kpler

Solar Curtailment in Europe

Drivers, trends, and forecasts

9th July 2025

QR code to download the solar curtailment report

Kpler Power Data Points

Kpler creates different types of data products, including post-process market data, proprietary AI-driven forecasts, and market analysis services.

Power market data

Generation (asset-level and country-level)
Availabilities (asset-level and country-level)
Outages
Interconnections (import, export)
Sensitivity (Hourly bid curves and block orders)
Demand
Prices (balancing, intraday, spot, and futures)
Weather data + forecasts (temperature, radiation, precipitation, and more)

Proprietary forecasts

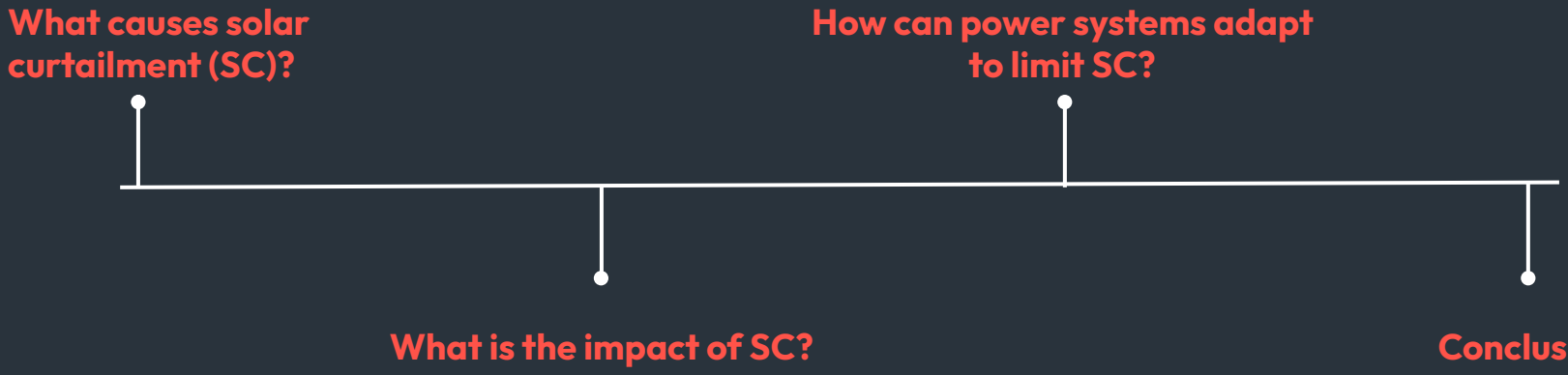
Demand and **residual demand**
Wind and solar generation
Hydro (run of river) generation
Availability forecasts including nuclear
Power prices (balancing, intraday, spot, futures, hourly forward curves, and long term - year 2050)
Gas and carbon futures
France red Tempo days
Price trend signals (power, gas, and carbon prices)

Market analysis

Power Market Outlook report
Custom forecasts and scenarios
Technical reports
Market insights

kpler

Agenda

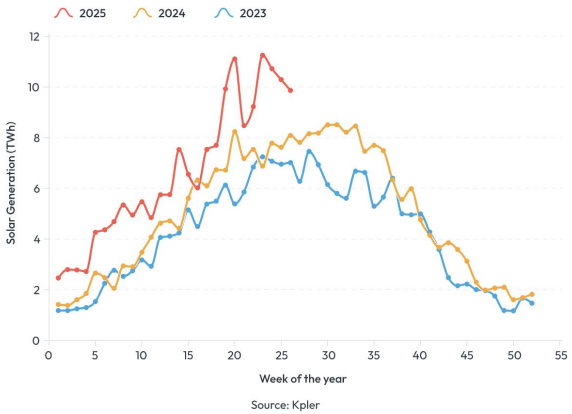


kpler

CAUSES OF SOLAR CURTAILMENT

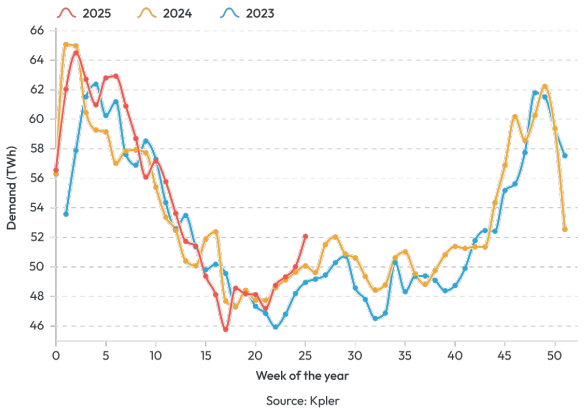
Sustained European solar generation growth is being jeopardized by stagnant power demand and limited grid flexibility

EU Solar Power Generation (TWh)



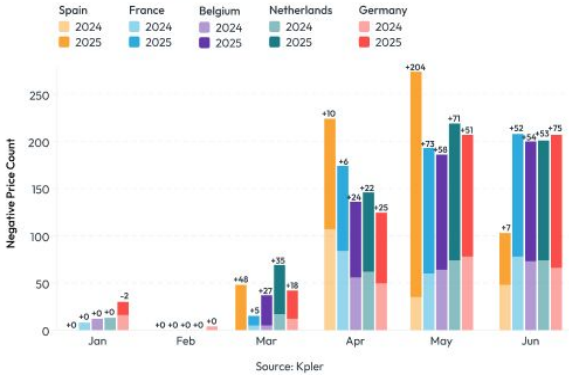
Source: Kpler

EU demand (TWh)



Source: Kpler

Monthly negative price hours occurrences (2024 vs 2025)



Source: Kpler

+40% EU solar generation[1]

+1% EU demand[1]

+80% negative price hours[2]

[1] 2025 vs 2024, January-June
[2] The % increase accounts for BE, DE, ES, FR, NL day-ahead markets
Sources: ENTSO-E, EEX, TSOs, Kpler platinum, and official national sources or institutes (ex. Netztrasparenz)

kpler

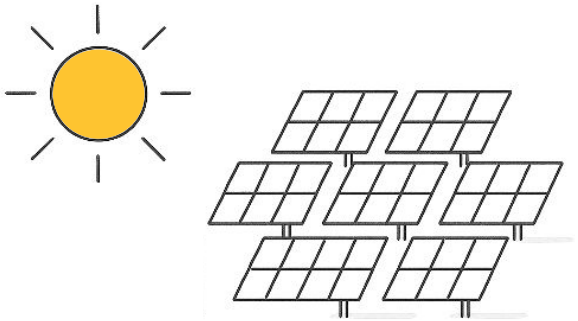
Solar curtailment is the deliberate reduction of electricity generated from solar assets

Solar curtailment can be economic, driven by producers and market auctions, or **technical**, triggered by TSOs in real-time

Economic curtailment

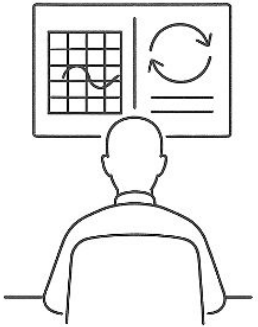
Asset manager

Cause	Market price, mostly negative prices
Decision-maker	Asset manager
Decision timing	Day-ahead or intra-day, based on price forecasts
Revenue stream	None, unless specifically linked to subsidy design



Technical curtailment

TSO (Control room)



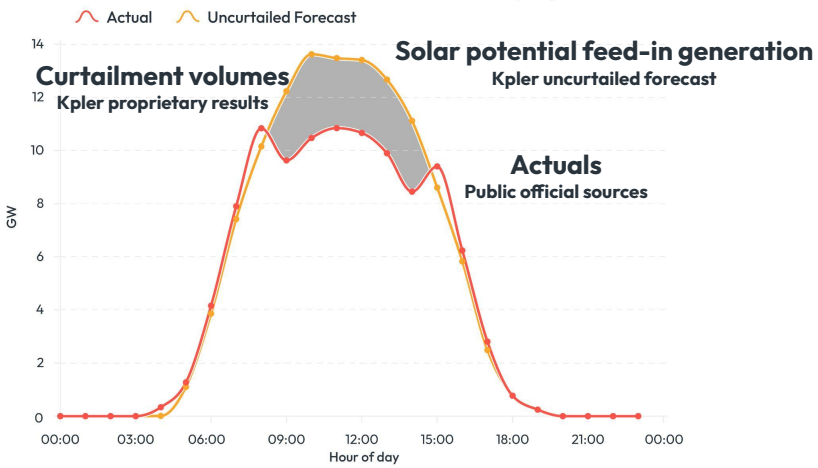
Cause	Physical constraints or grid stability needs (congestion, voltage, frequency issues)
Decision-maker	System operators
Decision timing	Real-time, based on grid conditions
Revenue stream	Varies by regulation, but mostly it is the TSO that fully or partially compensates the asset to curtail.

kpler

Solar curtailment is defined as the delta between grid potential feed-in and actual generation

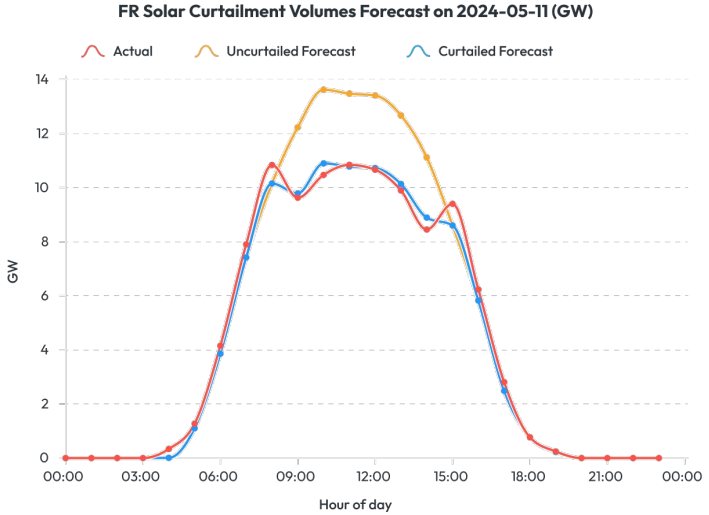
We use the same methodology, but differentiate **historical curtailment volumes estimates** with **proprietary ML-based day ahead-forecasts**

Historical Volumes



Sources: ENTSO-E, EEX, TSOs, Kpler platinum, and official national sources

Day-Ahead Forecasts



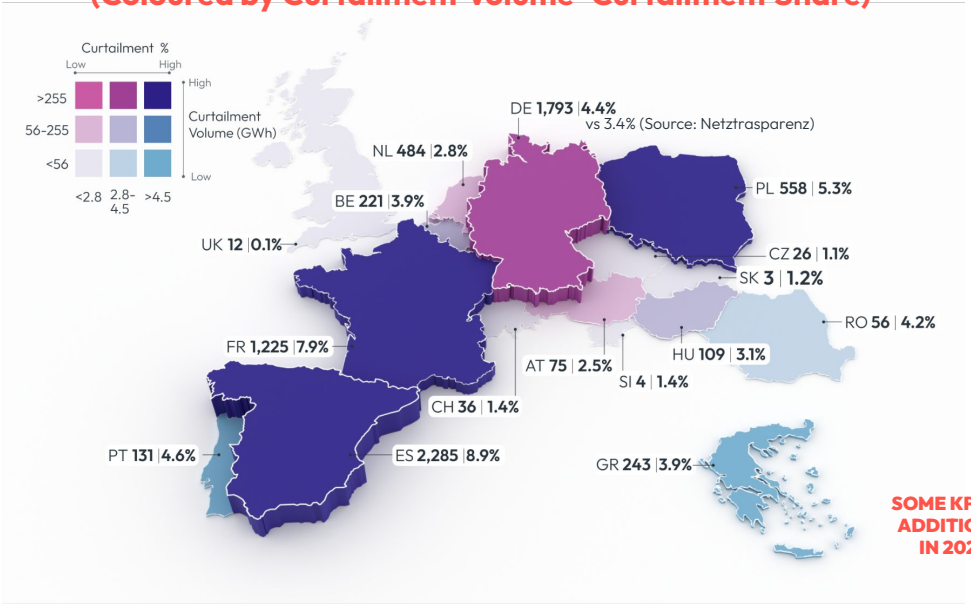
Sources: Kpler

Kpler day-ahead curtailed forecasts predict the primary driver: economic curtailment

IMPACT OF SOLAR CURTAILMENT

Solar curtailment is accelerating in 2025, with Kpler tracking around 7.3 TWh volumes as of June 27

Solar Curtailment in Europe (GWh) as of June 27
(Coloured by Curtailment Volume-Curtailment Share)



Source: Kpler

Country	Curtailment share in 2024 (%)	Curtailment share in 2025 (%)	Delta[1] Δ (%)
Spain	10.9	**8.9**	▼ 2
France	4.4	**7.9**	▲ 3.5
Germany	4.1	**4.4**	▲ 0.3
Belgium	2.4	**3.9**	▲ 1.5
Poland	1.2	**5.3**	▲ 3.9
Netherlands	<1	**2.8**	▲ 2.7
Switzerland	<1	**1.4**	▲ 1.3
Czechia	<1	**1.1**	▲ 1
Austria	0	**2.5**	▲ 2.5
Greece	–	**3.9**	–
Hungary	–	**3.1**	–
Portugal	–	**4.6**	–
Romania	–	**4.2**	–

SOME KPLER ADDITIONS IN 2025

[1] 2024 vs 2025 volumes and delta, January 1 to June 27

$$Solar\ curtailment\ (\%) = \sum_{h=0}^{t} \frac{Solar\ Curtailed\ Output_h}{Solar\ Potential\ for\ Grid\ Feed{-}in(Curtailed + Delivered)_h}$$

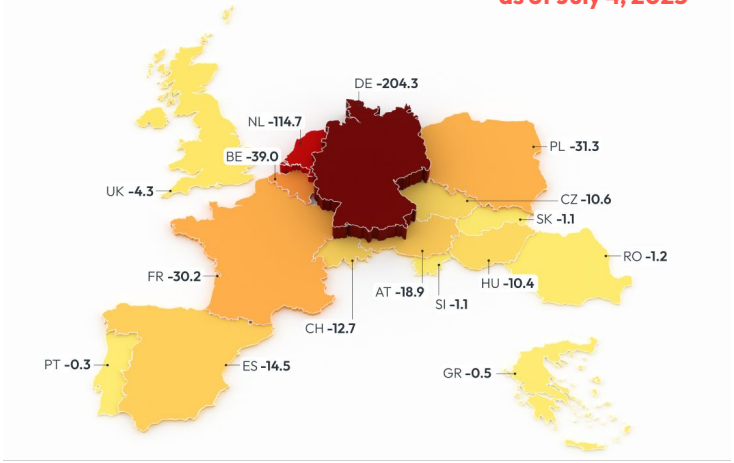
kpler

IMPACT OF SOLAR CURTAILMENT

Germany and the Netherlands lead in day-ahead solar value losses, reflecting deep price collapses and must-run solar volume, unlike more flexible systems in France and Spain

EU Solar Day-Ahead Market Value Loss (M€)

as of July 4, 2025

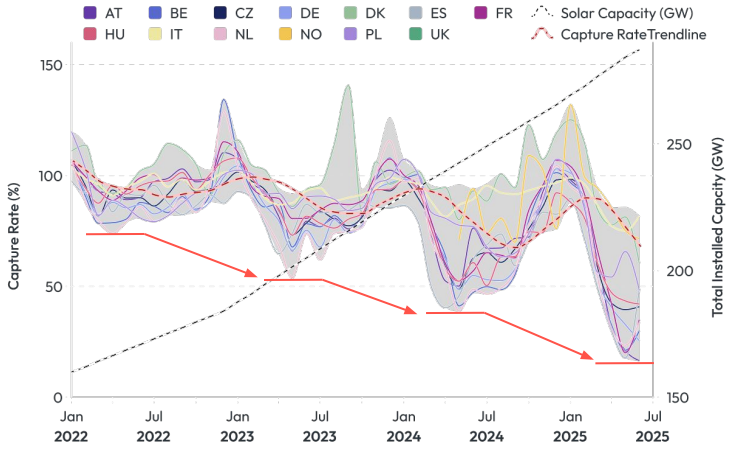


Source: Kpler

450+ M€ loss tracked in the CORE region

$$\textit{Solar market value loss (M€)} = \sum_{h=0}^{t} 1_{\{Price_h<0\}} \cdot (\textit{DA price} \cdot \textit{Solar Actuals})_h$$

EU Solar Capture Rate



Source: Kpler

20% yearly floor decrease in EU capture rates over 4 years

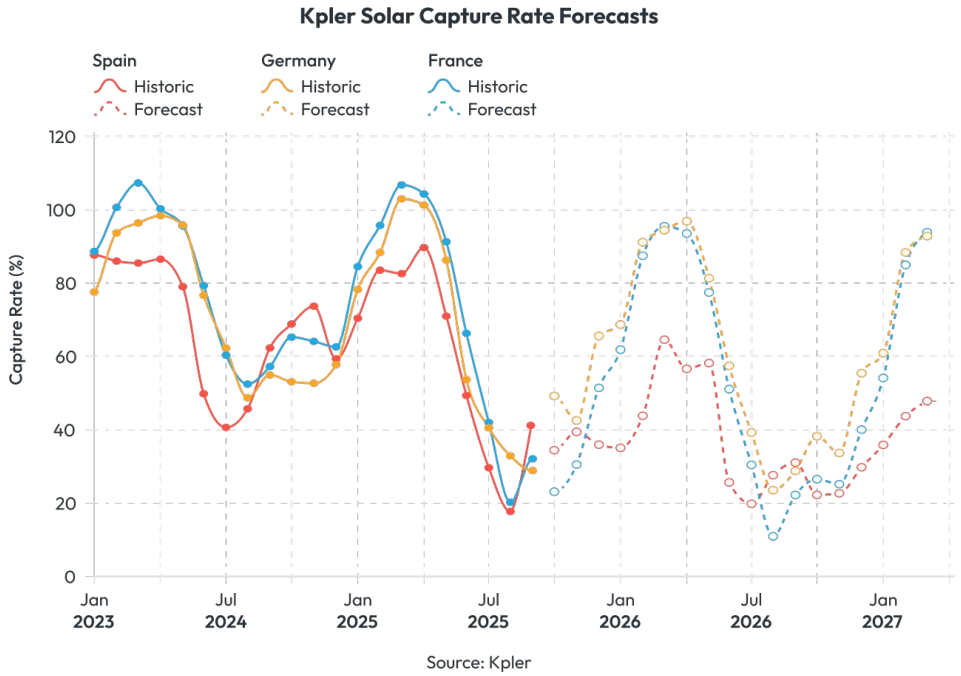
$$\textit{Solar Capture Rate (\%)} = \frac{\textit{Average Day Ahead Solar Revenue}}{\textit{Average Day Ahead Price}}$$

kpler

Kpler expects solar capture rates to dip to 10% in 2026

Our **proprietary curtailment, capture price and rate forecasts** offer a **forward-looking view in the short and long term.**

LT Solar Capture Rate Forecasts



Source: Kpler

kpler

A shift from a paradigm of production maximisation to value optimisation is required

While **causes are similar** , there is **no silver bullet to mitigate solar curtailment**

Major EU countries curtailing solar: origins and roadmaps

Feature	France	Germany	Spain
Dominant Power Source (% generation in 2024)	Nuclear (67%)	Solar and Wind (RES) (46%)	Balanced - Fossil gas, solar, wind, nuclear, hydro (~20% each)
Key Flexibility Source	Nuclear modulation & Hydro	Natural Gas	Hydropower & CCGTs
Primary Curtailment Driver	• Abundant nuclear fleet degree of inflexibility • Uncontrolled small-scale solar injection	• High simultaneous wind and solar generation • Uncontrolled small-scale solar injection • North-South transmission congestion	• Geographical mismatch between solar generation and demand centers • Transmission bottlenecks
Historical Solar Subsidy Scheme	'Obligation d'achat' (Feed-in Tariff)	EEG Feed-in Tariff	Royal Decree 436/2004 (Feed-in Tariff)
Current Policy Focus	• Transition to 'Complément de Rémunération' (CR) • S21 amendment	• EEG amendment • Gas reserve fleet • 'Redispatch 2.0' • Solar Package I • HVDC transmission "highways" connecting northern generation to southern demand (ex. SuedLink) • Innovation tenders to promote RES hybrid projects	• Royal Decree-Law 7/2025 • FEDER 21-27 auction • Improved interconnection with France and Italy

California's CAISO: a global benchmark for solar integration

With 13.4 GW of BESS capacity and 93% of curtailment coming from solar in 2024, CAISO takes a pragmatic approach: **curtailment is a modelled, least-cost feature**, not a system failure.

Solutions combining demand response, battery deployment and market solutions are being rolled out, but progress is too slow

Boosting baseload demand

- 👎 Recovering **industrial demand**
- 👍 Investing strategically in **data centers.**
- 👎 **Electrifying heating** and **transport** sectors.

Accelerating deployment of flexibility resources

- 👎 **Industrial dynamic pricing**
- 👎 **Demand response services** (ex. V2G, dynamic water heating)
- 👎 **Consumer behaviour tools** (ex. Tibber and Octopus Energy services)

Scheduling curtailment and "operating windows" for assets

- 👎 Acknowledging **some curtailment is cheaper than overbuilding transmission lines and storage assets**.
- 👍 Establishing **operating windows contractually** in advance, to handle highly unlikely simultaneous peaks.

Investing in BESS

- 👍 Promoting **standalone or hybrid BESS projects** and co-located storage retrofits **to tackle grid congestion**, while optimizing for CAPEX-intensive grid infrastructure investments.

Modernizing grid infrastructure

- 👎 Shifting from grid following inverters to **grid forming inverters** enables "passive generators" to become active grid stabilizers, while unlocking new revenue streams.

Phasing out feed-in tariffs

- 👍 Shifting to a **feed-in premium model**

👍 **On track**

👎 **Lagging behind**

kpler

02

Q&A

QR code to download the solar curtailment report