World Energy Council Austria

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Final Report

Group: Security of Supply

Title: “*Addressing the Energy Trilemma by focusing on ensuring Security of Supply*”

ÜBER YOUNG ENERGY PROFESSIONALS

Die Young Energy Professionals (**YEP**) bilden das interdisziplinäre Netzwerk junger Berufstätiger im WEC Austria. Gegründet „von jungen Menschen für junge Menschen“ auf dem Weltenergiekongress 2007 in Rom, sind die Ziele der Young Energy Professionals:

- **faktenbasiert Wissen** zu energiewirtschaftlichen Themen zu vermitteln,
- ein fachlich übergreifendes **Netzwerk** aufzubauen,
- **junge Entscheidungsträger und Meinungsbildner** sowie den energiewirtschaftlichen Nachwuchs anzusprechen,
- **Erfahrungs- und Wissensaustausch** innerhalb des WEC-Netzwerks zu ermöglichen sowie
- die internationalen Aktivitäten der **Future Energy Leaders** Community von WEC zu unterstützen.

Der WEC Austria beschloss im Jahr **2015** eine **nationale YEP-Gruppe** zu etablieren. Zum einen werden auf nationaler Ebene Lösungsvorschläge zu verschiedenen energiewirtschaftlichen Fragestellungen erarbeitet. Hierbei deckt ein interdisziplinärer Pool an jungen Berufstätigen der Energiewirtschaft vielfältige Themenbereiche ab. Zum anderen unterstützen die YEP von WEC Austria die Arbeiten der internationalen Nachwuchsorganisation des World Energy Council. Ein Board aus Mentoren unterstützt und begleitet die YEP.

Der YEP-Zyklus dauerte in dieser Kohorte ein Jahr. Im Anschluss werden die YEP-Programmteilnehmer in die YEP-Alumni-Community aufgenommen.

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GROUP

Security of Supply

TITLE

Addressing the Energy Trilemma by focusing on ensuring Security of Supply

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1. Abstract

Energy security has become a major challenge in the European energy transition. In the context of the World Energy Trilemma - balancing security, affordability, and sustainability - security of supply is no longer only about having enough energy available. It is increasingly about system resilience, flexibility, and the ability to respond to and recover from disruptions.

This report examines security of supply from different perspectives. At the **European level,** the main challenges include the growing share of variable renewables, ageing infrastructure, rising electricity demand, supply chain dependencies, and geopolitical uncertainty. At the same time, there are clear opportunities in stronger cross-border interconnections, greater flexibility, better resource adequacy planning, and digital and smart grid solutions. A coordinated European approach is therefore essential.

From the **Austrian government perspective**, the report highlights strong legal and institutional frameworks, including crisis preparedness, preventive planning, and emergency response mechanisms across electricity, gas, and oil. Austria also benefits from high storage capacity and effective coordination. However, important challenges remain, particularly import dependency, increasing system complexity, and geopolitical risks, which are intensified by the transition to a decarbonised energy system.

In addition, the report includes the views of key stakeholders in the energy system. For **power producers**, security of supply is closely linked to operational reliability, flexibility, and the ability to provide energy under both normal and stressed conditions. From the perspective of **gas transmission system operators**, important issues include infrastructure integrity, diversification of sources and routes, storages and the future role of hydrogen. For **industrial production**, energy security is directly tied to operational continuity, competitiveness, and resilience against supply shortages and price shocks. These perspectives show that security of supply is not only a system-level issue, but also a key factor for economic stability and industrial performance.

Overall, the report finds that security of supply is shifting from a static focus on energy availability to a broader resilience-based approach. Ensuring it in Austria and Europe will require stronger flexibility, resilient infrastructure, cross-border cooperation, and innovation. If managed well, the energy transition can strengthen security of supply while also supporting sustainability.

2. Introduction

Security of supply has evolved from a focus on stocked reserves to a multi-dimensional challenge. It now covers availability, affordability, reliability, resilience and system stability for electricity, gas, oil — and increasingly for low-carbon gases like hydrogen. These issues are driven by the green transition, changing demand, market changes and geopolitics, and they also include cyber and hybrid threats to critical infrastructure.

Each energy type has different problems and needs different solutions. Electricity needs more storage, flexibility and stronger interconnections because of variable renewables and falling inertia. Gas needs diversified sources and routes, storage, stable TSO operations and adaptation for future hydrogen use. Oil depends on strategic reserves and international coordination. Producers and TSOs are key actors: they must ensure delivery, system services and preparedness in normal and stressed conditions.

Because many risks cross borders and sectors, security of supply needs coordinated national and EU planning, clear laws and market rules, targeted investments, common technical and hydrogen quality standards, and stronger cyber defence. Austria has useful laws and large storage buffers, but it is still import-dependent and faces growing interdependencies, so diversification, flexibility and regional cooperation are essential.

This paper sheds light on the concept of security of supply from different dimensions: the role of producers and industrial consumers, transmission system and EU and Austrian policy lense.

3. Security of Supply from a European Perspective

The following section provides an overview of security of supply in the electricity sector at the level of the European Union. It outlines the fundamental concept as well as current developments, key challenges, and policy approaches within the EU. The aim is to offer a clearer understanding of how a secure and reliable electricity supply can be ensured in an increasingly integrated European energy system undergoing a profound transition.

Security of supply refers to the ability of a country or region to ensure a reliable, continuous, and affordable provision of essential resources, most notably energy, including electricity, gas, and increasingly renewable sources. On a European level, this concept goes beyond national borders and focuses on the stability and resilience of the integrated European energy system. It is commonly defined as the availability of sufficient energy at all times and at reasonable prices.[1]

In the European Union, security of supply is closely linked to the idea of an Energy Union, where member states cooperate to reduce vulnerabilities, share resources, and respond collectively to disruptions. This includes ensuring that energy can flow freely across borders, that infrastructure is robust, and that dependency on single external suppliers is minimized. EU legislation explicitly emphasizes cooperation and coordinated crisis management across countries to guarantee supply.[2]

3.1 The Current Debate in Europe

The debate around security of supply in Europe has intensified in recent years, driven by geopolitical tensions, climate goals, and market transformations. A key issue has been the EU's historical dependence on external energy suppliers, particularly natural gas imports. Events such as the war in Ukraine have exposed vulnerabilities and highlighted the risks of relying on dominant suppliers, prompting a shift toward diversification and resilience.[3]

At the same time, Europe is undergoing a green transition, aiming to reduce carbon emissions and increase the share of renewable energy. While this transition supports long-term sustainability, it also raises short-term challenges for security of supply, as renewable sources are variable and require additional flexibility, storage, and grid investments.[4]

Another dimension of the debate concerns the balance between national sovereignty and European coordination. Energy security in the EU is shaped by the interaction between national interests and the need for solidarity among member states, especially during crises. This tension has become more visible in recent years, reinforcing calls for stronger EU-level coordination.[5]

3.2 Key Risks to Security of Supply

Ensuring security of supply in the European electricity sector is increasingly challenged by structural transformations, policy shifts, and external uncertainties. As the EU transitions towards a low-carbon energy system, new vulnerabilities emerge alongside traditional risks.

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[1] European Commission (2025): *Security of electricity supply*

[2] European Commission (2022): *REPowerEU Plan*

[3] European Parliament (2024): *Security of Supply*

[4] Stiftung Wissenschaft und Politik (2022): *Security of Supply*

[5] ScienceDirect (2022): Breaking the era of energy interdependence in Europe: A multidimensional reframing of energy security, sovereignty, and solidarity

These developments require a comprehensive understanding of potential threats to maintain a stable and reliable electricity supply across interconnected markets.[6]

Some would say a possible risk arises from the increasing share of variable renewable energy sources such as wind and solar. While these are essential for decarbonisation, their dependence on weather conditions introduces fluctuations in electricity generation. Without sufficient balancing mechanisms, periods of low renewable output can lead to supply shortages and increased reliance on backup generation, posing challenges for system stability.[7]

Another critical issue is the ageing and sometimes insufficient electricity infrastructure across Europe. Many transmission and distribution networks require modernization to handle new generation patterns and increased electricity demand. Delays in grid expansion and upgrades can create bottlenecks, limit cross-border electricity flows, and ultimately threaten the reliability of supply in certain regions.[8]

Supply chain disruptions and dependency on critical raw materials also represent emerging risks. The expansion of renewable technologies, batteries, and grid infrastructure depends heavily on materials such as lithium, cobalt, and rare earth elements. Concentration of supply in a few countries can create geopolitical and economic vulnerabilities, potentially slowing down the energy transition and affecting long-term security of supply.[9]

Electricity demand uncertainty is another important risk factor. The electrification of sectors such as transport, heating, and industry is expected to significantly increase electricity consumption. However, the pace and scale of this demand growth remain uncertain, making it difficult to accurately plan future generation and infrastructure investments. Misalignment between supply and demand developments could lead to imbalances and system stress.[10]

Financial and investment risks further complicate the situation. The energy transition requires substantial capital investments in generation, grids, and flexibility solutions. Economic instability, high interest rates, or insufficient policy support can delay or reduce investments, potentially resulting in capacity gaps and increased risks for electricity supply reliability.[11]

In addition, extreme price volatility in electricity markets can threaten both affordability and supply security. High and unpredictable prices may lead to demand destruction, financial stress for consumers and businesses, and reduced incentives for long-term investments. Market instability can therefore indirectly undermine the resilience of the electricity system.[12]

Cybersecurity threats and risks related to digital infrastructure are also becoming more prominent. As the electricity system becomes more digitalized and interconnected, it becomes increasingly exposed to cyberattacks and technical failures. Such incidents can disrupt system

[6] Council of the European Union (2026): *How did the EU respond to the 2022 energy crisis?*

[7] European Environment Agency (2023): *Energy*

[8] European Investment Bank (2022): *The future of the european energy system*

[9] European Commission (2023): *Electricity market design and security of supply*

[10] International Renewable Energy Agency (2022): *Global Energy Transformation*

[11] World Bank (2022): *Energy*

[12] OECD (2022): *Energy*

operations, compromise data integrity, and potentially lead to large-scale power outages if not properly managed.[13]

Finally, insufficient coordination and solidarity among EU Member States remain a structural risk. While the European electricity system is highly interconnected, national policies and priorities can still diverge, especially during crises. A lack of coordinated responses can reduce the effectiveness of collective measures and increase the likelihood of disruptions spreading across borders.[14]

3.3 Key Opportunities to Enhance Electricity Security of Supply

In light of ongoing market transformations, increasing renewable integration, and growing system complexity, strengthening electricity security requires a comprehensive and coordinated approach at the EU level. The measures discussed below highlight essential areas where targeted action can improve system resilience, ensure reliability, and support the efficient functioning of an increasingly interconnected and decarbonised energy system.

3.3.1 Strengthening Cross-Border Interconnections

A more integrated European electricity grid is one of the most effective tools to enhance security of supply. Interconnectors allow electricity to flow between countries, helping to balance supply and demand across regions and reduce the need for redundant national capacity. Studies show that increased interconnection capacity significantly improves system adequacy and reduces costs.[15]

3.3.2 Expanding Flexibility Options

As renewable energy sources increase, flexibility becomes crucial. This includes investments in battery storage, demand-side response, flexible generation and sector coupling. Flexibility helps manage variability and ensures system stability during supply-demand imbalances. [16]

3.3.3 Improving Resource Adequacy Frameworks

Ensuring sufficient generation capacity remains essential. The EU promotes coordinated adequacy assessments through ENTSO-E’s European Resource Adequacy Assessment (ERAA), which supports evidence-based policymaking and reduces the risk of over- or under-investment. [17]

3.3.4 Digitalisation and Smart Grids

Digital technologies enable real-time monitoring, forecasting, and system optimization. Smart grids improve resilience by allowing more efficient integration of distributed energy resources and enabling active consumer participation.[18]

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[13] ENISA (2022): *Cybersecurity of Critical Sectors - Energy*

[14] European Court of Auditors (2022): *Climate spending in the 2014-2020 EU budget - Not as high as reported*

[15] ENTSO-E (2023): *European Resource Adequacy Assessment (ERAA)*

[16] IEA (2023): *Electricity Market Report*

[17] ENTSO-E (2023): *European Resource Adequacy Assessment (ERAA)*

[18] European Commission (2021): *Digitalisation of the Energy System*

3.3.5 Strengthening Risk Preparedness and Regional Cooperation

The EU Risk Preparedness Regulation requires Member States to coordinate their responses to electricity crises. Regional cooperation mechanisms, including joint risk assessments and emergency plans, enhance the ability to manage cross-border disruptions and ensure solidarity in crisis situations. [19]

[19] Regulation (EU) 2019/941

4. Security of Supply in Austria – A National Perspective

4.1. What does security of supply mean from a governmental perspective?

Security of energy supply constitutes a fundamental public policy objective and a core responsibility of the Austrian federal government. From the perspective of the competent authority—the Federal Ministry for Economic Affairs, Energy and Tourism (BMWET)—security of supply encompasses not only the uninterrupted availability of energy but also the protection of critical infrastructure, the safeguarding of public welfare, and the minimisation of economic and societal impacts in crisis situations.

In recent years, the concept has evolved significantly. It is no longer limited to ensuring sufficient physical supply, but has become a multi-dimensional policy objective, integrating:

- the physical availability of energy carriers,
- The stability and resilience of energy systems,
- protection against cyber and hybrid threats, and
- robustness against geopolitical and macroeconomical disruptions.

This broader understanding reflects the increasing complexity of modern energy systems, which are shaped by decarbonisation, digitalisation and deeper European integration.

Austria's approach is based on a comprehensive and structured crisis preparedness framework, combining legal instruments, technical planning, and institutional coordination. The guiding principle is clearly stated in the introduction of the Crisis Prevention Management Plan[20], where „*ensuring the basic energy supply of the population, protecting people and the environment, and minimising economic impacts in case of disruptions*" is stated as first priority.

The legal backbone of this system is the Energy Intervention Powers Act (Energielenkungsgesetz 2012, EnLG 2012)[21], which establishes a layered and flexible mechanism allowing the government to intervene in energy markets when necessary. These interventions range from market-supporting measures to far-reaching regulatory interventions in cases of severe crisis, including allocation measures, demand curtailment, and prioritisation of protected customers. Importantly, such interventions are subject to principles of proportionality, temporality, and democratic oversight.

Austria's overall strategy can be summarised as a four-pillar model:

- Prevention, including risk assessments and infrastructure planning,
- Preparedness, including emergency planning and strategic reserves,
- Crisis response, including both market-based and non-market-based measures, and
- Resilience building, including diversification, renewable energy expansion and efficiency improvements.

[20] Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie (2022): Krisenvorsorgemanagement

[21] Bundesgesetz über Lenkungsmaßnahmen zur Sicherung der Energieversorgung, BGBl. I Nr. 41/2013.

This framework reflects both national priorities and European obligations, embedding Austria firmly within the EU's energy security architecture. At the same time, it highlights the increasing importance of cross-border cooperation and solidarity mechanisms, as energy security can no longer be ensured at national level alone.

4.2. Electricity: System Stability and Blackout Preparedness

4.2.1 What are the key risks?

Electricity supply security is governed by the Risk-Preparedness Plan for the Electricity Sector of the Republic of Austria[22], developed pursuant to Regulation (EU) 2019/941 on risk-preparedness in the electricity sector.

he plan identifies a broad range of potential crisis scenarios, including:

- cyber-attacks and physical attacks on infrastructure,
- extreme weather events such as storms, heatwaves, and flooding,
- fuel shortages, particularly in relation to gas supply, and
- system-wide failures and cascading outages.

These risks demonstrate that electricity systems are increasingly exposed to complex and interdependent threats, where technical failures, market dynamics, and external shocks can reinforce each other. As a result, risks are no longer purely technical in nature but also digital, climatic, and geopolitical.

At the national level, Austria evaluates these risks in close cooperation with key institutional actors, particularly the regulatory authority (E-Control) and the transmission system operator (Austrian Power Grid – APG). The primary focus lies on transmission system stability, as disruptions at this level have the most severe and far-reaching systemic consequences, often extending beyond national borders.

The most critical electricity-related risk is a blackout, defined as „*a large-scale and sudden power outage leading to failures of infrastructure and supply systems*“[23]. Unlike local outages, a blackout affects entire regions or countries and leads to cascading failures across sectors. The Austrian Court of Audit emphasises that such events would result in:

- the loss of communication systems (mobile networks, internet),
- disruptions in transport and logistics, and
- the breakdown of supply chains for essential goods.[24]

In addition, critical services such as healthcare, water supply, and emergency response systems would be severely affected.

[22] Federal Ministry Republic of Austria Climate Action, Environment, Energy, Mobility, Innovation and Technology (2024): Risk-Preparedness Plan for the Electricity Sector of the Republic of Austria

[23] Rechnungshof Österreich (2025): Vorbereitung auf den Blackout-Fall

[24] Rechnungshof Österreich (2025): Vorbereitung auf den Blackout-Fall

From a governmental perspective, blackout preparedness is therefore not limited to the energy sector but constitutes a whole-of-government challenge involving:

- civil protection authorities,
- municipalities and federal states, as well as
- defence and interior ministries.

4.2.2 How is security of supply ensured?

Austria's electricity security strategy is based on a multi-layered governance approach, combining preventive infrastructure development, real-time system operation, and coordinated crisis management mechanisms at both national and European level. The underlying objective is not only to avoid disruptions, but to ensure that the electricity system remains operationally stable even under stressed conditions.

At the core of this approach lies a strong emphasis on preventive system strengthening.[25] Grid expansion and reinforcement play a central role, particularly in light of the increasing decentralisation of generation and the growing share of renewable energy sources. Investments in transmission and distribution infrastructure aim to reduce congestion, improve cross-regional balancing, and ensure that electricity can be transported efficiently from generation sites to consumption centres. In parallel, the integration of renewable energy is supported through grid adaptation, forecasting improvements, and market-based incentives, ensuring that decarbonisation objectives are aligned with system stability requirements.

A second key pillar is the enhancement of system flexibility. As the share of variable renewable energy increases, the ability of the system to respond to fluctuations in generation and demand becomes critical. Austria therefore promotes the development of flexibility options such as battery storage, pumped hydro storage, and demand-side response. These resources enable the system to absorb short-term imbalances and reduce the need for emergency interventions. In addition, sector coupling—particularly between electricity, heating, and gas systems—provides further flexibility by allowing energy to be shifted across sectors.

Digitalisation and cybersecurity form another essential component of Austria's electricity security strategy. The increasing reliance on digital control systems and real-time data exchange improves system monitoring and operational efficiency, but also introduces new vulnerabilities. Consequently, significant efforts are being made to enhance cyber resilience, including the protection of critical infrastructure, implementation of security standards, and coordination with national and European cybersecurity frameworks.

In terms of system operation, Austria relies on well-established mechanisms to ensure real-time stability. These include redispatch measures, balancing markets, and ancillary services that maintain frequency and voltage stability. In situations of severe system stress, controlled load shedding may be implemented as a measure of last resort to prevent a total system

[25] Federal Ministry Republic of Austria Climate Action, Environment, Energy, Mobility, Innovation and Technology (2024): Risk-Preparedness Plan for the Electricity Sector of the Republic of Austria

collapse. Importantly, such measures are embedded in clearly defined operational protocols and are coordinated with neighbouring transmission system operators.[26]

Crisis preparedness and response are further strengthened through institutional coordination and predefined emergency procedures. Roles and responsibilities are clearly allocated among key actors, including the BMWET, E-Control, APG, and other stakeholders. Regular exercises and stress tests are conducted to ensure that all actors are prepared to respond effectively in crisis situations. Communication strategies also play a crucial role, ensuring that information is shared rapidly and transparently among authorities, market participants, and the public. These measures aim to stabilise the system in real time and prevent escalation into large-scale disruptions.

Regional cooperation[27] plays a central role. Austria is part of the Central Europe System Operation Region, requiring close coordination with neighbouring countries. This requires continuous coordination with neighbouring countries in areas such as capacity allocation, system balancing, and emergency response. European mechanisms, including joint risk assessments and coordinated crisis management under Regulation (EU) 2019/941, ensure that security of supply is addressed not only at national level but also within a broader regional context.

Taken together, these measures reflect a shift from a purely capacity-based understanding of security of supply towards a dynamic, system-oriented approach, where flexibility, coordination, and resilience are central elements.

4.2.3 Current Challenges

Recent debates about potential large-scale outages (e.g. in Spain) illustrate that even highly developed systems face increasing risks due to:

- higher shares of variable renewable energy,
- reduced system inertia, and
- increased digitalisation and cyber exposure.

One of the most significant challenges is the increasing share of variable renewable energy sources, such as wind and solar. While these technologies are essential for achieving climate targets, their inherent variability introduces new complexities for system operation. Periods of low renewable generation, combined with high demand, can create situations of system stress, requiring additional balancing resources and flexibility options.

At the same time, the gradual phase-out of conventional generation technologies leads to a reduction in system inertia, which is traditionally provided by large synchronous power plants. Lower inertia makes the system more sensitive to frequency deviations and requires new

[26] Federal Ministry Republic of Austria Climate Action, Environment, Energy, Mobility, Innovation and Technology (2024): Risk-Preparedness Plan for the Electricity Sector of the Republic of Austria

[27] Federal Ministry Republic of Austria Climate Action, Environment, Energy, Mobility, Innovation and Technology (2024): Risk-Preparedness Plan for the Electricity Sector of the Republic of Austria

technological solutions, such as grid-forming inverters and advanced control systems, to maintain stability.

Another key challenge is the increasing digitalisation of the electricity system, which, while enabling more efficient system operation, also increases exposure to cyber risks. The protection of critical infrastructure against cyberattacks and technical failures therefore becomes a central element of security of supply.

In addition, the growing electrification of other sectors—such as transport, heating, and industry—leads to rising electricity demand and greater uncertainty in demand patterns. This requires forward-looking planning to ensure that generation capacity, grid infrastructure, and flexibility resources develop in line with future demand.

Finally, the high level of interconnection with neighbouring countries creates both opportunities and challenges. While cross-border integration enhances system efficiency and resilience, it also means that disturbances in one country can quickly propagate across the system. This underscores the importance of effective regional coordination and robust European governance structures.

For Austria, addressing these challenges will require continued investment in infrastructure, further development of flexibility options, and ongoing adaptation of regulatory and market frameworks. In particular, ensuring that the energy transition proceeds in a way that maintains system stability and reliability will remain a key policy priority.

4.3 Gas: Geopolitics, Infrastructure and Crisis Management

4.3.1 What are the key risks?

Austria occupies a strategic position in the European gas network, acting both as a transit country and a domestic consumer market. Its infrastructure — comprising high-pressure transmission pipelines (namely the Trans Austrian Gas Pipeline „TAG“, the West Austrian Gas Pipeling „WAG“ and the Penta-West Pipeline), regional distribution networks, extensive (underground)storage facilities, and the Baumgarten gas hub — has historically played a central role in the distribution of gas flows across Europe.

Despite these structural advantages, the gas sector is characterised by a distinct set of risks, which are more strongly influenced by geopolitical and market dynamics than in the electricity sector.

A key structural vulnerability is Austria’s high import dependency. Domestic production covers only a small share of demand, making the country reliant on external suppliers and international transport routes. This dependence exposes Austria to supply disruptions, price volatility, and political risks originating outside its borders.

The Russian war of aggression against Ukraine has fundamentally reshaped the European gas landscape and revealed the extent of these vulnerabilities. These risks were highlighted in the Austrian Preventive Action Plan[28]. Traditional supply routes were disrupted, long-established contractual relationships were called into question, and gas flows across Europe had to be rapidly reconfigured. This resulted in:

- a reversal of flow directions (west-to-east instead of east-to-west),
- increased competition for alternative supply sources, and
- significant price volatility on wholesale markets.[29]

In addition, infrastructure constraints and bottlenecks may limit the ability to redirect gas flows efficiently, particularly during periods of high demand. While Austria's storage capacities provide an important buffer, they do not fully eliminate risks related to sustained supply disruptions.

Finally, the ongoing transformation of the energy system introduces new uncertainties. The gradual shift towards renewable gases and hydrogen raises questions regarding infrastructure adaptation, investment needs, and future supply patterns. During this transition phase, the coexistence of legacy systems and emerging technologies may create additional coordination challenges and transitional risks.

This crisis served as a stress test for Austria's gas security framework, demonstrating both vulnerabilities and strengths.

4.3.2 How is security of supply ensured?

Austria's gas security framework is characterised by a comprehensive and highly structured governance approach, combining preventive planning, market-based mechanisms, and, where necessary, state intervention. The objective is to ensure that gas supply can be maintained under a wide range of scenarios, including severe supply disruptions. Austria's gas security strategy is built on three key instruments:

A central element of this framework is the Preventive Action Plan, which identifies potential risks and defines measures to mitigate them before a crisis occurs.

This plan identifies risks and defines mitigation strategies, including[30]:

- the diversification of supply sources and transport routes,
- regulatory measures to ensure sufficient storage levels,
- incentives for demand reduction and efficiency imporvements, and
- the gradual integration of renewable gases.

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[28] Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (2023): Gas Preventive Action Plan of the Republic of Austria

[29] Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (2023): Gas Preventive Action Plan of the Republic of Austria

[30] Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (2023): Gas Preventive Action Plan of the Republic of Austria

The plan reflects a forward-looking approach, aiming to reduce structural vulnerabilities and strengthen the resilience of the gas system over the medium to long term.

Completing this is the Gas Emergency Plan,[31] which establishes a clearly structured crisis management framework. It distinguishes between three escalation levels — early warning, alert, and emergency — each triggering specific measures and coordination mechanisms.

The Emergency Plan defines:

- the roles and responsibilities of all relevant stakeholders, including public authorities, transmission system operators, and market participants,
- procedures for information exchange and decision-making, and
- mechanisms for coordination at both national and European level.

This structured approach ensures that responses to supply disruptions are predictable, transparent, and coordinated, reducing the risk of uncoordinated or inefficient interventions.

A defining feature of Austria's gas security strategy is its extensive storage capacity, which plays a critical role in buffering supply disruptions. With storage volumes roughly equivalent to annual domestic consumption, Austria is particularly well positioned to manage short-term supply shocks. In addition, a strategic gas reserve of approximately 20 TWh has been established to ensure supply for protected customers in crisis situations.

Storage therefore functions not only as a commercial asset but as a key instrument of public policy, enhancing both national and regional security of supply.

In situations where market-based mechanisms are insufficient, the government may resort to energy intervention measures based on the Energielenkungsgesetz 2012 (EnLG 2012). These measures include:

- consumption restrictions,
- prioritisation of protected customers (e.g. households, critical infrastructure), and
- the controlled release of strategic reserves.

Such interventions are designed as measures of last resort and are subject to strict legal and procedural requirements, ensuring proportionality and safeguarding market functioning as far as possible.

Another important dimension is European and regional coordination. Austria's gas system is closely integrated into the European network, and security of supply is addressed within the framework of Regulation (EU) 2017/1938. This includes:

- joint risk assessments,
- cross-border emergency planning, and
- solidarity mechanisms between Member States.

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[31] Federal Ministry Republic of Austria Climate Action, Environment, Energy, Mobility, Innovation and Technology (2022): Gas Emergency Plan of the Republic of Austria

These mechanisms ensure that, in the event of a severe crisis, gas can be allocated and distributed in a coordinated manner across borders, thereby enhancing overall system resilience.

Overall, Austria's approach reflects a shift towards a resilience-based model of gas security, where diversification, storage, and coordination play a central role alongside traditional supply considerations.

4.3.3 Interdependencies with Electricity

A key characteristic of modern energy systems is the increasing interdependence between different energy carriers, particularly between gas and electricity.

Gas-fired power plants play a crucial role in ensuring electricity system stability, providing:

- flexible generation capacity,
- balancing services, and
- backup during periods of low renewable output.

As a result, disruptions in gas supply can have immediate and significant impacts on electricity security, potentially leading to cascading effects across the energy system.

Conversely, electricity is also becoming increasingly important for the gas sector, particularly in the context of:

- gas infrastructure operation (e.g. compressor stations), and
- the production of renewable gases, such as hydrogen via electrolysis.

This bidirectional dependency highlights the need for integrated energy system planning, where risks are assessed and managed across sectors rather than in isolation.

From a policy perspective, this implies that security of supply can no longer be addressed within sectoral silos. Instead, it requires:

- coordinated planning across electricity and gas systems,
- aligned regulatory frameworks, and
- joint crisis preparedness mechanisms.

In this context, sector coupling is not only a tool for decarbonisation but also a key element of system resilience, enabling greater flexibility and reducing vulnerability to single-point failures.

4.4 Oil: Strategic Reserves and Import Dependency

4.4.1 What are the key risks?

Despite Austria's long-term decarbonisation objectives, oil continues to play a central role in the national energy system. With a share of approximately 34.5% of gross energy consumption, it remains the single largest energy source, particularly in the transport sector and parts of industry.

However, Austria's oil sector is characterised by a pronounced structural import dependency. Domestic production covers only a small fraction of national demand, meaning that the vast majority of crude oil and petroleum products must be imported. This reliance on external supply chains exposes Austria to a range of risks that are largely beyond national control.[32]

A primary risk factor is exposure to global market dynamics. Unlike electricity and, to some extent, gas markets, oil markets are globally integrated and highly sensitive to geopolitical developments. Disruptions in major producing regions, changes in global demand, or strategic decisions by oil-exporting countries can lead to significant price volatility and supply uncertainties.

Although Austria no longer imports oil directly from Russia, indirect dependencies remain through international supply chains and trading partners. This means that geopolitical tensions—such as conflicts in the Middle East or disruptions of key transport routes (e.g. maritime chokepoints)—can have immediate and indirect effects on Austria's supply security.

In addition, oil supply chains rely heavily on critical infrastructure, including pipelines, refineries, storage facilities, and transport systems (road, rail, and shipping). Disruptions at any point along this chain—whether due to technical failures, natural disasters, or security incidents—can affect the availability of oil products at the national level.

Another important risk relates to the energy transition itself. As Europe moves towards decarbonisation, investment in fossil fuel infrastructure may decline, potentially leading to tighter supply conditions or reduced flexibility in the system. At the same time, demand for oil products may become more volatile, creating uncertainties for both suppliers and policymakers.

Taken together, these factors illustrate that oil security of supply is shaped by a combination of global dependencies, infrastructure vulnerabilities, and transitional dynamics, requiring a distinct policy approach compared to electricity and gas.

4.4.2 How is security of supply ensured?

Austria's approach to oil security of supply is primarily based on a robust and long-established stockholding system, complemented by monitoring mechanisms, emergency planning, and regulatory intervention powers.

At the core of this framework is the obligation to maintain strategic oil reserves equivalent to at least 90 days of net imports, in line with European and international requirements. This obligation is enshrined in the Erdölbevorratungsgesetz 2012 (EBG 2012), which forms the legal basis for Austria's oil security regime.

The responsibility for managing these reserves lies with the Erdöl-Lagergesellschaft (ELG), which acts as the central stockholding entity. ELG is responsible for acquiring, maintaining, and, if necessary, releasing oil stocks to ensure supply in crisis situations. This centralised system allows for efficient management and rapid mobilisation of reserves when needed.

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[32] Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (2022): Contigency Plan for the Secure Supply of the Republic of Austria with Crude Oil and Petroleum Products.

Strategic reserves serve as a critical buffer against short-term supply disruptions, enabling Austria to maintain supply even in the event of significant import interruptions. They also contribute to market stability by reducing the immediate impact of supply shocks on domestic availability.

In addition to stockholding, Austria employs continuous monitoring and assessment mechanisms to track developments in oil supply and demand. This includes:

- monitoring of import flows and stock levels,
- analysis of global market developments, and
- coordination with European and international partners, particularly within the framework of the EU and the International Energy Agency (IEA).

These monitoring activities provide the basis for timely and informed decision-making in both normal and crisis situations.

In the event of a severe supply disruption, the government may implement energy intervention measures, based on the Energielenkungsgesetz 2012 (EnLG 2012). These may include:

- controlled release of strategic reserves,
- allocation measures to prioritise critical sectors, and
- demand-side interventions where necessary.

Such measures are designed to ensure that essential services and critical infrastructure remain supplied, even under conditions of significant scarcity.

Furthermore, Austria's oil security framework is embedded within a broader European and international coordination system. Under EU law and IEA obligations, Member States are required to coordinate their actions in the event of major supply disruptions. This includes:

- joint release of strategic reserves,
- information sharing, and
- coordinated market interventions.

This multilateral dimension enhances the effectiveness of national measures and contributes to overall system resilience.

Overall, Austria's oil security strategy reflects a highly institutionalised and precautionary approach, where strategic reserves play a central role in managing short-term risks. However, in the long term, improving security of supply will increasingly depend on reducing structural import dependency, particularly through electrification, efficiency improvements, and the substitution of oil with renewable energy sources.

4.5 Cross-Sector Assessment

4.5.1 Strenghts of the Austrian System

From a governmental perspective, Austria's security of supply framework is characterised by a high degree of institutional maturity and structural robustness, reflecting decades of policy development and alignment with European energy legislation.

Key strengths of the Austrian system include:

- a strong and well-established legal basis, in particular the Energielenkungsgesetz 2012 (EnLG 2012), which provides clear mechanisms for state intervention in crisis situations,
- comprehensive and EU-compliant planning instruments, including risk assessments, preventive action plans, and emergency frameworks across all energy sectors,
- significant storage capacities, especially in the gas sector, which provide a substantial buffer against short-term supply disruptions,
- well-functioning institutional coordination between key actors such as BMWET, E-Control, APG, and AGGM, ensuring coherent decision-making and efficient crisis response, and
- advanced crisis management structures, including predefined procedures, clearly allocated responsibilities, and regular coordination mechanisms at both national and European level.

Taken together, these elements form a resilient and adaptive governance framework, enabling Austria to effectively manage a wide range of potential energy supply disruptions.

4.5.2 Key Challenges

Despite these strengths, Austria's energy system faces several structural and emerging challenges, many of which are closely linked to the ongoing transformation of the energy sector.

A central challenge remains the country's continued dependence on imported fossil fuels, particularly in the gas and oil sectors. This structural reliance exposes Austria to external supply risks, price volatility, and geopolitical developments beyond its direct control.

At the same time, energy systems are becoming increasingly complex and interconnected, leading to heightened systemic risks. Interdependencies between electricity, gas, and other sectors mean that disruptions can propagate rapidly across the system, potentially amplifying their overall impact.

Geopolitical uncertainty represents another key risk factor. Recent developments, most notably the war in Ukraine, have demonstrated how quickly external shocks can affect supply conditions, infrastructure utilisation, and market dynamics. Such events underline the importance of both diversification and European-level coordination.

Finally, the energy transition itself introduces new challenges. While the expansion of renewable energy is essential for achieving climate objectives, it also requires significant adaptation of infrastructure, market design, and system operation. The increasing share of variable renewable energy sources raises questions related to system stability, adequacy, and flexibility, necessitating new technological and regulatory solutions.

4.5.3 Strategic Outlook

Austria's long-term strategy aims to address these challenges through a comprehensive transformation of the energy system, combining decarbonisation with enhanced resilience and security of supply.

Key strategic priorities include:

- the expansion of renewable energy sources, particularly in the electricity sector, to reduce dependence on imported fossil fuels and increase domestic energy production,
- the progressive reduction of fossil fuel use, supported by electrification, efficiency measures, and the development of alternative energy carriers such as hydrogen and renewable gases,
- the strengthening of European integration and cooperation, recognising that security of supply in an interconnected system can only be ensured through coordinated action at EU level, and
- the enhancement of system flexibility and resilience, including the development of storage solutions, demand-side response, sector coupling, and digital system management.

In this context, security of supply is increasingly understood as a dynamic and forward-looking policy objective, requiring continuous adaptation to technological, economic, and geopolitical developments.

5. Security of Supply from the perspective of a Power Producer

5.1. Introduction

Power producers play a crucial role in ensuring security of supply. As they produce and trade electricity, invest in assets, and provide system services, they sit at the intersection of the goals set forth in the energy trilemma – security of supply, affordability and sustainability. Their decisions directly shape trade-offs and outcomes across all three dimensions.[33]

As the energy system changes with more renewables and climate goals, producers must change how they operate.

Power producers do not necessarily have to be big companies, rooftop PV-installations also make private households a power producer potentially affecting security of supply. For the sake of this paper, private households are not the focus amongst the power producers.

Security of Supply[34]for energy producers can be described alongside IEA's definition.

Key electricity security terms and definitions[35]

Term	**Definition**
Operational security	The ability of the electricity system to retain a normal state or to return to a normal state after any type of event as soon as possible.
Adequacy	The ability of the electricity system to supply the aggregate electrical demand within an area at all times under normal operating conditions. The precise definition of what qualifies as normal conditions and understanding how the system copes with other situations is key in policy decisions.
Resilience	The ability of the system and its component parts to absorb, accommodate and recover from both short-term shocks and long-term changes. These shocks can go beyond conditions covered in standard adequacy assessments.
Reliability	A metric for the historic or projected availability of electricity supply within a region under all conditions.

[33] World Energy Council, World Energy Trilemma 2024 (2024*): Evolving with Resilience and Justice*

[34] Security of Supply and Electricity Security are often used interchangeably, with the latter's focus on electricity rather than all forms of energy.

[35] IEA - International Energy Agency (2021): *Analytical Frameworks for Electricity Security*

Robustness	The capability of the electricity system to avoid extreme adverse impact. Note: This is not the same as resilience. Robustness is about avoiding impact, but not necessarily by adapting. Resilience can refer to situations with substantial negative impact, but where the system could overcome this, possibly by adaptation.
Stability	The property of the electricity system to maintain the state of operational equilibrium and to recover from disturbances on very short time scales (a few seconds or less). Note: The difference with operational security is that stability always refers to pure electrical disturbances and a return to equilibrium. Security is more general and can cover equipment failure, and does not necessarily imply a return to equilibrium but to within acceptable limits.

For the sake of this chapter, this concept will be broken done to the level of power producers:

"Security of Supply for power suppliers means ensuring that the right amount of energy is available, at the right times, in the right form, and delivered to the right customers so that reliable electricity services can be provided under both normal and stressed conditions."

5.1.1. Ensuring availability and reliability

Ensuring availability is synonymous with providing reliable service. Power suppliers must plan and operate so that capacity and energy are present real-time when needed, and they must be prepared to deliver services even when components fail or unexpected events occur. On-site storage solutions can increase local availability and provide backup during contingencies. Innovation in this field will be a gamechanger. Suppliers must also participate in coordinated system operations and contingency planning so that services continue when things go wrong.

5.1.2. The right amount

Power suppliers must ensure that they have procured or can produce the correct volumes of energy to meet contractual and system obligations. Planning and forecasting are crucial to meet this goal. This requires commercial planning across time horizons: long-term contracts and futures for hedging and adequacy, and active participation in short-term and spot markets to balance real-time positions.

Renewable generators often face curtailment risk when system constraints prevent full injection of available energy. From the view of a power supplier, it has implications on the operation of plants. As wind and solar plants are the easiest to shut down, this decreases the share of renewables in the system leaving a bigger share of fossil sources in the system[36]. In the short term, there is often no viable alternative to curtailment measures to avoid a blackout or regional interruptions of power supply[37]. However, operators that are curtailed are typically compensated for lost production potential. In Germany, a draft of a grid package for the new

[36] Next Kraftwerke (2026): *What is Curtailment of Electricity*

[37] Next Kraftwerke (2026): *What is Curtailment of Electricity*

EEG foresees a re-dispatch reservation for wind plants allowing the grid operator to designate so called capacity limited grid areas. In these areas, operators will need to "waive their entitlement to compensation in the event of redispatch". This would clearly set a negative signal for wind power and should be re-thought.[38]

Managing volume risk therefore involves a mix of contracting, market participation, and flexibility measures such as storage or demand response. Intelligent grid management and dispatch could be the solution to this issue.

5.1.3. The right time

Security of supply requires matching energy delivery to temporal demand patterns, including intra-day variability and seasonal cycles. Temporal mismatch is a particular challenge for many renewables because production profiles can be highest in seasons or hours that do not align with peak demand, for example lower wind and solar output in winter when heating demand rises. Flexibility again will help levelling positive and negative production spikes, such as the typical duck curve for PV production.

5.1.4. The right form

Electricity must be delivered in forms and with qualities that the grid and customers require. Beyond energy, power suppliers provide essential ancillary services such as frequency regulation, voltage support, fast reserves, and black-start capability. Some generators, such as large pumped-storage plants or thermal plants, can perform black starts and restore service without external supply; these capabilities are critical in system restoration and resilience planning. As inverter-based resources increase, suppliers must also invest in technologies and control firmware that can provide grid-forming behavior and emulate traditional synchronous services where needed.

5.1.5. Customers

Customers are heterogeneous and have diverse needs, ranging from single households to industrial parks, campuses, cities, and critical infrastructure. Power suppliers must tailor products and service capabilities to different customer segments and ensure reliable access. Customers should be also educated/incentivized to plan their energy consumption; E.g. switching on household devices during day time; consumption curtailment for industry venues either voluntary or mandatory. Demand response programs on national or local levels can increase power consumption in businesses in hours[39].

5.1.6. "Under normal and stressed conditions" - Resilience

Resilience means the ability to withstand, adapt to, and recover from shocks. This becomes even more relevant in our digital area. But not only cyber risks (see below) also hardware outages have to be tackled within minimum required time.

The following sections examine the key prerequisites and considerations for power suppliers, and summarize the main risks, and opportunities following these considerations.

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[38] Taylor Wessing (2026): *The German Government's Grid Package: New Rules for Grid Connection*

[39] Next Kraftwerke (2026): *What is Curtailment of Electricity*

5.2. Risks and interdependencies

The phase-out of fossil and nuclear plants in some systems can increase pressure on flexibility and adequacy.

Power suppliers face multiple risks that affect security of supply. The European Commission bases the risks of security of supply around these core dimensions: natural, accidental, malicious[40]. This paper suggests that a fourth dimension "geopolitical" is introduced since international tensions could have the intent to have effects on security of supply, however not all geopolitical issues affecting security of supply should be viewed as malicious nor accidental.

As suppliers do not act in a vacuum and other players are also part of the equation to cater security of supply, suppliers are also dependent on grid and network resilience; constrained or damaged infrastructure can force curtailment of renewable generation. Gird and network resilience play a crucial role in this regard. Chapter Security of Supply from the perspective of a Gas Transmission System Operator will deep dive into this aspect in greater detail.

5.2.1. Climate Risks

Environmental and climatic variability makes renewable output more weather-dependent and can increase volatility in supply[41]. Events like droughts, heatwaves, or prolonged low-wind periods put stress on deploying energy from renewable sources. This raises forecast errors and volatility. As described later, storage solutions can be the way to mitigate these risks.

5.2.2. Geopolitical Risks

As recent times showed, fossil energy sources are highly affected by geopolitical tensions in different regions. Not only rises in prices but also availability constraints showcased again the importance of energy autonomy. Therefore, renewable energy producing units, often close to where energy is consumed will be a measure to mitigate the risk of geopolitical implications[42]. Geopolitical risk on security of supply show the importance of energy autonomy of Europe. This can be reached through an increase in renewable energy resources while phasing out fossil sources.

Additionally, not only the supply of energy is affected by geopolitical risks. The supply of components underpins security of supply because shortages, long lead times for spare parts or poor quality increase outage and failure risks.

5.2.3. Cybersecurity

As part of critical infrastructure, power plants are a potential target for malicious attacks on a country. However, not only attacks fall under the term cybersecurity, but also unintended cyber incidents could be a problem[43].

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[40] European Commission (2016): Electricity security in the EU: features and prospects

[41] IEA (2025): *Electricity 2025*

[42] Wind Europe (2026): *Wind delivers the energy society wants*

[43] IEA (2021): *Enhancing cyber resilience in electricity systems*

A wide regulatory framework aims at making energy assets “cyber-fit”, such as the NIS2 Directive and the European Union Agency for Cybersecurity (ENISA) guidelines.[44] The NIS2 directive also imposes the obligations to adopt cyber security plans for electricity suppliers and sets EU-wide standards.[45]

Power plants are often complex systems. Following up on the supply chain to prevent potential loop holes for cyberattacks in the delivered good e.g. by requiring certification could be a tool to enhance cyber security preparedness[46]. This holds true for both IT and OT perspectives. This holds especially true for old assets as energy assets often have a long lifetime. Exchanging or updating outdated equipment is a key measure for cyber resilience[47].

The relevance of raising awareness and distributing and sharing information is often overlooked. Since the target for cyber attacks is often one individual, education campaigns on cyber awareness are often a simple tool to prevent potential attacks.

5.3. Opportunities

Despite risks the concept of security of supply and corresponding measures can be identified to strengthen the system while seizing the opportunities lying ahead.

5.3.1. Flexibility and storage solutions

Storage and flexibility resources are central to securing supply in systems with high shares of variable renewables. A variety of solutions are on the table

- short-duration flexibility (batteries, fast-ramping plants),
- medium-duration flexibility (thermal storage, demand response), and
- long-duration options (pumped hydro, hydrogen).

Storage can be co-located with generation or operated as stand-alone assets; the regulatory environment determines the commercial viability of each configuration.
Co-location with flexibility solutions is a good tool to stabilize energy feed-in from renewable sources with delay to avoid feeding into the grid at times of congestion hours. Diversified portfolios that combine renewables with flexible backup become the new normal. Development of battery systems (BESS) is well advanced. Some key challenges of the past were overcome by BESS producers with modular BESS, AI-based energy management, and improved thermal safety through liquid cooling.[48] The deployment of the latest technologies will be crucial to increase security of supply.

Hydrogen as storage medium is also examined on a wide area since it is perceived a potential game changer. However, to produce utility scale hydrogen amount, huge power plants are required. Therefore, countries outside of Europe pose significant opportunities. However, there are market signals that the investment appetite into hydrogen is decreasing. Moreover, the

[44] ENISA (2026): *National Cybersecurity Strategies*

[45] Taylor Wessing (2026): *The NIS2 Directive: Challenges Renewable Energy Companies*

[46] IEA (2021): *Enhancing cyber resilience in electricity systems*

[47] IEA (2021): *Enhancing cyber resilience in electricity systems*

[48] Anengji Power (2026): *What is BESS? The Complete Guide to Battery Energy Storage Systems*

political optimism of previous years seems to be halted. Analysts expect a re-evaluation of the EU hydrogen goals set forth in the RED III directive.[49]

5.3.2. Innovation and Digitalisation

Innovation will be a key supporter of security of supply for power producers. Innovative solutions combined with supportive regulatory frameworks can accelerate deployment of new technologies. New innovations but also recent designs help boost security of supply.

Innovation is also progressing in the development of hardware. An already widely rolled-out development is sensor technology e.g. for ice-related downtimes[50], tracker modules, low wind speed turbines etc. A key technology to ensure security of supply can be grid-forming inverters. Some systems can even provide black-start capacities.[51]

Digitalisation is key for the secure energy system of tomorrow. Despite potentially opening up to cyber-attacks, the benefits of digitalization in the energy system prevail. Remote plant monitoring and failure detection for example, increase speed for intervention and decrease downtimes and allow for stability of supply.

Bundling energy generated by numerous smaller production sites including smaller wind plants, rooftop PV, electric vehicles etc. from different sources is the idea of a virtual power plant (VPP).[52] Dispatching the energy in a streamlined way at the right time, helps balance the system[53][21]. Virtual Power Plants are not only interesting for utilities but also for the private sector with profitability of virtual power plants rising[54]. Currently, Statkraft operates the largest VPP in Europe with “more than 10 GW installed capacity from over 1,000 power generator […] and could power a major city.[55]

However, innovation needs investment. Energy producers need incentives and support in investing into new technology. A beneficial environment should be provided. Business Cases for the respective project must lead to a positive outcome for the power producers. This will help align commercial incentives with system security needs.

5.3.3. Boost for Renewables

To reduce strategic dependencies, Europe should prioritize the environmentally friendly and safe energy sources it controls domestically: renewables. Accelerating renewable deployment while minimizing risks and capturing opportunities is the way forward. Power suppliers should be incentivized to expand their portfolios and invest in new plants, supported by secured revenue (e.g., PPAs, tariffs or contracts for difference) to buffer market volatility. Market design (e.g., merit-order dispatch) should remain efficient while valuing flexibility and system services. Punitive redispatch/curtailment regimes would deter new investment. Local regulations and

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[49] FCW Inc (2026): *Hydrogen Sector Faces 'Year of Reckoning' In 2026 as EU Mandates Waver and Middle East Ambitions Falter, Warns Wood Mackenzie*

[50] APG (2022): *Ice build-up on wind turbines*

[51] Federal Ministry for Economic Affairs and Energy (2025): *Grid-forming inverters as a cornerstone of future power system stability*

[52] Statkraft (2026): *Virtual power plants*

[53] POWER (2025): *How Virtual Power Plants Enhance Grid Operations and Resilience*

[54] POWER (2025): *How Virtual Power Plants Enhance Grid Operations and Resilience*

[55] Statkraft (2026): *Virtual power plants*

spatial planning must balance rapid renewable deployment with the protection of nature and biodiversity. This boost for renewables would contribute to security of supply.

6. Security of Supply from the perspective of a Gas Transmission System Operator

6.1. Understanding Security of Supply in the Gas and Hydrogen Sector

Security of supply is a fundamental requirement for any energy system and depends on a range of factors, including reliable infrastructure, diversified supply routes, effective crisis management and long-term adaptability of the system.
For Austria, security of supply, with regard to natural gas and hydrogen, has a particular strategic relevance. As a central European transit country, Austria must ensure that domestic demand is met at all times while at the same time maintaining its role as a reliable partner in cross-border energy transport. The intended transformation of the energy system, including the gradual shift from natural gas to hydrogen and other low-carbon gases, adds complexity but also creates opportunities to strengthen resilience over the long term.

At its core, security of supply relies on a robust and reliable transport infrastructure. This includes pipelines, compressor stations, metering and regulating facilities, and connections to storage sites. These assets must be properly maintained, operated, and, where necessary, expanded to ensure that gas can be transported safely and efficiently to where it is needed.
Long-term security of supply requires continuous investment in infrastructure integrity, digital monitoring, and preventive maintenance. In addition, new infrastructure projects increasingly need to be designed to be H_2-ready, providing the flexibility required for future conversion to hydrogen or the transport of other green gases.
This approach helps safeguard investments while supporting the energy transition.

Another key dimension of security of supply is the ability to deliver gas reliably to customers. Households depend on gas for heating, industrial customers require continuous and predictable supply for their production processes, and power plants rely on gas to provide electricity and system balancing.
This becomes particularly important during periods of peak demand, such as cold winter months. A secure system must be capable of handling these demand peaks without interruptions, even under challenging conditions. The gas volumes imported via Transmission System Operators (TSOs) form the physical basis of supply for Distribution System Operators (DSOs), which deliver the gas to households and other end users through regional distribution networks.

6.2. Key Risks to Security of Supply

6.2.1. Technical and Operational Risks

Like any large-scale infrastructure, gas networks could theoretically be exposed to technical or operational risks. Equipment failures, pipeline damages, compressor outages, or IT-related incidents could potentially reduce transport capacity. In addition, extreme weather events linked to climate change are becoming more frequent and must be taken into account in infrastructure planning and operation.

While such risks cannot be fully eliminated, they can be mitigated through preventive maintenance, high technical standards, and effective contingency planning. For this reason,

gas-TSOs are integrated into national and European emergency and prevention mechanisms, such as the *Gas Preventive Action Plan of the Republic of Austria*.[56]
In general, transmission system operators use a combination of technical, organisational and operational measures to monitor and maintain the integrity of their pipeline networks. These typically include protective systems to prevent corrosion, regular technical inspections of the pipelines, and systematic monitoring of the pipeline routes using different inspection approaches. In addition, operational control systems allow the continuous supervision of network status, while sectionalising devices enable the isolation of pipeline segments in the event of incidents or technical irregularities.[57]

6.2.2. Historical Dependence and Geopolitical Uncertainty

Geopolitical risks play a role in the gas sector. Conflicts, sanctions, and political instability can potentially disrupt gas flows along international transport routes.
Close cooperation with neighbouring countries, transmission system operators, and European institutions is essential to mitigate these risks. Coordinated approaches and solidarity mechanisms are crucial, especially in crisis situations.

Austria has traditionally covered a large share of its natural gas demand through imports from the east. This high level of dependence has created structural vulnerabilities, particularly in times of geopolitical tension. Recent developments have highlighted how strongly energy prices can be affected by political and economic conflicts. In a two-week review published on Gas Connect Austria’s website, the development of the physical gas flows from Russia to Europe at the European entry points in GWh/day units can be found. The data originate from the ENTSOG Transparency Platform[58], to which the European transmission system operators report their data on a daily basis.[59]
Furthermore, due to recent developments, an escalation occurred in the Middle East at the end of February 2026, which has had, or is having, significant effects on the entire world. Shortages always lead to higher prices, and the longer the conflict lasts, the more nervous the market becomes – including the resulting price fluctuations on the wholesale market.

In Austria, no importing company is currently reliant on gas supplies from the Middle East.[60]
The physical supply situation remains stable - gas continues to flow via existing import and transit routes and has been moving into storage since the beginning of April. Furthermore, most end customers have fixed-rate tariffs with their utilities and are not affected by global market fluctuations.[61]

Reducing reliance on single suppliers and routes remains a key priority for strengthening security of supply.
A diversification of transport routes and energy carriers could be a solution to the topic.

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[56] Federal Ministry Republic of Austria Climate Action, Environment, Energy, Mobility, Innovation and Technology (2023): *Gas Preventive Action Plan of the Republic of Austria*

[57] TAG GmbH (2024): *Transmission System*

[58] European Network of Transmission System Operators for Gas (ENTSOG) (2026): *ENTSOG Transparency Platform*

[59] Gas Connect Austria GmbH (2026): *Network information - At a glance - Import from Russia*

[60] FGW - Fachverband Gas Wärme (2026): *Krise im Nahen Osten - Energie*

[61] Gas Connect Austria GmbH (2026): *Energiewirtschaftliche Entwicklungen rund um Iran*

6.2.3. Challenges for Austria in emerging Hydrogen Corridors

Austria has the potential to play an important role in emerging European hydrogen corridors due to its existing infrastructure, central geographic position and established function as as regional gas transit hub. Realising this potential, however, requires timely planning, clear regulatory frameworks, appropriate financing mechanisms and close cooperation at both Austrian and European level.
If hydrogen corridors were to develop in a way that bypass Austria, this could reduce hydrogen transport to and through the country and weaken Austria's role in the future European energy system.

Hydrogen Purity

Hydrogen purity is currently one of the most hotly debated topics when it comes to the successful roll-out of the hydrogen economy and is linked to security of supply. The aim is to agree on a uniform standard across the EU to ensure interoperability between countries. Depending on the application or use of the hydrogen, specific requirements are imposed on its purity or composition. This means that the positions and opinions of relevant stakeholders on this matter sometimes diverge.
In 2025 and 2026, a discussion has emerged in particular regarding the minimum purity grade of 98 mol% versus 99.5 mol%[62][63]. Furthermore, the question is sometimes raised as to whether it makes sense to focus on the molar percentage of hydrogen, or whether it would be more sensible to measure the individual components or impurities and introduce corresponding threshold values.

Both higher and lower degrees of hydrogen purity have advantages, although from Gas Connect Austria's perspective, the advantages of ≥ 98 mol% outweigh the disadvantages.
This paragraph describes a brief overview of the advantages of this purity level.
Among other things, the implementation of many hydrogen projects involving pipelines or storage facilities is likely to be faster with a standard of ≥ 98 mol%, as fewer technical modifications would be required than would be the case with higher purity levels. To achieve higher purity levels, the hydrogen would also need to be further purified, which would incur additional costs, even though only a fraction of hydrogen consumers require purity levels in this range. It should be noted here that even 99.5 mol% would be too low for some applications, such as fuel cells.

Importantly, overly strict purity requirements may also pose risks to security of supply. If hydrogen flows were restricted or interrupted due to not meeting high purity thresholds, this could lead to reduced availability and increased price votality. In this context, a more pragmatic standard supports both market development and system resilience.

Despite numerous differing opinions, the overarching goal must be to agree on a standard that strikes a balance between operational feasibility and cost-efficiency, whilst remaining acceptable to all stakeholders along the hydrogen value chain.[64]

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[62] EASEE-gas Quality Harmonisation Working Group (2026): *EASEE-gas study - Optimum Hydrogen Purity in Europe*

[63] GIE Hydrogen Purity Task Force (2025): *GIE Position Paper on Hydrogen Quality Specifications*

[64] GIE Hydrogen Purity Task Force (2025): *GIE Position Paper on Hydrogen Quality Specifications*

6.3. Opportunities to Enhance Security of Supply

6.3.1. Diversification of Routes and Sources

Diversification is one of the most effective tools to improve security of supply. By ensuring access to multiple supply sources and transport routes, the system becomes less vulnerable to disruptions affecting a single corridor or supplier.
Compared to 2022, Europe today possesses significantly expanded LNG import capacities. This has created additional access to global gas markets and increased the flexibility of the European supply system.[65]

For Austria, diversification means strengthening connections to different entry points, neighbouring markets, and storage facilities. This principle applies not only to natural gas today, but also to hydrogen in the future. Austrian Gas TSOs are therefore involved in various projects and corridors aiming to transport hydrogen to and through Austria, like the SoutH2 Corridor[66] or H2EU+Store[67].

6.3.2. Preparedness and Risk Management

Well-developed crisis management frameworks are essential for dealing with supply disruptions. These include clear emergency procedures, regular risk assessments, stress tests, and close coordination with authorities and market participants.
Preparedness measures help ensure that operators can respond quickly and effectively, limiting the impact of disruptions on customers and the wider economy.[68]
Apart from that TSOs, like Gas Connect Austria, always try to keep planned maintenance periods as short as possible as they can result in temporary capacity reductions. Planned maintenance is announced on GCA's website.[69]

6.3.3. Reverse-Flow Capabilities and Network Flexibility

Selected reverse-flow adaptions can contribute to improving operational flexibility and supporting access to alternative supply routes. The extent to which such measures enhance system flexibility depends on the specific pipeline configuration, technical capabilities and the respective situation.

The West-Austria Gas Pipeline (WAG) is one of the most important transmission system pipelines in Austria. As part of the *WAG Loop 1* project, the section between Oberkappel and Bad Leonfelden is being extended by a 40 km-long parallel pipeline. This project is intended to enhance network flexibility by increasing transport capacity from the west to Austria and neighbouring regions by around 30%, thereby contributing to security of supply.
The WAG was initially optimised for east-west gas transport. This involved laying a parallel pipeline after the compressor stations, but not along the entire length. As a result, the capacity of the pipeline in the reverse direction (from west to east) is much lower than in the original

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[65] Gas Connect Austria GmbH (2026): *Energiewirtschaftliche Entwicklungen rund um Iran*

[66] TAG GmbH, Gas Connect Austria GmbH, bayernets GmbH, Snam S.p.A (2026): *SoutH2 Corridor*

[67] Projektkonsortium H2EU+Store (2026): *H2EU+Store*

[68] Federal Ministry Republic of Austria Climate Action, Environment, Energy, Mobility, Innovation and Technology (2023): *Gas Preventive Action Plan of the Republic of Austria*

[69] Gas Connect Austria GmbH (2026): *Network Information - Maintenance*

east-west flow direction. Over the years, however, there has been an increasing demand for transportation from west to east.
With the discontinuation of gas supplies via Ukraine, the reverse flow compressors reached their limits as they were operated close to capacity to fill storage facilities. Operating a pipeline in reverse flow is inefficient, like driving a car in reverse. The gradual expansion of the WAG is essential to increase the much-needed transport capacity for west-east operations.
Moreover, the project also opens up prospects for a carbon-neutral future, as the pipeline will be suitable for transporting climate-friendly hydrogen in the future.[70]

6.3.4. The Role of Gas Storage

Gas storage is a central pillar of security of supply. Access to sufficient storage capacity allows seasonal demand fluctuations to be balanced and provides a crucial buffer in the event of sudden supply interruptions. Storage facilities therefore play a key role in stabilising the system during winter periods, prolonged cold spells, or major supply disruptions.
In addition to underground storage, the pipeline system itself contributes to short-term flexibility through linepack. By temporarily increasing or decreasing the amount of gas held within the network, operators can absorb intraday imbalances, respond to unexpected demand spikes, and stabilise pressures across the system. While linepack cannot replace dedicated storage facilities, it serves as an important complementary flexibility option.
Well-integrated storage sites, combined with the effective use of linepack, significantly enhance system resilience. Together, they support both short-term operational needs and long-term security of supply, ensuring that the network can respond to rapidly changing conditions as well as sustained periods of stress.

In Austria in 2022, the amendment to the Gaswirtschaftsgesetz mandated the procurement of a strategic gas reserve totalling 20 TWh, to be funded from federal resources. In accordance with § 169 Abs 9 of the Gaswirtschaftsgesetz, this was due to expire on 1 April 2027. On 11 March 2026, Federal Minister Hattmannsdorfer announced the extension of the strategic gas reserve. At a time of geopolitical tensions, the strategic reserve ensures security and thus helps to stabilise prices on the wholesale market[71].

6.3.5. Hydrogen Infrastructure and the Strategic Role of Baumgarten

The integration of low-carbon hydrogen into the energy system presents a major opportunity to enhance long-term security of supply. Existing gas infrastructure and market hubs can be leveraged to facilitate the transition and accelerate hydrogen market development.
In this context, the further development of Baumgarten as a hydrogen hub represents a strategic opportunity for Austria. Building on its established role as a central gas hub, Baumgarten could secure access to hydrogen for the Austrian market while maintaining the country's strategic importance within the European energy system.
A hydrogen hub at Baumgarten would support cross-border trade, enable diversification of supply sources, and strengthen security of supply in a decarbonised system.

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[70] Gas Connect Austria GmbH (2026): *Projects - WAG Loop 1*

[71] FGW - Fachverband Gas Wärme (2026): *Strategische Gasreserve*

6.3.6. Sector Coupling and Multi-Purpose Infrastructure

Sector coupling offers additional opportunities to enhance security of supply by linking gas/hydrogen, electricity and heat systems. This integration allows flexibility in one sector to compensate for constraints or disruptions in another, thereby increasing overall system resilience.
Gas Connect Austria, for example, has planned the *Power-to-Gas for Austria* project in collaboration with Austrian Power Grid, which aims to convert surplus electricity into hydrogen. This would have involved building a 50 MW plant, which would have been made available to the market on a non-discriminatory basis. At present, this is not permitted.

Gas and hydrogen infrastructure can provide storage and balancing services for the electricity system, particularly during periods of high renewable generation volatility.
In the long term, adapting infrastructure for multi-purpose use - including hydrogen, biomethane, and synthetic gases - reduces the risk of stranded assets while supporting both decarbonisation objectives and security of supply. This approach maximises the value of existing infrastructure and ensures its continued relevance in a rapidly evolving energy system.

7. Security of Energy Supply from the Perspective of Industrial Production

7.1. Starting point: Why the Energy Trilemma is decisive for industry

The Energy Trilemma describes the systemic challenge of designing an energy system that is simultaneously (i) secure, (ii) affordable/accessible (equity), and (iii) environmentally sustainable (sustainability). The World Energy Council (WEC) explicitly defines these three dimensions as the core of the Trilemma Framework and uses them to assess national energy systems.[72]
For industrial production, the Trilemma is particularly relevant because industrial companies depend on reliable energy availability, predictable costs, and compatible decarbonisation pathways to safeguard investment, utilisation, and delivery capability. These tensions were significantly intensified by the 2021–2023 energy crisis and the renewed energy crisis triggered by the current Iran conflict, and have since moved further into the focus of energy and industrial policy.[73]

Industrial lens:
For manufacturing, the Trilemma is not an abstract policy triangle—it directly translates into three operational constraints that shape productivity, quality, and delivery reliability:

1. **Security of supply as operational continuity:** Industrial output is highly sensitive not only to long outages but also to short disturbances. Many plants experience disproportionate losses due to restart times, quality disruptions, and logistics knock-on effects (e.g., missed shipment slots, downstream line stoppages). Security, therefore, is fundamentally about maintaining continuity of energy services at the point of use—not merely “having energy somewhere in the system.[74]

[72] *World Energy Council (2024): World Energy Trilemma 2024: Evolving with Resilience and Justice.*

[73] Publications Office of the European Union (2024): *Study on Energy Prices and Costs: Evaluating Impacts on Households and Industry — 2023 Edition*.

[74] International Energy Agency (IEA) (2021): *Analytical Frameworks for Electricity Security*.

2. **Affordability as competitiveness and investment certainty:** Energy is both a variable cost (OPEX) and a determinant of investment decisions (CAPEX). Sustained high prices can reshape industrial structure by encouraging the relocation of energy-intensive stages or reducing domestic value-add. EU-level assessments stress that the recent price shock had significant consequences for industry and public finances, reinforcing the link between price stability and economic resilience.[75]
3. **Sustainability as license-to-operate and market access:** Decarbonisation is increasingly tied to compliance, customer expectations, financing conditions, and reputational risk. Firms face a practical challenge: decarbonise at pace while maintaining production stability and cost competitiveness—i.e., manage trade-offs rather than allow them to become unintended constraints.[76] [77]

Practical translation of the Trilemma for industry:

• **Energy security:** Can production run reliably – even under shocks (scarcity, grid outages, geopolitical risks)?

• **Equity/affordability:** Are energy and system costs competitive and predictable?

• S**ustainability:** Can emissions be reduced and regulatory requirements be met without jeopardizing security of supply?

What "shocks" mean for factories: From an industrial perspective, "shocks" include at least four categories, each with distinct mitigation levers:

- **Fuel and price shocks** (e.g., sudden cost spikes transmitted via electricity/gas markets), affecting margins and planning
- **Physical system shocks** (e.g., extreme weather, plant or line outages, transformer failures), affecting reliability and availability
- **Geopolitical supply shocks** (e.g., import disruptions, sanctions, regional conflicts), affecting fuels, materials, and upstream supply chains
- **Transition-related shocks** (e.g., tighter adequacy margins during the build-out phase, permitting delays, ramping constraints), affecting adequacy and stability

7.2. Energy security in transition: From supply to resilience

Historically, energy security was often understood as safeguarding energy supply (energy carriers, imports, infrastructure). However, the WEC emphasizes that the security dimension in modern energy systems has evolved: in addition to "traditional" supply security, it now includes system resilience, reliability in a renewable and digitalised system, critical raw materials, and physical as well as cyber risks.[78]

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[75] *Publications Office of the European Union (2024): Study on Energy Prices and Costs: Evaluating Impacts on Households and Industry — 2023 Edition.*

[76] *World Energy Council (2024): World Energy Trilemma 2024: Evolving with Resilience and Justice.*

[77] *Siemens Energy AG (2024): Sustainability Report 2024.*

[78] *World Energy Council (2024): World Energy Trilemma 2024: Evolving with Resilience and Justice.*

Why "resilience" is now central:
In highly electrified and increasingly digital energy systems, security is less about a single "supply chain" and more about system performance under stress—i.e., the ability to absorb disruptions and recover with minimal industrial impact. Resilience therefore includes:

- **Operational resilience** (frequency stability, voltage support, contingency handling)
- **Infrastructure resilience** (grid reinforcement, redundancy, maintenance regimes)
- **Market and governance resilience** (coordination protocols, emergency procedures, transparency)[79] [80]

This expansion is central for industry because decarbonisation and electrification increase dependence on power-system stability, bringing questions of grid capacity, flexibility, and crisis preparedness more strongly into focus. Austria addresses this development explicitly in its Electricity Security of Supply Strategy, which highlights the growing importance of electricity across different sectors and the need for resilience measures.

Austria-specific implications for industry:
Austria's pathway toward higher renewable shares and electrification raises the importance of:

- **Flexibility and balancing capability** to manage variable generation
- **Grid connection and capacity availability**, especially for industrial expansion and electrified process step
- **System-level preparedness** for adverse conditions and compound events (e.g., high demand + low renewable output + outages) [81] [82]

At EU level, energy security is also operationalised through crisis-preparedness obligations:
• For electricity, Regulation (EU) 2019/941 sets a framework for risk assessment, crisis planning, and cooperation.

• For gas, Regulation (EU) 2017/1938 establishes mechanisms to safeguard security of gas supply, including risk assessments and emergency plans.

7.3. Energy security from the perspective of industrial production: Four core aspects

For manufacturing companies, energy security is not merely a macro indicator, but an operationally experienced reality. With a view to industrial production in Austria, it can be structured into four aspects:

Availability & adequacy – "Is there enough energy?"

Industry requires sufficient power (kW/MW) and energy (kWh/MWh), particularly during load peaks (start-up, test bays, process heat) and with increasing electrification. EU risk-prevention

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[79] *European Union (2019): 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.*

[80] *International Energy Agency (IEA) (2021): Analytical Frameworks for Electricity Security.*

[81] *Republic of Austria (2024): Elektrizitäts-Versorgungssicherheitsstrategie.*

[82] *E-Control (2025): Monitoringreport Versorgungssicherheit Strom 2025*

logic (electricity) targets, among other things, such adequacy risks and coordinated preparedness.[83]
For Austria, the E-Control Monitoring Report on Electricity Security of Supply 2025 provides a systematic assessment of generation, demand, networks, and future pathways through to 2040.[84]

What "adequacy" means in practice: For plants, adequacy is not only about annual energy volumes but also about:

- **Peak capacity availability**: whether enough capacity exists during rare but critical hours (cold snaps, heatwaves, low-wind periods).
- **Local deliverability**: whether the grid can physically deliver required power at the plant's location (congestion, transformer limits, maintenance outages).
- **Ramp capability and contingency margins**: whether the system can quickly respond to sudden imbalances without load shedding.[85]

From an industrial planning perspective, adequacy translates into confidence that:

- expansions (new lines, electrified heating, test infrastructure) can be connected on time,
- production will not face systematic curtailment risk during stressed conditions, and
- price spikes caused by scarcity will not become structural.[86]

Reliability & power quality – "Does the supply remain stable?"

Industry does not only react to blackouts, but also to short interruptions, voltage dips, or other disturbances that can cause restarts, quality losses, or plant shutdowns. The Austrian security-of-supply strategy addresses action fields to increase the resilience of the electricity system; the E-Control Monitoring Report covers, among other things, networks, availability, and measures in extraordinary situations.[87] [88]
As an analytical framework for reliability and outage impacts, the IEA publication on electricity security frameworks is also relevant (definitions, outage costs, institutional responsibilities, and adaptation to cyber/climate).

Industrial sensitivity mechanisms: In many manufacturing environments, the cost of a disturbance is driven by:

- **Restart and stabilisation time** (minutes to hours)
- **Quality impacts** (scrap, rework, testing repetition)

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[83] *European Union (2019): 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.*

[84] *E-Control (2025): Monitoringreport Versorgungssicherheit Strom 2025*

[85] *European Union (2019): 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.*

[86] *Publications Office of the European Union (2024): Study on Energy Prices and Costs: Evaluating Impacts on Households and Industry — 2023 Edition.*

[87] *Republic of Austria (2024): Elektrizitäts-Versorgungssicherheitsstrategie. Republic of Austria.*

[88] *E-Control (2025): Monitoringreport Versorgungssicherheit Strom 2025 (Berichtsjahr 2024).*

- **Process integrity risks** (thermal cycles, curing/drying, precision machining stability)
- **Safety and compliance** (controlled shutdown requirements)

Consequently, improving reliability is not limited to preventing blackouts; it also includes:

- **power quality management** (voltage stability, protection coordination),
- **redundant supply architecture** (internal network design, critical feeders), and
- **operational procedures** that enable controlled reduction rather than uncontrolled outage.[89] [90]

Affordability & competitiveness – "Do I remain internationally competitive?"

For industry, energy security is closely linked to price risks and competitiveness. The EU study on energy prices and costs describes how the 2021–2022 price peaks affected competitiveness and the economic stability of households and companies. For Austria, model-based analyses show that persistently higher energy prices can reduce industrial production and employment and increase the offshoring risk for energy-intensive production stages.

How affordability links back to security: Affordability influences security of supply through multiple feedback loops:

- If industrial demand is destroyed through sustained high prices, system adequacy may appear "easier" in the short run, but at the cost of deindustrialisation and loss of investment capacity for modernisation.
- High prices can slow electrification and efficiency upgrades, delaying structural measures that would otherwise reduce exposure to fuel imports and scarcity.[91] [92]
- Price volatility can undermine long-term contracting and planning for flexibility resources, storage, and grid upgrades—measures that directly support resilience.[93] [94]

This makes a central Trilemma trade-off visible: measures to accelerate decarbonisation can increase costs in the short term or raise flexibility needs; conversely, a focus on short-term security of supply (e.g., fossil-based back-ups) can weaken sustainability goals. The WEC emphasizes that actively managing these trade-offs is at the core of the Trilemma logic.

Resilience against shocks – "How robust is my operation in the face of disruptions?"

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[89] *Republic of Austria (2024): Elektrizitäts-Versorgungssicherheitsstrategie. Republic of Austria.*

[90] *International Energy Agency (IEA) (2021): Analytical Frameworks for Electricity Security.*

[91] *International Energy Agency (IEA) (2025): Energy security.*

[92] *Austrian Institute of Economic Research (WIFO) (2023): Competitiveness of Austrian Industry with Continued High Energy Prices.*

[93] *Publications Office of the European Union (2024): Study on Energy Prices and Costs: Evaluating Impacts on Households and Industry — 2023 Edition.*

[94] *European Parliament (2025): Increasing Flexibility in the EU Energy System: Technologies and policies to enable the integration of renewable electricity sources.*

Resilience encompasses, in addition to systemic shocks (extreme weather, grid disturbances, geopolitical supply disruptions), cyber risks driven by increasing digitalisation. The WEC explicitly embeds cyber and physical threats in the evolving understanding of energy security.[95]

Resilience as a layered concept for plants: For industrial operations, resilience can be viewed as layered capabilities:

- **Prevent**: reduce likelihood (maintenance, redundancy, diversified procurement, hardening critical systems)
- **Absorb**: reduce immediate impact (UPS for controls, ride-through capability, operational buffers)
- **Respond**: execute controlled load reduction, safe shutdown, rapid repair coordination
- **Recover**: restart quickly with minimal quality loss and stable logistics[96]

7.4. Why Energy Efficiency and Industrial Flexibility Can Strongly Enhance Security of Supply

7.4.1. Energy efficiency as a "first fuel" for security of supply

Energy efficiency improves security of supply by reducing total energy demand and therefore lowering exposure to import dependencies, fuel-price shocks, and system stress during tight supply conditions. The IEA explicitly links efficiency to energy security, noting that efficiency gains can reduce reliance on fossil fuel imports and act as a buffer against supply disruptions. In industrial settings, efficiency measures (e.g., high efficiency motors/drives, waste heat recovery, compressed-air optimisation, process control) not only cut consumption but also reduce peak loads, which directly improves power-system adequacy and reliability—key objectives in European electricity security frameworks.[97] [98]
From a system perspective, lower demand eases the need for scarce dispatchable capacity and grid reinforcements, thereby helping maintain supply security at lower cost. This is consistent with the WEC's Trilemma framing: security is increasingly about resilience and the ability to "withstand and bounce back" from shocks—something efficiency supports by reducing system strain.
Industrial relevance in Austria: Austria's security-of-supply strategy emphasizes that electrification increases the importance of a resilient electricity system; efficiency is a structural tool to manage rising demand without compromising reliability.[99] [100]

How efficiency strengthens security concretely: Efficiency contributes to security of supply through three concrete mechanisms:

1. **Adequacy relief:** Lower system demand reduces the probability of scarcity hours and lowers the amount of backup/peaking capacity needed.

[95] *World Energy Council (2024): World Energy Trilemma 2024: Evolving with Resilience and Justice.*

[96] *International Energy Agency (IEA) (2021): Analytical Frameworks for Electricity Security.*

[97] *International Energy Agency (IEA) (2025): Energy security.*

[98] *International Energy Agency (IEA) (2021): Analytical Frameworks for Electricity Security.*

[99] *Republic of Austria (2024): Elektrizitäts-Versorgungssicherheitsstrategie. Republic of Austria.*

[100] *E-Control (2025): Monitoringreport Versorgungssicherheit Strom 2025*

2. **Grid relief:** Lower peak demand reduces congestion and defers costly network reinforcement, supporting deliverability to industrial nodes.

3. **Price resilience:** Reduced exposure to marginal fossil generation lowers vulnerability to fuel-driven price spikes, supporting competitiveness and investment planning.

7.4.2. Industrial flexibility: turning demand into a reliability resource

Industrial flexibility (demand response, load shifting, controlled curtailment, on site storage, self-generation) supports security of supply by enabling the system to balance supply and demand under stress—especially with higher shares of variable renewables. EU crisis preparedness rules for electricity explicitly aim to strengthen risk assessment and coordinated measures to prevent and manage electricity crises; demand-side resources are part of the toolbox that can mitigate scarcity events before they escalate.[101] Flexibility is increasingly central to European policy and system planning. EU level analyses highlight that demand response and storage are critical across timeframes (intra-day through seasonal) to integrate renewables while maintaining reliability, which directly strengthens the "security" dimension of the Trilemma.[102]

Further detail (industrial flexibility typology): Industrial flexibility is not one single measure; it spans a portfolio with different response times and business impacts:

- **Fast response (seconds–minutes):** temporary load reduction or ride-through actions that stabilise operations and support grid stability.
- **Operational shifting (hours):** rescheduling energy-intensive steps to off-peak or high-renewable windows.
- **Strategic flexibility (days–weeks):** maintenance scheduling, inventory buffering, and flexible production planning to avoid exposure during high-risk periods.

Why this matters for industrial production: flexibility improves operational security in two directions:

1. **System-level security:** reduces Loss of Load risk in tight situations by lowering peak demand or providing rapid response.

2. **Plant-level resilience:** enables factories to maintain critical operations through controlled load management rather than uncontrolled outages.

7.4.3. Practical enablers for industry: combining efficiency + flexibility

A robust approach is to treat efficiency and flexibility as complementary layers:
• Efficiency reduces the baseline and peak, shrinking the problem the system must secure.[103]

[101] *European Union (2019): 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.*

[102] *World Energy Council (2024): World Energy Trilemma 2024: Evolving with Resilience and Justice.*

[103] *International Energy Agency (IEA) (2025): Energy security.*

• Flexibility provides operational options (shift/curtail/store) when the system is stressed, supporting adequacy and reliability.[104]

Implementation logic for factories: To convert flexibility into a reliable security contribution, industrial sites typically need:

- **Measurement and controllability** (sub-metering, control logic, clear load segments)
- **Operational rules** (what can be shifted/curtailed, for how long, with what quality constraints)
- **Market or grid interfaces** (participation in DR programs, contractual interruption options, internal response procedures)[105] [106]

For Austria specifically, where the system is expected to become more weather-dependent and where long-term security planning highlights the role of flexibility and storage, industrial efficiency and flexibility can be positioned as high-impact contributions to national supply security—often faster to deploy than large infrastructure, while also supporting competitiveness.[107] [108]

7.5. Example: Integrated Energy System for Industrial Production

In the following chapter a best practice example is described. The example shows how an integrated energy system that incorporates energy efficiency and provides flexibility can be designed.

Figure 1 shows the conventional energy system that was planned for a factory before optimization. The main consumers of energy in this factory are drying furnaces, climate chambers, oil treatment plants and the production buildings. Process heat is provided through electrical heaters and green district heating where appropriate. The electrical energy is provided fully by the power grid. The cooling power for buildings and processes is being provided by central chiller units.

[104] *International Energy Agency (IEA) (2021): Analytical Frameworks for Electricity Security.*

[105] *European Parliament (2025): Increasing Flexibility in the EU Energy System: Technologies and policies to enable the integration of renewable electricity sources. European Parliament.*

[106] *European Union (2019): 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.*

[107] *E-Control (2025): Monitoringreport Versorgungssicherheit Strom 2025*

[108] *Republic of Austria (2024): Elektrizitäts-Versorgungssicherheitsstrategie. Republic of Austria.*

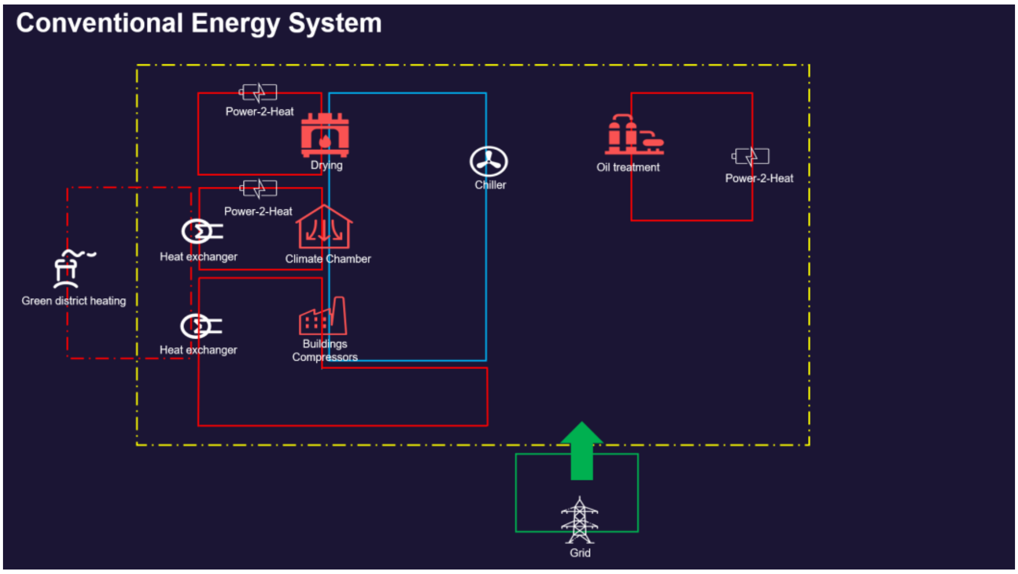

Figure 1: Conventional Energy System before Optimization

The first step towards an integrated energy system was to incorporate energy efficiency measures and onsite energy production. Figure 2 shows the implementation of a solar power plant, a battery electric stationary storage and a waste heat recovery system. The waste heat recovery system is a two-stage heat pump system that provides the necessary cooling power on the one side and lifts the temperature level of the collected waste heat to a level where it can be utilized for the oil treatment plants and building heating systems.

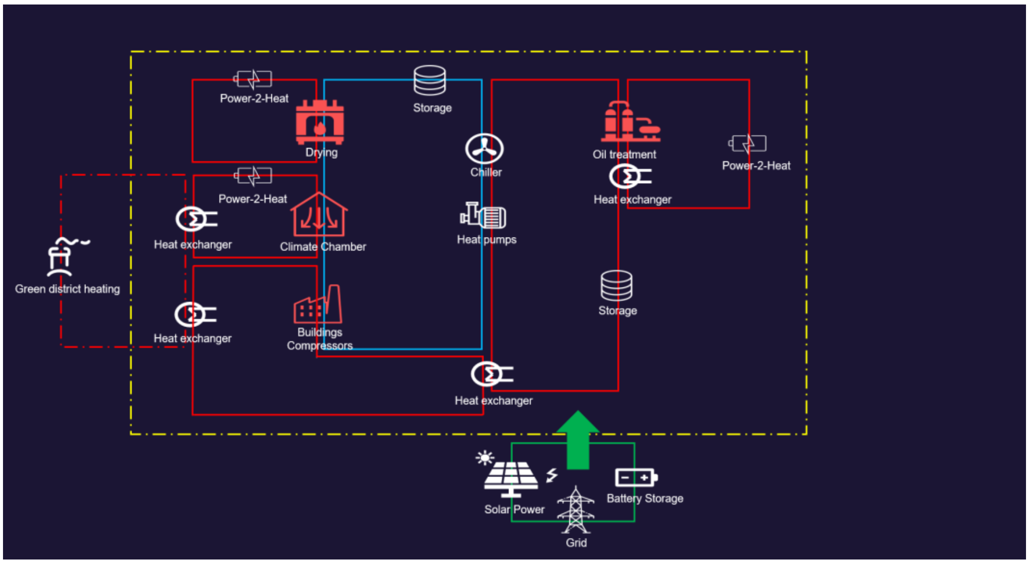

Figure 2: Adding onsite energy production, storage and waste heat recovery

Figure 3 shows the introduction of a Smart Energy Management system. This system consists of a factory wide SCADA-System to collect energy consumption data and control the factory's assets. The consumption data is subsequently enriched with production schedules, weather forecasts and energy price forecasts. This data is used to feed an optimization model that gives back:

- A forecasted load profile for the factory's energy consumption
- An optimized production plan considering energy cost reductions

- Optimized dispatch plans for flexible assets (e.g. heat pumps, battery storage, processes) based on weather & price forecasts

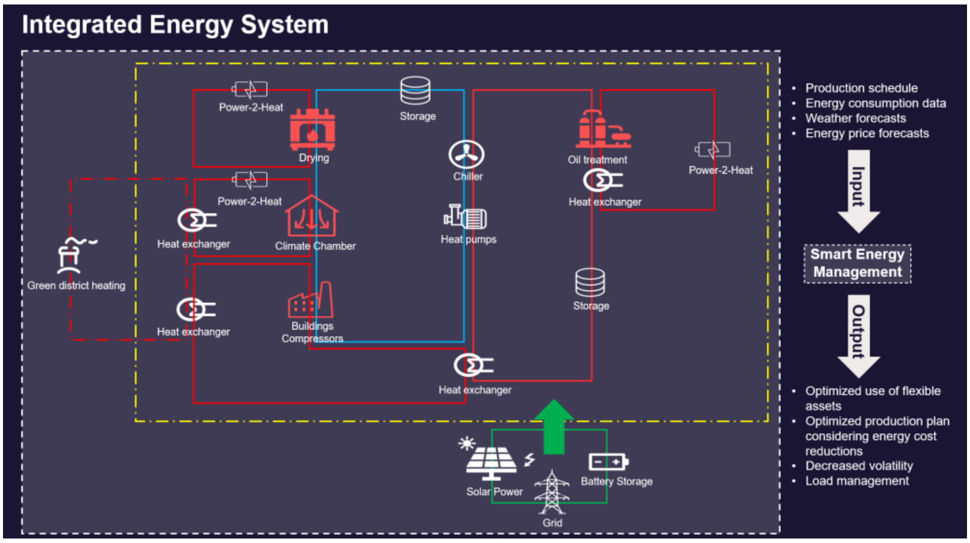

Figure 3: Integrated Energy System including Smart Energy Management

The implementation of this integrated energy system reduces the energy demand by 20-30%. Furthermore, the intra-day fluctuations in electricity prices can be utilized. The system would also allow for participation in balancing energy markets which would contribute to national grid stability. Altogether the system increases the energy resilience of the production, decreases the energy costs and contributes to security of supply.

8. Recommendations for Action

Based on an examination of the different perspectives, clear recommendations for action across all dimensions can be deducted:

→ Accelerate infrastructure expansion and system integration
Speed up the build-out of cross-border interconnectors, domestic grids, and smart network infrastructure, while aligning planning across electricity, gas, and emerging hydrogen systems to manage interdependencies and avoid bottlenecks or cascading risks.

→ Scale flexibility and storage across all time horizons
Expand short-, medium-, and long-duration flexibility options such as batteries, pumped hydro, thermal storage, hydrogen, demand-side response, and sector coupling to manage renewable variability, reduce system stress, and maintain adequacy.

→ Reduce structural dependencies and external exposure
Strengthen domestic renewable generation and diversify supply sources and routes to reduce vulnerability to geopolitical shocks, price volatility, and supply chain disruptions.

→ Strengthen crisis preparedness and operational resilience
Continuously improve preventive action plans, emergency frameworks, and coordination between authorities, system operators, market participants, and European partners, supported by stronger cybersecurity, redundancy, storage access, and emergency communication.

→ Ensure system stability during the energy transition
Match electrification and renewable integration with timely grid modernisation, sufficient dispatchable capacity, and reliable system services so that decarbonisation progresses without undermining reliability or security of supply.

→ Create bankable conditions for investment and industrial capacity
Provide stable regulatory frameworks, predictable returns, faster permitting, and targeted incentives to unlock investment in renewables, storage, flexibility, grids, and European manufacturing capacity for technologies such as transformers, inverters, battery cells, and electrolysers.

→ Improve industrial resilience through efficiency, flexibility, and digital control
Lower baseline and peak demand through efficiency measures, build operational flexibility through load shifting and on-site assets, and use integrated energy management systems and crisis procedures to protect production continuity, control costs, and support decarbonisation.

9. Conclusion: Security of Supply in the Context of the Energy Trilemma

Security of supply remains a central pillar of the **Energy Trilemma**, alongside affordability and sustainability. As highlighted throughout this report, these three dimensions are no longer separable policy objectives but increasingly interdependent and, at times, in tension with one another. Ensuring a secure energy system in Europe and Austria therefore requires not only maintaining reliable supply, but also actively managing trade-offs between decarbonisation, cost competitiveness, and system resilience.

Across all perspectives presented in this report—European policy, national governance, power producers, transmission system operators, and industrial consumers—a clear shift becomes evident: **security of supply is evolving from a question of availability to a question of resilience**. In a highly interconnected, decarbonised, and digitalised energy system, risks are no longer isolated but systemic, often crossing sectoral and geographic boundaries.

At the **European level**, security of supply is increasingly understood as a collective responsibility. The integration of electricity markets, the expansion of cross-border infrastructure, and coordinated risk preparedness frameworks demonstrate that national solutions alone are no longer sufficient. At the same time, the energy transition introduces new challenges, including variability of renewable generation, infrastructure bottlenecks, and dependencies on critical raw materials. Addressing these risks requires enhanced cooperation, investment certainty, and a stronger alignment between national and EU-level strategies.

From the **Austrian governmental perspective**, a comprehensive and well-structured framework for crisis preparedness and energy governance is already in place. Austria benefits from strong legal foundations, high storage capacities—particularly in the gas sector—and well-developed institutional coordination. However, structural challenges remain, most notably import dependency, geopolitical exposure, and increasing system complexity driven by the energy transition. The growing interdependencies between electricity, gas, and other sectors further underline the need for integrated system planning.

From the perspective of **energy producers and infrastructure operators**, security of supply is ultimately operationalised in real time. It requires ensuring that energy is delivered in the right amount, at the right time, in the right form, and to the right customers—under both normal and stressed conditions. This highlights the importance of flexibility, system services, and technological innovation. At the same time, producers and operators are increasingly exposed to new types of risks, including climate variability, cyber threats, and evolving market conditions. Their ability to respond to these challenges depends heavily on stable regulatory frameworks and viable business models.

The **gas and emerging hydrogen sector** illustrates both the risks and opportunities of the current transition. While geopolitical uncertainties and historical dependencies remain critical challenges, investments in diversification, storage, and infrastructure flexibility—such as hydrogen-ready networks—offer pathways to enhance long-term resilience. Austria's strategic position as a transit country and potential hydrogen hub further emphasises the importance of forward-looking infrastructure planning.

From an **industrial perspective**, security of supply translates directly into operational continuity, competitiveness, and investment certainty. Even short disruptions or price spikes can have disproportionate impacts on production processes. This makes clear that energy security is not only a system-level concern but also a key determinant of economic resilience. Industrial energy efficiency and flexibility emerge as particularly powerful tools, as they simultaneously reduce system stress, enhance resilience, and support decarbonisation.

Across all chapters, a number of **common key insights** emerge:

- Security of supply is increasingly **systemic and cross-sectoral**, requiring integrated approaches rather than siloed solutions.
- **Flexibility, storage, and digitalisation** are becoming central enablers of system stability.
- **Geopolitical and climate-related risks** are gaining importance and must be addressed proactively.
- **European cooperation** is essential to manage interdependencies and ensure effective crisis response.
- **Market design and regulatory frameworks** must align economic incentives with system security needs.

Ultimately, the transformation of the energy system does not weaken security of supply—but it fundamentally **changes its nature**. A resilient system is no longer defined by excess capacity alone, but by its ability to anticipate, absorb, and recover from disruptions.

In this context, the Energy Trilemma provides a useful framework to guide policy and investment decisions. Strengthening security of supply must go hand in hand with ensuring affordability and advancing sustainability. This requires a careful balancing of short-term stability and long-term transformation.

Looking ahead, maintaining security of supply in Austria and Europe will depend on:

- continued investment in infrastructure and flexibility,
- stronger integration of energy sectors and markets,
- innovation and digitalisation, and
- coordinated governance across all levels.

If these elements are successfully aligned, the energy transition can not only maintain but ultimately **enhance security of supply**, while delivering a more sustainable, resilient, and competitive energy system.

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ÜBER DEN WORLD ENERGY COUNCIL AUSTRIA

Der World Energy Council Austria ist das **österreichische Nationalkomitee des World Energy Council** und **Gründungsmitglied** der internationalen Mutterorganisation. Der World Energy Council und damit der World Energy Council Austria feierten im Jahr **2023** ihren **100. Geburtstag**. Der Sitz der Mutteroganisation befindet sich in London, der Sitz der österreichischen Organisation seit Beginn der Aktivitäten an in Wien. Die Tätigkeiten orientieren sich bzw. gliedern sich in die Aktivitäten der Mutterorganisation ein. Dabei gilt jedoch immer ein von den Mitgliedsorganisationen gesetzter individueller und bedarfsorientierter Fokus. Mit einem engagierten Team und einem starken Netzwerk konnte der WEC Austria seine Aktivitäten gerade in den letzten Jahren weiter ausbauen und Sichtbarkeit gewinnen. Eine Besonderheit des WEC Austria ist die durch den Sitz in **Wien** bedingte enge Beziehung zu einer **Vielzahl internationaler Organisationen**, zu denen über den Vienna Energy Club formelle Beziehungen etabliert werden konnten.

In Österreich sind maßgebende Unternehmen, Organisationen und Verbände Mitglied. Die nationale Organisation unterstützt **globale, nationale und regionale Energieinitiativen** durch hochkarätige **Veranstaltungen**, wissenschaftliche Studien und Ausarbeitungen über die aktuelle Energiesituation im Konnex mit den europäischen und globalen Herausforderungen. Dialoge unter den Mitglieds-organisationen und die Förderung von **Young Energy Professionals** (YEP) sind ein wesentlicher Bestandteil.

Der **Nutzen für Mitglieder** liegt vor allem in dem breiten Portfolio von Aktivitäten des World Energy Council Austria:

1. Sicherung des Zuganges zu den Studien, Ausarbeitungen und Veranstaltungen des World Energy Council, der **einzigen weltweiten Nicht-Regierungs-organisation im Bereich Energie**.
2. Bereitstellung des **globalen Netzwerkes** für nationale und internationale energiewirtschaftliche Fragestellungen.
3. Möglichkeit der unmittelbaren **aktiven Teilnahme** an den energie-wirtschaftlichen **Arbeiten des World Energy Council** und damit an der aktiven Mitgestaltung von langfristigen strategischen Zielen der **Energie-transformation**.
4. Behandlung aktueller Fragen der Energiewirtschaft in den eigenen **Gremien**, in öffentlichen **Veranstaltungen** sowie durch **Veröffentlichungen** und damit Verbreitung von Fachwissen sowie Meinungsbildung in energiewirtschaftlichen und energiepolitischen Fragen.
5. **Plattform** für auf Konsens aufgebaute Informations- und Lobbying Arbeit.

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