Hydrogen for an energy resilient Europe

Hydrogen Europe's paper

July 2024

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Executive Summary and Recommendations

Europe's energy system is vulnerable to both geopolitical shocks and increased technical challenges. While the EU has made strides in reducing its reliance on Russian gas, over two-thirds of the Union's energy needs are imported, leaving it exposed to external shocks.

Faced with new geopolitical circumstances, Europe must, where possible, implement a balanced approach that combines scaled-up domestic production of clean energy molecules with the strategic diversification of its energy imports. Without such an approach, the risk persists as one dependency may simply be exchanged for another, thereby shifting, rather than resolving, Europe's precarious energy situation.

The rising share of variable renewables is introducing new technical challenges: there was an eighteen-fold increase of negative price periods in 2024, and flexibility needs are set to double by 2030 according to ACER. The growing dominance of variable and inverter-based generation increases intermittency and the operability issues of the power system.

The blackout in the Iberian Peninsula on 28 May of 2025 exposed the weakness of an overreliance on a single energy carrier (electricity) without sufficient system diversification. This event, assumed to statistically happen once-every-10,000-years, shows that while Europe still needs to strengthen its power system, it can no longer afford to put all its eggs in one basket.

Diversification – not only of energy suppliers, but also of energy carriers and various energy grids – is the armour that keeps Europe's energy secure, affordable and on track to net-zero.

This paper highlights how clean domestic hydrogen can play a significant role in strengthening Europe's resilience: local production, strategic imports, more sustainable capacity markets and stronger system integration offer clear pathways to reduce vulnerabilities, increase resilience, and support renewable energy integration. All of this will be essential to guarantee the long-term security of the EU energy supply.

In this context, Hydrogen Europe proposes to address energy vulnerability and strengthen resilience with the following measures:

A. Enhanced tools for generation adequacy and flexibility:

a. Align capacity mechanisms with broader goals of sustainability, affordability, and competitiveness: the Security of Supply package should provide incentives and/or allow state aid to cover the green premium of non-fossil capacity mechanisms and include non-price criteria for cleaner, resilient capacity options.

b. Implement the Union Strategy on Flexibility as mandated by the Electricity Market Design to unlock the much-needed flexibility potential of the EU.

c. Plan strategic reserves for non-fossil adequacy**:** Allow Member States to set up non-fossil strategic reserves of molecules and fuels to strengthen security of supply.

d. Develop the Storage Action Plan and strategic anticipatory investments framework for large-scale and long-duration storage infrastructure.

B. Improve system planning and integration:

a. Grids Package with system integration and flexibility at the core: Ensure that system integration is at the core of the Grids Package to support both the decarbonisation and resilience of the European Union with electricity, gas, and hydrogen networks to be jointly planned (e.g. via revised TEN-E and ONDP).

b. Launch a Hydrogen Grid Action Plan: the hydrogen sector needs a stand-alone strategy to provide holistic vision and define specific tools for deployment of European hydrogen backbone, as well as precise specific steps, planning tools, roles of different stakeholders, and financial and regulatory measures.

c. Propose an Energy Storage Action Plan with a clear plan for all types of available storage for different timeframes, and a roadmap to achieve targets for 2035, 2040 and 2050.

1. Rationale of the paper

The aim of this paper is to demonstrate how hydrogen and system integration can strengthen the European Union's energy resilience and autonomy. It explores hydrogen's role not only as a decarbonisation tool, but as a strategic asset in building a robust, flexible, and crisis-resilient energy system.

The new energy system architecture must question what can be done to design structures that combine decarbonisation and resilience. Decarbonisation alone will not be enough. The energy system must be prepared to tackle high-impact events, and factor in social-economic security, all within the context of moving away from fossil fuels and strengthening Europe's competitiveness. To effectively confront these challenges, Europe must place system integration at the heart of its upcoming security of supply legislative package.

The paper begins by outlining first the energy imports dependency vulnerabilities and the technical challenges that arise from integrating massive shares of variable renewable energy into the system. It then explores how hydrogen can address these challenges through storage, flexibility, and sector coupling. Finally, it offers policy recommendations to embed resilience into Europe's evolving energy strategy.

2. The context: Europe's growing energy vulnerabilities

A. The need to reduce the effect of external shocks

One of the greatest vulnerabilities of Europe is our energy dependency. The EU has been a net energy importer for more than two decades - with energy import dependency rate at almost 60% in 2023, reaching over 90% in some Member States (European Council, 2025). More than two thirds of the gross available energy source in the EU comes from coal, oil, gas which must be secured via imports either from Norway (intra-Europe) or outside Europe (Russia, North Africa, US, and others).

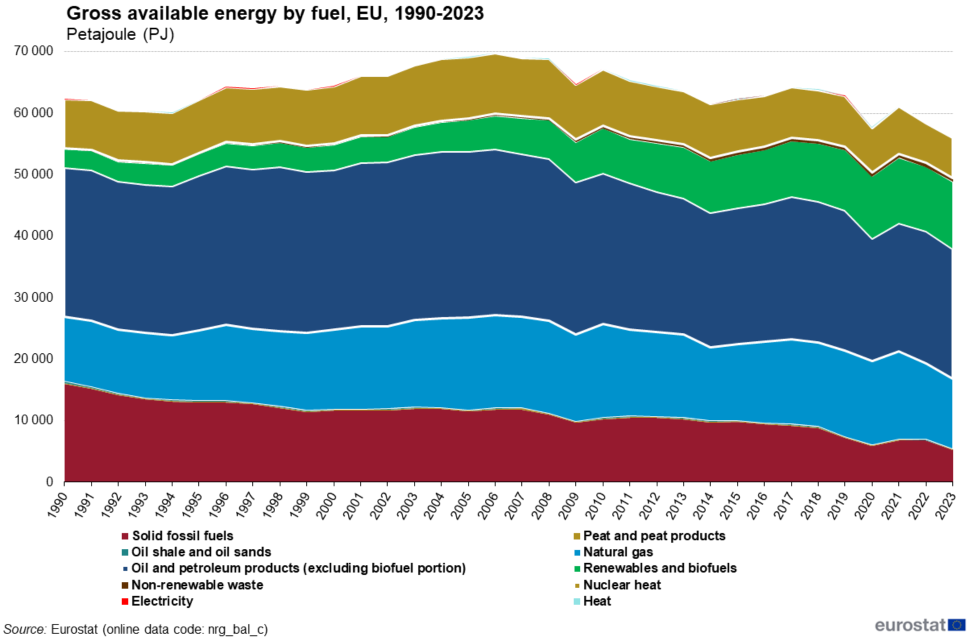


Figure 1 Gross available energy by fuel, EU, 1990 - 2023. Source: (Eurostat, 2023)

The invasion of Ukraine in 2022 brought to light Europe's extreme energy dependence: the resulting cuts to imports of gas, oil, and coal from Russia (IEA) caused a knock-on effect that was felt by the entire continent. The uncertainty of future supplies had a direct effect on energy prices, which reached record highs in August 2022 (EC, 2025), contributing significantly to generalized inflationary pressure (European Parliment, 2022) ensuing discernible economic consequences for all of us.

To mitigate these risks, in May 2022 (after the Versailles Declaration in March 2022[1]) the EU adopted the REPowerEU plan (European Commission, 2022), which helped Europe successfully achieve an important reduction in its share of Russian pipeline gas imports, which dropped from over 40% in 2021 to about 8% in 2023.

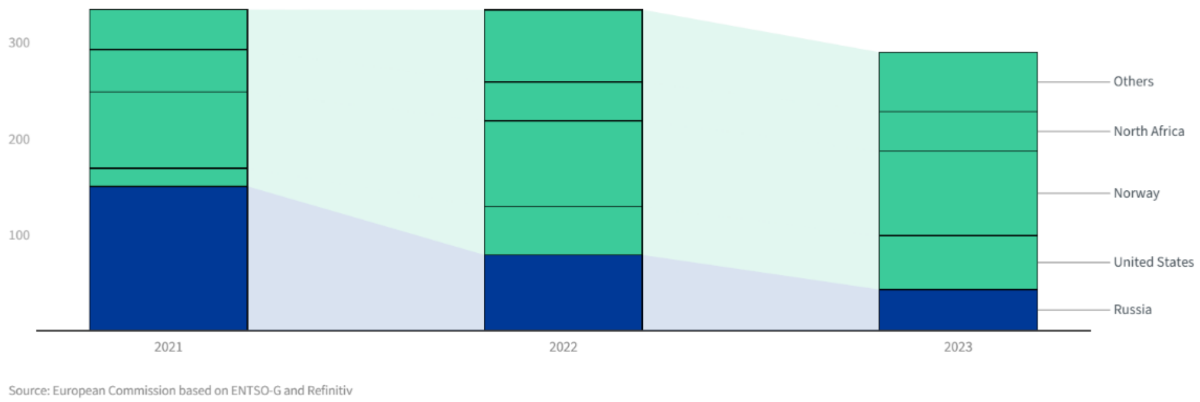


Figure 1. Where does the EU's gas come from? Source: [European Council.](#)

However, reliance on Russian gas is slowly rising again: the EU imported 30% more natural gas from Russia in 2024 compared to 2023 (European Parliment, 2025) . The report calls for a revision of the security of supply framework, highlighting the need to accommodate the integration of renewables and low carbon gases.

With growing conflicts as well in the Middle East, Europe's import supplier diversification approach is not enough. The next step is to expand Europe's fossil fuel reduction policy.

Without a strategic and diversified approach, the risk persists that one dependency may simply be exchanged for another, thereby shifting, rather than resolving, Europe's energy vulnerability.

FOCUS: Several key regulations and policies have shaped the EU's approach to energy security:

1. Regulation (EU) 2017/1938 on Security of Gas Supply – Establishes risk assessments, solidarity measures, and preventive action plans to address gas supply disruptions
2. Regulation (EU) 2019/941 on Risk-Preparedness in the Electricity Sector – Requires Member States to assess electricity crisis risks and coordinate responses.
3. Gas Storage Regulation (EU) 2022/1032 – Introduced mandatory gas storage filling targets to ensure supply resilience after the Ukraine crisis.
4. TEN-E Regulation (EU) 2022/869 – Supports cross-border energy infrastructure projects critical for system resilience.
5. REPowerEU Plan (2022) – Sets out measures to reduce dependence on Russian gas, accelerates renewable energy deployment, and scale up hydrogen.
6. The European Commission introduced in June of 2025 a *"Proposal for a regulation on phasing out Russian natural gas imports, improving monitoring of potential energy dependencies and amending Regulation (EU) 2017/1938"*.

[1] The EU Member States agreed in the Versailles Declaration to reassess how to ensure the security of their energy supplies and to phase out their dependency on Russian energy supplies 'as soon as possible' (Informal meeting of the Heads of State or Government, 2022).

Recognising this, the European Commission is now preparing further measures, including a revision of the Gas Security of Supply Directive as well, and a comprehensive reform of the energy security framework by 2026. (European Comission, 2025).

This new framework **should target the need for clean and diverse energy sources and have system integration at its core**. Indeed, given the EU's relatively scarce domestic fossil fuel production, coupled with its ambitious policies aimed at their progressive phase out, the European continent is resolute in investing in more domestic renewable energy sources (RES). These are not only a means towards decarbonisation, but a greater volume of RES will also provide us with greater energy independence.

Greater resilience and energy autonomy also require seeking diverse and reliable partners for clean energy imports. Faced with new geopolitical circumstances, **Europe also must develop an import strategy of clean fuels that will both support domestic RES development and promote diversification.** By exploiting renewables-rich regions and strengthening import infrastructure capacity (at port and pipeline corridors). This will be essential to guarantee the long-term security of the European Union's energy supply.

B. Technical vulnerabilities: setting the scene with the recent Spanish Blackout

When it comes to energy resilience, Europe is currently facing unprecedented technical, economic, social and even geopolitical challenges. Energy resilience has often been discussed in the context of geopolitical shocks and energy independence. However, the recent blackout in the Iberian Peninsula that occurred on the 28th of May has reminded us that the energy transition introduces and accentuates a new dimension of vulnerability: technical fragility within the electricity grid itself.

FOCUS: How do VRES influence grid stability?

Variable renewable energy sources, such as wind and solar, are asynchronous generators (also sometimes referred as inverter-based[2]): they are not directly connected to the grid and interact with it through power electronics. Meaning they require additional equipment to provide voltage and frequency control. In contrast, traditional or “rotating” generators such as nuclear, gas, coal or hydro are synchronous machines which are directly connected to the grid and support its stability through their physical inertia.

The inverter-nature of VRES complicates system operations, as does the inherent weather variability (intermittency) of wind and solar generation. This weather variability of makes it more difficult for system operators to ensure the critical real-time balance of electricity supply and demand.

When generation exceeds demand, voltage levels rise. Conversely, when generation is lower than demand, voltage levels drop. If not properly managed, these deviations can lead to destabilisation of the system and even lead to blackouts.

In conclusion, **the greater the share of asynchronous and variable generators, the more complex and demanding the technical needs for controllability become** – increasing system operator’s vulnerability in maintaining balance between generation and demand, as well as voltage and frequency control.

[2] Solar panels and wind turbines generate DC electricity (some wind turbines produce variable-frequency AC). This means the electrons flow in one direction. However, most of our appliances and the power grid use AC electricity, where the current reverses direction periodically. For that, they need to have an inverter and power electronics that convert DC electricity from solar panels and variable-frequency AC from wind turbines into a stable, usable form for the grid.

Investigations are still ongoing regarding the blackout, with a report from the Spanish government (Consejo de Seguidad Nacional, 2025) and the Spanish TSO (Red Electrica, 2025). And while it is a "multifaceted" incident - it demonstrates that today´s electricity systems are less reliable than stated. The probability of an 8-hour full Iberian blackout was considered to be less than 0.01%, a 1 in 10,000 years event, and the undelivered energy on the 28th was about 2,000 times higher than what Spain typically experiences over an entire year (an average of 20 MWh). (REE, 2024)

This event revealed that the growing electrification and increased volume of inverter-based and variable generation can make our energy system more vulnerable to disruption if not adequately regulated. The old wisdom – "Don't put all your eggs in one basket" – applies here. Hydrogen could be another basket with which we can increase our resilience.

3. The solution: diversified energy carriers coupled with adapted market design and sector integration

A. Diversifying energy carriers is key to strengthening EU autonomy

Europe's push for renewables on this direction under REPowerEU has been commendable, as installed wind and solar capacity increased by 58% cumulatively between 2021 and 2024 (European Comission, 2025). However, even if Europe continues with the current pace of electrification and VRES deployment, decoupling from natural gas is not going anywhere near fast enough.

Natural gas is dispatched to ensure security of supply, to cover the so-called residual load: the gap between RES (and nuclear) and electricity demand. Natural Gas cycles provide firm generation capacity[3], especially in winter months when demand is particularly high due to higher heating and power demand, and lower solar output – worsened with higher chances of cold spells or *dunkelflaute*[4] events.

ACER's latest Security of Supply report (ACER, 2024) shows that fossil fuel generators hold 85% of long-term capacity contracts for 2035 for security of supply and 76% for 2040 while clean energy alternatives still play a marginal role.

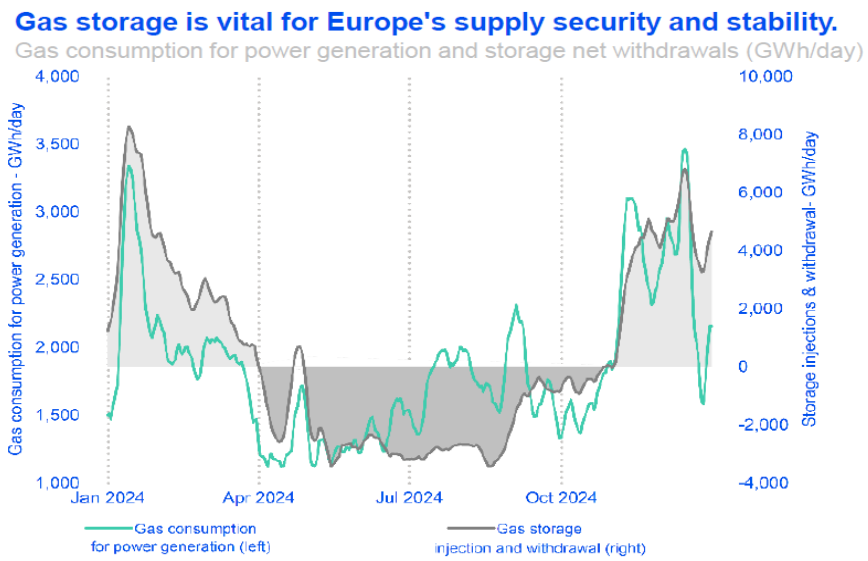


Figure 2: Gas consumption for power generation. Source: (ACER)

[3] Firm generation capacity, in the context of power generation, refers to the guaranteed amount of electricity that a power plant or generator can reliably produce, even under adverse conditions or during peak demand. It's the dependable power that can be counted on, unlike variable sources like wind or solar that fluctuate with weather. (IEA, n.d.)

[4] *Dunkelflaute* is a German word referring to a period of low or very little wind and solar electricity generation due to unfavourable weather conditions. These events are characterized by a combination of low wind speeds and overcast skies, which last several days. They happen approximately every two years.

FOCUS: What is Security of Supply?

Security of supply is the ability of an energy system to guarantee a stable balance between supply and demand at any time, across various timeframes, with a clearly established level of performance. Europe ensures its security of supply though exercises such as the European Resource Adequacy Assessment exercise to identify future capacity needs. These capacities are secured either via capacity payments and/or strategic reserves, which will be further explained in the following section.

Hydrogen can adapt to natural gas storage and dispatch profiles by using surplus solar energy or curtailed renewable electricity, and then it can be transformed into electricity during periods of low variable renewable energy sources (VRES) production – usually taking place in winter. Indeed, hydrogen and its derivatives can be stored for months and, according to several sources and studies, hydrogen is the most techno-economically proven solution for long term storage. For example, underground hydrogen storage can have almost 1 million times the capacity of a battery.

At large scales, hydrogen requires significantly less space and lower cost than batteries for storing energy: this unique capability and advantage can compensate for the efficiency losses during the conversion of hydrogen back to electricity.

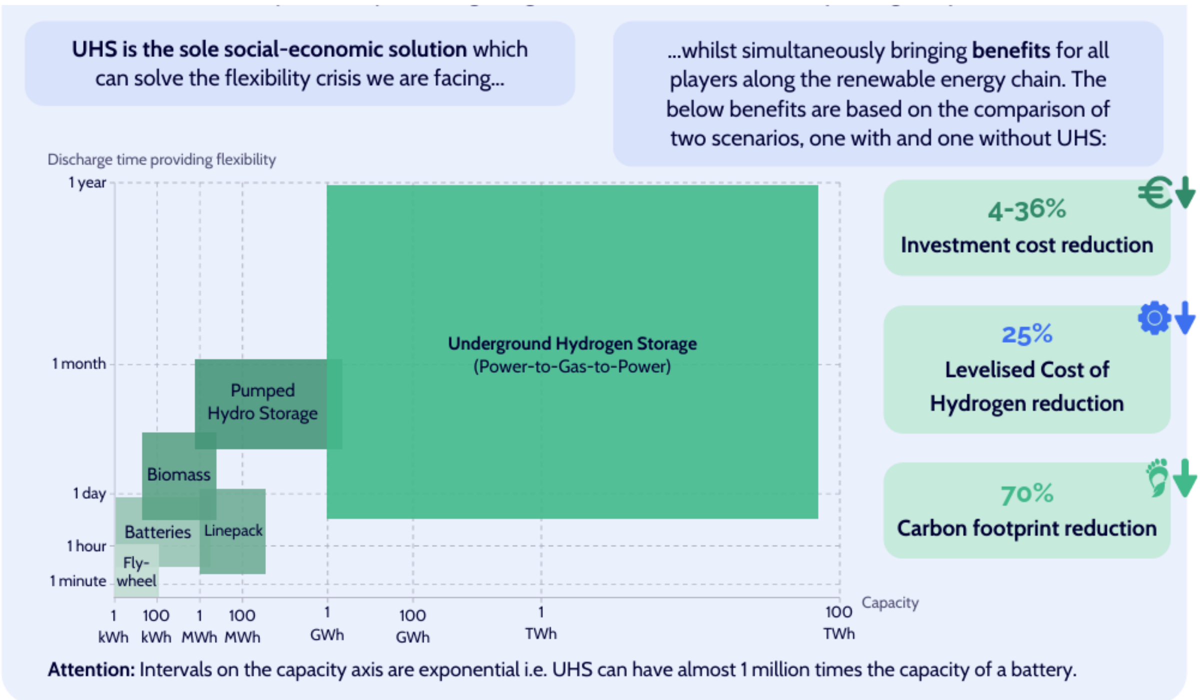


Figure 3: Hydrogen storage discharge duration. Source: (Europe, 2024)

Moreover, Hydrogen-to-Power (H2P) can support the system with ancillary services, balancing, inertia, and act as capacity reserves – much like any other traditional gas turbine but with the added benefit of being clean and domestically produced energy sources. Certainly, H2P solutions can provide clean power at peak capacity from days to months, if they are coupled with adequate storage and transport capacity.

Large-scale power plants can require hundreds of tons of hydrogen per day, especially if they are using hydrogen to generate electricity or produce synthetic fuels. In order to provide hydrogen at the required volumes, Europe will also need access to imported clean hydrogen either shipped or through pipelines (to be tackled in the upcoming Hydrogen Import Strategy). This is also important to ensure the affordability of hydrogen, and to kick-start the clean hydrogen market as European domestic production ramps up.

Clean hydrogen, produced domestically from renewables or nuclear power, coupled with strategic imports not only reduces Europe's exposure to geopolitical risk - it also supports Europe's energy autonomy and strategic resilience.

B. Adapting market design to new challenges

The growing share of VRES in the system has one caveat: more adequacy concerns. Wind and solar have an unpredictable energy output. As a result, while VRES might help us become more energy autonomous, it also decreases generation reliability.

The challenge of security of supply in the power sector is usually referred to as generation adequacy, which is the ability of the system to meet expected electricity demand with sufficient resources (Florence School of Regulation, 2025) – and it remains largely dependent on fossil-based capacities (Hrelja, Fulli, Poncela Blanco, & Spisto, 2023).

However, the system also needs flexibility: flexibility describes the system's capacity to adjust to changes in supply and demand (Florence School of Regulation, 2025), particularly those caused by VRES. It is worth noting that more flexible system is, the more it contributes to greater adequacy capabilities as the system will be equipped with more response capabilities in situations of generation scarcity (through demand response and stored dispatchable energy).

The need for greater flexibility and adequacy needs is already palpable: negative prices rose by 12 times in 2023, and by 18 times in 2024 (ACER for TTE Council Ministerial, 2025). Flexibility needs are expected to double by 2023 (ACER, EEA, 2023). And, long-term adequacy concerns are present and will increase in most EU Countries in the foreseeable future, as seen in graph below from ACER:

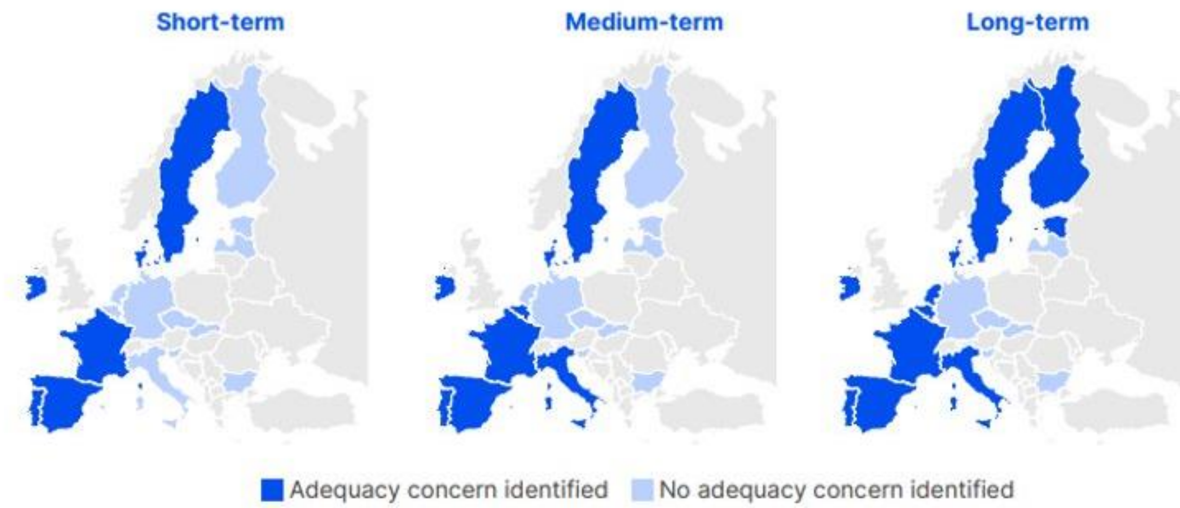


Figure 4: Adequacy concerns identified in NRAAs for different timeframes. Source: (ACER, 2024).

FOCUS: Investment signals for flexibility and adequacy

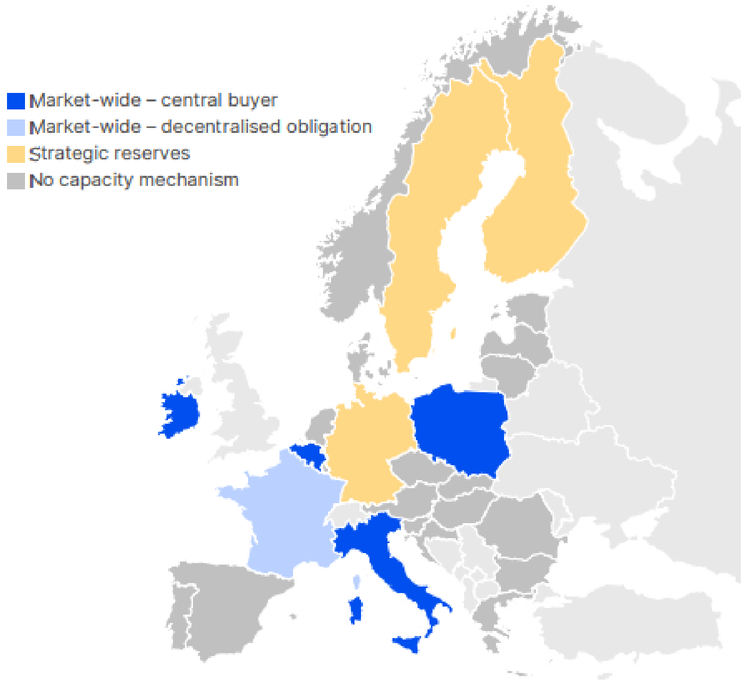
1. **Flexibility is incentivised through price signals and non-fossil flexibility support schemes** introduced in the new EMD reform (European Comission, 2024). While the non-fossil flexibility support schemes are crucial in reducing the need for additional firm generation capacity, their current design is largely focused on short-term flexibility services (ENTSOE, 2025). At least 10 Member States are implementing, or are in the process of setting up, support schemes for non-fossil flexible resource (ACER, 2024). Member States can choose to implement non-fossil flexibility support schemes instead of capacity mechanisms or also have both systems in place at the same time.
2. **Adequacy require long-term energy storage and firm capacities laying outside the market ready to be ramped up when generation is reduced**. They are usually addressed via capacity payments or strategic reserves:
    - **Capacity mechanisms**: market-based schemes where dispatchable generation units are paid to be available when needed. They are designed to ensure a reliable and sufficient supply of electricity by compensating power plants by being available to generate power when needed, not just for the energy they produce.
    - **Strategic reserves**[5]: state-funded fossil reserved kept outside the market, activated only in emergencies.

Power-to-Gas (P2G) will participate on non-fossil flexibility support schemes. However, these are mostly focused on short term flexibility. And, when it comes to ensuring long-term storage for adequacy and seasonal flexibility (more H2P), there are several barriers hindering the entrance of decarbonised options:

1. **Non-fossil flexible technologies have not been in the focus of the ERAA analysis.** Hence, the RES- and system integration aspect is not properly reflected on this aspect, missing the opportunity to identify how can they further contribute to adequacy.
2. **The 550g CO_2/kWh emission limit introduced in the EMD reform[6] in 2023 is insufficient to shift investments away from natural gas**. It only limits coal participation but allows natural gas.
3. Commission's Guidance on streamlining Capacity Mechanisms[7] and CISAF[8] encourage non-fossil inclusion in capacity mechanisms but **lack concrete tools to favour clean dispatchable options over natural gas**.

[5] As ACER highlights in its 2024 SoS report, strategic reserves tend to cost a fraction of the costs of market—wide capacity mechanisms.
[6] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=legissum:4404054
[7] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52025DC0065&qid=1741261561534
[8] https://competition-policy.ec.europa.eu/about/contribution-clean-just-and-competitive-transition/clean-industrial-deal-state-aid-framework-cisaf_en

Figure 7: Status of capacity mechanisms in the EU – 2023



Source: Created by ACER based on NRA data.

Figure 5: Status of capacity Mechanisms in the EU. Source: (ACER, 2024).

There is a structural gap: clean, dispatchable solutions like hydrogen, and other clean molecules and biomethane are not yet fully integrated into adequacy strategies and instruments. To address this gap, Europe must **prioritise instruments that support long-term non-fossil adequacy and system flexibility**.

While Member States can always introduce stronger criteria for capacity mechanisms, and are free to secure strategic reserves of clean hydrogen and fuels, stronger guidance and direction from the European Commission would be extremely beneficial to align security of supply with the broader goals of autonomy, decarbonisation and competitiveness.

C. System integration is key to increasing our resilience and security of supply

Europe shouldn't put all its eggs in one basket when it comes to energy production and transport. **Diversification – through energy suppliers, energy carriers and various energy grids – is the armour that keeps Europe's energy secure, affordable and on track to net-zero.** While development and modernisation of electricity grids is an absolute imperative, electrification should not be the sole focus of EU policies. Only relying on grid electricity could even reinforce our vulnerability (as presented in the first section).

Despite progress in decarbonising the power sector, electrification rates are stagnating, remaining around 23% for the past decade (Eurelectric, 2024). Moreover, demand for gas and other molecules remains persistent, declining too slowly to meaningfully displace their role in the energy system (Caspar Hobhouse, 2025). This showcases that a one-size fits all solution through electrification won't suffice to deal with the monumental challenges that lie ahead for European energy transition.

Europe must consider system integration as a more realistic and pragmatic option for the near future. In this more comprehensive approach, P2G solutions will play a significant role, provided there is also a comprehensive sector integration-based planning for all energy grids, including hydrogen infrastructure.

This is relevant also because **sector integration can bring significant costs savings**. To give an example, much more energy can be transported and/or stored for less cost as molecules compared to electrons:

- **Hydrogen pipelines can transport between 4-15 times more energy than electric cables**: with a hydrogen pipeline capacity potentially reaching 20-30 GW, while cables typically range between 2 GW (HVAC) – 5 GW (HVDC) (European Hydrogen Backbone, Guidehouse, 2021)
- Studies show that **hydrogen pipelines can be up to eight times cheaper than electricity transmission per delivered MWh**. These differences generally hold for shorter distances as well (Daniel DeSantis, 2021).

This is also important when it comes to storage capacities. For instance, Germany's electrical power system can statistically store about half an hour's worth of electricity consumption. In comparison, the German natural gas grid has enough stored reserves to last for three months (Dr. Thomas Hüwener, Prof. Dr. Alexander Martin, 2021).

System integration's benefits go beyond transport efficiency and cost savings: it offers a strategic edge as it relies on fewer critical raw materials and avoids dependence on complex electrical components such as high-voltage circuit breakers, transformers, and converters – thus minimizing Europe's exposure to global electricity components supply chain disruptions.

Hydrogen infrastructure also unlocks flexibility. With hydrogen transport and storage infrastructure, electrolysers can operate more flexibly. P2G can either ramp up or ramp down to adapt to network needs and it can be located in areas with high grid-stress. Consequently, system integration not only enables security of supply but also flexibility and RES integration.

Thus, when planning with system integration and flexibility in mind, Europe reduces network needs, energy transport costs, and reduces exposure to system vulnerabilities stemming from relying on only one dominant energy vector.

For this to be realised, Europe must ask itself what the right energy system architecture is, and what can be done to design structures that combine decarbonisation and resilience.

Our current scenario frameworks (TYNDP, ERAA, national planning, etc.) are not built for expected worst-case events and not yet with sector integration in mind. They often follow the "energy efficiency first" principle, making security of supply, resource adequacy, and system vulnerability secondary. The Spanish blackout shows that we need to reevaluate the risks of high impact events and their probability and focus on integrated energy planning for better systemic resilience.

4. Recommendations for enabling hydrogen to contribute to Europe's energy resilience

For clean molecules to have a more significant role in power generation and help substitute fossil fuels, Europe needs to put in place an adequate framework for clean hydrogen production coupled with necessary infrastructure and tools to cover the green premium of cleaner adequacy options. It will also require better tools for generation adequacy and flexibility coupled with optimal and sector integration focused planning for future energy systems.

A. Enhanced tools for generation adequacy and flexibility

Hydrogen will be part of the big energy system enabling flexibility and decarbonisation in parts of the energy system where wired (electric) solutions face limitations, thus helping to strengthen robustness and resilience of our energy systems by enhancing our capacity to address adequacy gaps.

This is why we recommend the European Commission to:

a) **Set stronger environmental criteria for capacity mechanisms:**
   - Including non-price criteria and making state-aid cover the green premium of more environmentally friendly and resilient capacity options should be envisioned in the upcoming Security of Supply Legislative Package.
   - It is very important to define and detail a clean flexibility concept at an early stage in order to enable the quick entry of existing and new solutions into a technology-open capacity market to ensure generation adequacy and a high degree of confidence in the electricity market design.

b) **Rapidly draft and implement the Union Strategy on Flexibility as mandated by Electricity Market Design**[9], where measures to accelerate the deployment of flexible solutions across different timeframes will be promoted (including demand response and storage). It should be followed with a legislative proposal that is technology-neutral for the optimal provision of flexibility capabilities.

c) **Create an adequate regulatory and financial framework to ensure the build-out of H2-to-Power plants** by 2030 to test the ecosystem and infrastructure of flexible hydrogen plants before a significant number of gas power plants are transformed into fully hydrogen-ready.

d) **Implement an Energy Storage Action Plan and strategic anticipatory investments framework for large-scale and long-duration storage infrastructure**. More than ever, Europe needs an Energy Storage Action Plan, with a clear plan for all types of available storage for different timeframes, with concrete targets for clean and long-duration energy storage roadmap to be achieved for 2035, 2040 and 2050. Production must be planned alongside physical underground storage to match supply and demand, ensure the continuous balance of the hydrogen system whatever the load profile of hydrogen consumers, contribute to cross-commodity flexibility, back up supply during shortages and ensure continuity of supply. Underground hydrogen storage (UHS) will be a cornerstone of a resilient, flexible, and decarbonised hydrogen economy.

For those countries that do not wish to implement capacity mechanisms and still need to bridge the gap in non-fossil adequacy support, **the upcoming Security of Supply legislative Package could consider the use and value of introducing voluntary strategic reserves of clean hydrogen and fuels**

[9] Indeed, according to Article 19f of the Electricity Market Desing Regulation (EU) 2024/1747, each Member State shall define, based on a report, an indicative national objective for non-fossil flexibility. The Commission, after receiving the national indicative objective shall submit a report to the European Parliament and to the Council assessing the national reports. On the basis of the conclusions of the report communicated by Member States, the Commission may draw up a Union strategy on flexibility, with a particular focus on demand response and energy storage. That Union strategy on flexibility may be accompanied, where appropriate, by a legislative proposal.

in the medium term. Those reserves could be considered specifically in countries that will depend on H2 imports or/and that will explicitly mention the use of H2 for the balancing of the power system**.**

They would require planning for hydrogen production with a physical back-up such as underground hydrogen storage and could be backed up by Member States. By doing so, they would operate outside the wholesale market, preventing price distortions, ensuring that initially costly Hydrogen-to-Power units do not disrupt electricity markets during supply shortages. By implementing strategic reserves for clean hydrogen and fuels in the medium term, Europe would both support domestic production of energy, diversify its supply chain, and tackle affordable energy pricing with a much cheaper adequacy instrument.

B. Better planning for future energy systems

System integration and flexibility are not luxuries: they're resilience tools. By linking electricity, gases, and storage more intelligently, we can reduce overall grid stress and network needs. This is why we recommend to the European Commission:

- **Provide Member States with precise guidance and assistance when it comes to implementation of the Decarbonised Gases and Hydrogen package**[10];
- **Propose in the upcoming Grids Package to have system integration at its very core:** so that any investment and planning decision in electricity grids considers the benefits of flexibility, non-wired solutions and system integration to ensure a more robust grids architecture design. The plan should include more integrated planning provisions in the revised TEN-E: so that natural gas, hydrogen and electricity grids are planned together (especially in the TYNDP and ONDP) seeking to optimise cross-system efficiency. It should be followed by:
- **A Hydrogen Grids Action Plan** : just like the electricity sector has its own EU Action Plan for Grids[11] and upcoming Electrification Action Plan[12], hydrogen sector needs a stand-alone strategy to provide holistic vision and define specific tools for deployment of European hydrogen infrastructure, as well as precise specific steps, planning tools, roles of different stakeholders, and financial and regulatory measures (new to be defined or existing ones to be implemented). It should integrate specific provisions for storage planning to fully leverage all benefits of long-duration storage provide by hydrogen. This requires a coordinated approach that considers spatial and temporal alignment between hydrogen production, storage capacity, and end-user demand

[10] The Package was adopted in May 2024, see here

[11] On 28 November the EU Commission launched an Action Plan for Grids, a 14-points plan to modernise Europe's electricity grid and prepare for the renewables-based electrification of the energy system. It says €584bn of new investments are required by 2030 to upgrade Europe's grids.

[12] A new Electrification Action Plan is planned in Q1 2026, according to the Affordable Energy Action Plan published on 26 February.

Bibliography

ACER. (2024). *Security of EU electricity supply.* Retrieved from https://www.acer.europa.eu/monitoring/MMR/security_EU_supply_2024

ACER. (n.d.). *2025.* Retrieved from https://www.acer.europa.eu/sites/default/files/documents/Publications/2025_ACER_Gas_Electricity_Key_Developments.pdf

ACER for TTE Council Ministerial. (2025). *Key developments in European electricity and gas markets - TTE Council Ministerial – Council Presidency of Poland.* Retrieved from https://www.acer.europa.eu/sites/default/files/documents/en/The_agency/Documents/20250317_ACER_Presentation_TTE_Council.pdf

ACER, EEA. (2023). *Flexibility solutions to support a decarbonised and secure EU electricity system.* Retrieved from https://www.acer.europa.eu/sites/default/files/documents/Publications/EEA-ACER_Flexibility_solutions_support_decarbonised_secure_EU_electricity_system.pdf

Caspar Hobhouse. (2025). *Reimagining European energy security: Towards a whole-of-system approach*. Retrieved from European Union Institute for Security Studies: https://www.iss.europa.eu/publications/briefs/reimagining-european-energy-security-towards-whole-system-approach#:~:text=Blunt%20measures%2C%20such%20as%20government,reestablish%20its%20own%20energy%20security.

Consejo de Seguidad Nacional. (2025). *Versión no confidencial del informe del comité para el análisis de las circunstancias que concurrieron en la crisis de electricidad del 28 de abril de 2025 .* Retrieved from https://www.lamoncloa.gob.es/consejodeministros/resumenes/Documents/2025/Informe-no-confidencial-Comite-de-analisis-28A.pdf

Daniel DeSantis, B. D. (2021). Cost of long-distance energy transmission by different carriers. *iScience*. Retrieved from https://www.sciencedirect.com/science/article/pii/S2589004221014668#:~:text=Summary,%2C%20distribution%2C%20and%20utilization%20scenarios.

Dr. Thomas Hüwener, Prof. Dr. Alexander Martin. (2021). Expert interview with Dr. Thomas Hüwener, Open Grid Europe GmbH, and Prof. Dr. Alexander Martin, Fraunhofer IIS. *Gas pipelines for hydrogen?* Retrieved from https://www.iis.fraunhofer.de/en/magazin/series/series-hydrogen/hydrogen-gas-pipelines.html#:~:text=Firstly%2C%20they%20have%20the%20capacity%20to%20transport,as%20much%20as%20a%20high%2Dvoltage%20power%20line.

EC. (2025). Retrieved from https://energy.ec.europa.eu/document/download/42ced477-ea11-4d50-a269-5a581128a761_en?filename=Proposal%20for%20a%20Regulation.pdf

EC. (2025). *Actions and measures on energy prices.* Retrieved from https://energy.ec.europa.eu/topics/markets-and-consumers/actions-and-measures-energy-prices_en#:~:text=Following%20Russia's%20invasion%20of%20Ukraine,in%202022%2C%20peaking%20in%20August.

ENTSOE. (2025). *DSO Entity and ENTSO-E submit joint Methodology on Flexibility Needs Assessment*. Retrieved from https://www.entsoe.eu/news/2025/04/16/dso-entity-and-entso-e-submit-joint-methodology-on-flexibility-needs-assessment/#:~:text=The%20FNA%20Methodology%2C%20jointly%20developed,addressing%20increasing%20network%20flexibility%20needs.

Eurelectric. (2024). *Unlocking the untapped potential of industrial electrification*. Retrieved from https://www.eurelectric.org/in-detail/unlocking-the-untapped-potential-of-industrial-electrification/#:~:text=Eurelectric's%20latest%20data%20report%20shows%20that%20the,European%20Commission's%20Impact%20Assessment%20on%202040%20targets.&text=That%20is%2

Europe, H. f. (2024). *The role of underground hydrogen storage in Europe H2eart for Europe.* Retrieved from https://www.researchgate.net/figure/Hydrogen-storage-advantage-Hydrogen-can-be-stored-for-months-without-losing-much-of-its_fig5_334233674

European Comission. (2021). Retrieved from Energy, Climate change, Environment: https://energy.ec.europa.eu/topics/markets-and-consumers/capacity-mechanisms_en

European Comission. (2024). *Electricity market design*. Retrieved from https://energy.ec.europa.eu/topics/markets-and-consumers/electricity-market-design_en

European Comission. (2025). *COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS Action Plan for Affordable Energy Unlocking the true value of our Energy Union to secure affordable, eff.* Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52025DC0079&qid=1741780110418

European Comission. (2025). *REPowerEU 3 years on: Commission takes stock of progress to phase out Russian fossil fuels*. Retrieved from https://energy.ec.europa.eu/news/repowereu-3-years-commission-takes-stock-progress-phase-out-russian-fossil-fuels-2025-05-16_en#:~:text=Almost%20half%20of%20electricity%20in,16%20additional%20bcm%20of%20gas.

European Commission. (2022). *"RePowerEU, Affordable, secure and sustainable energy for Europe".* Retrieved from https://commission.europa.eu/topics/energy/repowereu_en

European Council. (2025). *Where does the EU's gas come from?* Retrieved from https://www.consilium.europa.eu/en/infographics/where-does-the-eu-s-gas-come-from/#:~:text=Import%20from%20Russia%20declined%20from,2021%20to%2087.7%20in%202023.

European Hydrogen Backbone, Guidehouse. (2021). Analysing future demand, supply, and transport of hydrogen. 113. Retrieved from https://www.natrangroupe.com/sites/default/files/2021-06/European-Hydrogen-Backbone-report-June2021.pdf#:~:text=Whereas%20a%2048%2Dinch%20hydrogen%20pipeline%20can%20have,used%20today%20with%20natural%20gas)%20using%20power

European Parliment. (2022). *Inflation explained: What lies behind and what is ahead?* Retrieved from https://www.europarl.europa.eu/thinktank/en/document/EPRS_BRI(2022)729352

European Parliment. (2025). *DRAFT REPORT on the security of energy supply in the EU.* Retrieved from https://www.europarl.europa.eu/doceo/document/ITRE-PR-769948_EN.pdf

Eurostat. (2023). *Energy statistics - an overview.* Retrieved from https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Energy_statistics_-_an_overview

Florence School of Regulation. (2025). Flexibility in Power Systems. Retrieved from https://fsr.eui.eu/flexibility-in-power-systems/#:~:text=Indeed%2C%20as%20renewable%20capacity%20progressively,Ulbig%20&%20Andersson%2C%202015).

Hrelja, N., Fulli, G., Poncela Blanco, M., & Spisto, A. (2023). *Generation adequacy methodologies review.* Institute for Energy and Transport (Joint Research Centre), Publications Office of the European Union. Joint Research Centre. Retrieved from https://op.europa.eu/en/publication-detail/-/publication/c0e25a5a-4e3d-11e6-89bd-01aa75ed71a1

IEA. (n.d.). *Firm Power generation*. Retrieved from https://iea-pvps.org/key-topics/firm-power-generation/

IEA. (n.d.). *International Energy Agency, "Energy Fact Sheet: Why does Russian oil and gas matter?".* Retrieved from https://www.iea.org/articles/energy-fact-sheet-why-does-russian-oil-and-gas-matter

Informal meeting of the Heads of State or Government. (2022, March 11). *Versailles Declaration*. Retrieved from https://www.consilium.europa.eu/media/54773/20220311-versailles-declaration-en.pdf

Official Journal of the European Union. (2024). *Directive (EU) 2024/1711 of the European Parliament and of the Council of 13 June 2024 amending Directives (EU) 2018/2001 and (EU) 2019/944 as regards improving the Union's electricity market design (Text with EEA relevance).* Retrieved from EUR-lex: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L_202401711

Red Eléctrica. (2025). *Red Eléctrica presenta su informe del incidente del 28 de abril y propone recomendaciones.* Retrieved from https://www.ree.es/es/sala-de-prensa/actualidad/nota-de-prensa/2025/06/red-electrica-presenta-su-informe-del-incidente-del-28-de-abril-y-propone-recomendaciones

REE. (2024). *Energía no suministrada (ENS) y tiempo de interrupción medio (TIM) de la red de transporte*. Retrieved from ree.es: https://www.sistemaelectrico-ree.es/es/informe-del-sistema-electrico/transporte/energia-no-suministrada-ens-y-tiempo-de-interrupcion-medio#:~:text=En%20el%20sistema%20el%C3%A9ctrico%20nacional,a%20159%20MWh%20en%202023).

Viktor Walter, L. G. (2023). Low-cost hydrogen in the future European electricity system – Enabled by flexibility in time and space. *Applied Energy*. Retrieved from https://www.sciencedirect.com/science/article/pii/S0306261922015720

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