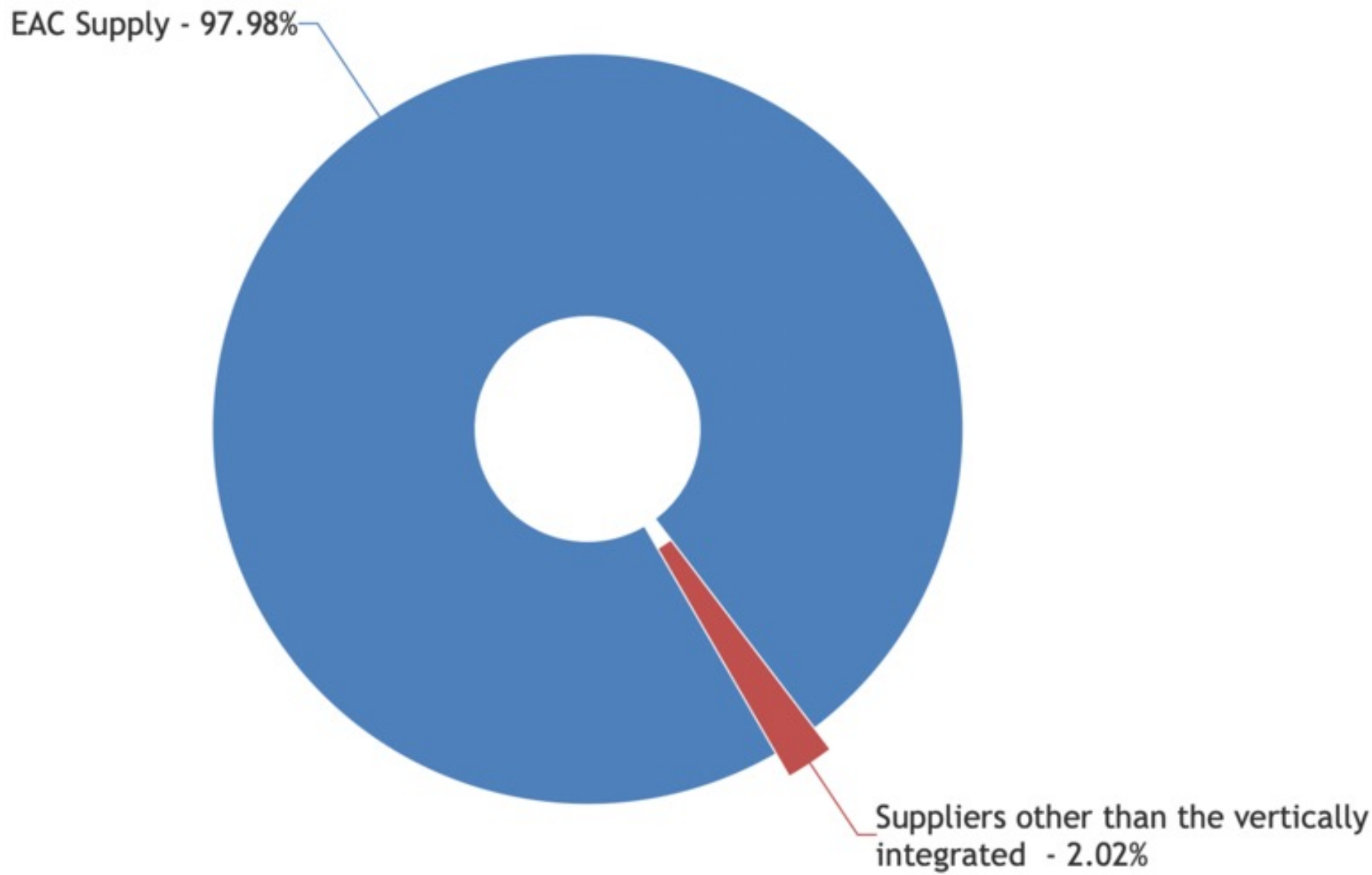


* www.cera.org.cy

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

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

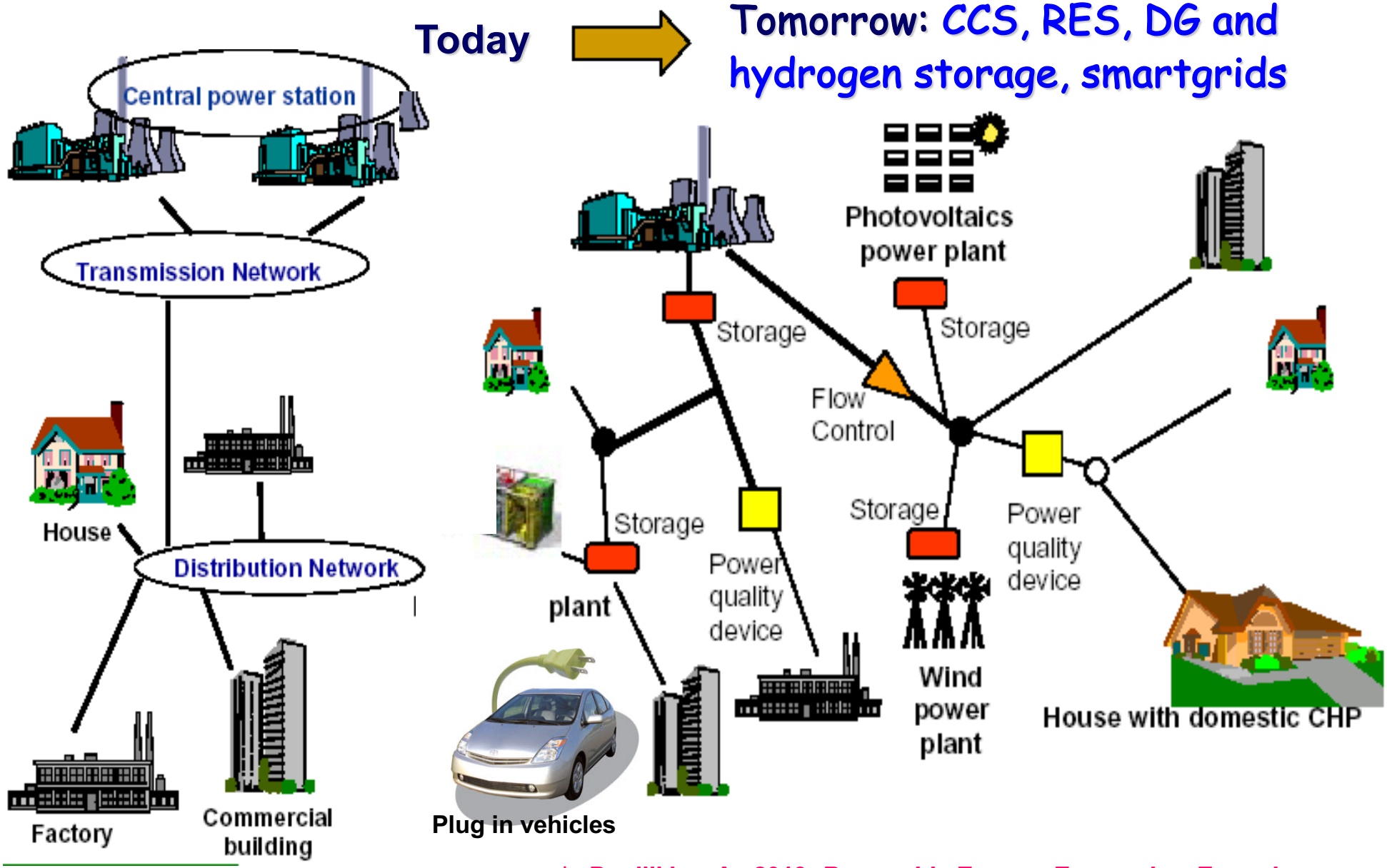
CERA Energy Transition Regulatory Decisions

- **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**

Challenges in electricity markets

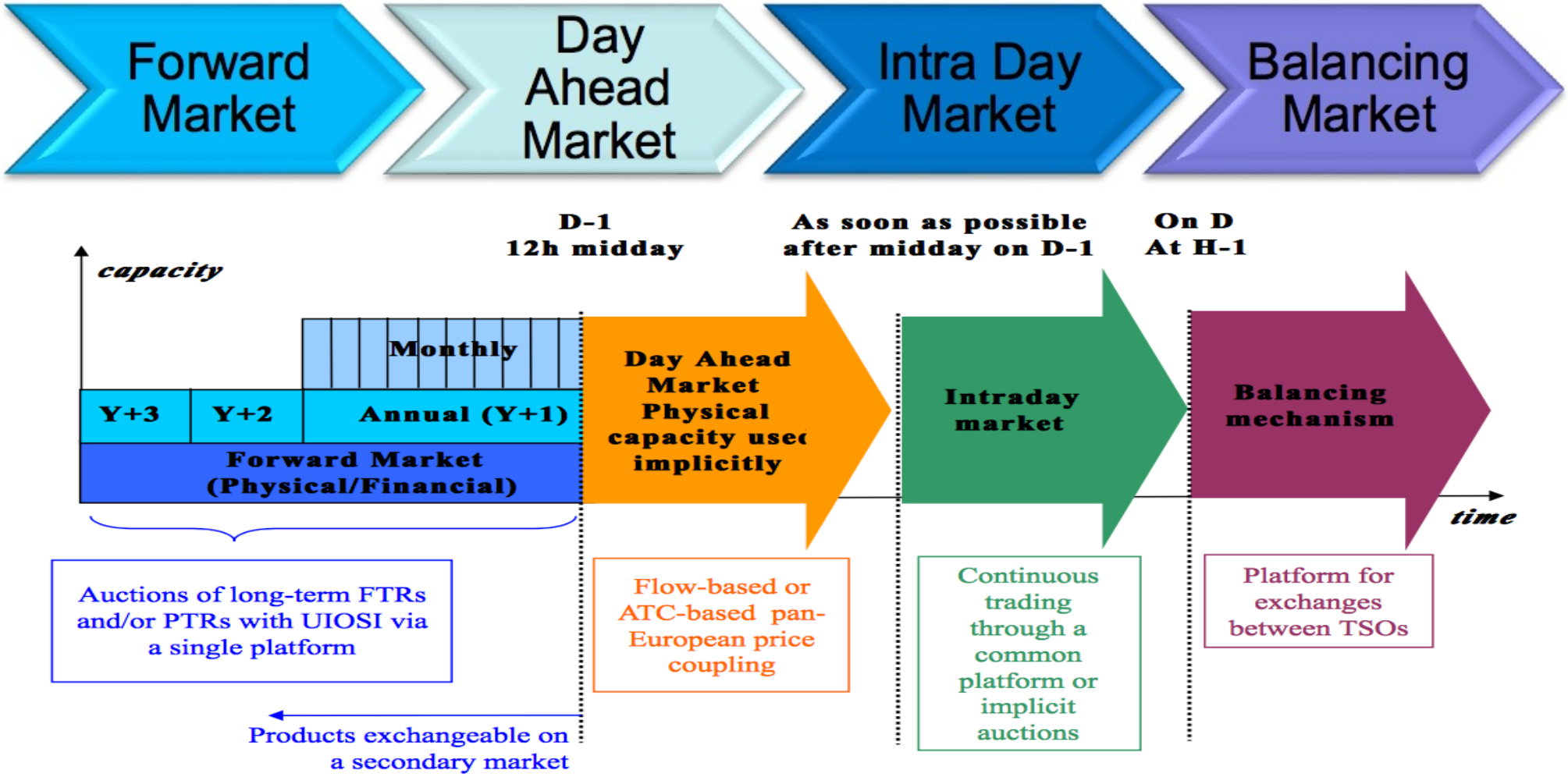
Large scale integration of RES, storage, interconnections and hydrogen

Future power systems*



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

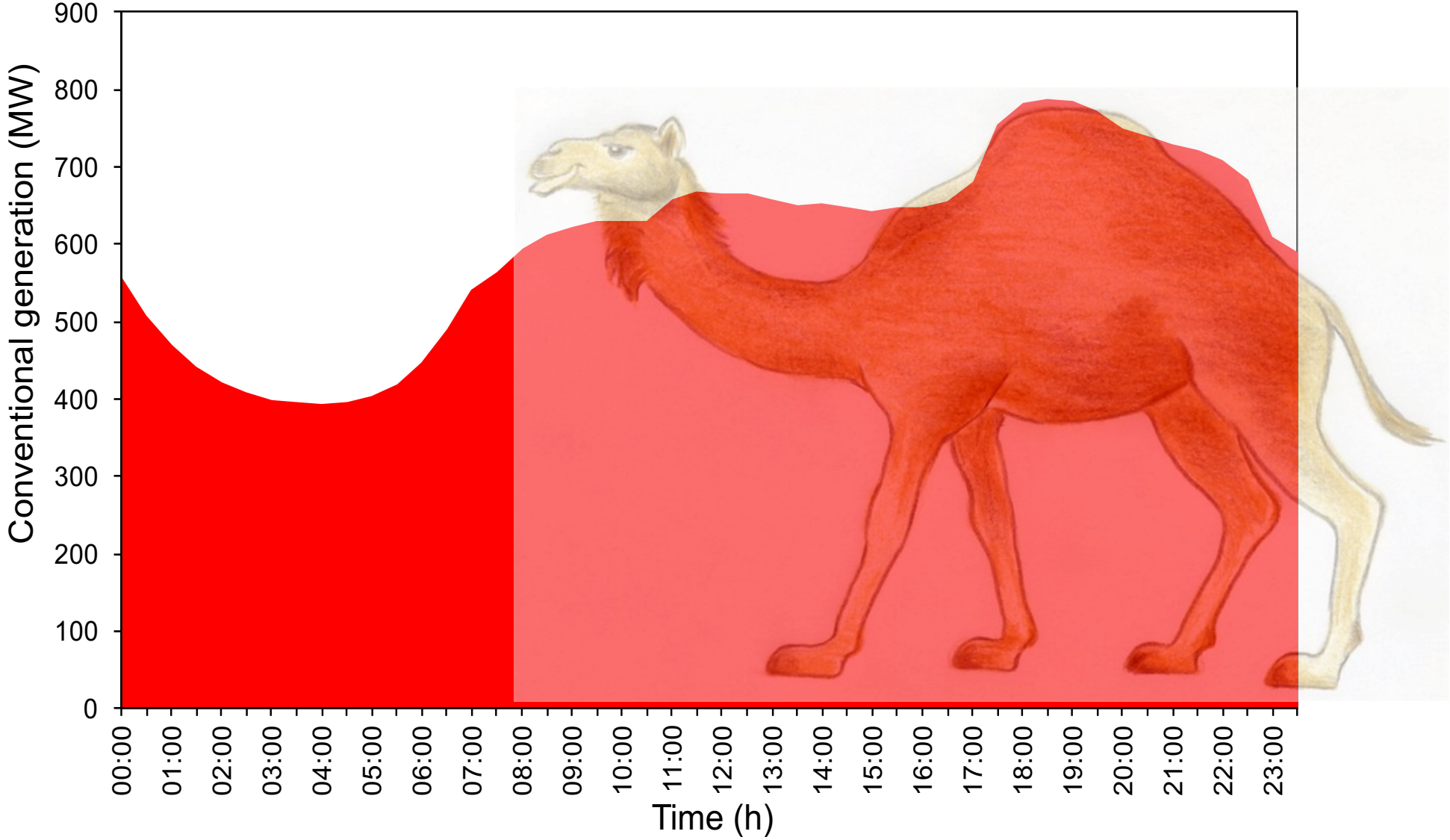
EU electricity market target model



Integration of RES*: LCOE *vs* Reliability

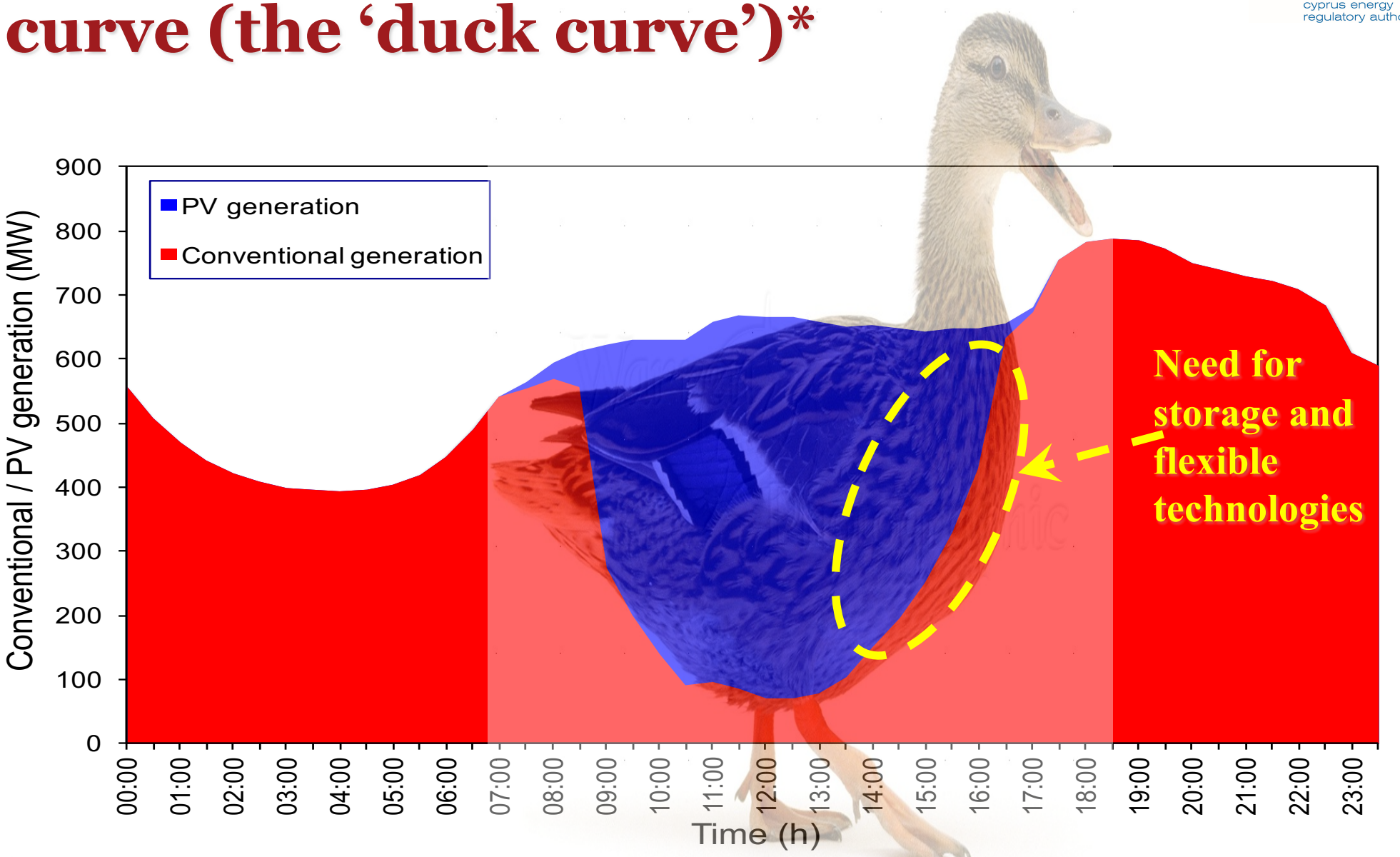
* Nicolaidis P., Chatzis S., Poullikkas A., 2018, "Renewable energy integration through optimal unit commitment and electricity storage in weak power networks", *International Journal of Sustainable Energy*

Daily load curve (the 'camel curve')*



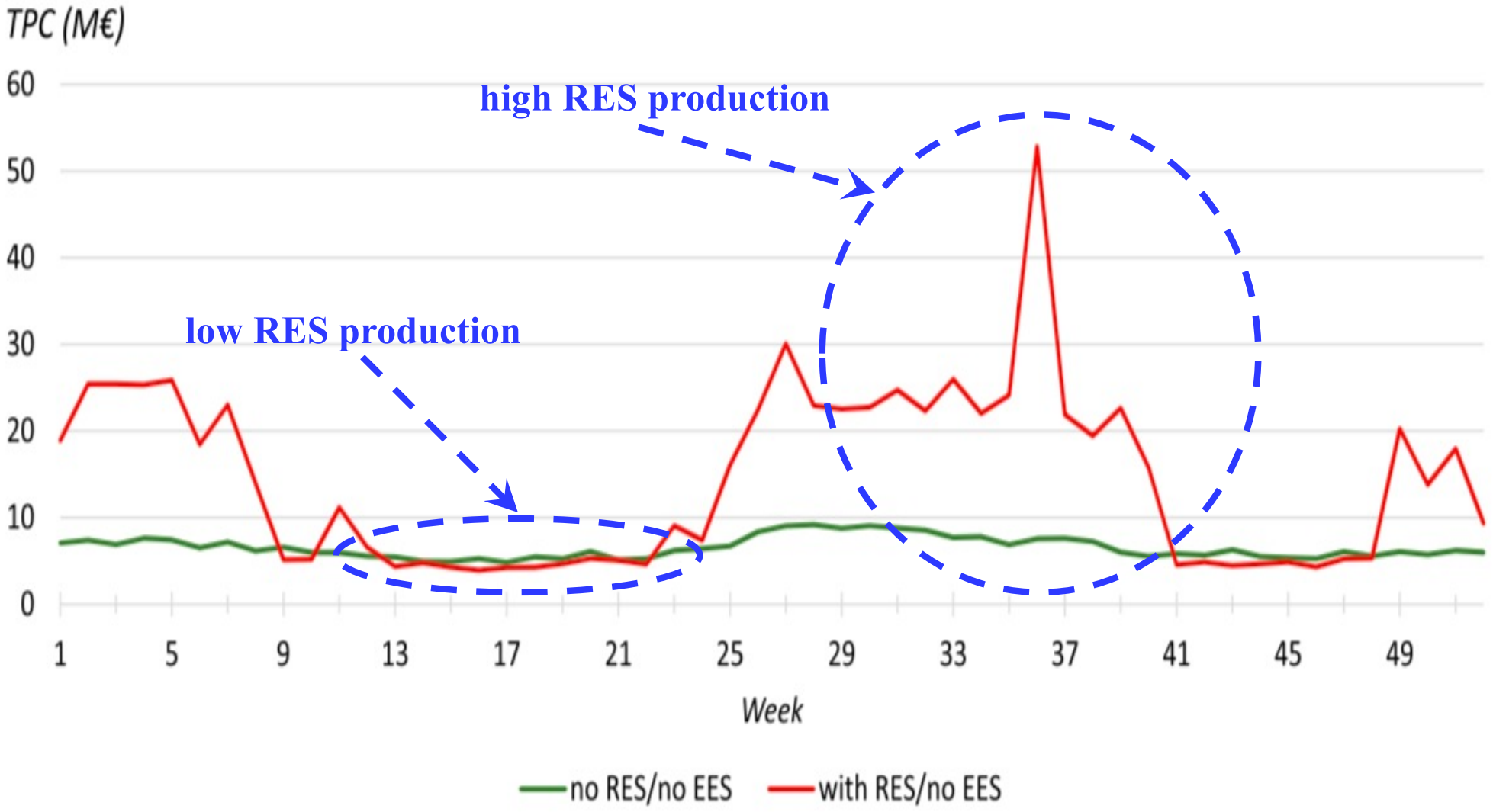
* **Poullikkas A., 2016, "From the 'camel curve' to the 'duck curve' on electric systems with increasing solar power", *Accountancy***

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



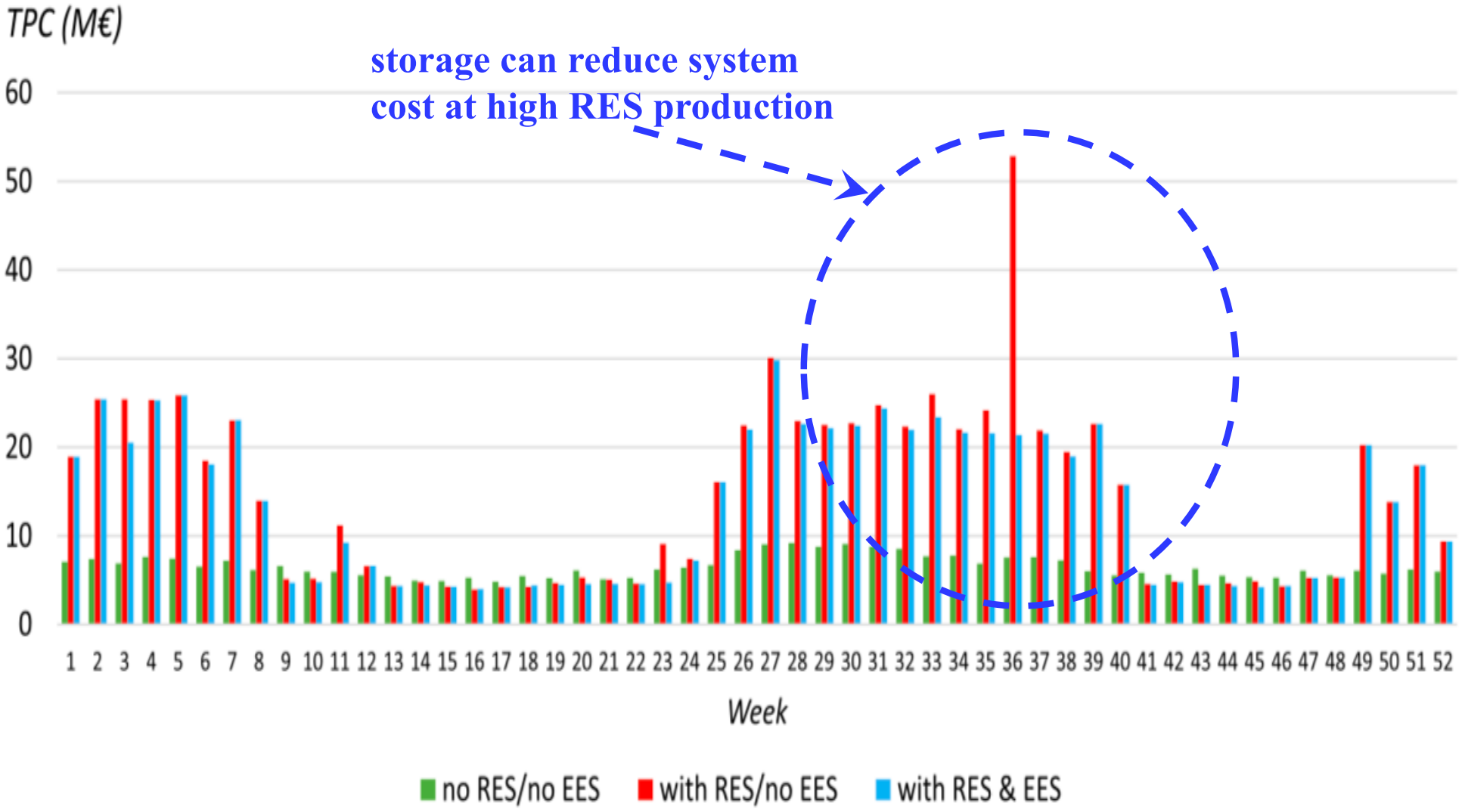
* Poullikkas A., 2016, "From the 'camel curve' to the 'duck curve' on electric systems with increasing solar power", *Accountancy*

Cost of reserves with RES production*



* 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*

Integration of storage*



* 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*

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

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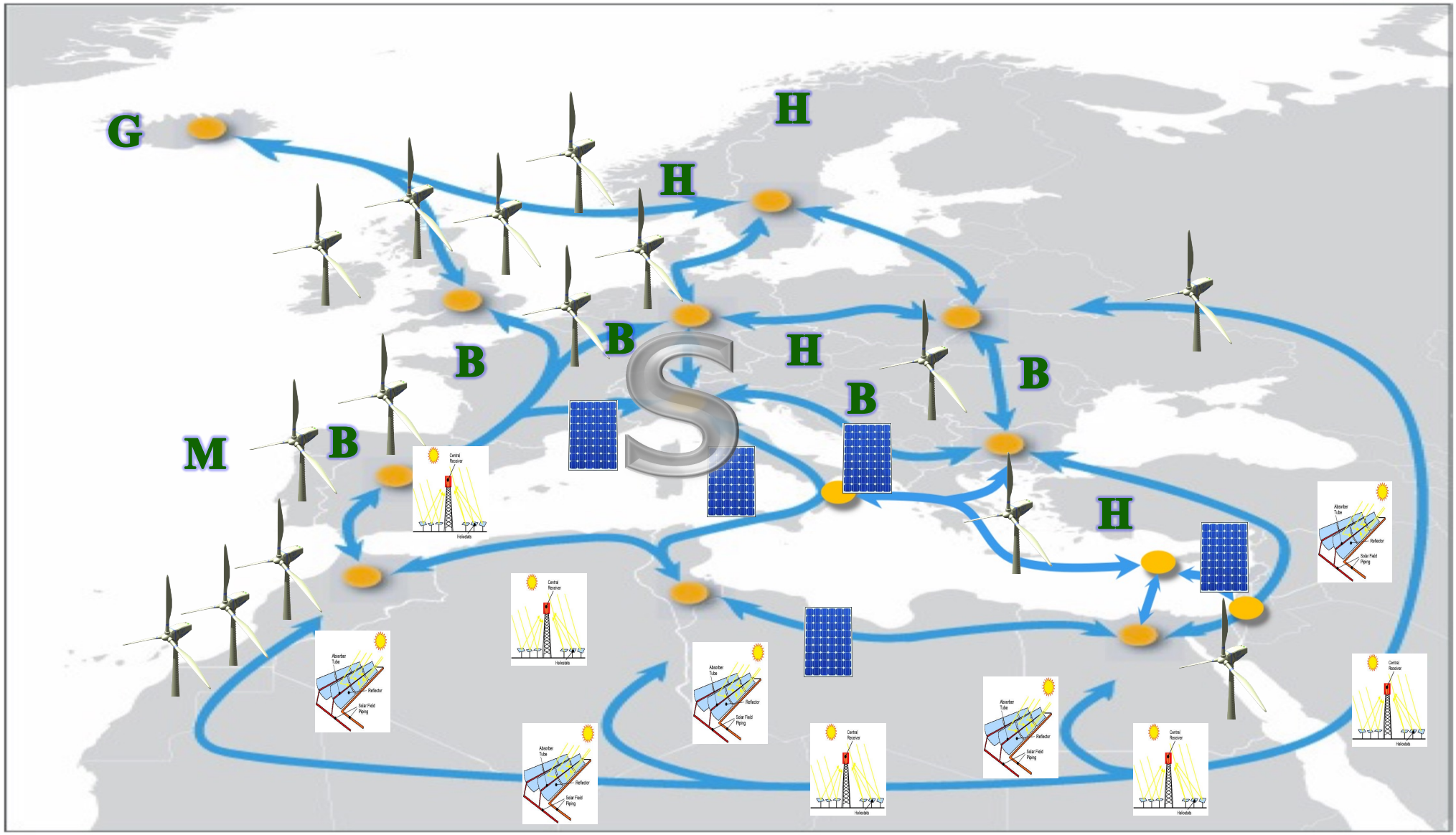

* Poullikkas A., 2013, *Sustainable Energy Development for Cyprus*, ISBN: 978-9963-7355-3-2

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 to this effect by May 2022
  - …

Long term scenarios in Europe

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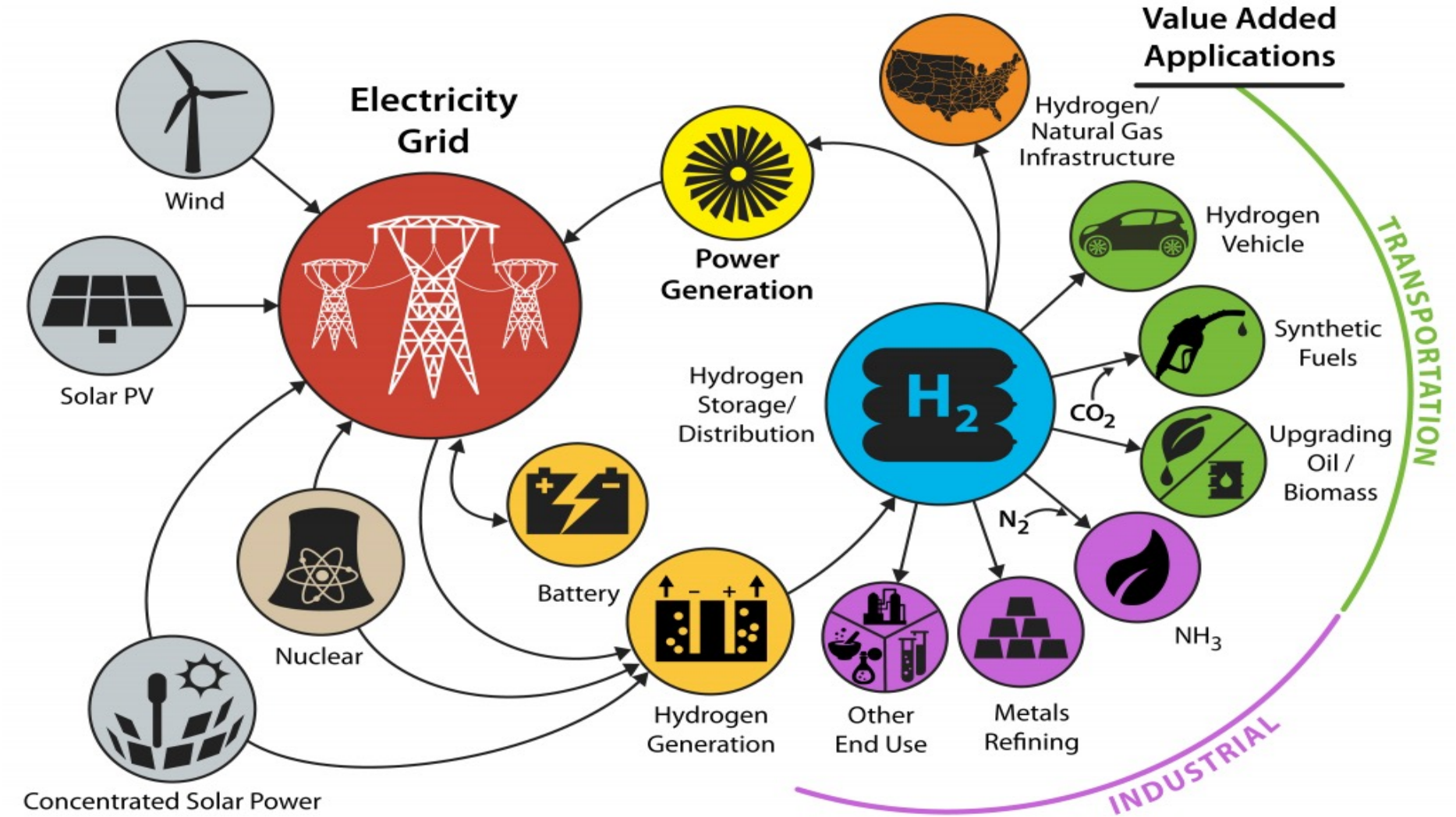
Moving from Carbon economy to Hydrogen economy



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

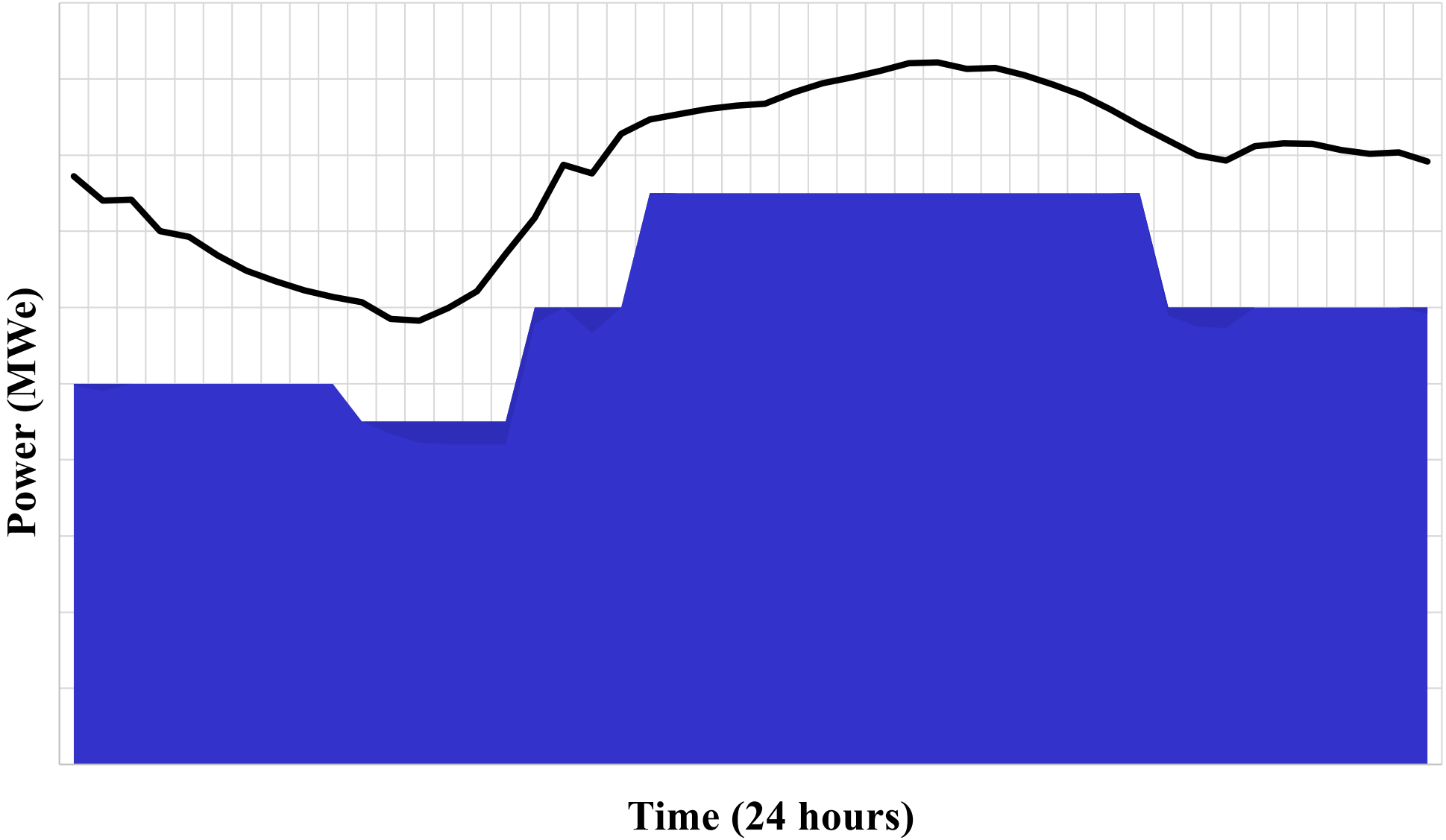
Additional Slides

Electricity market operation

EU target model

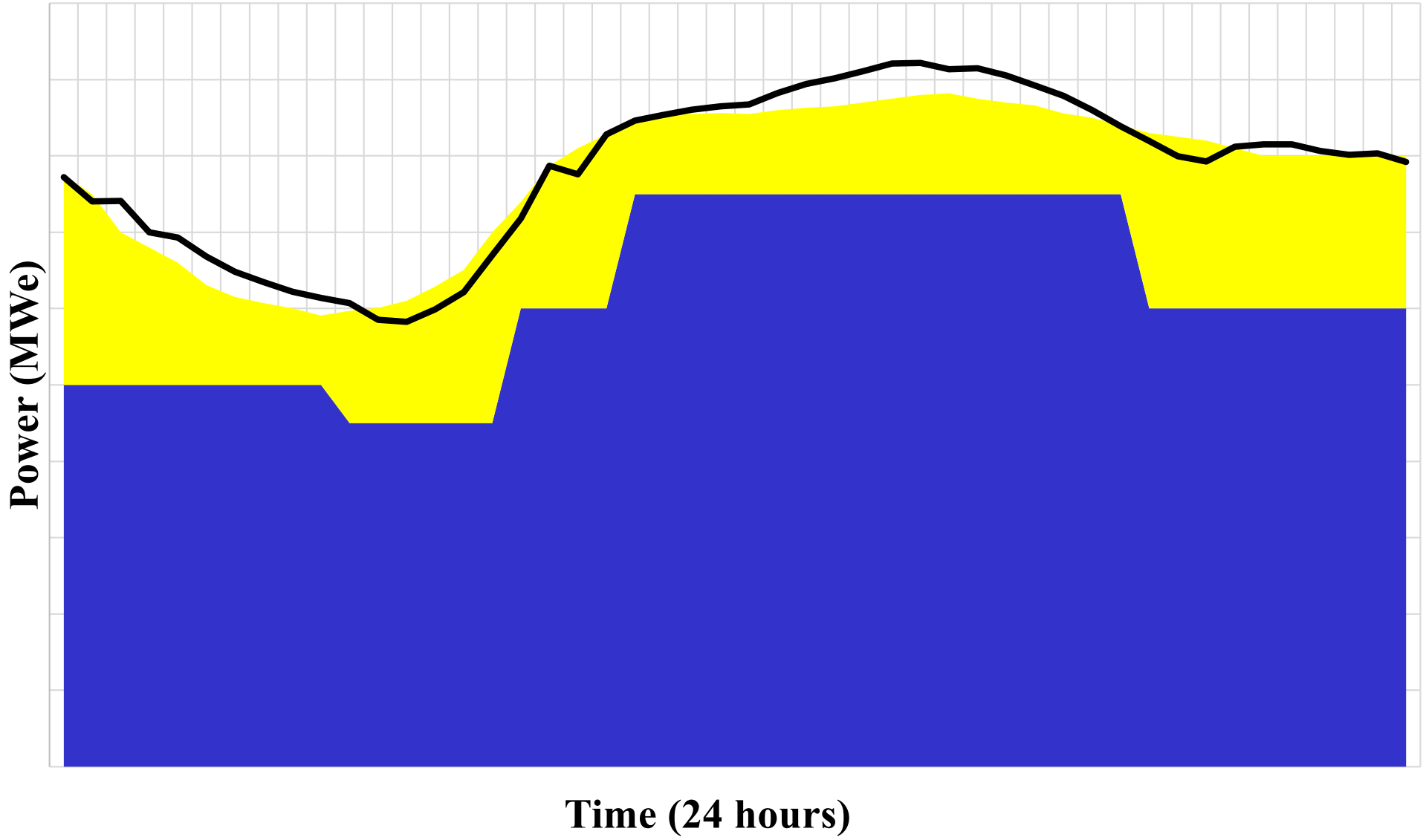
Electricity market operation

- **Forward market**



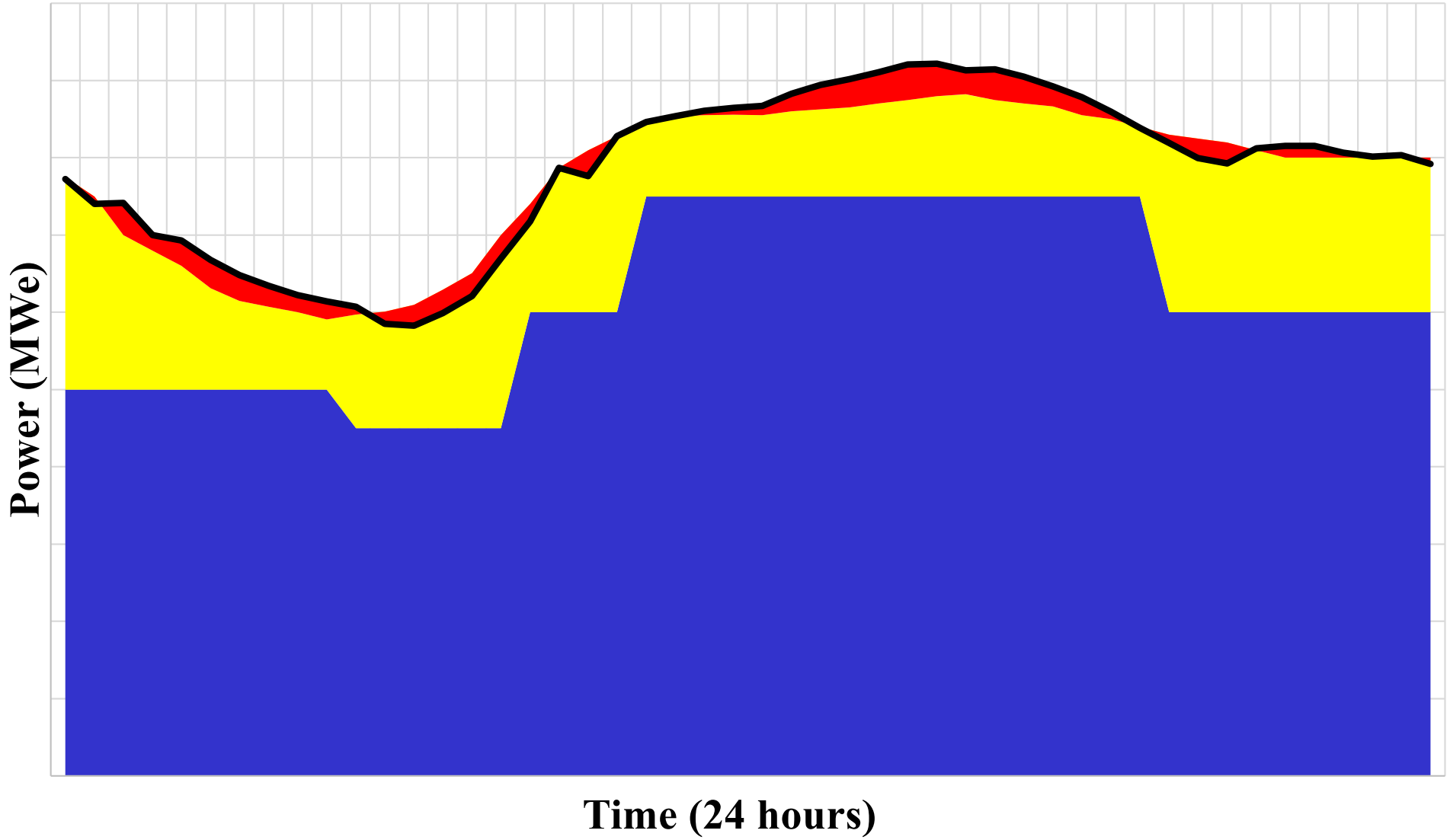
Electricity market operation

- **Forward market + Day ahead market**

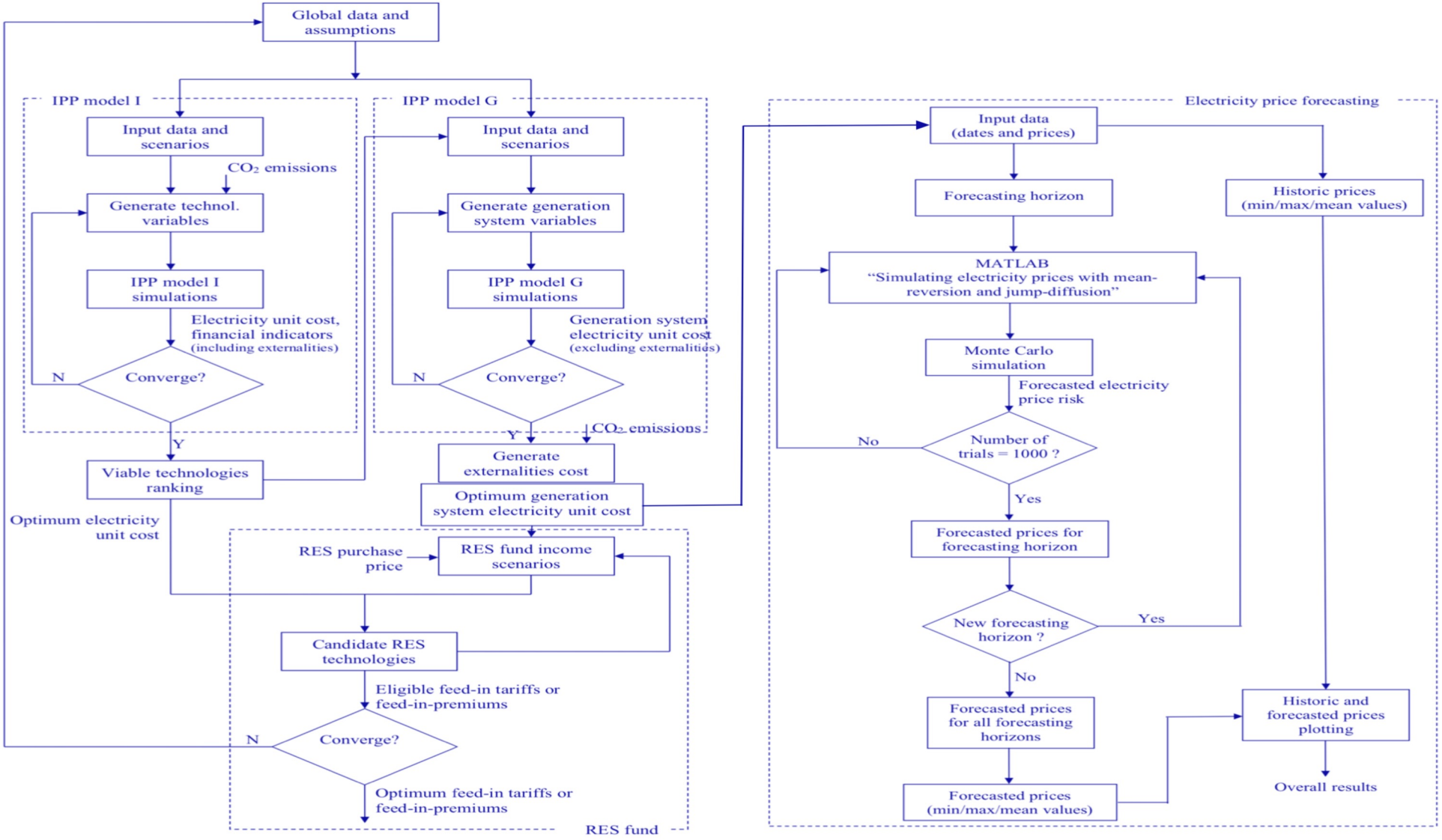


Electricity market operation

- **Forward market + Day ahead market + Balancing market**



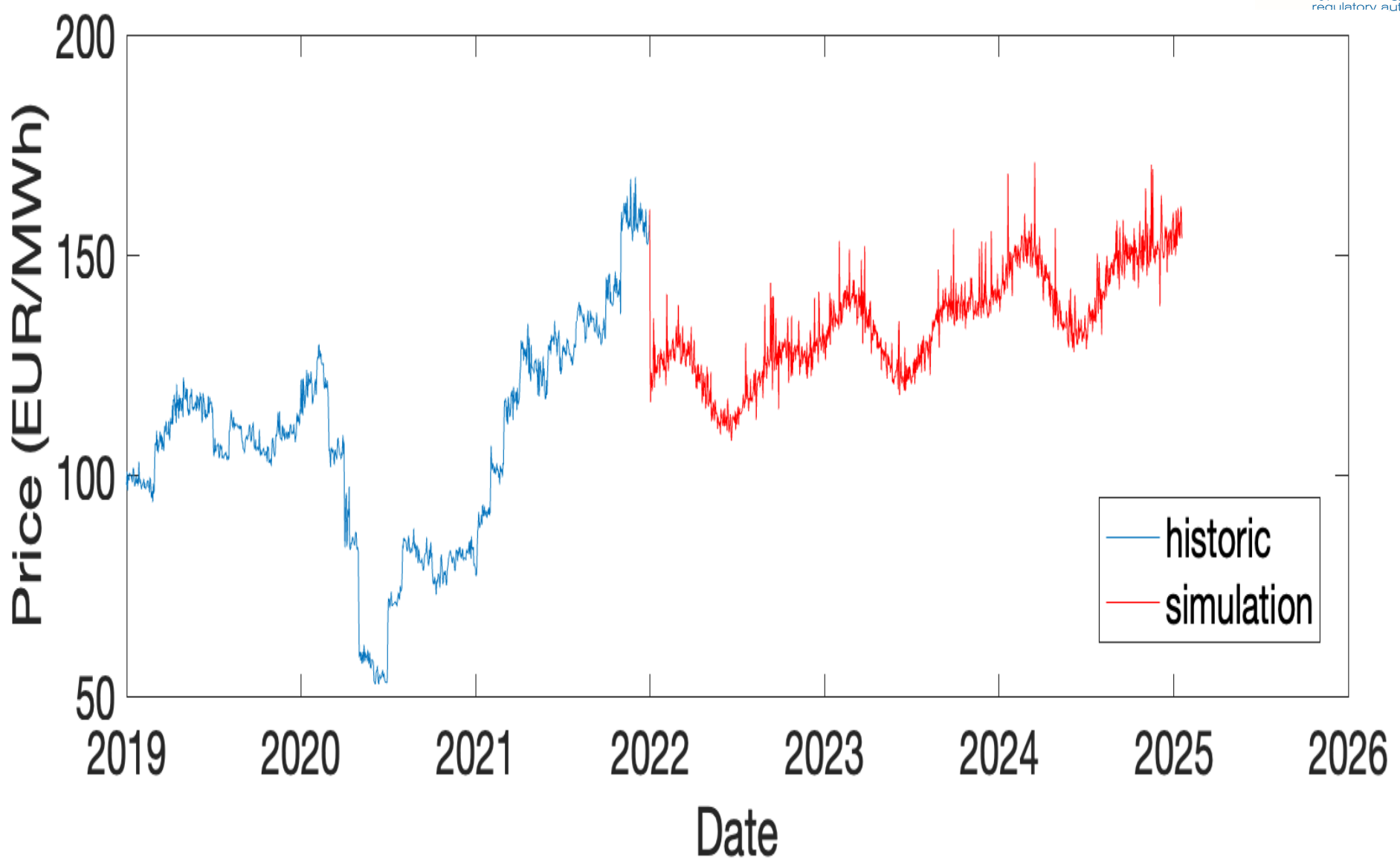
Optimization model*,**



- 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***

Storage and flexible technologies are the missing links

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Energy storage

Flexible technologies

Hydrogen technologies

CERA
Storage, Flexible Technologies and Hydrogen Regulatory Frameworks

EU medium and long term targets

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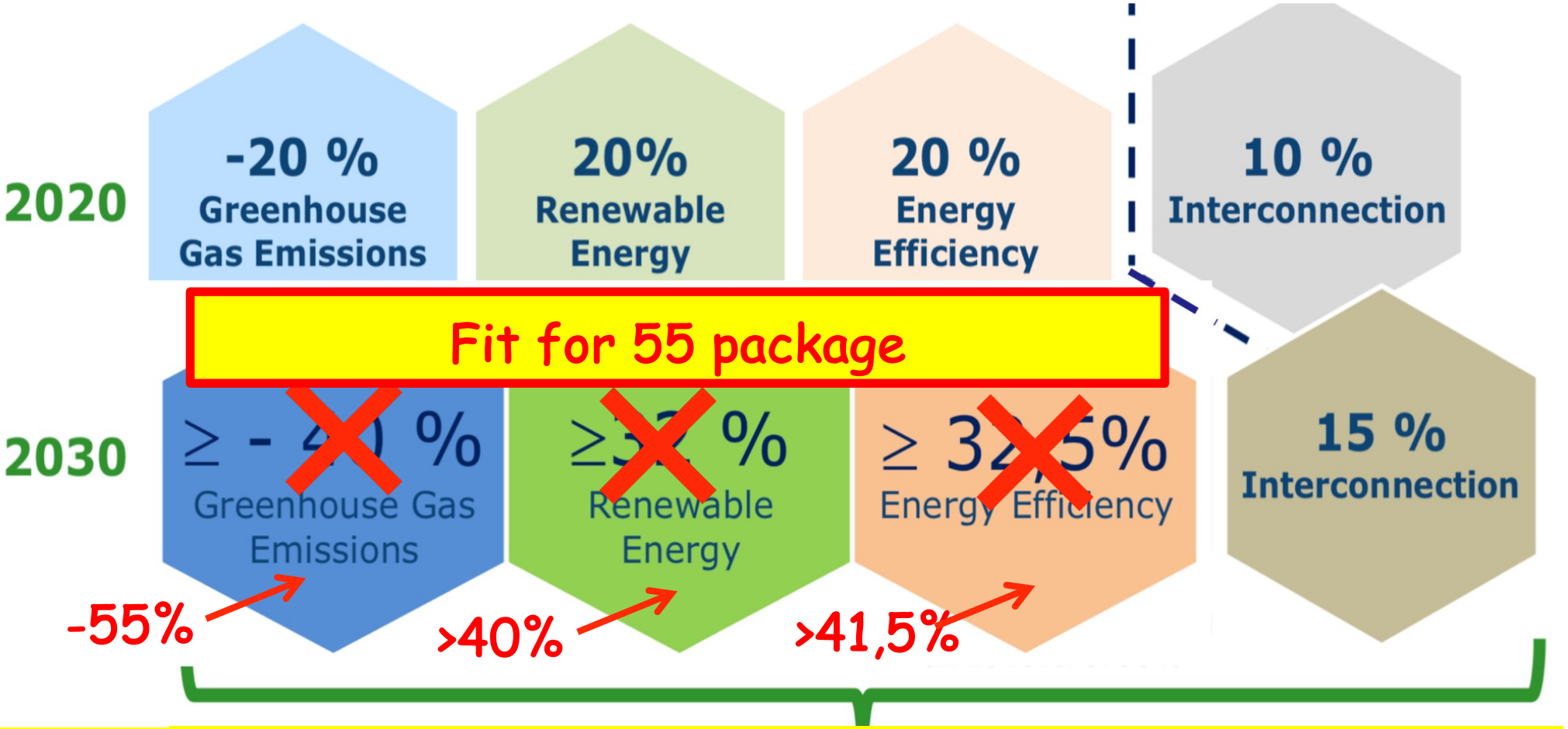


2050 **Climate-Neutral**

(an economy with net-zero greenhouse gas emissions)

Saudi Arabia $5bn Helios H2 project

- **Desert area = Belgium**
- **4GW of Wind and PVs**

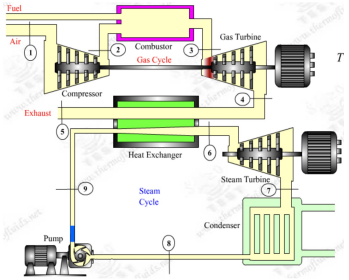
- **Production of 650t/day of H_2**
- **Reduce of H_2 production from 5US$/kg to 1.5US$/kg**
- **Long-term: Saudi Arabia to become H_2 exporter**

Regional primary energy sources

Indigenous energy sources

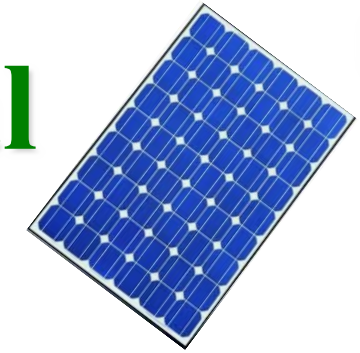
Main indigenous energy sources in SE Mediterranean region

- Natural gas



- Wind potential

- Solar potential



hydrogen

Energy transition by 2050

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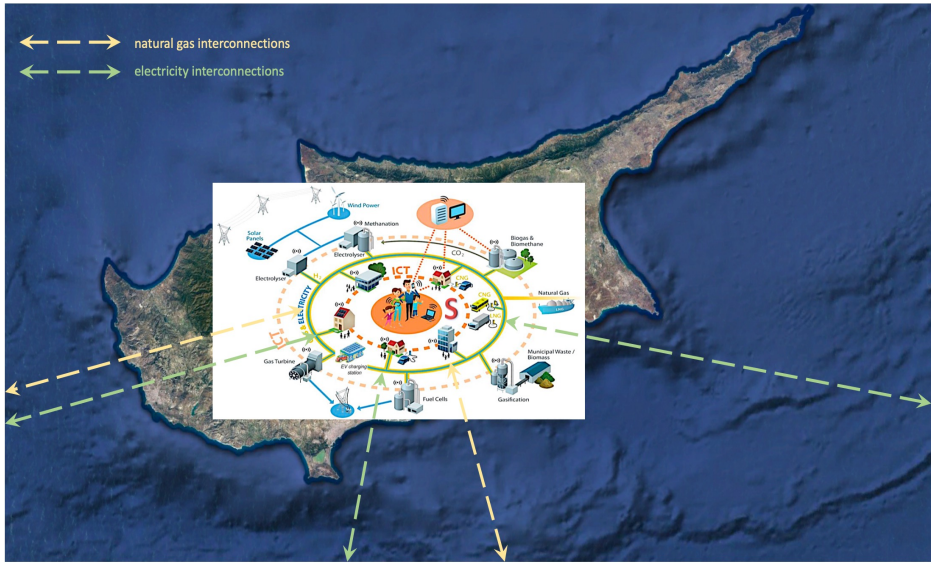
Cyprus' energy system:

- 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**