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ORLEN

Baltic Cooperation: Momentum for Energy Transition

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The Baltic Sea plays an increasingly important role in the European energy sector, both in terms of supporting the energy transition and ensuring energy security in the region. In the context of the energy transition, the role of the Baltic Sea is critical as the location of offshore wind energy developments and enabling low carbon technologies such as renewable hydrogen and CCS. Import infrastructure in the Baltic Sea region is also critical in terms of energy security and supporting the switch away from Russian hydrocarbon sources.

Additionally, physical security of infrastructure in the Baltic is also a key concern of regional and international stakeholders.

In light of these developments, the Baltic Sea region has become a compelling example of the Energy Trilemma that combines Energy Security, Sustainability and Affordability. ORLEN Group, being one of the largest energy groups in the Baltic Sea region, is strategically aligning its ventures to pursue these three imperatives. Energy transition efforts and the rise of low carbon technologies are also driving our shift in focus towards the Baltic Sea. We are developing offshore wind farms, low carbon hydrogen units and pursuing CCS projects along with establishing CO_2 *value chains. We also remain focused on energy security, ensuring gas imports via marine infrastructure.*

At ORLEN, we recognise that partnerships and collaboration are critical to the development of these projects and therefore to the success of the region's energy transition. The cooperation within the Baltic Sea Region is also crucial for the security of the region and affordable prices for energy consumers. This implies the need for a more systematic approach to driving new developments and projects at the regional level.

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Geopolitical instability is driving nations to protect their national security, economic vitality, and access to reliable and sustainable energy. Near-shoring increasingly is seen as a means to de-risk supply chains. But the concept is far wider. Bringing energy supply "closer to home" can prove a powerful tool for companies and countries to shield energy from external risks and take advantage of complementary resources and markets with neighboring countries. These are proven measures fundamental to national security.

Unlocking such potential hinges on nations and companies working with like-minded neighbors. Few regions of the world are better positioned than the Baltic Sea nations[1]. All are members of the EU and NATO. All share legal foundations to collaborate on national security, energy and sustainability. All have committed to the EU's goals on decarbonization. Simply attaining North Sea levels of integration could triple regional power interconnections, raise offshore wind generation by six-fold, and develop competitive carbon storage projects.

This report, in effect, is a foundation for regional security — in its broadest sense. It provides pathways to lower costs, to increase reliability and to reduce emissions. It reinforces political choices on national security in a region where neighbors have come under threat. Indeed, the Baltic Sea potential underscores how energy corridors can be an indispensable tool across willing neighbors for a more competitive, prosperous, and secure future.

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Executive Summary

S&P Global Commodity insights (SPGCI) were requested by ORLEN to produce an independent whitepaper assessing the status of the energy transition around the Baltic Sea region[1] and the opportunities for collaboration within the region to promote decarbonization and energy security.

The Baltic Sea region accounts for over one-third of the EU's energy consumption and emissions. It plays a key role in Europe's decarbonization efforts, holding significant resource potential, with differences in power generation costs within the region offering opportunities for trade. Energy security has moved to the fore with the security of gas supplies, their affordability impacting business competitiveness, and synchronization of the Baltic states with the European power network as key regional initiatives. Decarbonisation and Energy Security are key challenges facing the region.

Regional collaboration in areas such as carbon capture, gas, hydrogen, offshore wind, and power interconnectors presents a valuable opportunity to advance decarbonization goals and secure energy supplies.

The key findings are as follows:

Harmonizing Permits: Unleashing 4400TWh of Power Potential through Interconnector Development

The region's renewable resource potential is **4.5 times greater** than its total power generation in 2023. Levelised power generation cost differences of **€15-30/MWh** create opportunities for regional trade. Increasing proportions of intermittent renewables generation make power interconnectors key for energy security. A regional working group could establish a cost-sharing framework and harmonise permitting processes.

Collaboration in Maritime Spatial Planning to achieve the 19.6 GW Marienborg Declaration target

Offshore Wind plays an important role in moving hydrocarbons out of the power mix, collaboration in maritime spatial planning can be a key enabler to meeting the **19.6 GW** generation target of the Marienborg declaration.

A regional Renewable Hydrogen Auction to meet RED III targets

The region is projected to face a shortfall of at least **300,000 tonnes** of renewable hydrogen to meet 2030 RED III targets. A regional hydrogen auction leveraging the regional basket within EU H2Bank model could be an enabler for securing supplies within the region.

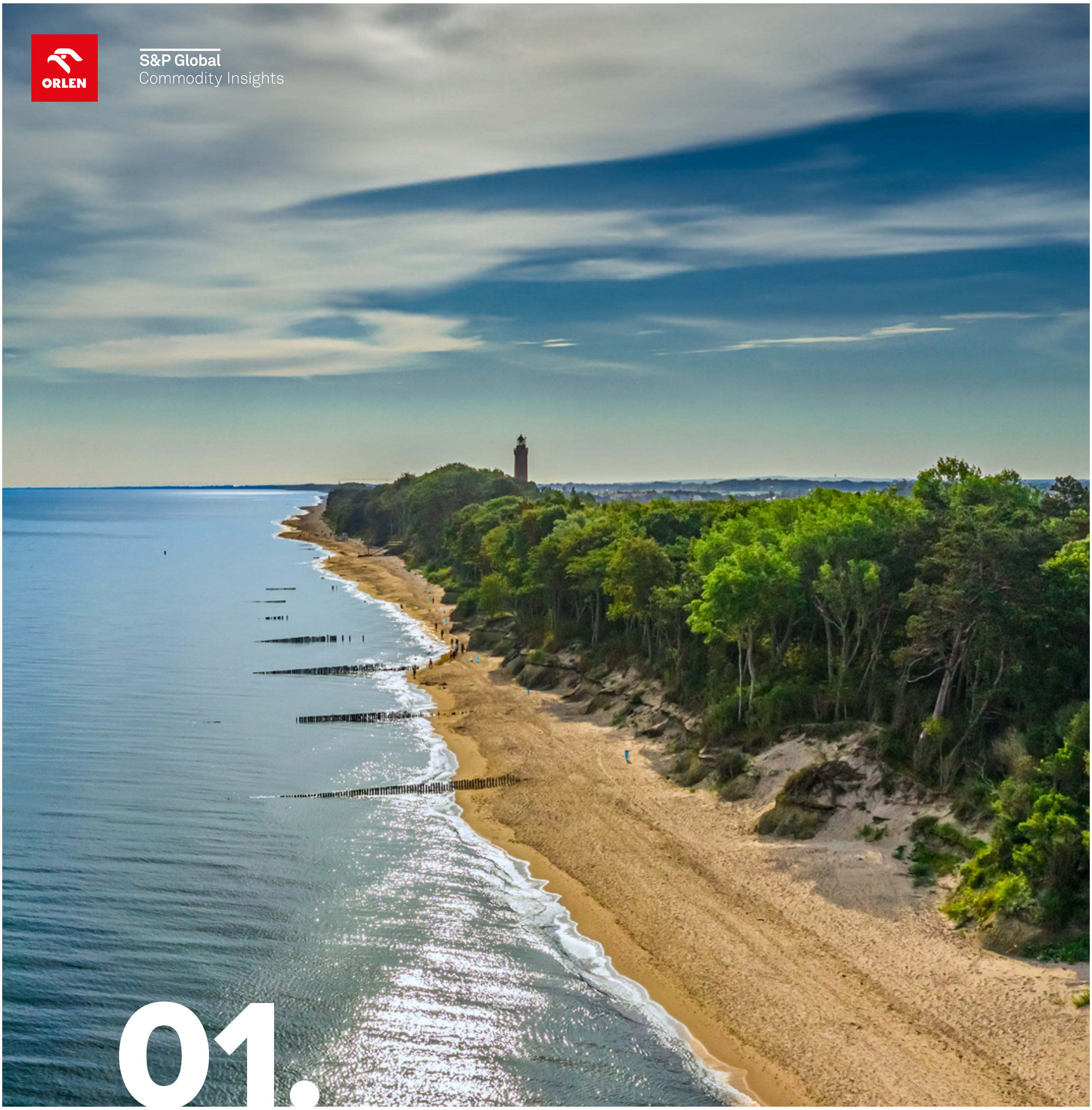
Joint subsurface mapping for cost-effective carbon storage under the Baltic Sea

CO_2 storage in the Baltic Sea could be cheaper than North Sea storage, with transportation costs **€15/metric tonne** cheaper. Joint subsurface mapping of the Baltic Sea and regulatory clarity regarding investments in the Baltic Sea could unlock CO_2 storage under the Baltic Sea.

Expanded gas interconnections to ensure energy security

Gas imports from Russia accounted for **68%** of the region's imports in 2018, but only **4%** in 2023. LNG and Baltic Pipe imports have been an important replacement, but pressure now exists on gas infrastructure. Expansions of gas interconnectors can support regasification and pipeline capacity utilisation within the region.

1. Baltic Sea region referring to the countries within the scope of this report, Denmark, Sweden, Finland, Estonia, Latvia, Lithuania, Poland, Germany



01. Introduction

The purpose of the study is to identify areas of co-operation amongst Baltic Sea countries that can promote decarbonization and energy security.

S&P Global Commodity insights (SPGCI) were requested by ORLEN to produce an independent whitepaper assessing the status of the energy transition around the Baltic Sea region[1] and the opportunities for collaboration within the region to promote decarbonization,energy security and affordability, supporting industry competitiveness. The region lags behind the North Sea across several decarbonisation and energy security metrics but holds significant resource potential, and differences in power generation costs provide the opportunity for trade.

Five sectors have been selected for analysis. Decarbonisation options such as Electric vehicles and Solar PV will have a major role to play in decarbonizing the region but do not necessarily require high levels of collaboration between countries to be deployed. Given the potential for collaboration within the region and available resource potential, the sectors selected for analysis within this report are **Carbon Capture Utilisation & Storage (CCUS), Hydrogen/derivatives, Offshore Wind, Gas and Power Interconnectors.**

The hypotheses demonstrate the scale of opportunity that could be realized through collaboration within the region.

Theme	Sectors	Hypothesis
Decarbonisation	**1.** Carbon Capture, Utilisation and Strorage	**Large scale transportation of CO_2 within the Baltic Sea can be >50% cheaper than shipment to the North Sea**
	2. Hydrogen/Derivatives	**Collaborating on hydrogen trade within the region would reduce the need for imports by ~300,000 tones to 2030**
	3. Offshore Wind	**Collaboration on spatial planning can bridge the 16 GW gap to the goal of the Marlenborg declaration**
Energy Security	**4.** Gas	**Pooling existing regasification infrastructure will optimise the distribution of 52 billion cubic meters of LNG imports in 2030**
	5. Power Interconnectors	**The development of power interconnectors will enable the region to share the benefits of ~€9 billion/year[2] lower generation costs to 2040**

Source: S&P Global Commodity Insights

All five sectors have a role to play across decarbonisation and energy security, **Carbon Capture** and **Hydrogen/derivatives** are focused more towards decarbonization, although hydrogen in the longer term could act as an important form of energy storage to balance intermittent renewables in the region. Offshore wind is a key decarbonization tool that can replace fossil fuels in the energy mix and provide energy independence to power importers in the region such as Lithuania and Latvia.

Gas is more prominently focused towards energy security but has an important role in ensuring affordable energy is available to maintain competitiveness of the industry. It also plays a key role in removing coal from the energy mix in Poland and Germany and decarbonizing heavy industry. **Power interconnectors** can bring excess clean energy from Scandinavia to displace fossil fuels and act as an important form of energy security in times of shortage.

For each of the collaboration hypothesis identified across CCUS, Hydrogen/derivatives, Offshore Wind, Power Interconnectors & Gas, the report highlights the advantages of collaboration, the key challenges and actionable collaboration opportunities that are impactful for both, decarbonization and energy security.

2. Data source: ENTSOE, EU assumption

Countries in Scope

The 'Baltic Sea countries' referred to within this report are:

These are the countries within the scope of this report given their shared border of the Baltic Sea and shared participation in existing collaborative initiatives including the Baltic Energy Market Interconnection Plan (BEMIP) working group.

Data source: ENTSOE, EU assumption

02.

Decarbonisation Collaboration Opportunities

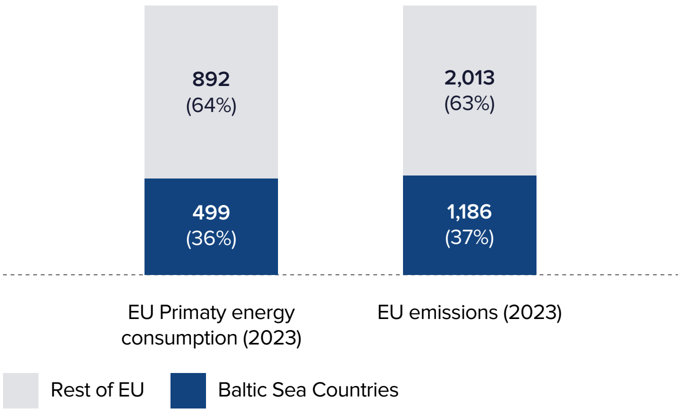
The countries bordering the Baltic Sea account for more than a third of all emissions and energy consumption in the EU, but compared to the North Sea basin, the region is lagging behind across several decarbonization initiatives. Significant renewable resource potential and a ~€15-30MWh difference in production costs between countries provides opportunities for cooperation in the region.

2.1 Offshore Wind

2.2 Hydrogen /Derivatives

2.3 Carbon Capture Utilisation & Storage (CCUS)

Figure 1 **EU Primary energy consumption (2023)** (mmtoe) **& EU Emissions (2023)** (MMt CO_2)



The Paris Climate Agreement, adopted at COP 21, set the goal of limiting temperature rises to less than 1.5 degrees Celsius above pre-industrial levels. Following the agreement, the European Union has enacted a range of regulations and policies supporting decarbonisation, including the EU Green Deal, Fit for 55, and the Third Renewable Energy Directive (RED III). These measures have significant impacts at the member state level.

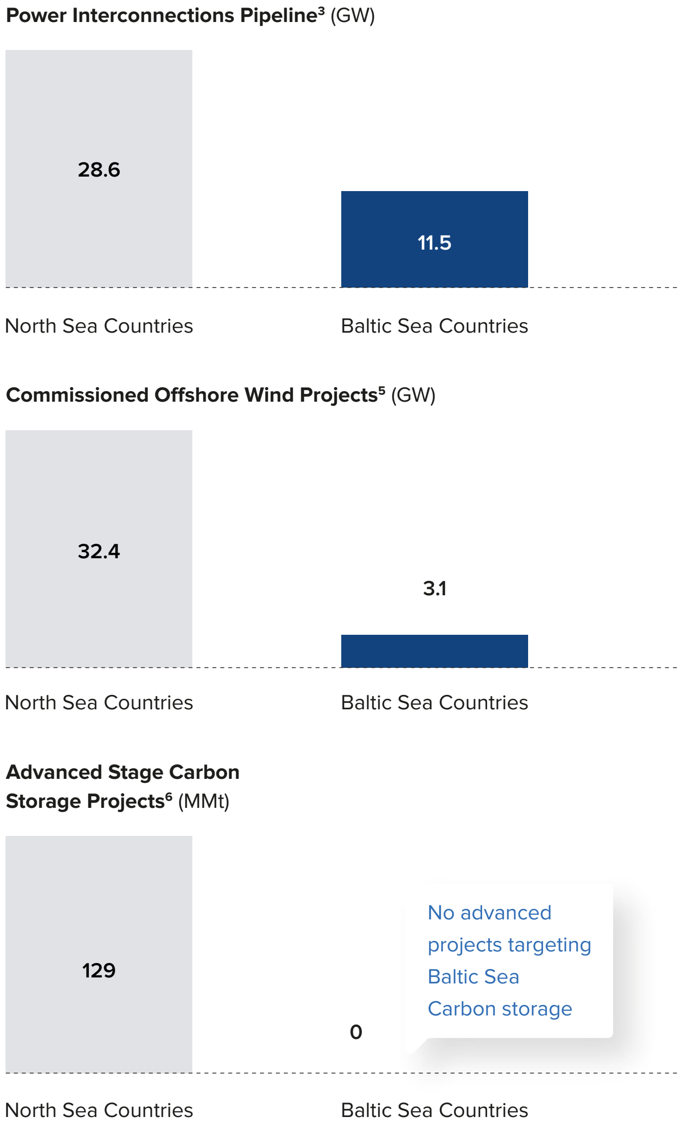
The Baltic Sea region accounts for over **35%** of the EU's primary energy consumption and emissions, making it crucial for meeting EU climate targets. **However, the Baltic Sea lags behind the North Sea in key decarbonization metrics.** Power interconnections are crucial for moving low carbon electrons and yet the Baltic Sea country pipeline is about **40% of that of the North Sea.**[3]

Despite the Baltic Sea region holding **93 GW of offshore wind potential** (as highlighted in the Marienborg declaration)[4] just 3 GW are partially/fully commissioned in the Baltic Sea, compared with **32 GW** in the North Sea[5].

The recent commissioning of the Northern Lights CCUS project highlights the ongoing development of carbon storage opportunities in the North Sea. In contrast a lack of subsurface mapping and regulatory clarity have resulted in **zero tonnes of CO_2 storage**[6] at an advanced stage in the Baltic Sea. Decades of energy collaboration in the North Sea have paved the way for clean energy initiatives. Similar collaboration could enable decarbonization within the Baltic Sea region.

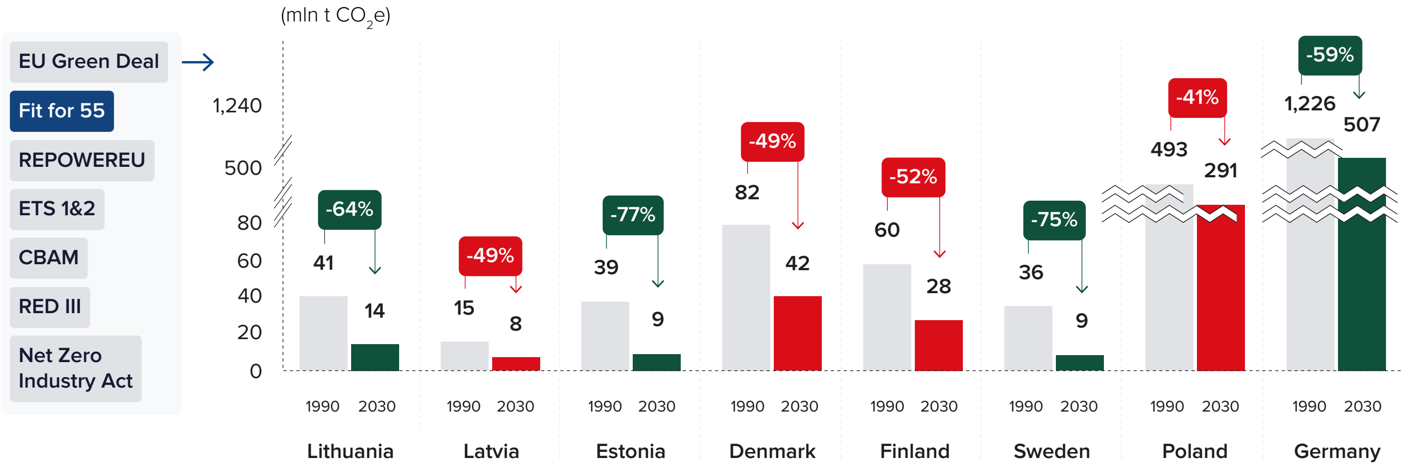
3. Data source1: SPGCI re-elaboration of the draft TYNDP 2024. It includes projects Under Consideration, in Planning, In permitting, Under Construction. Baltic Sea hub includes the water basins contained in the BEMIP framework, while North Sea includes all the NSOG basins.
4. The Marienborg declaration was signed between all 8 countries in scope in August 2022 to foster collaboration within the region to secure gas supplies and promote offshore wind development. The declaration set an offshore wind target of 19.6 GW by 2030 and outlined an offshore wind potential of 93 GW within the Baltic Sea.
5. Based upon partially or fully commissioned projects. Baltic Sea hub includes the water basins contained in the BEMIP framework, while North Sea includes all the NSOG basins.
6. Data source: S&P Global research, Advanced stage = Operational, Financed, Designed or Permitted North Sea countries as UK, Netherlands, Norway, Baltic Sea countries Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Sweden.

Figure 2 **Baltic Sea lags behind the North Sea on decarbonization initiatives**



Regulations and policies are propelling decarbonization efforts; however, Denmark, Finland, Latvia, and Poland are projected to fall short of the Fit for 55 targets.

Figure 3 **Key EU regulations & policies supporting Decarbonization and Total emissions by country versus Fit for 55 targets**



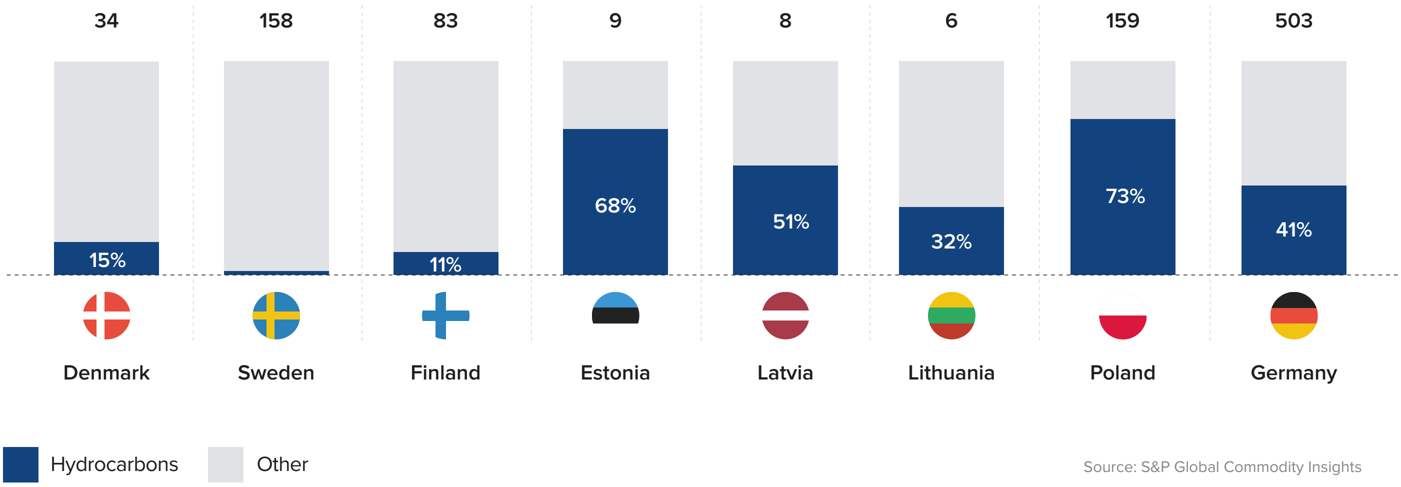
S&P's Inflections scenario is a base case and envisions a world where emissions reduce significantly, but Net Zero is not reached in 2050 with a global temperature rise of 2.4 degrees Celsius assumed

Source: S&P Global Commodity Insights

Key regulations and policies at an EU level including the EU Green Deal, REPOWEREU, Emissions Trading System (ETS 1&2), CBAM, RED II and the Net Zero Industry Act are all driving decarbonisation (Details provided in appendix).

An underlying lack of collaboration on decarbonisation initiatives in the region is likely to be a factor behind EU targets being missed. Fit for 55 refers to the EU's target of reducing net greenhouse gases by **at least 55%** by 2030 from 1990 levels. Based upon SPGCI's Inflections scenario[7], **Poland, Denmark, Latvia** and **Finland** are projected to miss the target to 2030, with emissions within the power, transportation and industrial sectors as key factors (shown within appendix).

Figure 4 **Power generation mix by country 2023** (%) (960TWh total)



Source: S&P Global Commodity Insights

The remaining presence of Hydrocarbons (Coal, Oil and Natural Gas) in the region's power generation mix is a key remaining hurdle for lowering emissions. They accounted for approximately **35%** of the power generation mix in 2023. Coal alone contributes to about **one-quarter** of power generation within the region led by continued use in Germany and Poland. Cleaner energy sources are required to achieve decarbonization goals. **Offshore wind energy emerges as a crucial solution in this context.**

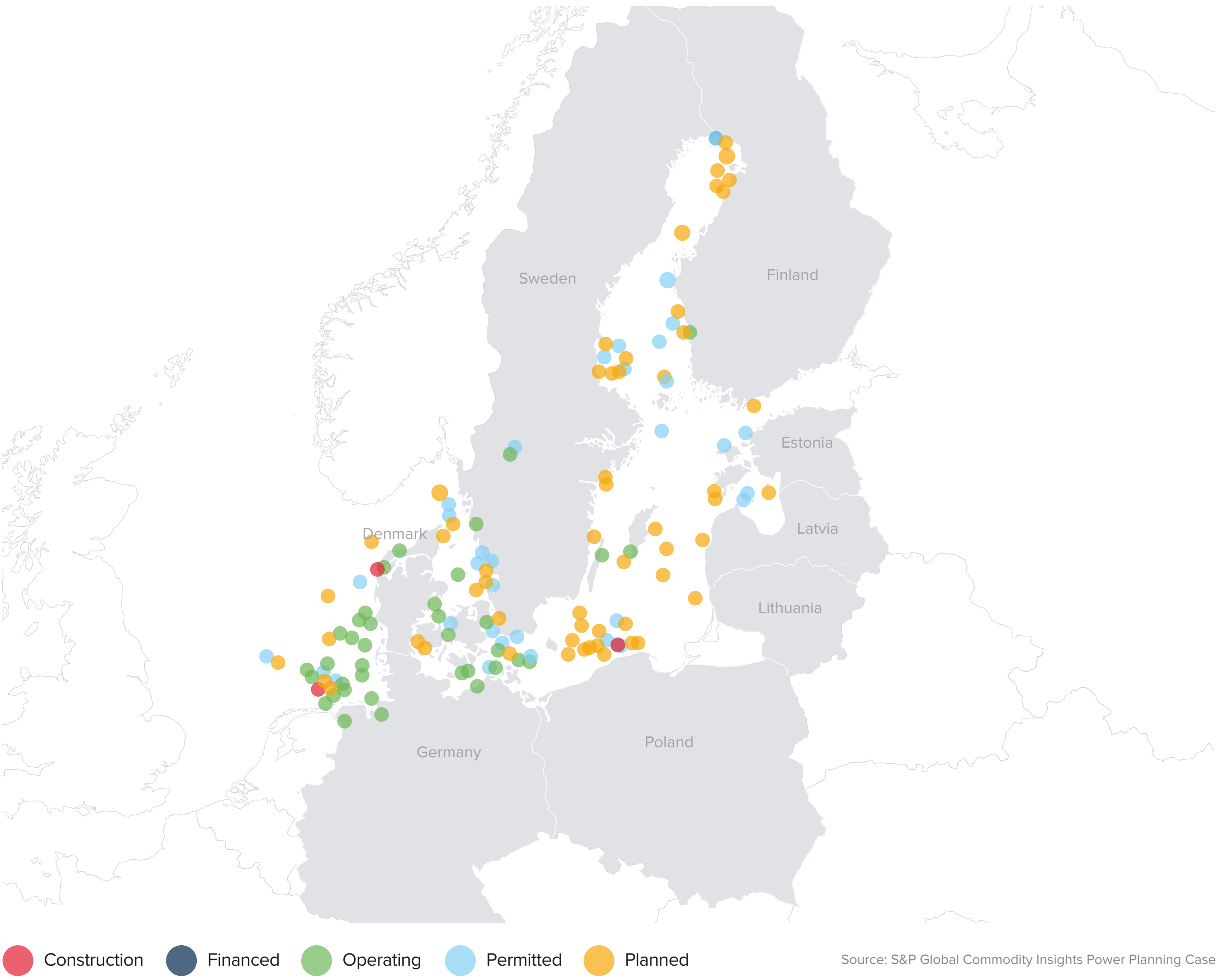
7. S&P's Inflections scenario is a base case and en isions a world where emissions reduce significantly, but Net Zero is not reached in 2050 with a global temperature rise of 2.4 degrees Celsius assumed.

2.1. Offshore Wind

Offshore wind plays an important role in moving hydrocarbons out of the energy mix. To meet the goals of the Marienborg declaration, challenges in spatial planning, regulatory/permitting and supply chain need to be overcome. Joint maritime spatial planning and harmonization of processes within the region are key enablers.

Offshore wind presents an important decarbonisation option, as part of a mix of renewable options within the region. It is an important tool for meeting rising power demand from increased electrification, the adoption of electric vehicles and production of renewable hydrogen. The map below shows that a significant number of projects are under consideration within the Baltic Sea, but the vast majority are either at planning or permitting stage.

Figure 5 **Baltic Sea Countries Offshore Wind Pipeline**

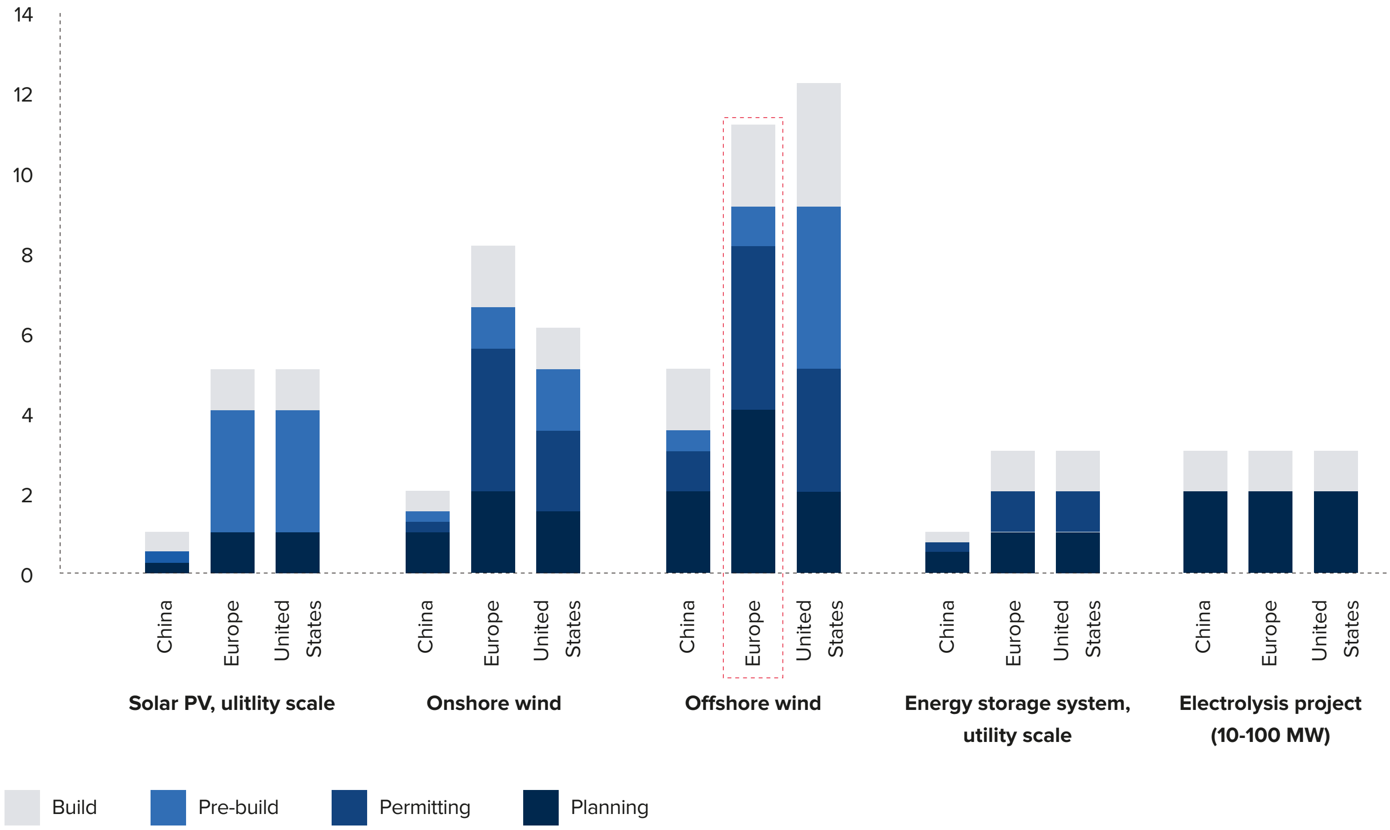


Source: S&P Global Commodity Insights Power Planning Case

A lack of regional spatial planning is a key bottleneck to projects moving to the point of financing or commissioning. The importance of this has been highlighted by the November 2024 rejection of plans for **32 GW** of offshore wind capacity in Sweden, driven by security concerns. The region will need to overcome challenges to attain the additional **16.5 GW of offshore wind** that needs to be added by 2030 to meet the goals of the Marienborg declaration (Based upon 3.1 GW existing operational capacity).

Marienborg Declaration = Signed by all eight Baltic Sea countries, targeting **19.6 GW** of installed capacity in the Baltic Sea by 2030, leveraging cross-border projects and identifying shared infrastructure needs.

Figure 6 **Indicative time to market for renewables and electrolysis projects by development phase** (years)[8]



Offshore wind projects, particularly in Europe, face a longer time-to-market compared to other technologies, complicating the development of offshore wind initiatives. As shown in the figure below, offshore wind projects in Europe can take 11 years to come online, compared to significantly shorter lead times in China where an established supply chain is in place. Efficient use of supply chains will be key in the Baltic Sea, leveraging installation and service facilities at ports such as Esbjerg and Thyboron in Denmark, Cuxhaven in Germany and Świnoujście in Poland.

8. Source: S&P Global,
Planning = The project is in early planning stages. It has not obtained approvals from the relevant authorities. Permitting = The project is in its permitting process. Planning documentation (for environmental permits, interconnection rights, etc.) are being prepared or are submitted to the relevant authorities for approval. Pre-build = The project has its required permits and is preparing for construction. Financing is being finalized, tenders for equipment and construction contracts are being awarded, site preparations and front-end engineering design studies are being completed. Build = The project is under construction or in testing /commissioning phase.
For electrolysis projects: Planning phase duration is based on best scenario when off-taker is clear such as petrochemical plant. Build time based on alkaline electrolysis.

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Summary
Offshore Wind

Whilst all eight countries are trying to realise their underlying offshore potential, several key challenges are holding the region back:

- A lack of integrated maritime spatial planning.
- Complex regulations and permitting processes.
- Differing auction structures and support mechanisms by country.
- The cost of financing projects.
- A lack of supply chain in the region outside of Denmark, Germany, and Poland.

The Netherlands offshore wind strategy provides a reference for actions that could be replicated in the Baltic Sea region. With **>5 GW** of operational offshore wind, the country already has operational volumes above the Baltic Sea and provides key lessons that can be leveraged in the region.

Long-term strategy – The Offshore Wind Energy Roadmap is supported by clear regulations, tenders, and responsibilities.

Centralised permitting – Centralised management of permitting, site selection, and tenders enabled a 3–4-year development timeframe for Borssele 1&2 from tender award in 2017 to commissioning in 2021.

Established support mechanisms – The previous Contracts for Difference (CfD) support scheme and current SDE++ scheme resulted in **over 8.5 GW** of contract awards between 2016 and 2024.

Key takeaways

- Joint spatial planning alongside clear regulations and clear tender processes are a facilitator of project development.
- A harmonised approach towards permitting can keep project leadtimes to a minimum.

Collaboration opportunities in Offshore Wind

Greater co-operation on maritime spatial planning and a harmonized approach towards environmental permitting can be key areas of collaboration to unlock offshore wind potential in the region.

Greater collaboration on maritime spatial planning

- Spatial planning enables accurate zoning of offshore wind opportunities.
- The Baltic Energy Market Interconnection Plan (BEMIP)[9] working group for offshore wind has already been collaborating with the Helsinki Commission (HELCOM)[10] and Vision and Strategies around the Baltic Sea (VASAB)[11] working group on spatial planning.
- Sweden's decision not to pro ide permits for 13 offshore wind sites in November 2024[12] highlights the need for greater collaboration within the region on spatial planning.

Desired Outcome – Publication of regional spatial planning enabling project developers to identify viable production zones, reducing the timeline from planning to commissioning.

- Trans-border elements of the environmental impact assessments, although often necessary, can lead to considerable project delays. It should be ensured these are executed in a reasonable and standardized manner and only when justified.
- Within these agreed production zones, a harmonised approach towards environmental permitting could significantly reduce project delays.

Desired Outcome – A working group to harmonise the approach to environmental permitting within production zones, providing consistency of approach across the region to reduce delays.

9. BEMIP – Stands for the Baltic Energy Market Interconnection Plan. It is an initiative aimed at enhancing energy security and market integration in the Baltic Sea region. The members of the BEMIP High-Level Group are Denmark, Germany, Estonia, Latvia, Lithuania, Poland, Finland and Sweden
10. HELCOM - Stands for the Helsinki Commission, which is an intergovernmental organization established to protect the marine environment of the Baltic Sea. Formally known as the Baltic Marine Environment Protection Commission, HELCOM was founded in 1974 and is focused on promoting cooperation among the countries bordering the Baltic Sea to address environmental challenges and to ensure sustainable use of the sea's resources.
11. VASAB - Stands for the "Vision and Strategies Around the Baltic Sea." It is a regional intergovernmental cooperation initiative focused on spatial planning and sustainable development in the Baltic Sea region. Established in the late 1990s, VASAB aims to promote integrated spatial development and to enhance cooperation among the countries surrounding the Baltic Sea
12. Swedish government, S&P, https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/electric-power/110524-swedish-government-denies-13-offshore--wind-permits-over-defense-concerns

2.2. Hydrogen/Derivatives

The region is projected to be short of renewable hydrogen to meet RED III targets, potential surpluses in Sweden and Denmark can be leveraged to offset deficits in Poland and Germany to minimize import requirements. A regional hydrogen auction could be an enabler for securing supplies within the region.

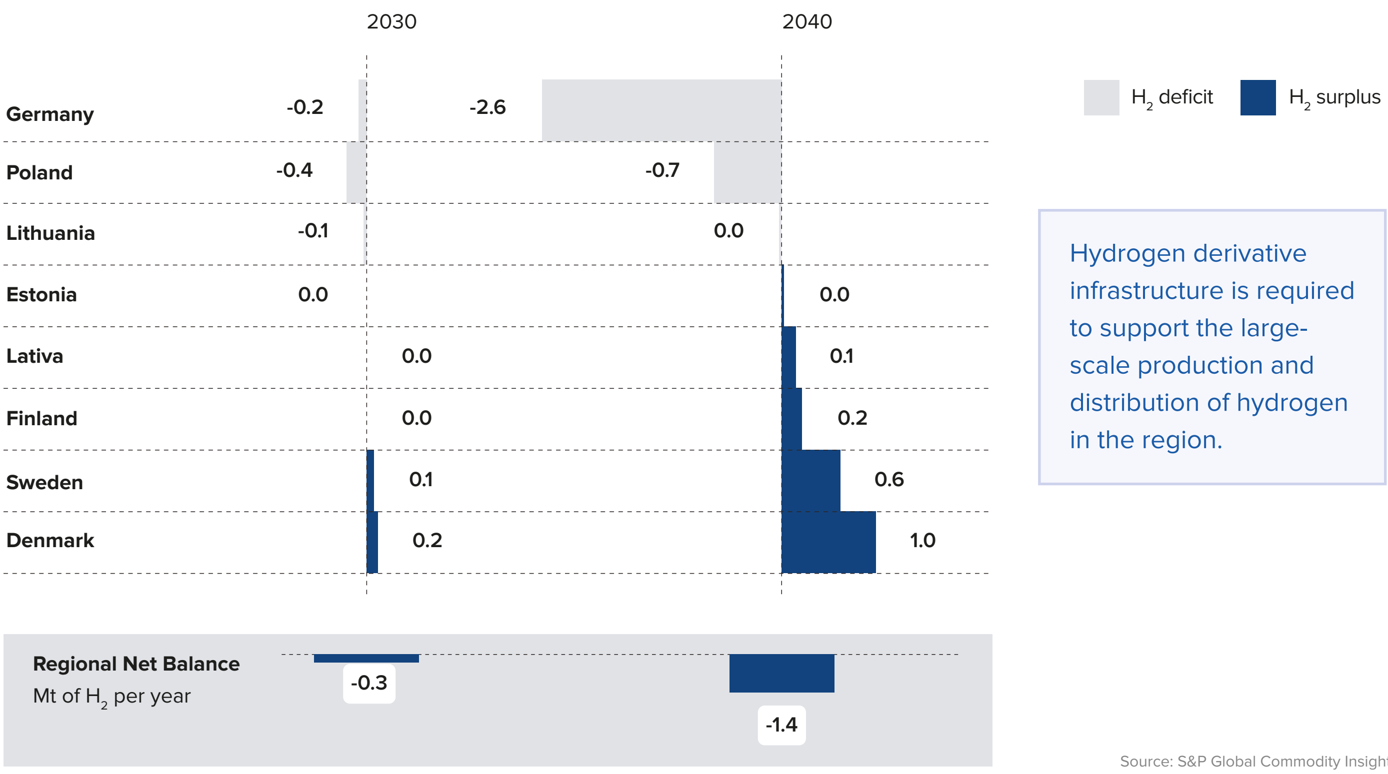
The region is projected to experience a shortfall in the hydrogen required to meet 2030 RED III Renewable Fuels of Non-Biological Origin (RFNBO) targets.

RFNBO = Renewable liquid and gaseous fuels of non-biological origin. Renewable hydrogen leveraging renewable power is considered an RFNBO alongside derivatives such as ammonia, methanol or e-fuels.

Denmark, Sweden, Finland and Estonia have potential hydrogen surpluses, driven by available renewables and a relatively limited requirement for renewable hydrogen as a feedstock for ammonia production. Shortfalls are projected in **Germany** and **Poland** where high ammonia production volumes and likely requirements for RFNBO in transportation drive RFNBO demand to 2030. Even with this trade, imports from outside the region are likely to be required.

Despite a pipeline for the Baltic Sea region of about **50 GW** of electrolyser capacity either announced, planned or under construction, projects online by 2030 are likely to be limited and hydrogen production within the region is **likely to fall short** of what it would be needed to meet **2030 RED III targets**.

Figure 7 **Hydrogen net trade balances in the Baltic Region**[13] (Mt of H_2 per year)

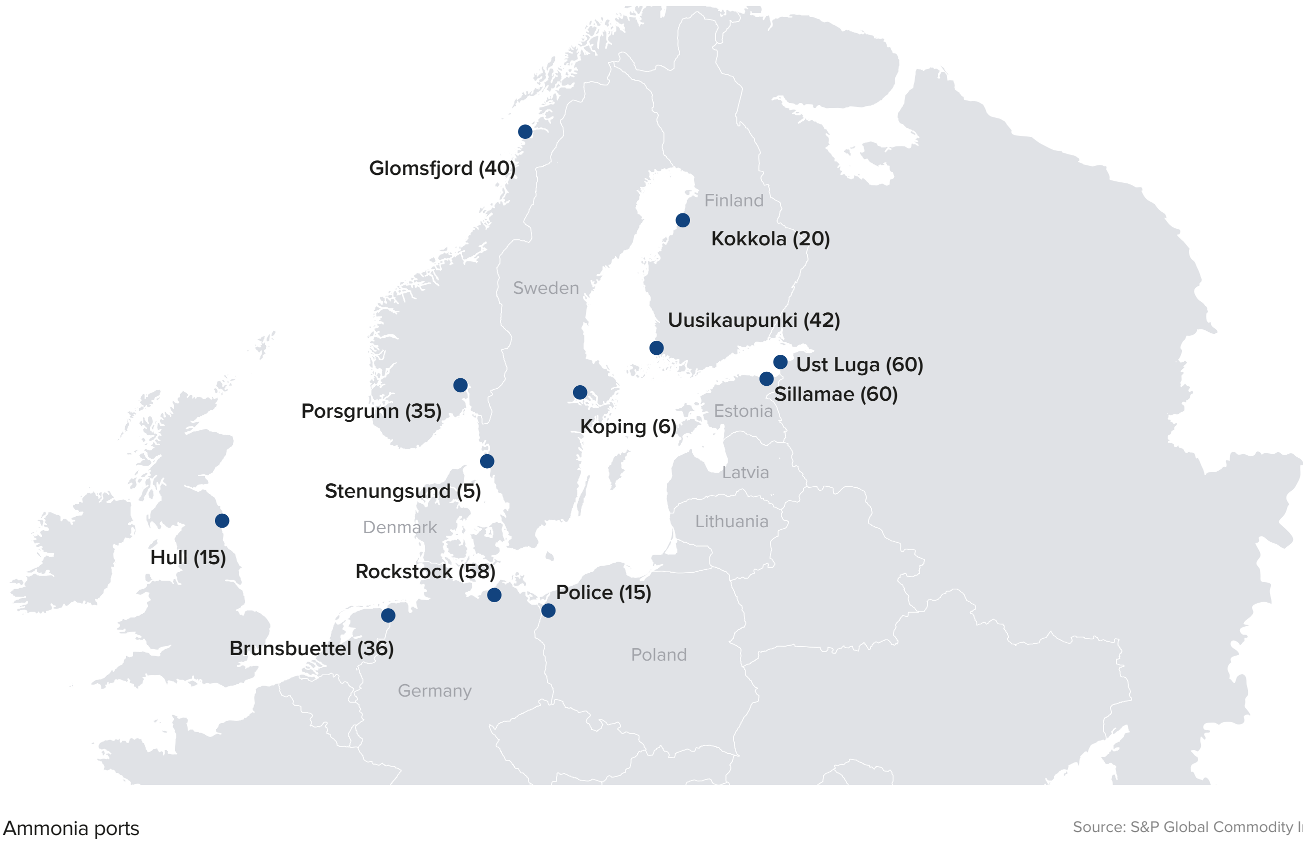


Hydrogen derivative infrastructure is required to support the large-scale production and distribution of hydrogen in the region.

Source: S&P Global Commodity Insights

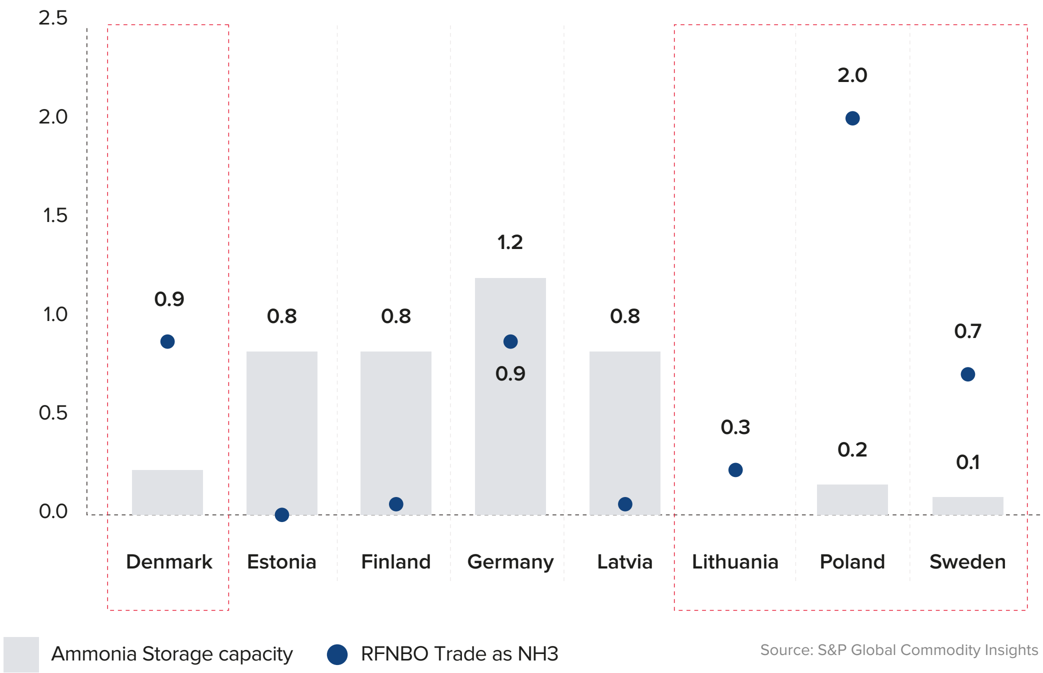
13. Note: Supply of renewable hydrogen is calculated in the SPGCI planning case, Hydrogen demand was calculated as the sum of REDIII minimum targets for industry + transportation, plus additional RFNBO to meet the 29% renewables in transportation target. Targets are 42% (2030 binding) & 80% (2040) for industry; and 1% (2030 binding) & 8% for transport (2040). The transport targets in 2030 and 2040 have a 2X multiplier applied.

Figure 8 **Ammonia storage capacity in the Baltic Sea region** (Thousant Mt)



Source: S&P Global Commodity Insights

Figure 9 **2030 RFNBO trade requirement vs. annual ammonia storage capacity** (NH3 MMt)



Source: S&P Global Commodity Insights

Based upon an assumption that hydrogen trade to 2030 is via ammonia as a carrier, Denmark, Lithuania, Sweden, and Poland currently lack the ammonia storage capacity to handle the trade volumes required to achieve 2030 RFNBO targets. This shortfall outlines the requirement for investments in hydrogen/derivative infrastructure in the region. The European Hydrogen Backbone initiative is a key piece of infrastructure that could support hydrogen transportation in the region. Corridor D of the initiative would enable pipeline transportation through all eight countries within the region but requires collaboration between public and private stakeholders to facilitate construction.

Note: To meet the annual storage capacity requirements, it is assumed that each facility will undergo 13 terminal refills.

Summary
Hydrogen/Derivatives

Hydrogen/derivatives can be a key decarbonization solution for heavy industry and transportation within the region, but challenges are limiting its development in the region:

- Limited renewables supply available for hydrogen production and high power prices in the key demand markets of Poland and Germany.
- A current lack of renewable hydrogen production and import infrastructure within the region.
- Regulatory uncertainty regarding the levying of non-compliance penalties under RED III.
- Supply chain congestion for key production components such as electrolysers.

The matching of cheap renewables producers with high demand offtakers could be a key enabler for hydrogen demand within the region and provide a significant incentive for infrastructure development. The first **EU Hydrogen Bank auction** has provided a foundation that the region could leverage. The auction awarded **€720 million** to seven renewable hydrogen projects, across Finland, Norway, Portugal, and Spain. This equated to **~1.58** million tonnes of renewable hydrogen over a 10-year period. Key enablers were:

Significant financing – With funds provided through EU ETS trading system revenues.
Regulatory clarity - With clear rules regarding the auction process and a maximum 5-year lead-time before hydrogen production must commence.
Provision of an auction model – Which has laid the platform for an 'auctions as a service' model to be developed, facilitating future auction rounds.

Key takeaways

A regional auction leveraging national funds could be an enabler for securing renewable hydrogen volumes to meet RED III targets.

Collaboration Opportunity in Hydrogen /Derivatives

Creation of a Baltic Sea regional hydrogen auction

- Germany and Poland are major demand centres for hydrogen, but both are projected to be short on volumes, whilst surplus RFNBO volumes may be available in other countries such as Sweden and Finland.
- Levelized costs of Hydrogen are also higher in Germany and Poland when compared to other countries in the region.
- Local support mechanisms for RFNBO can account for production prices within the region.

A regional auction could align offtakers with suppliers in the region and strengthen regional co-operation.

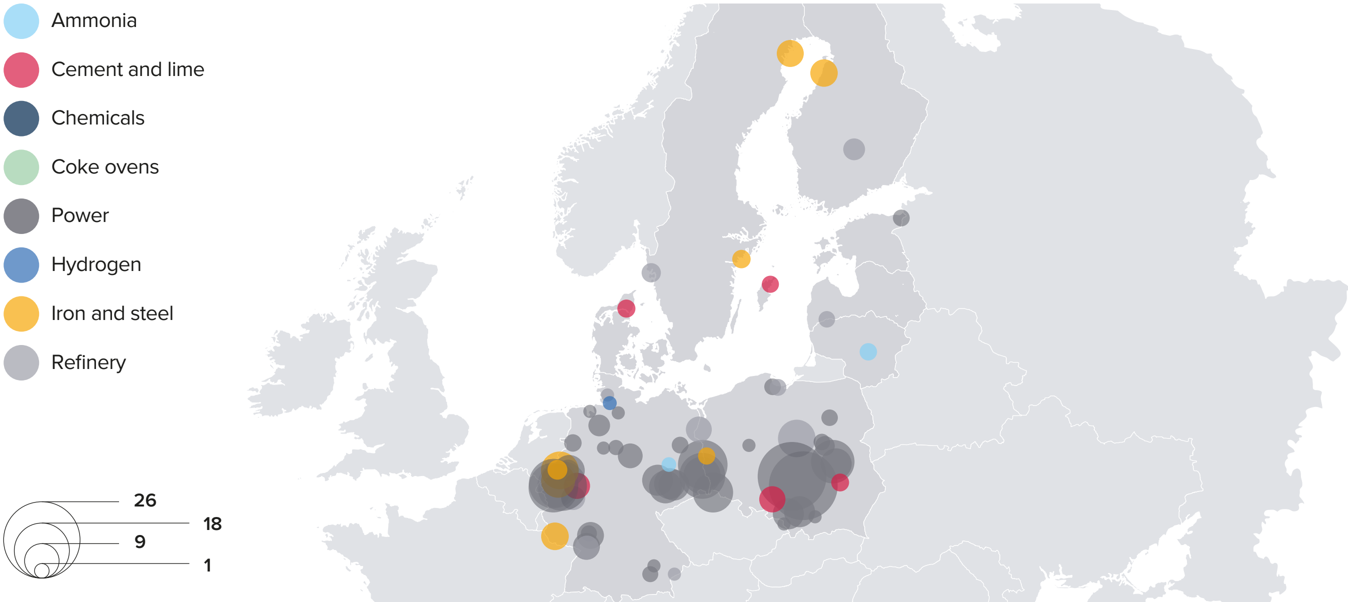
- It could also indicate the volume of demand in the region to stimulate investment in infrastructure such as the European Hydrogen Backbone.
- The auction model promoted by the EU commission could provide a hosting mechanism for such an auction, aligning budget funds at the regional level with hydrogen projects within the region.

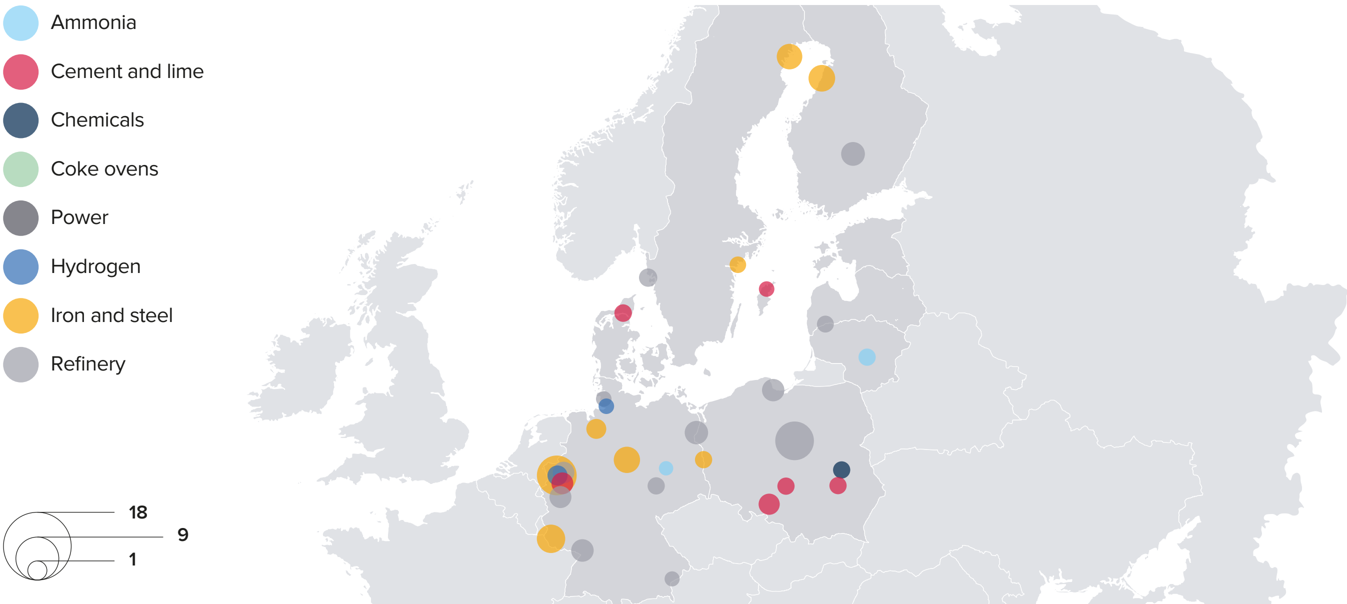
Desired Outcome – Leverage the 'Auction as a service' model to host a regional auction, aligning offtakers and producers regionally to enable projects to reach final investment decision.

2.3. Carbon Capture Utilisation & Storage (CCUS)

CCUS plays a key role in decarbonizing the hard to abate facilities that are dispersed around the region. CO_2 transportation to the Baltic Sea is significantly cheaper than shipping to the North Sea but a lack of subsurface mapping and regulatory clarity convention are restricting storage development. Joint subsurface mapping and regulatory clarity regarding investments in the Baltic Sea could unlock CO_2 storage under the Baltic Sea.

Figure 10 **Key emitters 2023 including and excluding power generation** (Million Tonne CO_2e)





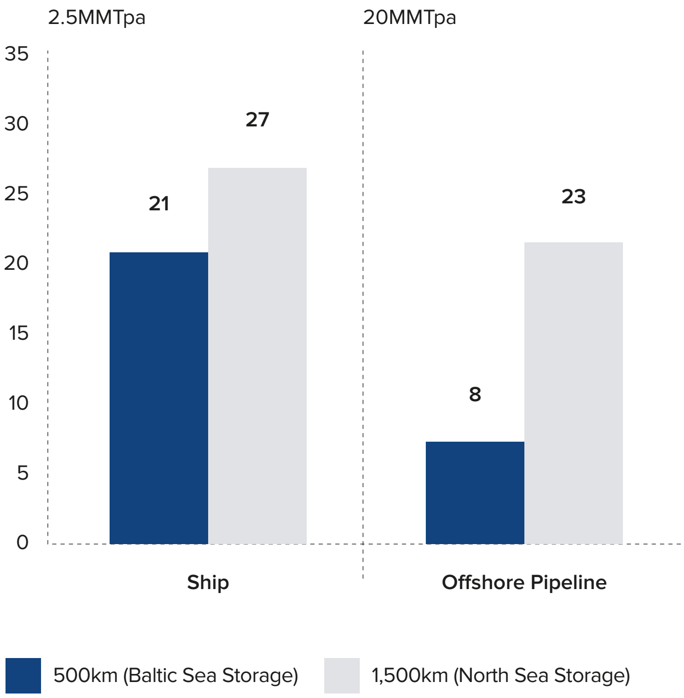
Source: S&P Global Commodity Insights

Assuming that power generation is decarbonized, the landscape of heavy emitters is fragmented. Steel, cement, chemicals, and refining are hard to abate due to their inherent reliance on carbon-intensive processes.

To address the emissions from these sectors and maintain industry competitiveness, Carbon Capture, Utilization, and Storage (CCUS) presents a solution. Infrastructure for capturing, transporting, and storing carbon dioxide will need to be coordinated and aligned given the geographical dispersion of hard to abate facilities.

Transportation of CO_2 to the Baltic Sea is cheaper than transportation to the North Sea.

Figure 11 **Cost of carbon transportation**
(2021 €/metric ton CO_2)



Using 1500 km as a proxy for a shipping route from Gdansk to Bergen (North Sea) and 500km as a proxy for a shipping route from Gdansk to a Baltic Sea storage site, the cost dynamics of carbon transportation have been assessed.

At 2.5 million metric tons per annum (MMTpa), transportation via ship to the North Sea is more expensive than shipping to the Baltic Sea. However, the limited availability of depleted oil and gas wells in the Baltic Sea necessitates the identification of saline aquifers for storage. This coupled with existing regulatory support in the North Sea will likely see **North Sea storage preferred** as witnessed by the pipeline of projects targeting carbon storage in the North Sea.

When considering a future hub scale of **20 MMTpa**, transportation to the Baltic Sea is likely to be significantly cheaper than transportation to the North Sea. In such a scenario, pipelines are likely to emerge as a more cost-effective solution compared to ships. Pipeline over a 500km distance is significantly cheaper than over 1500km. Therefore, despite the potentially significantly higher expense of using saline aquifers for storage in the Baltic Sea, transportation and storage could be competitive with the North Sea.

Therefore, **identifying cost-competitive saline aquifers within the Baltic Sea could make the transportation and storage of carbon under the Baltic Sea** a viable option. The Net Zero Industry Act is promoting the need for greater carbon storage options.

Net Zero Industry Act - The act sets a target of 50MMTpa of carbon storage in the EU by 2030 and places obligations on oil and gas producers to make contributions to this target based upon their share of EU production. Making storage available in the Baltic Sea would be a key enabler to meeting this target.

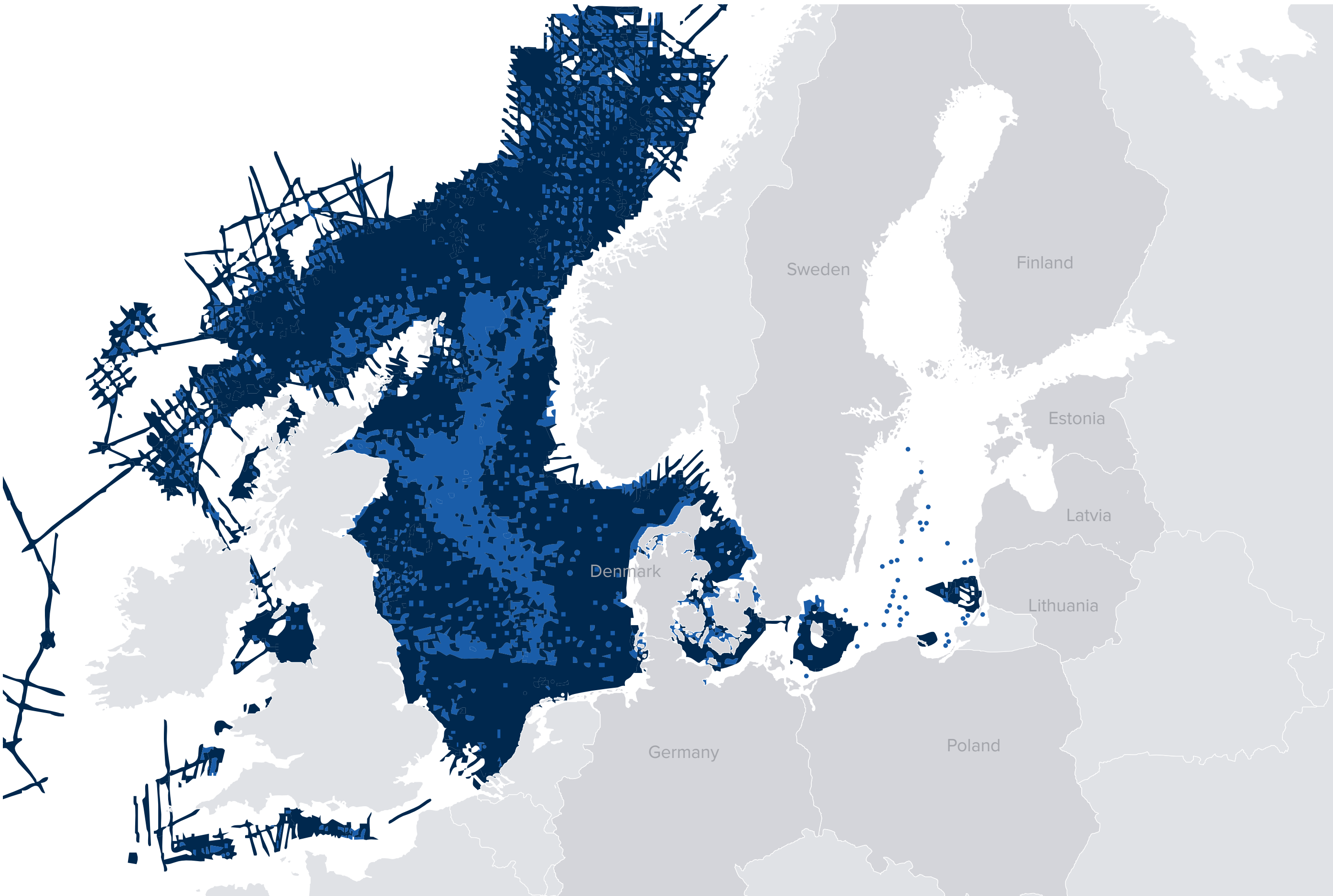
Key challenges for the development of CCUS in the region include the lack of subsurface mapping and regulatory clarity regarding investments in the Baltic Sea.

- Limited hydrocarbon exploration in the Baltic Sea leaves significant gaps in subsurface mapping.

Seismic and well data plays a key role in providing clarity on the potential for CO_2 storage. The North Sea is significantly more advanced in this analysis due to decades of oil and gas exploration, which has yielded extensive subsurface data. Due to fewer hydrocarbon deposits, the Baltic Sea region holds significantly less well and seismic data to support the identification of suitable carbon storage sites.

Source: S&P Global Commodity Insights & Zero Emission Platform

Figure 12 **North Sea & Baltic Sea Subsurface mapping comparison**[14]



2D Seismic field   Offshore wells

Source: S&P Global Commodity Insights

14 Seismic lines are paths along which seismic data is collected to map and visualize underground geological structures by analyzing the reflections of seismic waves.

Summary

Carbon Capture Utilisation & Storage (CCUS)

The Northern Lights project provides an example of collaboration between public and private entities to facilitate large scale carbon storage. The project is the transportation and storage component of 'Longship', the Norwegian government's full-scale carbon capture and storage project. Following the commissioning of storage facilities in September 2024 the project is set to receive up to 1.5 million tons of CO_2 per year during phase 1 of the project. Key enablers for this project to be successful were:

National Funding – **Nkr10.4 billion** (€0.97billion 2020 Exchange rate) of initial Norwegian government funding in 2020 alongside continuous national and EU funding.
Subsurface mapping – Enabled through decades of oil and gas exploration that have provided a foundation of seismic and wells data.
North Sea Basin Task Force – Bringing together private and public entities since its inception in 2005 with Equinor and Shell as early members that have since formed the Northern Lights joint venture with Total Energies.
Permitting – Fast track permitting approval for the project given its support of national climate goals

Key takeaways

- National funding coupled with EU funding can be a key enabler.
- A well mapped subsurface provides clarity of storage sites, reducing developer costs and risk.
- Private sector entities can bring valuable technical and commercial expertise to projects.

Collaboration opportunities in CCUS

To maximize the potential of CCUS in the region, collaboration in subsurface mapping, infrastructure planning, and hub development would be key facilitators. Such cooperation can leverage economies of scale and enhance the overall effectiveness of CCUS initiatives.

Joint subsurface mapping of the Baltic Sea

- Subsurface mapping is key for identifying saline aquifer opportunities.
- Subsurface mapping takes time and is particularly expensive, Sweden has recently conducted its own seismic mapping, but collective mapping could boost efficiency.
- The Baltic Sea Countries can pool financial resources and have a common plan to explore the Baltic Sea subsurface.

Desired Outcome - A joint mapping effort can leverage economies of scale to identify the most promising saline aquifer opportunities, reducing time and costs.

Actions

- The identification of storage options in the Baltic Sea could serve as an enabler for CCUS projects in landlocked countries further south e.g. Czech Republic, Austria

Desired Outcome - A regional conference to develop joint approach about the CCUS at the Baltic Sea with key stakeholders including the National energy ministers, industry stakeholders and EU representatives.

Energy Security Collaboration Opportunities

The Ukraine-Russia war served as a wake-up call for European countries, highlighting the urgent need to enhance energy security. This includes finding ways to increase reliability, lower costs and reduce emissions across Europe, and particularly in the Baltic Sea region.

Gas infrastructure and power interconnectors are crucial components in this complex equation. They are essential for enhancing security, ensuring affordability - a key component of maintaining competitiveness of the European industry, and decarbonizing the energy sector.

The drastic reduction in pipeline gas flows from Russia - down 95% from 2018 to 2023 - necessitates a complete reassessment of the infrastructure needed to meet regional energy demands. Expanding LNG infrastructure to offset the decline in pipeline imports requires a thorough review of inter-regional infrastructure availability and bottlenecks to ensure smooth flows within the region.

Power interconnectors are vital for unlocking and efficiently distributing renewable energy across the region. They also contribute to energy security and help optimize the cost of renewable power usage throughout the Baltic Sea area.

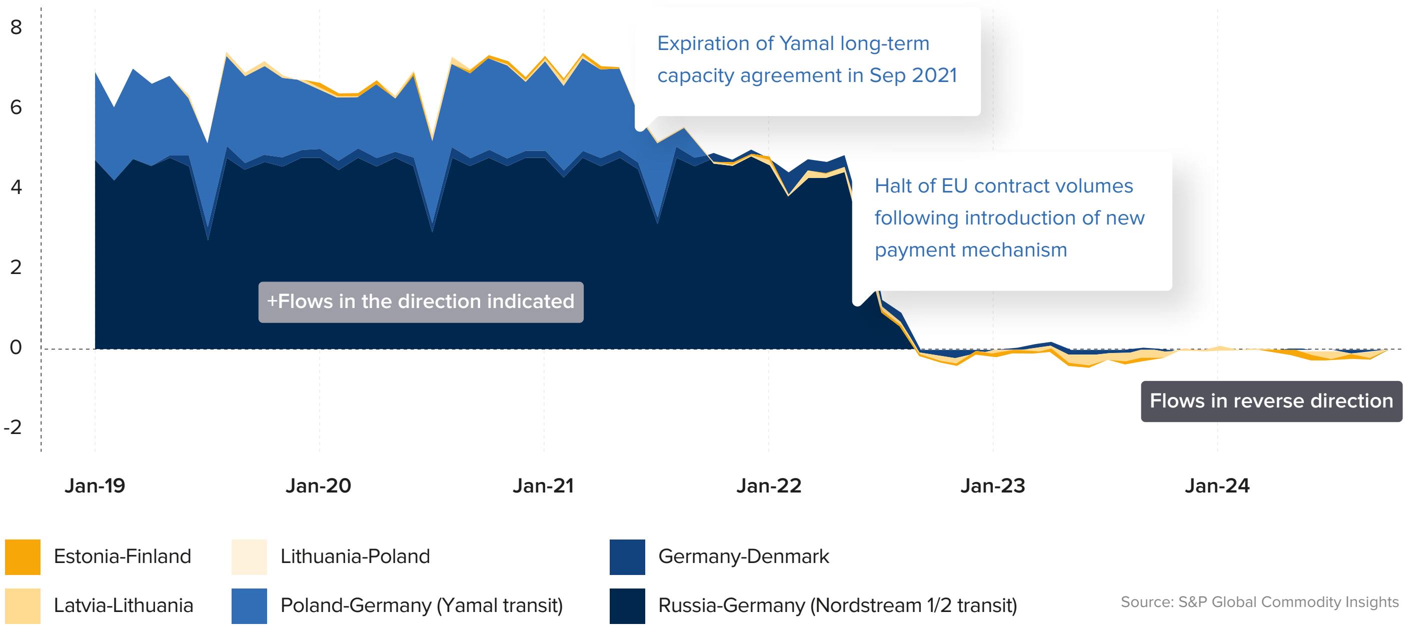
3.1 GAS

3.2 Power Interconnectors

3.1. Gas

Concerns around energy security have intensified in the wake of the war in Ukraine, leading to changes in gas pipeline flows and increased LNG imports to ensure stable supplies. Several pipelines and re-gasification facilities within the region are at/near capacity, additional pipeline capacity is a potential collaborative solutions to these challenges.

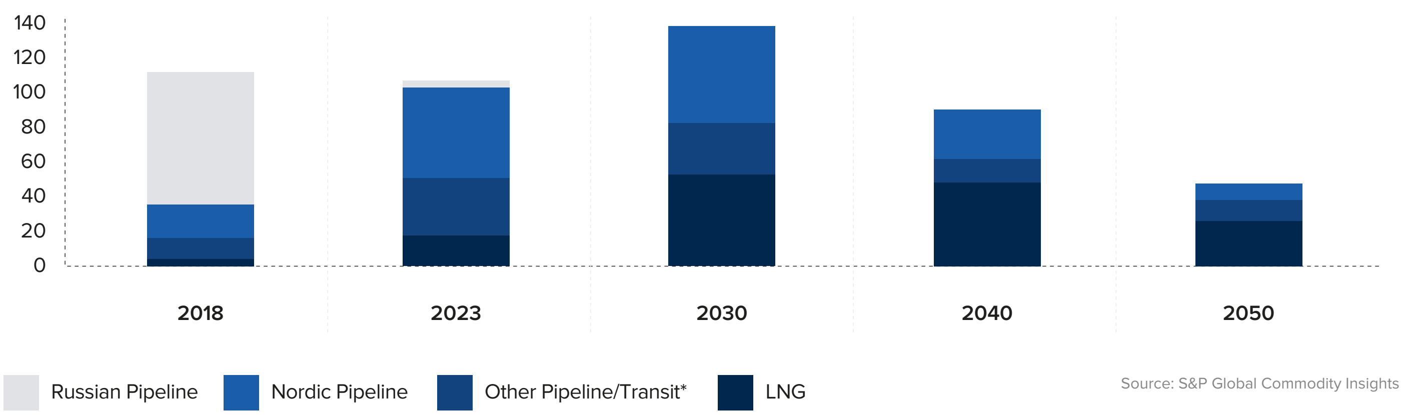
Figure 13 **Intra Baltic routes – gas flows (net)**[15] (Bcm/month)



Source: S&P Global Commodity Insights

With the halting of shipments through the Yamal and Nordstream 1 and 2 pipelines, the gas supply landscape within the region has changed significantly. Pipeline flows from Russia have **reduced by 95%** from 2018 to 2023 with many pipelines now running in reverse flow, transporting LNG imports.

Figure 14 **Baltic Gas imports by source**[16] (Bcm/year)



Source: S&P Global Commodity Insights

15. S&P EU Long-term balances planning case 2024.
16. *Other Pipeline Imports/Transit includes imports from Netherlands/UK into Germany and transit flows to other states further south e.g. Austria, Czech Republic

Security of supply has been retained through additional Norwegian pipeline supplies and LNG imports. Norwegian flows are now more than **2.5 times higher** than they were in 2018.

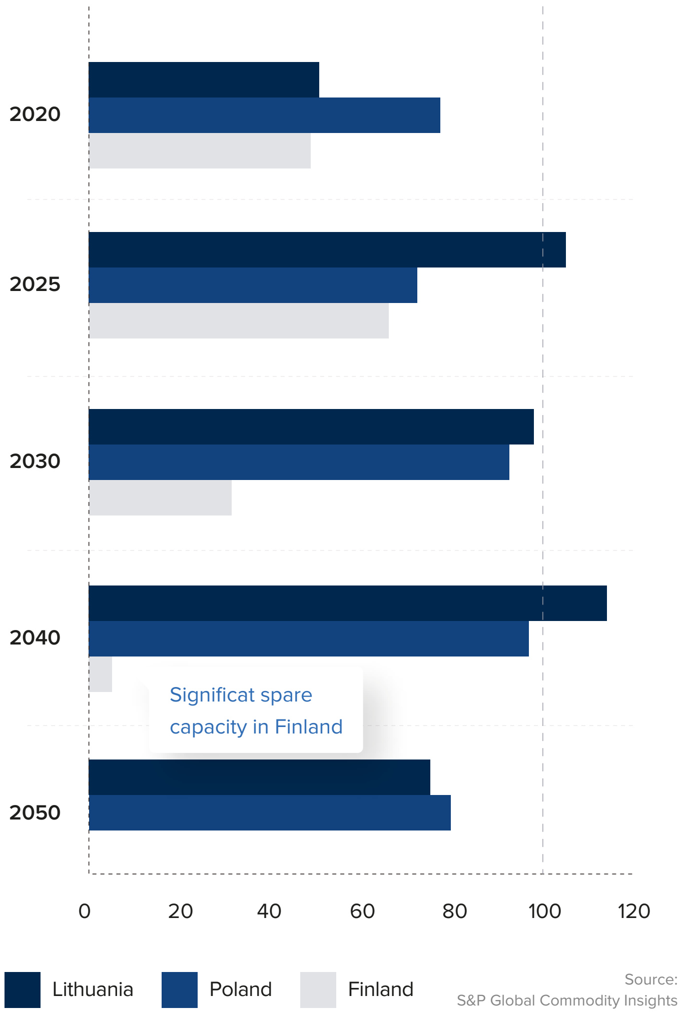
Import terminals such as those in in Wilhelmshaven and Brunsbüttel - Germany, Świnoujście in Poland, Klaipėda in Lithuania and Inkoo in Finland play a key role in maintaining energy security. These facilities support a stable supply of natural gas, diversifying energy sources and reducing dependency on any single supply route. Several terminals are however currently operating near or at capacity.

> LNG capacity has significantly expanded to enhance supply security; however, limitations in re-gasification and pipeline capacity now present challenges.

Despite significant expansions in LNG infrastructure, utilization rates at regasification terminals in Poland and Lithuania are expected to be near or at full capacity to 2040. Pipeline flows between Lithuania and Latvia have already reached capacity limits several times with significant supplies of gas to Latvia and Estonia flowing through Lithuania.

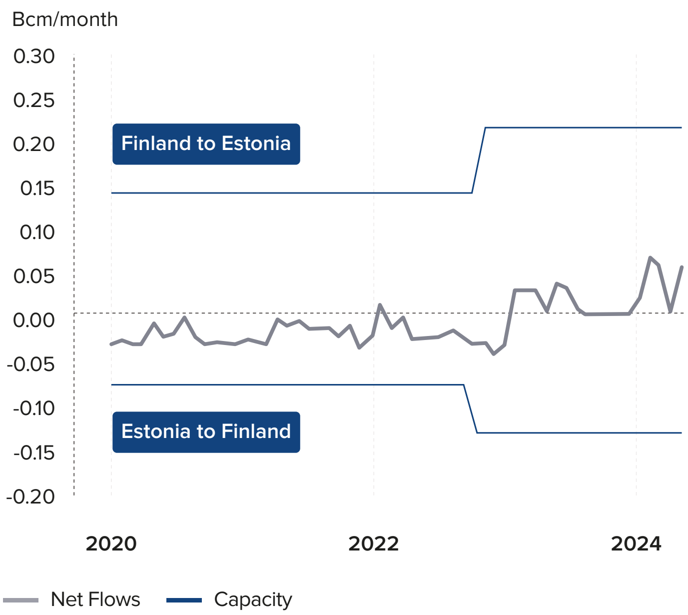
To alleviate this pressure, there is potential regasification capacity in Finland that could be utilized as an alternative supply source for Estonia and Latvia via Baltic Connector to reduce the strain on Lithuanian regasification capacity. Expansions in pipeline capacity between Lithuania and Latvia would also alleviate some capacity constraints.

Figure 15 **Re-gasification Utilization rates** (%)

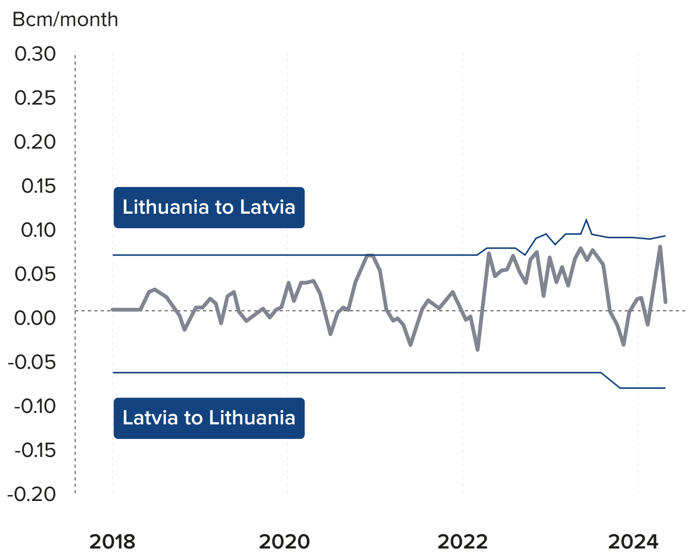


Source: S&P Global Commodity Insights

Figure 16 **Baltic Connector Utilization: Net Flows**



Lithuania-Latvia Utilization: Net Flows



Source: S&P Global Commodity Insights

Summary
Gas

Key challenges for the region include:

- Regasification capacity at Świnoujście and Klaipėda is expected to be near/at capacity to 2040, causing congestion.
- Pipeline capacity utilization between Lithuania and Latvia is near capacity limits.
- Uncertainty exists regarding the availability of long-term German LNG capacity to provide liquidity for the region.
- Limited visibility regarding long-term pipeline tariffs.
- Longer-term declines in Norwegian production.

Collaboration across the region can be an enabler to avoiding bottlenecks in gas availability and to maximizing the utilization of existing infrastructure. Gas Infrastructure in the region will also need to be able to accomodate increasing volumes of hydrogen and biomethane, both of which are being promoted by EU regulations and will play a role across decarbonisation and energy security in the region.

The GIPL pipeline is an existing example of collaboration within the region whereby collaboration between the public and private sector has been a key enabler. The GIPL gas pipeline project between Poland and Lithuania was commissioned in May 2022 enabling ~2 billion cubic metres/year of gas flow. The project has provided security of gas supply within the region, facilitating gas flows from LNG regasification plants at Świnoujście and Klaipėda. Key enablers were:

Project finance were funded through the Connecting Europe Facility (CEF)

Existing regulatory frameworks – Enabling the construction of 508km of pipeline alongside compressor systems and interconnection points.

Clarity regarding demand – Gas demand studies, scenario modelling and stakeholder engagement provided a clear view of utilisation rates across the region.

Political support – Strong backing from the Polish, Lithuanian and EU government, facilitated regulatory approval.

Key takeaways

- The adoption of the TEN-E regulation in June 2022 has placed a ban on gas projects being eligible for EU financial aid. National funding within the region would remain an enabler for increasing gas interconnection capacity.
- Further regulatory alignment with the region can be an enabler for an expanded balancing regime.
- Political support is key for the development of further interconnection capacity.

Collaboration opportunities in Gas

A joint study to expand gas interconnection capacity.

- Re-gasification infrastructure at Świnoujście and Klaipėda is expected to be near capacity to 2040. Lithuania-Latvia pipeline flows have been operating near capacity.
- A lack of interconnection between countries is causing a bottleneck and reducing liquidity.
- Expanding pipeline capacity between Lithuania, Latvia and Estonia could enhance liquidity, reduce pressure on existing infrastructure and pave the way to improved balancing, facilitating greater regional security of supply.

Desired Outcome A Joint study regarding expansion of gas pipeline capacity between Lithuania, Latvia, and Estonia.

Collaboration to enhance liquidity within the region

- Baltic area Governments, TSO's and market participants should seek to find a way to ease physical and virtual flows within the region whilst reducing transaction costs.
- This includes reducing transmission and balancing costs to encourage use of regional infrastructure and increase throughput creating a more cost competitive wholesale gas market in the region.
- Virtual flow and capacity products could be developed and will be accessed by shippers in Baltic gas markets with the co-operation of exchanges and auction platforms.

Desired Outcome

- Create a working group of TSO's, Utilities, Suppliers and Trader industry bodies to evaluate potential structures and products, in partnership with Capacity platforms (i.e. GSA and PRISMA) and exchanges (i.e. EEX) that are active in the region.

3.2. Power Interconnectors

Baltic Sea Countries are rich in renewables resources, The uneven distribution of wind, solar and hydropower resources create opportunities for arbitrage.

The region boasts a **renewable energy potential** of approximately **4400 TWh**, spanning Offshore Wind, Onshore Wind, Solar, and Hydropower. This underlying potential is **4.5 times greater than 2023 power generation** across the 8 countries (960TWh).

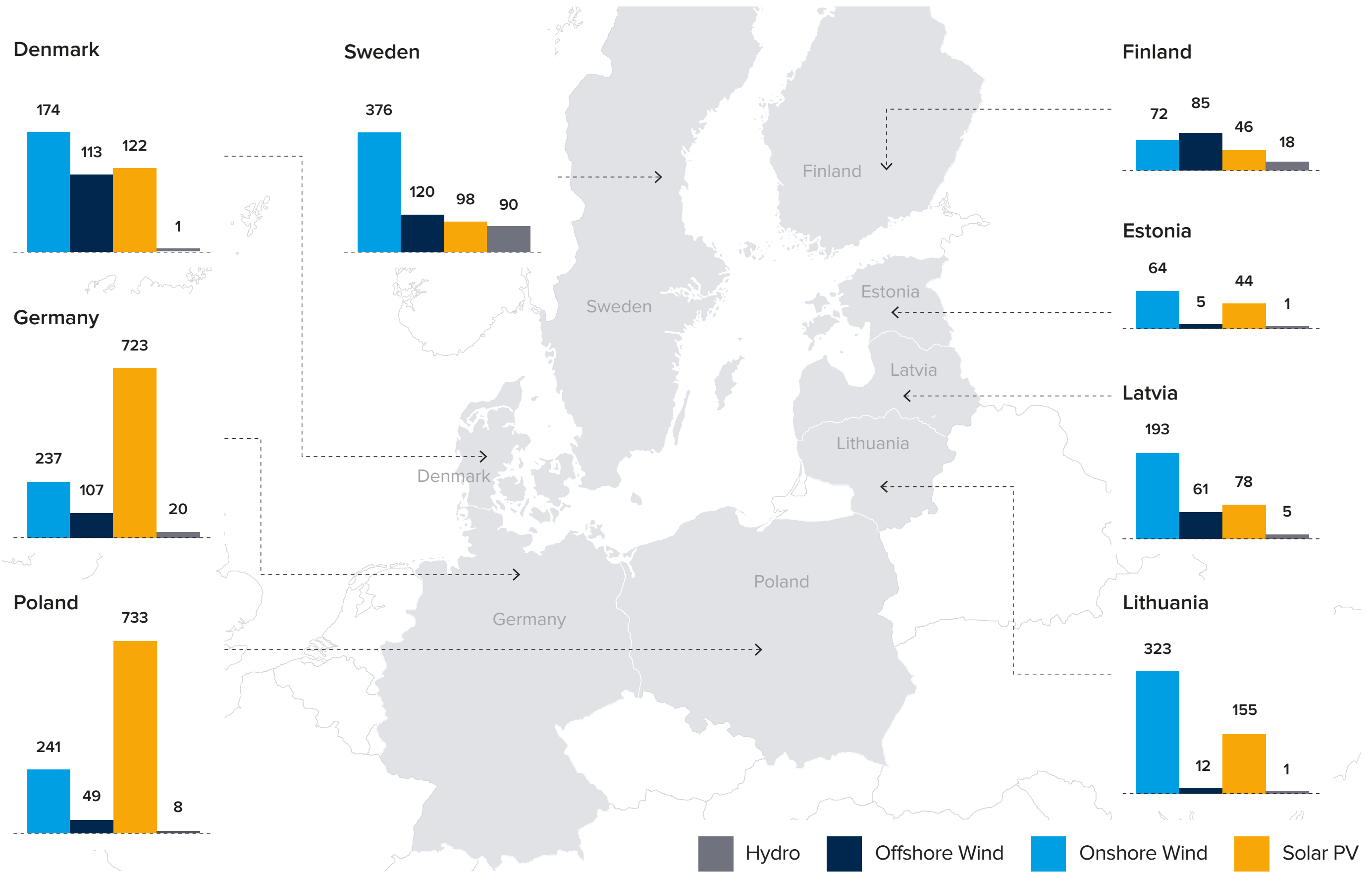
Poland and Germany are particularly notable for their significant solar potential. Their geographic positioning and climatic conditions see them best placed within the region.

The Baltic Sea's high wind speeds and shallow waters create suitable conditions for large-scale offshore wind projects. All 8 countries have significant potential with Sweden, Denmark and Germany each holding **>100TWh** of offshore wind potential.

Sweden, Lithuania, Poland & Germany lead the region in Onshore Wind potential.[17]

Sweden and Finland are unique in the region for their significant hydropower resources.[18]

Figure 17 **Baltic Sea Renewable Resource Potential** (TWh)



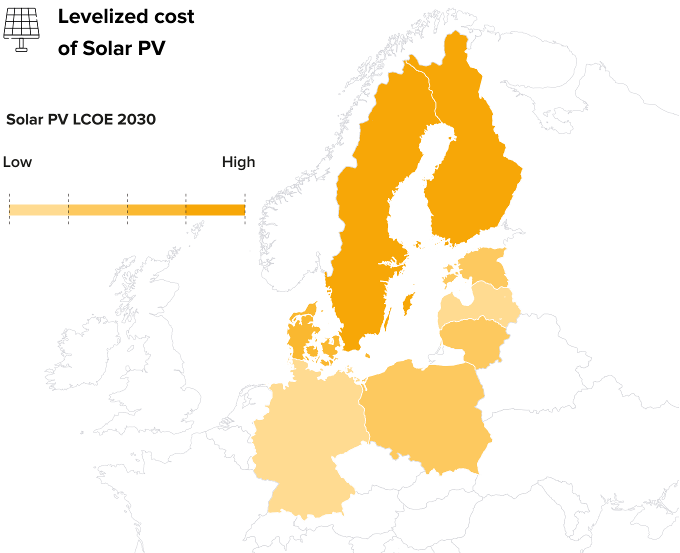
Source: S&P Global Commodity Insights

Cost differentials provide arbitrage opportunities across the countries in the region.

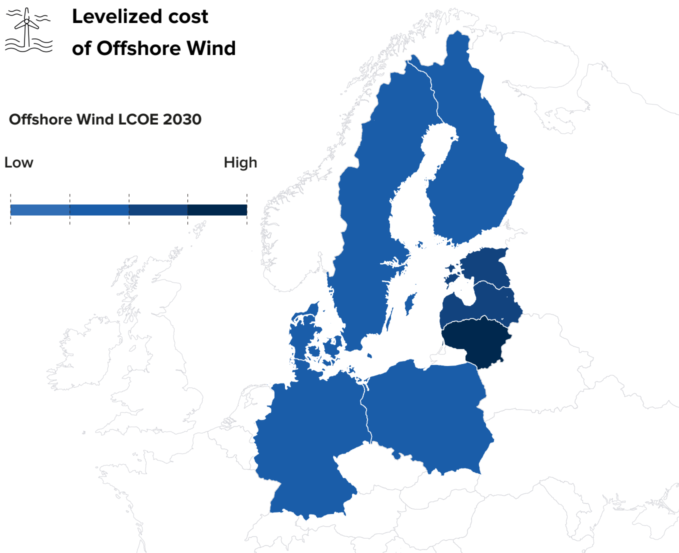
17. ijs, Wouter (2019): ENSPRESO - WIND - ONSHORE and OFFSHORE. European Commission, Joint Research Centre (JRC) [Dataset] PID: http://data.europa.eu/89h/6d0774ec-4fe5-4ca-3-8564-626f4927744e
18. SPGCI data

The following figure illustrates the projected variations in production costs for Solar PV, Offshore Wind, Hydropower, and Renewable Hydrogen across different countries for the year 2030.

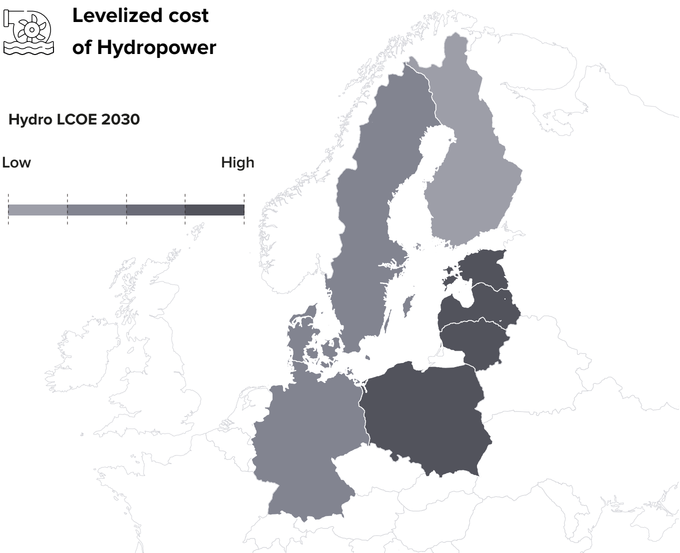
Figure 18 **The deviation from average[19] LCOE of renewable technologies in the Baltic Sea region**
(Indicative high and low €/MWh and €/kgH_2) [19]



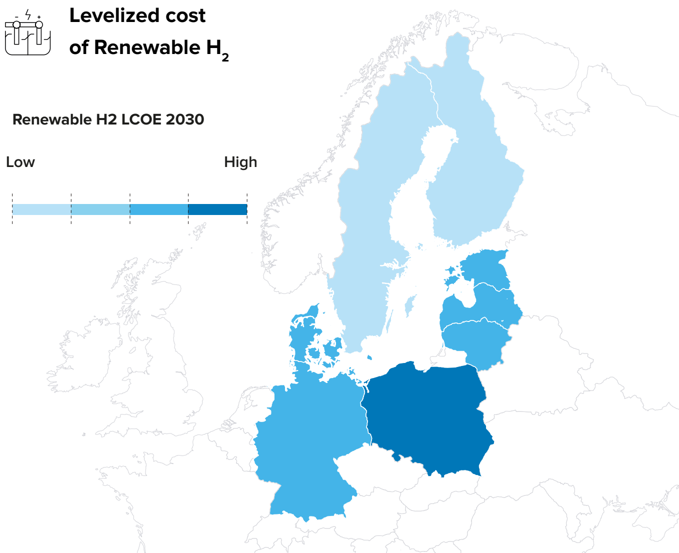
Germany and Latvia are amongst the most competitive for solar costs



Denmark and Germany lowest LCOEs, due to early entry info offshore wind and establishead supply chains



Sweden, Germany and Finland have low LCOE and additional production potential



Sweden and Finland are the cheapest, driven by availability of hydropower

Source: S&P Global Commodity Insights
19) Source: S&P research

The levelized cost of renewable energy in the region is shaped by various factors, including geographical location, historical investments, and natural resources.

As an example, Germany, Poland, Lithuania, Latvia and Estonia are the most competitive countries for solar power production in the region driven by latitude.

Whilst new hydropower construction is relatively expensive in comparison with other technologies, Sweden and Finland's significant hydropower resources can pro ide low-cost power at times of surplus to other countries within the region.

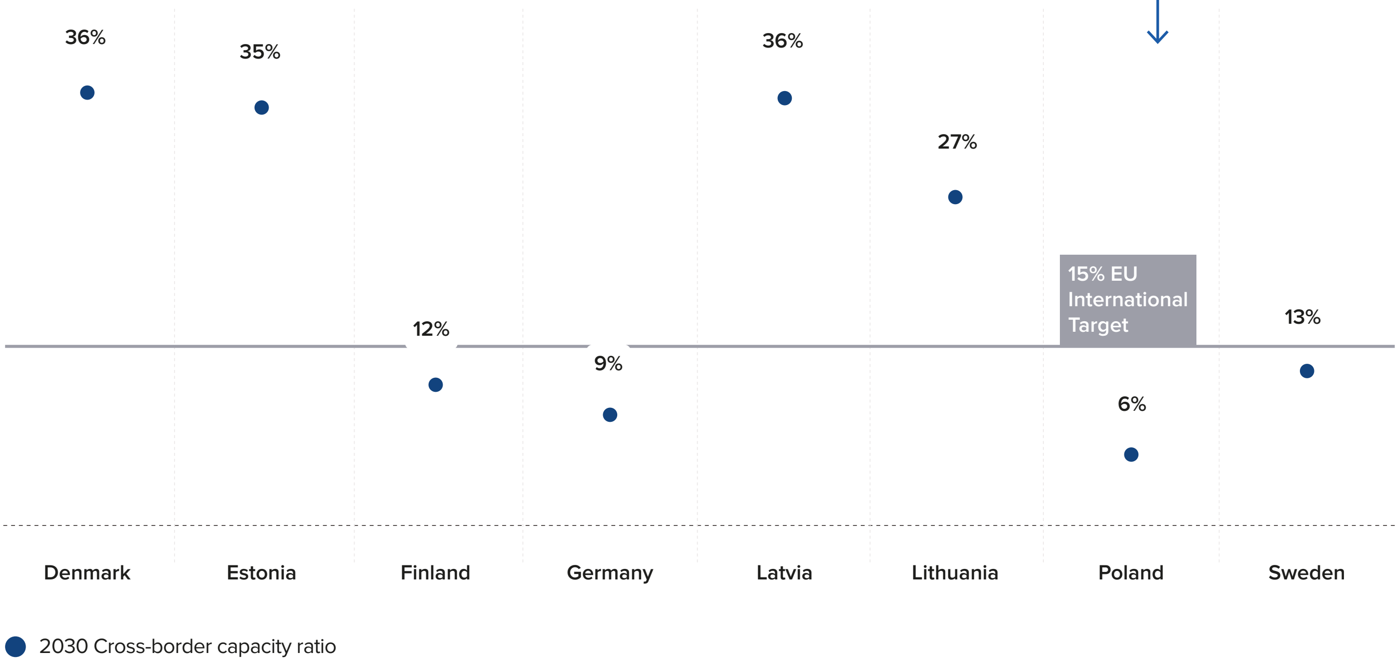
The difference in the levelized cost of energy for renewables also impacts renewable hydrogen production costs. Sweden and Finland are expected to be among the cheapest producers by 2030, thanks to high electrolyzer utilization rates driven by available hydropower.

Significant differences in production costs provides the opportunity for trade within the region to lower generation costs and support energy security. Availability of power interconnection capacity is a key enabler for this trade.

Countries in the region are behind the 15% EU power interconnection capacity ratio target. Additional interconnection capacity would be an enabler for decarbonisation and reduced power curtailment. Disagreements surrounding cost sharing and permitting delays are key challenges, but a joint working group focused on harmonizing processes and aligning on cost sharing would be a key enabler.

Figure 19

Cross border interconnection capacity ratio – 2030[20] (GW)

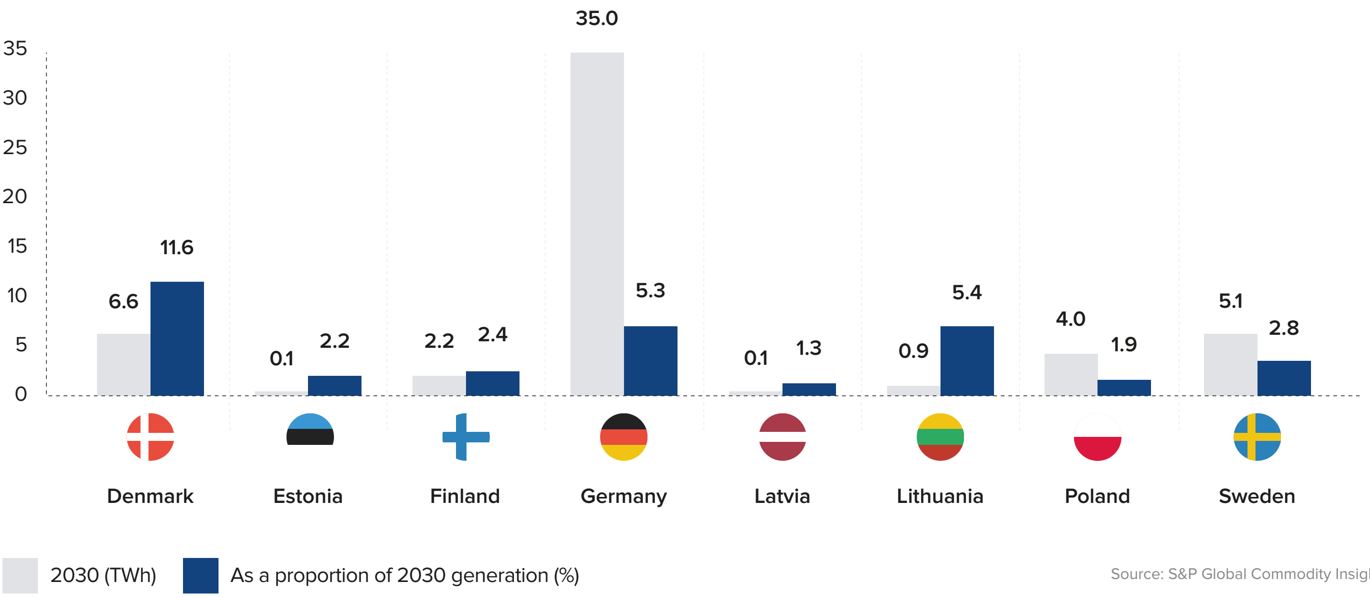


Finland, Germany, Poland, and **Sweden** are currently tracking behind the EU 2030 15% power interconnection capacity ratio target. This delay is attributable to a combination of technical, regulatory, and financial barriers including differing grid standards, high capital expenditure requirements and a lack of agreement on cross-border cost sharing. These challenges should be addressed to facilitate the timely achievement of interconnection goals.

Curtailment, the reduction of output from renewable energy sources due to grid constraints, significantly impacts the financial viability of renewable projects. When renewable energy cannot be fully utilized, it leads to lost revenue and reduced incentives for further investment in the sector. As shown in the figure below, projected curtailment could equate to 1.3%-11.6% of total 2030 power generation in each country.

20. Data source: S&P Global commissioning assumptions based on Entso-e TYNDP 2022. The cross-border capacity ratio is defined as the ratio between the import capacity and the total generation capacity, based on S&P Global forecast in 2030.

Figure 20 **Projected curtailment of renewables in 2030 (TWh) and as a proportion of total generation** (%)[21]



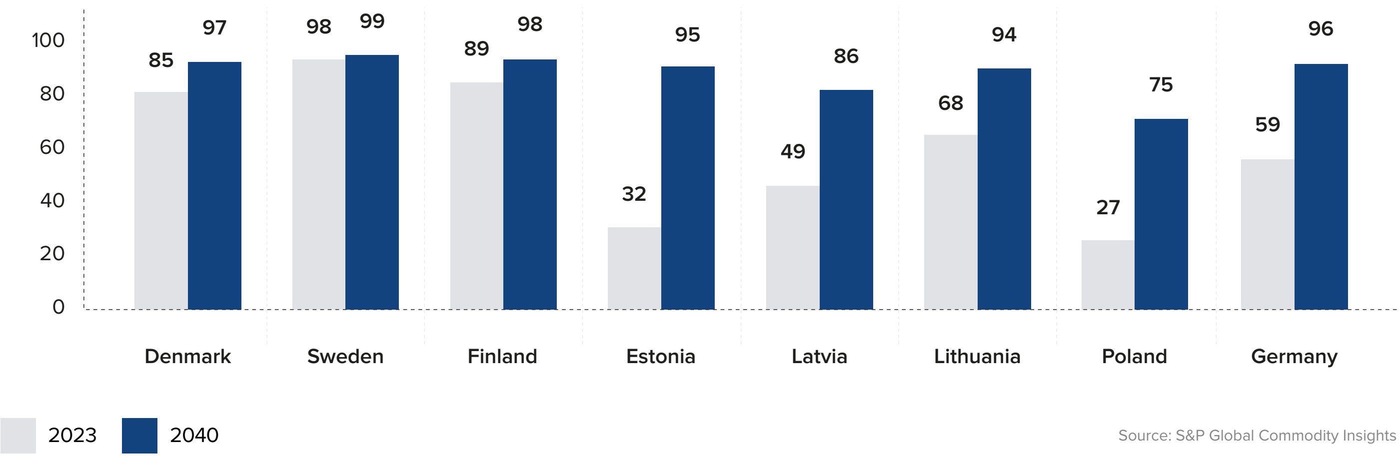
Source: S&P Global Commodity Insights

> Increasing proportions of renewable power and significant differences in weather patterns within the region strengthens the importance of power interconnectors.

Under S&P's power planning case, non-fossil-based generation is set to increase significantly across the region, **rising from ~600TWh in 2023 to >1550TWh in 2040 and an increase in proportion from 63% to 93%**. This increase in renewables generation brings increased variability in power supply, particularly given the planned integration of offshore wind projects in the region.

One effective solution to mitigate curtailment and enhance system flexibility is the expansion of cross-border transmission capacity. By improving the infrastructure for energy transmission between countries, the region can better balance supply and demand, reduce energy wastage, and support the integration of renewable energy sources into the grid.

Figure 21 **Non-Fossil based power generation as a proportion of total power supply** (%)[22]



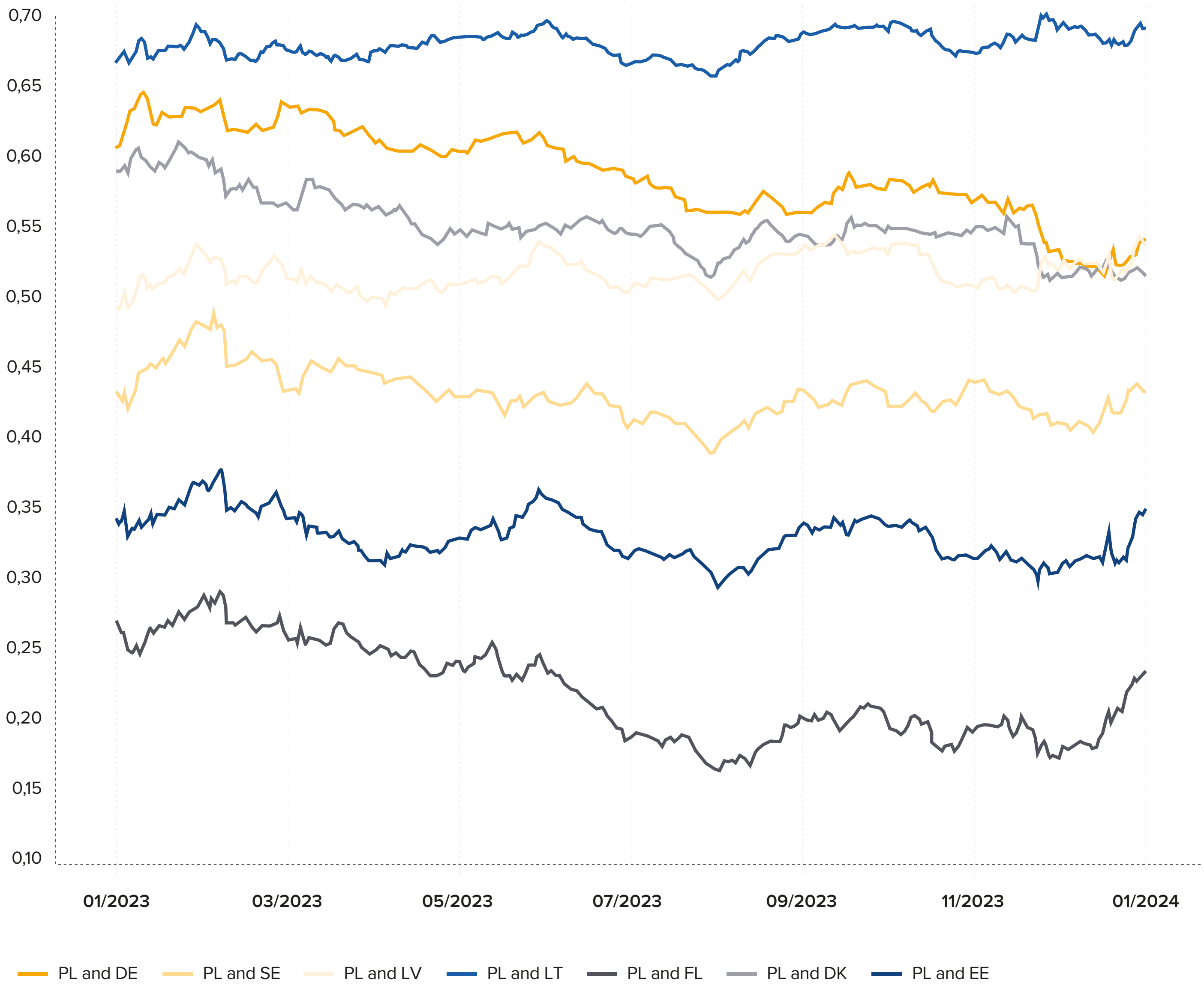
Source: S&P Global Commodity Insights

21. Curtailment of renewable electricity is calculated as the difference between the potential generation (based on the country's installed capacity) and the actual generation, considering interconnection capacity constraints. It takes into account only cross-border lines and not the internal infrastructure. Data source: S&P Global Planning Case.
22. Excludes Coal, Oil, Natural Gas and Other non-renewables.

Interconnectors will not always be available as a solution to curtailment, for instance when production profiles are similar in neighboring countries. However, wind production profiles are not uniform across the 8 countries and neighboring countries have wind speeds that are not directly correlated with each other. Poland/Germany and Poland/Lithuania for example only have a moderate correlation in wind profile, whilst there is limited correlation between Poland and other states as shown in the figure below.

Given the difference in weather patterns and renewables power production profiles, power interconnectors would provide the opportunity to trade electricity between countries within the region when there are significant differences in wind generation profiles.

Figure 22 **Wind speed correlation between Poland and other Baltic Sea countries** (2023)



Source: Copernicus Climate Change Service (2021): Climate and energy indicators for Europe from 2005 to 2100 derived from climate projections. Copernicus Climate Change Service (C3S) Climate Data Store (CDS). DOI: 10.24381/cds.f6951a62

Summary

Power Interconnectors

Key challenges to the development of power interconnectors in the region include:

- Lengthy and complex permitting processes delaying the approval and implementation of power interconnector projects.
- A lack of agreed cost-sharing mechanisms complicating collaboration between countries.
- High capital expenditure and constrained public resources, limiting access to finance for grid operators, this can deter transmission system operators from building interconnections.
- Country-specific differences in grid standards, systems integration, and technology are leading to delays.

The Kriegers Flak Combined Grid Solution provides an example of collaboration to facilitate power interconnections. It is a power interconnection project enabling 400MW of transfer capacity to be enabled between Denmark and Germany. The project involved collaboration and cost sharing between two transmission system operators (TSOs), Energinet and 50hertz, and was commissioned in 2020. Key enablers were:

Cost sharing between TSOs – With both TSOs owning equal shares in the asset, collaboration was fostered with reduced financial burden and risk on each shareholder.

Market design - The two TSOs jointly asked for a derogation from the European Union 70% power derogation rule[23], providing greater project flexibility.

Financing – Joint application for EU funding saw €150 million provided via the European Energy Programme for Recovery.

Key takeaways for the Baltic Sea region

- Agreement on cost sharing between TSOs can facilitate interconnector projects.

Collaboration opportunities in Power Interconnectors

A Baltic Sea working group developing a framework for cost sharing and harmonising permitting processes.

- Power interconnectors are a key enabler for transferring surplus power within the region and avoiding negative pricing.
- Interconnectors face challenges including disputes regarding cross-border cost sharing and 1-3 year permitting delays.
- A working group focused on developing a standardized framework for cost sharing on interconnection projects could reduce disputes across countries, setting guidance on how much each country should pay based upon type/length of interconnection.
- The group could also develop harmonized permitting processes for power interconnectors across the eight countries to facilitate faster approvals for interconnector projects within the region.

23. The EU power derogation rule refers to specific provisions within the European Union's regulatory framework that allow member states to temporarily deviate from certain EU energy market regulations under specific circumstances. This is particularly relevant in the context of ensuring energy security, promoting the integration of renewable energy sources, and addressing market failures. The derogation can be applied to various aspects of energy market regulations, such as capacity mechanisms, state aid rules, or the internal electricity market rules. It is often invoked to support investments in energy infrastructure or to maintain the reliability of supply in situations where market conditions do not adequately incentivize such investments. For example, the European Commission may grant derogations to member states that face unique challenges, allowing them to implement measures that would otherwise conflict with EU regulations, provided these measures are justified and aligned with the broader objectives of the EU energy policy.

04.

Conclusion

The analysis provided in this paper provides the rationale for collaboration within the Baltic Sea region. The Baltic Sea region holds significant resource potential and lies at the forefront of EU decarbonization and energy security goals. Differences in renewable power and hydrogen prices within the region presents opportunities for trade for the mutual benefit of all countries within the region.

The proposed collaboration opportunities from joint subsurface mapping to hydrogen auctions and maritime spatial planning are designed to unlock the region's potential and promote further engagement between public and private sector entities. Whilst actions at a national level will remain key, collaboration within the region can provide a route around challenges and support the decarbonization and energy security of the region.

Conclusion

Appendix

Key regulations and policies

EU Green Deal - The EU Green Deal is a comprehensive policy initiative launched by the European Union aimed at making Europe the first climate-neutral continent by 2050. It encompasses a range of strategies to reduce greenhouse gas emissions, promote sustainable economic growth, and enhance biodiversity
Fit for 55 - Fit for 55 refers to a package of measures targeting a reduction in net greenhouse gases by at least 55% by 2030 from 1990 levels.

REPOWEREU – REPowerEU is an initiative by the European Union aimed at reducing dependence on fossil fuels, particularly in light of the energy crisis exacerbated by geopolitical tensions. Launched in May 2022, it focuses on accelerating the transition to renewable energy sources and enhancing energy efficiency across member states.

ETS 1 & 2 - The EU Emissions Trading Scheme (EU ETS) is a key component of the European Union's climate policy, established to reduce greenhouse gas emissions cost-effectively. Launched in 2005, it operates on a "cap-and-trade" principle, where a limit (cap) is set on the total emissions from specific sectors, such as power generation and heavy industry. EU ETS 2 aims to cover emissions from buildings and road transport, sectors previously outside the original EU ETS framework.

CBAM - The Carbon Border Adjustment Mechanism (CBAM) is a policy proposed by the European Union to address carbon leakage and ensure a level playing field for EU industries. Set to be implemented in 2023, CBAM aims to impose a carbon price on imports of certain goods from non-EU countries that do not have equivalent carbon pricing mechanisms.

RED III - The Renewable Energy Directive III, is part of the European Union's legislative framework aimed at promoting the use of renewable energy sources. It is a revision of the previous directives and is designed to further increase the share of renewables in the EU's energy mix, targeting a binding renewable energy target of at least 42.5% by 2030, aiming for 45%.

Net Zero Industry Act - The Net Zero Industry Act is a legislative proposal by the European Union aimed at accelerating the transition to a net-zero economy by promoting the development and deployment of clean technologies. Introduced in early 2023, the Act focuses on enhancing the EU's industrial capacity to produce renewable energy technologies, such as solar panels, wind turbines, batteries, and hydrogen production equipment.

Regional emissions

Power

Emissions in power generation are **41% below 1990 levels** but continue to account for a quarter of all emissions in the region. The reduction of coal-fired power generation in Denmark, Estonia, Germany, and Poland provides significant scope for further potential emissions reductions. **Offshore Wind** and **Power Interconnectors** are key collaboration areas that can facilitate the reduction of emissions within the sector.

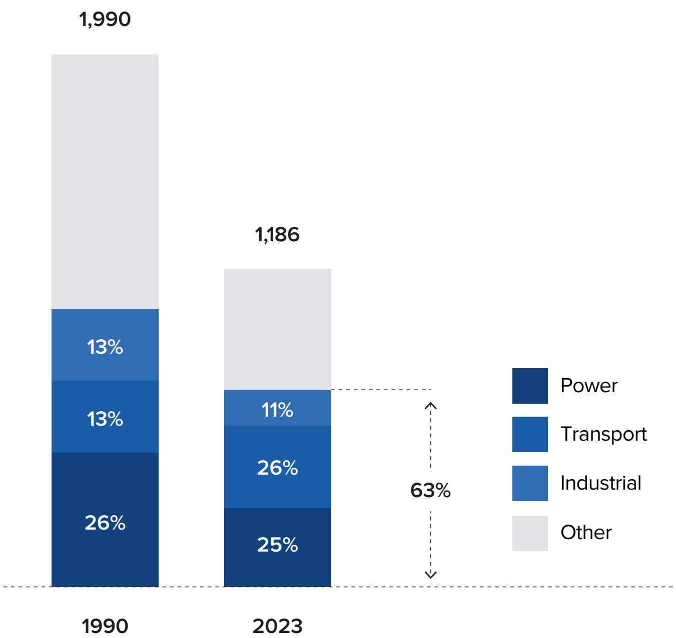
Transportation

Emissions from transportation are now **16% above 1990 levels**, with the sector accounting for **twice** the proportion of emissions it did in 1990. While electric vehicles have a key role to play in decarbonizing light duty vehicles, **hydrogen and derivatives** including ammonia, methanol and E-fuels offer a key decarbonisation route for heavy duty vehicles, maritime and aviation

Industry

Industrial emissions are now **49% below 1990 levels**. For hard to abate sectors such as Cement, Refining, Chemicals and Steel, **CCUS** offers a key decarbonization option alongside **hydrogen and derivatives**.

Figure 23 **Total emissions in the Baltic Sea states by sector** (Million Tonne CO_2e)



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The data and graphs shown in the report was calculated and generated in November 2024. Baltic Power - ORLEN's offshore project was updated to "construction" phase.

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