REGULATORY ASSISTANCE PROJECT

# Navigating power grid scarcity in the age of renewable energy

## Policy and regulatory context and tools

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# Executive Summary

The lack of power grid capacity is increasingly the new normal in many parts of the world, evolving to be one of the key barriers in the energy transition. As grids are essential for decarbonising the power sector and the overall economy, all options to ease grid scarcity — from quick fixes to more fundamental solutions — are worth considering. We need new grids (at the right locations) and, importantly, must improve the use of what we have now. Regulatory tools can be grouped into:

- (re)allocation of remaining grid capacities,
- better use of existing grid capacities, and
- creating new grid capacities.

National regulators employ a range of options to deal with the grid problem. For the more efficient allocation of existing grid capacity, the publication of grid hosting capacity maps by grid operators is one key solution. These maps alleviate the number of grid connection requests submitted to the transmission system operator (TSO) and distribution system operator (DSO), as project promoters would not need to submit multiple grid connection requests for various locations. It enables identifying where new capacity can be connected and where flexibility solutions such as storage and demand-side flexibility are in high demand (see our case study of Belgium).

Cable pooling or shared connection is another often-used tool to make best use of available connection capacities, but other measures need to be implemented to make the grid connection process more efficient and to bring more renewables online quicker (see our case study of Poland).

The development of new renewable energy resources, such as wind and solar PV, drives new grid capacity. Those resources often are located in different areas than old power plants, a long distance from load centres. Therefore, spatial planning for renewable energy can be an important factor in power grid investment planning (see our case study of Texas).

The survey conducted by the ERRA Secretariat confirmed that grid congestion is already a problem for all or some zones in most countries. In others they expect it to become an issue, mainly due to renewable projects wanting to connect to the grid.

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## Acronyms

| | |
|---|---|
| CREZ | Competitive Renewable Energy Zone |
| CfD | Contract-for-difference |
| DSO | Distribution system operator |
| ENTSO-E | European Network of Transmission System Operators for Electricity |
| ERCOT | Electric Reliability Council of Texas |
| FACTs | Flexible Alternating Current Transmission System |
| GETs | Grid enhancing technologies |
| ISO | Independent system operator |
| NECP | National energy and climate plan |
| NRA | National regulatory authority |
| NERC | North American Electric Reliability Corporation |
| OPEX | Operational expenditure |
| PV | Photovoltaics |
| PSE | Polskie Sieci Elektroenergetyczne S.A. |
| RES | Renewable energy sources |
| TSO | Transmission system operator |
| UKPN | UK Power Network |

# Introduction

The lack of power grid capacity is increasingly the new normal in many parts of the world, evolving to be one of the key barriers in the energy transition. Power grids are the main integrators of future energy systems, fundamental vehicles for the swap from fossil to renewable generation capacity, and electrification facilitated by maximum flexibility.

The widening gap between available and optimal grid capacity (we do not aim for a grid without any congestion) is manifested in clogged connection queues, increasing congestion management costs, and rising curtailment of renewable energy sources. Optimal grid capacity is when the cost to society of congestion in terms of curtailment, $CO_2$, redispatch, etc. is equal to the cost of adding new grid capacity.

As grids are essential for decarbonising the power sector and the overall economy, all options to ease grid scarcity — from quick fixes to more fundamental solutions — are worth considering. We need new grids (at the right locations) and, importantly, must improve the use of what we have now. Technology development opens the door for the 'smarting' of grids and the system-friendly integration of millions of distributed energy resources.

The goal of this paper is to help policy makers and regulators to tackle the problem caused by insufficient power grid capacity by

- providing an overview of regulatory tools (RAP's 'Grid scarcity Toolbox') that can be employed to ease grid congestion grouped by their aim: utilization of existing grid capacities, (re)allocation of remaining grid capacities, and creating new grid capacities,
- discussing a real-world implementation of a regulatory tool from each group above:
    - (re)allocation of remaining grid capacities: hosting capacity maps in Belgium
    - utilization of existing grid capacities: cable pooling in Poland
    - creating new grid capacities: competitive renewable energy zones in Texas (U.S.),
- providing an indicative overview of grid scarcity and actions to tackle it in selected ERRA members countries, and
- drawing a set of recommendations for policymakers and regulators.

# Grid scarcity toolbox

Not having enough grid capacity became a top priority in several countries, as it limits and slows down the switch from fossils to renewables and electrify transport, heating and industry and is a barrier for economic growth and competitiveness. After taking a closer look at how the government and the regulator of the Netherlands[1] — being the most severely impacted country in Europe – deals with problem, RAP has developed a regulatory toolkit for tackling power grid scarcity in its report entitled *RIP: First come, first served.*[2]

The following table from the mentioned report provides a list of regulatory tools that can be employed by national regulators to ease grid congestion. To provide the reader a more structured view, the tools are grouped by their aim: better (re)allocation of existing available grid capacities, better use of existing grids, or the building of new grid capacities. The table indicates how quickly each tool can be implemented using a colour code.

Time horizon of implementation – legend:

| ≤2 years | 2-3 years | ≥3 years |
|---|---|---|

| | Options and implementation time | Description |
|---|---|---|
| (Re)allocation of remaining grid capacities | Managing 'contractual congestion' | Reallocating the unused share of contracted capacities of current grid users: use it or lose it. |
| | Priority lanes | Some projects stagnate or have multiple applications taking away opportunities from other projects. Priority can be granted to more advanced investments on a first-ready, first-served basis, and/or to projects with higher social or system benefits. This means a move away from first-come, first-served principle. |
| | Cleaning the queue | Amnesty to leave the queue and/or measures to discourage non-viable projects entering the queue often due to hoarding of capacities for future rent seeking. |
| | More transparency on the available capacities | Frequently upgraded granular maps that provide location-specific information on available hosting (connection) capacities of the grid and, potentially, the estimated connection cost and time. This enables investors to factor in grid availability to their investment decisions. |

[1] Pató, Z. (2024, February). *Gridlock in the Netherlands*. Regulatory Assistance Project. https://www.raponline.org/knowledge-center/gridlock-in-netherlands/

[2] Pató, Z. (2024, May). *RIP first come, first served*. Regulatory Assistance Project. https://www.raponline.org/toolkit/rip-first-come-first-served/

| | | |
|---|---|---|
| | Better governance | Actions to speed up the process: parallel permitting for grid connection and other permits, more efficient grid assessment process, accountability and process standardisation. |
| | Competitive allocation of grid capacities | Scarce resources are best allocated to those who value them most. This means moving away from the first-come, first-served principle to auctioning grid capacity. Often it is not a separate grid capacity but renewable energy sources support auctions being location specific. The lower the support need for an RES project, the more contracts-for-difference (CfD) auctions are about allocating scarce grid access. |
| **Better use of existing grids** | Shared connection / hybridization / colocation / pooling | Sharing of a single connection point to utilize the complementarity of resources and better use of land. This transfers the optimization of grid use from the network operator to users. |
| | Setting up a congestion management platform | Organised platforms for network operators to procure flexibility for congestion management. |
| | Mobilising participation in congestion management | Engaging additional grid users to offer their flexibility. Awareness-building on the revenue option. |
| | Alternative connection contracts | Limiting continuous access to grid, such as through fully flexible connection agreements, time-limited firm connection agreements or any combination of the two. |
| | Rethinking grid assessment | Relaxing some of the conservative assumptions in grid capacity assessment. |
| | Grid enhancing technologies (GETs) | New technologies that enhance the existing transmission grid infrastructure creating new 'virtual' capacity and hence reduce the need to build. Most important mature technologies are dynamic line rating, FACTs, smart grid topology, grid-integrated storage, etc. They can be implemented more quickly than building new grids. |
| | Incentives for network operators | Making network operators indifferent to the type of solution (wire versus non-wire) they use for managing congestion by neutralising the CAPEX-bias and introducing performance/output-based regulations to incentivize them to pursue predefined goals and metrics. |
| | Better scarcity signals for grid users (time and location) | Dynamic network tariffs and/or connection charges optimize the use of grid (in time) and can provide locational signals for new connections. |

| | | |
|---|---|---|
| | ISO | System operators — not owning the grid — can deliver more efficient grid services because they are not subject to an incentive to favour new build as a solution to congestion problems. |
| **Creating new grid capacities** | Contestable built | Competing for the buildout can bring down costs and accelerate the process. Grid elements can either be owned by the developer and operated by an ISO or transferred to the public grid. |
| | Anticipatory planning/RES zones | The development of new grids and new users is a circular dilemma: one gets built only once the other is committed to building. The welfare loss from delayed grid buildout needs to be balanced with the risk of a new asset remaining underutilised. Coordination can be facilitated by defining zones with good endowment, proximity of load, land availability and building transmission; the grid is sized for the capacity of full RES potential in the zone. |
| | Co-opting/buying-in of local communities | Financial compensation paid to local communities and/or property owners affected by the new grid element can speed up the development. |
| | Locational marginal pricing | A wholesale electricity market design, whereby the price paid to feed in a kWh from a specific location on the transmission grid and the price charged to withdraw a kWh at a specific location reflect the real costs of grid congestion affecting those locations. Failure to reflect locational costs in wholesale prices can aggravate congestion in the short term and obscure the relative value of investment options for reducing grid congestion. Reviewing and/or splitting the current bidding zones is a second-best option, due to quickly changing congestion topology in a RES-based power system. |

Source: The Grid Scarcity Toolbox was developed by the Regulatory Assistance Project (RAP) in 2024.

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# Case studies

The following section discuss the real-life implementation of one regulatory tool from each category of the toolbox. The first category includes options to optimize the allocation of remaining grid capacities. The default, 'first-come, first-served' regime in Europe is increasingly contested as being slow and inefficient. The fundamental tenet of better capacity allocation is that potential grid users know the locations where the grid can host additional users. The first case study based on our grid toolbox categories explains the use and the content of hosting capacity maps in Belgium.

The second category focuses on enhancing the utilization of existing grid capacities. Cable pooling, as show in this case study of Poland, is one the most widely used possibility to optimize the use of a single connection point.

Building new grid capacities is the last option to meet grid demand once existing grids are used efficiently. The third case study is a well-known case on coordinating transmission and renewable development in Texas (U.S.).

## Grid transparency in Belgium

### Grid toolbox category: (Re)allocation of remaining grid capacities

Responsibility for Belgium's energy policy is divided between the federal government and the regional governments of Flanders, Wallonia and the Brussels-Capital Region. With regards to power grids, the federal government is responsible for transmission and large-scale generation, and the regional governments for distribution, retail markets and renewables (except offshore wind). Belgium[3] has closed its last coal-fired plant in 2016 and will close all but two of its nuclear reactors in 2025. Nuclear closure will be substituted in the short run by import and gas, then from 2030 by renewables (including offshore wind) and import after the commissioning of major interconnectors. Belgium does not have a net zero power system target, but its power sector is covered by the European Emission Trading Scheme, which effectively phases out $CO_2$ emissions in the power sector by 2035-2040. Belgium forecasts to reach a 60% renewable share in domestic electricity generation by 2035.[4]

Belgium invests into a major inland transmission project (Ventilus[5]) that would tie in off-shore wind to the mainland grid, and several interconnectors (Nautilus[6] and Triton Link[7]).

[3] Peeter, C., ed. (2023, June). *Adequacy & flexibility study for Belgium (2024-2034).* Elia Group. https://issuu.com/eliagroup/docs/adequacy_flexibility_study_for_belgium_2024-203?fr=sOTBhNDYxOTUwMTY

[4] Translating into 42% share in gross domestic consumption due to import.

[5] Elia Group. (n.d.). *Ventilus*. https://www.elia.be/en/infrastructure-and-projects/infrastructure-projects/ventilus

[6] Elia Group (n.d.). *Nautilus*. https://www.elia.be/en/infrastructure-and-projects/infrastructure-projects/nautilus

[7] Elia Group (n.d.). *Triton Link*. https://www.elia.be/en/infrastructure-and-projects/infrastructure-projects/tritonlink

In its draft investment plan 2024-2033,[8] Fluvius, the biggest Flemish DSO, calculated that the additional cost of the energy transition for distribution grid management in Flanders would amount to 6 billion euros by 2050, on top of the normally foreseen investment budgets. The plan defines responsible parties for each action to be implemented by 2025. Ores,[9] in Wallonia, plans to build approximately 9000 km cables in the low and medium voltage network, 3500 electrical stations and install 1.3 million smart meters in the next five years.

Electrification and the shift to renewables are the main levers to decarbonise Belgium's economy. The electrification of industry, transport, heating and the new load of data centres and electrolysers is foreseen to double today's electricity consumption[10] between 2024 and 2034. Three main actions are planned to mitigate additional generation capacity need, enhance system efficiency and control system cost: promoting flexible consumption by flattening it, digitalisation, and grid infrastructure development. Newly electrified industrial demand operating flexibly can reduce the 4100 MW additional capacity requirement to a 1500 MW additional net load.

## Hosting capacity maps

A fundamental condition for the better use of existing grid capacity is knowing where there are capacities. Hosting capacity maps[11] published and updated regularly by DSO and TSOs provide information about the available space on the power grid for new users at a certain location, at various voltage levels, incorporating planned future grid development. The maps often define the available capacity for different types of grid users: load or generation, and the type of generation.

Having visibility on available capacity at various locations would bring multiple benefits:

- Project promoters aiming to develop new renewables, electrolysers, data centres or large electric vehicle chargers to factor in grid availability to their planning hence reducing the time spent in grid connection queues, potentially speeding up investment decisions.
- It could reduce the number of grid connection requests TSO/DSO need to process, as project promoters would not need to submit multiple grid connection requests for various locations. Today grid operators in most jurisdictions use the 'first-come, first-served' principle and decide on individual location-specific connection applications.
- It would indicate where flexibility solutions such as storage and demand-side flexibility are in high demand.

[8] Fluvius, (n.d.). *Investeringsplan 2024-2033*. https://over.fluvius.be/nl/fluvius-kijkt-vooruit/investeringsplan-2024-2033?app-refresh=1727808227220

[9] Ores. (n.d.). *Des investissements pour assurer la fiabilité du reseau*. https://www.ores.be/pannes-et-interruptions/les-investissements

[10] Peeters, 2023.

[11] Pató, Z., Cremona, E., and Rosslowe, C. (2024, July). *Transparent grids for all. Grid (un)lock: hosting capacity maps*. Regulatory Assistance Project and Ember. https://www.raponline.org/toolkit/transparent-grids-for-all/

Utilities[12] in 24 U.S. states have provided grid capacity maps for years. Some European grid operators[13] have been following suit to increase transparency. The revised EU electricity market legislation of 2024,[14] however, made the development of these maps mandatory for all European TSOs and DSOs. The EU Grid Action Plan mandates ENTSO-E and the EU DSO Entity to put forward a harmonised definition for available grid hosting capacity, and a pan-EU overview of available grid hosting capacities.

These maps are no-regret options as grid operators possess these data, the development and maintenance cost of these maps most likely takes less time than dealing with the flood of requests. Data collection and transparency does not need to stop informing users on available grid capacity and can serve as the platform for integrating grid data (e.g. open data portal of UKPN[15]). Interesting to note that grid capacity information can be provided by third-party service providers as well (e.g. Grid Capacity[16] in France or Pearl Street Technologies[17] in the U.S.).

Existing maps are different in the amount of information they provide, the time horizon they use, whether they include information on the queue and to what extent they differentiate among applying resources. As they are intended to pre-inform grid users on grid availability, these maps are non-binding.

# Implementation in Belgium

## Transmission map (Elia)

The hosting capacity map of Elia (as seen in Figure 1)[18] covers transmission grid (30-380kV) and specifies how many additional MW consumption or production could be hosted without additional grid investments:

- per substation,
- for a given target year (2026 or 2031),
- or a given type of grid user (load, generation, storage),
- for a given flexibility level (0 or 5% maximum yearly energy curtailment), and
- for a set of underlying assumptions such as planned infrastructure, evolution of other grid users.

[12] Office of Energy Efficiency & Renewable Energy. (2024, May updated). *U.S. Atlas of Electric Distribution System Hosting Capacity Maps*. https://www.energy.gov/eere/us-atlas-electric-distribution-system-hosting-capacity-maps#:~:text=Hosting%20capacity%20maps%20provide%20greater,an%20upgrade%20may%20be%20required

[13] Pató, et al., 2024.

[14] Council of the EU. (2024, May). *Electricity market reform: Council signs off on updated rules* [press release]. https://www.consilium.europa.eu/en/press/press-releases/2024/05/21/electricity-market-reform-council-signs-off-on-updated-rules/

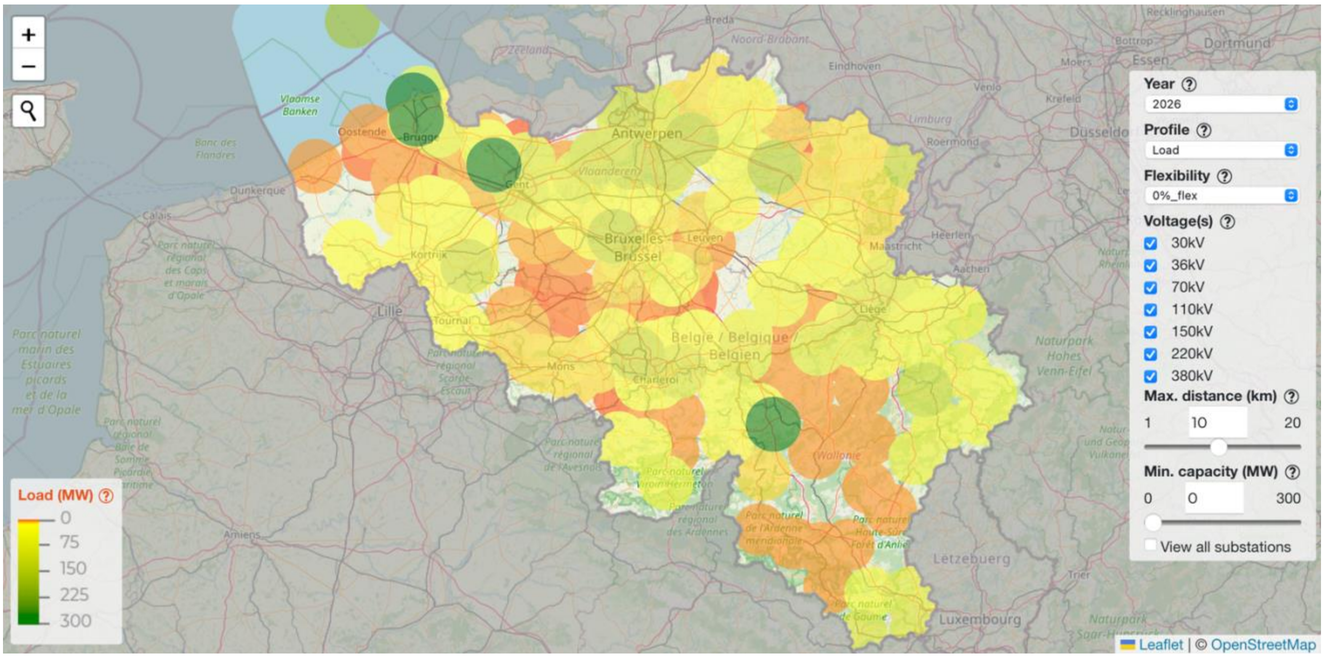
[15] UK Power Networks. (n.d.). *UK Power Networks Open Data Portal*. https://ukpowernetworks.opendatasoft.com/pages/home/

[16] Grid Capacity. (n.d.). Grid Capacity: simulate your connection to the distribution network, in just a few minutes. https://www.grid-capacity.com/en/home/

[17] Pearl Street Technologies. (n.d.). *Homepage*. https://pearlstreettechnologies.com

[18] Elia Group. (2023, December). *Grid Hosting Capacity*. https://www.elia.be/en/customers/connection/grid-hosting-capacity

**Figure 1. The hosting capacity map of Elia**




Source: Elia Group. (2023, December). *Grid Hosting Capacity.*

## Distribution map (Fluvius)

The map[19] covers the medium voltage grid in Flanders providing an overview of remaining capacity both for new load (up to 5 MW connection capacity) and generation (up to 4 MW). It displays the remaining available capacity (without the need for reinforcement of the network) for load and generation for each substation. The map also shows the capacity of each transformer linking the transmission and distribution grid together with the current peak load, the current and future peak injection capacity, the current connected users per technology and reservation made for that transformer.

For any location the map shows the following information:

- all the information discussed above on the transformer station,
- distance to the first connection point with sufficient available capacity,
- indicative lead time of connection from approval of request, and
- indicative connection costs.

Fluvius had no legal requirement to develop the map but decided to do so for transparency and efficiency. It was, however, included among the 25 action points of the flexibility action

[19] Fluvius. (2023, December). *Capaciteitswijzer*. https://opendata.fluvius.be/pages/map_perceel/

plan[20] of the Flemish government and the Flemish Energy and Climate Agency [21]prepared jointly with energy sector organisations.[22] The plan is a response to the recognition that to meet the growth of renewable energy sources and further electrification, more grid investment and more flexibility is needed to prevent congestion and to reduce system costs.

The features and layout of the Fluvius map has been developed after the validation by the grid user group of the flexibility forum, Elia and the NRA. Fluvius closely coordinated with Elia (the TSO) to integrate transmission grid limits on the distribution map.

There is no special regulatory incentive behind the development of these maps. The cost of development and maintenance is part of the OPEX and there are no monitoring mechanisms established on these maps in Flanders.

# Cable pooling in Poland

## Grid toolbox category: Better use of existing grid capacities

Poland is the 6th largest country[23] in the European Union in terms of nominal GDP and fourth largest[24] in terms of greenhouse gas emissions, with the power sector still dominated by coal (over 60% of electricity was generated from coal in 2023, a sharp drop from over 70% in 2022).

While Poland has not yet adopted a net zero target until recently has been rather under-ambitious in its energy transformation goals, the recent summary of the draft of the updated NECP[25] shows reaching 56% of renewables in the electricity generation by 2030, which would be more than doubling the share reached in 2023.

Electrification of heating and transportation progresses, albeit there is no coherent strategy to promote it, with heat pumps sales stalling after a boom in 2022[26] and electric vehicles sales lagging way behind[27] Europe's leading countries. However, the NECP draft[28] published in

[20] Vlaamse Regering. (2022, October). *Visienota Flexibiliteitsplan 2025*. https://beslissingenvlaamseregering.vlaanderen.be/document-view/635A45301EA6B745D23CC9F2

[21] Vlaanderen. (n.d.). *Vlaams Energie – En Klimaatagentschap*. https://www.vlaanderen.be/veka

[22] The plan will be reviewed later this year by the new government.

[23] Eurostat. (n.d.). *Gross domestic product at market prices*. https://ec.europa.eu/eurostat/databrowser/view/tec00001/default/table?lang=en

[24] European Environment Agency. (2024, April). *EEA greenhouse gases — data viewer*. https://www.eea.europa.eu/en/analysis/maps-and-charts/greenhouse-gases-viewer-data-viewers

[25] Ministerstwo Klimatu i Środowiska. (2024, September). *Prekonsultacje projektu aktualizacji Krajowego Planu w dziedzinie Energii i Klimatu do 2030 roku.* https://www.gov.pl/web/klimat/prekonsultacje-projektu-aktualizacji-krajowego-planu-w-dziedzinie-energii-i-klimatu-do-2030-roku

[26] Port PC. (2024, February). *Czy rok 2024 przyniesie nowe otwarcie polskiemu rynkowi pomp ciepła? Podsumowanie 2023 roku i perspektywy dla branży*. https://portpc.pl/czy-rok-2024-przyniesie-nowe-otwarcie-polskiemu-rynkowi-pomp-ciepla-podsumowanie-2023-roku-i-perspektywy-dla-branzy/

[27] Monteforte, M., Diaz de Aguilar, S., Mock, P., Tietge, U., & Rajon Bernard, M. (2024, March). *European market monitor quarterly: European car and van market and charging infrastructure development: January–December 2023*. The International Council on Clean Transportation. https://theicct.org/publication/eu-car-and-van-market-development-quarterly-december23-mar24/

[28] European Commission. (2024, March). *Poland - Draft updated NECP 2021-2030*. https://commission.europa.eu/publications/poland-draft-updated-necp-2021-2030_en

March 2024 envisages up to 2 million heat pumps installed in Poland by 2030 (up from the current stock of over 600 thousand units).

As in other countries, Poland's energy transition depends very much on the extent of the grids are able to cope with increasing amounts of renewable energy installations and increased demand stemming from electrification of heating and transport. Whereas the Polish challenge is very big also on the supply side (all of the coal-based power generation needs to be replaced with low and zero-emission sources in the coming years), the grids are becoming a bottleneck as well.

The most prominent problem in recent years has been the lack of available grid capacities to host more renewables. One (imperfect) indicator of this issue is the number of declined connection requests. According to the Energy Regulatory Office (ERO) 2023 monitoring report,[29] whereas in 2020 over 1,300 connection requests amounting to 6 GW were declined, this has grown to 14.5 GW in 2021, 51 GW in 2022 and to 83.6 GW in 2023. Reasons for the rejections were the lack of technical and/or economic justification. Of course, to be able to properly evaluate the scale of the problem we need to look at the number of connection requests that were granted in the same period. According to PSE, the Polish TSO, the pool of granted active connection requests amounts to nearly 50 GW of wind and solar capacities[30] (not including prosumer installations) that could be installed by 2030. Together with currently installed >28 GW, such an amount, if realised, would mean the potential to meet over 80% of electricity demand by wind and solar.

The overall grid congestion strategy is currently not very well defined and is heavily skewed towards CAPEX-heavy solutions. The most recent draft grid development plan[31] of PSE calls for around 15 billion euros of investment outlays for the years 2025-2034, double the amount that was planned for the years 2023-2032. This ambitious new plan envisages the connection of up to 18 GW of offshore wind installations and over 3 GW of nuclear.

However, most of the onshore renewable capacities will be connected to the distribution grid, therefore efforts must be made to make this part of the electricity system fit for transformation. In 2022 the five biggest DSO and the ERO agreed on the "Charter for efficient transformation of distribution grids."[32] The document calls for alignment of investment plans with decarbonisation objectives and better utilization of existing grids through, e.g. offering non-firm connection agreements, as well through cable pooling, new rules of connecting storage and development of flexibility markets.

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[29] Urząd Regulacji Energetyki. (2024, July). *Sprawozdania z działalności Prezesa URE*. https://www.ure.gov.pl/pl/urzad/informacje-ogolne/edukacja-i-komunikacja/publikacje/sprawozdania-z-dzialaln/2916,Sprawozdania-z-dzialalnosci-Prezesa-URE.html

[30] Elżbieciak, T. (2024, July). Inwestycje w wiatraki i fotowoltaikę w sieciowym matriksie. *WysokieNapiecie.pl*. https://wysokienapiecie.pl/102863-inwestycje-w-wiatraki-i-fotowoltaike-w-sieciowym-matriksie/

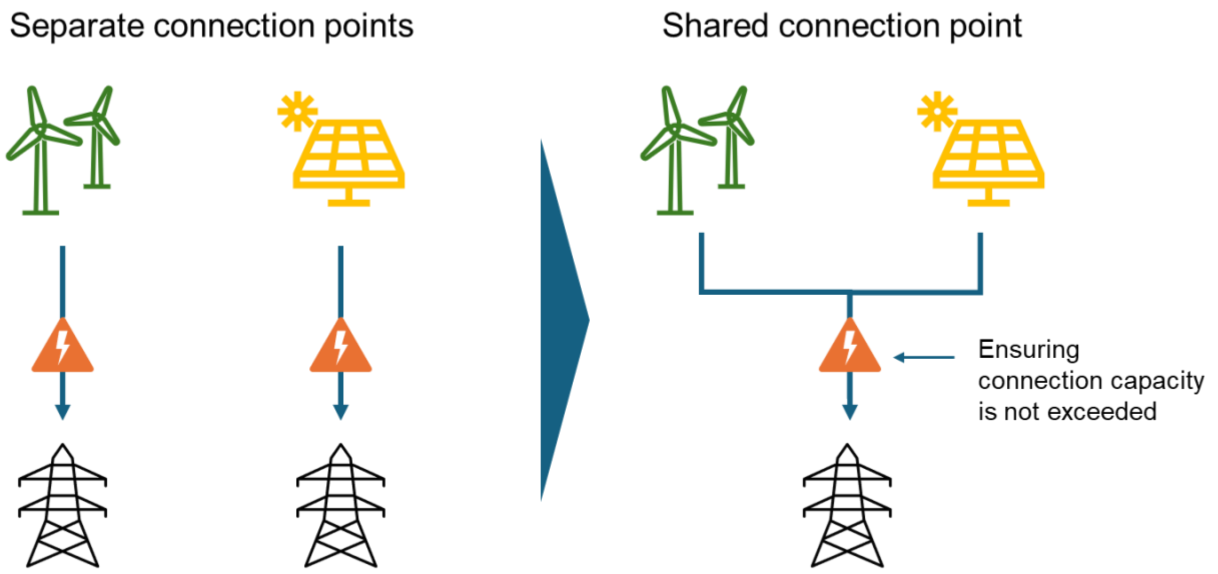
[31] Polskie Sieci Elektroenergetyczne S.A. (2024, June). *Documents*. https://www.pse.pl/dokumenty

[32] Urząd Regulacji Energetyki. (2024, July). *Rynek energii elektrycznej: historyczne porozumienie sektorowe regulatora i operatorów systemów dystrybucyjnych*. https://www.ure.gov.pl/pl/urzad/informacje-ogolne/aktualnosci/10630,Rynek-energii-elektrycznej-historyczne-porozumienie-sektorowe-regulatora-i-opera.html

# Cable pooling

Cable pooling[33] is defined as the ability to share a grid connection point and the allocated connection capacity between two or more power generators (or power generator and storage) typically with different operating characteristics (e.g. PV and wind). A typical application is adding a PV installation to an existing wind farm (stylized example in Figure 2).

**Figure 2. Cable pooling/shared connection – illustration**




Source: RAP figure. For an example of a more detailed analysis see here.[34]

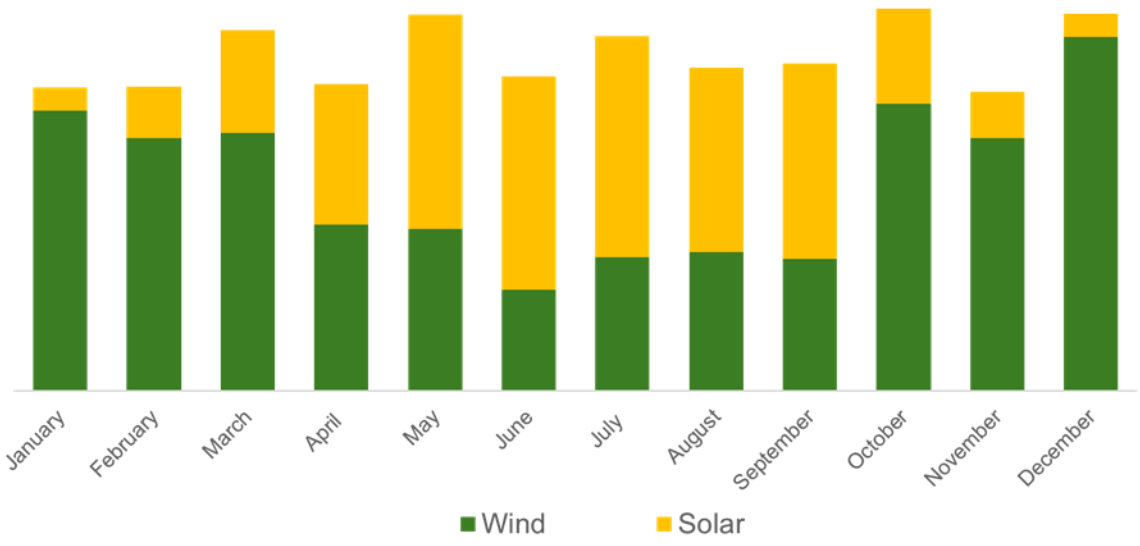
In a cable pooling situation there is one connection, but the installations can be owned by different investors, with an agreement governing their cooperation and cost-sharing of joint connection and installation as well as contractual obligations vis-a-vis the grid operator. The aim of the measure is better utilization connection capacities, flattening of the generation profile at a given connection point and better use of land. This type of connection regime gained a lot of interest with the rise of intermittent renewables when it became apparent that the previous grid access regime of one user per connection point was an inefficient use of a scarce resource. Cable pooling is particularly appealing in geographies where generation profiles of different resources are complementary throughout the year (Figure 3[35]).

[33] In other jurisdictions cable pooling might also be called co-location, hybridization, or shared connection.

[34] S.Z.M. Golroodbari, D.F. Vaartjes, J.B.L. Meit, A.P. van Hoeken, M. Eberveld, H. Jonker, W.G.J.H.M. van Sark. (2021, May). Pooling the cable: A techno-economic feasibility study of integrating offshore floating photovoltaic solar technology within an offshore wind park. *Solar Energy, Volume 219*. Pages 65-74, ISSN 0038-092X. https://doi.org/10.1016/j.solener.2020.12.062

[35] Ember. (n.d.). *Electricity Data Explorer*. https://ember-climate.org/data/data-tools/data-explorer/

**Figure 3. Monthly wind and solar generation profile in Poland**




Source: RAP figure based on real 2023 data from Ember's Electricity Data Explorer.

Allowing cable pooling is one of the most obvious no-regret strategies to make better use of grid capacities as this is purely regulatory measure, does not require any additional investment outlays and brings immediate benefits to all concerned. It allows for more renewable resources to be connected to the system quickly and when managed correctly[36] does not cause any disadvantage to the network.

## Implementation in Poland

The renewable industry was calling[37] for the introduction of cable pooling already in 2021. The legislative process[38] started in 2022 and concluded only in August 2023, with many stakeholders participating in public consultations.[39] The new rules allowing cable pooling entered into force on 1 October 2023.

While it is still too early to comprehensively judge the effectiveness of the new measures, since grid operators have 150 days to assess the applications for grid connections filed under the new law, it quickly became apparent that the regulations are far from optimal and will need to be changed to bring full benefits. Already in March 2024 the ERO issued guidance[40]

[36] Preventing connection capacity from being exceeded.

[37] Elżbieciak, T. (2022, January). Zielona energia utknęła w sieci. Gospodarka będzie tracić. *WysokieNapiecie.pl*. https://wysokienapiecie.pl/44016-zielona-energia-utknela-w-sieci-gospodarka-bedzie-tracic/

[38] Cable pooling was introduced to the Polish legal framework within the scope of implementing the RED II Directive.

[39] Rządowy Proces Legislacyjny. (2024, October). *Projekt ustawy o zmianie ustawy o odnawialnych źródłach energii oraz niektórych innych ustaw*. https://legislacja.gov.pl/projekt/12357005/katalog/12858155#12858155

[40] Urząd Regulacji Energetyki. (2024, March). *Informacja nr 15/2024*. https://www.ure.gov.pl/pl/urzad/informacje-ogolne/komunikaty-prezesa-ure/11816,Informacja-nr-152024.html

on some of the aspects of the grid connection process, including cable pooling. In particular, ERO gave their opinion on some of the implementation principles that were not uniformly applied by the DSOs (e.g. some DSOs disputed the fact that cable pooling could be used to connect a new generation source to an existing one, demanding that this should only pertain to new investments of two or more sources).

Problems still remain, however. The two major ones[41] are: (1) exclusion of storage from cable pooling (shared connection can only be granted to two or more generation installations), and (2) exclusion of installations connected via cable pooling from the contracts for difference RES support scheme (only one of the connected installations sharing the same connection point is allowed to participate in the scheme). Also, cable pooling does not necessarily shorten the time and cost of connecting, since the DSOs are still performing a full assessment on the impact of the grid and the "additional" investors are required to make an advance payment for connection costs — even though they do not cause more cost to the DSOs.

These and other problems[42] with grid congestion are supposed to be discussed in working groups with the participation of renewable energy associations, DSOs, the ERO and the Ministry of Climate. Poland might draw on the experiences from other markets, notably Netherlands,[43] to address these. One of the systemic issues is the lack of transparency within the grid connection process. While the TSO regularly publishes[44] a detailed list of connection requests, DSOs are currently only required to publish the amount of available grid connection capacities,[45] with no details on the size, composition, legal disputes, etc. of the connection queue. Also, measures to clear the queue from the connection requests that are not being realised and prioritizing more advanced projects are not being pursued.

Thus, cable pooling is a very good tool to make best use of available capacities but a list of other measures need to be implemented to make to Polish grid connection process more efficient and to bring more renewables online quicker.

[41] Szczodra, A. & Kolenda, A. (2024, April). *Legal Alert: Cable pooling - podsumowanie na pierwsze półrocze obowiązywania nowych przepisów*. KPMG. https://kpmg.com/pl/pl/home/insights/2024/04/legal-alert-cable-pooling-podsumowanie-na-pierwsze-polrocze-obowiazywania-nowych-przepisow.html

[42] Elżbieciak, 2024 July.

[43] Pató, 2024 February.

[44] Polskie Sieci Elektroenergetyczne S.A. (n.d.). *Wykaz obiektów planowanych do przyłączenia do sieci przesyłowej*. https://www.pse.pl/obszary-dzialalnosci/krajowy-system-elektroenergetyczny/wykaz-obiektow-planowanych-do-przylaczenia

[45] PGE Dystrybucja S.A. (2024). *Tabela łącznej dostępnej mocy przyłączeniowej [MW] dla źródeł przyłączanych do sieci o napięciu znamionowym wyższym niż 1kV na terenie PGE Dystrybucja SA*. https://pgedystrybucja.pl/przylaczenia/informacje-o-dostepnych-mocach-przylaczeniowych

# Competitive Renewable Energy Zones in Texas

Grid toolbox category: Creating new grid capacities

Even though Texas generally lacks ambitious climate policies,[46] it is a leader in renewable energy among U.S. states. In 1999, it was one of the first to adopt a renewable portfolio standard (RPS) and shifted generation towards renewables.[47] Wind was the second-largest source of generation at 22% in 2023. Solar (predominantly utility-scale) and nuclear each provided about 7% of the state's electricity net generation in 2023.[48] Natural gas-fired power plants supplied still more than half of the electricity generated, coal-fired power plants supplied 13% of the state's total generation in 2023, down from 34% in 2013.

Texas is an energy-only market that is not under the federal jurisdiction. The Electric Reliability Council of Texas (ERCOT) is the independent system operator that manages the flow of electric power on the Texas Interconnection and the independent planning authority for transmission projects.[49,50] ERCOT examines the need for proposed transmission projects based on ERCOT planning criteria and North American Electric Reliability Corporation (NERC) Reliability Standards. Once a project need has been identified, ERCOT evaluates project alternatives based on cost-effectiveness, long-term system needs, and other factors. ERCOT performs an annual assessment of the transmission system, and also conducts a biennial 15-year Long-Term System Assessment.[51]

Texas is successful[52] in bringing new generation, mainly renewables, online. Renewables zoning and adjacent transmission development (the topic of this case study), together with its unique connection regime, were/are key in this success.

ERCOT is the only U.S. grid operator to use the 'connect and manage'[53] approach for transmission grid connections. It only focuses on what local upgrades are needed for a project to connect to the grid and — in contrast to the rest of the U.S. — it doesn't examine the possible need for broader network upgrades. ERCOT manages any grid bottlenecks caused by a new generator through market redispatch and curtailment. Its congestion pricing

[46] Douglas, E., Foxhall, E. & Martinez, A. (2023, 2 June). Climate proposals withered at the Texas Capitol this year. *The Texas Tribune*. https://www.texastribune.org/2023/06/02/texas-environment-climate-energy-bills-legislature/

[47] Public Utility Commission of Texas. (2024, January). *Electric Substantive Rules - Chapter 25. §25.173 - Goal for Renewable Energy*. https://www.puc.texas.gov/agency/rulesnlaws/subrules/electric/25.173/25.173ei.aspx

[48] U.S. Energy Information Analysis. (2024, July). Texas: Profile Analysis. https://www.eia.gov/state/analysis.php?sid=TX

[49] Key real time data on Texas grid: ERCOT. (n.d.). *Grid Info*. https://www.ercot.com/gridinfo

[50] Outlined in the Public Utility Regulatory Act (PURA) and Public Utility Commission of Texas (PUCT) Substantive Rules.

[51] ERCOT. (n.d.). *Planning*. https://www.ercot.com/gridinfo/planning

[52] Engel, J. (2022, 2 August). Renewables make up nearly all of Texas' new generating capacity. Can the market keep up the momentum? *Renewable Energy World*. https://www.renewableenergyworld.com/wind-power/renewables-made-up-nearly-all-of-texas-new-generating-capacity-in-2021-can-they-keep-up-the-momentu/#gref

[53] Howland, E. (2023, 27 November). Can ERCOT show the way to faster and cheaper grid interconnection? *Utility Dive*. https://www.utilitydive.com/news/connect-and-manage-grid-interconnection-ferc-ercot-transmission-planning/698949/

mechanism[54] charges utilities for the cost of turning on (gas) power plants, to meet demand when wind or solar is curtailed.

The ‘connect and manage’ approach allows adding new generation to the grid quickly, but if grid operators aren’t identifying and building needed transmission upgrades, power plant operators will face significant curtailment. Curtailment is not capped (unlike in Europe) so the plant owners have to assess the risk of curtailment in their business plans.

## Renewable energy zones

The development of new renewable energy resources, such as wind and solar PV, drives new grid capacity. Those resources often are located in different areas than old power plants, a long distance from load centres. Therefore, spatial planning for renewable energy can be an important factor in power grid investment planning.

Texas established the Competitive Renewable Energy Zone (CREZ) initiative in 2005 to support large-scale wind projects and ensure enough electricity transmission capacity to integrate this new wind power into the grid.[55]

The CREZ approach has similarities to the Renewable Energy Resource Areas (YEKA) used in Turkey[56] to inform transmission infrastructure planning, and the Renewable Energy Acceleration Areas[57] defined in the revised European Renewable Energy Directive, which also calls for identifying areas for the associated grid and storage infrastructure.

## Implementation in Texas

In 2005, the Texas legislature ordered the Public Utility Commission of Texas to designate CREZ and develop a transmission plan to deliver renewable power from CREZ to customers. This was in response to increasing redispatch costs. The designation of CREZ focused on large-scale wind resources that can be developed in sufficient quantities to warrant transmission system expansion and upgrades.[58] The program started with initial studies in 2006, and in 2014, the last CREZ line went into operation. The project had been projected at $4.9B but went $2B over budget.[59]

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[54] ERCOT. (n.d.). *Congestion Revenue Rights*. https://www.ercot.com/mktinfo/crr

[55] National Renewable Energy Laboratory. (2016, May). *Renewable Energy Zones: Delivering Clean Power to Meet Demand*. https://www.nrel.gov/docs/fy16osti/65988.pdf

[56] Republic of Türkiye Ministry of Energy and Natural Resources. (n.d.). *Production Activities: Renewable Energy Resource Areas (YEKA).* https://enerji.gov.tr/production-activities-en

[57] European Commission. (2024, May). *Guidance on designating renewables acceleration areas*. https://energy.ec.europa.eu/publications/guidance-designating-renewables-acceleration-areas_en

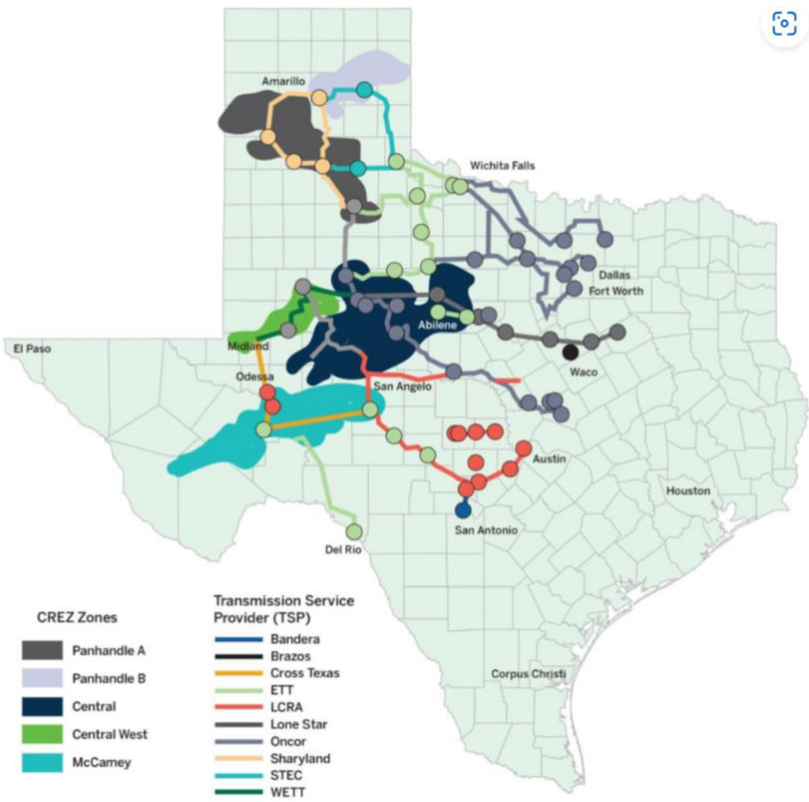
[58] Americans for a Clean Energy Grid. (2023, October). *Texas as a National Model for Bringing Clean Energy to the Grid*. https://cleanenergygrid.org/texas-national-model-bringing-clean-energy-grid/

[59] Miller, E. (2024, 21 May). Texas’ Transmission Troubles and CREZ II. *Texas Solar Energy Society*. https://txses.org/texas-transmission-troubles-and-crez-ii/

The CREZ initiative (as seen in Figure 4[60]) delivered:[61]

- five zones totalling 83.000 square km for 23 GW wind development,
- 6.100 km new, high-voltage transmission lines, and
- improved air quality in Texas despite an increasing load.

**Figure 4. Texas Competitive Renewable Energy Zone (CREZ) projects**




Source: Lasher, W. (2014). The Competitive Renewable Energy Zones Process.

A 2020 study[62] points out that after the implementation of CREZ, curtailment of wind fell from 17% to 1.2%, and wholesale prices fell to a historic low of $24.62/MWh in 2016. The study also found that prices converged and were less volatile across the state.

In Texas, the cost of transmission is shared equally by ratepayers, regardless of where they or the power sources are located.[63] This offered a clear method for repayment to transmission

[60] Lasher, W. (2014, August). The Competitive Renewable Energy Zones Process. https://www.energy.gov/sites/prod/files/2014/08/f18/c_lasher_qer_santafe_presentation.pdf

[61] Jankovska, O. & Cohn, J. (2020, November). *Texas CREZ Lines: How Stakeholders Shape Major Energy Infrastructure Projects*. Rice University's Baker Institute for Public Policy. https://www.bakerinstitute.org/research/texas-crez-lines-how-stakeholders-shape-major-energy-infrastructure-projects

[62] Jang, H. (2020, June). Market Impacts of a Transmission Investment: Evidence from the ERCOT Competitive Renewable Energy Zones Project. *Energies* 2020, *13*(12), 3199. https://doi.org/10.3390/en13123199

[63] See Texas Utilities Code § 35.004, Provision of Transmission Service, 2019.

investors without burdening renewable generators that would be the predominant users of the lines.[64] PowerUp Texas notes that the typical ratepayer paid 3% more on their electric bill for CREZ wire costs.[65]

Congestion remains a problem in Texas. In its December 2023 report, ERCOT describes 10 existing and 10 potential grid congestion areas.[66] Its system continues to experience a rapid shift in the type and location of generation available to serve demand. More than 62 GW of transmission-connected wind, solar, and battery energy storage capacity was expected to be installed by the end of 2023. Their capacity has the potential to exceed 110 GW in 2025. Over 7,300 MW of coal and natural gas generation has retired since 2018. The change in generation mix resulted in increased distance between generation sites and demand centres. A June 2023 report by the nonprofit Americans for a Clean Energy Grid describes an "almost doubling of congestion" on the ERCOT grid from 2020 to 2021.[67]

Some stakeholders call for a CREZ II to address renewable energy curtailment and congestion costs.[68,69]

[64] Jankovska & Cohn, 2020.

[65] PowerUp Texas. (n.d.). *The Importance Of Transmission: Bringing Texans More Affordable, Reliable Power*. https://www.poweruptexas.org/wp-content/uploads/2021/01/Transmission-Fact-Sheet-Web-Version.pdf

[66] ERCOT. (2023, December). *Report on Existing and Potential Electric System Constraints and Needs*. https://www.ercot.com/files/docs/2023/12/22/2023-Report-on-Existing-and-Potential-Electric-System-Constraints-and-Needs.pdf

[67] Americans for a Clean Energy Grid. (2023, June). *Transmission and Planning Development Regional Report Card*. https://www.cleanenergygrid.org/wp-content/uploads/2023/06/ACEG_Transmission_Planning_and_Development_Report_Card.pdf

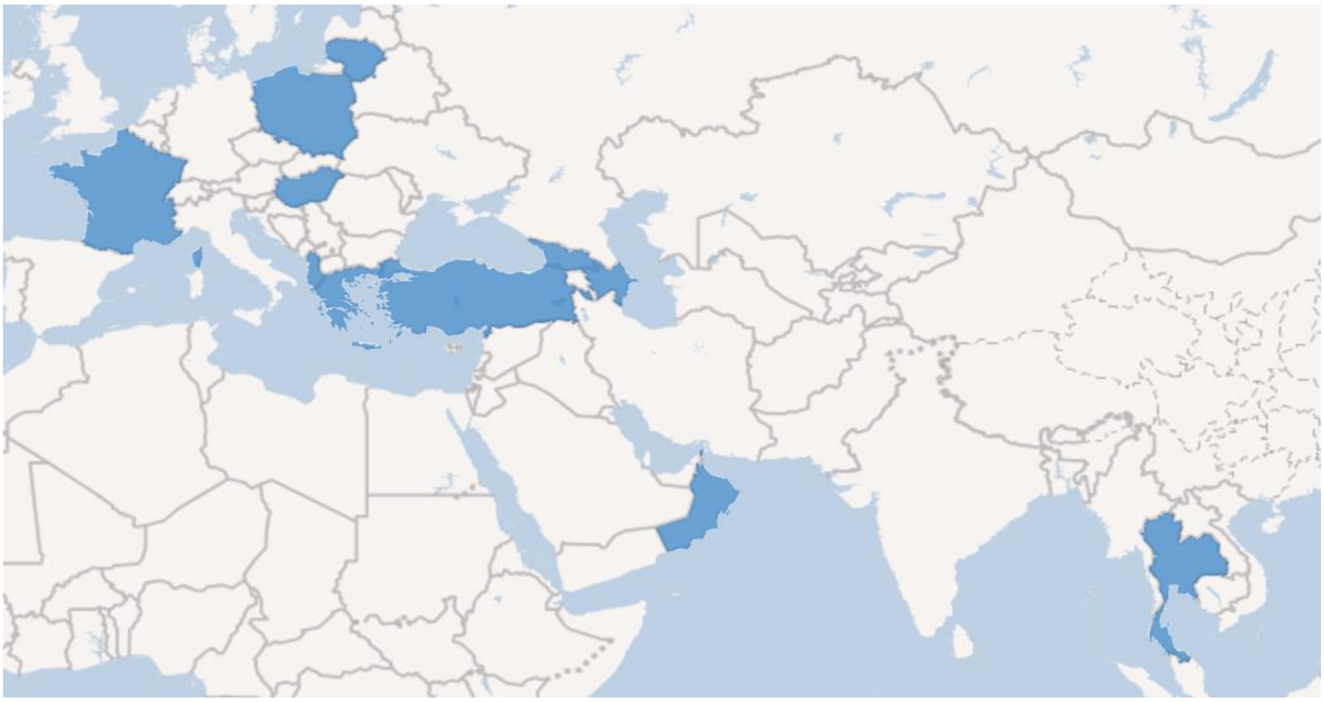
[68] Miller, 2024.

[69] Watson, M. (2021, 4 January). Feature: Texas support for massive transmission boost for renewables in question. *S&P Global*. https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/electric-power/010421-feature-texas-support-for-massive-transmission-boost-for-renewables-in-question

# Status quo in select ERRA member countries

The ERRA Secretariat conducted a survey among its members in Q2 2024 to assess grid scarcity among ERRA member countries in light of the ongoing decarbonization of energy systems and the increased renewable energy penetration. The survey was answered by 11 ERRA members — Albania, Azerbaijan, France, Georgia, Greece, Hungary, Lithuania, Oman, Poland, Thailand and Türkiye (see Figure 5).

**Figure 5. ERRA member countries participating in the survey**



Source: ERRA data.

In seven member countries congestion is a problem today, and three foresee problems soon or in specific zones already. Only Oman reported having no grid congestion problems. The prime reason for grid scarcity is — both at transmission and distribution levels — renewable projects wanting to connect to the grid.

The surveyed countries apply a portfolio of regulatory tools to tackle grid scarcity. The following tables show the popularity of the tools in the three categories of the toolbox.

**Table 1. "What regulatory actions have you implemented to better use of existing grids?"**

| Regulatory Action | Number of Countries | Sum of Number of Countries |
|---|---|---|
| Grid enhancing technologies (GETs) | FR, GR, HU, LT, OM, TR | 6 |
| Shared connection/ hybridization/ colocation/ pooling | FR, GR, HU, LT, PL,TH | 6 |
| Better scarcity signals for grid users (time and location) | FR, OM, TR | 3 |
| Incentives for network operators | FR, OM, PL | 3 |
| Other | AZ, GE, PL | 3 |
| Rethinking grid assessment | AL, LT, OM | 3 |
| Setting up a congestion management platform | FR, HU, OM | 3 |
| Alternative connection contracts | FR, HU | 2 |
| Mobilising participation in congestion management | FR, TR | 2 |
| ISO | OM | 1 |

Sharing connection points among grid users is a tool widely used in these countries to improve the utilization of the grid. This option is relatively quick to implement as it most often requires only the update of the network code. It tasks the grid users to agree on how they share the connection capacity. The implementation of cable pooling in Poland is an illustrative case study. Grid enhancing technologies are commercially available technologies that enhance the existing transmission grid infrastructure and can be implemented more quickly than building new grids. Most important are dynamic line rating, FACTs, smart grid topology and grid-integrated storage.[70]

**Table 2. "What regulatory actions have you implemented in order for better allocation of existing grid capacities to existing and new users?"**

| Regulatory Action | Countries | Sum of Number of Countries |
|---|---|---|
| More transparency on the available capacities | AL, AZ, FR, GE, GR, HU, LT, OM, PL, TR | 10 |
| Better governance | FR, HU, LT, OM | 4 |
| Cleaning the queue | FR, HU, OM, TR | 4 |
| Priority lanes | FR, HU | 2 |
| Managing 'contractual congestion' | FR | 1 |
| Other | PL | 1 |
| This question is not applicable to my country | TH | 1 |
| Competitive allocation of grid capacities | TR | 1 |

The most widely used option that regulators use to enhance the allocation of existing grid capacities is to provide more transparency on available capacities. Belgium provides good practice as both the TSO and its DSOs already publish their hosting capacity maps that allows for a more efficient allocation of capacities.

[70] For an overview, see ENTSO-E. (n.d.). *Technopedia*. https://www.entsoe.eu/Technopedia/

**Table 3. “What regulatory actions have you implemented in order to expedite the construction of new grids?”**

| Regulatory Action | Countries | Sum of Number of Countries |
|---|---|---|
| Anticipatory planning/ RES zones | AL, AZ, FR, HU, OM, PL | 6 |
| Other | AZ, GE, GR, PL, TR, TH | 6 |
| Contestable built | LT, OM, TR | 3 |
| Co-opting/ buying-in of local communities | FR, LT, TR | 3 |

The core regulatory action for expediting the construction of new grids is anticipatory planning and the approval of network expansion plans, submitted by DSO and TSO. Turkey expedites grid buildout by allowing new grid users to build the required grid that gets reimbursed ex post by the TSO (‘contestable built’). The 3,600 circuit miles of transmission lines in CREZ (see case study above) has been built by 10 transmission service providers.[71]

Key planned regulatory actions of the countries are:

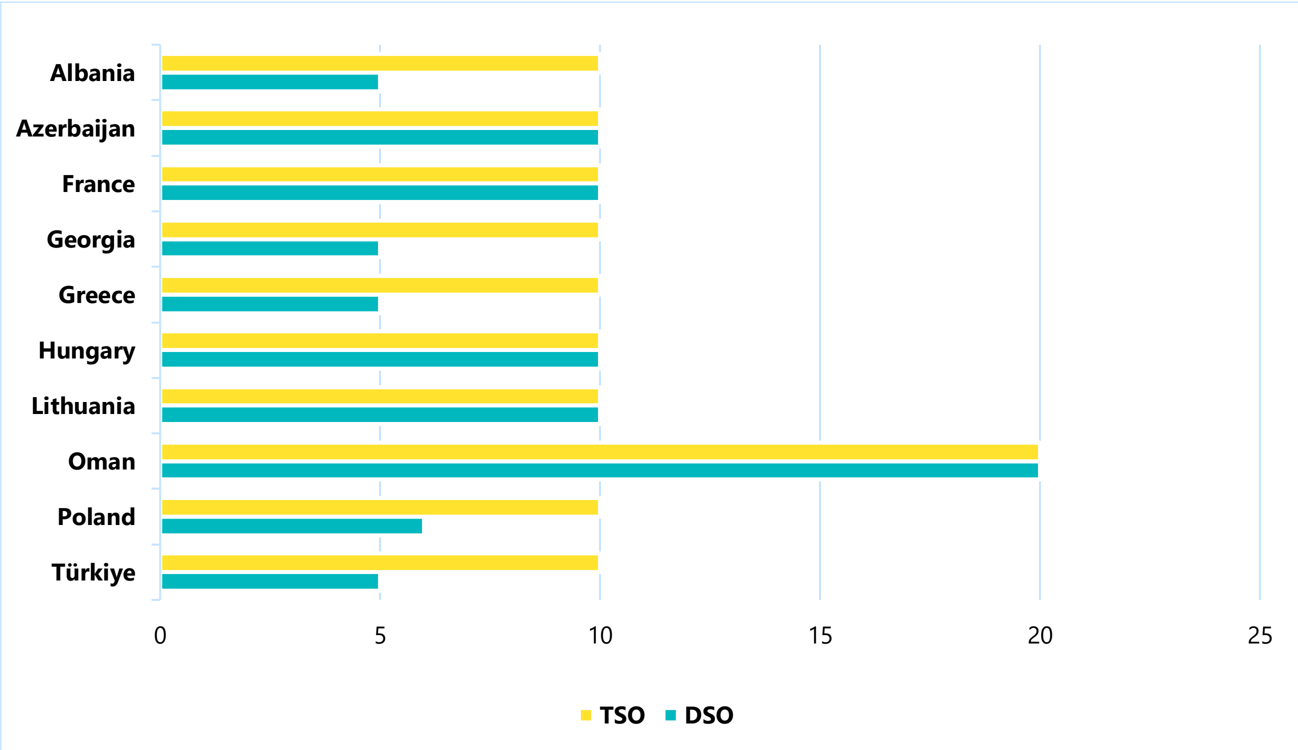
- *Albania*: eliminate connection request that are not likely to get built but create a queue
- *Azerbaijan*: TSO and DSO prepare a 10-year network development plan, and the NRA takes the plan into account when setting tariff proposals
- *France*: maximise flexibility by expanding flexible connection offers, integrating flexibility in grid sizing, facilitating participation in flexibility mechanisms and further improving the coordination between TSO and DSO.
- *Georgia*: introduce flexibility services and consider demand response as an alternative to system expansion.
- *Greece*: Competitive allocation (of grid capacities) for publicly available charging stations and reform incentives for network operators.
- *Hungary*: undecided
- *Lithuania*: change the current ‘first come, first served’ grid capacity allocation mechanisms to auctions, invest in grid enhancing technologies, smart grids, establish re-dispatching market
- *Poland*: wider use of cable pooling, direct lines (statutory), energy storages solutions (flexibility services needed), NRA plans to issue flexibility guidelines and assessing the potential for flexibility services under the Charter for the Efficient Transformation of the Polish Energy Distribution Networks — agreement signed by NRA and some DSOs.
- *Türkiye*: EMRA put the demand side regulations in force. Additionally, the draft regulation for the energy aggregators have already been released and the feedbacks are currently being evaluated by EMRA.

The examples of international regulatory practice from across ERRA members show that the most successful regulatory principle on resolving grid scarcity lays in long-term grid planning. Grid planning is key in closing the gap between grid capacity and the demand for it not only

[71] Jankovska & Cohn, 2020.

in terms of the volume of capacity but also with regards to their location. As the operation of the distribution and the transmission grid depends on each other but governed by different entities, their cooperation is of utmost importance. In most countries in the survey, TSO and DSOs prepare grid plans jointly. In Albania, Oman and Thailand it is done by the TSO only. Grid plans are approved by the NRA with the exception of Thailand and Azerbaijan where they require the approval by the Cabinet of Ministers. The surveyed countries apply different planning horizons (Figure 6). The longer horizon at the transmission level reflects the longer lead time of such investments.

**Figure 6. Planning horizon of DSO and TSO in the surveyed countries**




Source: ERRA data

# Recommendations

The energy transition is not a gradual change of energy systems. It is an overhaul that places novel responsibilities on policymakers and regulators alike.

In addition, to sustain credible commitment to the decarbonisation ambition, policymakers have a key role in recognising that grids are essential for a net zero power sector and eventually a net zero economy. They have the power to provide strong mandate to national regulators that would enable them developing a future-proof framework around concrete requirements and actions for the system operators.

National regulators are the main actors to navigate the transition according to the political targets while keeping the cost at the minimum and protecting vulnerable consumers. Moving quickly to the future power system often necessitates the rethinking of well-established regulatory approaches to give room for bold innovations.

We conclude with some recommendations that we believe to be key in dealing with power grid scarcity.

## Recommendations for policymakers

- Define goals for renewable energy in combination with new grid infrastructure. Coordinated development of renewables and grids is especially important when ideal locations for renewables are far from load centres. These large-scale projects can provide a significant boost to decarbonization.
- Give the national regulator a 'net zero mandate'. Such a mandate (similar to OFGEM's) increases the regulatory power and incentivizes regulatory innovation for decarbonization.
- Perform a thorough assessment of the grid congestion problems and identify those that could be remedied with the minimum effort and short lead time. Mandate the regulator to suggest a portfolio of regulatory actions that matches the scale and urgency of the grid scarcity problem.
- Acknowledge implicit benefits/explicit costs of renewables projects to all connected to the power pool. Anticipate local communities defining desired benefits and costs that will influence final total size, cost, and location of energy infrastructure.

## Recommendations for regulators

- Define a 'net zero' or 'target' grid together with grid operators. Sizing of such a target grid should assume its flexible use and end-use efficiency improvements, not just the additional load from electrification.
- Make sure that planned grid scarcity tools are well consulted with all stakeholders and that minimum discretion remains when applying those measures in order to minimise uncertainty for the investors and maximise speed of connections.

- Consider grid transparency as a no-regret option. Digitalisation of available information on grid connection processes with full transparency on connection queues will help achieve greater overall market efficiency: it helps both prospective grid users wishing to connect and grid operators overwhelmed with the flood of requests. It is a quick fix for speeding up the deployment of new renewable capacities and new loads. Capacity maps can be the first step to open grid data portals.
- Establish incentives for grid operators to use non-wire solutions (better use of grids) whenever more cost-efficient than building new infrastructure ('efficiency first').
- Base selection of geographically desirable locations for renewables and transmission development on thorough economic assessment of ideal renewable locations and alternative transmission line options. Combine planning and final decision powers for renewable energy zones and transmission infrastructure.
- Use a comprehensive planning process to reduce or eliminate the administrative process for subsequent individual new power lines. Seek citizen input at every stage of the process. In Texas this allowed regulators to acknowledge objections and build a thorough and defensible record.