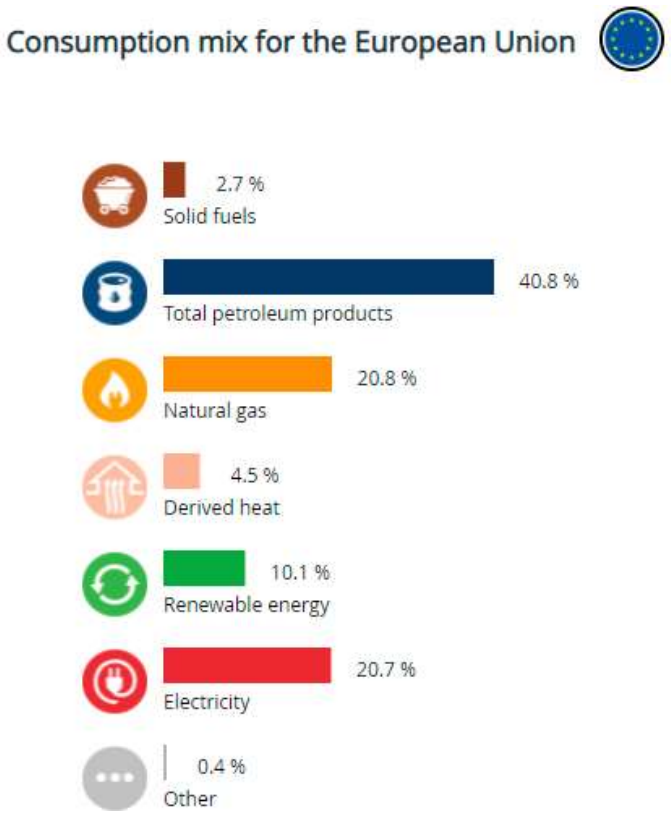
THE ENERGY PRICE RISE

ITS IMPACT ON THE IMPLEMENTATION OF CARBON CAPTURE AND UTILISATION TECHNOLOGIES

Carbon neutrality means covering the complete energy demand – not only electricity

Carbon neutrality comes with deep challenges

11 000 TWh/year



(*) 2019 data Eurostat EU27

Pathways

1. **Electricity only 20% of the energy demand**, but will increase with the growing RES electrification of industry and transport.

2. **Renewable heat** (ex. biomass, geothermal,…) will increase further

3. **Carbon Capture & Sorage (CCS)** is back on the European agenda

4. **Hydrogen & Power-to-X (or CCU)**
   - Replace fossil fuels of **hard-to-abate sectors**
   - Electrolyzers to **store RES electricity**
   - **Import of renewable energy** from regions where it is abundant and cheap (ex. Iberia, North Africa,…)

Constraints

Electrical storage and electrical network will remain the bottleneck

Will not be sufficient

Infrastructure & treaties

- **Green H_2 is the most expensive pathway**
- Blue H_2 ?
- Intermitttency
- Import green H_2 or e-fuels ?

RepowerEU intend to boost Renewable Electricity deployment

The growth of renewable will be done by **wind and solar** as the growth potential for hydro power and biomass is limited.
Because of the limited capacity factor of wind and solar, it is mandatory to find a solution **to store electricity or the transform the electricity into a valuable molecule for EU economy.**

Capacity factor*

40% = 3500 h/y
30% = 2600 h/y
20% = 1750 h/y
15% = 1300 h/y
10% = 900 h/y

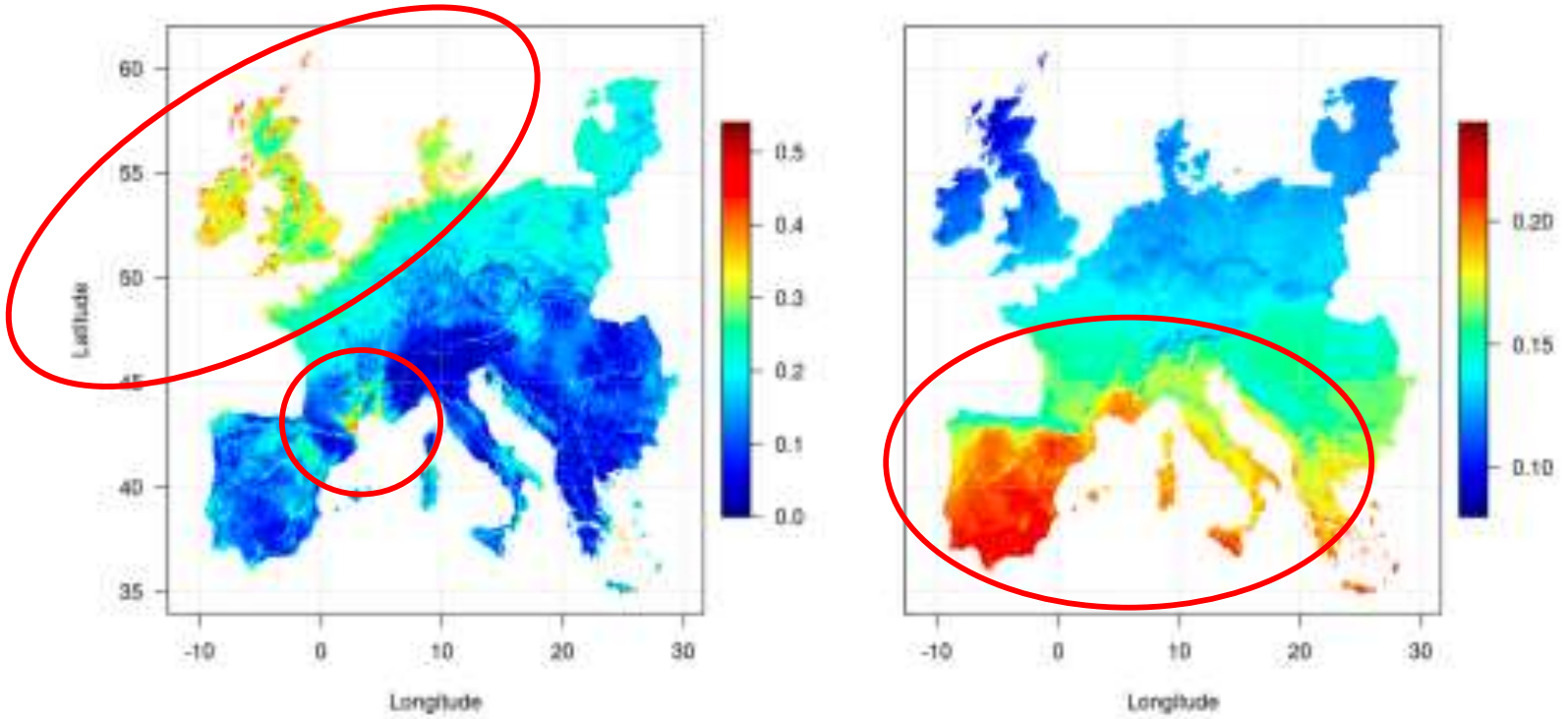
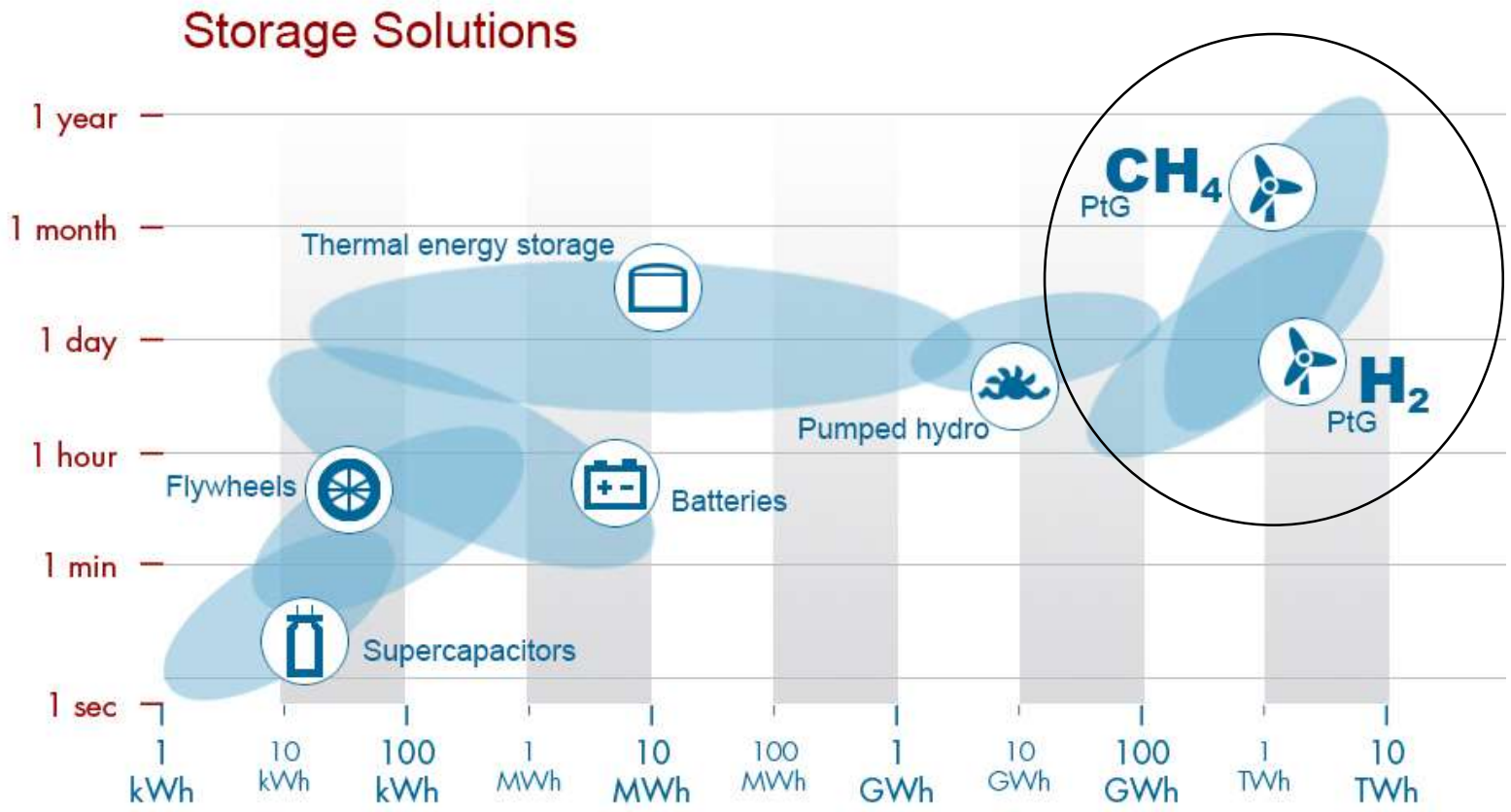


Figure 2. Average capacity factors for wind (left) and photovoltaics (right) in Europe (1995–2015) derived from the regional reanalysis COSMO-REA6 and the satellite-based SARAH 2 dataset.

What’s are the electricity storage possibilities?



Efficiency of Power to gas to power is very low (~30%), better to use the green hydrogen directly in existing industry or to produce molecules

Green H_2 to use excess of power

Mainly industrial uses (**generally baseload**) of H_2

Storage + grid support

Power to H_2

Existing use of H_2

Ammonia (NH_3) production
Limited willingness to pay green premium
~ 130 TWh H_2 or 200 TWh green elec
Less expensive to produce green ammonia outside EU.

Refineries
Willingness to pay green premium but
~50 TWh H_2 or 75 TWh green elec
Decreasing market due to mobility electrification

New use of H_2

Difficult to develop without infrastructure.

New Steel production (only green H_2)
~180 TWh H_2 or 275 TWh green elec
Capex required for green steel without green H_2
~40 b€ (for 100% green steel in EU)

Mobility
Still small market

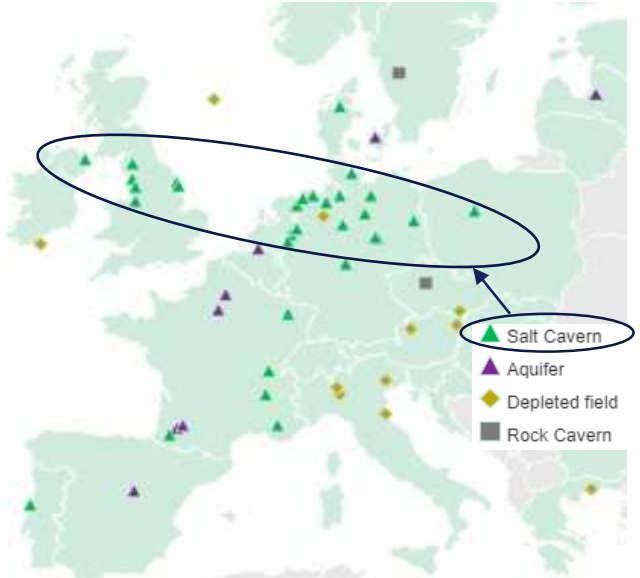
Heat/electricity production
Still need of technical development

Constraints of H_2 development

How to ensure a green H_2 baseload profile?

1. Very limited and 100% private transport infrastructure (sized for current needs)

2. No current storage and storage potential technically limited to salt caverns ~50 TWh at European level, compared to 1200 TWh for natural gas at present.



Source: The European Hydrogen Backbone (EHB) initiative

➔ Transport infrastructure and storage are key to start the hydrogen economy, but this will be built only if there is a business case.

Energy density (LHV)				
	kWh/kg	kWh/m³	kWh/l	°t
		Gas	Liquid	
Hydrogen	33.33	2.7	2.36	-252°C
Methane	13.9	10.5	6.2	-161°C
Methanol	5.5		4.3	Ambient
Ammonia	5.2	3.8	3.2	-32°C
Diesel	12		10	Ambient

E-fuels to kickstart green H_2 economy
Customer willingness to pay green premium

Regulation driven

Aviation: E Kerosene
- Total EU market size 800 TWh/y
- Carbon-neutrality target 2030: 5% ⇨ **40 TWh/y**

Shipping: E LNG, E Methanol, E Diesel
- Total EU fossil market: 640 TWh/y
  - 475 TWh/y Fuel oil, 165 TWh/y Diesel ~20 TWh LNG.
- Carbon-neutrality target 2030: 6% ⇨ **40 TWh/y**

Customer driven

Petro chemistry*: E Naphta & E Methanol
- Total EU market size 35 Mt/y
- Market growing could reach 30% recycled plastic in 2030.

Steel before 2030: E methane
- Customers demand: Car, Wind turbine, …
- Recycling steel production EU: 60 Mt/y

Steel after 2030: Hydrogen & E methane
- DRI (H_2 or CH_4) kilns up to 80Mt/y steel
  - H_2 (or CH_4) : up to 180 TWh/y baseload!

* Today EU petrochemical industry rely on naphta

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Conclusion

- Carbon neutrality in 2050 is a big challenge.
- Electrification will take RES demand to levels never seen before.
- Electricity storage is key, but also currently the bottleneck.
- H_2 allows to transform electricity into valuable product.
- H_2 infrastructure do not exist yet, without big projects it will not be developed
- CCU is currently **the best business model** to start the green H_2 economy in Europe.

Today we are building the low-carbon system of tomorrow!

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