DSO ENTITY
DSOs FOR EUROPE

EU DSO Entity's Technical Vision

Supported by:

COMPASS LEXECON

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Executive Summary

This document presents EU DSO Entity's Technical Vision, developed with the support of the economic consultancy Compass Lexecon.[1] It builds on the work of all its expert groups (Distributed Flexibility, Finance, Data Interoperability, Existing Network Codes, Digitalization of the Energy System Action Plan, Ten Year Network Development Plan and Cybersecurity), as well as on extensive knowledge sharing sessions and working sessions with the Board of Directors, Country Expert Group and Strategic Advisory Group. The content of this report remains however the sole responsibility of EU DSO entity.

The transformation of Europe's energy system towards a more electrified, decentralized and customer centric system, requires DSOs to meet new demands, including the connection of most of Europe's renewable energy capacity, EV charging infrastructure and heat pumps. The objective of this Vision is to establish an integrated and unified framework and common language among DSOs, supporting DSO Entity's initiatives and raising awareness of the essential role DSOs play in empowering customers and driving the energy transition

DSOs' core development areas to reach net-zero and serve customers include four main areas, supported by digitalization and data, acting as a steppingstone for the other areas to deliver value to customers.

- ✓ **Planning and investment:** DSOs provide value to customers with efficient investments to expand and smarten grid infrastructure to enable a reliable energy transition, while ensuring uninterrupted service, enhanced flexibility, and smart technology integration, in collaboration with stakeholders.
  - Unlocking investments:
    - DSOs make investments in expanding and smartening infrastructure to ensure a seamless energy transition, thereby guaranteeing customers have a reliable service and access to energy in areas with lack of capacity.
    - Anticipatory investments aim to accelerate energy transition, guaranteeing that customers benefit from a resilient and modernized grid that meets future energy needs.
    - By utilizing adequate financing, including EU funding and national support, DSOs enhance flexibility, digitalization and address supply chain challenges, promoting the growth and competitiveness of EU industry.
  - Distribution Network Development Plan:
    - The adaptation of DNDPs based on best practices and with DSO Entity's support, will facilitate data-driven grid investments by DSOs, efficiently targeting system parts that require capacity to enable the transition.
    - Further developments of DNDPs will foster transparency, facilitate collaboration with ENTSO-E and TSOs to effectively integrate DSOs into the EU system of systems and ultimately drive customer benefits such as quality of service, lower costs, and increase

[1] Compass Lexecon Energy Practice. Contact: Fabien Roques froques@compasslexecon.com.

access to more competitive energy markets. Furthermore, this will boost the overall economy and customer welfare across the EU efficiently.

- ✓ **Market facilitation and prosumers engagement:** DSOs enhance consumer value by facilitating system flexibility, enabling market access, and ensuring secure, equitable energy supply through regulatory and infrastructure improvements.
  - Flexibility:
    - Flexibility will allow customers to better participate in and benefit from the evolving energy landscape, as it offers various forms that can be tailored to different needs.
    - DSO Entity will be a key partner to achieve a common language and increase harmonization to facilitate the use of flexibility for congestion management and voltage control.
    - DSOs incorporate various types of flexibility into their operations, creating opportunities for customers to unlock their active participation in energy markets and optimize their energy costs.
  - Energy sharing:
    - The EU framework paves the way for energy communities, and energy sharing models will be increasingly implemented in the coming years and decades.
    - DSOs will be key partners for customers to navigate these new opportunities, by managing the system, data, and contracts.
    - DSOs, supported by DSO Entity, will actively cooperate and communicate with consumers, by raising awareness and facilitating new business cases.
- ✓ **Operations and maintenance:** To address the growing demands of RES and DER, DSOs are taking decisive steps to upgrade their system management capabilities. With customers being the centre of the energy transition, DSOs aim to secure the future bi-directional power system and its operational efficiency.
  - Active System Management: By adopting digital technologies, DSOs are empowering customers and creating a secure, adaptable energy system that drives Europe toward a low-carbon, affordable, and competitive future. DSOs, with the support of DSO Entity to identify best practices, will work towards:
    - System stability and security: By enhancing system management with digital technologies and collaborating with TSOs, DSOs will ensure stability across the EU's interconnected power system. This includes adapting the power system to growing DER and RES, managing energy flows, and implementing robust system security measures to protect against new risks (e.g. EV charging surges) while keeping the lights on.
    - Operational efficiency: With the use of predictive maintenance, advanced diagnostics, and partnerships with technology providers, DSOs will ensure quality of service and asset longevity.
    - Empowering customers: DSOs are equipping customers with accurate data, providing insights into their energy usage. This fosters active participation in flexibility services, thereby optimizing energy use and cost savings.
- ✓ **Resilience and Sustainability:** DSOs provide value to customers by adapting their grids and operations to climate change, ensuring resilience during extreme weather events, accommodating evolving energy consumption patterns, and addressing digitalization challenges through improved cybersecurity and risk management.

- Climate adaptation via observability and reinforcement:
  - To enhance value for customers, DSOs will implement actions that include fortifying infrastructure and strengthening emergency response capabilities. This will help ensure a resilient and reliable energy system amid increasing climate-related risks. DSO Entity will provide guidance on optimal actions.
  - By continuously analysing system performance and leveraging real-time data, DSOs will respond more effectively to extreme weather events, reducing outages and recovery times.
  - Additionally, DSOs, with the support of DSO Entity to identify best practices, will integrate sustainable practices within their operations, such as eco-friendly vegetation management and sourcing sustainable materials, contributing to climate change mitigation and supporting a greener energy system for customers.
- Cybersecurity:
  - DSOs, with the support of DSO Entity to identify risks and response strategies, will prioritize robust cybersecurity measures to protect customer data and ensure reliable energy services in an increasingly interconnected and digitalized energy grid.
  - By coordinating with stakeholders and adapting continuously to emerging threats, DSOs will safeguard the energy infrastructure, providing customers with secure and uninterrupted access to energy as well as peace of mind regarding their data's safety.

✓ **Digitalization and data:** Digitalization is the foundation enabling DSOs to deliver value across their core areas. To cope with the growing complexity of digitalisation, DSO Entity is supporting the EC in building an EU role model that defines the roles and responsibilities and enables data interoperability across the Union. Moving towards a European Data Space involves securing, making interoperable, and ensuring the accessibility of diverse data for a broad range of stakeholders, including customers, energy producers, aggregators, and other grid operators (DSOs and TSOs). The DSO data space represents a critical component of the future decentralised and customer-driven energy system. As custodians of essential customer and system data, DSOs enable the efficient operation of the system while facilitating the integration of DERs and the growth of energy markets. By balancing the need for data access to different players with strong data privacy and security practices, DSOs can help create a more resilient, efficient, sustainable, competitive and customer-centric energy system.

- Planning and investment:
  - DSOs will leverage digitalization to enhance network planning by analysing high-quality, diversified data that accommodates evolving customer profiles and electrification trends.
  - By ensuring secure and collaborative data management, DSOs can deliver more accurate forecasts, anticipate infrastructure needs, and reinforce the grid where necessary, ultimately creating a more reliable and customer-responsive energy system.
- Market facilitation and prosumers engagement:
  - DSOs will leverage digitalization to enhance flexibility, engage customers through data-driven insights, and ensure secure, interoperable data systems.
  - By effectively managing and analysing vast data streams, DSOs will foster community-based renewable initiatives and deliver customized services that adapt to evolving energy demands.

- Operations and maintenance:
  - DSOs will leverage digitalization and advanced monitoring technologies to enhance grid observability, optimize asset utilization, and maintain maintenance efficiency.
  - By implementing new technologies such as dynamic ratings, proactive monitoring, predictive analytics, and automation, DSOs will improve reliability, and increase responsiveness, ultimately delivering a more resilient and customer-centric energy system.
- Resilience and sustainability:
  - DSOs will leverage digital tools and real-time monitoring to strengthen grid resilience, reduce outage durations, and ensure a reliable energy system.
  - By collaborating with cybersecurity experts and government agencies, DSOs will establish robust cybersecurity frameworks, protecting customer data and securing critical energy systems. This will provide stable and resilient energy infrastructure for customers in a digitalized world.

The picture below illustrates how this vision encompasses all the core areas with the objective of serving customers and drive the energy transition.

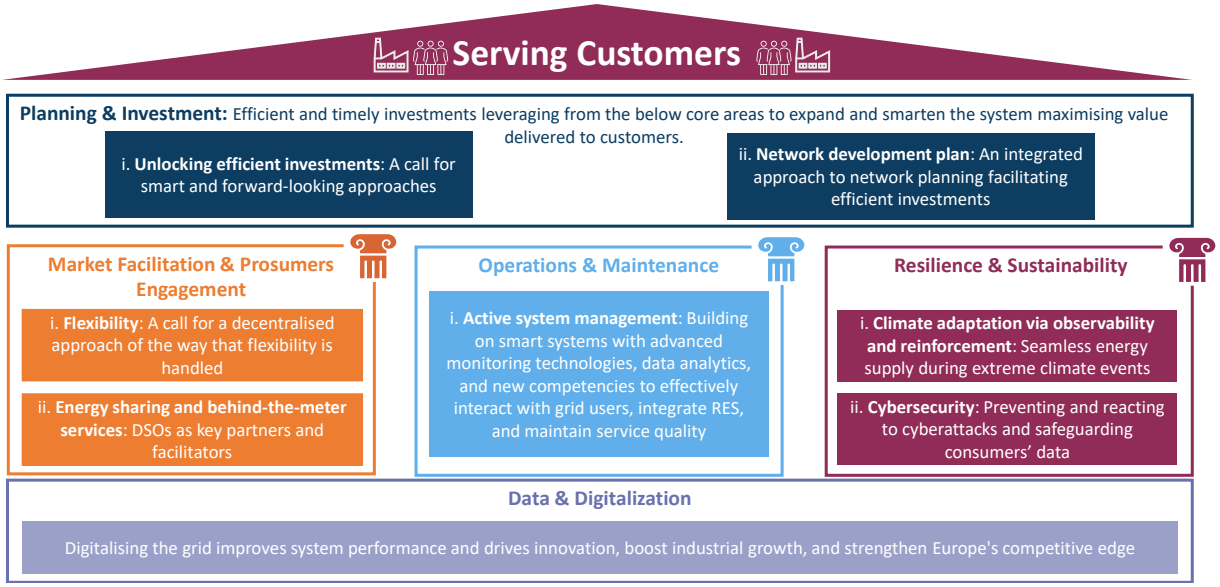

Figure 1: DSO's core development areas to reach net zero and serve customers.

This Vision is also a call to cooperation for European stakeholders to work together towards serving European customers

- ✓ **Increased cooperation with ENTSO-E** for an efficient system operation, market integration, planning and investment.
- ✓ **Close collaboration with the European Commission and ACER** to enable forward-looking regulatory adjustments that align the power system with society's transition towards a net-zero energy future.
- ✓ **Close collaboration with all system players** to ensure a competitive, resilient, efficient, and customer-centric power system that reinforces Europe's industrial leading in the global energy transition.

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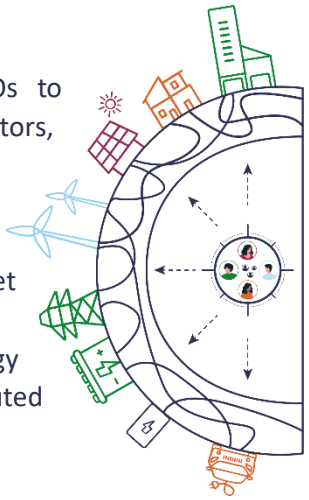
1. About DSO Entity: Uniting DSOs to deliver a just energy transition

Who we are

DSO Entity is the EU's legally mandated body representing the interests of the European Distribution System Operators (DSOs). Established in June 2021, DSO Entity unites over 830 DSOs across all 27 EU member states, connecting more than 250 million electricity customers and covering more than 95% of the connections in Europe.

Our mission

As mandated by EU regulation, our mission is to promote the completion and well-functioning of the internal market for electricity, and to help drive Europe's energy transition. The mission includes:



- **Promoting cooperation:** Providing a trusted platform for DSOs to cooperate with each other and engage with TSOs, regulators, policymakers, and other key energy stakeholders.
- **Providing technical guidance** to the European Commission and other EU bodies on issues related to DSOs, particularly in the integration of renewable energy sources, fostering efficient market performance.
- **Empowering DSO's customers:** Supporting a customer-centric energy system by enabling active customer participation, through distributed energy resources, demand response, and prosumer models.

Our values

We are committed to ensuring a **diverse** and balanced representation of all electricity DSOs within the European Union. DSO Entity strives for transparency in all its workflows and embraces an open-minded, fact-based and customer-centric approach.

Our core tasks

Our mission and mandate inspired our three pillars of activity:

1. **The development of technical rules** for the electricity system in the form of Network Codes & Guidelines that reflect the role of DSOs in the energy transition.
- Joint proposal with ENTSO-E on a Network Code for Cybersecurity (January 2022).
- Joint proposal with ENTSO-E on a Network Code for Demand Response (May 2024).
- Joint proposal with ENTSO-E on Implementing Regulation for Customer Switching (October 2024).

2. **DSO/TSO cooperation:** Close interaction with ENTSO-E on most of the activities promoting the optimal and coordinated planning and operation of DSO and TSO systems.
- Memorandum of understanding with ENTSO-E on general cooperation.
- Joint DSO/TSO Work Plan (2024-2025).

3. **Sharing best practices:** Organizing DSO Expert Groups and participating in fora of expertise with key stakeholders to share knowledge and best practices on DSO relevant topics relating to the functioning of the internal market and energy transition. For example, the promotion of the digitalization and smartening of the grid.

2. The energy system is changing: The role and relevance of DSOs is increasing

Today, DSOs in Europe manage over 10 million kilometres of networks, host 4 million electricity substations, and connect more than 250 million customers ensuring reliable energy delivery across Europe. However, as the EU Green Deal accelerates the transformation of Europe's energy system towards a more electrified, decentralized and customer centric system, DSOs are requested to meet new demands, including the connection of:

- 70% of Europe's renewable energy capacity, contributing to the EU's ambitious targets of 530 GW of solar and 510 GW of wind.
- 85% of EV charging infrastructure, accommodating an additional demand of 65–100 TWh per year for 30m EVs.
- 40 million heat pumps to electrify heating, adding 80–100 GW of capacity demand.

As such, DSOs will be the enablers of the energy transition, as illustrated below.

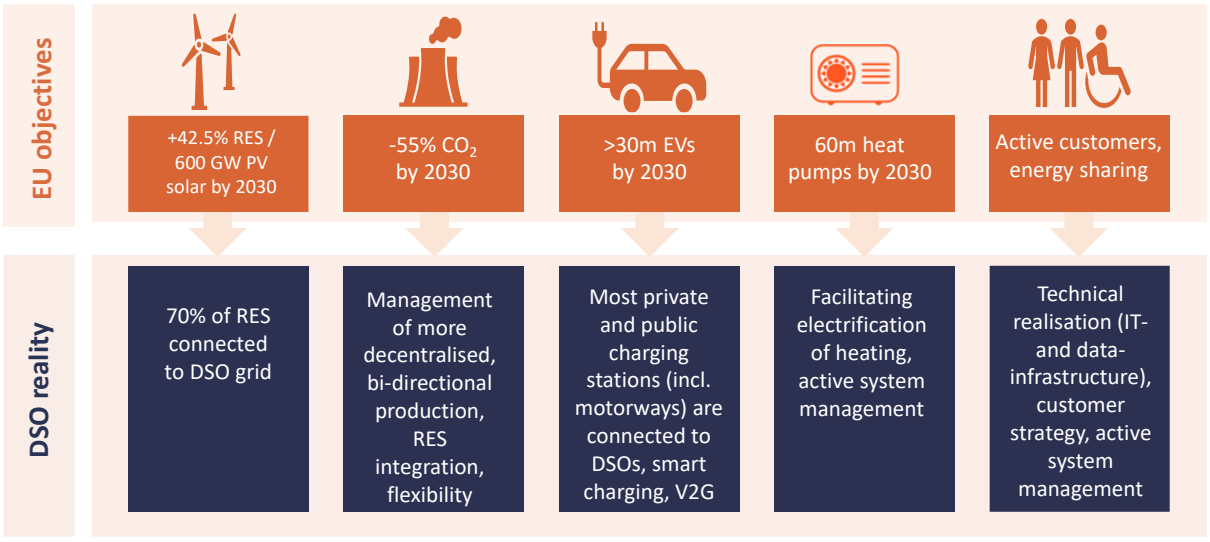


Figure 2: DSOs as key enablers of the energy transition.

In this context, DSOs are fully committed to expanding and smartening their systems to align with future energy needs, by leveraging their current strengths and making efficient investments that deliver value to customers. DSOs will not only enhance the resilience and sustainability of the energy system but also unlock opportunities for innovation, industrial growth, and strengthened European competitiveness. This dual focus on meeting today's responsibilities and enabling tomorrow's needs cements the role of DSOs as foundational pillars of Europe's energy future.

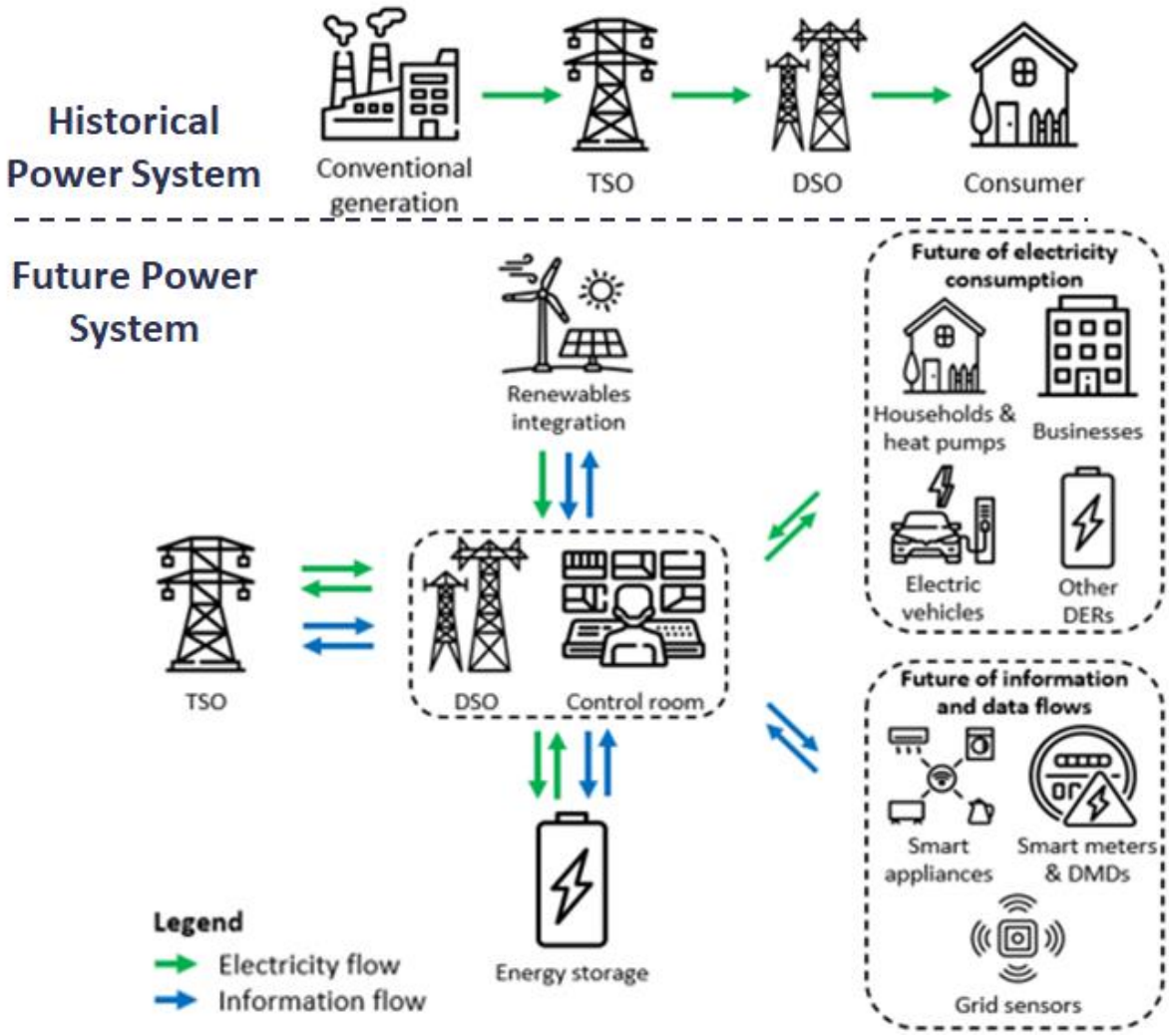


Figure 3: Historical and future power system comparison.

Considering the background of previously summarized developments, DSOs must work on the following areas to accelerate energy transition and serve both industrial and consumer clients by enabling a new system-of-systems to emerge:

Enhanced planning and investment for Distribution Systems to build a net-zero, decentralized energy system

- Develop an integrated approach to network planning by elaborating Distribution Network Development Plans.
- Unlock investments up to 55-67bnEuro/yr, enabled by implementing a smart and forward-looking approach to regulatory conditions and leveraging integrated development plans that include flexible, smart and resilience aspects to select the most efficient investments.

Foster market facilitation & prosumers engagement

- Enhance deployment of flexibility by designing a decentralized approach to the way that flexibility is procured.
- Facilitate energy sharing and behind-the-meter services, looking for feasible business cases.

Develop futureproof procedures for DSO operations & maintenance

- Implement Active System Management based on smart grids components and new competencies.

Invest in resilience & sustainability

- Adapt to climate change via observability and reinforcement to provide seamless energy supply during extreme climate events.
- Cybersecurity: preventing and reacting to cyberattacks and safeguarding consumers' data.
- Contribute to sustainability with greener DSOs.

Build on data & digitalization as foundations for system performance and industry competitiveness

- Digitalizing the grid improves system performance and drives innovation, boosts industrial growth, and strengthens Europe's competitive edge.

3. DSO Technical Vision

In this section, which is the core of the document, we highlight the key role of DSOs in planning and investment, market facilitation and prosumers, operations and maintenance, resilience and sustainability, and in digitalization. The different subsections highlight the challenges for DSOs and the Entity in the evolving system-of-systems, and look at solutions that can be implemented, in close cooperation with other European stakeholders.

Objective: *To establish a unified framework and common language among DSOs, supporting DSO Entity's initiatives and raising awareness of the essential role DSOs play in empowering customers and driving the energy transition.*

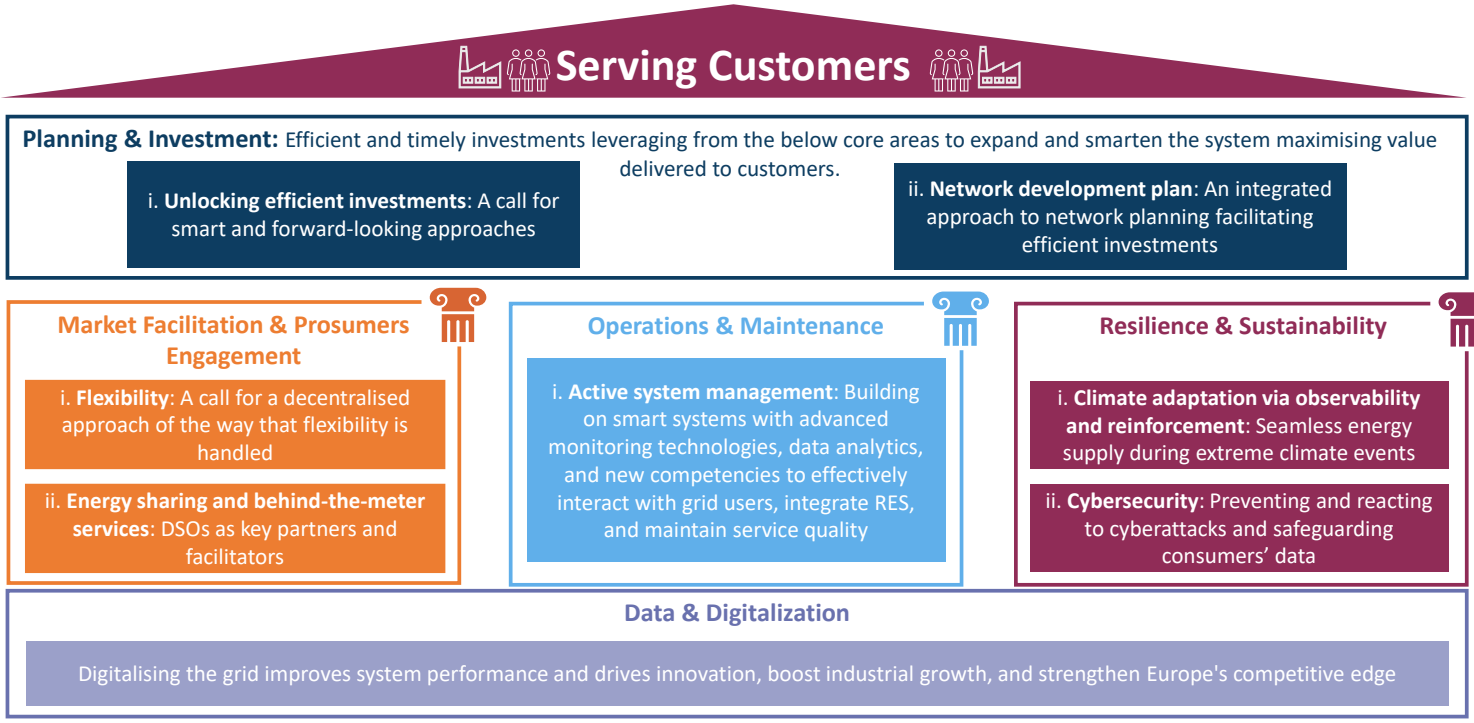


Figure 4: DSO's core development areas to reach net zero and serve customers.

This document is the **first issue** of EU DSO Entity's technical vision. It aims to be developed in further versions, with additional topics covered. The implementation of this vision is associated with the EU Targets for 2030 & 2050 and the implementation of current regulation e.g. Network Codes.

3.1. Planning and investment

This section first highlights how **unlocking efficient and timely investments** will be necessary to expand and smarten the system, maximizing value delivered to customers. The evolving system calls for smart and forward-looking approaches when it comes to investments. This section also covers **Distribution Network Development Plans** and shows how an integrated approach to network planning is key to facilitate efficient investments.

3.1.1. Unlocking investments: DSO infrastructure development to enable the energy transition and create value for customers

Since the transition of the energy system primarily takes place in the distribution grid, unprecedented investments are required within a short timeframe to ensure reliable power supply for customers

The connection of 70% or RES in the distribution system will lead to a decentralized, two-way system-of-systems, with DSOs serving as key enablers. To support this shift, DSOs need to accelerate investments with an estimated €55-67 billion per year on average until 2050 to ensure the energy transition benefits European citizens.[2]

Ensuring a transition that benefits European citizens will require investments in network expansion to expand network capacity for RES-infeed, new demand, and increased climate resilience. These will represent the large majority of investments (€37 billion per year until 2050), and will be complemented by:

- Investments to smarten networks (€8 billion per year until 2050), for a more efficient energy use, to optimize electricity flow and result in both fewer outages and better service for customers;
- Investments in resilience (€ 5 billion per year until 2050), as increasing weather variability and renewable energy fluctuations bring new challenges to a stable and consistent power supply for consumers;
- Investments in the renewal and maintenance of the grid (€ 18 billion per year until 2050) to ensure customers benefit from a reliable access to energy in the long-term.

First steps toward solutions: Success factors of DSOs to efficiently accelerate the development of the grid

To accelerate grid development and improve customers' experience, DSOs will focus on several key areas. Distribution Network Development Plans (DNDPs) ensure better coordination and visibility, allowing for faster, more transparent infrastructure upgrades. Digitalization speeds up grid expansion, ensuring customers benefit from quicker, more efficient energy access. Addressing supply chain bottlenecks will prevent delays, while streamlined permitting processes will allow faster implementation of projects.

To ensure that customers benefit from a rapidly evolving energy system, it is essential to identify investments using an anticipatory investment approach with a focus on non-regret investments

Anticipatory investments result from planning aimed at identifying investments that proactively address expected developments, looking beyond immediate needs of generation or demand into the mid and long-term. The planning should consider new generation and/or demand that will materialize with sufficient certainty, even while utilization could be low in the short term. Negative impacts of

[2] Eurelectric, Grids for speed, Current.

delaying the decarbonization process due to a lack of grid capacity as well as the increased costs of expanding in several stages should be considered.

TRANSFORMING THE ENERGY SYSTEM AT THE FORESEEN PACE REQUIRES A FORWARD-LOOKING INVESTMENT APPROACH AND CORRESPONDING REGULATORY FRAMEWORKS

This forward-looking approach requires the extension of grid investment plans to a 10–20-year horizon (beyond what is currently considered by NRAs), enabling more strategic, long-term planning. A supportive regulatory framework is also key, allowing network operators to make these critical investments while adapting efficiency metrics to meet evolving needs.

The regulation should encompass a framework to manage uncertainties associated with longer forecast periods, to ensure that costs are minimized for customers. Within such a regulatory regime, output-based regulation, benefit sharing and balanced CAPEX/OPEX incentives could also be applied to ensure efficiency.

To facilitate investments and ensure financiability, those need to be considered in the regulatory asset base with minimum delay, and the regulatory cost of capital must be market competitive.

These investments, supported by DSO Entity, will bring public value in accelerating the energy transition, but also economic value that will directly contribute to European industry competitiveness.

EU FUNDING INSTRUMENTS FOR DSOS

DSOs should be able to benefit from EU funding instruments, and tailor-made funds for distribution grid projects to be set up in parallel to grid mainstreaming at national and local levels. As DSOs have a key role to play for EU competitiveness, they could also benefit from the EU Competitiveness Funds proposed by the European Commission. Such financing can reduce the costs for grid users.

3.1.2. Network Development Plan: Enhanced distribution system development to serve grid users in an evolving, cross-vector, smart and decentralized system of systems

Empowering grid users through strategic grid investments and future-proof planning

Interconnected systems (electricity, gas, hydrogen, heat, and transport) will evolve in response to changing generation and consumption patterns and technological progress, leading to more uncertainty. Future DNDPs will be crucial for DSOs to continue serving grid users in this evolving framework. They will frame the planning of necessary investments to address the unprecedented need for grid expansion, including distributed, flexible, and smart energy solutions. By (i) ensuring sufficient grid capacity to connect grid users, (ii) maintaining security of supply, and (iii) increasing resilience, future DNDPs will enhance the competitiveness of the EU industry, support GDP growth, and ultimately improve customer welfare. The development of DNDPs and their harmonization will

be supported by EU DSO Entity, and coordination between TSOs and DSOs will be enhanced through cooperation with ENTSO-E.

Delivering smarter reliable energy solutions for grid users through collaboration

DNDPs drive value for grid users by enhancing collaboration and data exchange among DSOs and TSOs and other stakeholders (industry, green gas and heat networks), improving the planning and implementation of efficient energy solutions at national level and, as a result, effectively integrating DSOs into the EU system of systems. By fostering societal acceptance and supporting strategic planning of substations and powerlines, DNDPs ensure that evolving energy infrastructure meets local needs and avoids costly delays. Through coordination with local governments and stakeholders, DNDPs help secure future connections to meet growing energy demand, with Europe's electricity consumption expected to rise 50% by 2050 driven by electric vehicles and heat pumps. Leveraging DSO knowledge and integrating all relevant data into an interoperable system allows efficient information sharing, optimal resource allocation and lowering of costs.

BRINGING DNDPS A STEP FORWARD

While current DNDPs are fit for purpose under current system needs, harmonized definitions for available grid hosting capacity will be a step forward. A pan-EU overview of available grid hosting capacities for new network users to connect will be developed.

DNDPs aim for an increasingly integrated planning exercise in the EU through stronger harmonization and cooperation, ensuring a reliable and resilient energy system that delivers long-term benefits to all system users.

DNDPs integrate mechanisms to deal with uncertainty and increasing openness to innovative regulatory solutions. DNDPs are seen as the foundation for discussions on anticipatory investments. Additionally, prioritizing investments through a simple taxonomy approach ensures the timely delivery of smart, flexible, and reliable energy solutions, further enhancing customer satisfaction.

They can also foster the establishment and management of value chains essential for supporting and advancing DSO activities, including infrastructure, processes, and resources necessary for effective network development and operations. This ultimately ensures grid users can benefit from a reliable energy network in the long-term.

Further enhancing DNDPs will rely on various tools and solutions to achieve a more advanced and increasingly harmonized network planning. In some cases, DSO Entity is already working on these solutions, for instance as part of the tasks assigned in the 'Grid Action Plan'.

DNDPS ENABLE THE EFFICIENT DELIVERY OF GRID INVESTMENTS AIMED AT:

- Strengthening the competitiveness of EU industries.
- Driving positive impacts on GDP through strategic grid investments.
- Improving consumer welfare by ensuring reliable and affordable energy access.

3.2. Market facilitation and prosumers

This section highlights how facilitating the use of **flexibility** and of **energy sharing** models are already and will increasingly be core tasks for DSOs to empower and increase value for customers. First, for **flexibility**, there is a call for a decentralised approach of how flexibility is managed. Second, DSOs are key partners and facilitators of emerging models for **energy sharing** and behind-the-meter services.

3.2.1. Flexibility: Empowering customers with flexible, affordable energy solutions through strategic investments, market integration, and regulatory innovation

Maximizing the benefits of flexibility for customers through strategic investments and system integration

Flexibility will increasingly be an essential component in addressing specific system needs, such as congestion management and system stability, though it is not a one-size-fits-all solution. To fully harness its benefits, flexible capacity must be assessed alongside other critical investments, such as infrastructure upgrades and the integration of new technologies. This ensures that customers experience a more reliable, efficient, and resilient energy system that remains adaptable to future challenges.

Flexibility presents opportunities for development, with potential for clearer definitions and broader understanding among grid users

Flexibility will allow customers to better participate in and benefit from the evolving energy landscape, as it offers various forms that can be tailored to different needs.

Furthermore, as the European market evolves, there is potential for harmonization across DSO areas and countries (e.g. Network Code for Demand Response, Implementing Regulations on Data Interoperability), which will bring a common language, consistency in definitions, products, and processes, ultimately enhancing customer engagement and making it easier for customers to access flexible energy services. DSO Entity has a key role to play in achieving this harmonization.

OPPORTUNITIES FOR THE DEVELOPMENT OF FLEXIBILITY

Coordination

- Collaboration and coordination between DSOs within the DSO Entity framework.
- Coordination between markets and between DSOs and TSOs.

Products

- Common list of attributes for flexible products.
- Combination of national and EU products.

Data

- Data management by DSOs.

Tarification

- Format of grid tariffs.

Contracting mechanisms

- Flexible connection agreements (national frameworks have to be implemented).
- Long-term procurement (availability contracts).
- Flexibility markets.

Unlocking the full potential of flexibility through market liquidity and strategic regulation will result in a more active and affordable energy system for customers

DSOs shall value all flexibility mechanisms to access flexibility (market-based, rules-based, FCA, network tariffs) and choose the best solution or the best combination for safe, reliable, and efficient grid development and operations.

Flexibility solutions are maturing and require new processes, skills, and continuous dialogue with potential service providers to ensure effective integration. For flexibility prices to remain low, sufficient market liquidity is vital.

Furthermore, a regulatory framework that appropriately values flexibility and provides clear financial incentives is essential. Such regulations will enable the full realization of flexibility's potential, ensuring both supply and demand side participants can operate economically and profitably. Collaboration with TSOs on the use of flexibility is crucial to ensure smooth operations over the different voltage levels in a system-of-systems. Indeed, TSOs and DSOs are both responsible for congestion management, and while the TSO is ultimately responsible for balancing, most of flexible assets are connected to DSOs. Hence, the use of flexibility must be coordinated to be mutually beneficial to TSOs' and DSOs' systems. DSO Entity and ENTSO-E will collaborate to provide support.

DSOs' role in enabling flexibility and customer participation

DSOs are key partners in optimizing customer participation across electricity markets, enabling consumers to adjust their energy usage in response to various price signals. By incorporating advanced technologies and supporting decentralized energy solutions, DSOs ensure that customers can manage their energy consumption more efficiently and profit from cheap electricity prices, while also contributing to grid stability and energy efficiency goals.

DSOs incorporate various types of flexibility into their operations, considering the specific requirements of different network types. This approach leads to tailored investment strategies that address the unique needs of each network

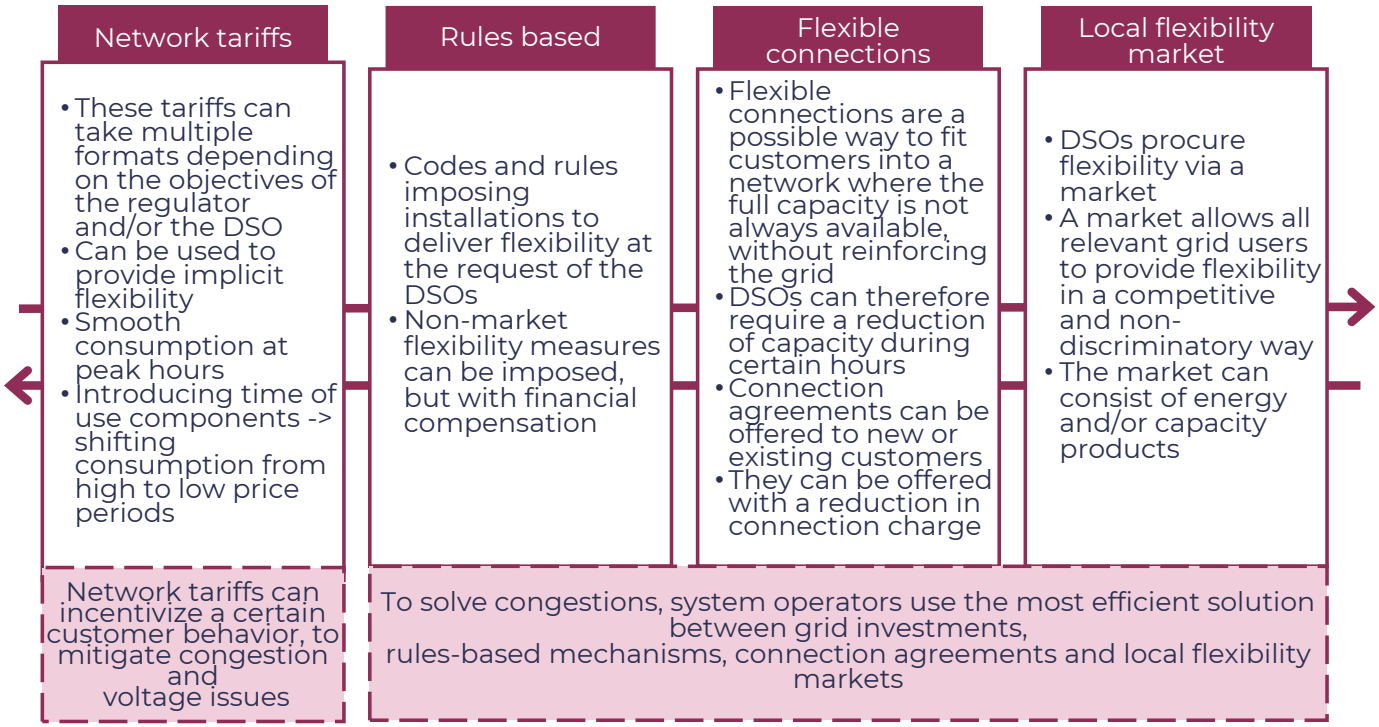


Figure 5: DSOs incorporate various types of flexibility into their operations.

3.2.2. Energy sharing: DSOs empower their customers to participate in an increasingly decentralized sustainable energy system while keeping the lights on

DSOs facilitate consumer engagement and community-based renewable initiatives

DSOs are crucial in supporting initiatives that enhance consumer engagement and integration into the evolving energy landscape. The Clean Energy Package, which introduces renewable energy communities and citizen energy communities, underscores this by fostering community involvement in energy production and consumption.

Figure 6: Energy sharing model.

SOURCE: IBM.

Even if energy sharing models are still not fully developed at the Member State level (mostly experimental and/or at an early stage), the current EU framework paves the way and energy sharing models will be implemented in the coming years. Increasing personalization of services and the massive scale of interactions between customers create new challenges. Handling vast amounts of data is now a critical aspect of managing energy systems, involving not only efficient data creation, storage, and analysis but also ensuring system stability and responsiveness to evolving demands. In this context, facilitating energy sharing for customers without introducing new bottlenecks becomes crucial. Hence digitalization plays a key role in streamlining these processes, reducing costs, and optimizing cost-reflectivity.

As a first step, a societal cost-benefit analysis is needed to understand cost and benefits and allocate them appropriately.

DSOs empower customers to navigate uncharted environments with millions of interactions

DSOs empower customers by:

- Managing the system: Ensuring the reliability and efficiency of the distribution systems while supporting TSOs to maintain overall system stability. This involves anticipating and responding to fluctuations in demand and supply while integrating new energy sources.
- Managing data: DSOs are responsible for facilitating data-sharing with third parties, for ensuring that data transparency, privacy, and security are maintained. This role becomes increasingly complex as data volumes grow with the proliferation of decentralized energy resources and digital systems.
- Managing contracts: DSOs connect prosumers to the grid and manage contractual connection agreements. The challenge lies in adapting to the evolving system dynamics as we shift from a traditional model with millions of customers and a single supplier to a "Many-to-Many" model, with millions of customers and suppliers interacting in real-time across decentralized networks.

In particular, the role of DSOs in raising awareness among customers is key

Energy sharing requires engagement from consumers. This engagement will come from awareness of the benefits of energy sharing, and from the development of business cases at the societal level. DSOs' role in this context, supported by DSO Entity, is to build up an understanding of energy sharing practices to make energy sharing as simple as possible, making it user friendly, and being proactive in informing customers.

DSOS AS ENABLERS OF ENERGY SHARING

- DSOs facilitate connection of heat pumps, EVs, rooftop-solar etc.
- Consumers should be able to arrange data access for own use or sharing with third parties like aggregator, ESP, home energy management system (HEMS) etc.

3.3. Operations and maintenance

This section covers the topic of **active system management** and shows how the evolving role of DSOs in the fields of operations includes building on smart systems with advanced monitoring technologies, data analytics, and new competencies to effectively interact with grid users, integrate RES, and maintain service quality.

3.3.1. Active system management: Enhanced observability and control to ensure a reliable, flexible energy system that provides customers with access to affordable clean energy

The increasing volumes of DER and RES require DSOs to strengthen active grid management capabilities. This involves effectively handling DER, intermittent and bi-directional energy flows, and procuring flexibility services where necessary. To achieve this, with the support of DSO Entity, DSOs must upgrade the electrical system with digital technologies, including artificial intelligence or digital twins, that enable enhanced monitoring, communication, and control. These advancements are essential for managing the complexities of the modern energy landscape, ensuring a reliable, flexible, and sustainable power system. The key areas of focus include:

Supporting system stability in coordination with TSOs

DSOs play a crucial role in maintaining stability within the EU's interconnected power system as they integrate increasing volumes of DER with grid-forming capabilities. These capabilities enable DSOs to provide essential system services such as voltage control and congestion management by dynamically responding to fluctuations in power generation and consumption. Although grid forming DER presents new technical challenges, it also strengthens overall system stability by enabling parts of the system to operate in islanded mode, disconnected from the main power system when needed.

Enhanced system security measures

As residential electric vehicle (EV) charging, electric heating, and consumer-owned energy generation (especially rooftop PV) increase, DSOs must adopt enhanced system security measures. These measures are essential to adapt to new consumer behaviours and manage associated risks, such as potential grid overloads and security vulnerabilities, thereby ensuring system security and customer safety.

Empowering customers through smart metering and accurate data

Use smart metering and accurate data to provide consumers with near real-time insights into their energy usage, enabling them to participate in demand response or flexibility services. These systems also enhance DSOs' observability over the distribution network, aiding efficient system management.

In addition to leveraging smart metering systems for real-time insights and demand response, DSOs may need to rely on Dedicated Measurement Devices (DMDs) in cases where smart meters are not yet installed or where they lack sufficient data granularity. To ensure safe and reliable system operation, DMDs must meet strict technical and regulatory standards. Validation at the connection point is crucial to ensure that DMDs align with primary metering data and do not compromise system reliability or introduce security vulnerabilities. Additionally, any data used for settlement must be accurate and verifiable, reflecting the exact services provided to the grid, as required by EU regulations. This alignment is essential for fair compensation in energy markets and for maintaining transparency in demand response and flexibility services.

Operational efficiency and advanced maintenance

The complexity of the modern grid requires maintaining operational efficiency through sophisticated maintenance strategies and real-time condition monitoring. Advanced diagnostics and predictive maintenance tools should be utilized to ensure the longevity and reliability of grid components. Collaborative efforts with technology providers are essential for continuous improvement and innovation in maintenance practices.

ADVANCED DIGITAL TECHNOLOGIES TO EMPOWER CONSUMERS

By adopting advanced digital technologies, DSOs will empower consumers with accurate insights of their energy usage and fair compensation for flexibility services delivered, while also enhancing system stability and security through coordinated efforts with TSOs.

3.4. Resilience and sustainability

This section first highlights challenges and solutions for DSOs in the field of **climate change**, and then in the field of **cybersecurity**. External challenges, such as climate change or geopolitical threats, directly impact the DSOs' business and operations. Moreover, on top of adapting to climate change, DSOs have a role to play in the mitigation of climate change with sustainable practices. Hence, ensuring resilience will be more and more important for DSOs to provide seamless energy supply during extreme climate events; and to prevent and react to cyberattacks and safeguard customers' data.

3.4.1. Climate adaptation: Adapting DSO grids to combat climate change, ensuring reliable, sustainable energy for customers

Strengthen infrastructure, operational efficiency, and emergency response capabilities to ensure reliable energy supply for customers

Climate change is increasingly impacting DSO grids in Europe. The frequency and intensity of heat spells, floods, storms, and landslides are rising, often resulting in the destruction of network equipment and subsequent power outages that directly affect customers. These extreme weather events also have indirect effects on the grid, exacerbated by shifting consumption patterns, such as higher demand for air conditioning during heatwaves. The cumulative impact of climate change threatens both the reliability and affordability of energy supply for consumers.

Strengthening monitoring and resilience strategies to safeguard grids against extreme weather events

By continuously analysing grid performance data, potential risks from extreme weather events are identified in real-time, and their wider implications are estimated in advance thanks to DSO's enhanced simulation capabilities.

Figure 7: Extreme weather events have adverse effects on DSO grids.

Emergency management and real-time responsiveness to extreme weather events, combined with the ability to maximize network capacity through observability, demand response and grid forming capabilities, means fewer outages and quicker recovery times for customers.

Over time, these insights are used to strengthen the grid through long-term reinforcement strategies, that will make the physical grid more resilient. As a result of these investments, customers will experience fewer interruptions and enjoy more reliable energy services, even as climate-related challenges intensify.

Driving green initiatives in DSO operations to boost sustainability and combat climate change

A "greening" of DSO activities will also play a crucial role in mitigating climate change. This involves incorporating "green" considerations into planning and investments. Key initiatives include defining relevant products to counteract losses, implementing ecological vegetation management, ensuring network assets are compatible with wildlife, and procuring sustainable materials. DSO Entity will support DSOs in identifying the best initiatives.

DSOS KEY ROLE TO ADAPT TO AND MITIGATE CLIMATE CHANGE

DSOs play a key role in identifying vulnerable grid areas and reinforcing critical assets to enhance reliability. By continuing to develop emergency protocols and strengthening grid resilience, they ensure a reliable energy supply and protect customers. Additionally, integrating greener practices into planning and investments will further contribute to climate change mitigation.

According to the grid action plan, DSOs and TSOs should collaborate to strengthen value chains. This collaboration aims to streamline the procurement processes for grid components from EU manufacturers, which adhere to higher sustainability and security standards. By integrating these environmentally friendly practices, DSOs can significantly contribute to climate mitigation efforts while enhancing the sustainability of their operations, to the direct benefit of customers.

3.4.2. Cybersecurity: Collaborating for a secure energy future to protect customers

Ensuring cybersecurity for a secure and reliable energy future: Protecting customers in the age of electrification and digitalization

The push towards electrification and the European Green Deal's goals of carbon neutrality by 2050 are accelerating the adoption of electric vehicles, renewable energy, and smart grids. As a result, the digitalization of energy systems is increasing, and with it, the risk of cyberattacks. The integration of distributed energy resources (DERs), smart appliances, and electric vehicles into the distribution grid introduces more points of connectivity between DSOs, TSOs, aggregators, customers, OEMs and other stakeholders of DER. This interconnectedness, while essential for creating a more flexible and efficient energy system, also presents more opportunities for cyber threats.

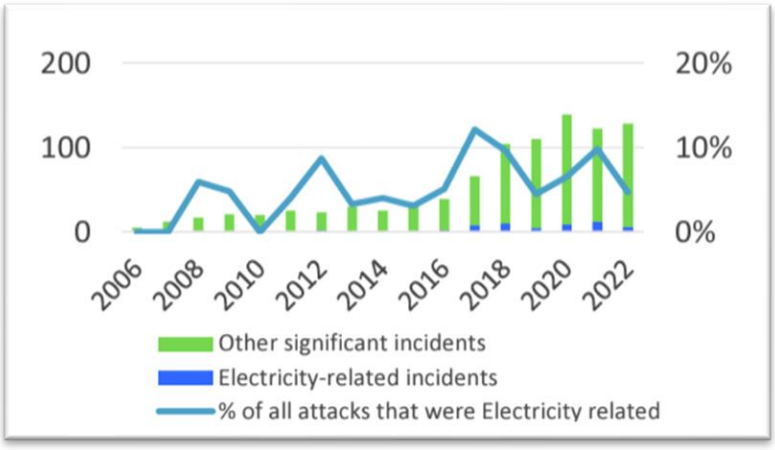


Figure 8: Number of cyberattacks.

SOURCE: GRIDS FOR SPEED, EURELECTRIC, BASED ON CENTER FOR STRATEGIC AND INTERNATIONAL STUDIES (CSIS), INTERNATIONAL ENERGY AGENCY (IEA).

As cybersecurity responsibilities are now spread across multiple actors, the need for effective coordination has become paramount. This multi-actor responsibility means that each entity must

work together to ensure a unified defence against cyber threats. In this evolving energy landscape, DSOs play a crucial role in safeguarding customer data and ensuring the reliability of energy systems.

By implementing robust cybersecurity measures, monitoring grid performance, and coordinating with stakeholders, DSOs protect sensitive customer information from cyber threats while minimizing disruptions to energy supply. For customers, this adds significant value by ensuring that their personal data is secure and their access to reliable, uninterrupted energy services is maintained, even as the energy grid becomes more digitalized and interconnected. The result is a seamless energy experience where customers can trust both the security and the stability of their energy systems.

Strengthening cybersecurity through collaboration and continuous adaptation: Safeguarding operations and customer data in a dynamic threat landscape

Given the evolving nature of threats, where cyberattackers are constantly developing new methods, it is critical to continuously learn, improve, and adapt cybersecurity strategies. This dynamic threat landscape demands a proactive approach to safeguard operations and customer data. Establishing a framework for collaboration, fostering a strong cybersecurity culture, and enhancing understanding of digitalization risks are key components for DSOs in addressing these challenges. DSOs will be supported by DSO Entity, in cooperation with ENTSO-E. Building trust among various stakeholders—including the public and private sectors, as well as academia—can significantly strengthen cybersecurity defences.

Strengthening cybersecurity collaboration: Implementing the current regulatory framework while ensuring reliable and secure energy services for customers

DSOs play a key role in implementing the Network Code on Cybersecurity by fostering cooperation with TSOs and other energy stakeholders to ensure a unified approach to managing cyber risks. The current legislation on cybersecurity is comprehensive, and DSOs need enough time for implementation. Through close coordination, real-time information sharing, and joint risk assessments, DSOs enhance the resilience of the energy grid, protecting it from cyber threats. By ensuring that cybersecurity standards are consistently applied across the entire energy value chain, DSOs safeguard critical infrastructure and customer data. For customers, this collaboration ensures reliable, secure, and uninterrupted energy services, even as the energy system becomes more digitalized and interconnected.

Low-regret

- Identification of operators of essential services (high impact and critical impact entities)
- Development and sharing of initial basic guidance on connection-requirements for many features
- Implement EU existing framework on Critical Entities Resilience/Network code on CS
- Implement training programs for employees and increase awareness

Short-term

- Development of crisis management plans and business continuity plans in case of attacks
- Implement coordination frameworks between different actors
- Improvement of security by design with decentralization/isolation to limit the impact
- Establishment of clear data protection standards, anonymization practices, and authentication procedures

Long-term

- Establish a European cyber security maturity framework for energy
- Continuing development of cybersecurity standards for network operators' equipment, including guidance for mass market manufacturers to follow the cybersecurity procedures. This would enable the implementation of the best cybersecurity standards, and practices in general, at DSO level in particular
- Better anonymization/encryption process in the long-run to protect sensitive data
- Continuous capacity/knowledge building and information sharing among all relevant actors

Figure 9: Low regret, short-term and long-term solutions for cybersecurity.

HARMONIZED FRAMEWORK CREATED BY THE NETWORK CODE ON CYBERSECURITY

By fostering cooperation through the implementation of the Network Code on Cybersecurity, DSOs ensure that the entire energy sector operates within a harmonized framework, creating a resilient, secure, and reliable energy system for customers across Europe.

3.5. Digitalization

This section highlights how digitalization will act as a steppingstone and will be key to support DSOs' activities in the four core areas presented above. It first reviews how **DSOs play a pivotal role in leveraging data to bring value to customers in the four core areas**, and then shows the **key role of the Decentralized Data Space**.

3.5.1. DSOs play a pivotal role in leveraging data to meet customer needs in the four core areas

Planning & Investment - The digital era creates challenges and opportunities for planning and investments:

New customers emerging with the electrification of different sectors (industry, EVs, heat pumps, aggregators, RES developers…) create new challenges for network planning:

- Higher uncertainty: Customers' load profiles are becoming less predictable and are moving away from standard load profiles; hence increased volume of high-quality data is required to better understand these new profiles.
- Engage with more stakeholders: Processing high volumes of non-harmonized data from different sources creates challenges.
- Digitalization: Large amounts of data available need to be collected in a safe way that respects privacy laws.

Grid planning fit for the future energy system:

Increased ability to access and analyze data for engineers and analysts leads to enhanced forecasts and plans in the future energy system. Indeed, network planning can be enhanced with digitalization: For instance, better data (or simply access to data) improves knowledge of where the network needs to be reinforced.

DIGITALIZATION TO ENHANCE NETWORK PLANNING

DSOs will leverage digitalization to enhance network planning by analyzing high-quality, diversified data that accommodates evolving customer profiles and electrification trends. By ensuring collaborative data management, DSOs aim to deliver more accurate forecasts, anticipate infrastructure needs, and reinforce the grid where necessary, ultimately creating a more reliable and customer-responsive energy system.

Market Facilitation & Prosumers Engagement - Managing distributed flexibility through data:

The data-related challenges for DSOs arise from the growing complexity of modern energy networks, which involve numerous data sources and a variety of participants, including customers, aggregators, energy producers, and other grid operators (DSOs and TSOs). In particular:

- DSO Entity supports the European Commission in developing harmonized definitions for roles and responsibilities related to data exchange among all stakeholders, emphasizing interoperability to facilitate seamless data exchanges across the European Union.
- Raising data-driven user awareness: Educating system users on how their energy usage impacts the grid and encouraging data-informed behavior adjustments when necessary.
- Ensuring secure and interoperable data systems: Effectively using smart meters in combination with IoT, and other embedded metering devices (i.e. DMDs) to harness the full potential of digitalization. This requires robust data security measures to protect against cyber risks, and standards for interoperability to ensure they can integrate seamlessly with existing grid infrastructure and provide reliable data.

Facilitating customer engagement and community–based renewable initiatives:

DSOs face significant data-related challenges as they manage the increasing demand for personalized services and interactions under the Clean Energy Package. As energy-sharing models evolve, DSOs must manage and analyze vast amounts of data to ensure efficient operation, system stability, and responsiveness to changing demands. Digitalization is essential to address these challenges, enabling streamlined processes, optimized storage, and analysis, and ensuring cost-effective scalability.

DATA SYSTEMS FOR MARKET FACILITATION

Interoperable data systems are critical for DSOs to manage complex, data-driven energy ecosystems efficiently, securely, and with greater flexibility.

Operations & Maintenance:

Digitalization is key for DSOs to enhance grid observability and maintain system security. Upgrading the grid with digital technologies enhances monitoring, communication, and control, offering several benefits for operations and maintenance:

Using network flexibility

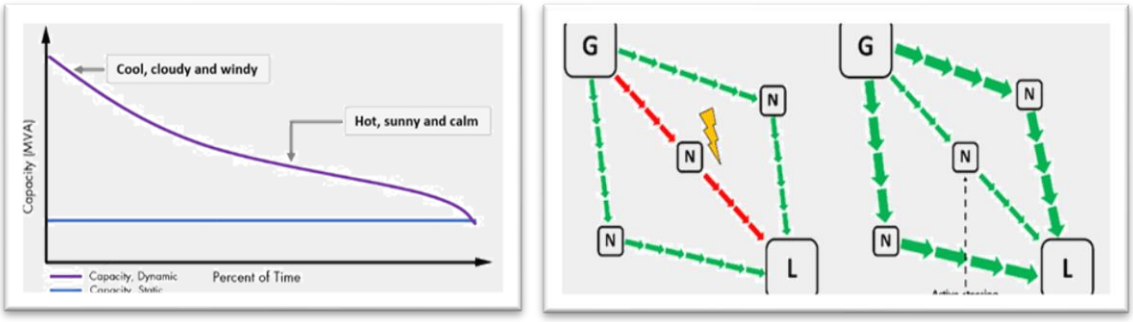


Figure 10: Power flow control dynamically adjusts flow like traffic management, maximizing use of grid capacity.

Dynamic Ratings optimize asset use by allowing real-time adjustments to transformer and line limits, reducing conservatism and unlocking capacity.

Improved maintenance

Proactive Monitoring enables real-time health assessments of grid assets, reducing maintenance costs and preventing failure. Predictive Analytics help identify faults early, improving reliability and reducing downtime.

Scalability and automation

Automation streamlines routine tasks (e.g., connection requests), allowing DSOs to scale operations efficiently and focus resources on complex tasks. Remote Operations enable quicker, safer, and more efficient fault corrections.

Resilience & Sustainability:

Digitalization plays a critical role in enhancing grid resilience by enabling real-time monitoring and implementing proactive measures. This reduces the frequency and duration of power outages and shortens recovery times for customers. With advanced digital tools, DSOs can detect issues before they escalate, ensuring a more reliable energy supply.

Strengthening resilience through cybersecurity collaboration

As digital integration and interconnectivity increase, the resilience of the energy grid faces new challenges, particularly in cybersecurity. The adoption of advanced technologies heightens exposure to cyber threats that could disrupt energy services, compromise customer data, and jeopardize grid stability.

To build resilience against these risks, DSOs collaborate closely with government agencies, technology providers, and cybersecurity experts. This collaboration enables the establishment of robust cybersecurity frameworks, protecting sensitive data and ensuring secure, uninterrupted access to critical energy systems. Such proactive efforts are essential for maintaining a resilient energy infrastructure in a highly interconnected and digitalized environment.

ENSURING RESILIENCE OF ENERGY INFRASTRUCTURE

In a highly interconnected and digitalized environment, robust cybersecurity frameworks and collaboration ensures the resilience of energy infrastructure.

3.5.2. Leveraging and streamlining existing (often DSO-run) national and regional data spaces to develop a Decentralized Data Space around the customer

The DSO data space, supported by DSO Entity, represents a critical component of the future decentralized and customer-driven energy system. As custodians of essential customer and system data, DSOs enable the efficient operation of the system while facilitating the integration of DERs and the growth of energy markets. By balancing the need for data access to different players with strong data privacy and security practices, DSOs can help create a more resilient, efficient, and customer-centric energy system.

The DSO's Data Space: Set of decentralized and interoperable spaces collected, used and shared by the DSO

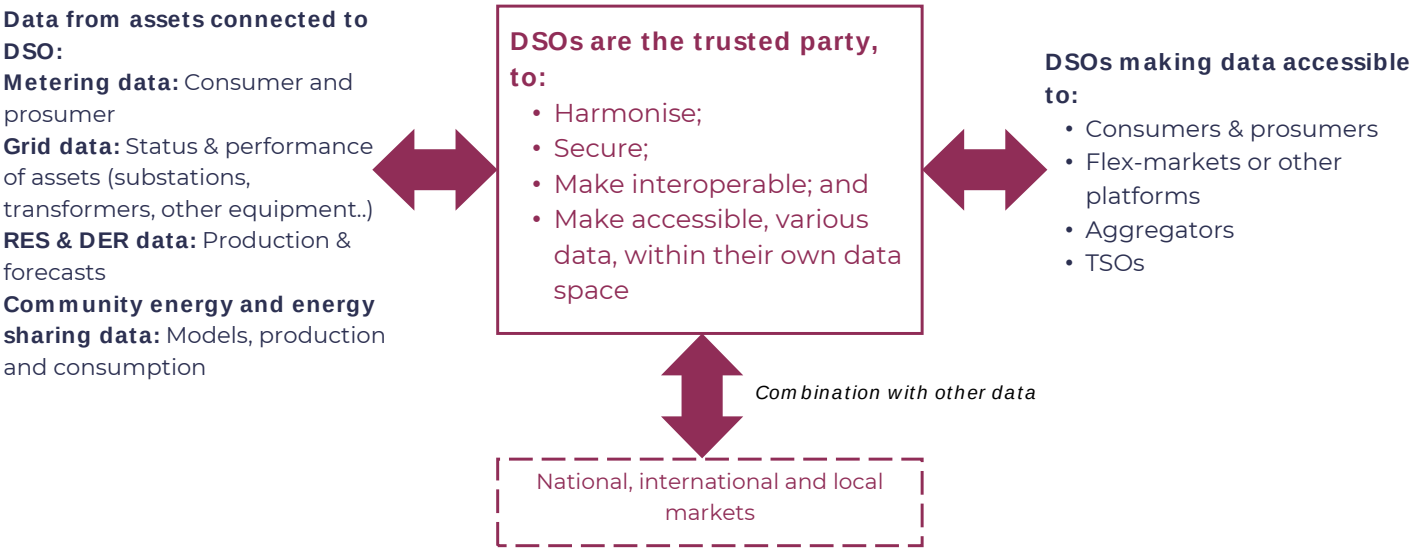


Figure 11: DSO's data space: Set of decentralized and interoperable spaces collected, used and shared by the DSO.

THE KEY ROLE OF DSOS IN THE DATA WORLD

DSOs have a key role to play as data custodians and processors in a customer centric system. DSOs are at the beginning of their data journey. A number of challenges are still to be surmounted, before the significant benefits of better data can be unlocked.

4. Conclusion

This section summarizes the key conclusions drawn from the Technical Vision. For each of the key building blocks, we highlight the system needs, the importance for customers, and the role of DSOs and of the Entity. The vision also concludes with a call to cooperation with European stakeholders.

Planning and investment

		What does the system need?	Why is it important for the customers?	What is the role of DSOs?
Planning & Investment	i. Unlocking investments	Since the transition of the energy system primarily takes place in the distribution grid, unprecedented investments in **grid expansion** and **smartening** are required, estimated at €55-67 billion per year on average until 2050.	These investments, supported by DSO Entity, will drive value for society at large by accelerating the **energy transition,** enhancing **competitiveness** of European industry**,** and fostering sustained economic growth.	DSOs will identify and implement **investments** required by customers using an anticipatory approach. DSO Entity will contribute to the improvement of **forward-looking regulation** and adequate remuneration surrounding **efficient** investments at the EU level.
	ii. Network development plan	The **cross-vector** energy system will evolve in response to changing generation, consumption patterns and technological progress. **Increasing uncertainty**, and the need to **adapt** the **planning** exercise.	Further developing DNDPs will enable efficient investment selection and visibility of system capacity needs, ultimately **optimizing costs** and facilitating the implementation of **reliable services** for customers.	DSOs will develop data-driven DNDPs in a **coordinated** and **collaborative** approach with TSOs and other key stakeholders, facilitating the development of forward-looking and strategically aligned **investment plans**.

Market facilitation and prosumers engagement

		What does the system need?	Why is it important for the customers?	What is the role of DSOs?
Market Facilitation & Prosumers Engagement	i. Flexibility	Flexibility will increasingly be an essential component in addressing specific system needs such as **congestion** management or system **balance**, by adapting to increasingly variable generation.	Flexibility will allow all consumers (both households and industry) to benefit from the evolving energy landscape by allowing them to **monetize** their energy use, facilitating a reliable system while avoiding unnecessary investments.	DSOs will integrate flexibility with **infrastructure upgrades**, while the DSO Entity develops frameworks with ENTSO-E and key stakeholders to improve **customer access** to flexibility services and ensure efficient **system operation**.
	ii. Energy sharing	The increasing decentralisation of generation and consumption will require the right **infrastructure** and **models** to enable efficient cost-reflective and secure energy sharing.	Energy sharing enables consumers to **access** affordable, **decarbonised energy**, and to share resources. It also enables increased participation of customers in the electricity markets.	DSOs will **support customers** in navigating more decentralised ways of generating and consuming energy and defining business cases for the **benefit of society**. DSO Entity will contribute to develop a framework for cooperation and collaboration for all energy sharing actors.

Operations and maintenance

		What does the system need?	Why is it important for the customers?	What is the role of DSOs?
Operations & Maintenance	i. Active system management	The increasing volumes of DER and RES require DSOs to manage **intermittent** and **bi-directional energy flows** and **procure flexibility** services where necessary to ensure the secure operation of the system in **coordination with TSOs**.	To maintain a **reliable and secure** power system that integrates **RES and DER**, while empowering customers to optimize **energy use**, and manage **costs**.	DSOs, with the support of DSO Entity, will **adopt advanced digital technologies** e.g. (artificial intelligence, digital twins, and smart metering) to enhance their **monitoring, communication, control and maintenance** capabilities ensuring a reliable, flexible, and sustainable power system.

Resilience and sustainability

		What does the system need?	Why is it important for the customers?	What is the role of DSOs?
Resilience & Sustainability	i. Climate adaptation via observability and reinforcement	Climate change is increasingly **impacting DSOs** often resulting in **power outages**. This calls for **resilient infrastructure** to mitigate risks and adaptative **emergency measures** to ensure effective response after an incident.	Customers benefit from uninterrupted **access to energy** and **fast recovery** amid increasing climate-related risks.	DSOs will use **DNDPs** to improve infrastructure resilience as well as active system management capabilities to boost **operational efficiency**, strengthen **emergency response**, and advance their decarbonization and sustainability efforts.
	ii. Cybersecurity	The integration of DERs, smart appliances, and electric vehicles into the distribution system significantly **spreads responsibilities** across multiple actors and **amplifies vulnerabilities** to cyber threats. **Robust cybersecurity measures** and coordinated strategies are needed to protect the system and its stakeholders.	Robust cybersecurity protects **customer data**, ensures reliable **energy supply**, and supports the safe adoption of smart technologies, building trust in the service provider.	DSOs will **prioritize the implementation** of the current regulatory framework, ensuring that cybersecurity standards are consistently applied across the entire value chain.

Data and digitalization

		What does the system need?	Why is it important for the customers?	What is the role of DSOs?
Data & Digitalization	Data & digitalization	The growing complexity of modern energy networks, involving **diverse data sources** and **participants** requires **seamless data exchange** to ensure innovation, competitiveness and efficient collaboration among all stakeholders.	Customers benefit from **reliable supply** and **managed costs**. Data and digitalization enable active participation in energy markets as well as innovative solutions and competitiveness for the optimization of their energy consumption.	DSOs with the support of DSO Entity will develop a framework for interoperability aimed at smartening the system, facilitating seamless data exchanges by working with TSOs and stakeholders in the harmonization of the different components of these exchanges, facilitating the competitiveness of EU industry

Call to cooperation

This inclusive technical vision relies on the cooperation with all stakeholders, such as ENTSO-E, the European Commission, ACER, and all network users. Hence, this Vision is also a call to cooperation to work together towards serving European customers.

Increased cooperation with ENTSO-E for an efficient system operation, market integration, planning and investment.

Close collaboration with the European Commission and ACER to enable forward-looking regulatory adjustments that align the power system with society's transition towards a net-zero energy future.

Close collaboration with all system players to ensure a competitive, resilient, efficient, and customer-centric power system that reinforces Europe's industrial leadership in the global energy transition.

Glossary

- **ACER:** European Union Agency for the cooperation of energy regulation.
- **Active system management:** The increasing volumes of DER and RES require DSOs to strengthen active grid management capabilities. This involves effectively handling DER, intermittent and bi-directional energy flows, and procuring flexibility services where necessary.
- **Aggregators**: An aggregator plays a role in energy systems and can be described as an agent who provides services to combine energy production from various sources (generators) and interacts with the grid as a single entity. This includes managing local demand (demand response management) and supply (generation management).
- **Anticipatory investments**: Anticipatory investments result from planning aimed at identifying investments that proactively address expected developments, looking beyond immediate needs of generation or demand into the mid and long-term. The planning should consider new generation and/or demand that will materialize with sufficient certainty, even while utilization could be low in the short term.
- **CAPEX**: Capital Expenditure
- **Congestion management**: In the energy sector, congestion happens when a specific part of the grid is overwhelmed with power. Congestion management is a strategy designed to adjust either the supply or demand of energy during peak times, when the grid's capacity is maxed out.
- **Customers**: The definition includes households, businesses and industries.
- **Data interoperability:** Facilitating the exchange and transferability of data across various systems.
- **DER:** Distributed energy resources
- **DMDSs:** Dedicated measurement devices
- **DNDPs:** Distribution Network Development Plans. The Distribution Network Development Plan (DNDP) is a strategic document mandated by the EU Directive 2019/944 to be developed, published, and updated biennially by European Distribution System Operators (DSOs).
- **Dynamic ratings:** Dynamic Ratings optimize asset use by allowing real-time adjustments to transformer and line limits, reducing conservatism and unlocking capacity.
- **Energy sharing:** Energy sharing is the self-consumption by active customers of renewable energy either:
    - generated or stored offsite or on sites between them by a facility they own, lease or rent in whole or in part; or
    - the right to which has been transferred to them by another active customer for a price or free of charge
- **ESP:** Energy sharing provider
- **European Data Space:** Moving towards a European Data Space involves securing, making interoperable, and ensuring the accessibility of diverse data for a broad range of stakeholders, including customers, energy producers, aggregators, and other grid operators (DSOs and TSOs). The DSO data space represents a critical component of the future decentralized and customer-driven energy system.
- **EVs:** Electric vehicles.
- **Expansion:** Building of new capacity.

- **Flexibility:** 'flexibility' means the ability of an electricity system to adjust to the variability of generation and consumption patterns and to grid availability, across relevant market timeframes.
- **GAP:** The "Grid Action Plan" is a non-legislative communication presented by the European Commission in November 2023.
- **Grid forming capabilities:** Grid forming refers to the capability of an inverter-based energy source, like solar, wind, or battery, to supply voltage and frequency support to the grid, particularly during disturbances or outages. This technology is crucial for integrating more renewable energy into the grid.
- **HEMS:** A Home energy management system is a digital system that monitors and controls energy generation, storage and consumption within a household.
- **Maintenance:** Different means of prolonging lifetime of assets and improving quality of existing capacity.
- **Network Codes:** Network Codes are legally binding European Commission implementing Regulations. They govern all cross-border electricity market transactions and system operations alongside the Regulation on conditions for accessing the network for cross-border electricity exchanges.
- **NRAs:** National Regulatory Authorities.
- **OEMS:** Original equipment manufacturers.
- **OPEX:** Operational Expenditure.
- **Prosumers:** Prosumers are those consumers that both consume and produce electricity.
- **Renewal**: Renewing existing capacity
- **RES:** Renewable energy sources.
- **System of systems:** An integrated electricity system requiring coordination among all different stakeholders.
- **System Operators (SOs)**:
    - **Transmission System Operators (TSOs)**: European Transmission System Operators (TSOs) are entities operating independently from the other electricity market players and are responsible for the bulk transmission of electric power on the main high voltage electric networks. TSOs provide grid access to the electricity market players (i.e. generating companies, traders, suppliers, distributors and directly connected customers) according to non-discriminatory and transparent rules. In order to ensure the security of supply, they also guarantee the safe operation and maintenance of the system. In many countries, TSOs are in charge of the development of the grid infrastructure too.[3]
    - **Distribution System Operators (DSOs)**: European Distribution System Operators (DSOs) are legal persons responsible for operating, ensuring the maintenance of and, if necessary, developing the distribution system in a given area and, where applicable, its interconnections with other systems and, for ensuring the long-term ability of the system to meet reasonable demands for the distribution of electricity as defined in the Electricity Directive (EU) 2019/944.[4]

3 ENTSOE.

4 ACER (Status of EU DSO Entity).