

The integration of wind power in the energy system with different energy vectors

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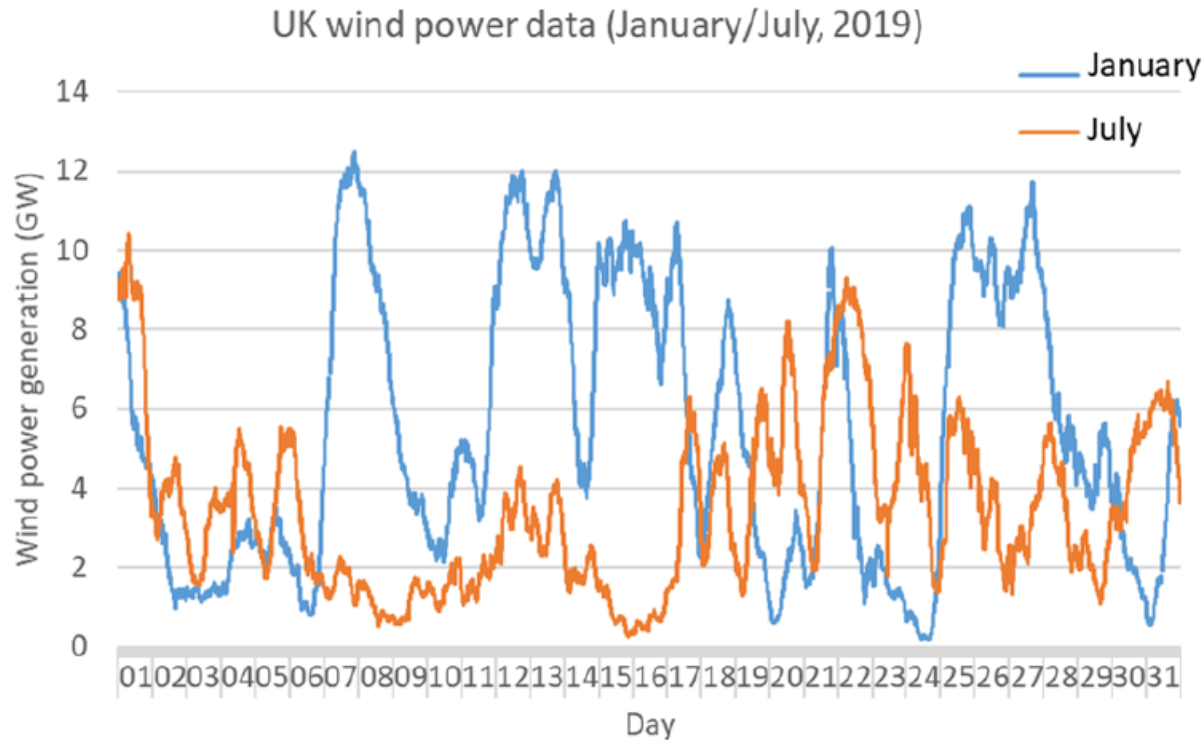
Outline

- Wind power basic
- The potential of wind power in net-zero energy systems
- The characteristics of wind energy and its correlation to the energy demand
- The integration of wind power into the energy systems through different energy carriers

Source or Reference: APA citation style

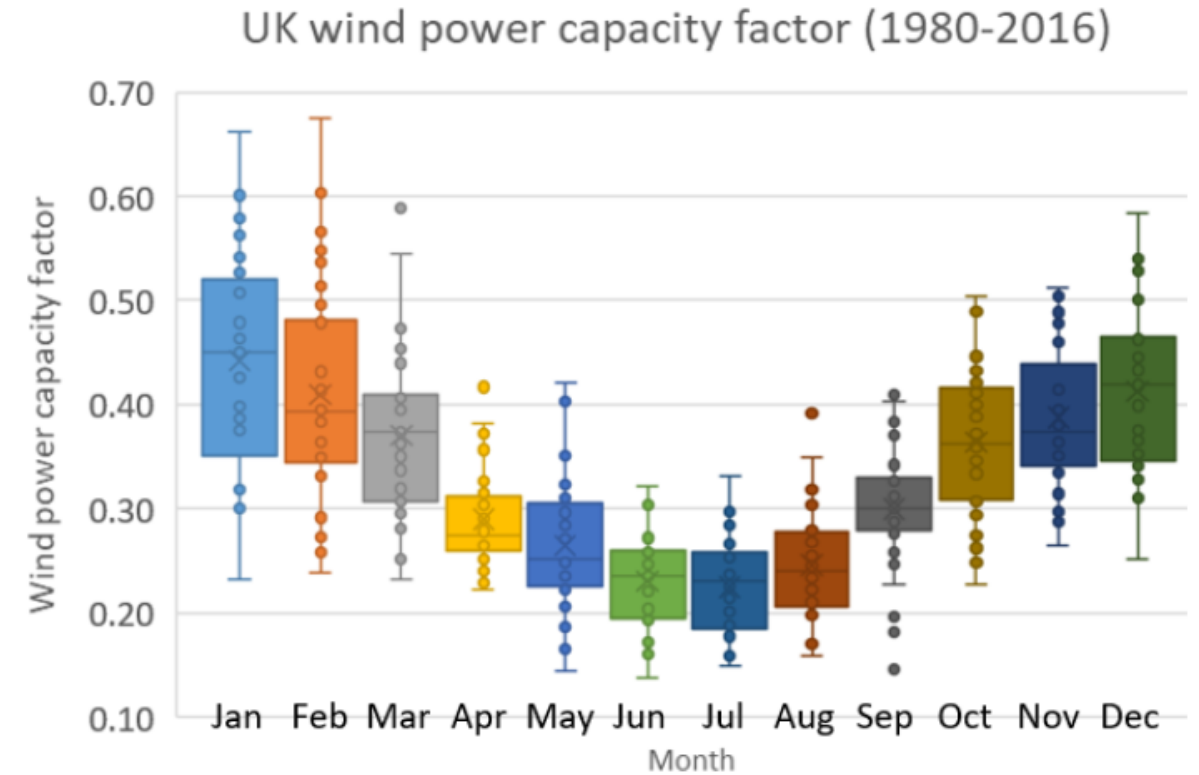
Correlation between wind power and energy demand

Characteristics of wind power



Wind power has variations in the different time scales:

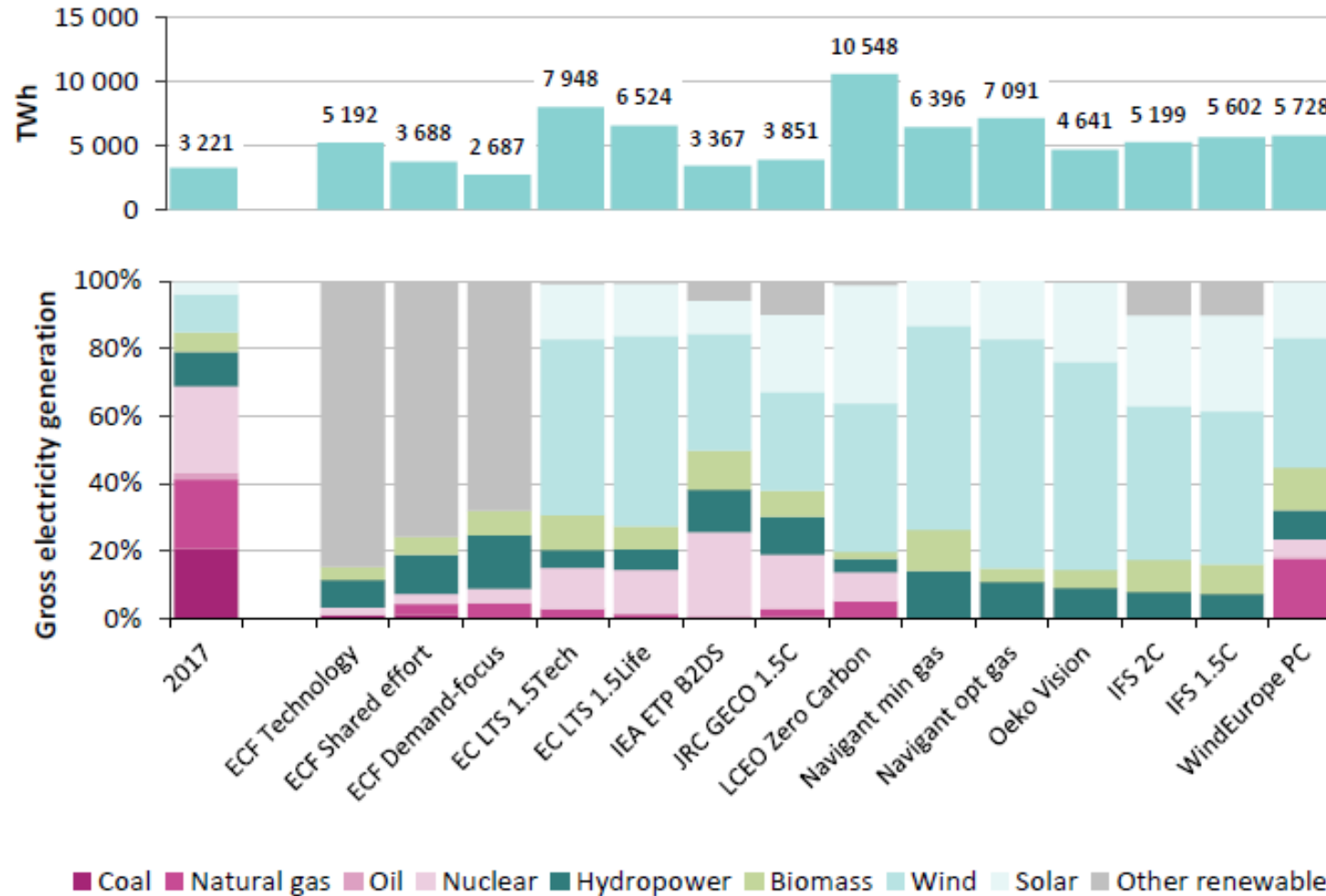
- Within an hour (e.g. gust, turbulence)
- Within a day (e.g. temperature changes)
- Within a few days (e.g. fronts, storms...)



- Seasonal (e.g. winter vs. summer)
- Year-to-year variation
- Climate changes

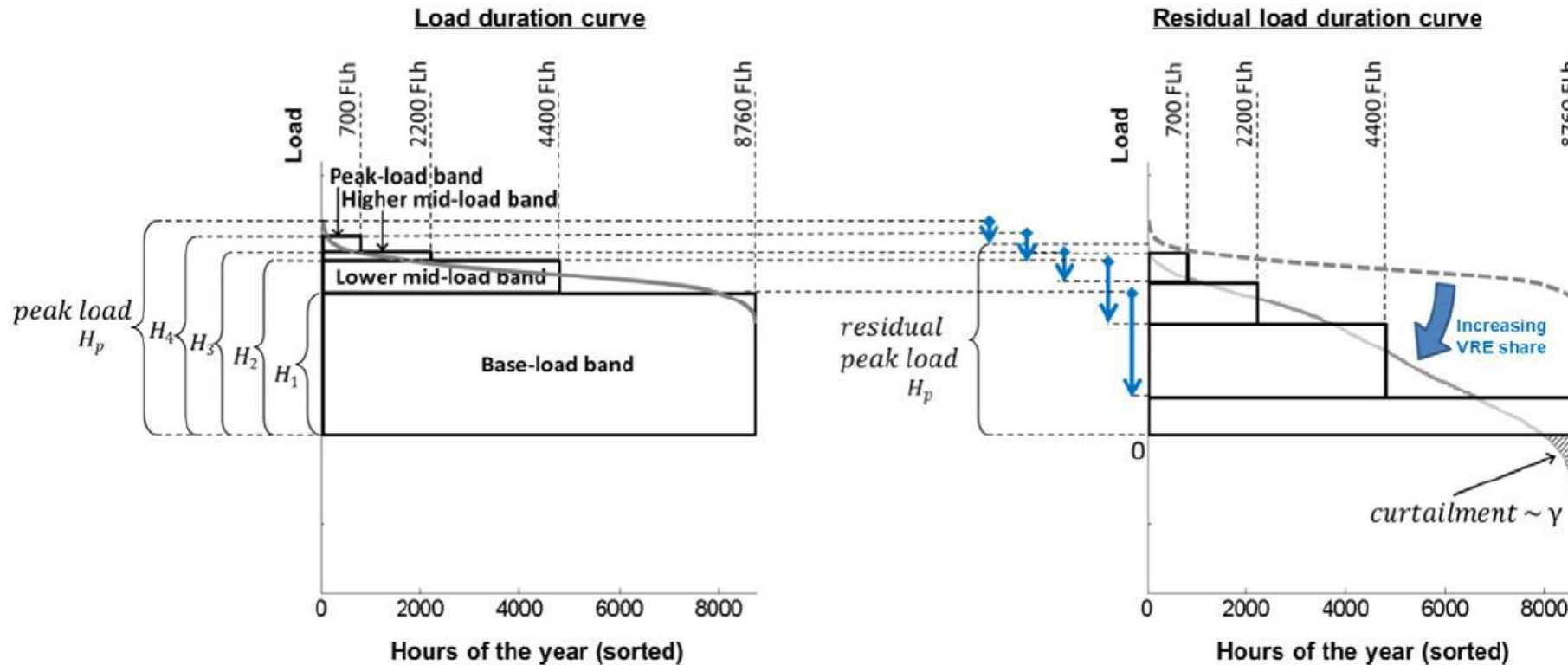
Wind power in the EU energy system

Figure 16 Gross electricity generation per technology in scenarios that achieve at least 90% emission reduction by 2050



JRC Technical reports (2020): Towards net-zero emissions in the EU energy system by 2050

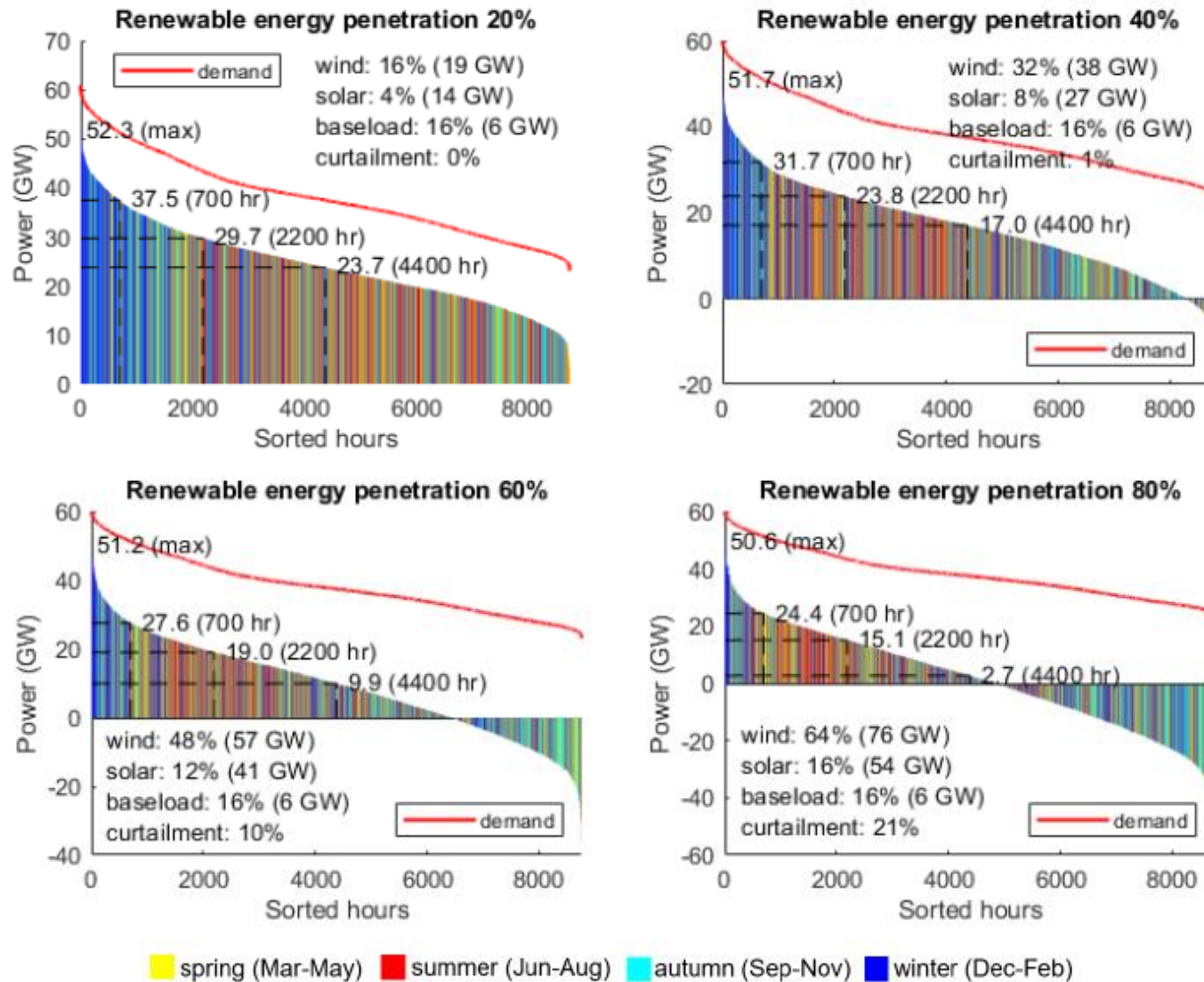
How high renewable share affect the energy system - residual load analysis



$$\text{Residual load} = (\text{electricity demand}) - (\text{renewable generation})$$

Decarbonizing global power supply under region-specific consideration of challenges and options of integrating variable renewables in the REMIND model," Energy Econ., vol. 64, pp. 665–684, May 2017

Residual load with high share of renewable



- 10-21% renewable is generated at the “excess energy time” while RE share increased to 60-80%
- Peak residual load still high

Figure 4.2: Residual load duration curves with different VRE shares, based on 2018 electricity data for the UK [29]; seasons are shown in different colours.

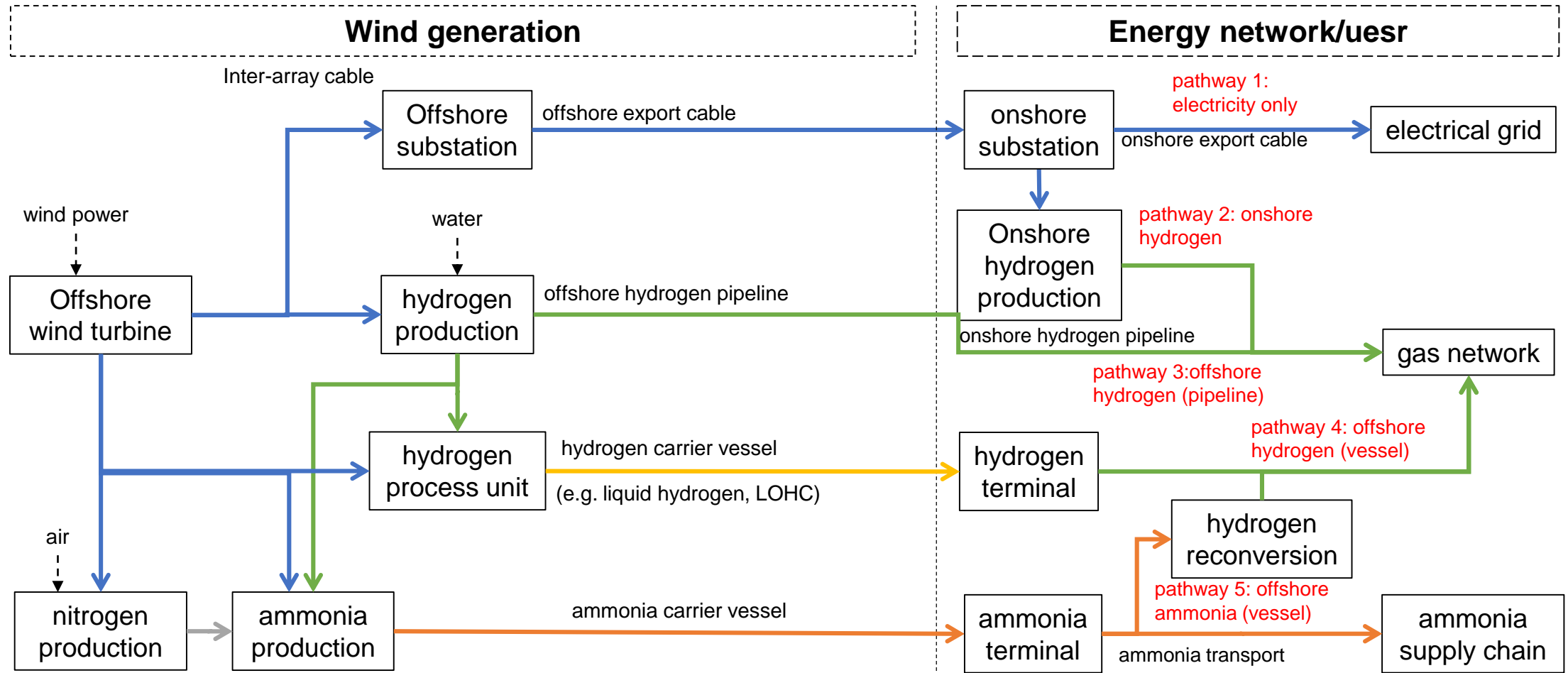
Integration of wind power to the energy system via different energy carriers

Potential low-carbon energy carrier

Energy vector	Feedstock	Energy efficiency	Storability	Transmission distance	Reuse existing infrastructure	Limitations; Hazards
Fossil fuel + CCS	Fossil fuel	- (note 1)	++ / -	+	++ / -	Permanent carbon storage required; capture rate not 100%
Electricity	x	++ (note 2)	--	-	-	High capital costs for long distance transmission
Hydrogen	Water	+	-	+	+ / - (note 3)	High flammability
Ammonia	Water, air	-	+	++	+	Toxic, corrosive, environmental hazards
Synthetic fuel or biofuel	Water, CO ₂ ; biomass	--	++	++	++ / -	Local carbon emissions

Note 1: a third of energy is used for carbon capture; 2: based on renewable electricity; 3: repurpose offshore oil & gas pipelines

Wind power-to-x pathways



- Converting wind power to synthetic fuels can reduce the short-term intermittency to the energy system
- Each pathway has suitable for specific applications and scenarios

Wind generation impact the European power system

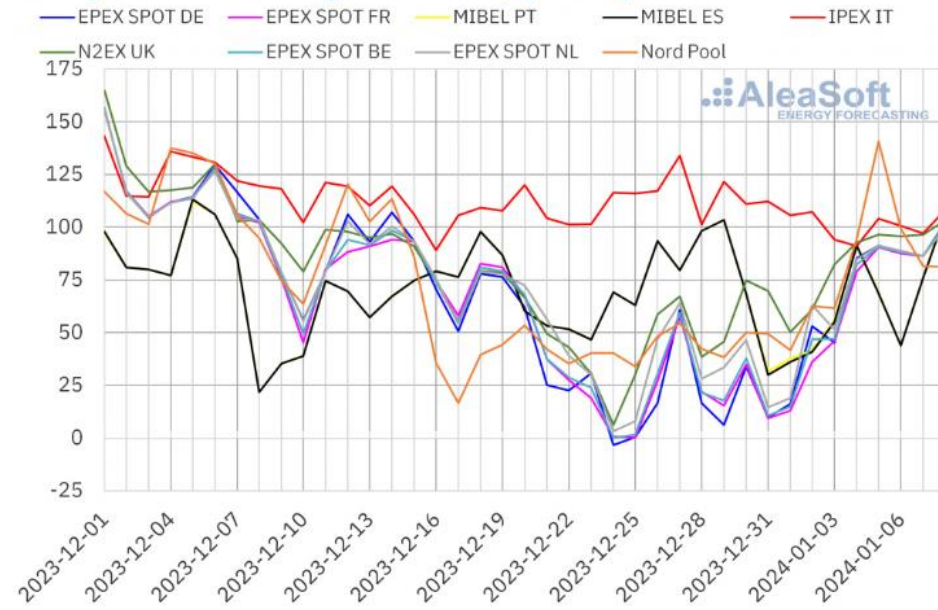
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Dec 27, 2023

Strong Wind Generation Turns European Power Prices Negative

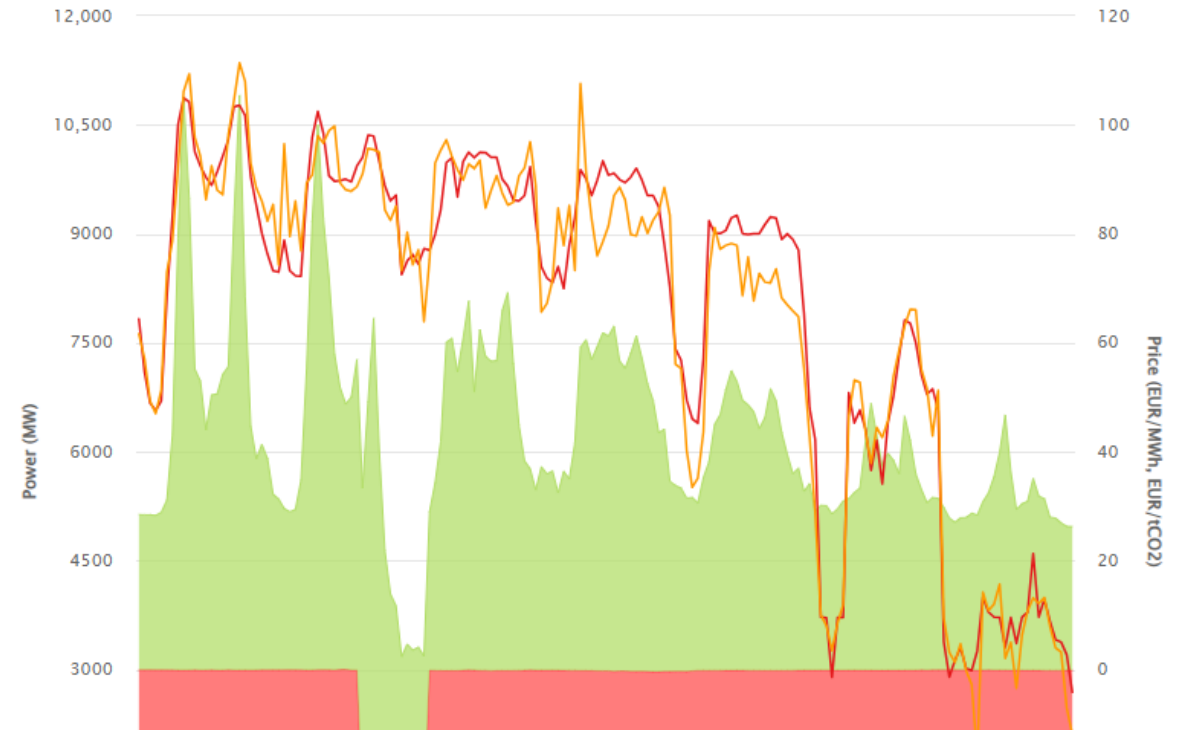
Rachel Morison, Bloomberg News

European electricity markets [€/MWh]



<https://aleasoft.com/european-electricity-market-prices-start-2024-up-demand-wind-energy-causes-declines-south/>

Electricity production and spot prices in Switzerland in week 51 2023



Energy-Charts.info - last update: 09/04/2024, 22:56 CEST

Takeaway messages

- Wind power will be one of the main energy sources in the future; its intermittency has a significant impact on the energy system.
- Converting wind power to synthetic fuels (e.g. hydrogen, ammonia, methane...) can enable long-distance transport and long-duration storage.
- Even though Switzerland has a low share of wind power, it will still significantly impact the Swiss energy system via international energy networks.
- Question: Can Switzerland provide 'positive flexibility' to the European energy system?
 - Wind variation in days: storing low-price and low-carbon intensity
 - Seasonal variation: storing wind power at autumn

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