Flexibility as a Key Enabler of the Energy Transition

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Context

EU law now legally binds **carbon neutrality by 2050**, with an intermediate target of at least 55% GHG emissions by 2030.

Pathway scenarios envisage **electricity covering 50 to 57 %** of final energy demand by 2050, doubling or more from today's levels.

Annual electricity demand is projected to rise from around 3 000 TWh today to about 6 800 TWh by 2050, with renewables supplying roughly half of it. In 2024, renewables covered 47 % of EU electricity.

As renewable shares grow, **flexibility** becomes the backbone of system stability.

Flexibility is the ability of the grid to adjust generation, consumption, or storage in response to external signals, such as market prices, grid constraints, or balancing needs, to maintain reliability and efficiency.

Context

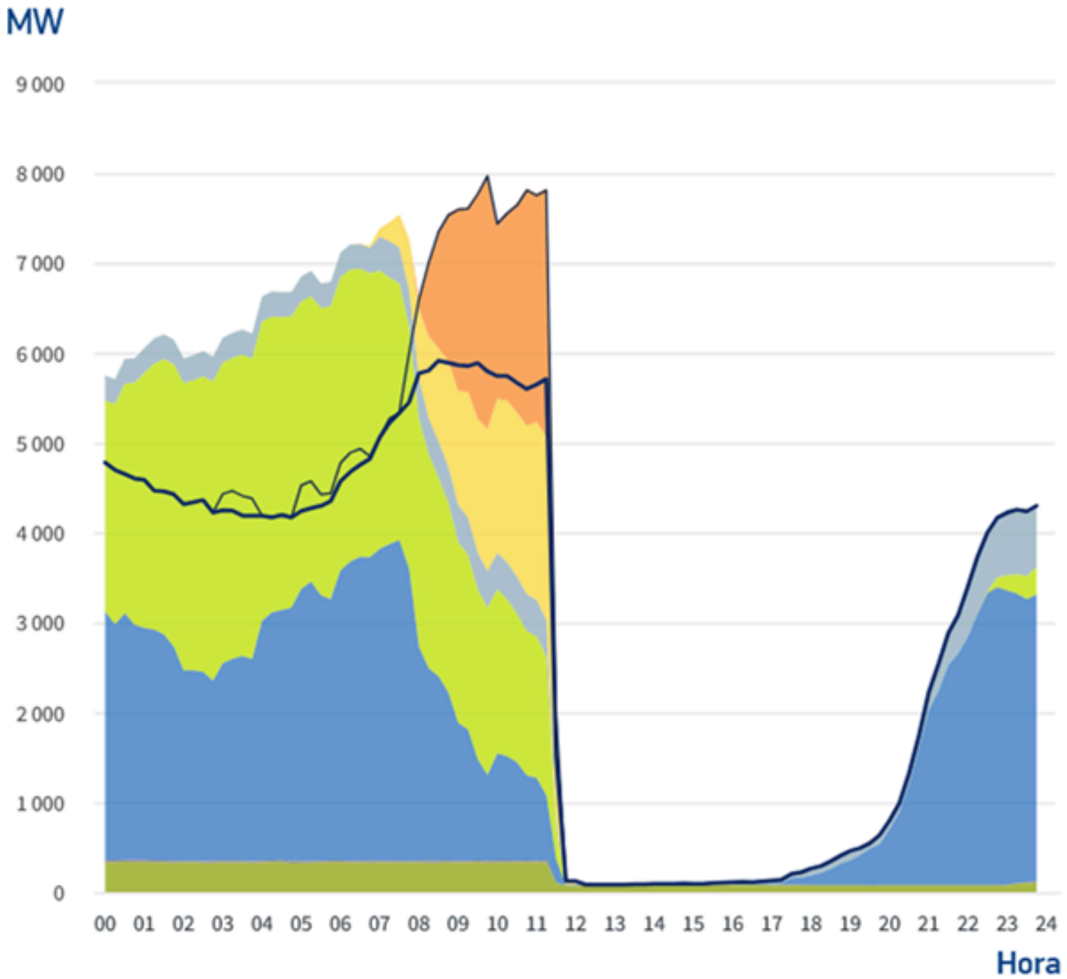
Iberian Blackout

Preliminary reports indicate that a **major generation loss** in southeast Spain triggered a frequency drop, followed within seconds by further disconnections, including a second generator and France halting imports.

Since electricity demand remained constant at the same moment, the grid became underpowered. This caused the grid frequency to fall below 50 Hz.

Rapid frequency collapse exceeded control capabilities, cascading into a full shutdown across Spain and Portugal before reserves could respond.

Could things have gone differently if the system was more **flexible**?



Source: REN

Context

Why do we need flexibility?

Renewables are more variable and less dispatchable.

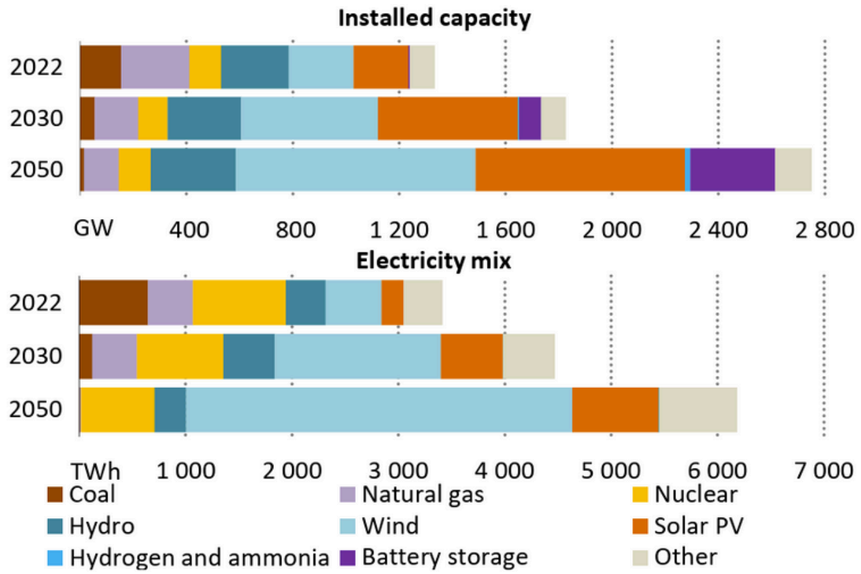
Demand electrification (e.g. Transport, Heating & Cooling)

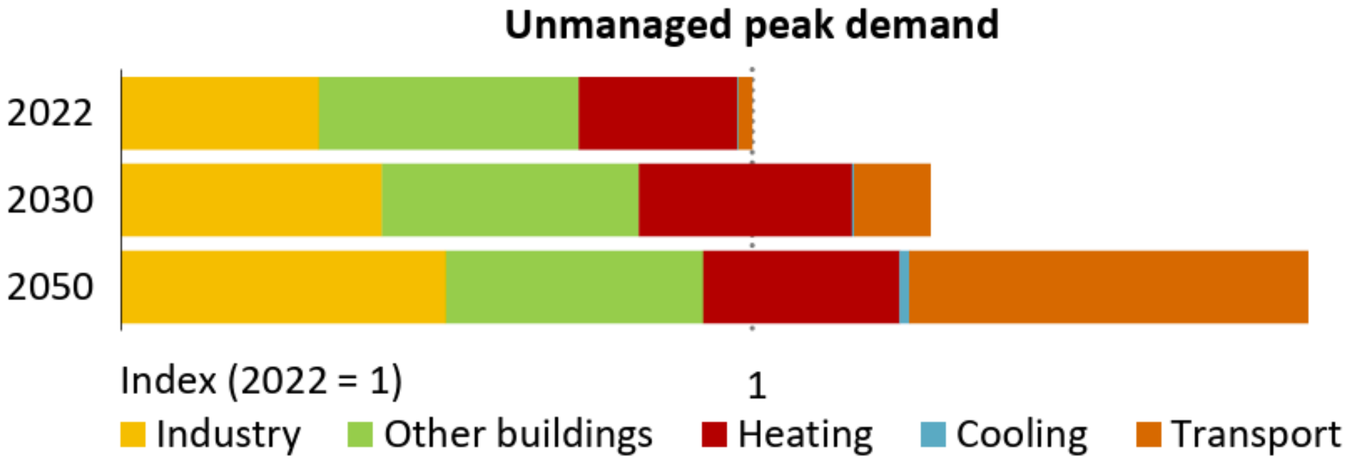
Decentralization of resources (e.g. self-consumption)

New demand types (e.g. data centers)

Technology development (e.g. storage, automation, AI)

Leveraging flexibility from distributed energy resources such as solar, battery storage, electric vehicles are crucial to managing peak demand and price fluctuations.



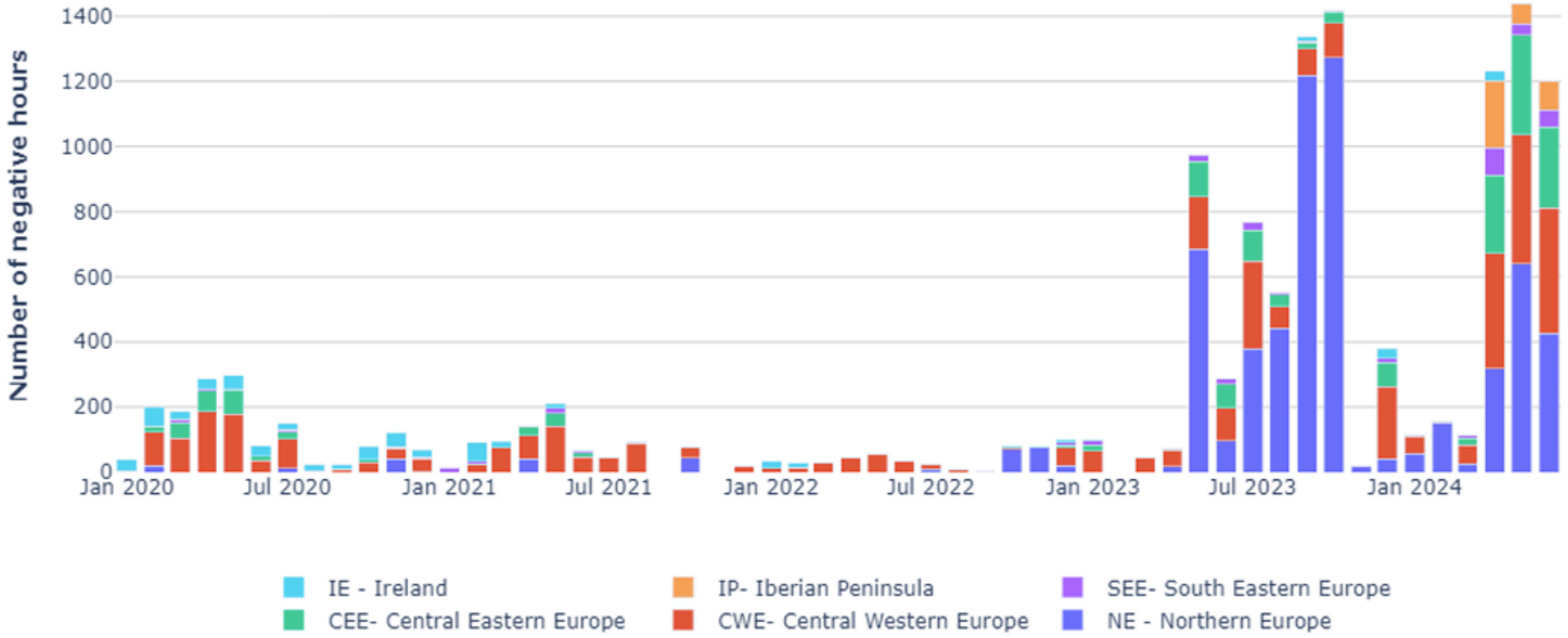


Source: IEA

Figure: Evolution of installed capacity, generation mix and unmanaged peak demand, 2022-2050

Negative Prices as a Result of Missing Flexibility

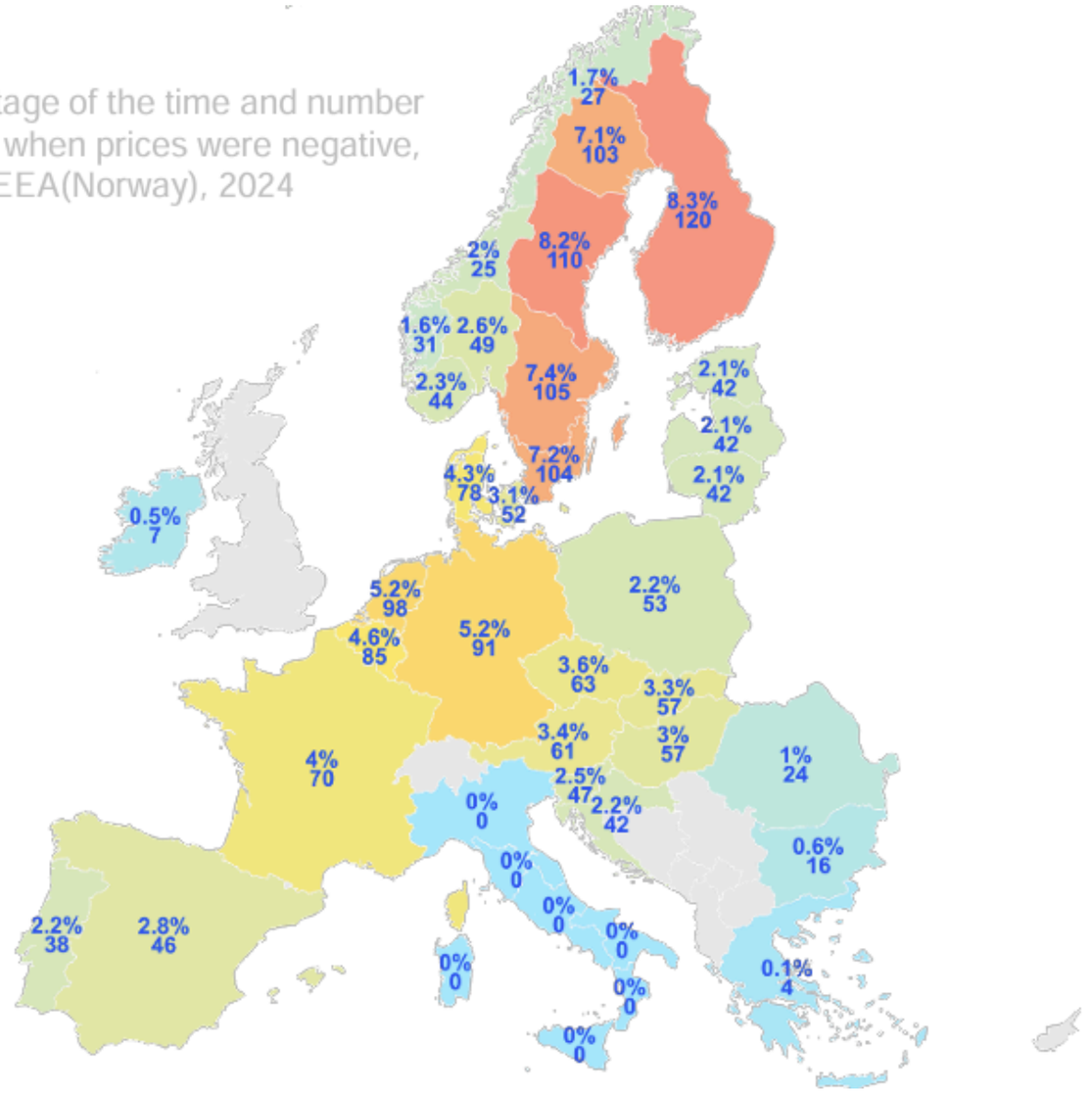
Figure 19 – Number of negative hourly wholesale prices on selected day-ahead trading platforms in Europe.



Source: ENTSO-E.

Negative Prices as a Result of Missing Flexibility

Percentage of the time and number of days when prices were negative, EU-27/EEA(Norway), 2024



Source: ACER

Different Flexibility Mechanisms

Explicit Flexibility

- Pre-agreed volume reduction or increase, traded in structured markets.
- Participants earn revenues for providing flexibility as a service.
- Used in formal markets like balancing, day-ahead, and intraday.

Implicit Flexibility

- Consumer-led response without fixed commitments on volume.
- Triggered by price signals like dynamic tariffs or time-of-use rates.
- Main benefit is bill reduction, not market income.

Technology Incentives

- Public or private funding supports tech adoption (e.g. subsidies, tax breaks).
- No direct flexibility commitment, but tech enables future potential.
- Targets smart devices, such as thermostats, batteries, and control systems.

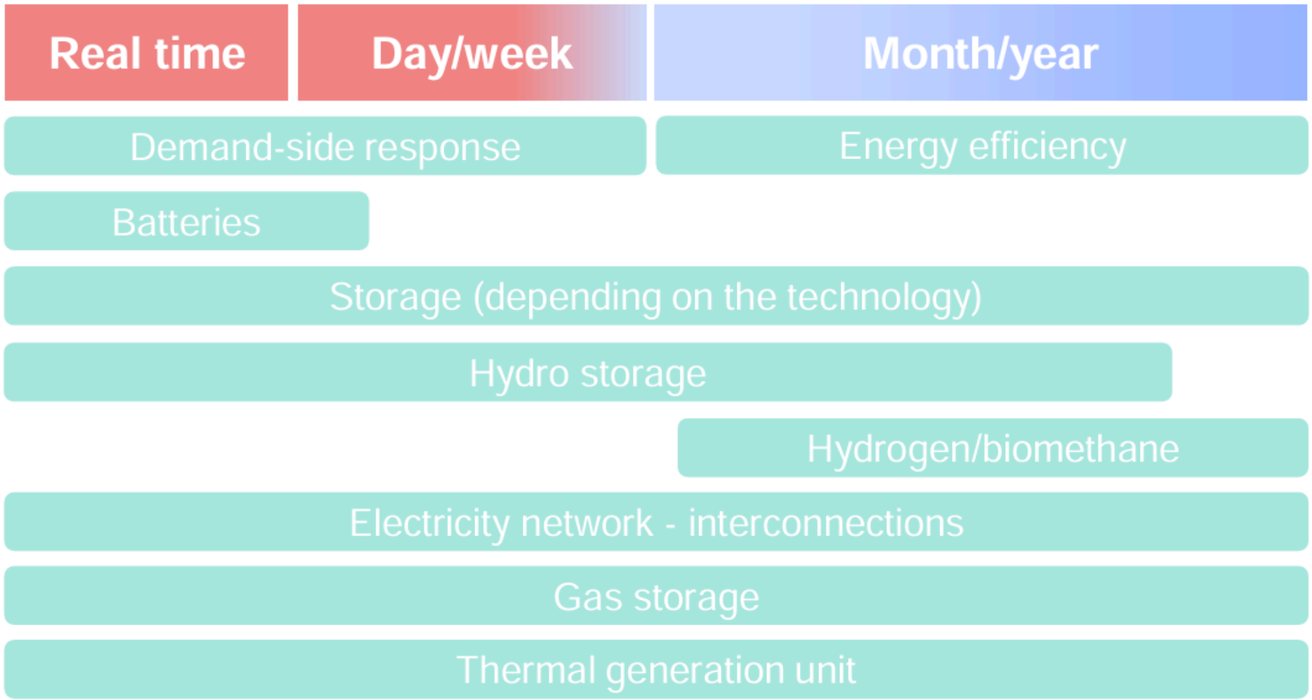
Awareness

- Informational campaigns promote energy-saving behaviors.
- No direct incentives or price signals involved.
- Focus is education and engagement, turning awareness into action.

Different Flexibility Mechanisms

Different technology solutions can offer flexibility

Flexibility services provided by various technologies, sorted according to their duration

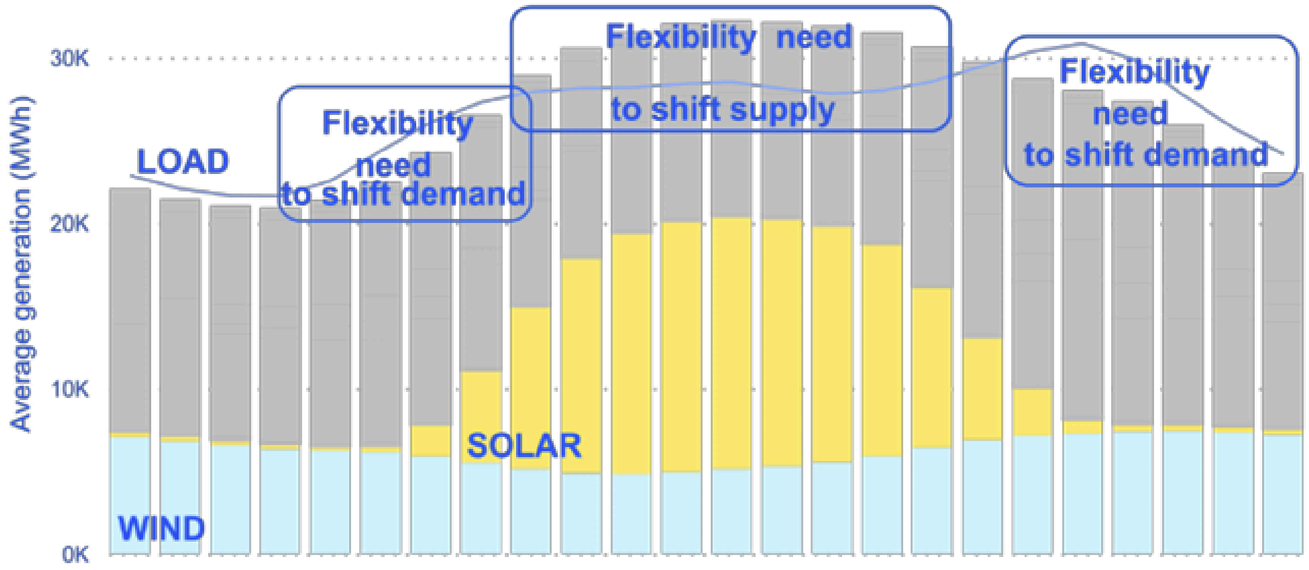


Source: ACER

When exactly is flexibility needed?

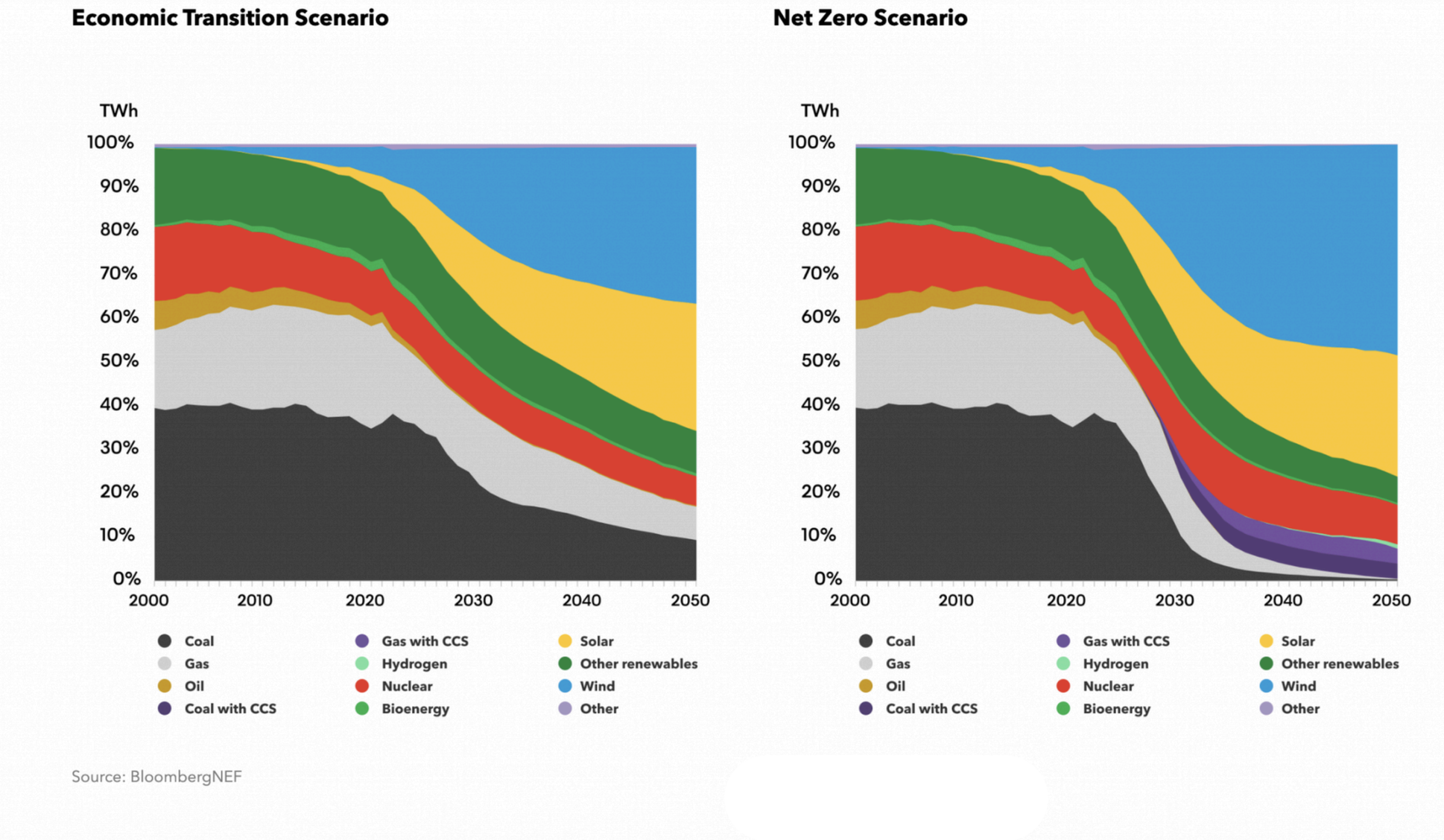
The gap between midday solar oversupply and evening demand is growing

Hourly averages of energy generation in Spain, 2024 (MWh)



Source: ACER

How much flexibility is needed?



Source: BloombergNEF

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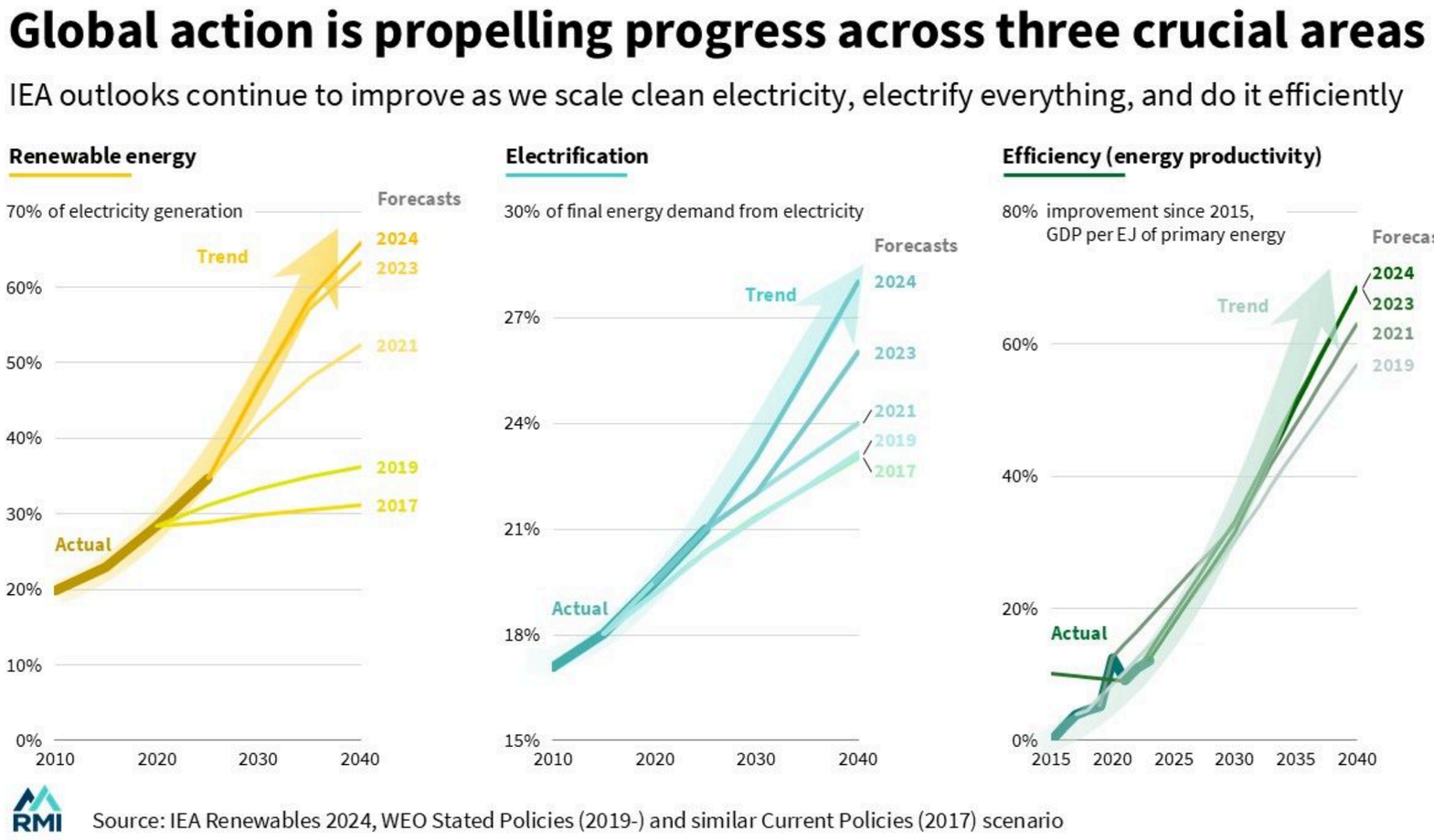
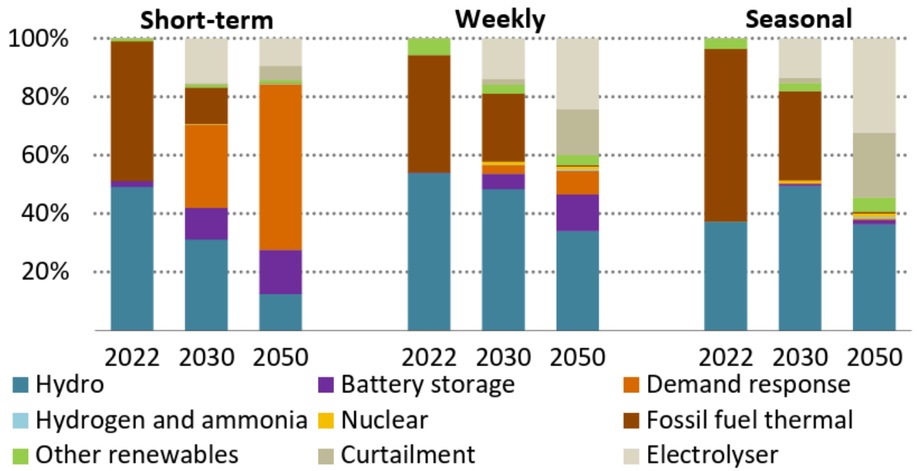


Simple Answer: As much as possible from as many reliable sources as needed.

How much flexibility is needed?

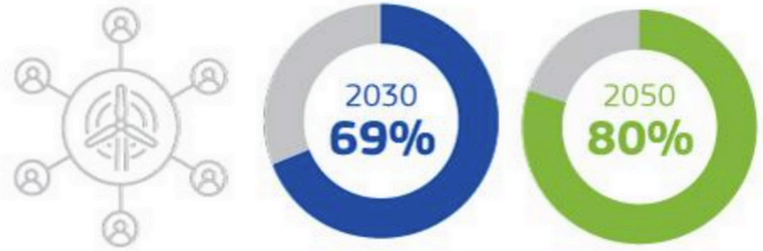
Complex Answer: It depends on the time horizon and the available technologies.

Flexibility supply by source, 2022-2050

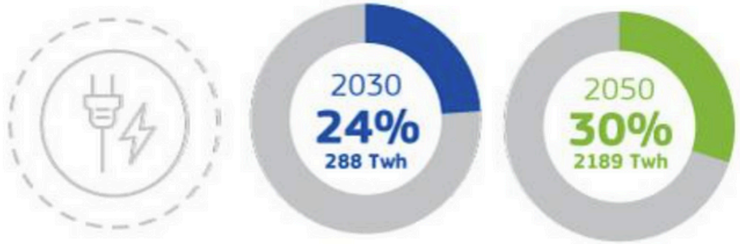


Source: IEA

System flexibility is particularly needed in the EU's electricity system, where the share of renewable energy is estimated to reach around 69% by 2030 and 80% by 2050 (from 37% in 2021).



The need for flexibility in the electricity system will increase significantly in all EU countries, reaching 24% (288 TWh) of total EU electricity demand in 2030 and 30% (2 189 TWh) by 2050 across all timescales (from 11% in 2021).

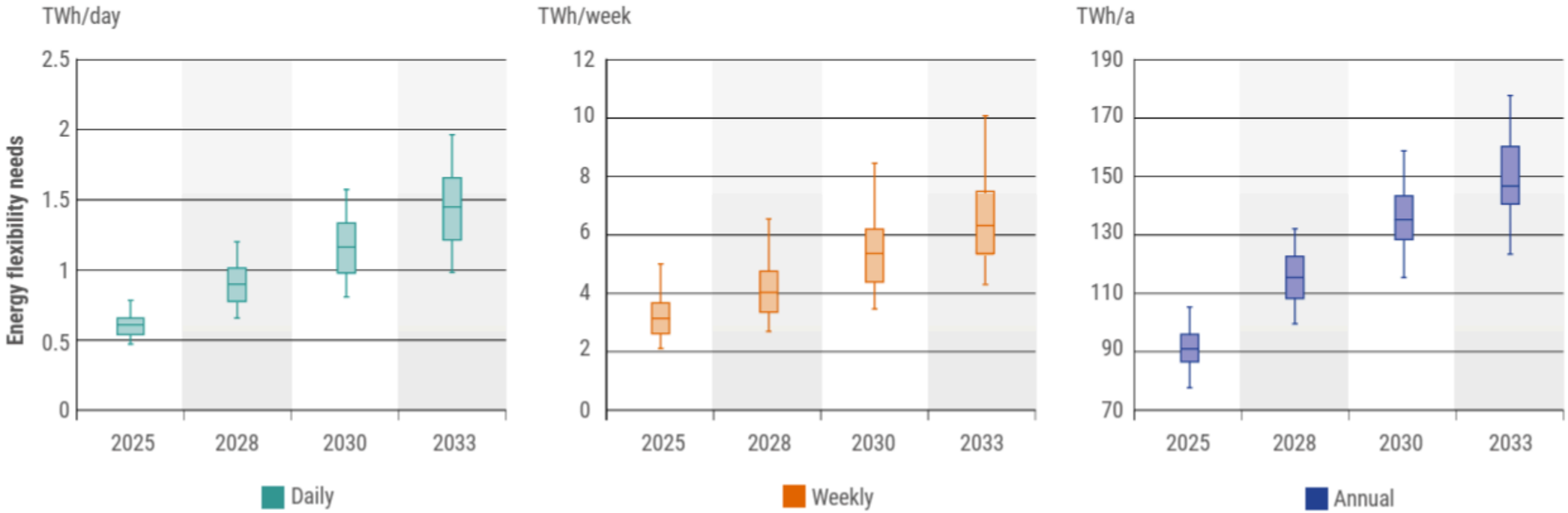


Different studies have analysed the likely future paths for the deployment of energy storage in the EU. These studies point to more than 200 GW and 600 GW of energy storage capacity by 2030 and 2050 respectively (from roughly 60 GW in 2022, mainly in the form of pumped hydro storage).

Source: energy.ec.europa.eu

How much flexibility is needed?

Evolution of European flexibility energy needs in the (a) daily, (b) weekly, and (c) annual timeframes from 2025 to 2033



Source: ENTSO-E

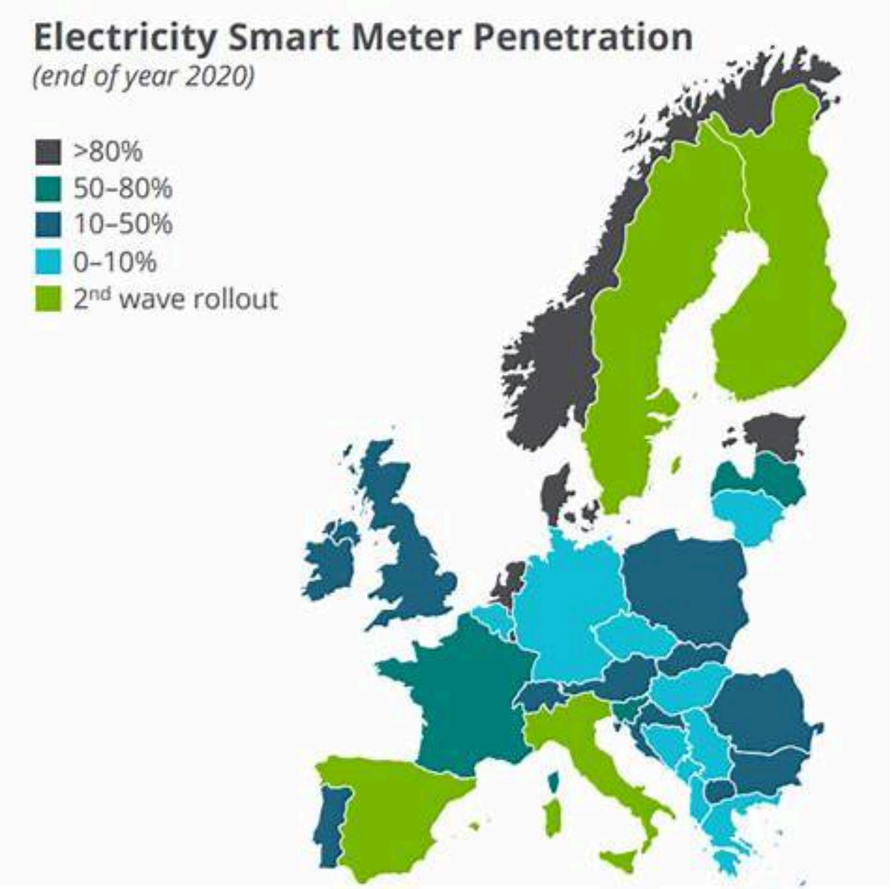
How do we get there?

Infrastructure Readiness

Flexible Demand: Widespread deployment of controllable assets (e.g. batteries, EV chargers, heat pumps) is essential to unlock flexibility.

Smart Meter Rollout: By the end of 2022, 54 % of EU households had smart meters and thirteen Member States already exceeded 80%. EU law calls for 80 % rollout where cost-effective by 2024.

Interoperability Standards: Protocols like IEC 61850 (for substation and DER communication) and OpenADR (for automated demand response) are essential to ensure seamless integration of devices across the grid.



Source: Landys Gyr

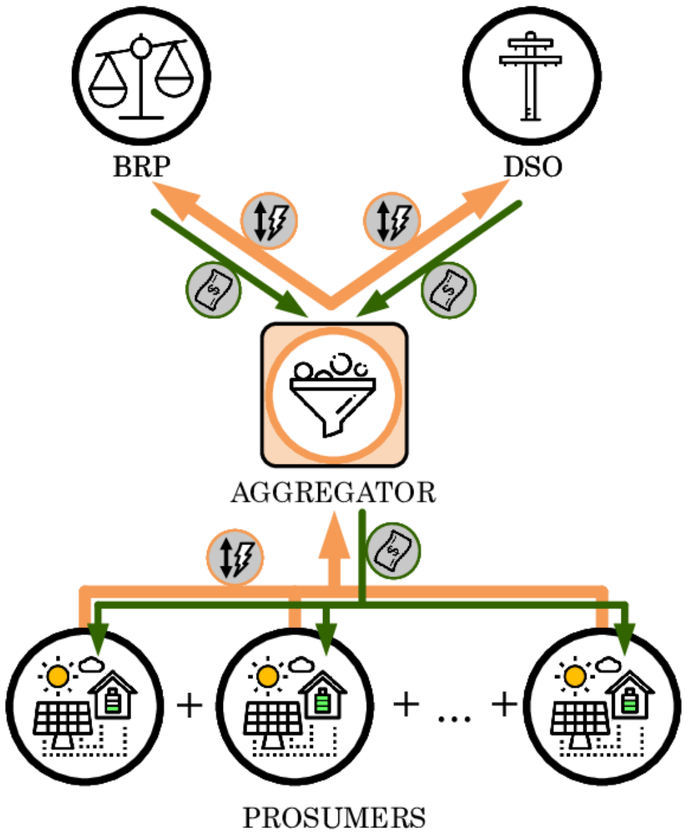
How do we get there?

New Roles, Market Access & Design

Non-Discriminatory Access: Ensure that new roles such as aggregators and prosumers can participate in all relevant markets (balancing, congestion, capacity) under fair rules.

Remuneration for Flexibility: Establish transparent, technology-neutral payment mechanisms for delivered flexibility, both capacity and activation-based.

Locational & Temporal Signals: Introduce price signals that reflect local grid conditions and time-sensitive needs, enabling efficient dispatch and investment (e.g. local flexibility markets).



Source: Olivella-Rosell et al.

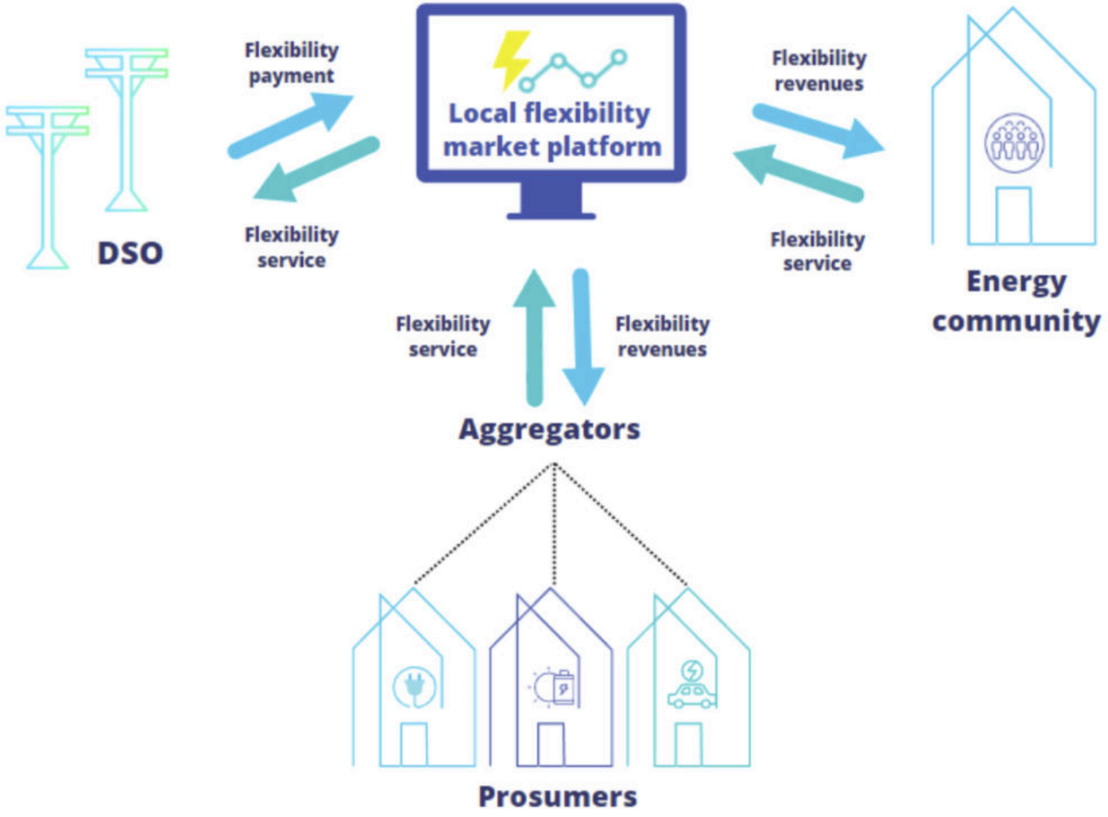
How do we get there?

Technology & Consumer Enablement

Automated and Scalable Control: Enabling scheduling of energy assets, scaling from individual homes to aggregated fleets.

User-Centered Interfaces: Apps and dashboards empower consumers with actionable insights, such as real-time pricing alerts, consumption monitoring, and one-click scheduling.

Flexibility Incentives: Dynamic tariffs and incentive programs paired with user-friendly automation encourage active load shifting and participation.



Source: V2Market

Flexibility as a Key Component of Morocco's Transition

The Kingdom aims for **52% of installed capacity from renewables by 2030**, with major additions in solar, wind, and hydro already underway.

Higher renewable shares introduce variability, making grid stability more sensitive to **fluctuations in generation and demand.**

Grid-scale storage, demand-side management, and flexibility will be essential to integrate variable renewables cost-effectively.

An accelerated deployment of **smart meters, data systems, and automated controls** is needed for real-time balancing and visibility of distributed resources.

Embedding flexibility **early** through regulation, investment, and planning will strengthen Morocco's long-term resilience and readiness for future exports or market integration.

Morocco, an enabler for European Flexibility?

Exceptional solar and wind potential, exceeding many European sites. This enables stable generation profiles ideal for export and flexibility services.

Existing Morocco–Spain link (1.4 GW) and planned HVDC projects like Xlinks (3.6 GW) position Morocco as a credible **exporter of clean electricity to Europe.**

Different climate and time zone patterns allow Moroccan supply to **offset European peak demands**, enhancing cross-border balancing and firming capacity.

Morocco is advancing **large-scale green hydrogen** initiatives aimed at export, offering flexibility through hydrogen-to-power and sector integration pathways.

Deeper regulatory alignment and access to European electricity and flexibility markets (e.g. balancing services, capacity mechanisms) could **unlock long-term system value for both regions.**

Closing Remarks

Flexibility is not just a technical feature, it is a **foundational requirement** for a resilient and decarbonized power system.

The Iberian blackout was not a failure of renewables, but a **failure to prepare the system** to operate with them.

Flexibility could have contained the frequency drop through fast reserves, demand response, and distributed inertia before the cascade happened. As renewable shares grow, so does the need to anticipate variability, respond rapidly, and coordinate distributed resources.

The path forward requires aligning infrastructure, regulation, and market signals to **unlock flexibility at scale.**

For **Morocco**, building this foundation early is not optional, it is the **key to a secure and future-proof energy transition.**

Thank you for your attention!

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