



# Strategies towards clean energy for islands

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# **Characteristics of island energy systems**

## **Isolated electricity 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**

\* 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\*

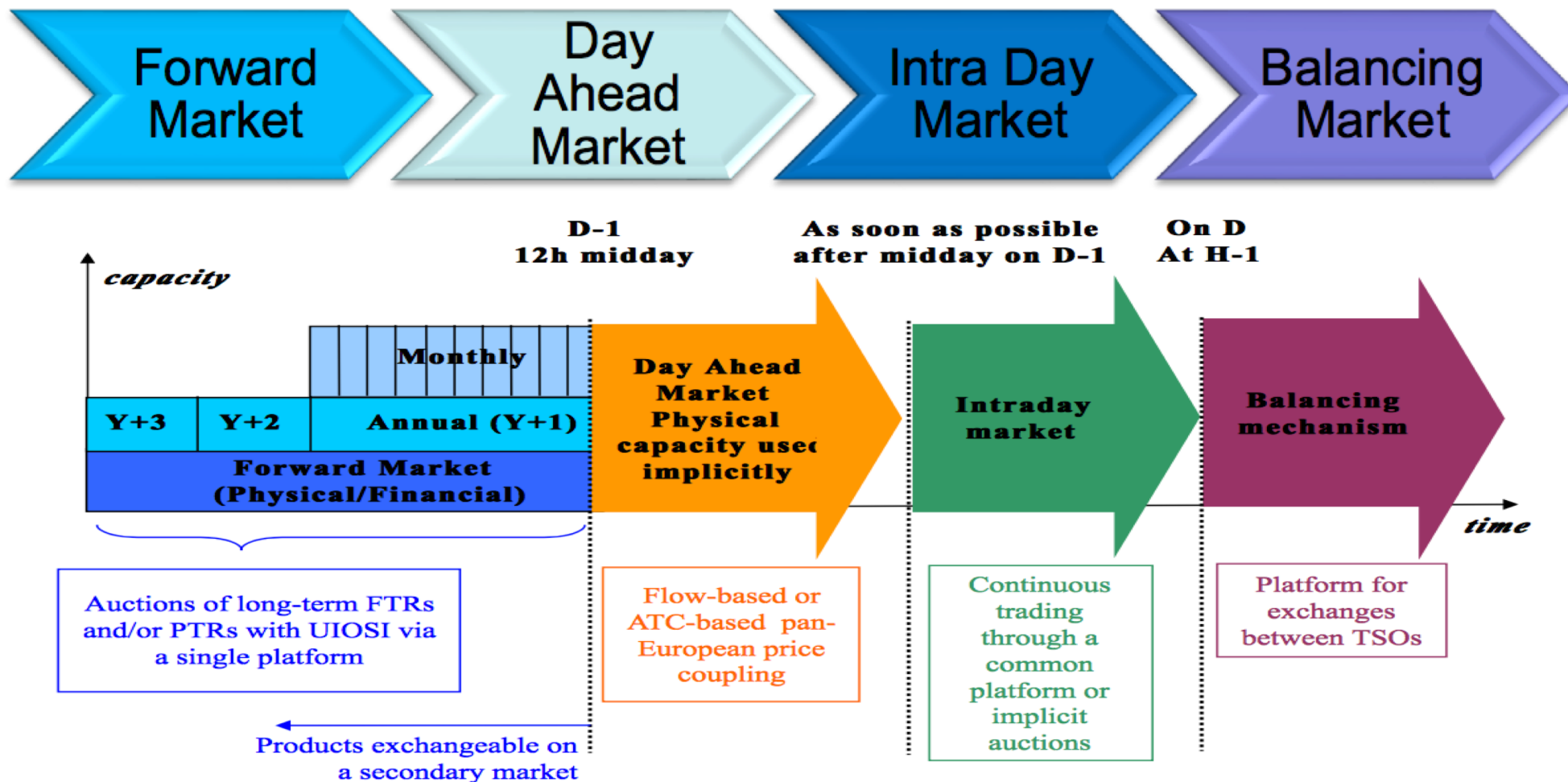
- **Increase system flexibility**
  - ~ integrate RES into electricity market
  - ~ use natural gas and RES for power generation
  - ~ promote e-mobility (V2G technology - bidirectional flow of electricity between the electric car and the grid)
- **Establish electricity interconnections**
  - ~ with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

# Short to medium term strategy

## Large scale integration of RES

# EU electricity market target model

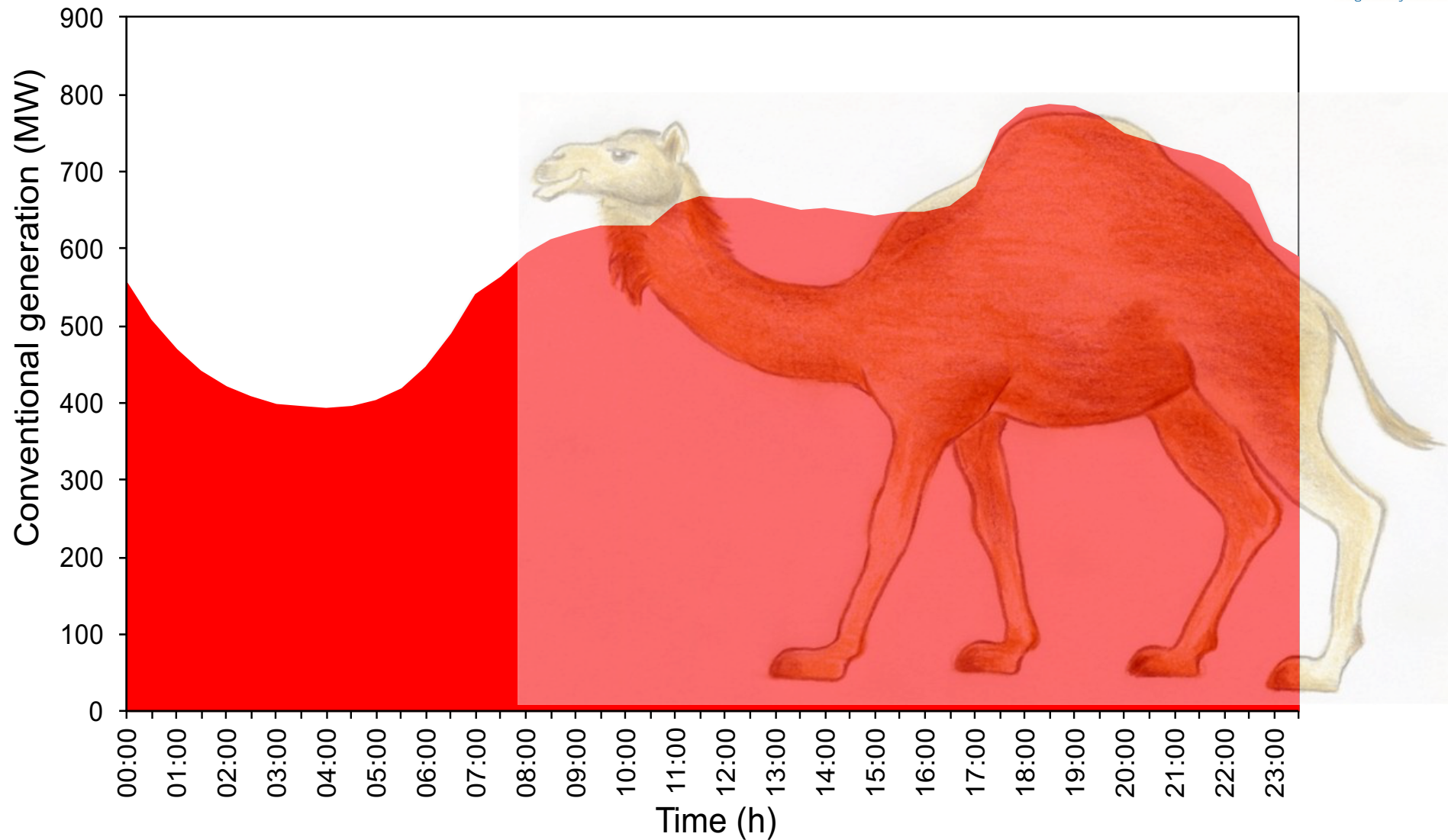


## Integration of RES\*: LCOE vs Reliability

\* 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*

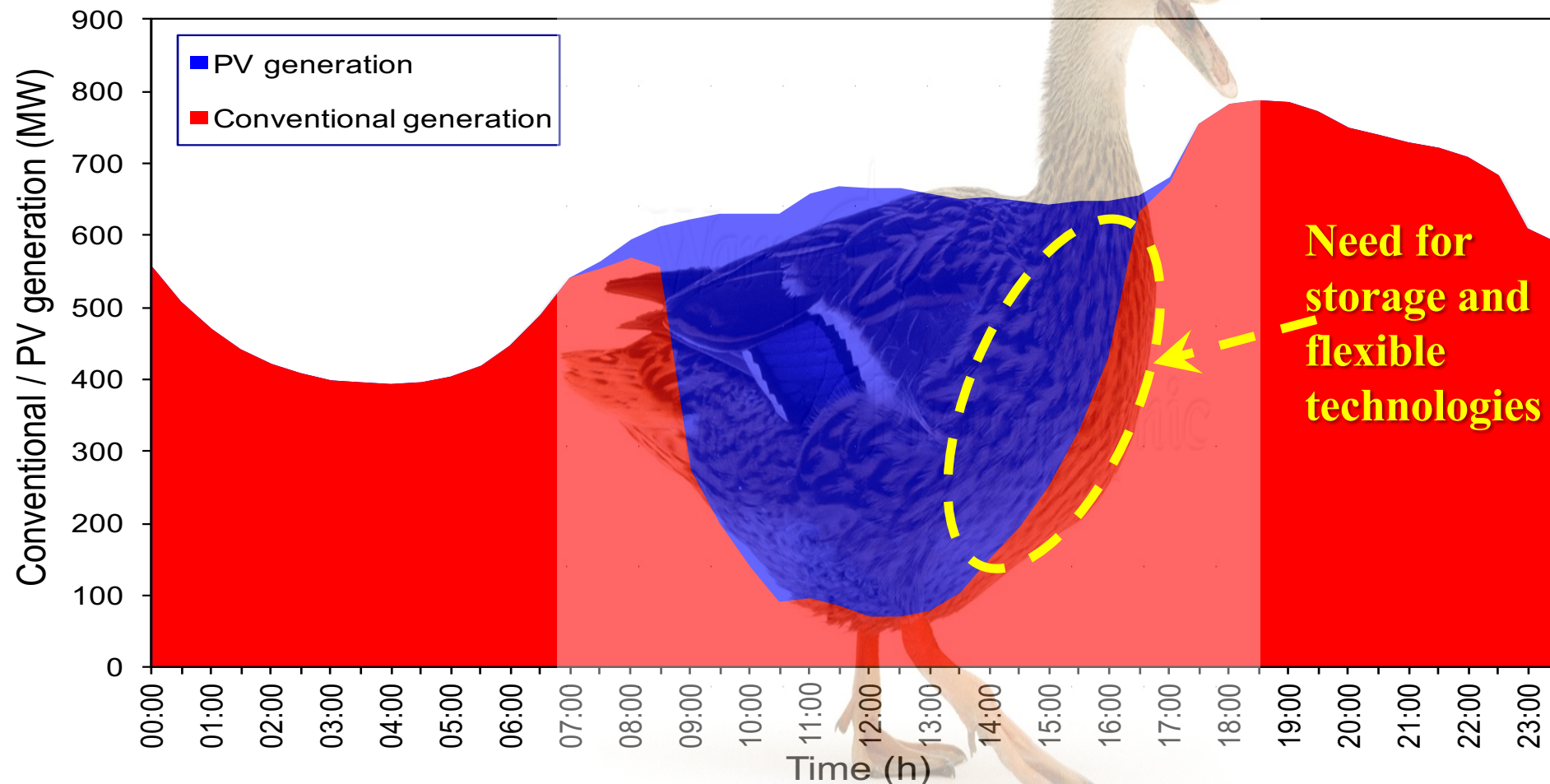


# Daily load curve (the 'camel curve')\*



\* 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')\*



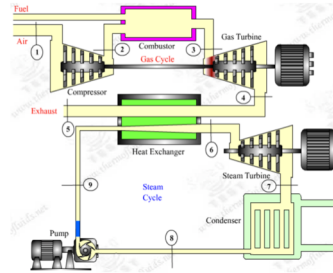
\* Poullikkas A., 2016, "From the 'camel curve' to the 'duck curve' on electric systems with increasing solar power", *Accountancy*

# Medium to long term strategy

**The role of interconnections and hydrogen**

# Main indigenous energy sources in Mediterranean region

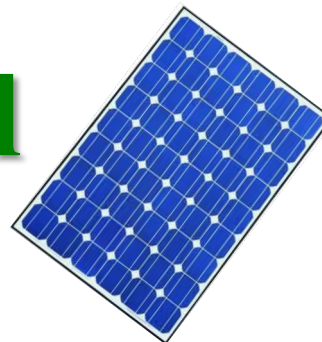
- **Natural gas**



- **Wind potential**

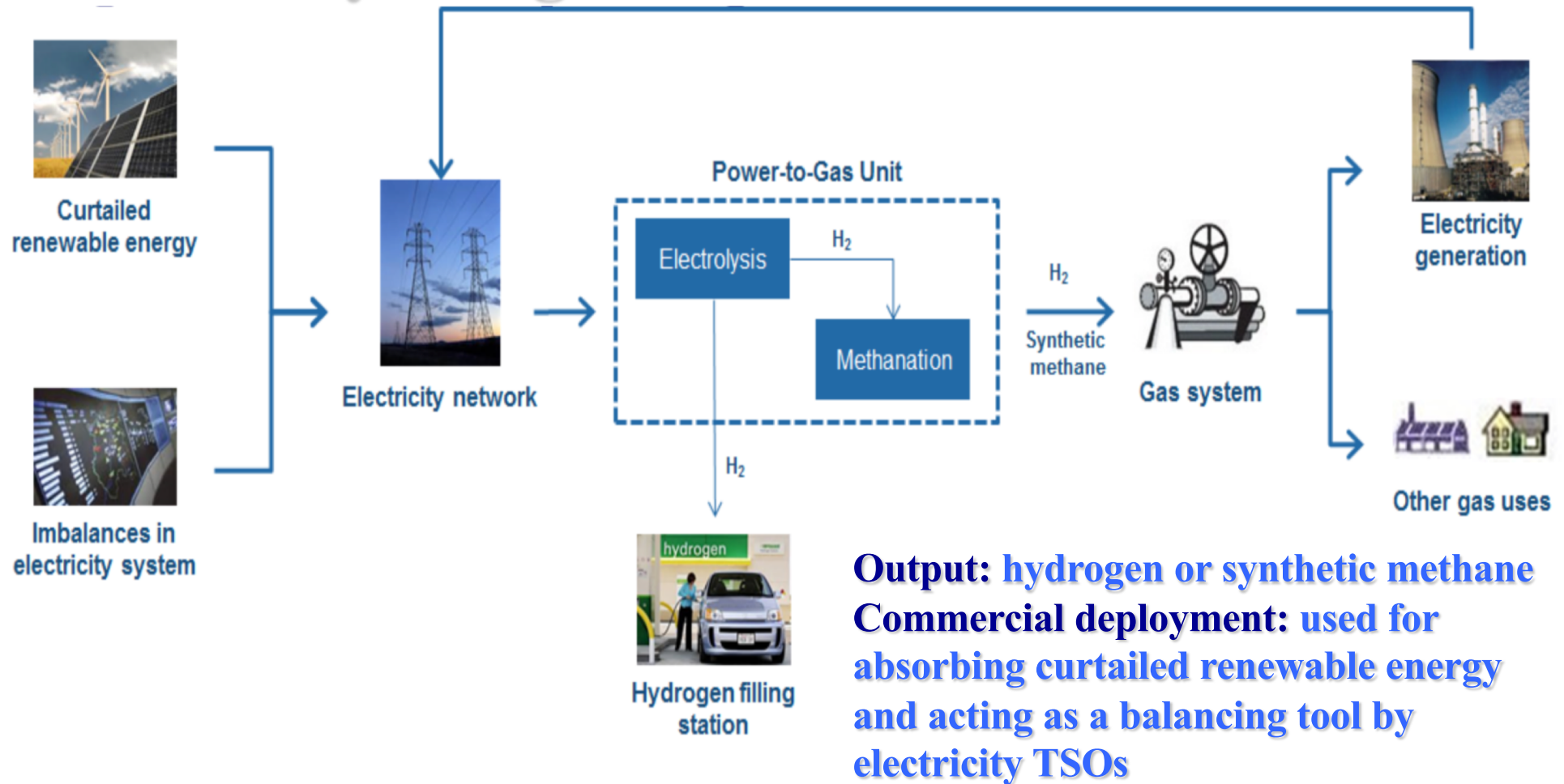


- **Solar potential**



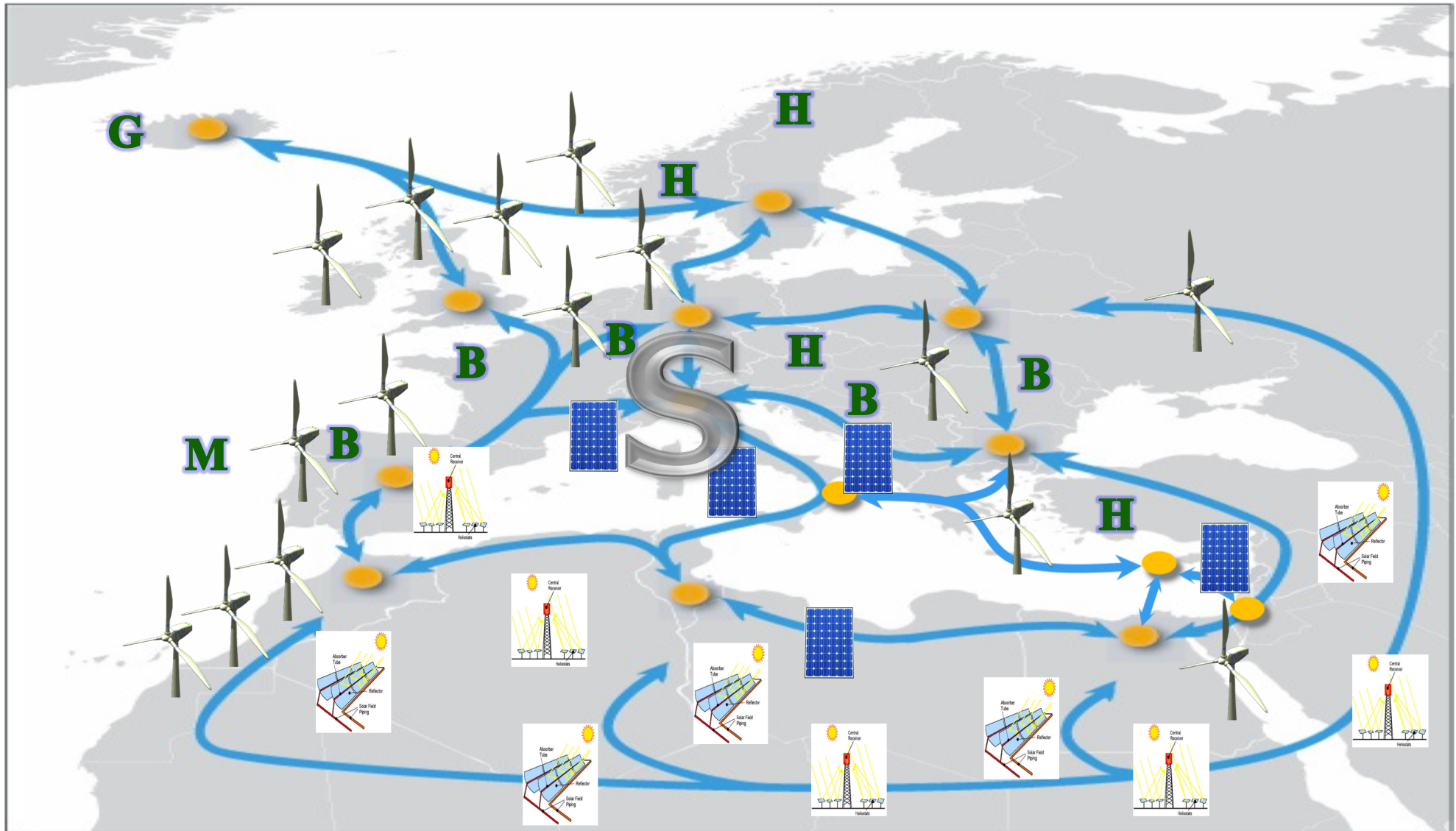
# Power-to-Gas (P2G)\*

- energy storage technology linking the electricity and gas infrastructure



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

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



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

# Next steps

## Towards hydrogen economy

# Next steps

## First steps towards the development of sustainable energy strategy

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

