Renewable and Sustainable Energy Futures

Dr. Andreas Poullikkas

Ph.D, D.Tech

apoullikkas@cera.org.cy

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- **Medium term strategies towards 2030**
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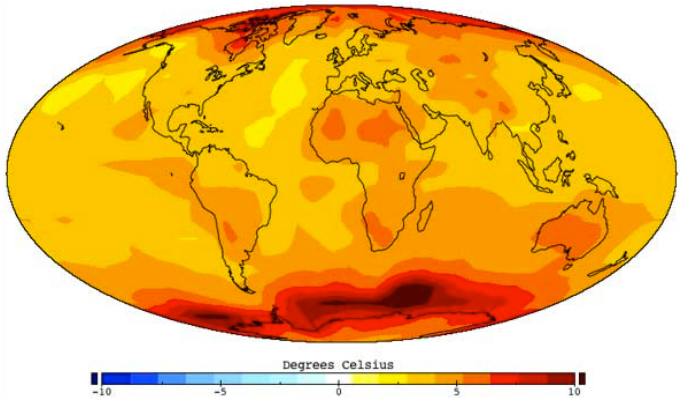
Long term strategies Towards 2050

Future energy systems

- **Climate change**

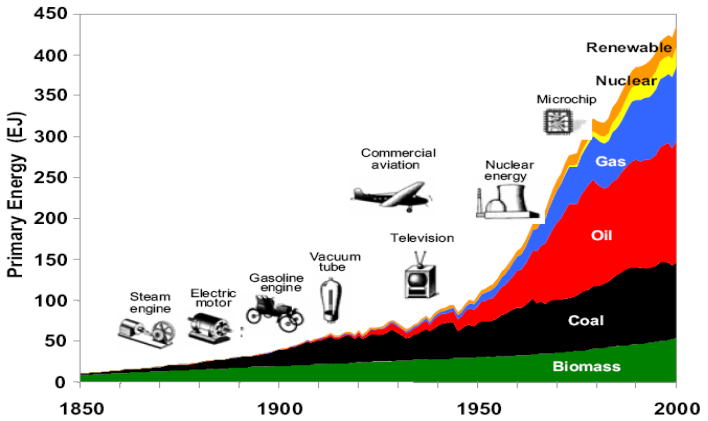


- **Third industrial revolution**

- **Future energy economics**

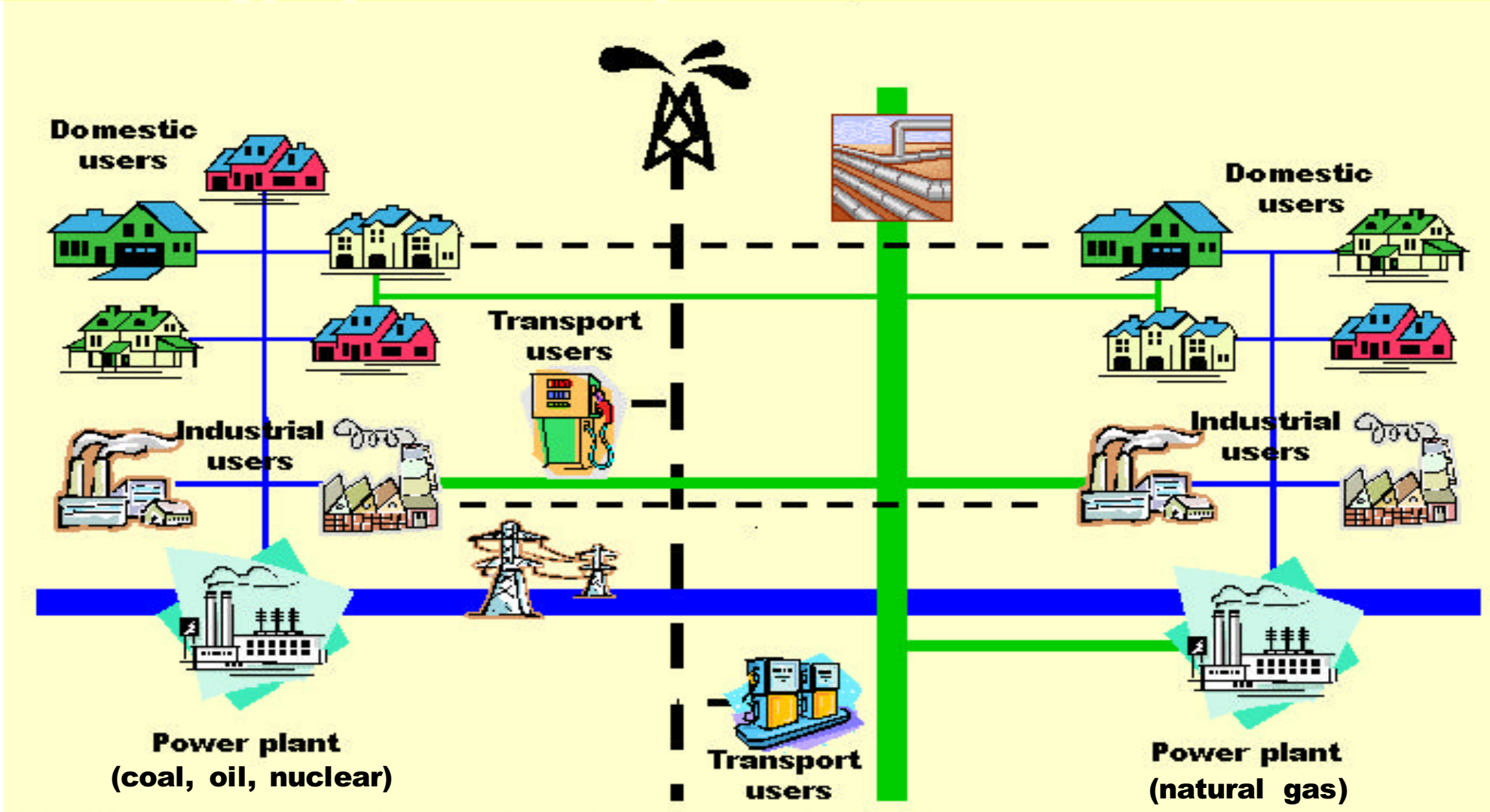
EU energy objectives

- **greenhouse gas reduction**
- **sustainable production and consumption**
- **security of supply**



Future energy systems

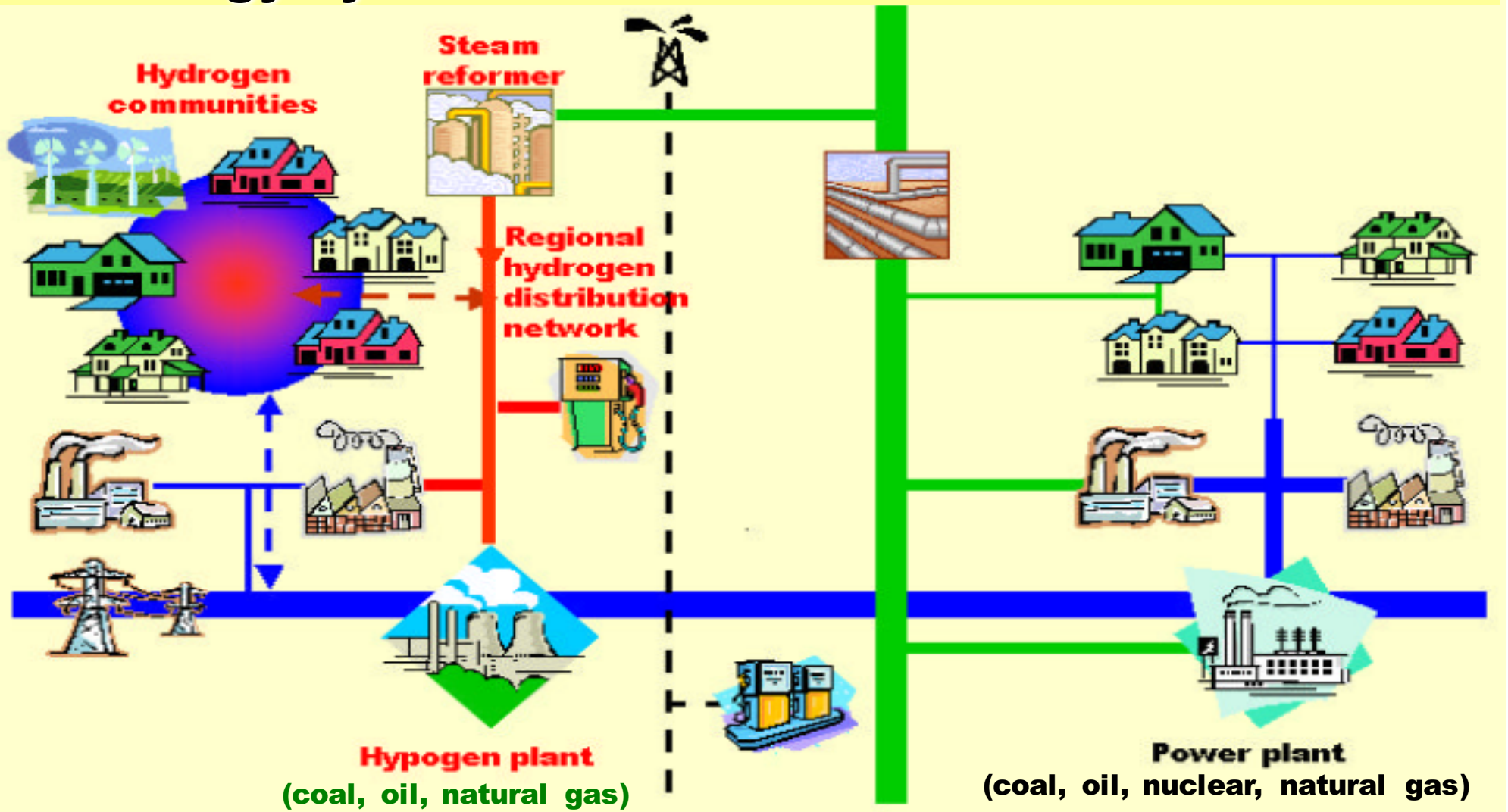
EU energy system today*



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

Future energy systems

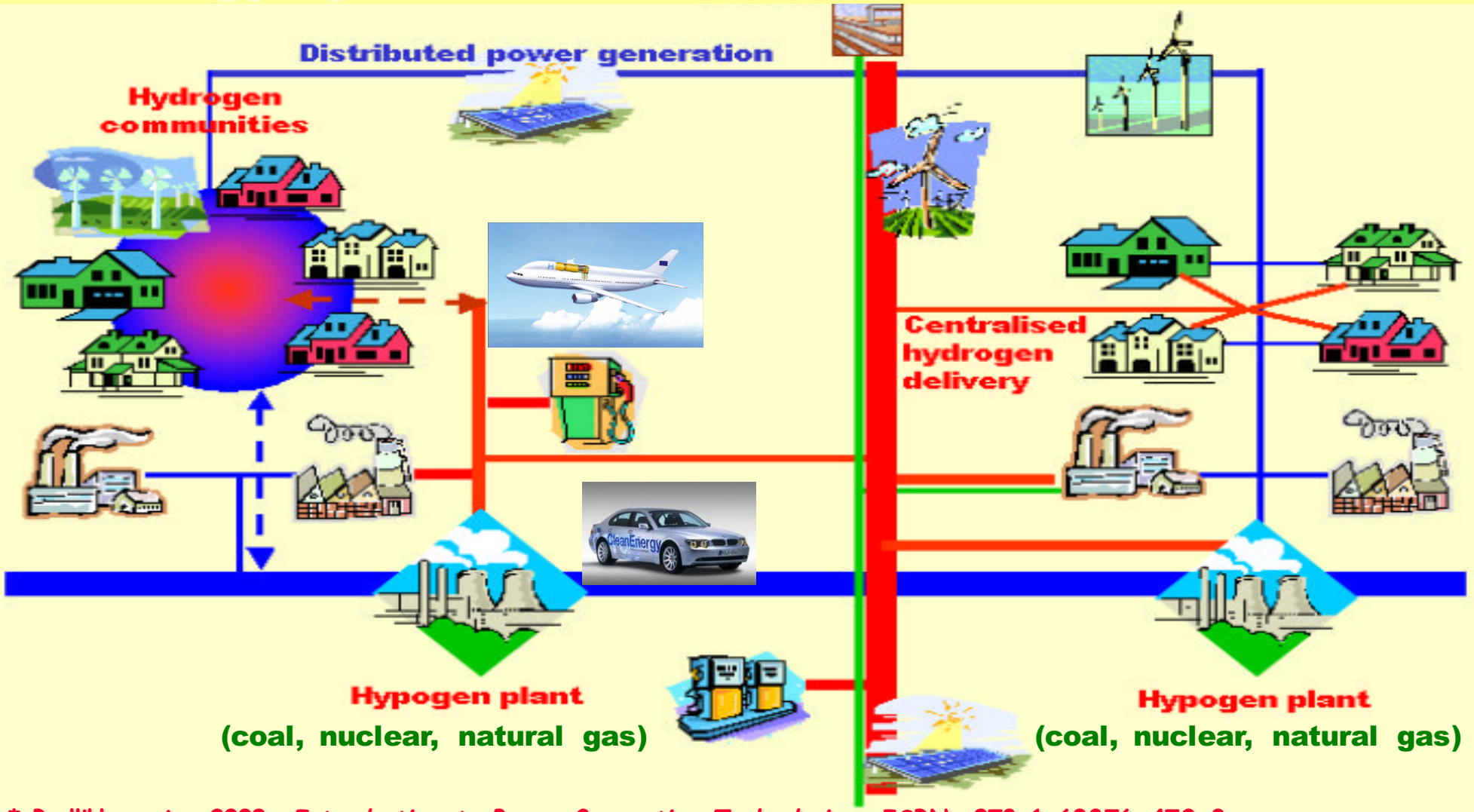
EU energy system in 2020-30*



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

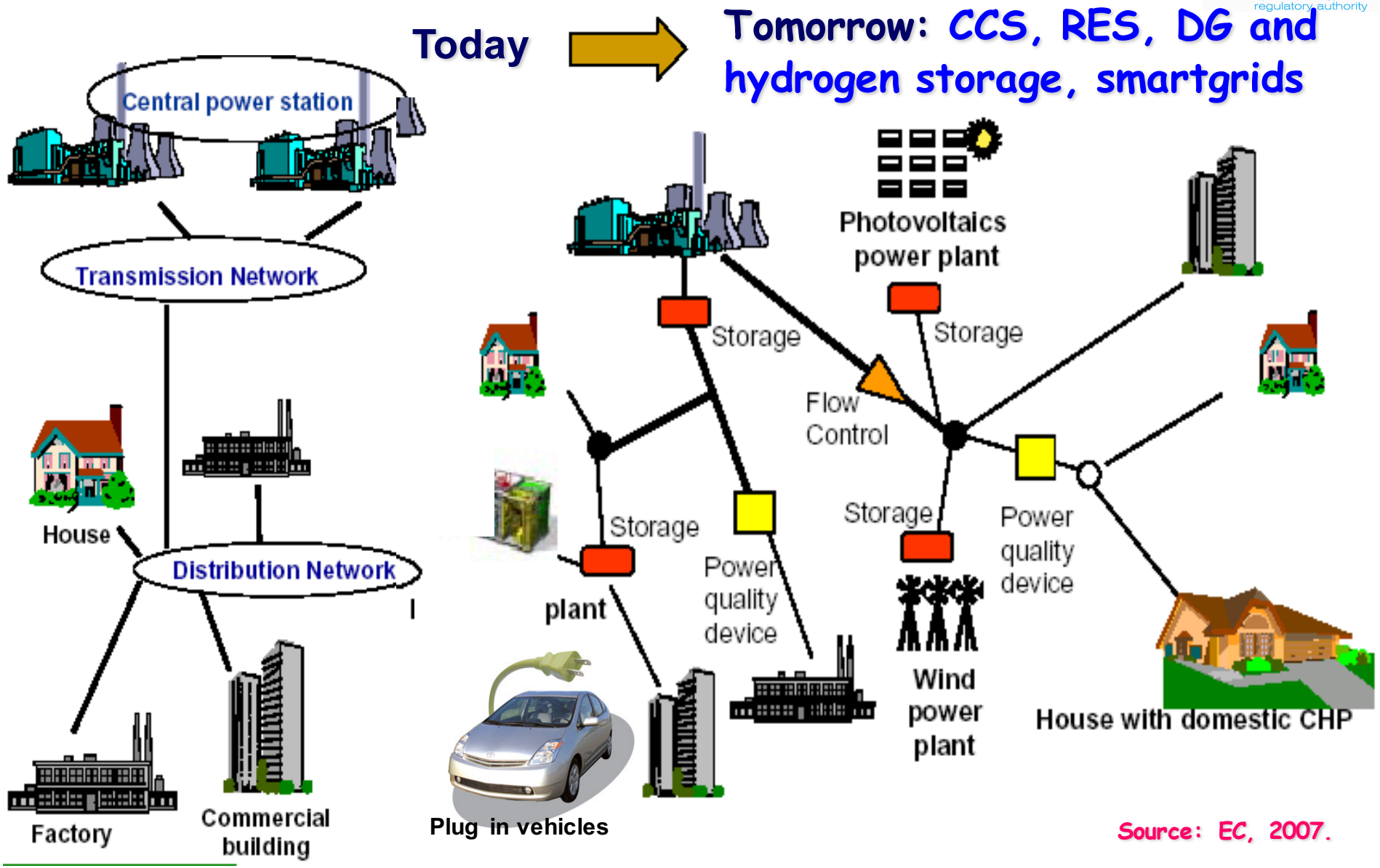
Future energy systems

EU energy system in 2040-50*



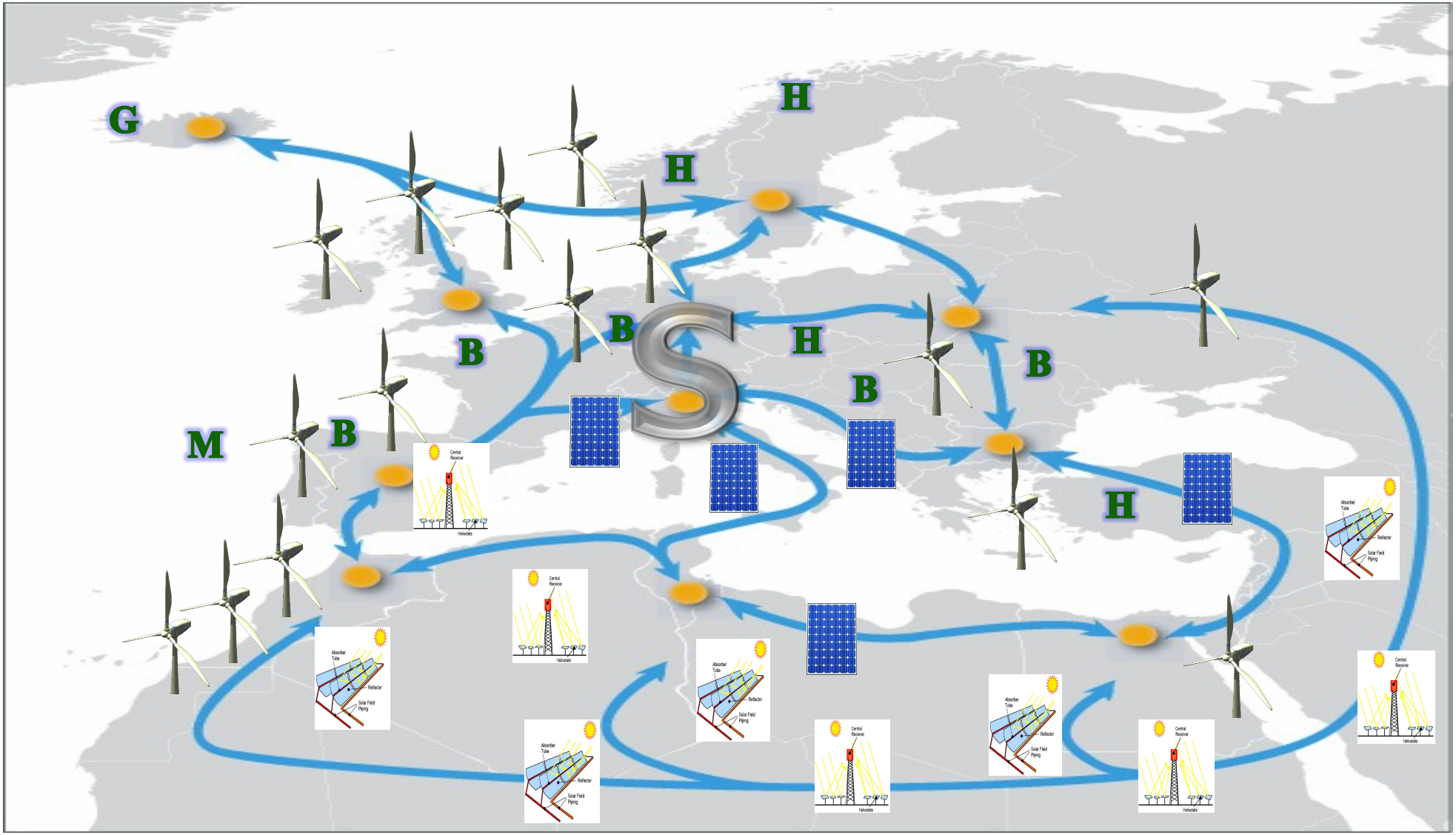
* Poullikkas A., 2009, *Introduction to Power Generation Technologies*, ISBN: 978-1-60876-472-3

Future PS


Today
Tomorrow: CCS, RES, DG and hydrogen storage, smartgrids
Central power station
Transmission Network
House
Distribution Network
Factory
Commercial building
Photovoltaics power plant
Storage
Storage
Flow Control
Storage
Storage
Power quality device
Power quality device
plant
Wind power plant
House with domestic CHP
Plug in vehicles
Source: EC, 2007.

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

ρυθμιστική αρχή ενέργειας κύπρου
cyprus energy regulatory authority



Main ingredients of future sustainable electric systems

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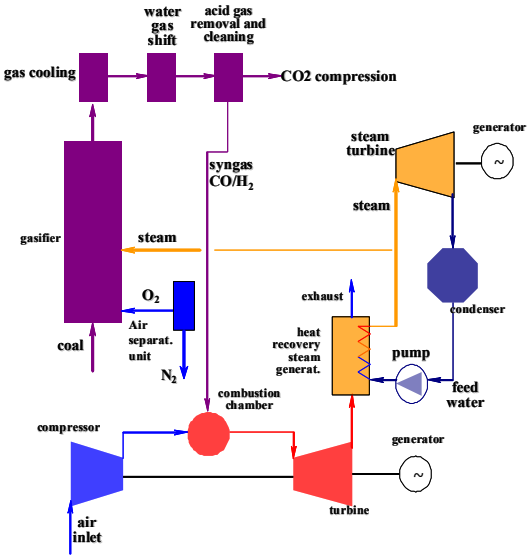
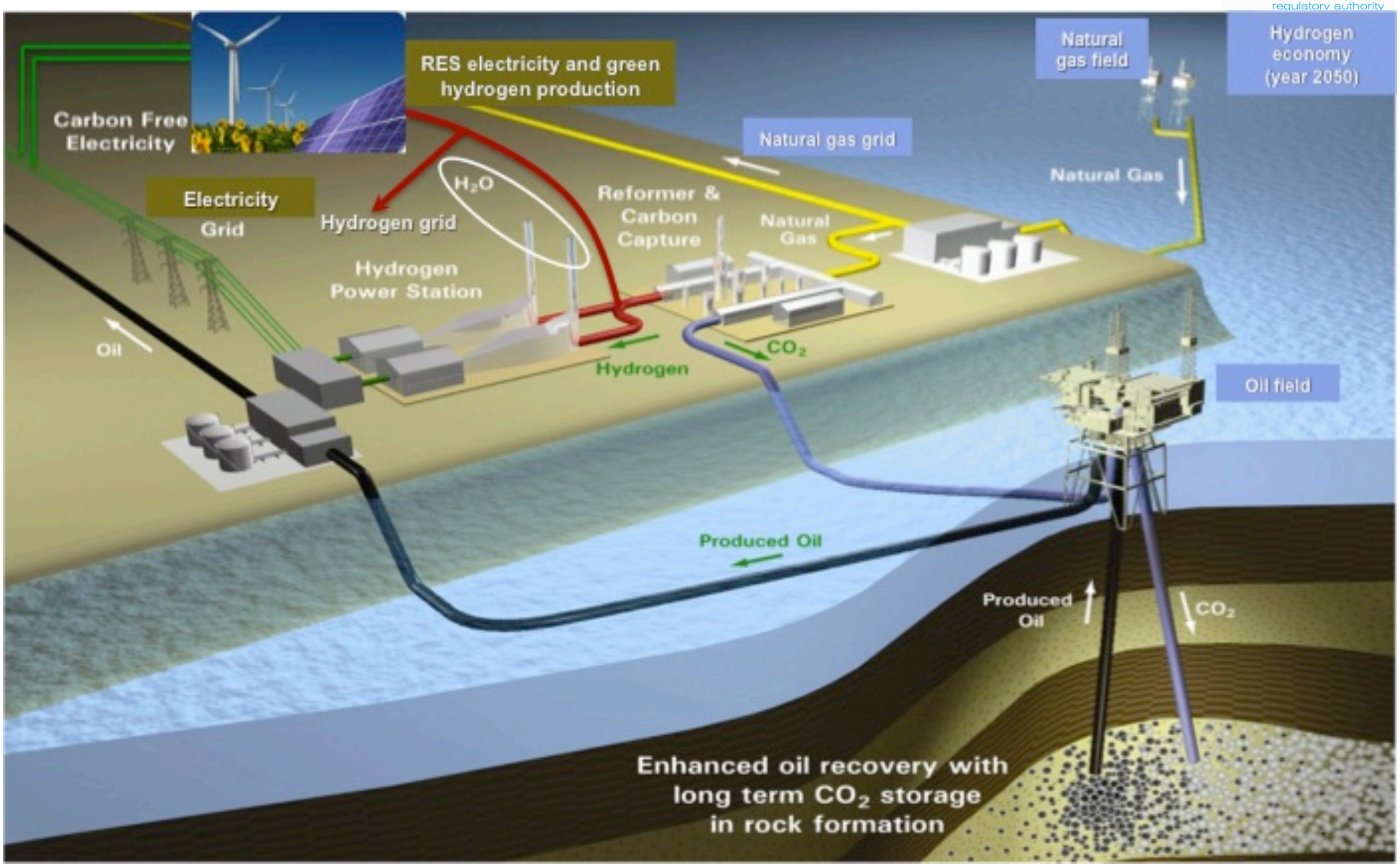
- Large scale integration of renewable energy sources
- Distributed generation
- Carbon capture and storage
- Smartgrids
- Electric vehicles
- Storage devices
- Hydrogen



Development of new sustainable technologies and infrastructure

Towards hydrogen economy in 2050



Medium term strategies Towards 2030

Towards Energy Union

« I want to reform and reorganise Europe's energy policy in a new European Energy Union. »

Jean-Claude Juncker

Energy Union

- a binding EU target of at least 40% less greenhouse gas emissions by 2030, compared to 1990
- a binding target of at least 27% of renewable energy use at EU level
- an energy efficiency increase of at least 27%
- the completion of the internal energy market by reaching an electricity interconnection target of 15%
- increase energy security (natural gas South Corridor)

Connecting electricity markets

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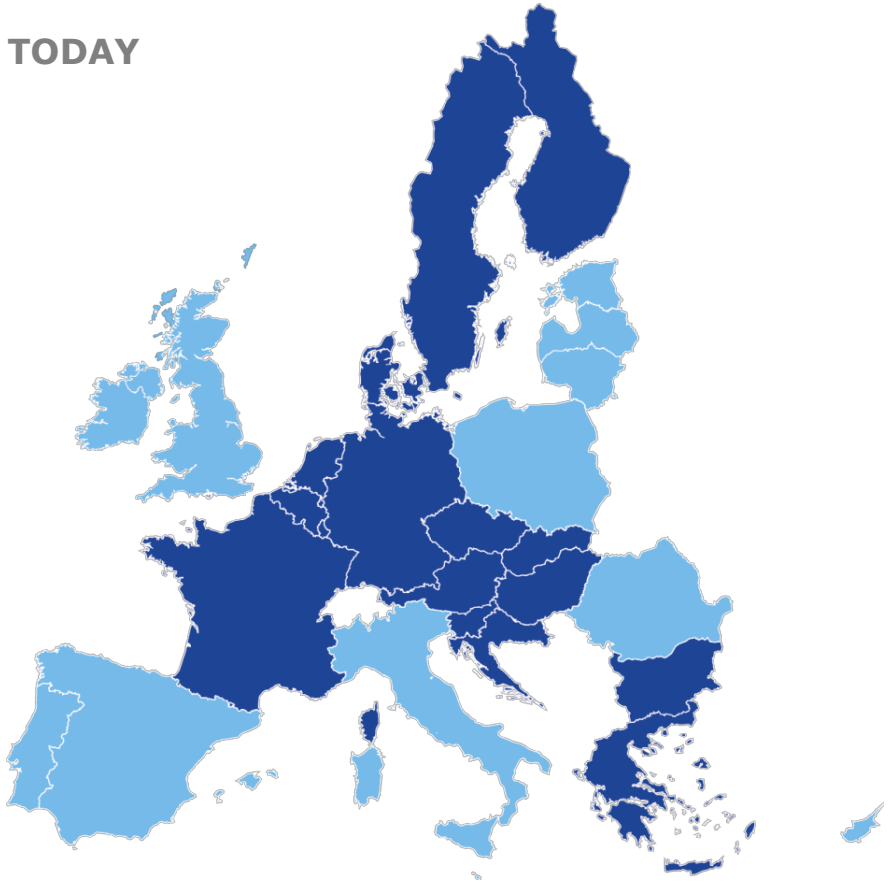
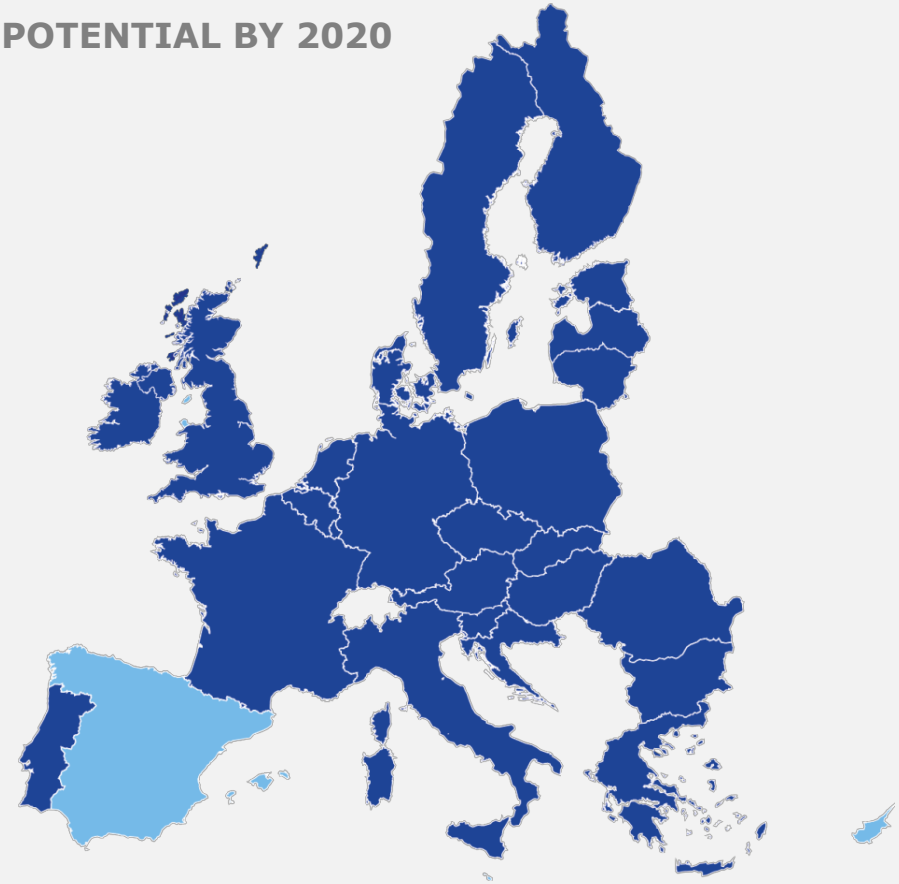
TODAY



Countries meeting the 10% **interconnection** target

Countries not meeting the 10% **interconnection** target

POTENTIAL BY 2020



Efforts need to be stepped up for those below the 10% target by 2020, mainly Spain and Cyprus, and in view of achieving the 15% target by 2030.

Importance for Cyprus

- **Great importance for Cyprus**
  - **Special attention is made to the more remote and isolated energy systems such as Cyprus**
  - **EU financing for electric interconnections with the rest of the internal energy market**
  - **implement critical projects of common interest in the gas sector, such as:**
    - **the Southern Gas Corridor**
    - **the promotion of a new gas hub in Southern Europe**
- **Action Plan**

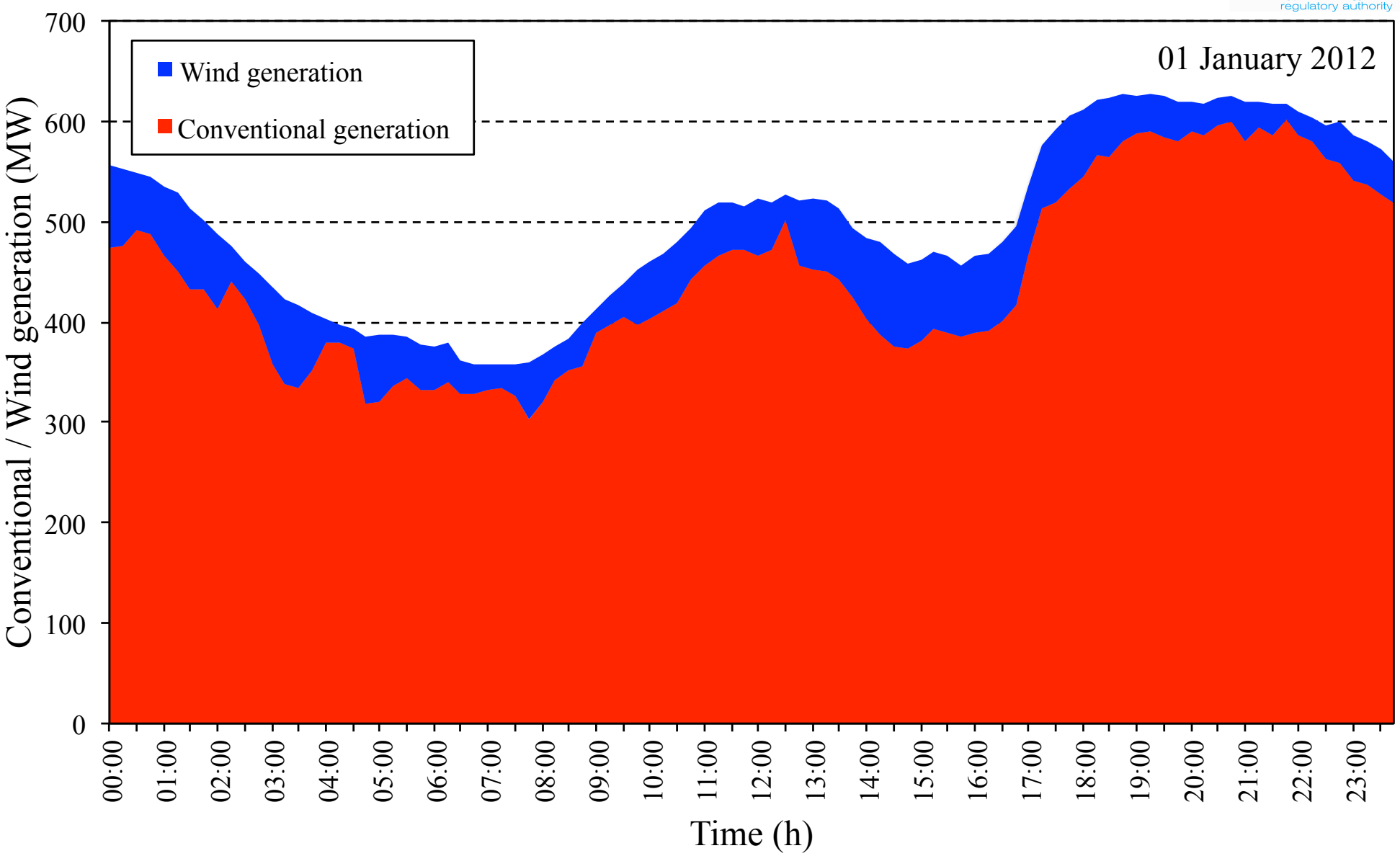
The fundamental requirement of electrical power supply:

Get me what I want, when I want it !!!

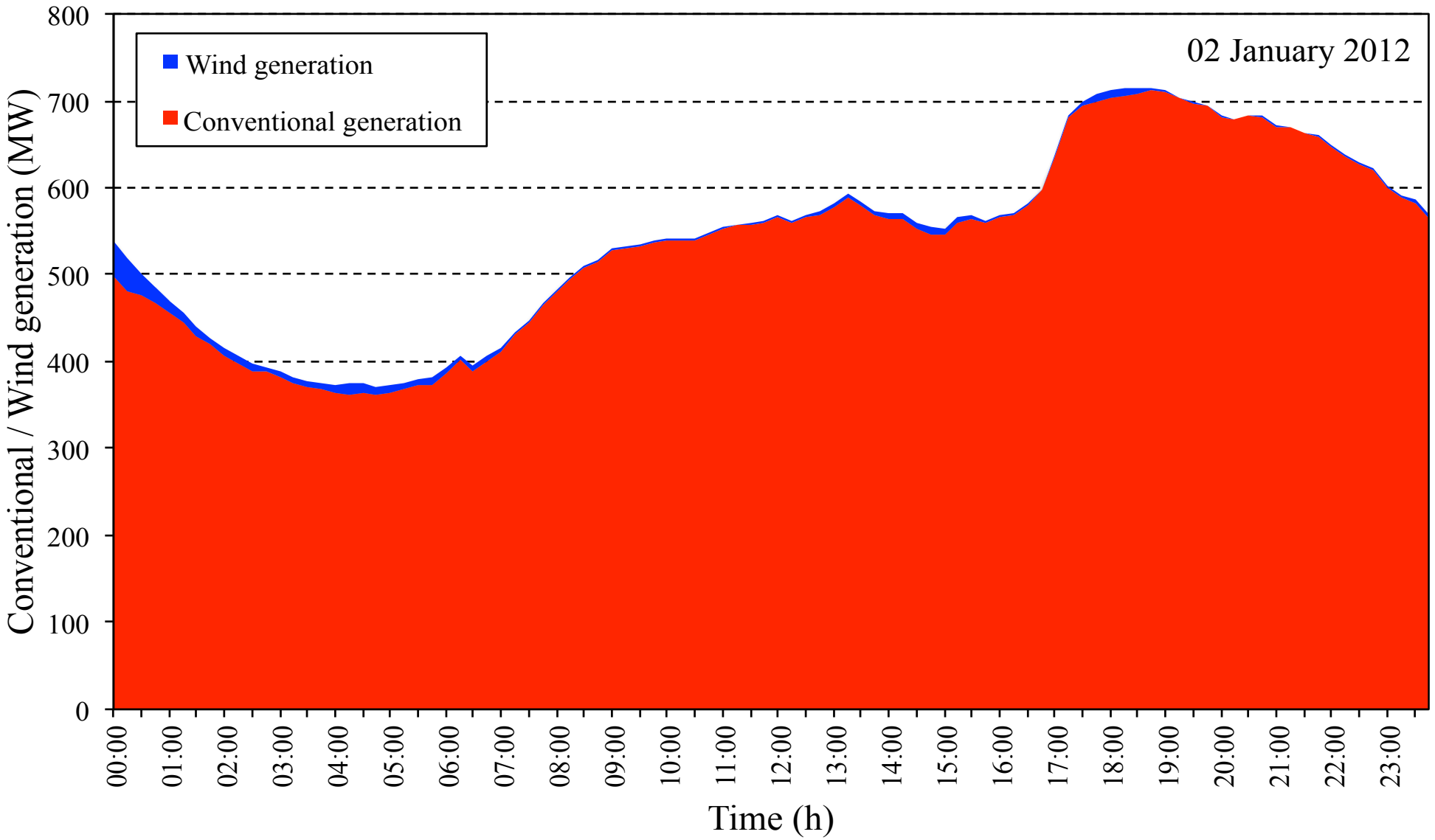
Intermittent energy source

- **Any source of energy that is not continuously available**
- **May be quite predictable**
- **Cannot be dispatched to meet the demand of a power system**
- **For dispatching need storage**

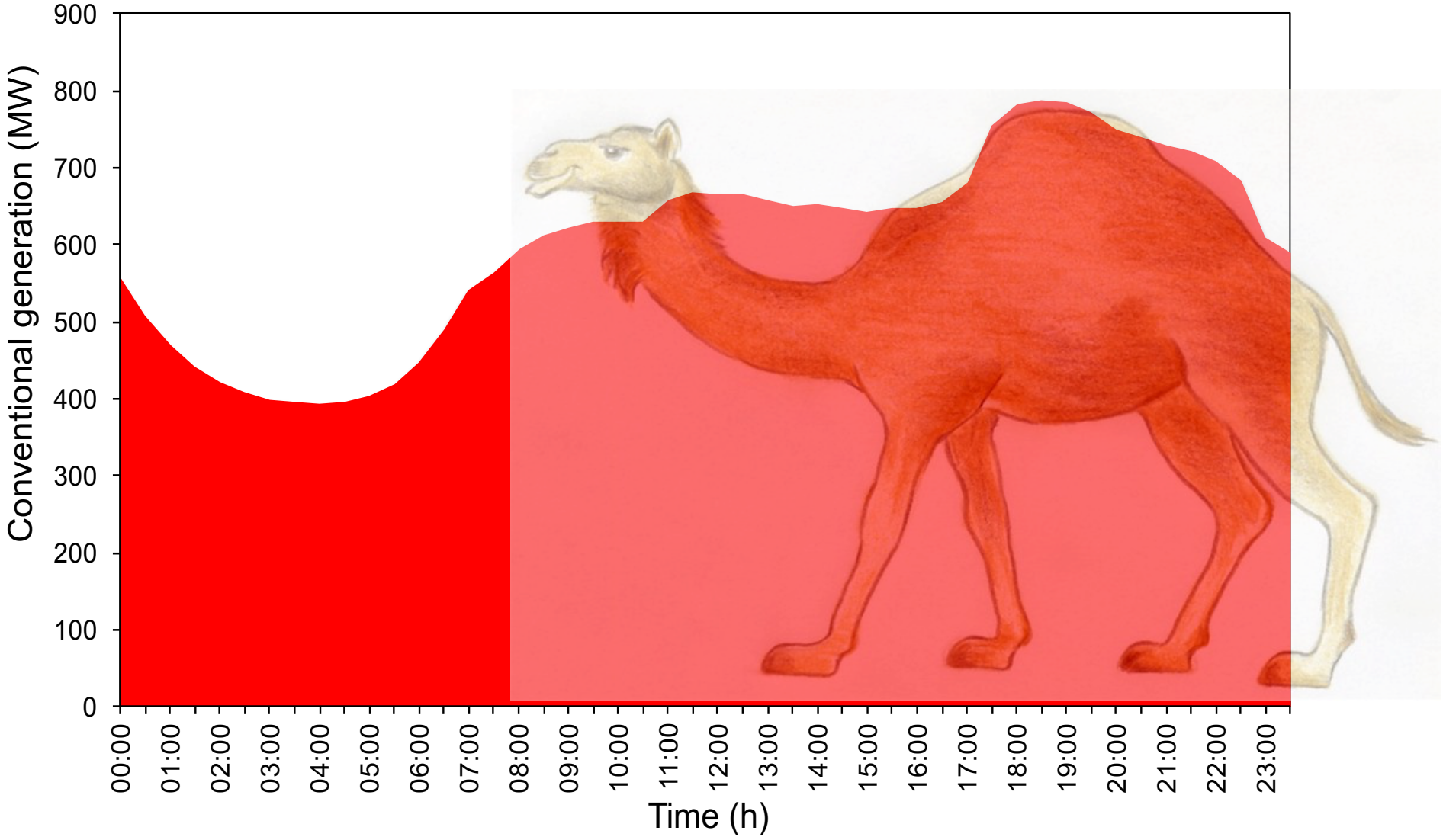
Wind generation



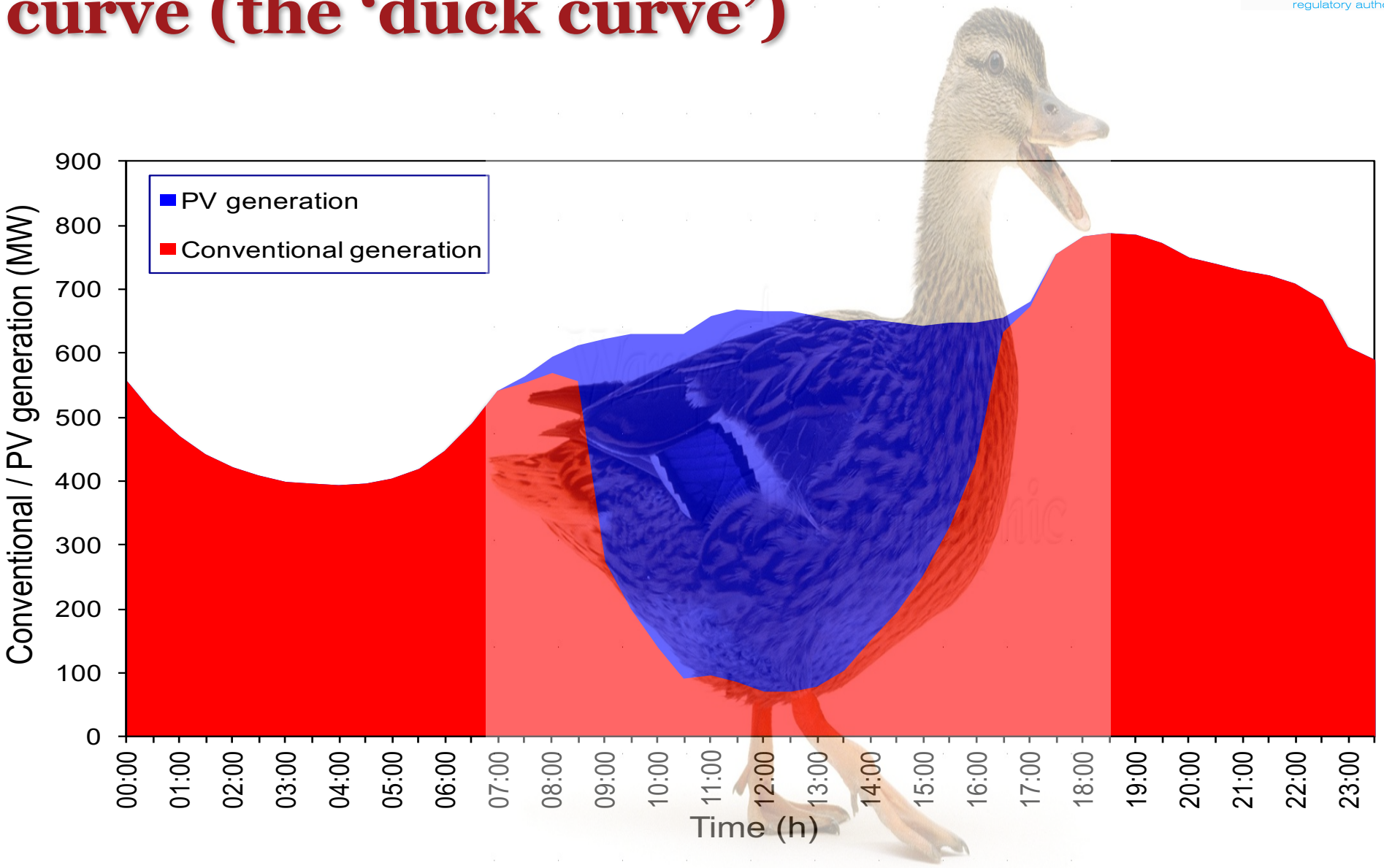
Wind generation



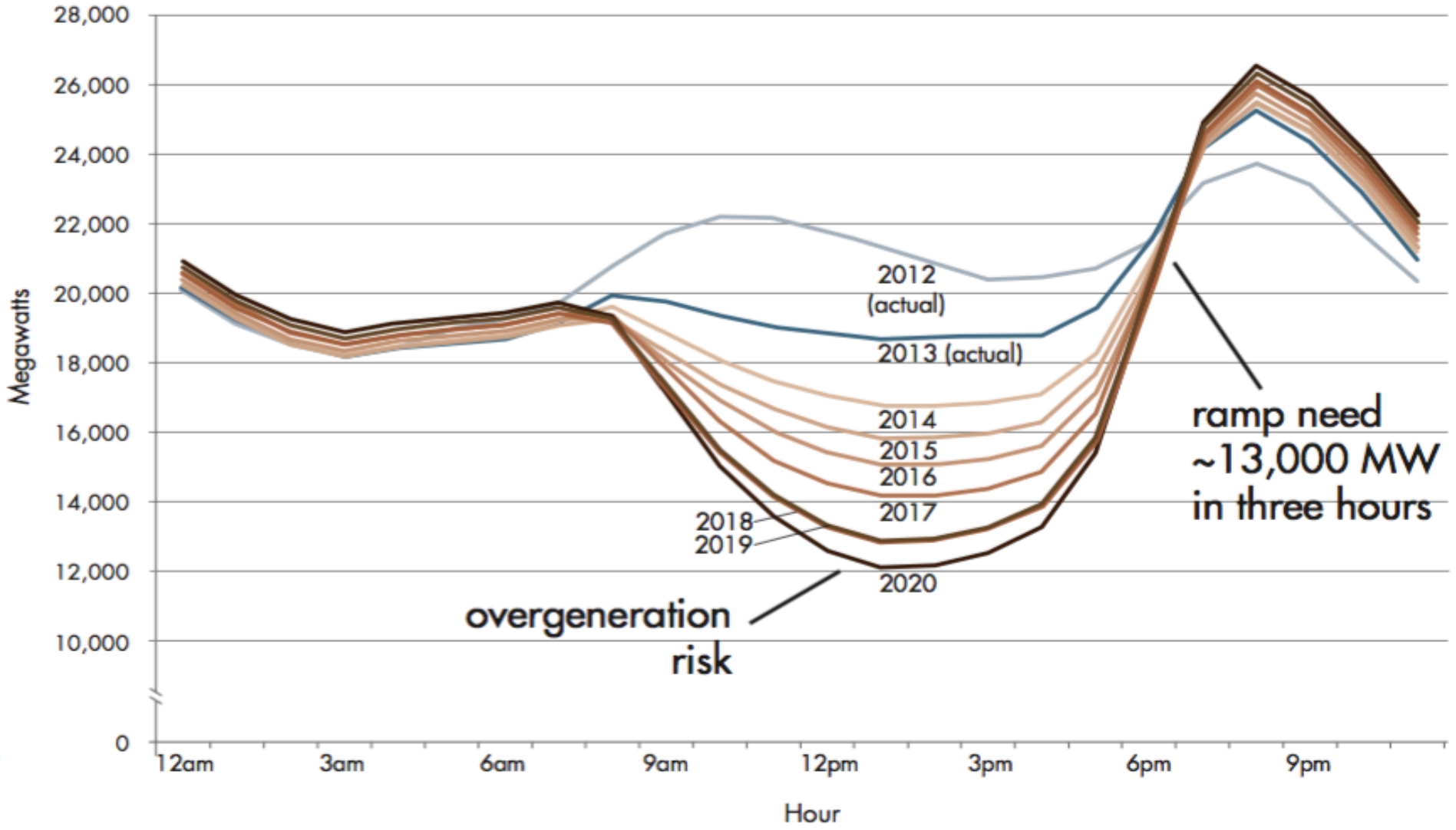
Daily load curve (the 'camel curve')



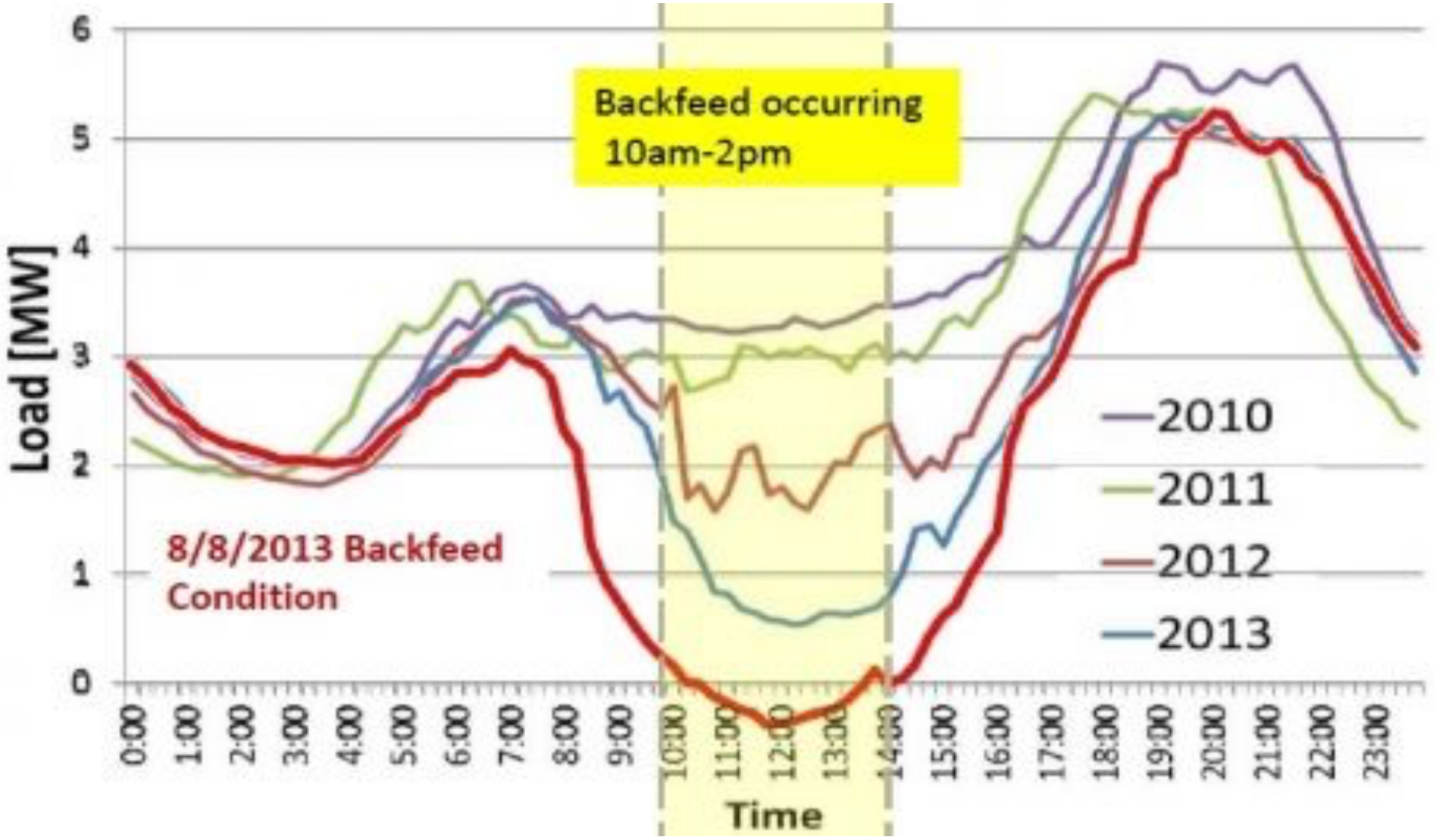
Effect of PV generation on load curve (the 'duck curve')



Steep ramping needs and overgeneration risk in California



Backfeed condition at 46kV level in Hawaii



Short term strategies Towards 2020

RES-E strategic plan 2010-20 main objective*

- … to assess the optimum (minimum) increase in the cost of electricity of the Cyprus generation system by the integration of the necessary RES-E technologies for Cyprus to achieve its national RES energy target …

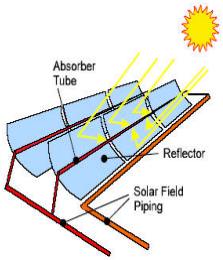
* Poullikkas A., Kourtis G., Hadjipaschalis I., 2011, "A hybrid model for the optimum integration of renewable technologies in power generation systems", *Energy Policy*

RES technologies considered

- Wind

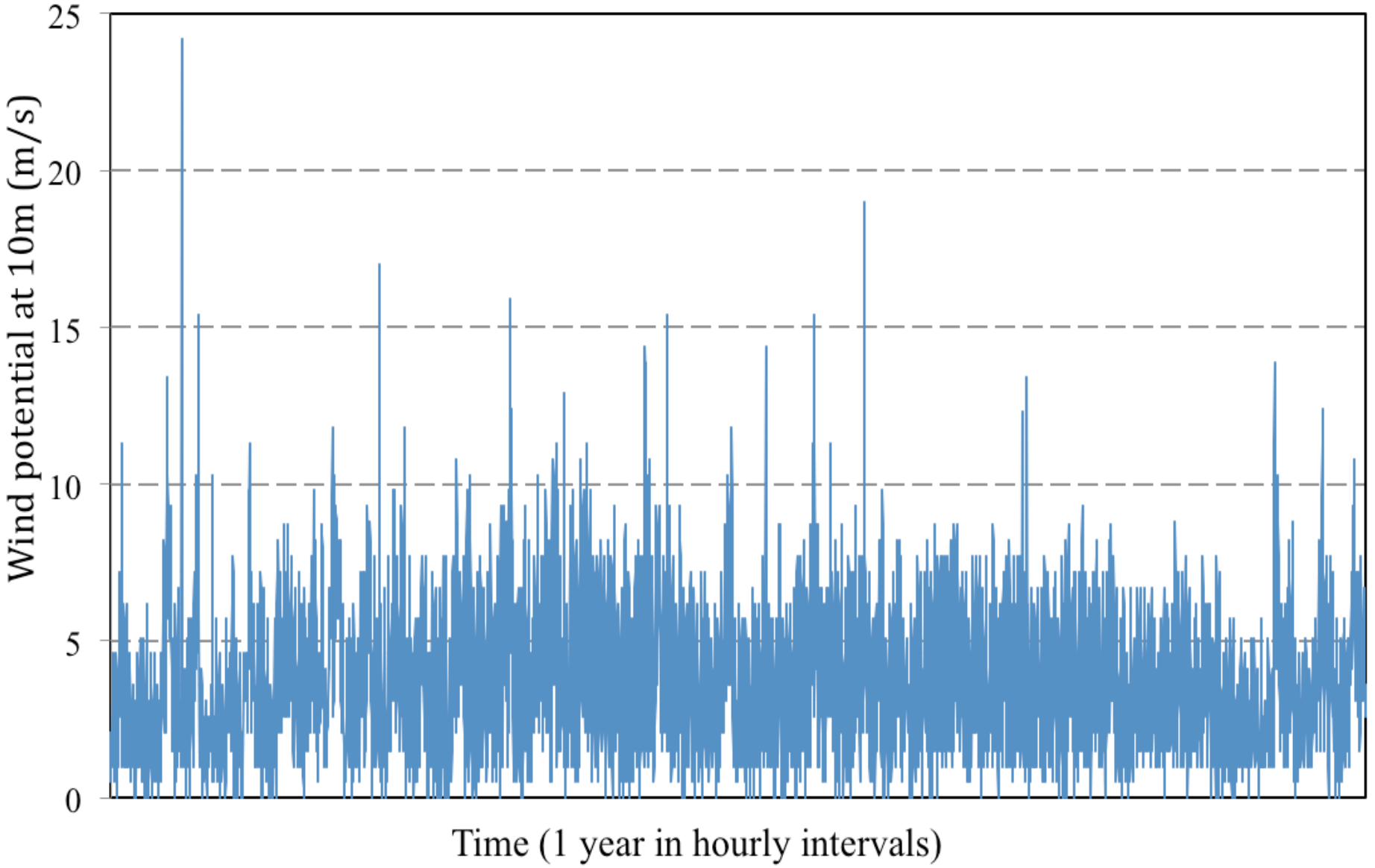
- PVs

- CSP with 6 hours thermal storage

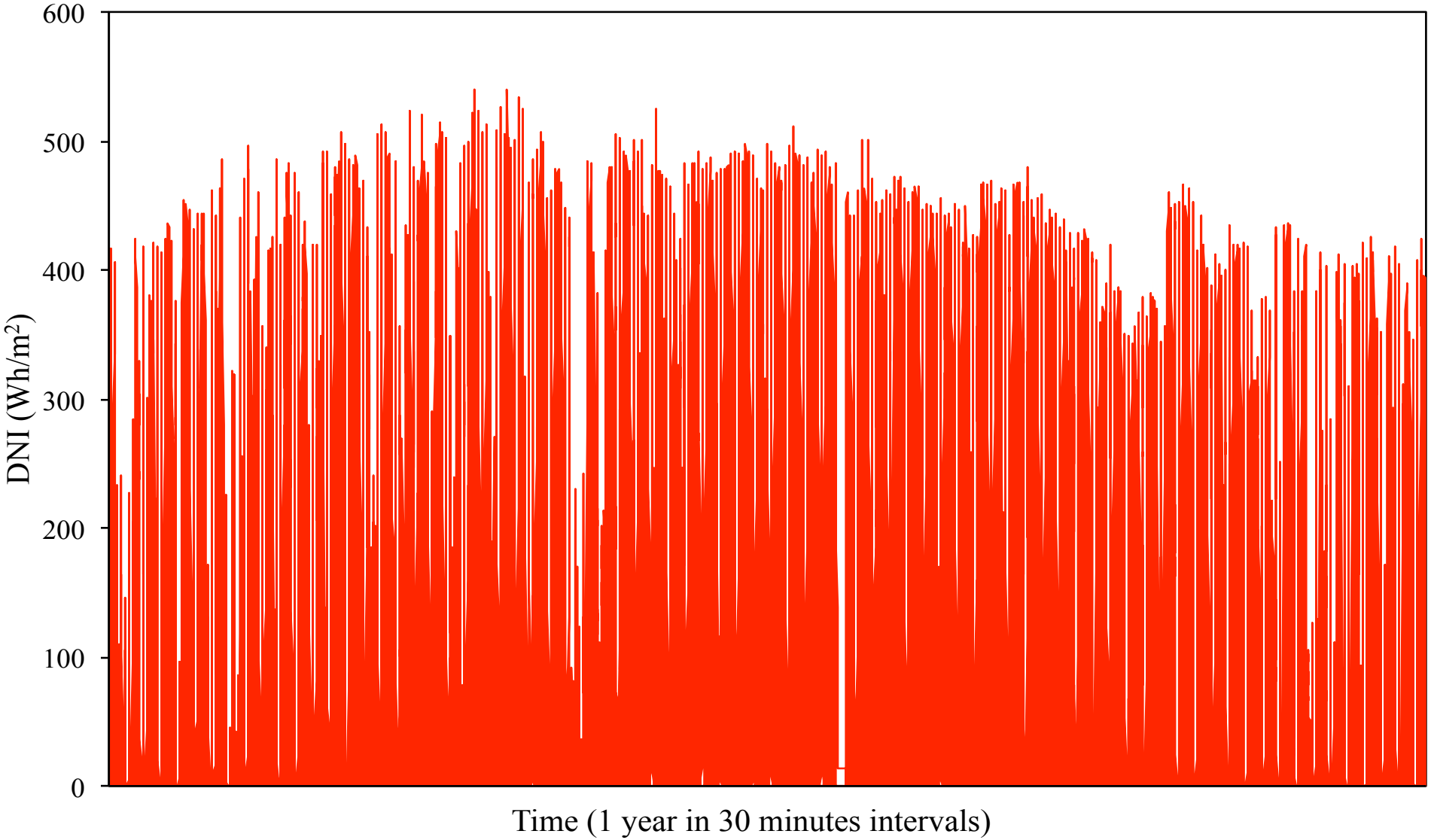


- Biomass

Hourly annual wind potential



½ hour annual solar potential



Model capabilities

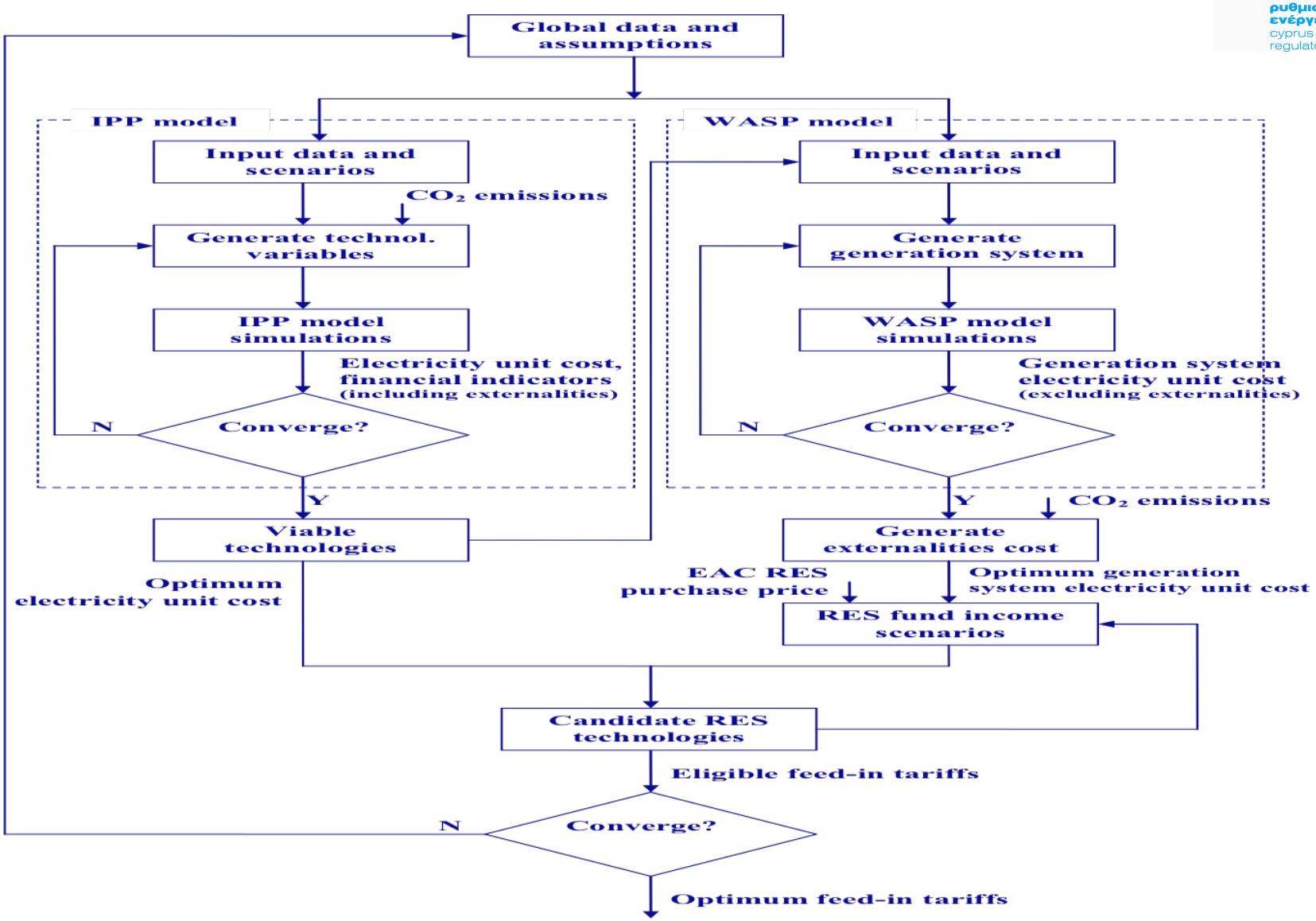
- Use of unit commitment algorithms
- Energy mix
- Cost or benefit in the cost of electricity
- Price of feed in tariffs
- Green tax

Important factors considered

- **Fuel avoidance cost: by increasing RES-E penetration fuel consumption reduced**
- **CO_2 avoidance cost: by increasing RES-E penetration CO_2 emissions reduced**
- **Conventional power system operating cost: by increasing RES-E penetration the conventional power system operating cost is increased due to the increased requirements of conventional reserve capacity**

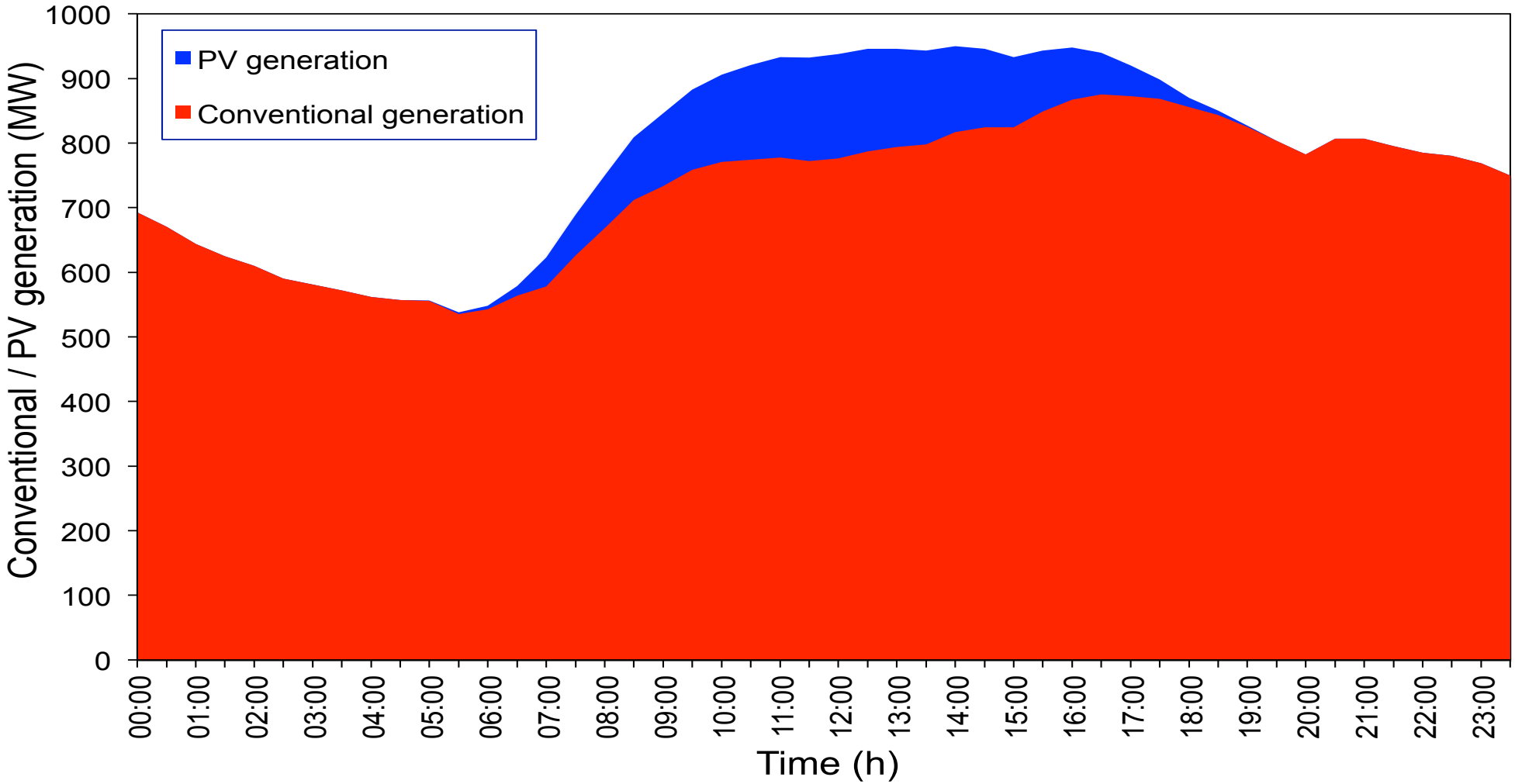
Optimization model*

Optimization model (hybrid model implementing IPP and WASP models)



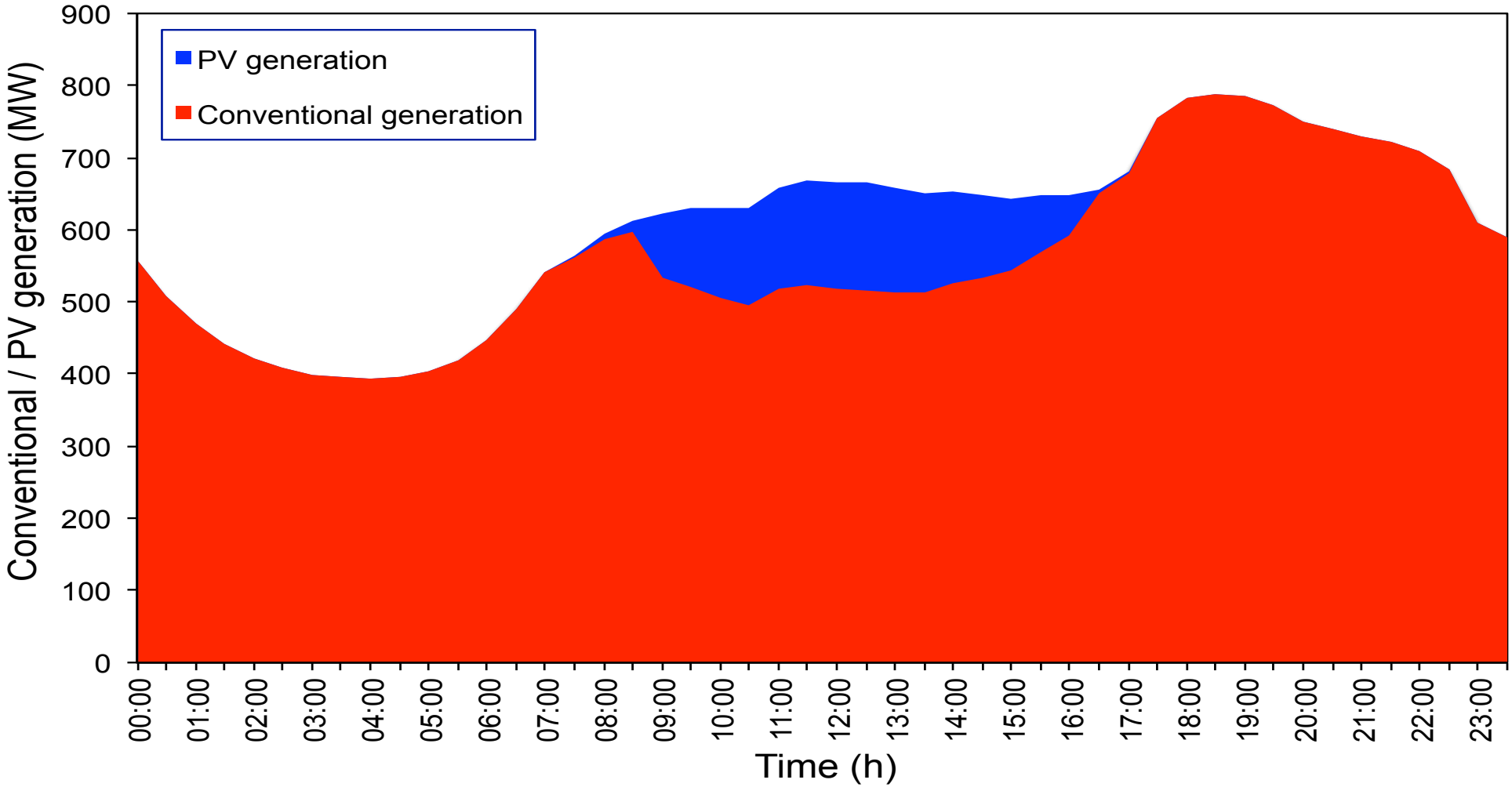
*** Poullikkas A., Kourtis G., Hadjipaschalis I., 2011, "A hybrid model for the optimum integration of renewable technologies in power generation systems", *Energy Policy* and Poullikkas A., 2009, "A decouple optimization method for power technology selection in competitive markets", *Energy Sources*.**

Example of PV generation during Summer time*



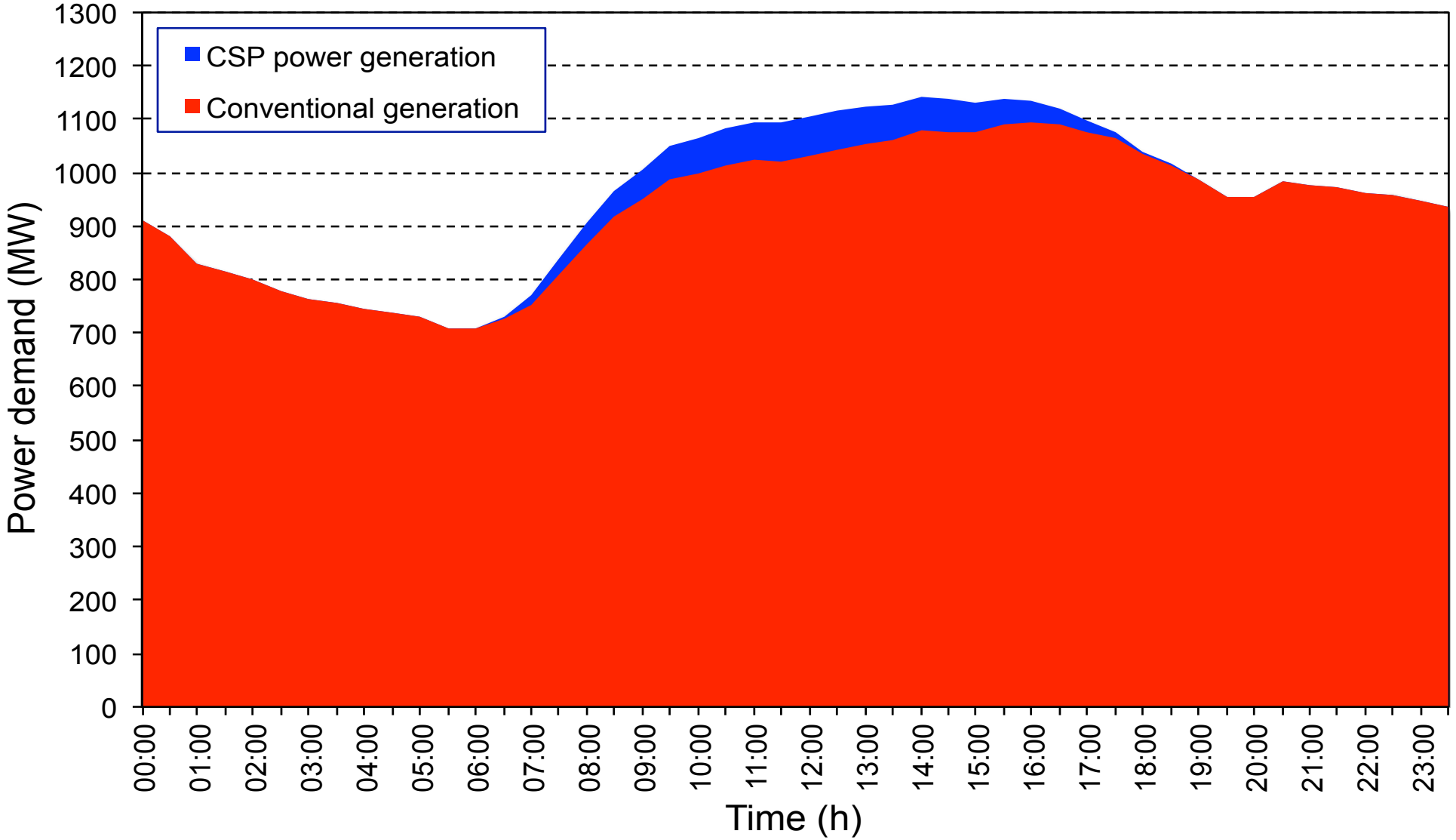
* **Poullikkas A., 2009, "Parametric cost-benefit analysis for the installation of photovoltaic parks in the island of Cyprus", *Energy Policy***

Example of PV generation during Winter time*

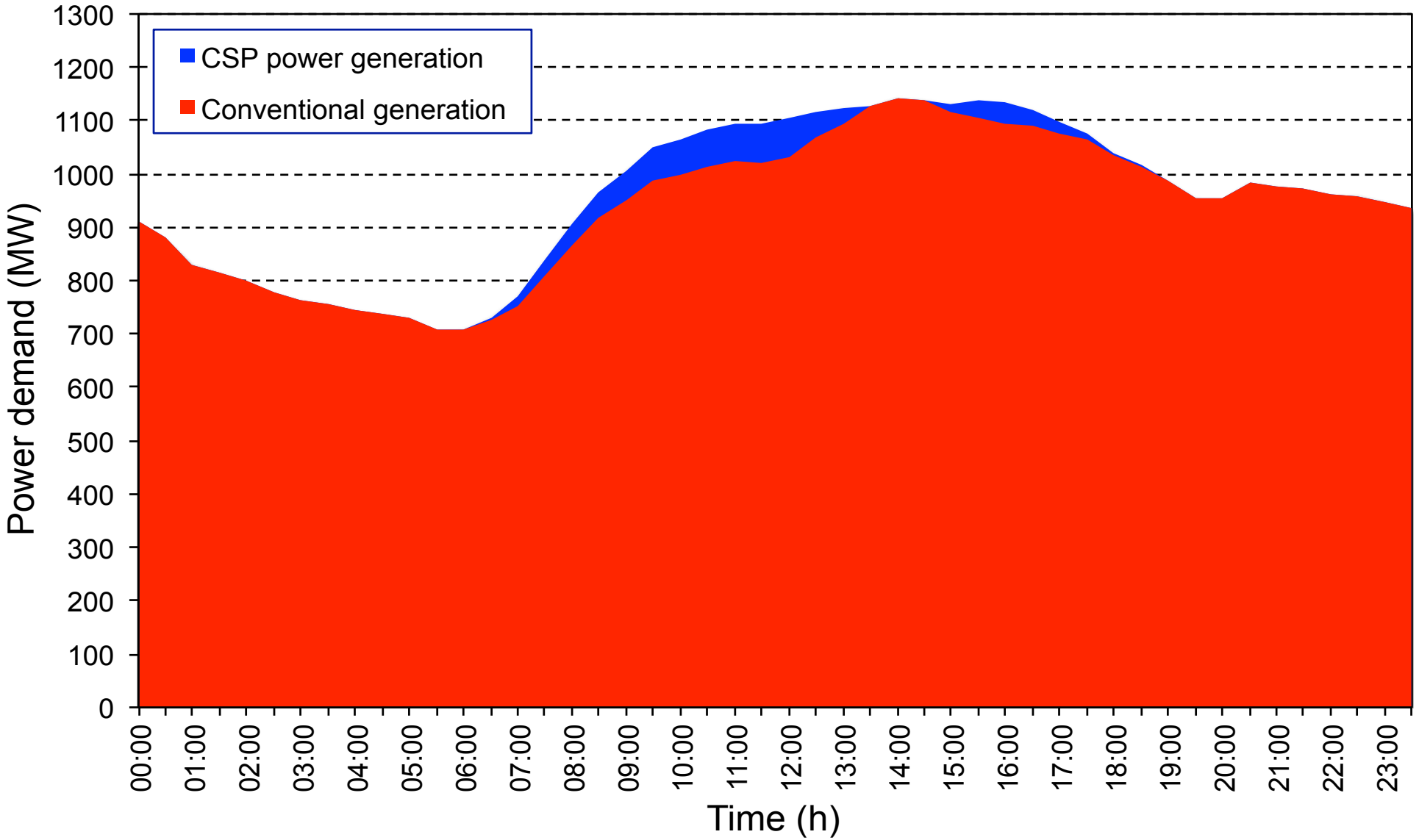


* Poullikkas A., 2009, "Parametric cost-benefit analysis for the installation of photovoltaic parks in the island of Cyprus", *Energy Policy*

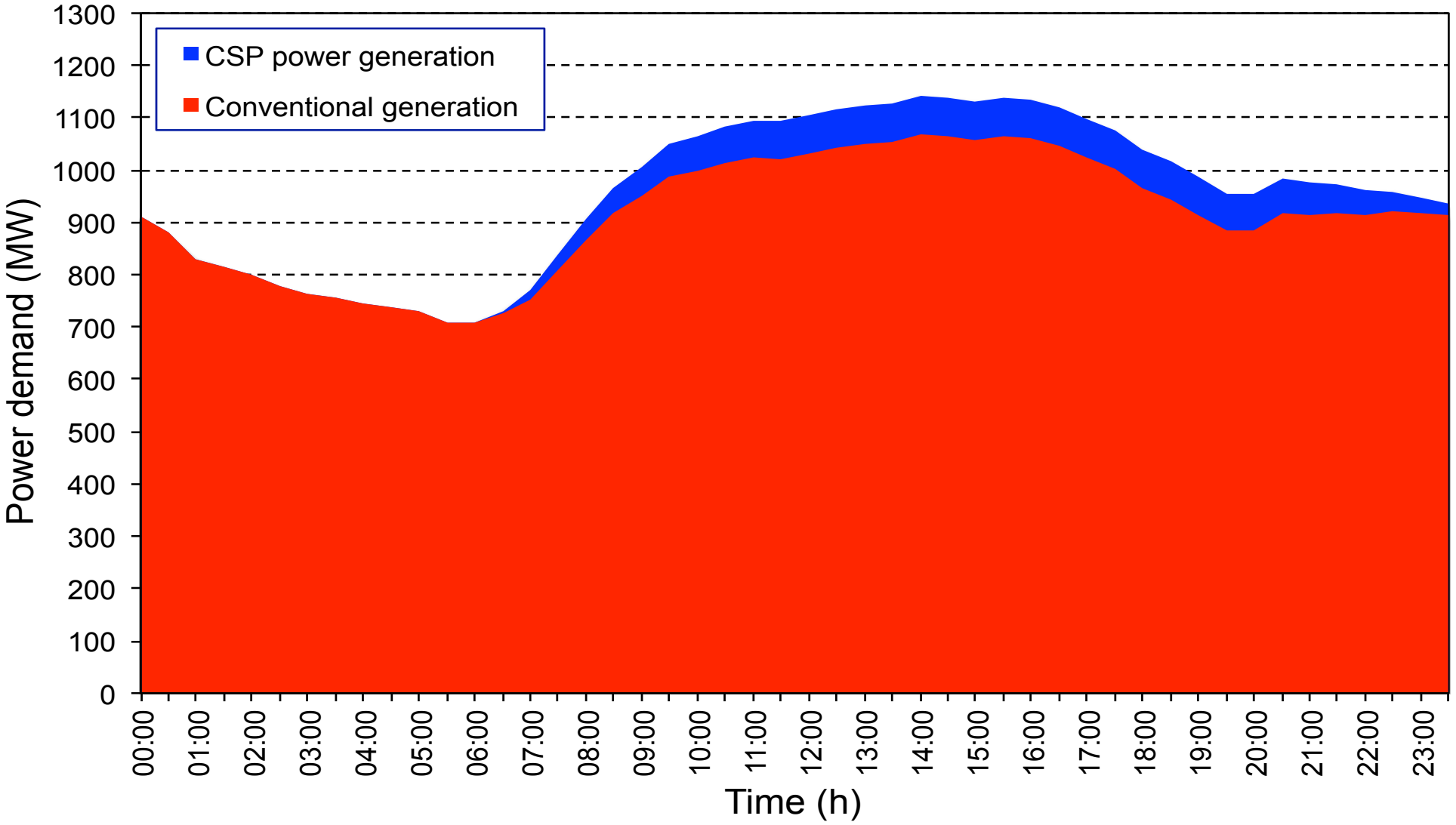
Example of 75MW CSP generation during peak load (no storage, normal conditions)



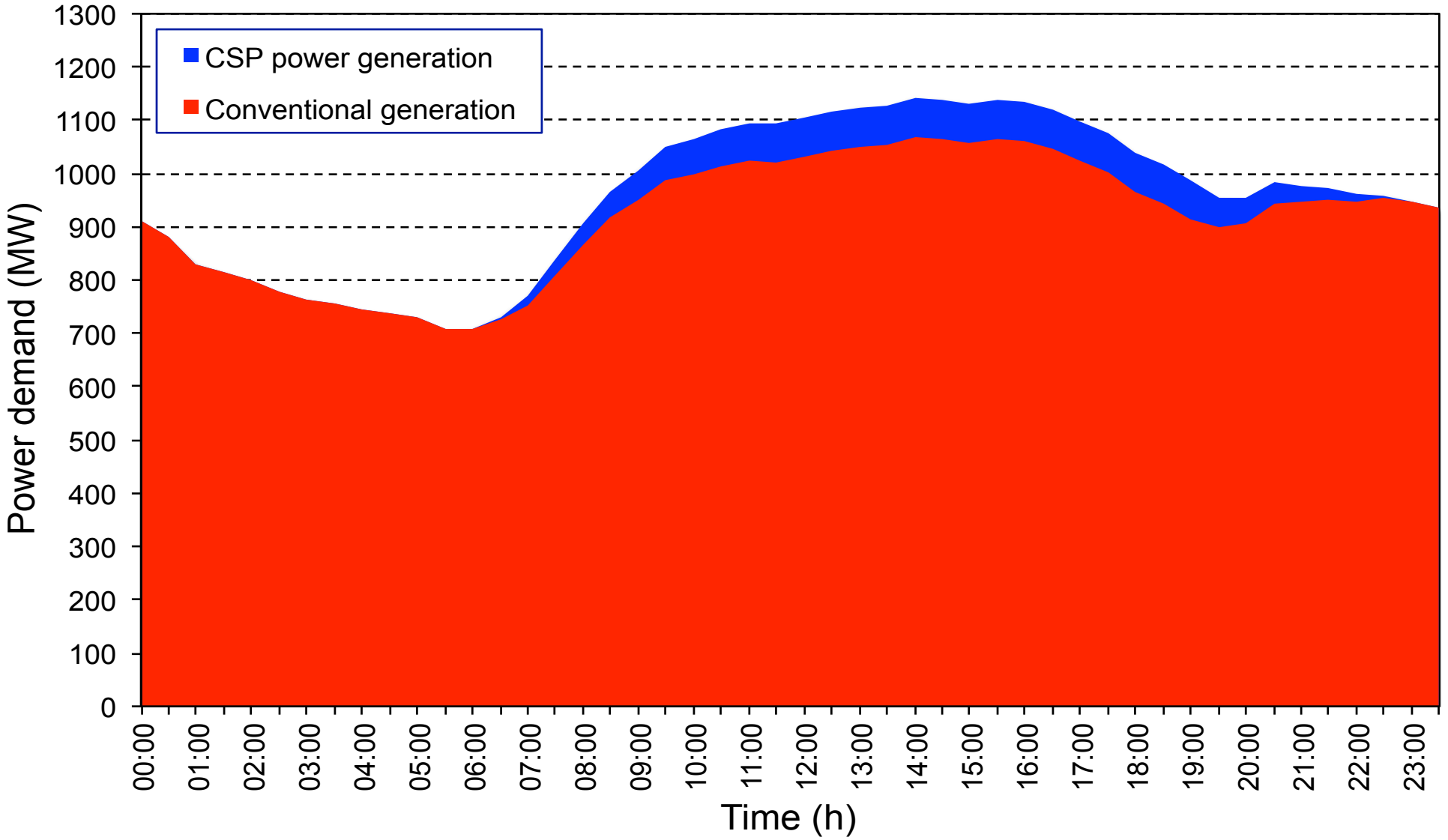
Example of 75MW CSP generation during peak load (no storage, with clouds)



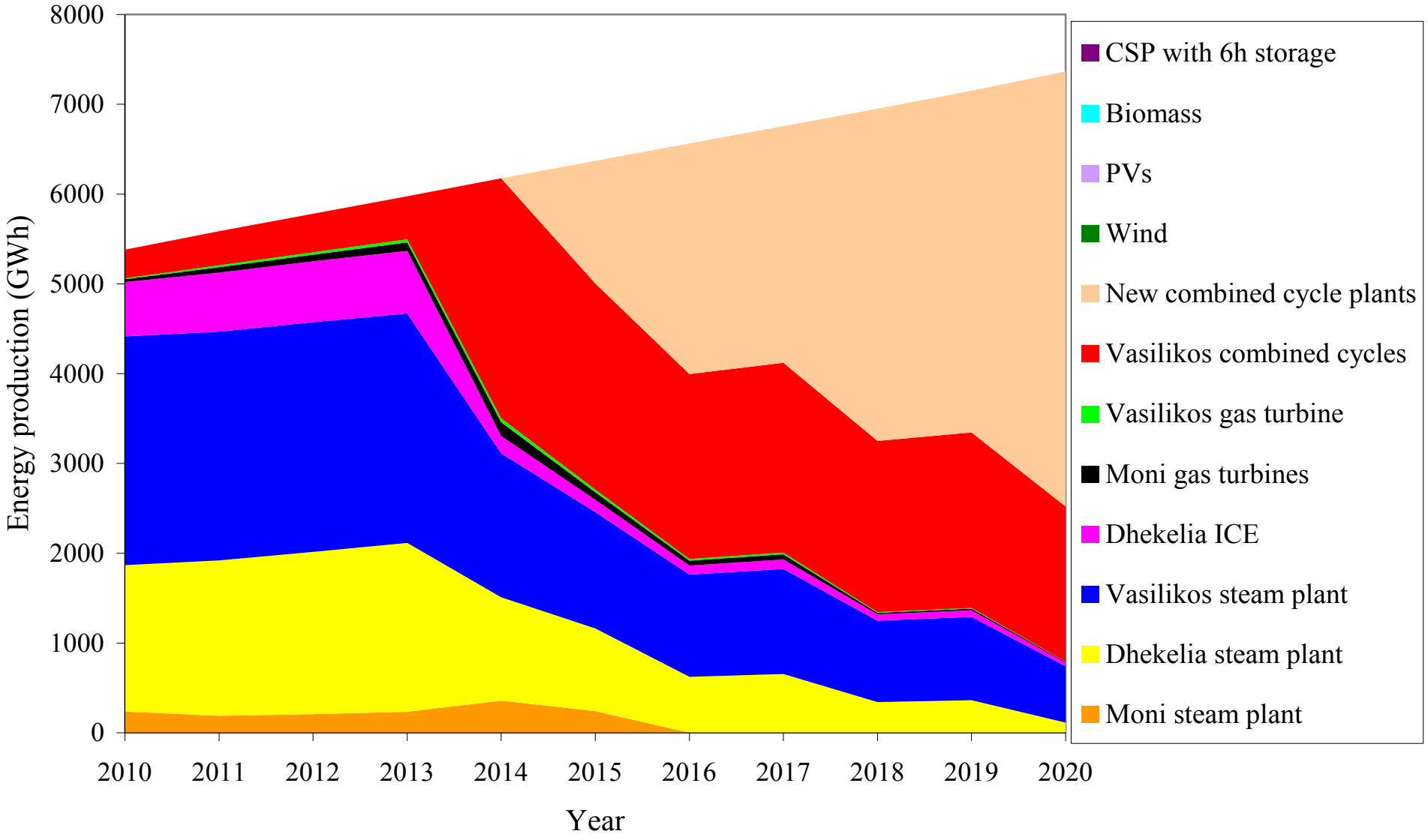
Example of 75MW CSP generation during peak load (6h storage, normal conditions)



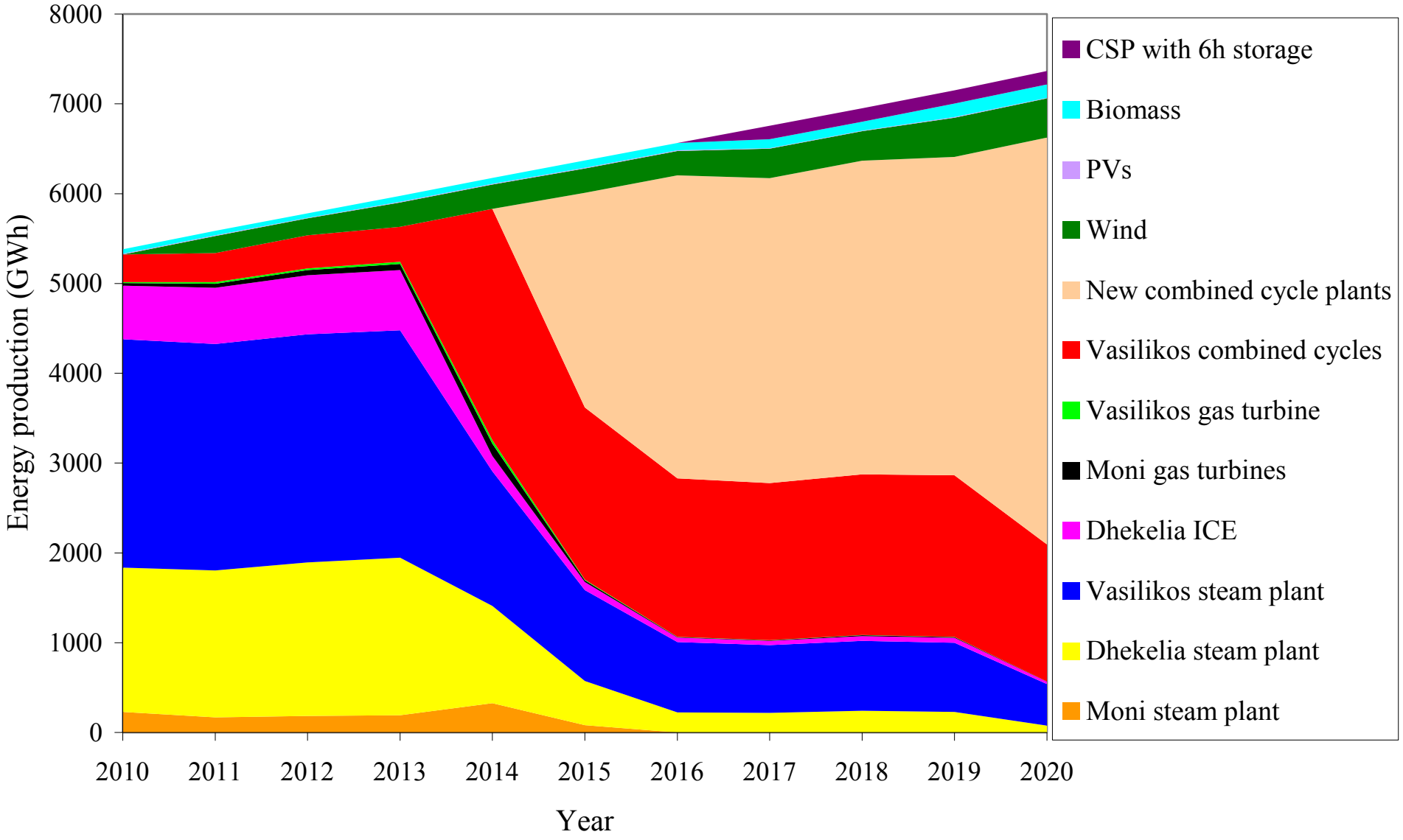
Example of 75MW CSP generation during peak load (6h storage, with clouds)



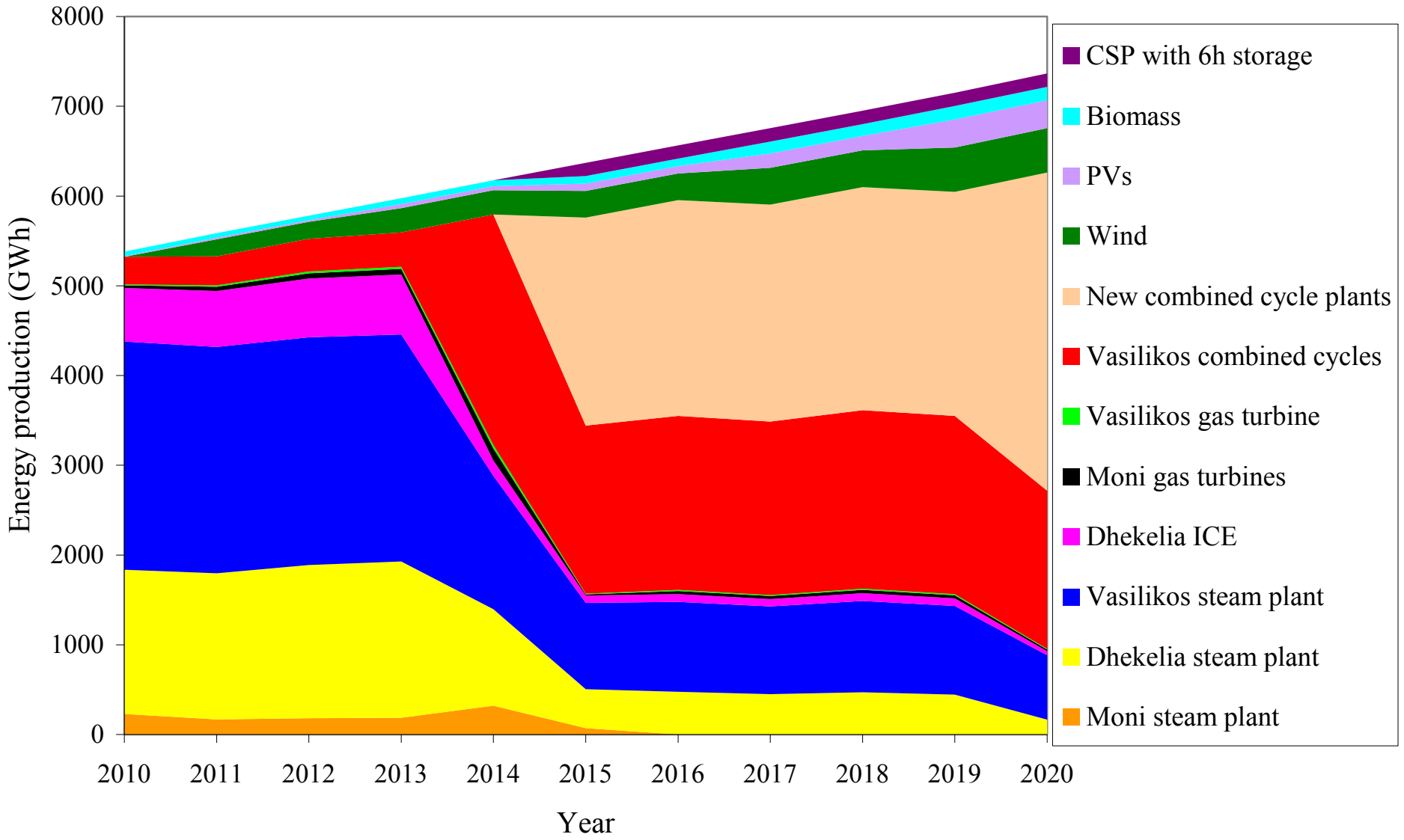
Power generation system energy mix with BAU



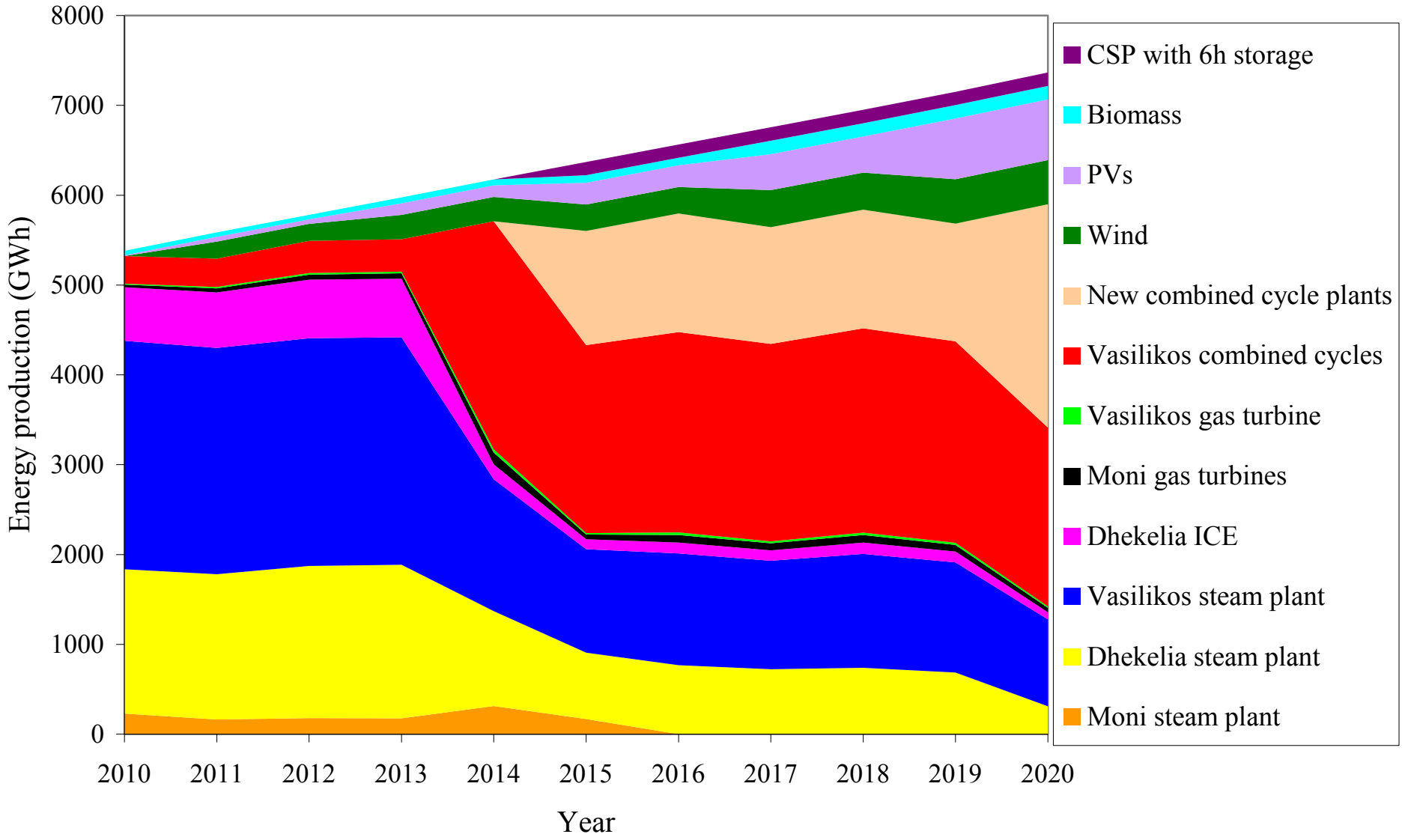
Power generation system energy mix with 10% RES-E penetration



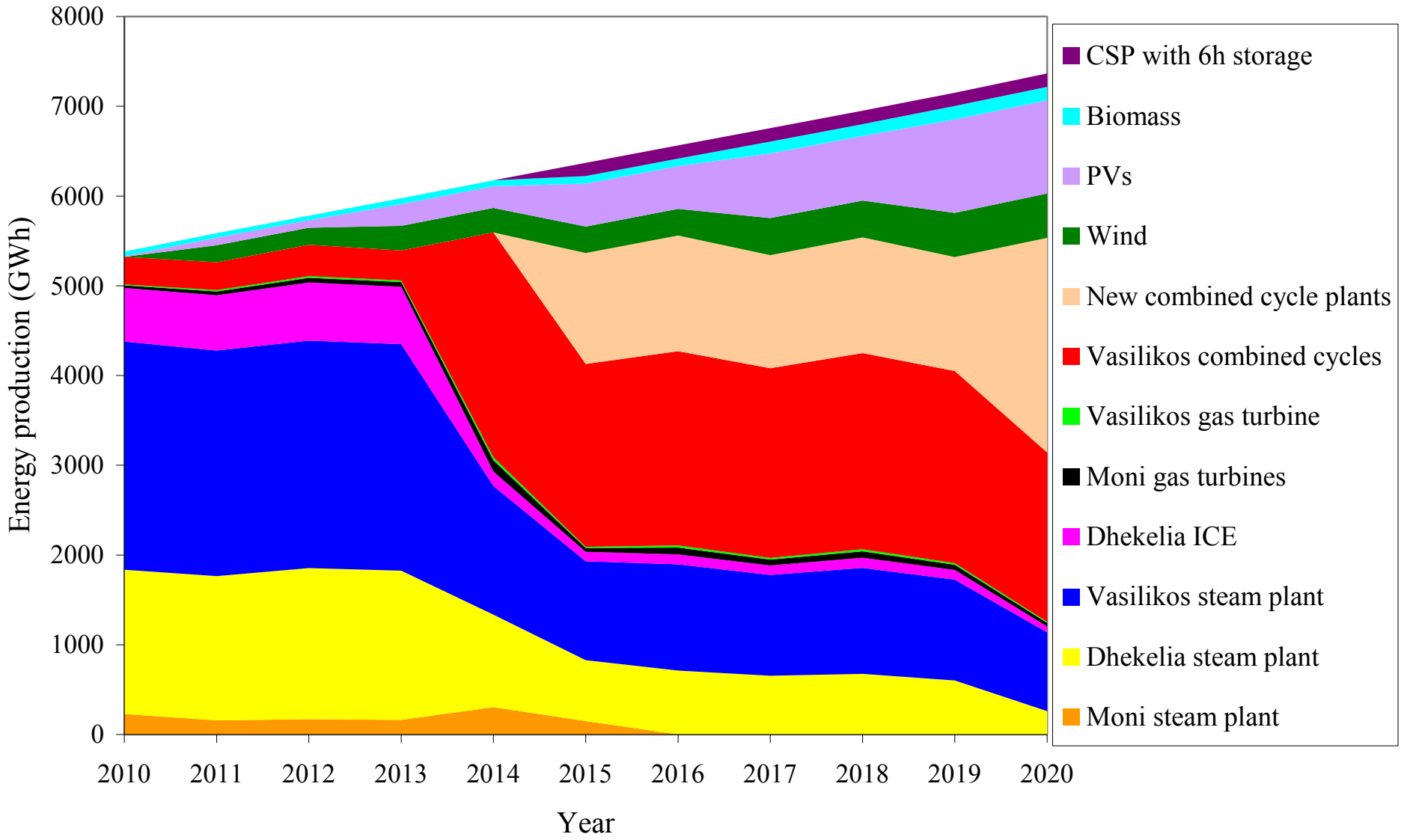
Power generation system energy mix with 15% RES-E penetration



Power generation system energy mix with 20% RES-E penetration



Power generation system energy mix with 25% RES-E penetration



RES-E strategic plan 2010-20

- RES-E penetration at 16% by 2020
- Important measures
  - Shifting from FiT mechanism, which is independent of electricity market prices, to a more market based mechanism
  - Introduction of the net-metering scheme
  - Use of competitive auctioning processes for RES-E capacity