



Ενεργειακή Μετάβαση: Ρυθμιστικές προκλήσεις για τον Κυπριακό Ενεργειακό Τομέα

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- **EU energy strategy** – energy transition towards 2050
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EU energy strategy

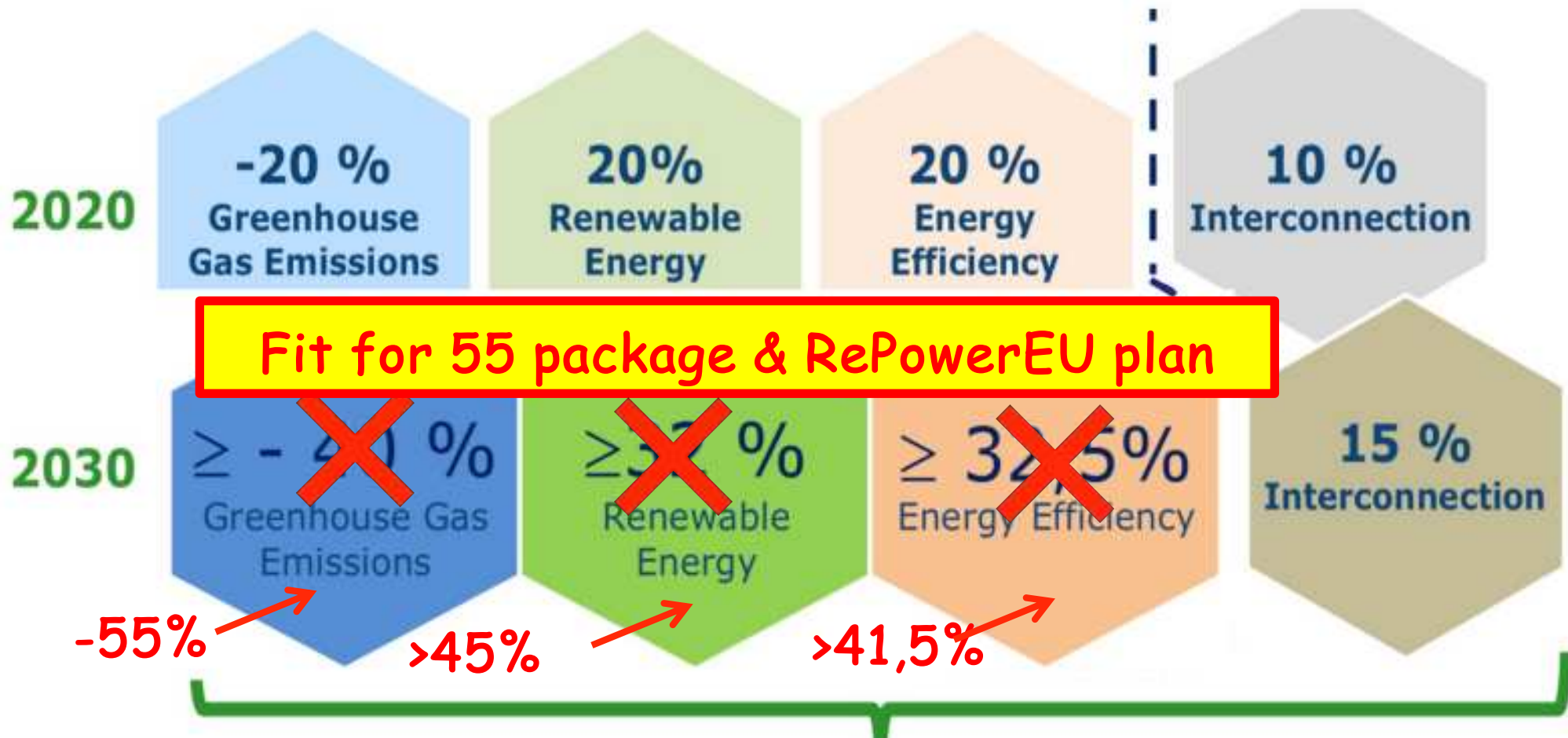
Energy transition towards 2050

Energy transition

- **greenhouse gas reduction**
 - EU: climate neutral by 2050
- **sustainable production and consumption**
- **third energy revolution**
- **competition in electricity and natural gas markets**
- **security of supply**



EU medium and long term targets

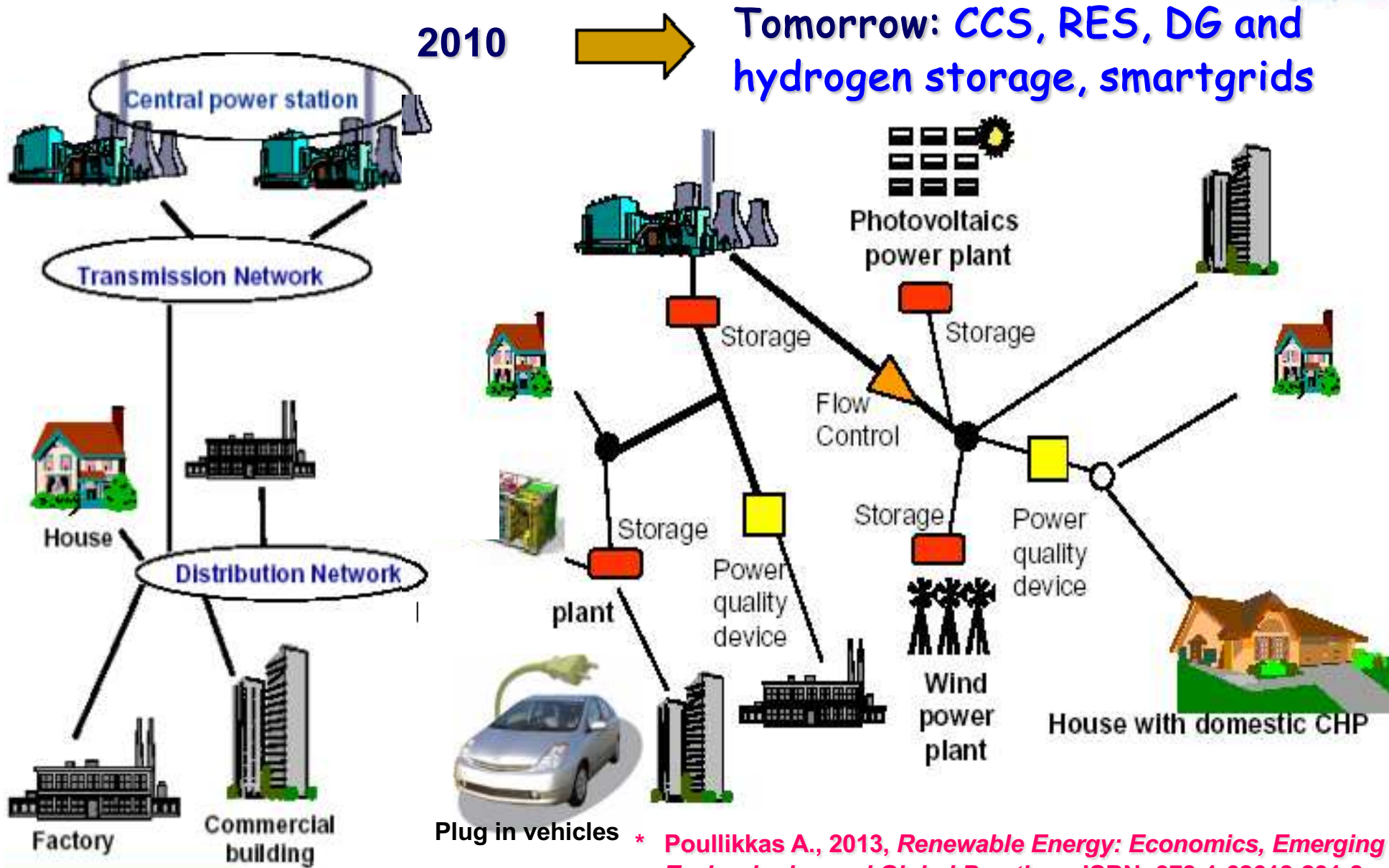


2050

Climate-Neutral

(an economy with net-zero greenhouse gas emissions)

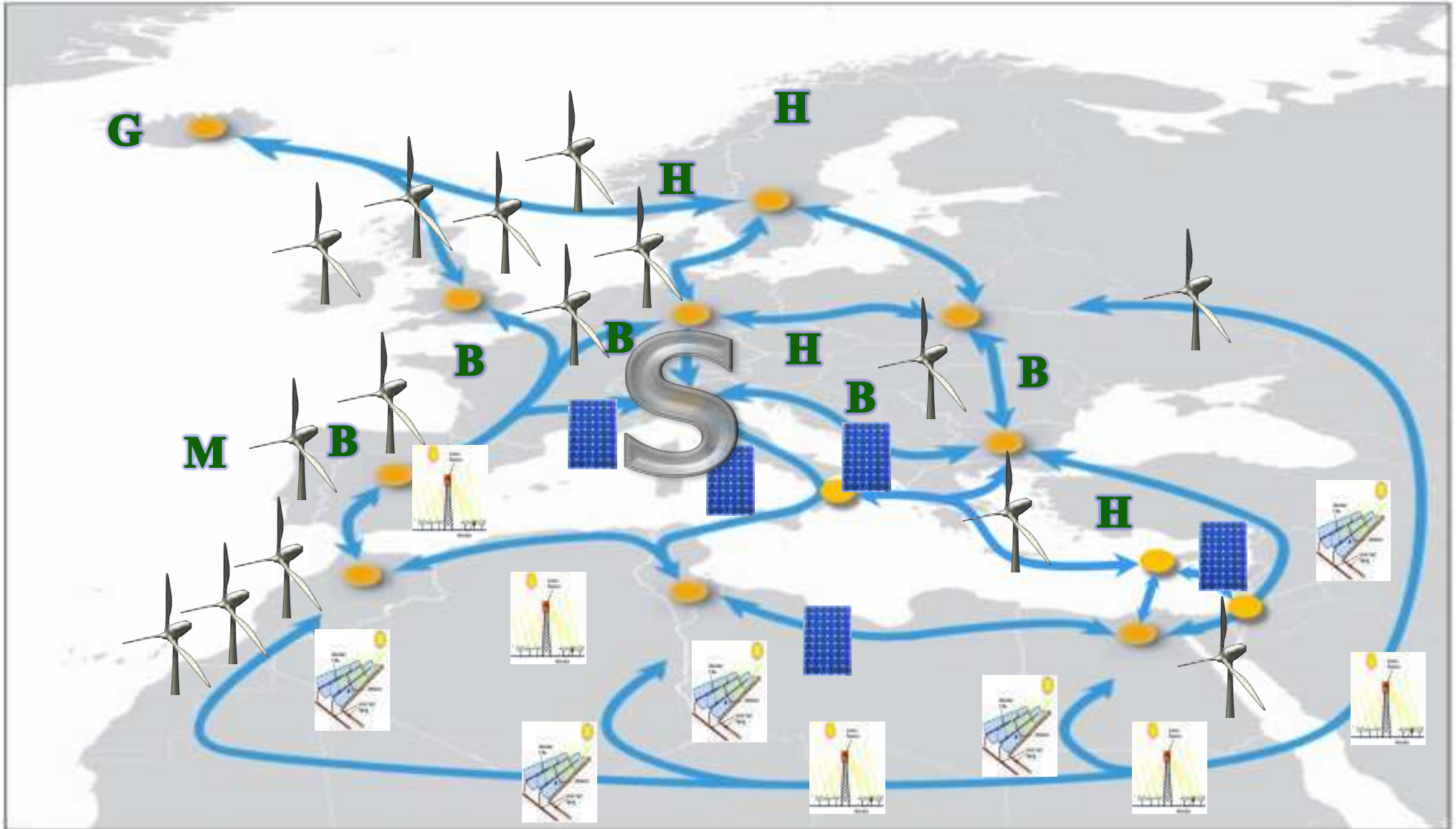
Future power systems*



Plug in vehicles *

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

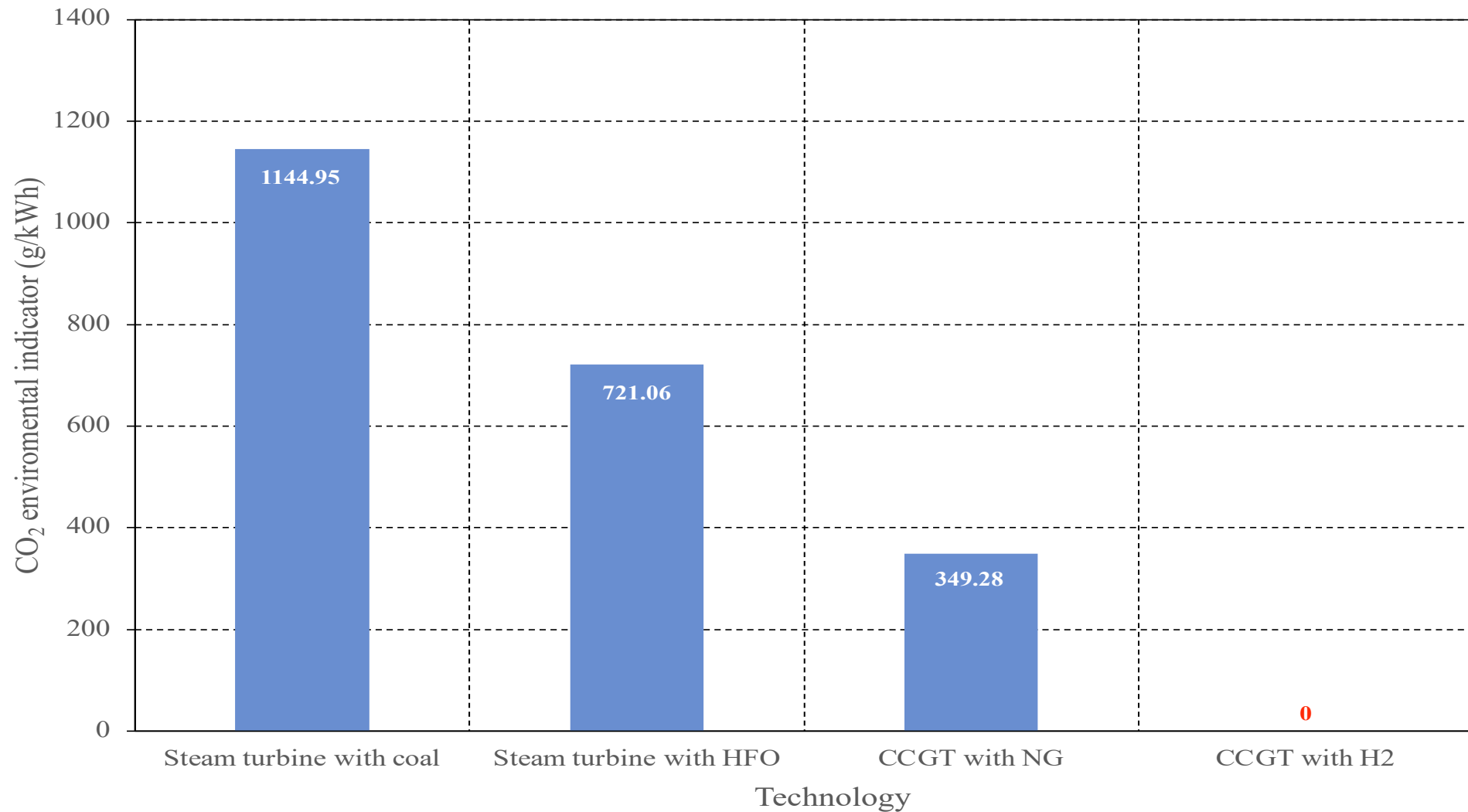
The Super Smart Grid after 2050* (may allow for 100% RES)



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

Το αυξανόμενο κόστος ενέργειας και οι τρόποι αντιμετώπισής του
Ημερίδα ΔΗΚΟ, Λευκωσία, 25 Νοεμβρίου 2023

CO₂ emissions from green hydrogen power generation*



* Nicolaidis P., Poullikkas A., 2023, “Power-to-hydrogen concepts for 100% renewable and sustainable energy systems”, *Hydrogen Economy*

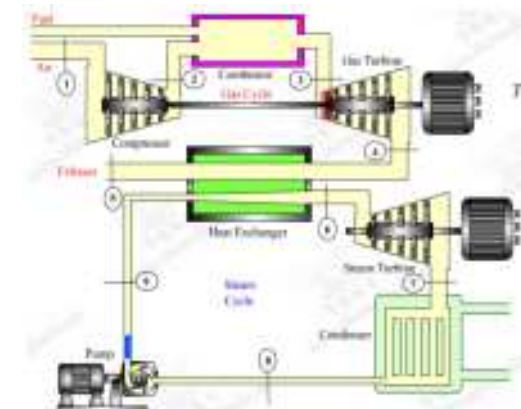
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Cyprus current electricity and NG systems

Systems characteristics

Existing power generation system

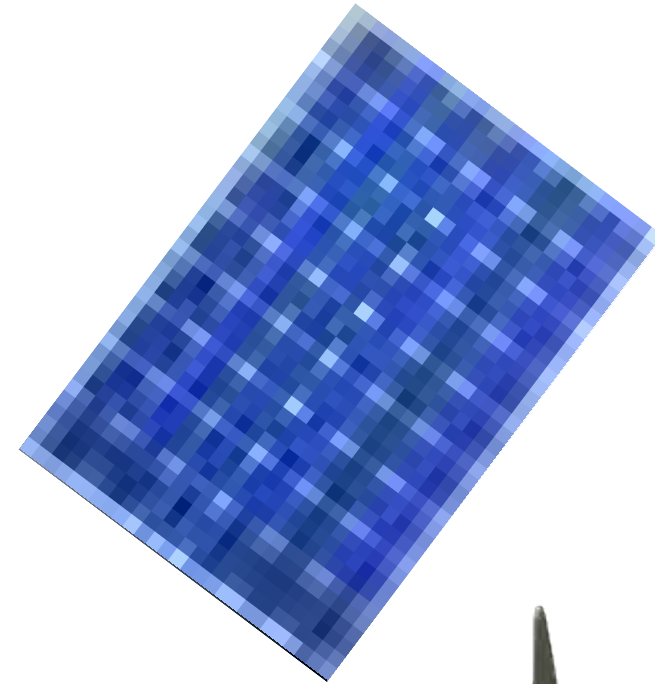
- **Steam turbine units (HFO)**
 - Dhekelia power station 6x60MWe
 - Vasilikos power station 3x130MWe
- **Internal combustion engines (HFO)**
 - Dhekelia power station 6x17.5MWe
 - W2E1 (Kofinou) station 3x1.5MWe
- **Combined cycles (Diesel)**
 - Vasilikos power station 2x220MWe
- **Gas turbine units (Diesel)**
 - Moni power station 4x37,5MWe
 - Vasilikos power station 1x38MWe



Existing power generation system (cont.)

- **Renewables**

- **PVs: 606MWe**
- **Wind: 157MWe**
- **Biomass: 13MWe**

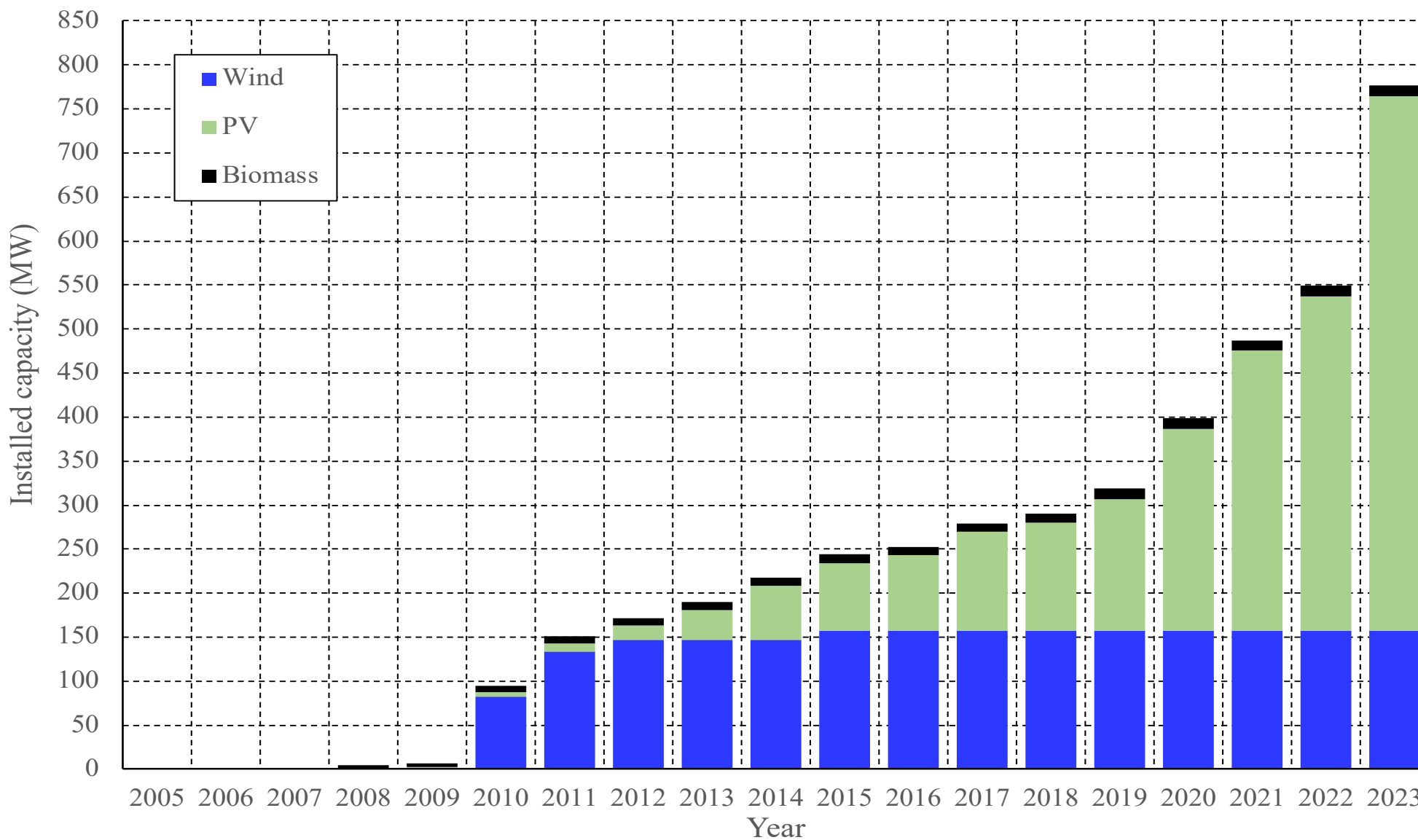


- **Total installed capacity:**

- **Conventional: 1488MWe**
- **Renewables: 776MWe**

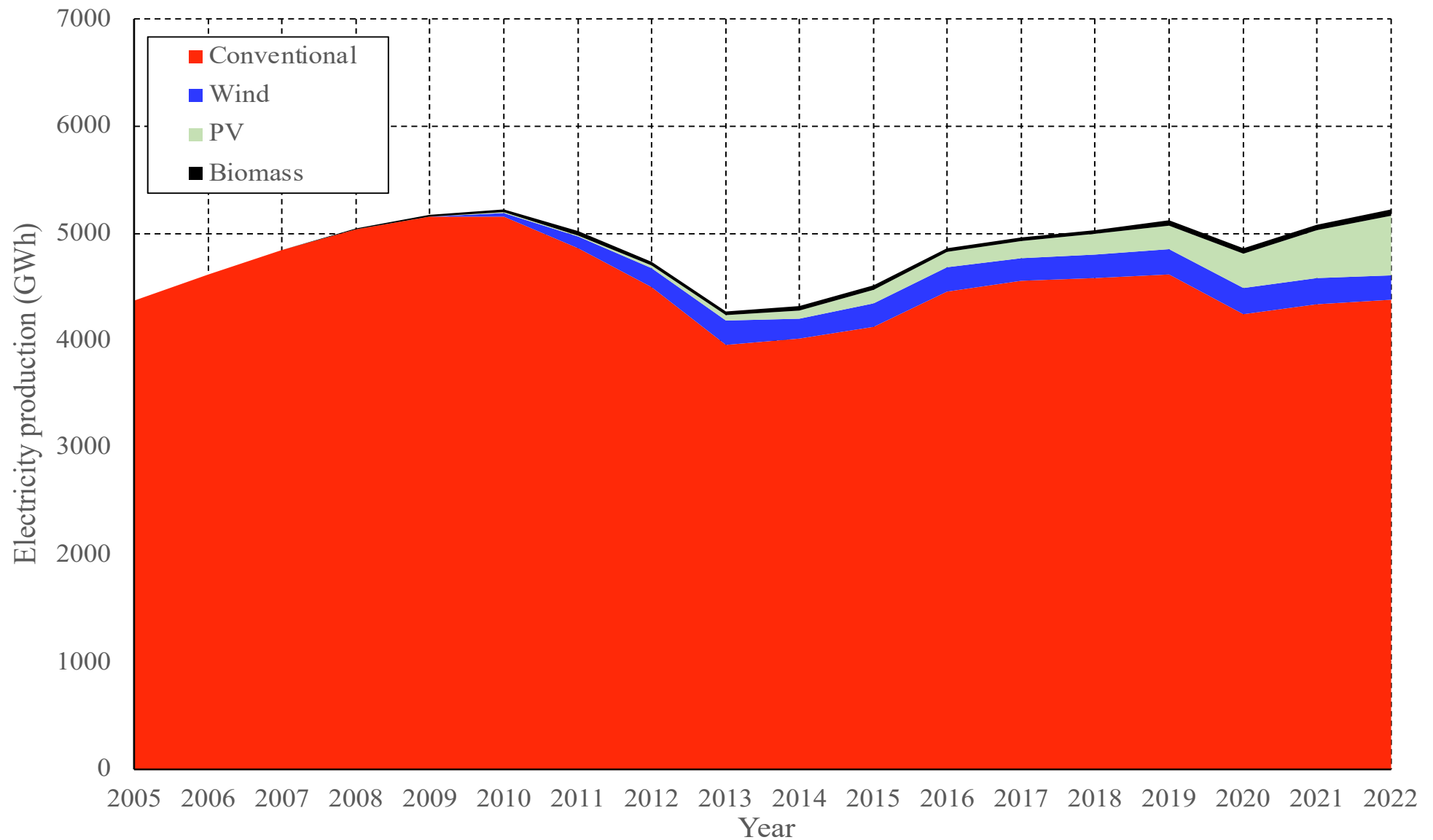


RES-E installed capacity*



* www.cera.org.cy

Total electricity production per year*



* www.cera.org.cy

EU electricity market target model*



Διμερή
συμβόλαια,
κλπ

Αγορά άμεσης
παράδοσης
(spot)
προηγούμενης
ημέρας

Αγορά άμεσης
παράδοσης
(spot) ίδιας
ημέρας

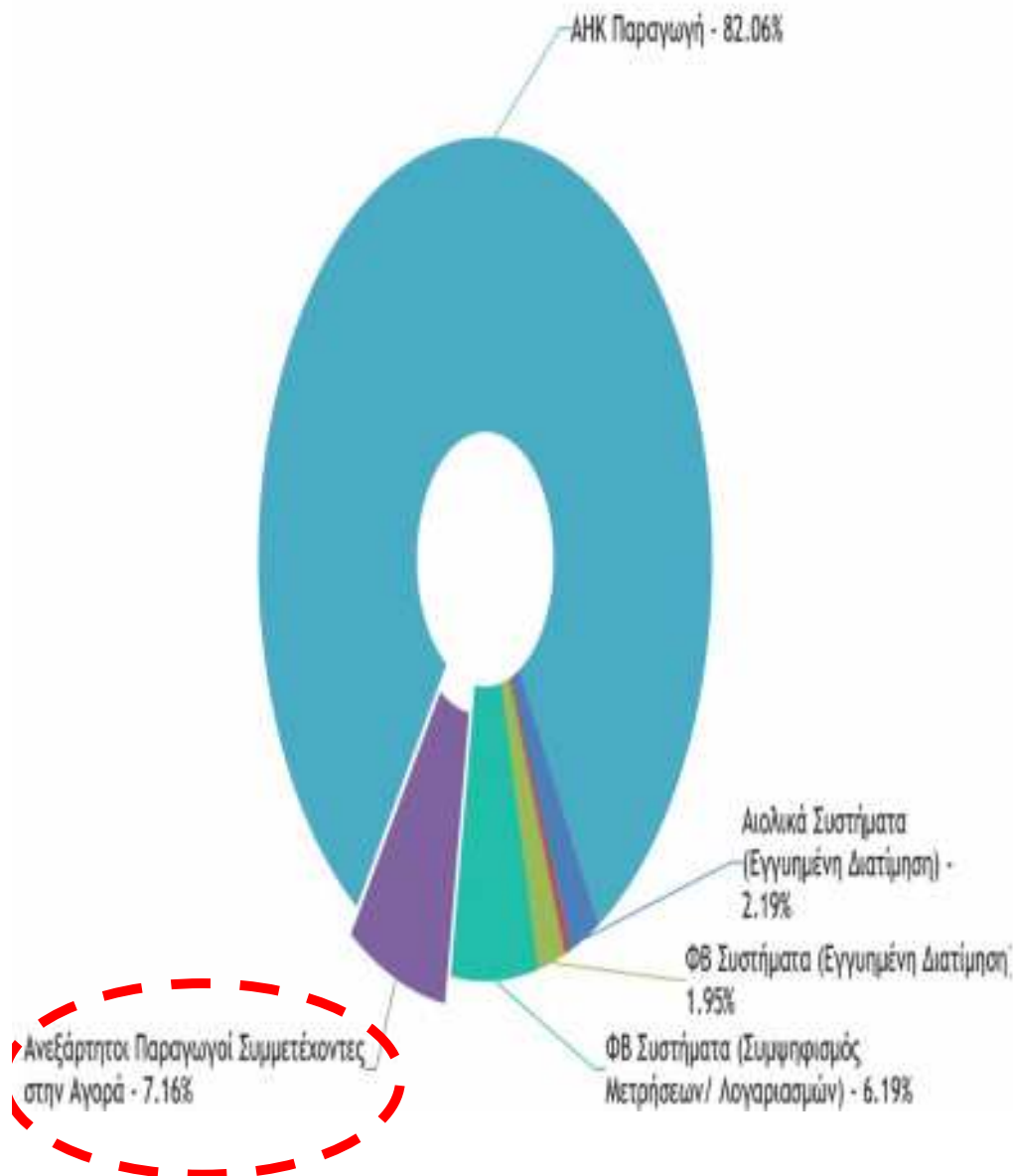
Αγορά
εξισορρόπησης

Integration of RES*: LCOE vs Reliability

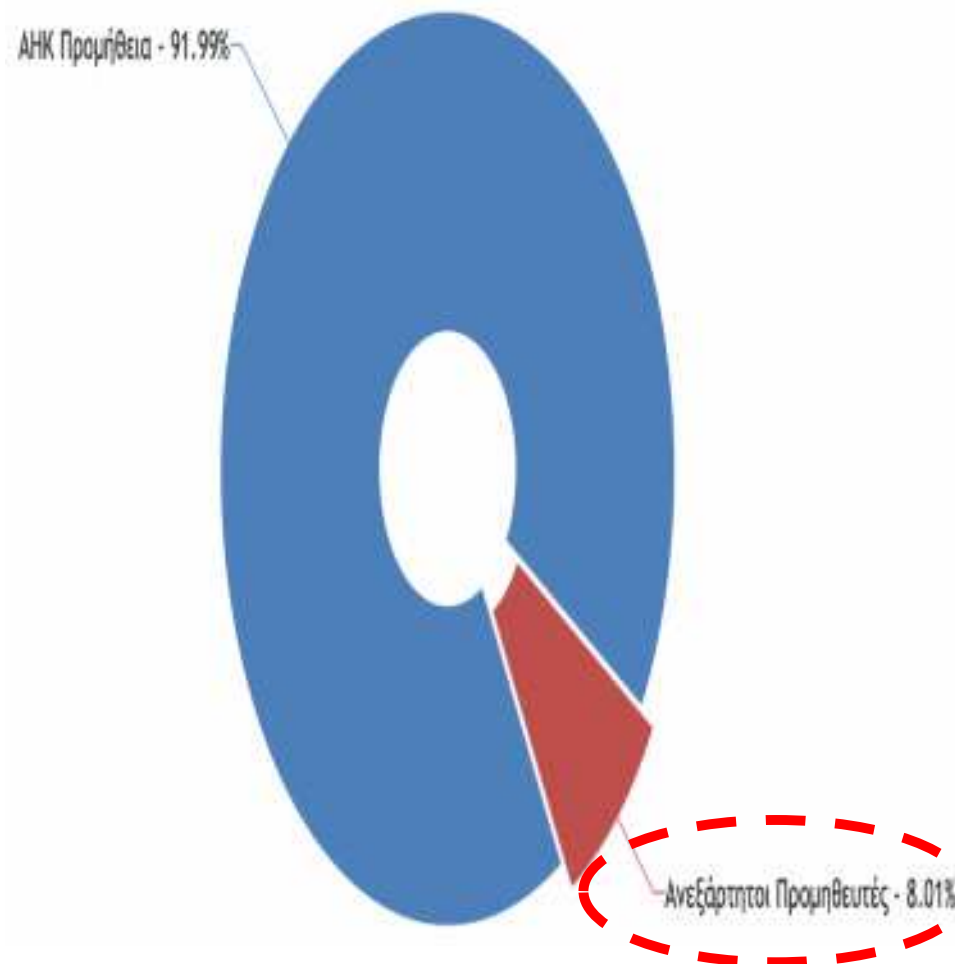
* Nicolaidis P., Chatzis S., Poullikkas A., 2018, "Renewable energy integration through optimal unit commitment and electricity storage in weak power networks", *International Journal of Sustainable Energy*

Market share (Aug 2023)

Wholesale market

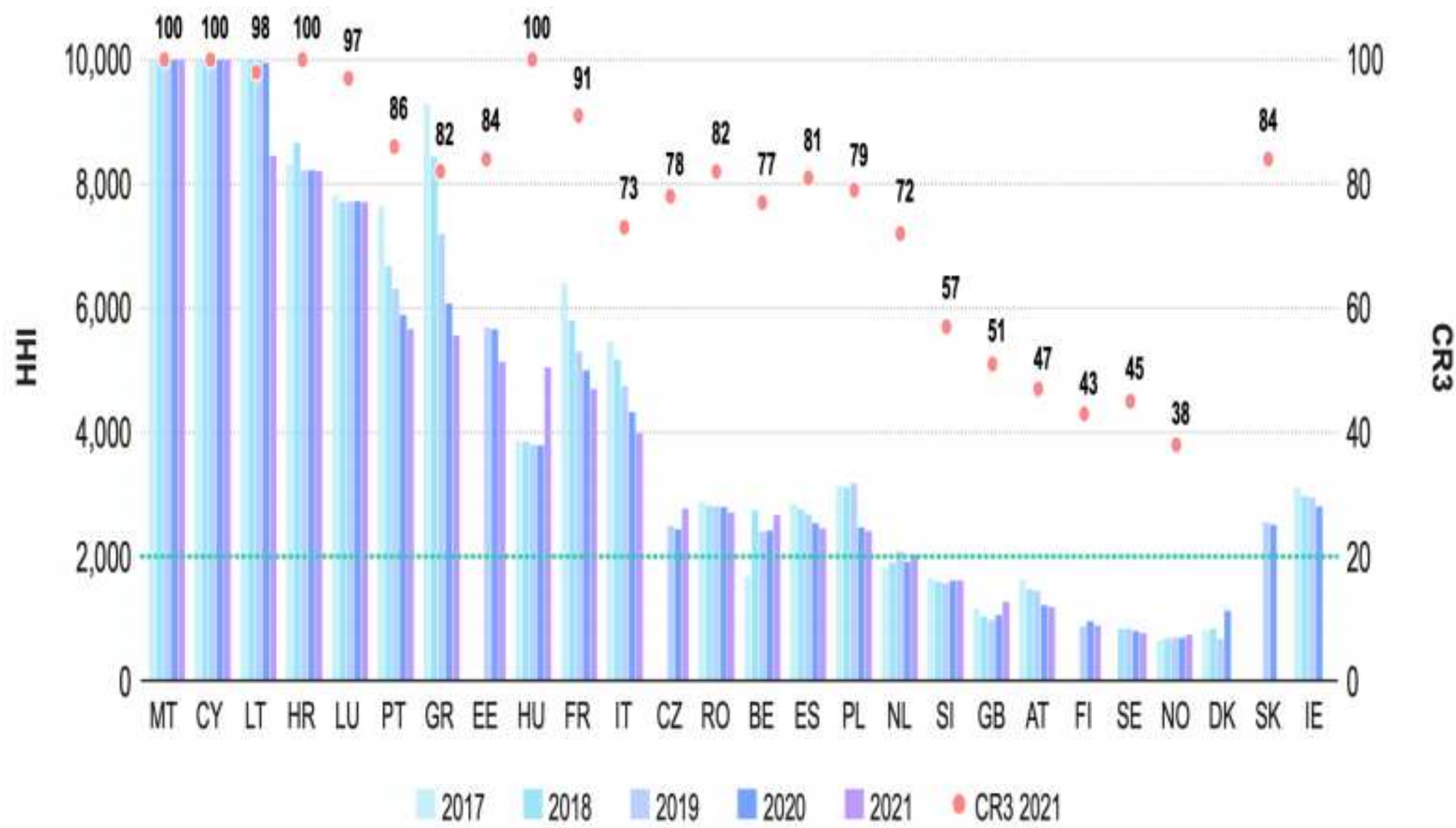


Retail market



Market concentration in EU (retail market)

Herfindahl-Hirschman Index: $HHI = (X_1)^2 + (X_2)^2 + (X_3)^2 + \dots + (X_n)^2$



*** ACER, 2021**

Existing natural gas system

- **Under development !**
- **For power generation as a start...**



Challenges of energy transition in island systems

Price comparisons and solutions for isolated systems

Characteristics of isolated electricity systems*

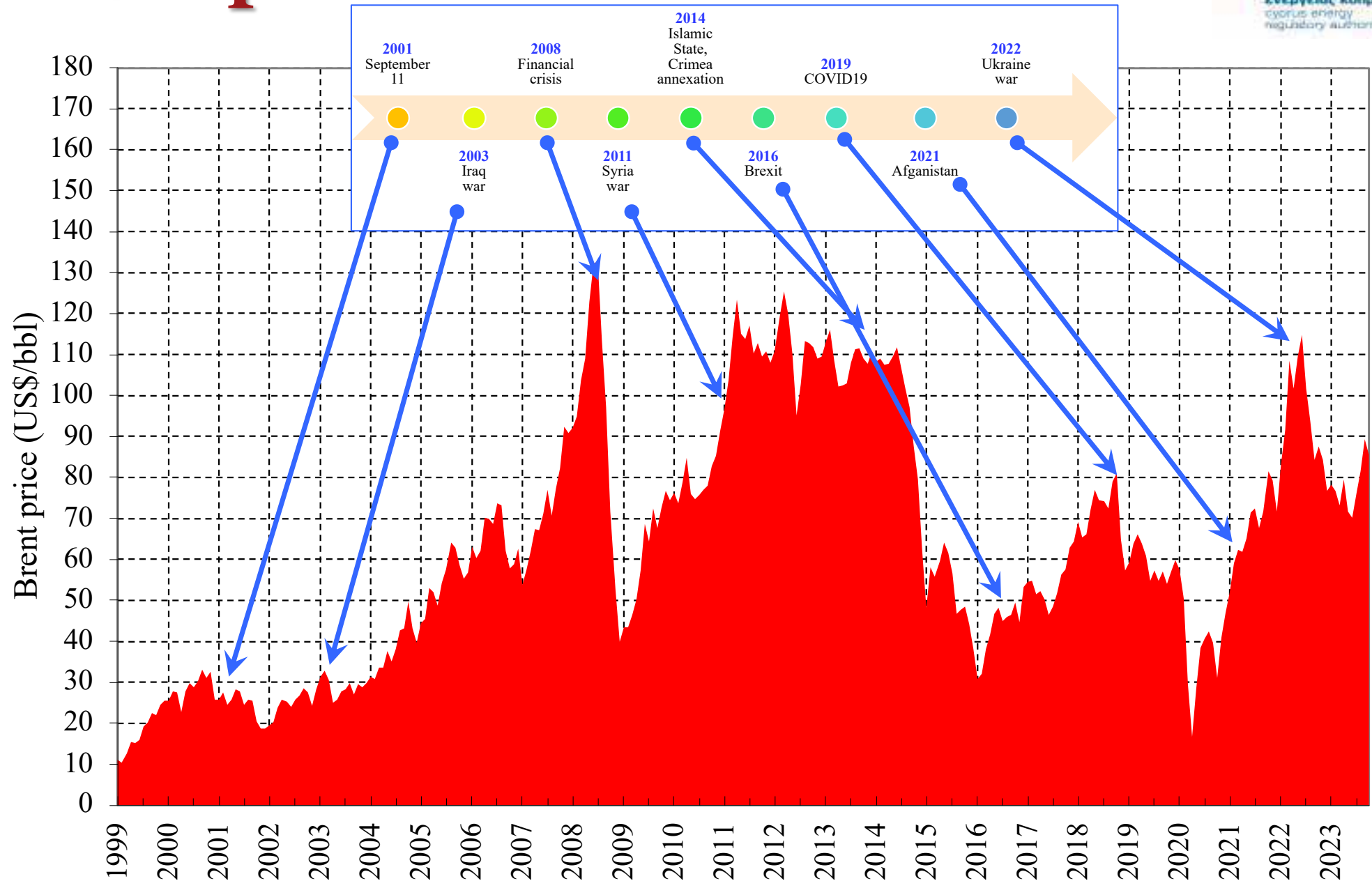


- **High fuel costs**
 - ~ use of oil derivatives
 - ~ high CO₂ emissions (additional cost)
- **Economies of scale cannot be adequately exploited**
 - ~ generation units cannot exceed a certain size since the loss of a unit would mean the loss of a high percentage of the entire system
- **Need to maintain high reserve capacity to ensure power system reliability**

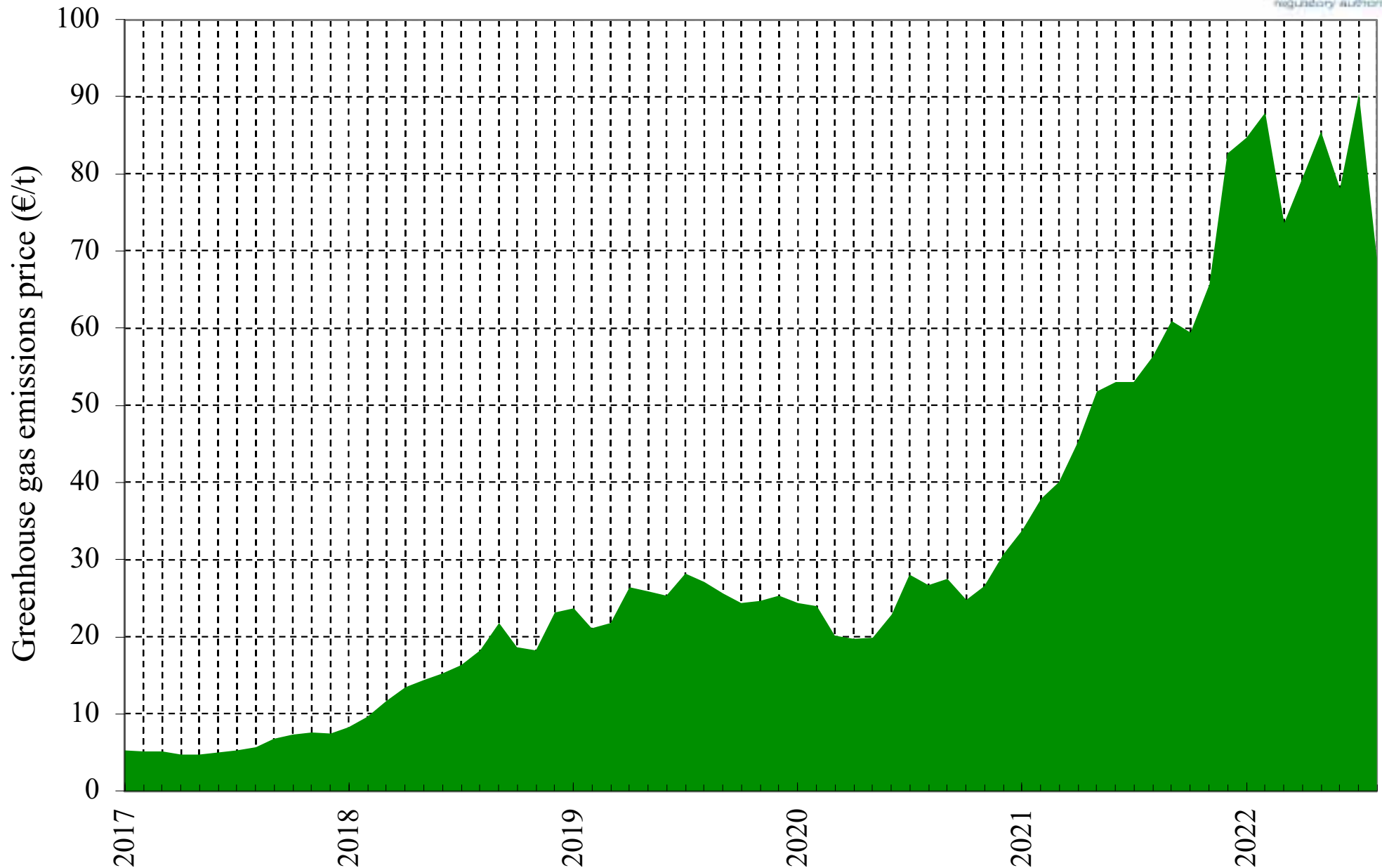
The smaller the electrical system size, the more the expenses will be

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

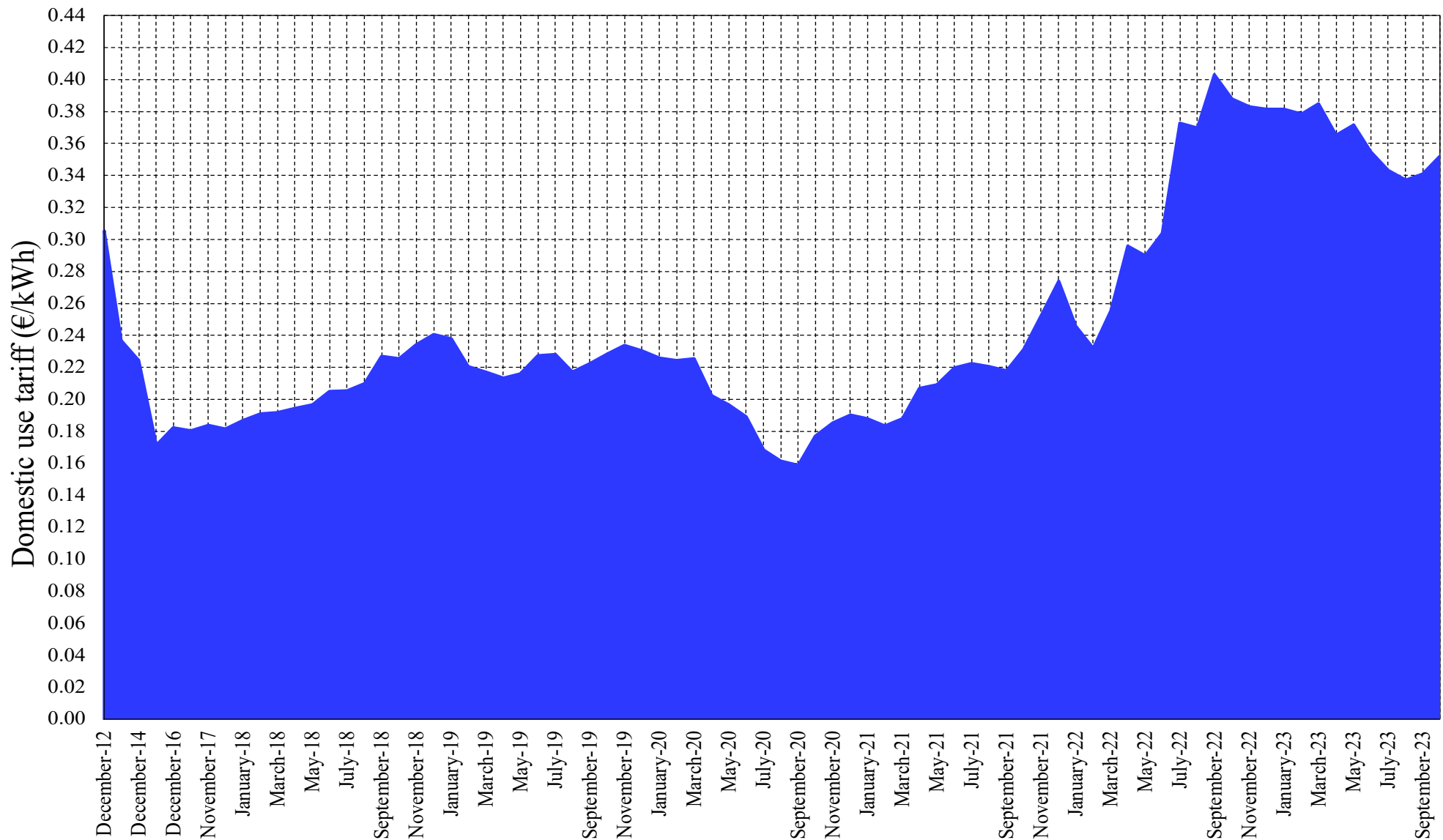
Brent price



Greenhouse gas emissions price



Electricity price for domestic use*

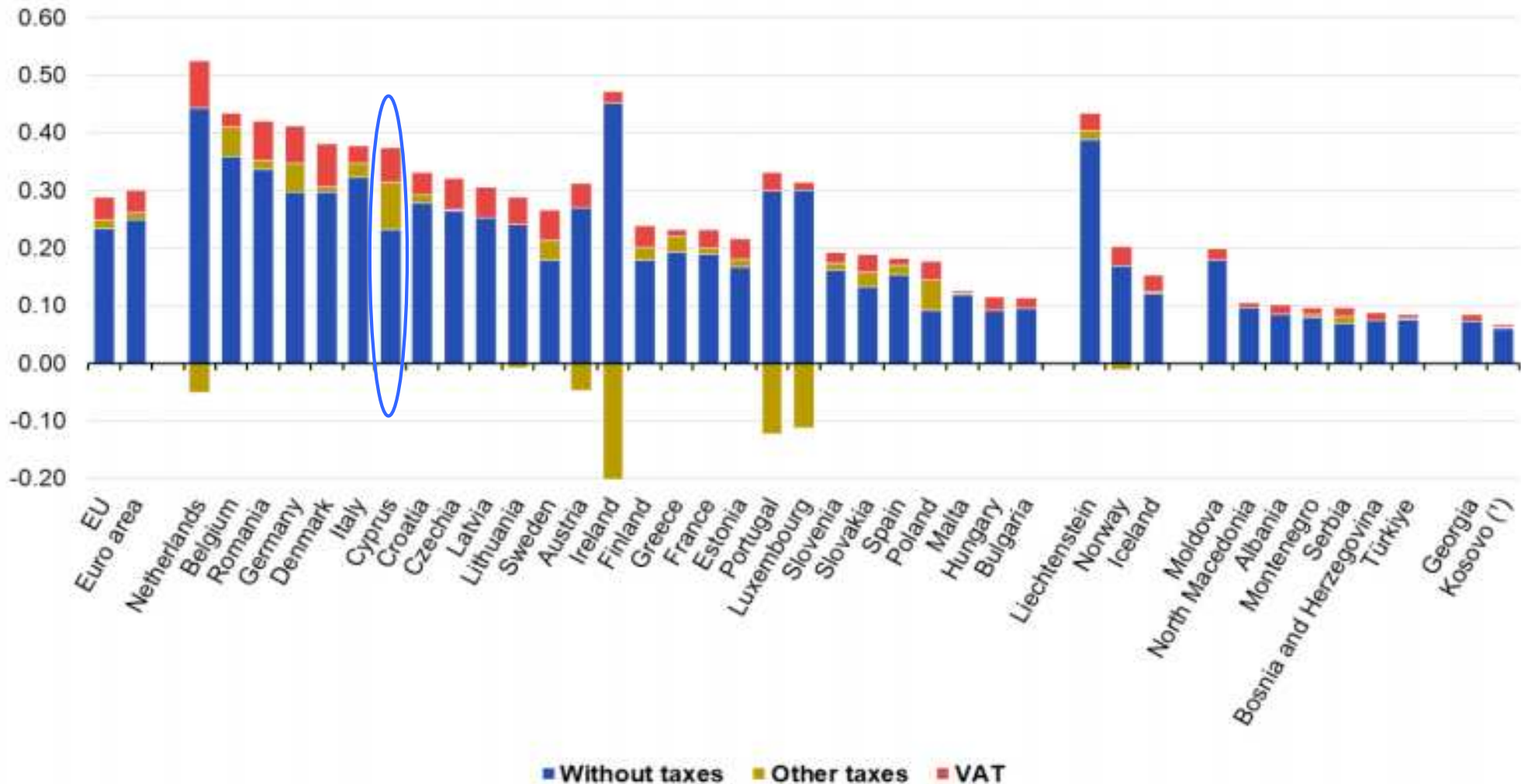


* www.cera.org.cy

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EU statistics*

Electricity prices for household consumers, first half 2023
(euro per kWh)

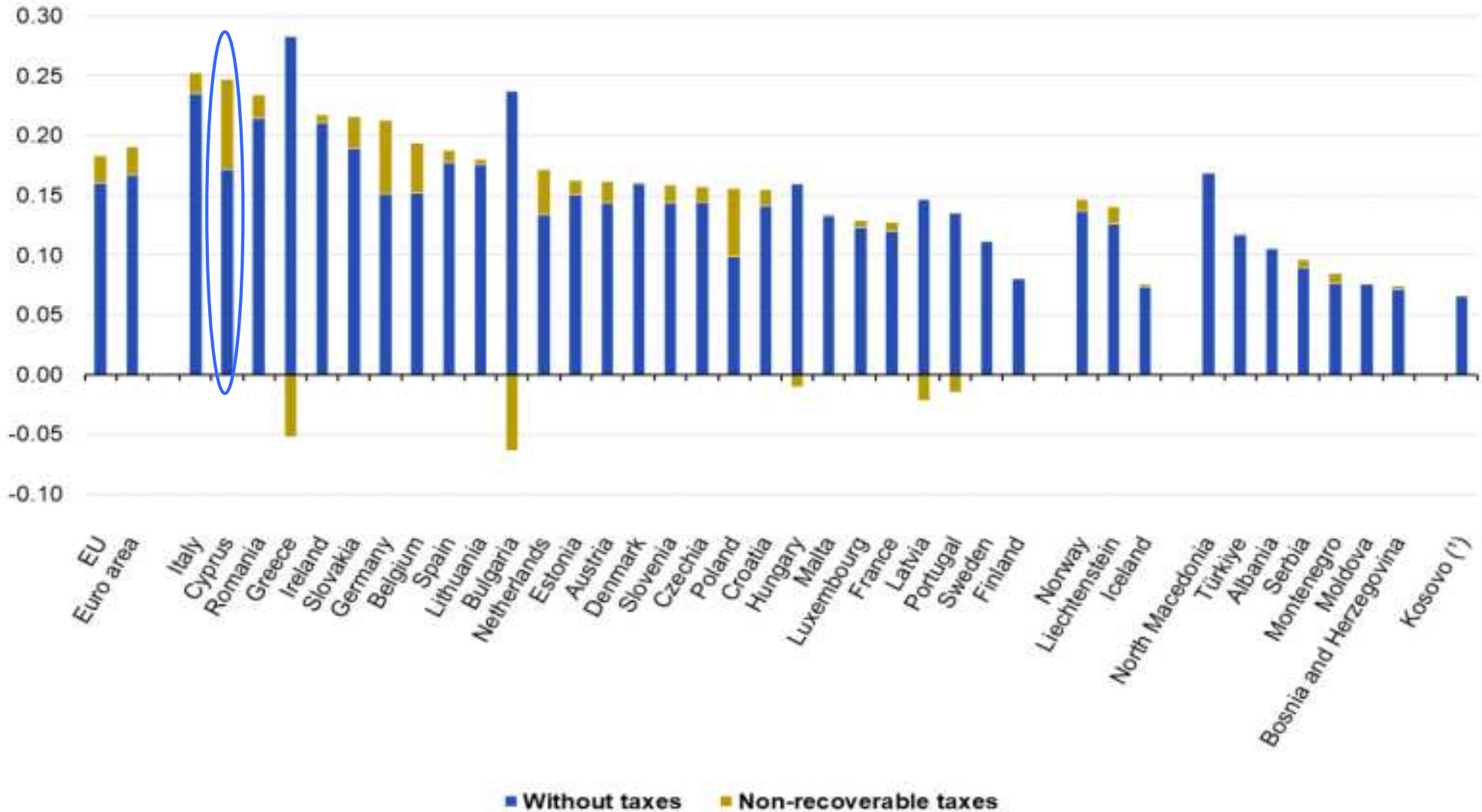


* Eurostat

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EU statistics* (cont.)

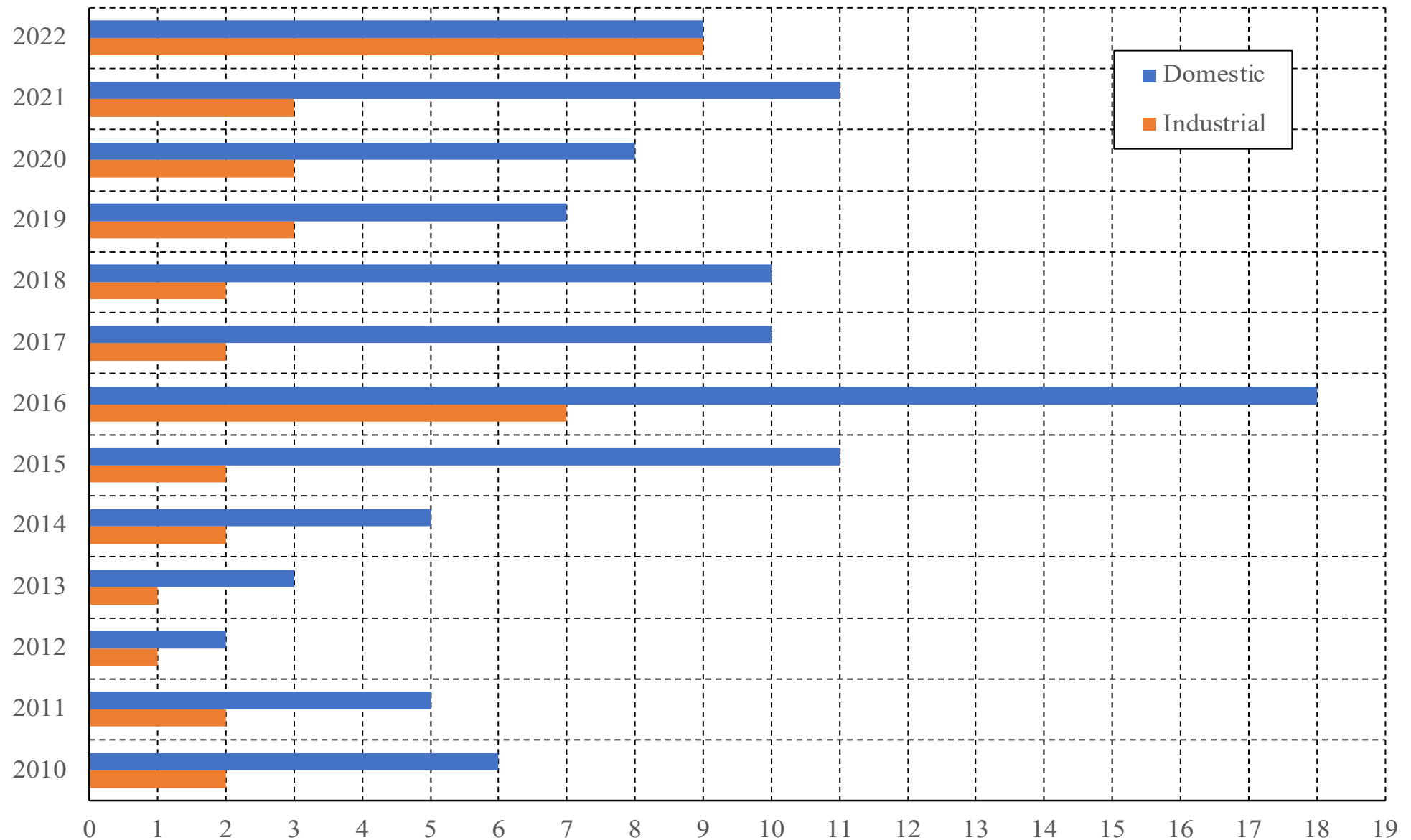
Electricity prices for non-household consumers, first half 2023
(euro per kWh)



* Eurostat

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Electricity price - Position of Cyprus in EU*



* Eurostat

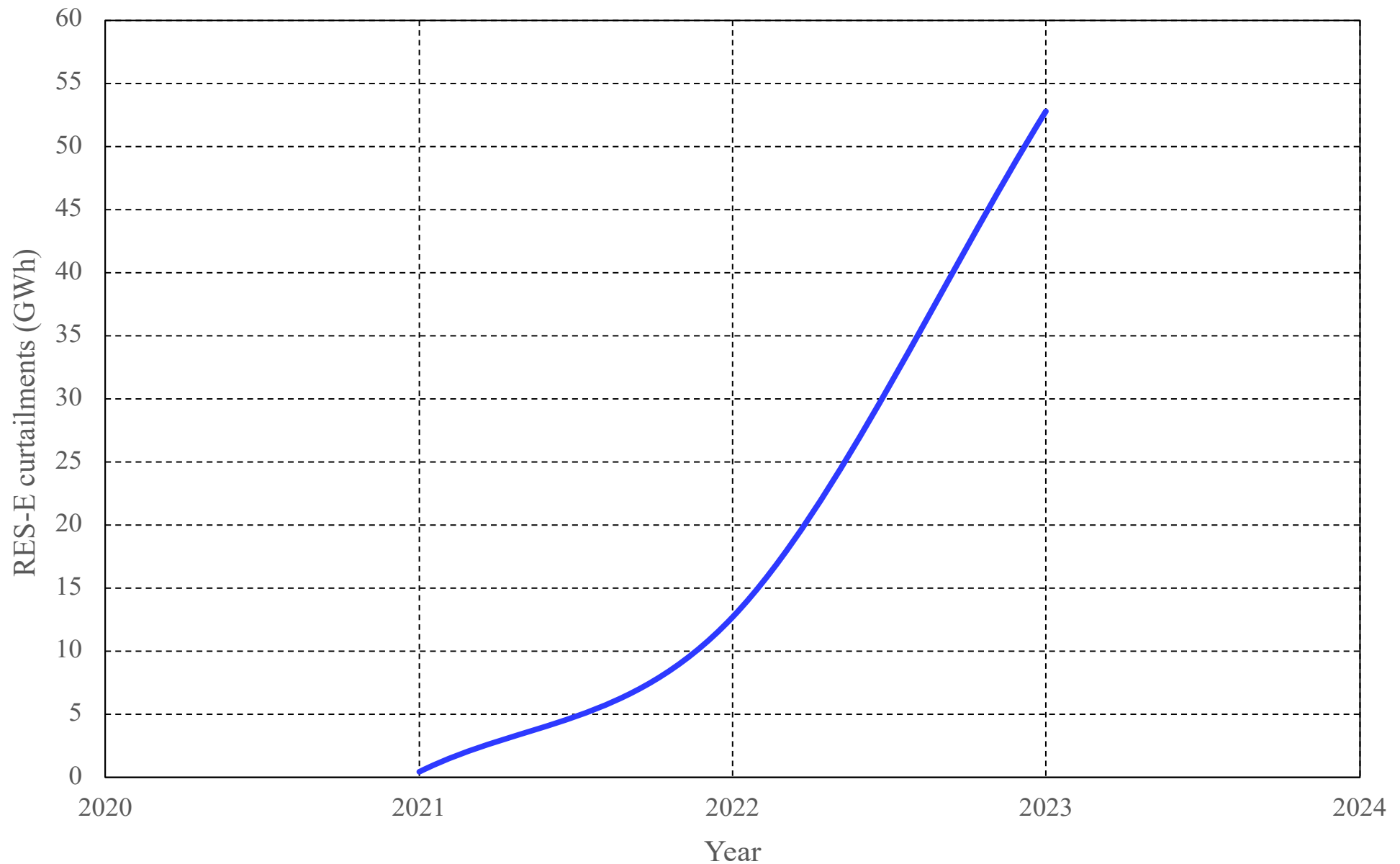
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The solution*

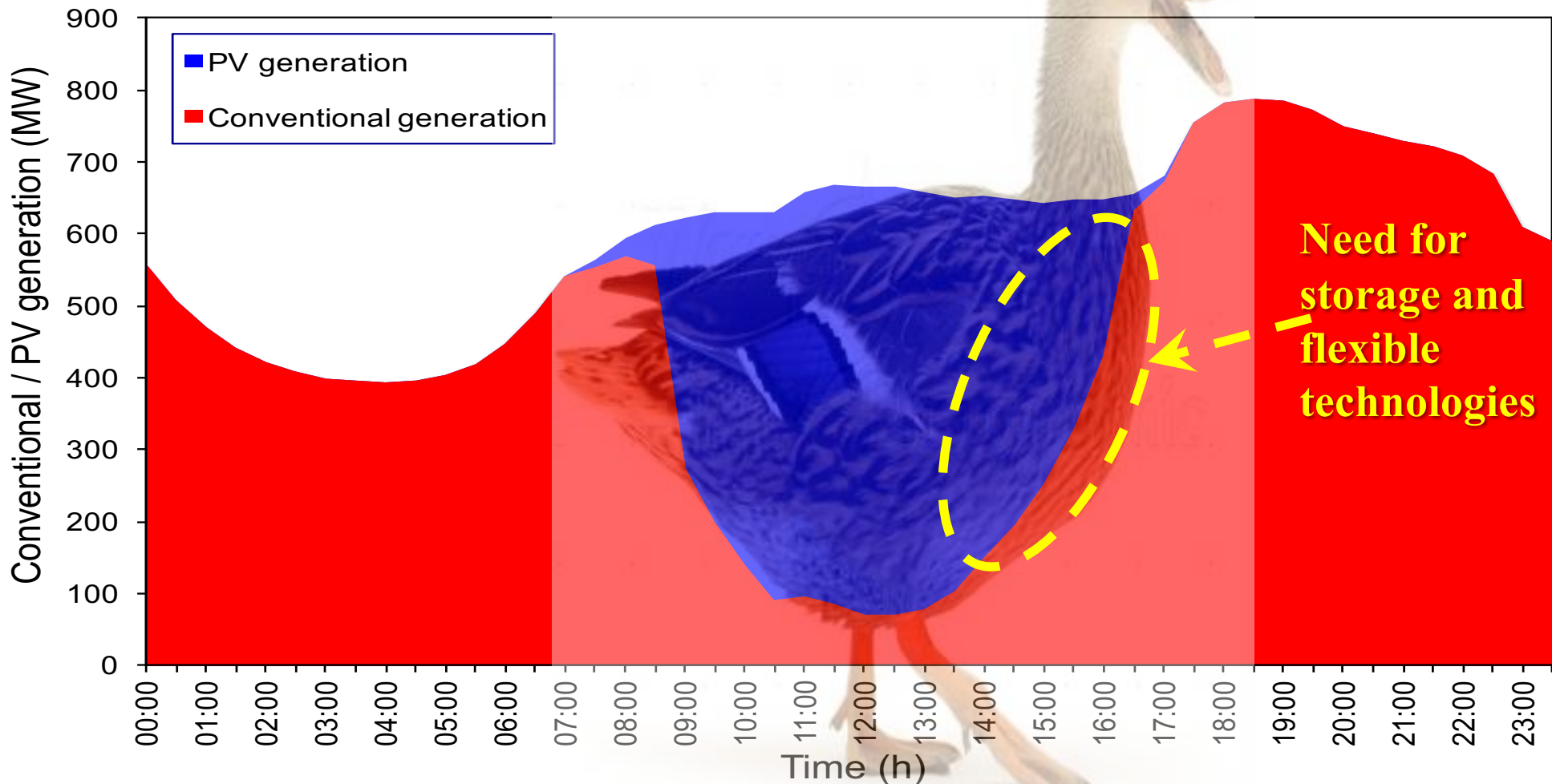
- **Increase system flexibility**
 - ~ integrate RES into electricity market
 - ~ use natural gas, storage and RES for power generation
 - ~ promote e-mobility (V2G technology - bidirectional flow of electricity between the electric car and the grid)
- **Establish electricity interconnections**
 - ~ 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

RES-E curtailments

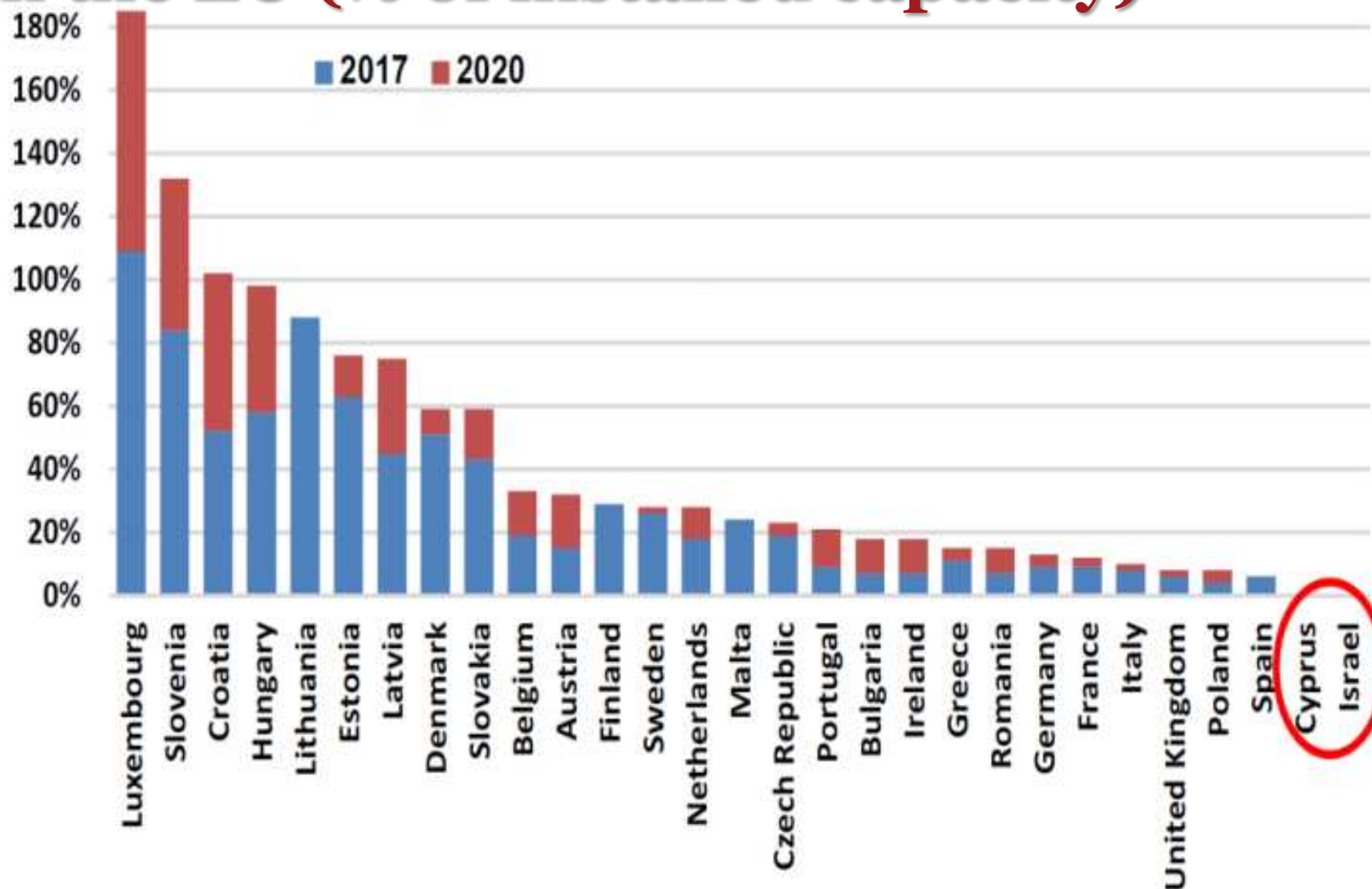


Effect of PV generation on load curve (the 'duck curve')*



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

Interconnection between countries in the EU (% of installed capacity)



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

CERA Energy Transition Regulatory Decisions (in preparation)

- **Regulatory framework: Energy communities and Renewable energy communities**
- **Regulatory framework: Electrical interconnections**
- **Regulatory framework: Hydrogen market**
- **Regulatory framework: Price comparison tools**

• ...



Long-term energy strategy for Cyprus

Regional cooperation towards hydrogen economy

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**

- Poulikkas A., 2020, "Toward Hydrogen Economy -The Energy Transition of Cyprus", *AIP Publishing*, ISBN 978-0-7354-2400-5

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**



* **Poullikkas A., 2021, "Perspectives for the development of energy strategies - Challenges towards a hydrogen economy in Cyprus", *Green Energy and Sustainability***