MOVET

Centro d'iniziativa per i MOtori, VEicoli e Tecnologie

Il ruolo dell'idrogeno nella transizione tecnologica
ed ecologica dell'energia

17 dicembre 2021

Limiti e prospettive della produzione di idrogeno da rinnovabili

IN SUPREMÆ DIGNITATIS 1343
UNIVERSITÀ DI PISA

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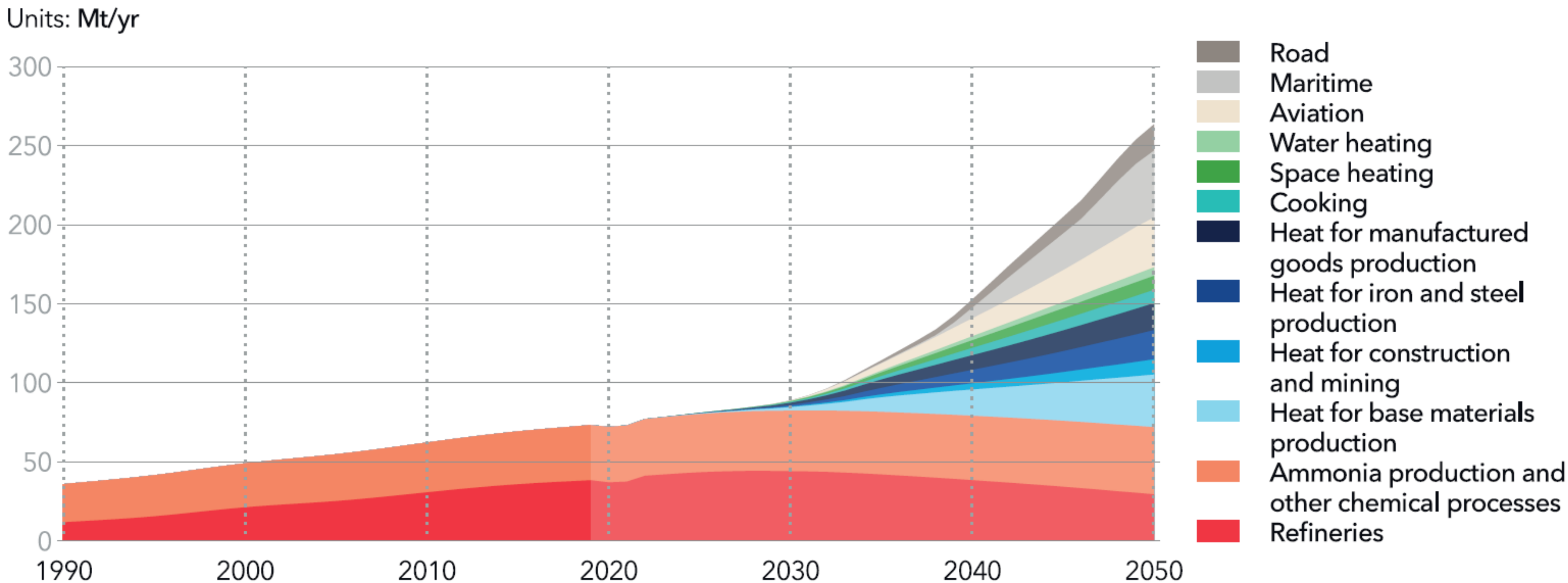
The future of hydrogen

World hydrogen demand by sector

DNV – Energy Transition Outlook 2021



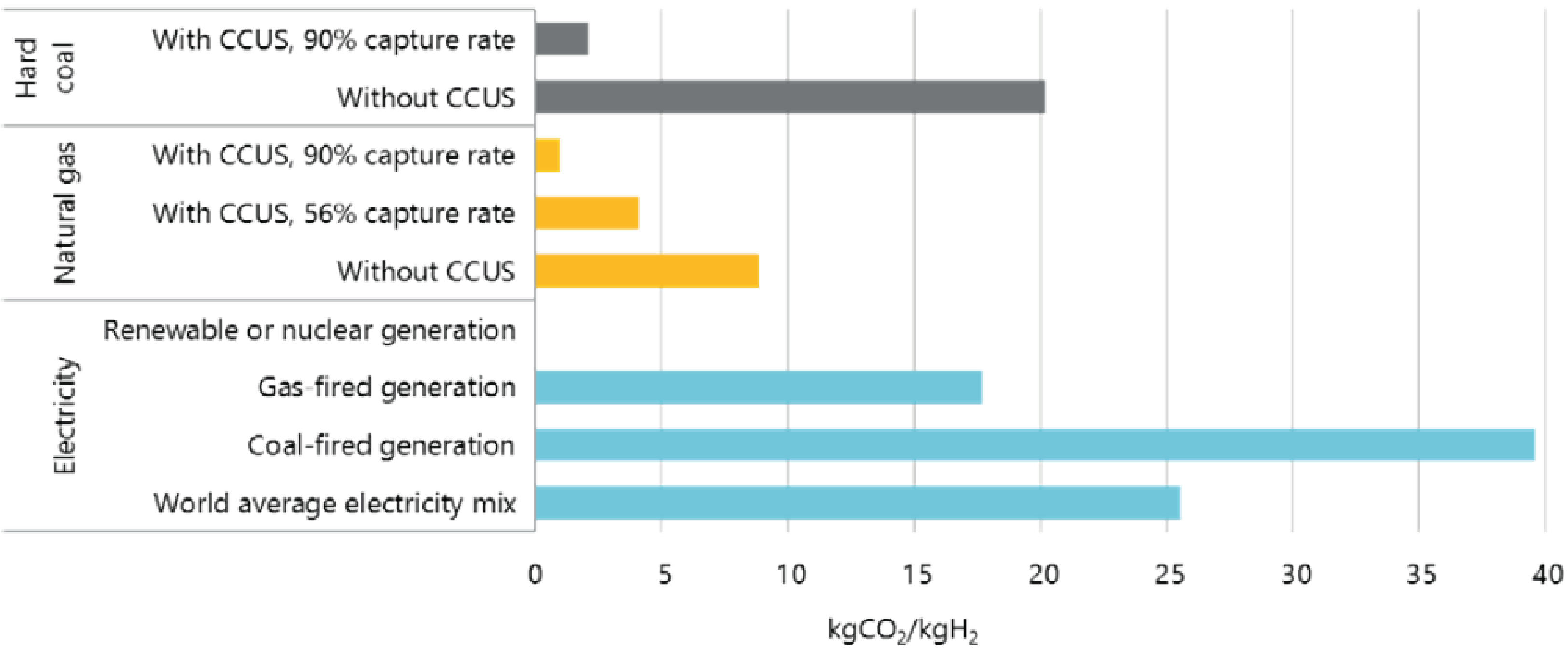
Only includes pure hydrogen demand. Maritime and aviation demand includes synthetic fuels derived from hydrogen.
Historical data source: IEA Future of Hydrogen (2019)

The color of hydrogen

Color	GREY HYDROGEN	BLUE HYDROGEN	TURQUOISE HYDROGEN*	GREEN HYDROGEN
Process	SMR or gasification	SMR or gasification with carbon capture (85-95%)	Pyrolysis	Electrolysis
Source	Methane or coal	Methane or coal	Methane	Renewable electricity

Note: SMR = steam methane reforming.
** Turquoise hydrogen is an emerging decarbonisation option.*

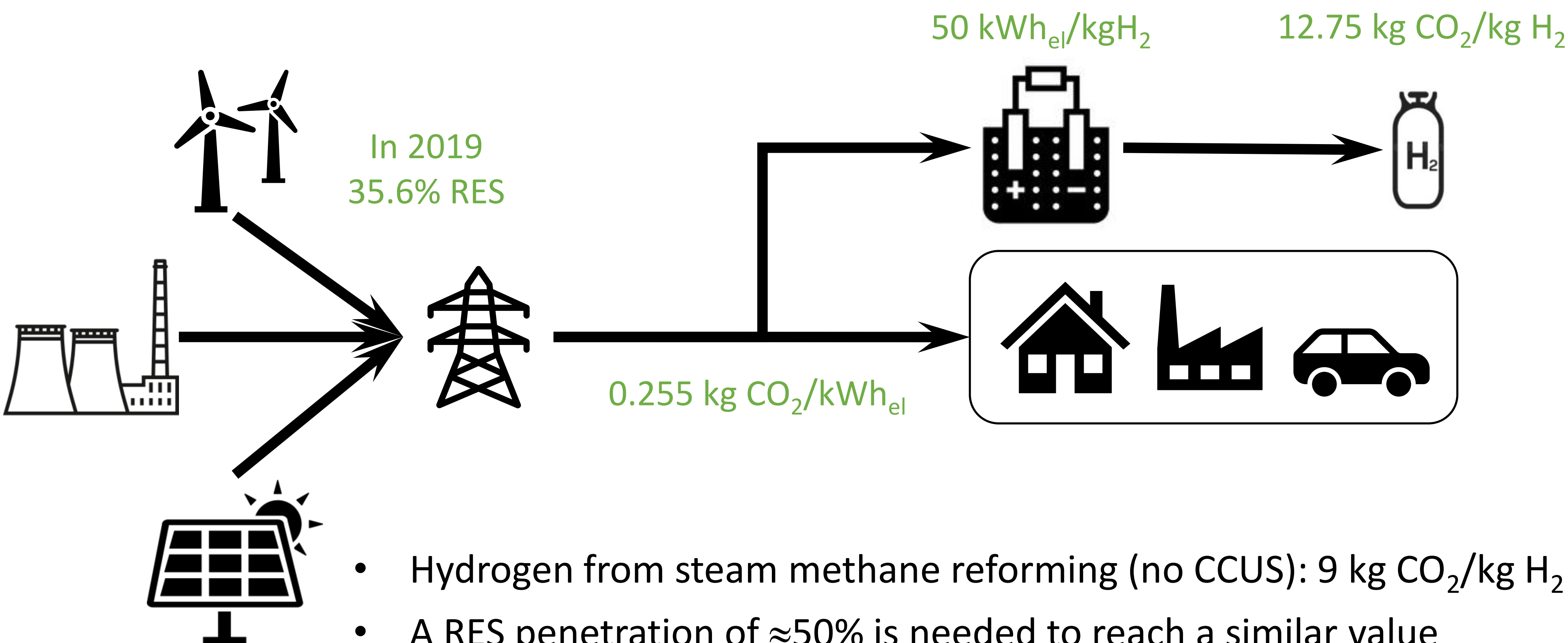
Impact of hydrogen production



Notes: Capture rate of 56% for natural gas with CCUS refers to capturing only the feedstock-related CO_2, whereas for 90% capture rate CCUS is also applied to the fuel-related CO_2 emissions; CO_2 intensities of electricity taking into account only direct CO_2 emissions at the electricity generation plant: world average 2017 = 491 gCO_2/kWh, gas-fired power generation = 336 gCO_2/kWh, coal-fired power generation = 760 gCO_2/kWh. The CO_2 intensities for hydrogen also do not include CO_2 emissions linked to the transmission and distribution of hydrogen to the end users, e.g. from grid electricity used for hydrogen compression. More information on the underlying assumptions is available at www.iea.org/hydrogen2019.

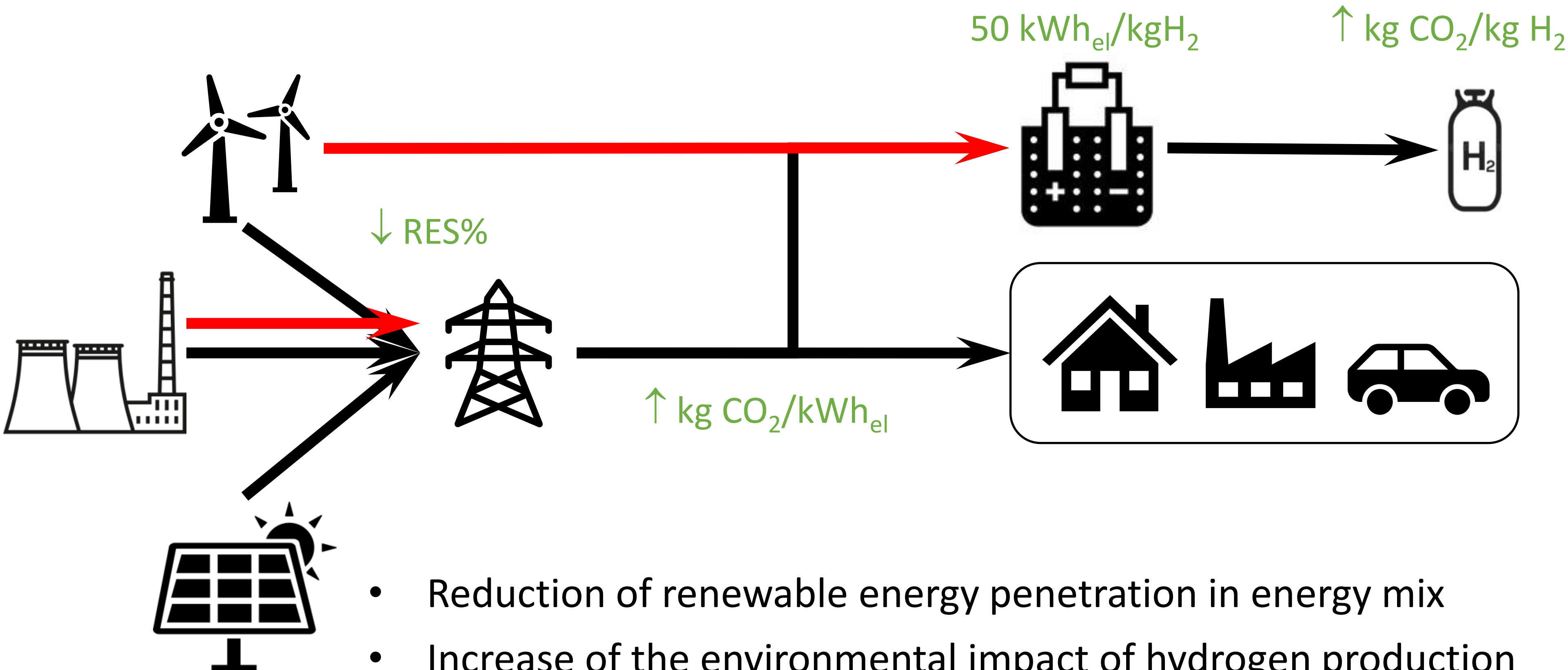
Source: IEA 2019.

Hydrogen production from the grid



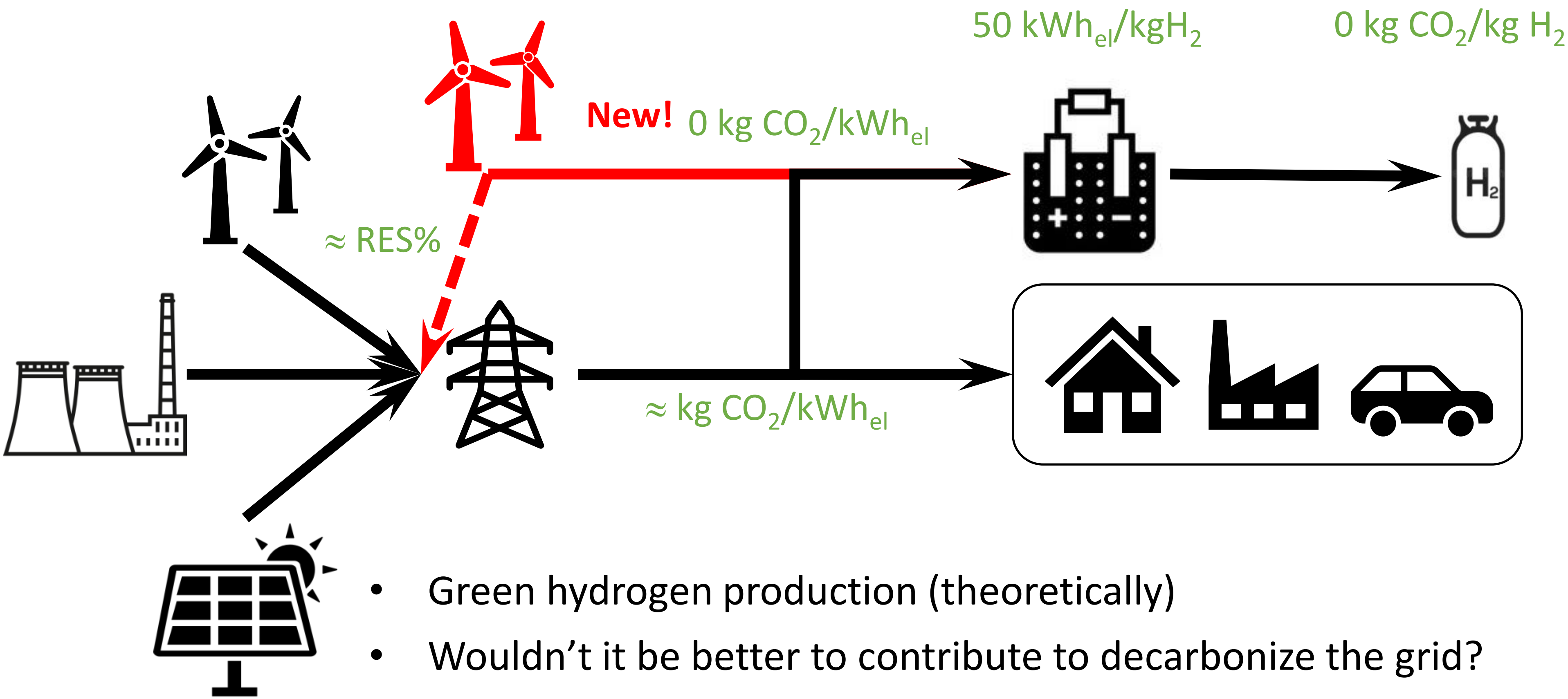
- Hydrogen from steam methane reforming (no CCUS): 9 kg CO_2/kg H_2
- A RES penetration of ≈50% is needed to reach a similar value

Hydrogen production from renewables



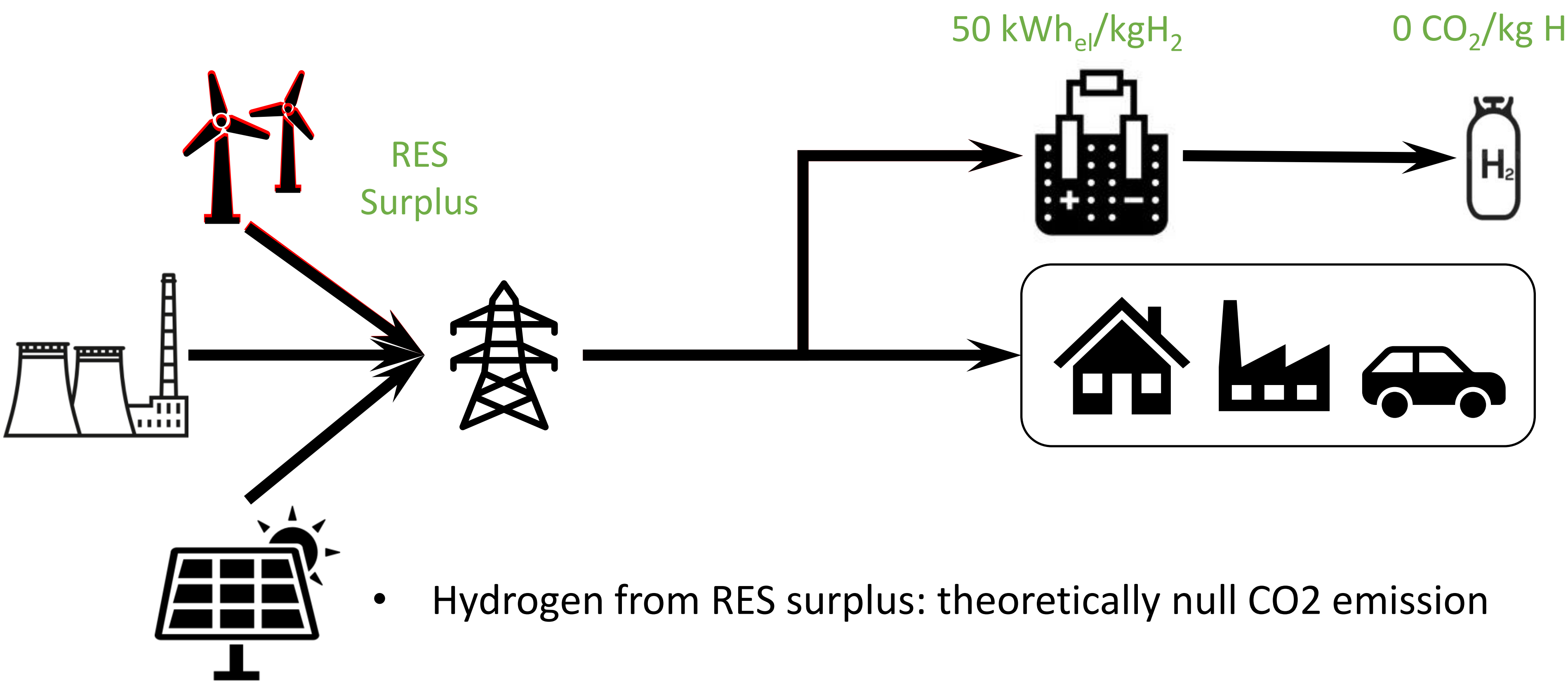
- Reduction of renewable energy penetration in energy mix
- Increase of the environmental impact of hydrogen production

Hydrogen production from renewables



- Green hydrogen production (theoretically)
- Wouldn't it be better to contribute to decarbonize the grid?

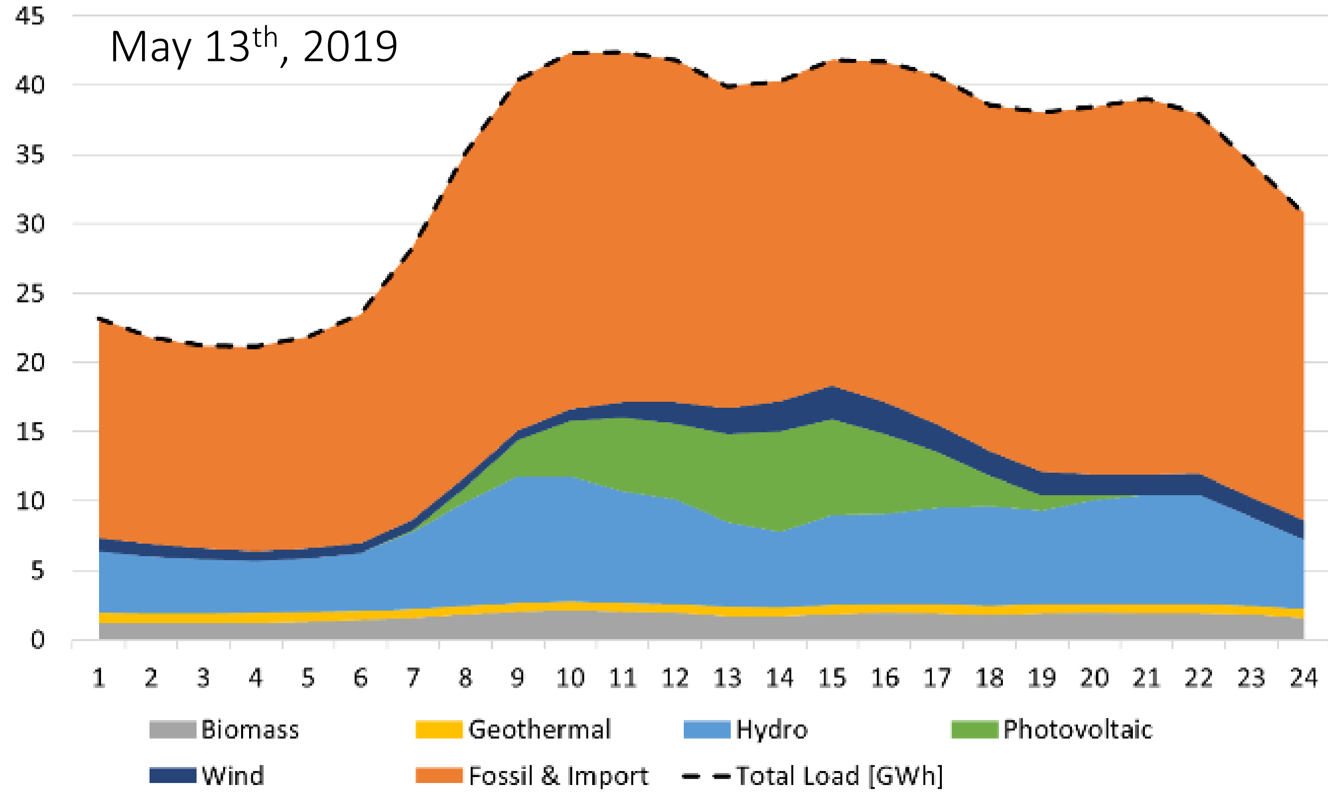
Hydrogen production from renewables



- Hydrogen from RES surplus: theoretically null CO2 emission

Let's suppose…

Source: Terna, GSE

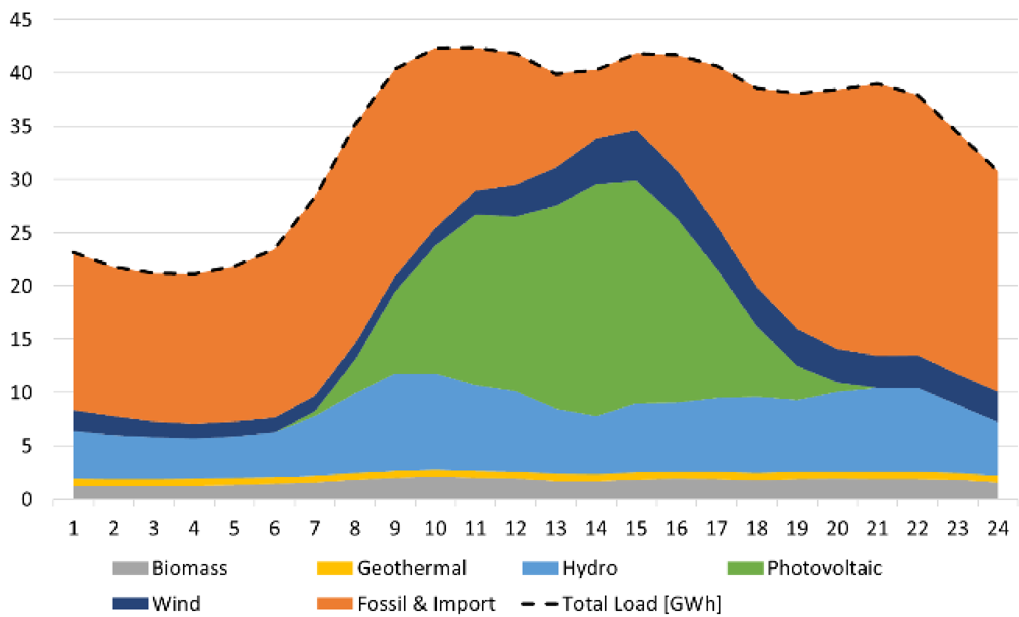


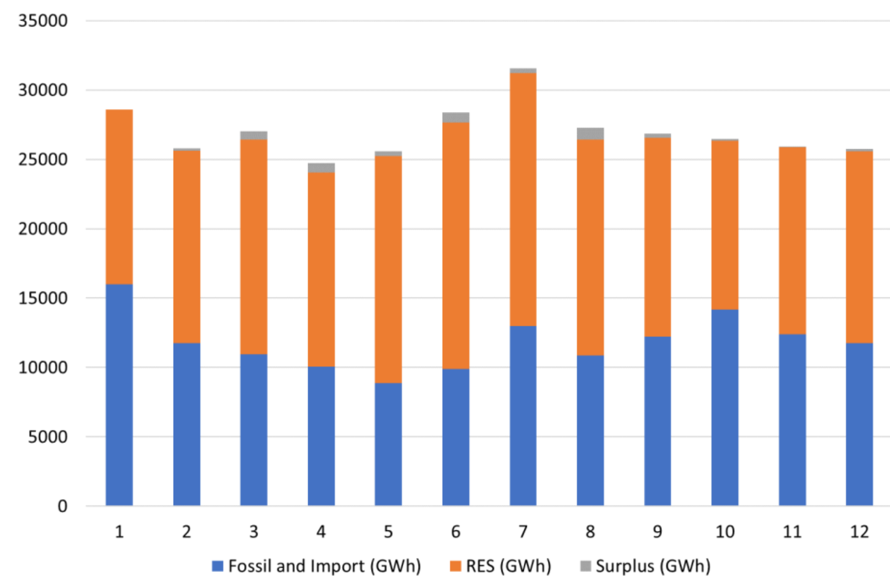
Italy 2019

- Consumption: 320 TWh
- Import/export: 38 TWh
- Renewables: 114 TWh
  - PV: 24 TWh
  - Wind: 20 TWh
  - Geothermal: 6 TWh
  - Hydropower: 47 TWh
  - Biomass: 17 TWh
- Renewables % 35.6%
- No surplus of renewables

…to increase the % of renewables

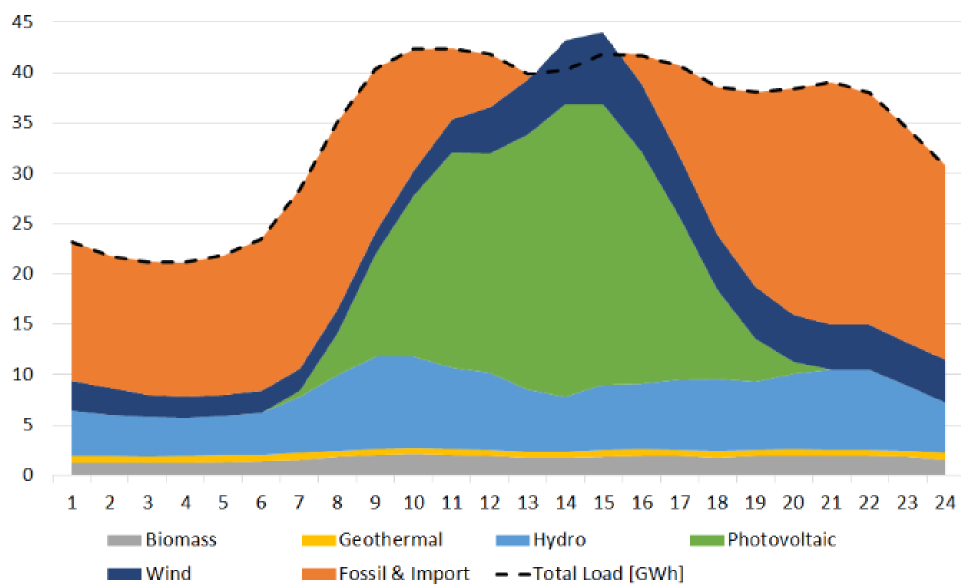
- Three times the production from PV and twice the production from wind
- RES penetration 55,6% and annual RES surplus of 4351 GWh

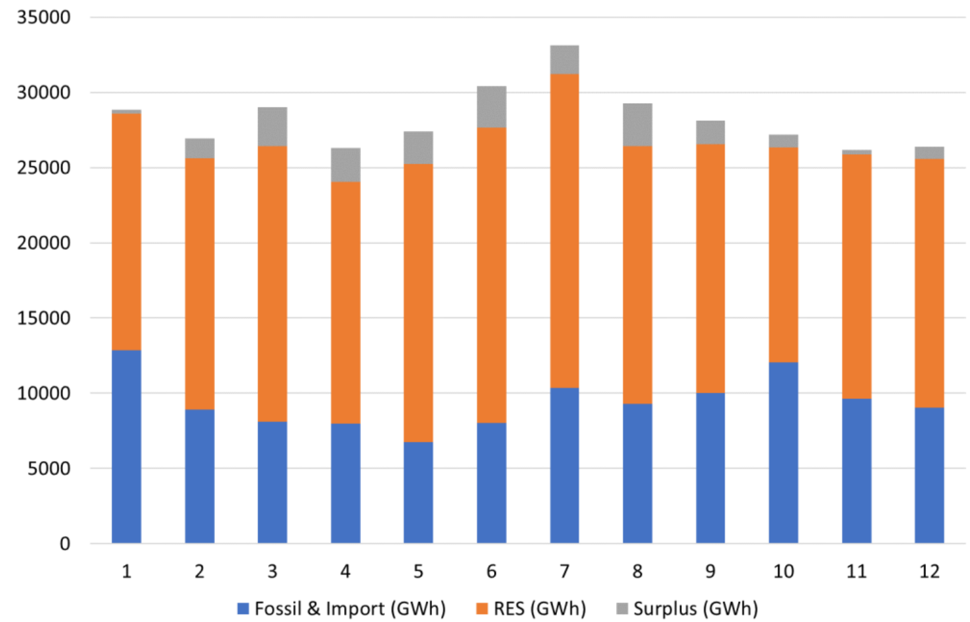




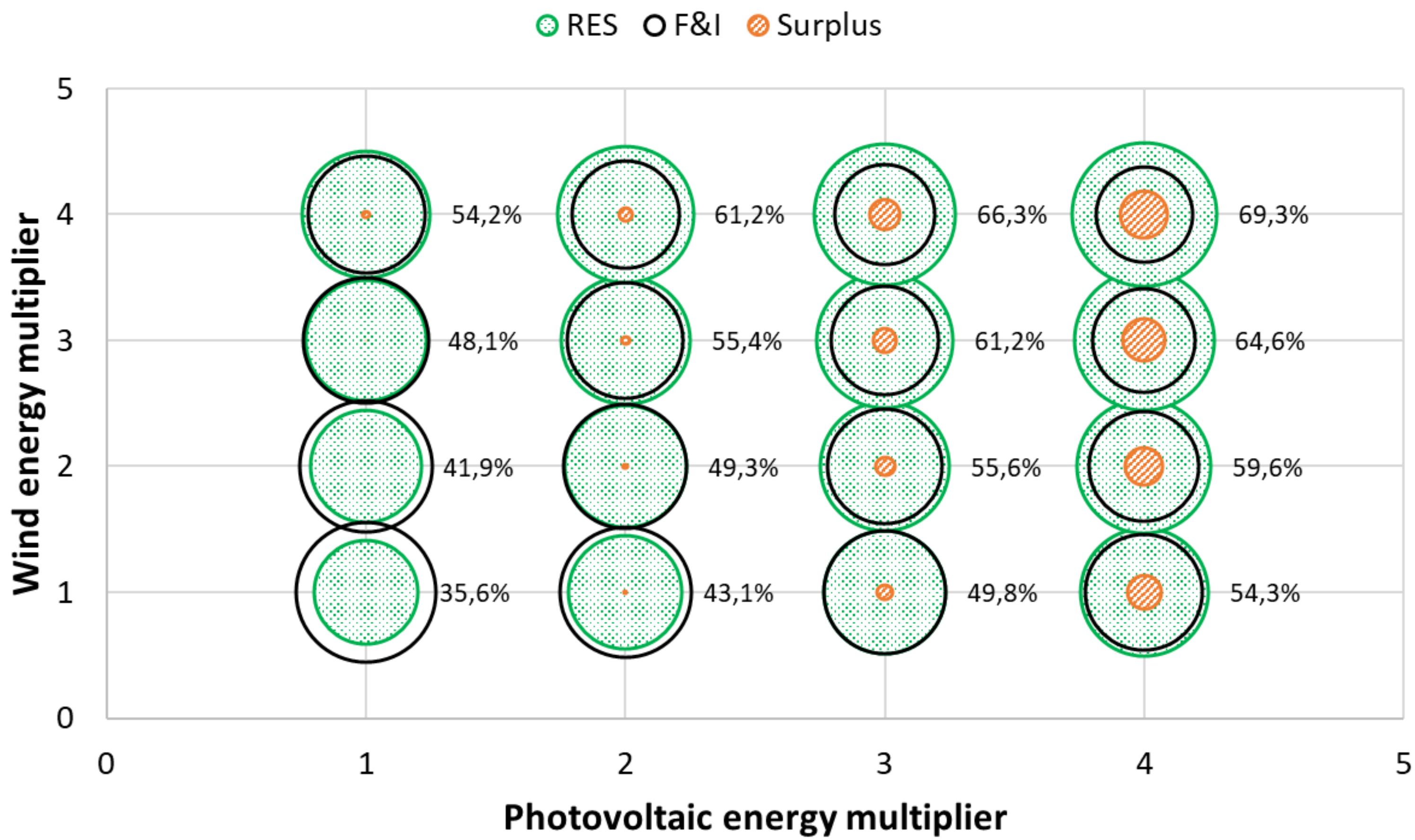
…to increase the % of renewables

- Four times the production from PV and trice the production from wind
- RES penetration 64,6% and annual RES surplus of 19651 GWh



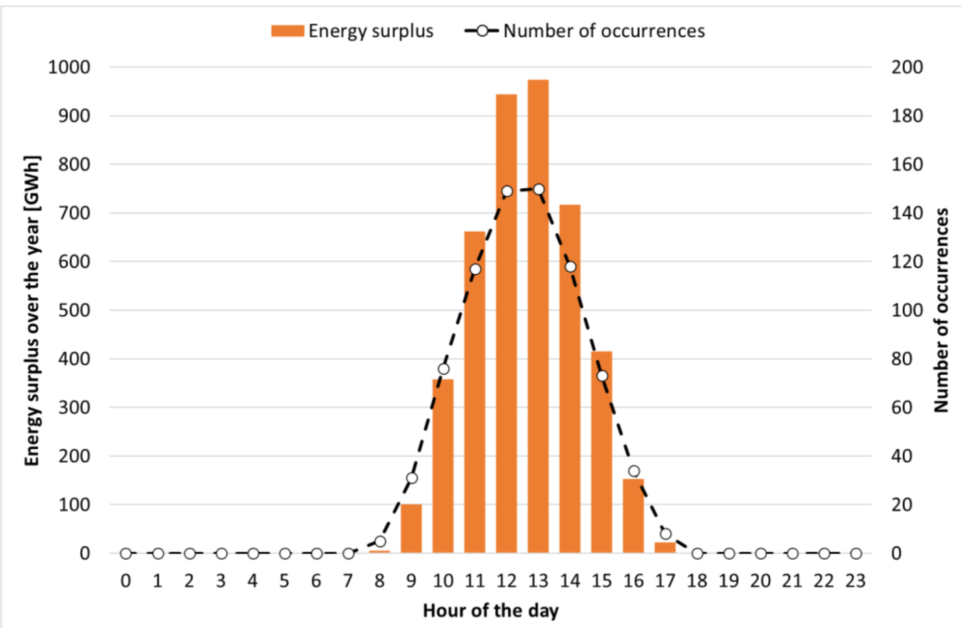


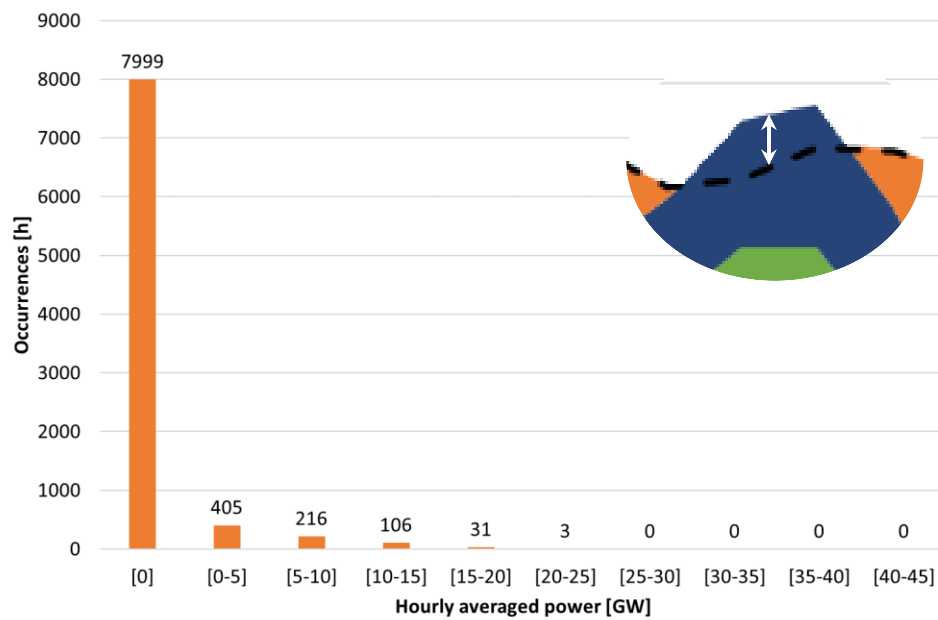
Relation between renewables and surplus



Surplus availability (3 PV - 2W)

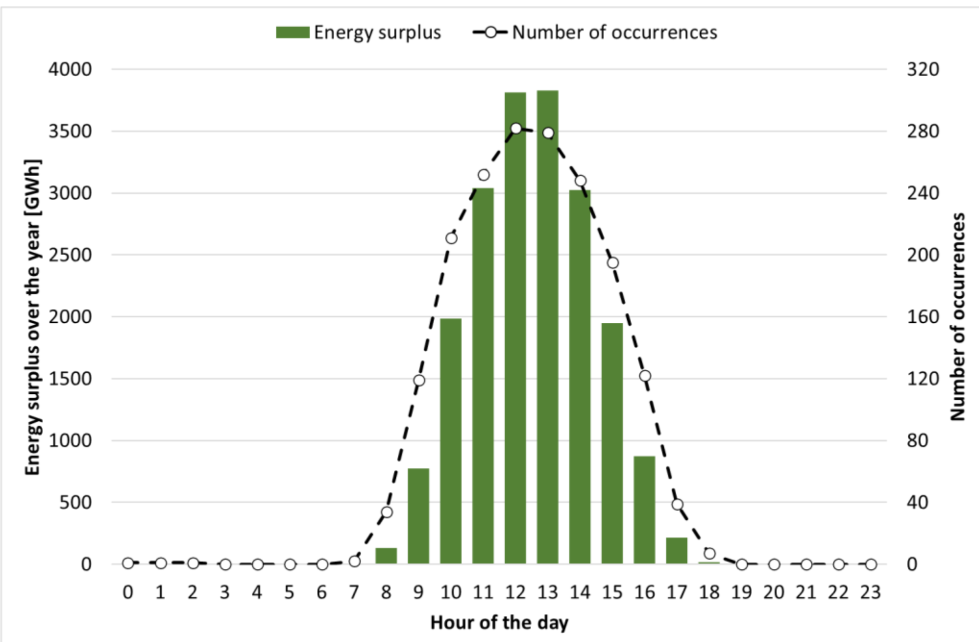
- RES surplus is concentrated in the central hours of the day
- Hydrogen pruduction system switched off for most of the year

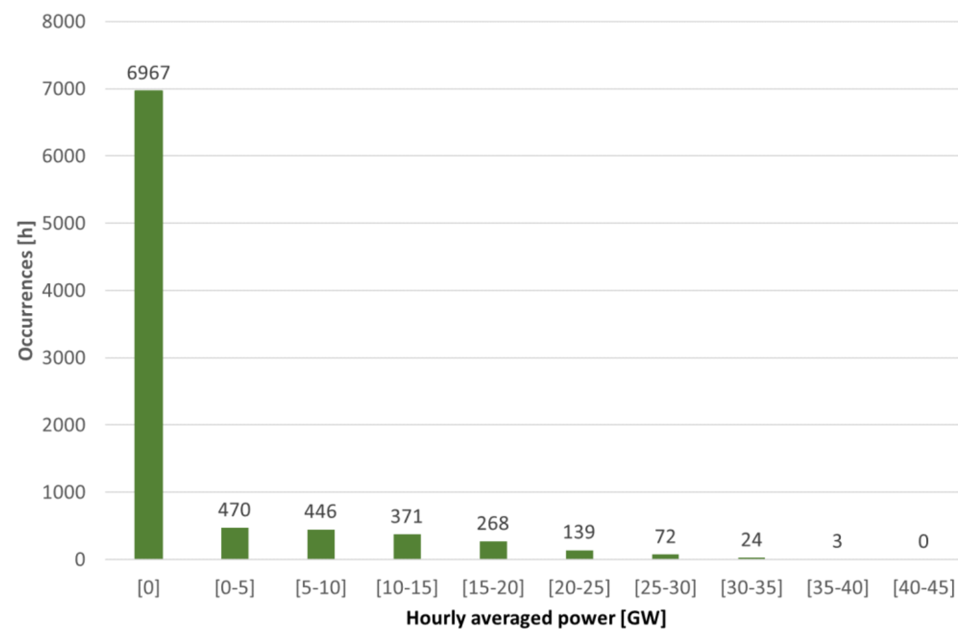




Surplus availability (4 PV - 3W)

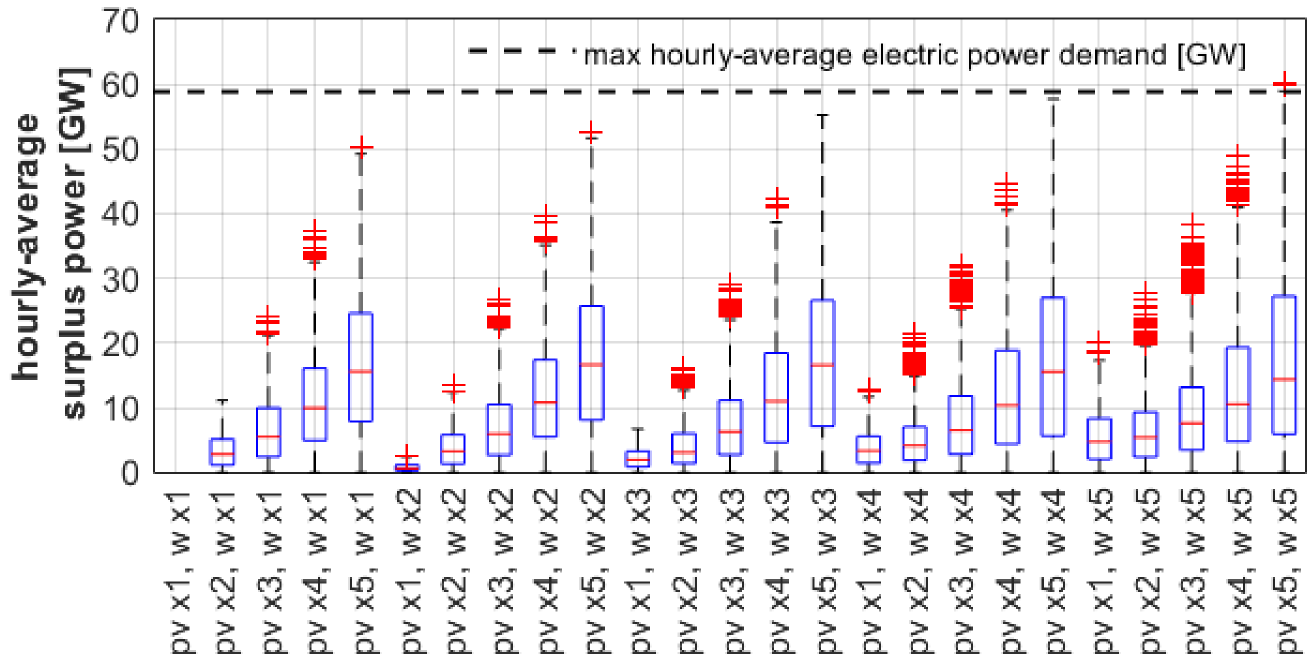
- The situation improves by increasing the RES surplus, but still the hydrogen production systems wuold be switch off for most of the year





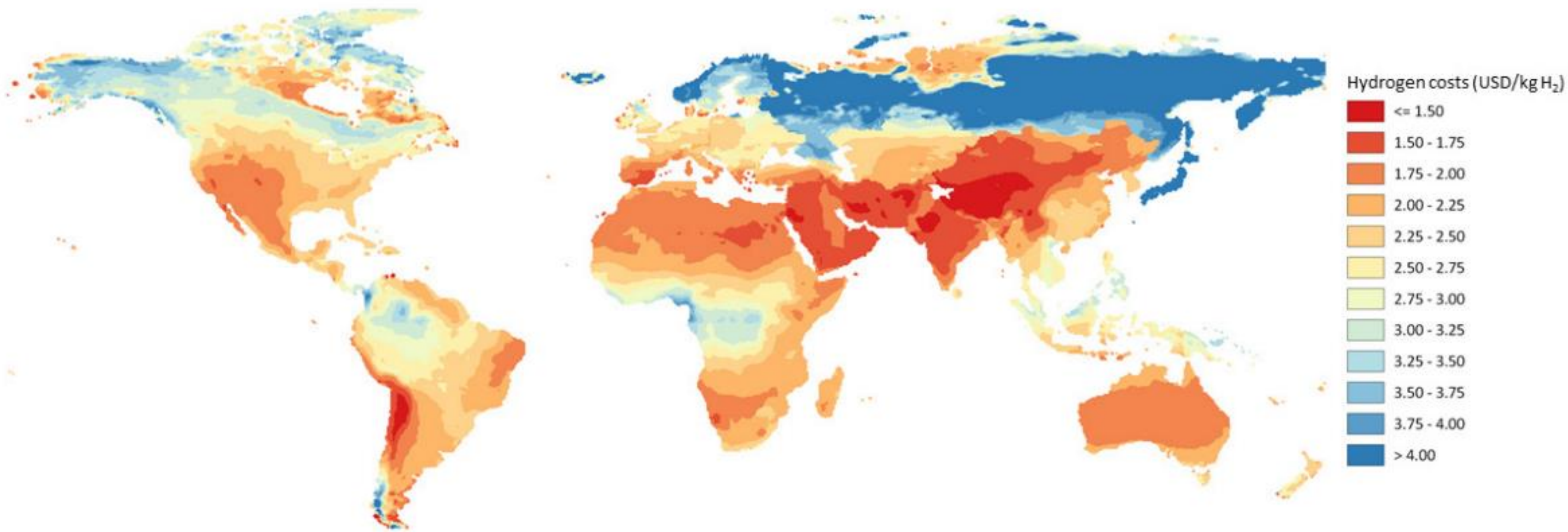
Green hydrogen - Power & Energy

- From an economic point of view, the full exploitation of surplus might be critical
  - Electrolyzers of big capacity but with low operating hours
  - Production of hydrogen also when there is no surplus



Cost of hydrogen from PV and Wind

Hydrogen production cost from hybrid solar PV and wind systems in 2030



Notes: This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area. For each location, production were derived by optimising the mix of solar PV, onshore wind and electrolyser capacities, resulting in the lowest costs and including the option to curtail electricity generation.
Sources: Based on hourly wind data from Copernicus Climate Change Service and hourly solar data from Renewables.ninja.

Conclusions

- Hydrogen and its derivates:
  - Effective way to decarbonized several energy fields
  - Increase in the renewable energy penetration (used as energy storages)
- The production of green hydrogen is only possible by exploiting renewable energy surplus
- Simplified analysis to investigated the potential surplus in scenarios with increased RES penetrations
- Strong increase in renewable energy production to achieve high values of RES surplus
- Potential criticalities due to the gap between power and energy of RES surplus
- Cost of green hydrogen very variable with the location (availability of RES)

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