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Grid expectations: The distribution backlog stalling Europe’s energy transition

BEYOND FOSSIL FUELS

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Glossary

Abbreviation	Definition
BESS	Battery Energy Storage System
BtM	Behind-the-Meter
CAPEX	Capital Expenditure
C&I	Commercial and Industrial
CIM	Common Information Model
CHP	Combined Heat and Power
COI	Conflict of Interest
DMS	Distribution Management System
DNO	Distribution Network Operator
DSO	Distribution System Operator
DSR	Demand Side Response
EEX	European Energy Exchange
EHV	Extra High Voltage
EPEX	European Power Exchange
ETS	Emissions Trading System
EU	European Union
EV	Electric Vehicle
FCFS	First-Come-First-Served

Abbreviation	Definition
GB	Great Britain
GDP	Gross Domestic Product
HV	High Voltage
LF	Load Factor
LV	Low Voltage
MV	Medium Voltage
NECP	National Energy and Climate Plan
NWA	Non-Wire Alternatives
O&M	Operation & Maintenance
OPEX	Operating Expenditure
PPA	Power Purchase Agreement
PV	Photovoltaic
RES	Renewable Energy Sources
SCADA	Supervisory Control And Data Acquisition
TOTEX	Total Expenditure (CAPEX + OPEX)
ToU	Time-of-Use
TSO	Transmission System Operator
UK	United Kingdom

Content

Distribution grids are holding back billions in investment: urgent action is needed to make them the backbone of Europe’s electrification and renewables build-out

1 Across the eight European markets analyzed (Bulgaria, Czechia, Great Britain, Germany, Greece, Italy, Poland, Spain), **distribution-level queues** have reached **volumes that can directly influence system costs and market outcomes**—making grid access a binding constraint on decarbonization pathways.

- **~375GW** RES projects (Wind +PV) in the queue[1]
- **~455GW** BESS projects in the queue[1]

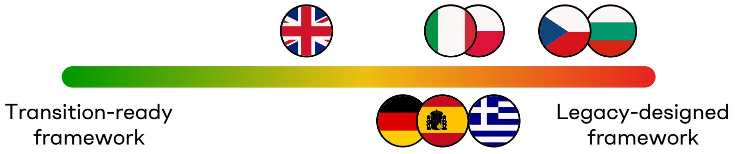
2 The **high number of grid connection requests** highlights the intense level of **operational and administrative work** needed to process, study, and manage connection applications. Distribution networks are constrained not only by physical hosting capacity, but also by the ability of DSOs to run connection processes quickly, consistently, and at industrial scale.

- **+11k** Average yearly number of RES+BESS connection requests >1 MW at distribution level per market
- **~70%** Number of requests linked to solar PV plants

3 The **scale of capital value** whose delivery is postponed by distribution-level connection bottlenecks **is huge,** indicating that **connection delays** should be viewed not only as a climate issue, but also **as a competitiveness, resilience, and energy security issue.**

- **~€100bn** Value of clean energy projects trapped in the queue

4 The issue is not limited to physical grid scarcity but reflects a broader **governance failure**. While regulatory tools to address connection bottlenecks have been identified and are being rolled out across countries, gaps between regulation and effective implementation persist. To close these gaps, regulatory provisions must be **enforceable** and **near-automatic**.



Notes: 1) For data transparency problems across countries, only projects above 1 MW have been taken into account. Given the majority of distribution grid connection requests are made for smaller capacities the real volumes are likely larger.

Agenda

This study aims to shed light on distribution-level grid connection backlogs, identifying underlying drivers, and outlining potential solutions

Context

- Local electricity grids, operated by DSOs and DNOs, are the vital infrastructure that links households and businesses to the benefits of renewable energy and clean flexibility solutions. **DSOs play a crucial technical role in enabling the energy transition**: they are responsible for connecting a diverse range of projects — from heat pumps and electric vehicle charging points to solar PV and onshore wind installations.
- Long waiting times faced by renewable projects in securing grid connections are a well-documented and widely recognized bottleneck to the clean power transition across Europe. To date, policy discussions and regulatory reform efforts have largely focused on transmission networks, where congestion and connection queues have become increasingly visible.
- However, the magnitude of grid access constraints at distribution level remains significantly under-acknowledged. Across Europe, distribution networks are already experiencing substantial backlogs of renewable and storage projects awaiting connection. Lengthy and complex permitting and connection processes affect developers, businesses, regional and local authorities, and households alike, while consumers are unable to fully benefit from flexible consumption solutions that could reduce energy costs and support system efficiency. In this context, distribution grids increasingly act as a limiting factor, rather than an enabler, of a timely and equitable energy transition.

Purpose & geographical scope

Against this background, the present study aims to:

- **Assess the scale** and characteristics of renewable and storage **grid connection queues at distribution level** across a selected set of European markets (**Bulgaria, Czechia, Great Britain, Germany, Greece, Italy, Poland, Spain**), chosen to reflect a representative range of grid maturity levels and network organization models
- Develop a high-level **estimate** of the **system-wide impacts** of distribution-level connection delays
- **Identify** the **key regulatory drivers** contributing to the emergence and persistence of these constraints
- **Outline potential solutions** to address distribution-level grid access bottlenecks and accelerate the energy transition

Content

Grid connection queues for RES projects have become a structural challenge for network operators across Europe, affecting distribution networks

What's happening

- **Grid connection queues** for renewable energy projects have become a **structural challenge for network operators** across Europe.
- While the grid connection issue has long been recognized at transmission level, the evidence increasingly shows that **congestion and backlogs are now equally material at distribution level**.
- Despite this evolution, the level of transparency and monitoring remains highly asymmetric across network layers. If transmission-level connection queues are relatively well documented and subject to regulatory scrutiny, **distribution-level queues remain largely opaque**, making it difficult to assess the true scale of the problem or to compare it across countries.

Why it matters

- Distributed energy resources deliver **systemic** and **local benefits**. At system level, they can accelerate electrification and renewable deployment, helping reduce Europe's exposure to fossil-fuel-driven crises. At local level, they absorb surplus generation, provide time-shifting and fast flexibility, mitigate peak congestion, support outage management, and defer grid reinforcement CAPEX. **Connection delays effectively block these benefits**, increasing reliance on operational interventions to keep the system within technical limits and, in turn, raising **system security risks**.
- By postponing the connection of renewables, storage and electrified loads, connection delays **undermine the energy transition.**
- Delays prevent households and businesses from accessing the benefits of renewable energy and clean flexibility, in terms of **bill reductions.**

Key questions

How many renewable energy projects are currently waiting to be connected to the distribution grid across Europe?

What impact do these delays have on the energy transition?

What are the causes of the problem and what are the possible solutions?

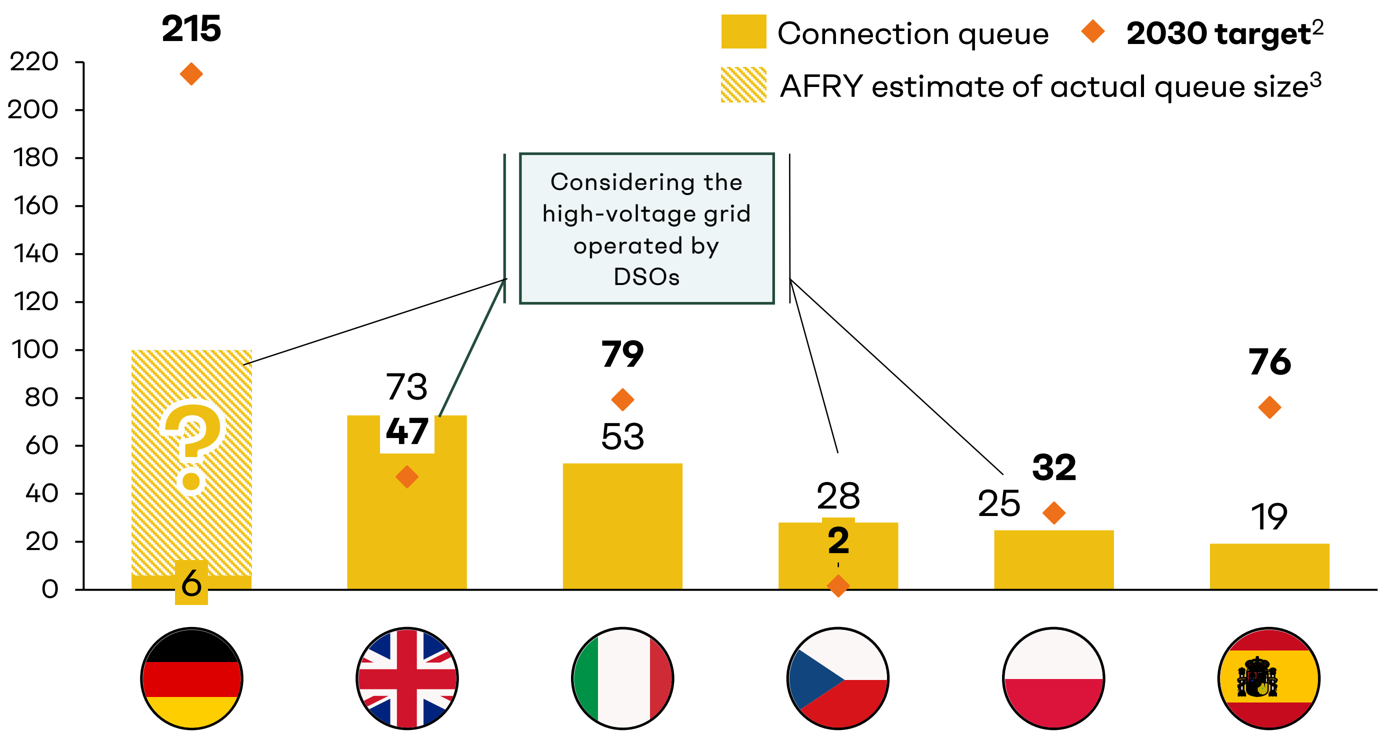
Projects in the connection queue

In this report, projects in the connection queue refer to new renewable generation and storage projects **larger than 1 MW** that are waiting to be **connected to distribution networks** and have submitted a formal grid-connection request. This minimum size threshold was selected due to the lack of uniformly available and comparable data across countries for projects below 1 MW.
The upper size threshold varies by country, depending on the perimeter of assets managed by DSOs[1].
These projects—covering solar PV, wind and BESS—are either still under assessment or already approved but awaiting commissioning. Queue delays may stem from permitting timelines, required grid reinforcements, project-specific issues, or broader process and queue-management frictions.

Notes: 1) which in some jurisdictions also includes portions of the high-voltage network.

Distribution-level PV queues are now a critical bottleneck: DSO capacity constraints already threaten 2030 delivery in major markets

Grid connection queue at distribution level[1] against targets - Solar PV (GW)



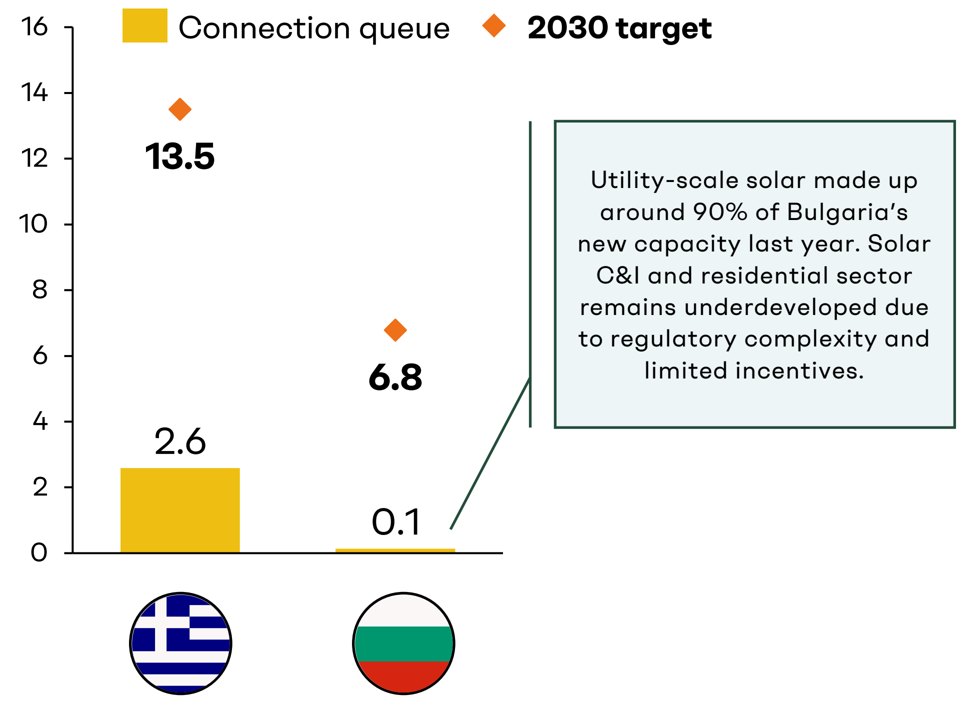
Commentary

- The grid-connection challenge is particularly acute for solar PV, especially in more mature markets, further advanced along the energy transition. In several countries, distribution-level connection queues already account for a **substantial share of national renewable targets**—and in some cases exceed them—pointing to a growing mismatch between planning frameworks and investor demand. Great Britain and Czechia stand out in this respect.
- Importantly, the figures shown should be interpreted as a **lower bound**. First, only projects larger than 1 MW are considered. Second, data availability remains uneven across jurisdictions: in Germany, for example, official statistics capture only a few gigawatts, while the "hidden" distribution-level queue is likely an order of magnitude larger.
- From a system perspective, this lack of visibility has material consequences. It hampers effective network planning, distorts signals for investors, and increases the risk of misalignment between renewable targets and deliverability. Connection queues at distribution level are no longer a marginal issue, but a **core constraint on the pace of decarbonization**.
- For DSOs, this implies a **fundamental shift in operating model**: DSOs must significantly scale up their case-handling capacity, **digitalizing and standardizing connection workflows**.

Notes: 1) The connection queue figures presented here should be interpreted as indicative only. Data sources, definitions, and levels of coverage differ across countries, and as a result the figures are not necessarily fully comparable on a like-for-like basis. Differences may reflect variations in data availability, reporting practices, network levels covered, and methodologies used by individual DSOs and national authorities. Further details and country-specific assumptions are provided in the dedicated country slides. 2) The targets presented in this and in the following slides refer to the total installed capacity by 2030, as set out in the national plans (rounded to the nearest whole number). 3) AFRY estimated the total volume of grid-connection requests by deriving an annual installation rate from the 2030 target (evenly spread over 2026–2030) and interpreting this rate as a technology-specific success rate applied to the overall request pipeline.

Smaller markets show early warning signals: even ~10% queue shares create operational strain and risk a sudden, disruptive surge without action

Grid connection queue at distribution level[1] against targets - Solar PV (GW)



Commentary

- Even in **smaller and comparatively less mature markets**, distribution-level **solar PV** connection queues are now becoming a meaningful system constraint—albeit on a smaller absolute scale than in the largest European markets. In Greece, queued PV volumes already **exceed 10%** of the national 2030 target, making them material in relative terms and sufficient to generate operational and planning pressure for DSOs.
- A key point, from a system planning standpoint, is that 2030 **RES targets will not be delivered solely through distribution-connected projects**. Transmission-connected utility-scale capacity must also contribute materially; therefore, even where the distribution queue appears only "moderate" relative to the target, the overall pipeline and delivery challenge can already be substantial.
- Operationally, the relevance of these queues does not scale linearly with gigawatts. DSOs can face a non-negligible workload even at modest queued volumes, because PV projects at MV/LV[2] tend to come in high volumes of smaller requests, creating a heavy administrative and engineering throughput need.
- From a system operation angle, PV at MV/LV also tends to surface constraints that are local and fast-acting rather than system-wide and slow-moving: transformer loading limitations, reverse power flows, and voltage management challenges become binding at feeders and substations long before reinforcement cycles can catch up.

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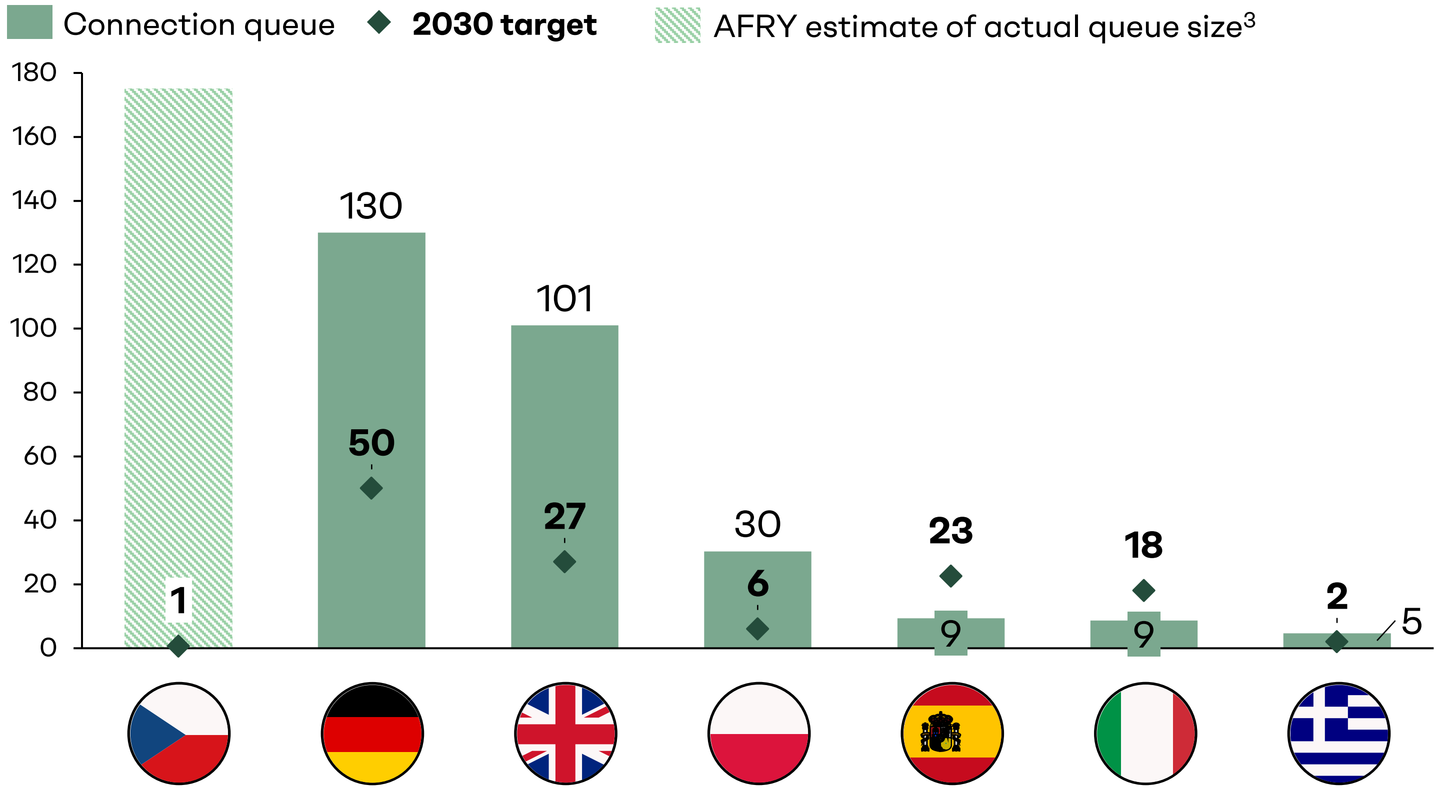
Grid access has become a binding constraint even for BESS, with queues already at a scale that can materially influence the pace and cost of the energy transition

Grid connection queue at distribution level[1] against targets - BESS (GW)



Commentary

- For **BESS**, distribution grids are already facing an **exceptionally large backlog** of projects waiting for connection.
- The Czechia stands out as a particularly critical case: while the figures presented are not exhaustive, they clearly reflect the severity of the situation reported by network operators and point to an overwhelming volume of speculative connection requests. This represents a clear example of process failure, resulting in severe system inefficiencies.
- The magnitude is also striking in more mature markets such as Germany and Great Britain, where the distribution-level queues shown (order of ~130 GW and ~101 GW, respectively) materially exceed the scale observed in other markets and highlight that grid access at distribution (and sub-transmission) interfaces is becoming a critical gating factor for clean flexibility deployment.
- From a system standpoint, **delayed storage connections translate directly into system costs**, considering the role BESS can play in absorbing surplus renewable output, limiting curtailment, and providing time-shifting and fast flexibility to the grid.

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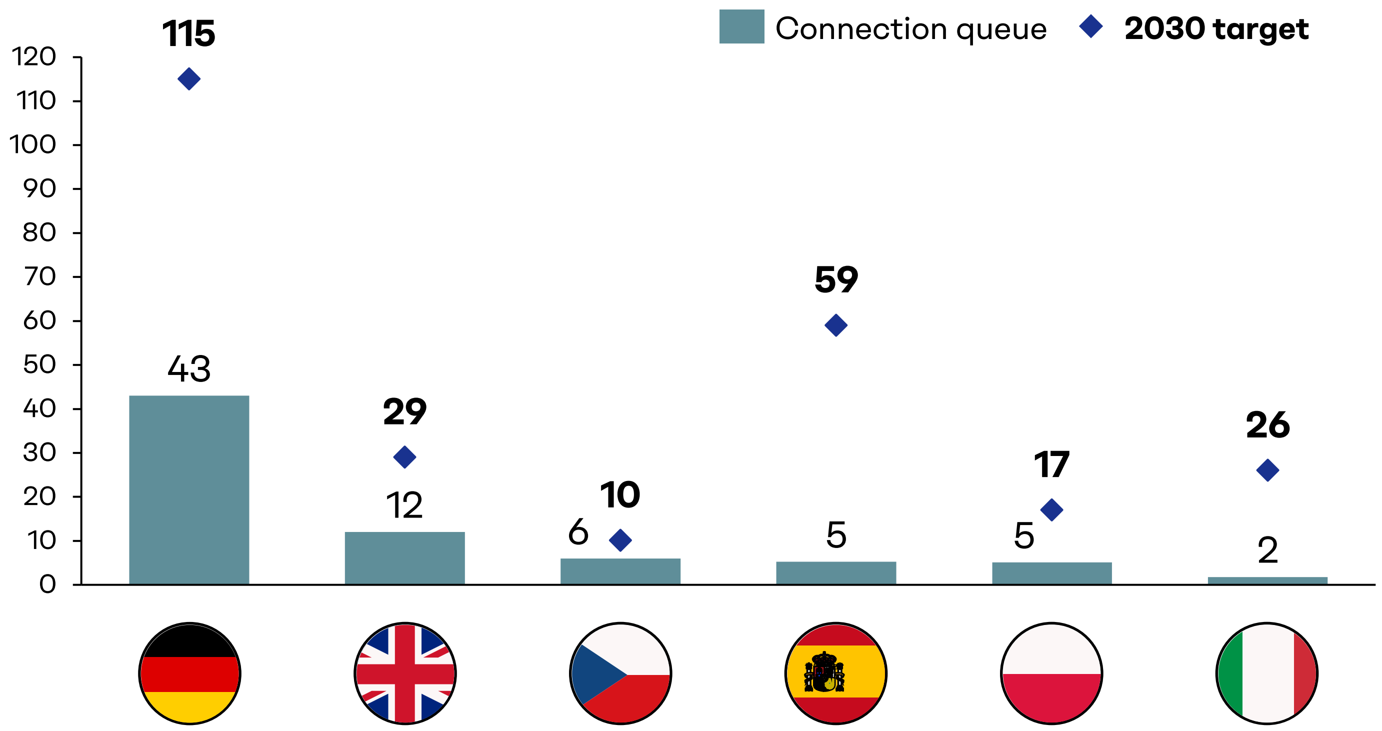
For wind, connection queues are already visible, reaching ~28% of the 2030 target in Germany and ~25% in GB

Grid connection queue at distribution level[1] against targets - Wind (GW)



Commentary

- Distribution-level connection queues are **increasingly visible** for **wind**, although the degree of urgency differs materially by market and by the role wind plays in each national pathway.
- Interpretation of wind queues requires particular caution: **wind projects are typically larger than solar PV** and, in many jurisdictions, are connected via **high-voltage transmission connection processes** rather than through distribution grids. As a result, distribution-level queue metrics in many countries under-represent the true system-wide grid access constraint.
- **Germany and Great Britain** stand out in the sample. In Germany, the distribution-level wind queue accounts for around **28%** of the 2030 target, while in Great Britain it represents roughly **25%**, already constituting a material share of medium-term deployment ambitions. In both cases, this is partly explained by the inclusion of HV/MV connections within the "distribution" perimeter.
- It should be noted that Poland's and Great Britain's figures are also influenced by recent de facto restrictions, as both markets implemented planning and/or setback-distance rules (only recently eased/removed) that made the development of new onshore wind projects extremely difficult—if not nearly impossible—for several years.

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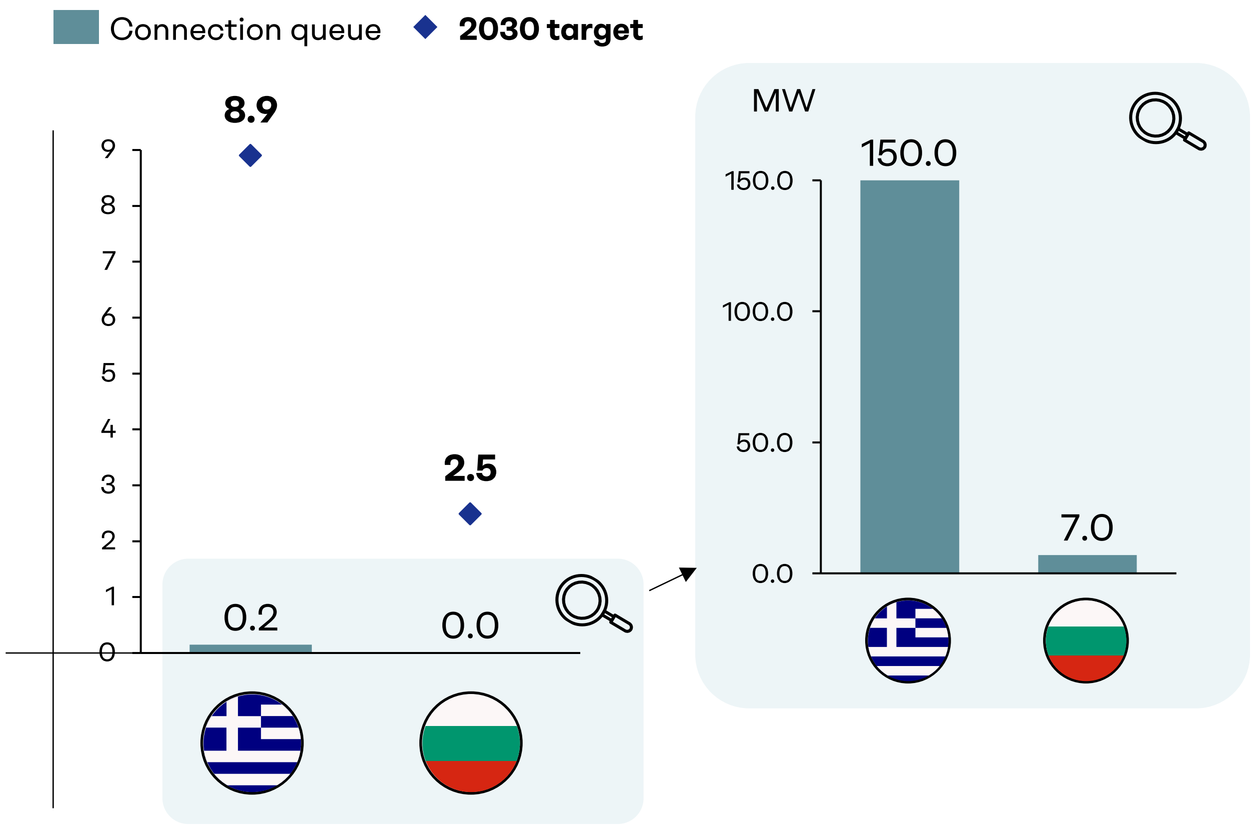
In smaller markets, the first hurdle is accelerating project origination and permitting

Grid connection queue at distribution level[1] against targets - Wind (GW)



Commentary

- The distribution-level wind connection queues are negligible across the two smaller markets shown. This suggests that, unlike larger European markets, distribution networks are not currently acting as a binding bottleneck for wind deployment in these geographies—at least within the distribution perimeter captured by the dataset.
- However, a negligible distribution-level queue should not be interpreted as "smooth" or "fast" delivery. In these markets, **the limiting factors can sit elsewhere**—particularly in **project origination, administrative processing, and permitting timelines**—and, for utility-scale wind, in transmission-level grid access and system integration that is not reflected in distribution-only queue data.

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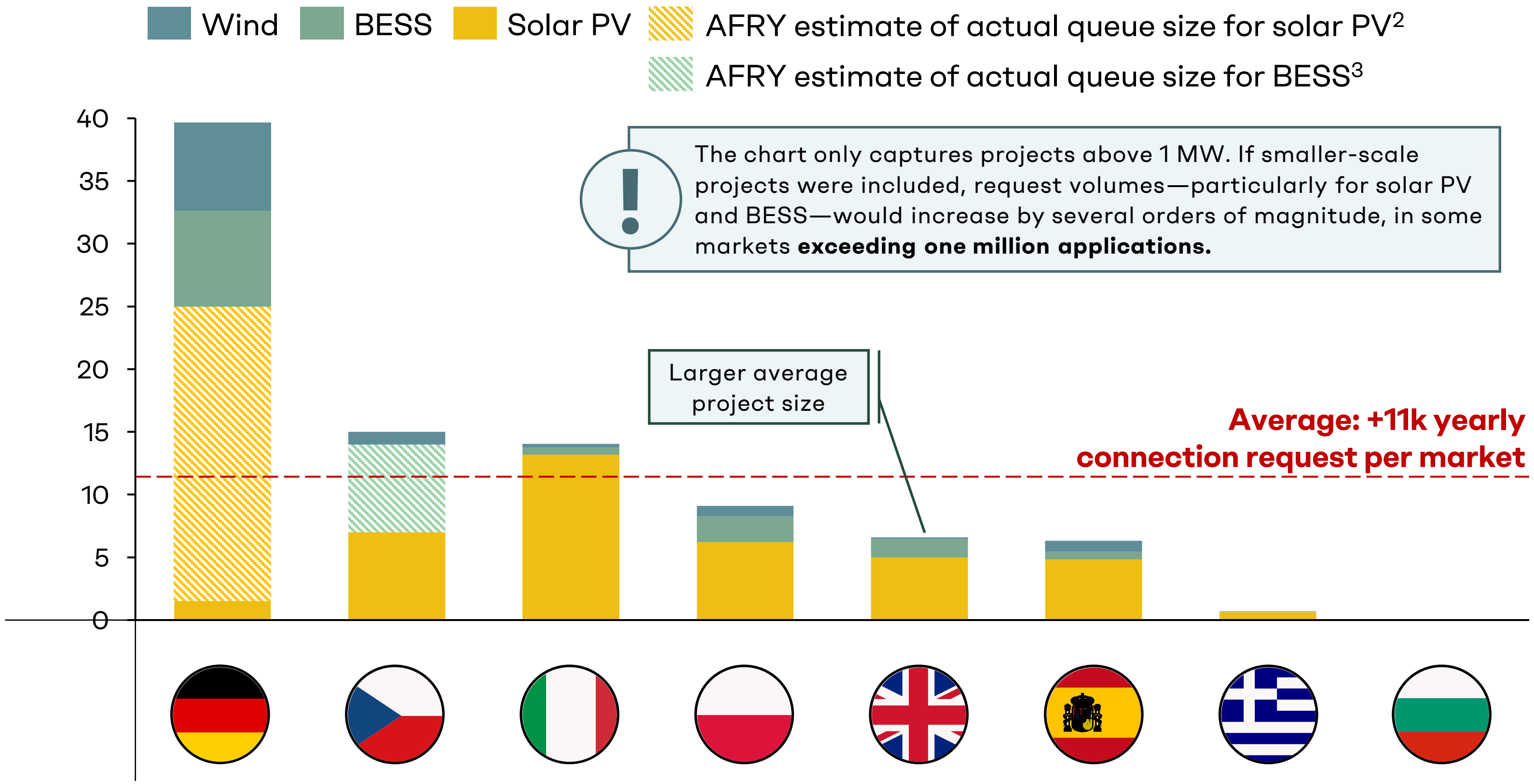
The request counts highlight a second, distinct system constraint: the operational and administrative throughput required to manage connection applications

Grid connection queue at distribution level (thousands of requests)



Commentary

- Looking at connection queues through the lens of the number of requests reinforces how urgent the distribution-level grid access challenge has become. Even where the queue is already alarming in GW, the **request counts** highlight a second, distinct system constraint: the **operational and administrative throughput required** to process, study, and manage connection applications at scale. In other words, distribution networks are constrained not only by physical hosting capacity, but also by the ability of DSOs to run connection processes quickly, consistently, and at industrial scale.
- At a high level, the distribution of request volumes across markets broadly follows the same hierarchy observed in GW terms, with the largest markets displaying the highest case volumes.
- The **largest share of distribution-level requests is attributable to solar PV** (70% on average); BESS also appears as a notable component of the request count. The issue is far less pronounced for wind, which typically involves larger projects and fewer connection requests.

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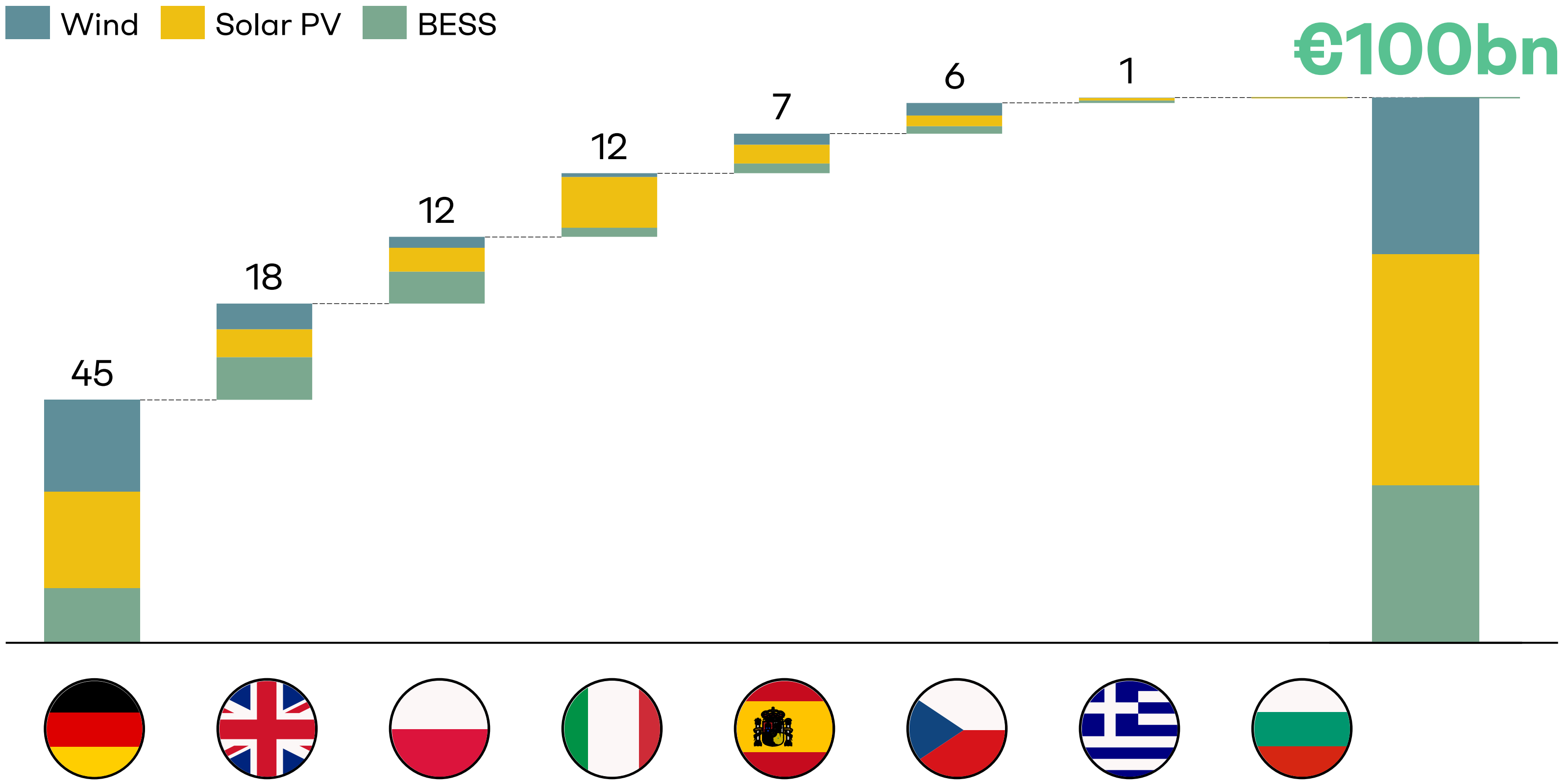
Even considering a conservative success rate (~20-25%), €100bn remains trapped in connection queues, slowing decarbonization and weakening Europe's resilience

Value of «realistically buildable[1]» capacity in the queue (bn€)



Commentary

- Grid connection delays **should not be framed solely as an environmental issue** that slows the energy transition; they also **undermine Europe's competitiveness, resilience and energy security**.
- AFRY estimates that, even just considering only the "realistically buildable" capacity, roughly **100bn€** of value remains "blocked" in connection queues.
- The €100bn figure should be interpreted as an order-of-magnitude proxy for the economic impact of distribution-connection bottlenecks. The "value in the queue" approximates the scale of capital tied up (or at least postponed) by connection constraints; under standard investment decision logic, a project that proceeds to construction is expected to generate a non-negative net present value at the investor's hurdle rate; otherwise, it would rationally be screened out. In other words, the capital cost is a **lower-bound benchmark for the scale of value that the project is expected to create** as private value. Broader system value from decarbonization and flexibility should be considered in addition.

Notes: 1) To estimate what is realistically buildable, AFRY applies conservative technology-specific success rates (20% for wind, 25% for solar PV and batteries), which are reduced to 10% in cases where connection queues materially exceed targets, and further lowered to 1% for the specific BESS case in Czechia. The CAPEX and OPEX inputs underpinning the estimates are sourced from AFRY's internal databases.

Distribution-level grid access remains a blind spot: opaque queues, fragmented EU rules, patchy tools, ongoing reforms targeting only transmission

Lack of focus	– Distribution-level connection queues remain largely "out of sight" — despite clear signs that the issue is now critical. This is evident in the fact that, while many countries provide developers with visibility on pipeline status and queue volumes at the transmission level, **no equivalent transparency framework has been established at the distribution level**. – The indicative figures we have been able to compile, which underestimate the real size of the issue, nonetheless point to a **clear urgency to act** and to make resolving distribution-side grid access a priority on distribution-side grid access.
Weak and non-prescriptive EU backbone	– **European regulation** sets high-level principles for non-discriminatory and transparent network access and information obligations[1], but it **does not explicitly require DSOs to publish standardized queue/backlog datasets.** In practice, this has translated into a patchwork of country-specific tools and data sources: for example, Germany can rely on an open renewable-plant register, while comparable information is not open in Italy; some DSOs publish congestion "heat maps", but these often remain qualitative (e.g., indicating reverse power flows) and cannot be translated into actionable MW hosting capacity. – While such tools can still support early-stage siting decisions, the lack of consistent, quantified disclosure ultimately means developers must re-learn connection "rules of the game" every time they enter a new market—adding time, cost, and risk to project development. – The situation is further compounded by the **highly uneven DSO landscape across Europe**, both in terms of how many DSOs exist and how responsibilities are allocated. At one end of the spectrum, Greece relies on a single DSO, resulting in a centralized setup for managing grid access and connection processes; at the other end, Germany has more than 850 DSOs, each operating with its own connection processes and practices.
Regulatory momentum - but partial	– Grid connection constraints are now firmly on policymakers' agendas at the transmission level, and early reforms indicate a **shift** away from pure first-come, first-served **toward deliverability- and maturity-based gatekeeping**. In UK, a grid connections reform package (TMO4+) approved in 2025 replaced the historical FCFS principle with a gated approach. In Italy, the recently approved "DL Bollette" explicitly targets "virtual saturation" and tighter allocation discipline, including provisions that allow TSOs/DSOs to issue connection solutions above the nominal hosting capacity at a node ("overbooking"), alongside stronger transparency mechanisms (e.g., periodic publication of available capacity). In Germany, the government has tabled a grid package which is due to be officially consulted in the coming weeks. – However, **this momentum remains largely transmission-led**, while the distribution layer continues to lag behind in both transparency and governance—even as the scale of the issue increasingly sits in distribution grids.

Notes: 1) Regulation (EU) 2019/943 (principles on charges and network access); Directive (EU) 2019/944 (principles on access, information and digitalisation).

Content

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Grid queues stem from limited capacity, reactive planning, slow permitting, weak queue management, and speculative requests

Drivers of grid connection queues

Grid capacity constraints

The current pace of distribution grid reinforcement and expansion is not keeping up with the level of new projects wanting to connect (solar PV, wind, storage, EV charging, heat pumps).

Poor long-term planning

Grids are often developed reactively rather than through anticipatory planning based on robust scenarios and credible forecasts of future demand and supply—worsening congestion and queues.

Lengthy permitting & administrative processes

There are a number of bureaucratic steps slowing down the process - internal approval and external permitting, often combined with legal challenges, slow grid works and connection delivery.

Inefficient governance & process design

Queues grow because many systems rely on FCFS processing without robust maturity/ prioritization criteria. In addition, DSOs may lack regulatory mandates to remove stalled projects, while limited staffing and digitalization can constrain processing capacity.

Zombie projects (Virtual grid saturation)

Many requests reserve capacity (and require studies) but never become real projects; this inflates queues, consumes DSO resources, and slows down mature, ready-to-build projects.

Supply chain and skilled workforce shortages

Procurement constraints and shortages of qualified labor further delay grid build-out and reinforcement, amplifying the capacity and permitting issues.

In Europe there is a common framework for grid connections, defining roles, responsibilities and principles on transparency, tariffs and remuneration criteria

Area of analysis	Relevant EU legislation	Relevant UK legislation	What it prescribes
Governance	Directive (EU) 2019/944	Electricity Act 1989 Electricity Distribution Licence (Ofgem SLCs)	Defines the scope of DSO/DNO responsibilities and the minimum governance framework; introduces independence requirements and accountability (separation of DSO/DNO and supply), including obligations on investment planning and transparency
DSO ownership	Directive (EU) 2019/944	Ofgem SLCs	Imposes DSO/DNO independence in legal/organizational/decision-making terms (without ownership unbundling, except in specific cases); generally, limits DSO/DNO ownership of competitive assets such as storage, allowing it only under specific conditions
Planning & investment	Regulation (EU) 2019/943 (tariffs) Directive (EU) 2019/944 (DNDP and planning)	Ofgem SLCs Price control framework context (RIIO)	Introduces the concept of tariffs and remuneration criteria to send incentives consistently. Introduces "forward-looking" planning through the mandatory 2-year publication of development plans; requires DSOs/DNOs to consider anticipatory investments and non-wire alternatives
Connection process	Regulation (EU) 2016/631, Regulation (EU) 2016/1388 (Technical Requirements) Regulation (EU) 2019/943 (principles on charges and network access) Directive (EU) 2019/944 (principles on access, information and digitalisation)	Electricity Act 1989 ESQCR 2002 (principles on access and charges) Distribution Code, ENA EREC G98/G99 (Technical Requirements) DCUSA, Ofgem decisions (connection & charging methodologies)	Defines technical requirements for generation and demand connections; distribution networks and conditions for "grid-friendly" connections and non-conformity. Economically, establishes principles for network charges related to connection and any reinforcements. Sets principles for a non-discriminatory connection process (information obligations and strong push towards digitalization).
Transparency	Regulation (EU) 2019/943 (network charges) Directive (EU) 2019/944 (DNDP transparency)	LTDS Direction pursuant to SLC	Introduces principles of transparency in the definition and application of network charges, including those related to network access. Requires transparency through periodic publication of plans (including visibility on investments, grid congestion and flexibility needs) and clarifies DSO/DNO tasks on data management and sharing
Fossil-free flexibility	Directive (EU) 2019/944 (procurement of flexibility, limits on ownership)	Ofgem SLCs	Requires DSOs/DNOs to procure flexibility services (congestion management) through transparent, non-discriminatory and market-based mechanisms

Member States have then tailored the shared EU baseline to local specificities; differences concentrate on how consistently and effectively rules are implemented

Area of analysis	Common across framework	What differs across frameworks
Governance	National legal/regulatory basis exists for grid access and connection, with a general non-discrimination principle. Some form of procedural obligations typically exists (rules, timelines, oversight)	– Strength of enforcement (penalties/compensation vs soft oversight) – Degree of performance incentives tied to connection outcomes – Consistency of implementation (uniform vs operator/region-specific)
DSO ownership	Ownership structures can create potential conflicts of interest; most frameworks rely on some combination of unbundling, neutrality rules, and complaint mechanisms	– Concentration and integration level (fragmented DSOs vs large integrated utility groups) – Practical effectiveness of COI safeguards[1] (formal vs actively enforced)
Planning & investment	DSOs typically have some obligation to plan network development and publish planning outputs. Plans usually have multi-year horizons and link (at least implicitly) to expected connection needs	– Frequency and horizon (annual vs multi-annual; short vs long outlook) – Depth consultation/regulatory approval requirements – Explicit priority to non-wire alternatives/anticipatory investments
Connection process	– All frameworks manage scarcity by some ordering/prioritization logic and have defined procedural steps for applications and offers – Most have some route for simplified handling of smaller projects	– Allocation logic: pure FCFS vs priority lists vs gating/maturity-based – Queue management tools vs limited cleaning – Availability of flexible/non-firm connection options as standard
Transparency	Some public information exists	– Whether transparency is mandatory vs voluntary – Granularity and standardization – Centralized access to information vs fragmented DSO-by-DSO
Fossil-free flexibility	Flexibility is widely recognized as a lever to relieve constraints and complement reinforcement, at least conceptually	Maturity level: absent / pilots / defined framework / operational

Notes: 1) Safeguards for conflicts of interest.

The European Commission has put forward recommendations aimed at ensuring timely grid connections

European Commission recommendations in the EU Grids Package

Governance

- Establish a structured EU-level dialogue between TSOs, DSOs and national regulators to coordinate grid development strategies
- Set up permanent working groups between TSOs/DSOs and network users to integrate user needs early in network planning, align connection timelines with grid development, and fully leverage flexibility potential

Transparency and DSO Ownership

- Publish hosting-capacity information through digital capacity maps linked to connection procedures
- Ensure hosting-capacity maps cover low-voltage networks, are updated regularly, and reflect both current capacity and planned network development
- Establish a single national hosting-capacity platform with transparent and harmonized capacity assessment methodologies
- Provide regular, transparent updates on application status and expected timelines/waiting times

Planning & investment

- Enable unrestricted use of anticipatory (ex-ante) investments
- Link the network development plans to hosting-capacity maps and infrastructure developments to increase their implementability
- Expand the use of direct lines where they offer a more efficient and timely connection
- Regularly assess the efficiency of allocated network capacity and reallocate unused capacity

Fossil-free flexibility

- Introduce dynamic network tariffs to incentivize demand shifting, reduce peak loads and free up network capacity
- Incentivize network operators to invest in cost-effective flexibility solutions
- Enable broad use of flexible connection agreements and hybrid connections and reward users providing flexibility
- Use non-fossil flexibility as an alternative /complement to grid reinforcement

Connection process

- Decongest queues by applying maturity criteria and gates, backed by use-it-or-lose-it rules and proportionate reservation fees
- If prioritization is required, base it on objective and non-discriminatory criteria reflecting system value, climate objectives, security and social relevance
- Ensure any prioritization framework includes a clear transition period and active stakeholder involvement
- Define clear schedules for the full use of reserved capacity and enforce release mechanisms when contractual network use conditions are not met
- Ensure full digitalization of connection request handling
- Introduce clear benchmarks for connection timelines, milestones and operational efficiency, with penalties for non-compliance
- Use locational signals (e.g., differentiated connection rates) to steer applications toward network-ready area

However, the measures identified to date are not sufficient. Additional, bolder regulatory impetus is required to address the issue effectively

Recommendations from Beyond Fossil Fuels[1]

Governance

- Strengthen the energy regulator's mandate to ensure climate-aligned, long-term oversight of DSOs
- Create an independent public body for integrated, system-wide planning at both TSO/DSO level
- Ensure DSO profits are reinvested into grid upgrades
- Remove all barriers to flexibility, distributed assets and community-led solutions
- Reform incentives/price controls to prioritize market-based flexibility, customer value, connection performance over traditional grid expansion

Transparency and DSO Ownership

- Mandate full ownership unbundling of DSOs to minimize conflicts of interest

Planning & investment

- Prioritize non-wire solutions (e.g. flexibility, storage, smart technologies)
- Ensure transparent and structured stakeholder consultation, with clear assumptions
- Strengthen regulators' powers to intervene where investment plans are misaligned with the target system
- Require all DSOs, including smaller ones, to prepare long-term network development plans
- Monitor and scrutinize DSO plans and investments to ensure alignment with the energy transition

Fossil-free flexibility

- Prioritize clean flexibility as a secure, affordable energy resource
- Reform ancillary and balancing markets to enable wider participation by households and businesses
- Accelerate the smart meter roll-out
- Promote incentives and benefits for households to encourage engagement in flexibility markets
- Support the establishment and operation of local flexibility markets

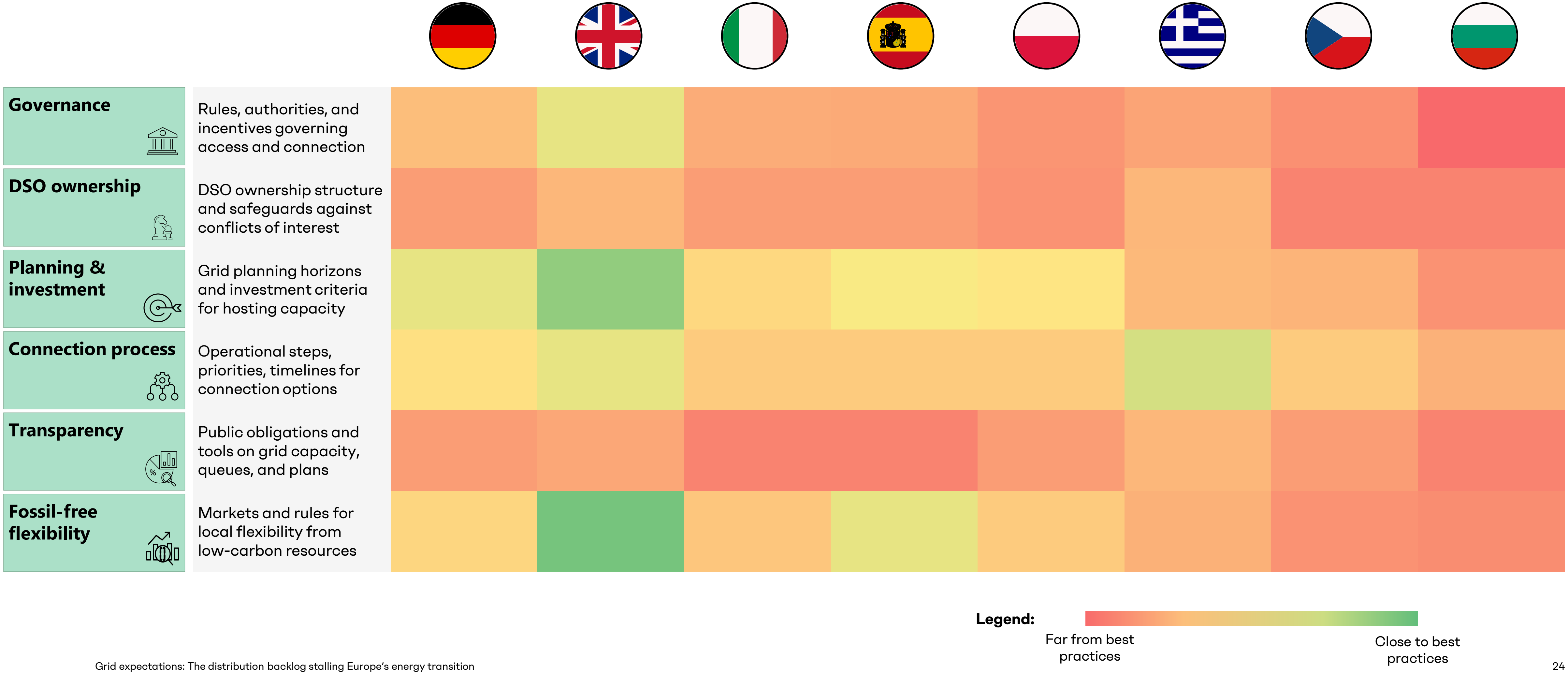
Connection process

- Unlock grid capacity and speed up connections through co-location and national rules enabling hybrid installations
- Strengthen queue-management with entry criteria, milestones, "use-it-or-lose-it" rules and release of unused capacity
- Incentivize DSOs, via price control frameworks, to adopt innovative, problem-solving approaches to grid connections
- Streamline connection procedures for energy communities, social housing, SMEs and other small-scale or community-led projects.

Sources: 1) Beyond Fossil Fuels (2025), From Gatekeepers to Enablers.

AFRY

The analyzed markets are progressing at different speeds along this regulatory reform trajectory



Regulatory action alone is not sufficient: grid readiness depends on enabling conditions being in place

Why do very large queues persist even where frameworks are mature?

Pressure effect	More mature frameworks often sit in markets at the center of electrification and the surge in connection requests. As a result, the volume of applications can outpace both network reinforcement and administrative throughput.
Visibility effect	Where transparency is stronger, the backlog is more measurable and therefore "looks worse". In less transparent settings—especially at DSO level—backlogs can be underestimated or fragmented across operators, masking the true scale of constraints.
"Denial vs queue" effect	In some markets, constraints materialize less as a visible "queue" and more as refusals / capacity not granted: applications are rejected and therefore do not appear in the queue, but still materially slow down the transition (a different manifestation of the same binding constraint).
Implementation gap	"Good rules" are not sufficient if they are not enforceable, consistently applied, and supported by adequate incentives and resources; without this, virtual saturation and process frictions persist.

How to make regulatory measures *actually effective*?

1. Hard rules, not just principles

Measures such as maturity criteria, milestones, penalties, and systematic queue cleaning work when they are automatic or near-automatic (not discretionary), backed by real consequences (e.g., deposits/fees, loss of priority, capacity release), and applied consistently. Similar incentive- and penalty-based mechanisms should also apply to DSOs, linking remuneration and performance assessments to measurable improvements in processes, timelines, and connection outcome.

2. Operational capacity at DSOs

Regulatory reform requires DSOs to modernize the end-to-end process (digitalization, standardized portals, automation). Otherwise, reforms risk remaining "paper rules" as application volumes overwhelm processing capacity.

3. Permitting and supply chain as binding constraints for reinforcements

Even perfect queue governance cannot solve the problem if reinforcement works cannot be delivered due to permitting bottlenecks and supply-chain constraints; regulatory reform must therefore be coupled with delivery enablers for grid build-out.

Content

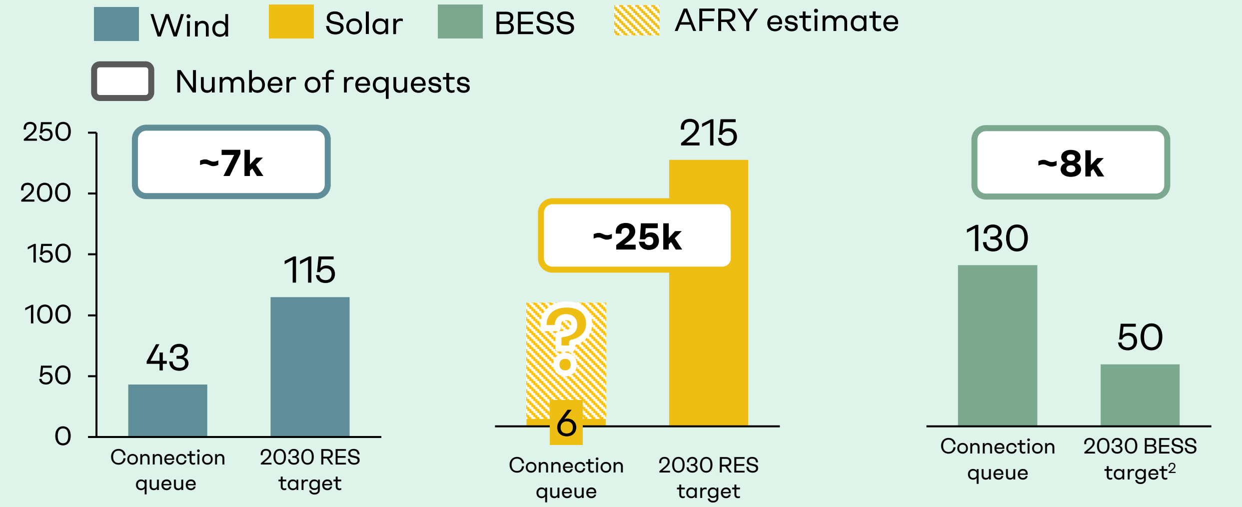
Germany

Market structure

The German electricity system is characterized by:

- Approximately **866 DSOs**, many of which are relatively small in size
- **4 TSOs** (TenneT, Amprion, 50Hertz and TransnetBW)
- A strong presence of large energy groups (E.ON, EnBW, EWE, among others) active in generation and supply and, through legally unbundled subsidiaries, in distribution

Grid connection queue at distribution level[1] against targets (GW)

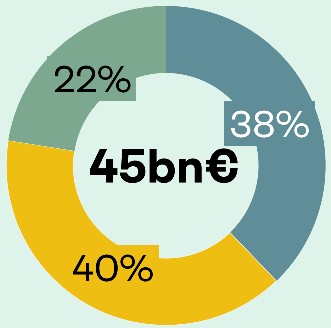


Queue already materially significant, large number of HV/MV connections with implications for transformer capacity and local network constraints

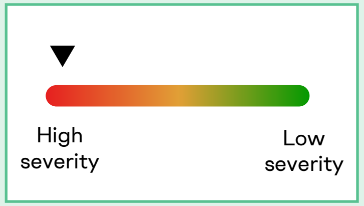
Proven queue relatively low compared to the 2030 target; AFRY estimates that the actual project queue could be more than 10× larger[3] than what is currently visible in official registers

BESS queue already more than double the expected 2030 target, signaling material and growing operational pressure on DSOs

Value of the queue



Queue severity indicator



Notes: 1) AFRY analysis on Marktstammdatenregister data (for PV and Wind, as of Dec 2025) and .Federal Network Agency (for BESS). Targets as for NECP 2) There is no official target for battery installation in Germany by 2030. Industry associations propose a value of 100 GWh, which, considering an average battery life of 2 hours, corresponds to approximately 50 GW. 3) AFRY estimated the total volume of grid-connection requests by deriving an annual installation rate from the 2030 target (evenly spread over 2026–2030) and interpreting this rate as a technology-specific success rate applied to the overall request pipeline.

Germany

Governance		The regulatory framework explicitly links network development to long-term climate objectives. A **common national rulebook applies across DSOs**, but operational implementation (e.g., portals, forms, level of detail, capacity-reservation practices) can still vary by operator. No automatic monetary penalties are typically specified solely for missing connection timelines. For RES, §8 EEG[1] establishes a priority, "without undue delay" connection obligation and sets minimum procedural requirements, including defined information and timeline duties.
DSO Ownership		The fragmentation of the German DSO landscape leads to a highly uneven and complex operational set-up; non-discrimination relies heavily on formal regulatory safeguards (unbundling and equal-treatment rules). The presence of large vertically integrated energy groups raises persistent concerns around transparency and effective neutrality.
Planning & Investment		Germany requires DSOs to submit **biennial network development plans** to the regulator. Plans must be based on regional scenarios and cover both near-term developments and the long-term 2045 decarbonization pathway. Consultation on these plans is not mandatory and takes place mainly through bilateral, highly localized interactions, aiming at transparency rather than at co-creation and reflecting the fragmented German DSO structure. The Authority has limited scope to intervene where plans prove insufficient. While the regulatory framework allows **forward-looking grid expansion** costs to be reflected in tariffs, it does not explicitly address or promote anticipatory investments. Non-wires solutions are formally permitted, but there is no regulatory incentive to prioritize them over traditional network reinforcement.
Connection process		Germany does not apply a single, universally enforced "pure FCFS"; the framework is anchored in priority status for renewables and minimum obligations on process transparency and timelines. Where multiple projects compete for limited capacity at the same connection point, practical implementation can become more heterogeneous. Some DSOs apply local **project-maturity criteria** and/or **use-it-or-lose-it-type rules** to limit speculative queue positions. However, no single, nationwide priority framework consistently applies across operators. Connection charges likewise vary materially by operator and location, reflecting network conditions and the scope of required works. Ongoing discussions focus on the appropriate level of a one-off connection contribution as a price signal, intended to steer new projects towards less-congested areas. From 2025, new requirements aim to **digitalize and largely standardize** how requests are submitted and processed—particularly for renewables **up to 30 kW** on existing residential connections—through mandatory web portals and harmonized information formats to the greatest extent possible; however, there is no single nationwide portal, so **implementation remains distributed across individual DSO** portals, and operator-specific differences tend to persist for larger projects, higher voltage levels, and complex cases.
Transparency		§14d EnWG[2] requires DSOs to include **network maps** and to **identify congestion areas** as part of the distribution network development plan. The obligation does not extend to LV networks. While German DSOs are required, since 2023, to operate a **common internet platform** and publish at least the regional planning scenario and the network development plan within defined timelines, this only provides a partial transparency layer. There is no national hosting-capacity map, and visibility on the status of connection requests remains limited.
Fossil-free flexibility		**Flexible connection** arrangements **are available** both for renewable generators (typically limiting export/feed-in) and for storage and demand connections (potentially limiting both export and import), with limits that can be static or dynamic and, where relevant, structured by time windows. Germany has **experimented with local flexibility** procurement through large-scale pilots (e.g., SINTEG projects such as Enera and C/sells), including prototype regional flexibility marketplaces to relieve local constraints. **A legal framework** for market-based procurement of distribution-level flexibility **exists**, but a fully standardized nationwide DSO flexibility market is still evolving. There are forms of time-of-use network tariff, together with forms of incentives for participation in flexibility markets, but the limited diffusion of smart meters limits the application of these measures.

Notes: 1) Erneuerbare-Energien-Gesetz (German Renewable Energy Act). 2) Energiewirtschaftsgesetz (German Energy Industry Act).

Great Britain

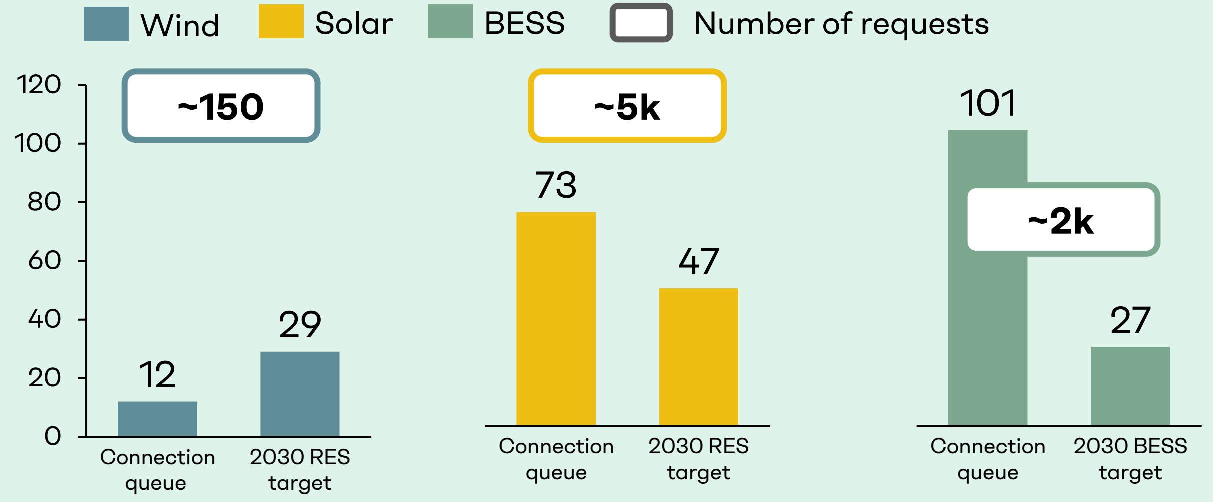
AFRY

Market structure

Great Britain electricity system is a liberalized market characterized by:

- **six major DNOs** holding a total of 14 regional distribution licenses[2]
- **a single system operator**, the National Energy System Operator (NESO)
- **three onshore TOs**
- a diversified base of large energy groups active in generation and retail supply (including SSE, ScottishPower, EDF, RWE, Centrica, Octopus and others)

Grid connection queue at distribution level[1] against targets (GW)

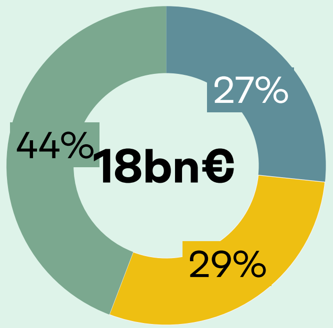


Queue already materially significant, large number of HV/MV connections with implications for transformer capacity and local network constraints

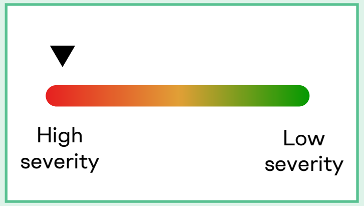
Queue already larger than the 2030 target – clear sign of oversubscription. Implies high likelihood of non-delivery, but in the meantime creates material processing burden

Queue massively above target with relatively few requests – indicates large average project size and a pipeline dominated by big-capacity connections

Value of the queue



Queue severity indicator



Notes: 1) As of Feb 2026; AFRY estimation on public available data. It is worth noting that GB figures tend to be higher in terms of queued capacity but less elevated in terms of the number of requests, because the distribution network includes Extra High Voltage (EHV) levels. In practice, this means a DNO can connect very large customers and assets at distribution level, and EHV sites are explicitly treated as part of the distribution system. Targets as for Clean Power 2030 Action Plan. 2) In GB, DSOs are referred to as DNOs.

Great Britain

Governance		RIIO-2/RIIO-ED2[1] is explicitly designed to support the low-carbon transition; this intent is reflected in how DNOs are required to build their internal planning to deliver national and local authority priorities. Within RIIO-ED2, Ofgem[2] links revenues to connections performance through defined outputs and incentives on service quality and timeliness, including payments when standards are missed.
DSO Ownership		DNOs are typically either part of **vertically integrated groups** or owned by **infrastructure investors**, reinforcing concerns around conflicts of interest. Formal mechanisms—including transparency and standardization requirements, as well as complaints and dispute-determination routes—provide mainly safeguards.
Planning & Investment		UK DNOs have a long-standing obligation to publish **Long Term Development Statements** (LTDS) on an **annual basis**, typically setting out a rolling planning outlook of around five years. This obligation stems from Standard License Condition 25 and is implemented through an Ofgem Direction, which specifies the required form, content and publication expectations for the LTDS. The LTDS framework is designed to support network planning, investment visibility and system adaptation as the power system evolves. Network development interventions are mechanically driven by congestion maps. There are **direct incentives** for DNOs **to evaluate non-wire solutions** as alternatives to network development; furthermore, the **TOTEX architecture** favors the implementation of these solutions. Ofgem has indirect but strong control over the quality of the development plan through decisions on allowed revenues, outputs, incentives, and uncertainty mechanisms, which may be linked to the quality of the planning. The plans are extensively consulted, both formally and informally, with local stakeholders and other network operators.
Connection process		At distribution level in Great Britain, a FCFS logic has historically been the key organizing principle. However, the Connections Reform (TMO4+) introduces a **gated approach based on projects maturity level** for plants where a Transmission Impact Assessment is required, while "distribution-only" cases (i.e., demand projects and generation projects that do not require such an assessment) are still treated within the FCFS logic. DNOs manage queues through milestone-based progress checks (e.g., planning, land rights and project commitment) and allows termination of stalled projects to release capacity, but no comprehensive framework exists to rank projects according to system or societal benefits. **Digital tools and portals** are available in different forms, but for generation projects the process is not always fully end-to-end digital. For very **small installations**, **simplified procedures** exist (microgeneration up to 16A per phase) based on a "fit-and-notify" approach with notification after commissioning. Connection costs vary with the project's scale, location and the network's ability to accommodate the required capacity, and there is an ongoing policy discussion about strengthening locational signals through reforms to network/connection charging (often framed as moving toward more locationally reflective charges).
Transparency		Under the revised LTDS requirements, DNOs are expected to publish (i) **hosting capacity / node capacity** insights via "Capacity Heatmaps", intended to provide a consistent view of available capacity and congestion and delivered against defined milestones and updated deadlines, and (ii) **machine-readable grid model** using the CIM standard. No nationwide obligation for nationwide platform aggregating connection and queue data, nor a consistent obligation to publish backlog information, resulting in fragmented visibility.
Fossil-free flexibility		In GB, distribution-level flexibility is treated as an operational pillar of the system: there are local flexibility markets operational and active on a system-wide basis, with explicit and transparent remuneration. The framework (including ToU[3] network tariffs and the broad diffusion of smart-meters) favors the participation, even direct, of end users in flexibility services. DNOs are required to make available a standardized **non-firm/curtailable connection option** in circumstances where providing full firm capacity would otherwise require network reinforcement, with defined curtailment limits and associated terms.

Notes: 1) UK Incentive Regulation (Revenue = Incentives + Innovation + Outputs). 2) UK Energy Regulator. 3) Time-of-Use.

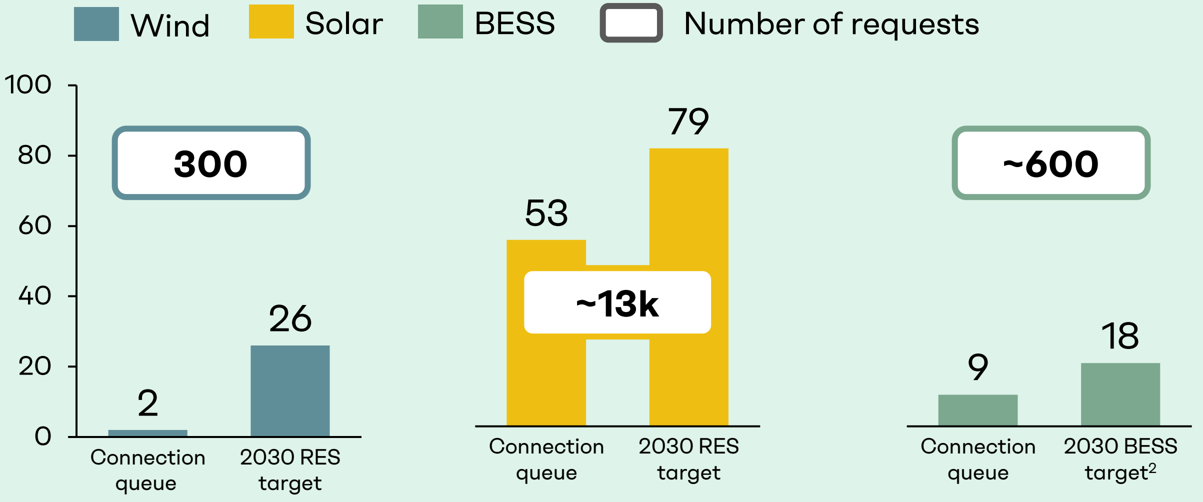
Italy

Market structure

The Italian electricity system is a liberalized market characterized by:

- **approximately 130 DSOs**, with e-distribuzione alone serving around 85% of end users; other major operators are A2A (~4%), Ireti (~3%), Areti (~2%)
- **a single national TSO** (Terna)
- the presence of large vertically integrated energy groups (including Enel, A2A, Edison, Iren)

Grid connection queue at distribution level[1] against targets (GW)

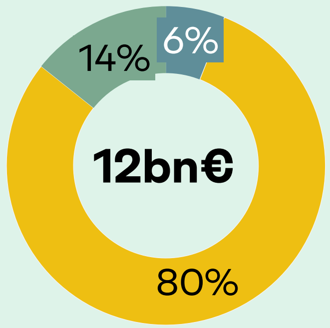


Wind is not a material congestion driver for the distribution network: wind development is constrained by geographical limitations; plants are therefore mostly connected at HV

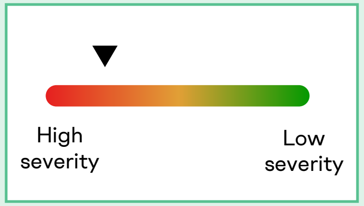
Very strong pressure from solar PV. In recent years, available incentive schemes have driven a surge in the deployment of small-scale installations

Significant queue relative to the target, which also accounts for BESS connected HV. Currently, in Italy, 58% of installed BESS capacity is attributable to systems below 10 kW

Value of the queue



Queue severity indicator



Notes: 1) As of Dec 2025; AFRY analysis on Terna data. Targets as for NECP. BESS target derived from Terna's Documento di Descrizione degli Scenari 2024. 2) Considering an average battery duration of 4h

Italy

Governance	**ARERA,** the Italian regulator, governs the connection of generation plants to electricity networks subject to third-party connection obligations through the TICA[1]. **Connection timelines are also regulated**, with penalties in case the predefined standards are not met. However, the prescribed timelines apply net of the time required for permitting; moreover, there are several other accepted reasons for connection requests to be placed in a **"suspension" status**. As a result, the stated timelines are largely theoretical and far from what happens in practice.
DSO Ownership	In Italy, DSOs are often part of vertically integrated groups that may also operate in generation and/or retail, structurally reinforcing potential conflicts of interest. In these cases, DSOs activities are subject to functional unbundling requirements. The regulatory framework includes enforcement tools and procedural safeguards.
Planning & Investment	TICA requires **distribution companies with at least 100,000** customers to publish and submit their **network development plans** by 30 June **each year**, including (among other items) plans for HV lines / HV-MV primary substations and significant interventions on the MV network. Smaller DSOs are not subject to publication obligations. The plan is subjected to public consultation, but in practice this process mainly involves institutional actors rather than local stakeholders. ARERA defines the rules governing plans preparation, but doesn't approve it. While ARERA is working to make network development more selective, at present there is **no explicit reference to anticipatory investments** and **non-wire solutions**. Although DSOs are required to consider flexibility needs within development plans, flexibility remains treated primarily as an operational tool rather than a planning lever.
Connection process	The **baseline rule** applied at distribution is **FCFS**; however, there is also an option (a discretionary measure, not a mandatory one) to activate a quarterly "**OPEN SEASON**" procedure in critical areas, which groups connection requests by quarter, to manage congestion in critical areas. Unlike at transmission level, where reforms are underway to introduce maturity-based prioritization, no comparable framework applies to distribution networks. There is no priority framework for community-centered projects. **Clear expiry and lapse mechanisms apply** where connection offers are not accepted or where projects fail to progress. Simplified connection procedures are available for plants below 200 kW (for e-distribuzione). In capacity-constrained areas and on critical lines, network operators may require financial guarantees and/or reservation-related charges. Connection costs also depend on the scale and characteristics of the project and, indirectly, on the degree of local congestion. Connection applications can be done through fully digital, end-to-end channels. **Portals**, **online templates/guides**, and **pre-check/estimation tools**, plus some **advanced digital features**[2] are available online, at least at major DSOs.
Transparency	TICA requires **distribution companies with at least 100,000** customers to publish and submit their **network development plans** by 30 June **each year**. All DSOs are required to publish a **qualitative "critical areas" map/classification** indicating hosting capacity availability (color-coding), as well as the **list of HV/MV primary-substation** sections exhibiting **reverse power flows.** There is no public information on the status of connection requests and no national, centralized platform for data aggregation.
Fossil-free flexibility	**No "flexible connection"** is explicitly defined; instead, what emerges are fixed caps on export (injection) capacity, and operational limitations/suspensions for security and network management reasons. There are no direct time-of-use network tariffs, nor other forms of incentives supporting end-user participation in flexibility services/markets. ARERA has launched a dedicated regulatory framework for DSOs' local flexibility procurement **pilots**, under which pilot projects are ongoing at major DSOs—including Areti (RomeFlex), e-distribuzione (EDGE) and Unareti (MindFlex)—to test competitive procurement of local services aimed at managing distribution-level constraints.

Notes: 1) Resolution ARG/elt 99/08, as subsequently amended. TICA = Integrated Text Active Connections 2) e.g., automated quoting, case tracking, and automated document checks 3) Resolution 352/2021/R/eel.

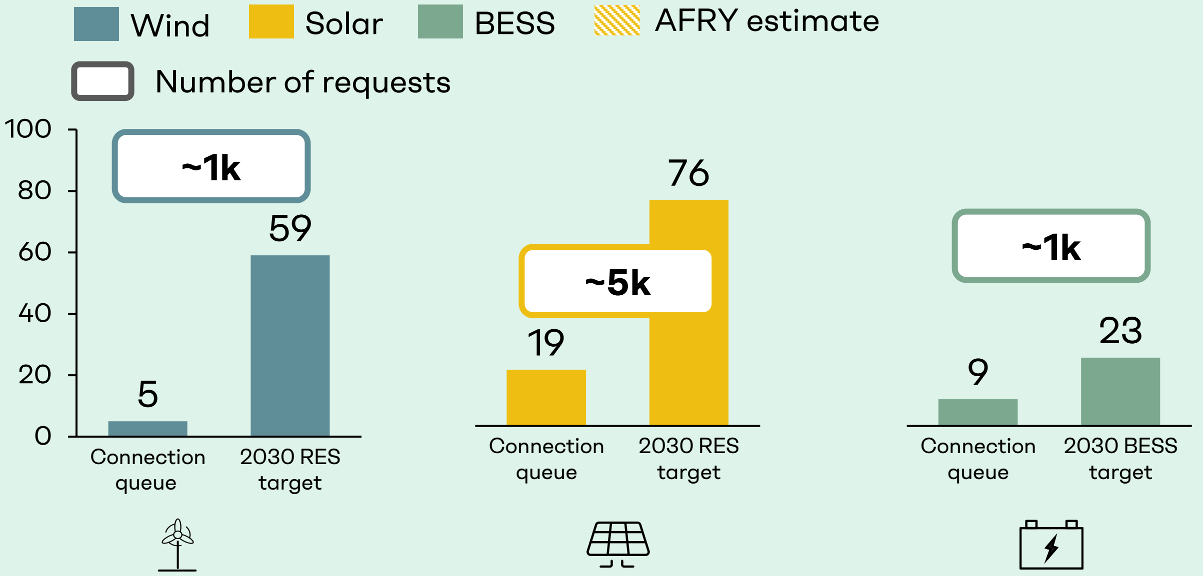
Spain

Market structure

The Spanish electricity system is a liberalized market characterized by:

- **a single national TSO** (Red Eléctrica de España (REE))
- **multiple DSOs** operating under regional concessions, with a limited number of large operators accounting for the majority of customers and network assets (Endesa, Naturgy and Iberdrola)
- the presence of large vertically integrated energy groups active in generation and retail supply

Grid connection queue at distribution level[1] against targets (GW)

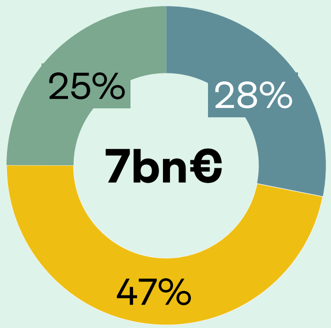


Queue-to-target ratio low, which is consistent with wind projects tending to be larger and more frequently processed at HV

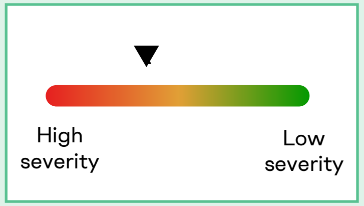
With the queue already amounting to around 25% of the target, the figures reflect Spain's rapid solar expansion over recent years, spanning both utility-scale projects and distributed installations

Queue already substantial relative to the target (close to ~40% on a simple ratio), suggesting that storage is rapidly scaling at distribution level

Value of the queue



Queue severity indicator



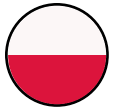
Notes: 1) As of Feb 2026; AFRY analysis on REE data. Targets as for NECP 2) To derive this estimate, AFRY applied the solar project success rate observed in its internal database to the 2030 solar PV target.

Spain

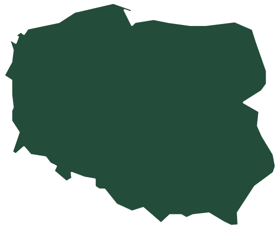
Governance	Spain's distribution grid access framework is anchored in **national legislation** (Royal Decree 1183/2020) and **CNMC[1] circulars** governing access and connection. The CNMC explicitly frames third-party access as a cornerstone of market liberalization and sets regulatory objectives that include facilitating the integration of new generation and storage. CNMC has published guidance clarifying how "dates" are computed for distribution-connected permits in the context of the milestone / expiry regime (Real Decreto-ley 23/2020). While at transmission level a reform has introduced capacity allocation tenders for demand, a more **recent reform** on the distribution side has **focused on process and transparency**. This includes a voluntary flexible access option for demand, alongside mandatory measures to standardize and increase transparency in connection procedures.
DSO Ownership	Spain's largest DSOs are predominantly owned by **vertically integrated utility groups**—i-DE (Iberdrola), e-distribución (Endesa/Enel), UFD (Naturgy), and EDP's distribution companies (E-Redes/Viesgo/Begasa, via an EDP–Macquarie partnership)—which inherently creates the need for strict neutrality safeguards in network operations.
Planning & Investment	Electricity Sector Law (Ley 24/2013) establishes an obligation for transmission and distribution network owners to submit **annual and multi-annual investment plans** for approval by the Ministry. There is no structured, generative public-consultation process prior to the publication of DSO development plans. This framework is operationalized through Government secondary legislation (Royal Decree 1048/2013). Decrees also set a **maximum annual investment volume** for distribution networks, expressed as a percentage of Spain's GDP forecast, namely **0.13% for distribution**. In parallel, the CNMC's distribution remuneration framework for the 2026–2031 regulatory period (Circular 8/2025) explicitly evolves the regulatory model toward a multi-annual **TOTEX** trajectory (investment + O&M[2]) combined with an incentive scheme and benefit-sharing, with the stated aim of promoting efficient investment. The approach to planning is centered on transition and decarbonization objectives; anticipatory investments are allowed, although mainly framed against macro-level development benchmarks rather than local parameters. Non-wires alternatives are not prioritized over conventional network reinforcement.
Connection process	Spain's **grid access** and connection regime is primarily **chronological**: Royal Decree 1183/2020 sets "prelación temporal" as the general ordering principle for granting access and connection permits (i.e., time-priority allocation), while allowing explicit exceptions (notably for capacity tenders and hybridization cases). There are no general or structural priority criteria for grid access based on the socio-economic benefits of projects. Nor is there, at present, a system of locationally differentiated connection charges used as an incentive. In some exceptional cases, access to specific nodes is allocated through competitive procedures. "Maturity" is primarily managed through requirements and documentation, and, above all, through milestones and the risk of lapse/expiry. A framework of guarantees and payments is in place to deter speculative applications. Accelerated/abbreviated procedures are available; an explicit operational threshold (at least for e-distribución) is ≤ 15 kW. The main DSOs referenced provide end-to-end digital channels. DSOs provide public web pages dedicated to capacity and connection information, including maps/datasets, methodology notes and disclaimers; i-DE also provides usage / interpretation instructions for the capacity map.
Transparency	Major DSOs have to publish standardized, **node-level access capacity data** (for nodes >1 kV) and present it through maps and/or downloadable datasets[4]. Low-voltage networks are not covered. There is no public information on the status of individual connection requests, nor a national, centralized data platform aggregating such information.
Fossil-free flexibility	For **demand,** the framework has expanded beyond pure "firm" access by enabling **voluntary flexible access** under CNMC Circular 1/2024. Network tariffs include time-of-use components, supported by high smart-meter penetration. The MITECO[3] approved a set of **pilot projects** under the national sandbox, including **S2F** (Soluciones de flexibilidad en redes de distribución), which explicitly proposes use cases involving local flexibility markets and flexible access capacity. E-Distribución, i-DE, and UFD are involved.

Notes: 1) Comisión Nacional de los Mercados y la Competencia. 2) Operation & Maintenance. 3) Ministry for the Ecological Transition. 4) RD 1183/2020 and CNMC circular requirements.

Poland



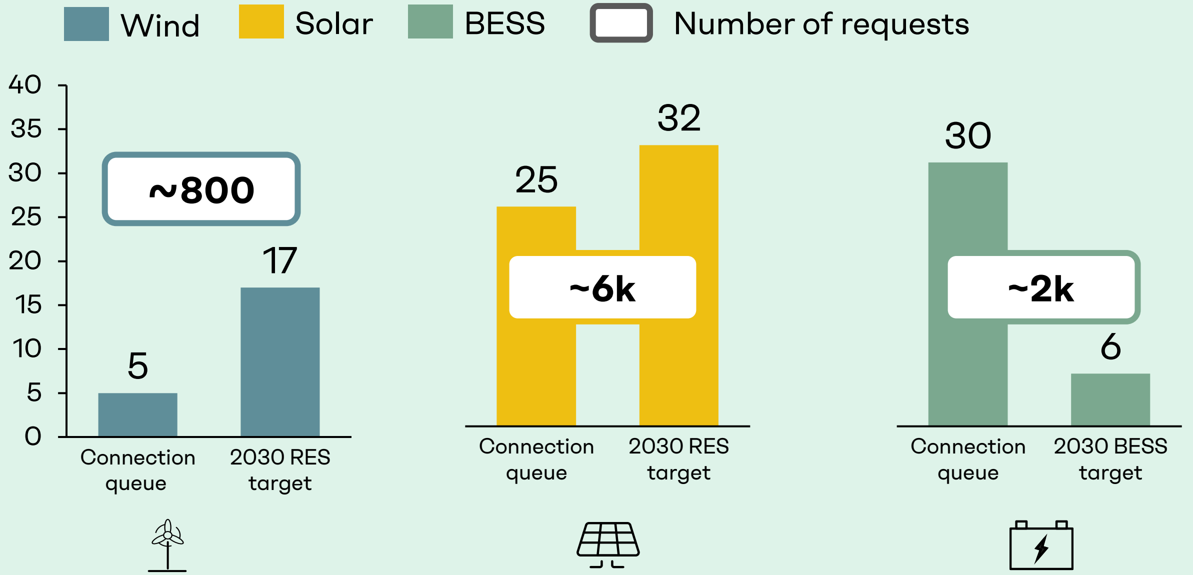
Market structure



The Polish electricity system is a liberalized market, characterized by:

- **multiple DSOs**, largely belonging to five major energy groups (PGE, TAURON, ENEA, ENERGA, E.ON), complemented by a number of smaller DSOs operating on limited geographic areas (around 200)
- **a single national TSO**, Polskie Sieci Elektroenergetyczne (PSE)
- competitive generation and supply activities alongside the continued presence of large, vertically integrated energy groups

Grid connection queue at distribution level[1] against targets (GW)

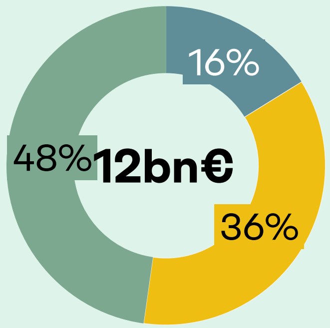


Onshore wind connection queue already materially significant, with projects largely concentrated on 110 kV networks that remain predominantly under DSO responsibility

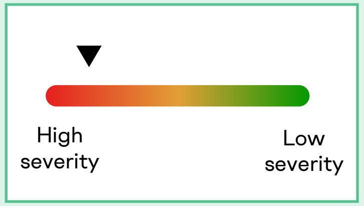
Distribution-connected PV is a structural pillar of the Polish market, creating persistent and systemic pressure on distribution networks

BESS connection queue disproportionately large relative to current market size, reflecting rapid acceleration of the storage segment supported by targeted regulatory and support measures

Value of the queue



Queue severity indicator



Notes: 1) As of Apr 2026; AFRY analysis on PSE data. Targets as for NECP

AFRY

Poland

Governance		The framework for distribution-grid connections in Poland is primarily defined by the **Polish Energy Law** (Prawo energetyczne), which sets the general connection regime, and the **Renewables Act**, which introduces technology-specific provisions. These rules are complemented by secondary legislation on system operation—most notably the **Ministry's regulation** on the functioning of the electricity system (Rozporządzenie MKiŚ of 22 March 2023)—and are implemented in detail through each DSO's **IRiESD**, approved and supervised by the President of URE. **Statutory timelines** apply to grid connection procedures, with formal enforcement mechanisms in case of non-compliance. While micro-installations follow a distinct technical and procedural regime, larger projects are subject to the full administrative and contractual process. Beyond connections, grid development planning is explicitly aligned with national energy and climate objectives, including the NECP, which must be reflected in DSO development plans approved by the regulator.
DSO Ownership		Four of Poland's largest DSOs have material shareholdings held by the Polish Treasury, and all five operate within large, vertically integrated utility groups active across the wider energy value chain. Regulatory safeguards are in place to mitigate conflicts of interest; nevertheless, recent media reports highlight competition inquiries into preferential treatment of group-linked RES connection requests.
Planning & Investment		Under Article 16 of the Polish Energy Law, DSOs are required to prepare a **network development plan**, which must take into account the NECP. The plan must cover a minimum six-year horizon, be updated every two years, and be approved by the URE. Stakeholder consultation is formally required; however, it remains largely technical and limited in scope, with little involvement of local communities. The planning approach is strongly regulatory-driven, with intensive ex-ante and ex-post scrutiny by the regulator, whose role tends to constrain rather than steer investments. Poland does not explicitly apply a formal "NWA-first" policy. Anticipatory investments are allowed but tend to remain tightly constrained, reflecting existing grid-capacity limitations.
Connection process		Following the adoption of UC84 (the so-called **Grid Act**, entered into force on **30 April 2026**), Poland is significantly tightening maturity and anti-speculation safeguards while expanding the use of flexible and commercial connection arrangements. According to URE's official position, connections must be granted on the basis of equal treatment and only where technical and economic conditions are met; any refusal must be duly justified and notified by the DSO. The reform replaces previously soft and discretionary practices with a **stricter and more automated regime**, including binding project milestones with automatic lapse of connection agreements in case of non-compliance, a reduction of the validity period of connection conditions from 24 to 12 months, and a layered system of non-refundable application fees, higher advance payments and performance securities. **Simplified** and fully digitized procedures apply at least to **micro-installations up to 50 kW**. These measures respond to Poland's structural grid congestion, which materially limits new RES and BESS connections at both transmission and distribution levels. **Policy responses** therefore combine **increased transparency** with **"connection efficiency" tools**—such as cable pooling, negotiated commercial connections where economic conditions are not met, and the formal recognition of direct load-to-generator connections in congested areas.
Transparency		Following the Grid Act, the five major DSOs that collectively cover the vast majority of the market are **required to publish quarterly lists of entities applying for grid connection**.
Fossil-free flexibility		"**Flexible connections**" in constrained areas—allowing earlier connection with temporary curtailment without compensation until reinforcements are completed—were explicitly **discussed** as part of the Grid Act mentioned above but are not implemented yet. Recent reforms have introduced distribution-network tariffs incorporating temporal signals. Poland has hosted pilot and demonstration initiatives on flexibility for several years. In September 2025, TAURON launched a flexibility service, signing its first contracts. Alongside this, TGE, TAURON Dystrybucja, and PSE have signed an agreement to establish a trading platform for flexibility services. Anyway, explicit incentives to support end-user participation in flexibility markets remain absent.

Notes: 1) Capacity associated with refused connection conditions reached ~83.6 GW in 2023. The refusals were attributed primarily to lack of technical conditions, due to an outdated infrastructure, and economic grounds.

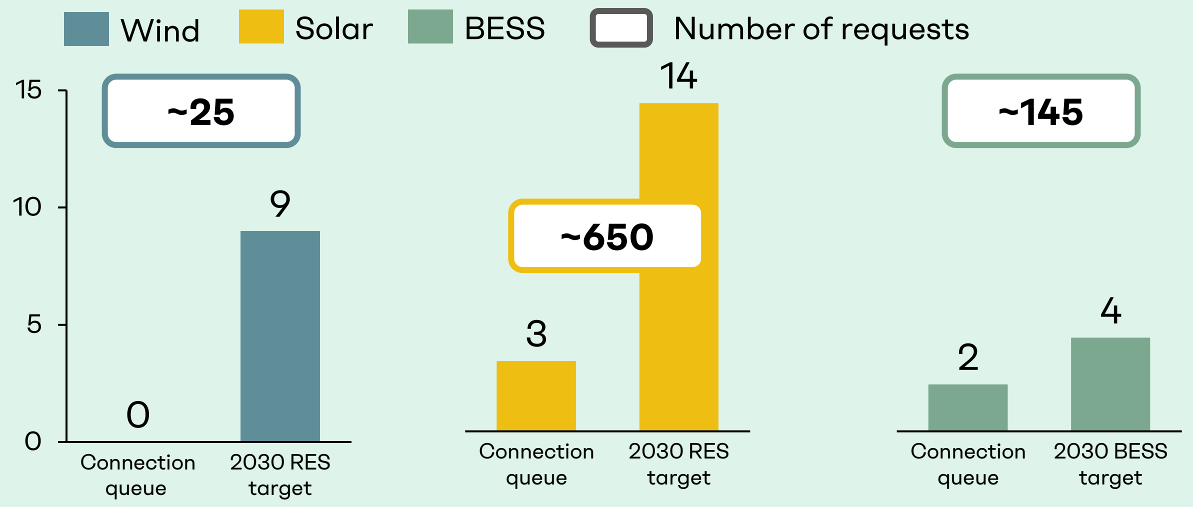
Greece

Market structure

The Greek electricity system is a liberalized market characterized by:

- Electricity distribution managed by **a single DSO**, HEDNO (DEDDIE)
- Transmission network operated by **a single national TSO**, IPTO (ADMIE)
- competitive generation and supply activities alongside a historically strong incumbent presence

Grid connection queue at distribution level[1] against targets (GW)

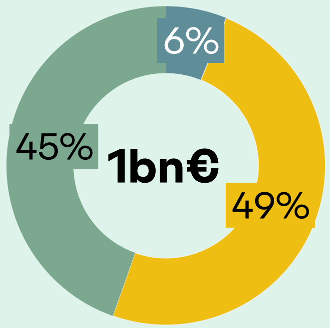


Onshore wind is expanding at a slower pace, reflecting longer permitting timelines and a development focus predominantly on HV connections

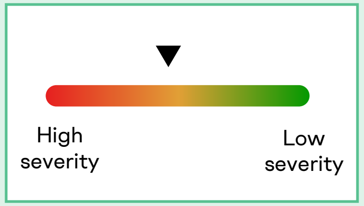
Queue at 20% of the 2030 target. In recent years, sharp expansion of small-scale PV installations, to the extent that measures to curb this growth were introduced

BESS pipeline also appears substantial relative to the stated targets, supported in recent years by dedicated incentive schemes

Value of the queue



Queue severity indicator



Notes: 1) As of Dec 2025. Targets as for NECP.

AFRY

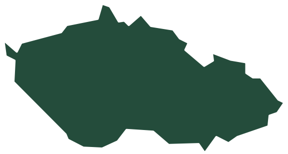
Greece

Governance	Greece's distribution-level grid access and connection framework is grounded in primary **national legislation** (Law 4001/2011) and implemented through the Hellenic **Distribution Network Code**[1], which serves as the implementing rulebook for network access, connection application protocols, performance targets, and development planning. The Distribution Network Code explicitly requires **network development procedures** to take into account multiple drivers, including the need to connect new users and environmental protection. The regulatory framework sets **performance targets** for distribution (losses, reliability, voltage quality, customer service) and includes penalty clauses linked to service quality, including incentives/penalties that are directly tied to **connection performance** (connection times, backlog reduction, and data quality for connection queues).
DSO Ownership	PPC (Greece's former vertically integrated incumbent) unbundled its distribution business into DEDDIE/HEDNO and later partially privatized it by selling a 49% stake to Macquarie. The risk of conflicts of interest is recognized and addressed through appropriate regulatory safeguards. Anyway, the presence of a single nationwide DSO contributes to uniformity.
Planning & Investment	The **multi-annual network development plan**[2] is prepared by the DSO, submitted to public consultation, and approved by the Authority (Law 4001/2011); it is subsequently published on the DSO's website. Network planning remains predominantly CAPEX-driven, and no structured "NWA-first" test—are in place. The Authority accepts that the plan may include investments to increase RES hosting capacity based on **scenarios/targets** (an "anticipatory" logic) but requires economic rationality as well as review and updates as new data become available. Severe and persistent grid congestion continues to push planning towards a largely reactive approach rather than a proactive one; **alternative tools** (e.g., demand control) as levers that could defer certain investments—tools are envisaged by the Code but **not yet implemented**.
Connection process	Following sustained pressure on grid connections, Greece has introduced a highly structured framework. A formal "Grid Connection Priority Regime" classifies projects according to policy-driven objectives (decarbonization, energy security, industry, territorial cohesion). Rather than a pure FCFS approach, **connection requests are grouped, ranked, and assessed within a defined priority framework**, with offers issued through publicly available lists reflecting a stable monthly priority order. "**Saturated networks**" follow dedicated lists and rules. For standalone storage, the process is gated on formal application completeness; once a "completeness date" is assigned, applications are processed chronologically. No regulatory mechanism based on locationally differentiated connection charges is used as an incentive. However, direct load-generator connections are formally recognized as an option in congested network areas, together with other forms of flexible connection. Connection applications can be fully digital. **Greece faces severe grid congestion**, and the DSO response focuses on (A) scarcity management **through lists and priority criteria**, (B) **grid investments**, and (C) higher hosting efficiency via operational rules and digitalization, such as the proposed framework on injection limitations for RES, currently under development.
Transparency	Although there is no formal obligation to publish congestion maps or equivalent tools, transparency is used as a key instrument to manage grid congestion. HEDNO publishes **maps**[3] **and information** on its website—albeit in a non-standardized format—together with announcements and archives of connection requests and available margins, helping stakeholders understand where and to what extent additional capacity may be connected.
Fossil-free flexibility	HEDNO participates in multiple EU R&I programs covering demand response / demand-side flexibility and local flexibility market concepts (e.g., X-FLEX, ENFLATE, EV4EU), while simultaneously upgrading SCADA/DMS and remote-control capabilities that are prerequisites for active network management. There is not any operational, recurring DSO-led flexibility procurement/dispatch scheme at scale. This is also linked to the limited rollout of smart meters and to the continued prevalence of static network tariffs.

Notes: 1) Κώδικας Διαχείρισης ΕΔΔΗΕ. 2) Σχέδιο Ανάπτυξης Δικτύου / ΣΑΔ. 3) public-facing, node-level hosting capacity disclosure via the WebAPE tool ("Χάρτης Περιθωρίων ΑΠΕ").

Czech Republic

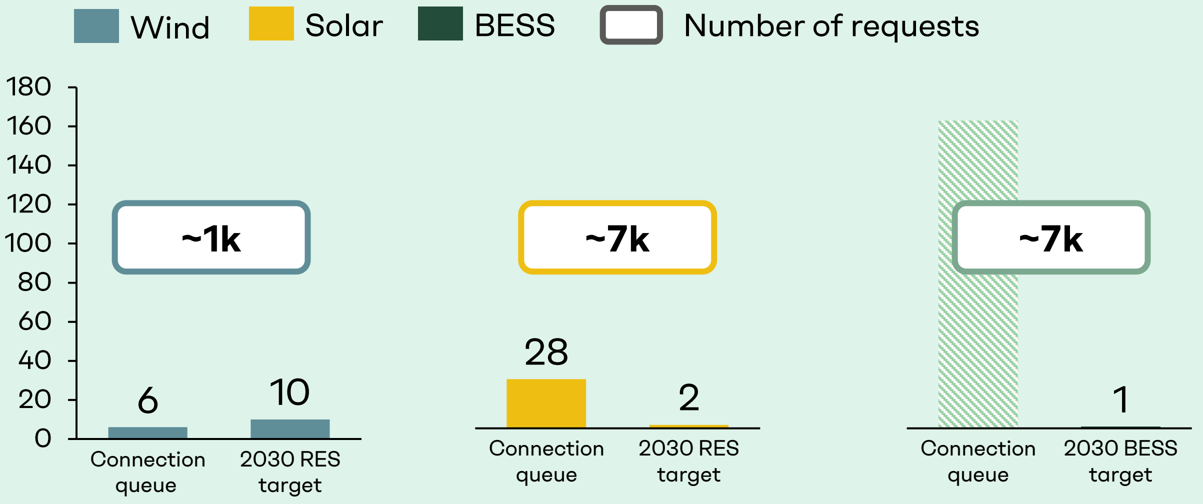
Market structure



The Czech electricity system is a liberalized market characterized by:

- Electricity distribution managed by **three main regional DSOs**—ČEZ Distribuce, EG.D and PREdistribuce—alongside a large number of small local DSOs operating limited networks
- Electricity transmission network operated by **a single national TSO**, ČEPS, which is fully state-owned
- legally unbundled generation, transmission, distribution and supply activities

Grid connection queue at distribution level[1] against targets (GW)

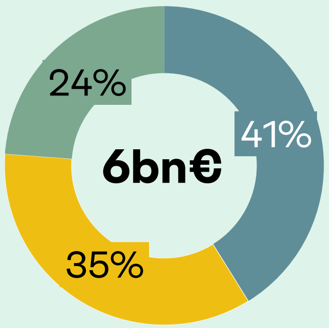


The connection queue has already reached around 50% of the stated target, indicating increasing pressure on the distribution network

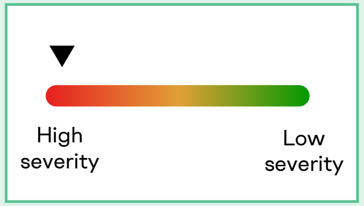
The queue has already reached very large volumes compared to the target, against the backdrop of a distribution network that is already highly congested

Pressure increased disproportionately in recent years. The scale of the issue suggests that a significant share of these requests is speculative; nevertheless, they still represent a material challenge for the DSOs

Value of the queue



Queue severity indicator



Notes: 1) As of Dec 2024. Targets as for NECP.

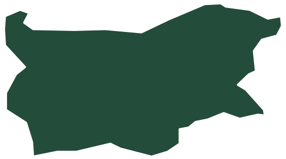
Czech Republic

Governance	Grid connections to the Czech distribution network are governed by the **Energy Act** (Act No. 458/2000 Sb.), **ERÚ[1] Decree** No. 16/2016 Sb. **on connection conditions**, and the **Distribution System Operation Rules** (PPDS)—in particular Annex 4, which sets the requirements for the parallel operation of generation and electricity storage with the DSO network. The Czech energy regulator (ERÚ) explicitly frames regular monitoring of connection outcomes (applications, acceptances, refusals, and realized connections) as necessary to ensure equal conditions and non-discriminatory access for applicants.
DSO Ownership	The three main Czech DSOs are owned by **large energy groups** (ČEZ[2], E.ON, PRE/EnBW). Conflicts of interest are managed through a package of safeguards. There is at least one well-documented case in which preferential treatment for large PV projects is alleged.
Planning & Investment	Czech DSOs **are required to prepare a Regional Distribution System Development Plan (PRDS)** at least biennially, while its planning horizon typically spans the next 5–10 years. The PRDS is published, opened to public consultation, and subsequently submitted to the ERÚ. However, consultation is predominantly technical in nature, and the regulator's involvement is largely technical and ex-post rather than strategic. While "anticipatory investment" is not codified as an explicit, recurring regulatory category, the overall framework provides limited support for proactive investment. DSOs' investment **incentives** remain largely skewed toward network expansion, as the regulatory framework is predominantly **CAPEX-oriented**. While OPEX- and efficiency-related KPIs have been introduced in recent years, they remain relatively unambitious. As a result, DSOs have limited incentives to actively pursue non-wire alternatives or non-investment solutions.
Connection process	FCFS applies, but it is not the only criterion: other elements act as maturity/queue-cleaning criteria, but they are not efficiently implemented. Indeed, projects can be accepted with alternative conditions ("accepted with restrictions"), for example with a **lower installed capacity**, a **lower reserved capacity**, or a connection that allows **production limitations upon DSO instruction** without compensation. For eligible **micro-sources[3]** that meet specific technical conditions, a **simplified connection pathway** exists: if the prescribed conditions are met, the DSO does not conduct a feasibility assessment and cannot refuse the connection under the simplified regime. Connection applications can be fully digital. At distribution level, the Czech connection bottleneck is real but geographically concentrated: it is most acute in EG.D's territory (notably South Moravia / parts of Moravia and Silesia), where DSOs increasingly restrict or delay export-enabled PV connections. Small residential PV is often still feasible, but surplus export may be limited (no-export / capped export), while medium-scale rooftop PV faces higher risk of downsizing or refusal in constrained feeders.
Transparency	**Public registers** related to RES grid-connection procedures are primarily published to ensure compliance with the applicable legal framework. In parallel, DSOs are required to disclose information on **available capacity at distribution-level electrical substations**. This information is typically made available through interactive maps published on DSO websites.
Fossil-free flexibility	"Non-guaranteed" connection / curtailment can therefore be used as a tool to increase capacity. These can be considered forms of "**flexible connection**." In the short term, DSOs are directing investment toward advanced technologies that enable more flexible management of network loading, while long-term physical reinforcements remain necessary. No real pilot projects have been implemented yet. Moreover, network time-of-use tariffs are absent, and low smart-meter penetration significantly constrains the effective deployment of flexibility solutions.

Notes: 1) Energy Regulatory Office. 2) The ČEZ Group has a shareholder structure with roughly ~70% held by the Czech State. 3) as defined in Decree No. 16/2016 Sb.

Bulgaria

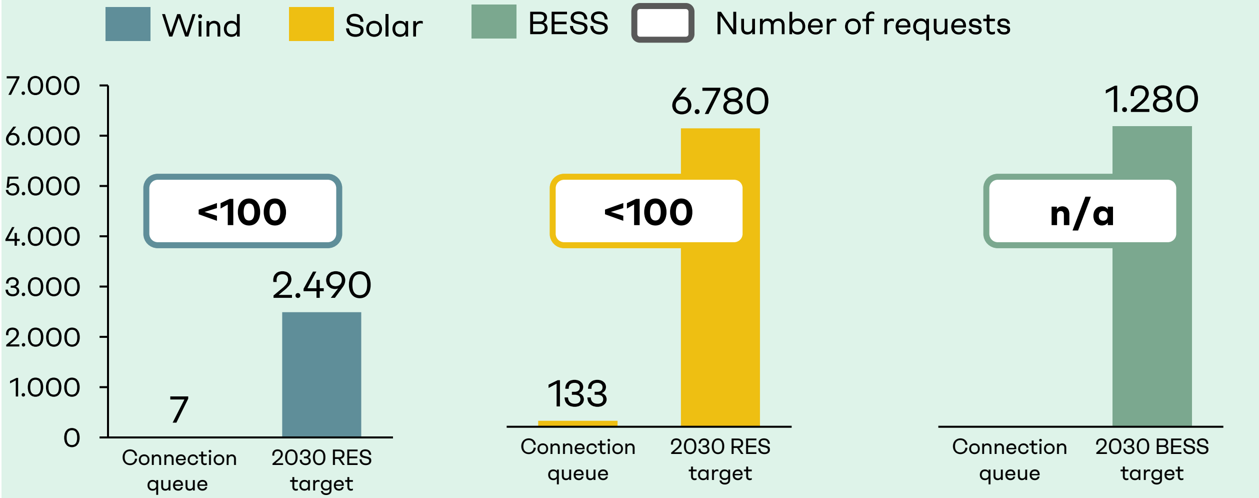
Market structure



The Bulgarian electricity system is a liberalized market characterized by:

- Electricity distribution primarily carried out by **three vertical players through their own regional distribution companies—** ENERGO-PRO, EVN, and Electrohold —as well as smaller licensed operators such as Elektrorazpredelenie Zlatni Pyasatsi AD (the Golden Sands resort area) and Balkan AD
- Electricity transmission network operated by **a single national TSO** (ESO EAD)

Grid connection queue at distribution level[1] against targets (MW)

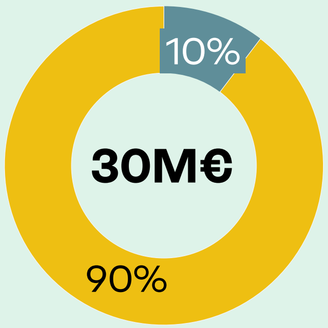


Onshore wind is underdeveloped and has been stagnant for years relative to its potential, primarily due to administrative barriers, legal uncertainty, and local opposition

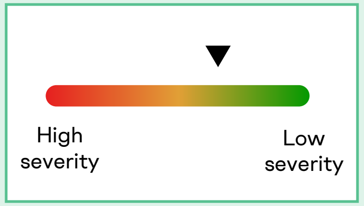
Small-scale deployment remains limited compared with utility-scale PV, with installations predominantly ground-mounted due to the complexity of the permitting process

Data limitation at distribution level. Big storage pipeline at transmission level, supported by incentive schemes

Value of the queue



Queue severity indicator



Notes: 1) As of Dec 2025. Targets as for NECP.

AFRY

Bulgaria

Governance	Bulgaria's grid connection framework is set out in **Ordinance No. 6 of 28 March 2024** on connecting sites to electricity networks, covering connections for consumption, generation, and electricity storage. Within this framework, certain procedural timelines for handling connection applications are explicitly defined. No explicit evidence of incentive or penalty mechanisms at DSO level that are directly tied to connection timeliness, backlog reduction, or the quality of queue data.
DSO Ownership	Bulgaria's main DSOs are part of **wider energy groups** that also run supply/trading (and in some cases generation). Even so, EU/national unbundling rules apply, alongside a set of "anti-discrimination" safeguards for network access. Some non-fair treatment has been documented specifically in relation to access to, or use of, distribution infrastructure.
Planning & Investment	DSOs are required to prepare a **distribution network development plan**. This plan should cover, on the one hand, measures to improve the efficiency of the existing network, including modernization and rehabilitation activities, and, on the other hand, the construction of new network assets. Distribution-level network planning is explicitly required to take into account a range of public-interest objectives (including, for example, security of supply, quality of electricity, and environmental protection). However, this requirement is **not framed through an explicit linkage to national decarbonization targets**. The energy regulator is mandated to approve and monitor the implementation of DSOs' investment plans—covering both maintenance and modernization—and to set **minimum levels for planned investment and repair expenditure**. Anticipatory investment and non-wires alternatives are not explicitly mentioned. Planning is predominantly reactive rather than proactive.
Connection process	Grid connection is implemented under technical conditions and connection arrangements defined by the relevant network operator, with an explicit reference to selecting the best **available solution from both a technical and economic perspective**. However, this formulation does not in itself amount to an explicit, nationally standardized FCFS rule for access. National **maturity gates** (title/ownership documentation; lapse in case of missing integrations; financial guarantees) act as filters against immature or speculative requests. Grid access is therefore managed through administrative filtering rather than explicit prioritization and is not differentiated on the basis of socio-economic or wider system-benefit criteria. National regulation requires network operators to enable submission and document exchange also via electronic means.
Transparency	**Public registers** related to RES grid-connection procedures appear to be published primarily to comply with the applicable legal framework. No mandatory requirement for DSOs to publish additional transparency tools such as capacity maps or broader capacity-check platforms. ERM Zapad provides on voluntary basis a public capacity-check feature that lets users select a region/municipality/locality and verify the "presence or absence of available capacity" for RES connections; the page also shows when the tool was last updated.
Fossil-free flexibility	A relevant element is a provision in the Energy Act under which the TSO and, respectively, DSOs may connect two or more sites whose combined import/export capacity exceeds the network's transfer capability, by setting the applicable technical requirements and contractually agreeing conditions for the optimal utilization of network capacity. This mechanism could resemble a **form of non-firm access** (i.e., access conditional on operational constraints), although "non-firm" is not explicitly stated in the cited legal provision. About flexibility procurement, there is no evidence of pilots. DSOs' initiatives are largely framed around **grid modernization and digitalization**. Network time-of-use tariffs are absent, and low smart-meter penetration significantly constrains the effective deployment of flexibility solutions.

Content

Distribution grids access is now a critical bottleneck for the energy transition; regulatory tools exist, but effective implementation is essential

Conclusions	Description
Distribution networks have become a critical bottleneck for the energy transition 01.	Connection congestion and queue backlogs are now as material at the distribution level as they are at the transmission level across multiple markets. In many of them, storage and PV queues have already reached a scale that can meaningfully affect system costs and slow the pace of the energy transition. Yet, these backlogs still remain a significant blind spot.
The current system is inefficient because it treats the queue like a delivery pipeline 02.	In reality, a substantial share of queued connection requests will never materialize. Without robust "maturity" filters, virtual saturation ties up available capacity and DSOs resources, slowing down the subset of projects that are genuinely ready to build.
The economic stakes are already very large 03.	Even under conservative success-rate assumptions, the study estimates that around €100bn of value is "blocked" in connection queues. The magnitude of this delayed private investment highlights the tangible impact of connection delays in constraining European economic growth and hindering the energy transition.
Regulatory momentum exists, but stronger enforcement is still needed 04.	EU policy is increasingly converging around a common direction, but implementation remains uneven across Member States, and effective enforcement is still critical. Regulatory recommendations can deliver results only if they are translated into operational mechanisms (incentives, enforcement levers, data transparency, adequate resourcing) and if they are explicitly designed to address the specific bottleneck they aim to resolve.

Content

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In addition to generation plants, many consumption units, which actively contribute to the energy transition, are also stuck in the queue

Case study: EV charging infrastructure in Italy

- **Motus-E** (an Italian industry association) reports that, as of 31 December 2025, Italy had 73,047 public charging points installed across 38,854 charging stations and 24,187 sites. Of these, 62,145 charging points were operational, while the remaining **14.9%** were **temporarily unavailable** as they **were awaiting connection to the electricity grid**[1].
- These activation bottlenecks contribute to a charging network that is not yet sufficiently widespread and reliable, which in turn is one of the factors behind Italy's slower uptake of electric vehicles compared with leading European markets.
- Against this backdrop, Motus-E highlights that a key priority is to streamline, accelerate and increasingly digitalize both permitting and grid-connection procedures—consistent with the direction of the European Grids Package.

	LV	MV
Average activation time	3-4 months	7-8 months
Inactive share	12%	30%

Case study: Connection queue on demand side in GB

- The latest figures released by the **Energy Networks Association** on connection queues in GB (June 2025) indicate that 106 GW of demand-side capacity is currently stalled in the queue. This confirms that the queue challenge is not limited to generation injections: it is increasingly material also on the demand side.
- It is also noteworthy that the Association publishes a split of queued volumes by the type of network works required. Data show that ≈20% of the queue is held up by the time and capacity needed to assess, decide and communicate reinforcement needs, rather than construction itself. In practice, this points to process throughput limitations, which can be tackled through clearer service levels, standardized assessment methodologies, and greater digitalization/automation of triage.

Distribution queue by network works

No reinforcement needed + distribution reinforcement needed	60 GW
Transmission reinforcement needed + Distribution and Transmission reinforcement needed	79 GW
Awaiting decision on reinforcement requirements (if any)	35 GW

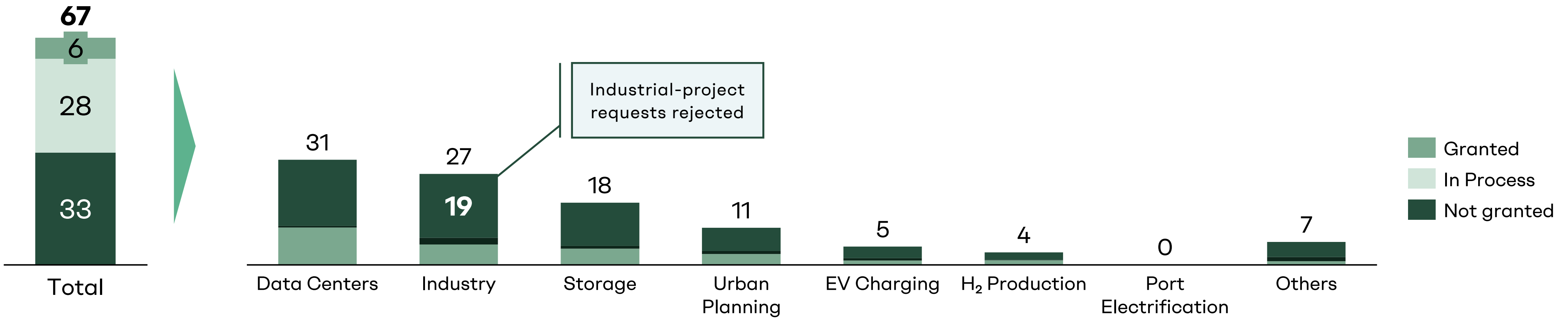
Sources: 1) Motus-e (2025), Le infrastrutture di ricarica a uso pubblico in Italia, settima edizione.

As new industries seek grid access, meeting this demand would offer a pathway to transition-aligned electrification and unlock green reindustrialization-led growth

Case study: Connection queue on demand side in Spain

- Eurelectric reports that electrification demand in Spain is rising on two fronts: existing loads are seeking to electrify, while new industrial players are applying for grid access and connection to establish operations in the country. In 2024, requests to DSOs amounted to around 40% of Spain's current contracted capacity (174.5 GW).
- Eurelectric flags concerns that demand integration is not progressing fast enough: the share of requests that cannot be granted—primarily due to insufficient capacity—is increasing at a double-digit rate and, by 2024, already represented 50% of the requested capacity. The inability to progress 19 GW of industrial-project requests is particularly concerning given their potential contribution to the Spanish economy; if these needs are not met in a timely manner, the broader opportunity may not materialize.

Total capacity requested in 2024 to Spanish DSOs, broken down by processing status and demand type[1] (GW)



Sources: 1) Eurelectric (2025), From Backlog to Breakthrough: Managing Connection Queues in Distribution Networks.

Content

Germany (1/2)

Data sources and interpretation note

- The analysis relies primarily on the **Market Master Data Register** (Marktstammdatenregister – MaStR), which is the national registry for electricity generation units in Germany. The register includes all permanently installed ("ortsfest") generation assets and allows projects to be recorded at different stages, including in planning ("in Planung"), under construction, or commissioned. The MaStR lets users filter data (including by location) and exported. Registration requirements differ by technology. In particular, only wind projects are subject to mandatory registration already at the planning stage, due to the need for federal-level permits (e.g. under the Federal Immission Control Act). By contrast, solar PV projects are not required to be registered while still in planning, and registration becomes mandatory only shortly before or after commissioning. As a result, the figures presented for solar PV connection queues are likely to underestimate the actual pipeline of projects awaiting connection, especially at distribution level. A similar "visibility gap" affect storage.
- To derive a more realistic indication of the scale of the solar PV pipeline, AFRY applied a simplified, target-based methodology. Starting from the national 2030 solar PV installation target, the target was evenly distributed over the five-year period from 2026 to 2030 to derive an implied annual installation rate. This annual rate was then interpreted as a share of total grid-connection requests, corresponding to AFRY's standard project success rate for grid connection (e.g. 25%). On this basis, the total volume of connection requests was inferred by scaling up the annual buildable capacity by the inverse of the assumed success rate. The number of solar PV connection requests was calculated by applying an average project size of 6 MW, while for other technologies the actual figures reported by the respective data sources were used. The resulting figures should therefore be interpreted as indicative, but they provide a useful order-of-magnitude estimate of the underlying queue.
- To complement register-based evidence, to estimate the BESS queue, we used the Federal Network Agency's (Bundesnetzagentur) 2024 monitoring-based figures. Battery-related figures reported for 2024 are already substantial. However, given that grid connection backlogs at higher voltage levels further deteriorated in 2025 (total requests for 720 GW), it is likely that the backlog at distribution level is larger than what is currently reflected in the available data.
- For the purpose of this study, we restricted the scope to projects **larger than 1 MW** connected to distribution grids, to ensure cross-country comparability. In practice, achieving consistent visibility below the 1 MW level is extremely challenging, as small-scale projects are rarely captured in a harmonized way across national datasets. At the same time, this means that the pipeline can be materially understated here, especially for resources with a massive distributed presence, as PV and BESS. Differences in registration obligations and data coverage mean that results should be interpreted with caution, particularly when comparing technologies or extrapolating solar PV queue volumes.
- Hybridization projects (e.g., PV coupled with batteries) are not fully observable as a distinct category in the available datasets; therefore, the contribution of hybrid plants is captured indirectly by accounting for solar and storage volumes separately, rather than as an integrated "hybrid" queue.

Germany (2/2)

Data sources and interpretation note

- For electricity consumption units (such as EV charging infrastructure), there is no single, harmonized national statistic on pending connection requests. While there is strong qualitative evidence of backlogs and delays, available data is limited to proxies or partial indicators rather than an official, comprehensive queue count.
- In Germany, DSOs publish local or regional maps showing area-based loading and congestion conditions, often through a qualitative identification of critical zones intended to support and guide connection requests (e.g., indicating where reinforcement needs or constraints are more likely). However, these maps are not centralized and do not consistently cover all DSOs, reflecting the fragmented structure of the German distribution landscape. The most comprehensive aggregation point for distribution-level planning information is the DSO Portal ("VNB digital"), which consolidates DSOs' official publications on network status, reinforcement needs, and regional scenario data. The Federal Network Agency recently published a valuable dataset for this purpose, based on the self-declarations of over 800 distribution network operators. The 1000GW Institute is now making this data visible: on maps, as scatterplots, and in benchmarking. There is no data on queues, but rather on request processing times.

Great Britain

Data sources and interpretation note

- To estimate the data related to the grid connection queue, the Northern Powergrid database was used. This database provides a comprehensive register of all projects that have applied for a grid connection, distinguishing between "connected" and "accepted request". Projects falling into the latter category were classified as projects in the connection queue. Data availability provides visibility on projects larger than 50 kW. When narrowing the scope to projects above 1 MW, the number of connection requests declines; however, the issue remains unchanged in capacity terms, as the volumes involved (in GW) are broadly comparable.
- The capacity figures were then extrapolated to the entire GB territory, taking into account that Northern Powergrid represents approximately **13% of the GB distribution market**, measured by the number of connected customers. To estimate the corresponding number of connection requests at national level, the average project size derived from the Northern Powergrid dataset was applied.
- The resulting figures indicate a total of **186 GW of connection requests**. This value is broadly consistent with the aggregated figure published in the "Joint Transmission & Distribution Databook" by **ENA** (Energy Networks Association), under the Export & Storage category, which refers to generation units connected to the distribution network. Considering that this register only includes connection requests above 1 MW, it is reasonable to infer that the reported value underestimates the actual scale of the issue.
- Overall, the GB is one of the most transparent markets in terms of publicly available data. This is due to the presence of binding transparency obligations. In particular, the publication of Long Term Development Statements (LTDS) has long been a mandatory requirement for Distribution Network Operators (DNOs), "mandated through a direction, pursuant to paragraph 25.2" of the Electricity Distribution Licence Standard Conditions.
- The updated Direction introduces **explicit data-driven transparency requirements**, including the publication of **grid model data** (in Common Information Model – CIM format) and the publication of **Capacity Heatmap data**, i.e. standardized information on available capacity and network congestion.
- In the GB, a new grid connections reform package (TMO4+) was approved in 2025. The reform replaces the historical FCFS principle with a gated approach: only projects that can demonstrate both readiness and strategic alignment are awarded a firm position in the connections queue (including a confirmed connection date and point of connection). Projects that do not meet these Gate 2 requirements are issued an indicative offer, which may be revised as the queue is re-assessed over time. Anyway, the reform is primarily targeted at the transmission-facing connections process; it has implications for DNOs/DSOs through associated license and code changes and because certain distribution-connected generation and storage projects that require a Transmission Impact Assessment (TIA) are assessed under the same gated framework. By contrast, purely distribution-level demand connections are generally out of scope of the reform.

Italy

Data sources and interpretation note

- Publicly available information mainly concerns the number of plants actually connected on a year-by-year basis, while there is limited visibility on the total number of connection requests received.
- In Italy, a partial transparency tool for connection requests is Terna's e-Connection portal, which, however, only covers high-voltage (HV) connections. For low- and medium-voltage (LV/MV) connections, DSOs do not systematically publish comprehensive data on the total number of requests received or on the connection backlog.
- DSOs submit quarterly reports to Terna pursuant to TICA Articles 37–38, covering LV/MV generation plants to be connected. These reports contain aggregated information (e.g. at primary substation level) and are handled separately from HV/EHV connection procedures. To estimate the number and capacity of projects awaiting connection, the analysis relies on the connection requests submitted by DSOs to Terna that are attributable to renewable generation plants. This approach implies that **the resulting figures may be underestimated**, as it excludes all projects that do not affect the high-voltage (HV) network—typically sub-1 MW installations.
- The reference dataset from Terna's 2025 Development Plan was therefore rescaled and disaggregated by technology, based on the current composition of connection requests. To estimate the number of individual requests, average project size assumptions were made (namely: Solar PV: ~6 MW; Wind: ~4 MW; Storage: ~15 MW). Size assumptions are larger than those typically observed in Italy; AFRY adopted these thresholds to enable a more robust cross-country comparison across heterogeneous datasets.
- Hybridization projects (e.g., PV coupled with batteries) are not fully observable as a distinct category in the available datasets; therefore, the contribution of hybrid plants is captured indirectly by accounting for solar and storage volumes separately, rather than as an integrated "hybrid" queue.
- As intermediate transparency measures, DSOs publish the following information:
  - **Primary substation AT/MT sections with reverse power flows**, as required by TICA – Article 4, paragraph 4.2(c).The list identifies substations where reverse energy flows were recorded in the previous calendar year for at least 1% and 5% of annual hours, respectively
  - **Critical Areas Maps**, providing an interactive and qualitative indication of network capacity availability, through a classification of geographical areas by level of criticality[1]
- Overall, **connection progress is strongly influenced by permitting** timelines. In LV/MV networks, construction timelines reported as for "Commercial Quality of Service" are net of suspensions, including those related to permitting procedures. As a result, there is a structural component of "reserved" or "pending" capacity that cannot be observed through data on plants actually connected alone, and which remains largely invisible in publicly available statistics.

Notes: 1) For e-distribuzione, this tool is publicly available here.

Spain

Data sources and interpretation note

- Red Eléctrica de España (REE), the national TSO, publishes information on the number of access requests received for new capacity and the corresponding requested capacity (MW) at national level. A more granular visualization is also available, including regional-level data. The figures reported clearly distinguish between requests related to the transmission network and those related to the distribution network. However, the dataset does not include all access requests to the distribution network. It only covers those distribution-level requests for which DSOs are required to submit information to REE because the projects may have an impact on the transmission network (size >1 MW). As a result, the data considered should be regarded as partial. AFRY estimates that the backlog at lower capacity levels, at least for solar, could be at least of a comparable magnitude.
- Access requests are classified into three status categories:
  - **In service** (Puestas en servicio): installations that have obtained all required permits (access and connection), have been built and commissioned, and are already in operation, injecting electricity into the grid
  - **With permit** (Con permisos): installations that have already obtained both access and connection permits in accordance with the applicable regulation. These projects are authorized to proceed to construction and subsequently request commissioning, but are not yet operational
  - **In progress** (En curso): access and/or connection requests that are still under assessment and have not yet received a final permit. This category includes requests under technical evaluation, requests awaiting corrections from the developer, and applications in the administrative phase.
- To estimate the project queue, only projects classified as "with permit" and "in progress" in this registry were considered.
- The number of grid connection requests was estimated indirectly by applying the same average project sizes assumptions used for other countries (i.e. Solar PV: ~6 MW; Wind: ~4 MW; Storage: ~15 MW), in order to ensure a reasonable level of comparability across geographies.
- Hybridization projects are treated as a separate category in the Spanish reporting framework and are therefore not embedded within the solar and wind figures presented for generation. As a result, the reported solar and wind volumes should be interpreted as **excluding hybridized capacity**, which is accounted for separately; the order of magnitude of hybridized projects is estimated at 1.6 GW.
- Finally, Spanish DSOs are required under Royal Decree 1183/2020 and CNMC Circulars to publish the available access capacity at grid nodes above 1 kV. This information is made publicly available through interactive maps or georeferenced datasets, using color coding or numerical values to indicate saturated nodes, partially available capacity, or available capacity. These tools therefore constitute functional equivalents of congestion heat maps, even if they are not always explicitly labelled as such.

Poland

Data sources and interpretation note

- The figures for Poland were derived primarily from publicly available information published by **Polskie Sieci Elektroenergetyczne** (PSE), the Polish transmission system operator (TSO), in the context of the "Transmission Network Development Plan for 2027–2036" (Plan rozwoju w zakresie zaspokojenia obecnego iprzyszłego zapotrzebowania na energię elektryczną na lata 2027-2036). Figures are available for high and medium voltage.
- PSE documentation distinguishes projects by technology (wind, solar PV and BESS) and network level (transmission vs. distribution). Large-scale wind and solar projects are typically processed at transmission or high-voltage distribution levels; smaller PV installations dominate the medium- and low-voltage distribution grid but are often reported in a more aggregated or fragmented way by DSOs. As a result, the distribution-level queue visible in the chart should be interpreted as an indicative representation of connection pressure, rather than a precise or exhaustive measure of system-wide conditions.
- The number of grid connection requests was estimated indirectly by applying the average project sizes used for other countries (i.e. Solar PV: ~6 MW; Wind: ~4 MW; Storage: ~15 MW), in order to ensure a reasonable level of comparability across geographies. This is, of course, a simplification: because Polish DSOs operate both low- and high-voltage networks, typical project sizes differ slightly. Wind projects tend to be larger, while smaller solar installations are concentrated at lower voltage levels; at higher voltage levels, the average size of solar plants has increased in recent years.
- PSE also publishes data on refused connection requests by reason for refusal, without distinguishing between voltage levels. The reasons include technical, economic, or a combination of both. Technical constraints are the dominant driver across all years, both in terms of number of projects and refused capacity. This points to persistent congestion and insufficient grid hosting capacity in several regions. The sharp increase in refused capacity between 2022 and 2023 reflects a rapid surge in connection requests. The presence of a large "technical + economic" category suggests that, in many cases, resolving physical constraints would require network reinforcements that are not considered economically viable under current rules.
- Poland displays a relatively **good level of transparency**. At the transmission level, PSE publishes consolidated and well-structured information on grid-connection applications, refusals and their underlying reasons, as well as system development plans and planning assumptions. At the distribution level, all five major DSOs—which together cover the vast majority of the market—**publish quarterly lists of grid-connection applicants**, and several smaller DSOs provide similar disclosures. However, transparency remains heterogeneous across operators: some DSOs offer interactive maps, while others mainly publish static tables or PDF documents.
- No publicly available data were identified for demand-side units within the scope of this analysis.

Greece

Data sources and interpretation note

- For Greece, the estimates of the DSO-level connection queue are derived from **official publications by HEDNO/DEDDIE**, which maintain public registries of connection applications under their jurisdiction. Two distinct extraction approaches were used, reflecting differences in the underlying regulatory process and in the maturity/validation status of the projects captured by each source.
- For RES (and "other" non-storage generation under DSO jurisdiction), the queue is built from the public archive of connection applications under HEDNO's competence, which relates to the processing of pending connection requests for RES & CHP plants. In this approach, applications are counted as being "in the queue" only if they:
  - have not yet received a Final Connection Offer (Οριστική Προσφορά Σύνδεσης) and
  - have not been activated or cancelled.
- For standalone BESS, a more stringent, "gated" dataset is used: projects included correspond to applications published by HEDNO/DEDDIE as "complete applications" (βεβαίωση/ημερομηνία πληρότητας), pursuant to Article 3(4) of Ministerial Decision ΥΠΕΝ/ΓΔΕ/28255/1143/2024 (Government Gazette FEK 1248/B/13.03.2025). The DSO publication explicitly describes this list as the set of requests submitted up to the relevant cycle (referenced as October 2025 in the DSO announcement) that have received a completeness confirmation for granting a Final Connection Offer to standalone storage stations. Methodologically, these projects are treated as being in the DSO-level queue because they:
  - have submitted a full application for a Final Connection Offer,
  - have been formally validated by the DSO as complete, and
  - have not yet received the Final Connection Offer.
- The expected reliability of this dataset is robust, as it is produced and maintained by the competent DSO for the purposes of transparency on connection requests. However, this has to be considered as a lower bound: if projects that have been accepted but are not yet physically connected were also taken into account, the figures would be higher.
- DEDDIE / HEDNO publishes a dedicated map of RES "margins" ("Χάρτης Περιθωρίων ΑΠΕ[1]"), showing the absorption capacity by geographical area. The data are indicative, and the margins are calculated (among other factors) with reference to transformer thermal limits and short-circuit capacity.
- No publicly available data were identified for demand-side units within the scope of this analysis.

Note: 1) Available here.

Czech Republic

Data sources and interpretation note

- For the Czech Republic, the key sources include "Možnosti zlepšení integrace obnovitelných zdrojů do elektrizační soustavy: Otázky zadavatele", a study prepared for Friends of the Earth Czechia. The analysis is based on **actual DSOs data** as of end-2024 and, while not fully up to date, provides a useful indication of the level of pressure on the distribution network. This was complemented by insights from sector associations partnered with BFF, which supported the derivation of the technology split (solar vs. wind). The high figures reported reflect the fact that, in the Czech Republic, part of the high- and extra-high-voltage network is operated by DSOs.
- The number of solar and wind connection requests was derived by applying the average project sizes already used for other countries (i.e. Solar PV: ~6 MW; Wind: ~4 MW), in order to ensure a reasonable level of comparability across geographies.
- With regard to **batteries**, no single, comprehensive source presenting aggregated and fully reliable data was identified. However, ČEZ Distribuce reports in an official press release that in 2025 it received over 6,000 grid-connection requests for batteries, with a total storage capacity of 351 GWh and a total power of **170 GW** across the high- and extra-high-voltage network, compared with available connection capacity for stand-alone batteries in the network of only around 800 MW. This refers to just one distribution operator, and the topic is currently the subject of intense debate in the Czech Republic.
- The BESS connection queue has grown to exceptionally large levels since legislation allowing stand-alone battery connections entered into force. This has been driven primarily by speculative applications, including mass submissions enabled by AI tools. Some investors, particularly targeting revenues from system balancing services, have sought to reserve very large capacities across the country. A key issue was the absence of a fee for submitting a grid-connection application. The regulator now intends to introduce such a fee to discourage speculative behavior and prevent repeated mass submissions after application deadlines.
- Regardless of how many requests may have been processed or rejected, the bar shown in the chart in the body of the document is intended to illustrate the scale of the issue rather than to provide a precise estimate of the actual backlog.
- In light of the specific context, a significantly lower project success rate was applied for the Czech Republic only when estimating system costs, set at **1%**. This reflects the fact that expressed developer interest exceeds available network capacity by a factor of approximately 200.
- In the Czech Republic, grid hosting maps are available as per energy law.
- No publicly available data were identified for demand-side units within the scope of this analysis.

Bulgaria

Data sources and interpretation note

- The analysis for Bulgaria is based on publicly available, aggregated information on grid connection queues and pending projects. Publicly available sources provide **aggregated data** on the number of projects and the total requested capacity (MW) currently in the connection queue, with a **distinction between DSO-level and TSO-level** applications. These datasets generally cover projects that have formally fulfilled the application criteria and are therefore considered to be awaiting grid connection. The information is typically updated on a periodic basis (approximately quarterly), allowing for a snapshot view of the size and evolution of the connection pipeline.
- Only projects that have passed the formal application stage and are included in official registries are considered. Informal expressions of interest or early-stage developments not yet registered are excluded. This implies that the figures represent a lower bound of overall developer interest, but a reliable proxy for effective pressure on the grid.
- The publicly available datasets do not systematically provide a breakdown by generation technology. To estimate the technology split, an assumption has been applied whereby approximately **95% of the queued capacity is attributed to solar PV**. This assumption is supported by multiple qualitative and market-based considerations. Onshore wind capacity is not expected to grow significantly, due to regulatory constraints and persistent resistance at local level, which limits new project development. Given these factors, solar PV is considered the dominant technology driving new connection requests.
- Overall, the Bulgarian connection market is characterized by **limited transparency** and **significant access barriers**. Securing a grid connection is widely regarded as difficult, and qualitative evidence suggests that outcomes may depend not only on formal criteria but also on the ability to navigate institutional processes and maintain effective coordination with TSOs and DSOs. As a result, while the aggregated figures provide a robust indication of overall congestion and demand for connections, they should be interpreted with caution when used for granular forecasting or technology-specific analysis.
- In Bulgaria, there is a **public capacity-check tool**[1] (not strictly a color-coded geographic "heat map"), which allows users to select an area/municipality/locality and verify the "presence or absence of available capacity" for RES connection.
- No publicly available data were identified for battery energy storage systems or demand-side units within the scope of this analysis.

Notes: 1) Available here.

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