Nordic Energy
Research

ENERGY SECURITY IN THE NORDICS

Contents

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FOREWORD: CRUCIAL COOPERATION IN UNCERTAIN TIMES

Secure, affordable, and clean energy is fundamental to realising the Nordic vision of becoming the most sustainable and integrated region in the world. Yet, in a time of geopolitical uncertainty, securing supply chains, power grids, and enabling technologies for an increasingly electrified society remains a major challenge.

Energy security is a prerequisite for both national security and industrial competitiveness. It carries strategic, political, and economic implications for countries and citizens alike, as well as for Nordic and international cooperation. If the Nordic countries are to meet their ambitious electrification and decarbonisation goals, policymakers must address not only the opportunities of the energy transition, but also the vulnerabilities of an increasingly interconnected energy system.

Despite growing risks, Nordic energy cooperation remains unique. Built on trust and longstanding collaboration, the Nordic countries have created one of the world's most integrated and resilient cross-border energy systems. However, the strategic environment in the Nordic region has changed significantly. Disruptions in one part of the region can quickly affect neighbouring countries, while global supply chains, digitalisation, and growing strategic attention on the Arctic and North Atlantic introduce new dependencies and vulnerabilities.

Energy security is therefore high on the agenda for Nordic cooperation. In October 2025, the Nordic energy ministers adopted a joint declaration calling for closer cooperation to strengthen energy security and security of supply.

The declaration highlights the need to expand and intensify joint initiatives in response to climate change and geopolitical instability. Securing critical infrastructure and developing strong models for regional cooperation have become increasingly urgent priorities (Nordic energy ministers call for closer co-operation on security and competitiveness).

Against this backdrop, Nordic Energy Research commissioned this report from Economic Security Forum to assess energy security in the Nordic region, examine the resilience of Nordic cooperation itself, and propose actions to help ensure a clean, secure, and resilient energy system for businesses and citizens across the region.

At a time of growing uncertainty, the Nordic cooperation is more important than ever.

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SUMMARY

Image: **stateofgreen.com**

The Nordic energy system is often described as a model of regional integration, backed by low-carbon power generation, mature market institutions, and decades of cross-border cooperation. That description is partly accurate but incomplete. The system is not yet fully operationally prepared for the threat environment that has emerged since 2022.

Three developments exposed the gap between reputation and reality. Russia's full-scale invasion of Ukraine demonstrated that energy market integration transmits geopolitical shocks regardless of domestic energy mix: Nordic electricity prices tracked continental European gas-indexed prices despite the region's limited natural gas dependence. A sequence of sabotage and anchor-dragging incidents on Baltic Sea subsea infrastructure between 2022 and 2024 established that critical energy infrastructure is subject to direct physical disruption. And the 2026 Strait of Hormuz crisis has shown, within days of the strait's closure, that even a region structurally buffered from Middle Eastern oil imports is exposed through global price transmission.

This report maps the state of Nordic energy security cooperation across all eight Nordic jurisdictions: Denmark, Finland, Iceland, Norway, Sweden, the Faroe Islands, Greenland, and Åland. It assesses the region's energy systems, the existing cooperation architecture, the regional threat picture in the Baltic and Arctic regions, and the carrier-specific vulnerabilities in electricity, oil, and natural gas. It concludes with a roadmap of 25 recommendations for strengthening Nordic cooperation over the short term (zero to three years) and the medium term (three to ten years), complemented by country-specific recommendations for each of the eight jurisdictions.

A dual-track energy system

The Nordic energy system runs on two parallel tracks. The first is a largely decarbonised electricity sector: roughly 90 per cent of Nordic electricity generation comes from hydropower, wind, nuclear, and a growing share of solar. The second is the continuing dominance of combustion-based fuels outside of electricity. Oil alone still covers 29 per cent of total Nordic final consumption, concentrated in road transport, industry, aviation, and as the dominant energy in the Faroe Islands and Greenland. The eight Nordic jurisdictions are not an internally uniform bloc: energy mixes, import dependencies, grid integration, and institutional setups differ substantially across the region, from Norway's position as a structural net energy exporter to the isolated microgrids of Greenland and the oil-dependent system of the Faroe Islands.

The outlook is clear: electricity consumption is expected to rise substantially as transport and industry electrify, with all national scenarios projecting electricity demand growth of 1.2 to 2.6 times current levels by mid-century. At the same time, oil and refined products will remain materially important at least through the 2030s as will natural gas in parts of the Nordics.

Two regional threat theatres: the Baltic and the Arctic

The Nordic energy system sits at the intersection of two distinct strategic environments. The Baltic Sea is shallow, contained, and holds one of the densest clusters of cross-border subsea energy infrastructure in Europe. It generates a clustering risk: many high-value cross-border assets concentrated in a small sea area, where a single anchor-dragging incident can disable a pipeline and a power cable within hours. The Arctic operates on a different geometry. The Norwegian Sea reaches depths of 2,500 metres across a sparsely monitored area, response times to incidents are measured in days rather than hours, and the region's most exposed offshore production sits in waters that have been subject to intensifying geopolitical pressure especially since 2022. The Hammerfest LNG plant on Melkøya, the only export route for Norwegian Barents Sea gas, is the clearest single illustration of Arctic single-point-of-failure exposure. A 2020 fire took the plant offline for 21 months, removing an entire production basin from the export market. The Russian shadow fleet that has emerged since 2022 generates risk in both theatres simultaneously and is the single threat that most clearly bridges them.

Key vulnerabilities

In electricity, weather-dependent sources now account for nearly three quarters of Nordic generation, and system adequacy in any given winter depends on hydrological conditions, wind output, and temperature simultaneously. The 2026 Finnish dunkelflaute, when an extended cold-and-low-wind episode in January and February pushed prices to levels last seen during the 2021–2023 European energy crisis and forced sustained imports averaging 1,830 MW, was the clearest recent operational illustration of this risk. The new Aurora Line between northern Sweden and Finland, commissioned in December 2025, held the system together; had a major nuclear unit been unavailable at the same time, automatic demand restraint might well have been triggered. The early 2030s represent the period of highest modelled adequacy risk as demand growth from electrification outpaces new supply and grid build-out. New demand can come online in one to two years; new transmission lines take seven to eight. That timing mismatch is the central structural risk for Nordic electricity security over the next decade.

For fuels, overall dependence on oil is trending downward and Norway's production base provides a regional buffer that few other parts of Europe enjoy. The aggregate picture, however, conceals the points of real exposure. Nordic refining capacity has fallen by 16 per cent since 2021 and is skewed towards gasoline. Diesel and jet fuel are the products where Nordic refining falls furthest short of demand, with combined Nordic jet fuel import dependency reaching 68 per cent. The stockholding picture is uneven: Denmark, Finland, and Sweden meet their obligations, but Norway reduced its mandatory readiness to 20 days in 2007, and the Faroe Islands and Greenland sit outside both EU and IEA stockholding frameworks entirely despite being the most physically exposed.

In natural gas, Nordic consumption is marginal by EU standards but retains sub-regional significance during the ongoing phase-out, especially in Denmark. The structural asymmetry is that Norway, Europe's largest pipeline gas supplier, sits outside the EU frameworks that govern its main customers, and no pan-Nordic gas coordination forum exists.

Across all carriers, risks to subsea and offshore critical infrastructure have moved from theoretical concern to operational vulnerability. The Nord Stream explosions, the Balticconnector and Estlink 1 damage, and the Estlink 2 cable severance established that subsea energy infrastructure is now a target. Supply chain risk compounds the picture: large power transformers carry 12 to 18 month replacement lead times, and HVDC cable and converter equipment longer still, sourced from a small number of global suppliers.

State of Nordic energy security cooperation

The political signal in support of Nordic cooperation is sharper than at any point in the post-Cold War period. The Nordic Council of Ministers Energy Cooperation Programme 2025–2030 places energy security as the first of four programme goals, and Nordic energy ministers and prime ministers have reinforced this at the highest level. The political will is formally stated. The gap is that the institutional machinery to operationalise it has not yet caught up.

Cooperation is strongest where it has had decades to develop. The electricity market and its operational layer built around Nord Pool and the Nordic Regional Coordination Centre is the most institutionally mature energy cooperation arrangement in Europe. The Nordic Contingency Planning and Crisis Management Forum (NordBER) and the bilateral emergency electricity sharing agreements provide a functioning preparedness architecture. The Finland-Sweden bilateral cooperation between their emergency supply agencies (NESA and MSB) is the most developed preparedness relationship in the region and provides a concrete template for scaling cooperation to the wider Nordic group.

The cooperation gaps are sharpest in four areas. First, the strategic layer: there is no joint Nordic energy security strategy, no standing cross-sectoral forum, and no mechanism for ministers to systematically compare the trade-offs they are managing nationally. Second, the threat-response layer: NordBER, the bilateral transmission system operator (TSO) agreements, and the Nordic System Operation Agreement contain no provisions for hybrid or military attacks that could result in coordinated multi-asset disruption. Third, the Arctic theatre is institutionally thinner than the Baltic: there is no Arctic equivalent of the May 2025 Council of the Baltic Sea States Vihula Memorandum on undersea infrastructure, and the Arctic Council has been operating in reduced functionality since 2022. Fourth, for fuels and gas there is no dedicated Nordic cooperation framework comparable to what exists for electricity.

Roadmap for strengthening Nordic energy security cooperation

The report sets out 25 recommendations across nine cooperation domains, sequenced over short-term (zero to three years) and medium-term (three to ten years) horizons. The principle throughout is to build on what already exists and to focus on areas where Nordic cooperation adds value over national approaches.

- **Strengthening system-level cooperation.** The most consequential recommendation is the development of a Nordic Energy Security Strategy, adopted through the Nordic Council of Ministers, that synthesises cross-border vulnerabilities with actionable cooperation priorities. Complementary measures include an annual joint threat assessment, a standing information-sharing protocol, a feasibility study on a Nordic energy security operations centre, harmonised physical protection standards, priority cable repair vessel access agreements, formalised chief information security officer (CISO) and transmission system operator (TSO)-level cyber cooperation, and a dedicated assessment of energy security in the Island Energy Systems to address the two-tier participation pattern.
- **Strengthening electricity security cooperation.** The priority is to extend the market-and-operations mandate of existing institutions to cover adequacy and security coordination. A Nordic TSO demand pipeline protocol would ensure that major new demand projects, including the 5.4 GW data centre queue already visible in Norway alone, are notified across borders. A common adequacy assessment methodology would provide the foundation for coordinated flexibility and capacity investment. A joint inventory and strategic reserve of critical components targets the long replacement lead times that define recovery time after disruption.
- **Strengthening fuel supply cooperation.** Recommendations centre on a harmonised Nordic emergency demand management protocol with explicit provisions for protecting the remote Faroe Islands and Greenland that are most exposed to fuel supply shocks, private sector fuel security guidelines for logistics-critical sectors, and a dedicated Nordic jet fuel cooperation mechanism addressing the most acute carrier-level vulnerability.
- **Strengthening natural gas cooperation.** The priority is to integrate Norway into Nordic emergency gas coordination through bilateral emergency sharing agreements and a pan-Nordic gas TSO forum, filling the gap that the EU solidarity mechanism does not reach. Over the medium term, the same logic extends to hydrogen: the security-of-supply dimension should be embedded in emerging hydrogen infrastructure from the feasibility study phase rather than retrofitted after the first crisis.

The regional recommendations are complemented by country-specific recommendations. The country profiles surface priorities that do not always emerge at the regional level, including the Bornholm Energy Island pivot for Denmark, the Northern Finnmark grid bottleneck for Norway, and the maritime logistics exposure of the Faroe Islands and Greenland.

The Nordic energy system is not underprepared because of a lack of cooperation. It is underprepared because cooperation has not yet moved into operational reality. Operational preparedness, as used in this report, means the capacity of the Nordics to act jointly and effectively under stress through shared protocols, pre-agreed response procedures, interoperable systems, and material reserves that can be deployed across borders without requiring a lengthy political process in the moment. The political will is now formally stated at the highest level. The institutional machinery, the operational protocols, and the material reserves needed to give that will practical effect are the subject of the recommendations in this report.

Section 1

UNDERSTANDING NORDIC ENERGY SECURITY

Image: **iStock**

This section sets out the conceptual frame for the rest of the report. It does so in four steps. Sub-sections 1.1 and 1.2 describe the two structural realities that any Nordic energy security framework needs to take seriously: the parallel tracks of electrification and continuing fuel dependence, and the geographic and institutional heterogeneity of the region. Sub-section 1.3 sets out the value-add test that determines where Nordic-level cooperation makes sense relative to bilateral, EU and NATO-level alternatives. Sub-sections 1.4 and 1.5 introduce the analytical tools used in the rest of the report: the energy trilemma as the lens for navigating the trade-offs between security, affordability and sustainability, and a typology of risks and resilience measures that informs the carrier-specific analysis. Sub-section 1.6 carries the framework forward into the cooperation discussion that follows.

In April 2026, an online headline announced that Norway was facing a fuel shortage within weeks. Months earlier, the claim would have looked like clickbait. By mid-April it reflected a real set of pressures. As of May 2026, the Strait of Hormuz crisis had removed around a fifth of global oil and gas flows from the market and sent commodity prices sharply higher, with spillover effects across the Nordic region despite the region's relatively low dependence on direct imports through the Strait.[1] The episode illustrates the starting point for this report. Energy security in the Nordic countries is not a solved problem, and the tools required to manage it are not only national ones.

Important note: all references to the Strait of Hormuz crisis in this report reflect the state of knowledge as of May 2026 and include both verified events and analytical stress-test scenarios.

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[1] The effects of the Hormuz Strait crisis are based on information available as of 18 May 2026. The most detailed account of the developments at the time is presented in the IEA's monthly oil market report. See IEA (2026), Oil Market Report – May 2026, International Energy Agency, https://www.iea.org/reports/oil-market-report-may-2026

1.1 Two tracks of Nordic energy security: electricity and fuels

The Nordic energy system story of the past two decades has two parallel tracks, and a Nordic energy security framework needs to keep both in view. The first is the ongoing transformation of electricity generation towards low-carbon sources: roughly 90 per cent of Nordic electricity now comes from hydropower, wind, nuclear, and a growing share of solar. The second is the slow decline of combustion-based fuels in the energy mix outside of electricity. Oil alone still covers close to a quarter of total Nordic energy consumption, concentrated in road transport (roughly 60 per cent of oil use), industry, aviation, and as the dominant heating and back-up fuel in the Faroe Islands and Greenland.[2]

The distinction between electricity and energy matters for how this report frames Nordic energy security. In everyday discussions, the two terms are often used interchangeably, but electricity is only one of several energy carriers alongside oil products, natural gas, district heat, and biofuels that together make up the energy a society consumes. Despite the globally accelerating electrification trend, electricity has accounted for a remarkably stable share of total Nordic final consumption over the past two decades: roughly a quarter. Iceland is the clear outlier, because of its electrified industrial base.[3] The rising share of renewables in electricity generation, not overall electrification, has done most of the work in displacing fossil fuels in final consumption since the early 2000s. The outlook for the future is clear: electricity consumption is expected to rise substantially as transport and industry electrify. Rising electricity consumption combined with variable renewable generation will create new energy security demands, from managing system complexity to investing in flexible generation, demand-side flexibility, and grid-scale batteries and storage.

The dual reality has two implications for this report's framing. The security of combustion-based fuels remains a first-order energy security concern. Oil products, residual natural gas, and the maritime and refinery logistics that bring them to consumers are not a legacy issue erased by the energy transition in the short term. At the same time, the centre of gravity of energy security is shifting towards electricity, and the institutional architecture for managing energy security needs to balance both the present reality and the direction of change.

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2. Eurostat, energy statistics, https://ec.europa.eu/eurostat/web/energy/data
3. IEA, Iceland country profile, https://www.iea.org/countries/iceland/electricity

1.2 Nordic energy security cooperation’s geographic and institutional realities

The second feature that a Nordic-specific framework must take seriously is the internal heterogeneity of the region. The four mainland Nordic countries are not a uniform energy bloc, and Island Energy Systems of Iceland, Greenland, the Faroe Islands and Åland have different energy system architectures and distinct challenges. Three structural distinctions matter for energy security analysis.

The first is geographic configuration. The four mainland Nordic countries' electricity systems are tightly interwoven with each other and with Central Europe and the Baltic States, operating as one integrated market through Nord Pool and ENTSO-E. Iceland is a single, fully isolated synchronous system with no connection to continental Europe. The Faroe Islands operate a small, oil-dominated isolated grid. Greenland is not a single grid at all but a set of standalone microgrids spread across coastal settlements. These configurations exhibit different vulnerabilities and call on different cooperation instruments.

The second distinction is resource endowment and overall energy mix. Norway is a major fossil fuel exporter and the cornerstone of Europe's natural gas supply. Sweden combines large hydro and nuclear electricity generation with a structurally constrained north-south transmission corridor. Denmark is at the leading edge of offshore wind development. Finland has added new domestic nuclear capacity, complemented by tenfold growth in wind generation over ten years. Iceland is the global leader in geothermal energy. Greenland and the Faroe Islands are oil-import-dependent for the bulk of their primary energy despite ramping up renewable generation. These differences mean that the same external shock from a low-wind cold winter, a geopolitical supply disruption to a subsea cable cut has very different local effects across the region.

The third distinction is institutional. Denmark, Finland, and Sweden are EU member states operating within the full Energy Union regulatory framework. Norway participates through European Economic Area (EEA) membership, with technical engagement but no vote in EU political decisions. Iceland is also in the EEA but, because of a lack of physical links, its energy market integration with the rest of Europe is more limited. The Faroe Islands and Greenland are self-governed regions of the Kingdom of Denmark and sit outside the EU framework altogether. Åland is an autonomous part of Finland with a distinctive demilitarised status.

Nordic energy security cooperation needs to take this institutional diversity into account by neither over-promising cohesion nor under-utilising the participation that is available. Heterogeneity is not only a complication; it is also the region’s most important asset. An interconnected system that brings together Norwegian hydro, Swedish nuclear and hydro, Finnish nuclear and wind, and Danish wind hedges against concentration risks at national level. For example, interconnections and diversified energy systems provide a buffer against shortfalls in wind output. At the same time, the distinct energy profiles especially of Island Energy Systems mean that Nordic energy security cooperation needs to be flexible: not every issue is relevant to every actor.

Energy security was, until recently, a politically sensitive area within Nordic cooperation. The word 'security' carried defence connotations that fell outside the mandate of the Nordic Council of Ministers: practitioners familiar with that history describe a culture in which discussions would 'shut down' at the first mention of national security framing.[4] Three developments have dissolved that hesitancy. Russia's full-scale invasion of Ukraine in February 2022 triggered a Europe-wide energy crisis whose price effects reached deep into the Nordic electricity market. A series of incidents of suspected sabotage on subsea energy infrastructure in the Baltic Sea between 2022 and 2024 (the Nord Stream pipeline explosions, the Balticconnector gas pipeline, and the Estlink 2 interconnector anchor-drag damage) demonstrated that infrastructure previously assumed safe from deliberate attack is now a target (See Table 1.1 for overview of the incidents).

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[4] Interview with senior Nordic energy official, conducted for this project, 2026 (not for attribution).

Table 1.1. Major sub-sea infrastructure incidents in the Baltic and Nordic region, 2022–24

Incident	Description and energy security impact	Investigation status
Nord Stream 1 and 2	26–29 September 2022. Four leaks on the Nord Stream 1 and 2 gas pipelines in the Swedish and Danish EEZs near Bornholm, caused by underwater explosions. Both pipelines rendered inoperable; several hundred million cubic metres of methane released. Direct supply impact limited as Nord Stream 1 flows had been halted and Nord Stream 2 was not operational.	**Confirmed sabotage; perpetrator under investigation[5].** Swedish and Danish investigations confirmed gross sabotage and were closed in February 2024. Germany's investigation is ongoing and in 2024 issued a European Arrest Warrant for a Ukrainian suspect. State responsibility not established.
Balticconnecto	8 October 2023. The 77 km Balticconnector gas pipeline between Finland and Estonia and two adjacent telecommunications cables damaged in the Finnish EEZ. Pipeline offline for around seven months; Finland's gas system relied on LNG imports via Inkoo. Direct gas dependency on the pipeline was around 5 per cent.	**Vessel-caused damage confirmed; intent contested[6].** Finnish NBI identified the Hong Kong-flagged *NewNew Polar Bear* and recovered its anchor. China acknowledged the vessel caused the damage in 2024 but characterised it as accidental; investigators have remained sceptical.
Estlink 2	25 December 2024. The Estlink 2 submarine power cable between Finland and Estonia plus four telecommunications cables severed in the Gulf of Finland. Cross-border transfer capacity reduced from 1,016 MW to 358 MW for over seven months, with repair costs of approximately €60–70 million. Outage during peak winter demand.	**Vessel-caused damage confirmed; intent disputed in court[7].** Finland seized the Cook Islands-flagged tanker *Eagle S*, assessed as Russian shadow fleet. The Helsinki District Court dismissed the criminal case in October 2025 on jurisdictional grounds (UNCLOS Article 97); the Deputy Prosecutor General has appealed.

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5. Reuters (2025), What is known about the Nord Stream gas pipeline explosions?, https://www.reuters.com/world/europe/what-is-known-about-nord-stream-gas-pipeline-explosions-2025-08-21/
6. Ringbom, H., & Lott, A. (2024). Sabotage of Critical Offshore Infrastructure: a Case Study of the Balticconnector Incident. In A. Lott (Ed.), Maritime Security Law in Hybrid Warfare (pp. 155). Brill. https://urn.fi/URN:NBN:fi-fe2025022614432
7. Reuters (2025) "Finnish Court Dismisses Case Againt Crew in Baltic Sea Cable Breah Trial", https://www.reuters.com/business/media-telecom/finnish-court-deliver-verdict-baltic-sea-cable-breach-trial-against-tanker-crew-2025-10-03/

The 2026 Strait of Hormuz crisis has demonstrated that even in the absence of direct disruption of fuel supply, global price shocks have cascading effects that directly affect Nordic energy security. These developments represent a structural shift in the threat environment for which existing cooperation frameworks are not yet fully adapted.[8]

1.3 The value added of Nordic energy cooperation

Within these overlapping geographies, Nordic cooperation adds distinctive value where it is situated as a complementary addition to existing cooperation taking place under EU, NATO and other international frameworks, not as a duplicative process.

The continental Nordic countries are also embedded in a wider regional system that extends beyond the Nordic perimeter. The Baltic Sea region has seen rapid integration in recent years, both in infrastructure terms and in cooperation architecture. Denmark, Finland and Sweden maintain deep bilateral energy ties with their Baltic Sea neighbours, and the synchronisation of the Baltic States' electricity grids with continental Europe in February 2025 has materially altered the regional connectivity picture. Nordic and Baltic TSOs now operate in a shared synchronous area, and the security of cross-border infrastructure in the Baltic Sea, subsea cables, interconnectors, and gas pipelines is a matter of joint concern that cuts across the Nordic-Baltic region. This regional embeddedness shapes what Nordic energy cooperation can and should do: some challenges are best addressed at the Nordic level, others require a broader Nordic-Baltic or EU-level framing.

This study and roadmap for deepened Nordic-level energy security cooperation argues that Nordic cooperation adds value over national and/or existing international cooperation when:

1. **The risk is genuinely cross-border.** No single country can address it alone, and national action creates externalities for neighbours.
2. **Collective action creates economies of scale.** For example, joint stockpiling of large power transformers, shared cable repair vessel access, and joint cyber exercises are cheaper or more effective collectively than individually.
3. **Common standards reduce friction in emergency response.** Interoperability built in peacetime is the precondition for cooperation in crisis. The speed of joint response during an emergency depends on the depth of the relationships established before it.
4. **Norway's inclusion matters.** Norway participates in the internal energy market through the EEA Agreement and is fully integrated into Nordic and European electricity market structures through ENTSO-E and Nord Pool. It is not, however, subject to EU energy security legislation in the same way as member states, and key EU emergency coordination mechanisms do not automatically extend to it. Nordic cooperation provides a framework for measures where the gap is consequential, particularly in gas supply coordination and cross-border

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8. European Commission and NATO (2023), EU-NATO Task Force on the Resilience of Critical Infrastructure: Final Assessment Report.

emergency response, and this framework includes Norway in ways that EU-only mechanisms do not.

5. **Island Energy Systems are involved.** Faroe Islands, and Greenland, which fall outside EU energy frameworks entirely, and for Åland, with its specific autonomous status, Nordic cooperation is the main forum for international cooperation. Iceland participates in the internal energy market through the EEA Agreement and participates in ENTSO-E and Nordic electricity market structures. It is not, however, subject to EU energy security legislation or part of EU emergency coordination mechanisms.

The Nordic region is not only part of European energy security frameworks but also a structural provider of energy security beyond the Nordic region. Norway supplied approximately 130 billion cubic metres of natural gas in 2024, with roughly 95 per cent exported to EU and UK markets by pipeline, making Norway the single largest gas supplier to European markets by volume.[9] Norwegian and Swedish hydro reservoirs, with combined storage capacity of around 140 TWh, function as a seasonal battery for the wider European electricity system. Denmark and Norway are in the early stages of becoming major offshore wind exporters, with projects such as the Bornholm Energy Island already under development.[10]

The Nordic region's role as an energy security provider is a genuine strength but also a source of domestic political tension, visible most sharply in Norway and Sweden: the integration that delivers European energy security also transmits European price shocks into Nordic household bills. This has prompted calls to halt the construction of new interconnectors to the rest of Europe, and in some cases to sever existing links. In parallel, EU-NATO threat assessments document that Russian intelligence activity actively maps Nordic undersea infrastructure that is critical to the provider role.[11]

1.4 Theoretical framework: the energy trilemma

The Energy Trilemma, formalised by the World Energy Council, treats energy policy as the simultaneous management of three goals (security, affordability, and sustainability) that often pull in different directions.[12] The trilemma has become the dominant framing in European and Nordic policy discussion because it captures the political reality of trade-offs between keeping the system reliable, keeping it affordable, and keeping the energy transition on track. This report adopts the trilemma as its analytical lens, applying it to the directions in which the threat environment, the carrier scope, and the geographic coverage of Nordic energy security have moved since 2023.[13]

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9. Council of the European Union, 'Where does the EU's gas come from?', https://www.consilium.europa.eu/en/infographics/where-does-the-eu-s-gas-come-from/.
10. Nordic Energy Research (2024), Tracking Nordic Clean Energy Progress 2024 – More flexible storage needed, NER 2024-05, http://dx.doi.org/10.6027/NER2024-05
11. European Commission and NATO (2023), EU-NATO Task Force on the Resilience of Critical Infrastructure: Final Assessment Report.
12. Nordic Energy Research (2023), Nordic Energy Trilemma, http://dx.doi.org/10.6027/NER2023-04
13. Nordic Energy Research (2024), Energy Poverty in the Nordic Countries, https://pub.norden.org/nordicenergyresearch2024-02/

1.4.1 The three pillars of the energy trilemma

The trilemma captures three intertwined dynamics that sometimes present trade-offs between each other:

- **Security:** the ability to supply current and future energy demand reliably and to withstand and recover from system shocks through effective crisis management. In the Nordic context, this covers the physical adequacy of electricity supply across seasonal and geopolitical stress windows, the protection and repair of critical infrastructure (notably subsea electricity cables and gas pipelines), the security of fuel supply chains for transport and heating, and the resilience of the clean-technology supply chains underpinning the energy transition. This is the pillar this report develops in depth, in recognition that policy choices need to balance the full trilemma.
- **Affordability:** the ability to provide reliable energy for residential and industrial consumers at a price that does not undermine public welfare or political support for the energy transition. In the Nordic context, the 2022 price crisis showed how continental European gas-indexed electricity prices generate significant spillover effects across the Nordic countries[14], and the 2026 Strait of Hormuz crisis illustrated the same logic in fuel pump prices. The political need to manage the affordability-integration tension is itself a security variable, since cross-border integration depends on public support.
- **Sustainability:** the extent to which the green energy transition mitigates potential climate impacts by transitioning from fossil-based to low-carbon energy systems. In the Nordic context, the energy security relevance of sustainability lies in the way the transition itself reshapes the security agenda: with the increased role of electricity in the overall energy mix, new clean-technology supply-chain dependencies emerge, and new physical infrastructure risks arise, ranging from offshore wind farms to high-voltage interconnectors.

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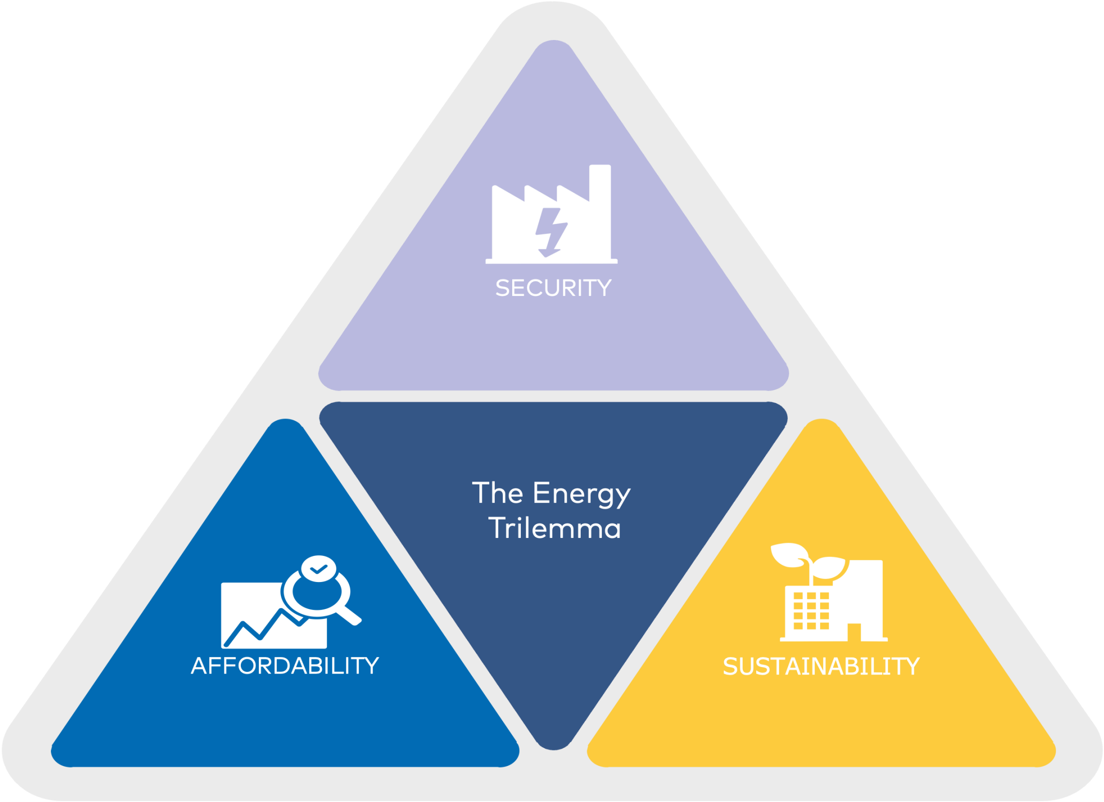
[14] Ember (2026), Global Electricity Review 2026, https://ember-energy.org.

Figure 1.1: the energy trilemma



Source: Nordic Energy Research, 'The Nordic Energy Trilemma'.

In the context of the trilemma, energy security is most usefully understood as making available a sufficient quantity of energy in a reliable and affordable way. It is not an end state that can be achieved and then maintained passively; it requires constant attention and management as the system, the actors, and the threats all evolve. Political decisions to strengthen energy security also need to be balanced against sustainability and affordability, and the policy response has to evolve with the underlying conditions.

Three trade-offs make the trilemma concrete in the Nordic context. Electricity interconnections deliver cross-border supply security and integrate Nordic renewables into European markets, but they also transmit European price volatility into Nordic household bills, generating political pressure that can constrain future integration. The offshore infrastructure that underpins Norway's role as Europe's largest pipeline gas supplier and the Nordic region's emerging position in offshore wind also concentrate security exposure in subsea assets that are difficult to monitor, protect, and repair.

Electrification illustrates the trilemma in both directions at once: it reduces the system's exposure to continuous fossil fuel import flows and advances the sustainability pillar, but shifts security weight onto physical electricity infrastructure where disruption of a single critical node can cascade across the system. The sustainability tension is sharpest on the fuel side: imported refined products remain critical for transport and aviation despite gradual demand decline, and addressing that exposure through expanded domestic refining capacity would run directly against the climate commitments of Nordic governments and energy companies.

1.5 Types of energy security risks and resilience measures

The concrete threats to energy security range from local to global, and the impact of a materialised risk can be short-lived (an extreme weather event) or persistent (a structural shift in geopolitical alignments or supply chains). Local risks originate within a country and have local impact. Regional risks may originate in one country but have an impact at the Nordic level. Global risks affect all countries regardless of their origin. The categories are not mutually exclusive; a single event such as the Estlink 2 incident or the 2026 Strait of Hormuz disruption can generate effects across all three levels simultaneously.

Figure 1.2: Analytical typology of different types of energy security risks

Risk level	Short-term impacts (days to weeks)	Long-term impacts (months to years)
Local risk	Prolonged extreme weather patterns may lead to electricity rationing when large share of generation is based on wind, solar or hydro.	Concentrated supply chains for energy commodities elevate the impacts of supply disruptions. Unpredictable changes in national energy and climate policies may slow investments in energy infrastructure and unfairly punish the front-runners. Misinformed municipality-level policy decisions may block nationally important energy infrastructure projects.
Regional risk	Military aggression by a neighbour country may target key energy infrastructure, including via sabotage. Sudden loss of a large electricity generation unit or an interconnector may elevate the prices in the Nordic electricity markets.	Lack of support for regional cooperation may lead to sub-optimal energy system design (e.g. by slowing interconnection development).
Global risk	Energy resource supply shocks due to military conflict or other logistical chain disruptions quickly elevate end-use prices. Cyber attacks may incapacitate critical energy infrastructure (e.g. transmission systems, pipelines, power plants).	Prolonged global supply shocks may dry out fuel stocks, leading to sky-high prices and fuel rationing. Climate change gradually changes the weather patterns, impacting weather-dependent electricity generation but also the seasonal energy demand.

Notes: Local risks originate from within the country and have local impact;
Regional risks may originate from one country but have an impact at the Nordic level;
Global risks may impact all countries regardless of the origin of the risk.

1.5.1 Energy security resilience measures

While the threats are multidimensional, the mitigation concepts are relatively simple and universally applicable: predictability of policies, diversification of the energy system, and cooperation at the regional and international level. Implementation is where the challenge lies, because some measures require notable time and financial investment.

Resilience can be understood as the capacity of an energy system to (i) prepare for disruptions, (ii) withstand shocks while maintaining operations, and (iii) rapidly restore service. That capacity needs to be adequate across the full range of relevant circumstances, from weather events to deliberate geopolitical action.

The IEA has distilled lessons from Ukraine's experience under sustained Russian attack on its energy system since 2022 into a ten-point resilience toolkit.[15] The list is not specific to wartime conditions: most of the items map directly onto vulnerabilities the Nordic region already faces, and the report returns to several of them in the carrier-specific sections that follow:

1. Put resilience at the centre of energy system planning.
2. Implement physical hardening and defence measures.
3. Build comprehensive emergency response capabilities that cover multiple threat scenarios.
4. Ensure effective emergency communication mechanisms to reach citizens.
5. Leverage decentralisation and distributed resources as strategic security assets.
6. Maintain emergency oil stocks as a buffer against supply shocks.
7. Standardise and stockpile critical equipment.
8. Treat data as a strategic asset and continue its collection during emergencies.
9. Embed cyber resilience into all aspects of system planning and operations.
10. Build mechanisms for cross-border cooperation.

The resilience principles set out the philosophy that should shape energy security policy. To translate those principles into action, governments need to be able to measure where their system stands, where it has improved, and where it remains exposed.

1.5.2 Measuring energy security

A small set of widely used quantitative indicators provides the basic toolkit for this purpose. The indicators in Table 1.2 are the ones most commonly used to assess national energy security performance, and the report draws on them throughout the energy profiles and the country-level analysis in later sections. No single indicator captures all aspects of energy security, but together they help governments to ask the right questions and to measure the impact of the actions taken.

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15. IEA (2026), Energy System Resilience: Lessons from Ukraine, International Energy Agency.

Table 1.2: Key indicators to measure energy security

Indicator	Question answered	Description and data source
Import dependency	How much of our energy is imported?	Share of energy demand met through net imports, for the overall energy balance or by source. Emphasises external exposure.
Self-sufficiency	How much of our energy demand can we produce domestically?	Share of energy demand met by domestic production, for the overall balance or by source. Emphasises domestic capacity. Technically the inverse of import dependency, but the framing matters in policy discussion.
Fuel share in supply or consumption	Which energy sources are we most exposed to?	Relative share of an energy source in supply or consumption, total or by economic sector. Most useful when tracked over time.
Sectoral share in total consumption	Which sectors will be most affected by supply disruptions?	Relative share of an economic sector in total energy consumption. Most useful when tracked over time.
Supply diversity	Is our supply heavily dependent on a small number of suppliers?	Concentration of imports across supplier countries, measured via the Herfindahl-Hirschman Index. For the Nordic countries this indicator is mainly relevant for oil.
Storage and stocks	How many days' worth of stocks do we hold?	Total storage and stocks in relation to average and peak demand (primarily oil).

1.6 From energy security concept to energy security cooperation

Three points carry forward into the rest of the report. Combustion-based fuels still account for a substantial share of the Nordic energy mix outside the power sector, and the maritime, refinery, and aviation logistics that bring them to consumers remain first-order security concerns alongside the electricity system. The Nordic region is heterogeneous in geography, resource base and institutional setup, and that heterogeneity is both a challenge and the region's most important asset. Nordic cooperation operates as the inner ring of a wider Nordic–Baltic–European architecture, with distinctive value where speed, the inclusion of all Nordic countries, and operational depth matter and a complementary role where larger frameworks are better placed. The energy trilemma provides a lens that makes the trade-offs between security, affordability, and sustainability visible enough to manage them deliberately. Energy security is not an end state, and the success of the efforts to build it should not only be tested in shocks but also carefully measured and evaluated with data.

Section 2

ENERGY SECURITY ON NORDIC SYSTEM LEVEL

Image: **Vattenfall**

Section 1 set out the trilemma lens and the heterogeneity of the region. This section unpacks the different energy security challenges across the Nordics through data. The sub-sections describe the Nordic energy system at aggregate level (2.1), the import dependence picture and how it is changing alongside the security implications of clean-energy supply chains (2.1.1), the consumption patterns that determine where supply disruptions are felt (2.2), and the implications that carry forward into the carrier-specific chapters that follow (2.3). The picture that emerges is one in which the security pillar of the trilemma is no longer adequately captured by oil import dependency alone, and the affordability pillar is shaped by mechanisms that operate well outside the Nordic perimeter.

Aggregate Nordic energy demand is roughly ten per cent of the EU total, comparable in size to Spain or Italy.[16] However, the four mainland Nordic countries and Iceland are not an internally uniform bloc (see Figure 2.1. Detailed country profiles are in Annex 1). Norway is a structural net exporter with zero import dependency, driven by its hydrocarbon production and an almost entirely hydro-based electricity system. Sweden and Finland are the largest energy consumers in the region, both with electricity generation mixes anchored in hydro, wind and nuclear, and both have substantially reduced their import dependence over the past two decades through domestic wind and biofuel growth. Denmark has moved in the opposite direction, from full self-sufficiency in 2004 to 40 per cent import dependence today as North Sea fields have depleted, even as wind now dominates its electricity mix. Iceland is an outlier in a different sense: a geothermal and hydro-powered system with no physical connection to the continental grid, low import dependence, but energy consumption that has grown 61 per cent since 2004 on the back of industrial electrification and population growth.

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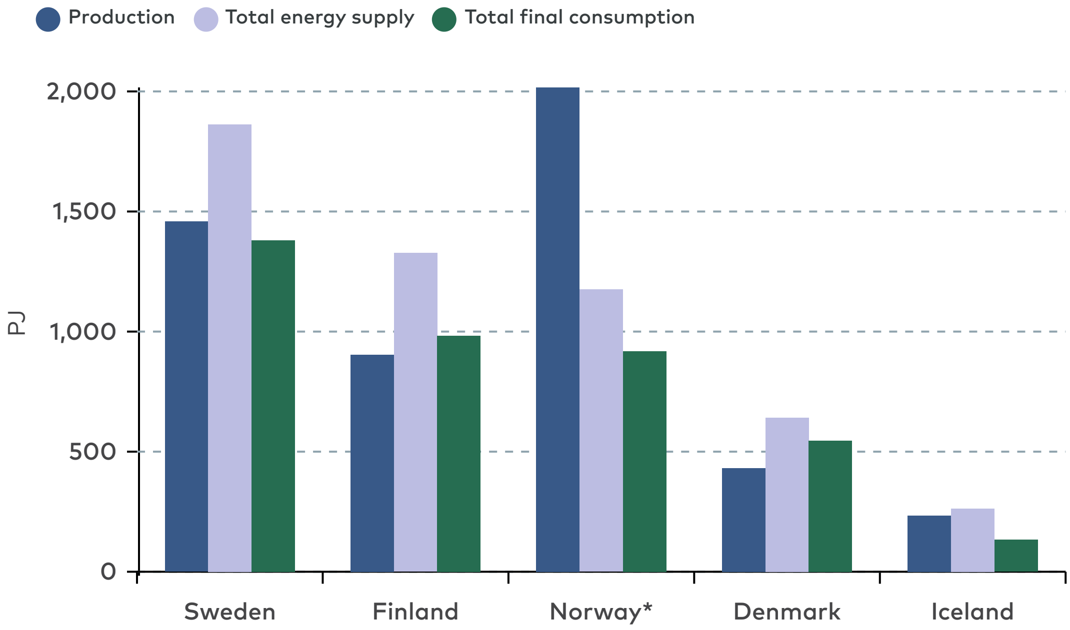
[16] Eurostat, energy statistics, https://ec.europa.eu/eurostat/web/energy/data

Figure 2.1: Energy balances of the Nordic countries, 2024 (in petajoules (PJ)



* Norway energy production > 9000 PJ

Source: Eurostat.
Notes: Production refers to primary energy production (e.g. oil and gas extraction, solid biofuel production). Total energy supply (TES) is the primary energy fuelling the economy, including transformation losses (e.g. electricity generation, oil refining). Total final consumption (TFC) is the energy used by end consumers (industries, transport, households). The difference between TES and TFC reflects transformation losses, distribution losses, the energy sector's own consumption and changes in stocks. Transformation losses arise whenever primary energy is converted into a different carrier, for example when fuels are burned to generat electricity, or when crude oil is refined into usable products. These losses are not a sign of inefficiency but a physical characteristic of energy conversion.

The gap between production and final consumption is even starker for the Island Energy Systems (Figure 2.2). The Faroe Islands, Greenland and Åland depend on imports for the bulk of their primary energy, mostly oil products, with self-sufficiency ratios of 11, 17 and 31 per cent respectively.[17] In terms of absolute volumes, their imports are small, but they are concentrated through a small number of ports. Energy security in these regions is therefore as much a logistics question as an energy question. Prolonged extreme weather, constrained ice-breaker availability and deliberate disruption can quickly translate into fuel shortages depending on local storage levels.

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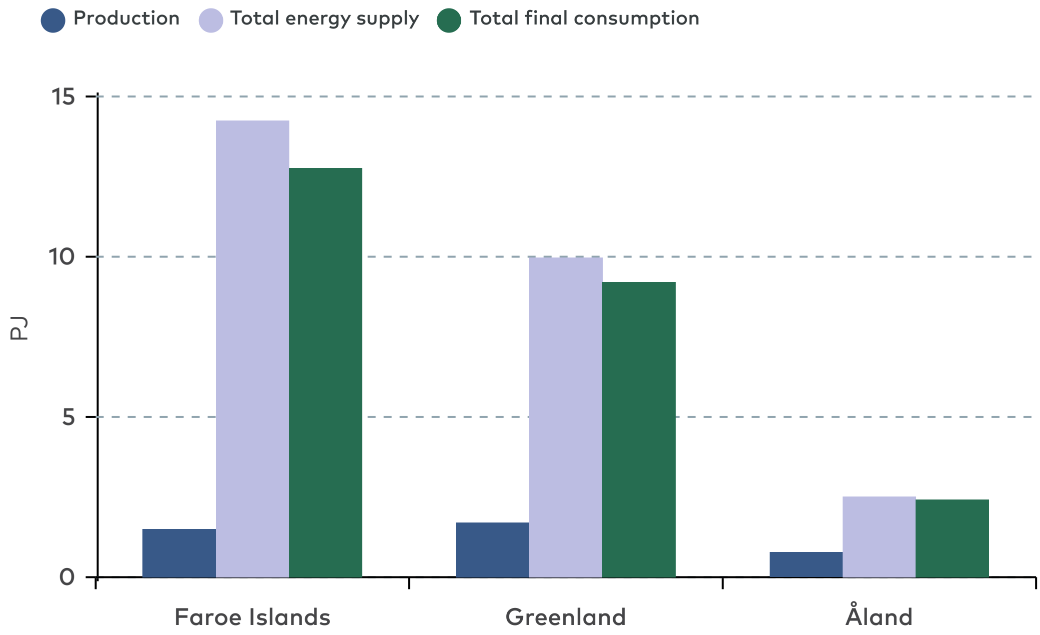
17. Statistics Greenland, Faroese Environment Agency, Ålands statistik- och utredningsbyrå. Self-sufficiency is the ratio between domestic production and total energy supply.

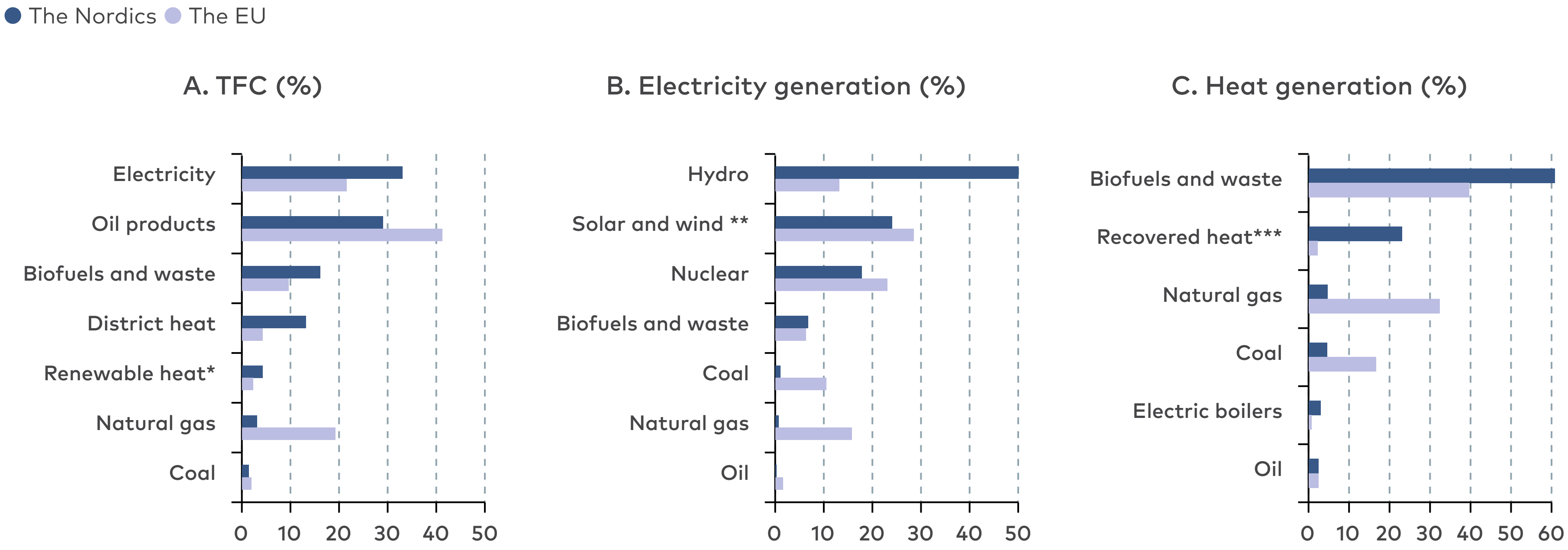
Figure 2.2: Energy balances of the self-governed and autonomous and island regions, 2024



Sources: Faroese Environment Agency, Statistics Greenland, Ålands statistik- och utredningsbyrå.

Overall, the relative weights of energy carriers in Nordic consumption differ notably from EU averages (Figure 2.3). Three differences matter for energy security. Electricity already accounts for the largest share of Nordic final consumption at 33 per cent in 2024, and that share is set to grow as transport and industry electrify. Oil still accounts for 29 per cent, especially because transport but also many industry sectors (including petrochemical feedstocks) and aviation depend on it. Coal and natural gas together account for low single-digit shares, well below the EU average.

Figure 2.3: Shares of energy sources in the Nordic energy system compared with the EU, 2024



Source: Eurostat.

Notes: Panel a) total final consumption; b) electricity generation; c) heat generation.

Renewable heat includes ambient, geothermal and solar heat. Recovered heat includes ambient, waste, geothermal and solar heat.

The low Nordic shares of coal and natural gas have a direct energy security implication. A coal or gas supply shock would not have a large direct effect on Nordic energy security at regional level. The indirect effect through electricity prices, especially in the case of natural gas, is a different matter. Natural gas is often the marginal fuel setting the wholesale electricity price in the integrated European market. The 2022 European energy crisis showed how that channel transmitted continental gas price spikes into Nordic household bills despite low gas use in the Nordic generation mix itself.[18]

2.1 Dependence on imports as an energy security vulnerability

Overall, energy import dependence has shifted substantially over the last two decades (Figure 2.4). Denmark went from energy self-sufficiency in 2004 to roughly 40 per cent net import dependence in 2024, mainly because of declining oil and gas production from its depleting North Sea fields. Finland and Sweden moved in the opposite direction as domestic wind generation and biofuel production reduced their import needs. Norway has remained a structural net exporter throughout and is Europe's largest producing country of both oil and natural gas (excluding Russia). With the United States, Norway is also EU's largest supplier of oil and its largest source of natural gas.

The overall dependence ratio masks important nuances. In fuels, the headline figures do not capture import dependence in specific refined products such as jet fuels (explored further in Section 7). While import dependence on combustion-based fuels is gradually decreasing, the clean energy transition and electrification are generating new dependencies in the form of batteries, electric vehicles, components and critical minerals that the Nordic energy data does not yet capture.

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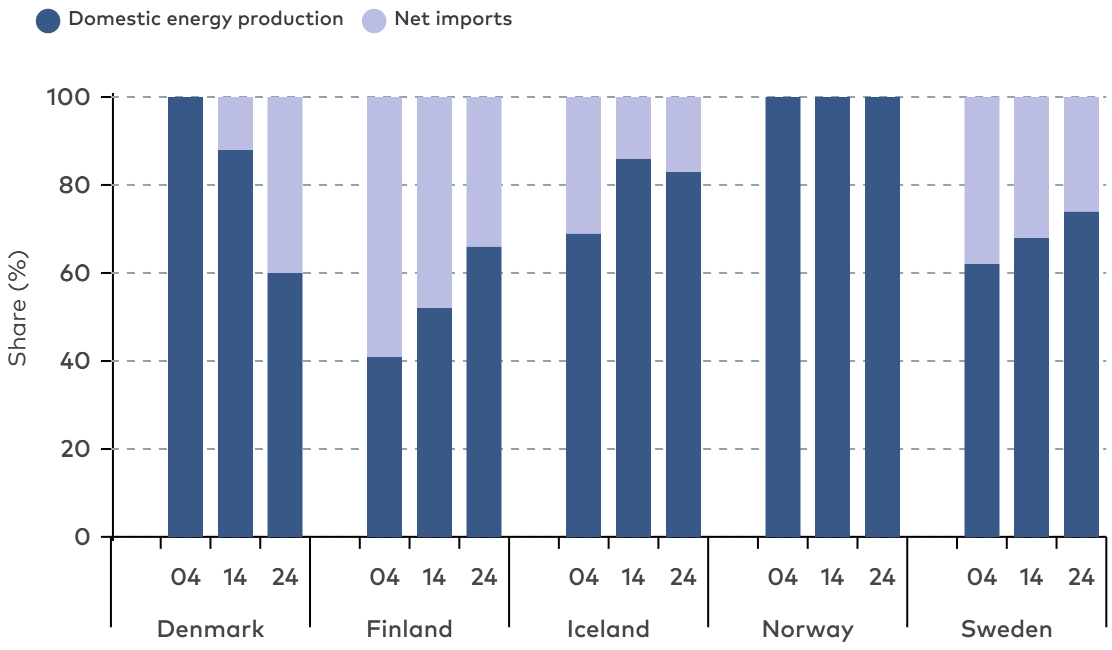
[18] Ember (2026), Global Electricity Review 2026, ember-energy.org/latest-insights/global-electricity-review-2026/

Figure 2.4: Change in energy import dependence in the Nordics, 2004–2024



Source: Eurostat.
Notes: The shares represent the portions of a country's total energy supply that are covered by domestic energy production (yellow) and imports (purple). E.g. in 2024, Denmark produced 60% and imported 40% of its energy needs.[19] The origin of nuclear fuels and feedstocks for liquid biofuel production are beyond the scope of national energy data.

2.1.1 Clean energy transition and supply chain security

The new clean energy technology and underlying critical minerals dependencies are real, but their security of supply dimension differs fundamentally from fossil fuel imports. Oil and gas require a continuous flow. If those imports are stopped and, once limited reserves are exhausted, the fossil fuel energy system stops. Clean energy technology imports are different in kind. Disrupting the supply of solar panels or wind turbine components would slow the expansion of renewable capacity, but it would not interrupt the output of existing installations in the short to medium term (unless repair components are not available to damaged infrastructure). In this sense, electrification strengthens Nordic energy security over time: the more of the energy system that runs on domestically generated electricity from hydro, wind, and geothermal sources that require no imported fuel, the smaller the share of the system that depends on an uninterrupted flow of imported commodities.

The energy transition has created a deeper category of import dependency that is less visible than fossil fuel dependency but geographically more concentrated. The IEA's Energy

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[19] For simplicity, stock changes and international bunkers are excluded from the calculation.

Technology Perspectives 2026 estimates that China accounts for 60 to 85 per cent of production capacity for key clean-energy supply chains, and over 95 per cent for some individual production steps; less than 10 per cent of global rare-earth refining capacity sits outside China.[20] China's recent export controls on gallium, germanium, antimony, and rare-earth processing technologies underscore the risk of supply chain concentration.

In many cases, the most consequential bottlenecks are mid-chain, not at the mine: when a major Nordic mapped its wind turbine permanent magnet supply chain, it found that apparent supplier diversification masked a structural dependency, with the vast majority of high-performance magnets across multiple suppliers processed in China regardless of where final assembly took place.[21] On the flip side, the Nordics with vast minerals resources are well positioned to be part of the solution through domestic critical minerals production and processing.

2.2 How consumption patterns shape energy security

How energy is used matters as much as where it comes from. Combining sectoral weights with sectoral fuel shares (Figure 2.5) gives a quick read on where supply disruptions are felt. Industry and the buildings sector each account for close to 40 per cent of Nordic final consumption. The long Nordic heating season is the main driver of buildings demand, which makes building-stock energy efficiency one of the most powerful levers on aggregate demand in the medium and long-run. Transport remains over 80 per cent oil-fuelled despite high electric vehicle uptake. The expectation across all sectoral scenarios is that the share of electricity will rise.

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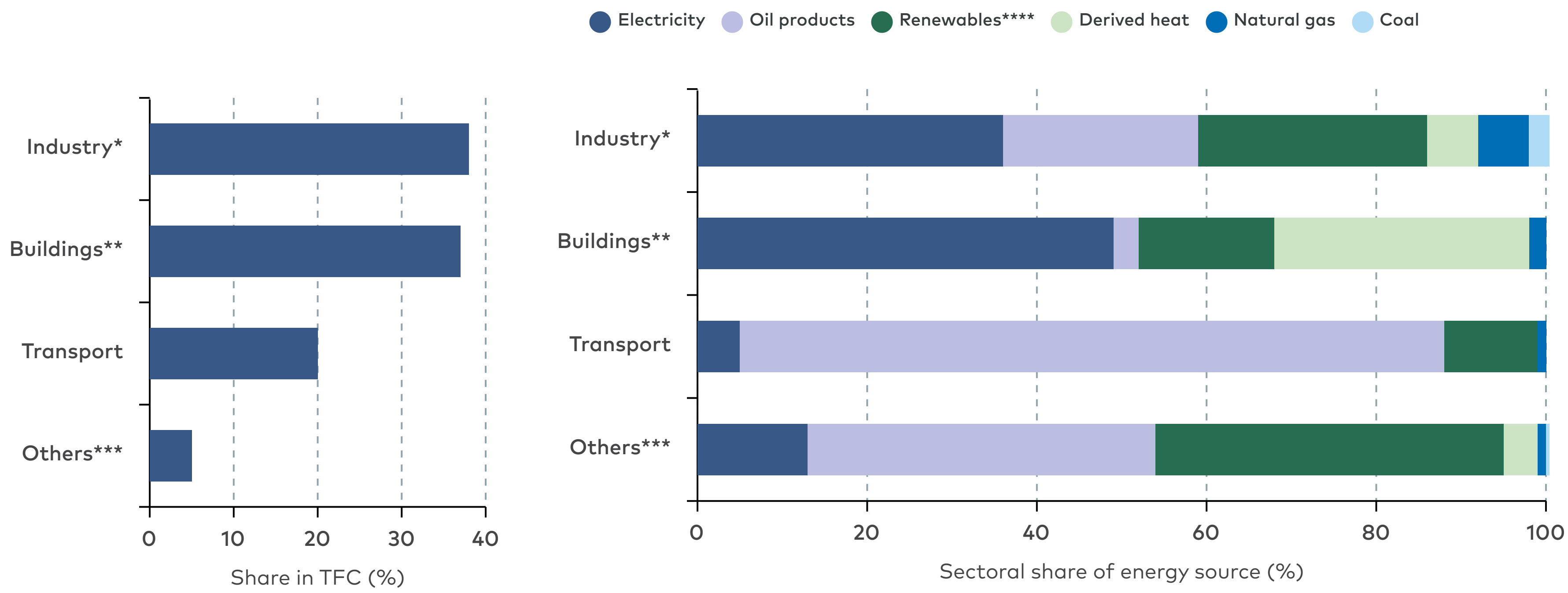
20. IEA (2026), Energy Technology Perspectives 2026, International Energy Agency, https://www.iea.org/reports/energy-technology-perspectives-2026
21. Depraiter, L., Goutte, S., and Porcher, T. (2025), 'Geopolitical risk and the global supply of rare earth permanent magnets: Insights from China's export trends', Energy Economics, vol. 146, 108496, https://doi.org/10.1016/j.eneco.2025.108496

Figure 2.5: Energy consumption by economic sector in the Nordics, 2024



Source: Eurostat.
Notes: Industry includes non-energy use. Buildings includes residential and services. Others includes agriculture, forestry, fishing and unspecified energy consumption. Renewables here include biofuels, geothermal and solar thermal.

Sectoral fuel mix shapes which type of shock translates into which kind of disruption. Transport, still over 80 per cent oil-fuelled, depends on the continuous arrival of imported fuels and is therefore directly exposed to the geopolitically induced supply and price shocks set out in Section 1.5. Residential energy use, by contrast, is largely electrified and largely backed by Nordic generation, which means residential consumers are well hedged against fuel-supply shocks even though they remain exposed to the price-transmission channel running through the wider European wholesale electricity market. The flip side is that the buildings and industry sectors, as they electrify further, become more exposed to a different category of risk: cyber events affecting system operations and the consequences of disruption or sabotage of critical cross-border power lines. Sectoral electrification is a security upgrade against fuel shocks and a security trade-off against electricity-system shocks at the same time.

2.3 System-level characteristics: key implications

Four conclusions follow from the overview, and they shape how the trilemma plays out in the rest of the report. First, coal consumption is in terminal structural decline and a coal supply shock would have only marginal direct impact; the report does not analyse coal further. Second, natural gas consumption is on the same trajectory within the Nordic countries themselves, but because gas is often the marginal fuel in the European electricity market, gas supply disruptions transmit into Nordic electricity prices regardless of how little gas the Nordic system burns. Gas also retains a direct role in fertiliser production, petrochemical feedstocks and some high-temperature industrial heating, where substitution is technically difficult. Nordic gas production capacity, dominated by Norway, is therefore covered in Section 6. Third, oil consumption is gradually declining but will remain materially important at least through the 2030s, particularly in transport, aviation and the Island Energy Systems. Fourth, the centre of gravity of energy security is shifting towards electricity, and the institutional architecture has to keep pace with both the present fuel reality and the direction of change.

In trilemma terms, the security and affordability pillars are increasingly transmitted through electricity and electricity prices, while sustainability shapes both the threat and the resilience picture by reshaping the system itself. The risk typology in Section 1.5 is the lens through which the carrier-specific sections that follow should be read: local, regional and global risks compound differently across electricity, oil and gas, and the cooperation needs differ accordingly.

Section 3

NORDIC-SYSTEM LEVEL ENERGY SECURITY COOPERATION

Image: **iStock**

Section 1 established when Nordic cooperation adds value over national or other international action: where the risk is genuinely cross-border, where collective action creates economies of scale, where common standards reduce friction in emergency response, and where shared positions amplify Nordic influence in larger frameworks. Section 2 grounded the analysis in the data. This section turns to the institutional reality at the Nordic system level. It maps the strategic-planning and policy-alignment architecture currently in place (3.1) and the Nordic-Baltic continuum within which Nordic cooperation sits (3.2). The regional threat geography of the Baltic and the Arctic, including the most acute system-level pressure point of cross-border subsea and offshore infrastructure exposed to hybrid threats, is treated in Section 4. Carrier-specific cooperation arrangements that sit beneath these system-level structures, in electricity, oil and gas, are addressed in Sections 5, 6 and 7 respectively.

The synthesis is straightforward: the political signal in support of Nordic cooperation is sharper than at any point in the post-Cold War era, but the institutional machinery to operationalise it has not yet caught up. Where the gap is widest is the analytical layer that should connect ministerial declarations on energy security to the trilemma trade-offs that ministers are actually managing at home.

3.1 Strategic planning, policy alignment and thematic cooperation

The formal architecture for Nordic strategic energy planning runs through three interlocking structures. The Nordic Council of Ministers for Energy (MR-E) is the political coordination level: energy ministers meet at least annually, issue declarations, and set the mandate for cooperation under the activities of the Council. The current mandate is detailed in the Nordic Council of Ministers (NCM) Energy Cooperation Programme 2025–2030, which for the first time places energy security as the first of four programme goals, ahead of market development and innovation.[22] The programme prioritises areas where the countries can produce stronger results together than separately, with special focus on ensuring high security of energy supply, an enhanced Nordic position in the energy transition, a more efficient electricity market, and a stronger Nordic voice in international cooperation. The Committee of Senior Officials on Energy (ÄK-E) translates ministerial direction into programme and budget approvals for Nordic Energy Research, which serves as the research and implementation arm under the Council.

The political signal from ministers has sharpened markedly since 2022. The October 2024 Stockholm ministerial meeting adopted energy security as the leading priority for the 2025–2030 period.[23] At the October 2025 Helsinki meeting, held under a Finnish presidency that had explicitly prioritised comprehensive security and preparedness, Nordic energy ministers adopted a joint declaration focused on energy security. The declaration emphasised that joint initiatives could be expanded to new areas and intensified considerably, and that securing critical infrastructure and developing strong operating models for regional cooperation had become more pressing. The Nordic prime ministers reinforced this at head-of-government level in a joint statement on crisis preparedness and resilience, which explicitly called for advancing the security and sustainability of Nordic energy infrastructure as a priority.

Yet the institutional machinery has not yet been given a specific mandate, or a dedicated forum, to operationalise a regional approach to energy security.[24]

A senior Nordic ministry official described the state of cooperation as mostly informal: *'there is no nominal energy security group in the Nordic context, but nothing prevents discussing and inviting relevant people within the current framework.'* The same interview flagged real constraints on political bandwidth: Nordic energy ministers cannot realistically convene a separate security crisis mechanism every time EU energy ministers are on a call over an unfolding situation. Any new Nordic strategic-planning structure has to fit into a realistic schedule, not an aspirational one.[25]

3.1.1 Nordic working groups and the thematic research base

Nordic Energy Research convenes three Nordic working groups and two networks relevant to energy security: the Nordic Electricity Market Group, covering market design, adequacy, and flexibility; alongside groups on Renewable Energy and Hydrogen; the Nordic-Baltic Group on Carbon Capture, Utilisation and Storage (CCUS); the climate-transition-focused Net Zero Islands Network; and Nordsyn, which focuses on energy efficiency, ecodesign, and energy labelling.[26]

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22. Nordic Council of Ministers (2024), Nordic Co-operation Programme on Energy Policy 2025–2030, https://www.norden.org/en/publication/nordic-co-operation-policy-energy-2025-2030
23. Nordic Council of Ministers (2024), 'Leading the energy transition' – Stockholm ministerial meeting, October 2024, https://www.norden.org/en/news/leading-energy-transition
24. Nordic Council of Ministers (2025), 'Nordic energy ministers call for closer co-operation on security and competitiveness', Helsinki ministerial meeting, October 2025, https://www.norden.org/en/news/nordic-energy-ministers-call-closer-co-operation-security-and-competitiveness
25. Interview with senior Nordic energy official, conducted for this project, 2026 (not for attribution).
26. Nordic Energy Research, Working Groups, https://www.nordicenergy.org/working-groups/

The Electricity Market Working Group's *Toolbox for a Secure Energy Supply* (2025) is the most significant prior Nordic energy cooperation security-focused output and the direct predecessor to this project.[27] Its core finding is that Nordic capacity and flexibility interventions must be coordinated rather than fragmented across national markets and that Nordic-level adequacy cooperation is institutionally feasible and worth commissioning. No working group is currently mandated to look across all energy security dimensions holistically. This report is the first attempt to do so within the Nordic Energy Research (NER) framework, and the 2025–2030 programme provides the political basis for making such a mandate standing rather than project-specific.

3.1.2 Transmission planning and the security-criteria gap

Strategic planning intersects with infrastructure in ENTSO-E's Ten-Year Network Development Plan (TYNDP), which is the vehicle through which Nordic transmission investment is identified, prioritised and channelled towards EU Project of Common Interest status.[28] TYNDP project selection criteria are primarily economic: congestion reduction, renewable integration, market efficiency. Security considerations such as redundancy, sabotage resistance, repair access and resistance to multi-point failure are not primary project prioritisation criteria, even though the security relevance of new interconnectors and offshore assets has changed sharply since the framework was designed.

The 2025–2030 Energy Cooperation Programme explicitly identifies the EU and EEA, and specifically ENTSO-E and the EU's Agency for the Cooperation of Energy Regulators (ACER), as forums where the Nordic countries should actively leverage the strength of Nordic cooperation to pursue shared positions. There is a concrete application of this in TYNDP: Nordic countries can develop a joint position advocating for security criteria, including subsea cable vulnerability assessment, redundant routing requirements and security-by-design standards for critical infrastructure, to be incorporated into project prioritisation. This is precisely the kind of issue where aligned Nordic submissions carry materially more weight than the same arguments made country-by-country, and where Norway's ENTSO-E participation provides a route to influence that EU-only frameworks cannot.

3.1.3 The strategic gap and the trilemma

The deeper structural problem is that the NCM framework provides the political forum but not ongoing analytical depth. There is no standing joint Nordic energy security threat assessment, no systematic alignment of national energy security strategies, and no mechanism for ministers to regularly compare the trilemma trade-offs they are managing domestically. The pressures on the three pillars (security, affordability, sustainability) do not align neatly across the region. National energy system planning decisions interact

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[27] AFRY for Nordic Energy Research (2025), Toolbox for a Secure Energy Supply – Capacity Mechanisms and Non-Fossil Flexibility Support Schemes, NER 2025-02, https://pub.norden.org/nordicenergyresearch2025-02/

[28] European Commission, Projects of Common Interest and Projects of Mutual Interest – PCI and PMI selection process, https://energy.ec.europa.eu/topics/infrastructure/projects-common-interest-and-projects-mutual-interest/pci-and-pmi-selection-process_en

across borders through Nord Pool and the shared transmission system in ways that four or five separately-optimised national plans do not adequately account for.

A Nordic strategic-planning forum that is honest about the trilemma trade-offs would give ministers a shared basis for understanding how national choices reverberate regionally. The institutional pieces to support such a forum already exist: NordBER for the emergency perspective, cooperation between national preparedness agencies, and the Nordic Chief Information Security Officer (CISO) network for the cyber threat picture. What has not happened is the instruction to assemble those inputs into a shared annual product.

3.1.4 National preparedness agencies and bilateral cooperation

Beneath the ministerial and TSO layers, an important strand of Nordic energy security cooperation runs bilaterally through the national preparedness agencies. Finland's National Emergency Supply Agency (*NESA*) is the most visible institutional driver of Nordic-relevant cooperation in this layer, partly because Finland's long security-of-supply tradition gives the agency unusually broad scope. NESA mainstreams business continuity and resilience across critical sectors through public-private partnerships, maintains strategic stockpiles across multiple sectors including energy, and acts as the operational counterpart for cross-border preparedness work.[29]

The most consequential bilateral relationship in this domain is between Finland and Sweden, conducted between NESA and Sweden's Civil Contingencies Agency (*MSB, Myndigheten för samhällsskydd och beredskap*) under the framework of the 1992 Finland-Sweden security of supply agreement and the NESA-MSB joint strategic cooperation plan 2021–2025. Concrete areas under active development include material preparedness, in particular the piloting of joint emergency stockpiles, submarine cable repair capacity, and logistics cooperation in the northern regions, alongside exchange of situational information and joint review of the risk and threat environment.

Both governments have publicly stated that the bilateral track is intended to complement rather than substitute Nordic, Nordic-Baltic and EU/NATO cooperation, and that they would welcome extension of the cooperation approach to other Nordic countries. The Finland-Sweden experience is therefore the most concrete template available for scaling preparedness cooperation across the wider Nordic group, with the joint stockpiling pilot of particular relevance to the fuel and critical-component reserves discussed in Sections 5 and 7.[30] The Finland-Swedish bilateral cooperation could also be the basis for a multilateral framework, bringing together all of the Nordic emergency supply agencies.

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[29] Finnish National Emergency Supply Agency (Huoltovarmuuskeskus), https://www.huoltovarmuuskeskus.fi/en/organisation/the-national-emergency-supply-agency

[30] Finnish Government (2024), 'Finland and Sweden engage in extensive and diverse cooperation in preparedness issues', https://valtioneuvosto.fi/en/-/1410869/finland-and-sweden-engage-in-extensive-and-diverse-cooperation-in-preparedness-issues

3.2 Nordic-Baltic energy security governance continuum

The most active regional energy security governance space in Europe right now is the Baltic Sea region, and Nordic cooperation needs to be positioned in relation to that architecture rather than alongside it. Three frameworks are directly relevant: the Baltic Energy Market Interconnection Plan (BEMIP), the Council of the Baltic Sea States (CBSS), and NATO's Maritime Centre for the Security of Critical Undersea Infrastructure (See Table 3.1 for a summary).

The Baltic Energy Market Interconnection Plan (BEMIP) High-Level Group is convened by the European Commission and brings together eight EU member states: Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, and Sweden, with Norway as an observer. BEMIP operates at ministerial, senior official, and technical levels and is the primary forum for regional energy infrastructure planning. Its renewed Memorandum of Understanding, signed on 12 May 2025, added the protection of energy-related subsea cables and pipelines to its scope, alongside the offshore renewables build-out. The MoU records political intent and does not create new legal commitments; the operational substance sits in the BEMIP Action Plan developed at a technical level beneath it. Iceland is not a BEMIP participant.[31]

The Council of the Baltic Sea States (CBSS) Memorandum of Understanding on the Protection of Critical Undersea Infrastructure in the Baltic Sea, signed at the Vihula Ministerial Session on 16 May 2025 by Denmark, Estonia, Finland, Germany, Iceland, Latvia, Lithuania, Norway, Poland, Sweden, and the European Union, is the broadest framework yet for coordinated protection of critical underwater infrastructure in the region. It establishes a joint Baltic Sea Expert Group for cooperation between relevant national authorities, with provisions for transmission system operators and energy and telecom service providers to be drawn in through competent national authorities. The group is to develop mechanisms for exchanging information and best practices and examining joint projects. The MoU operates at the foreign-minister level and is institutionally separate from BEMIP, but its inclusion of TSOs and infrastructure operators gives it an operational reach that purely diplomatic frameworks lack. Its distinct value within the regional architecture is the inclusion of all five Nordic countries alongside the Baltic states, Germany, and the EU within a single framework.[32]

NATO's Maritime Centre for the Security of Critical Undersea Infrastructure (MCSCUI), operational since May 2024 at Allied Maritime Command in Northwood, is a networking and knowledge centre that supports Commander MARCOM in decision-making and coordination rather than an operational command in its own right. The operational layer in the Baltic is Baltic Sentry, launched in January 2025 under Allied Joint Force Command Brunssum, which deploys frigates, maritime patrol aircraft and naval drones in

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31. European Commission (2025), 'New Memorandum of Understanding to bolster energy cooperation in the Baltic Sea Region', 13 May 2025, https://energy.ec.europa.eu/news/new-memorandum-understanding-bolster-energy-cooperation-baltic-sea-region-2025-05-13_en
32. Council of the Baltic Sea States (2025), Vihula Ministerial Session, May 2025, https://cbss.org/about-us/ministerial-sessions/ministerial-session-2025/

coordination with MCSCUI. Denmark, Norway and Sweden are among MCSCUI contributing nations; Finland's NATO accession in 2023 and Sweden's in 2024 have widened the regional footprint of Alliance command structures in the Baltic.[33]

Table 3.1: Baltic Sea regional energy security governance frameworks relevant to Nordic cooperation

Framework	Convener and level	Nordic membership	Mandate
BEMIP (Baltic Energy Market Interconnection Plan), HLG renewed MoU May 2025	European Commission. Three tiers: ministerial, senior officials, technical working groups.	Denmark, Finland, Sweden as full participants. Norway as observer. Iceland not a participant.	Regional energy infrastructure planning. 2025 MoU added protection of energy-related subsea cables and pipelines, plus offshore renewables build-out.
CBSS Vihula MoU on Protection of Critical Undersea Infrastructure, signed May 2025	Council of the Baltic Sea States. Foreign-minister level, with senior officials track and expert group beneath.	Denmark, Finland, Iceland, Norway, Sweden, alongside Estonia, Germany, Latvia, Lithuania, Poland and the EU.	Coordinated protection of critical underwater energy and communications infrastructure. Information exchange, best practices, joint projects.
NATO MCSCUI (Maritime Centre for Security of Critical Undersea Infrastructure), operational May 2024	NATO Allied Maritime Command, Northwood. Military command structure.	Denmark, Norway, Sweden among contributing nations. Finland a NATO member since 2023.	Networking and knowledge centre supporting Commander MARCOM in decision-making and coordination. Not an operational command in itself.

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33. NATO Allied Maritime Command (2024), 'NATO officially launches new Maritime Centre for the Security of Critical Undersea Infrastructure', https://mc.nato.int/media-centre/news/2024/nato-officially-launches-new-nmcscui

Nordic cooperation's comparative advantage within this architecture is not to lead Baltic Sea-wide coordination, since BEMIP, CBSS, and NATO are the appropriate vehicles for that. The Nordic value-add is particularly focused on expanding the Baltic Sea frameworks laterally to include relevant Nordic actors. Nordic cooperation can provide the technical and operational substance through Nordic TSOs, energy authorities, and operators feeding into the Baltic Sea Expert Group and through keeping bilateral arrangements such as the Finland–Estonia critical infrastructure MoU of September 2024 consistent with the broader regional architecture. The productive framing is Nordic cooperation as the inner ring of preparation, technical depth, and operational substance that gives the Baltic-level frameworks the content they need to function, rather than a parallel implementation layer running beneath them.

Section 4

NORDIC ENERGY SECURITY IN TWO REGIONAL CONTEXTS: THE BALTIC AND THE ARCTIC

Image: **iStock**

Section 3 mapped the institutional architecture for Nordic and Nordic-Baltic energy security cooperation. This section turns to the geography and the threat picture those frameworks are meant to address. The Nordic energy system sits at the intersection of two distinct strategic environments. The Baltic Sea is shallow, contained, multilateral, and holds one of the densest clusters of cross-border subsea energy infrastructure in Europe. The Arctic has seen mounting geopolitical tensions especially since 2022, in waters marked by vast, unguarded distances and the region's most exposed offshore energy infrastructure*. Sub-section 4.1 sets out the Baltic vulnerability picture; sub-section 4.2 covers the Arctic; sub-section 4.3 synthesises the cross-theatre patterns and the institutional gap.*

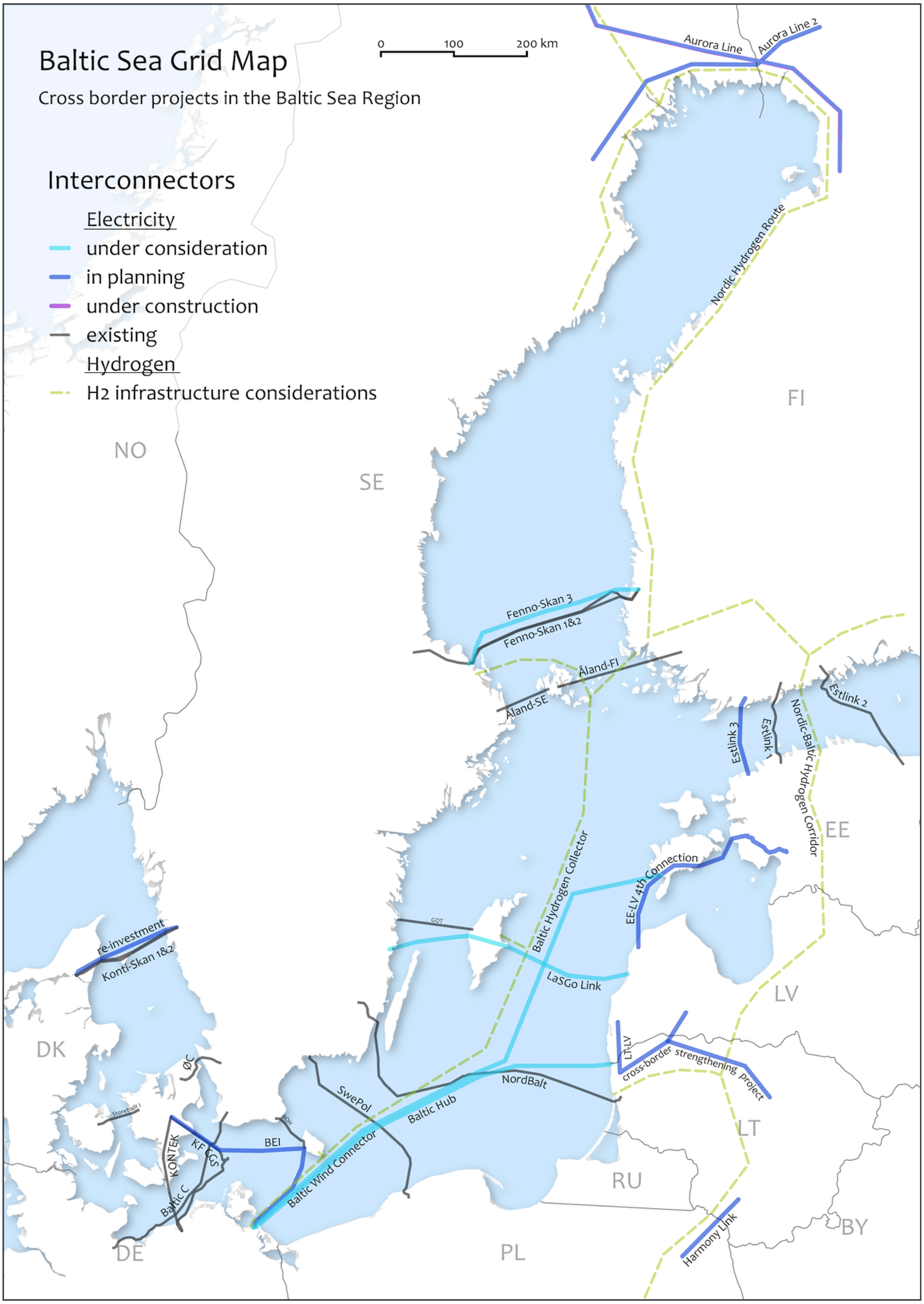
Both the Arctic and Baltic have been subject to rising geopolitical tensions since 2022, each with its own energy security vulnerabilities. The Baltic generates a clustering risk: many high-value cross-border assets concentrated in a small sea area, where a single anchor-dragging incident can disable a pipeline and a power cable within an hour and where busy maritime traffic makes attribution difficult. The Arctic generates a distance risk: high-value assets far apart, far from response and repair capability, and exposed to single points of failure where the next available alternative may sit a thousand kilometres away. The two pictures are different, but the underlying logic is the same: the post-2022 threat environment exposes the Nordic energy security system to two regionally distinct hazard profiles that cooperation must address in parallel.

4.1 The Baltic Sea: clustered exposure in a contained sea

4.1.1 The infrastructure cluster

The Baltic Sea concentrates more cross-border energy and digital infrastructure in a smaller and shallower water body than almost any other basin in the world. On the electricity side, the basin carries the NordBalt cable between Lithuania and Sweden, the Estlink 1 and Estlink 2 high-voltage direct current (HVDC) interconnectors between Finland and Estonia, the SwePol cable between Sweden and Poland, the Baltic Cable between Sweden and Germany, and several internal Nordic links, alongside the planned Estlink 3 and Harmony Link interconnectors. (See Figure 4.1).

Figure 4.1



Source: Adapted from Baltic Offshore Grid Initiative, Expert paper 2025

Notes: Routes for future interconnectors and energy hubs are for illustration only and not to scale. Landfall points and grid connections are approximate and only for graphical demonstration.

On the gas side, it carries the Balticconnector pipeline between Finland and Estonia, and the Baltic Pipe from Norway through Denmark to Poland. The North Sea–Baltic data backbone runs through the C-Lion1 cable between Finland and Germany and the BCS East-West cable between Lithuania and Sweden, with multiple shorter telecommunications cables in between.[34] The offshore wind build-out adds a further layer: the Baltic Energy Market Interconnection Plan (BEMIP) target of 19.6 GW of installed offshore wind capacity in the Baltic Sea basin by 2030, rising to 93 GW by 2050. Interconnectors supporting the offshore wind build up from the Bornholm Energy Island, the Kriegers Flak interconnector hybrid project and the Estonia-Latvia ELWIND project add to the long list of critical energy infrastructure in the Baltic Sea.[35]

The deepening cluster of energy infrastructure is the physical embodiment of Nordic-Baltic energy integration, which is only expected to deepen (see Box 4.1 for further details on specific vulnerabilities of Baltic island regions). The electricity grid desynchronisation of Estonia, Latvia and Lithuania from the Russian-controlled BRELL ring and their synchronisation with the Continental European Synchronous Area in February 2025 removed the last structural link between the Baltic states' electricity systems and the Russian grid, while simultaneously pulling the Baltic electricity market into full operational interdependence with the Nordic and Central European systems. The synchronisation was completed via the LitPol Link interconnector between Lithuania and Poland, making that corridor a load-bearing element of the new regional architecture rather than a supplementary tie.

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34. ENTSO-E, Interconnected Network of Northern Europe Map, 2024; European Commission, BEMIP High-Level Group, Renewed Memorandum of Understanding, 12 May 2025; Gasgrid Finland, 'Balticconnector,' company technical description; Energinet, 'Baltic Pipe Project,' project documentation.
35. BEMIP High-Level Group, Joint Declaration of Energy and Climate Ministers of the Baltic Sea Region, Marienborg, 30 August 2022, and renewed MoU of 12 May 2025; WindEurope, 'Baltic Sea countries pledge closer collaboration to secure critical offshore energy infrastructure,' 2024; Eight Baltic Sea TSOs, 'Roadmap for an efficient and resilient offshore grid,' 2024.

Box 4.1: Baltic island energy systems and their distinct vulnerabilities

Four Baltic islands have specific vulnerabilities that the system-level picture above does not capture. Each is a small system that depends on one or two subsea power cables to a mainland for most of its electricity and has limited capacity to generate its own power locally.

Bornholm (Denmark) depends today on a single subsea power cable to southern Sweden, backed up by a local power station in Rønne. That cable has been damaged or failed repeatedly: in 2004, 2010, 2013 and again in January 2026, when the island had to switch to local backup generation. From the early 2030s, Bornholm will also host the converter platform for the Bornholm Energy Island: a 3 GW offshore wind hub (enough to power around three million homes) connecting Denmark and Germany through two new high-voltage cables of around 200 km each. The island therefore shifts from being a small dependent system to a critical link in the wider Danish-German power system integration architecture. The cables will carry both the wind output and cross-border electricity trade, and the converter platform becomes a single point of failure for a much larger flow.

Gotland (Sweden) combines a large military presence, civilian population and growing industrial energy demand on a single island. It is connected to the Swedish mainland by two existing high-voltage cables with a combined capacity of 260 megawatts, with a new and larger connection contracted in December 2024 and due in 2030. Because these are direct-current links, Gotland's electricity system runs independently of the mainland grid frequency. Combined with a high local share of wind power, this places almost all the responsibility for system stability on the converter equipment at both ends.

Öland (Sweden), by contrast, is part of the mainland synchronous system and connected through the cable corridor that runs alongside the Öland Bridge from Kalmar. Its exposure is the more familiar one of a thin transmission spur into a tourist-and-agricultural area, sharpened by the fact that southern Sweden has the tightest electricity adequacy margins of any Swedish price zone.

Åland runs its own electricity grid through its own transmission company, Kraftnät Åland. The territory is supplied by an 80 megawatt alternating-current cable to Sweden, with a 100 megawatt direct-current cable to Finland (commissioned in 2015) as the reserve route, an older 10 megawatt cable to Finland, two gas turbines for standalone operation, and a small but growing battery base, including a 2 megawatt unit at the Söderby solar park commissioned in 2026 that can also restart the local grid after an outage. Either of the main cables on its own is enough to meet full island demand, and the Finnish cable has switched in automatically when the Swedish cable has failed. Åland's vulnerability is therefore less about physical capacity and more institutional: as a demilitarised autonomous region of Finland with only observer status at the Nordic Regional Coordination Centre for transmission operators, Åland is less embedded in operational Nordic energy security cooperation than the mainland systems are.

4.1.2 Offshore wind buildout as expanding attack surface

The Baltic offshore wind build-out is in the early stages of a roughly fivefold expansion to 2030 and a thirty-fold expansion to 2050, against an installed base of 2.8 GW as of 2024. The principal projects span the basin: the Bornholm Energy Island (3 GW, Denmark-Germany), the Kriegers Flak combined grid solution between Denmark and Germany, the Estonia-Latvia ELWIND project of approximately 1 GW, and a substantial Polish pipeline in the southern Baltic that includes the 1.2 GW Baltic Power project developed by Orlen and Northland Power, with generation expected from 2026, and the Equinor-Polenergia Baltyk II and III farms of 720 MW each, expected to reach full operation by 2028.[36]

From an energy security perspective, the build-out has two contradictory implications. On the supply side, offshore wind in the Baltic operates with a capacity factor in the range of 45 to 55 per cent at the better sites, which gives it a firmer power-system role than onshore wind and closer to that of conventional baseload generation; the contribution of offshore wind to Nordic-Baltic adequacy through the 2030s is therefore substantial.[37]

On the security side, the build-out compounds the cluster exposure that 4.1.1 identified. Every new offshore wind farm adds a network of inter-array cables, an offshore substation, and an export cable to the basin's stock of high-value subsea assets. The Bornholm and Kriegers Flak hybrid projects are particularly exposed because their export cables function simultaneously as cross-border interconnectors.

The 2023 NATO ENSEC Centre of Excellence Coherent Resilience tabletop exercise on a drone swarm attack against an offshore substation revealed coordination gaps across critical infrastructure protection, crisis management, strategic communication, and maritime law that have not been comprehensively addressed.[38] The trade-off is not whether to proceed with the build-out, which is required for both the climate and security pillars of the Nordic energy trilemma, but how to protect what is being built. That challenge is treated in Section 8.

4.1.3 The Baltic offshore infrastructure disruption risk

Since September 2022, a series of incidents has damaged or severed subsea energy and telecommunications infrastructure in the Baltic, from pipelines and HVDC power cables to data cables, through methods including explosions, anchor drag by commercial vessels, and suspected deliberate interference. In many cases, investigation and criminal proceedings remain ongoing to determine the ultimate perpetrator (see Section 1 for details). The ambiguity over the nature of the acts is itself operationally significant: the Baltic's shallow waters, dense commercial traffic, and overlapping jurisdictions create a

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[36] BEMIP High-Level Group, 'Marienborg Declaration on offshore wind in the Baltic Sea,' 30 August 2022; Energy Islands of Denmark, Bornholm Energy Island project documentation; Estonia and Latvia, ELWIND joint project communications; Baltic Power, 'About the project,' https://balticpower.pl/about-the-project/; Reuters, 'Equinor, Polenergia agree on Polish offshore wind project,' 19 May 2025.

[37] WindEurope, 'Offshore Wind in Europe: Key Trends and Statistics,' 2025 edition, with Baltic-specific capacity factor data; Energinet, 'Capacity factor assumptions for North Sea and Baltic Sea offshore wind,' internal note 2024.

[38] NATO Energy Security Centre of Excellence, 'Coherent Resilience 2023 Baltic table-top exercise: after-action observations,' 2023.

structural environment in which deliberate and accidental damage are difficult to distinguish in the short term, and in which plausible deniability creates opportunities for deliberate interference.

The pattern is more analytically important than any single incident. First, subsea energy infrastructure in European waters is now operationally vulnerable to physical disruption from sources ranging from state actors to commercial vessels operating with blurry ownership structures. Second, the Baltic is a low-attribution environment by design: shallow waters, dense traffic, and overlapping jurisdictional waters together make accidental anchor damage and deliberate sabotage operationally indistinguishable in the short term. Third, the repair gap that the Balticconnector rupture first exposed has been confirmed by every subsequent incident: HVDC cable repair takes between two and five months on a Baltic timeline, depending on the season and the availability of specialised cable-laying vessels, and gas pipeline repair takes longer still. Fourth, single events can disable energy and data assets simultaneously.[39]

4.1.4 Repair capacity and the post-incident response

The post-incident picture in the Baltic is shaped by three constraints that together explain why repair times have stretched and why the gap between an incident and its resolution is now itself a material vulnerability. First, the global fleet of specialised cable-laying and cable-repair vessels is small, geographically dispersed, and overwhelmingly contracted to commercial telecommunications operators on long-term arrangements; access to repair vessels on short notice depends on contractual priority that Nordic and Baltic operators have not historically held.

Second, HVDC power cable repair requires heavier handling equipment and specialist jointing techniques distinct from the telecommunications cable repair toolkit, and a smaller subset of the global fleet is equipped accordingly.

Third, weather windows in the Baltic are narrow in winter, when shorter daylight, ice formation in the Bay of Bothnia and Gulf of Finland, and frequent storm activity all narrow windows of opportunity for repair works. The combined effect is that a single fault on a Baltic HVDC cable now plausibly takes between two and five months to resolve from incident to restoration, with the variance dominated by season and vessel availability rather than by the technical complexity of the repair itself.[40] The institutional response to this is treated in Section 4 and the recommendations in Section 8.2; the point in this section is that the repair gap is a vulnerability of its own, not merely a consequence of the underlying physical exposure.

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39. For the typology of confirmed, suspected, under investigation and dismissed attribution applied here, see NER feedback on the report draft, May 2026, and the methodological discussion in Section 1.
40. European Commission, 'EU Action Plan on Cable Security,' February 2026, with the EUR 347 million Cable Security Toolbox allocation and the EUR 20 million Baltic Sea pilot for pre-positioned modular repair equipment; European Subsea Cables Association (ESCA), industry input on HVDC versus telecommunications cable repair lead times, 2024.

Image: iStock

Box 4.2: The shadow fleet as a cross-theatre vulnerability

Russia's shadow fleet, the term applied to the loose constellation of 600 or more aging tankers operated under blurred ownership and frequent flag-state changes that has emerged to transport Russian crude and oil products under the Western price cap regime, has become a year-round presence in both Baltic and Arctic Nordic waters. The fleet creates three distinct Nordic energy security pressures that none of the standard maritime cooperation frameworks fully address.

The first pressure is physical risk to subsea infrastructure. The Eagle S incident of December 2024, in which a sanctioned shadow-fleet tanker is alleged to have severed the Estlink 2 cable and four telecommunications cables by dragging its anchor for tens of kilometres, is the clearest single illustration of the convergence between sanctions evasion and infrastructure damage. Whether the damage was deliberate or the result of the operational degradation typical of poorly maintained shadow-fleet vessels matters less for vulnerability assessment than the fact that the type of vessels with the means to cause such damage has grown substantially since 2022.[41]

The second pressure is environmental risk to Nordic coastal energy infrastructure. Shadow-fleet tankers are typically older than the global commercial fleet average, frequently inadequately insured, and operate without the protection-and-indemnity coverage that would normally underwrite oil-spill response. A major spill in the Gulf of Finland, the Danish Straits, the Skagerrak or off the Norwegian Arctic coast would, beyond the ecological damage, directly threaten coastal energy assets including LNG terminals, oil terminals and offshore wind landing points, and would tie up Nordic emergency response capacity for weeks. The risk is structurally higher in Arctic waters, where response capacity is thinner and ecological recovery slower.[42]

The shadow fleet is therefore the single threat that most clearly bridges the two regional theatres covered in this section: the same vessels generate risks to the infrastructure and environment across the Baltic and Arctic regions.

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41. Finnish Border Guard and National Bureau of Investigation communications on the Eagle S case; Centre for Research on Energy and Clean Air (CREA), reporting on shadow-fleet operations in the Baltic, 2023–2025.
42. International Group of Protection and Indemnity Clubs, 'Reporting on shadow-fleet insurance gaps,' 2024 and 2025 updates; Norwegian Coastal Administration, communications on Arctic oil-spill response capacity assumptions, 2024.

4.2 The Arctic: distance, exposure and strategic contest

4.2.1 What the Arctic adds to the Nordic energy security picture

The Arctic theatre adds three structural features to the Nordic energy security picture that the Baltic does not contain in the same form. The first is distance. Response times to incidents in the Norwegian, Barents and Greenland seas are measured in days rather than hours; search-and-rescue coverage thins north of the Arctic Circle; and the global fleet of ice-class repair vessels capable of supporting Arctic infrastructure work is even smaller than the Baltic-capable fleet discussed in Section 4.1.4.

The second is geopolitical context. The Russian Northern Fleet headquartered in Severomorsk on the Kola Peninsula concentrates the bulk of Russia's strategic submarine force; and the so-called Bear Gap between Norway and Svalbard has, on the assessment of the Norwegian Chief of Defence in January 2026, replaced the Greenland-Iceland-United Kingdom (GIUK) gap as the principal point of military attention in the European Atlantic.[43]

The third is resource centrality. The Norwegian Barents Sea contains the bulk of Norway's gas production reserve base; the Nordic critical minerals frontier sits inside the Arctic Circle in northern Sweden, northern Finland and Greenland; and Greenland itself has emerged since 2024 as a focus of transatlantic political contestation in ways that have direct consequences for Nordic energy security cooperation. The remainder of this sub-section addresses each in turn.

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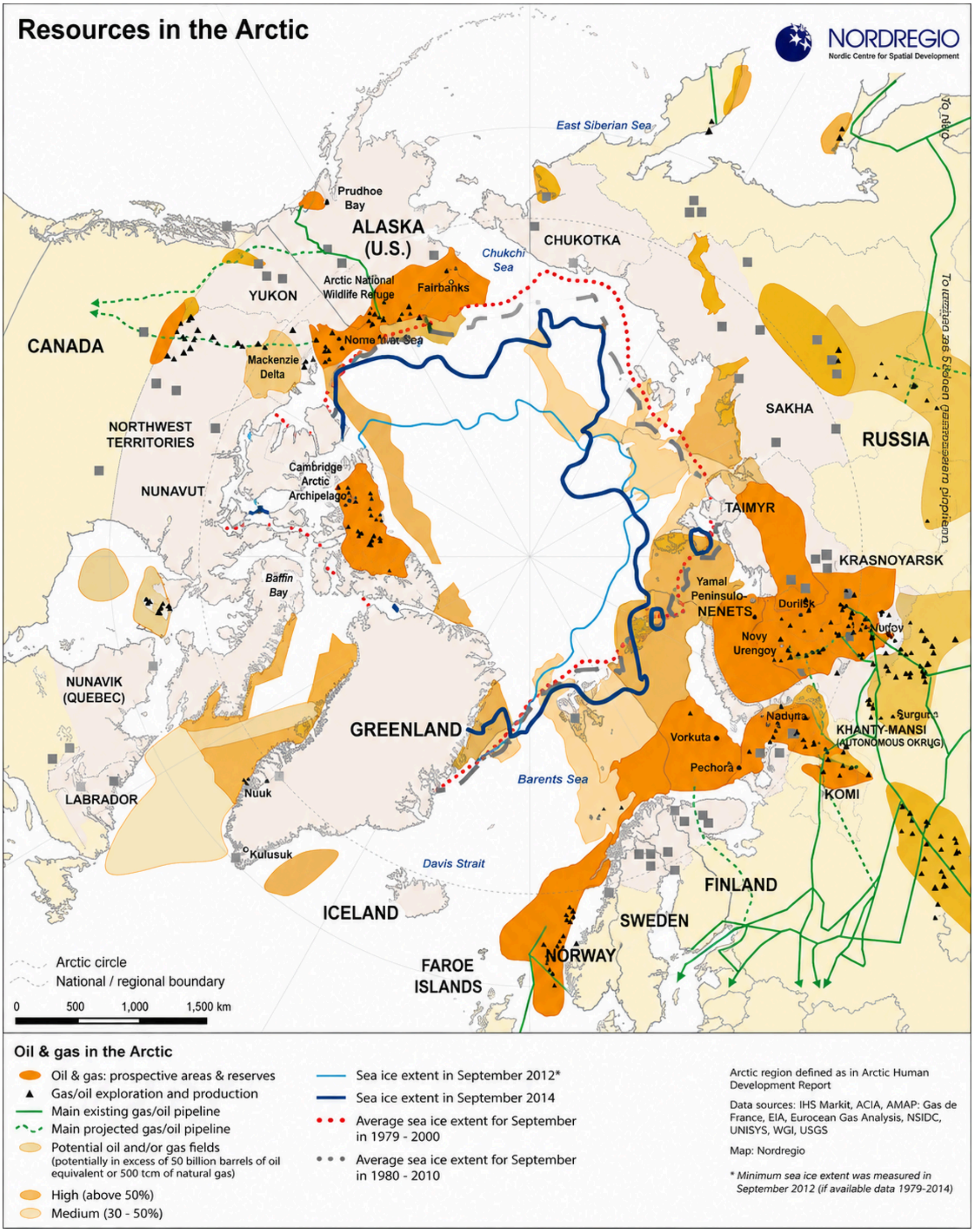
43. Norwegian Chief of Defence (Forsvarssjefen), Annual Address, Oslo Military Society, January 2026, as reported in Norwegian and international defence press; Russian Ministry of Defence, communications on the reorganisation of the Northern Military District, 2024.

Figure 4.2: Existing and potential oil and gas production, infrastructure, mining sites and sea ice extent in the Arctic



Source: Nordregio (2015)

4.2.2 Northern infrastructure vulnerabilities

The energy infrastructure of Northern Norway and the wider High North shares a set of structural characteristics that distinguish it from the rest of the Nordic region. Distance from mainland supply chains, limited grid redundancy, and the concentration of critical functions in single assets all apply with particular force in Arctic conditions, where harsh weather, thin repair capacity, and long logistics chains compound the consequences of any disruption.

The most acute single-point-of-failure in the Northern Nordic energy system is the Hammerfest LNG plant on Melkøya island: it is the only export route for Snøhvit gas and the only exit point for any Norwegian Barents Sea production, with no Barents-to-continent pipeline as an alternative. A fire in the plant's CO_2 removal unit in September 2020 illustrated what this concentration means in practice: an outage lasting 21 months, repairs costing over NOK 14 billion, and the need to import replacement equipment manufactured outside Norway before the plant could return to operation in May 2022.[44] A single disruption event at one facility removed an entire production basin from the export market for nearly two years.

The Northern Finnmark electricity grid exhibits a similar pattern. Single 132 kV transmission rings with limited redundancy serve an area that includes industry, defence installations, the Banak air base, and the Melkøya gas processing infrastructure. The planned 420 kV Skaidi-Hyggevatn link, originally scheduled for 2026, has been delayed to 2027–2028 and remains the central bottleneck for Northern Norwegian energy adequacy for the rest of this decade.[45] The grid constraint and the single LNG export point are linked: any electrification of Melkøya's own operations runs directly into the capacity ceiling of the transmission ring serving it.

Thin redundancy is a recurring theme across the wider High North. Svalbard's connectivity to the mainland depends on two submarine cables between Longyearbyen and Andøya; when one was cut in January 2022, the second carried the load and no service interruption occurred, but the margin was a single cable.[46] Longyearbyen's electricity supply, following the closure of its coal-fired plant in October 2023, now rests on diesel generation pending a low-carbon replacement that has not yet been commissioned, leaving the archipelago fuel-import-dependent for the foreseeable future.[47] The Faroe Islands and Greenland sit in a structurally similar position: isolated systems outside both the EU and IEA stockholding frameworks, where a single disruption to fuel imports has no network alternative to fall back on. That vulnerability is addressed in detail in Section 7.

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44. Equinor, public statements on the Hammerfest LNG fire of 28 September 2020 and the subsequent restart in May 2022; Norwegian Petroleum Safety Authority, investigation report into the incident, 2021.
45. Statnett, Network Development Plan 2023 and subsequent updates on the Skaidi-Hyggevatn 420 kV project; Norwegian Ministry of Energy, parliamentary briefings on Northern Norway grid capacity, 2024–2025.
46. Space Norway, public statements on the Svalbard Undersea Cable System incident, January 2022; Norwegian Police Security Service (PST), public communications, 2022 and 2023.
47. Store Norske Spitsbergen Kulkompani, communications on the closure of Mine 7 and the Longyearbyen coal-fired power plant, 2023; Government of Norway, parliamentary briefings on Svalbard energy transition, 2024.

4.2.3 Climate and weather risk specific to the High North

Arctic warming has been observed at approximately four times the global rate for the last 50 years, with the strongest warming in the Barents Sea region, where local warming over recent decades has reached peaks of 2.7 °C per decade.[48] Three consequences for energy infrastructure follow.

First, permafrost degradation is reducing the bearing capacity of foundations, runways and onshore pipelines, especially in Svalbard and Greenland. Second, hydrological shifts are increasing total Norwegian and Swedish Arctic hydropower potential by an estimated 5 to 15 per cent by mid-century, but with substantially widened inflow variance; the operational planning window for hydropower in the Northern Nordic region is therefore both larger in expected value and harder to manage, which directly affects winter adequacy planning. Third, changing climate is affecting energy production: wind-turbine icing losses at northern sites have been documented at between 5 and 15 per cent of annual output at the most exposed locations, requiring expanded use of anti-icing systems that themselves consume power.[49]

Two recent verified events illustrate the operational consequences of climate risks. Storm Gyda in mid-January 2022 brought wind speeds in excess of 35 m/s to large parts of Western and Northern Norway, with widespread power outages and storm-surge flooding affecting coastal energy infrastructure. Storm Hans in August 2023 caused the partial collapse of the Braskereidfoss dam in eastern Norway and forced the controlled draw-down of multiple Norwegian and Swedish reservoirs as inflows exceeded design assumptions.[50]

4.2.4 Hybrid threats and the geographic dimension

The Baltic is a shallow, densely monitored sea with average depth around 54 metres, where surface surveillance, NATO maritime patrols, and the high density of commercial shipping all create a relatively rich observational environment even if attribution remains difficult. The Arctic operates on an entirely different geometry. The Norwegian Sea reaches depths of 2,500 metres and the Barents Sea averages 230 metres across a vast, sparsely monitored area. At those depths, interference with subsea infrastructure requires capabilities beyond opportunistic anchor drag: it demands purpose-built equipment, remote vehicle operations, or submarine assets, a technological threshold that points towards state-level actors and that simultaneously makes detection from the surface far harder. The low event frequency and thin monitoring coverage mean that incidents may

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[48] M. Rantanen et al., 'The Arctic has warmed nearly four times faster than the globe since 1979,' Communications Earth and Environment 3, 2022; K. Isaksen et al., 'Exceptional warming over the Barents area,' Scientific Reports 12, 2022.

[49] Intergovernmental Panel on Climate Change, Sixth Assessment Report, Working Group I, Chapter 9 (Polar Regions) and Working Group II, Chapter 13 (Europe), 2021–2022; International Energy Agency, 'Climate Resilience for Energy Security,' 2021, with subsequent regional updates; Energiforsk, 'Vindkraft i kallt klimat (Wind power in cold climate),' 2023.

[50] Norwegian Water Resources and Energy Directorate (NVE), incident reports on Storm Gyda (January 2022) and Storm Hans (August 2023), including the Braskereidfoss dam partial collapse; Norwegian Meteorological Institute, climate event briefings, 2022 and 2023.

not be identified quickly, and when they are, attribution is structurally more difficult than in the Baltic.

4.2.5 Greenland’s strategic centrality

Greenland's position in Nordic energy security is materially different from that of any other Nordic jurisdiction and warrants separate treatment for two key reasons (See Box 4.3 for discussion of the vulnerabilities across Arctic island regions). First, the material energy picture: approximately 80 per cent of Greenland's final energy consumption is met by imported petroleum products. Greenland sits outside both the EU and IEA stockholding frameworks; and it operates a series of isolated microgrids rather than a synchronously connected national grid. Buksefjord, currently the largest hydropower plant in Greenland, is undergoing capacity expansion to meet rising Nuuk electricity demand, and the Tasersiaq prefeasibility study points to a potential 700–1,000 MW export-scale hydropower resource over a longer horizon; these would, if developed, materially change Greenland's energy security profile, but neither is currently part of the operational Nordic energy system.[51]

Second, the security dimension. Since late 2024, the second Trump administration has made explicit claims to Greenland, including statements declining to rule out economic or military coercion to bring Greenland under US sovereignty. What matters for the Nordic energy security frame is that the foreign and security policy axis of one of the eight Nordic jurisdictions is now exposed to direct external pressure from a treaty ally in a way that no other Nordic jurisdiction faces.

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[51] Government of Greenland, Energy Strategy 2030; Nukissiorfiit, public communications on the Buksefjord hydropower expansion, 2024; Government of Greenland, Tasersiaq hydropower prefeasibility study summary.

Ilulissat harbor, Greenland (iStock)

Box 4.3: Arctic and North Atlantic island energy systems and their distinct vulnerabilities

Iceland, Greenland, the Faroe Islands and Svalbard share one feature that sets them apart from every mainland Nordic country: none of them is connected to another country's electricity grid, and all four rely on imported oil products for the bulk of either their primary energy or their non-electricity demand. Resupply and emergency repairs are measured in days rather than hours, the ice-class shipping fleet available to serve them is small, and the Faroe Islands and Greenland sit outside both the EU and the International Energy Agency stockholding frameworks entirely. The Faroe Islands are not formally part of the Arctic, but their energy security logic is the same one that applies to Greenland and Svalbard rather than the one that applies to mainland Denmark.

Iceland runs a fully isolated electricity system supplied almost entirely by hydropower and geothermal energy, with no cable to continental Europe or the British Isles. Its electricity supply is therefore well shielded from external shocks. Iceland's exposure sits instead on the fuel side. Transport, the fishing fleet and aviation depend almost entirely on imported oil products that arrive by tanker into a small number of ports, with Keflavík airport serving as a major North Atlantic hub. Iceland is among the highest per-capita oil importers in Europe, and a sustained disruption to maritime fuel deliveries (whether from a price shock, North Atlantic shipping disruption or insurance withdrawal) would feed straight through into transport and fisheries, without an electricity-side buffer to soften the impact.

Greenland is not a single grid but around 70 standalone local power systems serving towns and coastal settlements separately. Hydropower at five plants (Buksefjord, Tasiilaq, Qorlortorsuaq, Sisimiut and Ilulissat) supplies roughly 70 per cent of electricity for the larger towns, with diesel generators serving the rest; recently approved expansion projects could raise the renewable share to around 90 per cent. Greenland's energy security exposure runs in two directions. Inwards, around 80 per cent of total energy consumption is met by imported petroleum products that arrive by sea. Outwards, the Tanbreez rare earth project in southern Greenland, consolidated under US-listed Critical

Metals Corp at 92.5 per cent ownership in 2025 with around USD 120 million in US Export-Import Bank financing interest, places Greenland inside the supply chain for some of the most strategically contested critical raw materials, with direct implications for the geopolitical context set out in Section 4.2.5.

The Faroe Islands run an isolated electricity grid operated by the municipally owned utility SEV. The mix is around 100 MW of diesel capacity, 40 MW of hydropower, around 60 MW of wind and a small but growing battery base. SEV reports one to three total blackouts a year, well above continental European frequencies. The Faroese 2030 target of fully renewable electricity reduces but does not eliminate the wider exposure, since heating, transport and the fishing fleet will remain dependent on imported oil products for some time to come.

Svalbard sits at the far end of the same logic. Since the closure of Longyearbyen's coal-fired power station in October 2023, the archipelago has run on diesel generators with a small battery providing short-duration backup; a long-term renewable replacement has not yet been built. Geographically, Svalbard sits inside what the Norwegian Chief of Defence in January 2026 identified as the principal point of military attention in the European Atlantic.

4.3 Cross-theatre patterns and the institutional gap

Three patterns connect the Baltic and Arctic vulnerability pictures. The first is shared threats with different geographic expression. The same shadow tanker fleet generates risks across both spaces. The same Russian intelligence vessel, the Yantar, has been documented in both the Baltic approaches and the Norwegian Sea. The same global constraint on cable repair vessel availability applies in both, with an additional ice-class capacity gap in the Arctic.

The second pattern is asymmetric institutional coverage. The Baltic theatre is densely institutionalised, with BEMIP at the energy-policy level, the Council of the Baltic Sea States Vihula Memorandum of Understanding at the foreign-minister level, NATO's Maritime Centre for the Security of Critical Undersea Infrastructure and the Baltic Sentry deployment at the military level, and the Nordic-Baltic Eight at the broader political level.

The Arctic theatre is institutionally thinner: the Arctic Council has been operating in reduced functionality since the 2022 pause in cooperation with Russia and the 2025 effective freeze of the working groups. There is no Arctic equivalent of the CBSS Vihula framework on subsea infrastructure; the West Nordic Council is focused on parliamentary cooperation between Iceland, Greenland and Faroe Islands but lacks technical depth; and the institutional response to Northern Nordic infrastructure exposure has therefore had to be improvised through national, Joint Expeditionary Force (JEF) and NATO channels rather than through a dedicated regional framework.

The third pattern is the implementation gap. In both theatres the political signal is sharper than at any point in the post-Cold War period, and in both the operational follow-through lags. The Baltic has the political vehicles but needs the technical and operational depth on which their declarations rely. The Arctic lacks both the political vehicles of equivalent density and the implementation depth, and is therefore at an earlier stage of the same trajectory. The roadmap in Section 8 addresses both, recognising that the Nordic value-add in the Baltic is principally to provide the technical substance beneath existing Baltic-level frameworks, and that the Nordic value-add in the Arctic is partly to compensate for the absence of equivalent frameworks until such time as the Arctic Council or successor arrangements can resume that role.

The vulnerabilities mapped in this section recur in different forms in the carrier-specific analysis that follows. Electricity exposure in the Baltic is treated in Section 5, where the cooperation architecture around Nord Pool, the Nordic Regional Coordination Centre and NordBER is the principal subject. Natural gas security, including the Hammerfest chokepoint and the Balticconnector exposure, is treated in Section 6. Fuel security exposure, including the shadow-fleet and Northern Sea Route dimensions, is taken up in Section 7. The recommendations that follow these analyses are gathered in the roadmap.

Section 5

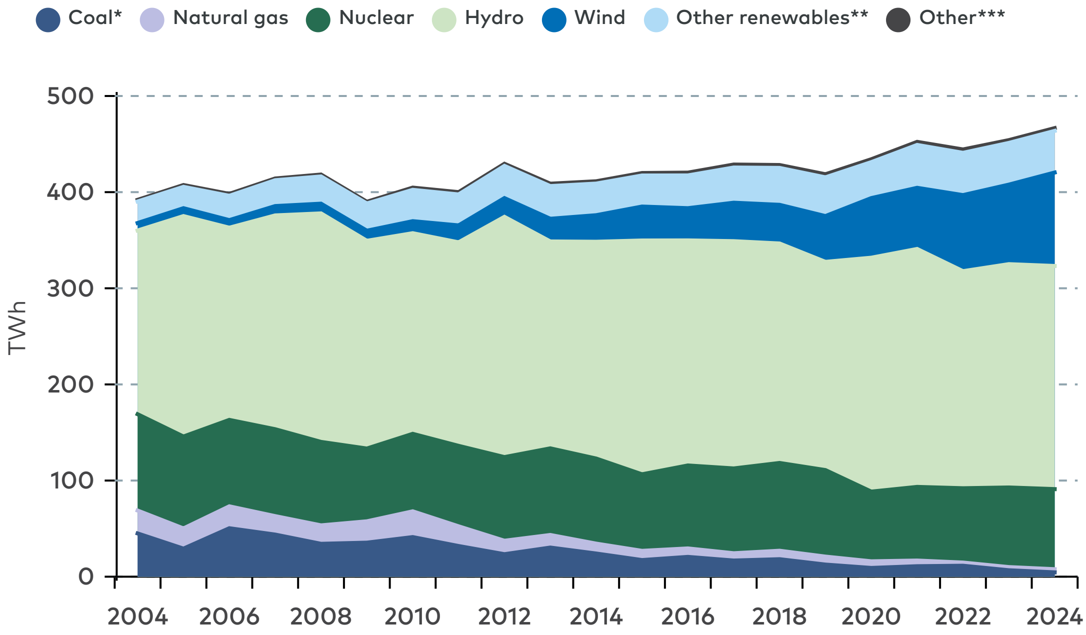
ELECTRICITY SECURITY


Image: **iStock**

Electricity is the largest single carrier in Nordic final consumption today and the carrier whose security profile is changing fastest. This section combines the system view with the cooperation view in a single sequence. Sub-sections 5.1 and 5.2 set out the demand outlook and the short-term adequacy picture. Sub-sections 5.3 and 5.4 cover the integration pattern across the region and the supply-chain exposures that affect it. Sub-section 5.5 maps the cooperation architecture against the vulnerabilities that 5.1-5.4 set out. The synthesis at 5.6 returns to the trilemma: the same integration that delivers the affordability pillar of the Nordic system also creates the price-transmission and cascade exposures that define the security pillar. In risk-typology terms, the electricity system is where local, regional and global risks compound most readily, and where Nordic cooperation has the deepest existing foundations to build on.

Total Nordic electricity generation output (measured in terawatt-hours) has grown moderately over the last two decades, by 18 per cent between 2004 and 2024. The composition has changed far more than the total (Figure 5.1). Wind generation has grown more than tenfold, hydro and nuclear remain the bulk-volume backbone, and solar power production is rising steeply even if it still remains nascent. The result is that in terms of carbon emissions, the Nordics have the cleanest electricity system in Europe, and one of the most weather-dependent.

Figure 5.1: Electricity generation output in the Nordics, 2004–2024

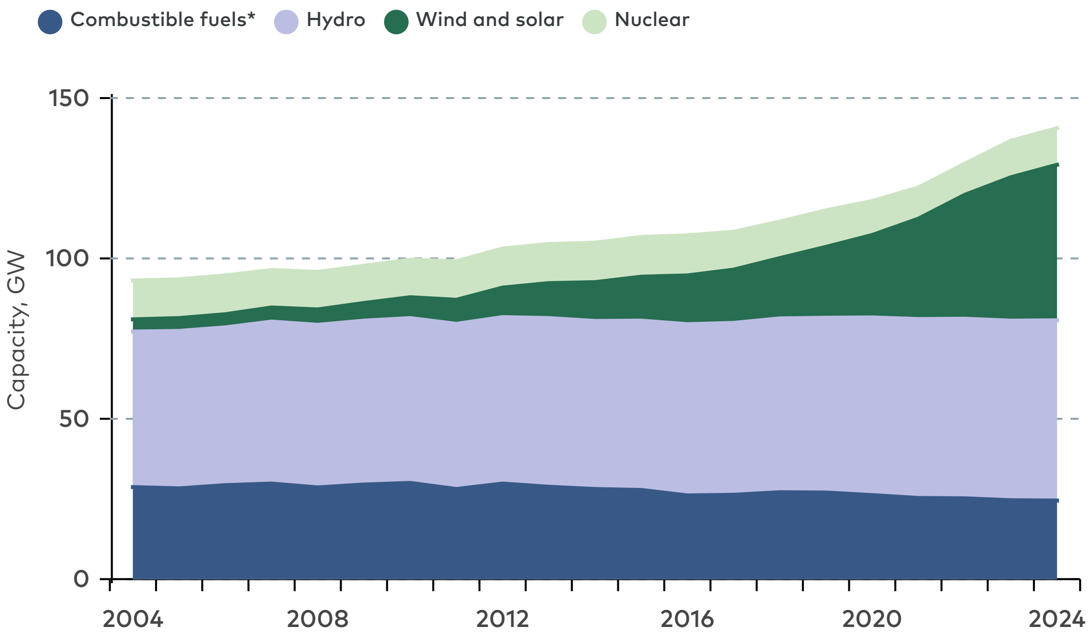


Source: Eurostat.

Notes: TWh = terawatt-hours. Coal includes peat. Other renewables include solid and liquid biofuels, biogases, geothermal and renewable municipal waste. Other includes oil, non-renewable waste and unspecified sources.

The weather-dependency becomes more obvious when looking at the Nordic electricity generation capacity. It stood at 141 gigawatts (GW) in 2024, a remarkable 48 GW increase from 2004. Effectively all capacity additions came from solar and wind (45 GW) (Figure 5.2).

Figure 5.2: Electricity generation capacity in the Nordics, 2004-2024

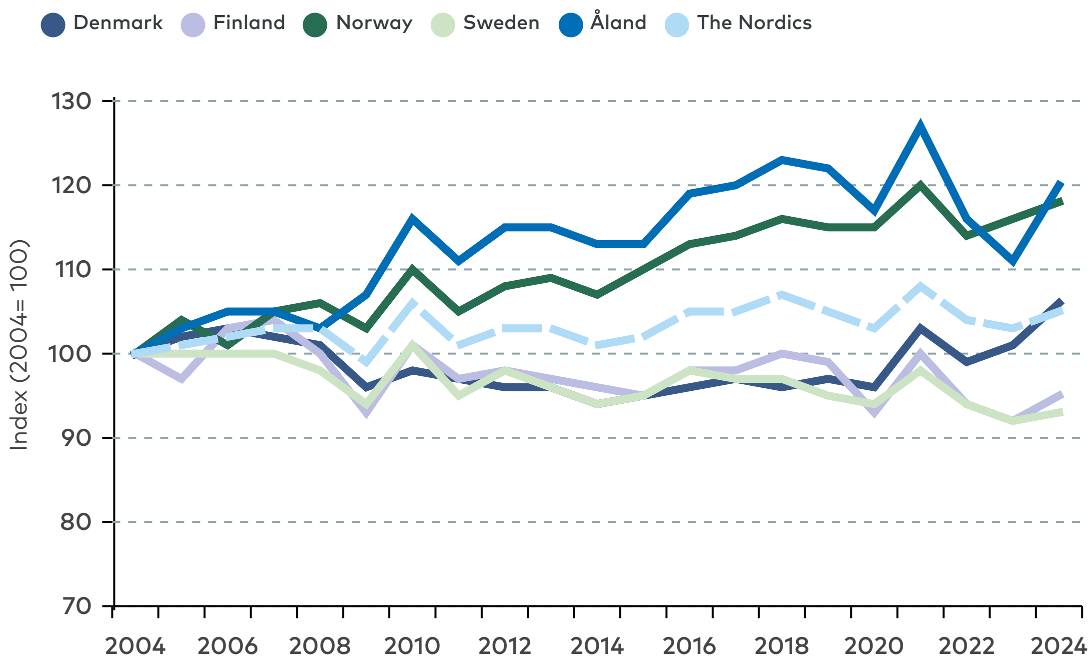


Source: Eurostat
Notes: *covers both fossil and renewable combustible fuels (breakdown not available). Includes also geothermal.

The surge in weather-dependent electricity capacity also means that the share of dispatchable capacity, that is, combustible fuels and hydro (for terminology on capacity types, see Annex 1) dropped from 83 per cent in 2004 to 57 per cent in 2024. In other words, balancing the electric grids has become more complex.

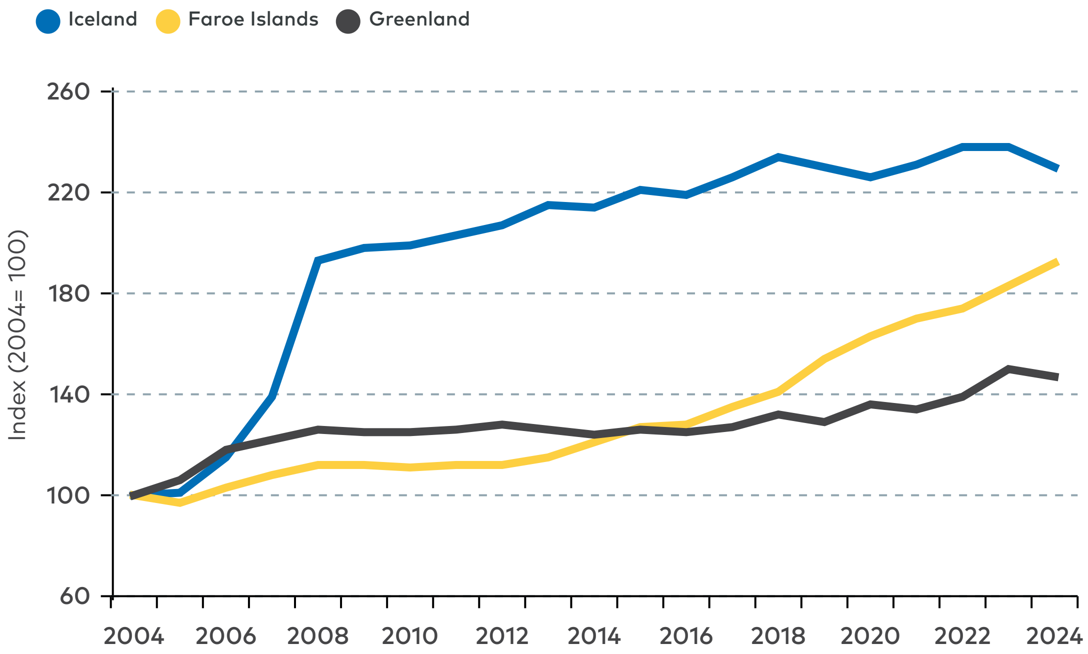
Total Nordic electricity consumption in 2024 was essentially at the level of 2004, but the regional overall picture masks divergent national paths (Figure 5.3). On the interconnected mainland, consumption has been broadly flat as parts of electricity-intensive industry (for example, paper) have declined and energy efficiency gains have so far managed to offset the growing demand from electric vehicles, heat pumps and new forms of industrial demand like data centres. In the Island Energy Systems, electricity consumption has grown markedly faster, driven by industrial electrification in Iceland and population and economic growth in the Faroe Islands and Greenland.

Figure 5.3a: Evolution of electricity consumption in the Nordics, 2004–2024



Panel a) Interconnected systems.
Source: Eurostat, Ålands statistik och utredningsbyra. Notes: Consumption includes final consumption and consumption for heat pumps, electric boilers and batteries.

Figure 5.3b: Evolution of electricity consumption in the Nordics, 2004–2024

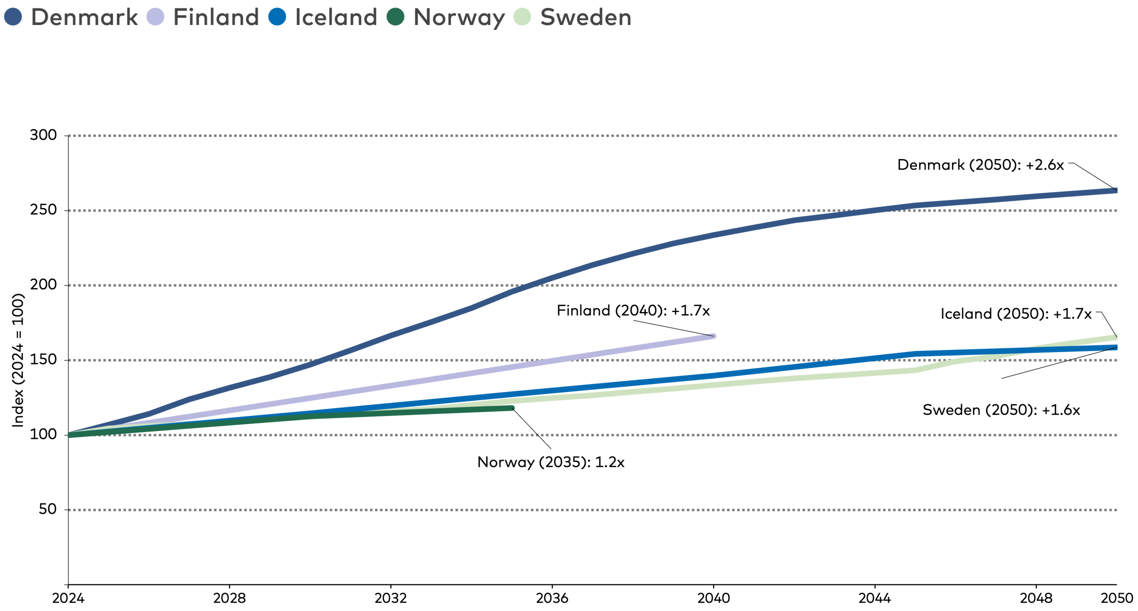


Panel b) Isolated (island) systems.
Source: IEA, national electricity companies.
Notes: The sharp rise in Iceland's electricity consumption around 2006–2008 reflects the commissioning of large new aluminium smelting capacity, notably the Fjarðaál smelter, rather than broad-based demand growth.

5.1 Future outlook for electricity demand in the Nordics

The relevant question for energy security is not the historical trend but the forward demand path. Each Nordic country is responsible for its own electricity planning, typically supported by scenario analysis that incorporates a range of assumptions. The official scenarios (see Annex 1 for sources and methodology) converge on a single message even at the conservative end: Nordic electricity demand will grow substantially over the next two decades (Figure 5.4). Denmark stands out with projections of 2.6 times current consumption by 2050. The other mainland systems sit in the 1.5x to 1.7x range, with Norway at the lower end at 1.2x by 2035.

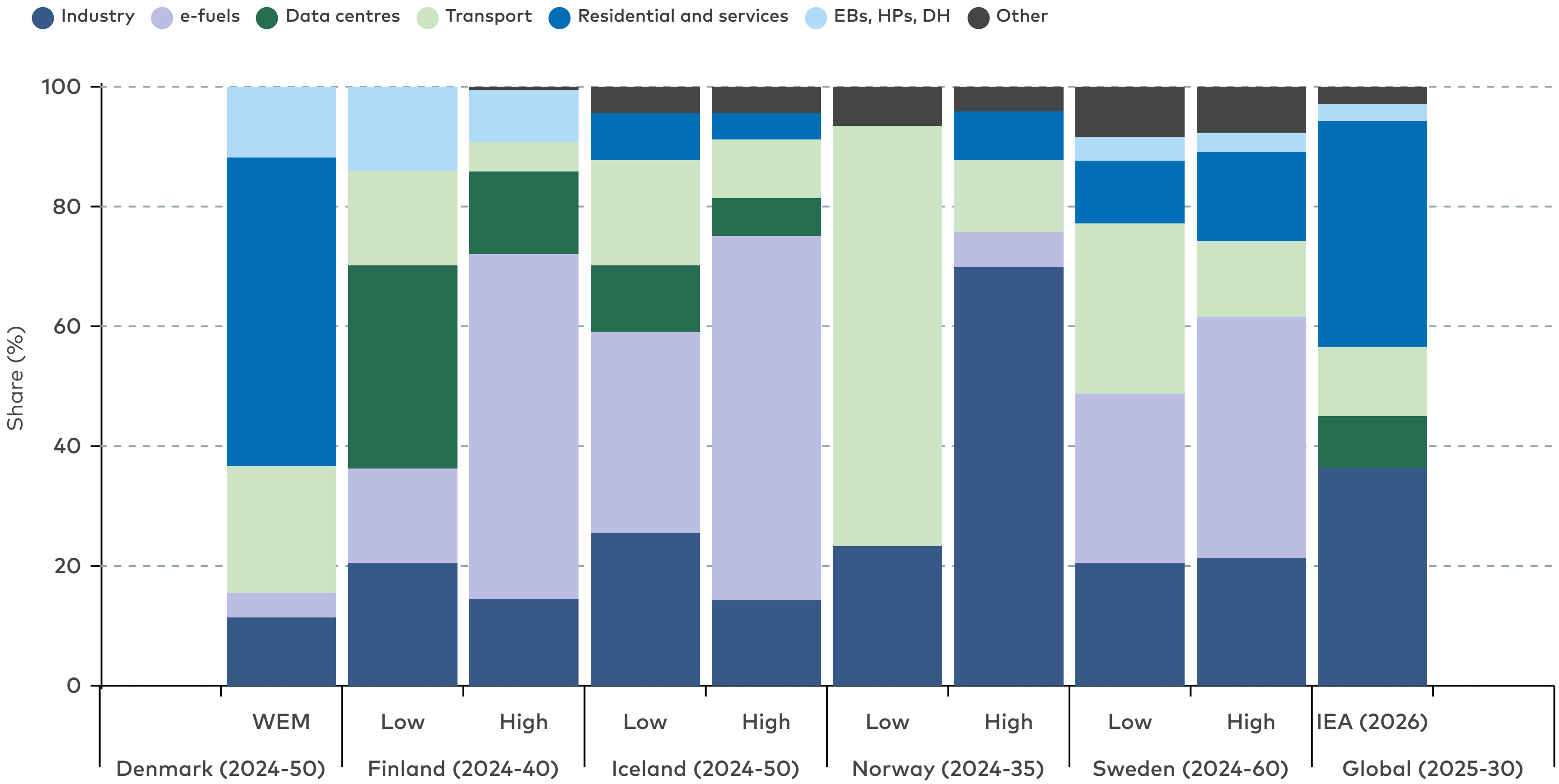
Figure 5.4: Relative electricity demand growth in the conservative national scenarios



Source: Author's calculations based on publicly available national electricity scenario data.

Most of the projected growth comes from industry and transport rather than from data centres (Figure 5.5). Data centres have nonetheless been subject to intense public debate across the Nordics over fears of their impact on household electricity prices. In the Nordic national scenarios, industrial electrification (including hydrogen and synthetic fuels) and electric transport account for the bulk of the growth, with data centres a secondary factor in those scenarios that explicitly model them.

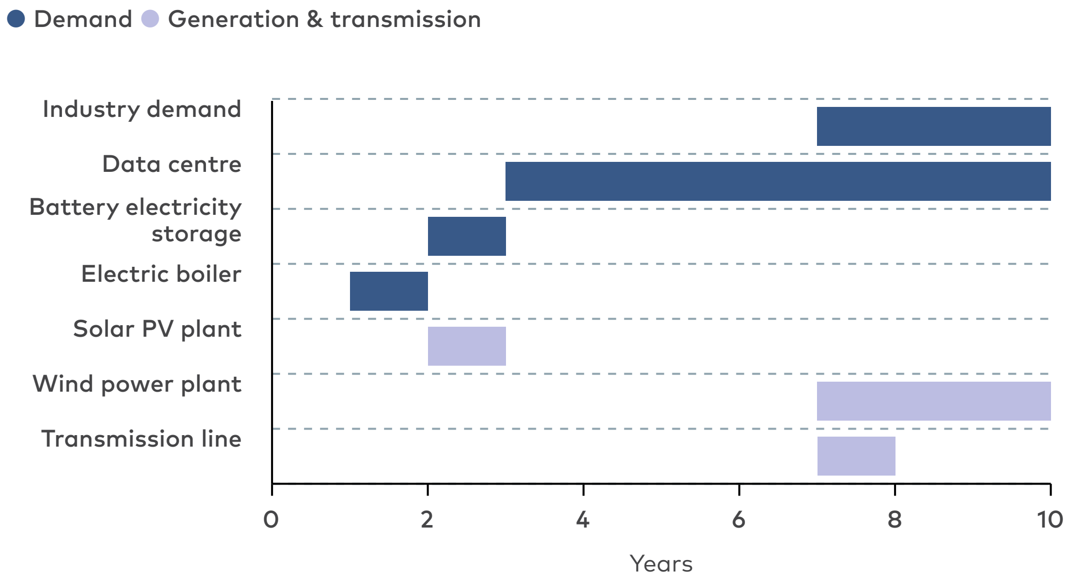
Figure 5.5: Drivers of electricity demand growth in the official Nordic energy scenarios



Source: Author's calculations based on publicly available national electricity scenario data; IEA Electricity 2026.
Notes: Some national scenarios do not explicitly model data centre demand (Denmark, Norway, Sweden). 'WEM' = with existing measures.
EBs, HPs, DH = electric boilers, heat pumps and district heating.

The energy security risk from projected demand growth is not a uniform demand-supply gap but a timing mismatch between demand additions and grid build-out. Lead times for the critical equipment that makes up an electricity system differ by an order of magnitude depending on equipment type and manufacturer (Figure 5.6). New industrial demand or a data centre can be operational in two to three years from planning to operation. At the same time, on the supply side, new wind farms take seven to ten years from planning to commissioning, and new high-voltage transmission lines seven to eight. The result is local grid congestion as fast-arriving demand outpaces the slower transmission build. Data on grid connection requests, both for generation and demand, are not systematically published, which makes the imbalance difficult to plan around.

Figure 5.6: Lead times of energy infrastructure projects

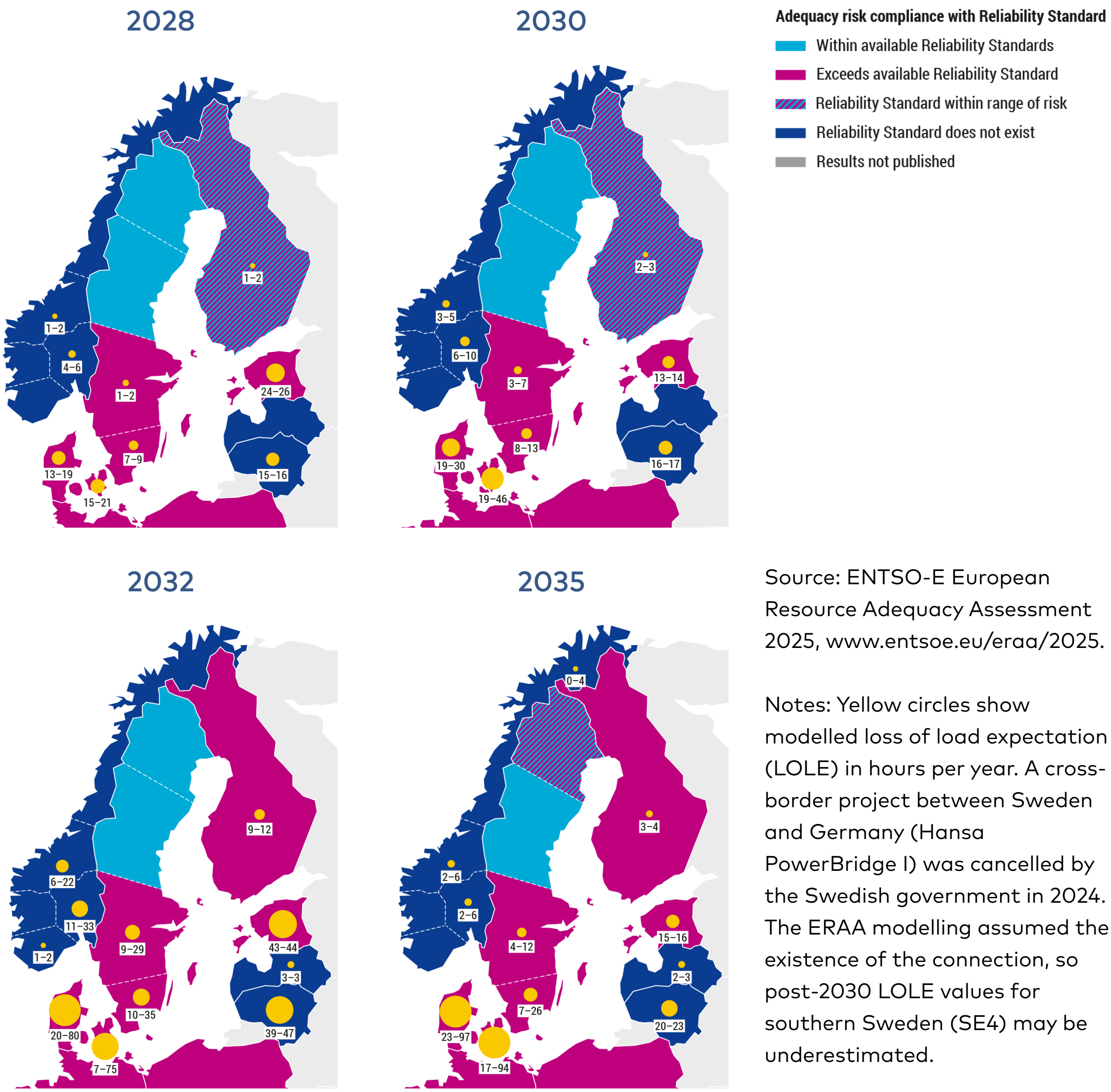


Source: Adapted from Fingrid, Kantaverkon kehittämissuunnitelma (TYNDP), www.fingrid.fi

5.2 Short-term electricity system adequacy and winter conditions

Beyond long-run demand growth, system adequacy in any given winter is the more immediate concern. ENTSO-E publishes the European Resource Adequacy Assessment (ERAA), which models the probability of supply shortages up to ten years ahead at the level of bidding zones. The Nordic results show the risk of imbalance rising in the early 2030s before partially easing later in the decade as new capacity comes online (Figure 5.7). The yellow circles indicate expected loss of load (LOLE) in hours per year (see Annex 1 for detailed methodology).

Figure 5.7: Modelled electricity adequacy risk in the Nordic and Baltic bidding zones, 2028, 2030, 2032 and 2035



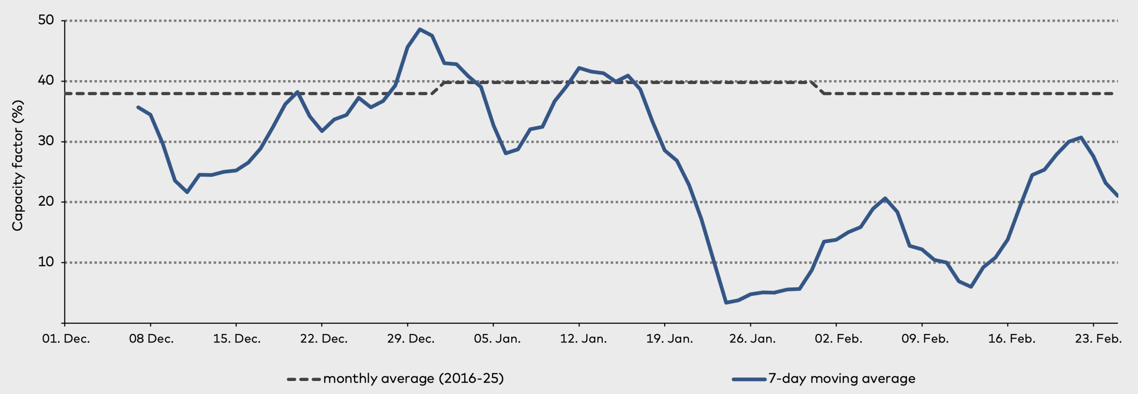
Source: ENTSO-E European Resource Adequacy Assessment 2025, www.entsoe.eu/eraa/2025.

Notes: Yellow circles show modelled loss of load expectation (LOLE) in hours per year. A cross-border project between Sweden and Germany (Hansa PowerBridge I) was cancelled by the Swedish government in 2024. The ERAA modelling assumed the existence of the connection, so post-2030 LOLE values for southern Sweden (SE4) may be underestimated.

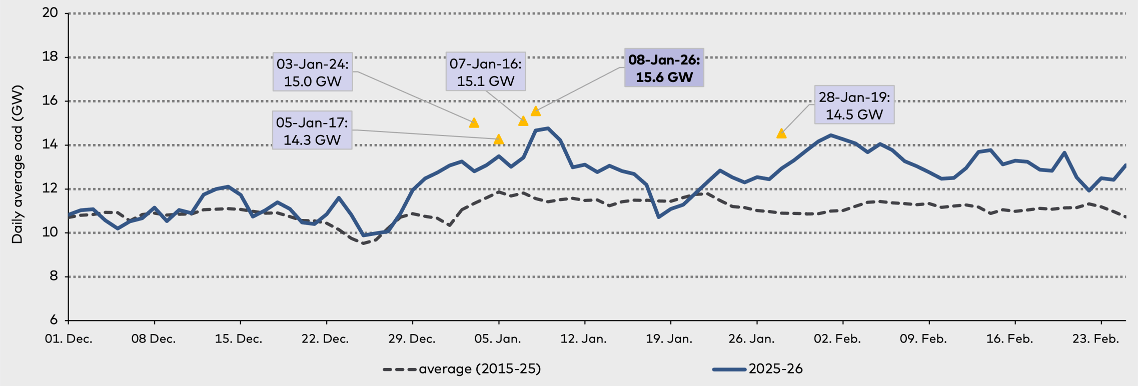
The model results moved from theoretical to operational during the winter of 2025–2026 in Finland, when an extreme cold-and-low-wind event came close to a real loss-of-load situation. The episode, summarised in Box 5.1, illustrates the kind of stress test the ERAA is designed to anticipate.

Box 5.1: The 2026 Finnish dunkelflaute

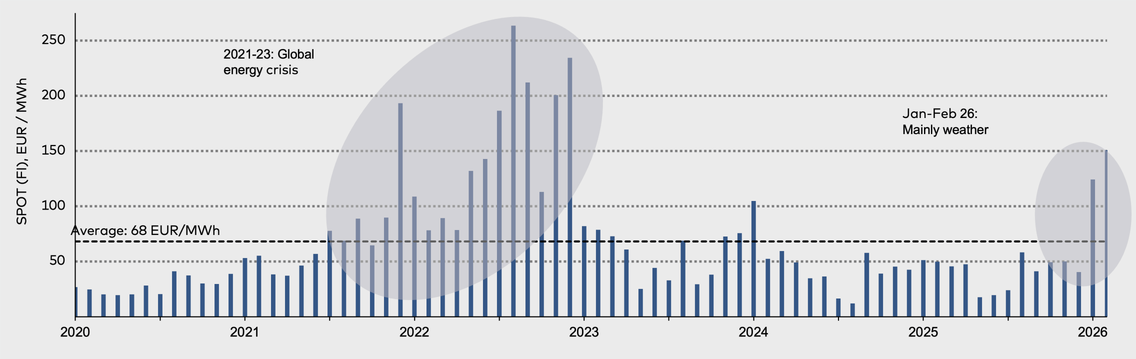
In January and February 2026, Finland experienced an extended period of below-average temperatures and below-average wind speeds, with sufficient ice formation on turbine blades to suppress wind generation further. Wind capacity factors fell well below the 2016–2025 reference range for weeks at a time.



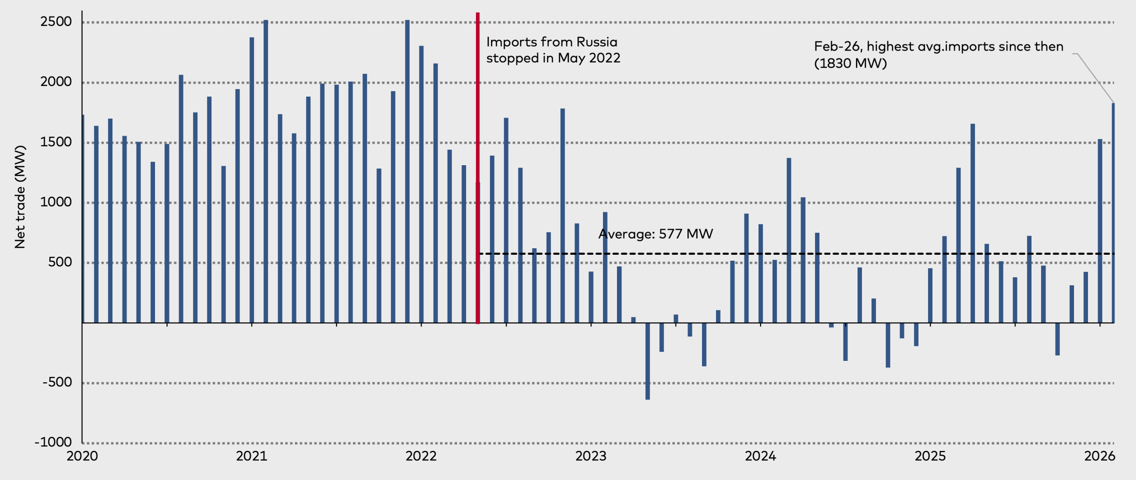
The timing was the worst possible. Finnish electricity demand peaks in January and February in almost every year. Twelve of the last thirteen annual fifteen-minute peak demands have fallen in those two months. The all-time peak load record was set on 8 January 2026 at 15.6 GW.



Finnish wholesale electricity prices spiked to levels last seen during the 2021–2023 European energy crisis, even though the underlying cause this time was weather rather than a wider geopolitical shock.



Finnish electricity imports reached their highest sustained levels since the cessation of trade with Russia in May 2022, averaging 1,830 MW in February 2026.

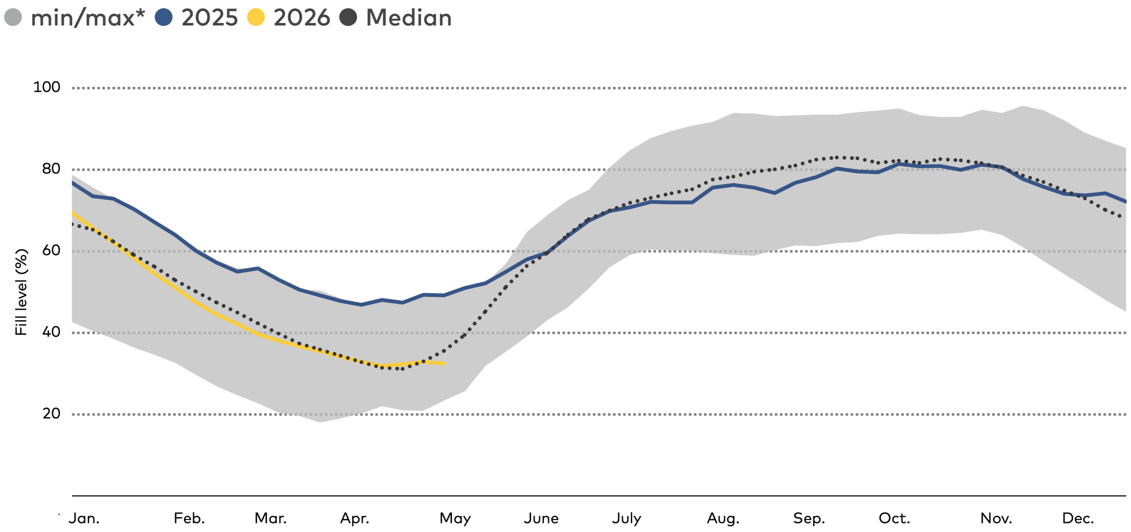


The system held. The new 400 kV AC transmission line between northern Sweden and Finland ("Aurora Line"), commissioned in December 2025, materially improved import capacity when it was needed the most. Had a major Finnish nuclear unit been unavailable during the same period, automatic demand restraint measures might well have been triggered. The episode is the cleanest recent example of why electricity security in the Nordics has to include resilience to compound weather events.

Source: Yle reporting, January–February 2026; Fingrid system data.

The weather conditions have an immediate impact on wind and solar electricity output. Hydro electricity generation is also dependent on the weather, but with a seasonal time lag. Future hydro capacity also depends on climate change scenarios. Norway closely monitors the fill levels of its hydro reservoirs, in other words the available potential energy in the system (Figure 5.8). These levels are highly relevant for the Nordic electricity system: the maximum storage capacity is roughly 90 TWh, which is more than Finland's total annual electricity production (83 TWh in 2024).

Figure 5.8: Total storage fill level of the Norwegian hydro reservoirs



Source: The Norwegian Water Resources and Energy Directorate (NVE)
Notes: Shaded area is between the weekly minimum and maximum fill levels of the last twenty years; the dotted line is the median weekly fill level, which is a more representative metric than the mean because extreme values can skew it.

Water levels in hydro reservoirs follow a clear seasonal pattern. Electricity demand during the winter heating season draws down storage while snow accumulates. By spring, reservoir levels reach their minimum. Through summer, melting snow refills storage as electricity demand remains low. By autumn, rainfall determines the maximum fill level before the next winter season begins.

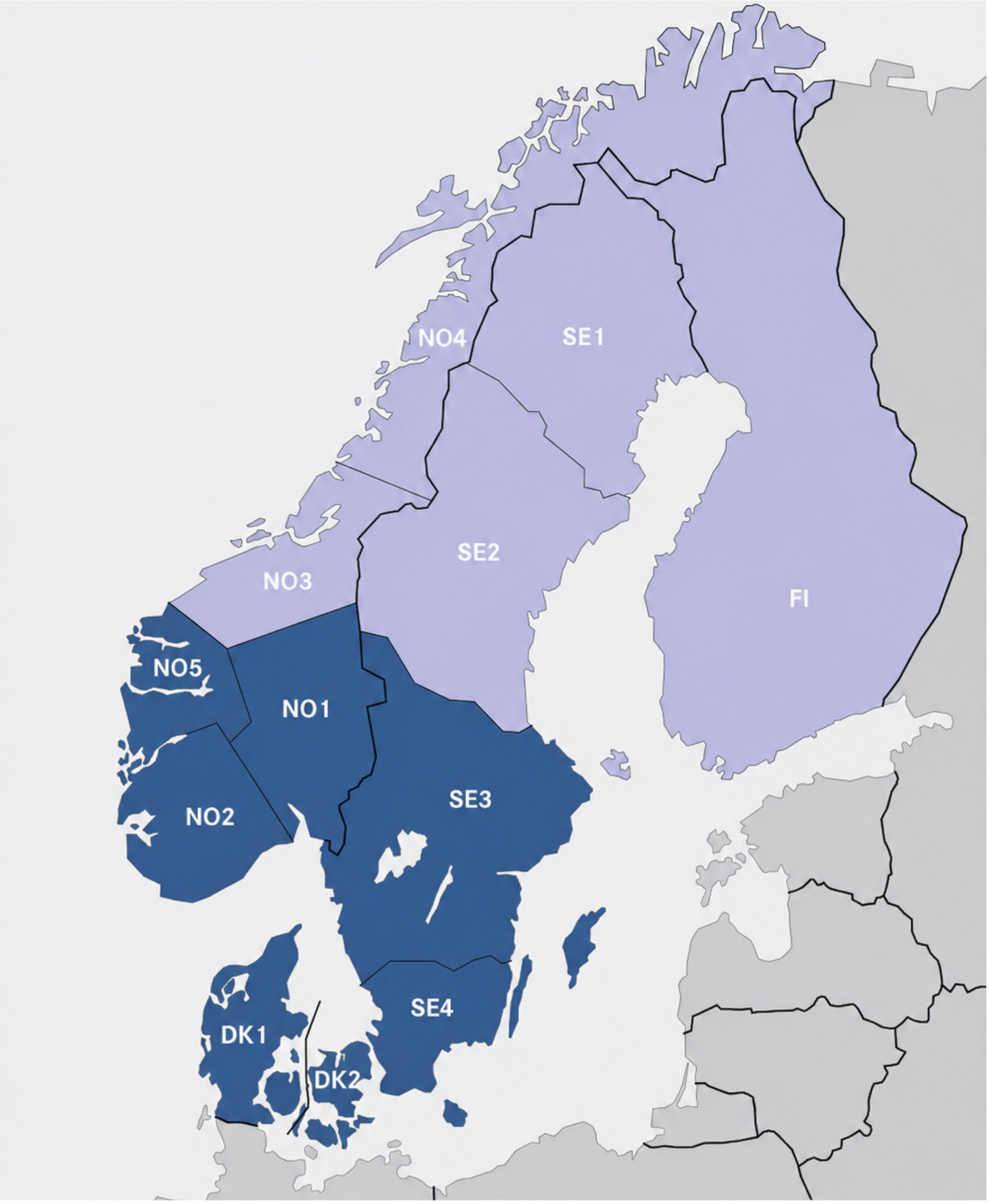
The storage fill levels of the last twenty years do not show a strong correlation with recent record-warm years. Even so, a changing climate is likely to put pressure on seasonal storage over the long term. If average rain- and snowfall decreases, so does the average peak fill level, while overall growth in electricity demand is likely to push winter demand higher. The minimum water flows of each reservoir are also strictly regulated. Less dispatchable hydropower capacity is therefore likely to be available to the Nordic and European electricity markets over the longer term.

5.3 Electricity infrastructure integration between the Nordics

Geographically the Nordic electricity systems split into the interconnected mainland (Denmark, Finland, Norway, Sweden, with Åland connected through Finland) and the Island Energy Systems of Iceland, the Faroe Islands and Greenland. The Faroe Islands and Greenland operate small distributed grids rather than a single national grid, with Greenland comprising a set of standalone microgrids tied to coastal settlements.

Within the integrated mainland market, transmission capacity has not kept pace with the changing geography of generation and consumption. The dominant flow is now on north–south corridors: hydro and onshore wind sit predominantly in the north of Norway and Sweden, while industrial and population centres are in the south. The result is the splitting of countries into bidding zones (see detailed definition and methodology in Annex 1), with Norway operating five and Sweden four (Figure 5.9). Finland is the only continental Nordic country still operating as a single bidding zone, and the Nordic electricity transmission system operators (TSOs) proposed to maintain the existing zone configuration in the 2025 ENTSO-E review.

Figure 5.9: Nordic electricity bidding zones. Map showing northern (purple) and southern (blue) areas of the Nordic region. Simplified representation of bidding zones.

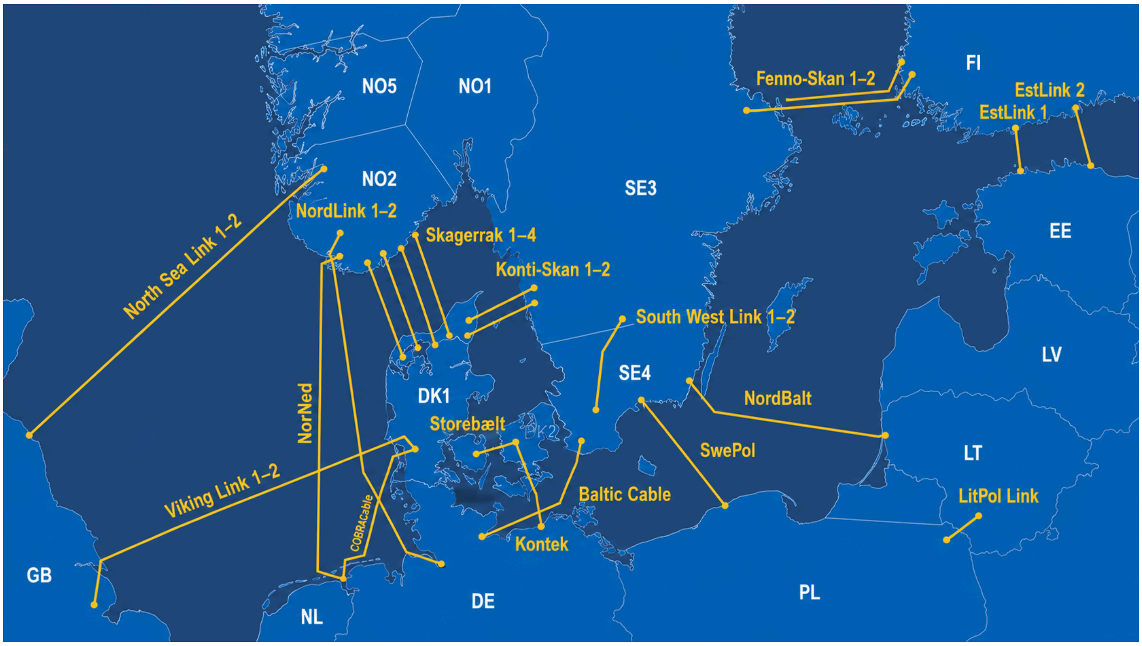


Source: Statnett, Nordic Grid Development Perspective 2025, www.statnett.no
Notes: Iceland forms its own price area (IS) but has no interconnections.

Prices in adjacent bidding zones can diverge considerably, and grid congestion is the primary reason why the divergence happens. Nordic countries simultaneously import and export large volumes of electricity. Sweden was the largest net exporter in 2024 (32 TWh) followed by Norway (18 TWh). Denmark, situated geographically between the Nordic and continental grids, runs large flows in both directions and was a small net importer. Across the region, the Nordics were a net exporter of about 45 TWh, mostly to Germany and Great Britain.

The cross-border infrastructure that supports this trade combines high-voltage direct current (HVDC) interconnectors and, in the Danish case, high voltage alternating-current (HVAC) connections to Germany (for detailed terminology on interconnectors, see Annex 1). The current map of HVDC interconnections is shown in Figure 5.10. The interconnectors are what allow the Nordic system to function as a single market and what make Norwegian and Swedish hydro reservoirs available as a flexibility resource for the wider European system.

Figure 5.10: Nordic HVDC interconnectors



Source: ENTSO-E HVDC Utilisation and Availability Statistics 2024.

The European Commission requires each EU member state to be able to import the equivalent of at least 15 per cent of its installed generation capacity from neighbours.[52] This is the headline measure of how well connected a country is to the wider European grid. As of 2026, all three Nordic EU members meet the target. The path to get there has not been straightforward. As wind and solar capacity grew rapidly over the past decade, cross-border transmission did not keep pace, and both Finland and Sweden dipped below

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52. European Commission, Electricity interconnection targets, European Commission, Electricity interconnection targets, https://energy.ec.europa.eu/topics/infrastructure/electricity-interconnection-targets_en

the 15 per cent threshold for several years. Denmark has remained well above it throughout, reflecting its position as a transit hub between the Nordic and continental European grids.

The politics of building interconnections complicate the technical picture. While more cross-border capacity raises system-level resilience and efficiency, the effects are uneven: in energy-producing regions, integration pushes prices up towards the system average, which is politically contentious. This tension has been visible in Norway, where the current government has resisted renewing ageing cables linking Norway with Denmark rather than face the domestic political cost of higher electricity prices that interconnection brings. Similar concerns were on display in Sweden in May 2026, when Energy Minister Ebba Busch ordered Sweden's TSO Svenska kraftnät to halt work on Konti-Skan Connect, a planned renewal and expansion of the HVDC links between south-western Sweden and Denmark.[53] The gap between what the system needs technically and what politics will currently deliver is one of the defining structural tensions in Nordic electricity security.

Table 5.1: Interconnection indicator (%) for the Nordic EU countries

Country	2021	2022	2023	2024	2025	2026
Denmark	45.8	42.7	41.3	36.0	36.5	35.5
Finland	24.2	24.0	20.1	15.5	15.2	18.4
Sweden	16.4	14.3	12.8	12.8	11.4	15.5

Source: European Commission, electricity interconnection targets (DG ENER calculations based on import interconnection capacity and generation capacity reported for 10 January 2026, 19:00), via ENTSO-E Winter Outlook 2025–2026.

The 15 per cent cross-border interconnection headline target is complemented by three further tests that give a more practical read on whether the grid is working for consumers and the energy transition. The first asks whether electricity prices in neighbouring zones stay reasonably close to each other. The EU Commission's benchmark is a gap of no more than €2 per megawatt-hour. The second asks whether countries can import enough to meet peak demand if their own generation falls short. The third asks whether export capacity is sufficient to carry renewable electricity to where it is needed. On the first and most visible of these tests, the Nordics are well outside the benchmark: price differences between adjacent bidding zones routinely and significantly exceed €2/MWh, as Figure 5.11 shows. The Nordic electricity system is interconnected but far from a unitary system, and that constraint limits how much the Nordics can support each other when electricity production in one country comes under sustained strain.

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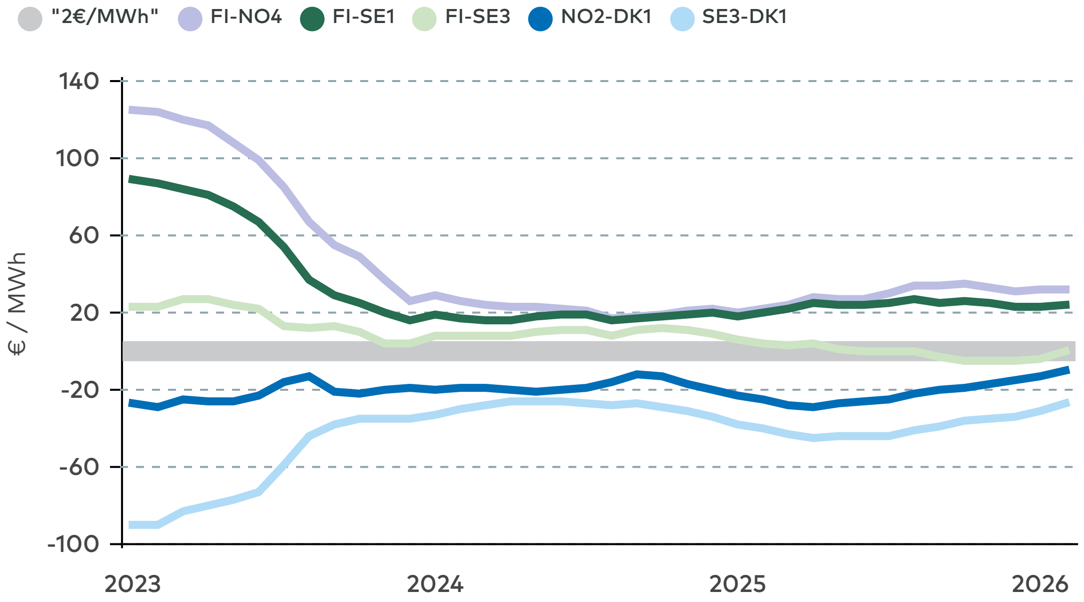
53. Reuters (2026), 'Sweden pauses plans for new power cable to Denmark', 8 May 2026, https://www.reuters.com/business/energy/sweden-pauses-plans-new-power-cable-denmark-2026-05-08/

Figure 5.11: Selected price differentials between Nordic bidding zones, 2023–2026



Source: Author's calculations based on Nord Pool monthly aggregate wholesale prices.
Notes: Prices expressed as 12-month moving averages. In 2023, prices were recovering from the shock caused by the war in Ukraine. Reference threshold of €2/MWh under the European Commission interconnection adequacy test shown in grey. All five sample bidding-zone pairs exceed the threshold in most months; the FI–NO4 differential averaged over €30/MWh through 2024 and 2025.

5.4 Supply chain vulnerabilities and the energy transition

Where hybrid action and natural hazards manifest in specific events, supply chain risk is a chronic exposure that becomes acute only when an asset fails and the time required to replace it determines the duration of the outage.

Three categories of electricity equipment carry concentrated supply chain risk for Nordic operators. Large power transformers have replacement lead times of twelve to eighteen months and are manufactured by a small number of global suppliers.[54] HVDC cables and converter station equipment have even longer lead times and depend on manufacturing capacity that is more limited still. Wind turbine components, including nacelles, main bearings, and transformer subsystems, have lead times of six to eighteen months.[55] Wind power now forms a substantial share of Nordic installed generation capacity, which

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54. National Infrastructure Advisory Council (2024), Addressing the Critical Shortage of Power Transformers to Ensure Reliability of the U.S. Grid, https://www.cisa.gov/sites/default/files/2024-09/NIAC_Addressing%20the%20Critical%20Shortage%20of%20Power%20Transformers%20to%20Ensure%20Reliability%20of%20the%20U.S.%20Grid_Report_06112024_508c_pdf_0.pdf
55. National Infrastructure Advisory Council (2024), Addressing the Critical Shortage of Power Transformers to Ensure Reliability of the U.S. Grid, https://www.cisa.gov/sites/default/files/2024-09/NIAC_Addressing%20the%20Critical%20Shortage%20of%20Power%20Transformers%20to%20Ensure%20Reliability%20of%20the%20U.S.%20Grid_Report_06112024_508c_pdf_0.pdf

means wind-component supply chain vulnerability is a systemic issue rather than a marginal technology challenge.

5.5 Nordic electricity security cooperation

Nordic electricity cooperation is the region's most institutionally mature energy security cooperation domain by a significant margin, and at the same time the one whose mandate is most visibly mismatched with the post-2022 threat environment. Four layers carry the architecture: the market and operational coordination layer (5.5.1), the system complexity and cascade-risk layer (5.5.2), the cybersecurity layer (5.5.3), and the physical-protection and emergency-response layer (5.5.4). Across all four layers the same pattern recurs: the operational-efficiency mandate is well developed, the threat-response mandate is consultative, and the gap between the two is widening as the system electrifies further. The trilemma trade-off here sits primarily between affordability (which integration delivers) and security (which integration partially undermines through new exposure channels).

5.5.1 Electricity market integration

Two interlocking structures underpin Nordic electricity market integration: Nord Pool as the common market platform and the Nordic Regional Coordination Centre (RCC) as the operational coordination centre. Both have direct but distinct implications for energy security, and in each case the security dimension is currently either underdeveloped relative to the market-efficiency mandate or absent altogether.

5.5.1.1 Nord Pool: the shared electricity market platform

Nord Pool is the commercial exchange that hosts Nordic wholesale electricity trading. It is not a system operator: it runs the auctions on which generators, suppliers and traders buy and sell electricity, and it publishes the resulting prices and volumes, but the physical grid is operated by the national TSOs (Statnett, Svenska kraftnät, Fingrid, Energinet and Landsnet), and security of supply, balancing and emergency response sit with them and with their national authorities.

Nord Pool originated in 1991 with Norway's deregulation of the power sector. It opened to Sweden in 1996 to become the world's first multinational electricity exchange, and progressively integrated Finland, Denmark, the Baltic States and a widening set of Continental and UK markets in the years that followed. Today Nord Pool runs day-ahead and intraday auctions across 15 European countries and 21 bidding zones, making it Europe's largest power exchange by traded volume.[56]

The ownership structure reflects the same division of roles. Nord Pool is jointly owned by Euronext and TSO Holding, which represents the Baltic and continental Nordic TSOs (Energinet, Fingrid, Statnett, Svenska kraftnät and Litgrid). The Nordic and Baltic TSOs

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56. Nord Pool, How does a power exchange work?, https://www.nordpoolgroup.com/en/the-power-market/how-does-a-power-exchange-work/

therefore retain a direct ownership stake in the exchange that prices their physical electricity flows, while Euronext provides the wider European market infrastructure.[57]

Three operational layers are particularly relevant for energy security. The day-ahead auction sets bidding-zone prices for every hour of the following day. The intraday market then runs continuously up to delivery, allowing market participants to rebalance against changes in wind output, demand, or power generation availability. Underlying both is the Nordic system price, which serves as the reference price for most financial contracts and as the analytical baseline for assessing congestion costs across the region.

The bidding-zone footprint is the geography of price-based adjustment. Norway is divided into five zones (NO1–NO5), Sweden into four (SE1–SE4), Denmark into two (DK1–DK2), with Finland operating as a single zone. Within this footprint, price-based dispatch and market coupling produce the structural effect that matters most for security: when Finnish demand spikes during a midwinter cold snap, the resulting price signal pulls in commercial offers from Sweden and Norway in the same hour, and the TSOs accommodate the resulting flows on the physical grid. Market coupling, operated by the platform, makes this work, while system operation, run by the TSOs, ensures the resulting flows can actually be delivered. In normal conditions, this combination is the system's primary resilience layer, and it functions to a degree that few other parts of the European grid can match.

Energy security functions sit alongside the trading platform in two specific forms. First, Nord Pool runs a market surveillance function under REMIT, the EU Regulation for Wholesale Energy Market Integrity and Transparency, with a dedicated team that monitors trading for insider trading and market manipulation.[58] This is not energy security in the physical-supply sense, but it is the integrity layer that gives the price signal its credibility and is a critical precondition for trusting market coupling as a security mechanism rather than only as an efficiency mechanism. Second, the data feeds Nord Pool publishes, from bidding-zone prices, capacities, and hydro reservoir levels to regulating-power volumes, are the public reference data on which adequacy assessments, regulatory monitoring and system-stress diagnosis across the Nordic region rely. The exchange does not coordinate emergency response, hold reserves, or run a security-of-supply function in its own right; those functions sit with the TSOs and the dedicated preparedness mechanisms discussed in Section 5.5.4.

The way market coupling transmits Continental European price shocks into the Nordic region is the clearest affordability-side trade-off in this architecture. The affordability dimension of Nord Pool integration is a structural feature, not a flaw, and its political management is a Nordic-level concern.

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57. Nord Pool, About us, https://www.nordpoolgroup.com/en/About-us/
58. Nord Pool, Market surveillance, https://www.nordpoolgroup.com/en/trading/Market-surveillance/

5.5.1.2 ENTSO-E and the Nordic Regional Coordination Centre

The Nordic Regional Coordination Centre (Nordic RCC) is the most institutionally mature element of Nordic energy security cooperation. Headquartered in Copenhagen, it is an independent A/S company owned equally by the four mainland Nordic TSOs, and it employs over a hundred staff full-time, plus more than 150 staff seconded from the four TSOs.[59] Iceland's national TSO operates outside the Nordic RCC because Iceland's grid has no physical connections to mainland Europe.

The Nordic RCC delivers the regional coordination services mandated by EU Regulation 2019/943 on the internal electricity market and Regulation 2019/941 on risk-preparedness in the electricity sector: coordinated capacity calculation, coordinated security analysis, outage planning coordination, short-term adequacy forecasts, and a critical grid situation function for cross-regional coordination during emergencies. Real-time operation of the grid, including all control room functions, declaration of system states, dispatch of reserves and emergency switching, remains the responsibility of the national TSOs. The Nordic RCC supports the TSOs; it does not replace them.[60] In the survey conducted for this project, operational coordination of this type, particularly the timely exchange of operational data, was the most positively assessed sub-dimension of any cooperation domain examined, with TSO respondents typically rating it as already well developed or as adding high value with room for further development.[61]

The Nordic RCC's mandate is operational efficiency, not security in the threat-and-response sense. It coordinates market coupling, congestion management and security analysis in the technical, system-operations sense, but not comprehensively in terms of threat intelligence, hybrid incident response, or physical protection.

5.5.2 System complexity and cascade risk

As the Nordic power system electrifies further, the share of inverter-based generation rises, and market coupling tightens, the system's exposure to fast-propagating technical cascades grows. The hazard is distinct from cyber attack: cascades arise from the system's own physical and protective dynamics under stress, not from a hostile actor, but they propagate in similar timescales and can affect the system within minutes.

The April 2025 Iberian peninsula blackout exemplifies the dangers of technical cascade events associated with a digitalized and complex system. A sequence of voltage and frequency disturbances on the Iberian network propagated to a system-wide outage within minutes, with millions of customers affected across Spain and Portugal. The post-event investigation by ENTSO-E and the Spanish and Portuguese system operators identified the interaction between high inverter-based generation, reduced system inertia, and protective relay behaviour as central to the cascade dynamics.[62] The Nordic system

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59. Nordic Regional Coordination Centre, About / Team, https://nordic-rcc.net/about/team/
60. Regulation (EU) 2019/943 on the internal market for electricity and Regulation (EU) 2019/941 on risk-preparedness in the electricity sector, https://eur-lex.europa.eu
61. Survey of Nordic energy security cooperation conducted for this project, 2026.
62. ENTSO-E (2025), Investigation report on the 28 April 2025 Iberian blackout, https://www.entsoe.eu/publications/blackout/28-april-2025-iberian-blackout/

has structurally similar features: rising inverter-based-resource shares, increasingly tight market coupling that lets disturbances propagate quickly across borders, and an operational baseline built on the assumption that the system retains enough conventional inertia to ride through disturbances. None of these assumptions is permanent as electrification and the uptake of variable renewable generation advance. The Iberian event is therefore a relevant scenario for Nordic risk planning.

Cascade preparedness is fundamentally a TSO and regulator function, with ENTSO-E as the pan-European analytical layer. The Nordic Regional Coordination Centre coordinates capacity calculation, security analysis, and short-term adequacy forecasts, but is not currently mandated to lead Nordic-specific cascade scenario testing or to apply Iberian-style lessons across the integrated Nordic-Baltic synchronous area.

The Nordic value-add is therefore in regional implementation: joint scenario testing of inverter-based-resource and inertia dynamics under transition pathways, shared protection-relay coordination assumptions across the four mainland TSOs, and a common operational baseline for the post-2025 system. The analytical framework already exists at the ENTSO-E level. What is missing is the Nordic-level instruction to use it for shared adequacy and cascade-resilience exercises on a recurring basis.

5.5.3 Cybersecurity cooperation

The cyber threats affecting the Nordic power system include intrusion into operational technology such as grid control systems, ransomware on energy company IT systems that cripple operational technology, supply-chain software attacks on energy management platforms, and state-sponsored mapping of infrastructure for potential future physical or cyber action.[63] The structural feature of the Nordic system is that the same digital integration that delivers operational efficiency through market coupling and the balancing infrastructure that lets surplus in one bidding zone backstop deficit in another also multiplies the attack surface. Resilience through integration and exposure through cyber transmission scale together.

The EU CyCLONe network and NIS2 obligations provide the baseline information-sharing and reporting framework for cybersecurity incidents within the EU, and Norway has been implementing the regulation since October 2025.[64] In terms of practical Nordic cybersecurity cooperation, the Nordic CISO network (an informal peer network of CISOs of Nordic TSOs and major energy operators, meeting through monthly calls and biannual in-person sessions) facilitates exchange of cyber threat information at practitioner level.[65]

An institutional layer above the CISO network was added in October 2024, when the four mainland Nordic TSO CEOs formalised an existing informal cooperation as the Nordic Security Group (NordSec).[66] NordSec sits under the Nordic CEO arrangement and is

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63. European Commission, Critical infrastructure and cybersecurity, https://energy.ec.europa.eu/topics/energy-security/critical-infrastructure-and-cybersecurity_en
64. Directive (EU) 2022/2555 (NIS2 Directive), https://eur-lex.europa.eu/eli/dir/2022/2555
65. Interview with senior Nordic energy official, conducted for this project, 2026 (not for attribution).
66. Svenska kraftnät (2024), 'Nordic cooperation in the security and preparedness area', https://www.svk.se/en/about-us/news/news/nordic-cooperation-in-the-security-and-preparedness-area/

intended to strengthen security and preparedness coordination among Energinet, Fingrid, Statnett and Svenska kraftnät before and during crises affecting more than one Nordic TSO. It is the most direct institutional response by Nordic TSOs to the post-2022 hybrid threat environment, even while its initial scope is consultative rather than operational.

Both mechanisms still operate as strategic discussion forums rather than operational information-sharing systems. Current mechanisms do not yet have the legal frameworks or classification arrangements that would enable real-time exchange of incident data, active vulnerability details, or attack signatures. The gap between strategic discussion and operational sharing is the principal unresolved challenge in Nordic cyber energy security cooperation.

The CRESCENDO initiative, launched in 2025 under the EU Digital Europe Programme, complements these mechanisms at project level. It links the National Coordination Centres of Norway and Finland, the Norwegian University of Science and Technology, and the Danish Energy Agency to deliver Nordic energy sector cybersecurity capacity-building aligned with NIS2 and CER Directive obligations.[67] CRESCENDO is project-based and time-limited, not a standing operational framework, but it demonstrates that Nordic cyber energy cooperation can attract EU co-funding when it has a defined deliverable.

5.5.4 Physical infrastructure protection and emergency electricity architecture

5.5.4.1 Bilateral interconnector maintenance arrangements

Cross-border interconnectors are governed by bilateral operation and maintenance agreements between the relevant TSOs. These agreements cover normal operational protocols, planned maintenance windows, incident notification chains, and emergency response contacts. They function adequately for peacetime operations and are well embedded in the working relationships between Nordic TSOs.

The bilateral and multilateral operation agreements were not fully designed for the post-2022 threat environment. The Nordic System Operation Agreement, which governs cross-border operational protocols and is updated on a rolling basis, addresses contingencies in the technical sense, such as fault conditions, frequency deviations, and restoration sequences, but the agreement contains no provisions for hybrid attacks, coordinated multi-asset disruption, or the involvement of state-sponsored actors.[68] The four mainland TSOs recognised this gap and responded at the institutional level by creating NordSec in October 2024 (discussed in Section 5.5.3), but that is a coordination forum, not an updated operational protocol. The gap between what the existing mandates cover and what the current threat environment requires has not yet been fully closed.

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[67] CRESCENDO project, https://www.project-crescendo.eu/

[68] ENTSO-E, Nordic System Operation Agreement – Main Agreement, https://eepublicdownloads.entsoe.eu/clean-documents/SOC%20documents/Nordic/Nordic%20SOA_Main%20Agreement.pdf

5.5.4.2 NordBER and the bilateral Nordic emergency electricity architecture

NordBER provides a framework for preparedness coordination against power disruptions across Denmark, Finland, Iceland, Norway and Sweden. It brings together the TSOs and the national authorities responsible for electricity transmission and distribution contingency for regular meetings on information exchange, regional drills and exercises, and policy coordination. The framework has been used to set up cross-border coordination mechanisms during large-scale energy shortages affecting one of its members, and it is the practical channel through which Nordic preparedness officials maintain a shared operating picture between crises.[69]

Complementing NordBER are the bilateral emergency electricity sharing agreements between Nordic TSOs that underpin mutual support during electricity shortfalls. Norway's Statnett and Sweden's Svenska kraftnät, for instance, maintain longstanding arrangements that allow emergency power transfers above normal commercial capacity limits during declared crisis situations.[70] Equivalent bilateral protocols connect Finland's Fingrid with both Svenska kraftnät and Statnett. These bilateral arrangements are the operational foundation; NordBER is the multilateral coordination layer above them that lets all five countries plan and exercise together.

The combined architecture is a genuine Nordic asset. It was, however, designed for the pre-2022 threat environment. NordBER and the underlying bilateral agreements contain no specific provisions for suspected hybrid attacks on interconnectors, for coordinated disruption of multiple assets, or for the involvement of third-country state actors. The question of coordinated multi-asset disruption is, however, beginning to be addressed at the national level. Norway's energy regulator NVE has recently consulted on requiring grid operators to plan for simultaneous sabotage of at least two installations, a direct departure from the weather-and-technical-failure baseline that NordBER was designed around.[71] What does not yet exist is the Nordic-level equivalent: a shared framework for what happens when the same stress event hits multiple countries at the same time, and a multilateral operational layer capable of rapid response to incidents that cross borders.

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69. Danish Energy Agency, Risk preparedness and Nordic cooperation, https://ens.dk/en/supply-and-consumption/risk-preparedness
70. Statnett (2021), 'New measures ensure better capacity between Norway and Sweden', https://www.statnett.no/en/about-statnett/news-and-press-releases/news-archive-2021/new-measures-ensure-better-capacity-between-norway-and-swedenny-side/
71. Reuters (2025), 'Norway's power grid operators asked to sharpen sabotage preparedness', 17 December 2025, https://www.reuters.com/sustainability/boards-policy-regulation/norways-power-grid-operators-asked-sharpen-sabotage-preparedness-2025-12-17/

5.6 Electricity security: key findings for the Nordics

The Nordic electricity system is one of the cleanest large power systems in the world, but its security profile is more demanding than its low-carbon credentials suggest. Weather-dependent sources now account for nearly three quarters of generation, and the system's adequacy in any given winter depends on hydrological conditions, wind output and temperature simultaneously moving in a favourable direction. The ENTSO-E adequacy modelling points to the early 2030s as the period of highest risk, as demand growth from electrification outpaces new supply and grid build-out.

The interconnected nature of the system is both its greatest strength and a source of structural tension. Cross-border flows allow Norwegian and Swedish hydro to balance variable wind across the region and beyond, and interconnectors have repeatedly cushioned national shortfalls. At the same time, the north-to-south transmission bottlenecks within Norway and Sweden mean that cheap renewable generation in the north does not reliably reach consumers in the south, producing persistent and large price differentials between bidding zones that sit well outside the EU's market integration benchmarks. Resolving this requires transmission investment on a scale and timeline that none of the Nordic countries has yet fully committed to.

The demand side adds further pressure. All national scenarios project substantial electricity demand growth, driven mainly by industrial electrification and transport. New demand can come online in one to two years; new transmission lines take seven to eight. That gap is the central structural risk for Nordic electricity security over the next decade, and it is one that no single country can manage in isolation.

The cooperation architecture is the deepest in the Nordic energy security space, and at the same time the architecture whose mandate gap is widest. Nord Pool and the Nordic RCC provide a market-and-operations layer that few European regions can match, but neither is mandated for security in the threat-and-response sense. The cascade-risk picture set out in Section 5.5.2 is a Nordic implementation problem on top of an ENTSO-E analytical framework that already exists.

The cybersecurity picture in Section 5.5.3 is one of working practitioner cooperation through the CISO network and a new TSO-level layer in NordSec, neither yet operational for real-time information sharing. The physical-protection picture in Section 5.5.4 rests on a NordBER and bilateral architecture designed before the post-2022 threat environment. In trilemma terms, electricity is where affordability and security trade-offs are sharpest and where Nordic cooperation has both the most existing infrastructure and the largest single backlog of unfinished work. Section 8 takes the resulting recommendations forward.

Section 6

NATURAL GAS SECURITY

Image: **iStock**

Compared to electricity, natural gas is a marginal energy carrier in the Nordics. It retains energy security significance at sub-regional level despite declining use and a far smaller role than in the rest of the EU (see Figure 6.1). Of the Nordic countries, Denmark is the most gas-dependent. Natural gas accounts for around 12 per cent of Danish final energy consumption, down from around 20 per cent ten years ago, and still plays a significant role in heating and industry during the ongoing phase-out.

In Finland, gas retains importance in some industrial processes even as its overall role has declined. Finland ended its Russian pipeline gas imports in 2022 and now depends on LNG imports, primarily through its shared terminal with Estonia, to supply its industrial users, mainly the petrochemical cluster around Porvoo.[72]

In Sweden, gas plays a minor role in a few industries and in the district heating networks of individual cities. Norway produces gas at vast scale for export but uses little domestically. The Island Energy Systems do not consume meaningful volumes of gas. The energy security implication across the region is therefore asymmetric: Denmark carries the most material domestic gas dependency and faces the clearest transition management challenge.

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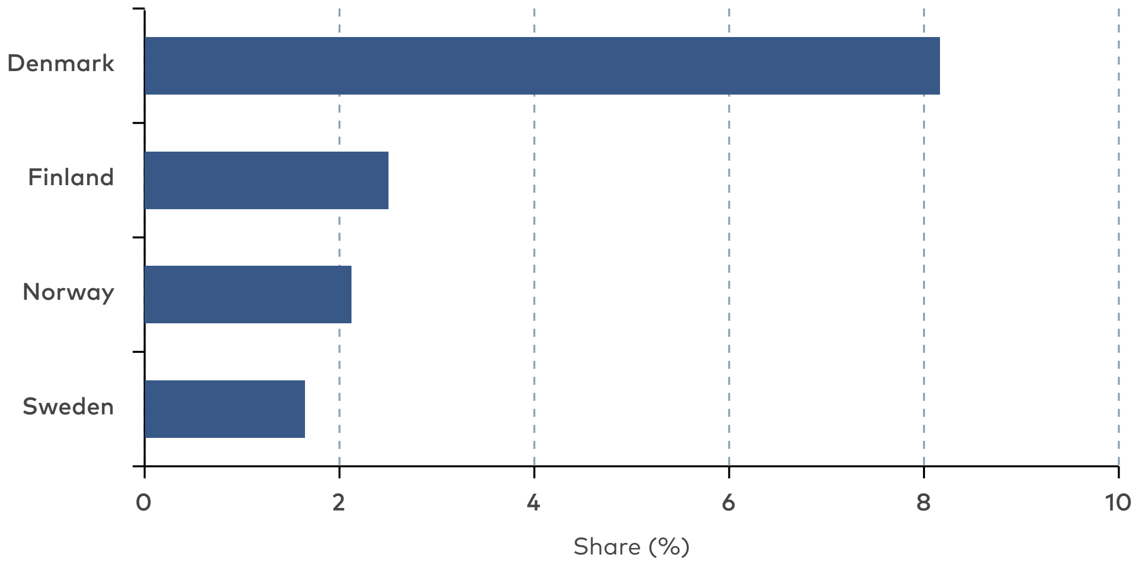
72. Gasgrid Finland, LNG terminal project (Inkoo), https://gasgrid.fi/en/lng-terminal/lngterminalproject/

Figure 6.1: Natural gas share of total final consumption, (%), year = 2024



Source: Eurostat

Notes: Iceland, Faroe Islands, Greenland and Åland do not consume natural gas

Unlike in the case of oil, neither the EU nor the International Energy Agency (IEA) mandates emergency stocks for natural gas. The IEA member countries have explored the possibility of establishing a gas stockholding system similar to oil, but as of May 2026 no such arrangements have been officially confirmed. In the Nordics, Denmark is the only country with underground gas storage capacity. Finland and Sweden built several LNG terminals during the 2010s, enabling supplies of natural gas by sea route (for details on LNG capacity, see Annex 1). Finland ended its imports of Russian pipeline gas in 2022 and is currently fully served by a floating LNG tanker off the coast of Inkoo. The tanker has reportedly been operated at a significant financial loss throughout, which is itself a security indicator: maintaining the route is more important than its commercial viability.[73]

The shift from pipeline gas to LNG changes the risk profile, not only the supply route. LNG is procured to a much greater extent on the global spot market rather than through long-term pipeline contracts, which means Nordic LNG buyers are exposed to price and availability shocks anywhere in the global system. The physical exposure profile is also different. Pipeline gas from Norway arrives through a fixed and largely below-surface system; LNG arrives through a small number of high-value, externally visible terminals and floating storage and regasification units served by long maritime shipping lanes. The Balticconnector incident of October 2023, discussed in Section 4.1, is a reminder that these facilities and their supporting subsea infrastructure are within the same hybrid threat envelope as the subsea electricity interconnectors. The resilience that LNG provides

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73. Tervola, J. (2026) 'Valtion jättihanke tekee tappiota [State's major project making a loss], Kauppalehti, https://www.kauppalehti.fi/uutiset/a/609c0805-4bba-4445-95ea-abce89fddf43

against pipeline dependence on a single supplier is real, but it comes with a market-exposure profile and a hybrid-threat profile distinct from those of pipeline gas.

Overall, natural gas does not represent a systematically important supply risk to the Nordics, but sub-regionally the risks retain importance during the ongoing phase-out.

6.1 Gas security cooperation

Two layers govern Nordic gas security cooperation. The EU Gas Storage Regulation (6.1.1) sets the storage compliance baseline for the three Nordic EU members but binds none of the producer or non-EU Nordic countries. The Nordic and bilateral emergency-arrangements layer (6.1.2) is where the structural gap is sharpest: Norway, Europe's largest pipeline gas supplier, sits outside the EU solidarity mechanism that governs its main customers, and there is no dedicated Nordic gas TSO coordination forum. The cooperation gap in gas is therefore not a gap in the rules that govern consumers but a gap in the framework that connects the producer to its Nordic consumer neighbours.

6.1.1 EU Gas Storage Regulation

The EU Gas Storage Regulation, adopted in 2022 and subsequently extended, requires EU member states with storage capacity to fill gas storage to 90 per cent of capacity by 1 November ahead of each heating season.[74] For the Nordic region, the binding compliance footprint is narrow. Denmark's Stenlille and Lille Torup underground storage sites together provide approximately 1 billion cubic metres of capacity. Finland's storage capacity is primarily limited to commercial volumes connected to the Inkoo floating LNG terminal. Sweden has no significant gas storage.

The structural asymmetry the Regulation exposes matters more than Nordic compliance with it. Norway is closely integrated with the EU internal gas market in most respects: through the EEA Agreement it has incorporated the EU's Third Energy Package on gas, including Directive 2009/73/EC and Regulation 715/2009, and its transmission system operator Gassco participates in ENTSOG as an Observer Member, contributing to the Ten-Year Network Development Plan and to Union-wide gas-supply disruption simulations.

EU security-of-supply legislation, however, is a separate matter. The 2017 Gas Security of Supply Regulation and the 2022 Gas Storage Regulation are not part of the EEA acquis; the solidarity mechanism under Regulation 2017/1938 applies between EU member states only. Norway has no bilateral solidarity agreement with any EU member state under that mechanism. The country most capable of influencing European gas supply security therefore sits inside the EU internal gas market for routine purposes but outside the binding security-of-supply framework, including the storage Regulation.

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[74] Council of the European Union (2025), 'Gas storage rules: Council agrees its negotiating mandate', press release, 11 April 2025, https://www.consilium.europa.eu/en/press/press-releases/2025/04/11/gas-storage-rules-council-agrees-its-negotiating-stance-mandate/

6.1.2 Bilateral and Nordic gas emergency arrangements

There is no dedicated Nordic gas security cooperation framework. Gas security is handled nationally and through the EU Gas Security of Supply (SOS) Regulation, which requires EU member states to maintain national emergency plans and protect 'protected customers' that include households, hospitals and other social services for at least 30 days during supply disruptions.[75] Sweden has entered a solidarity agreement with Denmark under the SOS Regulation, but Norwegian production sits outside this regional risk-group architecture entirely.

Gas TSO cooperation exists but runs along bilateral and sub-regional lines rather than a Nordic one. Gasgrid Finland's primary structured relationships are with the Baltic gas TSOs (Elering, Conexus Baltic Grid and Amber Grid) through the Finnish–Baltic regional market integration process rather than with Nordic neighbours. Energinet in Denmark and Nordion Energi in Sweden maintain bilateral operational agreements with each other and with the German TSO Gasunie Deutschland, reflecting Denmark's role as the transit point between Norwegian production and Continental European demand.[76] No pan-Nordic gas TSO coordination forum exists, and Norway's Gassco, operator of the export pipeline system that underpins European gas supply, participates in ENTSOG only as an observer, sitting outside the EU regulatory frameworks that govern its main customers.[77]

The Norway–EU bilateral gas partnership concluded in 2022 covers long-term supply commitments and LNG infrastructure cooperation and is the single most significant formal arrangement addressing Norwegian gas security contributions.[78] It is bilateral and EU-level, not Nordic-level. The structure of the arrangement reflects a structural gap: the region's largest producer and its main gas-consuming neighbours have no dedicated regional framework for gas emergency coordination.

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75. Regulation (EU) 2017/1938 concerning measures to safeguard the security of gas supply, https://eur-lex.europa.eu/eli/reg/2017/1938
76. Reuters (2023), 'Denmark, Sweden sign solidarity agreement on gas supply', https://www.reuters.com/article/business/healthcare-pharmaceuticals/denmark-sweden-sign-solidarity-agreement-on-gas-supply-idUSL8N3753DL/
77. ENTSOG, Members, https://www.entsog.eu/members
78. European Parliamentary Research Service (2023), EU-Norway energy cooperation, briefing PE 753.941, https://www.europarl.europa.eu/thinktank/en/document/EPRS_BRI(2023)753941

Section 7

FUEL SECURITY

Image: **iStock**

Oil is the second-largest energy carrier in the Nordics, and oil-based petroleum products remain the dominant fuel for transport, with a substantial role in industry, aviation and heating in the Island Energy Systems. Oil accounted for 29 per cent of total final energy consumption in 2024 in the Nordics, though the picture varies considerably across the region (see Figure 7.1). Iceland sits well below that average, with geothermal and hydro covering the bulk of its energy needs, while Greenland and the Faroe Islands are at the opposite extreme, depending on imported oil products for most of their primary energy. Among the mainland Nordic countries, Sweden has cut its oil intensity most sharply by half since 2004[79], while Denmark and Norway retain higher shares, reflecting the continued dominance of oil in transport and, in Norway's case, a heating and industrial base that has electrified more gradually.

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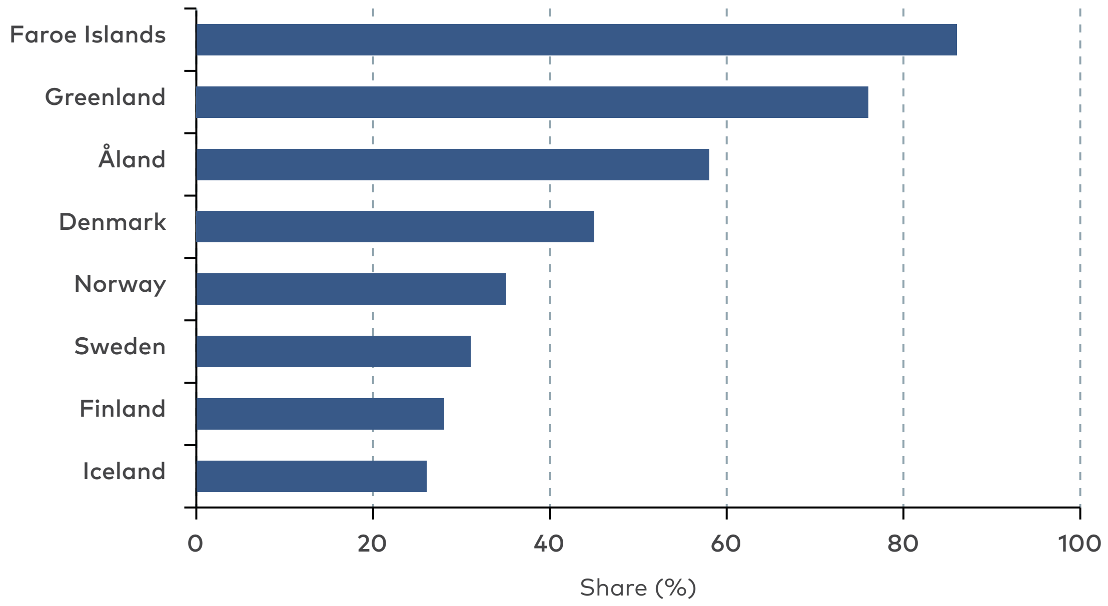
79. IEA (2024), Sweden 2024 – Energy Policy Review, International Energy Agency, https://www.iea.org/reports/sweden-2024

Figure 7.1: Oil share of total final consumption (%), year = 2024



Sources: Eurostat, national statistical offices
Notes: To allow for comparison with the Island Energy Systems, the share also includes international aviation and marine bunkers

Three things matter for oil security: how oil is consumed, how the supply chain is structured (refining, stockholding and emergency response), and how exposed the region is to external supply shocks. As of May 2026, the Strait of Hormuz crisis has provided a live example of how the three factors interact with each other (see Box 7.1).

Image: Shutterstock

Box 7.1: The 2026 Strait of Hormuz crisis and Nordic fuel security

In March 2026, US and Israeli military operations against Iran prompted Iran to close the Strait of Hormuz. Around 20 per cent of global oil and LNG trade passes through this narrow waterway. The IEA described the resulting supply disruption as the largest in history. As of May 2026, the near-complete closure had lasted over two months. In that time the IEA coordinated its largest-ever emergency stock release (400 million barrels); crude oil prices (Brent) have risen by over 50% and fluctuated heavily in response to hopes and fears that the closure might either ease or extend; and jet fuel prices have roughly doubled compared with 2025 averages.

The direct exposure of the Nordics to Middle Eastern oil supply is modest. Excluding intra-Nordic trade, the Middle East supplied only around 1 per cent of refinery inputs and around 10 per cent of refined products. Yet Nordic consumers are paying sharply higher prices at petrol stations and, increasingly, in airline ticket prices. Crude oil and refined product prices are set by global supply and demand: a sudden removal of 20 per cent of global supply moves prices for every buyer regardless of where their barrels originate. The Nordic region produces significant volumes of oil but does not meet its own refined product demand. Approximately 45 per cent of refinery inputs are sourced from outside the Nordic region, which leaves Nordic consumers fully exposed to global price shifts.

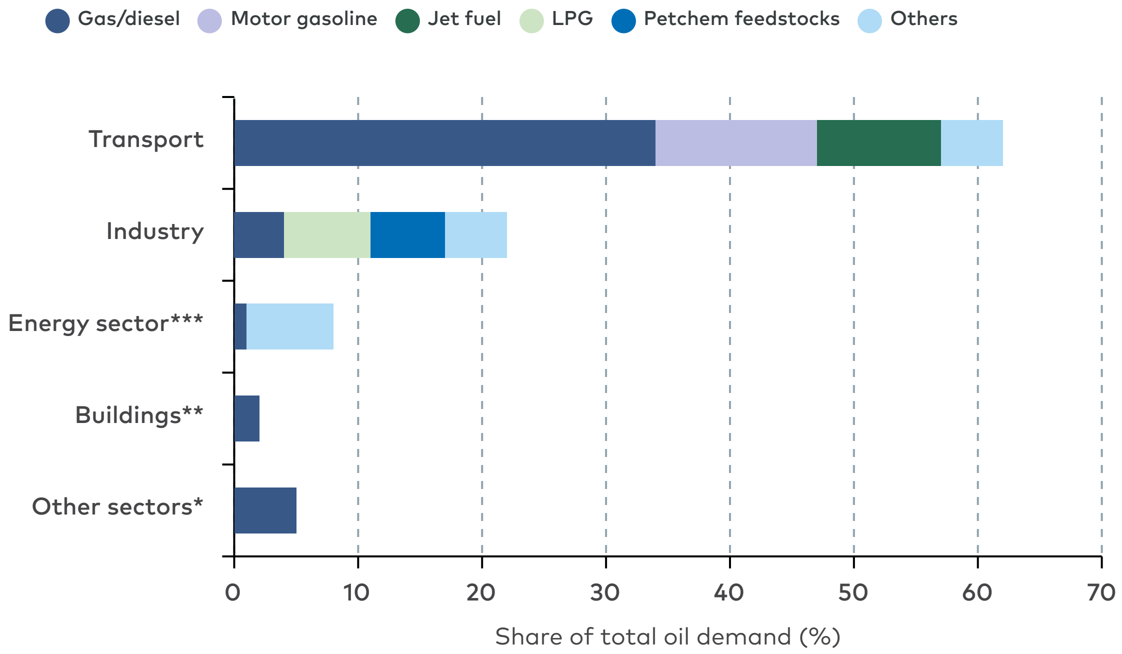
The crisis has not yet produced physical fuel shortages in the Nordic region; the primary constraint remains price rather than availability. By May 2026, jet fuel stocks had nonetheless fallen to their lowest levels since 2015, and a prolonged closure would risk tighter physical supply constraints. Prices had already risen to levels where consumption was becoming uneconomical for many users, and several airlines including Nordic carriers had cancelled flights and raised fares. The Strait of Hormuz crisis underscores a key lesson: reducing oil dependence is the most durable way to insulate Nordic energy security from geopolitical supply shocks.

Sources:
www.iata.org/en/publications/economics/fuel-monitor/
www.bbc.com/news/articles/cqxlnrqjvzyo
IEA (2026), Oil Markets Rerport: May 2026, www.iea.org/reports/oil-market-report-may-2026

7.1 Sectoral differences in oil use

Oil consumption is most often associated with road transport, but a significant share of demand sits outside transport in industry, the petrochemical sector and other applications, where electrification is progressing slowly (Figure 7.2). Transport accounts for over 60 per cent of Nordic oil demand, but industry, including petrochemical feedstocks, accounts for a further 21 per cent, driven mainly by petrochemical feedstocks and LPG use.

Figure 7.2: Oil demand in the Nordics by product and sector, 2024



Source: Eurostat.
Notes: Percentages correspond to fuel share in total oil demand. Other sectors include agriculture, forestry, fishing, military and unspecified consumption. Buildings include residential, public and commercial buildings. Energy sector includes electricity and heat generation and energy industry own use.

The sectoral split shapes the security profile in two ways that matter for the cooperation discussion that follows. Transport remains the dominant exposure channel: a road-fuel disruption would feed straight into the working economy by disrupting business logistics, commuting and the agricultural and fisheries sectors that depend on diesel. Industry exposure is concentrated in petrochemicals and feedstock use, where substitution options are slow to deploy and supply continuity is therefore a security rather than an affordability concern. Aviation is an acute case: jet fuel is both critical for connectivity and the most import-dependent product in the Nordic oil basket, as Section 7.3 sets out. The implication is that "Nordic oil security" does not have a single answer; the cooperation needs are different at the road-transport, industrial-feedstock and aviation tiers, and the geopolitically induced supply and price shocks discussed in Section 1.5 land differently in each.

7.2 Nordic oil supply: production, imports and structural exposure

Within the Nordic region, only Norway and Denmark produce oil at any significant scale, and their positions are fundamentally different (see Box 7.2 for details on their production). Norway is by far Europe's largest oil and natural gas producer. Norway (14 per cent of EU oil imports in 2025) is the second-largest supplier of oil products to the European Union, behind only the United States (15 per cent). Norway exports nearly 80 per cent of its crude production to the EU, the UK and Nordic neighbours. It is also the EU's largest supplier of natural gas in gaseous form (52 per cent of EU imports in 2025).[80] Denmark produces oil but is no longer self-sufficient: domestic crude production covers less than 40 per cent of consumption, and Denmark has been a net crude oil importer since 2017 as North Sea fields have depleted.

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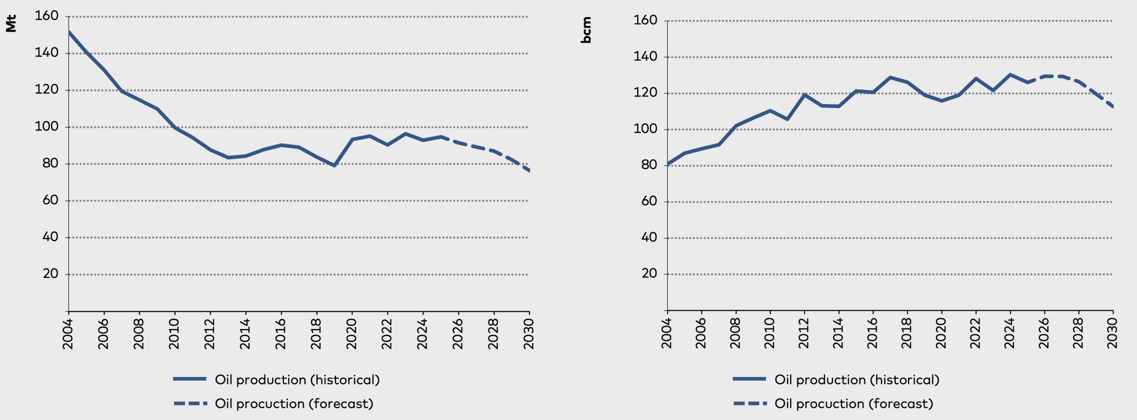
80. Eurostat, EU imports of energy products – latest developments, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=EU_imports_of_energy_products_-_latest_developments

Box 7.2: Oil and natural gas production in Norway and Denmark

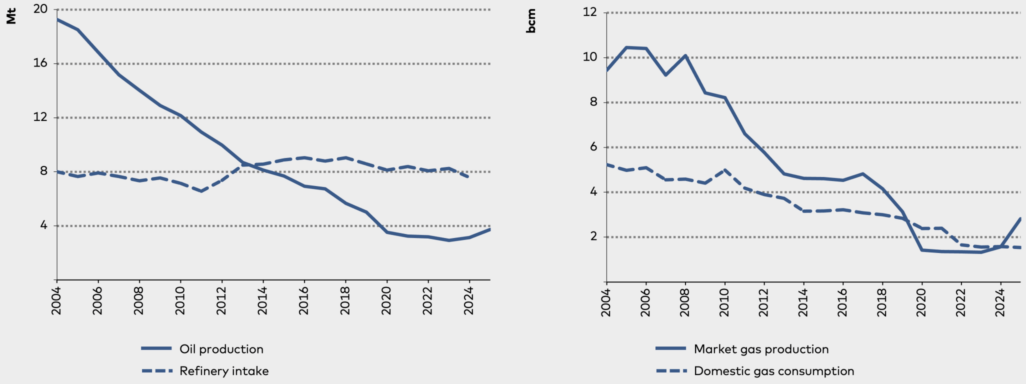
Norway is the only Nordic country that produces hydrocarbons at a scale that matters beyond its own borders. Oil production began in 1971, peaked in 2001 and has since stabilised at around 2 million barrels of oil equivalent per day (roughly 2% of global consumption). Natural gas production reached 126 billion cubic metres in 2025, just below the 2024 record (approximately 3% of global production). Output is forecast to decline by around 10 per cent by 2030. Production is concentrated in the North Sea, and the pipeline and terminal infrastructure connecting it to continental European and UK markets forms part of the wider European energy security system, not only the Nordic one.

Norway's oil and natural gas production, 2004–2025 with forecast to 2030



Sources: Eurostat, Norsk Petroleum.
Notes: Natural gas reported in standard conditions (15 °C). Reported volumes vary slightly between sources depending on the gas reporting condition.

Denmark's oil and natural gas production and domestic demand, 2004–2025

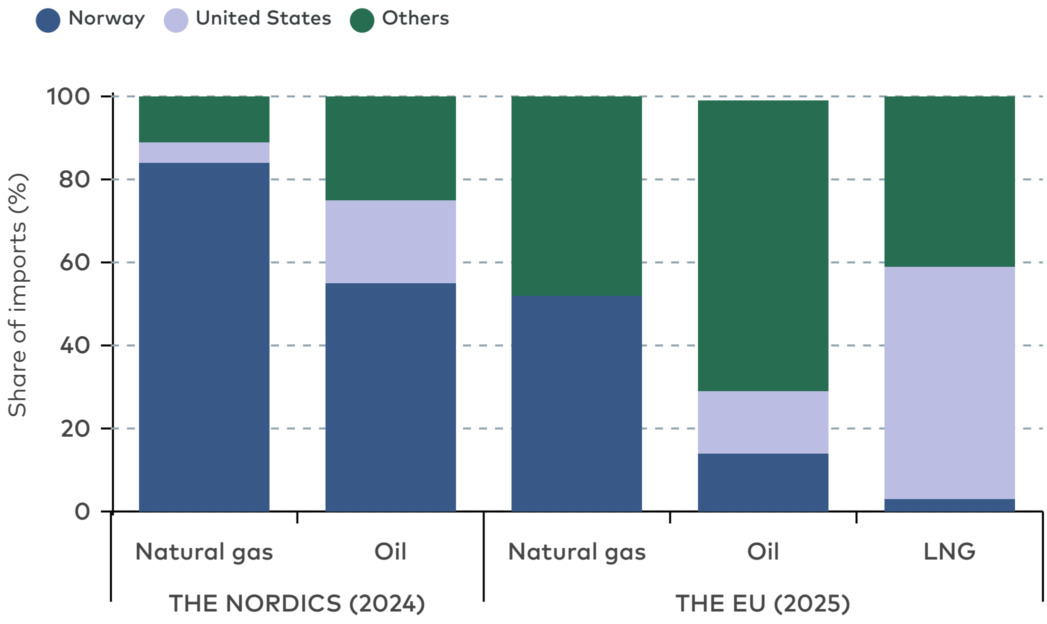


Sources: Eurostat, Energistyrelsen.
Notes: Gas figures exclude biomethane.

All other Nordic countries depend fully on oil imports. Norwegian supply offers a significant buffer against geopolitical oil supply risks: Norwegian oil accounts for 55 per cent of Nordic oil imports, a far higher share than its position as a supplier to the rest of the EU (see Figure 7.3). Even so, proximity to Norway does not shield the Nordics from price shocks, because oil is a globally traded commodity.

This aggregate picture understates the Nordic region's real exposure. The relevant security question is not whether the Nordics import oil in aggregate, which they do substantially, but which specific products are most import-dependent and how exposed those supply chains are to disruption.

Figure 7.3: Import shares of main oil and gas suppliers to the Nordics and the EU



Sources: Eurostat; European Commission, EU imports of energy products – latest developments. Notes: For the Nordics, natural gas includes both LNG and pipeline gas. Shares for the EU are calculated based on import values

7.3 Oil product import dependency and exposure

Headline import dependency understates the risk picture for refined products. A country can produce more energy than it consumes in aggregate and still depend heavily on imports for specific products with high domestic demand. The product-level analysis reveals four findings that matter for energy security.

First, Nordic refining capacity provides a meaningful but imperfect buffer against supply disruptions. Domestic refining reduces dependence on imported finished products from outside the region. In aggregate, the eight refineries operating across Denmark, Finland, Norway and Sweden have sufficient capacity to meet most Nordic refined product demand, but the security value of that capacity is limited in two ways (see Box 7.3 for details on Nordic refining capacity).

Second, the product mix of Nordic refineries does not match the region's import exposure. The Nordic refineries are collectively skewed towards gasoline and heavier products, and they do not have sufficient capacity to meet regional demand for diesel and jet fuel.

Third, regional refining capacity has been declining. Two refineries closed in 2021, removing roughly 15 per cent of Nordic refining capacity. The reduction in refining capacity increases the reliance on imports and further underlines the importance of emergency reserves.

Box 7.3: Nordic oil refining capacity

Eight refineries operate in Denmark, Finland, Norway, and Sweden. The Island Energy Systems have no refineries. The Nynäshamn refinery (Sweden) produces only specialised oil products. Relevant Nordic refining capacity stands at around 51 million tonnes per annum (Mtpa), equivalent to over a million barrels per day (Mbd). Of this capacity, liquid biofuel production accounts for 4 Mtpa (or 7%).

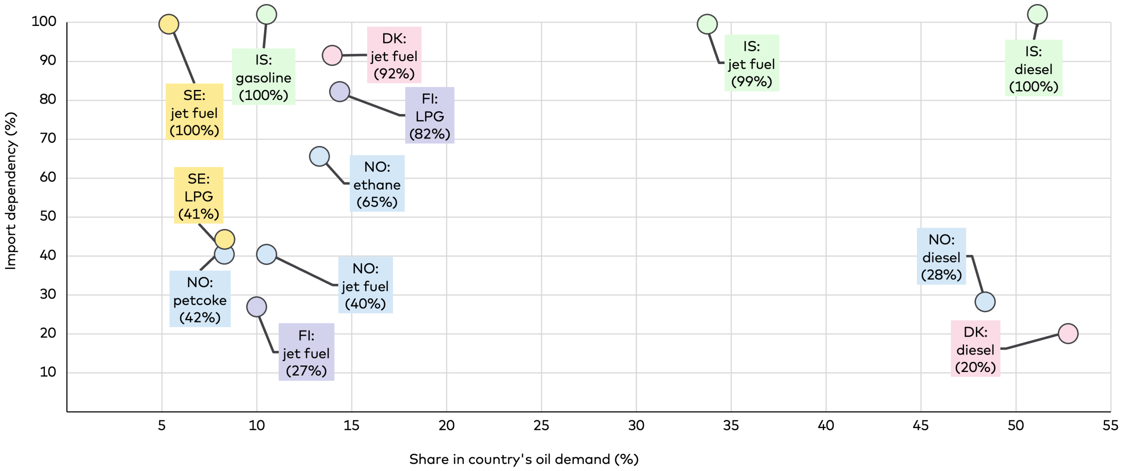
Two refineries closed in 2021, removing about 15% of the regional refining capacity: Naantali (Finland, 3 Mtpa) and Slagen (Norway, 5.8 Mtpa). Reliance on imported refined products has grown as a result. The Porvoo refinery in Finland is also expected to transition fully to renewable products, which would further reduce the region's capacity to refine crude oil.

	Country	In operation since	Total capacity (Mtpa)	Of which: Biofuels (Mtpa)	Operator
Main refineries					
Kalundborg	Denmark	1961	5.5	-	Klesch Group
Fredericia	Denmark	1966	~3.5	-	Crossbridge Energy
Porvoo	Finland	1966	12.0	2.0	Neste Oyj
Mongstad	Norway	1975	11.0*	-	Equinor / Shell
St1 Gothenburg	Sweden	1940s	4.0	0.2	St1
Preemraff Gothenburg	Sweden	1967	6.4*	0.3	VAROPreem
Preemraff Lysekil	Sweden	1975	10.7*	1.0	VAROPreem
Total			51.0	4.0	
Specialized refineries					
Nynäshamn	Sweden	1928	1.5	-	Nynas AB

Sources: Annual reports and websites of the operating companies
Notes: * capacity calculated from original reporting unit (1000 barrels / day = kbd) with average density of 7.5 barrels/tonne). For refinery capacity definition, see Annex 1.

Fourth, and most strikingly, jet fuel stands out across the entire region as a critical import dependence vulnerability: combined Nordic jet fuel import dependency reaches 68 per cent (see Figure 7.4). In the period 2004–2024, jet fuel production in the Nordics fell by one-third (total refined product output fell only 12 per cent). Finland has the highest share of domestic jet fuel production, accounting for two-thirds of demand. Norway is also able to cover more than half of its jet fuel demand from domestic production. Denmark, Iceland and Sweden are effectively fully dependent on imports for their jet fuel supply.

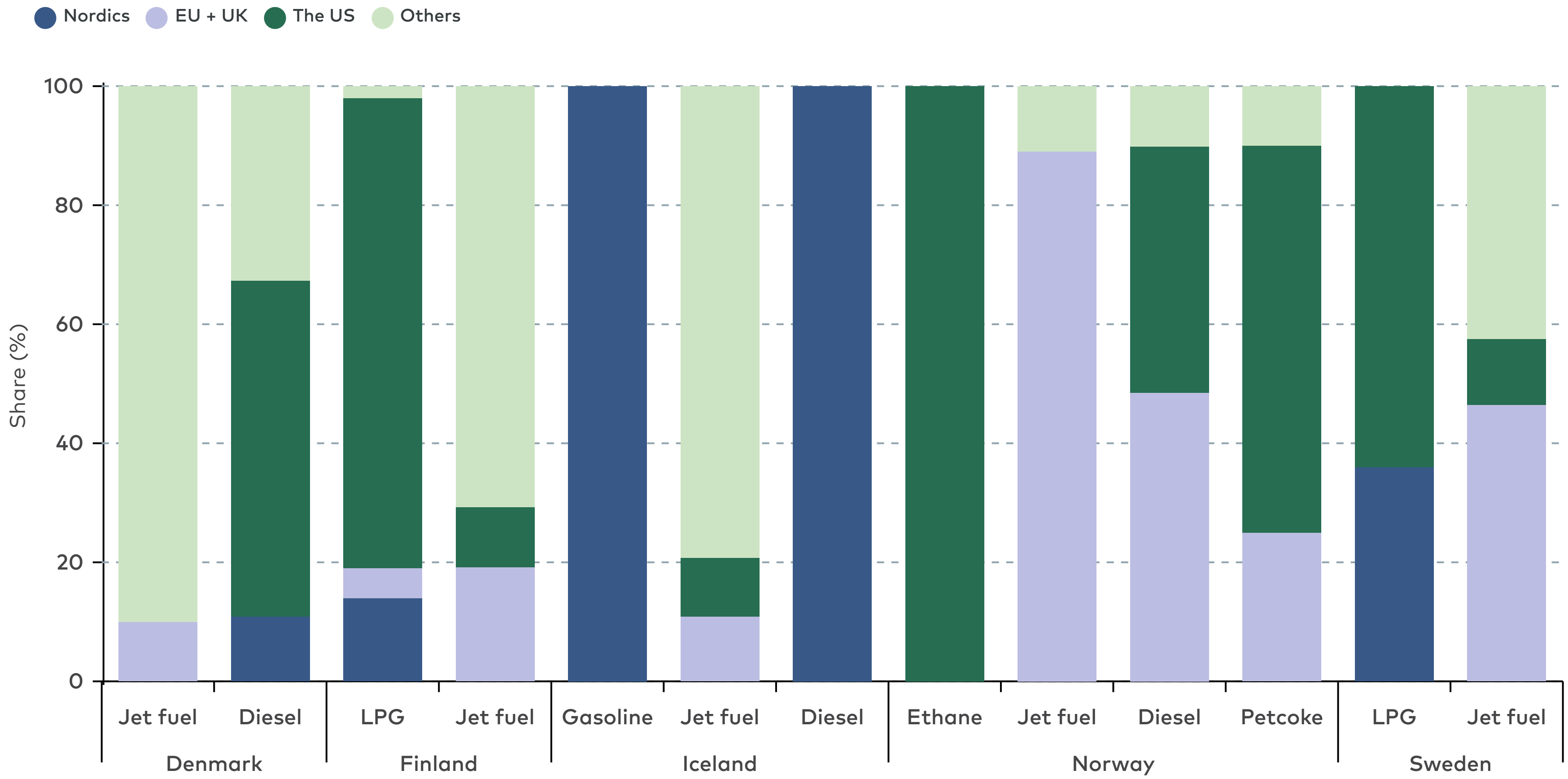
Figure 7.4: Nordic oil product import dependency, 2024



Source: Eurostat.
Notes: Analysis excludes Greenland, the Faroe Islands and Åland. Only products above a 5 per cent share of national oil demand are shown. Oil product demand includes international marine and aviation bunkers. See details of methodology in Annex 1.

Internal Nordic trade in refined products is small, and only Iceland imports most of its most-exposed refined petroleum products from other Nordic countries (see Figure 7.5). The EU, the United Kingdom and the United States supply most of the import needs for diesel, LPG and other major products. Jet kerosene is again the clear outlier: most Nordic imports originate in the Middle East and Asia. The aggregate picture of Nordic oil import dependence is therefore more favourable than the position in critical products such as jet fuel.

Figure 7.5: Origin of imports for the most-exposed oil products, 2024



Source: Eurostat.

Notes: Oil demand includes international marine and aviation bunkers.

7.4 Stockholding and emergency response mechanisms

Oil stocks are in place to give governments time to respond when supply is disrupted. Releasing reserves cushions the economic impact of price spikes and shortages and buys time for demand-restraint measures to take effect. They are not instruments for managing routine market-driven price movements that are better addressed through diversification and demand reduction.

The four mainland Nordic countries sit in three distinct governance frameworks, and the differences matter. Denmark, Finland and Sweden are members of both the EU and the International Energy Agency (IEA). They are bound by the more demanding of the two sets of obligations. Norway is an IEA member but not an EU member. Iceland belongs to neither, but emergency reserve regulations are under review by the Ministry for the Environment, Energy and Climate as of May 2026, but no requirements are yet in force. The obligations attached to the EU and IEA frameworks are set out in Table 7.1.

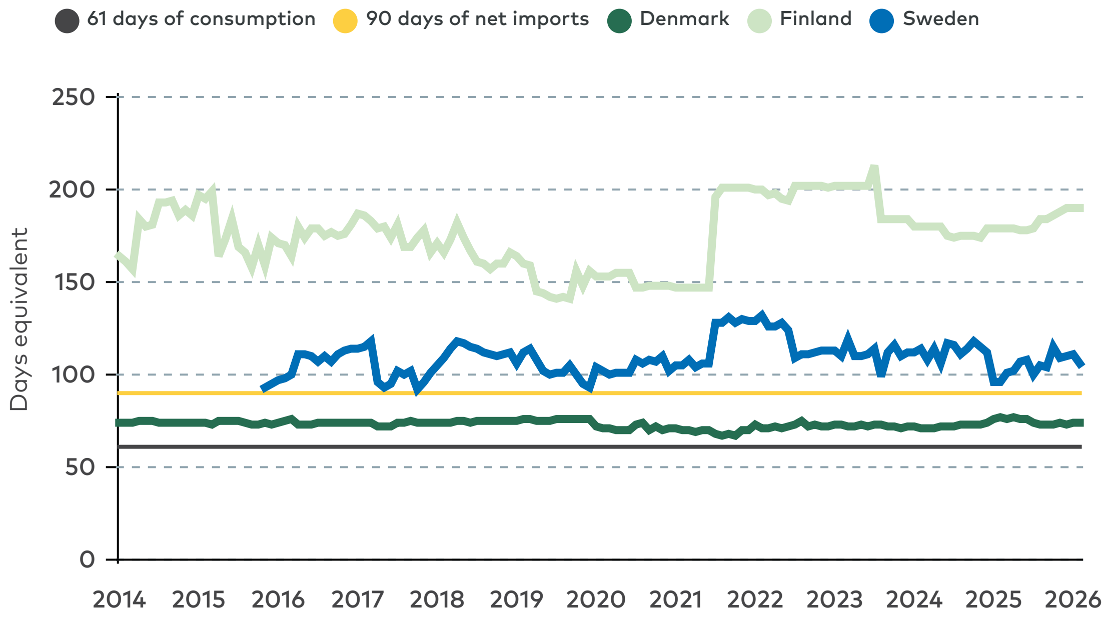
Table 7.1: EU and IEA oil stockholding and emergency response obligations

EU obligations	IEA obligations
Stockholding: At least 90 days of net imports or 61 days of consumption, whichever is higher. Monthly statistical reporting to the European Commission. Only stocks owned by the member state or its central stockholding entity are counted towards the emergency reserves. Legal basis: Directive 2009/119/EC (Oil Stocks Directive).	Stockholding: At least 90 days of net imports, only obliges net importers of oil. Obligation can be met flexibly through emergency stocks, commercial stocks, or stocks held abroad under bilateral agreements. Stockholding structures peer-reviewed every five years. Legal basis: Agreement on an International Energy Programme.
Emergency response: Each member state must analyse oil supply disruption risks and put crisis management procedures in place. The European Commission organises consultation between member states during a crisis. Stock withdrawals are not made before consultation except in urgent situations. The Oil Coordination Group provides standing advisory coordination with the IEA.	Emergency response: The IEA Secretariat assesses the market impact of disruptions and the case for coordinated response. If a disruption is judged sufficiently large, an IEA collective action may be recommended. Each member country contributes in proportion to its share of total IEA oil consumption. Members must maintain demand-restraint programmes capable of reducing oil consumption by up to 10 per cent.

Sources:
EU: energy.ec.europa.eu/topics/energy-security/security-oil-supply_en
IEA: www.iea.org/about/oil-security-and-emergency-response

Denmark, Finland and Sweden have consistently fulfilled their EU stockholding obligations (Figure 7.6). Finland stands out as the strongest performer by a considerable margin, holding stocks well above the required minimum level, reflecting a long-standing national preparedness culture that treats energy reserves as part of broader supply security policy. Sweden tracks the 90-day import threshold more closely, and Denmark operates under the 61-day consumption criterion because part of its consumption is met by domestic production, which reduces its import dependency.

Figure 7.6: Compliance of the Nordic EU countries with the EU stockholding requirement

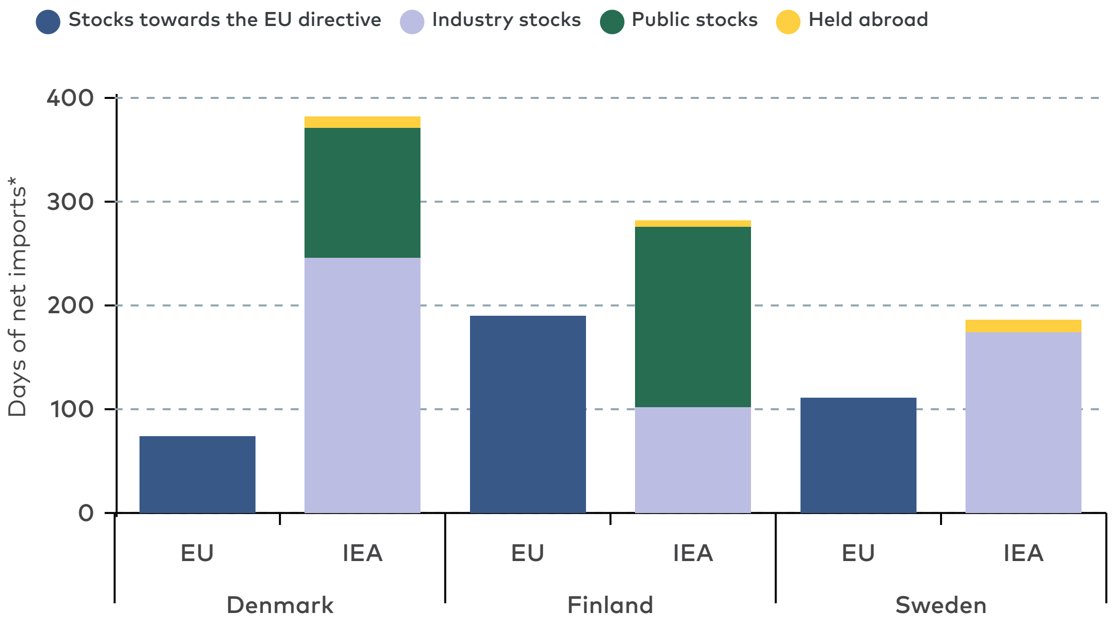


Source: Eurostat.

Notes: Finland and Sweden must meet the 90-day net imports criterion; Denmark the 61-day consumption criterion.

The EU and IEA mechanisms use different accounting rules, with the EU applying stricter eligibility criteria on industry-held stocks, which means the two headline numbers are not directly comparable for the same physical inventory. The EU rules are stricter on what counts, particularly on industry-held stocks. Figure 7.7 shows the comparison for January 2026 (For detailed calculation methodology, see Annex 1 section A1.2.5 and A1.2.6.

Figure 7.7: EU and IEA stock levels compared, January 2026



Source: IEA, Eurostat.
Notes: For Denmark, stocks towards the EU directive are measured as days of consumption.

Norway's position is the most anomalous among the Nordic countries. The IEA stockholding mechanism binds only member countries that are net importers. As Europe's largest oil producer and exporter, Norway is 'free' of these rules. This allowed it to reduce the mandatory fuel readiness requirement from 90 to 20 days of consumption in 2007 against the recommendation of the IEA. This was done at a time when the country had two operational refineries and a policy assumption that production volumes made large domestic reserves unnecessary. One of those two refineries (the Slagen plant operated by ExxonMobil) closed in 2021, reducing Norway's domestic refining capacity by roughly a third.[81] Norway remains significantly dependent on imports for diesel and jet fuel specifically, and the 20-day stockholding obligation has never been revised to reflect either the changed refining footprint or the product-level vulnerabilities.[82]

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81. Argus Media (2021), 'ExxonMobil shut Norway Slagen refinery in June', https://www.argusmedia.com/ja/news-and-insights/latest-market-news/2237347-exxonmobil-shut-norway-slagen-refinery-in-june
82. Nordic Reporter (2026), 'Norway ill-prepared for energy crisis: only 20 days of reserves', April 2026, https://nordicreporter.com/2026/04/norway-ill-prepared-for-energy-crisis-only-20-days-of-reserves/

The North Atlantic Island Energy Systems (Iceland, Faroe Islands and Greenland) are the most exposed in terms of limited emergency reserves. All three are entirely dependent on imported oil products delivered through a small number of ports, with no pipeline connections to continental Europe. None of them are subject to mandatory stockholding frameworks of the EU or the IEA. In all three cases, the stocks that exist are operational reserves held by private fuel importers, with quantities not publicly disclosed. In Iceland, emergency reserve regulations are under review by the Ministry for the Environment, Energy and Climate as of May 2026, but no requirements are yet in force.[83] The result is a striking inversion: the countries most physically exposed to supply disruption, and facing the most severe weather constraints on delivery, are also the ones that sit entirely outside the formal reserve frameworks.

7.5 Nordic fuel security cooperation

There is no dedicated Nordic fuel security cooperation framework comparable to NordBER for electricity. Cooperation runs along three tracks. The first is the IEA collective-action framework, which is the operational backbone for the four IEA-member Nordic countries (Denmark, Finland, Norway and Sweden) and was activated at the largest scale in the agency's history during the 2026 Strait of Hormuz crisis with a coordinated 400 million barrel release.[84] The second track is the EU oil stocks regime, binding on Denmark, Finland and Sweden but not on Norway, Iceland or the Island Energy Systems. The third track, and the most relevant for Nordic-level cooperation specifically, is bilateral.

The most developed bilateral relationship is between Finland and Sweden, set out in Section 3.1.4. Conducted between Finland's NESA and Sweden's MSB under the framework of the 1992 Finland-Sweden security of supply agreement and the NESA-MSB joint strategic cooperation plan, the cooperation covers material preparedness across multiple sectors, including the piloting of joint emergency stockpiles relevant to fuel security. The fuel-specific application of this cooperation has not been fully elaborated in public communications and is therefore one of the areas where Nordic-level extension would benefit from targeted scoping. Beyond the Finland-Sweden track, formal Nordic-level cooperation on fuel security is thin. No multilateral Nordic forum coordinates national positions ahead of IEA collective-action discussions, and there is no regional mechanism to channel demand-restraint or affordability protection towards the autonomous and Island Energy Systems that sit outside the IEA framework.

Jet fuel, the most exposed Nordic oil product, is the clearest single carrier-level cooperation gap. The EU Commission's May 2026 jet fuel coordination work, set up in response to the Strait of Hormuz Strait crisis to coordinate alternative jet fuel sourcing and propose distribution measures across Member States, is the binding framework for

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83. Iceland Monitor (2026), 'Government discusses emergency oil reserves', March 2026, https://icelandmonitor.mbl.is/news/politics_and_society/2026/03/14/government_discusses_emergency_oil_reserves/
84. IEA (2026), Update on IEA Collective Action decision of 11 March 2026, International Energy Agency, https://www.iea.org/news/update-on-iea-collective-action-decision-of-11-march-2026

Denmark, Finland, and Sweden.[85] Norway engages with this work through its bilateral arrangements with the EU rather than as part of a Nordic position, and the Faroe Islands and Greenland sit outside the framework. The structural gap that emerges is therefore narrower than the gas case in 6.1 but real: a region with structurally elevated jet-fuel exposure, a refining base that does not match its product mix, and a stockholding regime that runs through three separate governance frameworks does not have a Nordic-level forum in which to coordinate. Section 8.4 returns to this with concrete recommendations.

7.6 Fuel security: key findings for the Nordics

Overall oil dependence in the Nordics is trending downward, and Norway's production base provides a regional buffer that few other parts of Europe enjoy. The aggregate picture conceals where the real exposure sits. Refining capacity has fallen by around 16 per cent since 2021, and the regional product mix is skewed towards gasoline and heavier fractions. Diesel and jet fuel are the products where Nordic refining falls furthest short of demand, and jet fuel is a region-wide vulnerability. The 2026 Strait of Hormuz crisis is the live demonstration that price exposure to a global supply shock does not depend on direct import dependence.

The stockholding picture is uneven. Denmark, Finland and Sweden meet their EU and IEA obligations, with Finland holding stocks well above the required minimum. Norway sits outside the EU framework and reduced its mandatory readiness to 20 days of consumption in 2007, an obligation set when the country had two operational refineries. Iceland, the Faroe Islands and Greenland sit outside both the EU and the IEA frameworks and have no mandatory stockholding regime, despite being the most physically exposed parts of the region to supply shocks. Reducing oil dependence remains the most durable answer to global price shocks, but the more immediate cooperation question is whether the existing reserve and emergency-response architecture matches the actual exposure profile of the region.

Cooperation runs along three tracks: the IEA collective-action framework, the EU oil stocks regime, and bilateral arrangements, of which the Finland-Sweden NESA-MSB cooperation set out in Section 3.1.4 is the most developed. There is no dedicated Nordic fuel security cooperation framework. The trilemma trade-off in this carrier sits primarily on the affordability side: the Hormuz crisis demonstrated that price exposure to a global supply shock does not depend on direct import dependence, and the region's most acute carrier-level vulnerability, jet fuel, has neither a dedicated Nordic forum nor a framework that brings Norway's production base into shared regional crisis-response procedures. Section 8.4 takes that question forward.

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85. European Commission (2026), 'EU prepares coordinated response to address jet fuel supply situation', press release, 7 May 2026, https://energy.ec.europa.eu/news/eu-prepares-coordinated-response-address-jet-fuel-supply-situation-conflict-middle-east-persists-2026-05-07_en

Section 8

NORDIC ENERGY SECURITY COOPERATION ROADMAP

Image: **iStock**

The Nordic energy system is often seen as a model of regional integration. That description is in part accurate but incomplete. The Nordic region benefits from low-carbon power generation, mature market institutions, and decades of TSO cooperation in electricity markets. What it does not yet have is a regional framework adequate to the current threat environment.

Three developments have exposed the gap between reputation and reality. Russia's full-scale invasion of Ukraine in 2022 demonstrated that energy market integration transmits geopolitical shocks regardless of a country's own fuel mix: Nordic electricity prices tracked continental European gas prices despite the region's low gas dependence. A sequence of sabotage incidents on Baltic Sea subsea infrastructure between 2022 and 2024 established that energy assets previously assumed safe from deliberate attack are now targets. And the 2026 Strait of Hormuz crisis showed, within days of the strait's closure, that even a region structurally buffered from Middle Eastern oil flows is exposed through price transmission.

The cooperation architecture has not kept pace. It is strong where it has had decades to develop: electricity market operations, TSO coordination, and technical emergency preparedness protocols. It is largely absent in the areas where the current threat environment now calls for closer cooperation: joint strategic assessment, live information sharing with operational teeth, physical infrastructure protection, and gas and future hydrogen governance.

The nine cooperation domains in this roadmap address these gaps directly. Recommendations are sequenced over two time horizons: short-term actions achievable within existing structures in zero to three years, and medium-term measures requiring new arrangements or investment over three to ten years. Throughout, the principle is to build on what already exists rather than build parallel tracks, and to focus on issue areas where Nordic cooperation adds value over national approaches. Complementary to the regional cooperation roadmap, Annex 1 includes country-specific energy profiles and recommendations.

8.1 Strengthening system-level Nordic energy security cooperation

8.1.1 Regional energy security strategy

The implementation of effective regional energy security approaches depend on sufficient governance arrangements to facilitate them. Without a formally adopted Nordic Energy Security Strategy and the institutional anchor it provides, the following recommendations remain unallocated to any responsible Nordic body with the mandate to drive them. The recommendations here are therefore the connective tissue of the entire roadmap.

Short-term (0–3 years)

Recommendation 1: Nordic Energy Security Strategy. The Nordic Council of Ministers leads the development of a Nordic Energy Security Strategy that synthesises the key cross-border vulnerabilities identified in this report and the cooperation steps set out in this roadmap. The strategy should rest on two foundations. First, a clear public statement of what Nordic energy security cooperation is intended to achieve. Second, a continuous review and update process, for example a three-yearly cycle aligned with national energy and security planning.

Recommendation 2: Cooperation Architecture Mapping. The Nordic energy cooperation should publish and maintain a regularly updated public registry of Nordic energy security cooperation mechanisms (what exists, what is being developed, and where gaps remain). The registry would directly address one of the observations of this project: many actors across the Nordic states who are deeply involved in national energy security policies and implementation are not aware of either formal or informal cooperation mechanisms in their area.

Medium-term (3–10 years)

Recommendation 3: Dedicated Nordic Energy Security Working Group. Establish a dedicated Nordic Energy Security Working Group on energy security with a mandate covering the full cross-sectoral cooperation agenda mapped in this report. Membership should include representatives of TSOs (both electricity and gas) national energy regulators; energy ministries; national cybersecurity agencies. The purpose of the group would be to set priorities for cooperation in areas with cross-border relevance.

8.1.2 Cross-border situational awareness and information sharing

Section 3's analysis identified the absence of a joint Nordic energy security threat assessment as one of the most consequential strategic-planning gaps. The survey evidence is consistent with this: information sharing and situational awareness was the cooperation domain most frequently identified by respondents as the priority area for deepening Nordic cooperation.

Short-term (0–3 years)

Recommendation 4: Annual Nordic Energy Security Threat Assessment. Nordic Energy Research commissions and publishes an annual joint Nordic energy security threat assessment, drawing on national risk assessments, TSO operational data, and inputs from national cybersecurity agencies. The assessment takes a two-format structure: a public summary suitable for policy-facing audiences, and a classified annex shared with national authorities for operational and asset-specific detail.

Recommendation 5: Nordic Energy Security Information Sharing Protocol. Establish a standing protocol for trusted cross-border information sharing among Nordic national energy authorities, TSOs, and cybersecurity agencies. The protocol defines four parameters: scope (incident reporting, threat intelligence, infrastructure vulnerability data); classification levels (what can be shared at Nordic level versus what requires bilateral arrangements); access arrangements (who is authorised to receive what); and escalation procedures during a live incident. The EU's NIS2 cybersecurity incident-reporting obligations are the institutional foundation on which this protocol is built, not a parallel structure.

Medium-term (3–10 years)

Recommendation 6: Nordic Energy Security Operations Centre Feasibility Assessment. Commission a feasibility study into a Nordic energy security operations centre that provides 24/7 cross-border situational awareness, modelled on the operational logic of the Nordic Regional Coordination Centre but with an explicit security mandate and coverage of all energy carriers and critical infrastructure. The study examines institutional location, staffing, classification handling, and the interface with national security and intelligence agencies. No structural decision is pre-committed before the assessment is complete.

8.1.3 Subsea and on-land infrastructure protection

Section 4 set out the case that subsea infrastructure protection has moved from theoretical concern to operational necessity, with Estlink 2 the clearest single example of a problem with a known solution. The recommendations below convert that diagnosis into actionable Nordic measures, framed as complements to the emerging EU framework rather than parallel structures.

The EU framework has advanced substantially since 2025: the EU Action Plan on Cable Security, the Cable Security Toolbox with its €347 million budget allocation in February 2026, a €20 million Baltic Sea pilot for pre-positioned modular repair equipment, and the proposed multi-purpose EU Cable Vessels Reserve Fleet with icebreaker capability for northern latitudes.[86]

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86. European Commission (2026), 'EU Action Plan on Cable Security: Cable Security Toolbox', press release, February 2026, https://ec.europa.eu/commission/presscorner/detail/en/ip_26_327

Nordic cooperation in this area is not a substitute for the EU framework but addresses three structural gaps within it. First, the security-restricted CEF Digital cable repair capacity calls exclude non-EU participants, including EEA members. Norwegian public entities are not eligible for the Baltic Sea pilot or subsequent follow up projects, despite Norway's general association with the CEF programme. Norwegian North Sea infrastructure, including gas pipelines, NordLink, North Sea Link, and the planned North Sea offshore grid, therefore falls outside the funded EU repair capacity programme.

Second, the EU mechanism covers submarine telecom and data cables specifically. Currently, HVDC power cables and subsea gas pipelines fall outside the scope entirely. Power cables require heavier cable handling and different jointing techniques. The EU acknowledges the need for combined efforts between member states, cable owners, and producers to standardise electricity cable spare parts and repair crew training, but no funded mechanism yet exists. Subsea gas pipelines are governed by a separate framework altogether (the EU Gas Security of Supply Regulation and bilateral arrangements) and have no equivalent repair vessel or equipment programme at EU level despite the demonstrated vulnerability following the Balticconnector rupture in October 2023.

Short-term (0–3 years)

Recommendation 7: Priority Cable Repair Vessel Access Agreements. Negotiate Nordic priority-access agreements with specialist cable repair vessel operators, addressing three gaps in the emerging EU undersea cable protection architecture. First, extend repair capacity coverage to Norwegian subsea infrastructure: gas pipelines and HVDC interconnectors, which fall outside the EU CEF Digital framework because Norway is not an EU member state. Second, focus specifically on HVDC power cable repair capability, including specialised jointing equipment, heavy cable handling, and converter-specific components, which the EU's modular repair equipment calls do not yet cover. Third, establish standing contractual arrangements with identified vessel operators (pre-agreed activation triggers, response times, and cost-sharing). The agreement scope covers vessel operators with Baltic Sea and North Sea operating capability, bilateral and multilateral coverage of specific cable assets, and integration with the existing bilateral Finland-Estonia repair capacity work led by Finland's National Emergency Supply Agency. These Nordic arrangements should be designed from the outset to be compatible with the EU Cable Vessels Reserve as it becomes operational, so that Nordic contracts can be folded into the broader European framework rather than creating a parallel structure.[87]

Recommendation 8: Harmonised Physical Protection Standards for Critical On-Land Infrastructure. Agree minimum Nordic standards for the physical protection of critical on-land energy infrastructure (electricity substations, oil and gas storage facilities, interconnector landing points). Common standards help to create a shared investment floor and enable joint procurement of protective equipment and mutual audit between Nordic operators.

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[87] European Commission (2026), 'EU Action Plan on Cable Security: Cable Security Toolbox', press release, February 2026, https://ec.europa.eu/commission/presscorner/detail/en/ip_26_327; UK Parliament Joint Committee on the National Security Strategy (2024), Undersea cables: protecting critical infrastructure, HC 723, https://publications.parliament.uk/pa/jt5901/jtselect/jtnatsec/723/report.html

Medium-term (3–10 years)

Recommendation 9: Nordic Joint Emergency Repair Capacity Framework. Establish a Nordic mutual assistance framework for energy infrastructure emergency repair, comprising five components. First, a pre-positioned strategic spare parts reserve covering large power transformers and HVDC cable joining materials. Second, a shared register of specialist repair crews with pre-agreed cross-border access and liability arrangements. Third, joint procurement protocols for long-lead-time components (large power transformers carry 12–18 month lead times and HVDC cable and converter equipment longer still, manufactured by a small number of global suppliers).[88] Fourth, the priority cable repair vessel access agreements scaled up from Recommendation 7. Fifth, a biennial Nordic energy infrastructure repair exercise to test the framework end-to-end. Cost-benefit analysis should determine whether stockpiling is centralised or distributed across national sites with mutual access.

Recommendation 10: Nordic Offshore Infrastructure Security Framework. Develop Nordic security-by-design standards for offshore wind substations and export cables in Nordic waters, covering the North Sea and Baltic. Standards address three areas: siting decisions that incorporate explicit security risk assessments; redundant cable routing requirements proportionate to system criticality; and incident response protocols that integrate civilian operators with NATO maritime surveillance assets. Bornholm Energy Island, with commissioning currently targeted for the early 2030s, is the first major implementation case. Its design choices have the potential to set precedents for subsequent offshore projects across the region.[89]

8.1.4 Cyber and hybrid threat cooperation

Cyber and hybrid threats are the standout priority in practitioner assessment: in the survey of Nordic officials carried out for this project, hybrid and cyber threats were identified among the most pressing regional energy security challenges. The gap between the threat level and the current depth of Nordic cyber cooperation is one of the largest vulnerability-to-cooperation mismatches in the region. Nordic energy operators have developed an informal practitioner-level CISO network through monthly calls and biannual in-person meetings, which is the most concrete functioning cyber mechanism at Nordic level.[90] The network plays an important role in building people-to-people connections and trust but it is not a substitute for a timely information sharing system and protocol.

The new NordSec Group, established by the four mainland TSOs in October 2024, adds a CEO-level layer above this. Both currently function as discussion forums rather than operational information-sharing networks. The recommendations below convert these

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88. National Infrastructure Advisory Council (2024), Addressing the Critical Shortage of Power Transformers to Ensure Reliability of the U.S. Grid, https://www.cisa.gov/sites/default/files/2024-09/NIAC_Addressing%20the%20Critical%20Shortage%20of%20Power%20Transformers%20to%20Ensure%20Reliability%20of%20the%20U.S.%20Grid_Report_06112024_508c_pdf_0.pdf
89. Danish Energy Agency, Bornholm Energy Island, https://ens.dk/en/energy-sources/bornholm-energy-island
90. Interview with senior Nordic energy official, conducted for this project, 2026 (not for attribution).

forums into operational mechanisms, building on EU's NIS2 cybersecurity reporting obligations.

Short-term (0–3 years)

Recommendation 11: Formalise and Develop Nordic Energy Sector CISO Cooperation. The existing informal practitioner-level CISO cooperation among Nordic TSOs and major energy operators provides a working foundation that should be formalised and extended into a trusted operational information-sharing network. Four components are required: secure communication infrastructure enabling encrypted real-time information exchange; incident notification protocols with defined timescales (T+4 hours for significant incidents, T+24 hours for full assessment); a shared threat intelligence feed for energy-sector cyber risks, building on NIS2 obligations; and a defined classification framework for what can be shared at Nordic level. Formalisation should preserve the community character that makes the current arrangement effective while providing the legal and institutional basis for operational sharing.

Medium-term (3–10 years)

Recommendation 12: Nordic Energy Security Cyber Exercise Programme. Establish an annual or biennial Nordic energy security exercise programme testing cross-border response to coordinated cyberattacks on interconnected energy infrastructure. Three design features are essential. First, exercises must include maritime energy infrastructure scenarios. Second, participants span TSOs, national cybersecurity agencies, and energy regulators, not just one type of actor. Third, a mixed participation by civilian energy sector and the military and intelligence community participants is ensured to prepare for realistic hybrid scenarios.

Recommendation 13: Nordic TSO Hybrid Threat Operational Protocol. Nordic TSOs in coordination with national cybersecurity agencies should develop a joint operational protocol for coordinated response to hybrid and state-sponsored threats against energy infrastructure. The protocol should address four gaps that the current Nordic System Operation Agreement Annex on Operational Planning does not cover. First, classification and escalation procedures for incidents where hostile intent is suspected but not confirmed, covering the period between initial anomaly detection and formal attribution. Second, cross-border notification obligations with defined timescales when a hybrid incident affecting one TSO's infrastructure may have consequences for neighbouring systems. Third, operational coordination procedures for simultaneous or cascading multi-asset disruption scenarios, including defined lines of communication between TSO operational centres, national cybersecurity agencies, and relevant military and intelligence contacts.

8.1.5 Integration of self-governed and autonomous regions in regional cooperation

Section 4 highlighted the two-tier participation by Nordic governments in regional cooperation mechanisms. Mainland (Denmark, Finland, Norway and Sweden) TSOs and ministries cooperate closely with each other, while self-governed regions are less engaged.

On one hand, selective participation and flexibility are a strength in Nordic cooperation. Countries with very different needs and capacities are able to come together and selectively focus on the issues that matter to them most. At the same time, the special needs of the self-governed regions are not fully accounted for in current cooperation formats.

Short-term (0–3 years)

Recommendation 14: Dedicated Nordic Islands Energy Security Assessment. Commission a dedicated assessment of energy security in Island Energy Systems: the Faroe Islands, Greenland, Gotland, Iceland and Åland. The assessment should pay special focus on five dimensions: supply chain vulnerabilities including maritime logistics; repair capacity constraints for isolated systems; governance gaps in current cooperation arrangements; local renewable energy pathways as a security measure; and options for differentiated participation in Nordic cooperation frameworks.

8.2. Strengthening Nordic electricity security cooperation

8.2.1 Market design for flexibility and adequacy

The February crunch is the most specific near-term adequacy vulnerability identified in Section 2 and Section 5. It is a governance problem as much as a technical one. The Nordic electricity system is not five national systems that happen to be connected; it is one integrated system that operates as a whole, and national actions create externalities for neighbours.

Recommendation 15: Nordic TSO Demand Pipeline Protocol. Establish a formal protocol for cross-border sharing of major new electricity demand project pipelines. When a project above a defined threshold (e.g. 50 MW) receives grid connection approval in any Nordic country, the relevant TSO notifies all other Nordic TSOs and the Nordic RCC. This enables regional adequacy calculations to account for simultaneous demand surges. The protocol is achievable within existing Nordic RCC structures and existing TSO bilateral relationships. This is one of the most achievable and highest-value near-term measures in this roadmap to address challenges related to electrification dynamics. The scale of the problem is visible in Norway's data centre connection queue alone, which had reached 5.4 GW of reserved capacity by early 2026.[91]

Recommendation 16: Nordic Adequacy Framework Alignment. Agree a common Nordic methodology for adequacy assessment. The methodology covers three components: a shared approach to electrification scenario development across the four mainland Nordic countries, accounting for both data centre demand growth and the trajectory of new capacity additions; a common value-of-lost-load (VoLL) methodology enabling cross-border cost comparison, in line with the ACER Security of Supply 2024 recommendations; and agreed criteria for what counts as an adequate reserve margin in a weather-dependent system with growing dependence on variable renewable generation. This is the

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[91] Argus Media (2026), 'Nordic data centres to support power demand growth', https://www.argusmedia.com/en/news-and-insights/latest-market-news/2806298-nordic-data-centres-to-support-power-demand-growth

prerequisite for coordinated investment in flexibility resources, and it builds directly on the precedent set by NER's 2025 *Toolbox for a Secure Energy Supply*.[92]

Medium-term (3–10 years)

Recommendation 17: Coordinated Capacity and Flexibility Mechanisms. Explore the introduction of new national capacity remuneration mechanisms or flexibility market designs, coordinate the design to avoid cross-border distortions and market fragmentation. Joint procurement is explored for pan-Nordic flexibility resources, particularly for cross-border demand response and shared strategic reserve arrangements, drawing on the Nordic Energy Research (NER) *Toolbox* finding that dispatchable flexible reserve mechanisms benefit from cross-border participation when transmission constraints are accounted for.[93]

Recommendation 18: Data Centre Energy Security Integration. Develop Nordic guidelines for data centre siting, grid connection, backup power requirements, and demand response participation. The guidelines treat data centres as critical energy loads that require security classification distinct from other industrial loads in their concentration and inelasticity. Three components are essential. First, data centres above a defined size threshold must participate in demand response programmes during system stress events. Second, backup generation capacity (typically 72-hour diesel reserves at hyperscale facilities) is given credit in national resilience assessments. Third, the integration between data centre waste heat and district heating security is addressed in regulatory frameworks for both sectors, given the operational link Finnish data centres already create between the two.

8.2.2 Critical equipment storage, buffering, and component stockpiling

The energy system's ability to withstand and recover from disruption depends not only on operational cooperation but on the physical reserves and components available when something fails. Section 5 identified three dimensions of this problem. Large power transformers and HVDC cable components carry extremely long replacement lead times of twelve to eighteen months and are sourced from a small number of global manufacturers. In case of traditional fuel reserves for the self-governed regions, fuel stocks are often measured in weeks, not months, with maritime logistics the single point of failure. The Finland-Sweden bilateral work on joint emergency stockpiles is the only functioning Nordic mechanism addressing any of these dimensions. Scaling Nordic cooperation to a regional level would significantly strengthen preparedness in a system that is closely integrated.

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[92] ACER (2024), Security of EU Electricity Supply 2024, https://www.acer.europa.eu/monitoring/MMR/security_EU_supply_2024; AFRY for Nordic Energy Research (2025), Toolbox for a Secure Energy Supply – Capacity Mechanisms and Non-Fossil Flexibility Support Schemes, NER 2025-02, https://pub.norden.org/nordicenergyresearch2025-02/

[93] AFRY for Nordic Energy Research (2025), Toolbox for a Secure Energy Supply – Capacity Mechanisms and Non-Fossil Flexibility Support Schemes, NER 2025-02, https://pub.norden.org/nordicenergyresearch2025-02/

Short-term (0–3 years):

Recommendation 19: Nordic Critical Component Inventory and Stockpile Scoping Study. Commission a joint inventory of critical energy system components across the Nordic region, covering large power transformers, HVDC cable and converter equipment, and key wind turbine subsystems. Map existing national stockpiles, lead times, and manufacturer dependencies. The study would identify which components are most exposed to single-supplier concentration, longest lead times, and highest consequence of unavailability, and produces options for a coordinated Nordic stockpiling arrangement, including centralised versus distributed storage and opt-in procurement protocols.

Medium-term (3–10 years)

Recommendation 20: Nordic Strategic Component Reserve. On the basis of the inventory findings, establish a coordinated Nordic strategic reserve for the highest-risk component categories. The reserve model builds on the Finland-Sweden pilot and extends it regionally on three principles. First, distributed storage: components are held at nationally designated sites with pre-agreed mutual access agreements, avoiding the political and logistical complexity of a single centralised facility. Second, joint procurement: Nordic countries negotiate collectively with manufacturers for priority production slots and pre-positioned delivery commitments, targeting the large power transformer and HVDC converter categories where lead times are longest and supplier alternatives fewest.

8.3 Strengthening Nordic natural gas cooperation

8.3.1 Gas resilience and energy transition

Gas occupies a paradoxical position in Nordic energy security: the region's most significant structural cooperation gap lies in the sector that is being phased out. The 10–15 year transition period during which gas retains material importance for industry, peak generation backup, and winter heating in Denmark and Finland coincides with a structural asymmetry. Norway is Europe's largest pipeline supplier with approximately 130 bcm of production in 2024 and 95 per cent exported to the EU and UK by pipeline, but Norway sits outside the EU framework that governs its main customers.[94] Section 6.1.2 documented that no pan-Nordic gas TSO coordination forum exists; Norway's Gassco participates in ENTSOG only as an observer; and the structural relationship between Norwegian production and EU consumption is governed by the Norway–EU bilateral gas partnership of 2022 rather than by any Nordic regional framework. The recommendations here address both the transition period and the framework that will govern hydrogen as gas's successor.

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[94] Council of the European Union, 'Where does the EU's gas come from?', https://www.consilium.europa.eu/en/infographics/where-does-the-eu-s-gas-come-from/

Short-term (0–3 years)

Recommendation 21: Nordic Gas Emergency Sharing Framework: Norway Integration.

Integrate Norway into Nordic emergency gas coordination. Norway holds no bilateral gas emergency agreement with any Nordic country. This is a structural governance outcome: the EU solidarity mechanism under Regulation 2017/1938 applies to EU member states only, and Norway's position as a large-scale producer rather than a gas-dependent consumer means it has never had reason to construct such agreements from its own security-of-supply perspective. The Norway–EU bilateral gas partnership of 2022 and the subsequent Energy Dialogue of 2023 establish supply cooperation and volume commitments but contain no crisis activation procedures, no notification thresholds, and no emergency coordination mechanism. In a crisis scenario involving disrupted Norwegian output, whether from infrastructure failure, industrial action, or hostile action against offshore assets, no agreed procedure currently governs how Norway communicates with Nordic gas authorities, what information is shared, and on what timeline.[95]

First, bilateral emergency agreements should be negotiated between Norway and Denmark, and between Norway and Finland. Second, a pan-Nordic gas TSO forum should be established and include Norway’s Gassco. Currently, Gassco participates in ENTSOG only as an observer and has no standing engagement with Nordic gas TSOs as a group.

Medium-term (3–10 years)

Recommendation 22: Nordic Hydrogen Security-of-Supply Framework. Energy security considerations should be embedded in the development of hydrogen infrastructure from the outset.

First, and immediately: Nordic countries should collectively ensure that the security-of-supply dimension is embedded in hydrogen production projects in the region from the feasibility study phase onward.

Second, as the hydrogen market develops: Once cross-border hydrogen flows are material, develop Nordic-level emergency sharing arrangements drawing on the structural lesson from gas: the gas solidarity mechanism took until 2017 to legislate, bilateral agreements are still incomplete in 2025, and the LNG shift rendered much of the original framework obsolete before it was operational. For hydrogen, the framework should be designed before it is needed, not in response to the first crisis. The EU Regulation 2024/1789 does not establish hydrogen solidarity obligations.[96] Nordic countries can move ahead of the EU baseline here, as they have done on electricity. A Nordic hydrogen emergency consultation protocol should cover notification obligations, reserve capacity commitments, and cross-border disruption procedures.

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95. European Parliamentary Research Service (2023), EU-Norway energy cooperation, briefing PE 753.941, https://www.europarl.europa.eu/thinktank/en/document/EPRS_BRI(2023)753941
96. Regulation (EU) 2024/1789 on the internal markets for renewable gas, natural gas and hydrogen, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L_202401789

8.4. Strengthening Nordic fuel supply cooperation

8.4.1 Affordability and demand-side resilience under geopolitical shock

The 2026 Iran war began with US and Israeli strikes on 28 February and was followed by the Iranian closure of the Strait of Hormuz in early March. It exposed a vulnerability that the Nordic region is not yet structured to manage cooperatively. The IEA's 11 March collective action, with 400 million barrels released, was the largest coordinated release from strategic oil reserves in the agency's history. The joint action demonstrated both the value of the existing framework and its limits: stockholding obligations are met nationally, but without special provisions for remote and self-governed Island Energy Systems with structurally elevated baseline costs. There is no Nordic mechanism to coordinate demand-restraint or to channel collective protection to those regions.[97]

Short-term (0–3 years)

Recommendation 23: Nordic Emergency Demand Management Protocol. Develop a harmonised Nordic emergency demand restraint and fuel rationing protocol covering electricity, oil, and gas, aligned with IEA collective action procedures. The protocol defines four parameters: activation thresholds for each carrier; the sequence and scale of demand restraint measures; explicit provisions for protecting remote and self-governed regions; and a Nordic coordination mechanism that operates within IEA collective action processes rather than parallel to them.

Recommendation 24: Nordic Private Sector Fuel Security Guidelines. Issue Nordic guidelines for private sector energy security planning in energy-intensive and logistics-critical sectors. The guidelines should cover three key areas: minimum on-site fuel storage requirements for sectors where supply continuity is operationally critical; price-shock absorption mechanisms (hedging requirements, emergency contracts) for exposed sectors; and sector-specific contingency protocols for aviation, maritime freight, the fishing industry, and cold-chain logistics. The guidelines would be voluntary but promote a regionally cohesive approach in responding to supply shocks.

Recommendation 25: Nordic Jet Fuel Cooperation Mechanism. Establish a Nordic-level coordination mechanism for jet fuel security that addresses the carrier's distinct exposure profile and the institutional gap that no current framework fills. The mechanism should comprise four components. First, a standing Nordic coordination forum bringing together national emergency supply agencies, civil aviation authorities and major airline and airport operators, meeting at minimum twice annually and on demand during supply shocks. Second, a joint assessment of the case for sector-specific jet fuel reserve arrangements over and above general oil stockholding, including options for distributed storage at major Nordic airports and bilateral or multilateral surge-supply arrangements between Nordic refiners and the most exposed Nordic markets.

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[97] IEA (2026), Update on IEA Collective Action decision of 11 March 2026, International Energy Agency, https://www.iea.org/news/update-on-iea-collective-action-decision-of-11-march-2026

ENERGY SECURITY COUNTRY PROFILES AND RECOMMENDATIONS

This section provides energy system descriptions, key vulnerability assessments, and country-specific recommendations for the eight Nordic jurisdictions. Each country block follows the same structure: a synthesis of the energy system, a short discussion of one to three key vulnerabilities, and one to three country-specific recommendations.

The recommendations complement the 25 regional cooperation recommendations set out in Section 8 of the main report and are not a substitute for them. They identify the most operationally consequential country-level priorities that arise from the analysis in Sections 2 to 7 and from the primary research undertaken for the project.

Denmark

Denmark is the Nordic country that has moved furthest in two opposite directions at the same time. Its electricity system, 20 years ago dominated by coal, is now run primarily on wind, and Denmark sits at the operational crossroads of the Nordic and continental European grids, running large flows in both directions and acting as the principal transit corridor between the two systems. On the fuel side, Denmark has moved from full self-sufficiency two decades ago to roughly 40 per cent net import dependence today as the North Sea fields have depleted. The Tyra redevelopment has restored a share of domestic gas output, but the longer trend is clear: Denmark is becoming a net recipient in a regional architecture in which it used to be a supplier.

The forward direction of the Danish system is also visible from offshore. Denmark holds a structurally important position in the European offshore wind buildout, with the Bornholm Energy Island as the major project in the pipeline, scheduled for commissioning from the early 2030s and routing flows between Denmark and Germany through a 3 GW hybrid offshore hub. Bornholm itself currently runs on a single subsea cable from southern Sweden, with local backup generation in Rønne. The island therefore shifts over the coming decade from a small dependent system to a critical link in a much larger cross-border architecture, and the converter platform becomes a single point of failure for a substantial cross-border flow.

Key challenges

The Bornholm pivot. The cable that has failed in 2004, 2010, 2013, and again in January 2026 will, over the coming decade, become the landing point for a hybrid offshore hub of European significance. Bornholm therefore shifts from being a local resilience question to a regional one, and the security profile of the converter platform and the cables that connect to it has consequences well beyond the Danish system.

The transition from supplier to recipient. Denmark is now a net importer of oil and a smaller producer of gas than it was at the peak. The heating and industrial base remains partly gas-dependent during the transition period. The change does not in itself create a near-term energy security crisis, but it does mean that Denmark's position in regional fuel security conversations is no longer that of a producer whose questions are mainly about exports, but of a consumer whose questions are about supply continuity.

Cluster exposure in the offshore buildout. Every new offshore wind project adds inter-array cables, an offshore substation, and an export cable to the Baltic stock of high-value subsea assets. Denmark is the largest single contributor to that stock through Bornholm Energy Island, Kriegers Flak, and the projects in development behind them. The cumulative exposure rises faster than any single asset's.

Recommendations

Recommendation 1. Treat Bornholm Energy Island as a national security-of-supply project from the design phase. Lock in redundant cable routing, security-by-design standards for the converter platform, and a cross-border incident response protocol with Germany before commissioning, with the Rønne backup generation retained as the standing fallback whenever the cable system is unavailable.

Recommendation 2. Develop a Danish gas transition strategy to 2040 setting out how the residual gas role in winter heating, industrial users, and peak power is to be supplied, with explicit emergency-sharing provisions with Norway and Germany.

Key figures (2024):			**2004-24**
Population	Millions	6.0	*+11%*
Gross domestic product (GDP)	Billion EUR	311	*+32%*
Total final consumption (TFC)	PJ	540	*-14%*
Electricity generation	TWh	35.3	*-13%*
Electricity net trade (imports/exports)	TWh	3.7 (25.2/21.4)	..
Final consumption intensity	Index (2004 = 100)	78	*-21%*
Oil intensity	Index (2004 = 100)	58	*-42%*
Overall import dependency	%	40%	0% (2004)

Figure 1: Energy system exposure, 2024

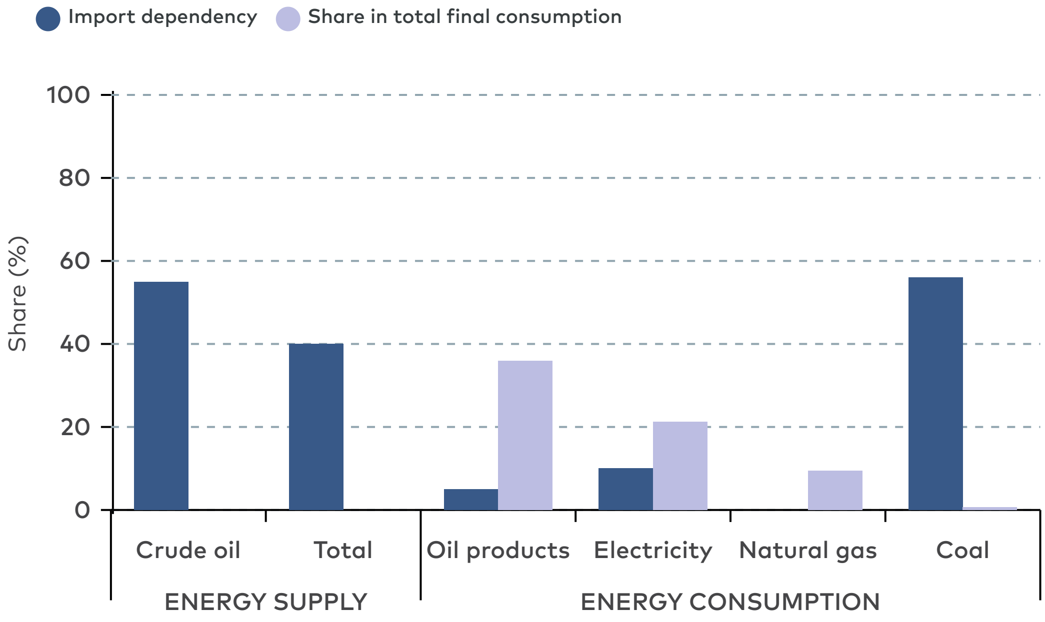


Figure 2: Electricity generation output (TWh), 2004-24

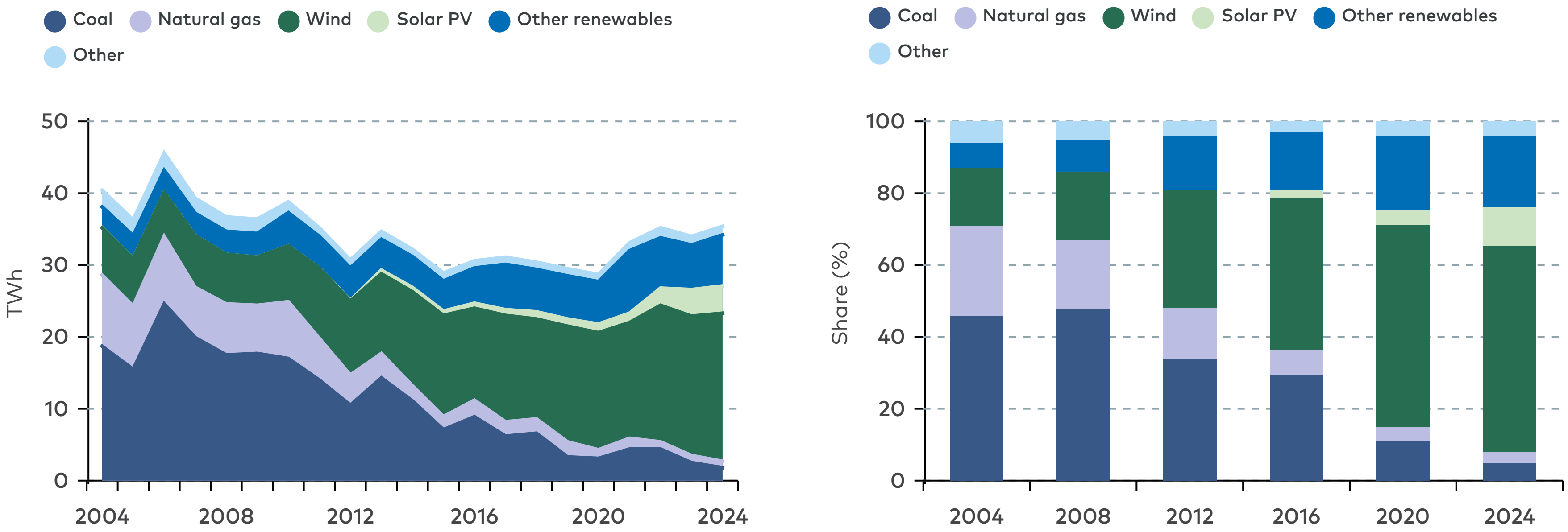


Figure 3: Electricity generation capacity (GW), 2004-24

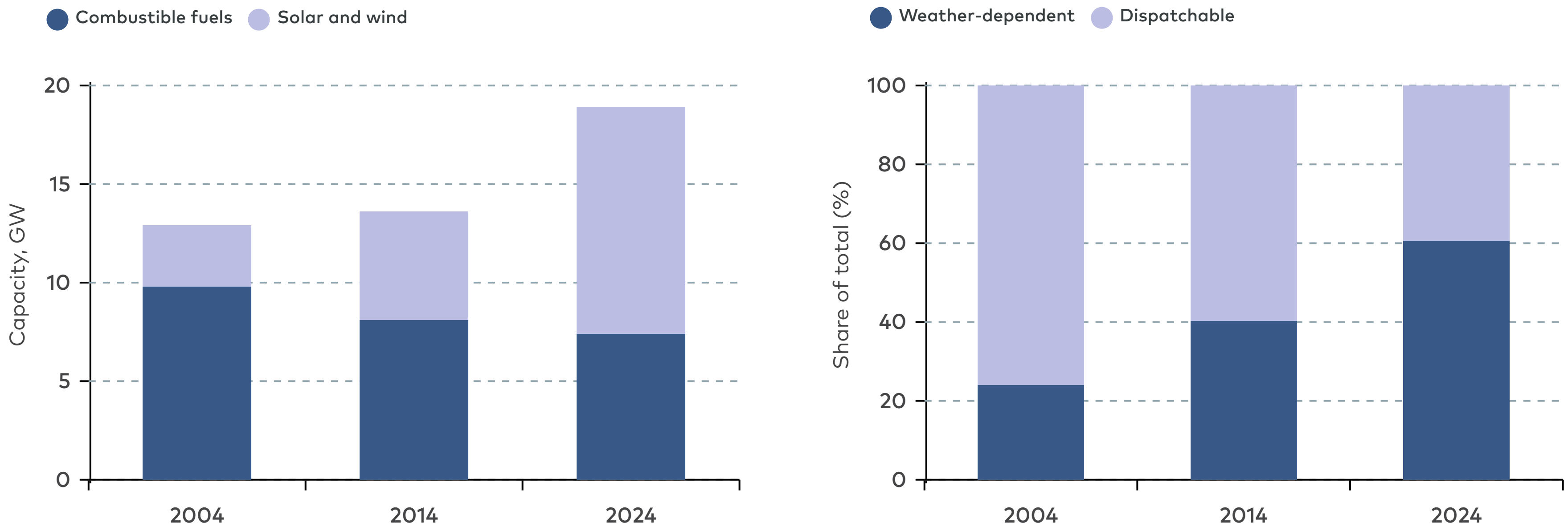


Figure 4: Total final consumption of energy (PJ), 2004-24

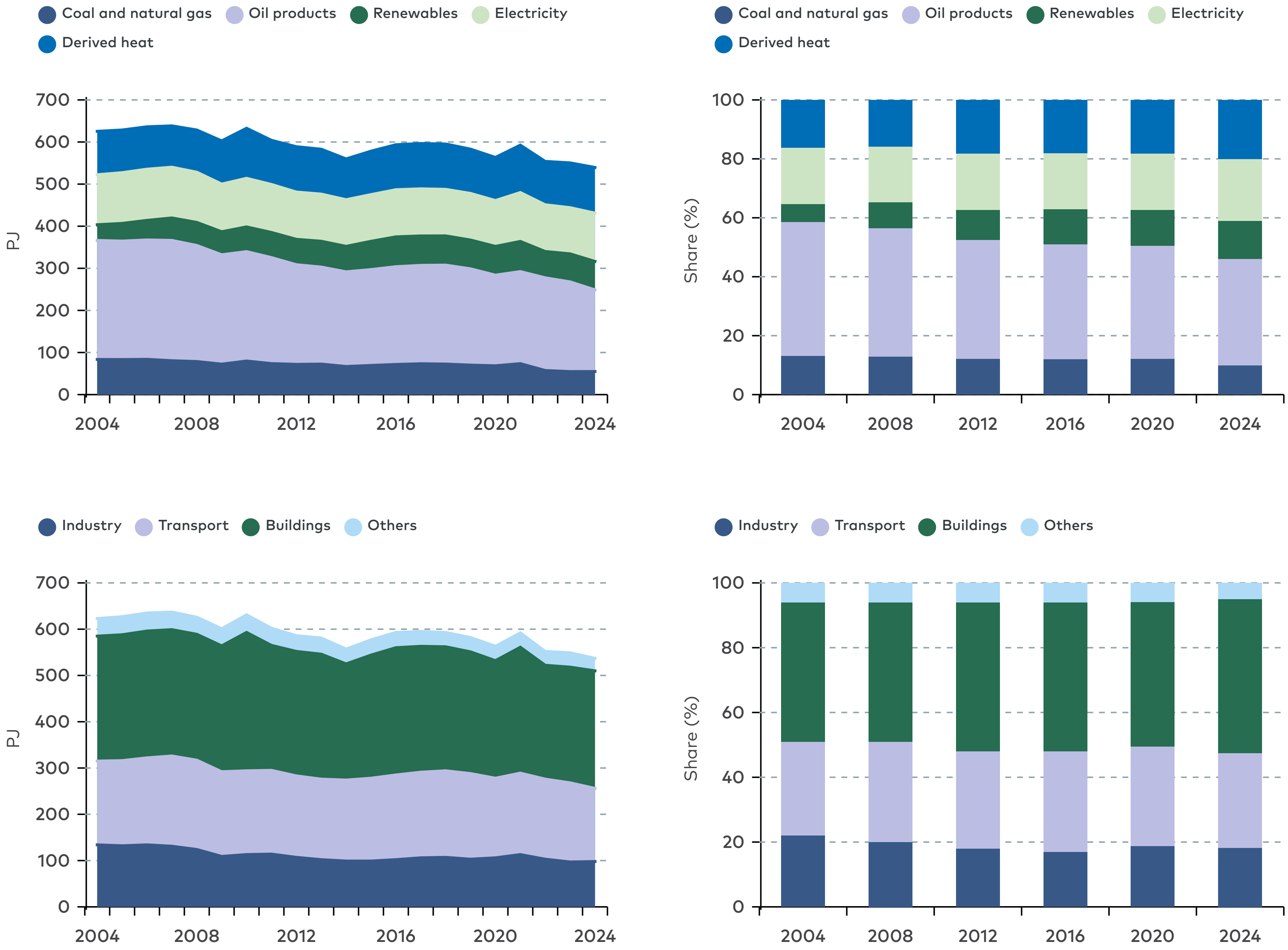
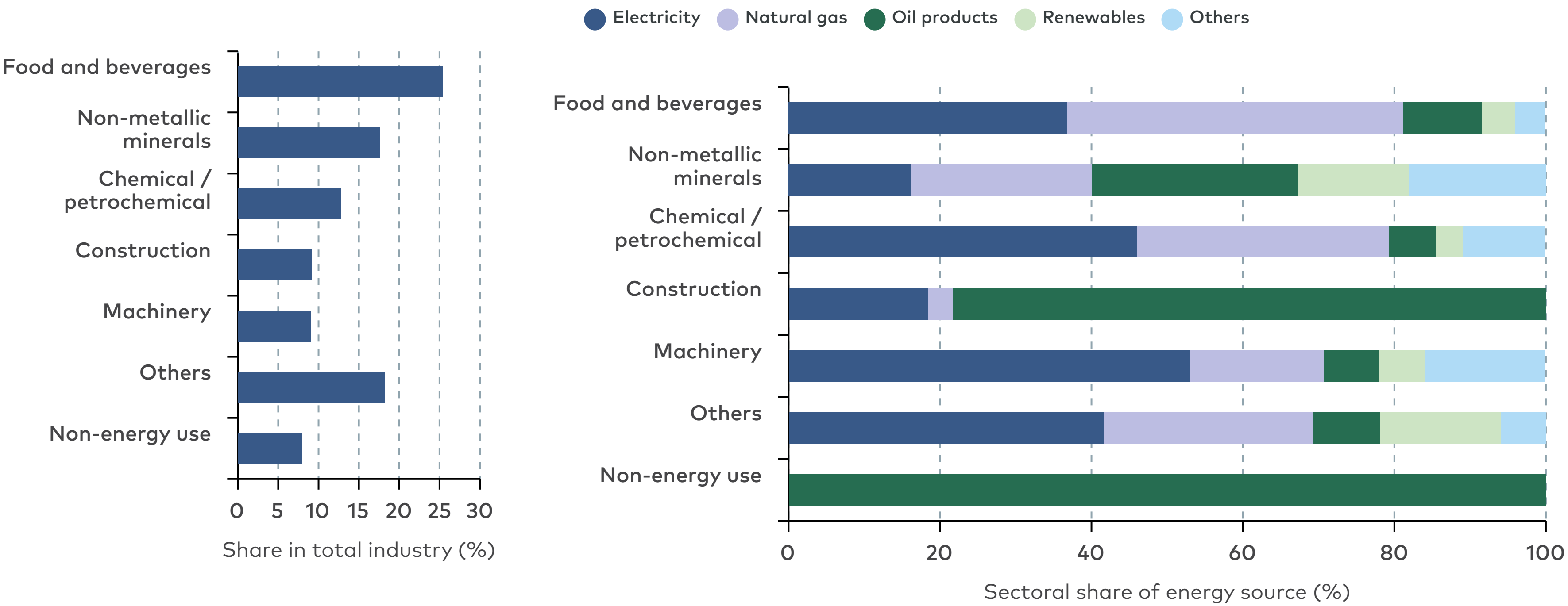


Figure 5: Industrial concentration (measured by energy consumption), 2024



Faroe Islands

The Faroe Islands run a small, isolated energy system whose electricity side is changing fast and whose fuel side is changing much more gradually. Electricity demand has grown by more than half over the past decade, driven by electrified heating and rising electrification in the fishing industry. The municipally owned utility SEV is in the middle of a buildout of wind, hydro, tidal, and battery capacity aimed at fully renewable electricity by 2030. The diesel fleet that today provides around 100 MW of capacity is in a slow phase-out. As recently as the 2010s, SEV reported one to three full blackouts a year, an order of magnitude above continental European frequencies, and a reminder that an island system with no external connection runs on a different reserve margin than a system that can lean on its neighbours.

The energy picture beyond electricity has transformed much slower. The Faroe Islands remain almost entirely dependent on imported oil products, with heating, transport, and the fishing fleet all running primarily on tanker-delivered fuel arriving into a small number of ports. Oil intensity has fallen modestly as electrification has progressed, but absolute fuel demand remains structurally high and the electricity-side transition does not change the fuel-side exposure. Institutionally, the Faroe Islands sit outside both the EU framework and the IEA stockholding regime.

Key challenges

A maritime fuel chain with no institutional backstop. The Faroe Islands are among the most fuel-exposed jurisdictions in wider Europe. No pipelines, no IEA or EU mandatory stockholding, and no Nordic emergency fuel-sharing mechanism to call on. A sustained disruption to maritime fuel delivery, whether from a price shock, North Atlantic shipping disruption, or extreme weather, would feed straight through to transport, fisheries, and heating.

An isolated grid in the middle of a renewables build. The SEV system has no interconnection to any other grid, and the renewables buildout is happening on a small reserve margin. Variability and storage management that mainland systems handle through cross-border flows have to be solved within the island system itself. The combination of rising renewable share and falling thermal backup will tighten this in the coming years.

Country-specific recommendations

Recommendation 1: Treat the 2030 renewable electricity target as a security-of-supply programme as well as a climate one, with dedicated reserve generation, battery storage, and grid restart capability that recognise the absence of any external connection.

Key figures (2024):			**2014-24**
Population	Thousands	54.5	*+12%*
Gross domestic product (GDP)	Billion EUR	3.74	..
Total final consumption (TFC)	PJ	12.8	..
Electricity generation	GWh	480	*+57%*
Electricity net trade	GWh	-	..
Electricity consumption intensity	Index (2014 = 100)	137	*+37%*
Oil intensity	Index (2014 = 100)	81	*-19%*
Overall import dependency	%	89%	..

Figure 1: Energy system exposure, 2024

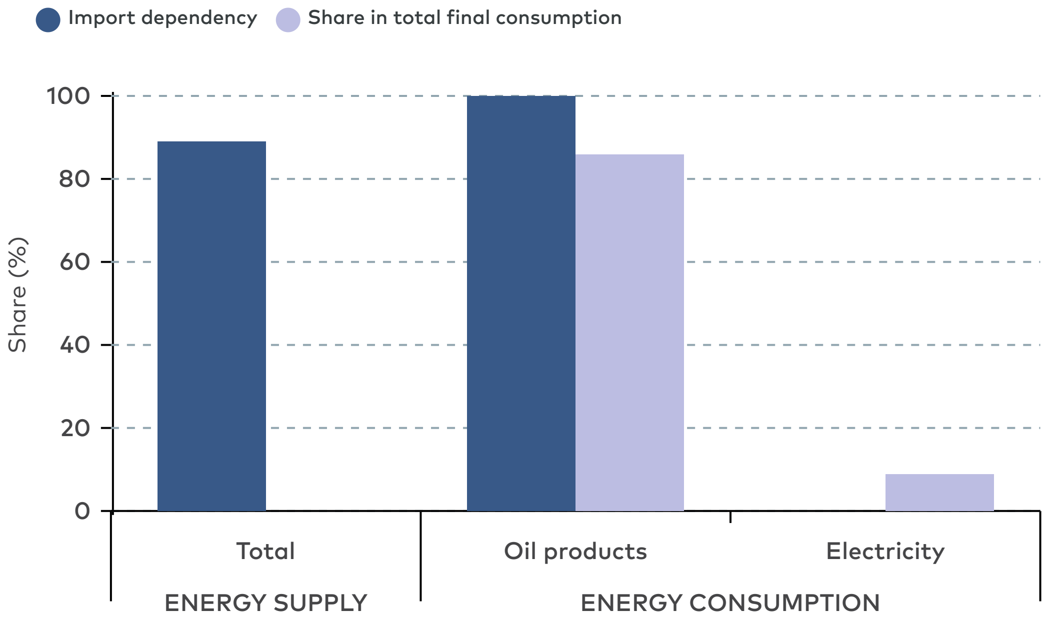


Figure 2: Electricity generation output (GWh), 2004-24

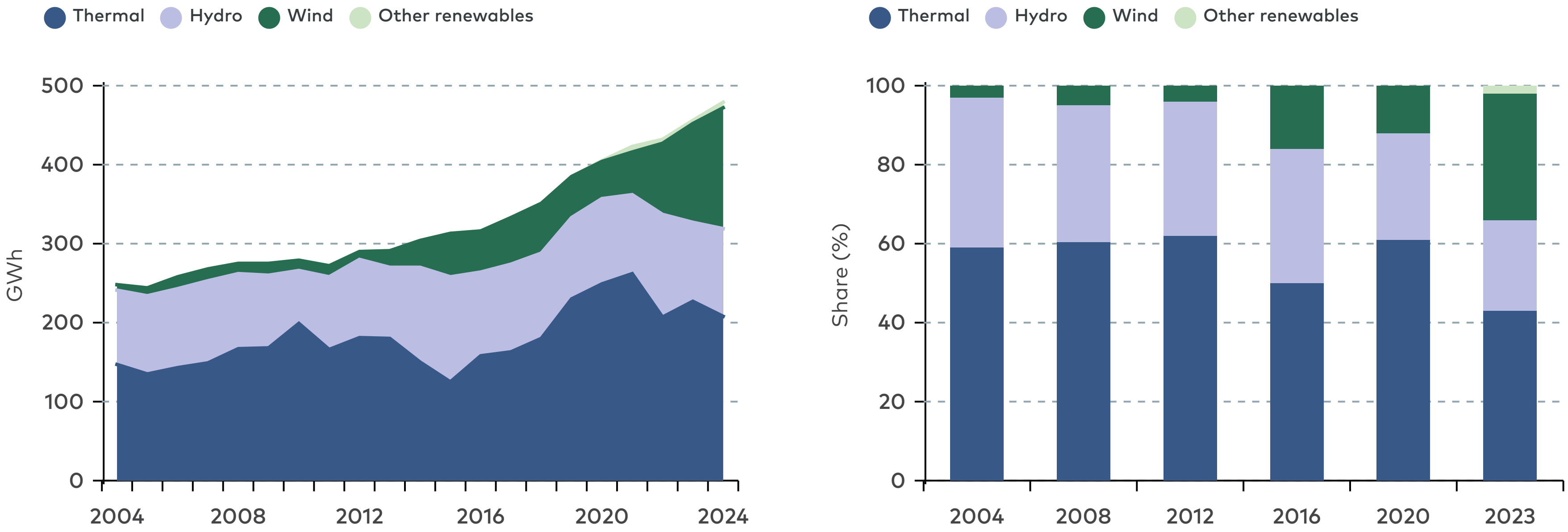
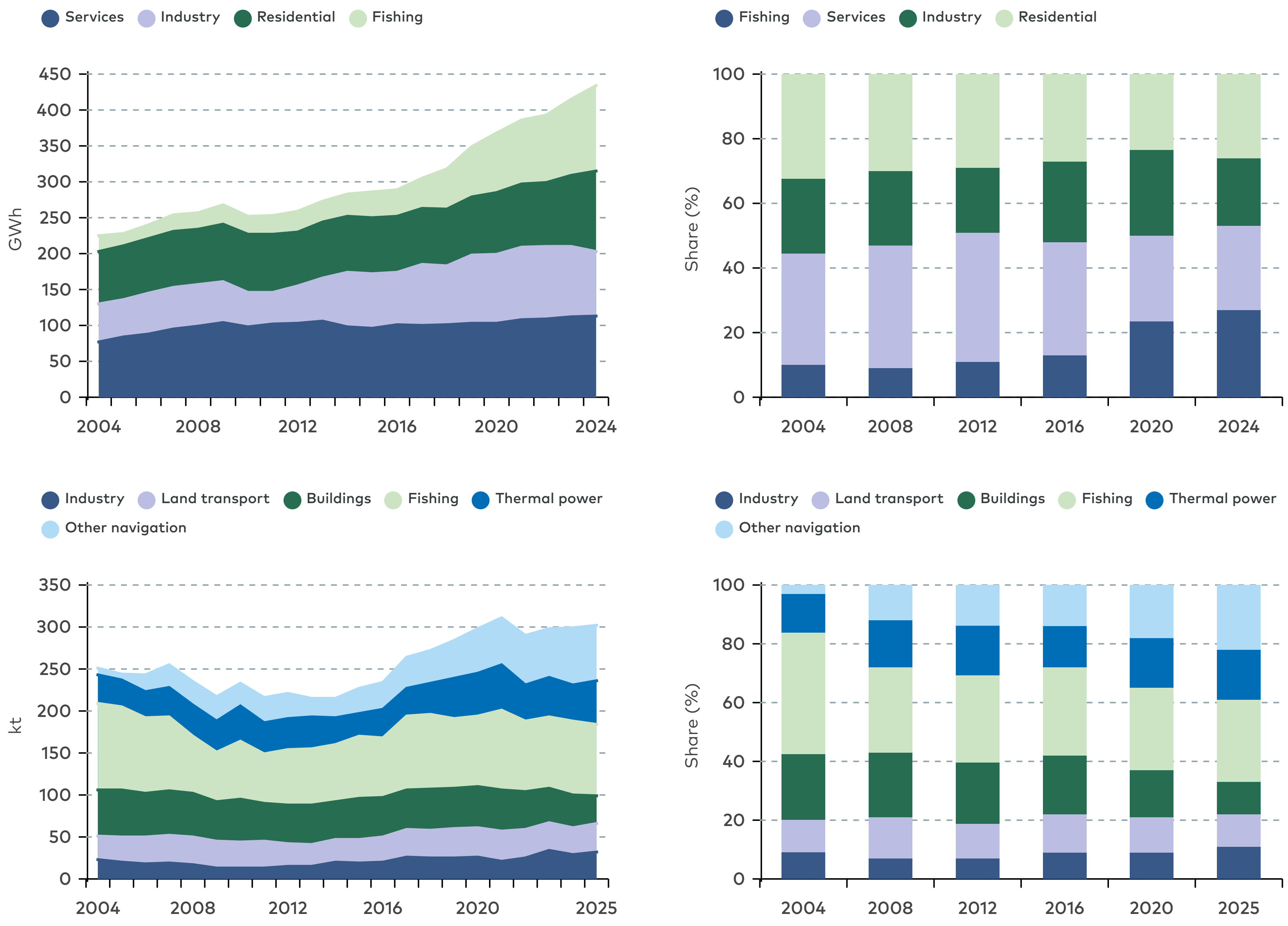


Figure 3: Consumption of electricity and oil products, 2004-24/25



Finland

Finland's energy system tells a story of strategic redirection. Twenty years ago the country was nearly 60 per cent net importer of energy, with substantial Russian gas and oil flowing across the eastern border. Today net import dependence is about half what it was, the Russian flows have been replaced, and the electricity system has been built around nuclear, and a tenfold increase in wind generation over the past decade. The country is now a small net exporter of electricity. The underlying institutional culture is the second part of the story: Finland's National Emergency Supply Agency runs the deepest preparedness apparatus in the region, holding oil stocks well above the EU minimum and coordinating strategic stockpiling across multiple sectors. The Finland–Sweden bilateral preparedness relationship, conducted between NESA and MSB, is the most developed of its kind in the Nordics.

The forward planning challenge is electrification at a pace that strains the system in winter. Industrial electrification, data centres at scale, and the potential for growing hydrogen and power-to-steel production point to 2050 electricity demand at 1.5 to 1.75 times today's level. The winter of 2025–2026 showed what this means in practice, when an extreme cold-and-low-wind event came close to a real loss-of-load situation in Finland, stabilised through emergency demand reductions and full imports across the interconnectors. Add to this the Gulf of Finland's status as the most concentrated subsea infrastructure cluster in the region, with Estlink, Balticconnector, and the data backbone all transiting waters now established as a target environment, and Finland sits at the front line of the Nordic energy security agenda.

Key challenges

The Gulf of Finland. Estlink 2, the Balticconnector rupture in October 2023, and the broader pattern of incidents associated with Russia's shadow fleet highlight the risks to subsea energy infrastructure in the Gulf of Finland. Repair capacity, response times, and the institutional architecture for handling suspected hybrid incidents are all pressure points in the current threat environment.

Winter adequacy under electrification. Finland is the EU's largest electricity consumer per capita (although both Norway and Iceland are larger consumers among the Nordics). The winter peak demand coincides with the lowest wind output, and the demand pipeline for electricity-intensive projects is among the steepest in the region. The single-bidding-zone structure means that no internal price signal differentiates regions, putting the full weight of adequacy management on cross-border flows and on Fingrid's system-wide planning.

Porvoo as a regional asset. Finland has the highest share of domestic jet fuel production in the Nordics. Porvoo is the single asset that delivers this. Any extended outage at Porvoo would have a regional consequence given the deeper jet fuel import dependence of Denmark, Iceland, and Sweden.

Recommendations

Recommendation 1. Lead Nordic operational implementation of priority cable repair vessel access arrangements, building on the existing Finland–Estonia critical infrastructure cooperation and scaling it to cover the Estlink, Balticconnector, and data backbone assets in the Gulf of Finland.

Recommendation 2. Anchor the cross-border demand pipeline protocol (Recommendation 15 in Section 8) in NESA and Fingrid, given that Finland has both the institutional depth and the most acute near-term exposure to combined cold-snap and large-load events.

Recommendation 3. Develop a Porvoo continuity plan covering scheduled and unscheduled outage scenarios, with pre-agreed Nordic and Baltic regional surge supply arrangements that recognise Porvoo's role in regional product balances rather than treating it as a purely national asset.

Key figures (2024):			**2004-24**
Population	Millions	5.6	*+7%*
Gross domestic product (GDP)	Billion EUR	204	*+17%*
Total final consumption (TFC)	PJ	989	*-9%*
Electricity generation	TWh	83.2	*-3%*
Electricity net trade	TWh	3.2	
Final consumption intensity	Index (2004 = 100)	82	*-18%*
Oil intensity	Index (2004 = 100)	60	*-40%*
Overall import dependency	%	34%	59% (2004)

Figure 1: Energy system exposure, 2024

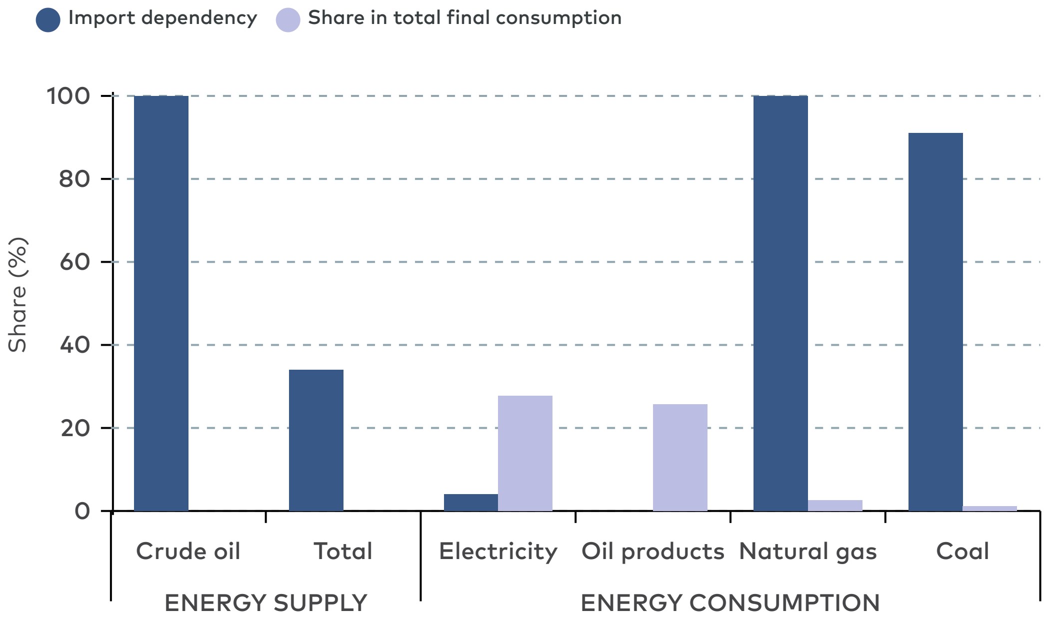


Figure 2: Electricity generation output (TWh), 2004-24

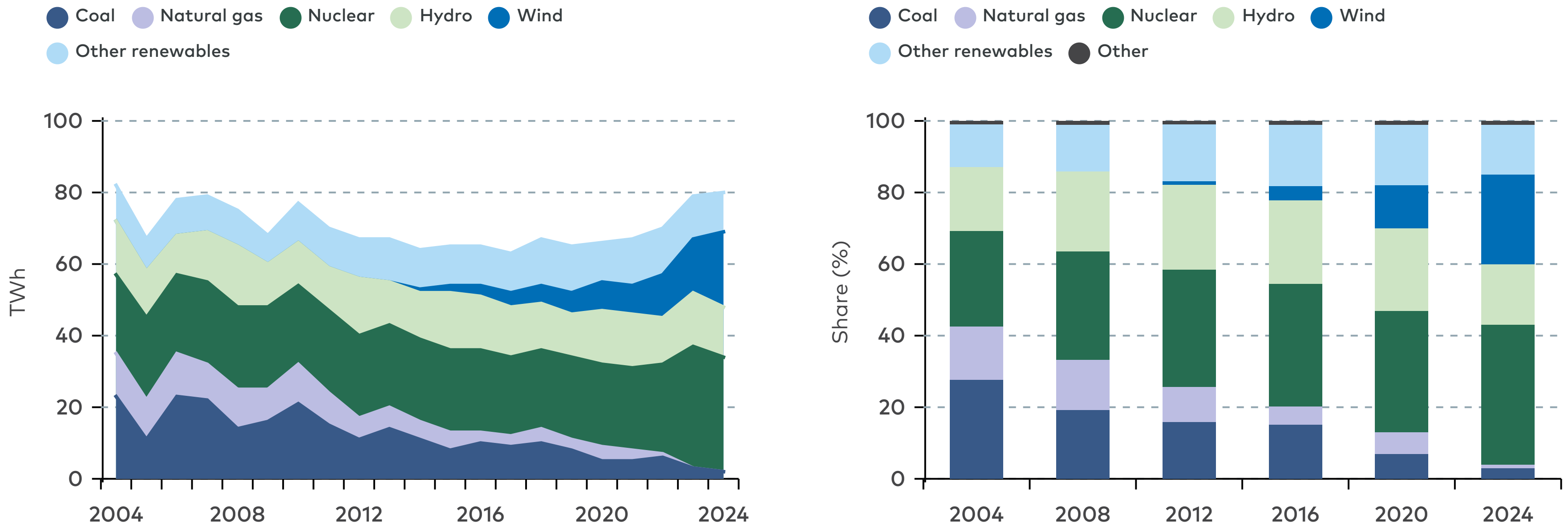


Figure 3: Electricity generation capacity (GW), 2004-24

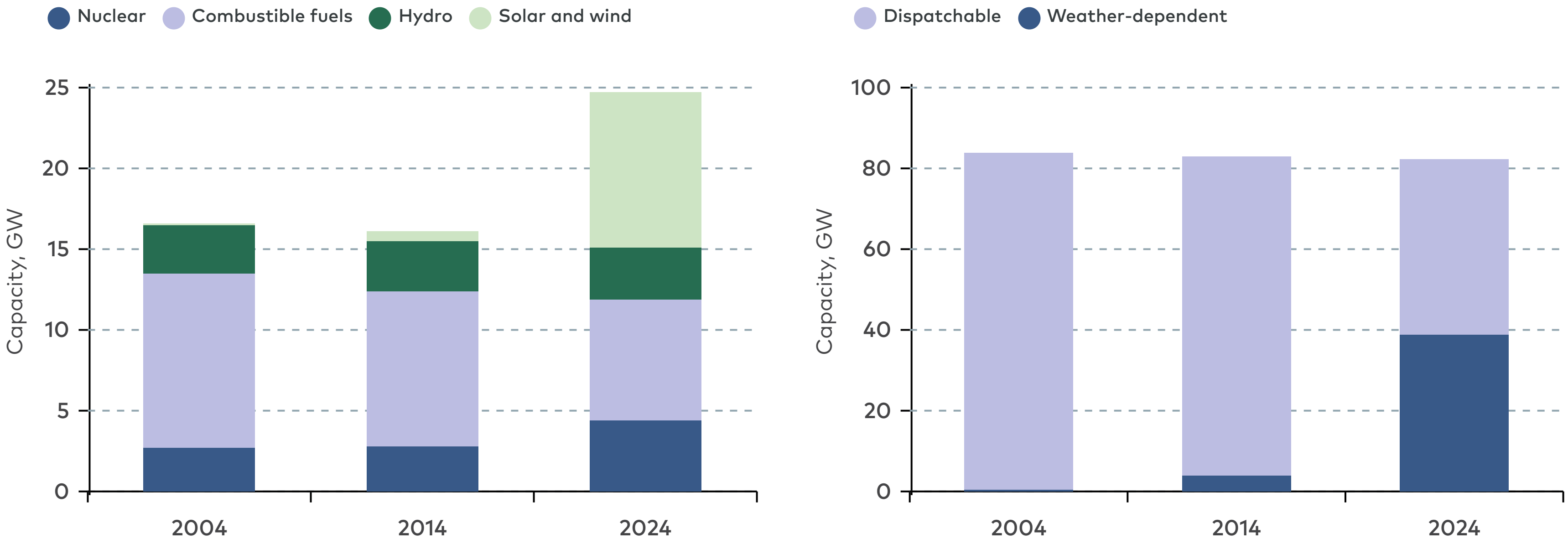


Figure 4: Total final consumption of energy (PJ), 2004-24

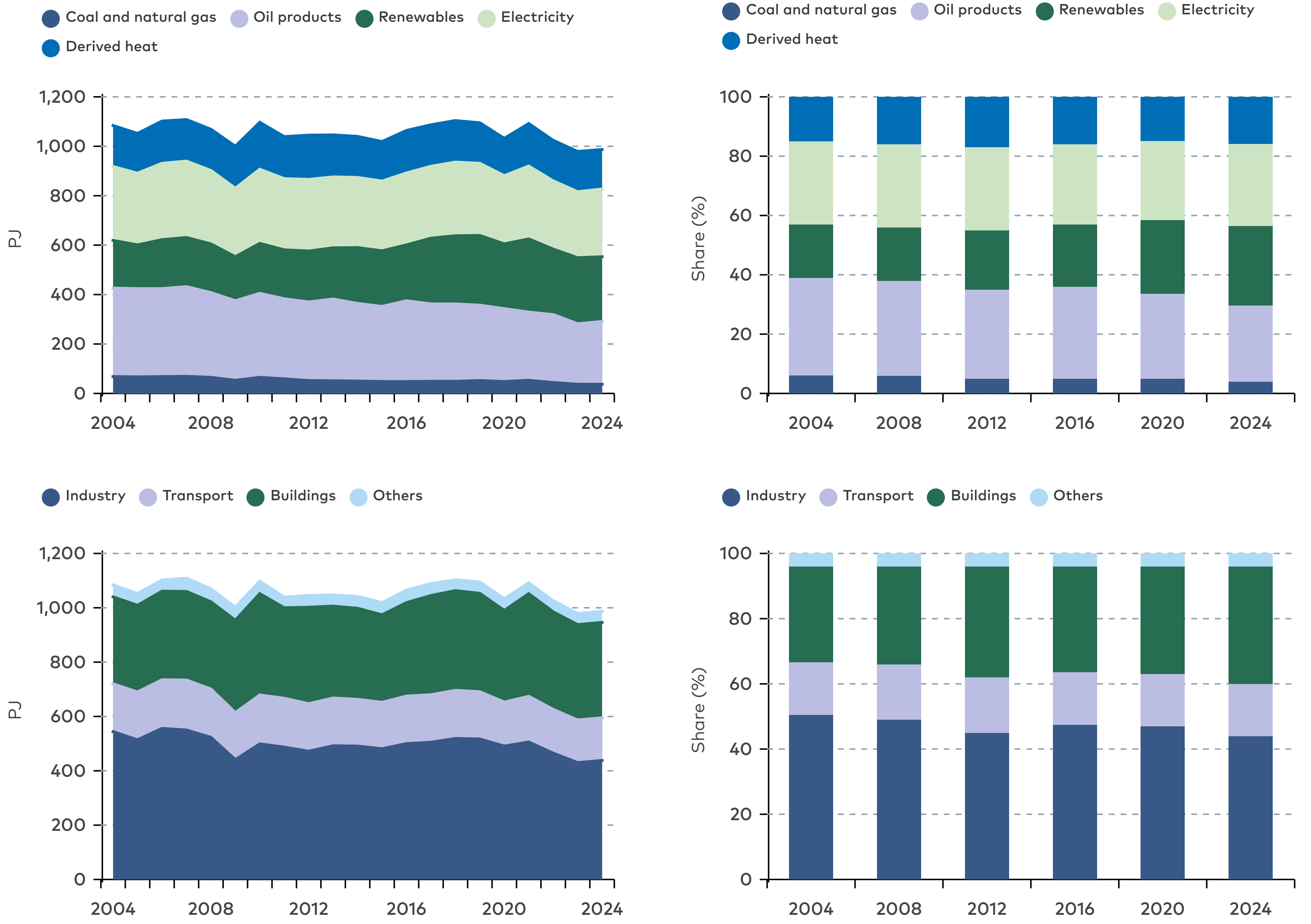
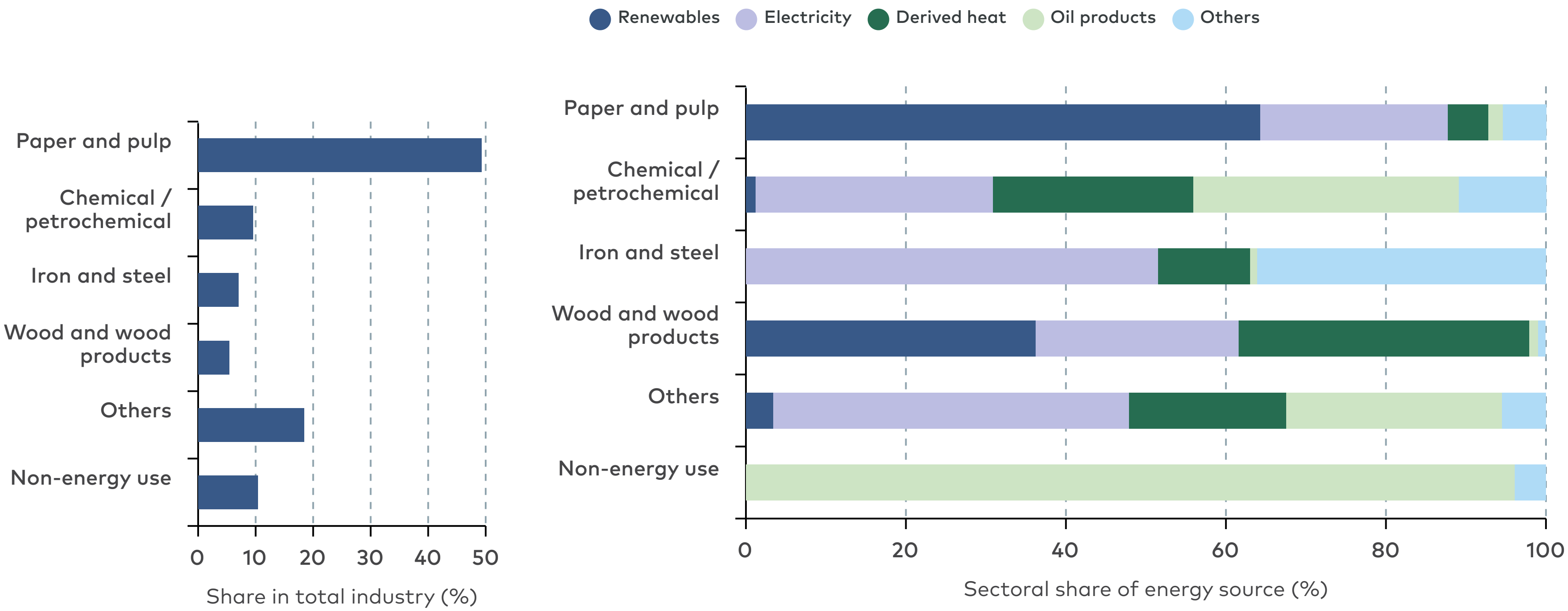


Figure 5: Industrial concentration (measured by energy consumption), 2024



Greenland

Greenland is not really a single energy system but a set of around 70 standalone microgrids strung along the coast. The larger settlements run on hydropower at five plants (Buksefjord, Tasiilaq, Qorlortorsuaq, Sisimiut, Ilulissat), with diesel generation serving the rest, and the renewable share is set to rise towards 90 per cent over the medium term as planned hydro expansions come online. Electricity demand has grown sharply since 2014, reflecting modest population growth alongside rising fisheries, construction, and tourism activity. The Tasersiaq prefeasibility study points to a potential 700 to 1,000 MW export-scale hydropower resource over a longer horizon, which would if developed materially change Greenland's position in the regional energy picture.

The wider energy mix tells a different story. Around four-fifths of total final energy consumption is met by imported petroleum products that arrive by tanker, with heating, fisheries, marine transport, and aviation all running primarily on imported fuel. Greenland sits outside both the EU framework and the IEA stockholding regime. Two further factors now shape Greenland's position in Nordic energy security in ways that no other Nordic jurisdiction faces. The first is the geopolitical context: since late 2024, the second Trump administration has made explicit claims to Greenland, including statements declining to rule out economic or military coercion. The second is the critical minerals layer. The Tanbreez rare earth project was consolidated under US-listed Critical Metals Corp in 2025, with around USD 120 million in US Export-Import Bank financing interest. Greenland now sits inside the supply chain for some of the most strategically contested critical raw materials.

Key challenges

A maritime fuel chain operating in Arctic conditions. Greenland's fuel supply depends on tanker deliveries into ports across an Arctic and sub-Arctic coast. Ice cover, narrow weather windows, and a thin ice-class shipping fleet all bind the delivery system, and there is no formal stockholding regime as a backup. Operational stocks are held privately with quantities not publicly disclosed.

Microgrids that cannot back each other up. The absence of a single connected grid means each settlement runs on its own equipment, and the loss of a single generator or hydropower plant has a localised but absolute effect on that community. Replacement parts and repair crews have to be flown or shipped in. The renewable buildout improves the long-run picture but does not change the topology caused by lack of interconnection.

Foreign and security policy under external pressure. The combination of strategic location, rare earth resources, and explicit external claims places the foreign and security policy axis of one of the eight Nordic jurisdictions under direct pressure from a treaty ally. Energy security in Greenland cannot now be separated from the wider strategic context.

Recommendations

Recommendation 1: Explore the feasibility of a coastal interconnection backbone for Greenland's settlement network. Connecting the main western settlements would transform the security picture by allowing generation assets to backstop each other, enabling excess capacity at one site to cover outages at another, and reducing per-settlement dependence on diesel backup.

Key figures (2024):			**2014-24**
Population	Thousands	56.7	*+1%*
Gross domestic product (GDP) (2023)	Billion EUR	2.19	*+11%*
Total final consumption (TFC)	PJ	9.2	*+24%*
Electricity generation (2023)	GWh	639	*+42%*
Electricity net trade	GWh	-	..
Final consumption intensity	Index (2014 = 100)	123	*+23%*
Oil intensity	Index (2014 = 100)	115	*+15%*
Overall import dependency	%	83%	..

Figure 1: Energy system exposure, 2024

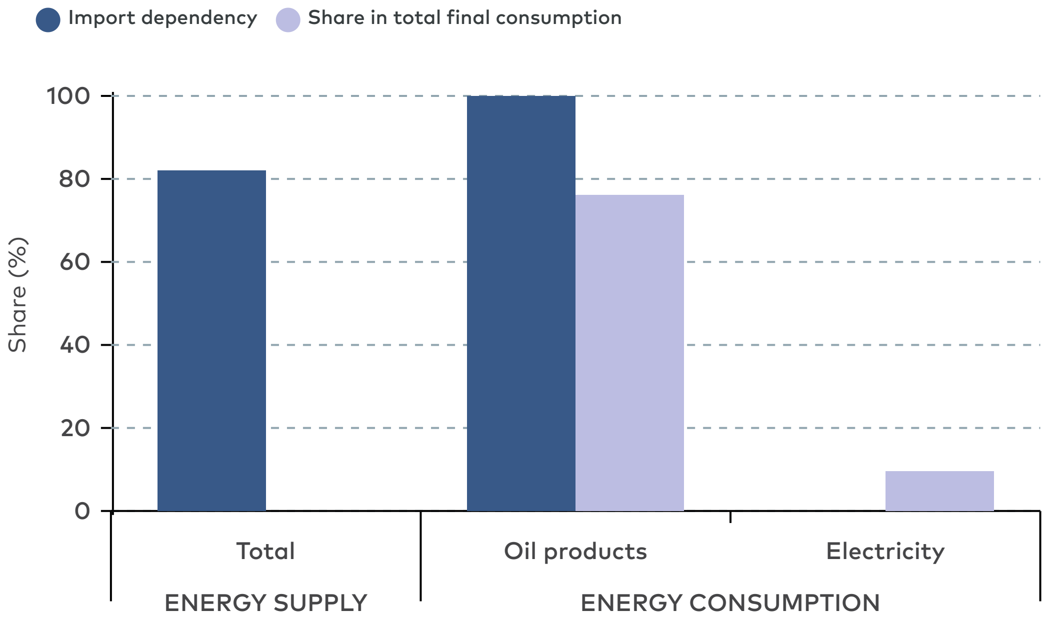


Figure 2: Electricity generation (GWh), 2004-23

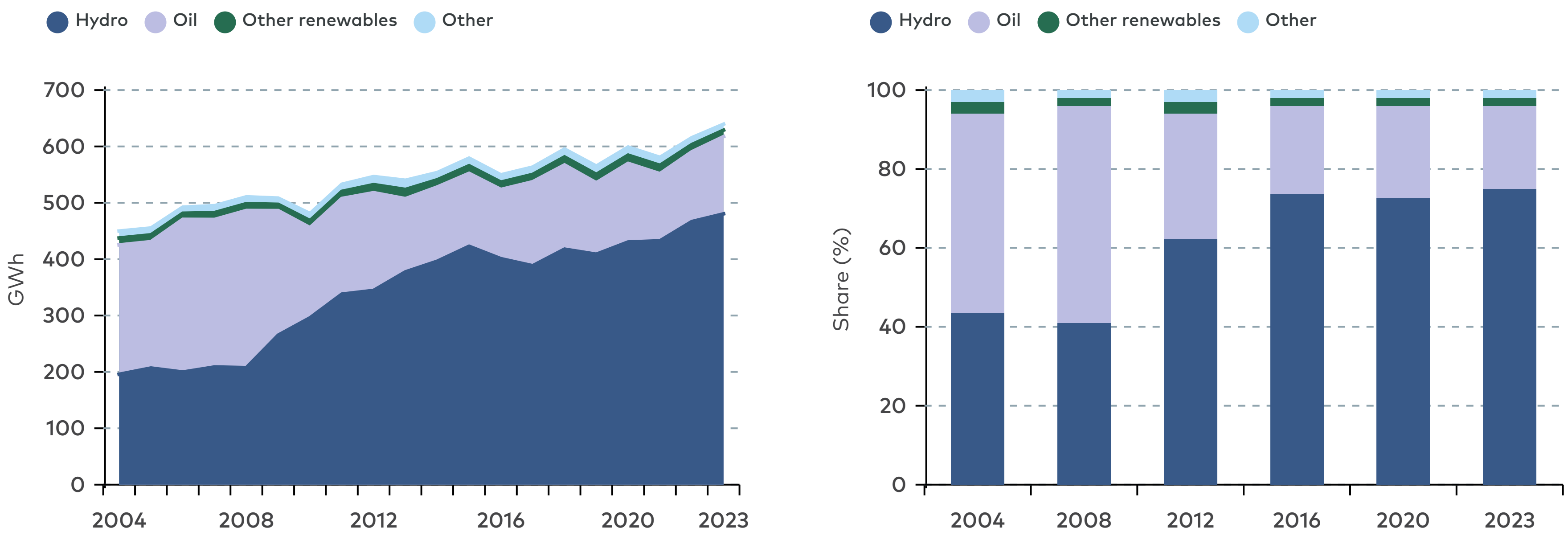
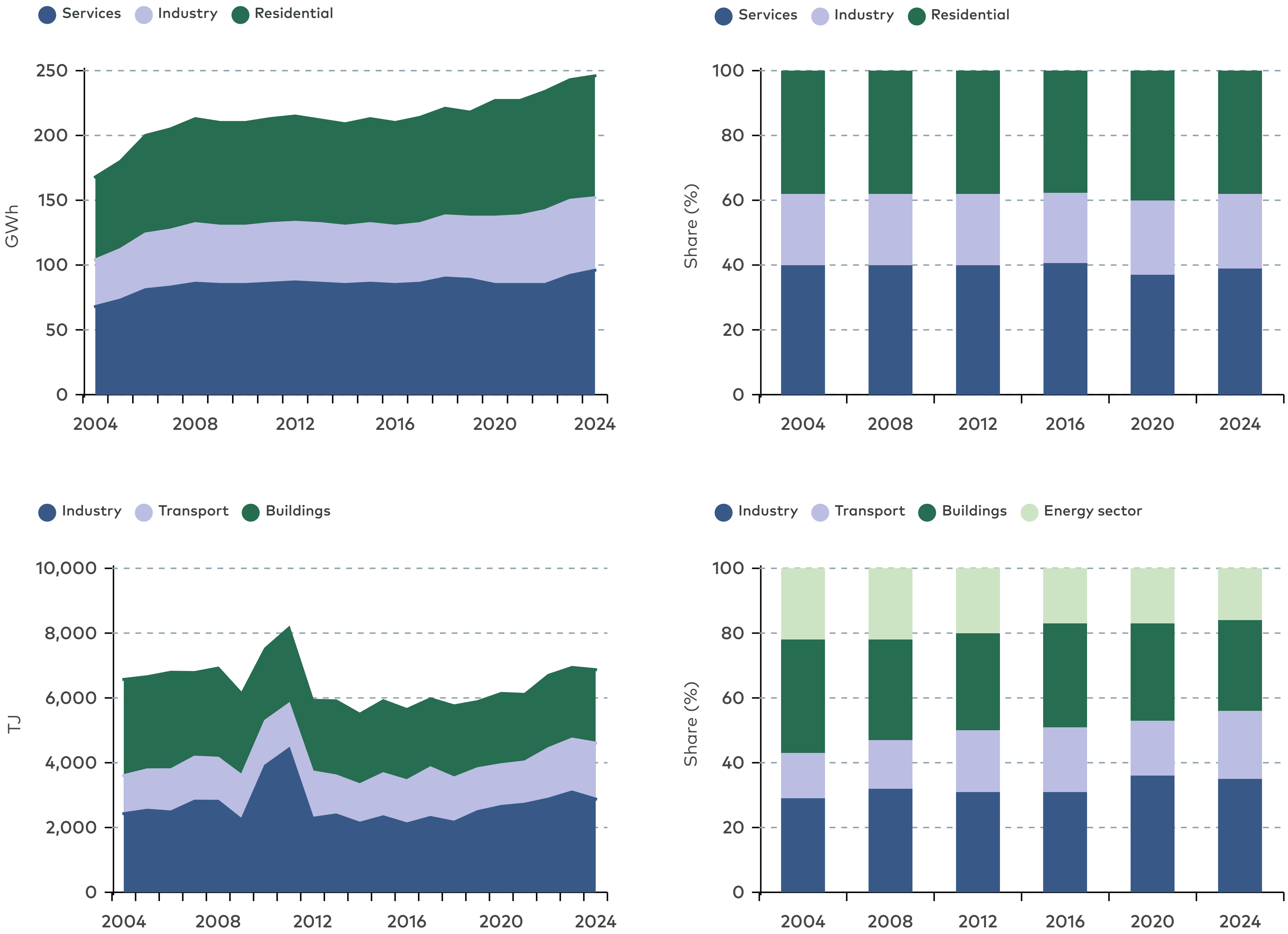


Figure 3: Consumption of electricity and oil products, 2004-24



Iceland

Iceland's electricity system is the most insulated from external shock in the Nordic region and probably in Europe. Generation has more than doubled since 2004 and the entire mix is hydropower and geothermal, with no physical connection to any other grid. Final consumption per capita has risen substantially over the same period, against a falling trend across the mainland Nordics, reflecting the buildout of aluminium smelting capacity from the late 2000s and the more recent growth in data centres. The result is a system that is highly electrified by Nordic standards, structurally insulated from continental price shocks because there is no cable, and operating with all the resilience and contingency questions concentrated within the domestic system.

The fuel side tells the opposite story. Iceland is among the highest per-capita oil importers in Europe. Transport, the fishing fleet, and aviation all depend almost entirely on imported oil products arriving by tanker into a small number of ports, with Keflavík serving as a major North Atlantic aviation hub. Iceland sits outside the IEA framework, and mandatory oil stockholding has been under review by the Ministry for the Environment, Energy and Climate since 2025 without a requirement yet in force. Operational reserves are held privately and monitored by the Environment and Energy agency, stock levels are not publicy disclosed. The shape of Iceland's exposure is therefore inverted from the mainland Nordic pattern: a highly resilient electricity side that does not hedge against a structurally exposed fuel side.

Key challenges

No mandatory stockholding regime for fuels. Iceland sits outside both the EU and the IEA stockholding frameworks. The ongoing review of mandatory reserves is the standing acknowledgement that the current arrangement is not adequate to the regional risk environment.

A single synchronous system with concentrated industrial load. Isolation insulates Iceland from continental price shocks but also concentrates all reserve and contingency questions on the domestic system. The aluminium smelting load is large and accounts for a substantial share of total electricity demand. Any major hydro or geothermal outage has system-wide consequences with no external import buffer.

Recommendations

Recommendation 1. Conclude the ongoing review of mandatory oil stockholding with a defined minimum reserve obligation, calibrated to Iceland's structural exposure and to the IEA 90-day net imports standard as a reference rather than a binding obligation.

Recommendation 2. Bring Landsnet into the Nordic Regional Coordination Centre as an observer with a defined scope of cooperation, focused on cybersecurity, information sharing, and emergency repair capacity for the geographically separate Icelandic system.

Key figures (2024):			2004-24
Population	thousands	387	*+32%*
Gross domestic product (GDP)	Billion EUR	15	*+62%*
Total final consumption (TFC)	PJ	137	*+61%*
Electricity generation	TWh	19.6	*+127%*
Electricity net trade (imports/exports)	TWh	-	..
Final consumption intensity	Index (2004 = 100)	122	*+22%*
Oil intensity	Index (2004 = 100)	62	*-38%*
Overall import dependency	%	17%	31% (2004)

Figure 1: Energy system exposure, 2024

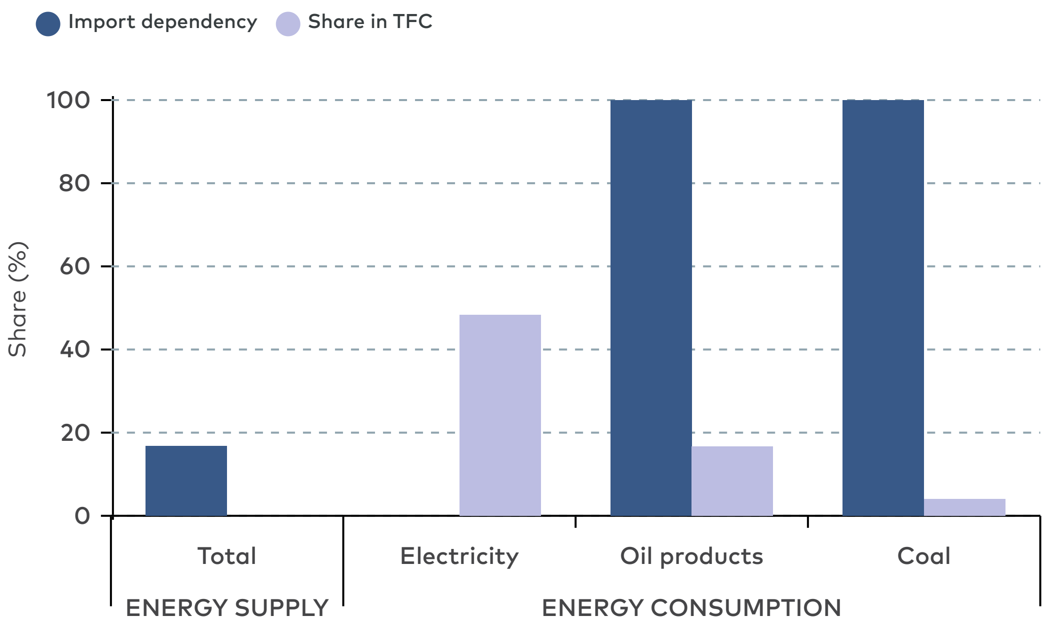


Figure 2: Electricity generation output (TWh), 2004-24

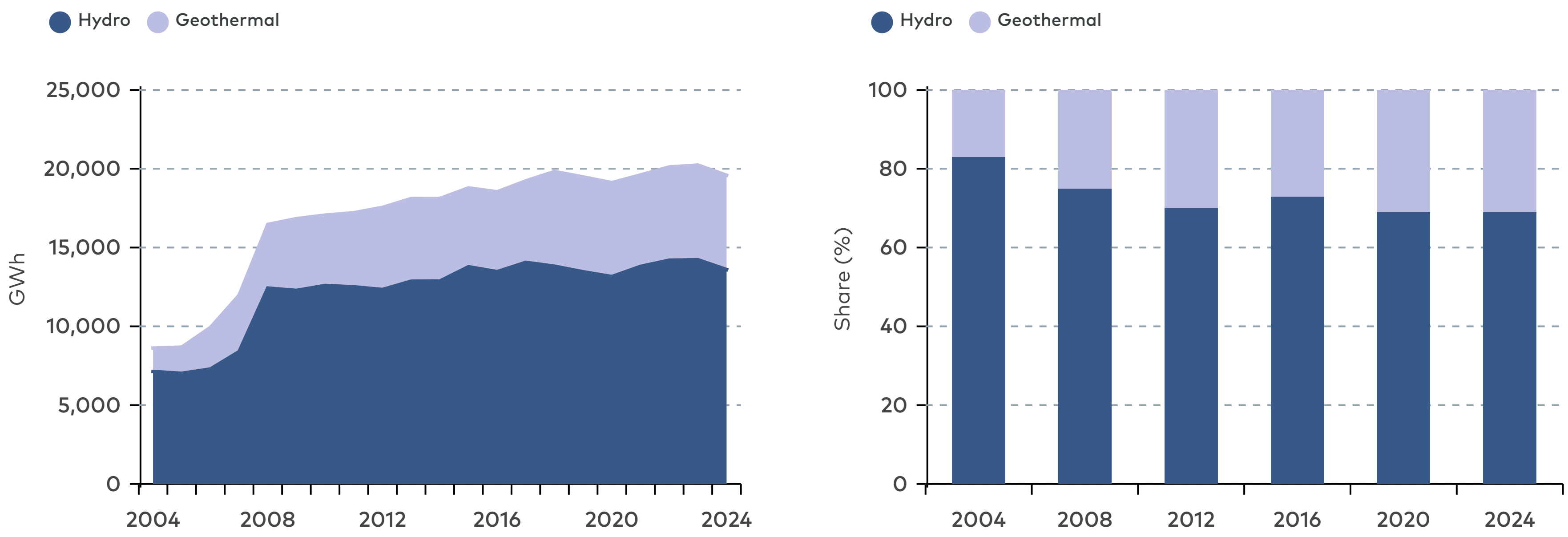


Figure 3: Electricity generation capacity (GW), 2004-24

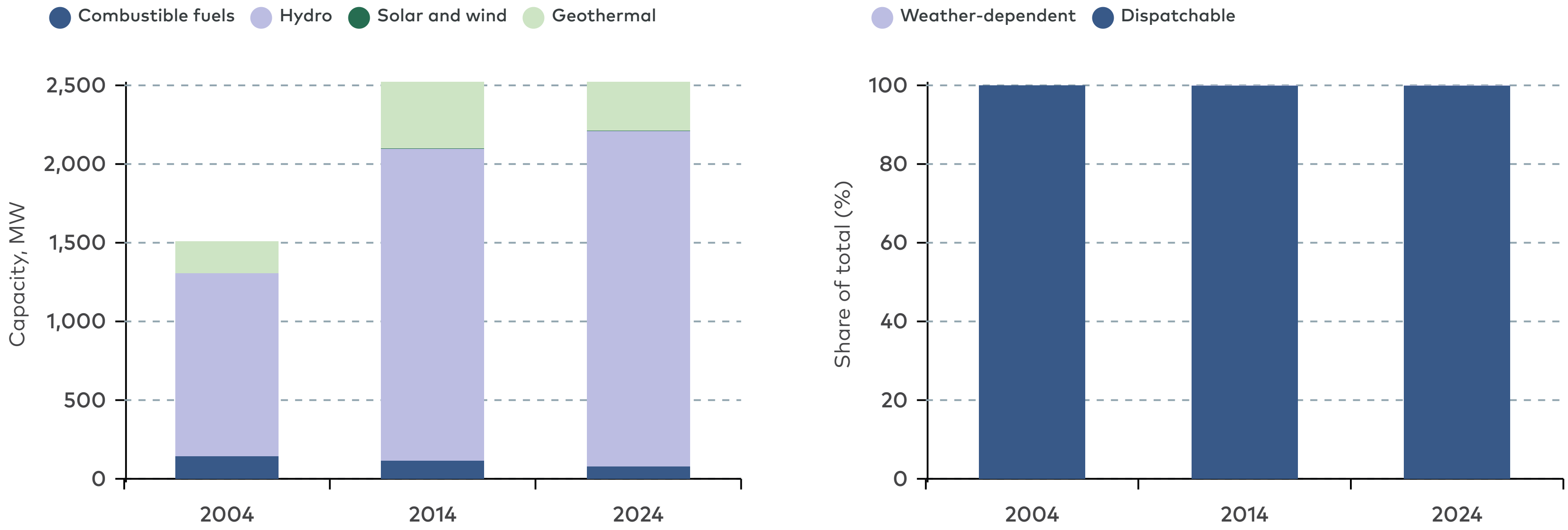


Figure 4: Total final consumption of energy (PJ), 2004-24

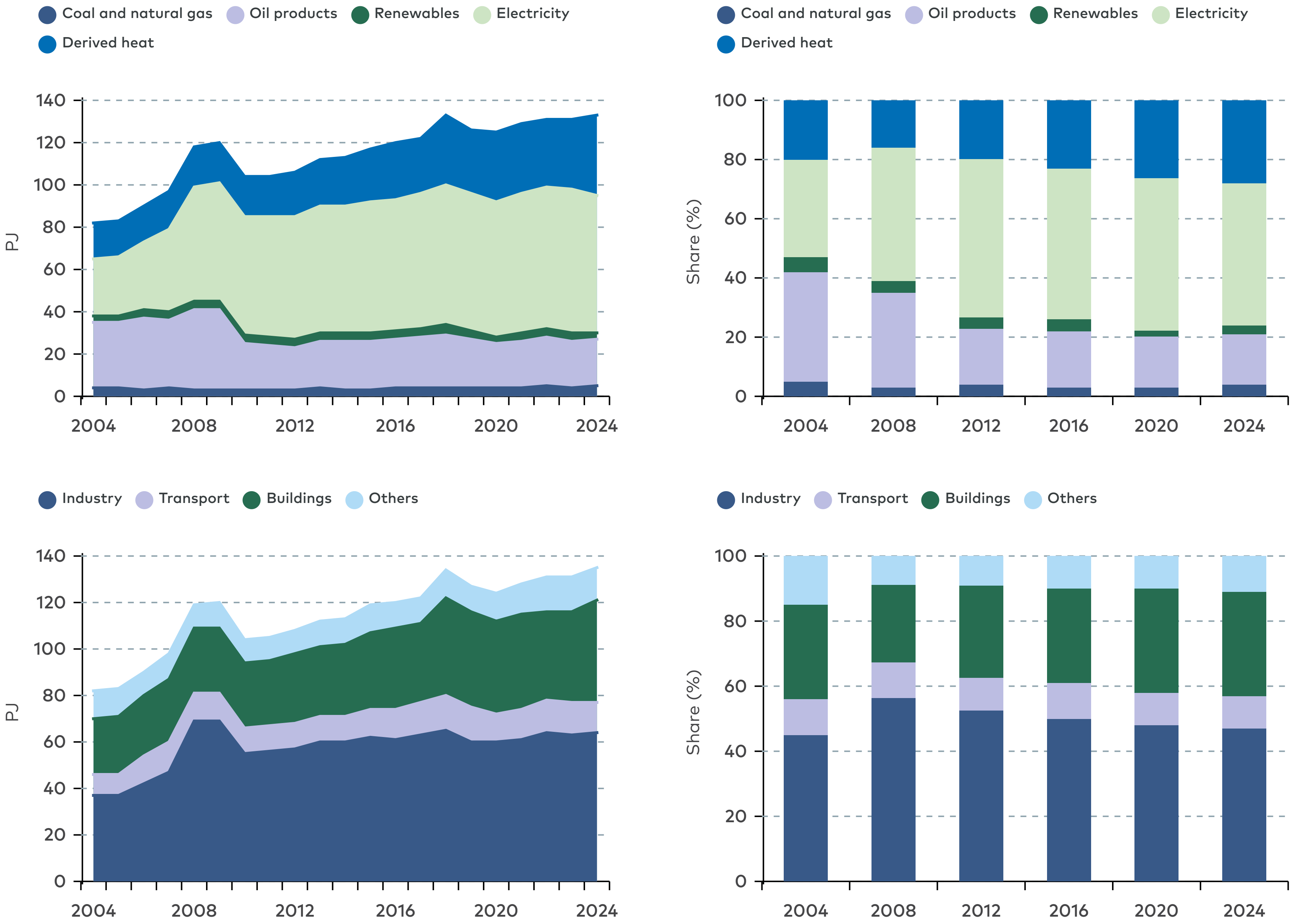
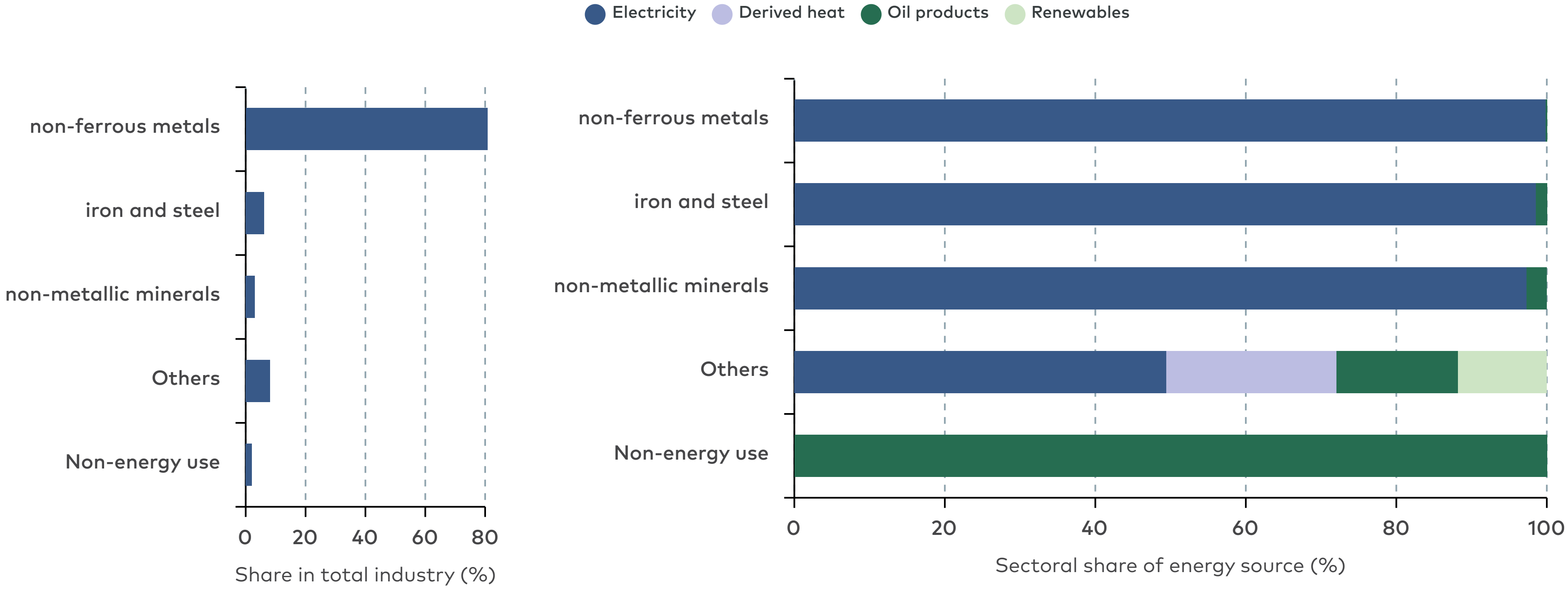


Figure 5: Industrial concentration (measured by energy consumption), 2024



Norway

Norway is the structural anchor of European energy security. It is the largest producer of both oil and gas on the European continent (excluding Russia), supplies more than half of Nordic oil imports and around half of EU gas imports, and is a structural net exporter of electricity to neighbouring Nordic markets and beyond. The hydropower base is the largest single source of dispatchable flexibility in the Nordic system and functions as a seasonal battery for the wider European grid. This position has expanded over the past two decades through interconnector buildout and rising offshore production, and it makes Norway central to the energy security picture not only of the Nordics but of the EU and the UK.

The flip side is that the same integration that delivers European energy security also transmits European price shocks into Norway. The political tension this generates has become a binding constraint on further interconnector buildout. The current Norwegian government has resisted renewing ageing cables to Denmark; Sweden halted work on the Konti-Skan Connect renewal in May 2026 on similar grounds.

Norway's institutional position is also the most asymmetric in the region. Norway participates fully in the internal electricity market through the EEA and in ENTSO-E and Nord Pool. Norway is not in the EU and is therefore not bound by the EU Gas Security of Supply Regulation, the EU oil stocks regime, or the EU solidarity mechanism. The 2022 Norway–EU bilateral gas partnership and the 2023 Energy Dialogue provide a forum for supply cooperation but contain no crisis activation procedures. Norway's own mandatory oil readiness obligation was reduced from 90 to 20 days of consumption in 2007, against IEA recommendation, and has not been revised since.

Key challenges

Single-point exposure of strategic export assets. The Hammerfest LNG plant on Melkøya is the only export route for any Norwegian Barents Sea production. The 21-month outage following the September 2020 fire is the documented precedent. The Mongstad refinery and the major offshore export terminals carry analogous concentration risk, sharpened on the oil side by the closure of the Slagen refinery in 2021.

Oil stockholding that no longer matches the country. The 20-day requirement was set when Norway had two operational refineries and a production base that was assumed to make large domestic reserves unnecessary. Norway remains significantly dependent on imports for diesel and jet fuel, and the obligation has not been revised to reflect either the changed refining footprint or the product-level vulnerabilities exposed by recent global disruptions.

No gas emergency coordination with Nordic neighbours. Norway holds no bilateral gas emergency agreement with any Nordic country. The EU solidarity mechanism does not apply. In a crisis scenario involving disrupted Norwegian output, whether from infrastructure failure, industrial action, or hostile action against offshore assets, no agreed procedure currently governs how Norway communicates with Nordic gas authorities, what information is shared, or on what timeline.

A north-south grid that does not move power as fast as the country produces it. Norway's hydropower base is the largest single source of dispatchable flexibility in the Nordic system, but the transmission infrastructure connecting northern generation to southern demand centres and to the interconnectors that carry power to Denmark, Germany, and Great Britain has not kept pace. The result is persistent congestion on the north-south corridors, large and sustained price differentials between bidding zones, and a situation in which Norwegian generation capacity that is theoretically available to the wider Nordic system cannot always be delivered when it is needed. The political reluctance to expand cross-border interconnection capacity compounds this: the same north-south bottleneck that limits domestic distribution also limits the export capacity that could, in a regional shortage, backstop neighbouring systems.

Recommendations

Recommendation 1. Negotiate bilateral gas emergency agreements with Denmark and with Finland, covering notification thresholds, activation procedures, and emergency volume commitments, complementing rather than substituting for the EU bilateral framework.

Recommendation 2. Adopt explicit security-by-design standards for the offshore production base, with redundant export routing for the Barents Sea basin and pre-agreed repair vessel access arrangements for the gas pipeline network covering both North Sea and Norwegian Sea assets.

Recommendation 3. Develop a Nordic-endorsed investment case for Norwegian north-south transmission expansion. The Norwegian TSO Statnett has long-run grid development plans that identify the required corridors, but the investment has consistently lost out to the political cost of higher prices in producing regions.

Key figures (2024):			**2004-24**
Population	Millions	5.6	*+21%*
Gross domestic product (GDP)	Billion EUR	424	*+40%*
Total final consumption (TFC)	PJ	892	*+3%*
Electricity generation	TWh	159	*+43%*
Electricity net trade (imports/exports)	TWh	-18.4 (14.7/33.1)	..
Final consumption intensity	Index (2004 = 100)	85	*-15%*
Oil intensity	Index (2004 = 100)	62	*-38%*
Overall import dependency	%	0%	0% (2004)

Figure 1: Energy system exposure, 2024

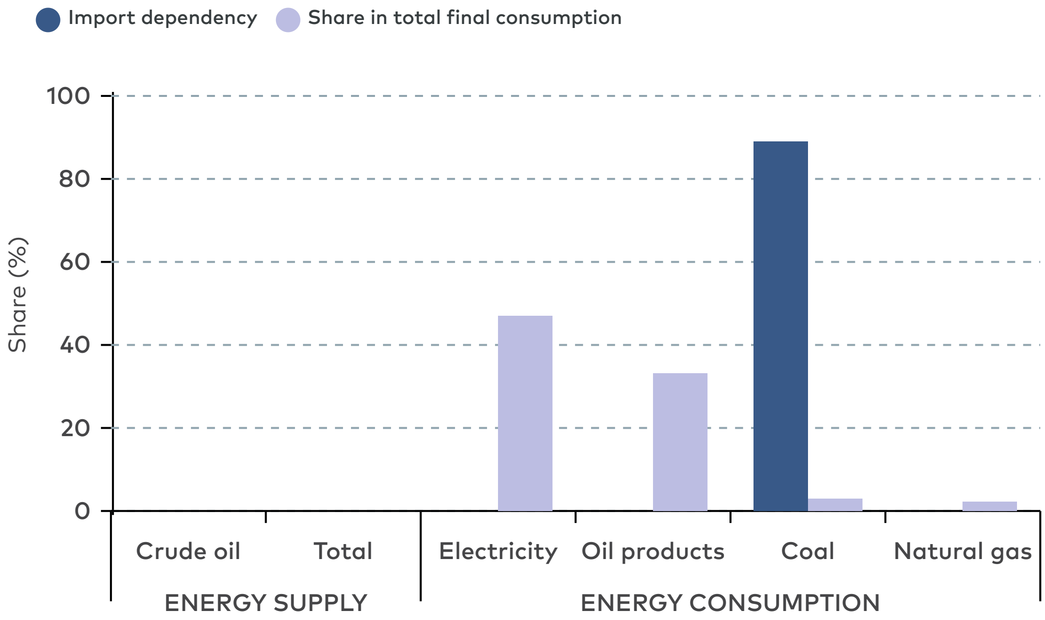


Figure 2: Electricity generation output (TWh), 2004-24

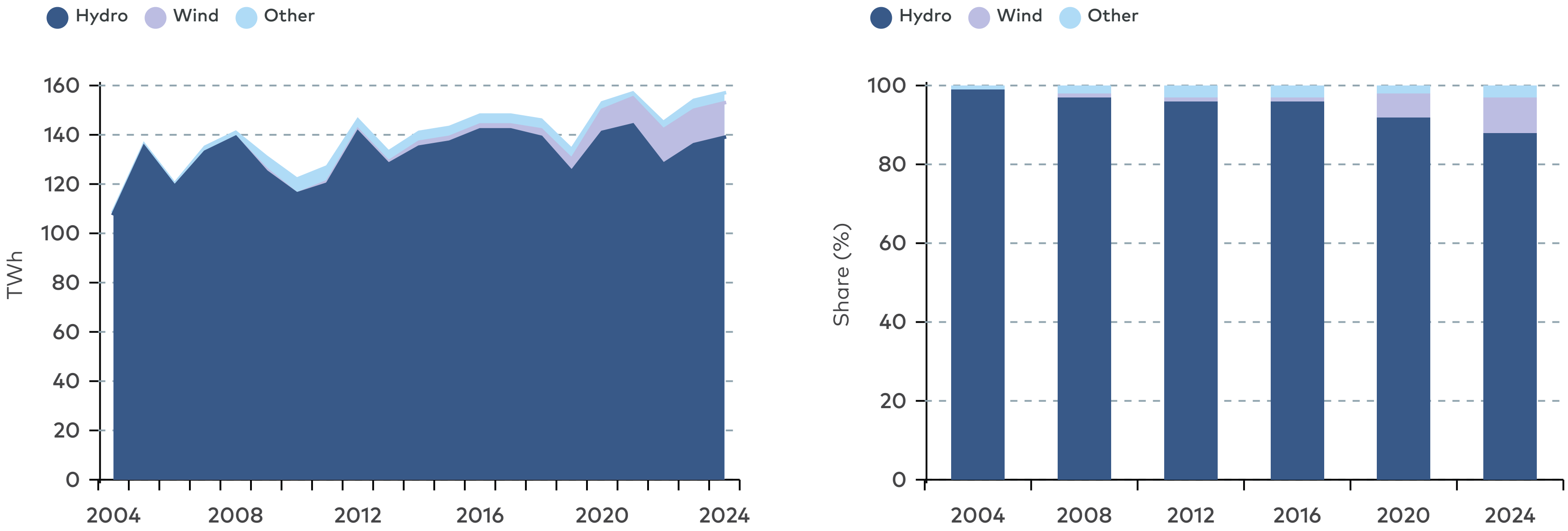


Figure 3: Electricity generation capacity (GW), 2004-24

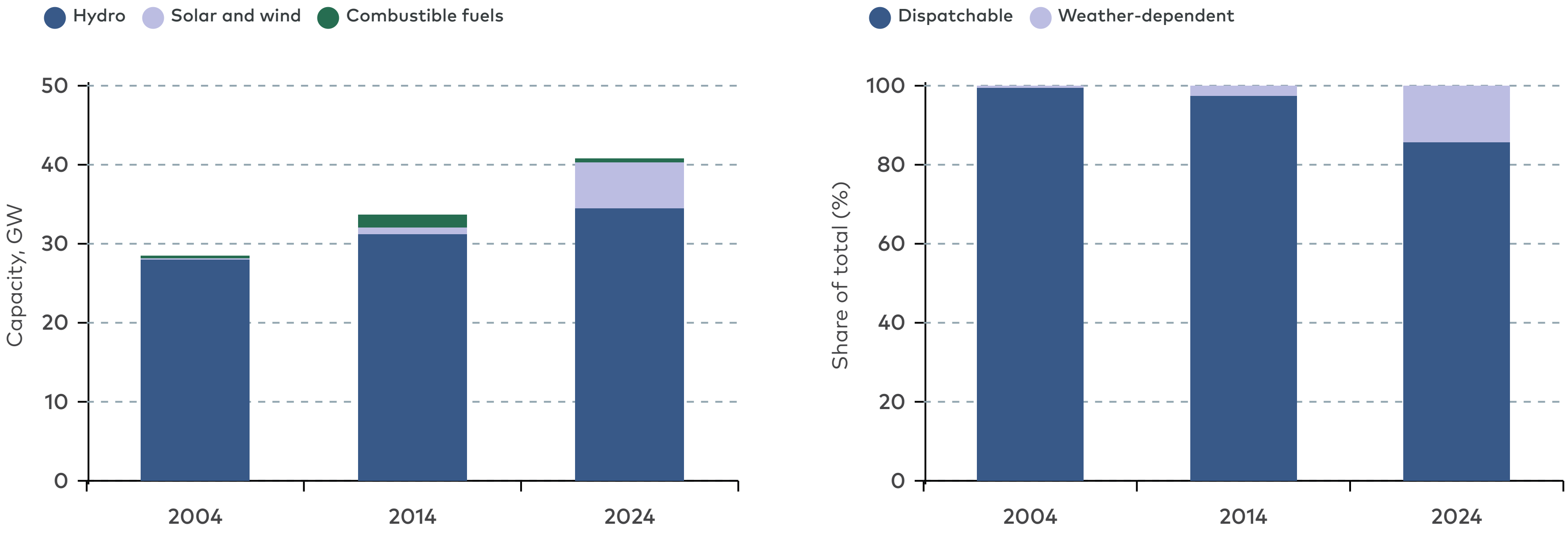


Figure 4: Total final consumption of energy (PJ), 2004-24

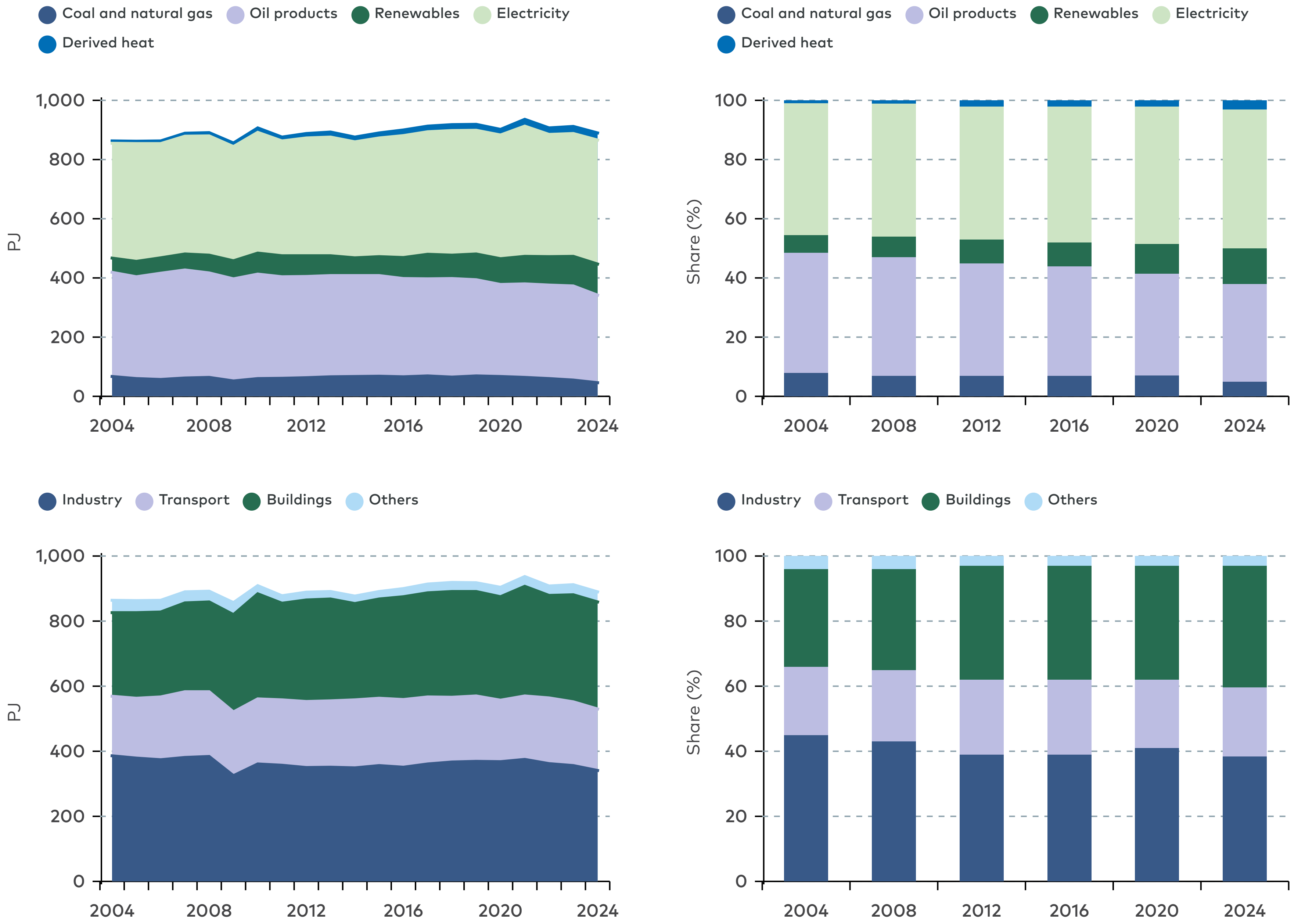
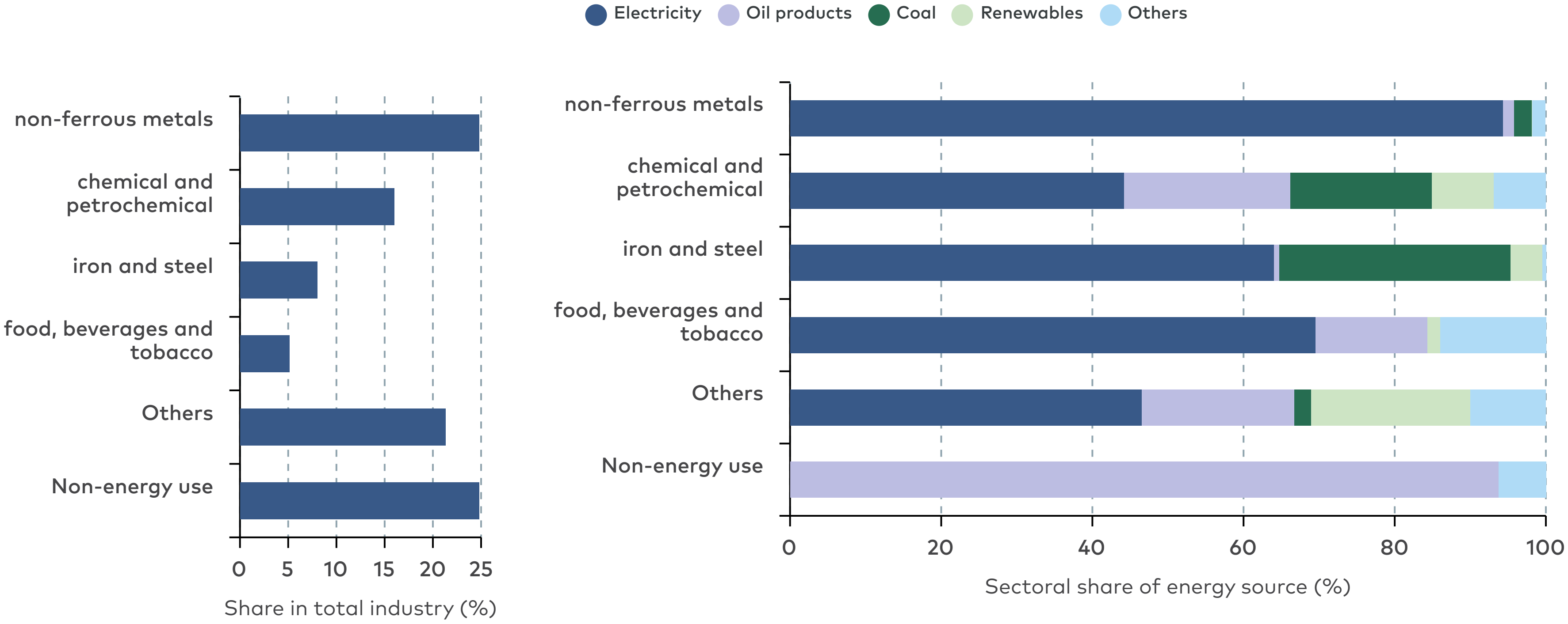


Figure 5: Industrial concentration (measured by energy consumption), 2004-24



Sweden

Sweden has the largest electricity generation base in the Nordic region and is its largest net exporter. The system is anchored in hydro, nuclear, and a growing wind base, and import dependence has fallen by roughly a third over the past two decades. The defining feature is internal rather than external: the geographic mismatch between generation and demand. Hydro and onshore wind sit predominantly in the north, the largest industrial and population centres are in the south, and the country operates in four bidding zones with persistent and large price differentials between them. Southern Sweden (SE3 and SE4) has the tightest electricity adequacy margins of any Swedish price zone. The May 2026 government order to halt Konti-Skan Connect, the planned renewal between south-western Sweden and Denmark, marked the point at which the political constraint on cross-border transmission renewal had direct infrastructure effects.

The Swedish system is also distinctive for its dispersed exposure across coastal and island geographies. Gotland combines a large military presence, a civilian population, and growing industrial energy demand on a single island connected to the mainland by two HVDC cables, with a new connection contracted for 2030. Because the existing connections are DC, Gotland runs as its own system frequency, with stability dependent on converter equipment at both ends. Öland is connected through a thinner transmission spur into the SE4 zone where adequacy margins are tightest. Institutionally, Swedish energy preparedness is concentrated in the Civil Contingencies Agency (MSB), the operational counterpart to Finland's NESA in the 1992 Finland–Sweden security of supply agreement. Sweden has consistently met its EU and IEA oil stockholding obligations.

Key challenges

The north-south transmission bottleneck. The persistent price spread between northern and southern bidding zones is the visible expression of a structural transmission constraint. The northern industrial buildout (green steel, battery manufacturing, hydrogen production) is adding load in a part of the country where transmission to demand centres in the south has not kept pace.

Gotland concentration risk. The combination of a large military presence, growing industrial demand, an autonomous system frequency dependent on converter equipment at both ends, and a high local wind share creates an unusually concentrated profile of operational risk on a single island. The new mainland connection due in 2030 changes the capacity picture without changing the structural concentration.

Capacity adequacy in SE3 and SE4 during cold and low-wind events. The same conditions that came close to a loss-of-load situation in Finland during winter 2025–2026 strain SE3 and SE4 from a different angle. Nuclear reactor maintenance schedules, wind variability, the halted interconnector renewal, and the planned phase-out of older thermal generation all converge on southern Sweden as the most likely site of a near-term Nordic adequacy event.

Recommendations

Recommendation 1. Treat the SE3–SE4 transmission constraint as a Nordic adequacy issue rather than solely a Swedish domestic one, with the Nordic adequacy framework alignment (Recommendation 16 in Section 8) tested first against the Swedish bidding-zone configuration.

Recommendation 2. Designate Gotland as a Nordic test case for security-by-design standards on island systems with dual military and civilian functions, covering converter platform protection, redundant cable routing, and emergency reserve generation, with findings applicable to Bornholm, Åland, and the Baltic island regions more widely.

Recommendation 3. Reinforce the Finland–Sweden bilateral preparedness track with an explicit fuel security extension, building on the existing material preparedness work, and use the bilateral as the basis for a multilateral Nordic emergency supply agency forum bringing in Norway, Denmark, and the Faroese, Greenlandic, Icelandic, and Ålandic authorities.

Key figures (2024):			**2004-24**
Population	Millions	10.6	*+18%*
Gross domestic product (GDP)	Billion EUR	473	*+41%*
Total final consumption (TFC)	PJ	1393	*-4%*
Electricity generation	TWh	172	*+14%*
Electricity net trade (imports/exports)	TWh	-33.4 (8.7/42.1)	*..*
Final consumption intensity	Index (2004 = 100)	82	*-18%*
Oil intensity	Index (2004 = 100)	50	*-50%*
Overall import dependency	%	26%	38% (2004)

Figure 1: Energy system exposure, 2024

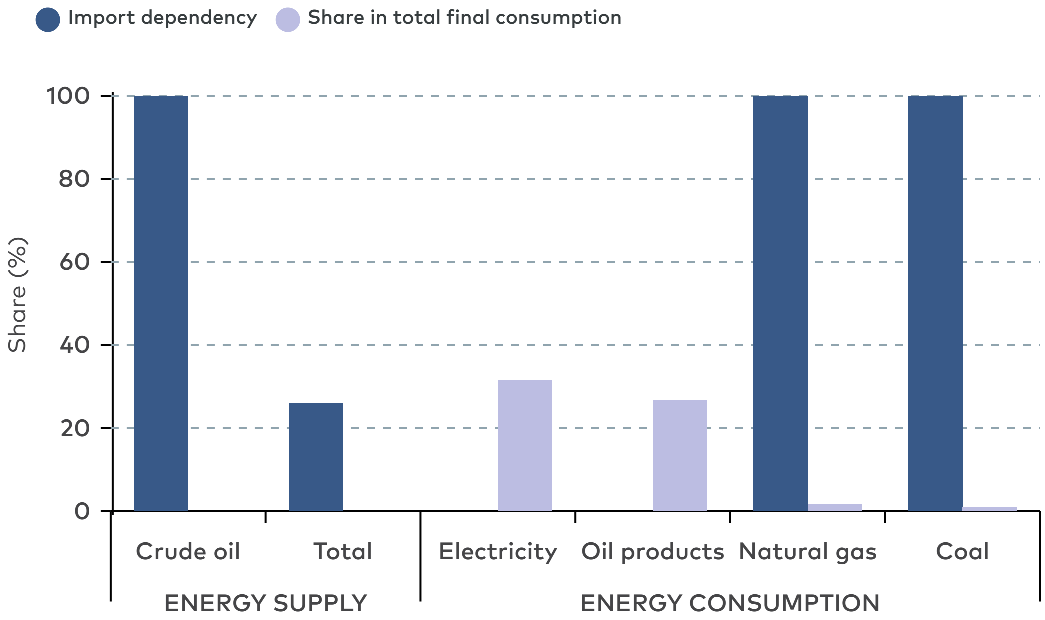


Figure 2: Electricity generation output (TWh), 2004-24

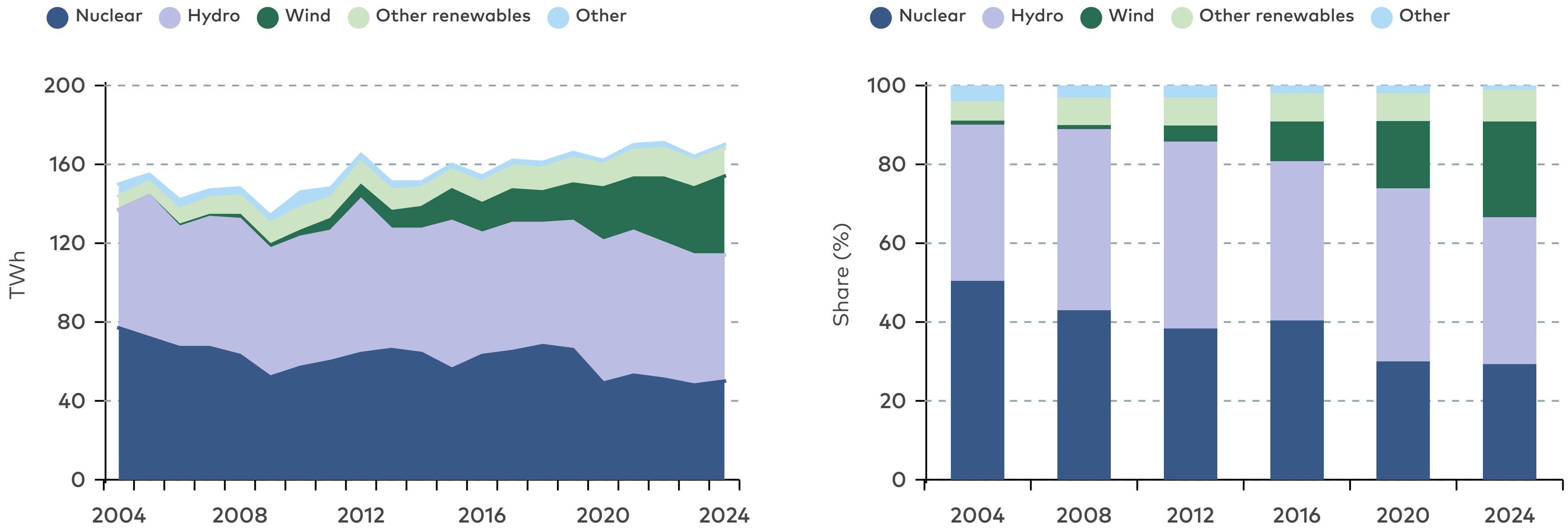


Figure 3: Electricity generation capacity (GW), 2004-24

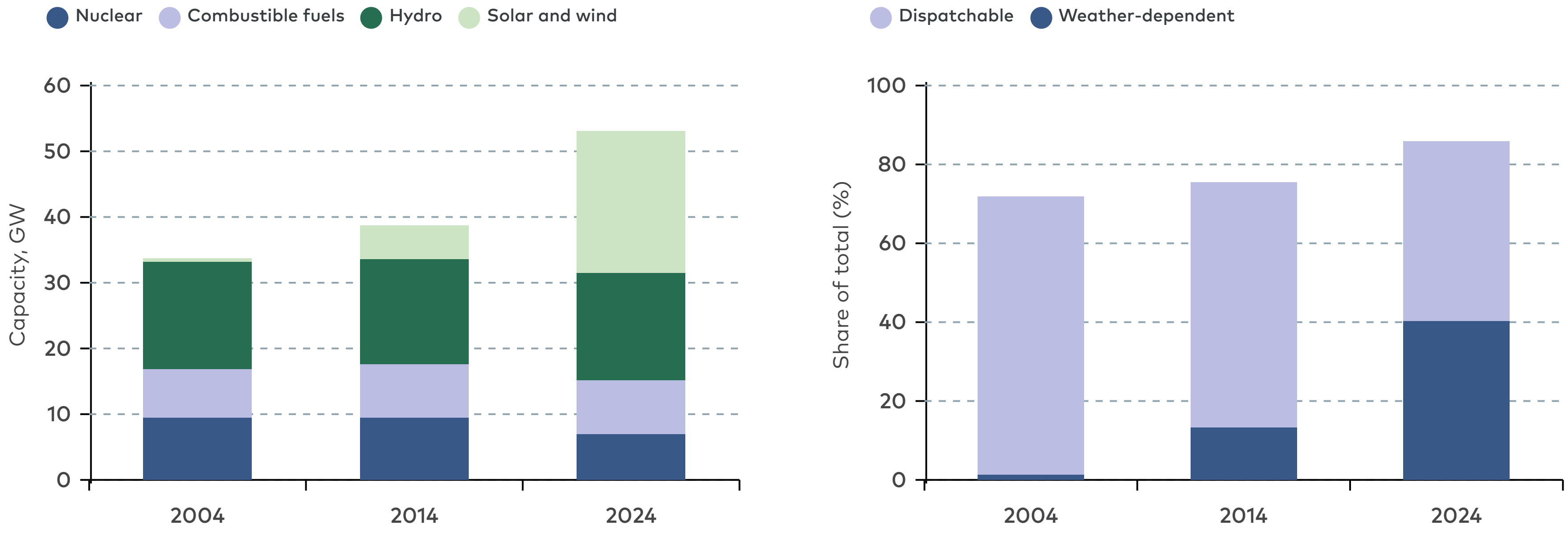


Figure 4: Total final consumption of energy (PJ), 2004-24

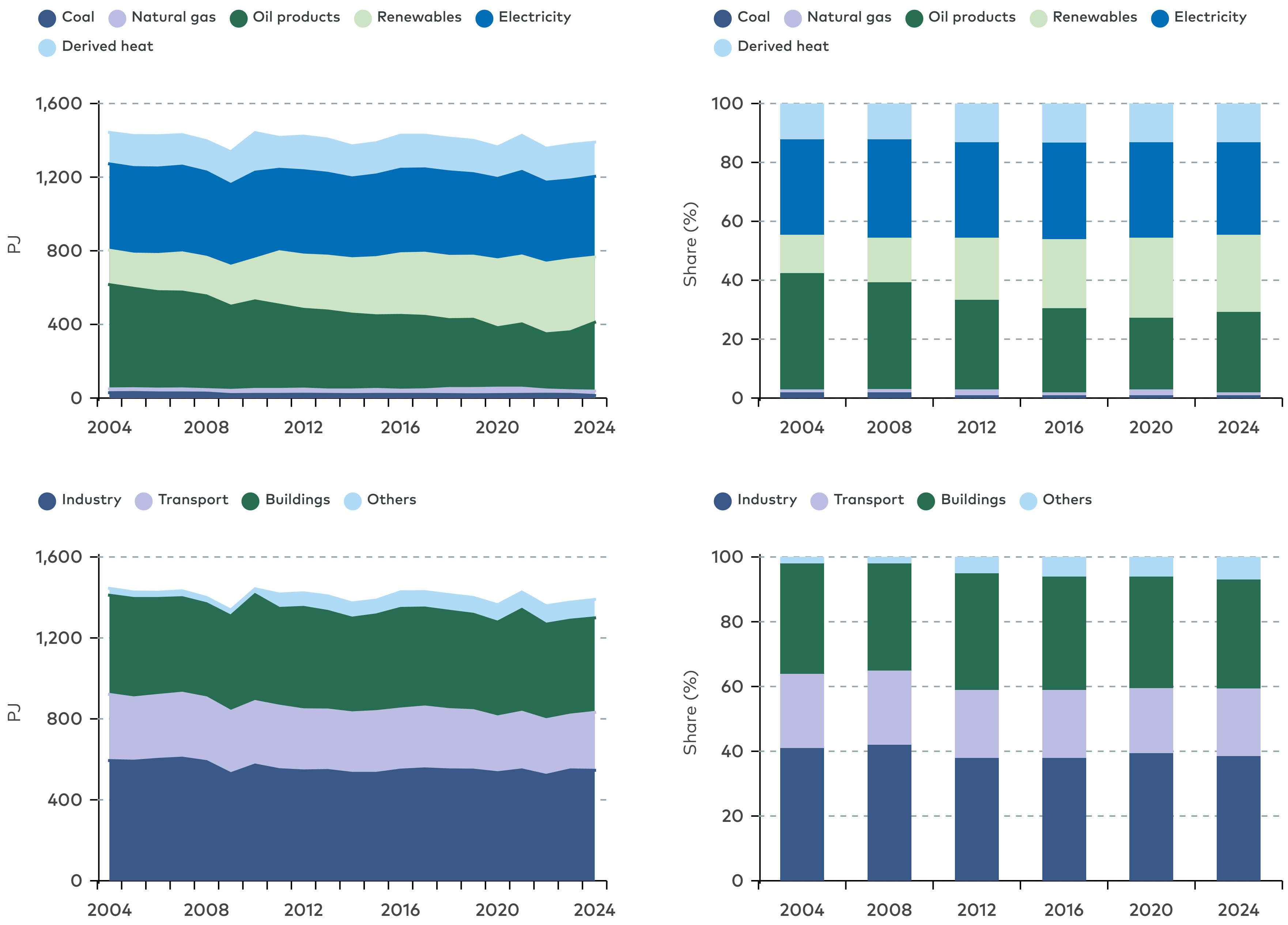
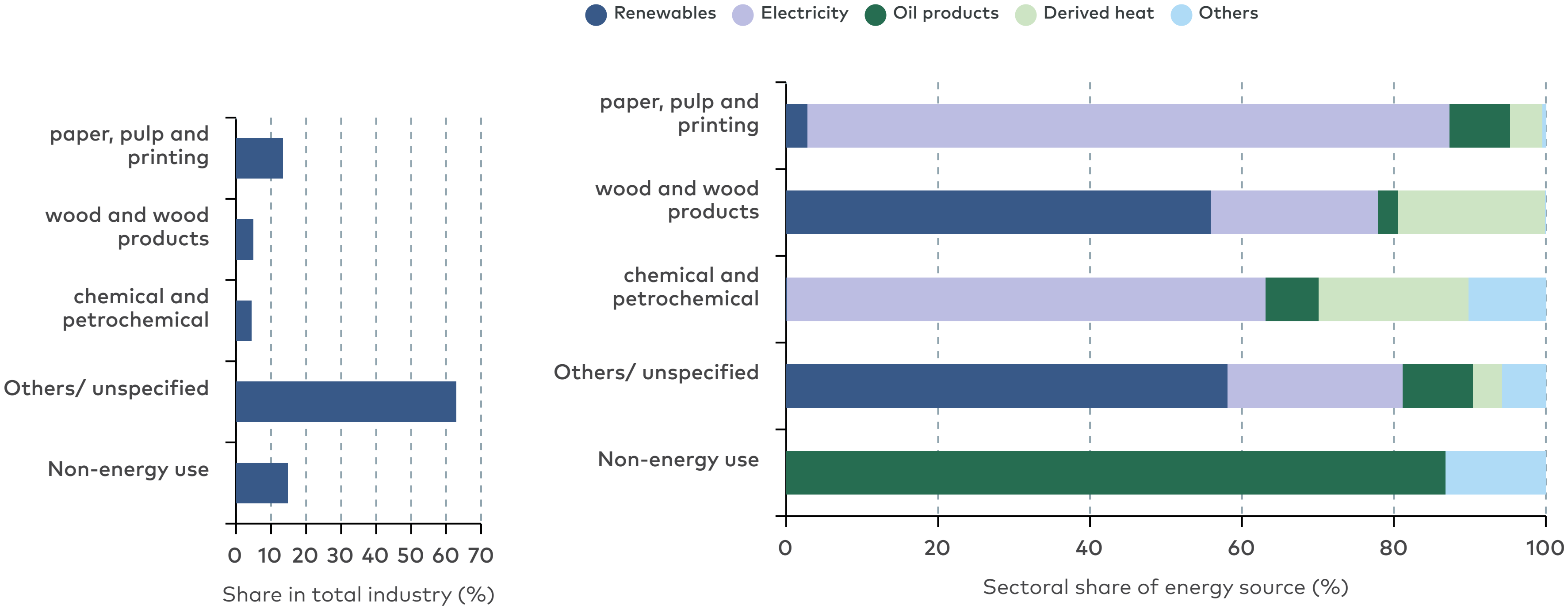


Figure 5: Industrial concentration (measured by energy consumption), 2024



Åland

Åland is an autonomous, demilitarised region of Finland with a physically resilient energy security profile by island standards. The main island is supplied by two main cables (one to Sweden, one to Finland), each individually capable of meeting full island demand, alongside an older reserve cable to Finland, two gas turbines for standalone operation, and a growing battery base including a 2 MW unit at the Söderby solar park commissioned in 2026 with grid restart capability. Electricity generation has more than tripled over the past decade as onshore wind has scaled up. The reserve route from Sweden has automatically taken over during outages on the Finnish cable, and vice versa. The system works.

Key challenges

Cable concentration in a contested basin. The Baltic Sea is now established as a target environment. Åland's main supply routes run through this basin, and the loss of both main cables simultaneously, whether through coincident technical failure or deliberate disruption, would leave Åland reliant on the older reserve cable and on the gas turbine and battery base. Standalone operation is technically possible but is not designed for sustained reliance.

Key figures (2024):			**2014-24**
Population	Thousands	30.7	*+6%*
Gross domestic product (GDP) (2023)	Billion EUR	1.54	*+5%*
Total final consumption (TFC)	PJ	2.4	*-8%*
Electricity generation	GWh	217	*+209%*
Electricity net trade	GWh	91 (135/44)	*-58%*
Final consumption intensity	Index (2014 = 100)	87	*-13%*
Oil intensity	Index (2014 = 100)	82	*-18%*
Overall import dependency	%	69%	92% (2014)

Figure 1: Energy system exposure, 2024

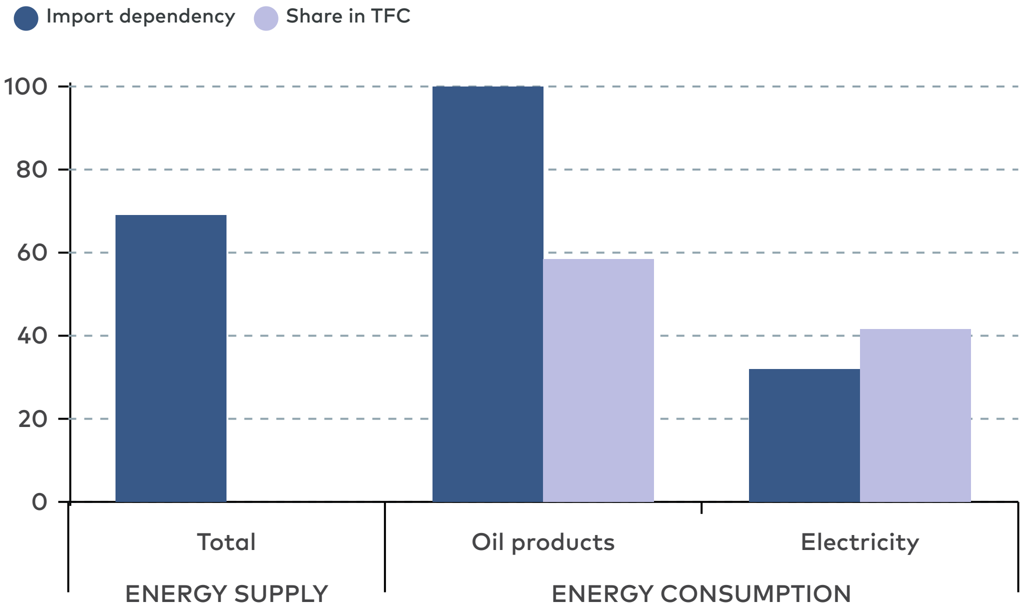


Figure 2: Electricity supply (GWh), 2004-23

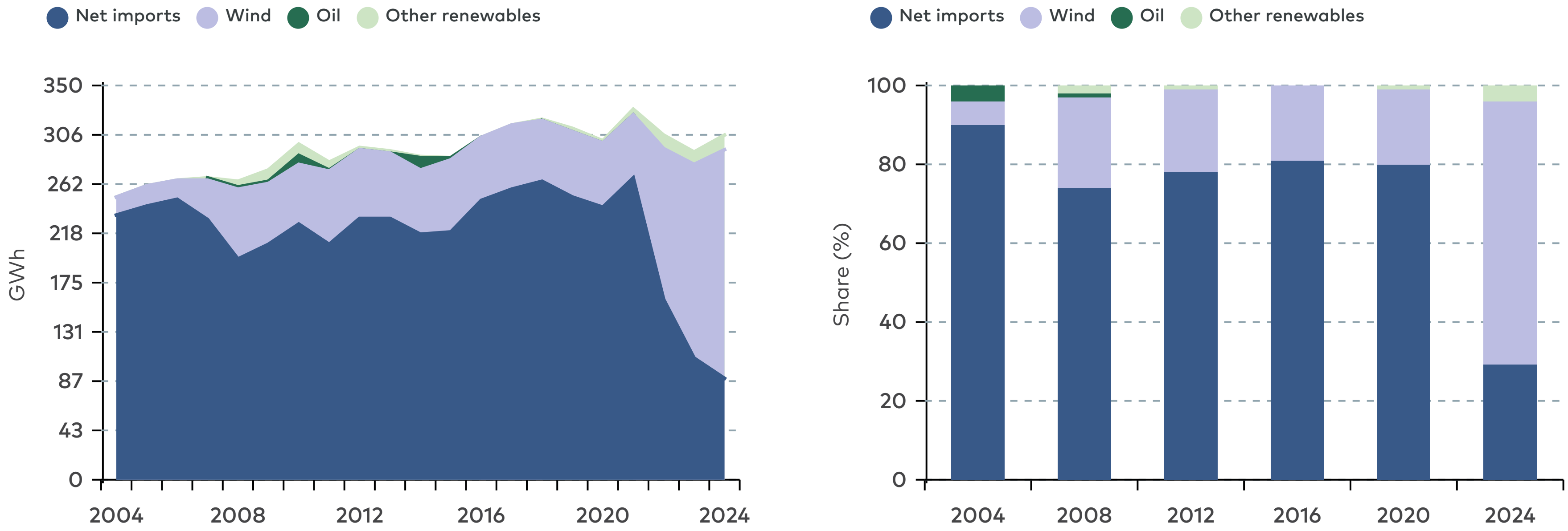
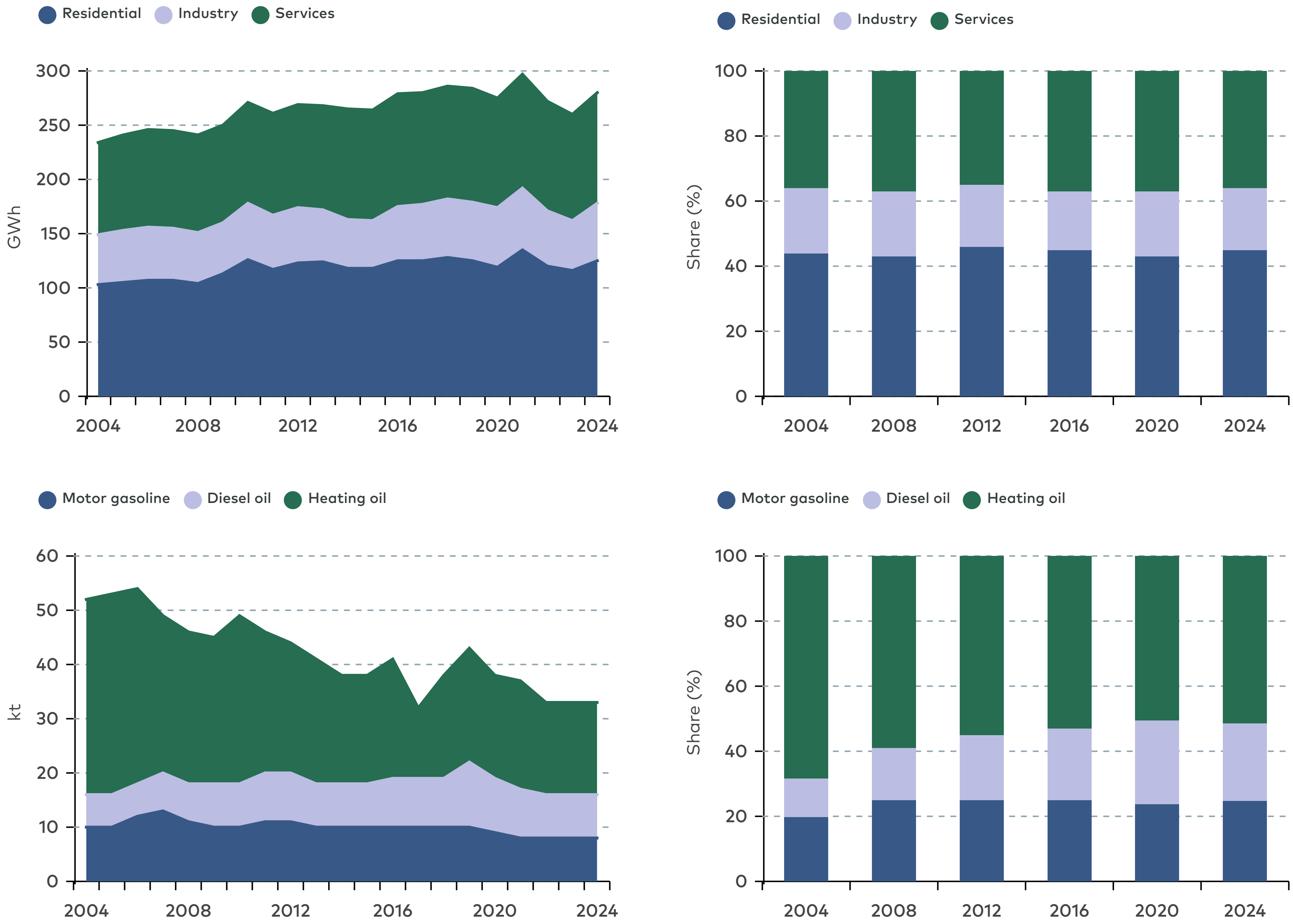


Figure 3: Consumption of electricity and oil products



Notes on data

Denmark, Finland, Iceland, Norway and Sweden

Sources: National statistical offices, International Renewable Energy Agency (IRENA) (Greenland electricity generation) and the World Bank (population).

Key figures: ".." indicates the figure is not available/applicable. GDP expressed in chain linked volumes with 2010 as the base year. Final consumption intensity calculated as the ratio of TFC/capita. Oil intensity calculated as the ratio of total oil demand/GDP. Overall import dependency calculated as the ratio of net imports/total energy supply. Note should be amended as follows: For simplicity, stock changes and international bunkers are excluded from the import dependency calculation.

Figure 1: Import dependency for coal, natural gas and total is calculated as the ratio of net imports over total final consumption (TFC); for crude oil (including NGLs), as the ratio of net imports over refinery intake; for oil products, as the ratio of net imports over total demand (= TFC + bunkers + energy sector); for electricity, as the ratio of net imports over total demand (excluding losses).

Figure 2: Depending on the country, other renewables may include small shares of solar, wind, biofuels, renewable municipal waste and hydro. Depending on the country, 'Other' may include small shares of non-renewable waste and oil.

Figure 3: Dispatchable share is the sum of combustible fuels and hydro over total capacity (for Iceland it also includes geothermal). Weather-dependent share is the sum of solar and wind over total capacity. For presentational purposes, negligible amounts of other generation capacity are excluded from the figure. Combustible fuels cover both fossil and renewable fuels as the breakdown for combustible capacity is not available.

Figure 4: Depending on the country, coal may include peat and non-renewable waste. Depending on the country, 'Renewables' may include biofuels, solar thermal, geothermal and ambient heat from heat pumps.

Figure 5: Industry includes non-energy use. Depending on the country, 'Others' may include agriculture, forestry, fishing, military and unspecified consumption. Buildings include residential, public and commercial buildings.

Figure 6: Represents shares of industry subsectors in total industry energy consumption. Shares of energy sources calculated for the largest subsectors. Non-energy use cannot be allocated to industry subsectors.

Faroe Islands, Greenland and Åland

Sources: National statistical offices and the World Bank (population).

Key figures: For Faroe islands, GDP is reported in current prices and converted from local currency (DKK) using an exchange rate of 7.5 DKK/EUR. For Greenland, GDP is reported in 2010-prices (chained values) and converted from local currency (DKK) using and exchange rate of 7.5 DKK/EUR. For Åland, GDP is reported in 2023 prices (latest year for whcih GDP is available)". Final consumption intensity calculated as the ratio of TFC/capita. Oil intensity calculated as the ratio of total oil demand/GDP. Overall import dependency calculated as the ratio of net imports/total energy supply.

Figure 1: Import dependency for coal, natural gas and total is calculated as the ratio of net imports over total final consumption (TFC); for crude oil (including NGLs), as the ratio of net imports over refinery intake; for oil products, as the ratio of net imports over total demand (= TFC + bunkers + energy sector); for electricity, as the ratio of net imports over total demand (excluding losses).

Figure 2: Depending on the country, other renewables may include small shares of solar, wind or biofuels.

Figure 3: Electricity consumption corresponds to the available sales data. This also explains the notable gap between the available electricity generation and consumption data for Greenland.

Figure 4: Oil consumption by sector not available for all countries. In this case, the figure represents available sales data by main products.

Annex 1: Guide to Figures, Methodologies and Infrastructure Terminology

This annex serves as a reference for readers of the main report. It is in two parts. Part 2.1 defines technical terms used in the figures and analysis. Part 2.2 documents the methodologies and data sources behind the quantitative figures in the report. Readers may consult entries directly without reading the annex in order.

A1.1 Terminology

A1.1.1 Electricity: capacity, output and dispatchability

Unless otherwise stated, electricity figures in the report refer to actual generation output (e.g. TWh) rather than installed generation capacity (e.g. GW). The two terms are often used interchangeably in speech, but they measure different things.

Generation output. The amount of electricity generated in a reference period, typically a calendar year. For example, Denmark produced 35 terawatt-hours (TWh) of electricity in 2024.

Generation capacity. The amount of installed capacity available to produce electricity. For example, Denmark's installed wind capacity in 2024 was 7.5 gigawatts (GW). Reported capacity may be nameplate (theoretical maximum if all units operated at their designed capacity) or operational (currently available for production). With rapid deployment of wind and solar, total capacity can change notably within a single calendar year, so the reporting convention should be confirmed when using capacity data.

Utilisation rate (capacity factor). The ratio of actual generation output over the theoretical maximum in the same period. It is an important indicator of generation performance.

Weather-dependent capacity. Generation capacity whose output depends directly on prevailing weather conditions. Low wind speeds or low solar irradiation can drop output close to zero regardless of installed capacity. The term usually excludes hydro, whose output is also weather-dependent but with a seasonal lag.

Dispatchable capacity. Generation capacity whose output can be controlled on demand and scheduled by system operators or market participants. Dispatchability matters because the grid must be balanced at all times: generation and consumption must always match. Typical dispatchable technologies are hydro reservoirs and gas turbines, and battery storage will increasingly contribute. Definitions are not always clear-cut. Run-of-river hydro provides less flexibility than reservoir hydro. Nuclear power is technically adjustable, but ramping is not instantaneous; in the Nordics it has traditionally been operated as must-run baseload, while in France (where nuclear supplies 64% of electricity) it has long been designed to follow load, increasingly so to accommodate the daytime solar peak.

A1.1.2 Electricity markets and grid geography

Several terms refer to different geographical units used in electricity markets and system operation. Some overlap, but they are conceptually distinct.

Bidding zone. The largest geographical area in which bids and offers from market participants can be matched without attributing cross-zonal capacity. Cross-zonal capacity is the maximum amount of electricity that can be physically transmitted between two bidding zones without overloading the grid, and is a key input to the price calculation algorithm. One country may form a single bidding zone (e.g. Finland, FI) or consist of several (e.g. Sweden, SE1–SE4). Sweden originally operated as a single price zone and was split into four in 2011 due to internal transmission constraints between the surplus north and deficit south. See ACER: bidding-zone review.

"Bidding zone", "price area" and "market zone" are often used interchangeably but are not identical:

Bidding zone	Price area	Market zone
The official term in EU electricity market regulation; used by ENTSO-E and ACER.	Market-oriented term commonly used by Nord Pool. Refers to the same geographical boundary as bidding zone.	A generic term that may also refer to balancing areas, reserve procurement zones or capacity calculation regions consisting of several bidding zones.

Single Day-Ahead Coupling (SDAC). A pan-European day-ahead electricity market mechanism covering most of Europe, including the continental Nordic countries. It allocates scarce cross-border transmission capacity through a common algorithm that simultaneously accounts for transmission constraints, increasing liquidity and the efficient use of generation across Europe. SDAC transitioned from hourly to 15-minute bidding periods in 2025. See ENTSO-E: SDAC implementation.

Control area. A territory operated by a single transmission system operator (TSO), physically demarcated by metering points at the interfaces with the rest of the interconnected network. All physical loads and controllable generation within the area are connected to the TSO's system. See ENTSO-E Operation Handbook glossary.

Synchronous area. A group of countries whose power systems are physically connected and share a synchronous system frequency (50 Hz in Europe, with minor deviations). A disturbance at any single point in the area is registered across the entire zone. Synchronous areas are interconnected through direct-current interconnectors. Notably, eastern and western Denmark belong to different synchronous areas.

Capacity calculation region (CCR). Defined by the EU Capacity Allocation and Congestion Management (CACM) Regulation 2015/1222 as a geographic area in which a coordinated capacity calculation is applied. CCRs are the set of bidding-zone borders for which TSOs coordinate capacity calculation. They are regularly reviewed to reflect new interconnectors, new bidding zones or new countries, and may overlap: Finland (FI) and southern Sweden (SE4) are part of both the Nordic and Baltic CCRs. Current CCRs are available in the ENTSO-E CCR map.

Regional group (RG). Bodies within ENTSO-E whose purpose is the reliable and efficient operation of the synchronous areas. RGs provide a framework for regional cooperation among ENTSO-E member TSOs. Up-to-date country lists for each RG are available at ENTSO-E system operations.

A1.1.3 Electricity system operators

Transmission system operator (TSO). The organisation responsible for transporting electricity at national or regional level using fixed infrastructure. The TSO is responsible for operational security within its control area, real-time operation and operational planning, prevention and remediation of disturbances, and procurement of services from third parties (redispatching, countertrading, congestion management, generation reserves and other ancillary services). The TSO also monitors and improves the tools needed to maintain operational security.

Distribution system operator (DSO). The organisation responsible for low-, medium- and high-voltage distribution networks and supply to lower-level distribution systems and directly connected customers. DSOs are typically natural monopolies overseen by national energy regulators. Their role has grown as more activity moves to the local distribution level, including active customers, self-generation, small-scale renewables, energy storage, power-to-heat and electric vehicles. The EU Clean Energy Package (2019) gave DSOs new responsibilities, including acting as neutral market facilitators in procuring energy to cover system losses, procuring non-frequency ancillary services, cooperating with TSOs to integrate connected market participants, publishing a transparent network development plan, and including demand response, energy efficiency and storage as alternatives to network expansion. See ACER: Clean Energy Package.

Significant grid user (SGU). A generation or demand facility deemed significant by the TSO because of its impact on the transmission system, including in terms of security of supply and ancillary services. SGUs must inform their connecting TSO or DSO of planned changes, tests and operational disturbances that could affect the grid, and must carry out compliance tests on request. Users providing demand response or reserves directly to the TSO must ensure compliance with the relevant regulations. See EU System Operation Guideline.

A1.1.4 Electricity interconnector infrastructure

The terms “cable”, “link” and “interconnector” are often used interchangeably. At a technical level they are not synonymous:

Cable	Link	Interconnector
The physical conductor that carries electricity (overhead or subsea). For example: “subsea cable”.	The functional connection between two nodes. A link may consist of one or several cables, converter stations and substations. For example: “HVDC link”.	A transmission connection between two separate electricity systems, bidding zones or countries (a strategic link). Typically includes cables, converter stations, grid interfaces and control systems.

Two interconnector technologies are in use: high-voltage alternating current (HVAC) and high-voltage direct current (HVDC). Both can be deployed as overhead or subsea cables. The main difference is that HVDC is independent of the frequency and phase angle of the AC system on either side.

HVAC. HVAC transmission has been used for decades and is efficient at reducing system losses at shorter distances. With the rise in weather-dependent generation, however, HVAC faces challenges including reduced transmission capacity, limited transmission distance, increased reactive power losses, and stability issues under faults and during transient conditions. HVAC operation also requires reactive power generation, and the non-controllable character of renewable generation affects the spinning reserves traditionally used for system balancing.

HVDC. Advances in power electronics have made efficient step-up of DC voltage possible, enabling HVDC systems suitable for long-distance transmission. The principal advantages over HVAC are that HVDC eliminates reactive power flow over the transmission link, supports higher power transfer for a given cable size, can interconnect asynchronous AC grids, and allows system operators to actively control power flow. After a break-even distance of 40–150 km for subsea cables and several hundred kilometres for overhead lines, HVDC becomes the more economical option, though break-even distances are highly project-dependent. HVDC technology has two main variants: Line Commutated Converter (LCC), a mature technology used for large bulk power transfer between strong AC grids, and Voltage Source Converter (VSC), a newer technology that can operate in weak or even passive AC systems, provide independent control of active and reactive power, and offer black-start capability. VSC is increasingly relevant for the Nordic system as wind expansion reduces system inertia. For detailed comparison, see ENTSO-E (2019), HVDC Links in System Operations.

A1.1.5 Oil refining metrics

Capacity. The maximum amount of inputs a refinery can process during a calendar year. Nameplate capacity refers to ideal operating conditions, without wear and tear. Operational capacity is the practical maximum accounting for equipment ageing, which is why older sources may quote higher figures than recent ones. There is no universal reporting standard. Nordic refinery operators use million tonnes of processed inputs per annum (Mtpa), thousand barrels per day (kbd) or tonnes per day. Conversion between them requires an assumption about the average density of the inputs:

$$\text{capacity [Mtpa]} = \text{capacity [kbd]} \times 365 / \text{density [barrels/tonne]} / 1000$$

Many Nordic refineries have integrated liquid biofuel production, which adds ambiguity: reported capacity may refer to total liquids, only crude oil processing, or only biofuel production. Operators generally do not publish detailed capacity figures, citing commercial sensitivity.

Throughput. The actual amount of inputs processed in a given period, typically a calendar year. Throughput is always lower than capacity. Refineries are in principle in continuous operation, but planned maintenance and unplanned outages lower running time.

Utilisation rate. The ratio of actual throughput over operational capacity. In theory 0–100%, typically above 90%.

A1.1.6 Gas storage types

Underground gas storage. A suitable geological formation (e.g. impermeable) into which natural gas can be injected for seasonal storage. Gas remains in the gaseous state. In the Nordic region, such sites are operated by Gas Storage Denmark, with storage capacity of approximately 1 bcm.

LNG import/export terminals. Terminals include a short-term storage facility for liquefied natural gas. When liquefied, natural gas occupies 1/600th of its gaseous volume. Terminal capacities are nonetheless a fraction of seasonal underground storage. For instance, the Hamina LNG import terminal has storage capacity of 30 000 m^3 LNG, equivalent to 18 million cubic metres (mcm) of natural gas in gaseous state.

Floating LNG storage (FSRU). A floating LNG terminal, in effect a marine vessel, has been operational in Inkoo, Finland since 2023. It can unload and load LNG vessels, store LNG, and regasify for redistribution to an inland pipeline. Storage capacity of the Inkoo terminal is 151 000 m^3 LNG (approximately 90 mcm).

Part 2: Methodologies and data sources

This part documents the principal methodologies and primary sources behind the quantitative figures in the report. Entries follow the order in which the underlying figures appear in the report.

A1.2.1 National electricity demand scenarios

The country-level electricity demand projections in Section 5.1 are drawn from the most recent official scenarios published by national authorities or TSOs. Each source uses its own scenario methodology and assumptions, so cross-country comparisons should be read as indicative ranges rather than harmonised forecasts. The table below summarises the sources.

Country	Scenario source	Responsible body	Notes
Denmark	Climate Status and Outlook 2025 (Klimastatus og -fremskrivning 2025). Source	Danish Ministry of Climate, Energy and Utilities	Annual technical assessment of greenhouse gas emissions, energy consumption and production under a frozen-policy ("with existing measures") scenario. Electricity-sector modelling documented in Danish: documentation. Datasheets available on the main report website.
Finland	Electricity system vision 2040. Source	Fingrid (Finnish TSO)	Biennial scenario-based analysis covering four pathways. The lowest-growth ("Voimaa vakaasti") and highest-growth ("Vedystä valtavirtaa") scenarios bracket the demand range used in the report. Scenario assumptions are documented in the report annexes (in Finnish). Datasheets not publicly available.
Iceland	Raforkuspá Landsnets fyrir 2024–2050 (Landsnet's electricity scenarios 2024–2050). Source	Landsnet (Icelandic TSO)	Second edition. Four scenarios ("low", "EU policy", "government policy", "high") cover future supply and demand and the impact of the clean energy transition. Assumptions documented in the report (in Icelandic). Datasheet available on the report website.
Norway	Scenarios for the power market 2025. Source	Norwegian Water Resources and Energy Directorate (NVE)	Three scenarios: "basis" (baseline), "klimaplan" (planned government climate measures) and "klimatiltak" (all proposed climate actions). Based on NVE's Long-Term Power Market Analysis 2025 (LA25). Assumptions documented in Norwegian. Datasheet available on the report website.
Sweden	Long-term scenarios 2025. Source	Energimyndigheten (Swedish Energy Agency)	Biennial study presenting four exploratory scenarios showing pathways to a net-zero energy system in 2050 and the following decade. Assumptions documented in Swedish. Datasheet available on the report website.

A1.2.2 Resource adequacy and Loss of Load Expectation (LOLE)

Adequacy modelling. ENTSO-E conducts an annual European Resource Adequacy Assessment (ERAA), which evaluates available resources against projected demand to identify supply-demand mismatch risks across scenarios. The ERAA-probabilistic methodology is considered the European reference for adequacy assessment, focused on the medium-term horizon and accounting for interconnections across the European perimeter. The model is a simplified representation of the pan-European power system, structured around five main elements: generation, demand, demand-side response, storage and network infrastructure. State-of-the-art adequacy studies use Monte Carlo simulation to capture system uncertainty, with results expressed as probabilistic indicators of adequacy under multiple plausible scenarios. Technical details and the full list of assumptions are in the ERAA Annex 2 Methodology document: ERAA 2025 methodology.

Loss of Load Expectation (LOLE). As part of the ERAA, LOLE is calculated for each bidding zone up to ten years ahead. The LOLE value is the expected number of hours per year in which generation resources are insufficient to meet demand. **LOLE is a modelled probability of insufficient supply, not a prediction of actual blackouts.** It does not capture the depth of any individual shortfall, but it is a useful comparative measure across years and zones.

Readers should always refer to the latest ERAA edition. Assumptions for a given target year can change rapidly from one edition to the next due to policy and system changes. For example, the cancellation of Hansa PowerBridge I between Sweden and Germany by the Swedish government in 2024 was not yet reflected in the 2025 ERAA, which assumed the link's existence; post-2030 LOLE values for southern Sweden (SE4) in that edition may therefore underestimate adequacy risk.

A1.2.3 Oil product import dependency

Calculations in Section 7.3 use the Eurostat annual database for oil and petroleum products supply, transformation and consumption (nrg_cb_oil).

Demand by oil product is calculated as the sum of gross inland deliveries (code GID) and international marine bunkers (INTMARB). Gross inland deliveries cover uses in the transformation and energy sectors as well as final consumption (industry, transport, residential, services, agriculture and non-energy uses), including the "unspecified" category which captures military consumption where reported.

Total oil product demand is the sum of demand across all oil products used in the country. The share of each product in the total indicates its relative importance in the economy.

Net imports are calculated as imports (IMP) minus exports (EXP).

Import dependency by product is the ratio of net imports over demand. Two boundary cases require treatment to avoid confusion:

- Negative values (net exporter) are set to 0, indicating the country is 0% import dependent for that product.
- Values above 100% can arise from stock builds (which are excluded from the demand calculation). These are capped at 100%.

A1.2.4 Strategic oil reserve obligations

Strategic oil reserves serve as emergency stocks against supply disruption. Nordic countries are subject to two parallel obligation frameworks: the EU minimum stockholding rule and the IEA emergency reserve commitment. The two rules use similar inputs but differ in their reference units and calculation rules. The headline rules are summarised below; readers needing full technical details should consult the source documents linked at the end of this entry.

A1.2.5 EU obligation (Directive 2009/119)

EU countries must maintain oil stocks amounting to at least the greater of 90 days of average daily net imports or 61 days of average daily inland consumption. The 90-day rule generally applies to heavily import-dependent countries; the 61-day rule generally applies to those with significant domestic crude oil or oil shale production. The applicable reference is recalculated each July based on production and trade data for the previous calendar year.

The directive sets out detailed methods for converting petroleum product imports and consumption into crude oil equivalents (with naphtha-yield deductions and a 1.065 factor for non-naphtha products, or a 1.2 factor when applying the inland consumption method), and for counting eligible stocks (with a 10% reduction for tank bottoms and excluded categories such as pipelines, retail stations, military stocks and ships at sea). Full conversion factors, the list of products counted, and the eligible storage locations are set out in Annexes I–III of the directive: Directive 2009/119 (consolidated).

A1.2.6 IEA stockholding obligation

IEA member countries hold emergency reserves equivalent to 90 days of the previous calendar year's average daily net imports. The obligation covers all petroleum (primary products and refined products), except naphtha and oil used as international marine bunkers. Refined products are converted to crude oil equivalent using factors broadly similar to the EU framework (a 4% naphtha-yield deduction on primary products, a 1.065 factor for refined products, or 1.25 if only the three main product groups—gasolines, middle distillates and heavy fuel oil—are counted). A 10% deduction is applied for unavailable stocks.

Days of net import cover is the ratio of emergency reserves over daily net imports. Full calculation details and notes on stocks held abroad are at IEA oil stocks of IEA countries.

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