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Power System of the Future

Keys to delivering capacity on the distribution grid

September 2023

Eurelectric represents the interests of the electricity industry in Europe. Our work covers all major issues affecting our sector. Our members represent the electricity industry in over 30 European countries.

We cover the entire industry from electricity generation and markets to distribution networks and customer issues. We also have affiliates active on several other continents and business associates from a wide variety of sectors with a direct interest in the electricity industry.

We stand for

The vision of the European power sector is to enable and sustain:

- A vibrant competitive European economy, reliably powered by clean, carbon-neutral energy
- A smart, energy efficient and truly sustainable society for all citizens of Europe

We are committed to lead a cost-effective energy transition by:

investing in clean power generation and transition-enabling solutions, to reduce emissions and actively pursue efforts to become carbon-neutral well before mid-century, taking into account different starting points and commercial availability of key transition technologies;

transforming the energy system to make it more responsive, resilient and efficient. This includes increased use of renewable energy, digitalisation, demand side response and reinforcement of grids so they can function as platforms and enablers for customers, cities and communities;

accelerating the energy transition in other economic sectors by offering competitive electricity as a transformation tool for transport, heating and industry;

embedding sustainability in all parts of our value chain and take measures to support the transformation of existing assets towards a zero carbon society;

innovating to discover the cutting-edge business models and develop the breakthrough technologies that are indispensable to allow our industry to lead this transition.

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WG Regulation & Network Customers

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Going through the use cases

KEY MESSAGES

The energy system is undergoing a transformative shift from a centralised to a decentralised generation model, highlighting the critical role of the distribution grid. However, the existing distribution grid is inadequately prepared to handle the integration of megawatts (MWs) outlined in the EU's Fit for 55 and REPowerEU objectives. To overcome this challenge:

- It is imperative to **prioritise grid expansion** through physical modernisation and digitalisation efforts. Failing to address the scarce capacity issue, which is already evident on the horizon in the EU, will impede the EU's progress on decarbonisation and energy independence initiatives;
- a marginal ~8% additional grid investments[1] versus business-as-usual must be realised and backed by sufficient revenues if a 55% greenhouse gas (GHG) reduction is to be reached (instead of the initial 46% targeted by the EU) by 2030;
- the emergence of distributed energy resources (DERs) and innovative energy flow schemes, as with energy sharing for instance, require a focus on the distribution grid's enhancement; and,
- the progressive electrification of most energy uses requires that the distribution grid show close to 100% reliability of power supply.

A new mindset must be adopted.
By investing in the grid's enhancement and implementing supportive policies, legislators can **pave the way to a resilient and efficient energy system**. The new mindset is to move **from incremental to anticipatory development**, and to go for a smarter system. This strategic approach will not only accommodate the rise of new energy generation and consumption forms, but also position the distribution grid as the central pillar for a sustainable and prosperous future.

The intent of the "Power System of the Future" workstream is to analyse the current state of the energy system and the changing dynamics in the network's use, identify **quick wins**, and develop recommendations to policymakers and industry stakeholders to shape the most efficient energy system model for a fully decarbonised and independent future of the EU.

METHODOLOGY

This paper intends to contribute to the targeted revision of the electricity market design (EMD), initiated by the European Commission on 14 March 2023.

[1] *Connecting the Dots*, Eurelectric, January 2021

SURVEY RESULTS

Twelve responses have been provided to the preparatory survey: Bulgaria (BG), Czech Republic (CZ), Finland (FI), Germany (DE), Ireland (IE), Italy (IT), Malta (MT), Netherlands (NL), Poland (PL), Romania (RO), Spain (ES) and United Kingdom (UK).

1. Introduction

Due to the non-renewable generation-based models, the current grid was initially designed to accommodate large power plants in a centralised manner, mainly at higher voltage levels. Historically, distribution networks were dominated by customers who solely created demand for energy. Indeed, power was transferred from large-scale transmission networks, and customers did not play an active role in providing flexibility.

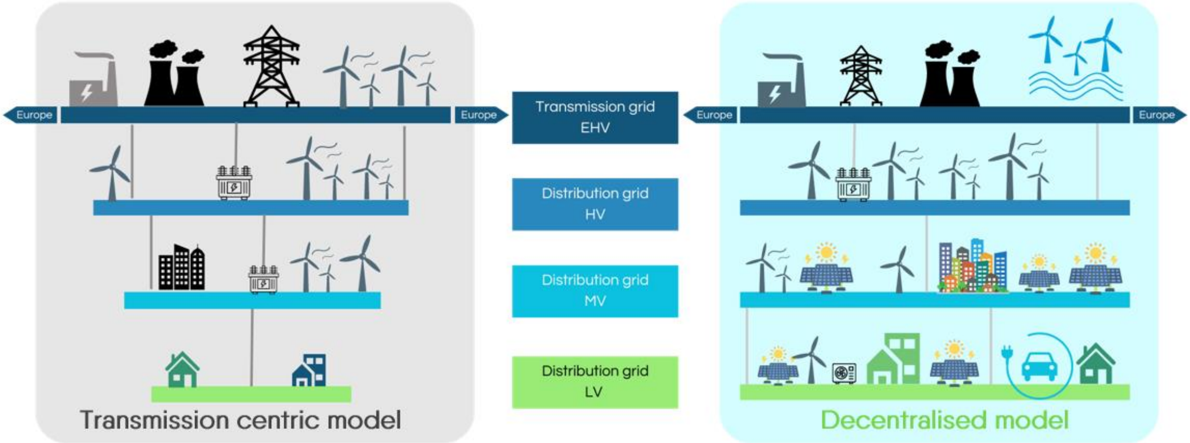
On the other hand, with the energy transition, the **emerging energy system** implies active customers and thereby incorporates[2] millions of heat pumps, many storage batteries, electric vehicle charging units, photovoltaics and wind farms. This requires:

- The connection of multiple devices across various locations **at the distribution level;**
- the management of decentralised and bidirectional energy and data flows; and,
- the implementation of an infrastructure and tools to manage the increasing share of **intermittent** renewable generation.

This necessitates a new mindset in the way the grid is handled. EU grids have been supporting the energy transition, but there is a necessity for more expansion, modernisation, and digitalisation in order to accommodate the additional RES capacity and electrification of final energy uses. This, while becoming smarter and more resilient to provide the necessary reliability and security of the energy system.

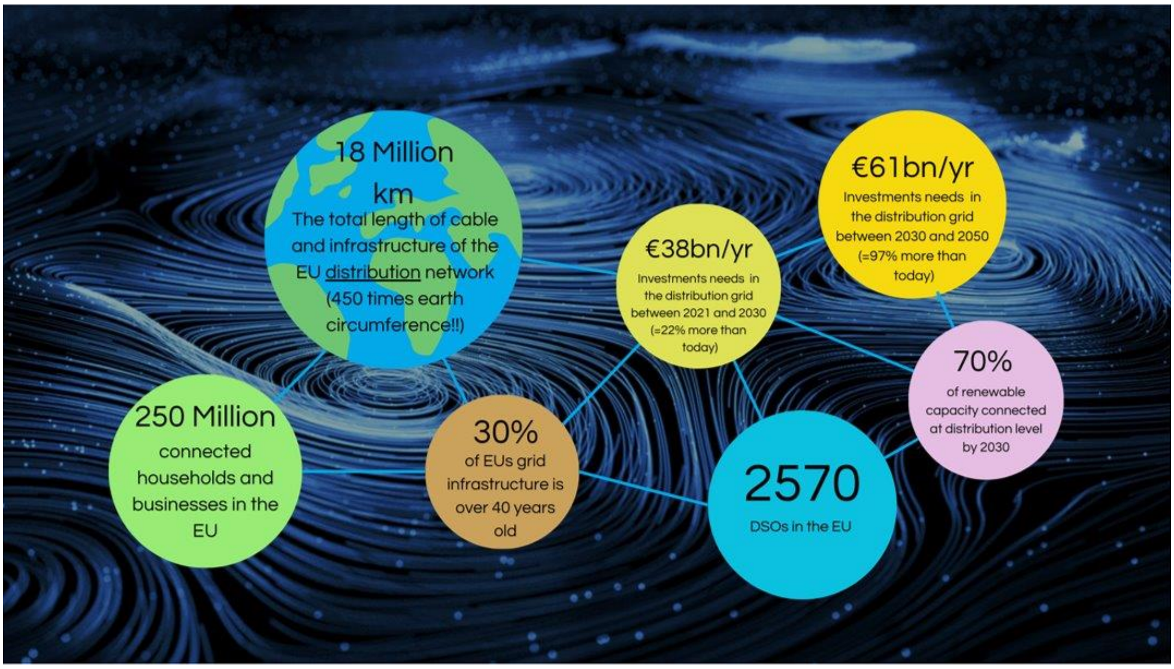
Nowadays, waiting times for grid connections can reach several years in certain congested areas, whereas constructing a renewable energy project typically takes a few months. In the context of accelerated decarbonisation and electrification, it is essential to address the delay that directly relates to the connection process. Therefore, it is **critical** to upgrade both the existing grid infrastructure and the additional infrastructure required to fulfil the electricity demand requirements of the EU. Additionally, obtaining permits for the expansion of grid infrastructure, particularly high voltage (HV), can be time-consuming. These delays seriously hinder the timely addition of much-needed capacity.

[2] According to the latest EU scenarios, grids will need to accommodate an additional 700-800 GW of renewable power generation, of which 70% from decentralised resources, and pave the way for the electrification of energy uses thanks to +60 million heat pumps and 69 million electric vehicles stock by 2030.



Handbook on the grid®, "from a TSO centric to a DSO centric model", by Eurelectric

2. Situation of the grid's capacity in Europe



Handbook on the grid®, "Unprecedented electrification objectives for the distribution grid as the energy system's backbone", by Eurelectric

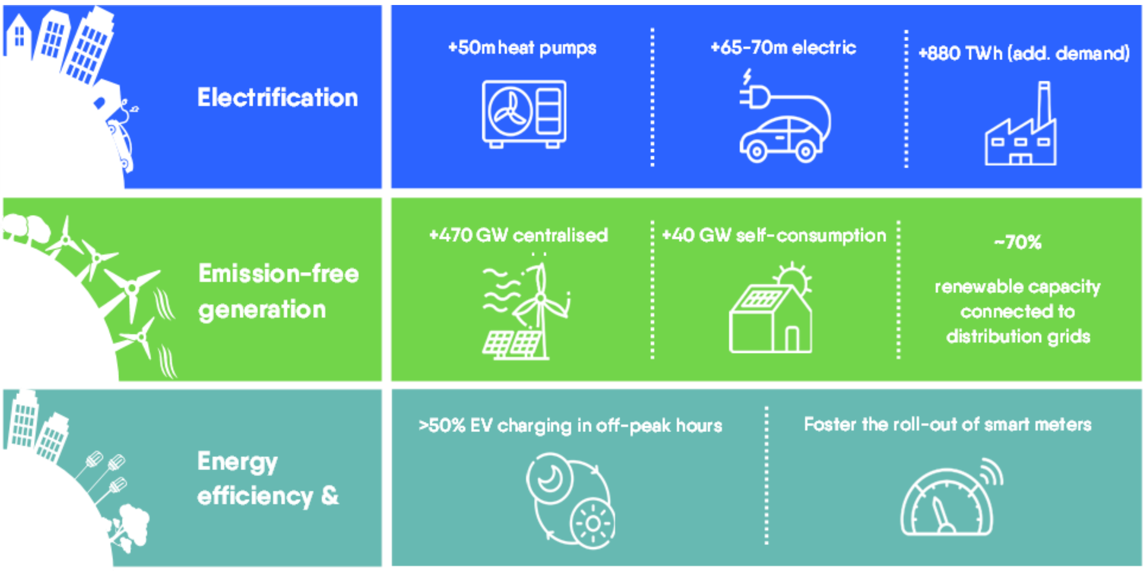
The ambitious and unprecedented objectives of the EU on electrification and decarbonisation imply new businesses and homes being energised, low-carbon technologies being developed, and ever more distributed energy resources (DERs) being added to the already increasing connection demands at the distribution level. Indeed, the so-called "DERs" (small- to medium-size generation assets, electric vehicles (EVs) via their charging points, heat pumps and electricity storage devices) are directly connected to the distribution grid both on the generation and on the consumption side, and they represent massive new capacity needs on top of the usual regular energy producers. Additionally, most onshore wind farms throughout Europe are connected to the distribution grid as well.

All in all, over 70%[3] of new renewable capacity would be eventually connected **to distribution grids directly**.

Moreover, an efficient process to get connected to the electricity network is key for the social and economic well-being of society. Timely electricity connections of all types are essential for the efficient and secure low-carbon and electrified system of the future.

In order to cope with all that new capacity that needs to be connected, **the distribution network must be reinforced and expanded**. It is crucial to change the way the EU's networks are developed, essentially by moving **from an incremental approach (where the grid operator responds after demand is observed) to a build-for-the-future approach** that includes, among other things, anticipatory investments. The timely transformation of the distribution grid will lead to the best outcome for customers. This involves ensuring customers' efficient and prompt connectivity for the benefit of both individual parties and the system overall.

Furthermore, the considerable potential of DERs is expected to result in a growing transfer of energy from the distribution system operator (DSO) grid to the transmission system operator (TSO) grid. The current grid was not initially designed nor anticipated to accommodate such substantial bidirectional energy transfers. In the past, electricity network companies employed a top-down approach to design and manage the distribution network. At that time, extensive management and monitoring tools were not necessary to analyse predictable electricity flows. However, with the increasing integration of DERs, the traditional design and management methods may no longer be sufficient to handle the complexities and variable nature of these energy flows. Now DSOs will need to put in place extensive monitoring to enable full network visibility, in particular by developing low voltage visibility, which in turn will enable greater management of the network and customer participation. **The new paradigm applicable to the grid makes investment in digitalisation and other tools key to becoming smarter and more flexible (see below).**



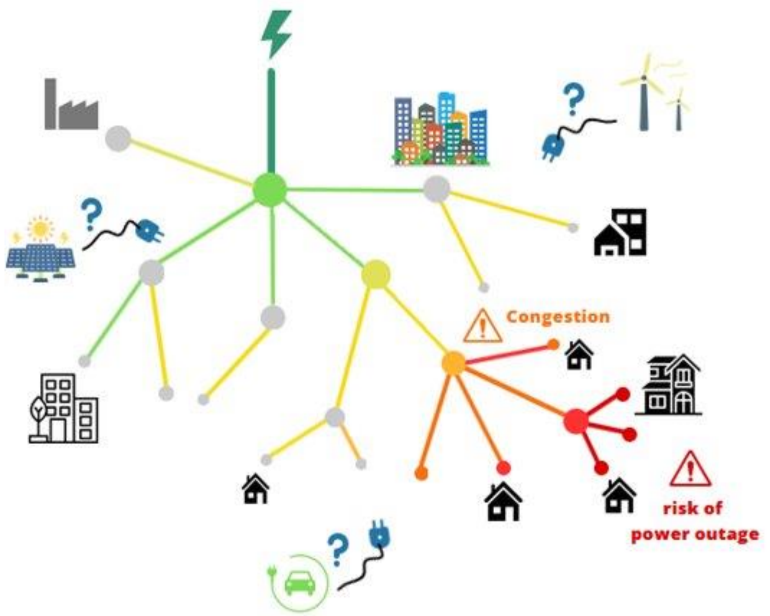
"EU27+UK energy transition levers by 2030" - updated, Connecting the Dots, Eurelectric

[3] *Connecting the Dots*, Eurelectric, January 2021

3. Limited spare capacity to connect demand and generation

Due to the expected increase of renewable assets that need to be directly connected to the grid, some geographic areas now have **limited spare capacity on the distribution network.** This is a **widespread situation** throughout Europe, already substantial among others in Spain, the Netherlands, Germany, Poland, Bulgaria and Ireland. It is useful to note that regional capacity is usually not homogeneous.

Although such limited capacity has been often reported at the generation level, **the problem is now also increasing at the demand level**. Rural areas, for example, which were once primarily characterised by low energy consumption, are now transitioning into consumption-intensive regions due to significant residential development and the adoption of DERs. This shift – relevant to any EU country – is evident for instance through the solarisation of supermarkets, the construction of logistics centres, and the introduction of EVs. Additionally, **switching heating consumption from fossil fuels to electricity** or introducing new electricity consumption in consolidated areas such as city centres is becoming complex as the network was not previously designed for it.



Handbook on the grid®, "Massive DERs integration: let's avoid congestion", by Eurelectric

In countries where the lack of grid capacity is only emerging, such as in Romania, the regulation does not impose any obligations yet on the lack of connection management. Therefore, in these countries, DSOs have spontaneously developed preventive solutions, which are generally in line with the ones existing in the congested countries. Consequently, the sharing of best practices is important.

Overall, the scarce capacity available on the grid implies **long waits to connect and higher costs** for network users because of the work required to accommodate new capacity connections. The main solutions to improve the situation of scarce capacity and allow more connections are analysed in this study.

3.1 The need for grid reinforcement and anticipatory investment

The most common and effective solution to cope with scarce capacity is grid reinforcement, i.e., **physical expansion, reinforcement and renovation of the networks**. This process can take **several years to plan and build**. Also, sometimes DSOs don't have the full visibility of new capacity requests. Even when they do obtain such insights, they might face limitations in proactively making corresponding investments. This is due to the perception that investments without clear tangible demand support could be deemed inefficient, potentially leading to rejection by the National Regulatory Authority (NRA).

- Anticipatory grid planning and anticipatory investment schemes shall be implemented

The regulatory framework and regulators must move from an incremental approach to a **build-for-the-future** approach.
Anticipatory grid planning must be promoted (as evoked in the EMD revision) through the development of tools and information provided to DSOs. These tools include fair compensation for DSOs – which brings the need to revise DSOs' budgetary rules.

Recommendation

Anticipatory planning

- Plan the distribution network at least 5 years ahead, with an option of reaching 10 years, taking into consideration the Ten Year Network Development Plan (TYNDP) conclusions, and actively participate in TYNDP elaboration.
- Have a 2050 horizon projection of the grid.
- Transparent information and data exchange on projects, on the requested time of connection and the capacity needs is paramount.
  ➔ Generators as well as demand must be duly and timely involved in the network development plans' (NDP) drafting: they must declare their connection intents.
  ➔ Where possible, network users can formulate connection requests by taking into account the grid availability details supplied by the DSO. This approach facilitates expedited connections.

Anticipatory investments
The regulator must be flexible on DSOs investment instruments:

- Remove regulatory obstacles (i.e., investment caps) in the national regulatory regimes regarding distribution grid investment.
- Output-based remuneration must be adopted: taking fully into account Capex + Opex, allow DSOs to incur result-oriented costs, eventually with a cost-benefit analysis in due course.
- Where needed, an agile reimbursement mechanism must be implemented, for instance through automatic indicators or cost equivalents, possibly supplemented by an *ad hoc* mechanism covering costs incurred for connecting larger plants.

Transitioning to this approach might have implications for the network connections fees policy in individual Member States. It could potentially result in a shift towards a flat (shallow) per MW fee instead of a fee directly tied to specific connection costs that can vary based on location.

On this note, Ireland is developing some programmes for a better management of grid capacity: the 'Build Once for 2040' concept will ensure that the distribution network and

supporting services such as demand management are designed and developed to meet the anticipated needs of customers in 2040 and to deliver a clean electric future. This includes developing an Advance Infrastructure Policy. Taken together this will eliminate the need for repeated, costly, and resource-intensive interventions on the network. Essentially, where possible, solutions will be deployed that are scalable to meet the needs of customers and stakeholders in 2040.
Like Ireland, the Netherlands is also developing programs to improve grid capacity management. The country is actively working on initiatives to better manage grid capacity and plan for future needs.
In Spain, traditionally the DSOs planned their investments based on the forecast of consumption and asset replacement. Since 2022, in order to accelerate the connection of RES, DSOs are obliged by the regulation to dedicate 10% of their total annual investment to reinforce the network to give access to new distributed generation capacity.
In Germany, the regulator has set no cap for the DSOs investment: the Capex is reimbursed at N+0.
In Denmark, the regulator is presently exploring the implementation of an indicator-based strategy, wherein revenue limits would be automatically raised in response to increased power demand.
DSOs in Switzerland possess a considerable degree of freedom in making investments that align with their strategic perspective. Operating under a “cost-plus” regulatory framework, DSOs undertake initiatives that are deemed rational from their perspective and bill customers accordingly. The pivotal factor in the decision-making process of these investments revolves around optimising the likelihood that the dimensioning of grid elements enables their utilisation throughout their designated lifetimes, eliminating the need for premature replacements. In this context, it is prudent for DSOs to adopt publicly accepted scenarios encompassing electricity consumption, the proliferation of EVs, renewable energy sources (RES), heat pumps etc. In Switzerland, these scenarios are consolidated into the national framework "Energieperspectiven 2050+".

- Grid reinforcement and expansion are mandatory to provide capacity

The EU aims to reduce greenhouse gas emissions by at least 55% from 1990 levels, striving for carbon neutrality by 2050. This places electrification at the heart of the EU's energy strategy, necessitating grid expansion to match rising electricity demand.

Recommendation
EU policies and funds must promote investments in the physical dimensioning of the grid. Dynamic line rating[4] (PL, ES, IE, DE) and construction of networks at higher voltage levels[5] (IE) are some other basic means to expand capacity.

- Relocation of connection to available areas is not viable in the long run

In some countries, such as Spain, if a generator needs connection in an area with no available capacity, they have the possibility to pay for the reinforcement or to be connected in another area that has available capacity, without incurring any cost. The process for determining if there is enough capacity is based on common regulated general guidelines to be applied by DSOs. In those cases, frequent disagreements lead the way to claims as the network users challenge the non-availability report. Relocation of connection is not the most accepted solution.

- Facing the "connect anywhere" principle while there is scarce capacity does not always serve the grid users

Bulgaria and Germany must apply the "connect anywhere" principle with costs that are entirely at the DSO's expense. This means the DSO cannot refuse the connection even in heavily congested areas. Similarly, in some other Member States, DSOs are generally expected to adhere to the "connect anywhere" principle. This is problematic for the grid in the sense that generators usually don't anticipate their connection request; the DSO is often informed last minute **with no permit nor funds at hand to execute the request**. This situation is becoming unviable in countries where congestion is widespread, while connection requests come in from all sides.

Some problematic aspects from the German perspective:

1. Additional generators in congested areas increase energy curtailment and corresponding costs
2. Grid reinforcements (in particular at the HV level) require more complex permit procedures than RES projects, which results in a structural time lag between new generation assets' readiness for commissioning and the grid's necessary expansion
3. Fast expansion of RES in combination with inflexible connection obligations for DSOs complicate the grid's management

[4] Enables the better use of the existing grid, allowing maximised RES integration by taking advantage of shifting weather conditions and their effects on a power line's thermal capacity.

[5] By doing so, it increases local capacity, but issues remain at higher levels that need to be addressed.

Recommendation
The principle of connecting anywhere is valid if it's feasible from both technical and economic perspectives.
Given the use cases throughout the Member States, anticipatory **investments and output-based incentives** are key to solve the scarce grid capacity issues. Anticipatory investments ensure that the grid infrastructure is adequately prepared to handle increasing demand and emerging technologies with a 2050 perspective, while output-based incentives encourage efficient and effective grid management solutions.

- Mechanisms to manage connection requests and unlock residual blocked capacity should be put in place

When the DSO bears the entire cost of grid reinforcements and generators are not financially bound or obligated when requesting capacity, there is a possibility that generators may ultimately choose not to proceed with their projects, even though the grid has been reinforced specifically to accommodate their connection. However, given the electrification effort of the whole energy system, as well as the long lifespan of the assets, such grid expansion is unlikely to become stranded as the infrastructure will be put to use one way or another. This grid expansion works will be utilised in any case given the massive electrification objectives of the EU.

Nevertheless, in such cases, capacity can be granted on a temporary basis for users who actually need the connection **by managing requests**. In order to avoid unrealistic connection requests leading to costly and unallocated extension work, some countries have developed mechanisms. For instance, in Germany, the client must go through a bidding phase for subsidised projects, then if the project is not realised as in the original commitment, penalties or loss of subsidies – where applicable – will be applied. Another example comes from Spain, Denmark and Italy where guarantee deposits must be made by connection requestors.

Recommendation
Implement:
- Expiration of grid connection offers against speculative connection applications.
- Removal of projects that have been queuing for a certain time without progressing in the project's course.

Explore the possibility to increase the concreteness of planning by implementing non-refundable reservation fees, thereby avoiding the tendency to over-request capacity.

Assess solutions and share good practices regarding connection requests and residual capacity management.

Ireland is proposing to develop **renewable hubs** as part of the "Built Once for 2040" concept. Renewable hubs will be substations where clusters of renewable generation will be connected. This should allow more microgeneration, mini-generation, and small-scale generation to be connected to the distribution system. Connection charging policy changes will need to be considered in conjunction with the development of renewable hubs. This is as opposed to the policy today where the network is developed incrementally as each generator connects.

3.2 "Grids is the new permitting", but grids need permits in the first place

Legislators are fully aware of the need to break down administrative hurdles for the decarbonisation of the EU. Hence the temporary Council Regulation (EU) 2022/2577 *laying down a framework to accelerate the deployment of renewable energy* has established a foundation that is partly built upon by the Renewable Energy Directive's (RED) longer time framework permitting – the RED's provisional form intends to facilitate permitting for RES and the associated infrastructure development.

As connection procedures might take 7 to 10 years in the most congested areas, it is crucial to overcome the cumbersome permitting process for construction and reinforcement of the grid which needs to be simplified in the interest of grid users. Additionally, this simplification should also encompass allowing for a lighter environmental assessment for energy infrastructure projects. In order to accelerate the process, the response procedure of the administrative bodies should be regulated.

Recommendation

The permitting topic must be a constant theme while dealing with the decarbonisation of the EU.

- The legislator is urged to set a **dedicated and permanently simplified permitting procedure** for the grid's development in accordance with electrification targets. This should include:
  - A mandatory permitting EU framework;
  - with simplified permitting procedures; and,
  - with deadlines/key performance indicators (KPIs) applicable to the public authorities delivering the permits for the grid's upgrade

- The **one-stop-shop concept** is also to be considered, in particular for HV. Indeed, **a unique permit** covering the generator's project permitting plus the grid expansion/upgrade linked to that project would help in fighting the administrative burdens as well as the lack of capacity.

3.3 Flexibility: Local markets and other tools to develop optimised grid management

Grid reinforcement will eventually be needed, and it may take some time to be built. Until the grid is reinforced – and beyond that point too – it is desirable that the existing grid capacity be used as efficiently as possible. For regular connection requests, system operators usually consider situations based on the worst-case scenario, which means they have to consider the maximum possible feed-in and/or withdrawal, including the simultaneity factor. Nevertheless, the frequency of hours per year in which maximum capacity utilisation occurs simultaneously is typically quite low, resulting in a significant amount of grid capacity available during non-peak hours. However, it is important to note that this scenario does not apply universally, as certain nodes with industrial customers connected often exhibit a more consistent and linear consumption pattern.

- Flexibility in the energy consumption scheme must be developed concurrently with grid expansion

Flexibility involves enabling network users to shift their electricity consumption to non-peak hours, reduce or increase their electricity demand within certain limits, or even participate in demand response programs where they actively respond to signals from the grid or market.

To optimise the use of the grid's capacity, so-called "flexible connection agreements" are to be promoted as an option, primarily on a temporary basis. This flexibility in demand allows for better management of electricity supply and demand imbalances, optimises grid utilisation, and enhances overall grid stability and efficiency. By enabling system operators (SOs) to regulate the electricity flow based on network usage levels, these flexible connection agreements play a vital role in upholding the stability and security of the power grid.

Nonetheless, this requires a certain degree of flexibility from system users and might not be a viable option for all system users as their supply and/or demand is inflexible.

Recommendation
Achieving this objective necessitates **significant digitalisation efforts**, diligent network monitoring, and the **implementation of robust communication mechanisms** and procedures between flexible users and network operators. The absence of comprehensive information regarding network availability can impede progress in this regard. Incentives should be readily available to promote flexibility agreements. **Also, coordination between TSOs and DSOs** in providing flexible connections is key to avoiding inefficient outcomes such as restricting network capacity access or other potential impacts of local actions in managing these schemes, such as congestion. Indeed, both SOs should be informed, but neither should have a say in the implementation of flexible contracts on one another's grid.

- Flexible connection agreements[6] as a choice for customers, with financial impact

Flexible connection agreements refer to contractual arrangements that provide a degree of adaptability and responsiveness in the process of connecting to the electricity grid. These agreements allow for a more dynamic approach to grid connections, taking into account factors such as available capacity, demand fluctuations, and the overall grid condition. The key idea behind flexible connection agreements is to enable more efficient utilisation of existing grid infrastructure while accommodating changes in demand patterns, technological advancements, and other variables that may affect the energy landscape. This can lead to faster, more cost-effective, and environmentally sustainable grid connections. The allocation of investments can also be redirected towards areas where they are most necessary.

Flexible connection agreements can also provide financial incentives to customers by offering them advantageous tariff structures thanks to the possible avoidance or deferral of grid reinforcement costs. Its primary benefit of to the system is the ability to flatten the load curve, thereby promoting customer behaviour aligned with this objective.

Recommendation
FLEXIBLE CONNECTION AGREEMENTs should be plainly used as a common tool in the EU. The revision of the Electricity Market design should ease the implementation of these agreements.

Different flexible connection agreement types have been analysed by the Council of European Energy Regulators (CEER) in its 2023 paper "Alternative Connection Agreements".

[6] Also called "managed connection" (IE), non-firm connection, conditional connection, etc. The term "flexible" is the one retained in the EMD revision proposals (as of May 2023). The Council of European Energy Regulators (CEER) refers to "alternative connection agreements".

One implementation example is the use of a "time window contract," where specific hours of the day are agreed upon for transportation rights, typically outside of peak periods. If one's energy requirements can be met within this designated timeframe, it becomes a regulated contract that provides alternative capacity, consisting of both firm capacity (e.g., for a facility operating continuously) and non-firm capacity (e.g., for an e-boiler that only needs to be filled during a specific non-peak period). Such contracts help control costs within the system. As a principle, non-firm contracts should be cost-reflective.

Recommendation

- Regulators should promote the implementation of flexible connection agreements.
- A comprehensive framework for determining the parameters of flexible connection agreements must be drafted.
- When considering the implementation of flexible connection agreements, the interaction between this mechanism and market-based local flexibility mechanisms for DSOs should be evaluated to continue creating a well-integrated and efficient system that enables the effective utilisation of flexibility resources within the distribution grid

Recommendation

DSOs are in the most advantageous position to assess and determine the contract type that best aligns with the specific requirements and profiles of their customers. This assessment considers factors such as network conditions and regulatory frameworks. In this regard, DSOs should have the freedom to propose flexible connection agreements to customers on a voluntary basis, adhering to the methodology outlined by the NRA. It is ultimately the customer's decision to opt for such an alternative connection agreement, taking into account that it is usually a temporary solution and that flexible connection agreements should be consistent with other available flexible options. flexible connection agreements should be regarded as a versatile "toolkit" at the disposal of DSOs, as emphasised in a CEER paper.

To accomplish this, active engagement with stakeholders and network users is crucial in comprehending their needs and how they can contribute to network flexibility. This collaborative approach entails gaining a comprehensive understanding of customers' specific demands and addressing the challenges they encounter during the connection process, particularly in the planning phase.

Recommendation

To successfully plan and operate a system with flexible connections, DSOs must allocate their resources and develop additional capabilities to effectively monitor, forecast, operate, and plan their networks. These expanded responsibilities entail additional costs that should be duly acknowledged and accounted for by the regulator. Recognising and appropriately addressing these extra expenses ensures that DSOs have the necessary support to fulfil their enhanced roles in managing flexible connection systems.

By doing so, DSOs can assess and anticipate emerging demands and stay well-prepared to respond accordingly. This proactive approach ensures that DSOs can adapt to evolving requirements and maintain the necessary infrastructure to support flexible connection agreements.

While flexible connection agreements offer significant benefits in areas experiencing congestion, it is preferable for the scope of these agreements to extend beyond such congested areas. Consequently, flexible connection agreements could become **voluntary options for all stakeholders**. This approach has the potential to optimise grid capacity, allowing for the inclusion of new users such as batteries in the future. Moreover, as the grid evolves, the cost impact on other network users would be less significant.

Recommendation

- DSOs strongly support **introducing voluntary flexible connection agreements** in all Member States. these agreements should be an option for all types of network users, generation, storage and demand. DSOs will offer them in a non-discriminatory manner, primarily as a temporary solution until planned network reinforcements are realised. There should be potential for flexible connection agreements' extended use, including as a long-term solution, particularly if a favourable cost-benefit analysis demonstrates positive overall outcomes.

- The EMD revision aims at **defining the legal framework** for such contracts. DSOs support the draft proposals stipulating that flexible connection agreements must rely upon specified conditions of connection limitation:
  - Maximum firm import/export of electricity and flexible import/export
  - Network charges related to the capacity of firm electricity and flexible capacity
  - Probabilities of curtailment

- **Power control systems (PCS) must be redesigned** to become more accessible to ease the implementation of flexible connection agreements. A PCS is a device or a service, such as a home energy management system, that provides consumers with improved power quality, energy efficiency, cost savings, and enhanced electrical safety. At the same time, the DSO benefits from a more stable grid, demand response capabilities, and improved load balancing.

- DSOs must systematically have the possibility to use managed connections if the network faces congestion problems through a contract with the grid user. In those cases, the contract must be limited in time until the grid is updated by the DSO.

Generation side application of flexible connection agreements

Flexible connections are a solution for connecting more capacity to the network. This concept comprises many different contract forms. In Spain for instance, when a generator requests capacity and the node is already full, an agreement to connect subject to installing a remote trip scheme can be offered to the generator. Thus, when a contingency occurs, the trip will be activated by the grid operator and the generator will be disconnected to prevent overloads. In Romania, grid connection endorsements are delivered to connection requestors with the same consequences as in Spain. In Ireland and in the Netherlands, non-firm connection agreements are in the pilot phase for generators connected at the DSO level.

In Finland, flexible connection agreements are allowed in the electricity legislation for generation as well as for energy storage in networks of 110 kV and above (TSO and DSO).

Demand side application of flexible connection agreements

In Germany, the existing scheme is the following: if requested by the customer, DSOs must grant a reduced grid tariff (3-7 cents/kWh) for appliances such as heat pumps, storage heating and charging infrastructure. In return, the customer allows the DSO to manage the device in question through the ripple control, for an agreed time interval.

There is also a scheme under discussion from 2024 on for customers who install manageable appliances such as private charging infrastructure (charge point) or heat pumps. It will be mandatory to provide the flexibility (fixed time intervals given by the DSO) of these appliances to the DSO. In return, the appliance is to be connected to the grid without delay and the customer receives a general reduction of their grid tariff. This regulation will expire end of 2028.

From 2029 on, customers' manageable appliances can only be used for congestion management in low voltage (LV) if there is documented proof that the intervention of the DSO is justified. By doing so, DSOs are urged to reinforce the concerned grid section.

In the Netherlands:

- In a pilot case, a Dutch factory installed a high-power e-boiler. However, due to limitations in the existing grid capacity, the factory faced a significant waiting time of 3 to 7 years to obtain a connection. To address this issue, the DSO proposed a pilot non-firm connection agreement to the factory, which revealed that the unused capacity outside of peak hours was sufficient to meet the factory's needs. By adjusting their e-boiler operations accordingly, the company successfully installed their e-boilers while the DSO simultaneously worked on expanding the grid capacity.
- The Flexpower3 pilot by Alliander, in collaboration with the municipality and charge point operators, grouped charging stations, with each station assigned a power level based on the group demand. During peak times, cars receive reduced power while still charging at optimal speed, and during quieter periods, they charge just as quickly. This optimisation allows for lower capacity reservations per station and creates room for more charging stations without overburdening the grid. The participation of charge point operators was voluntary, without further incentives.

3.4 Congestion management services: a complementary tool to network upgrade and flexibility

The use of flexibility services for congestion management in distribution networks shall be included in the medium and long-term network development plans, in accordance with Art. 32 of the Electricity Directive. It could be a key tool in heavily congested areas, complementing flexible connection agreements.

DSOs play a crucial role in managing congestion within the distribution grid and offer various services to address this challenge. Three common forms of congestion management employed by DSOs are **curtailment**, **redispatch and market-based procurement**.

- Curtailment refers to the deliberate reduction or interruption of electricity supply to specific consumers or areas experiencing congestion, aiming to alleviate the strain on the grid.
- On the other hand, redispatch involves adjusting the generation schedule or output of power plants to optimise the flow of electricity and mitigate congestion. In redispatching, the greatest responsibility lies with TSOs, but DSOs have an increasing responsibility.

Curtailment and redispatch measures are used, for instance, in Germany where RES must be connected and can inject anytime anywhere.

- Market-based procurement for congestion management services encourages market participants to offer their resources or adjust their consumption patterns based on the prevailing market conditions, ensuring that congestion is addressed in the most economically advantageous manner (this can be done via an existing market platform or other forms of interfaces, as long as there is enough liquidity and that the arrangements do not unduly distort markets).

  In the Netherlands, market-based procurement is provided via the online platform GOPACS, jointly operated by Dutch system operators. GOPACS is a platform with which the Dutch system operators can jointly access and coordinate flexible power in the electricity network. It mitigates grid congestion by collaborating with large business customers, who can temporarily adjust their electricity consumption or generation in exchange for compensation. This frees up grid capacity for others, ensuring grid reliability and affordability. GOPACS isn't a standalone trading platform but partners with energy trading platforms. It benefits any market player with flexibility in electricity use, including solar and wind farms and companies that can adapt their electricity consumption or store excess energy.

  In Ireland, "Beat the Peak" is a very successful programme which aims to increase awareness around the peak and incentivise domestic and commercial promises to reduce their use at peak times and people are paid to shift the loads. There is a component for businesses which pays for the reduction in usage at peak times (piloted at present). The programme is growing.

  In Italy, following the NRA's request for proposals, the EDGE (Electricity distribution grid evolution) pilot project conducted by e-distribuzione aims to test procurement of local flexibility markets for congestion management in Italy's electricity distribution system. The initiative concerns areas selected based on load evolution scenarios and potential criticalities in the medium term, quantified through a forecast tool on electrical flows. In the selected areas with congestion risk, tenders are issued and connected users can offer flexibility services through a dedicated market platform, ensuring the availability of necessary flexibility services through bilateral contracts.

These measures enable the DSO to ensure compliance with the network operating principles efficiently.

To enhance the congestion management capacities of DSOs, several additional strategies can be proposed. Priority dispatch schemes are one such approach, **wherein certain DERs or flexible loads are given priority when it comes to dispatch decisions**. This means that these resources are strategically dispatched to alleviate congestion or provide support during peak demand periods.

Recommendation

- Congestion forecasts provide information in advance about potential grid congestion enabling the DSO to plan and take proactive measures. These forecasts are typically based on detailed **analysis of historical data load forecasts and network simulations, which implies strong digitalisation**.
- Congestion notifications involve **timely communication between system operators** informing one another about current or anticipated congestion events or constraints.

3.5 Data and information exchange: an anticipatory tool to enhance alongside the other tools

DSOs are increasingly recognising the need for enhanced data exchange with multiple stakeholders to improve their operations and to proceed to **anticipatory grid planning**.

- Providing data to DSOs

Recommendation

Planning: One crucial aspect is establishing robust data-sharing mechanisms with generators and consumers. By obtaining **detailed forecasts from generators regarding their project locations and power capacities**, DSOs can gain a comprehensive understanding of emerging generation patterns. This information allows for better planning and coordination of the distribution grid, ensuring efficient integration of renewable energy sources and minimising potential congestion issues.

Operation: Furthermore, DSOs require effective **data from each metering/connection point** including prosumers that participate in any kind of energy sharing scheme. **Modelling the behaviour of prosumers** and accurately measuring changes in injection and consumption from the grid are vital for grid management.

By collecting data from local authorities (area development plan) as well as on energy generation and consumption patterns from these stakeholders, DSOs can gain valuable insights into the evolving demand profiles, identify peak periods, and optimise the distribution network accordingly. This facilitates the effective integration of DERs and promotes the use of demand response programs to balance supply and demand in real time.

Recommendation

In addition, **close collaboration, and information exchange with TSOs** are essential for congestion management and for providing capacity to their networks. DSOs need to stay informed about congestion events and constraints within the transmission grid as these can significantly impact their own distribution networks. By receiving **timely updates and sharing relevant data** with TSOs, DSOs can dynamically optimise the use of the network and prepare eventual support for the TSO grid. The long-term ambition should be to have a fully digitalised/automatised information exchange in real time.

Overall, fostering data exchange between DSOs, generators, demand, storage, and TSOs plays a critical role in enhancing the overall efficiency, reliability, and flexibility of the distribution grid. By leveraging comprehensive information, DSOs can make informed decisions, optimise grid operations, and effectively manage congestion challenges in a rapidly evolving energy landscape.

- Giving access to DSO data

DSOs also recognise the importance of giving access to data, particularly regarding the state of the grid, subject to security requirements. It is important to provide information about network availability, capacity and connection options to generators, end users and public authorities. By providing transparent and accessible information, DSOs enable stakeholders to make informed decisions, promote collaboration, and drive innovation in the energy sector.

In many countries, DSOs voluntarily publish their available capacity by means of a **DSO capacity map** of the electricity network for medium voltage (MV) and HV, which ensures that customers have access to up-to-date information about grid capacity. This has the merit of indicating where projects are most likely to be easily hosted. However, this publication does not solve *per se* the scarce capacity issue.

A survey was conducted among Eurelectric members to gather information on existing capacity mapping practices in Europe, in order to pinpoint best practices and areas to improve upon. 16 countries answered: Austria, Bulgaria, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Lithuania, the Netherlands, Norway, Poland, Portugal, Romania, Slovenia and Spain.

Out of the 16 responding countries, 14 indicated that there were publicly available capacity maps, either by DSO or by country. 16 weblinks to maps were given (2 for Norway, Poland and Spain) – see the annex below.

In the Netherlands as well as in France[7], the capacity mapping is done at national level. In Norway, the ambition is for capacity mapping to be a national service including data from all DSOs. Some DSOs have developed their own application but will most likely convert to WattApp, the dominant mapping platform. In Italy, Poland, Portugal and Spain, the mapping is done individually by DSOs (e-distribuzione, Tauron Dystrybucja, PGE Dystrybucja, E-Redes, i-DE, e-distribucion). In the case of Lithuania, Greece, Ireland and Slovenia, there is only one DSO in the country (or one main DSO in the case of Lithuania, covering 99.6% of customers), which is then responsible for capacity mapping. In Denmark and Romania, it is TSOs that are responsible for updating the capacity map (Energinet in Denmark, Transelectrica in Romania) with the data provided by DSOs on the distribution grid's capacity.

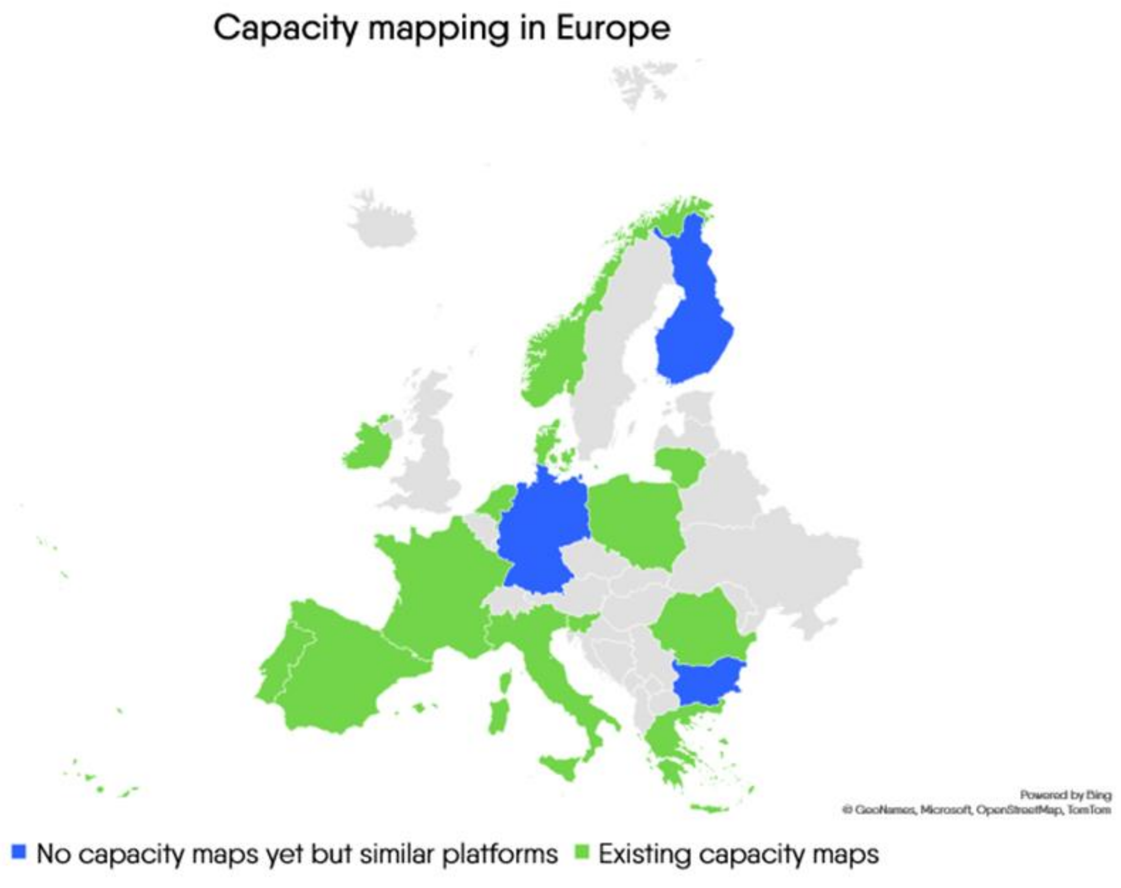
In Germany, Bulgaria and Finland, such maps do not currently exist. In Germany, there are no full-scale maps, but E.ON's grid operators are in the process of introducing tools that allow for automated connection checks – mostly for PV and mostly for smaller PV for now but other solutions are under development. In Bulgaria, there are platforms developed by individual DSOs that fulfil similar purposes: upon filling an electronic form indicating a specific place, the platform announces if there is available capacity to connect new RES electricity generation capacity or not. In Finland, DSOs do not currently publish wide scale capacity maps, due to security concerns, as electricity grids are critical pieces of infrastructure. Information on available capacity is provided to the customers via other means, namely on customer request. There are however some examples of map services available, such as an EV charging capacity map or a TSO capacity map.

[7] An update of France's capacity map (regarding updating frequency, granularity, and the overall process) is currently underway in collaboration with the French regulator.

Most maps are designed for generation and not consumption (16 positive responses out of 16 maps for generation versus 6 for consumption). Almost all capacity mapping shows available capacity at connection points, and most maps also show utilised capacity (69 % of maps). Most maps have a high level of granularity and show available MWs at connection points (AT, FR, RO, LT, IE, NO, PL, PT, SI, ES and DK), or available power at substations for RES (GR). Others are more visual and less granular, using colours to show the level of congestion or availability in different regions (NL), or the critical areas for connections of new generation plants (IT).

Capacity maps have quite variable updating frequencies from country to country. In some places it is monthly (SI, ES and RO), even daily (LT), in others quarterly (IT, NL, PL), and yet in others less regularly.

An interesting development is in Norway's WattApp platform, which shows **future possibilities of capacity**, also allowing users to select their potential connection time to forecast a hypothetical capacity availability.



Links to all capacity maps and further information can be found in the annex.

> **Recommendation**
> At least **quarterly update** of DSOs **capacity maps** would be a useful information base.
> Where this data is available, connection **requestors must take into account the availability of the grid before submitting** any connection request. Up to date means quarterly at least.
> A **common digital platform** involving public authorities, generators and DSOs could be created at each national level to share information on the status of the connection process. All connection requests could be centralised on this platform.

Also, with DSOs providing such information, developers could decide to form groups and finance grid extensions sharing the cost.

What's more, the mapping tool can be matched with a **"mandatory go-to areas"** practice for RES. For the moment, no country has opted for such an approach.

While providing access to data is crucial, each must ensure the appropriate protection of sensitive information, such as customer data and critical infrastructure details. Implementing robust data privacy and security measures is vital to safeguarding the integrity of the grid and maintaining trust among stakeholders. It is also paramount to ensure that collected data is reliable.

3.6 Other solutions to explore for more optimised grid integration

- Time of use (ToU) network tariff for the efficient use of capacity

Spain incentivises demand-side flexibility via different **ToU capacity tariffs based on 6 different periods**. The user can contract a different capacity level for each of the six periods. Off-peak periods are cheaper and peak periods are more expensive. This incentivises consumption to move to off-peak hours.

Ireland has 3 DSO domestic tariffs (24-hour flat; day and night are available to all customers and an additional peak tariff is available to smart meter customers on an opt-in basis) but the impact depends on whether the supplier passes on or highlights it.

Recommendation
Further investigate the benefits of static ToU tariffs on optimised use of the network since such tariffs might help reduce grid reinforcement needs and congestion costs.

- Exception to the non-discrimination principle

According to Art. 31 of the Electricity Directive[8], "in any event, the distribution system operator shall not discriminate between system users or classes of system users, particularly in favour of its related undertakings". This rule means that the first to come is first served irrespective of purpose, size, or other criteria, and DSOs treat customers in a non-discriminatory way unless decided otherwise by political authorities.
As massive grid expansions and reinforcements are an absolute precondition for achieving climate goals, NRAs and governments sometimes temporarily deviate from the EMD non-discriminatory principle for the access to energy networks and grid capacity, especially in congested network areas. In case exceptions to the non-discrimination principle are implemented, clear and transparent rules must be set. The framework put in place by national authorities and executed by the DSOs with **prioritisation decisions made by political authorities** must be transparent and run through an open process, based, for instance, on one of the following criteria:

- The social merit order;
- the resource (e.g, prioritisation of RES);
- the existence of, or duty to provide a storage solution attached to the generation asset; or,
- the reserved access to constituted generator "groups" or "batches".

[8] DIRECTIVE (EU) 2019/944 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU (recast)

By introducing exceptions to the non-discrimination principle, the aim is to bring flexibility to address grid limitations in congested areas, prioritise the most socially significant connections, and expedite the deployment of renewable energy sources. By doing so, the acceptance rate of the energy transition can be improved while upholding principles of transparency, fairness, and accountability in the access to energy networks and grid capacity.

In the long term, an implementation of this would be the introduction of **mandatory 'go to areas'** for certain categories, which gives governments more control over the targeted acceleration of renewable energy sources.

Recommendation
Further explore the outcomes of a derogation to Art. 31.2 of the Electricity Directive, allowing public authorities to prioritise the connection of specific assets to achieve decarbonisation objectives.

Another example comes from Ireland where a **gate system** – regulated by the NRA – was created for generators. This involves **assessing generator connections on a batch and group basis.** This has the advantage of providing optimal additions to the network but has the disadvantage of only a once-a-year connection process.

Whereas in Spain, the NRA is developing regulations for the efficient consideration of storage in the process of granting access to the grid. The general principle is to consider the worst case, both in generation and consumption mode, but a more elaborate approach is being discussed so that the flexibility of the storage asset allows for a faster and more affordable grid connection.

In Poland and in Spain, there's also a connection priority for RES.

- Queue management principle

This practice of the transmission level could be extended to distribution. It consists of evicting projects that are not progressing against agreed milestones and avoiding blocking capacity.

Another possible approach could be to introduce a bidding system for access to the connection queue. In this system, generators that are fully prepared to commence operations would offer higher bids, while those that are less ready may choose not to take the risk and bid lower. The primary advantage of this approach is the accelerated installation of renewable energy sources, resulting in quicker integration into the grid.

In Ireland, long-stop dates are defined to terminate capacity.

Recommendation
Set transparent criteria to relocate the capacity assigned to projects that are showing no tangible evolution.

4. Recommendations summary to facilitate connection

Grid planning, extension, and renovation

- Implement simplification and acceleration measures for grid construction permits
- Involve all relevant stakeholders in the NDP drafting procedure: Generators and larger customers should in good time provide information about future requests for increased production or demand to the DSO's NDP drafting procedure (Art. 32 Electricity Directive)
- Incentivise grid investment (i.e., revise the financial tools accessible to DSOs and allow anticipative investments as well as the consideration of Capex + Opex + *ad hoc* expenses for the grid's upgrade)
- Promote anticipatory planning of the grid with a 2040 horizon at least, and preferably 2050 as the ambition is to double capacity by then. This will allow a projection on the optimal design of the network to figure out what the network could look like in 2050 and then work back
- Harmonise the development of the DSO network with the development of the area of distributed energy resources and regional area development plans

Flexibility

- Promote flexible connections
- Stimulate local production and consumption, preferably as close as possible to the energy source
- Assess the outcomes of the exemptions introduced by the authorities to the non-discrimination principle in congested areas with high demand or high production

Grid management

- Implement "mandatory go-to areas" for generators to avoid congestion and ease the capacity management
- Invest in smart grid infrastructure
- Empower DSOs with enhanced tools and procedures to directly manage new kinds of users such as flexible demand, storage and energy sharing
- Promote the voluntary participation of generators to congestion management
- Grant a curtailment possibility as an emergency measure in case of congestion
- Develop forecasting tools and skills

Digitisation

- Assess and incentivise digitisation of grid management
- Invest in demand management and forecasting appliances
- Improve congestion management tools (curtailment, redispatching, TSO/DSO information flows, predictive congestion programs, etc.)
- Set an EU-level framework for access to reliable data

Investments

- Assess fair compensation of DSOs regarding their new responsibilities (complexification of balancing, complexification of electricity flows, etc.)

5. Annex

a. Links to capacity maps

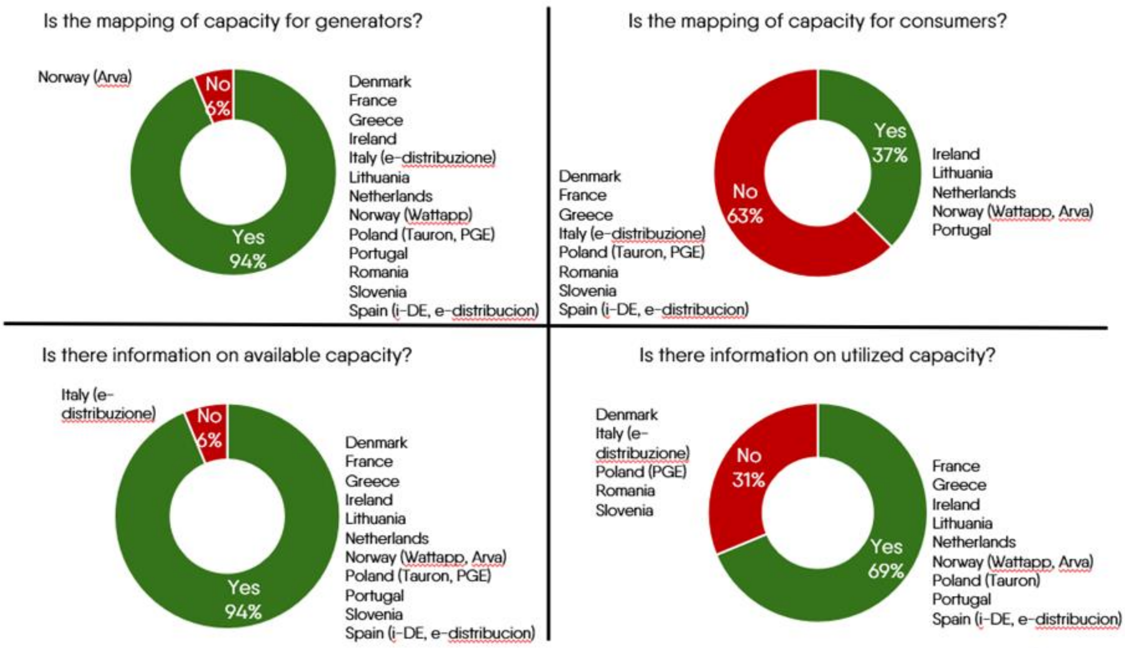
Country	Link to map
Denmark	https://storymaps.arcgis.com/stories/eb5b387e376f49b8996d5e7c47fbdd37
France	https://www.capareseau.fr/
Greece	https://apps.deddie.gr/WebAPE/main.html
Ireland (ESB)	Network Capacity Map | ESB Networks
Italy (e-distribuzione)	https://www.e-distribuzione.it/a-chi-ci-rivolgiamo/produttori/aree-critiche.html
Lithuania (ESO)	Generators: Transformatorių pastočių laisvų galių žemėlapis gamintojams - Elektros linijų žemėlapiai - ESO - Energijos skirstymo operatorius Consumers: Transformatorių pastočių laisvų galių žemėlapis vartotojams - Elektros linijų žemėlapiai - ESO - Energijos skirstymo operatorius
Netherlands	Capaciteitskaart elektriciteitsnet (netbeheernederland.nl)
Norway	www.wattapp.no
Norway	https://arva.no/Kapasitetskart/
Poland (PGE Dystrybucja)	https://pgedystrybucja.pl/przylaczenia/informacje-o-dostepnych-mocach-przylaczeniowych
Poland (TAURON Dystrybucja)	https://www.tauron-dystrybucja.pl/przylaczenie-do-sieci/dostepne-moce
Portugal (e-redes)	Wntech https://e-redes-rede.wntech.com/
Romania	https://web.transelectrica.ro/harti_crd_tel/ As of 2022, the TSO has the obligation to publish weekly on its website the capacities available in TSO and DSO network, **at 110 kV level**
Slovenia	SODOKart | GEO-PORTAL
Spain (i-DE)	https://www.i-de.es/conexion-red-electrica/produccion-energia/mapa-capacidad-acceso
Spain (e-distribucion)	https://www.edistribucion.com/es/red-electrica/Nodos_capacidad_acceso.html

b. Links of other similar tools

Country	Link to tool
Bulgaria (ERM Zapad)	https://ermzapad.bg/bg/za-klienta/uslugi/prisedinyavaniya/proverka-za-nalichie-na-kapacitet-na-erm-zapad-za-vei-proizvoditeli/
Bulgaria (EL Yug)	https://elyug.bg/ProduceCapacity/ProduceCapacity.aspx
Finland (DSO Kymenlaakson Sähköverkko)	https://www.ksoy.fi/sahkoverkko/ohjeet-ja-palvelut/sahkoautoilun-latauskapasiteettikartta/
Finland (Fingrid, TSO)	https://www.fingrid.fi/kantaverkko/liitynta-kantaverkkoon/verkkokiikari/

Finland (DSO, Elenia)	https://www.elenia.fi/uutiset/testaa-nyt-aurinkosahkolaskurilla-jo-suunnitteluvaiheessa-sinulle-sopivimmat-aurinkopaneelit
Germany (e-dis)	Netzanschlussmonitor (e-dis.de)
Greece	https://geo.rae.gr/?lang=EN&lon=23.79185135528876&lat=38.557522898343905&zoom=7
Poland (PSE)	https://www.pse.pl/obszary-dzialalnosci/krajowy-system-elektroenergetyczny/informacja-o-dostepnosci-mocy-przylaczeniowej
Portugal (e-redes)	Open data https://e-redes.opendatasoft.com/explore/dataset/postos-transformacao-distribuicao/mapa/
Portugal (e-redes)	Network investment plan https://www.e-redes.pt/sites/eredes/files/2022-07/PDIRD-E 2020 proposta final.pdf (page 257)

c. Detailed survey results



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- Commitment, innovation, pro-activeness

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- Transparency, ethics, accountability

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