



**UPDATING THE SECURITY
OF ENERGY SUPPLY
ARCHITECTURE AND
PREPAREDNESS TOOLBOX
FOR AN INCREASINGLY
ELECTRIFIED ENERGY SYSTEM**

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Executive Summary

Europe's energy landscape is undergoing a profound transformation marked by decarbonisation, decentralisation, and digitalisation. Rising electrification and renewable integration are increasing grid complexity and exposing new vulnerabilities, from physical congestion to cyber threats. While short-term electricity supply security remains stable, structural adequacy and systemic risks are projected to rise in the medium term. Against the backdrop of the 2021–2023 energy crisis, the EU faces the dual challenge of strengthening its regulatory and emergency response tools while reconciling national security-of-supply priorities with deeper EU-level coordination and integration.

Clarifying terminology is crucial to address these challenges. *Energy security* broadly refers to the uninterrupted availability of energy at affordable prices, encompassing the “4As” of availability, accessibility, affordability, and acceptability (now often extended with sustainability). *Security of Supply (SoS)* is narrower, focusing on the ability of the electricity system to continuously meet demand with adequate capacity, reliability, and quality. Unlike energy security, SoS is a defined EU policy objective under the Treaty on the Functioning of the European Union (TFEU). Since 2022, EU policy has increasingly framed SoS as a strategic pillar of decarbonisation and resilience – reducing fossil fuel dependence, integrating domestic low-carbon resources, and reinforcing European solidarity in times of crisis.

The EU's security-of-supply framework rests on three interconnected “layers.” The first embeds SoS in the electricity market design through measures ensuring adequacy, flexibility, and grid stability. The second layer adds supplementary mechanisms – such as capacity and flexibility markets – to address residual adequacy risks while avoiding cross-border distortions. The third layer consists of the risk-preparedness and emergency framework, which defines common EU crisis levels, coordination rules, and solidarity mechanisms. Ongoing reforms seek to modernise this architecture by improving cross-sector coherence (electricity, gas, and hydrogen), harmonising crisis definitions, reinforcing resilience against emerging risks (climate, cyber, geopolitical), and maintaining the delicate balance between EU coordination and national sovereignty.

The paper offers concrete policy recommendations to strengthen the EU's electricity security-of-supply (SoS) architecture and outlines practical tools for the forthcoming legislative revision. It focuses on electricity SoS – ensuring sufficient generation to meet demand at all times – and examines how the EU should reform its framework to address emerging risks while preserving market integration and accelerating decarbonisation in both normal and crisis conditions. Recommendations are organised around four issues:

1. A layered yet integrated SoS architecture
2. Upgraded adequacy rules with non-distortive supplementary mechanisms
3. A consolidated, coordinated, and efficient preparedness toolbox
4. A system-wide approach to SoS across sectors and levels



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About CERRE

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1. Introduction

1.1 Context, Definitions and Focus

1.1.1 The Changing Energy Landscape

Europe's energy supply and demand patterns are changing, moving towards greater decarbonisation, decentralisation, and digitalisation. Increasing electrification of Europe's energy system and higher renewables share entail new systemic risks and vulnerabilities, such as grid stability and congestion management. Recent blackout events have various causes, including ageing grid, increasingly complex operations, and a more interconnected system.¹ European Union (EU) countries are moving towards a more integrated EU energy system to increase resilience and cost-efficiency, but significant cross-border needs remain unaddressed.² The European energy system must adapt to these intrinsic changes while simultaneously developing response mechanisms to external stresses related to extreme weather events, as well as cyber and physical attacks.

These developments create new and multiple energy security challenges, particularly for the security of supply (SoS) of electricity. As concluded by the Agency for the Cooperation of Energy Regulators (ACER) in its 2024 Security of EU Electricity Supply Monitoring Report, *"the outlook for the security of Europe's electricity supply remains positive in the short term, but risks are projected to increase further out in the future, based on the resource adequacy assessments at the European and national levels"*.³ This assessment must be understood against the backdrop of the 2021-2023 energy crisis, which was mostly an energy price crisis driven by severe disruptions in the gas market. Yet, it reveals that more systemic supply and adequacy challenges are awaiting the EU energy system in the next decade.

This calls for a re-assessment and rapid strengthening of the available regulatory toolbox of emergency measures, as well as, as urged by the European Parliament in its Resolution of 8 July 2025, a revision of the SoS architecture.⁴ It also questions how national SoS responses are effectively coordinated with EU-level action through harmonised legislation, while there is an intuitive tendency for Member States to prioritise national security of supply. The scope and simultaneous occurrence of new emerging risks call for a re-thinking of how the EU and its Member States appraise energy security, and security of supply more specifically.

¹ E.g.: 2021 split of the Continental Europe synchronous area; 2025 Iberian blackout, July 2025 outages in the eastern and northern part of the Czech Republic.

² ACER, Electricity infrastructure development to support a competitive and sustainable energy system, December 2024. The report assesses cost-effective grid expansion for a secure, sustainable, competitive EU power system, concluding that multi-vector scenarios are needed.

³ ACER, Security of EU electricity supply - 2024 Monitoring Report, 16 December 2024, p.4.

⁴ The European Parliament calls upon a new EU security of supply architecture that "should reflect such fundamental shifts as increasing cross-sectoral integration of the energy system, the new geopolitical landscape, the profound changes in supply routes, the impact of climate change, as well as changes in the maturity of energy technologies reflected in shifts of levelised costs of energy and the opportunities this presents for the energy transition" https://www.europarl.europa.eu/doceo/document/TA-10-2025-0146_EN.html

1.1.2 Defining Energy Security and Security of Supply

To correctly address these concerns, a precise understanding of the terminology is needed, notably the interrelated but not substitutable concepts of energy security and security of supply. Confusion may indeed arise, as both EU policy documents⁵ and the literature⁶ at times, use the two terms interchangeably. In addition, there is no consensus on their definition, as they share some overlapping constitutive components. The paper builds on the understanding of the two concepts as described below.

Energy security is defined by the International Energy Agency (IEA) as the uninterrupted availability of energy at an affordable price.⁷ It relies on factors such as the physical availability of energy, price stability and affordability, and a country's overall energy independence, including concerning supply chains.

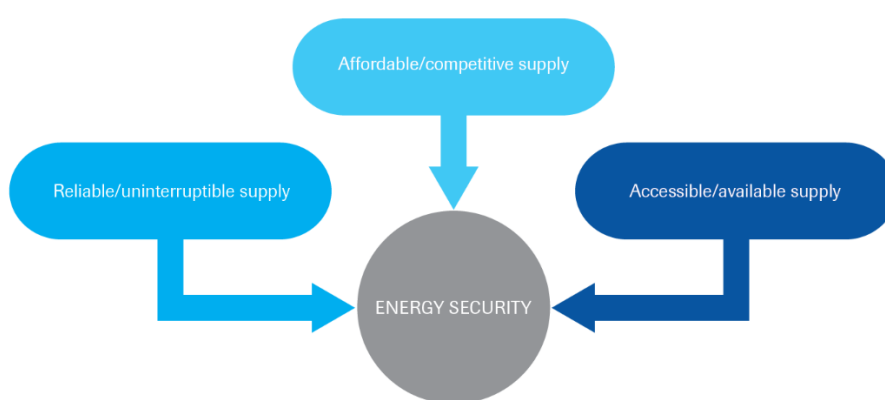


Illustration 1: Schematic presentation of security of energy supply according to the IEA.

Source: IEA.⁸

More in detail, energy security is defined in the literature as the uninterrupted availability of energy sources at an affordable price while minimising negative consequences from energy use, including efficiency, environmental, social, and geopolitical factors.⁹ Another commonly accepted definition of energy security is based on the 4As Framework Extended, where energy security means the availability of energy at all times in various forms, in sufficient quantities, and at reasonable and/or affordable

⁵ E.g. European Commission, Green Paper Towards a European strategy for the security of energy supply, COM(2000) 769 final, Brussels, 29.11.2000; European Commission, Communication to the Council and the European Parliament, Final report on the Green Paper "Towards a European strategy for the security of energy supply", COM(2002) 321 final, 26.6.2002.

⁶ Strojny, J., Krakowiak-Bal, A., Knaga, J., & Kacorzyk, P. (2023). Energy Security: A Conceptual Overview. *Energies*, 16(13), 5042. <https://doi.org/10.3390/en16135042>; T. Jakstas, 'What does Energy Security Mean?' in M. Tvaronaviciene and B. Slusarczyk (eds.) *Energy Transformation towards Sustainability* (Elsevier, 2019, pp.99-112; I. Chester, 'Conceptualising Energy Security and Making Explicit its Polysemic Nature' (2010) 38(2) *Energy Policy*, pp.887-95.

⁷ International Energy Agency (IEA), *What is Energy Security?* <https://www.iea.org/topics/energy-security>; IEA, *Energy Security in Energy Transitions*, *World Energy Outlook 2022*, available at <https://www.iea.org/reports/world-energy-outlook-2022/energy-security-in-energy-transitions>

⁸ Ibid.

⁹ Ang, Beng Wah, Wei Lim Choong, and Tsan Sheng Ng. 2015. "Energy Security: Definitions, Dimensions and Indexes." *Renewable and Sustainable Energy Reviews* 42: 1,077–1,09



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prices.¹⁰ This framework encompasses "availability", "accessibility", "affordability", and "acceptability" as the four sustainability-related dimensions of energy. This definition has since been supplemented with "sustainability" as an additional dimension.¹¹ Energy security is consequently a broader concept than security of supply and affordability, which it encompasses. By comparison, there is no legal definition of energy security in EU law.

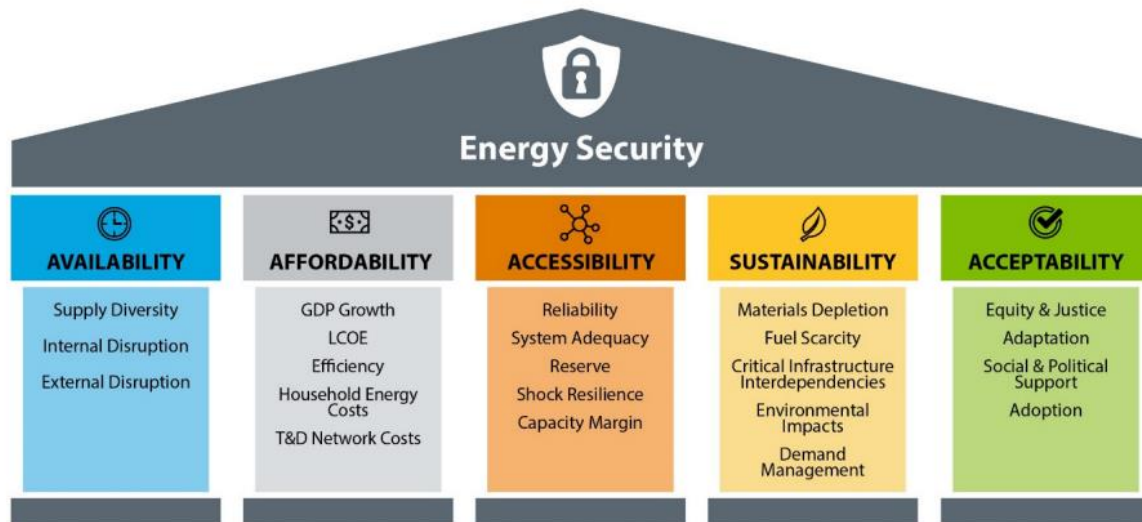


Illustration 2: Pillars of energy security.

Source: Leddy and Hotchkiss (2024), elaborated from Cox (2014).¹²

Security of energy supply is a narrower concept than energy security, although it constitutes an important part thereof. It is defined as the ability of the energy system to supply end-users with electricity of a certain quality on a continuous basis. Conversely, security of electricity supply is the ability of the electric power system to supply end-users with electricity of a certain quality on a continuous basis. The literature has identified four main aspects which are deemed central in security of electricity supply: energy availability, power capacity, reliability of supply (including cybersecurity and operational reliability), and power (voltage) quality.¹³ The main objective of SoS measures is to ensure that there is sufficient generation available to meet demand, which involves acting on several levels of the supply chains, from production to flexibility of consumption and storage.

By contrast with energy security, security of energy supply is defined as an objective of EU policy by the Treaty on the Functioning of the European Union (TFEU) (Art. 194(1)(b)). EU action to reach that

¹⁰ Cherp, Aleh, and Jessica Jewell. 2014. "The Concept of Energy Security: Beyond the Four As." *Energy Policy* 75: 415–421.

¹¹ Emily Cox "Assessing the future security of the UK electricity system in a low-carbon context." Paper submitted to the British Institute of Energy Economics 14th Academic Conference, Oxford, England, September 17-18, 2014.

¹² Laura Leddy, Eliza Hotchkiss, and Heidi Applegate. 2024. "Conceptualizing Energy Security and Resilience." National Renewable Energy Laboratory (NREL). Available at: <https://docs.nrel.gov/docs/fy24osti/89206.pdf>

¹³ G. H. Kjølle, "Security of electricity supply in the future intelligent and integrated power system," in *Women in Power: Research and Development Advances in Electric Power Systems*, J. S. Tietjen, M. D. Ilic, L. B. Tjernberg, and N. N. Schulz, Ed. Cham: Springer, 2023, pp. 189-207



objective must be conceived *“in a spirit of solidarity between the Member States”*.¹⁴ EU action in the field must be balanced against the facts that, pursuant to the Treaty on the European Union (TEU) (Art. 4.2), national security remains the exclusive responsibility of each Member State, and that, pursuant to Art. 194(2) TFEU, Member States retain the right to determine their energy mix.

EU legislation provides a definition of security of electricity supply in the Electricity Risk-Preparedness Regulation (EU) 2019/941 as being *“the ability of an electricity system to guarantee the supply of electricity to customers with a clearly established level of performance, as determined by the Member States concerned”*.¹⁵

Since the 2022 energy crisis, the EU’s view of security of supply has shifted towards prioritising domestic, low-carbon energy and reducing dependence on Russian fossil fuels. This reorientation must be balanced against the resilience and efficiency gains from integrated EU energy systems and markets. As Goldthau and Youngs note, three related shifts frame this change: framing the green transition as a security concern, adopting a more “realpolitik” external climate and energy posture and expanding the role of the state.¹⁶

Taken together, these developments recast the EU security of supply policy as both a decarbonisation agenda and an existential project anchored in European integration while lowering exposure to critical import and geopolitical risks.¹⁷

1.1.3 Objectives of the Paper and Scope within CERRE’s Resilience Forum

The paper aims to contribute to the upcoming revision of the EU energy security legislation by analysing the EU security of supply framework for electricity, including the Electricity Risk-Preparedness Regulation, while broadening the discussion to the whole SoS framework to ensure regulatory consistency.¹⁸ It sets out concrete policy recommendations to strengthen the EU electricity SoS architecture and reflects on the implementable toolbox measures for the upcoming legislative revision.

This paper is part of the CERRE’s Forum series *“Towards an Integrated Approach to Infrastructure and Market Resilience”*, in which each contribution has a targeted focus, a limited scope of analysis and is meant to complement the others. Hence, this paper focuses on SoS concerns within electricity, where the main objective is to ensure that there is sufficient generation available to meet demand at any

¹⁴ Art. 194(1)(b)) TFEU.

¹⁵ Regulation (EU) 2019/941 of the European Parliament and of the Council of 5 June 2019 on risk-preparedness in the electricity sector and repealing Directive 2005/89/EC, Art. 2(1).

¹⁶ Goldthau, Andreas C., and Richard Youngs. “The EU Energy Crisis and a New Geopolitics of Climate Transition.” *Journal of Common Market Studies* 61 (2023).

¹⁷ Ibid.

¹⁸ The European Commission has conducting a “fitness check” of the existing energy security framework, which includes a public consultation, to evaluate its effectiveness and identify areas for improvement. The European Commission is expected to revise the Gas Security of Supply Regulation and the electricity risk-preparedness regulation during the first half of 2026.



time. It will not address the security of gas supply, but the potential for a single legislative framework for both gas and electricity security is commented as it is being explored by the EC.¹⁹

1.2 Current Framework and Legislative Reform Processes

1.2.1 Existing SoS and Preparedness Framework

The currently applicable SoS legislative framework has been developed progressively, primarily in reaction to a series of heterogeneous crises on the gas and electricity sides. EU harmonisation efforts have oscillated between, on one side, reinforcing preparedness and crisis management, and, on the other side, acting on structural elements of security of supply in market design legislation. A more comprehensive framework began to emerge under the Clean Energy for all Europeans Package.²⁰

On the electricity side, the current EU SoS framework consists, for the most part, of measures defined in: the Electricity Directive; the Electricity Regulation; the Risk-Preparedness in the Electricity Sector Regulation (EU) 2019/941; the System Operation Guideline (SOG);²¹ the Network Code on Emergency and Restoration;²² the recommendation of the Commission on fair compensation for the assistance provided between Member States in accordance with Art. 15 of the Risk-Preparedness Regulation;²³ and the work of the Electricity Coordination Group established in 2012.²⁴ The Risk-Preparedness Regulation repeals Directive 2005/89/EC²⁵ which had been largely superseded by new provisions of the electricity market design legislation with the aim of ensuring the availability of sufficient capacity, that transmission system operators cooperate sufficiently to ensure system stability and that the necessary transport infrastructure is planned.²⁶ This already shows the interactions (further commented on in Section 3 below) between electricity market design legislation and the progressive construction of a European framework for crisis prevention and management.

On the gas side, the current EU SoS framework consists for most parts of measures defined in: the Hydrogen and Decarbonised Gas Directive;²⁷ and the Hydrogen and Decarbonised Gas Regulation;²⁸

¹⁹ Similarly, the manner to reinforce the strategic autonomy of the EU within energy and the energy security-supply chains nexus, as well as resilience towards cybersecurity risks are discussed in other papers in the series.

²⁰ Communication from the European Commission, Clean Energy for All Europeans, COM/2016/0860 final.

²¹ Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation.

²² Commission Regulation (EU) 2017/2196 of 24 November 2017 establishing a network code on electricity emergency and restoration.

²³ Commission Recommendation (EU) 2020/775 of 5 June 2020 on the key elements of the fair compensation and other key elements to be included in the technical, legal and financial arrangements between Member States for the application of the assistance mechanism under Article 15 of Regulation (EU) 2019/941 of the European Parliament and of the Council on risk-preparedness in the electricity sector.

²⁴ The ECG was established by Commission Decision of 15 November 2012 setting up the Electricity Coordination Group, OJ C 353, 17.11.2012, pp. 2–4.

²⁵ Directive 2005/89/EC of the European Parliament and of the Council of 18 January 2006 concerning measures to safeguard security of electricity supply and infrastructure investment, now repealed.

²⁶ Electricity Risk-Preparedness Regulation, Recital 4.

²⁷ Directive (EU) 2024/1788 of the European Parliament and of the Council of 13 June 2024 on common rules for the internal markets for renewable gas, natural gas and hydrogen.

²⁸ Regulation (EU) 2024/1789 of the European Parliament and of the Council of 13 June 2024 on the internal markets for renewable gas, natural gas and hydrogen.



the Gas Security of Supply Regulation (EU) 2017/1938;²⁹ the work of the Gas Coordination Group established in 2004³⁰ and its organisation set in 2006.³¹ The Security of Gas Supply Regulation repeals Regulation 994/2010,³² which itself repealed Council Directive 2004/67/EC, which was the very first EU legislative instrument concerning security of natural gas supply.

As further elaborated below, other pieces of legislation covering several energy carriers (e.g. TEN-E Regulation) complete this overview and support, affecting directly or indirectly, security of energy supply in the EU.

Nuclear energy is an important factor of security of supply for several EU Member States and thereof the EU as a whole. It is not covered separately in this paper as it pertains to the choice of energy mix of the Member States, but a broader re-thinking of the SoS framework may also require integrating the considerations specific to nuclear energy generation, the value chain characteristics (including the diversification of supplies) and investment strategy in new reactor technologies like Small Modular Reactors (SMRs).

Finally, EU measures on heating and cooling also reinforce security of supply, but they have to a lesser extent been encompassed by SoS frameworks. The new heating and cooling strategy³³ announced in February 2025 in the context of the Affordable Energy Action Plan and due to be released in 2026³⁴ could be an opportunity to reinforce the contribution of this sector to SoS.

1.2.2 Upcoming Legislative and Policy Processes

The Council Conclusions of 30 May 2024 on Electricity Grid Infrastructure asked the Commission to “conduct a targeted legislative review to further reinforce the EU’s security of electricity supply architecture over the longer term”.³⁵ In November 2024, the European Commission conducted a fitness check of this legislative framework.³⁶ It completed the evaluation with a public consultation assessing the legislative framework against five main criteria: effectiveness, efficiency, relevance, coherence and EU added value. This was completed by two calls for evidence in September-November

²⁹ Regulation (EU) 2017/1938 of the European Parliament and of the Council of 25 October 2017 concerning measures to safeguard the security of gas supply and repealing Regulation (EU) No 994/2010.

³⁰ Council Directive 2004/67/EC of 26 April 2004 concerning measures to safeguard security of natural gas supply, now repealed.

³¹ Commission Decision of 7 November 2006 establishing the composition of the Gas Coordination Group, now repealed.

³² Regulation (EU) No 994/2010 of the European Parliament and of the Council of 20 October 2010 concerning measures to safeguard security of gas supply and repealing Council Directive 2004/67/EC.

³³ The former EU Heating and Cooling Strategy is from 2016 and several of the measures proposed were implemented as part of the Clean Energy for All Europeans Package.

³⁴ See the terms of the Call for Evidence

³⁵ Council Conclusion, Advancing Sustainable Electricity Grid Infrastructure, 30 May 2024, <https://data.consilium.europa.eu/doc/document/ST-10459-2024-INIT/en/pdf>

³⁶ In November 2024, The European Commission announced that it had organised a comprehensive exercise to test the resilience of the EU security of supply framework. The simulation exercise helped testing procedures and measures that had never been applied in real conditions. [The EU’s energy security framework successfully tested to ensure winter preparedness - European Commission](#)



2024³⁷ and September-October 2025³⁸. The necessary link to the parallel revision of the Gas Security of Supply Regulation (EU) 2017/1938 is briefly addressed (see Section 4 of this Paper) and will be covered in greater detail in another paper under CERRE's Resilience Forum.

The scope of the stress factors and threats on the energy system to be addressed by the reform is wide. The Commission wants to address “*new emerging risks*” to the energy system, which include climate-change-related risks, cyber and physical attacks on critical infrastructure, as well as supply chain and ownership concerns in a changing geopolitical landscape.³⁹

Different types of stresses or threats will require the application of different tools and will not be covered by the same legal instruments. The set of legislative acts that specifically address security of supply is relatively short. Where relevant, the paper notes that some response elements are covered by other legislation. It is further important to recognise that legal de-risking relies on a combination of both legislative and contractual tools, and that some actors will need to reflect these risks in their contractual strategy towards shippers or providers, in addition to fulfilling legislative requirements.

1.2.3 Commission's Reform Objectives and Options

The Commission has stated that the upcoming legislative revisions will pursue the following objectives:

1. Making the framework more dynamic and adaptable to an increasingly decarbonised, electrified and integrated energy system;
2. Reinforcing the EU's resilience, e.g. against climate risks or threats to critical energy infrastructure, including cyber-attacks;
3. Incorporating the lessons from the crises (energy crisis from 2022/2023 following the full-scale invasion of Ukraine by Russia, as well as the Covid-19 pandemic);
4. Striving for simplification by streamlining reporting processes and establishing more agile crisis-management provisions.⁴⁰

Against this background, a fitness check has been performed in parallel to the consultation process. This fitness check will allow the Commission to assess the performance of the Security of Gas Supply and the Electricity Risk-Preparedness regulations, together with the crisis measures. In September 2025, the European Commission published a report on the application of the Risk-Preparedness Regulation (EU) 2019/941 and which is taken into account in the present paper.⁴¹

³⁷ https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/14392-Energy-security-architecture-fitness-check_en

³⁸ https://energy.ec.europa.eu/news/commission-takes-first-step-strengthen-eus-energy-security-framework-2025-09-15_en?prefLang=da

³⁹ https://energy.ec.europa.eu/news/commission-takes-first-step-strengthen-eus-energy-security-framework-2025-09-15_en?prefLang=da

⁴⁰ European Commission, Call for evidence for an impact assessment - Ares(2025)7679380, 19.09.2025.

⁴¹ Report from the Commission to the Council and the European Parliament reviewing the application of Regulation (EU) 2019/941, COM(2025) 539 final, 29.9.2025



Furthermore, the Commission has identified four options for the revision of its SoS legislation: smart streamlining, targeted reinforcement, cross-sectoral transformation, and EU-driven action.⁴² The European Commission has identified four degrees of action in relation to these four options:

1. Streamlining for greater consistency and efficiency
2. Improvement of *existing mechanisms* (e.g. solidarity mechanisms);
3. Revision of *provisions* – Encompassing the addition of new ones, the removal of outdated ones, and alignment with legislative adoption timelines;
4. New *governance tools* – Including centralised management, enhanced monitoring, and an “EU-level crisis alert” system.

These four degrees of action show the possible gradation of action envisaged by the Commission and indicate potential avenues for EU harmonisation. They are duly considered in the paper.

Given the broad scope of the revision of the EU energy security framework, some fundamental issues arise concerning the architecture of the revised framework and the consistency among its various requirements and mechanisms.

Finally and in parallel, the European Commission Work Programme for 2026 identifies other relevant legislative and policy initiatives: an Electrification Action Plan, including heating and cooling (non-legislative initiative, scheduled for Q1 2026), and the update of the governance system for the Energy Union including addition initiatives on the phase-out of fossil fuels subsidies (legislative proposal based on Articles 192 and 194 TFEU, scheduled for Q4 2026).⁴³

1.3 Key Questions

This paper addresses fundamental questions about how the EU should reform its security of electricity supply framework to meet emerging challenges while maintaining market integration and accelerating decarbonisation, in both regular and crisis times.

The overarching question examined in the paper is:

- How should the EU legislative and regulatory architecture be adjusted to strengthen Security of Supply within electricity and ensure sufficient supply to meet demand at all times?

Subsequent questions addressed in the paper, focusing on the SoS architecture and toolbox, include:

- Should the EU revise the SoS architecture – roles, responsibilities, governance, and scope – and to what degree should it be harmonised?
- How can regulation better align market design incentives with SoS goals to drive efficient EU-wide investment in adequacy, grids, flexibility, and demand response in an increasingly interconnected system?

⁴² European Commission, call for evidence for an impact assessment, EU energy security framework (revision), 15.09.2025.

⁴³ Commission work programme 2026 Europe's Independence Moment, OM/2025/870 final, 21 October 2025.



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- Does the EU have the right regulatory toolbox to address SoS risks?
- How should the preventive-action (risk-preparedness) framework – scenarios, metrics, triggers, sensitive information management, supply chains requirements, equipment stocks requirements – be improved and coordinated across Member States and between National Regulatory Authorities (NRAs) and system operators at transmission and distribution levels (TSOs/DSOs) to ensure resilience to disruptive events amid more volatile supply and demand?
- How can crisis-management rules – alert levels, decision-making, data sharing, solidarity mechanisms – be streamlined while preserving the internal market?

The integration of neighbouring states (e.g. EEA countries, UK, Energy Community countries) and accession countries into the EU risk-preparedness and SoS framework merits consideration in this context. However, it is not included in this paper due to scope delimitations.

2. The Three Layers of the EU SoS Legislation in the Electricity Sector

2.1 Description of the Three Layers of the EU SoS Legislation

The paper identifies three distinct layers within Security-of-Supply legislation. While focused primarily on electricity, this framework equally applies to other energy vectors. The first layer comprises the structural components of SoS embedded in the electricity market design, which takes an electricity market-only approach as a starting point. The second layer encompasses supplementary SoS mechanisms that address remaining adequacy concerns, particularly through capacity and flexibility market mechanisms. The third layer defines the risk-preparedness and emergency regime, which also contributes to maintaining or restoring security of supply, but in the specific circumstances of a crisis or emergency. These three interconnected layers, illustrated below, form all together the comprehensive architecture of EU security of electricity supply.

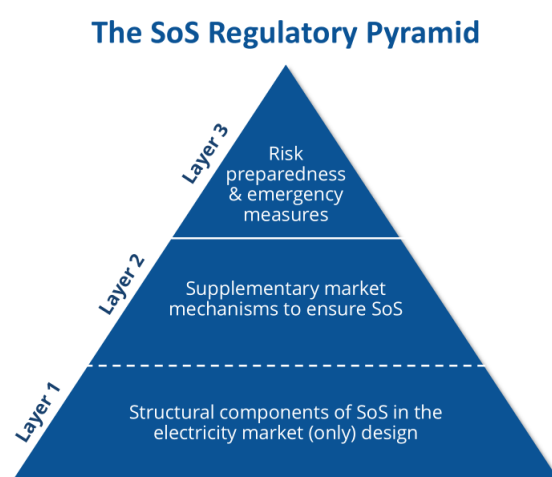


Illustration 3: The SoS regulatory pyramid: the three layers of the security of electricity supply regulation in EU law.

Author: Catherine Banet, UiO/CERRE.

2.2 Layer 1: Structural Components of SoS in the Electricity Market (Only) Design

This section raises the question of how to strengthen SoS by acting on the EU electricity market design framework, which forms the basis (Layer 1) of the SoS architecture. Integrating SoS considerations and tools directly into the market design layer enables SoS to become a structural component of the operation of the electricity system (system-related SoS measures) (Section 2.2.1). As sources of disruption diversify, there will also be a need to act on non-system-related measures to reinforce SoS (Section 2.2.2).

2.2.1 System-Related SoS Measures

Well-functioning, integrated, and coupled energy markets represent the basis of SoS in the EU. Pursuant to the Electricity Directive and Electricity Regulation, electricity markets shall be operated in accordance with market rules.⁴⁴ The starting point is therefore an energy-only market (EOM) fundamental, where power producers are paid only for the electricity they actually generate and deliver, not for their capacity to generate electricity⁴⁵ or the capacity to flexibly shave off the demand⁴⁶. On this basis, reinforcing SoS at the market design level would imply reinforcing mechanisms to ensure a well-functioning EOM and targeted support to resources supporting SoS.

However, there is a strong tendency, reinforced during the 2021-2023 energy crisis, toward government intervention that may distort market signals, often justified on security of supply grounds. Building on existing case law from the Court of Justice of the EU (CJEU) on the use of security of supply arguments to justify trade restrictions and the criteria attached to it (proportional, necessary and effective measure),⁴⁷ harmonisation of criteria for allowing such government intervention on EOM should, as far as possible, be subject to EU harmonised criteria and monitoring by regulatory authorities.

CERRE has already delivered a comprehensive analysis of the Electricity Market Design (EMD) regulation,⁴⁸ and this Paper builds upon these earlier findings and recommendations without reiterating them. In these previous reports, CERRE draws lessons from the 2021–2023 energy crisis and the Covid-19 pandemic that could inform a revision of the SoS legal framework, such as supply diversification, storage, demand-side measures, and solidarity execution.⁴⁹

The EU electricity market design legislation already defines a series of requirements that contribute to SoS. Some of these requirements could be improved or adjusted; other new measures could be added, including those outlined below.

Ensuring the Availability of Adequate Generation and Supply Resources into the System to Meet Demand and Grid Capacity

Pursuant to Article 194(2) TFEU, Member States retain control over their choice of energy mix. They have nevertheless agreed to steer their energy mix to reach specific Union targets, notably for the uptake of renewable energy sources.

⁴⁴ Electricity Regulation, Art. 3.

⁴⁵ Pollitt, M., von der Fehr, N.-H., Willems, B., & Banet, C. (2024). Recommendations for a future-proof electricity market design in Europe. *Energy Policy* Thomas Reverdy, Frédéric Marty, Ronan Bolton. The redesign of electricity markets under EU influence: The capacity mechanism in France and Britain. Janette Webb, Faye Wade, Margaret Tingey. Research Handbook on Energy and Society, Edward Elgar, 2021, pp.83-96.

⁴⁶ E.g. cross sectorial flexible heat electrification.

⁴⁷ See notably: ANRE v Societatea de Producere a Energiei Electrice în Hidrocentrale Hidroelectrica SA, C-648/18 (Hidroelectrica); C-539/11 [A5] Ottica New Line (47). See as well the Opinion of the Advocate General in the following cases, relevant to the matter: Opinion of AG Szpunar delivered on 6 February 2025 in Case C-499/23, European Commisison v Hungary; Opinion of AG Rantos delivered on 6 February 2025 in Case C-423/23, Secab Soc. Coop v ARERA et al.

⁴⁸ CERRE, Recommendations for a future proof electricity market design, 2022. <https://cerre.eu/publications/recommendations-for-a-future-proof-electricity-market-design/>

⁴⁹ See also M. Pollitt et al <https://www.sciencedirect.com/science/article/pii/S0301421524000715>



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The permitting regime enables a level playing field when it comes to access to the market for electricity generation. The construction of new generation capacity is based on an authorisation procedure adopted by the Member States based on the common criteria defined in the Electricity Directive (Art. 8). When laying down authorisation criteria for new generation, Member States must take into account, among others, the extent to which new generation will contribute to the overall Union target of at least 32% share of energy from renewable sources in the Union's gross final consumption of energy in 2030, as further defined in the Renewable Energy Directive (RED III) and the Energy Union Governance Regulation.

As part of the temporary emergency measures and the subsequent REPowerEU Plan, the further increase of generation capacity based on renewable energy sources has been identified as a central measure, which has been codified into the RED III revision. The speedy implementation of these new provisions will enable new RES generation capacity to contribute to SoS. The European Commission has been monitoring closely the implementation progress and has launched a series of infringement procedures against Member States that had not notified implementation measures on time.

In addition to generation capacity, there will be a need to implement and, when needed, reinforce provisions aiming at the acceleration of permitting procedures for flexibility, energy storage⁵⁰, and demand response. Likewise, the permitting procedure for grid infrastructures needs to be made more efficient and accelerated.

Inertia, Power Quality, Balance and Frequency Regulation⁵¹

More intermittent renewable energy sources in the system create challenges related to inertia.

When operating the power grid, the *system frequency*⁵² is required to stay within a very narrow interval (typically 50.00/60.00 +/-0,1Hz) to ensure *system stability*.⁵³ Too much power in the system (overproduction) will result in an increase in frequency. Conversely, too little power (due to a grid fault or production outage) will cause a decrease in frequency. The objective is therefore to maintain the frequency at the correct set point and to contain *frequency deviations* when they occur, as there must be a constant balance between load and production in the system.⁵⁴ To achieve this, the responsible Transmission System Operator (TSO) continuously monitors a series of critical parameters. In the event of an imbalance, the TSO must implement *immediate balancing actions*, such as using variable power production units or use frequency containment reserves. The tasks and actions taken by TSOs

⁵⁰ The European should soon publish an assessment of the implementation of the EC recommendations on energy storage. This could serve as basis for new legislative proposals.

⁵¹ This section builds on research outcomes in the Ocean Grid project and notably the following deliverable: Catherine Banet et al., Market design alternatives and cost and revenue sharing models for hybrid offshore wind projects between Norway and Europe, 5 July 2024. Available at: <https://oceangridproject.no/market-design-alternatives-and-cost-and-revenue-sharing-models-for-hybrid-offshore-wind-projects-between-norway-and-europe>

⁵² System frequency is defined in SOGL as “the electric frequency of the system that can be measured in all parts of the synchronous area under the assumption of a coherent value for the system in the timeframe of seconds, with only minor differences between different measurement locations”. Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation (SOGL), Art. 3.2(41).

⁵³ Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation (SOGL)

⁵⁴ In the Nordic system, the accepted minimum instantaneous frequency is 49.0 Hz.



to prevent and address system imbalances are regulated under the System Operation Guidelines (SOGL) established by Commission Regulation (EU) 2017/1485.⁵⁵

There are several parameters that challenge the stability of the grid, such as grid faults and production faults. The system must always be dimensioned and prepared for the worst-case scenario, for example, to safeguard against large-scale blackouts like the one experienced in the Iberian Peninsula in 2025. Although identified as critical risks, historically the risks to system stability have been mitigated almost by default. This is because traditional production resources have typically been both plannable and often involved synchronised generators. This combination ensured large amounts of physical inertia (synchronous rotating mass) and stability for the power system. The more *inertia*⁵⁶ a system has, the less it is affected by a major disturbance. A low level of inertia makes the system sensitive to disturbances, thereby entailing a high risk of cascading grid problems, such as partial or even total grid blackouts. For the power system to remain robust and stable, the level of physical inertia must be maintained at sufficient volumes and at strategically relevant locations within the power system. Location signals may here be an area of improvement.

The geographical context is likely important, as the “transfer of inertia” requires significant transfer capacities, which the grid is not necessarily dimensioned to accommodate.⁵⁷ With a higher share of, for example, offshore wind power, TSOs will also need to ensure access to sufficient *flexibility* resources (including storage) to balance the integrated power systems.

The overall change in the composition of production assets will inevitably require new strategies and mitigating measures to address the increased risks to the stability of the energy system, resulting from a lower level of inertia and a higher need for flexibility capacity. This must be planned – and implemented – well in advance of any large-scale build-out of intermittent power production.

Some central grid stability challenges for a power system with a higher share of intermittent renewable energy sources are identified below.

- Low inertia caused by incrementally lowered proportions of synchronous generators

The physical inertia in the power grid reacts instantly to any grid disturbance while other types of frequency reserve contributions, mainly Frequency Containment Reserves (FCR), take some seconds to be activated; during this period, it is the physical inertia that determines how fast the

⁵⁵ Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation (SOGL).

⁵⁶ System inertia is the electricity system ability to maintain a steady frequency. Inertia helps reducing the impact of imbalances in supply and demand following unexpected disturbances. Therefore, inertia helps maintaining reliability in the grid. It gives the system operator a chance to respond to power plant failures (contingencies), because inertia resists changes in frequency, and gives other parts of the system the time to respond and rebalance supply and demand, even within a very short timeframe. Per today, most part of inertia in power systems is ensured by large rotating generators and some industrial motors, which give them the tendency to remain rotating. These are rotating masses in synchronous generators. With higher shares of variable renewable energy sources in the system (non-synchronous generation), such as wind and solar, the system inertia is reduced. Source: Denholm, Paul, Trieu Mai, Rick Wallace Kenyon, Ben Kroposki, and Mark O’Malley. 2020. Inertia and the Power Grid: A Guide Without the Spin. Golden, CO: National Renewable Energy Laboratory. NREL/TP-6120-73856, <https://www.nrel.gov/docs/fy20osti/73856.pdf>

⁵⁷ Innovative solutions, such as grid forming converters, can be used to support the grid with “synthetic inertia” (non-synchronous) generated through power electronics, but to date, the scale of this type of synthetic inertia remains limited.



frequency will drop. Some market mechanisms exist that create incentives to support the system with inertia, or so-called Fast Frequency Reserves.⁵⁸ Given the increase in intermittent renewable power production and prospects of further reduced inertia, mitigating actions could be reinforced. Establishing large-scale inertia contributions requires significant investments and early planning. With an increased intermittent electricity production, grids must also be reinforced.

- Voltage variations in the grid due to intermittent production

When new power production assets are connected to the grid, the grid codes require that the power produced stays within certain specific power quality margins. However, the grid codes do not address the inherent consequences on the power system when the production varies significantly within short periods. Large variations in power generation cause equally large variations in power flows in the grid, leading to substantial voltage variations that need to be compensated for by the grid operators. Increased amounts of power and voltage variations in the power system require physical compensation equipment (shunt reactors, FACTS, phase shifters, etc.) as well as substantial amounts of grid reinforcements to enable the power grid to handle the increased dynamic power flows. These types of expensive and complex facilities and grid reinforcements are usually integrated into the existing TSOs' grid costs and not easily differentiated from the overall TSO operational budget.

- Congestion caused by intermittent production

Market capacities in the day-ahead market are set to avoid congestion and ensure operational security. In cases where generation deviates significantly from the forecast, this may lead to overloads that need to be alleviated close to real-time. The addition of a large volume of new generation capacity may result in grid bottlenecks that the grid operator will need to manage. The manner to address these additional costs and allocate them among actors could be subject to further guidance.

Some ideas around regulatory improvements on these issues have already been put forward at the national level.

In Great Britain, the National Electricity System Operator (NESO) has established several so-called Network Options Assessment or Network Options Assessment (NOA) Pathfinders.⁵⁹ Through the Pathfinders, ESO wants to find innovative new ways to operate the electricity system of today and tomorrow while keeping costs down for consumers.⁶⁰

⁵⁸ In the Nordics, a Fast Frequency Reserve market is operating in relevant time-periods, where TSOs buy capacity that can offer a response time from 0.7 to 1.3s depending on the frequency deviation and a duration of 5s or 30s and several types of suppliers may participate, e.g. batteries, pump storage etc. The main question here is whether the market incentives are sufficiently forward looking in terms of foreseeing the potential issues of declining inertia and making the necessary counter measures in time.

⁵⁹ National Energy System Operator (NESO), webpage on balancing services, available at: <https://www.nationalgrideso.com/industry-information/balancing-services/pathfinders>

⁶⁰ The Pathfinder approach means ESO is widening participation in the NOA process, opening new ways for the industry to help meet system needs. By “learning by doing”, ESO is engaging solution providers in an ongoing conversation about how to improve tender processes for long-term contract opportunities. This will help to attract competitive and innovative service proposals, leading to possible contracts for the services most needed. A follow up on the Stability Pathfinder NG (National Grid) is a project called Stability Market Design. One section



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In Denmark, Energinet has looked at how to provide system balancing services in the future through their “*Outlook for Ancillary Services 2023-2040*”.⁶¹ In March 2024, Energinet published a discussion paper on “Full Cost Balancing” (FCB), in which it argues that it would be reasonable to implement market mechanisms that help distribute the cost of grid balancing and stability services so that market participants with high imbalances cover their fair share of the cost. This will strengthen the market participants' incentives to minimise their own imbalances.⁶²

A next step is to design a rigorous analysis of models that estimate the full cost of balancing, assessments of alternative balancing mechanisms, and the impacts of different market settlement periods. In parallel, innovation in technologies and grid services, such as dedicated grid-forming plants, should be supported.

Strengthen Electricity Grid and Infrastructure Standards

To implement a “resilient-by-design-standards” approach, infrastructure standards could be strengthened to address specific risks. This can be addressed at the level of the network codes.

Further Reinforce System Flexibility, Including at Local Level and so Reinforcing the Local Dimension of SoS

Since the Clean Energy Package, new provisions have been added to the EU electricity market legislation to provide regulatory support to demand-side flexibility and storage.⁶³ Other legislative acts, such as the Renewable Energy Directive and the Energy Efficiency Directive, in their latest version, include supportive regulatory measures in favour of energy storage, batteries, demand-side response and flexibility. The regulatory framework could nevertheless be further strengthened, for example, at the local grid level by further supporting demand and supply flexibility, such as cross-demand flexibility in buildings and industries, also in relation to smart charging of electric vehicles (EVs), and installation of PV. The revision of the EU Heating and Cooling Strategy, scheduled for 2026 as part of the Electrification Action Plan, will be the opportunity to envisage a better integration of e.g. flexible electrification of heat.

This shows a need to reinforce the regime for cross-sectoral solutions as a means to increase electricity SoS by reducing stress on the grid, reinforcing the local dimension of SoS, including at the level of the building and neighbourhood.

from the description of that project reads as follows: “The Stability pathfinders allow us to test procurement approaches for long term stability requirements, but the ESO still relies on the dispatch of synchronous generation in the Balancing Mechanism to ensure stability. Whilst our current arrangements ensure security, they are narrow in their facilitation of provider types.”

The development of a stability market could offer the ESO a route to access stability services through an open, transparent, and competitive market.”

⁶¹ Energinet, Outlook for Ancillary Services 2023-2040, available at: <https://en.energinet.dk/media/gieparrh/outlook-for-ancillary-services-2023-2040.pdf>

⁶² Energinet, Energinet position on full cost balancing. A polluter-pays zero-sum-game, to avoid an unfair distribution of costs socialised to electricity consumers, 1 March 2024, available at: <https://energinet.dk/media/shzlgxoe/energinet-position-on-full-cost-balancing.pdf>

⁶³ For example, on energy storage: Electricity Directive, art. 2(59) for a legal definition, ownership and operatorship (Art. 36). And on flexibility: Electricity Directive, art. 32.



Reinforcement of Interconnection Capacity between Member States and Neighbouring Countries

The reinforcement of interconnection capacity between Member States and the maximisation of cross-zonal capacities have long been identified as a major bottleneck for both further internal energy market integration and security of supply across the EU, as interconnectors ensure cross-border assistance in both regular and crisis times. The current interconnection policy objective is set at a minimum of 15 % by 2030.⁶⁴ Concerning cross-zonal capacities, the Electricity Regulation defines a minimum requirement of 70% minimum electricity transmission capacity to be made available for cross-border trade (the 70% rule).⁶⁵

One way forward could be to render the 15% interconnection objective legally binding. This has, however, a series of implications in terms of investment – with the underlying question of access to state aid and the manner the new State aid framework accompanying the Clean Industrial Deal (CISAF) applies to grid investments – and compensation between Member States – between those connected and those benefiting from the interconnection. This issue could be quite contentious, as demonstrated by the Iberian blackout and the discussion around the reinforcement of the interconnection capacity between Spain and France.

With regard to the 70% rule, ACER has pointed out shortcomings in its implementation, notably due to the frequent granting of derogations.⁶⁶ Measures to improve implementation and to maximise cross-zonal capacities should also be investigated.

Protected Customers and Supply Standards

In its consultation documents, the European Commission has identified as a possible area for improvement the reinforcement of the regime for protected customers, with minimum requirements, and an alignment across electricity and gas frameworks. A comprehensive regime around the identification of protected customers and the process to apply in case of emergency situations (with application criteria to be defined) will be important to ensure SoS and a level playing field among EU Member States. A core question in that respect will be whether EU action should be limited to defining criteria for the identification of these protected customers – letting Member States apply these criteria – or whether some common categories are defined directly in EU legislation.

Similarly, the Gas Security of Supply Regulation defines gas supply standards. A question is whether it can be mirrored directly in the electricity regulation, with, for example, an electricity supply standard.

2.2.2 Non-System-Related SoS Measures

Some non-system/non-operational related risks can also be addressed by measures associated with market design regulation:

⁶⁴ https://energy.ec.europa.eu/topics/infrastructure/electricity-interconnection-targets_en

⁶⁵ Electricity Directive, Art. 16(8).

⁶⁶ ACER, Transmission capacities for cross-zonal trade of electricity and congestion management in the EU, 2025 Monitoring Report, 5 September 2025.



- Ownership risks can be addressed through a reinforced certification procedure for both TSOs and DSOs. The Risk-Preparedness Regulation contains one provision related to ownership, which is quite limited since it is only an information requirement. Article 7(4) of the Regulation requires Member States, within four months of the identification of regional crisis scenarios, to identify and notify the European Commission and the Electricity Coordination Group of any risks related to the ownership of infrastructure relevant for SoS. If relevant, the Member States have to indicate if they have or plan to adopt measures to prevent or mitigate such risks. In the assessments submitted to the Commission in 2021 and 2025, it is clear that the focus has been on transmission and, to some extent, on distribution.⁶⁷ Transmission infrastructure being largely either state-owned or owned by entities with full or partial public ownership, this assessment appears too limited. In terms of transport infrastructure, both transmission and distribution should be systematically included, but also other assets such as generation and storage. The assessment of ownership risks related to energy assets should be strengthened, also ex ante, at the level of market design rules as part of, for example, the certification procedure for system operators and permitting procedure for other installations. This should also be coordinated with the existing mechanisms for foreign direct investments⁶⁸ or information about a change in ownership structure in such assets.
- Risks of misalignment between Member States may arise due to differentiated implementation strategies. The European Commission should monitor closely when Member States implement the new provisions into national legislation, where the risk is that some Member States could change legislation quickly than others, while others will be slow to implement.
- National measures limiting free movement and grounded in SoS concerns – Some Member States have considered and proposed the adoption of national measures restricting free movement of energy (gas, electricity) on the grounds of security of supply. The compatibility of such national measures with internal market rules will be subject to a careful assessment with reference to the European case law (see Section 2.2.1 above). A further elaboration of the grounds and safeguards for the adoption of national measures grounded in security of supply concerns might be useful.
- There are, and there should continue to be, strict and well-defined conditions under which a Member State may, as a last resort, adopt national measures restricting the free movement of energy on grounds of security of supply. Allowing broader or loosely justified interventions risks undermining the integrity of the internal energy market and jeopardising the very foundations of the Energy Union, which is built on solidarity, market integration, and cross-border cooperation. At the same time, this safeguard should not be misused by “free riders” seeking to benefit without taking corresponding responsibilities. Member States, particularly those within the same region and benefiting from strong interconnections, should be encouraged and incentivised to achieve a common level of security of supply, in order to avoid

⁶⁷ Report from the Commission to the Council and the European Parliament reviewing the application of Regulation (EU) 2019/941, COM(2025) 539 final, 29.9.2025, para. 2.2.

⁶⁸ Regulation (EU) 2019/452 of the European Parliament and of the Council of 19 March 2019 establishing a framework for the screening of foreign direct (EU FDI Screening Regulation). Some national security laws also require such screenings.

cascading effects and ensure a coordinated and resilient regional response to potential disruptions.

- Secrecy considerations and requirements for information exchange – National authorities have started to introduce new requirements related to the secrecy of information exchanged, both concerning physical assets and information exchanges related to operations. Some governments also consider the strengthening of requirements towards the identity of actors receiving operational and market-related information.
- Transparency and market monitoring obligations under REMIT – REMIT has been newly revised to strengthen requirements on market transparency. Full, correct, and timely implementation should be sought.

A fundamental question for SoS within market design regulation is which regulatory approach, at the EU-level, best supports generation adequacy, grid stability, and resilience in the transition towards a largely electrified and energy system based on renewable energy sources (RES). To answer this question, it is necessary to consider the energy transition pathways identified by the European Commission⁶⁹ and in European legislation, while also taking into account national dynamics as reflected in the National Energy and Climate Plans (NECPs). Along these trajectories, there are some intrinsic SoS concerns related to the further deployment of electrification. Some stakeholders question whether placing greater emphasis on SoS may risk slowing the pace of electrification.⁷⁰ One risk that may be taken into consideration is the electrification of new uses, such as the electrification of mobility and heating in the building and industrial sectors. The associated risks are to bring to the electric system new consumption patterns for which the present electric infrastructure (grids and dispatchable power generation capacities) was not designed.

2.3 Layer 2: Supplementary Market Mechanisms to Ensure SoS: Capacity and Flexibility Mechanisms

2.3.1 Handling Scarcity Beyond Energy-Only Market

CERRE has already provided a comprehensive analysis of the Electricity Market Design (EMD) reform, building on earlier recommendations. A central question is whether energy-only markets deliver sufficient incentives for new generation, or whether capacity/flexibility mechanisms are warranted – especially given concerns that observed prices and spreads have at times been too low to sustain investment.

In well-designed energy-only markets with effective scarcity pricing, investment signals can be efficient. Hirth and Ueckerdt argue that energy-only markets do not require highly elastic demand to

⁶⁹ European Commission, Transition pathways for European Industrial ecosystems: https://single-market-economy.ec.europa.eu/industry/transition-pathways_en

⁷⁰ ACER, Challenges of the future electricity system, 2024



function and some maximum “renewables threshold.”⁷¹ Scarcity pricing places price risk on market participants – efficiently on producers and consumers rather than society at large.

Rather than imposing EU-wide reliability standards, any move beyond energy-only designs should prioritise regionally coordinated capacity mechanisms and joint vulnerability assessments, with compatible auction timelines, cross-border capacity accreditation and interconnector de-rating, and fair cost-allocation rules – so scarcity signals are preserved, and free-riding and other cross-border distortions are limited.⁷²

One potential measure is the introduction of a calibrated scarcity uplift to real-time energy prices during tight hours within an energy-only design. Following Abada et al., a solution could be to keep dispatch unchanged but embed a long-term adequacy component by setting a reliability standard, identifying high-risk hours, and applying a uniform adder equal to the annual value of an incremental MW spread over those hours.⁷³ This would align short-run efficiency with long-run adequacy and – relative to capacity markets that remunerate a separate availability product – embeds adequacy directly in energy prices with potentially simpler governance.

2.3.2 EU Adequacy Framework and Current Regulation of Capacity and Flexibility Mechanisms: Shortcomings and Possible Improvements

This section briefly presents the EU adequacy framework, including the way in which supplementary mechanisms, such as capacity and flexibility mechanisms, are regulated under EU law and which shortcomings are identified. It then discusses possible improvements to reinforce security of supply.

EU Adequacy Framework

EU legislation defines a European framework for adequacy. The Electricity Regulation requires Member States to monitor resource adequacy within their territory on the basis of the European Resource Adequacy Assessment (ERAA) (defined in Art. 23), and they can also carry out national resource adequacy assessments (nRAA) to complement the ERAA (pursuant to Art. 24).⁷⁴ Since the completion of the first ERAA in 2021, ENTSO-E has progressively refined the methodology of the assessment. The main adequacy metrics⁷⁵ include the value of lost load (VOLL), the cost of new entry

⁷¹ Hirth, Lion, and Falko Ueckerdt. "Ten propositions on electricity market design: energy-only vs. capacity markets." *Sustainable Energy Policy and Strategies for Europe, 14th IAEE European Conference, October 28-31, 2014*. International Association for Energy Economics, 2014.

⁷² According to Kapeller et al., comparability and standardisation remain weak; clearer guidance, greater transparency, and more uniform application are needed to ensure fairness and efficiency – so these standards are not yet reliable. Kapeller et al. (2026), A review of determining reliability standards for electricity supply via value of lost load and cost of new entry in the EU, Energy Policy 208 (2026) 114875.

⁷³ Abada, Ibrahim, Andreas Ehrenmann, and Yves Smeers. "Marginal pricing and the energy crisis: Where should we go?." *Energy Economics* (2025): 108716.

⁷⁴ Electricity Regulation, Art. 20(1).

⁷⁵ In 2024, ACER commissioned a study on the implementation of the methodology for the calculation of these metrics.



(CONE), and the reliability standard⁷⁶. In 2024, ACER approved, for the first time, an ERAA (ERAA 2023), based on the fact that it has reached a sufficient level of robustness that allows decision-makers to rely on it. In its assessment of the implementation of the EU adequacy framework, ACER notes some improvement potential as to the elaboration of ERAA and implementation by Member States through their nRAA on notably the following aspects:⁷⁷ better distinction of the use of terms (like scenario and sensitivity) in nRAA, the different speeds of the energy transition.

Capacity Mechanisms

When a resource adequacy concern is identified by either the ERAA or the nRAA, the concerned Member States must identify the source of regulatory distortion or market failure, and must develop and publish an implementation plan to solve the identified shortcomings.⁷⁸ The adoption of capacity mechanisms is one of the solutions at the disposal of Member States.⁷⁹

Where price caps or other constraints mute scarcity signals, capacity obligations can help to restore investment incentives.⁸⁰ Capacity mechanisms may also curb market power in energy markets, though potentially at the cost of non-competitive capacity prices and greater energy-price volatility.⁸¹

Non-Fossil Flexibility Mechanisms

With the further deployment of renewable energy sources, the need to ensure flexibility⁸² in the energy system has increased. Building on the Clean Energy Package, the Electricity Regulation (EU) 2019/943 introduced new provisions on flexibility which were later reinforced and extended to new requirements on non-fossil flexibility support schemes (nFFSS),⁸³ added after the EU Electricity Market Reform and REPowerEU by Regulation (EU) 2024/1747 of 13 June 2024, amending the Electricity Regulation. The objective pursued is to further promote non-fossil flexibility,⁸⁴ while the original tendency of CRM was to support fossil fuels. It also aims at addressing a market failure in addressing investment gaps and achieving flexibility objectives. However, nFFSS are, as for capacity mechanisms, only one way to enable the potential of non-fossil flexibility (in addition to more classic instruments, such as support schemes). The same resources of flexibility can also compete on capacity mechanisms.

As for capacity mechanisms, the introduction of nFFSS must be based on shortcomings identified in a national Flexibility needs assessment (nFNA). ACER will have to review the nFNAs and provide cross-

⁷⁶ Pursuant to Art. 25 of the Electricity Directive, a reliability standard shall indicate the necessary level of security of supply of the Member States that implements it, in a transparent manner. When a Member States decides to implement a capacity mechanism, it must have a reliability standard in place.

⁷⁷ ACER, Security of EU electricity supply, 2024 Monitoring Report, 16 December 2024. Pp.17-18.

⁷⁸ Electricity Regulation, Art. 20(2) and 20(3).

⁷⁹ Electricity Regulation, Art. 21(1).

⁸⁰ Joskow, P.L. and J. Tirole (2007). "Reliability and Competitive Electricity Markets." *Rand Journal of Economics*, 38(1), 68-84.

⁸¹ Schwenen, 2007.

⁸² Flexibility is defined in Art. 2(79) of the Electricity Regulation as "the ability of an electricity system to adjust to the variability of generation and consumption patterns and to grid availability, across relevant market timeframes".

⁸³ Electricity Regulation, Article 19e to 19h, as amended.

⁸⁴ There is no legal definition of non-fossil flexibility, but reference is often made in the Electricity Regulation in that connection to "flexibility through demand response, energy storage and other non-fossil flexibility solutions" (Art. 1(b) Electricity Regulation).



border recommendations on the national reports. For this, ACER is setting up an EU-wide flexibility assessment platform. ACER should estimate the flexibility needs in the electricity system at the Union level and its projected economically available potential. To further strengthen coherence across Member States, the European Commission tasked it with developing a Union strategy on flexibility, based on the national flexibility needs reports and indicative national objectives.

Based on the above review of the EU framework for capacity and flexibility mechanisms, some conclusions can be drawn, together with proposals for improvement.

Cross-Border Distortion and Free-Rider Risk

In today's highly interconnected EU system, asymmetric adoption or design of capacity mechanisms creates a free-rider problem. If some Member States pay for firm capacity while neighbours rely on (or retain) energy-only markets, the latter can implicitly benefit from imports backed by capacity payments made elsewhere, while their own consumers do not contribute to those adequacy costs. Uncoordinated national schemes can therefore (i) distort investment location, (ii) depress cross-border efficiency, and (iii) in extreme cases undermine security of supply in neighbouring systems. This situation also reinforces the need to look at the possibility of establishing regional capacity mechanisms. A possible higher degree of regional integration of capacity and flexibility mechanisms could be envisaged.

Cross-Sectoral Approach

How are domestic sources of supply currently mobilised, and could they be better mobilised? This touches upon the role of sectors that provide domestic sources (e.g., biogas) and on how their mobilisation may affect other supply chains (e.g. food supply chain).⁸⁵

Another area of improvement is the coordination between the metrics of the ERAA and the nFNA, as the same flexibility resources may compete under both capacity and flexibility mechanisms.

Another avenue would be to extend the energy storage obligation to electricity, as it seems to be envisaged by the European Commission. But the exact modalities of such extension must be defined in detail, and interaction with other legislation (e.g. Energy Performance of Buildings Directive) should be carefully considered.

2.4 Layer 3: Risk-Preparedness and Emergency Framework

This section looks at the EU risk-preparedness and emergency framework, which lies at the top of the SoS regulatory pyramid and aims to ensure security of supply in case of major disruption. It begins by recalling basic methodological elements in emergency management (2.4.1) before reviewing how this has been shaped in the EU energy context (2.4.2). Regarding the ongoing EU legislative revision process, this Issue Paper identifies some areas for improvement (2.4.3), building on the following key questions:

⁸⁵ Biogas as a source of security of supply cannot be activated on a short-term basis, compared to flexible heating electrification which can. The limitations reside mostly at the level of the plant, more than the feedstock.



- How to improve the emergency management framework and better coordinate actions across Member States and actors (such as NRAs, generators, TSOs/DSOs, flexibility providers, consumers) to optimise resilience and preserve the internal market?
- Does this require a new institutional arrangements framework around risk-preparedness and emergency response, and its streamlining across energy carriers and competence areas (e.g. defence)?
- How can the regime for solidarity mechanisms evolve to reflect solidarity and fair compensation?

It should be noted that many countries are in the process of revising their national legislation on energy security following an increased level of threats on energy infrastructures (drones over energy installations, digital attacks against hydropower plants softwares, physical attacks on cables). In the EU, some of these revision initiatives are driven by the implementation of new EU legislation, such as the Directive (EU) 2022/2557 of the European Parliament and of the Council of 14 December 2022 on the resilience of critical entities (Critical Entities Directive).⁸⁶ This also raises the question of the coordination between Member States in terms of regulatory approach. Under currently applicable legislation, the Electricity Coordination Group is the most relevant organ for Member States and stakeholders to exchange information and share good practices that can inform also the work of the European Commission.

2.4.1 Starting Point: Conceptual Framework to Emergency Management

The conceptual framework for emergency management differs among sectors, but it is common to distinguish four phases in emergency management: mitigation, preparedness, response, and recovery. Sometimes, prevention is added as a first phase to this cycle.

Key components of this framework include conducting risk assessments, developing plans, establishing multi-agency/actors' coordination, ensuring communication, and building resilient energy systems to handle disruptions from various stresses.

Although the title of Regulation (EU) 2019/941 indicates a focus on risk-preparedness only, the content of the act includes elements of all four phases. However, prevention (the 5th and preliminary phase) would be part of the market design legislation (Layer 1).

The emergency management framework in the electricity sector also comprises two other acts referred to earlier⁸⁷, which are the System Operation Guideline (SOGL) and the Network Code on Emergency and Restoration (ER NC).

⁸⁶ For example, the French Parliament is currently discussing the adoption of a new law on the resilience of critical infrastructures and the strengthening of cybersecurity (Projet de loi relatif à la résilience des infrastructures critiques et au renforcement de la cybersécurité, Texte n° 33 (2024-2025)).

⁸⁷ Section 1.2.1.



Illustration 4: The "Four Phases" of Emergency Management.

Source: Community Emergency Response Guide, Fairfax County, Virginia, 2019.

Although the combined approach along the three layers of the SoS regulatory pyramid seems to cover more situations, there is nevertheless a need to have a bigger reflection around the energy security architecture, including security of supply, due to the range of the new stresses faced by the European energy system, and the fact that the currently applicable legislation has not been elaborated with this complexity of factors in mind.

2.4.2 EU Risk-Preparedness and Emergency Framework

The EU's risk-preparedness framework for energy security, established by Regulation (EU) 2019/941, operates as an integrated three-tier system that progresses from analysis to action. Risk assessment forms the foundation by proactively identifying and evaluating potential threats (natural disasters, technical failures, geopolitical risks, cyber threats) through mandatory national and regional assessments updated every four years. These assessments directly inform formalised emergency plans, which consist of preventive action plans that mitigate identified risks before they materialise, and emergency response plans that define operational procedures across three crisis levels (early warning, alert, and emergency), all following standardised EU templates with both national measures and mandatory regional coordination chapters.

When these plans prove insufficient during extreme crises, solidarity mechanisms activate as a last-resort safety net, legally obligating Member States to provide cross-border assistance to ensure protected customers (households, hospitals) maintain energy access, with "fair compensation" arrangements.

This cascading framework – from identifying what could go wrong, to defining how to respond, to ensuring mutual support when national measures fail – embodies the broader solidarity principle that underpins the European Union's energy policy as defined in Article 194 TFEU. Solidarity plays an even greater role where interconnected energy flows across Member States form the foundation of a well-functioning and equitable European energy system. During supply disruptions, the solidarity principle implies that regionally connected Member States should maintain energy flows and provide mutual support, rather than restricting cross-border exchanges. This ensures that no Member State faces an energy crisis alone.



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The ER NC aims at ensuring the security of the electricity system as well as preventing incidents from spreading or worsening. It aims to avoid widespread disturbance and the blackout state, as well to allow for the efficient and rapid restoration of the electricity system from the emergency or blackout states.

For comparison, SOGL sets minimum system security, operational planning and frequency management standards to ensure safe and coordinated system operation across Europe.

This framework, strengthened following the 2022 energy crisis, balances EU-wide coordination and the fundamental principle of European energy solidarity with Member State sovereignty in determining their energy mix and resource exploitation. The risk-preparedness framework is intended to strengthen security of supply through infrastructure integration and complementarity of national energy mixes, thereby fostering regional solidarity. However, this framework requires further refinement to remain effective in a rapidly evolving energy landscape. There are several possible avenues for improvement, which are detailed below.

It has some points of similarity with the security of gas supply Regulation, but the two regulations do not follow the exact same structure and logic.

2.4.3 Areas for Improvement

1. Legacy of the Measures Adopted and Reinforced in Relation to the Energy Crisis in the Winter 2022/2023

Most of the emergency measures have now expired, except the gas storage obligations. A few have been inserted into secondary legislation.

It is worth remembering that the emergency measures taken during the energy crisis – facilitating joint gas purchasing, intervening to address high electricity prices, and introducing a market-correction toolbox – inevitably had major impacts on economic operators, prompting several legal challenges. At their core, these disputes often allege a lack of EU competence under Article 122 TFEU or breach of equal treatment or proportionality. Illustratively, Case C-675/22, *Poland v Council*, seeks annulment of the gas demand-reduction Regulation (EU) 2022/1369, arguing that Article 122(1) TFEU is an incorrect legal basis and, in the alternative, targeting specific provisions (notably Article 5). In case T-802/22, *ExxonMobil Producing Netherlands & Mobil Erdgas-Erdöl v Council*, ExxonMobil attacks the parts of Regulation (EU) 2022/1854 that set a temporary solidarity contribution for fossil-fuel sector companies (Arts. 14–16), invoking pleas such as wrong legal basis, unequal treatment, and interference with property and business freedom. In Case T-759/22, *Electrawinds Shabla South EAD v Council*, the utility challenges the same mandatory cap on inframarginal generators' market revenues and the collection of "surplus revenues" set by the Regulation, again contesting Article 122 TFEU, proportionality, and property-rights impacts.

It is therefore difficult to see the value of reconducting measures adopted during the 2021-2023 crisis other than the speeding-up of permitting procedures and storage obligation. The latter two provisions can, however, be extended to cover further infrastructure and assets (for example, grids and storage) and more regulatory support to batteries.



Finally, something missing during the adoption of the emergency measures was an impact assessment. One lesson for the future could be that it is foreseen in the upcoming revised framework that the Member States and ENTSO-E should consider price shocks and market distortions among the list of potential risks.

2. Further Development of Adequacy Assessments, Risk-Assessment Methodologies and Crisis Scenarios

Climate change and cyber-attacks are threats of different natures, yet both create cascading effects due to the interconnected nature of modern energy systems. Electricity grids and gas pipelines are strongly interconnected across the EU and well beyond. An outage in one country could trigger blackouts or shortages of supply in others. Moreover, the adoption of green technologies such as smart grids and IoT devices enhances environmental sustainability by minimising emissions and promoting efficient energy use. However, their reliance on digital infrastructure introduces significant cyber-security vulnerabilities, posing risks to critical systems. This interconnectedness means that both physical climate events and digital cyberattacks can propagate across networks, amplifying their impact beyond their initial point of origin.

As mentioned in the European Commission call for evidence, more energy system integration may lead to an increased risk of cascading cross-sectoral failures, in particular between the gas and electricity sectors. In 2023, natural gas notably accounted for around 15 % of EU electricity generation, while in the future, substantial volumes of electricity will be required for the production of hydrogen through electrolysis.

One option envisaged by the Commission is to extend certain requirements applicable to the gas sector to the electricity sector. To better measure the risks of cascading effects, it has been proposed to adopt the N-1 criteria also in the electricity sector.

Due to the evolving energy system with more intermittent decentralised sources and sources of flexibility, it should be further clarified to what extent distribution and local consumption are encompassed by emergency plans. In the future, security of supply will cover both a regional, national, and a local dimension. The scope of the Risk-Preparedness Regulation is not narrowed to the transmission network, but some explicit inclusion of distribution into the guidelines for resilience would clarify responsibilities. For the deployment of effective mitigation measures, DSOs should be included as a standard in the development plans, an option that currently appears to be out of scope.

3. Alignment of Crisis Management Provisions across Electricity and Gas

Alignment of the definition of crisis levels between gas and electricity frameworks could be envisaged in order to streamline practices. Under current legislation, there is a lack of alignment of the definition of crisis levels: The Security of Gas Supply Regulation defines three levels: “early warning”, “alert”, and “emergency”. The Risk-Preparedness Regulation defines two levels: “warning” and “crisis”.

The definition of “crisis” situation and the criteria that will trigger the activation of the associated regime should be aligned (e.g. EU-wide/regional electricity crisis definition in Electricity Directive (art. 66a)).



4. Functioning of Solidarity Mechanisms

There is a need to strengthen and coordinate crisis management tools, including the implementation of the solidarity mechanisms between EU Member States, in order to ensure mutual assistance and “fair compensation” during crises.

Address the moral hazard issue: As in any insurance-based system, solidarity mechanisms can unintentionally reduce incentives for risk prevention. If Member States know that others are legally obliged to share energy in times of shortage, they may underinvest in their own resilience measures – such as storage capacity, backup generation, or supplier diversification. The percentage and conditions of assistance are therefore crucial to avoid free riding. This concern is magnified by the EU's rapid deployment of wind and solar power. Because these intermittent sources increase the probability of supply disruptions, they also raise the likelihood of solidarity mechanisms being triggered, which could further encourage states to rely on their neighbours rather than strengthening domestic systems.

Challenges Associated with the "Solidarity" Principle

The "solidarity" principle has been discussed since at least 2006 (EC, 2006), but implementation has been difficult because Member States face markedly different energy conditions-import dependence, supplier diversification, fuel mix, and infrastructure, among others. These asymmetries weaken any "one-size-fits-all" approach and mean some countries can systematically benefit more from solidarity than others.

The energy solidarity principle has been recognised as a justiciable principle of EU law by the Court of Justice of the EU.⁸⁸

Solidarity can distort incentives.⁸⁹ When Member States do not internalise the full cost of their own risky energy choices, they may under-invest in resilience (e.g., remain highly import-dependent, delay infrastructure upgrades, or keep undiversified portfolios). This behaviour increases not only national risk but also the Union's aggregate exposure.

Heterogeneous shocks. Extreme events – e.g., severe weather, supply disruptions, storage shortfalls, fuel-switch limits, or pipeline bottlenecks – do not hit all countries equally. Uneven impacts reduce willingness to coordinate ex ante and complicate ex post burden-sharing.

Policy Options to Improve Coordination and Mitigate Moral Hazard include:

1. Targeted fiscal incentives. Introduce a rules-based transfer scheme that rewards participation and compliance (e.g., conditional support tied to pre-agreed resilience benchmarks).
2. Package deals across policy domains. Embed demand-side curtailment and other energy measures within broader political packages so asymmetric losses in energy are offset by gains elsewhere (Le Coq & Paltseva, 2008).

⁸⁸ OPAL judgement; Banet (2024)

⁸⁹ Le Coq & Paltseva, 2008



3. Mutual support with differentiated obligations. Design the solidarity mechanism with country-specific participation requirements and narrow, transparent exemptions. This can raise participation while recognising structural differences-though it may modestly dilute the strength of solidarity effects compared with a regime without exemptions.
4. Bilateral fallback agreements. Allow (and template) bilateral arrangements between Member States to complement the Union framework and speed implementation where regional interdependence is strongest.

A more centralised approach to solidarity mechanisms could also be envisaged.

5. Governance and Responsibility Allocation

The allocation of responsibilities among the various responsible actors for SoS (grid operators, producers, storage providers, consumers, etc.) must be improved and made more explicit and operative. This governance improvement could involve that:

- Key actors include the European Commission, Member States, associations of TSOs (ENTSO-E and ENTSO-G primarily), as well as associated countries (Energy Community, Moldova, and Ukraine). The involvement of EEA countries and the UK, through their respective agreements with the EU, also needs to be assessed.
- The role of the Electricity and Gas Coordination Groups could be reinforced, as well as the RCCs, with an enhanced role of the risk group with RCCs and all interested stakeholders.
- The role of the load in the event of an emergency must be clarified.
- The decentralised, local dimension of SoS should be strengthened, from both an institutional and operational point of view.

Finally, the question of the competences of the EU institutions, in particular the Council, to adopt temporary legislation in times of crisis relating to energy supply disruptions under Art. 122 TFEU should form part of the assessment of the toolbox.

6. Balance between EU Coordination and National Sovereignty

The framework must maintain a delicate equilibrium where Member States cooperate and coordinate their risk assessments and crisis responses, particularly for cross-border impacts, while retaining substantial autonomy in determining their specific measures, energy sources, and implementation approaches based on their national circumstances and priorities. This balance is increasingly tested as energy systems become more interconnected and interdependent.

7. Long-term pathway and dynamic regulation

In pursuing the energy transition toward net-zero, the risk-preparedness framework will need to continuously be adapted to new market structures and risks, particularly accounting for the growth of renewables, the phase-out of fossil fuels, and emerging technologies like large-scale energy storage and demand response. The European Commission has also called for a more dynamic approach to the energy security framework. How this can be translated into concrete measures is still



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to be defined, but it should reflect that the three layers of the SoS Regulatory Pyramid are composed of different types of legislative acts (Directive, Regulation, network codes, guidelines).

3. Articulation and Complementarity between the Three Layers of the SoS Legislation

As represented in the SoS Regulation Pyramid in Section 2.1, security of supply should be framed as an integrated architecture made up of the three connected layers: Layer 1 represents the structural components of SoS in the electricity market only design rules; Layer 2 is composed by supplementary market mechanisms aimed to address remaining adequacy issues, and consist primarily of capacity and flexibility markets; Layer 3 is composed of risk-preparedness and emergency measures aimed to maintain security of supply in case of disruption. Together, these three layers constitute the Security of Supply Regulatory Pyramid.

What triggers the move from one layer to the other should be clearly defined.

In this respect, the regulatory approach has evolved over time. Notably, concerning the move from Layer 1 to Layer 2, capacity mechanisms were for a long time perceived as exterior elements of market design. Following the latest revision of the Electricity Directive and Regulation, capacity mechanisms have been inserted as part of market design, with the implicit affirmation that they should be a permanent part of it. Then, the move to Layer 3 and crisis situation responses should be based on clear criteria, such as an alert system and triggers.

As part of the clarification on the alert system and triggers, the current methodology for the Ten-Year Network Development Plans (TYNDP) and the European Resource Adequacy Assessment (ERAA) could be improved, as they do not yet adequately account for unexpected shocks within a 5-year window. They do not sufficiently consider extreme weather (heatwaves, cold spells), stress testing, and geopolitical risks. Both TYNDPs and ERAA could explicitly include such events as extreme weather and geopolitical shocks within their modelling scope.

All layers are supported by additional legislation in the form of network codes and guidelines. Any change to the secondary legislation (Directive and Regulation) should take into account that some additional rules in network codes and guidelines may also need to be revised.

In any case, a comprehensive approach embracing all these three SoS layers appears essential to avoid, prepare for and manage electricity-crisis situations. The overall regime for SoS needs to ensure consistency between market-design legislation and supplementary SoS and adequacy mechanisms. It is also relevant to link SoS requirements to the role of capacity (and flexibility) mechanisms, infrastructure planning, cross-border investments, and cost-benefit sharing.



4. Interactions among the Security of Supply Frameworks for Different Energy Carriers

This section discusses the interaction between the Security of Supply frameworks for electricity and gas, respectively. The interaction with other components of the energy security legal framework, such as oil emergency stocks,⁹⁰ gas security of supply and storage,⁹¹ offshore safety,⁹² critical infrastructure protection,⁹³ cybersecurity⁹⁴ and resilience of critical raw materials' supply chains,⁹⁵ is not covered here since it will be addressed in separate papers under the Resilience Forum.

As explained in Section 1.2.1 above, the European SoS legislative framework has developed in parallel for electricity and gas, without being connected to each other. The market regulation follows the same fundamental principles (liberalisation, unbundling, PSO, third party access regime, etc.) and some institutional arrangements (ACER, ENTSO-E/ENTSO-G/ENNOH), but are nevertheless held separate. The risk-preparedness and emergency management framework has also been developed separately, with two distinctive pieces of legislation, but with the similarity of having established the same kind of Coordination Group with similar competencies. The main reason for the existence of two parallel SoS frameworks is the physical particularities and dynamics of electricity and gas, which make it difficult to establish a common framework. For example, many operations within the gas system can be done manually if there is a need, and to a much larger extent than electricity. In certain circumstances, requiring coordination between electricity and gas operations during emergency situation management, it may even delay the response time.

The main objective of the reform on that point should be to identify synergies and points of alignment.

Four main alternatives for a deeper alignment between the electricity and gas SoS frameworks can be identified:

- Option 1: The electricity and gas risk-preparedness frameworks remain separated, and there is an indirect alignment between the two by mirroring the same principles and institutions in each text.
- Option 2: The electricity and gas risk-preparedness frameworks remain separated, but there is an alignment of common principles for action, steering planning requirements and some operational requirements, in a separate legislative act;
- Option 3: The electricity and gas risk-preparedness frameworks remain separated, and institutional and coordinated matters are addressed through an amendment to the Governance of the Energy Union and Climate Action Regulation;

⁹⁰ Council Directive 2009/119/EC

⁹¹ Regulation (EU) 2017/1938

⁹² Directive (EU) 2013/30

⁹³ Directive (EU) 2022/557

⁹⁴ Directive (EU) 2022/2555 and Commission Delegated Regulation (EU) 2024/1366

⁹⁵ Regulation (EU) 2024/1252



- Option 4: The electricity and gas risk-preparedness frameworks are merged into a single joint piece of EU legislation, with a higher degree of harmonisation of processes, while keeping in mind the differences in operation between electricity (electrons) and gases (molecules).

Options 1 to 3 seem the most feasible ones, based on the considerations mentioned above.

If further alignment across frameworks is pursued, the following key points should be included:

- Methodology for the elaboration and application of the crisis scenarios

The same crisis scenarios and integrated risk analyses should be applied to both the electricity and gas sectors. This can enhance the efficiency and effectiveness of EU energy supply policy. A more integrated approach is desirable to better capture the interdependencies between electricity, gas, and emerging hydrogen markets.

Developing a common preparedness and emergency framework across electricity and gas would require streamlining definitions, such as alert levels. A joint alert system could also be developed.

- Cascading effects across electricity and gas operations.

The risks of cascading effects, such as power failures affecting gas supply, and vice versa, must be explicitly identified as a possible scenario and mechanisms to address them should be developed. In addition, the cascading effects of climate-related risks identified in the European Climate Risk Assessment should be better integrated on both sides.

Having institutional entities on both sides with similar competences, such as the Coordination Groups, could facilitate the dialogue on the manner to identify and respond to cascading effects.

Joint stress test exercises across electricity and gas supply chains, but also commodity supply as such, should be pursued.

- Greater focus is needed on integrated energy system security and identifying least-cost solutions.

This can be addressed within ENTSOs' assessments, which should be further aligned on this point.

- Joint meetings of the Gas and Electricity Coordination Groups

Two separate Coordination Groups have been established, although their mandates and compositions are very similar. There is no need to merge the two groups, but a joint meeting between the two groups could be particularly valuable when discussing sector integration issues.

- Harmonisation across commodities

The risk-preparedness framework currently differentiates between gas and electricity, with discussions emerging around hydrogen. The discussion around the role of nuclear within SoS is held apart. A key question is how much divergence between commodities can or should be tolerated, particularly as sector coupling increases and energy carriers become more interchangeable in end-use applications.



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- Aligning the regime for protected consumers in times of crisis

To avoid distortions in the internal energy market, an alignment of the regulatory approach on the definition of protected consumers during crisis events would be useful. It would also clarify the priority order among consumers when applying the emergency frameworks.

- Aligning approaches to storage

While gas storage has been identified early on as an important risk-preparedness measure, electricity storage has been considered to a lesser extent. With the advancement of batteries and the need for a reinforcement of civil contribution to security of supply, some alignment in the approach related to energy storage requirements could be envisaged.

- Aligning the functioning principles of solidarity mechanisms

Both frameworks define solidarity mechanisms. An alignment of their functioning would facilitate their usage.



5. Policy Recommendations

Energy security encompasses security for supply, but they are two distinctive, non-interchangeable concepts. The main objective of SoS action is to ensure that there is a sufficient and adequate supply of resources available in the power system to meet demand.

This paper has assessed the structure and content of the currently applicable EU Security-of-Supply framework. It has investigated how the EU should reform it to meet emerging challenges while maintaining market integration and accelerating decarbonisation, both in regular and crisis times. Four main recommendations are set out below.

5.1 Layered but Integrated SoS Architecture

The security of supply challenge should be framed as an integrated architecture made up of the three connected layers identified in the report: Layer 1 represent the structural components of SoS in the electricity market only design rules; Layer 2 is composed by supplementary market mechanisms aimed to address remaining adequacy issues (capacity and flexibility markets primarily); Layer 3 is composed of risk-preparedness and emergency measures aimed to maintain security of supply in case of disruption. These three layers constitute the security of supply regulatory pyramid.

Security of electricity supply relies on measures in all three layers of the SoS regulatory pyramid, including at the base of electricity market design (EMD). Several revisions of the EMD framework have been adopted in the past few years, including as a result of the Clean Energy Package, the European Green Deal, the Fit for 55 Package and the REPowerEU Plan. The focus is on the implementation of these recent revisions, and there is no clear case for reforming the Electricity Market Design.

However, some tools should be part of market design itself. As always, prices must send clear signals for operation and investment. Several actions follow. First, accelerating the EU permitting regime to ensure adequacy is a priority. Second, protecting system stability requires robust rules for power quality, balancing, inertia, and frequency. Third, flexibility must increase across the system, especially at the local level. Europe also needs more cross-border interconnection capacity to share resources, alongside common grid infrastructure standards. Finally, non-system risks – such as ownership structures and certification procedures for TSOs (and potentially DSOs) – should be taken into account.

The forthcoming legislative and policy initiatives identified in the European Commission's 2026 Work Programme should enable a few targeted legislative adjustments as part of: the Grid Package, a White Paper on deeper electricity market integration, the Electrification Action Plan, the revision of the governance of the Energy Union and Climate Action, in addition to the revision of the energy security framework in itself.

The risk of Member States' misalignment should not be underestimated. SoS concerns should not be misused to justify divergent implementation timelines and trade-restrictive national measures across Member States. The EU should set a clearer level of harmonisation on roles, responsibilities, and triggers across the three layers. Better coordination will also cut cross-border negative spillovers.



Recommendation 1: Adopt targeted legislative amendments and market-based SoS tools – prioritising power quality and inertia, local flexibility, stronger network operation, interconnections, and “fit-for-purpose” governance – to raise resilience without undertaking a disruptive, full EMD reform.

5.2 Upgraded Adequacy Regulation with Non-Distortive Supplementary Mechanisms

Scarcity may not always be handled by the energy-only market in extreme situations, but any supplementary mechanism must be carefully designed to support, not replace, market signals. The EU adequacy framework and the rules for capacity and flexibility mechanisms should be adjusted with this non-distortion principle in mind.

For capacity mechanisms, the European Commission’s work should continue, with two priorities: (i) stronger regional integration and cross-border participation, and (ii) consistent adequacy assessment. Alignment on timelines, performance obligations, de-rating, and cross-border access lowers costs and reduces the chance of national measures that shift costs to neighbours.

For flexibility mechanisms, progress is ongoing but uneven. Non-fossil flexibility support schemes (nFFSS) can help scale demand response, storage, and digital solutions, but only if they are technology-neutral, competitive, performance-based, and temporary. They must not suppress price signals. In addition, National Flexibility Needs Assessments (nFNA) should follow a common method, feed into the upcoming EU-wide flexibility assessment platform, and enable cross-border procurement when it is efficient. An EU flexibility strategy (foreseen in the Electricity Regulation) should set minimum design rules for nFFSS and flexibility in general, while preventing measures that fragment the internal market.

Coordination between adequacy and flexibility is essential to avoid conflicting incentives. The criteria used to perform the European Resource Adequacy Assessment (ERAA) and for the EU-wide flexibility assessment platform could be better aligned. ACER should run a regular EU-level assessment of flexibility needs aligned with the adequacy framework, using shared data and scenarios and distinguishing system-wide from local (distribution-level) needs.

Recommendation 2: Use supplementary mechanisms only when they are non-distortive, transparent, proportionate, open to cross-border participation, technology-neutral, performance-based, and time-limited – to address scarcity beyond the EOM while avoiding distortions and free-riding. Further align the criteria used to complete the European Resource Adequacy Assessment (ERAA) and for the EU-wide flexibility assessment platform.

5.3 Consolidated, Coordinated and Efficient Preparedness Toolbox

The EU should strengthen risk-preparedness by retaining the effective lessons from the 2022/23 winter energy crisis. Keep what worked – coordinated demand cuts, help for vulnerable consumers, and fast cross-border data sharing – with clear legal bases, especially for temporary market interventions. In addition, a single EU scale for crisis levels and a standard playbook – covering decision rights, timelines, market-rule changes, cross-border capacity use, protection of critical infrastructures and society functions, and communication – would enable a faster reaction. Clear allocation of



responsibilities among actors in the energy system should be pursued. The preparedness framework should ensure both local and regional/European SoS at the same time.

Risk-preparedness needs to be deeper and better harmonised to ensure a short response time and collateral effects between Member States. Methods should capture cross-border risks, extreme weather, gas–power coupling, outages, and cyber threats. Common stress-testing scenarios, with robust statistical analysis, would make results comparable across Member States and allow the Commission, ACER, NRAs, ENTSO-E and EU DSO Entity to draw EU-wide conclusions on resilience gaps. In addition, risk-preparedness plans – both preventive action plans and emergency plans – should be updated on a fixed schedule, including mandatory mid-term reviews. Each plan could list triggers, actions, and funding, and align with national energy plans and grid plans. Beyond planning, new requirements should be considered in terms of sensitive information management, supply chains requirements, stress testing, equipment stocks requirements and regular training.

Crisis management roles and responsibilities should be clear. All governance levels must be clearly defined: at national level, governments adopt plans and sets public service obligations, NRAs monitor implementation and regulatory supervision, TSOs and DSOs execute technical measures, and a designated national crisis coordinator leads the inter-agency response and manages cooperation with neighbouring countries; at regional/EU level, RCCs provide real-time regional assessments and coordinate remedial actions, the Commission ensures coherence with single-market rules, and ACER monitors implementation and publishes independent evaluations. The Electricity Coordination Group should see its mandate reinforced. Clear escalation paths and defined decision rights reduce delays when minutes matter.

Solidarity measures should operate reliably and without delay. Trigger conditions should be objective and verifiable, compensation formulas pre-agreed, and operational protocols – metering, nomination, balancing, and settlement – tested in regular drills. To limit moral hazard, solidarity must come with responsibility. Access to solidarity support should be conditional on credible national preparedness – adequacy planning, demand-side measures, storage and interconnection commitments, and compliance with market rules. Ex-post reviews and transparent reporting should assess whether beneficiary states took reasonable preventive actions, with incentives and penalties aligned to maintain discipline.

Recommendation 3: Adopt an EU-wide, rules-based risk-preparedness framework with harmonised assessments, regularly updated plans, streamlined crisis playbooks, and incentive-compatible solidarity conditioned on credible national preparedness to curb moral hazard.

5.4 System Approach of the SoS Architecture

A system approach is necessary because electricity and gas depend on each other. Today, the rules for electricity and gases are written in separate “silos.” Harmonising core concepts – what “adequacy” means, how scarcity prices work, who can provide demand response – will enable an interconnected framework and send the right signals for all types of investment (networks, storage, and flexibility). All sources of security of supply should be mobilised, such as biogases, and in all sectors, including heating and cooling.



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However, adopting a common legislative framework on risk-preparedness across energy carriers should not lead to bureaucracy and inefficiencies. Four main options are identified: (1) the electricity and gas risk-preparedness frameworks remain separated, and there is an indirect alignment between the two by mirroring the same principles and institutions in each text; (2) the electricity and gas risk-preparedness frameworks remain separated, but there is an alignment of common principles for action, Steering planning requirements and some operational requirements, in a separate legislative act; (3) the electricity and gas risk-preparedness frameworks remain separated, and institutional and coordinated matters are addressed through an amendment to the Governance of the Energy Union and Climate Action Regulation; (4) the electricity and gas risk-preparedness frameworks are merged into a single joint piece of EU legislation, with a higher degree of harmonisation of processes, while keeping in mind the differences in operation between electricity (electrons) and gases (molecules).

The parallelism of the institutional framework is positive, with a parallel evolution of: the Electricity/Gas Coordination Group, the role of regional crisis centres, the role of RCCs; and an “EU-level crisis alert” system.

Law-making should move in parallel. When the EU updates electricity security-of-supply rules, it should update gas (and hydrogen/low-carbon gases, as well as heating and cooling) at the same time, with linked timelines and consultations. This avoids conflicting obligations – like different stress-test years or incompatible emergency triggers.

Finally, SoS must be balanced with other EU goals: decarbonisation, market integration, consumer protection, and affordability. In particular, one should choose the least-distortive way to reach the other goals, including cross-border impact checks, but also ensure that competition on performance is ensured. This keeps the internal market strong while improving resilience at lower cost.

Recommendation 4: Build one integrated SoS framework for electricity, gas, and low-carbon gases, with aligned rules, joint planning, and shared data – so the system is resilient, efficient, and market-consistent.



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