



ENTSO-E STRATEGIC ROADMAP

**Prepare
the future
and manage
the present**

Foreword

ENTSO-E, the European Network of Transmission System Operators for Electricity, is the association of the European transmission system operators (TSOs). The 40 member TSOs, representing 36 countries, are responsible for the secure and coordinated operation of Europe's electricity system, the largest interconnected electrical grid in the world.

Before ENTSO-E was established in 2009, there was a long history of cooperation among European transmission operators, dating back to the creation of the electrical synchronous areas and interconnections which were established in the 1950s.

In its present form, ENTSO-E was founded to fulfil the common mission of the European TSO community: to power our society. At its core, European consumers rely upon a secure and efficient electricity system. Our electricity transmission grid, and its secure operation, is the backbone of the power system, thereby supporting the vitality of our society. ENTSO-E was created to ensure the efficiency and security of the pan-European interconnected power system across all time frames within the internal energy market and its extension to the interconnected countries.

ENTSO-E is working to secure a carbon-neutral future.

The transition is a shared political objective through the continent and necessitates a much more electrified economy where sustainable, efficient and secure electricity becomes even more important. **Our Vision: "a power system for a carbon-neutral Europe"**¹ shows that this is within our reach, but additional work is necessary to make it a reality.

With the present Strategic Roadmap, ENTSO-E has reorganised its activities around two interlinked pillars, reflecting this dual role:

- › "Prepare for the future" to organise a power system for a carbon-neutral Europe; and
- › "Manage the present" to ensure a secure and efficient power system for Europe.

ENTSO-E is ready to meet the ambitions of Net Zero, the challenges of today and those of the future for the benefit of consumers, by working together with all stakeholders and policymakers.

¹ <https://vision.entsoe.eu/>

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Executive Summary

Our society is based on secure and efficient electricity. The power grid, and its efficient and safe operation, is the backbone of the energy system and, thereby, our European economy.

This new **ENTSO-E Strategic Roadmap** provides a framework to address the ambition and the challenges of the European electricity system. It builds on activities necessary to ensure a secure and efficient power system for Europe and on the recently published ENTSO-E Vision “A Power System for a Carbon-neutral Europe”². It reflects the shared priorities of TSOs in Europe and serves as a compass for the work of ENTSO-E today and for the future.

Pillar 1:

a power system fit for a carbon-neutral Europe will need significant changes in five key areas:

- › The development of significant **Energy System Flexibilities** to balance the increased weather-dependency and complexity of the energy system;
- › The adaptation of the **Operation of Future Grids**, to deliver a secure and efficient operation of what will have become a “system of systems”;
- › A strong drive on **Infrastructure & Investments**, to accelerate the development and delivery of the grids needed for the transition;
- › An updated **Electricity Market Design** to give value to what will be needed for the energy transition and empower energy consumers; and
- › A coordinated and targeted **Innovation** effort, to enable the necessary technology developments, grid equipment and uptake of solutions.

The Strategic Roadmap is built around two interconnected pillars which reflect the shared twofold mission of TSOs in Europe: preparing a future **Power System fit for a Carbon-Neutral Europe**, all the while managing a **Secure and Efficient Power System for the whole of Europe**.

Pillar 2:

on the other hand, a secure and efficient power system for Europe requires:

- › **Operational Excellence**, to support TSOs for an efficient, secure and resilient system operation;
- › **Market Development and Operation**, to support and implement market mechanisms for efficiently operating the system and optimising social welfare;
- › **Regional Coordination** between national and regional actors at the scale of European regions;
- › **Information and Communication Technologies** and the tools to manage the power system.

2 [ENTSO-E Vision: A Power System for a Carbon Neutral Europe \(entsoe.eu\)](#)

1 Two Pillars: Deliver a fully Carbon-Neutral future with an Efficient and Secure Roadmap

Society depends on a reliable electricity supply that powers lights, communication systems, transport, health and public services. The TSO community strives to secure an efficient power system for all Europe, essential for enabling the energy transition.

The rapid integration of renewables, the pivotal role of electrification and the growing interdependencies across sectors make the European electricity system and grid infrastructure central to the future energy landscape and the European economy. The future power system must effectively address and solve the challenges arising from this ongoing transition. Therefore, while continuing to facilitate power system security, efficiency and resilience, ENTSO-E is adding a new central dimension to its activities; a forward-looking

approach based on the [ENTSO-E vision for a carbon-neutral Europe](#).

The Strategic Roadmap builds around two interconnected pillars, reflecting the two main missions of TSOs in Europe: preparing a future **Power System fit for a Carbon-Neutral Europe** while managing a **Secure and Efficient Power System for the whole of Europe**.

A Power System for a Carbon-Neutral Europe

The future system will rely on carbon-neutral energy sources, on flexibility resources to complement the weather-dependent generation and on a secure, efficient power grid. It demands flexibility development, dynamic system operation, regulatory adjustments, infrastructure delivery, market innovation, and the ongoing integration of new solutions.

A Secure and Efficient Power System for Europe

While preparing for carbon neutrality, TSOs will continue to provide a secure and efficient European power system for the whole of Europe. This will require the continuous deployment of operational excellence, implementing efficient and operational market mechanisms, increasing regional coordination, and making the best use of information and communication technologies.



Figure 1: Two Pillars contributing to the ENTSO-E strategic dual objective.

2 Building Blocks of the Strategy

2.1 Pillar 1: A Power System for a Carbon-Neutral Europe

The first strategic goal is to enable the energy transition through a power system fit for a carbon-neutral Europe – our **Pillar 1**. This is structured in five “building blocks” that represent the main areas where change is necessary to deliver a power system fit for a carbon-neutral Europe (see Figure 2):

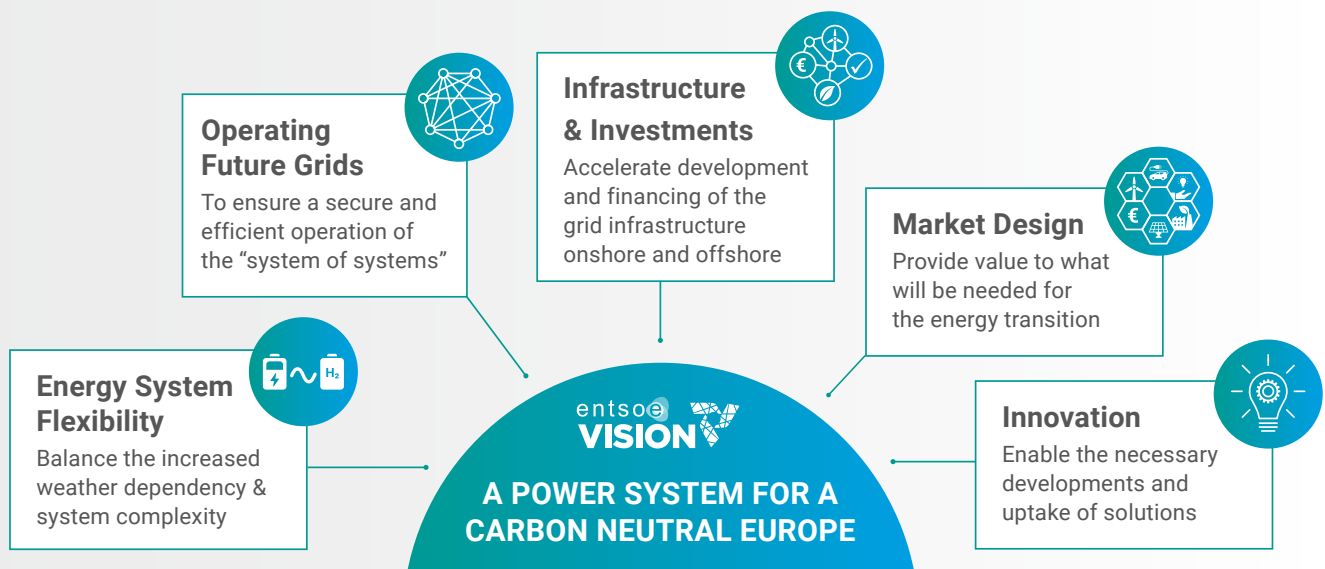


Figure 2: Pillar 1 – A Power System for a Carbon-Neutral Europe and its building blocks

Energy System Flexibility To balance the increased weather-dependency and energy system complexity

A carbon-neutral energy system, based on renewable energy sources and with increased electrified consumption, will become highly weather-dependent and complex. Flexibility sources including carbon-neutral solutions are necessary and should be promptly deployed. This includes: flexible generation, active management of the demand for electricity, storage, sector integration and flexible grid use. The electricity grid will facilitate resource exchange, thus reducing flexibil-

ity needs. With this new paradigm, an accurate assessment of flexibility needs and potential at national and European levels is vital for a cost-effective and reliable power system. A comprehensive “system of systems” approach involving TSOs, Distribution System Operators (DSOs) and other sectors such as hydrogen is necessary to coordinate the deployment and use of the most efficient flexibility resources.



Operating Future Grids

To ensure a secure and efficient operation of the “system of systems”

To operate our future power system’s securely and efficiently we need new approaches that go beyond current practices. Weather-dependent electricity generation, the coordination of transmission and distribution of electricity, and the integration of flexibility from various sectors will drive this evolution. This will require enhanced real-time grid visibility, forecasting capabilities and controllability. Automation and artificial intelligence will support operators in handling the dynamics

and grid complexity while enhancing system resilience. The electrification of end uses and sector coupling will increase the exposure to risks and threats, requiring new risk-based methodologies, cybersecurity and new concepts for the coordination of all operators within a “system of systems” approach. Collaboration among TSOs, Regional Coordination Centres (RCCs), DSOs and other sectors is crucial for future power system operation.



Infrastructure & Investments

To accelerate the development and delivery of the grid infrastructure onshore and offshore

Coordinated planning will be required across the system of systems: transmission and distribution, onshore and offshore, electricity and other energies. Massive investments in transmission networks are necessary to deliver the energy transition, to enable the exchange of energy surplus and deficits balances across regions, to support the large scale electrification and decarbonisation of the European economy,

to increase system flexibility and resilience, and to facilitate efficient and integrated markets for the benefits of consumers. The pace of development of the grid infrastructure³ must accelerate, which requires reforming regulatory frameworks, ensuring fit-for-purpose financing mechanisms, developing seamless supply chains to overcome the capacity bottlenecks, and enhancing engagement with local communities.



Market Design

To provide value to what will be needed for the energy transition

Electricity markets will need to evolve to support the energy transition⁴. First, they should enable investments in renewables, flexibility and grids with strong long-term signals. Second, short-term markets need to encourage efficient resource use and carbon-neutral flexibility across time, space and sectors. Third, electricity market design should align incentives with system capabilities and security. Ultimately, electricity markets should provide sustainable and affordable power,

diverse retail offers and engagement opportunities for consumers. Implementing the electricity market design reform involves amending rules and supporting new frameworks and mechanisms to accelerate investments in carbon-neutral generation and flexibility. Other important aspects to consider are transparency tools for a carbon-neutral system and potential changes to transmission tariff principles.



Innovation

To enable the necessary developments and uptake of innovative solutions

To accelerate the energy transition and provide the necessary tools and methods, TSOs, with ENTSO-E support, are making key existing and potential breakthroughs in new strategic technologies by implementing the Research Development and Innovation Roadmap and the deployment of solutions⁵. This includes integrating digitalisation with sustainable smart solutions to be further deployed into the electricity grids as an enabler for operating the future power system, and for

the integration of flexibilities and new approaches towards dynamic models and planning. Offshore developments, combined with the integration of renewables, will lead to an increasingly hybrid AC/DC system. New measures regarding the adaptation of regulatory frameworks, the de-risking of first-of-a-kind projects, demonstrators through allocated funds or financial support, and corresponding stakeholder engagement should be pursued.

3 [Grids, the missing link – An EU Action Plan for Grids](#)

4 Electricity Market Design Reform is a step forward in the direction of accompanying the energy transition

5 [ENTSO-E Technopedia](#)

2.2 Pillar 2: A Secure and Efficient Power System for Europe

The second strategic goal is to continuously provide a secure and efficient power system for Europe – our **Pillar 2** – from today and continuing through the complete course of the energy transition. This is achieved via strategic initiatives clustered into four “building blocks” (Figure 3):

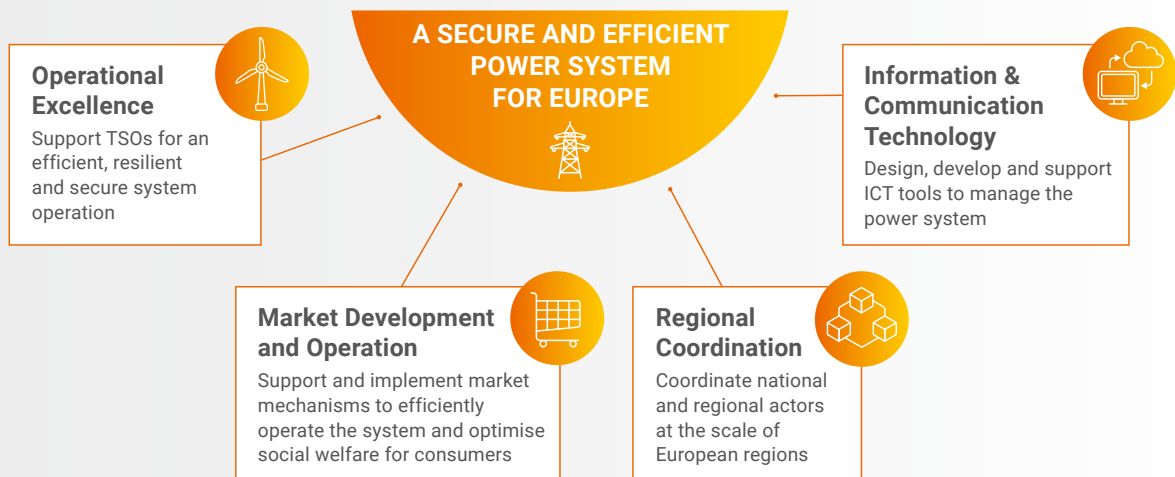


Figure 3: Pillar 2 – A Secure and Efficient Power System for Europe and its building blocks





Operational Excellence

To support TSOs for an efficient, resilient and secure system operation

Ensuring the secure operation of the power system is a collective responsibility of TSOs, assisted by RCCs. Given the extensive interconnection of the European grid, TSOs harmonise operational rules and processes at both European and synchronous area levels for risk preparedness and resilience. The development of methodologies, policies, tools and contractual frameworks at the European level facilitates efficient collaboration among TSOs. The seasonal outlook assessments assist in forecasting adequacy risks

over several months. ENTSO-E serves as a platform for TSOs to prepare for challenging operational scenarios, sharing assessments with the European Commission and Member States to enhance overall preparedness and resilience. ENTSO-E supports TSOs in achieving operational excellence by collecting information on power system incidents, issuing technical recommendations based on root-cause analysis of significant events and monitoring their implementation.



Market Development and Operation

To support and implement market mechanisms to efficiently operate the system and optimise social welfare for consumers

ENTSO-E supports TSOs in their role of market facilitators in addition to their role of developing and operating balancing and forward markets. This includes: preparing and implementing the rules and regulations concerning market coupling and balancing platforms, coordinating activities and decision-making processes with other TSO-implementing entities and market coupling operators, and oversight of market operations. ENTSO-E is constantly engaged in ensuring, enhancing and promoting market transparency. This is carried out by operating and developing the transpar-

ency platform, publishing market reports and reporting on events that may influence the markets, and maintaining close contacts with regulators, EU institutions and stakeholders. ENTSO-E also contributes to the completion of the Internal Electricity Market by implementing the network codes and the Clean Energy Package. Moreover, ENTSO-E oversees the implementation of the inter-TSO compensation mechanism and promotes principles for sound cost-sharing arrangements and a regulatory environment for TSOs, including the financing of grid investments.



Regional Coordination

To coordinate national and regional actors at the scale of European regions

The regions are the areas in which TSOs are working within regional frameworks, including the respective governance and responsibilities: RCCs, System Operation Regions (SORs), Capacity Calculation Regions (CCRs) and Regional

Investments Plans. ENTSO-E, acting at the pan-European level, ensures the necessary cooperation and coordination of all regional actors and initiatives for the implementation of operational, market, and planning products and deliverables.



Information and Communication Technology (ICT)

To design, develop and support the ICT tools to manage the power system

ICT is essential to enable most of the business processes of TSOs in Europe. ENTSO-E provides support to the steering and monitoring for the technical management, development and operation of TSOs' ICT infrastructure, products, portfolio, standards, architecture and services, applying recognised security standards and thus contributing to the state-of-the-art secure environment. By selecting and implementing cost-

effective, reliable and secure ICT solutions based on business requirements, ENTSO-E's goal is to support the security of the interconnected power system. In addition, ENTSO-E aims to optimise the functioning and development of European interconnected electricity systems and markets, including the seamless integration of electricity from renewable sources and emerging technologies.

3 Conclusion: Prepare the Future and Manage the Present

The two pillars **A power system for a carbon-neutral Europe** and **A secure and Efficient Power System for Europe**, in addition to their corresponding building blocks, are complementary and mutually influence each other (Figure 4).



Figure 4: Two intertwined pillars and the building blocks of the Strategic Roadmap

While planning and delivering our future power system, Europe needs to continue to rely on a strong, secure and efficient electricity supply. To ensure the balance between these two dimensions, ENTSO-E will need to manage intertwined and sometimes challenging approaches or activities while fulfilling these dual strategic goals. The Strategic Roadmap will focus its activities, resources, and the stakeholder

engagement of ENTSO-E on its twofold objective: ensuring that the European power system of the future is fit for a fully carbon-neutral economy while continuing to support the delivery of the present efficient and secure electricity system.

Have your say at info@entsoe.eu



Abbreviations

AC	Alternating Current
CCR	Capacity Calculation Region
DC	Direct Current
DSO	Distribution System Operator
ENTSO-E	European Network of Transmission System Operators for Electricity
EU	European Union
ICT	Information and Communications Technology
RCC	Regional Coordination Centre
SOR	System Operation Region
TSO	Transmission System Operator

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