Deep-dive study on energy security

Draft report published for public commenting in connection with OG21 Forum

10.11.2023 (Commenting is open until 16.12.2023)

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Rystad Energy's mandate has been to identify threats to the Norwegian security of supply given the importance to European energy security

Rystad Energy's mandate from OG21

Two strategic questions:

1. How important is Norwegian energy supply for the European energy security?

2. How important is technology that is being developed and implemented to secure reliable Norwegian energy supply, for maintaining and improving European energy security?

Project objective:

Identify threats to the energy supply from the NCS needed to meet demand during the energy transition in Europe and describe how the Norwegian O&G sector can contribute with technology and knowledge to eliminate, mitigate, or manage such threats.

Implications for this report

- The project objective has been to identify threats to Norwegian security of supply for European energy security.
- All evaluations and suggested actions throughout the report are given considering the Norwegian security of supply to Europe.
- EU and UK published forecast has been used as a basis for European demand to 2040.
- This report's aim is to point to threats and mitigation levers for the security of Norwegian energy supply to Europe. Other factors of importance exist that policymakers, operators, supply chain companies, research institutes and universities must consider in decision-making. To the degree that these factors have limited impact on the security of Norwegian energy supply to Europe, they have been given limited weight in this report . However, it is important to state that this report argues that a holistic view on the Norwegian energy system is critical for the security of supply to Europe.

Source: Rystad Energy research and analysis; OG21

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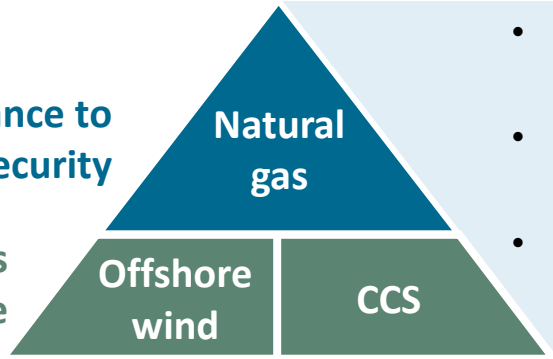
Norwegian security of supply has an important role in maintaining European energy security

Critical importance to European energy security

Key enablers of gas deliveries to Europe



- **Norwegian gas deliveries to Europe, present and in the future, account for 25-30% of European gas demand and is of vital importance to European energy security.**
- **Offshore wind is key to enable electrification of O&G facilities to reach climate targets in a fragile national power balance, and with future export potential long term.**
- **CCS, by developing transport infrastructure and storage in Norway enables decarbonized natural gas value chains in Europe and provides a pathway to reach European emission targets.**

Four key action points to retain Norwegian security of supply to Europe

1. **Need of a holistic energy roadmap for Norway**

Lack of integrated energy system planning is the most prominent threat towards Norwegian security of supply contributing to European energy security. A holistic energy roadmap with clear targets and prioritization of both energy supply and demand sources, stable and predictable regulatory frameworks, and a clear pathway to reach ambitions bringing clarity to financial incentives can contribute to reduce uncertainties improving Norwegian security of supply.

2. **Call for surveillance technologies, risk competence and new work processes to combat security treats**

Physical and cyber threats towards energy infrastructure is of high importance. Developing competence to benefit from synergies with existing operational activities and maintenance work processes to identify anomalies including inspections and data-gathering, can contribute to improved protection. Improved risk management and understanding through competence and technology development can contribute to creating resilience in protection.

3. **Digital tools needed to solve for resource constraints**

Digital toolsets will play an increasingly important role in O&G, using digital tools on growing and higher quality datasets to improve efficiencies to offset resource constraints for STEM professionals. Continued development of existing workforce and attraction of graduates is also of high importance.

4. **More collaborative efforts across energy verticals needed**

Collaboration across energy verticals will be of high importance. The O&G industry, through its significant emissions and large power demand, has an added responsibility to contribute to commercializing the Norwegian offshore wind industry through collaboration, integrated electrification projects, competence and technology development.

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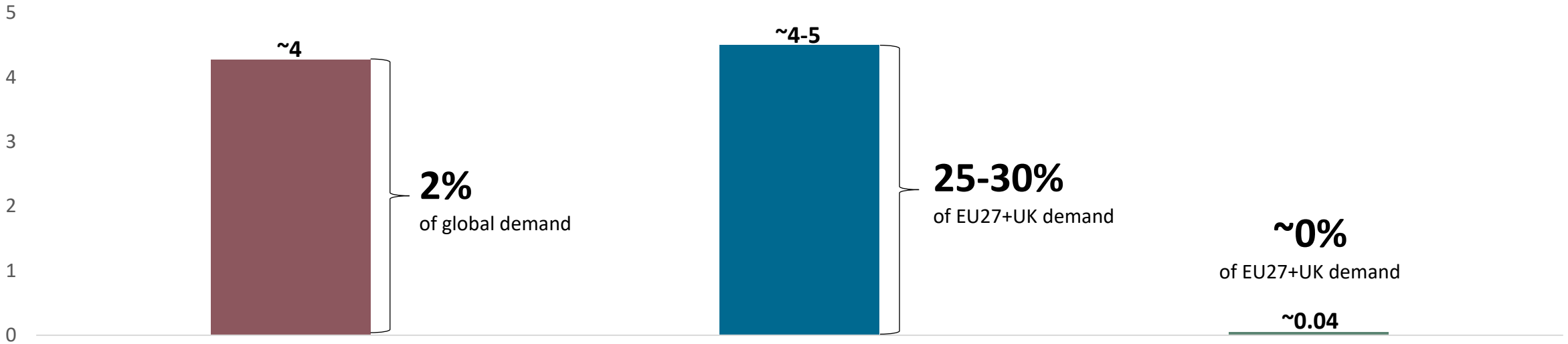
Norwegian gas export is crucial for Europe while export of oil and power is replaceable

Norwegian 2022 energy export split by source*
Exajoule



Oil

Norwegian oil production constitutes about **2% of global demand** for crude oil and sold in global market. Although a significant producer, Norwegian oil production is less impact on European energy security than gas.

Natural gas

In the past years, Norwegian natural gas export has covered between **25-30% of EU27+UK** gas consumption. This share is likely to increase going forward. Norway is the third largest natural gas exporter after Russia and Qatar.

Power

In 2022, Norway produced 144 TWh and had a **net export of about 12 TWh**, constituting about 8% of total generation. This is very small volumes from a European perspective. Norway exports most power to Denmark, Sweden and Germany.

* Power is converted from TWh to EJ using a conversion factor of TWh = 0.0036 EJ.
Source: Rystad Energy research and analysis; Rystad Energy UCube; Norsk Petroleum; Statnett

Norwegian natural gas deliveries is key for European energy security, while offshore wind and CCS are key enablers to ensure future natural gas production

Natural gas, offshore wind and CCS are important for European energy security

Key importance for European energy security

Key enablers for European energy security

Natural gas

- Norwegian gas deliveries are key to maintain European energy security in the short-term and enable a just transition in the long-term, given that Norwegian gas exports to Europe currently accounts for 25-30% of total European gas demand.
- Gas production from existing fields is expected to decline 55% towards 2040, making gas exploration and new developments important for European energy security.
- Europe is expected to be reliant on gas longer term, given current policies.

Offshore wind

- Offshore wind is a key enabler for access to electricity to continue abating emissions from O&G facilities on the NCS, and a potential new source of energy exports for Norway in the long run.
- The O&G industry, through its significant emissions and large power demand, has a role to play to contribute to commercializing the floating wind industry through electrification projects, technology development and investments.
- Closing the funding gap in industrialization of floating offshore wind will be important.

CCS

- CCS has an important role in reducing European emissions related to natural gas consumption from industrial clusters and gas power generation.
- Developing infrastructure and offshore carbon storages in Norway to handle European emissions is a key enabler for continued Norwegian gas deliveries to Europe, taking responsibility of scope 3 emissions. It is also an opportunity to Norway as an early mover to capture market shares from European emissions.
- The O&G industry is an important contributor for competence and technology development in CCS.

Source: Rystad Energy research and analysis

Decarbonization of Norwegian gas through blue hydrogen or gas-to-power will risk European energy security

Oil and hydrogen exports are not of particular importance for European energy security

Oil

Norwegian oil production constitutes of about 2% of global demand. Oil is a global commodity and Norwegian volumes are as such not of key importance to European energy security. However, oil production and exports are important to the Norwegian economy. Producing gas from gas-condensate and oil fields with associated gas is not possible without also producing oil, condensate and NGLs.

Blue hydrogen

Blue hydrogen production in Norway in the short to medium term adds to the risk of European energy shortage due to losses involved in conversion and use, impacting total energy volumes exported. Europe needs to move from energy scarcity to energy surplus before blue hydrogen should be considered. Also, EU policies only consider blue hydrogen as a transition fuel, with green hydrogen as the long-term solution.

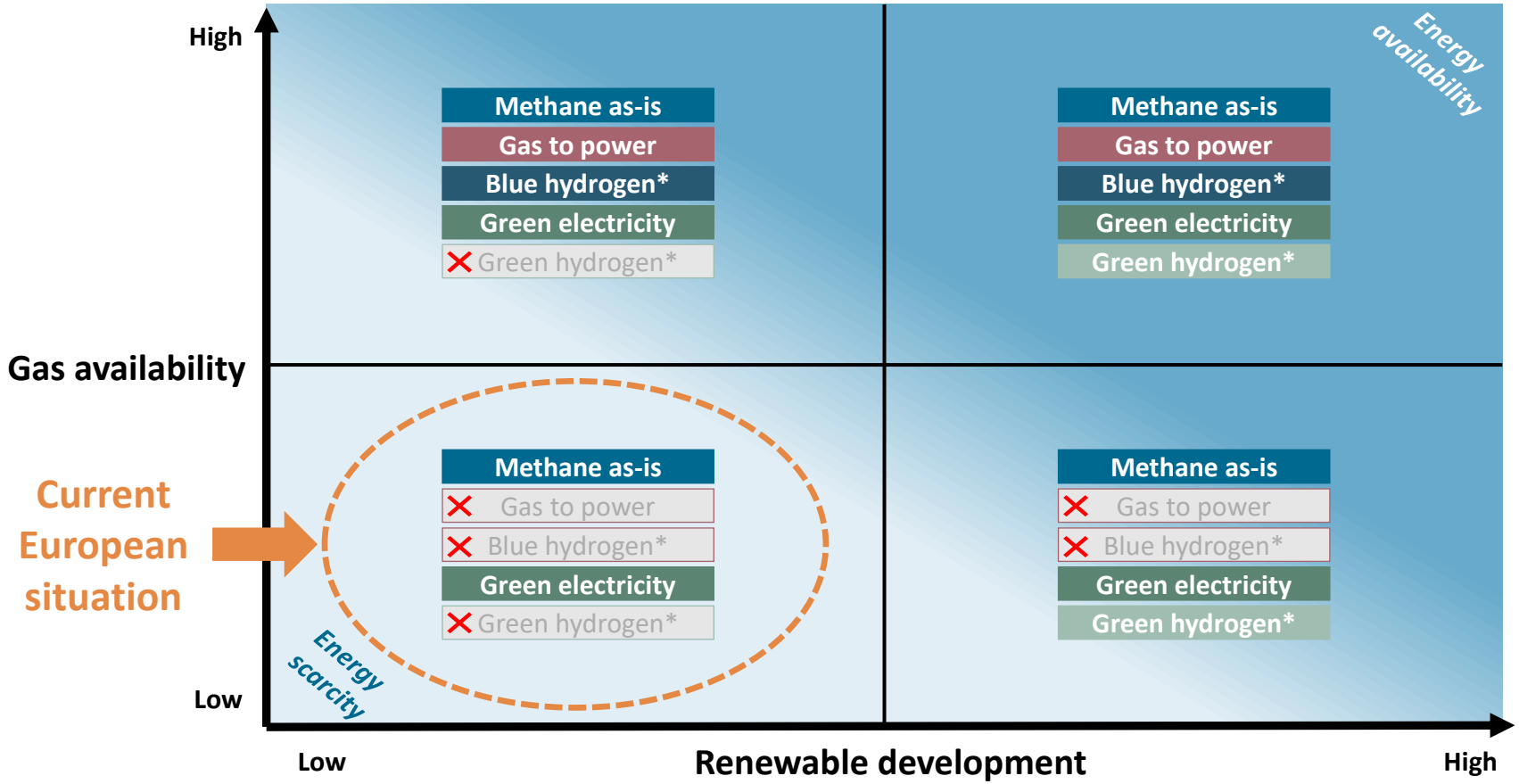
Green hydrogen

The Norwegian power balance is at risk towards 2030 without added energy production. Hence, there is limited room for green hydrogen production short- to medium term. Export potential is present long-term, as EU policies outline ambitions to import green hydrogen. However, Norwegian volumes will potentially compete against giga-setups with of lower-cost renewable power as input factors

Source: Rystad Energy research and analysis

Exporting converted energy resources is only feasible if energy is not scarce in Europe

Norwegian energy export depending on European gas availability and renewable development**



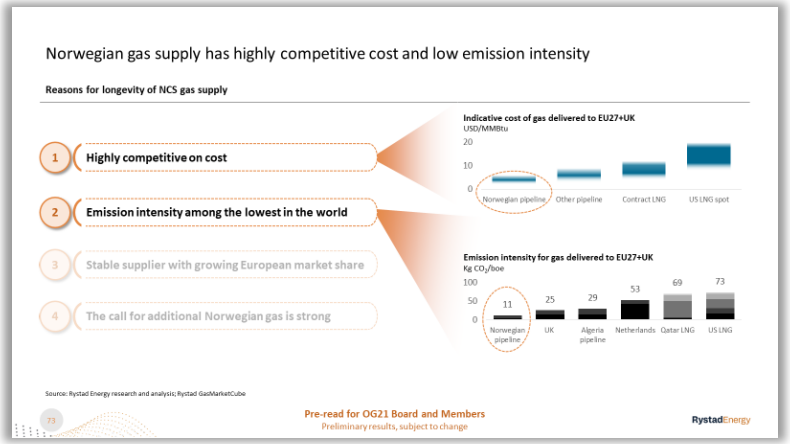
- Europe is currently facing energy security concerns. The diagram to the left illustrates the rationale for exporting different energy carriers from Norway to Europe, depending on energy availability.
- In a situation with constrained gas supply to Europe, methane should be exported as-is, as methane has the highest end-use potential. Converting gas to other energy carriers, such as blue hydrogen and power before export, should be avoided as this lowers the energy quality and leads to less efficient end use.
- In a situation with constrained access to renewable electricity, converting green electricity to green hydrogen before export is suboptimal as green hydrogen is a lower quality energy carrier with less efficient end use.

* Blue and green hydrogen produced in Norway.; ** Red cross indicates that it is not rational to convert gas or renewable electricity to a different energy carrier before export.
Source: Rystad Energy research and analysis

Norwegian gas supply is highly competitive and will be indispensable to EU and UK going forward

Norwegian gas competitiveness compared to other sources of supply to Europe

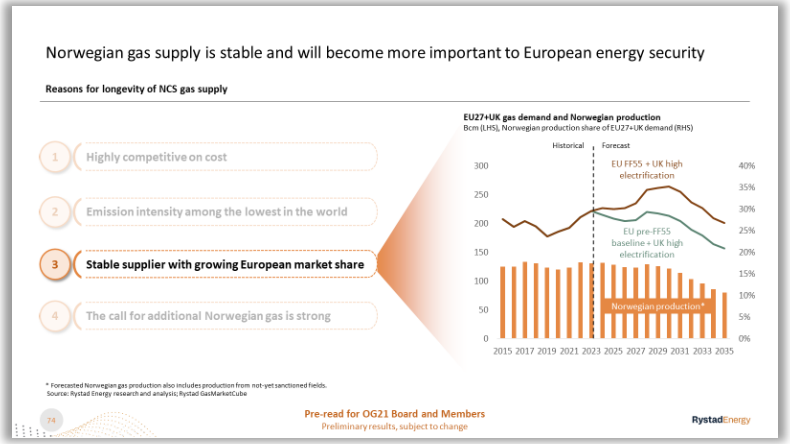
Best in class on cost and emissions intensity



Norwegian pipeline supply to EU and UK will remain **highly cost competitive compared to other supply sources** going forward.

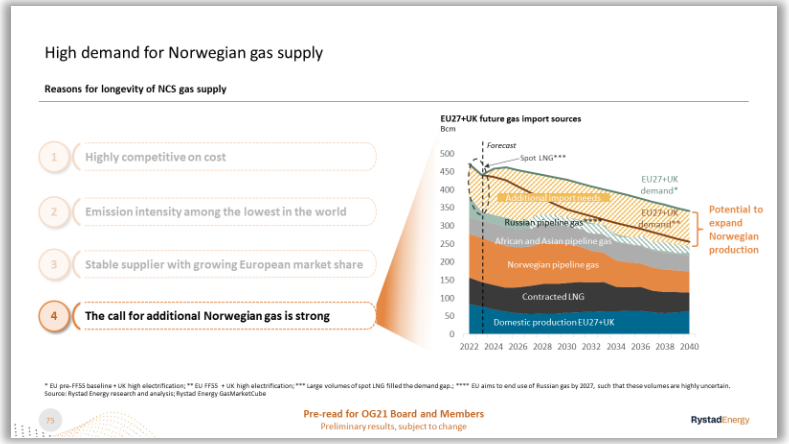
In addition, Norwegian pipeline gas delivered to EU and UK has among the **lowest emission intensities** in the world.

Stable supplier with growing market share



Historically, Norway has been a stable supplier of gas to continental Europe. Norwegian gas supply's European market share is expected to grow in the coming years.

Call for additional Norwegian supply is strong



With declining domestic gas production and loss of Russian gas, the **EU and UK will depend on significant volumes of gas import going forward even in aggressive transition scenarios**.

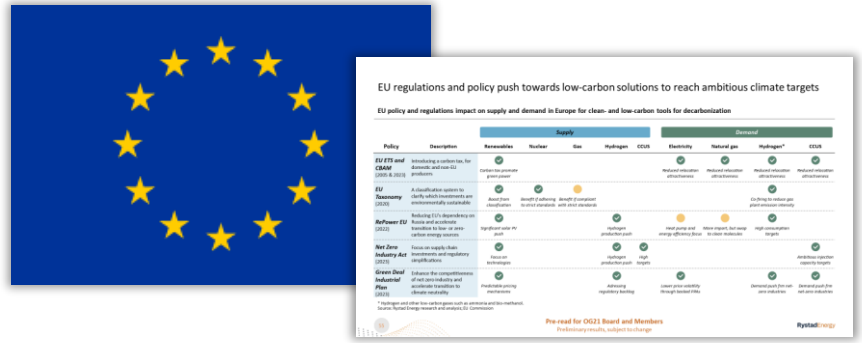
As **Norwegian gas supply is cost competitive, has low emission intensity and is reliable**, the call for Norwegian gas volumes will remain strong both for existing fields, development of new discoveries and exploration.

Source: Rystad Energy research and analysis

Norwegian competitiveness alleviates uncertainties in the future power mix and supply sources

Factors potentially impacting future European gas dynamics and demand for Norwegian gas

Uncertainties in European power mix development

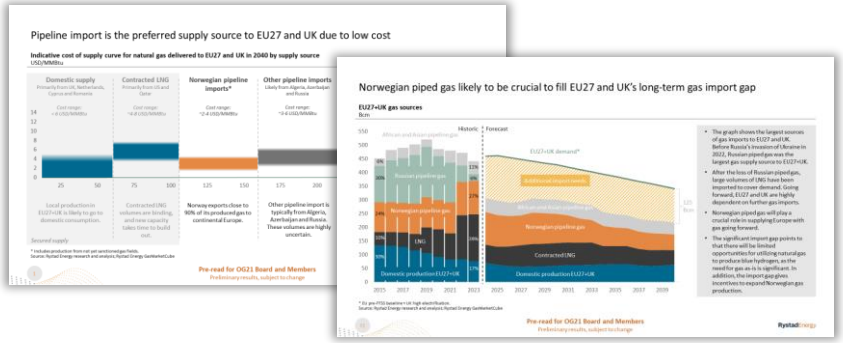


EU policies primarily prioritize development of renewables, while the outlook for nuclear power is uncertain.

EU policies are viewed as the most likely outcome, and competition from nuclear is not viewed as a likely threat to Norwegian gas supply. Even though the European power mix development is an uncertainty factor to future gas demand, other gas sources are expected to be outcompeted prior to Norwegian supplies.

Development of nuclear power presents significant challenges. At this stage, nuclear is far from commercial compared to renewables, the cost of safety and security measures is hard to scale and SMR is still immature, but with potential In addition, renewables are not ideal to combine with nuclear due to lack of flexible/dispatchable power sources.

Uncertainties in other gas supply sources



If European gas demand becomes lower than EU and UK government targets, Norwegian gas and other pipeline sources will likely dominate over LNG and other less competitive suppliers due to their cost and emissions advantages.

Significantly improved relationship with Russia may reintroduce Russian gas into the European market, potentially displacing marginal volumes like LNG rather than Norwegian gas. Russian gas imports rely on Nord Stream, which may not be rebuilt, and any reconstruction would likely take 3-5 years.

Thus, Rystad Energy does not consider other supply sources as a significant threat to Norwegian gas supply going forward.

Source: Rystad Energy research and analysis

Overview of threats to Norwegian energy supply for European energy security

Theme	Threat	Threat description
Regulatory and social license to operate	**Skewed understanding of energy security consequences in the public energy transition discourse**	*Public opinion on energy production impacts future policy development and social lciense to operate, referring to e.g. onshore wind or O&G exploration.*
	Increasing emission intensity of a maturing NCS	*Higher overall emissions intensity due to tail production going forward. These volumes can be at risk due to emission reduction targets.*
	Uncertainties in regulatory framework for the future of O&G	*Regulatory uncertainty related to future developments, exploration licenses and phase-out strategy.*
	Uncertainties in regulatory framework for new industries	*Regulatory uncertainty related to support schemes, contract structures, subsidies, tax regimes,national strategy related to energy exports, etc.*
	Major accidents related to maturing NCS	*Infrastructure reaching design lifetime can lead to increased risk of serious accidents with high impact on social license to operate.*
Financials	**Financials and innovation support affecting the development of new industries**	*Uncertainties related to support schemes, in addition to limited R&D funding in commercialization can affect speed of development of new industries.*
	Access to external capital in the O&G industry	*Banks are restricting funding to O&G due to increased focus on ESG.*
Security	**Lack of protection against cyber attacks**	*Technology development in the O&G sector increases risk of cyber attacks.*
	Lack of protection against physical attacks	*Norwegian O&G infrastructure exposure to physical attacks.*
Access to competence	**Challenges related to recruitment of STEM professionals**	*The competition for STEM professionals is expected to be harder going forward.*
	Challenges related to recruitment to STEM studies at the universities	*Educating the required number of STEM professionals is likely an increasing challenge going forward.*
Supply chain	**Bottlenecks in supply chain caused by geopolitical dependencies**	*Geopolitical tensions causes increased risk in supply chain with potential bottlenecks caused by trade wars and following price increases.*

Source: Rystad Energy research and analysis

Overall evaluation of threats to Norwegian energy supply in light of European energy security

Theme	Threat	Evaluation
Regulatory and social license to operate	**Skewed understanding of energy security consequences in the public energy transition discourse**	Lack of fact-based energy transition discourse today can have a large impact on Norwegian energy exports in the long term.
	Increasing emission intensity of a maturing NCS	Increasing emission intensity may challenge the social license to operate, potentially impacting future Norwegian energy exports.
	Uncertainties in regulatory framework for the future of O&G	Slows down investment decisions both on new projects and emission reduction measures, with potential large impact.
	Uncertainties in regulatory framework for new industries	Regulatory uncertainty slows down renewables development, which has low export impact, but affects electrification of O&G.
	Major accidents related to maturing NCS	A major accident would potentially impact the social license to operate, but the likelihood is still considered very low.
Financials	**Financials and innovation support affecting the development of new industries**	Potentially large impact on development of offshore wind and CCS in Norway, which also affects e.g. O&G electrification.
	Access to external capital in the O&G industry	Restrictions to O&G financing mainly impacts smaller companies, but can have large impact on exploration activity.
Security	**Lack of protection against cyber attacks**	Likelihood of high-impact attack is relatively small, but potential volume effect and HSE risk can be significant.
	Lack of protection against physical attacks	The likelihood of such an event is considered very low, but with potential fatal consequences to export volumes.
Access to competence	**Challenges related to recruitment of STEM professionals**	O&G already struggles to attract STEM professionals in competition with other industries, limiting future O&G activity.
	Challenges related to recruitment to STEM studies at the universities	Already observing less interest and capacity for STEM education, which can impact long term energy volumes.
Supply chain	**Bottlenecks in supply chain caused by geopolitical dependencies**	High concentration and geopolitical tension increases likelihood, with a moderate potential effect on energy volumes.

Source: Rystad Energy research and analysis

The mitigations address the presented threats to the energy security

		Regulatory and social license to operate					Financials		Security		Access to competence		Supply chain
Category	**Mitigation**	Skewed understanding of energy security consequences in the public energy transition discourse	Increasing emission intensity of a maturing NCS	Uncertainties in regulatory framework for O&G	Uncertainties in regulatory framework for new industries	Major accidents related to maturing NCS	Financials and innovation support affecting the development of new industries	Access to external capital in the O&G industry	Lack of protection against cyber attacks	Lack of protection against physical attacks	Challenges related to recruitment of STEM professionals	Challenges related to recruitment of STEM studies at the universities	Bottlenecks in supply chain caused by geopolitics
Technology	**Technologies for emission reduction**		■										
Technology	**Technologies for industrializing floating offshore wind**		■				■						
Technology	**Technologies for increased production from existing fields**		■										
Technology	**Smart engineering to reduce future needs for STEM professionals**					■					■	■	
Technology	**Technologies for improved infrastructure surveillance**					■			■	■			
Competence	**Better risk understanding and management**	■		■	■	■			■	■			
Competence	**Improve competence on AI, big data and machine learning applications in O&G**		■			■			■	■	■	■	
Competence	**Improve competence on circular economy**		■										■
Competence	**Improve collaboration with universities and academia to ensure future competence needs are met**		■			■			■	■	■	■	■
Communication	**Communicate the need for training and developing the existing workforce**										■	■	
Communication	**Communicate the need for a holistic energy roadmap**	■	■	■	■	■	■	■			■	■	■
Communication	**Collaborative modes across energy system verticals**	■	■	■	■		■				■	■	
Communication	**Communicate need for addressing funding in industrialization of offshore wind**		■		■		■						■

Source: Rystad Energy research and analysis; OG21 Workshop

■ Mitigation option relevant to reduce risk from threat

A holistic energy roadmap works as an enabler to help mitigate many of the identified threats

		Regulatory and social license to operate					Financials		Security		Access to competence		Supply chain
Category	**Mitigation**	Skewed understanding of energy security consequences in the public energy transition discourse	Increasing emission intensity of a maturing NCS	Uncertainties in regulatory framework for O&G	Uncertainties in regulatory framework for new industries	Major accidents related to maturing NCS	Financials and innovation support affecting the development of new industries	Access to external capital in the O&G industry	Lack of protection against cyber attacks	Lack of protection against physical attacks	Challenges related to recruitment of STEM professionals	Challenges related to recruitment of STEM studies at the universities	Bottlenecks in supply chain caused by geopolitics
Competence	Improve competence on circular economy												
Competence	Improve collaboration with universities and academia to ensure future competence needs are met								■	■			
Communication	Communicate the need for training and developing the existing workforce												
Communication	**Communicate the need for a holistic energy roadmap**	■	■	■	■	■	■	■			■	■	■
Communication	Collaborative modes across energy system verticals	■	■	■	■		■				■	■	
Communication	Communicate need for addressing funding in industrialization of offshore wind		■		■		■						■

A holistic energy roadmap is key to address uncertainties in most of the identified threats and can act as an enabler for other mitigations.

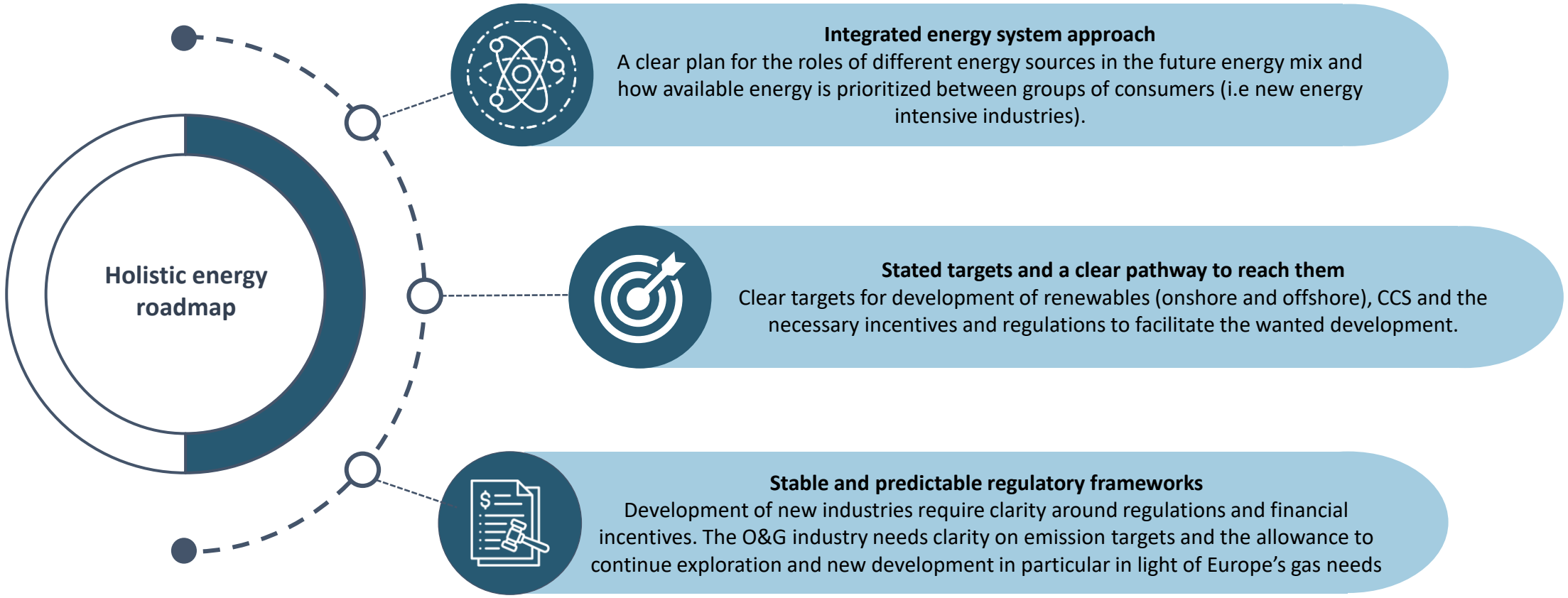
- *There is a clear need of an integrated energy system approach, instead of planning for the different energy verticals separately as they are inter-dependent*
- *OG21, together with other important stakeholders like Energy21, has a role in communicating the importance and need of a holistic energy system approach, as well as providing fact-based information on technology and competence development needs in order to achieve targets and ambitions.*
- *A holistic energy roadmap is an important tool to mitigate risks related to uncertainties in regulatory framework for both O&G and new industries by creating comfort around the regulatory and social license to operate giving clarity around the ambitions on role of the different energy sources in the future energy system, including exploration for gas.*
- *Such clarity would also enable planning and competence development according to future needs, reducing recruiting challenges, development of domestic supply chains and a clear mandate for new financial mechanisms and innovation support for new technologies/industries through stable and predictable frameworks.*

■ Mitigation option relevant to reduce risk from threat

Source: Rystad Energy research and analysis; OG21 Workshop

A holistic energy roadmap needs to plan for a future integrated energy system

Illustration of what the holistic energy roadmap should cover



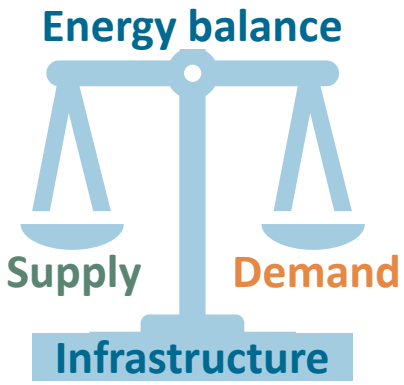
Source: Rystad Energy research and analysis

Planning for the future energy system involves a clear pathway for all components

A holistic energy roadmap needs to include a clear pathway for all components in the domestic energy balance

Supply

- Future energy system planning need clear targets on primary energy production: oil, gas and electricity.
- Ambitions on energy carrier level also need to be clearly stated, prioritizing between oil, gas, electricity, blue hydrogen, green hydrogen and CCS.
- The necessary primary energy production is a function of domestic energy demand needed to meet emission targets and export ambitions, but also of the losses defined by the energy carriers used to deliver the primary energy.
- Ambitions related to import reliance affect the need for domestic production and is an important component in the future energy balance.
- The supply side of the equation must consider daily, weekly and seasonal variations in energy production levels. In addition, balancing different energy sources and weather systems is key to avoid unnecessary storage demand and potential losses for Norway and possibly also for Europe.



Infrastructure

The targets and prioritizations give implications for the infrastructure required to distribute and balance the energy system. Some examples:

- Export of electricity requires significant new interconnector capacity and potentially a North Sea grid to balance offshore energy production and demand.
- New gas infrastructure like the Barents pipeline is an important measure to unlock new gas volumes.
- Prioritization amongst competing energy carriers for repurposing of gas infrastructure, relevant for both blue and green hydrogen, as well as CO2.

Demand = Domestic use + Exports

- Future energy system planning needs clear targets and prioritization between energy for domestic use and energy exports. This is a balance of pathways to provide the highest national GDP, employment considerations, climate targets and other societal factors.

Domestic use

- Ambitions includes prioritizing which consumers and industries have the right to access new consumption, including prioritization between electrification of O&G, new energy intensive industries*, etc.
- The availability of cheap and reliable energy affects new industries' growth opportunities, national decarbonization efforts and ability to keep existing energy intensive industries competitive.
- Increased domestic use implies securing employment and GDP growth outside the energy industry.

Export

- Export ambitions per energy carrier will require a strategic surplus of domestic energy production for selected energy sources.

*Battery manufacturing, data centers, hydrogen production, etc.
Source: Rystad Energy research and analysis

OG21 strategy recommended focus changes based on impact on European energy security

Evaluation of OG21 strategy considering impact on European energy security

		Focus area from current OG21 strategy	Importance in light of European energy security	Comment
Aggregated prioritized technology and knowledge areas	1	Improved subsurface understanding	→	Improved subsurface understanding remains important. In light of European energy security, a focus shift towards prioritizing gas as a more important than oil in technology and competence development should be considered.
	2	Cost-efficient drilling and P&A	→	Due to gas production being less drilling intensive than oil, with less focus on infill drilling, however cost-efficient drilling is important from a commercial perspective when evaluating future drilling targets.
	3	Utilize existing infrastructure	→	Maintaining high utilization and reducing operational costs to enable long-term operations of existing gas infrastructure remains important. However, facilitating new gas infrastructure to enable new volumes is of increasing importance due to the European gas situation.
	4	Unmanned facilities and subsea tie-back solutions	↑	Extending possible subsea tie-back distances has become more important for enabling discoveries at longer distance from existing infrastructure, to increase Norwegian gas supply utilizing existing infrastructure.
	5	Energy efficiency & cost-efficient electrification	↑	Electrification is currently the most important emission reduction measure on the NCS. Due to increased focus on emission reduction, cost-efficient electrification and new technologies to electrify using e.g. offshore wind is of key importance to ensure continued social license to operate.
	6	CCS (to decarbonize gas)	↓	Decarbonizing natural gas from Norway using CCS to produce hydrogen or low-carbon power (gas-to-power) has negative consequences for the total energy volumes delivered due to losses, and hence challenges current energy scarcity in Europe.
	7	World class HSE and environmental performance	→	A continued focus on HSE and environmental performance is important as the NCS is in a maturing phase. Data analysis and inspections to identify anomalies for HSE purposes also has potential synergies with improved risk management related to security.
	8	Digitalization	↑	Digitalization has increased importance as it can mitigate several threats such as cyber security and challenges related to recruitment of enough STEM professionals. Also, the use of AI and digital tools can help increase the resource base.
Stimulation of innovations	A	Attract & develop talent	→	A continued focus on attracting and developing the existing workforce is important to mitigate negative effects from an aging workforce and handle new technologies.
	B	Efficient innovation system	→	An efficient innovation system with sufficient governmental funding is still important. However, the focus towards new industries should be emphasized in the revised strategy.
	C	Technology leadership	→	A continued focus on technology leadership is important for proper implementation of new technologies along with knowledge on how the technologies should be communicated to suppliers.
New industry opportunities building on O&G competence and solutions		CCS for multiple industries	↑	Competence and knowledge from the O&G industry is important for implementing CCS technologies that can be used by other industries. Especially infrastructure, transport and offshore carbon storage are viewed as important.
		Hydrogen from natural gas with CCS	↓	Hydrogen from natural gas with CCS produced domestically is less important given the gas scarcity situation in Europe and the conversion losses that come from transforming natural gas to blue hydrogen.
		Floating offshore wind	↑	Floating offshore wind will play a role in ensuring electrification of O&G installations with minimal negative effects for the onshore energy balance.
		Marine minerals	→	Marine minerals have not been directly addressed in the work by Rystad Energy in 2023, but it is relevant for developing domestic supply chain and long-term reduced geopolitical dependency.

Importance in light of European energy security: ↓ Reduced → Continued ↑ Increased

Source: Rystad Energy research and analysis; OG21

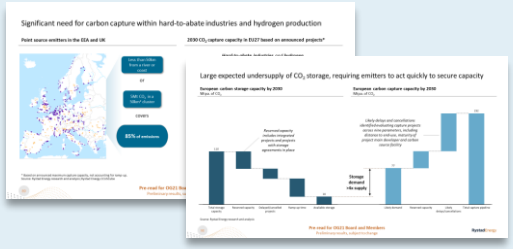
Increased focus on CCS and floating offshore wind is necessary considering European energy security

Evaluation of OG21 strategy new industry opportunities building on O&G competence and solutions considering impact on European energy security

CCS for multiple industries

Increased importance

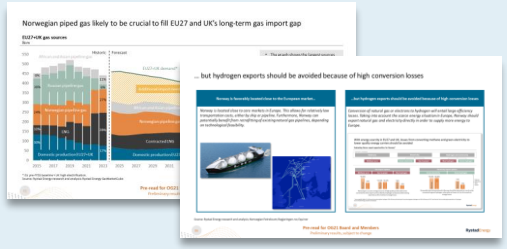
A Norwegian CCS industry, through infrastructure to transport and store carbon in offshore storages on the NCS, can play an important role in reducing European emissions related to natural gas consumption in Europe. Continued use of natural gas increases the need to reduce emissions from hard-to-abate industries through capture from flue stack or in gas power plants. Continued use of natural gas also increases the relevance of the O&G industry to take responsibility in scope 3 emissions. Existing CCS experience and positive authorities make NCS an attractive storage location and synergies from the O&G industry is especially viable.



Hydrogen from natural gas with CCS

Lower importance

As blue hydrogen production results in large efficiency losses, blue hydrogen production in Norway in the short-to medium-term adds to the risk of European energy shortage. In light of European energy security, direct use of gas should be preferred as long as Europe is in a position of energy scarcity. Since Norwegian pipeline gas is also very competitive both on cost and emissions compared to LNG imports, Europe's demand for Norwegian pipeline gas is likely to remain strong even if Europe's total gas demand is reduced. Also, EU policies only consider blue hydrogen as a transition fuel.



Floating offshore wind

Increased importance

Floating offshore wind has potential to increase Norwegian power generation and can as such be a key enabler for new O&G electrification projects. Through its significant emissions and large power demand, O&G companies have a responsibility to contribute to the development of floating offshore wind to ensure that enough electricity is available for electrification of the NCS. Increased focus from OG21 and the O&G industry can also contribute to communicating the need to cover the funding gap on industrialization of floating offshore wind.

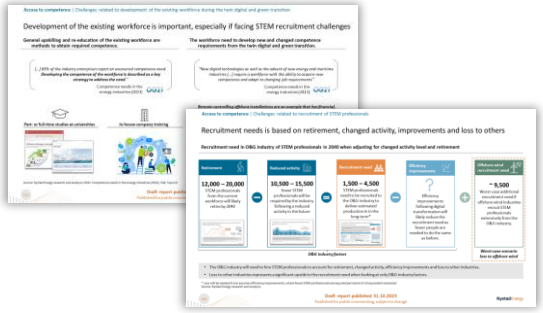
Source: Rystad Energy research and analysis; OG21

Four additions to the strategy are recommended considering European energy security

Recommended elements added to strategy with the goal of reducing risk to Norwegian security of supply towards Europe

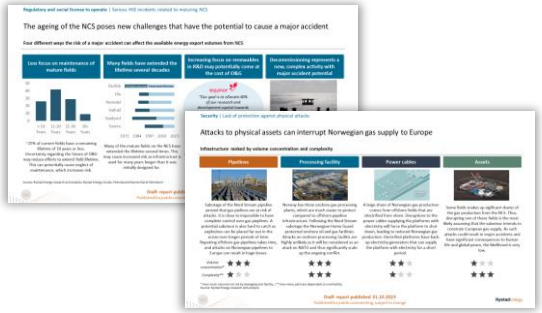
Digitalization to stem up for the shortage in STEM graduates and professionals

In light of challenges in recruiting STEM professionals, technologies to reduce the need for labor, both for skilled workers and engineering and development should receive increased focus. This include digital toolsets particularly for desktop work processes (enginnering, planning, applications, subsurface). Increased focus on digitalization can also enable improved risk understanding and management.



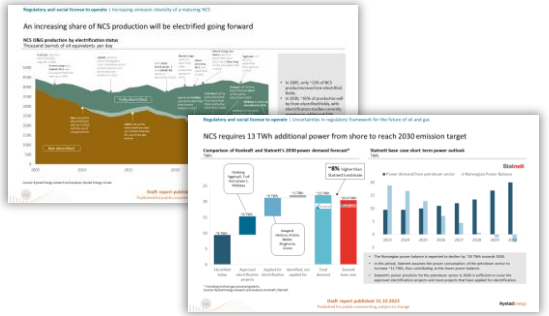
Building on synergies between maintenance and security workstreams

Recent events have put security on top of the agenda, which has previously gotten little focus. There is a clear synergy potential between maintenance and security workstreams through both inspections and anomaly detection in data analysis. Examples include infrastructure surveillance, gathering important data for both maintenance and security applications.



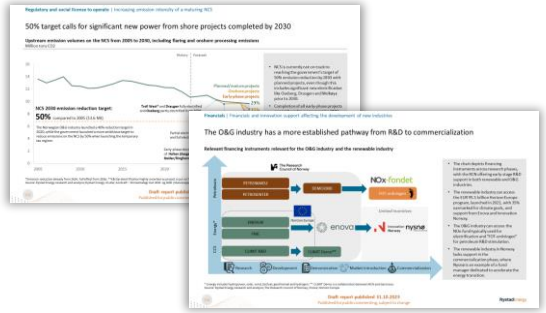
Communicating the need for increased collaboration between energy sources

The future energy system will be more integrated, which creates a need for collaboration across energy system verticals. OG21 would benefit from increasing focus on collaboration, e.g. with Energy21 and other relevant stakeholders. Communicating the need for a holistic energy roadmap is a key collaboration platform.



Communicating the role O&G companies should take in developing new industries

The target to reduce emissions from O&G by 50% by 2030 is under pressure, partly because of uncertainty regarding the access to electricity from shore and a high risk of negative power balance in Norway by 2030. This calls for efforts from the O&G industry to contribute to industrializing offshore wind and CCS through collaboration, industrialization projects, in addition to technology and competence synergies.



Source: Rystad Energy research and analysis

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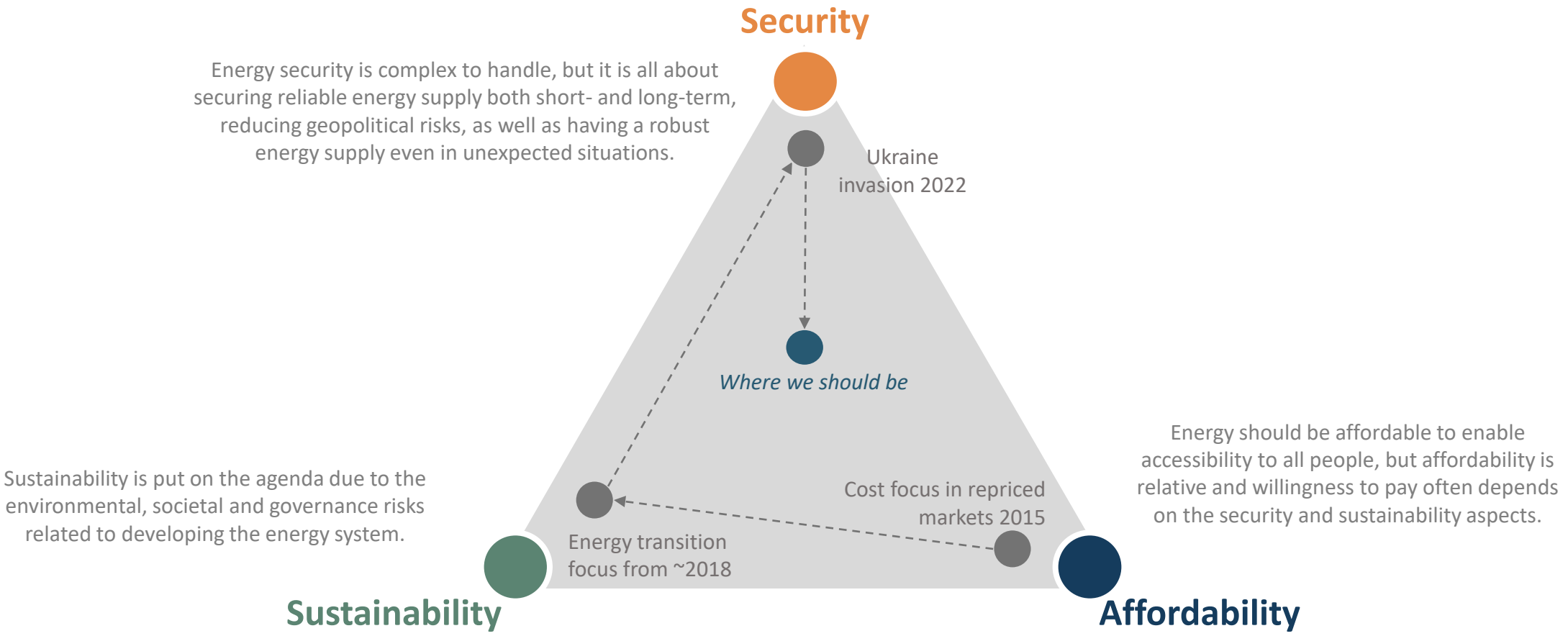
The energy system needs to balance security, affordability and sustainability

Energy trilemma illustration



Source: Rystad Energy research and analysis

The energy transition is driven forward by cost and performance of oil substitutes

Drivers of energy transition

Global warming & climate change

Public sentiment regarding global warming and climate change is increasing in importance and impact.

Cost & performance of oil substitutes

While the lighter transportation modes are well underway of becoming electrified, the jury is still out on the future for heavier segments such as long-haul trucking, aviation and shipping.

Cost of new generation

Decarbonization of the power sector will require massive investments in renewable power generation, but also sustainable solutions for energy storage. Solving the Long Duration Storage problem is one of the unsolved pieces of the puzzle.

Local air pollution

Local air pollution is a large challenge around the world, with harmful emissions being top on the agenda for many governments. Such emissions can damage ecosystems and result in the degradation of quality of life for humans and wildlife.

Source: Rystad Energy research and analysis

Asia prioritizes coal for power due to gas squeeze, willingness to pay for clean sources lower than in Europe

Changing focus in the energy sector over the past 2 years

Europe

Europe plans to spend $221 billion to ditch Russia's energy

By Anna Cooban, CNN Business
Updated 12:12 PM EDT, Wed May 18, 2022

EU plans to loosen state aid rules to boost renewables investment

Proposed use of tax credits follows pressure to respond to Biden's $369bn green subsidy scheme in US

No coal comeback: Europe's renewable energy transition is in hyperdrive

Asia

3 minute read · February 14, 2023 1:48 AM GMT+1 · Last Updated a month ago

Exclusive: Pakistan plans to quadruple domestic coal-fired power, move away from gas

By Gibran Naiyyar Peshimam

India's energy conundrum: committed to renewables but still expanding coal

3 minute read · March 6, 2023 9:51 AM GMT+1 · Last Updated 9 days ago

China leans on coal amid energy security push

By Andrew Hayley

China ramps up coal power despite carbon neutral pledges

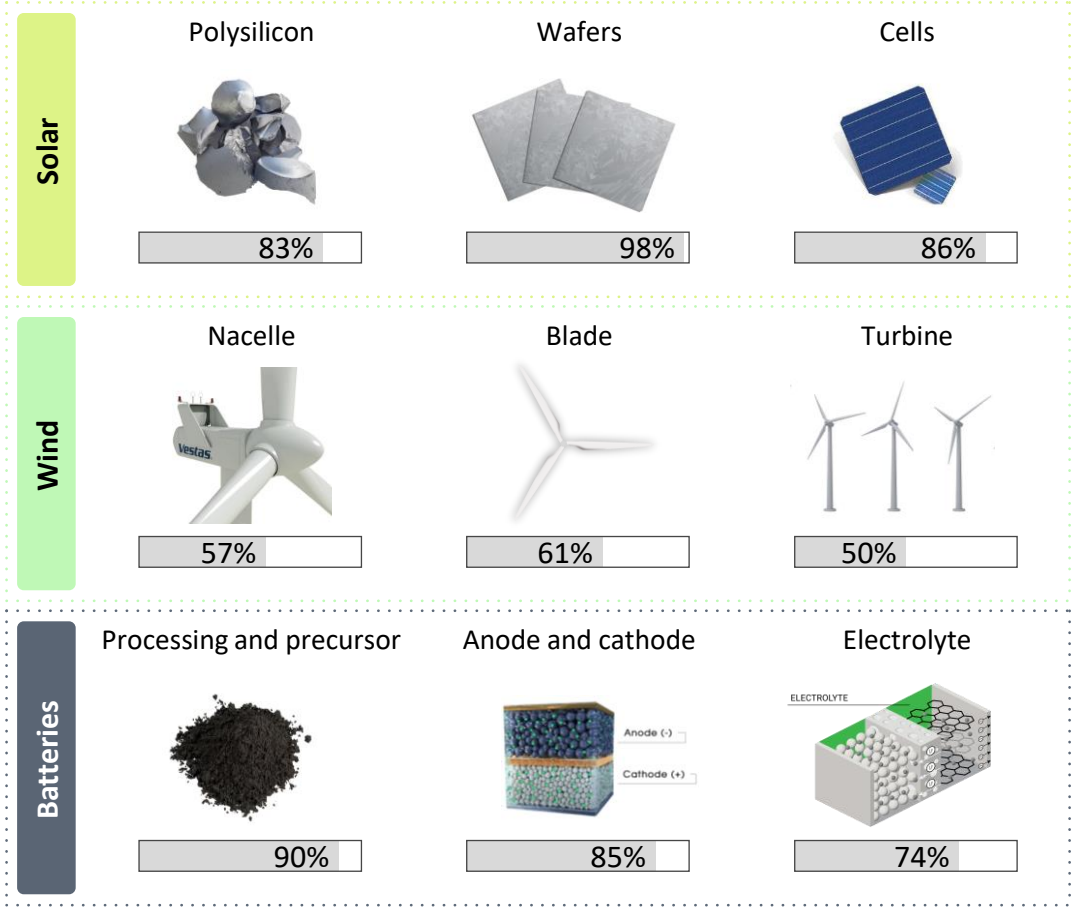
Local governments approved more coal power in first three months of 2023 than all of 2021

Europe → Asia

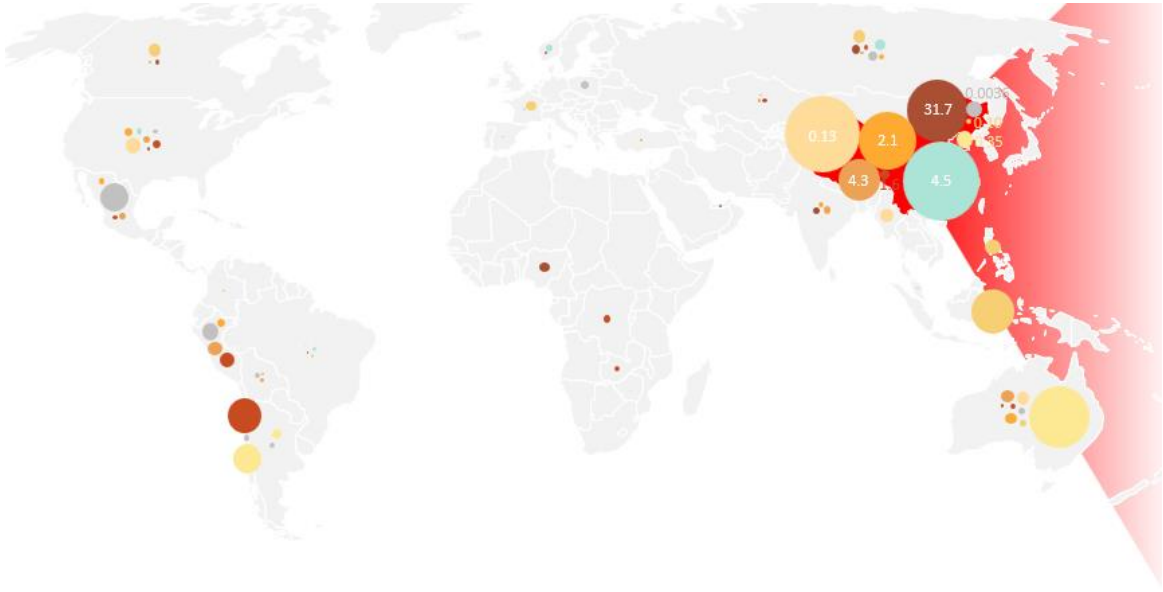
Source: Rystad Energy research and analysis; CNN Business; Reuters; The Guardian

China’s dominant position within the renewables supply chain has triggered de-globalization policies like the IRA due to increased geopolitical tensions

Chinese production market share by component



Global share of material production by country in 2019*

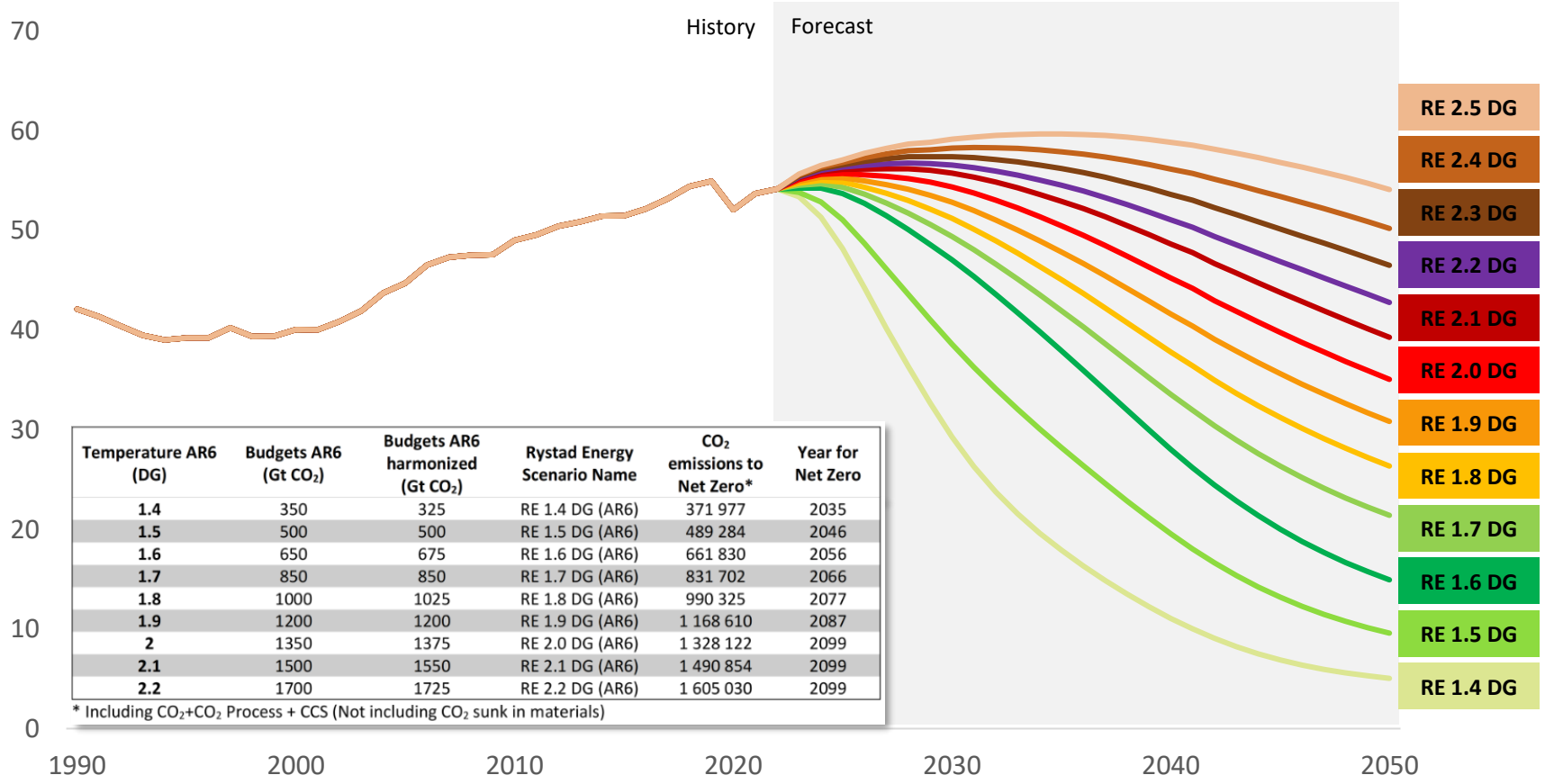


- A high share of global material resources are concentrated to a few important hot-spots like South-America and Australia.
- China dominates global production, even though resources are higher elsewhere. Chinese companies have shifted focus towards increasingly investing in mines in low-cost regions abroad, as China is prioritizing high-tech manufacturing.

Source: Rystad Energy research and analysis; IEA; S&P

The world is dependent on tracking the Rystad Energy 1.6 DG scenario to reach climate targets

Global greenhouse gas emissions by scenario (excluding CCUS)
Billion tonnes of CO_2 equivalents



Temperature AR6 (DG)	Budgets AR6 (Gt CO_2)	Budgets AR6 harmonized (Gt CO_2)	Rystad Energy Scenario Name	CO_2 emissions to Net Zero*	Year for Net Zero
1.4	350	325	RE 1.4 DG (AR6)	371 977	2035
1.5	500	500	RE 1.5 DG (AR6)	489 284	2046
1.6	650	675	RE 1.6 DG (AR6)	661 830	2056
1.7	850	850	RE 1.7 DG (AR6)	831 702	2066
1.8	1000	1025	RE 1.8 DG (AR6)	990 325	2077
1.9	1200	1200	RE 1.9 DG (AR6)	1 168 610	2087
2	1350	1375	RE 2.0 DG (AR6)	1 328 122	2099
2.1	1500	1550	RE 2.1 DG (AR6)	1 490 854	2099
2.2	1700	1725	RE 2.2 DG (AR6)	1 605 030	2099

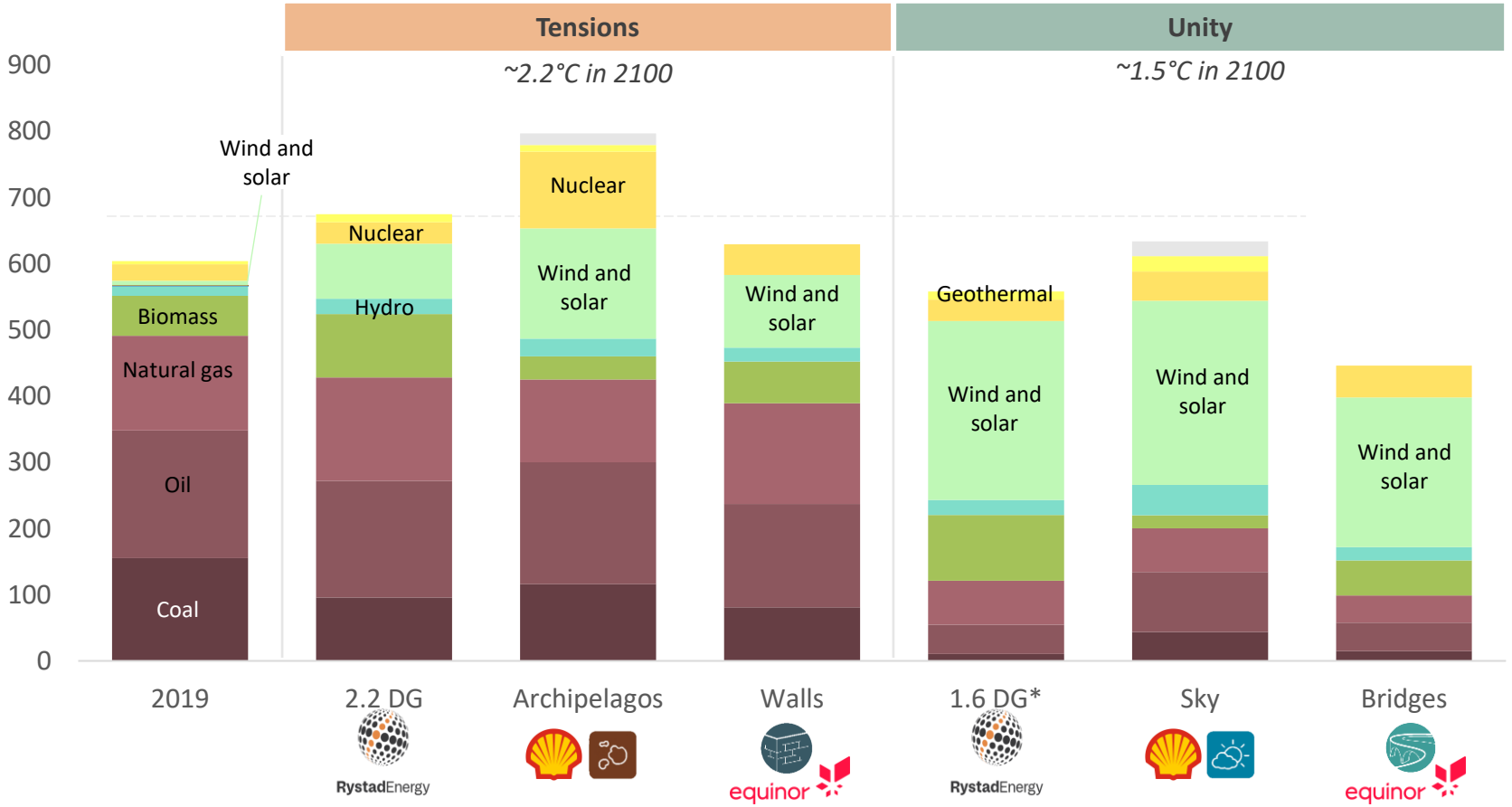
* Including CO_2+CO_2 Process + CCS (Not including CO_2 sunk in materials)

- The Rystad Energy Scenarios are compliant with the greenhouse gas emissions budgets for the IPCC AR6 climate report corresponding to a global warming limited to a.y degrees Celsius with a 50% probability.
- The table shows the remaining carbon budgets from the beginning of 2020.
- The chart excludes the effect of carbon capture, utilization and storage (CCUS) that has a significant impact in the most aggressive scenarios.
- The scenarios are not forecasting the reality, but back-casting potential net-zero pathways based on IPCC carbon budgets, illustrating outcomes tied to the speed of the energy transition.
- Each scenario aligns energy consumption and generation, determining added capacity for each source within the carbon budget.

Source: Rystad Energy research and analysis; Rystad Energy EnergyScenarioCube; IPCC AR6 Climate Report (Table 5.8)

1.5 DG scenario hinges on global cooperation and significant reduction in fossil fuel share

World primary energy demand scenarios, split by fuels
EJ/year

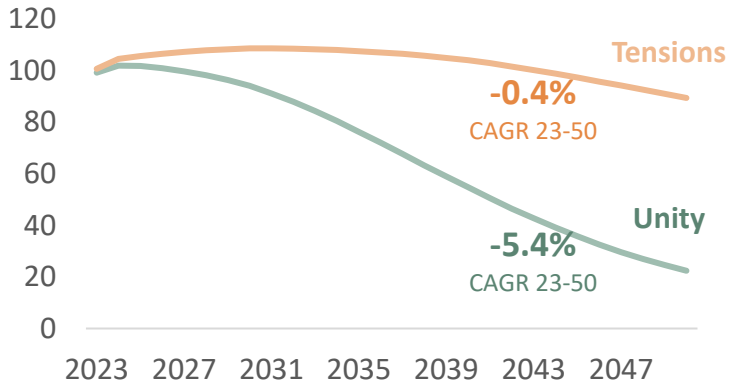


- Shell Archipelagos, Equinor Walls and Rystad Energy 2.2 DG scenarios are back-casted to achieve 2.2 °C by 2100, while Shell Sky, Equinor Bridges and Rystad Energy 1.6 DG scenarios are back-casted to achieve net-zero by 2050 and 1.5 °C ambition of Paris agreement.
- The Paris Agreement compliant scenarios assume faster electrification and achieve higher energy efficiency faster.
- The scenarios can be grouped into the two categories “Tensions” and “Unity”. “Tensions” is a more pessimistic view with continued geopolitical tensions, while the latter assumes more cooperation and optimalization made possible by low geopolitical tensions.

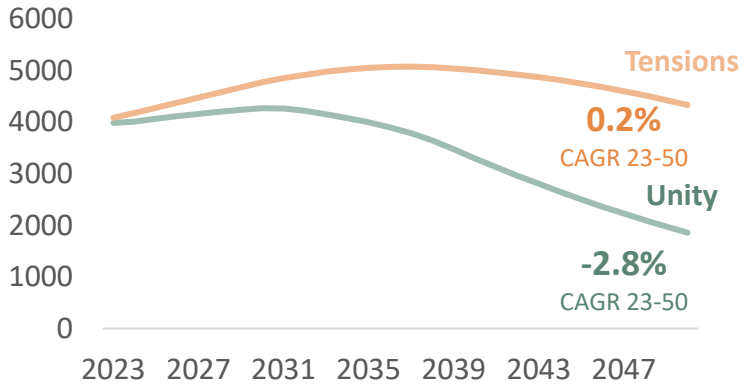
* Rystad Energy’s 1.6 DG scenario represents 1.5 DG global warming if methane pledges are accounted for.
Source: Rystad Energy research and analysis; Rystad Energy EnergyScenarioCube; Shell; Equinor

The pace of decline in fossil and growth of low-carbon solutions vary depending on scenario

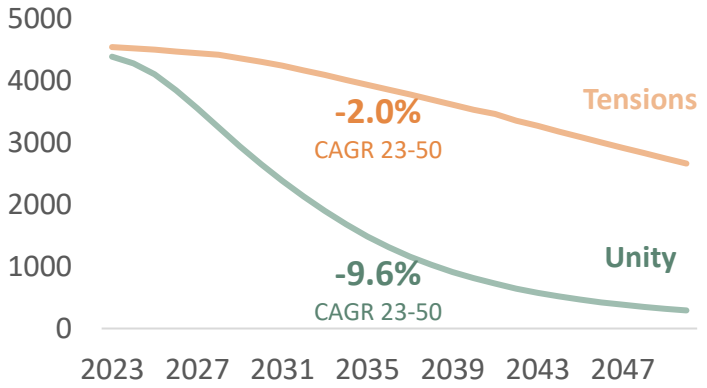
Liquids
Million boe per day



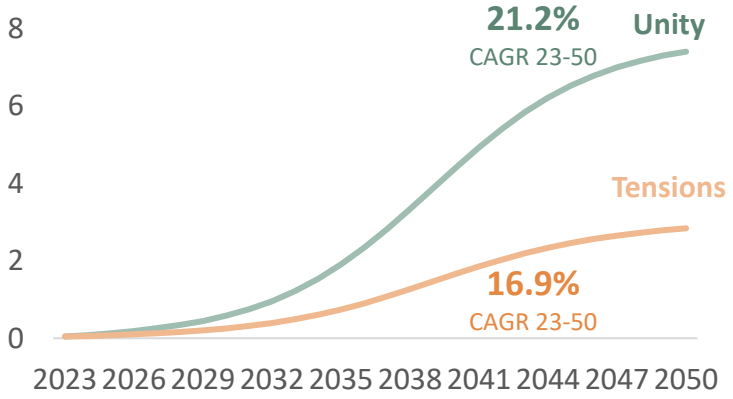
Natural gas
Billion cm



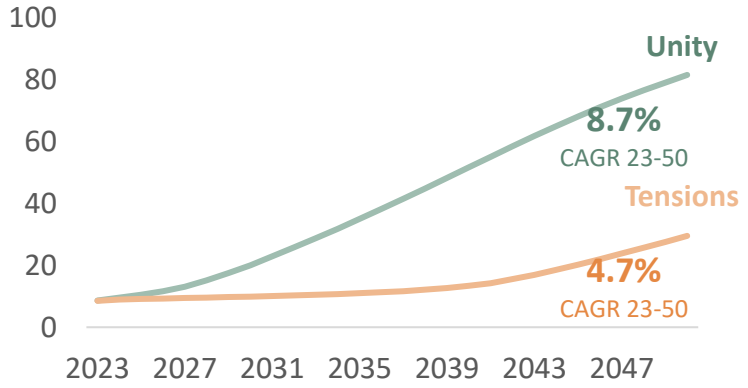
Coal
Billion cm



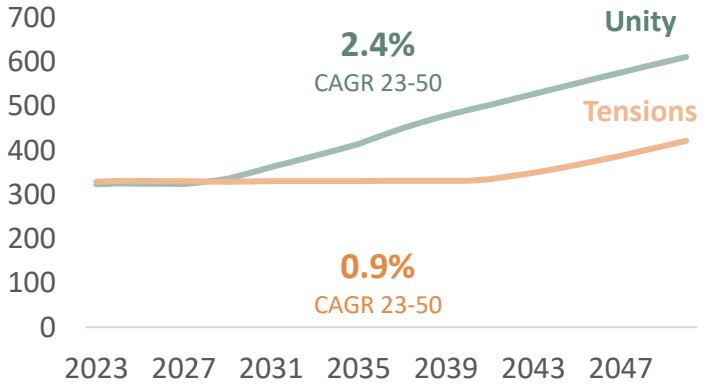
CCUS
Gigatonnes CO_2 per year



Renewables*
PWh**



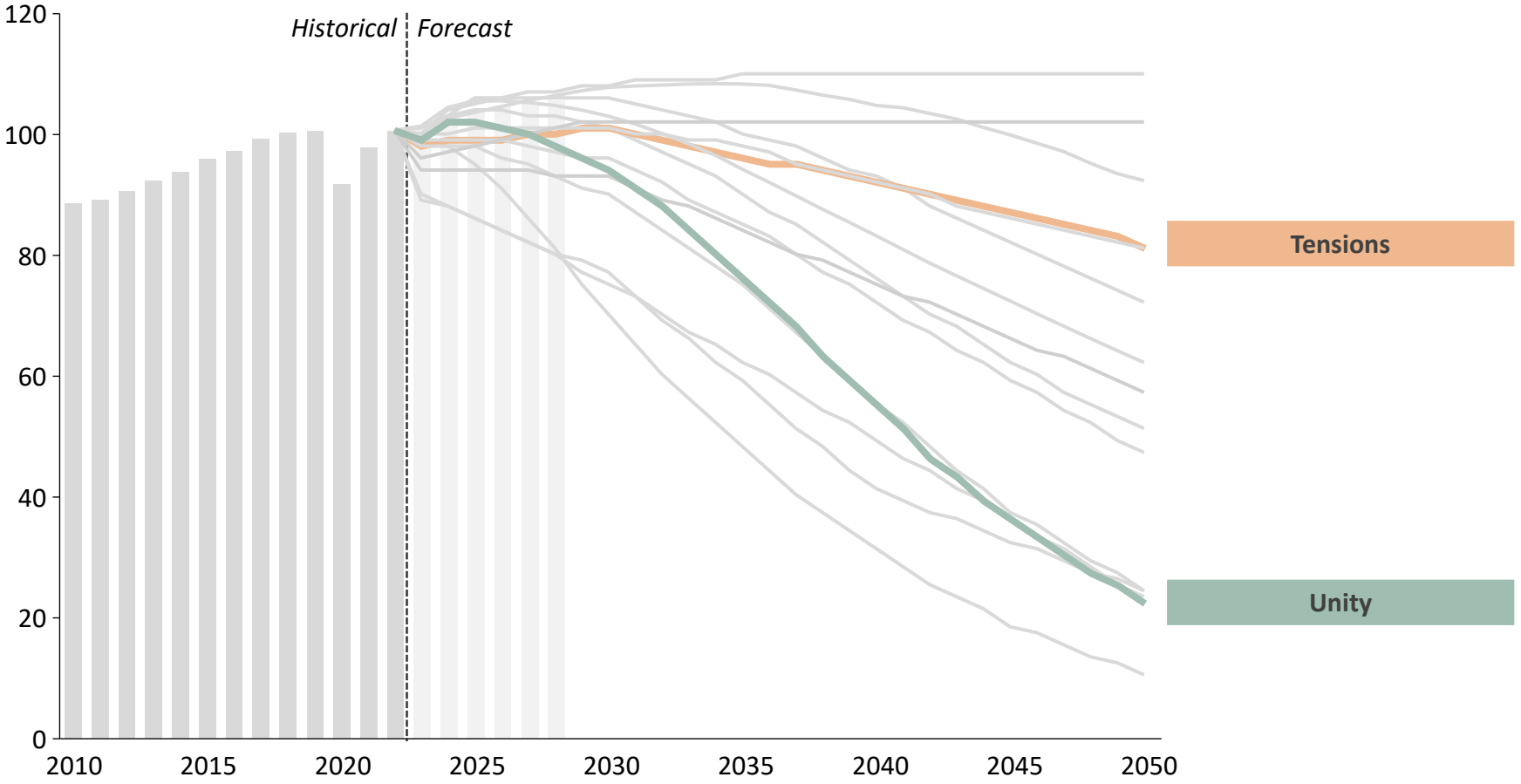
Hydrogen
Mt



NB: The unity scenario used here are equal to the 1.6 DG scenario from Rystad Energy and tensions are equal to the 2.2 DG scenario from Rystad Energy. * Solar, wind and hydro.; ** PWh = Petawatt-hour = 1000 TWh
Source: Rystad Energy research and analysis; Rystad Energy EnergyScenarioCube

Electrification of transport is expected to be the main driver for liquids demand reductions

Global liquids demand scenarios*
Million boe per day

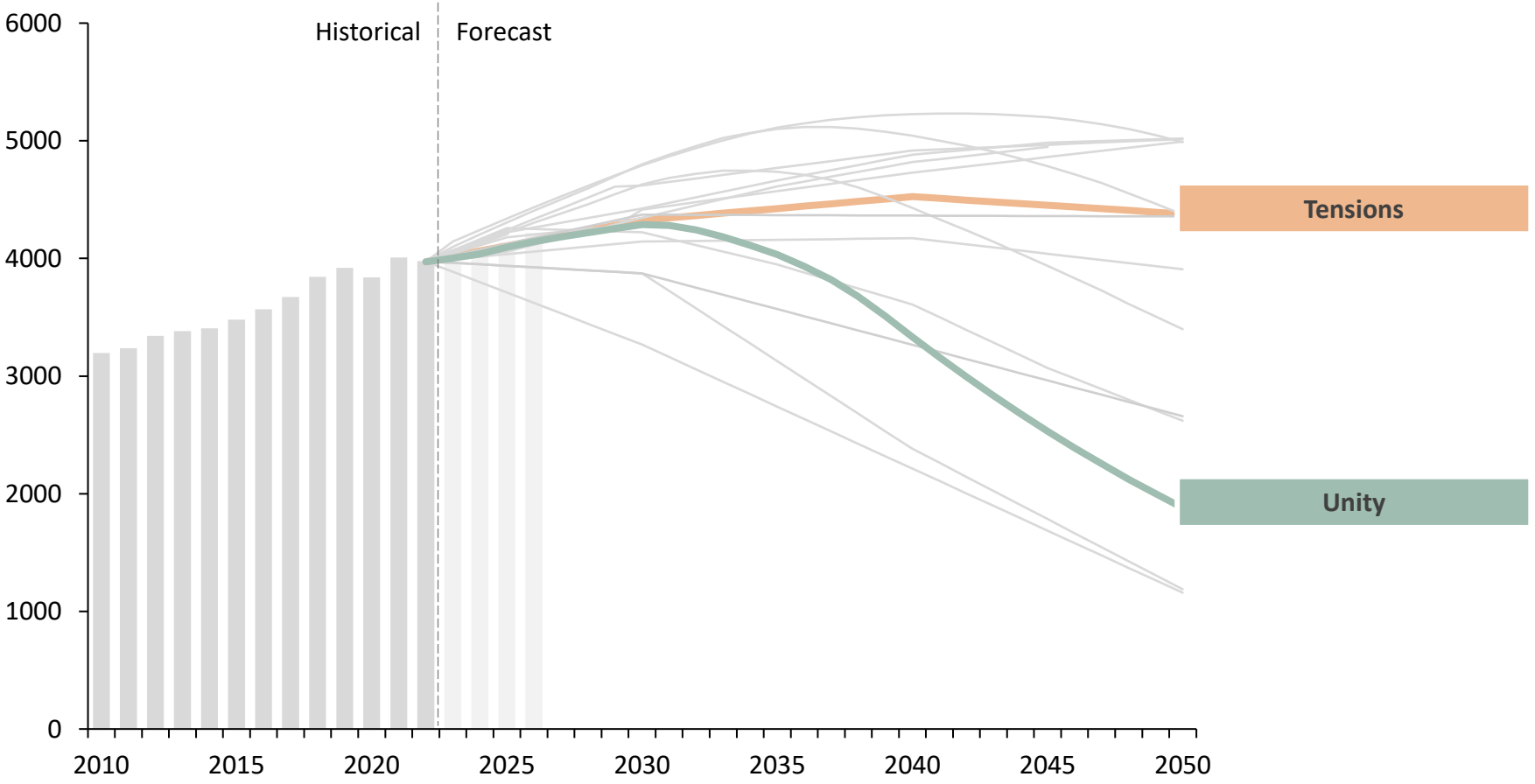


- Significant changes and a global focus on the transition are needed to significantly reduce liquids demand towards 2050.
- Liquids demand is dominated by transportation fuels mainly driven by road transportation, in addition to industrial and petrochemical demand.
- Electrification of passenger transport is the main driver reducing liquids demand short- to medium-term. For road transport, electric vehicles are replacing internal combustion engines with Europe and North America leading the way, as electric vehicles have become competitive to internal combustion engine vehicles.
- Industrial demand needs several solutions to be substituted, but the real challenge will be to reduce demand for liquids to petrochemicals.

* OPEC, IEA, EQNR, BP and Shell 2021 are adjusted to Rystad Energy's view on demand in 2021.
Source: Rystad Energy research and analysis; OPEC; IEA; Equinor; BP

Gas will play a role in the energy transition, but the significance varies between scenarios

Global gas demand scenarios
Billion cm per year

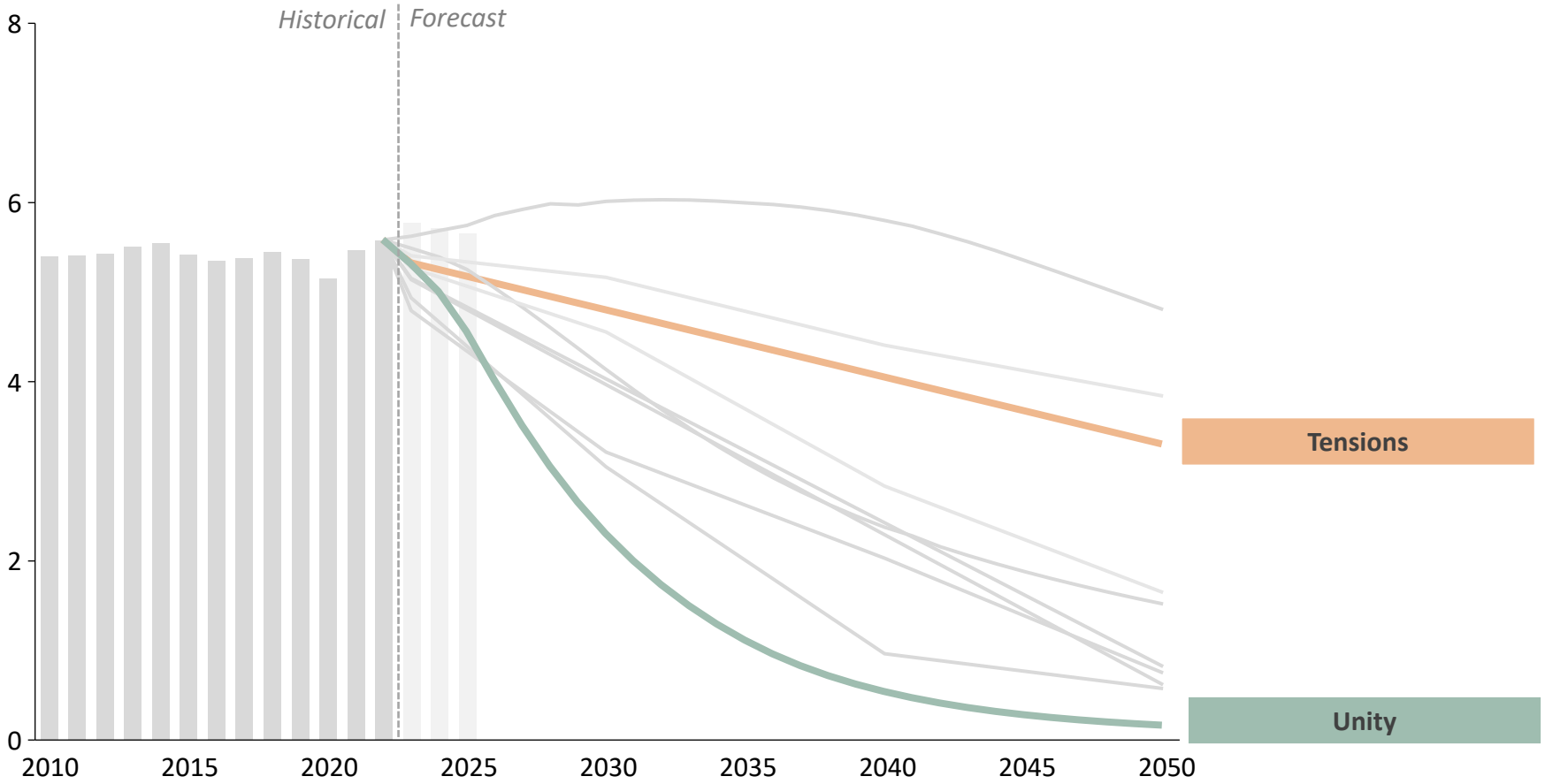


- For the world to reach climate targets, gas plays an important role as a transition fuel towards 2035, before a rapid shift is needed. Natural gas demand is expected to peak around 2030.
- Continued geopolitical tension is likely to lead to a prolonged high demand for gas as this delays renewables investments.
- Power generation from natural gas will be outcompeted on cost from new renewables as capacity learning curves for solar and wind make renewables cheaper on LCOE basis than the marginal cost of power generation from gas.
- However, the increasing share of renewables in the power grid will lead to a significant demand for balancing power, where gas can play an important role.

Source: Rystad Energy research and analysis; GasMarketsCube; EnergyScenarioCube; IEA; OPEC; Equinor; Total; BP; ExxonMobil

Global coal demand set to decrease regardless of scenario

Global coal demand scenarios*
Billion cm per year

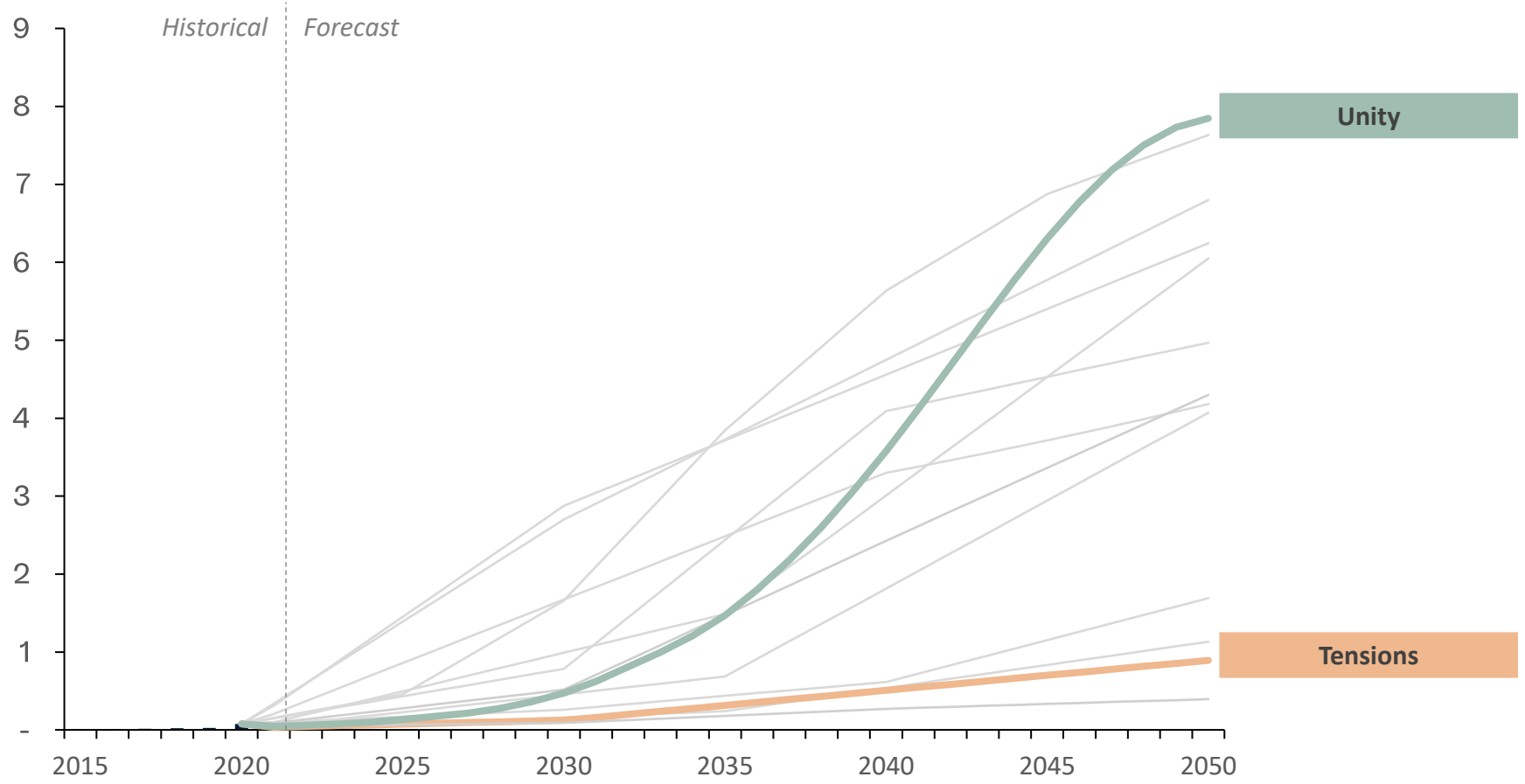


- To reach climate goals, significant new policies and commitments to reduce coal consumption are necessary.
- Due to conflicting interests between economic growth and climate commitments, the speed of the transition away from coal is uncertain.
- Coal for power production will eventually be outcompeted in most countries, if learning-curve effects continue to reduce costs going forward.
- However, in countries with cheap domestic coal production and limited economic possibilities, it is likely that coal will remain an important source of power for years to come.
- Coal consumption for the industrial sector like steel production needs a variety of technologies to mature.

* All outlooks reported in EJ and units of mass were converted to TCE using a standardized average calorific value of 7,000 kcal/kg from IEA;IEA's Short-Term Coal 2022 outlook projections were derived by scaling using 2021 as a base year.
Source: Rystad Energy research and analysis; BP; IEA; EIA

Significant CCS efforts are needed to reach the more ambitious climate targets

Global carbon capture, utilization and storage capacity by scenario
Billion tonnes CO_2 per year



- Currently stated policy includes less than 400 million tonnes of CCUS capacity in 2050. This may be explained by the immaturity of the technology and the uncertainties in cost and feasibility of scaling.
- However, as these technologies are proven, it is expected that policy will follow, and today the announced pledges represents capacity of over 4 billion tonnes of CCUS capacity in 2050.
- However, according to the Unity scenario (Rystad Energy 1.6 DG scenario), almost 8 billion tonnes of CCUS capacity will be needed by 2050 to reach current climate goals.

Source: Rystad Energy research and analysis; Rystad Energy CCUS Market Dashboard; European Commission; UK Department for Business; Energy & Industrial Strategy; IEA; Equinor; TotalEnergies; IRENA; BP

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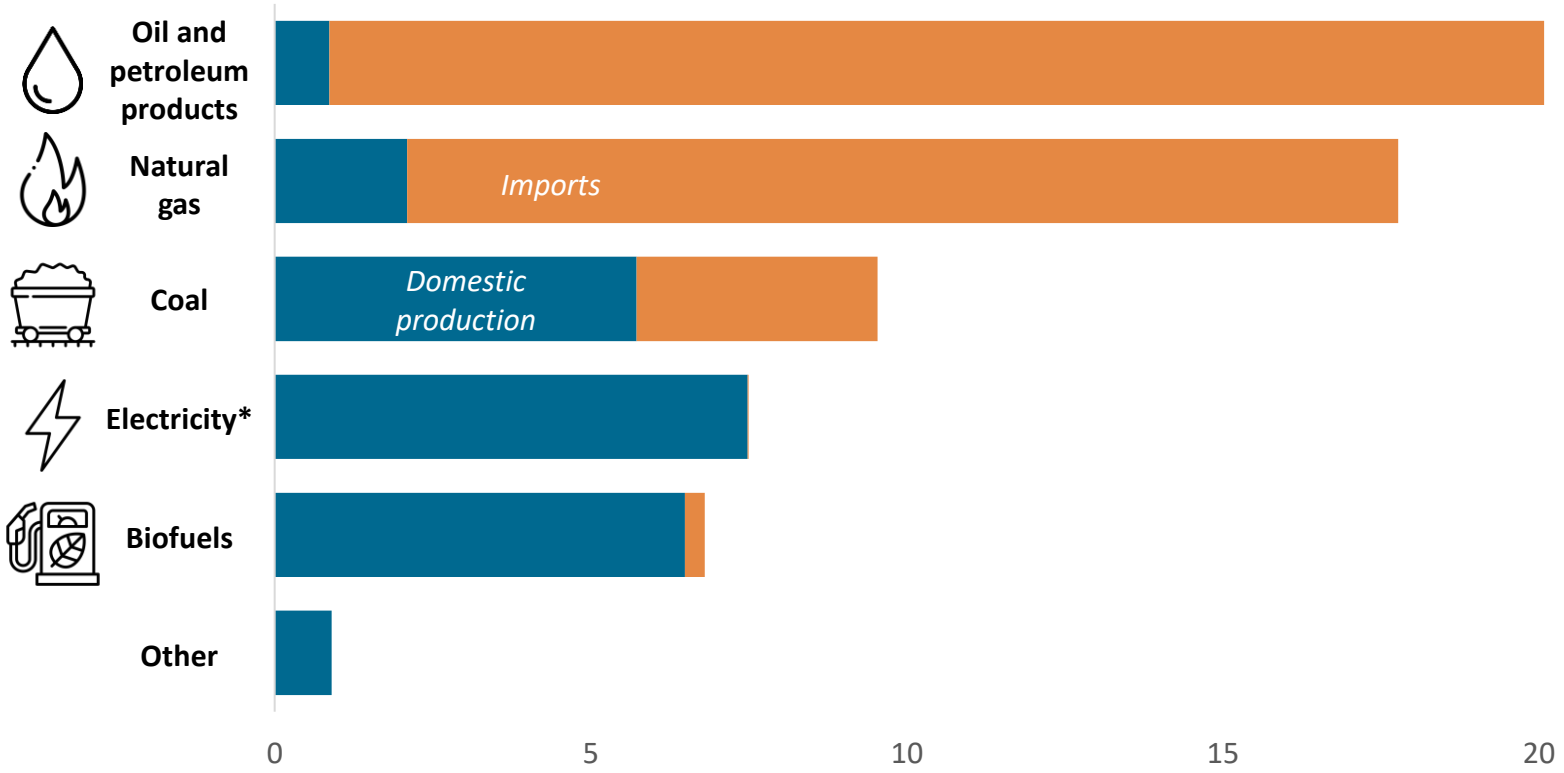
Europe has been and will still be highly dependent on imports of fossil fuels

EU27 energy demand in 2021
Exajoule



~60 EJ
primary energy demand in 2021

~75%
fossil fuels

~80%
of fossil fuels are imported

* From renewables and nuclear. Electricity generated from coal and gas are includes in the coal and natural gas categories, respectively.
Source: Rystad Energy research and analysis; Eurostat

Gas shortage in Europe encouraged positive changes, but had significant negative effects…

Main gas demand segments' response to energy shortage in Europe

Power

- Record high wind and solar capacity installed in 2022.
- Some coal-fired plants' operational lifetime was extended and others re-opened to replace expensive gas.
- Weather-related factors and some behavioral changes due to high prices drove a mild consumption reduction.

Buildings

- Energy efficiency focus, such as installing insulation and replacing boilers with heat pumps.
- Reduced quality of life due to fuel poverty. Some shift to inferior fuels, such as waste or low-quality fuel oil.
- Mild winter, voluntary demand reduction and fuel poverty caused a drop of almost 20% in 2022 compared to 2021.

Industry

- Increased focus on diversifying energy sources, such as on-site renewables or alternative low-carbon fuels.
- Production curtailment causing lower GDP growth and exports, and some permanent closures of factories.
- Production curtailment, importing of energy-intensive finished goods and fuel switching drove a 25% reduction of demand in 2022 compared to 2021.

Source: Rystad Energy research and analysis; IEA

…especially for the quality of living for citizens exposed to surging energy prices

Energy bills: 13m British homes 'did not turn on heating when cold last winter'

Which? survey finds about half of households with annual income of under £20,000 made such a decision

Millions of Britons did not switch on their heating during cold snaps last winter in an attempt to save on their energy bills as the cost of gas and electricity soared.

Almost nine in 10 households tried to cut back on their energy usage last winter, while almost half of all British households, or 13m homes, said they did not turn on their heating when it got cold, according to a survey of 4,000 people by the consumer group Which?.

The Guardian, August 2023

Excess winter deaths caused by cold homes in Great Britain 'up by about a half'

Campaigners tell MPs more than 1m households missed out on government support for bills

Fuel poverty campaigners told a parliamentary committee on Wednesday that despite relatively mild weather, the number of excess winter deaths had climbed to 4,706, up from 3,186 a year earlier, as a result of the energy cost crisis.

Simon Francis, a coordinator at the End Fuel Poverty Coalition, added that the number of excess winter deaths was likely to rise again this winter because of higher levels of energy debt while vulnerable households were forced to "hope for mild weather".

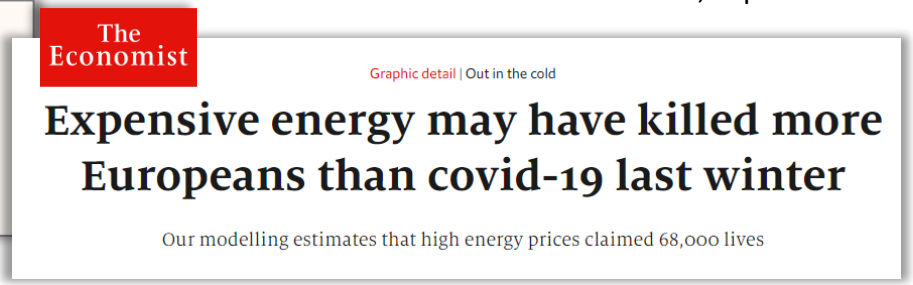
The Guardian, September 2023

The Guardian

A generation of Britons face long-term illness from being cold and poor this winter

Michael Marmot

The Guardian, September 2022



The Economist

Graphic detail | Out in the cold

Expensive energy may have killed more Europeans than covid-19 last winter

Our modelling estimates that high energy prices claimed 68,000 lives

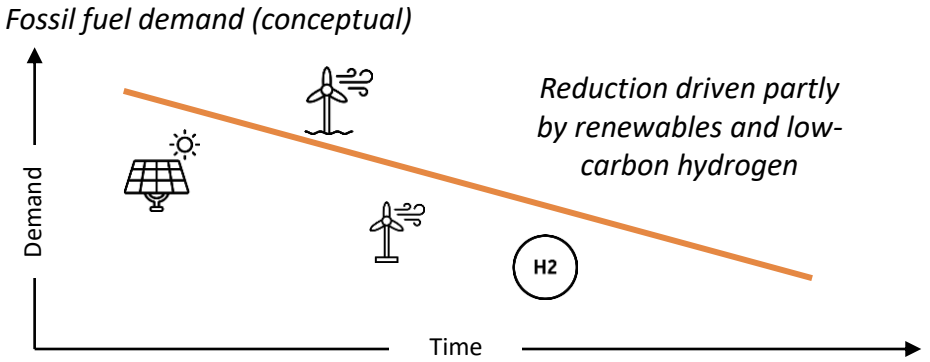
The Economist, May 2023

Source: Rystad Energy research and analysis; The Guardian; The Economist

EU and UK have set ambitious renewable and hydrogen targets to reduce fossil fuel consumption

	EU	UK
Solar PV	***592 GW*** *capacity required by 2030 (REPowerEU)*	***70 GW*** *installed capacity by 2035 (Powering Up Britain)*
Wind	***510 GW*** *capacity required by 2030 (REPowerEU)*	***50 GW*** *offshore wind by 2030 (Powering Up Britain)*
Hydrogen	***20 mtpa*** *of renewable hydrogen consumed annually by 2030 (REPowerEU)*	***0.9 mtpa*** *Low-carbon hydrogen production by 2030* (Powering up Britain)*
CCUS	***50 mtpa*** *of carbon injection capacity in the EU by 2030 (Net-Zero Industry Act)*	***20-30 mtpa*** *of captured and stored CO_2 by 2030 (Powering up Britain)*

Targets are set to decrease fossil fuel consumption



Targets for renewable power and consumption of hydrogen are intended to reduce the fossil fuel demand. Short-falls in reaching these targets mean that fossil fuel demand will not be reduced as much as it could be if goals were met.

> *"With the measures in the REPowerEU plan, we could gradually remove at least 155 bcm of fossil gas use"*
> European Commission

> *"Gas will continue to play a declining but still significant role in our energy system for decades to come"*
> Powering up Britain

* Assuming 50% electrolyzer capacity on the 10 GW hydrogen capacity target.
Source: Rystad Energy Research and Analysis; EU Commission; UK HM Government

EU's views on energy autonomy have been influenced by external events, recently war in Ukraine

STRATEGIC AUTONOMY
pathways to progressive action

EU strategic autonomy (EU-SA) refers to the capacity of the EU to act autonomously in strategically important policy areas.
There has been several phases to the debate about EU-SA, each with a different focus.

Think Tank
European Parliament

	2013 - 2016	***2017 - 2019***	***2020 - 2021***	***2022 and onwards***
	European defense technological and industrial base that can enhance its strategic autonomy and its ability to act with partners	*Defending European interests in an increasingly more hostile geopolitical environment*	*Mitigating economic dependence on foreign supply chains, and supporting Covid-19 recovery*	*Reducing energy dependency on non-reliant partners, and improve EU's competitiveness and autonomy in a hostile geopolitical environment*
Events that influenced				
Selected EU initiatives				

Source: Rystad Energy research and analysis; European Commission; European Parliament Think Tank

EU regulations and policy push towards low-carbon solutions to reach ambitious climate targets

EU policy and regulations impact on supply and demand in Europe for clean- and low-carbon tools for decarbonization

		Supply					Demand			
Policy	**Description**	**Renewables**	**Nuclear**	**Gas**	**Hydrogen**	**CCUS**	**Electricity**	**Natural gas**	**Hydrogen***	**CCUS**
EU ETS and CBAM (2005 & 2023)	Introducing a carbon tax, for domestic and non-EU producers	✓ *Carbon tax promote green power*					✓ *Reduced relocation attractiveness*	✓ *Reduced relocation attractiveness*	✓ *Reduced relocation attractiveness*	✓ *Reduced relocation attractiveness*
EU Taxonomy (2020)	A classification system to clarify which investments are environmentally sustainable	✓ *Boost from classification*	✓ *Benefit if adhering to strict standards*	● *Benefit if compliant with strict standards*					✓ *Co-firing to reduce gas plant emission intensity*	
REPower EU (2022)	Reducing EU's dependency on Russia and accelerate transition to low- or zero-carbon energy sources	✓ *Significant solar PV push*			✓ *Hydrogen production push*		● *Heat pump and energy efficiency focus*	● *More import, but swap to clean molecules*	✓ *High consumption targets*	
Net Zero Industry Act (2023)	Focus on supply chain investments and regulatory simplifications	✓ *Focus on technologies*			✓ *Hydrogen production push*	✓ *High targets*				✓ *Ambitious injection capacity targets*
Green Deal Industrial Plan (2023)	Enhance the competitiveness of net-zero industry and accelerate transition to climate neutrality	✓ *Predictable pricing mechanisms*			✓ *Addressing regulatory backlog*		✓ *Lower price volatility through backed PPAs*		✓ *Demand push from net-zero industries*	✓ *Demand push from net-zero industries*

* Hydrogen and other low-carbon gases such as ammonia and bio-methanol.
Source: Rystad Energy research and analysis; EU Commission

Low-carbon solutions set to replace emission intensive energy sources

Solar and wind
Corner-stones in the future energy mix. Its significance will increase going forward.

Hydro
Plays an important role for certain countries, such as Norway. Limited growth going forward but will remain a part of the future power mix.

Biomass
Biomass has decarbonization potential through CCS and could therefore remain as a part of the power mix in a low-carbon future.

Nuclear
Plays an important role for certain countries, such as France. Different views on growth going forward but will remain a part of the future power mix.

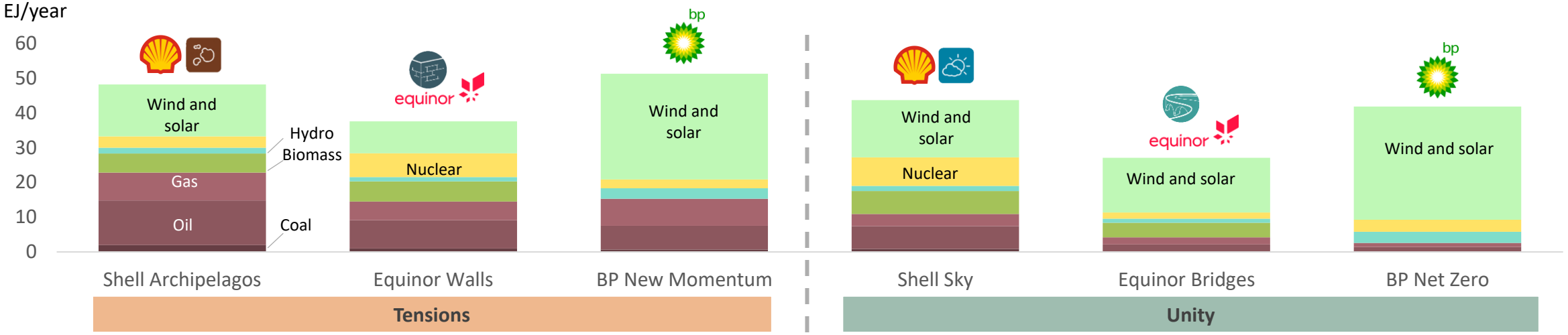
Natural gas
Plays an important role in the transition away from worst-in-class fuels, while at the same time being replaced by superior alternatives where possible.

Oil
Important historically but will be reduced. More aggressive decarbonization scenarios expects a higher decrease of oil than less aggressive scenarios.

Coal
Fuel of the past expected to be largely replaced by alternatives with lower emission intensity, such as natural gas and renewables.

EU primary energy demand scenarios for 2050, split by fuels*

EJ/year



Source: Rystad Energy research and analysis; Shell; Equinor; BP

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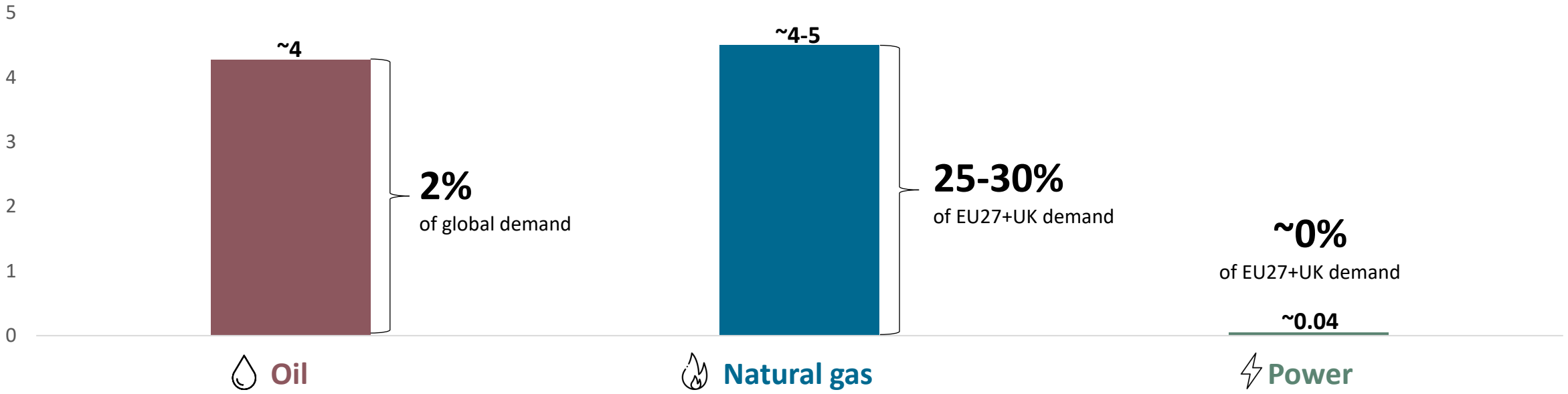
Norwegian gas export is crucial for Europe while export of oil and power is replaceable

Norwegian 2022 energy export split by source*
Exajoule



Oil

Norwegian oil production constitutes about **2% of global demand** for raw oil. Therefore, Norway can be considered as a relatively small and replaceable player in the global oil market. Close to all Norwegian oil production is exported.

Natural gas

In the past years, Norwegian natural gas export has covered between **25-30% of EU27+UK** gas consumption. This share is likely to increase going forward. Norway is the third largest natural gas exporter after Russia and Qatar.

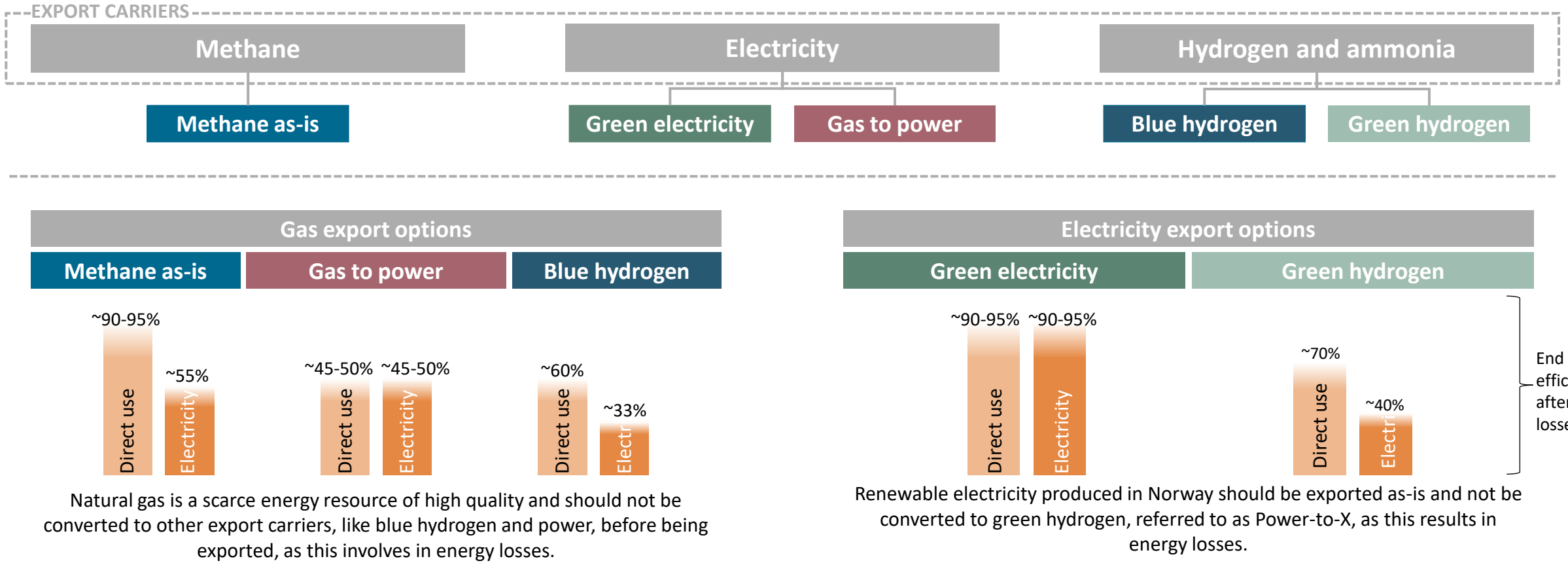
Power

In 2022, Norway produced 144 TWh and had a **net export of about 12 TWh**, constituting about 8% of total generation. This is very small volumes from a European perspective. Norway exports most power to Denmark, Sweden and Germany.

* Power is converted from TWh to EJ using a conversion factor of TWh = 0.0036 EJ.
Source: Rystad Energy research and analysis; Rystad Energy UCube; Norsk Petroleum; Statnett

With energy scarcity in EU27 and UK, losses from converting methane and green electricity to lower quality energy carriers should be avoided

Evaluating future export opportunities for Norway*



Natural gas is a scarce energy resource of high quality and should not be converted to other export carriers, like blue hydrogen and power, before being exported, as this involves in energy losses.

Renewable electricity produced in Norway should be exported as-is and not be converted to green hydrogen, referred to as Power-to-X, as this results in energy losses.

* Assuming 60% SMR+CCS efficiency for producing blue hydrogen, 70% efficiency of electrolysis for producing green hydrogen and 55% efficiency of CCGT and fuel cell. Not considering transportation of hydrogen which comes with additional losses.

Source: Rystad Energy research and analysis

Methane export requires no investments in new infrastructure as opposed to other export options

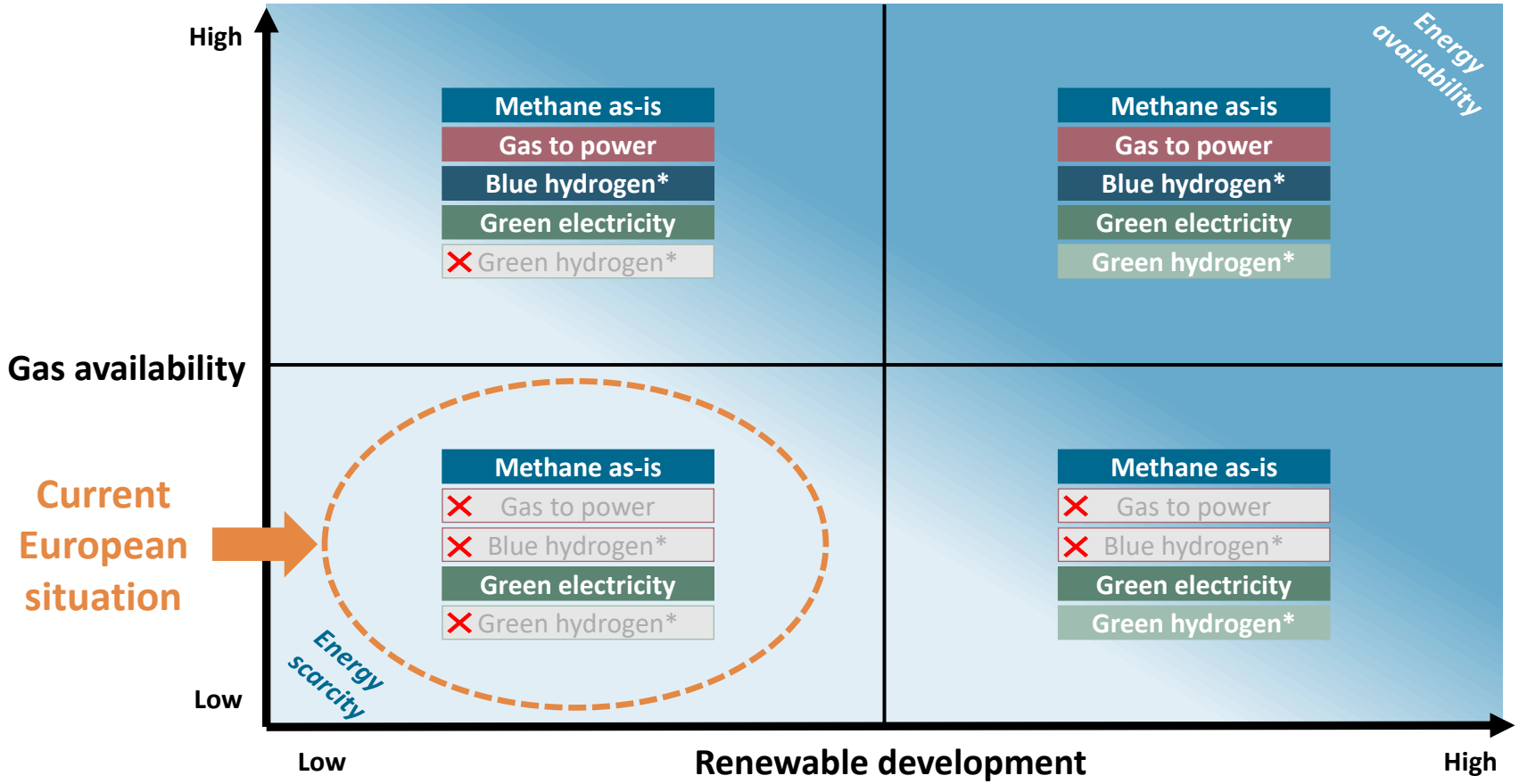
Evaluating future export opportunities for Norway*

Infrastructure investments required			Infrastructure investments required	
Methane as-is	Gas to power	Blue hydrogen	Green electricity	Green hydrogen
None	**Medium**	**High**	**Medium**	**High**
Methane can be transported through existing pipelines	*Requires gas-fired power plants and increased interconnector capacity for transportation*	*Requires SMR facilities, CCS technology and transportation systems, e.g., pipelines and ships*	*Requires increased interconnector capacity for transportation*	*Requires electrolysis facilities and storage and transportation systems, e.g., pipelines and ships*

Source: Rystad Energy research and analysis

Exporting converted energy resources is only feasible if energy is not scarce in Europe

Norwegian energy export depending on European gas availability and renewable development**



- Europe is currently facing energy security concerns. The diagram to the left illustrates the rationale for exporting different energy carriers from Norway to Europe, depending on energy availability.
- In a situation with constrained gas supply to Europe, methane should be exported as-is, as methane has the highest end-use potential. Converting gas to other energy carriers, such as blue hydrogen and power before export, should be avoided as this lowers the energy quality and leads to less efficient end use.
- In a situation with constrained access to renewable electricity, converting green electricity to green hydrogen before export is suboptimal as green hydrogen is a lower quality energy carrier with less efficient end use.

* Blue and green hydrogen produced in Norway.; ** Red cross indicates that it is not rational to convert gas or renewable electricity to a different energy carrier before export.
Source: Rystad Energy research and analysis

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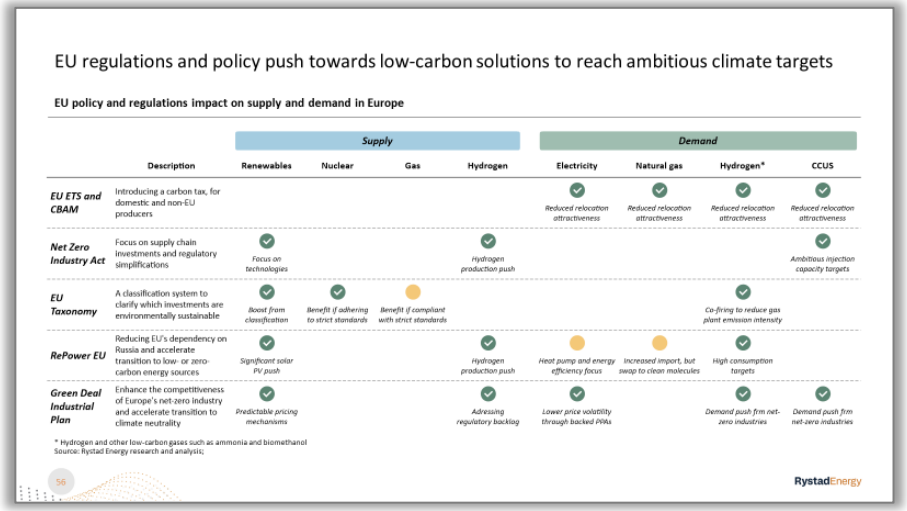
Policies favoring low-carbon solutions and its cost-competitiveness push out fossil energy in EU

EU policy and regulations push towards low-carbon solutions

EU has several policies and regulations in place to guide decision-makers, investors and developers to reduce greenhouse gas emissions, either through promoting low- or zero-carbon energy generation or consumption.



EU regulations and policy push towards low-carbon solutions to reach ambitious climate targets

EU policy and regulations impact on supply and demand in Europe

	Description	Supply: Renewables	Supply: Nuclear	Supply: Gas	Supply: Hydrogen	Demand: Electricity	Demand: Natural gas	Demand: Hydrogen*	Demand: CCUS
EU ETS and CBAM	Introducing a carbon tax, for domestic and non-EU producers					Reduced relocation attractiveness	Reduced relocation attractiveness	Reduced relocation attractiveness	Reduced relocation attractiveness
Net Zero Industry Act	Focus on supply chain investments and regulatory simplifications	Focus on technologies			Hydrogen production push				Ambitious injection capacity targets
EU Taxonomy	A classification system to clarify which investments are environmentally sustainable	Boost from classification	Benefit if adhering to strict standards	Benefit if compliant with strict standards				Co-firing to reduce gas plant emission intensity	
RePower EU	Reducing EU's dependency on Russia and accelerate transition to low- or zero-carbon energy sources	Significant solar PV push			Hydrogen production push	Heat pump and energy efficiency focus	Increased import, but swap to clean molecules	High consumption targets	
Green Deal Industrial Plan	Enhance the competitiveness of Europe's net-zero industry and accelerate transition to climate neutrality	Predictable pricing mechanisms			Adressing regulatory backlog	Lower price volatility through backed PPAs		Demand push frm net-zero industries	Demand push frm net-zero industries

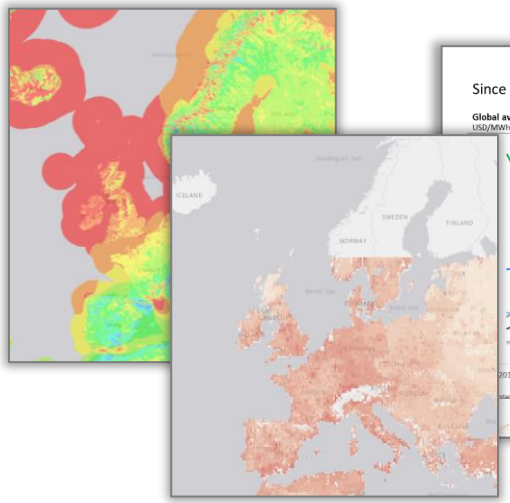
* Hydrogen and other low-carbon gases such as ammonia and biomethanol
Source: Rystad Energy research and analysis

RystadEnergy

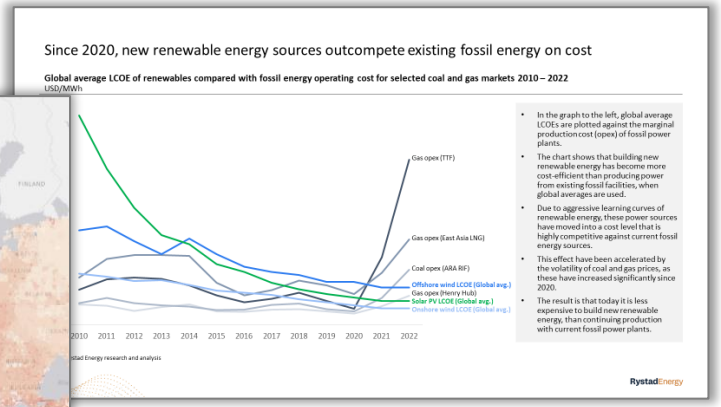
EU policies pushing low-carbon supply and demand

Renewables in Europe are attractive due to good conditions and low cost

Europe has favorable characteristics for renewable power generation through good solar conditions primarily in the south and strong wind conditions primarily in the north.
In addition, the levelized cost of renewable electricity is consistently decreasing, and has significantly lower operational costs and no feedstock cost volatility compared to fossil fuel power generation.



Favorable wind and solar conditions in Europe



LCOE for renewables at par with fossil energy sources

Source: Rystad Energy research and analysis; Rystad Energy RenewableCube

EU and UK have ambitious renewables targets as part of their decarbonization strategies

	EU	UK
Solar PV	***592 GW*** *capacity required by 2030 (REPowerEU)*	***70 GW*** *installed capacity by 2035 (Powering Up Britain)*
Wind	***510 GW*** *capacity required by 2030 (REPowerEU)*	***50 GW*** *offshore wind by 2030 (Powering Up Britain)*
Hydrogen	***20 mtpa*** *of renewable hydrogen consumed annually by 2030 (REPowerEU)*	***0.9 mtpa*** *Low-carbon hydrogen production by 2030* (Powering up Britain)*
CCUS	***50 mtpa*** *of carbon injection capacity in the EU by 2030 (Net-Zero Industry Act)*	***20-30 mtpa*** *of captured and stored CO_2 by 2030 (Powering up Britain)*

Targets are set to decrease fossil fuel consumption

Targets for renewable power and consumption of hydrogen are intended to reduce the fossil fuel demand. Short-falls in reaching these targets mean that fossil fuel demand will not be reduced as much as it could be if goals were met.

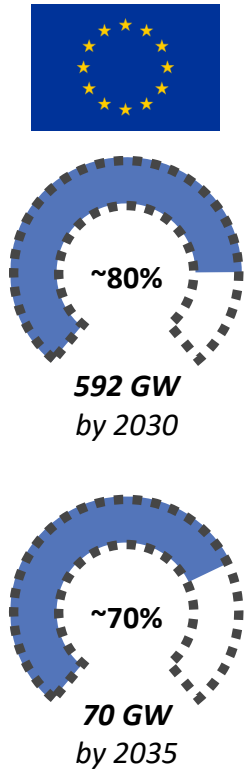
> *"With the measures in the REPowerEU plan, we could gradually remove at least 155 bcm of fossil gas use"*
> European Commission

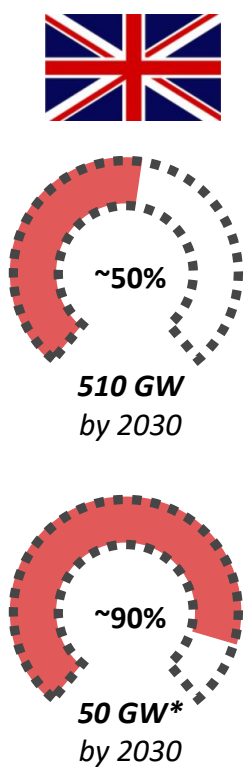
> *"Gas will continue to play a declining but still significant role in our energy system for decades to come"*
> Powering up Britain

* Assuming 50% electrolyzer capacity on the 10 GW hydrogen capacity target.
Source: Rystad Energy Research and Analysis; EU Commission; UK HM Government

Current development estimates yield a ~840 TWh shortfall of green electricity in EU27 and UK

EU27 and UK's development of renewables in Rystad Energy Base-case compared to targets





~140 GW short of targets → **~180 TWh**

Assuming 50% capacity factor for wind and 15% for solar PV

~150 GW short of targets → **~660 TWh**

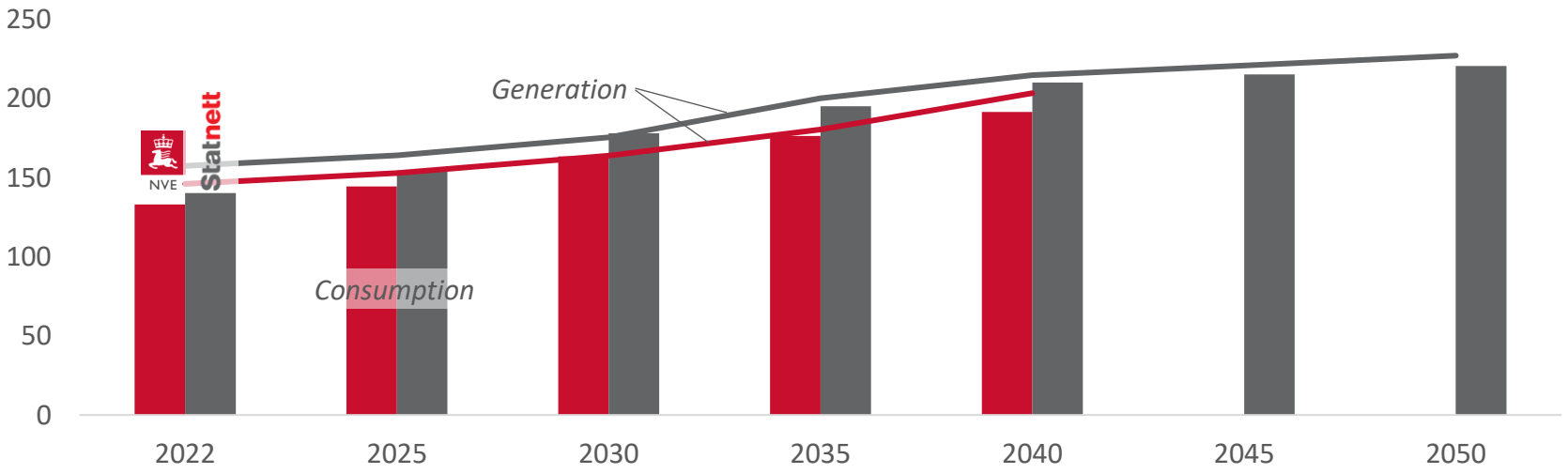
The shortfall in renewable power generation will either be covered through higher power generation from fossil fuels or imports of electrons or hydrogen.

* Only offshore wind.
Source: Rystad Energy research and analysis; Rystad Energy RenewableCube; EU Commission; UK HM Government

Norwegian power balance at risk towards 2030, upside longer term if new capacity is built

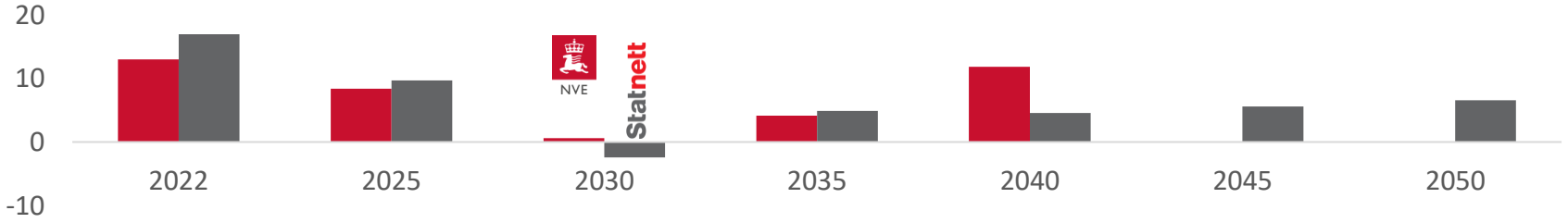
Latest long-term forecasts from NVE and Statnett on Norwegian power generation and consumption*

TWh



Norwegian power balance forecasts from NVE and Statnett

TWh

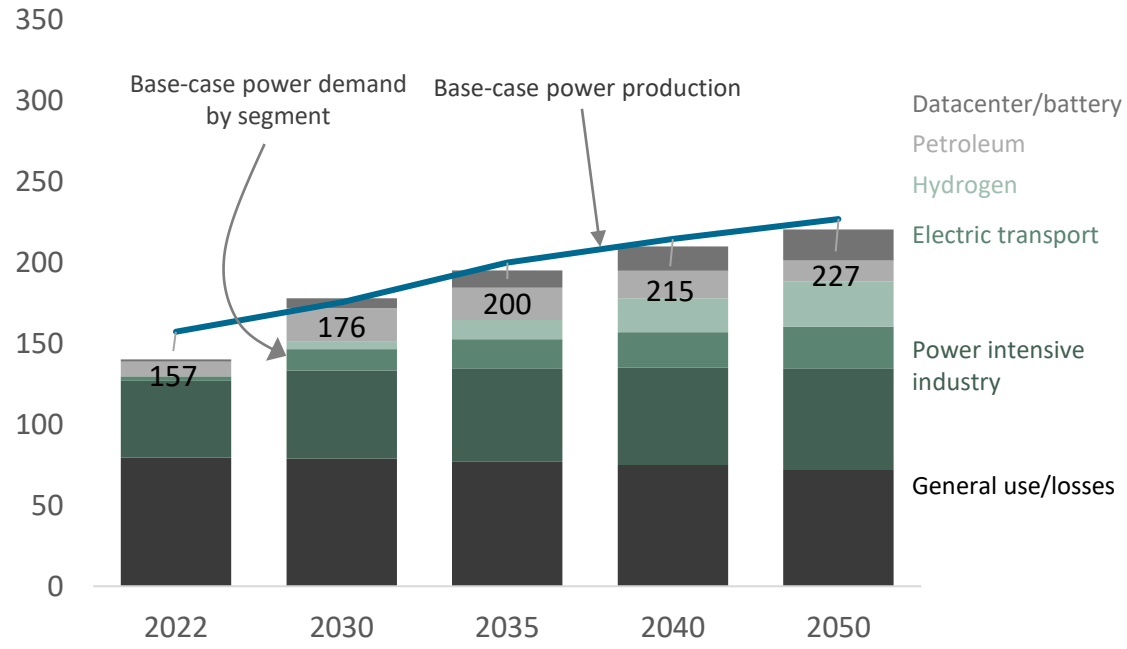


- Generation growth expected to pick up after 2030, primarily driven by more wind capacity, both onshore and offshore.
- Electricity consumption is expected to increase steadily caused by electrification of transport and industry in the medium- to long-term.
- The two agencies are largely aligned on the overall trends. The main difference is that NVE expects steeper growth in power generation between 2030 and 2040, driven by solar and offshore wind deployment.

* Based on NVE's "Langsiktig Kraftmarkedsanalyse 2023" (October 2023) and Statnett's "Langsiktig Markedsanalyse" (March 2023). NVE's outlook is likely to be outdated and a new version will be published in the fall of 2023.
Source: Rystad Energy research and analysis; NVE; Statnett

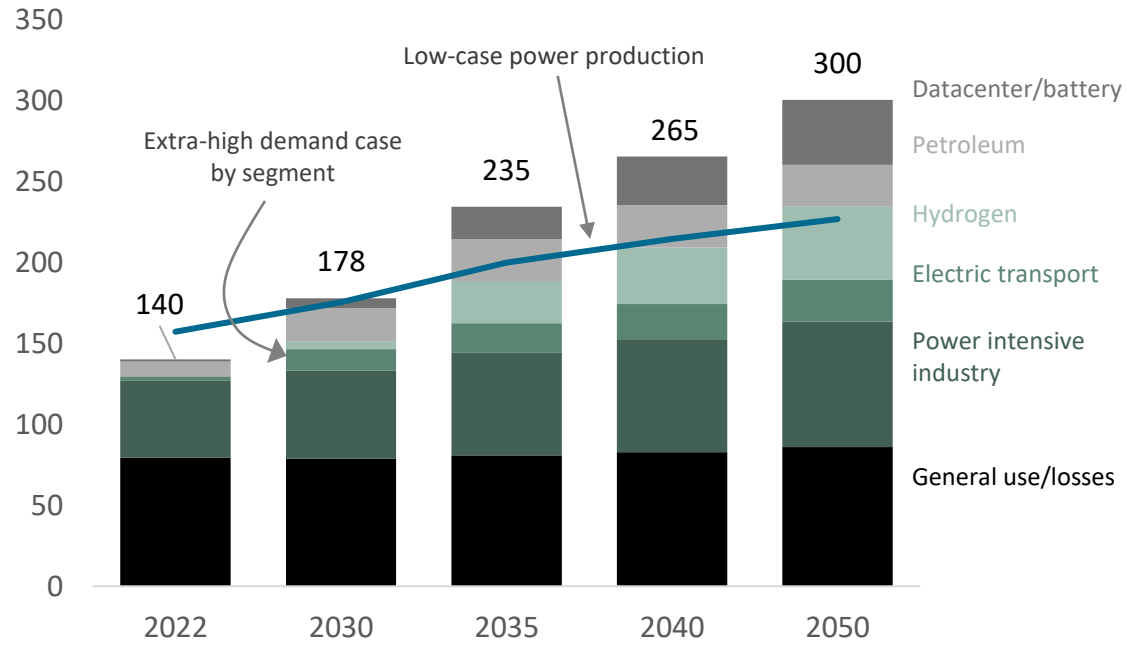
If power generation is not able to scale with demand, curtailment might be required

Base-case power balance, Norway
TWh, demand represented as columns, generation represented as the line



- Statnett expects that increased power demand going forward will be met through increased generation in its base-case power balance scenario.
- The increase is driven by the required electrification to meet the net-zero targets together with a substantial boost in industry activity.
- The base case scenario requires 50 TWh of new production within 2040.

Worst-case power balance, Norway
TWh, demand represented as columns, generation represented as the line



- Statnett expects a significant undersupply of power in its worst-case power balance scenario, where extra-high demand is not met by a slow increase in power generation.
- The unlikely worst-case scenario assumes a high demand response for an assumed low power price, making it slightly un-realistic.

Source: Rystad Energy research and analysis; Statnett

Industrial projects are the main driver behind growth in electricity consumption

Annual electricity consumption of selected potential projects as percentage of 2023 power generation*

Yara Herøya Green Ammonia

~ 1.8%**

… of total Norwegian power generation in 2023

Melkøya Electrification

~ 1.6%**

… of total Norwegian power generation in 2023

Morrow Batteries Arendal

~ 1.2%**

… of total Norwegian power generation in 2023

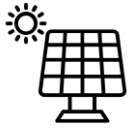
100 000 EVs

~ 0.2%***

… of total Norwegian power generation in 2023

* 156 TWh.; **Assuming 2.8 TWh for Yara, 2.5 TWh for Melkøya and 1.8 TWh for Morrow, calculated by assuming 70% utilization of announced capacity connection requirements; *** 12 000 km yearly with consumption of 0.2 kWh/km.
Source: Rystad Energy research and analysis; NVE; Statnett

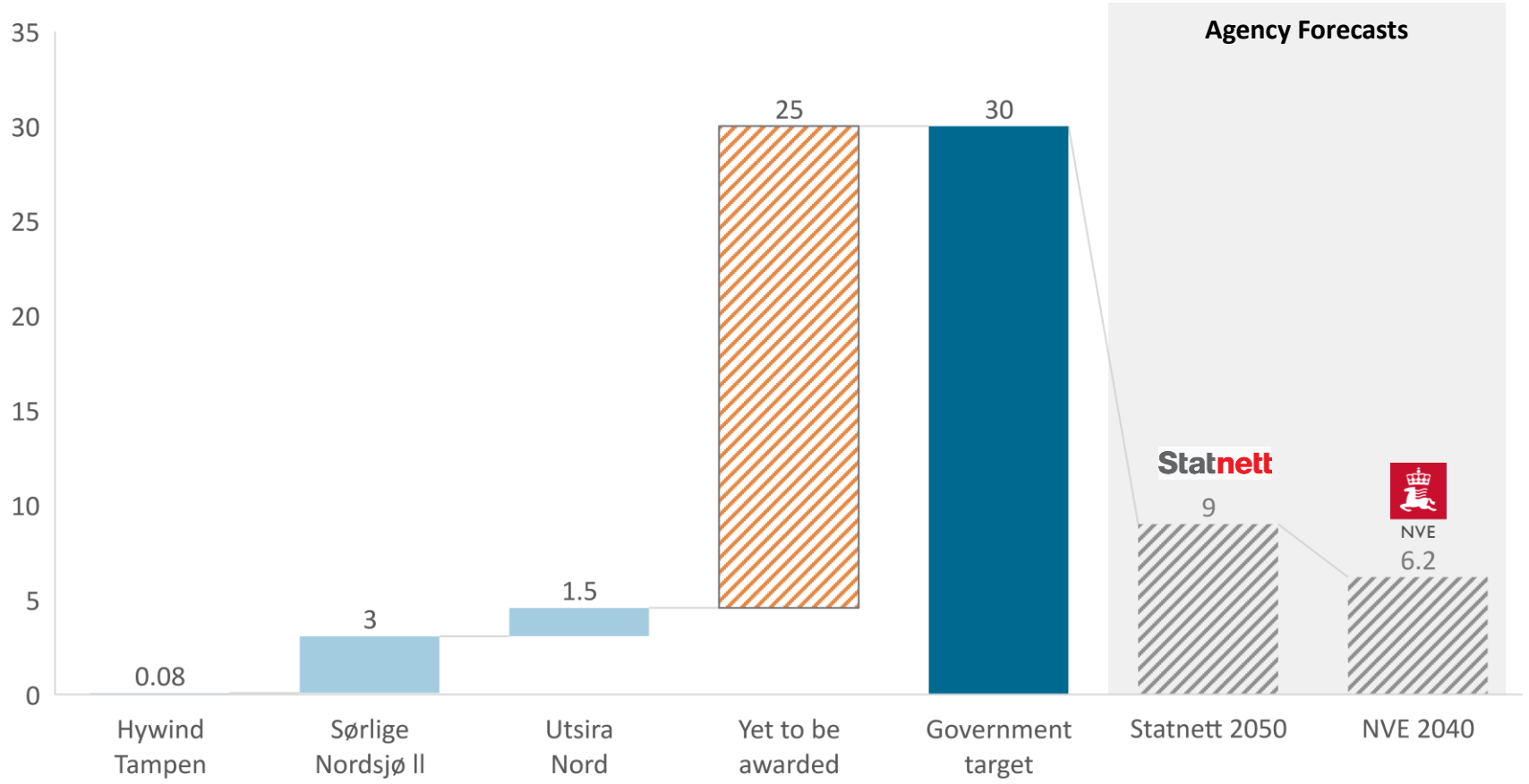
Norway needs more power, offshore wind may hold the largest potential

	Public perception	Government involvement	Generation potential	Competitiveness	Total assessment
Offshore wind 	Low public resistance, except from fishing organizations.	High ambitions but time-consuming processes.	30 GW target corresponds to 80% of Norwegian generation in 2022.	Bottom-fixed starting to become cost competitive, floating still immature.	
Onshore wind 	Protests and high uncertainty recently, e.g., the Fosen case.	Uncertainty slows down the concession process.	Large potential, but dependent on area allocation.	Well-proven technology with competitive costs in Norway.	
Solar PV 	Low opposition towards rooftop. Some resistance expected for utility-scale plants, e.g., from agricultural players.	Low awareness in government strategies. Enova subsidy recently reduced.	Limited potential caused by unfavorable climate and lack of suitable area.	Proven technology world-wide with decreasing costs. Profitability limited by Norwegian climate.	
Hydro 	Upgrading of existing facilities is possible, significant protests expected towards new capacity build-outs.	Limited actions to increase generation.	NVE identifies 6-8 TWh of new generation potential without major nature interventions.	Mature technology with low marginal cost. Flexible generation increases revenue.	

Source: Rystad Energy research and analysis

Known projects only account for 15% of Norwegian Government's 30 GW offshore wind target

Offshore wind capacity in Norway
GW



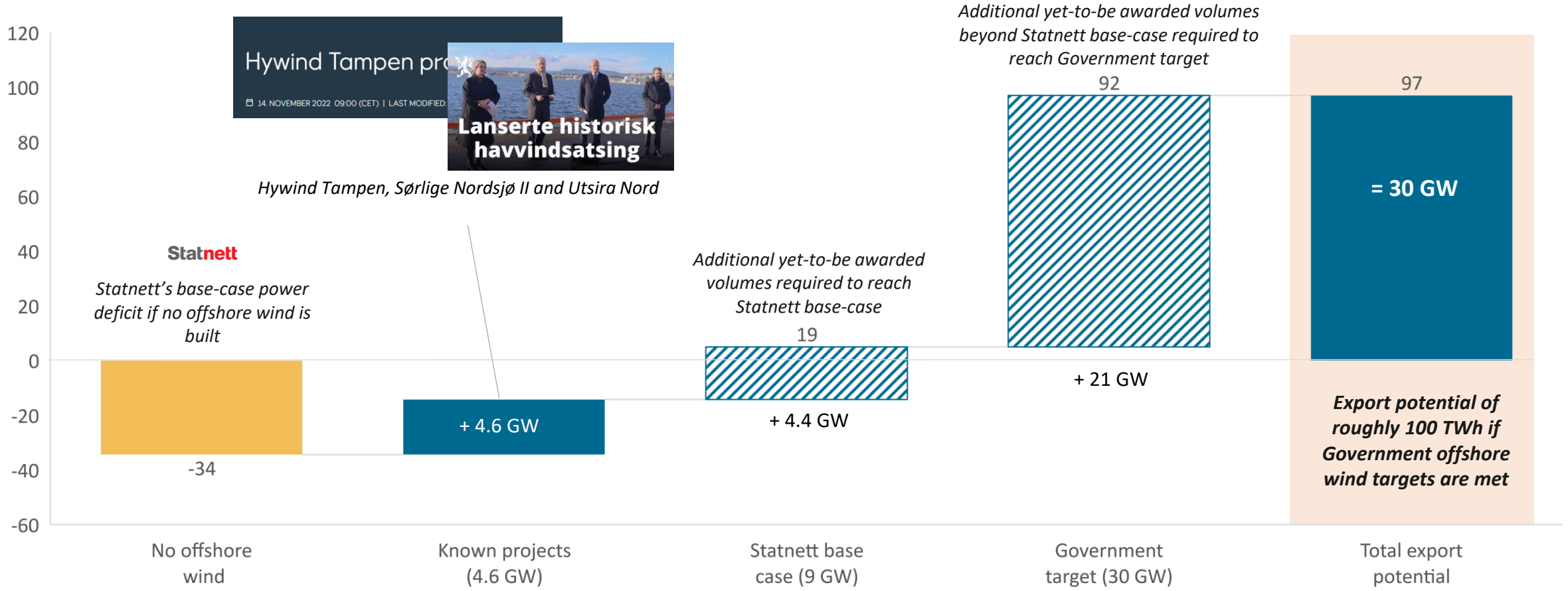
- The Norwegian Government's ambition is to announce 30 GW of offshore wind before 2040.
- Known projects only account for 4.6 GW. A significant ramp-up is necessary to reach the Government's target.
- The long-term forecasts by Statnett and NVE assume considerably lower offshore wind capacity than the Norwegian Government ambition.
- NVE's offshore wind forecast is particularly low, and lower than known projects.* This indicates that a large-scale development of offshore wind can have a positive impact on the power balances presented in previous slides.

* NVE's forecast is from "Langsiktig Kraftmarkedsanalyse 2021" (October 2021). Forecast likely to be revised upwards in the new version published in October 2023.
Source: Rystad Energy research and analysis; NVE; Statnett; Regjeringen.no

Significant export potential for Government 30 GW target, however significant uncertainties

Norwegian power balance in 2050 given various offshore wind scenarios*

TWh

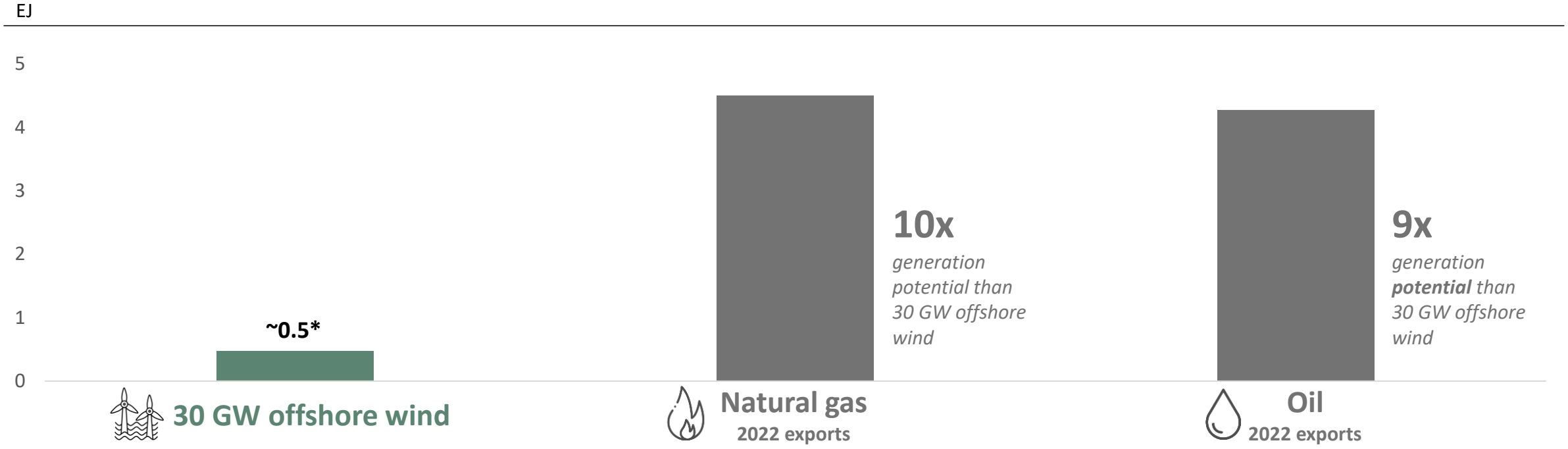


* Assuming 50% capacity factor

Source: Rystad Energy research and analysis; Statnett; Regjeringen.no

Even if government target is met, offshore wind will not replace Norwegian oil and gas exports

Energy generated from the Norwegian offshore wind target compared to 2022 oil and gas exports



Installation of 30 GW offshore wind in Norway, in line with the government target, can generate up to 0.5 EJ annually. This only accounts for **~5%** of the energy content of Norwegian O&G exports in 2022.

In the past years, Norwegian natural gas export has covered between **25-30% of EU27+UK** gas consumption. Shortfall of Norwegian gas supplies to Europe will be very hard to replace.

Norwegian oil production constitutes about **2% of global demand** for raw oil. Therefore, Norway can be considered as a relatively small and replaceable player in the global oil market.

* Power is converted from TWh to EJ using a conversion factor of TWh = 0.0036 EJ. Assuming 50% capacity factor for offshore wind.
Source: Rystad Energy research and analysis; Rystad Energy UCube; Norsk Petroleum

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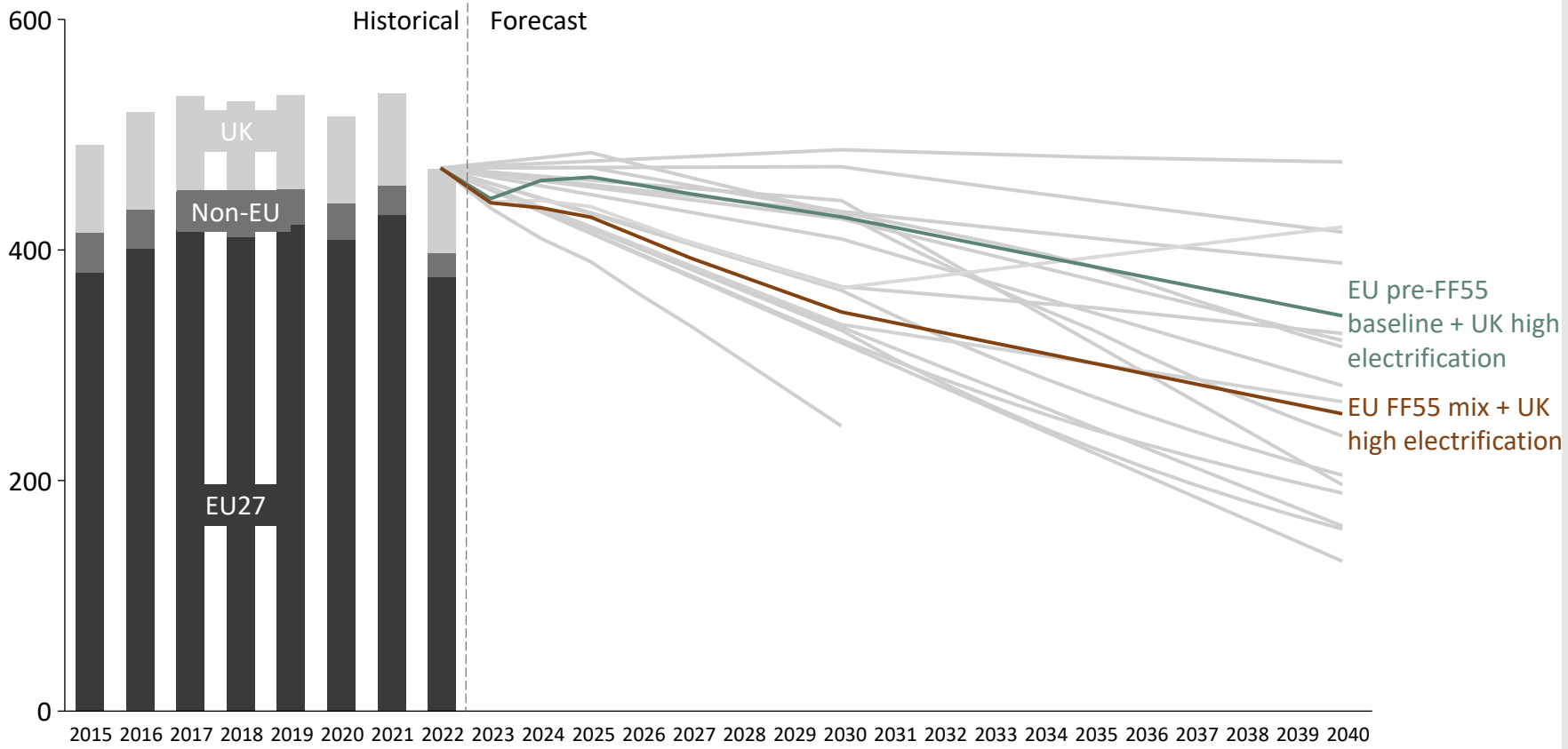
Uncertain long-term European gas demand depending on the extent of decarbonization…

European demand outlook by scenario*
Billion cm

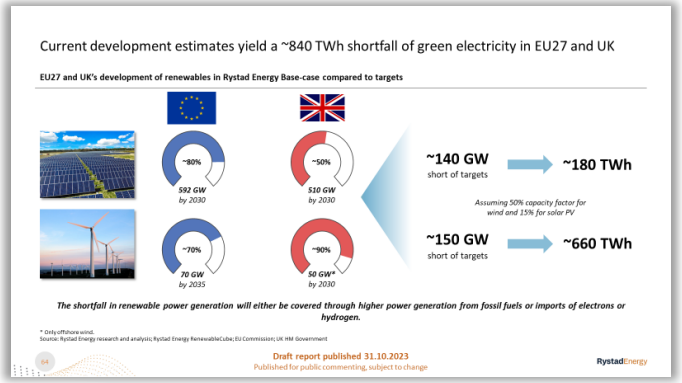


- The graph shows different scenarios for European gas demand going forward.
- The two highlighted scenarios have some distinct differences that can explain the different estimates for demand in 2040.
- The combination of the pre-Fit for 55 and high electrification scenario entails a reluctant support for continued investments in petroleum. This scenario is used for gas demand for rest of the report.
- The combination of the Fit for 55 and high electrification scenario entails continued support for investments in petroleum as a last resort.

* Countries included in the scope are EU, UK, Norway, Albania, Moldova, Montenegro, North Macedonia, Serbia, Switzerland, Ukraine – geographic coverage is not exactly 1 to 1 with historical data points. EU and UK forecasts only have 2030 and 2050 data points hence a simple linear extrapolation is used between each data point. Source: Rystad Energy research and analysis; Rystad Energy GasMarketCube; European Commission; UK Department for Business; Energy & Industrial Strategy; IEA; Equinor; TotalEnergies.

… but gas demand in Europe will remain high going forward

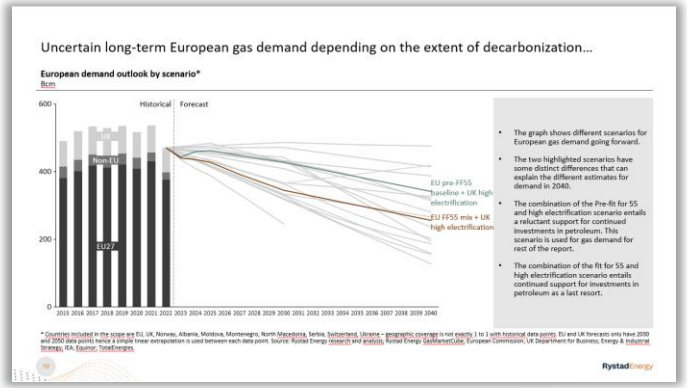
1 *Renewable energy development is falling behind ambitious EU and UK targets*



2 *Natural gas is less emission intensive than oil and coal and can serve as a transition fuel*

> *"Gas will continue to play a declining but still significant role in our energy system for decades to come"*
>
> *Power up Britain*

3 *European gas demand will remain high even in the most aggressive demand scenarios*



Despite the push for renewables, the demand for natural gas in EU27 and UK is expected to remain high. Declining domestic production and loss of Russian pipeline imports create a significant import gap.

Norway is uniquely positioned to play a pivotal role in expanding cost-effective and low-emission gas sources to fill this gap.

Source: Rystad Energy research and analysis

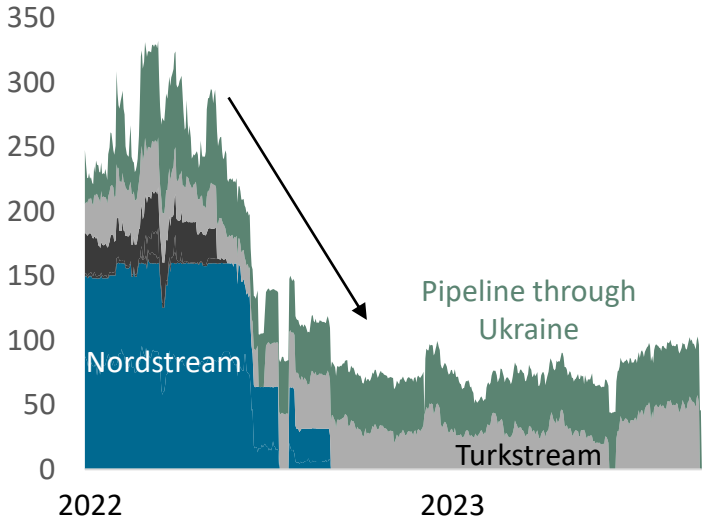
Significant changes to European gas market dynamics following the Russian invasion of Ukraine

The Russian invasion of Ukraine set off a chain of events in the gas market

Russian gas supply cut following Ukraine invasion…

Russian pipeline gas export to Europe 2022-2023

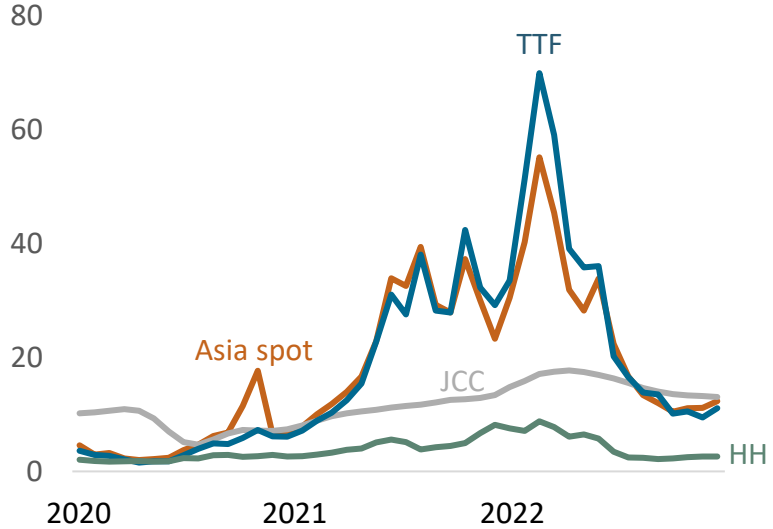
Million cubic meters per day



…followed by a historic price hike…

Gas prices 2020-2023

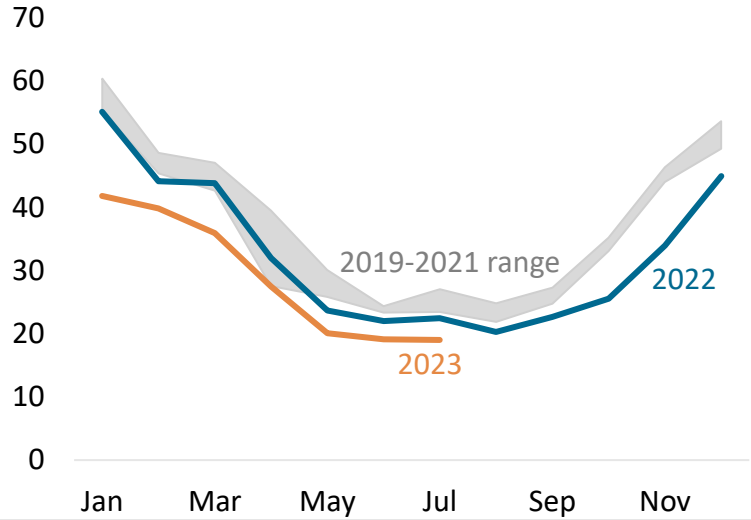
USD/MMBtu



…saved by a mild winter and cold summer

EU27 gas consumption trends 2019-2023

Billion cm



- The graphs show that Russian pipeline gas export to Europe declined with more than 70% from peak levels before the invasion to mid-2023. As a result, European gas demand was saturated by high volumes of LNG bought on the spot market, and the gas prices reached record highs. During 2023, the price has declined and settled on lower levels, but are still relatively high as it will take time for new projects to stabilize gas supply.
- As a result of high gas prices, EU's gas consumption has been lower on average than previous years. Lower consumption is also driven by a mild winter in 2022/2023 and a cold summer in 2023, implying that the situation could have been way worse.

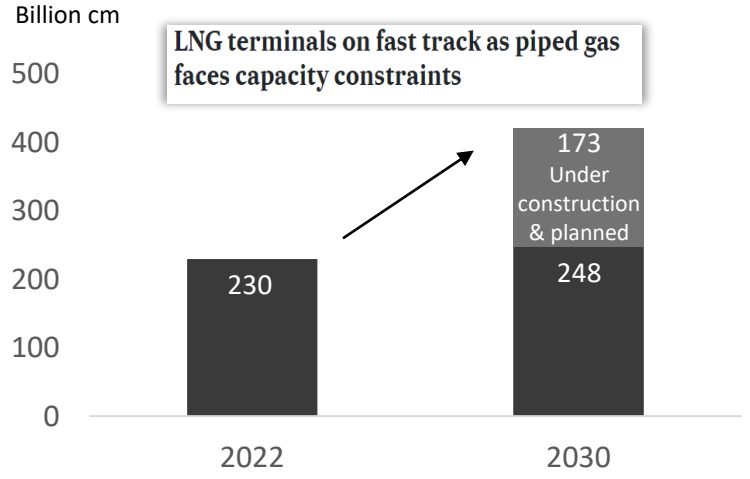
Source: Rystad Energy research and analysis, Rystad Energy GasMarketCube; Rystad Energy LNG Trade Solution

Europe forced to buy LNG at high cost – restarting Groningen and demand curtailment are options

Short-term supply alternatives in pecking order

Europe is expanding regasification capacity to access LNG

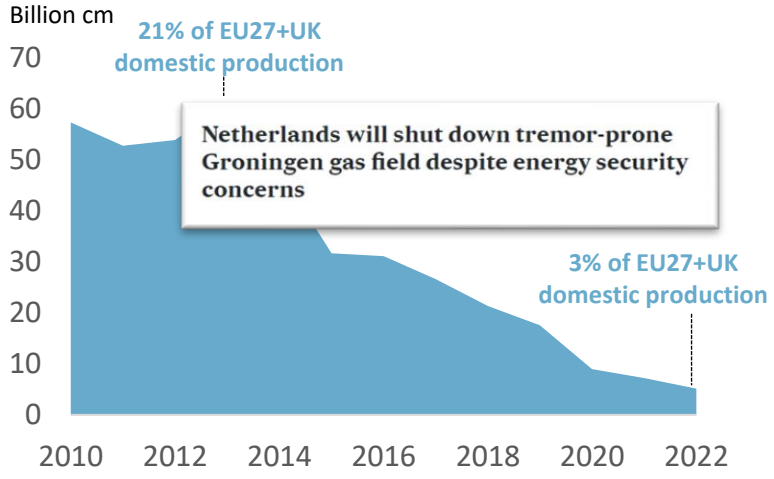
EU27+UK regasification capacity



- Regasification capacity utilization in Europe surged after the Russian invasion of Ukraine.
- Going forward, Europe will rely on LNG imports to cover demand. Countries are expanding regasification capacity to alleviate infrastructure pressure.

Energy security concerns can force Groningen gas field to increase output

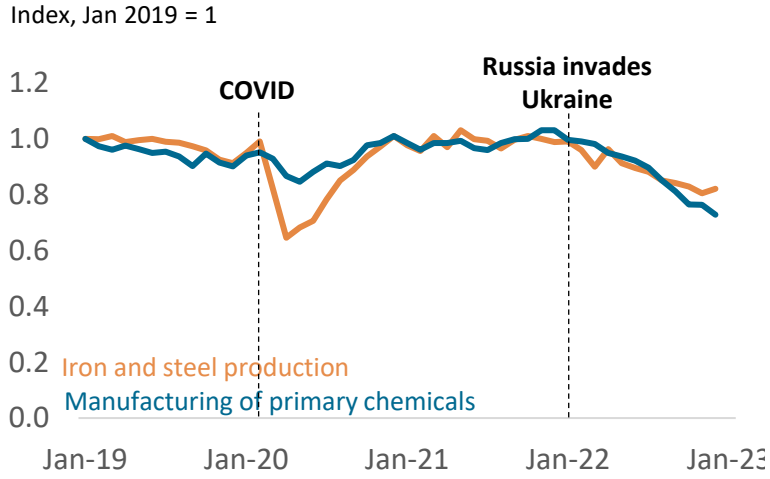
Groningen gas production



- The Groningen gas field in the Netherlands, once one of the world's largest, has seen production cuts due to regional earthquakes.
- The field is set to close in 2024 but could reopen to secure European gas supply, as a last resort.

Demand curtailment can be necessary

Output of selected energy-intensive industries in EU

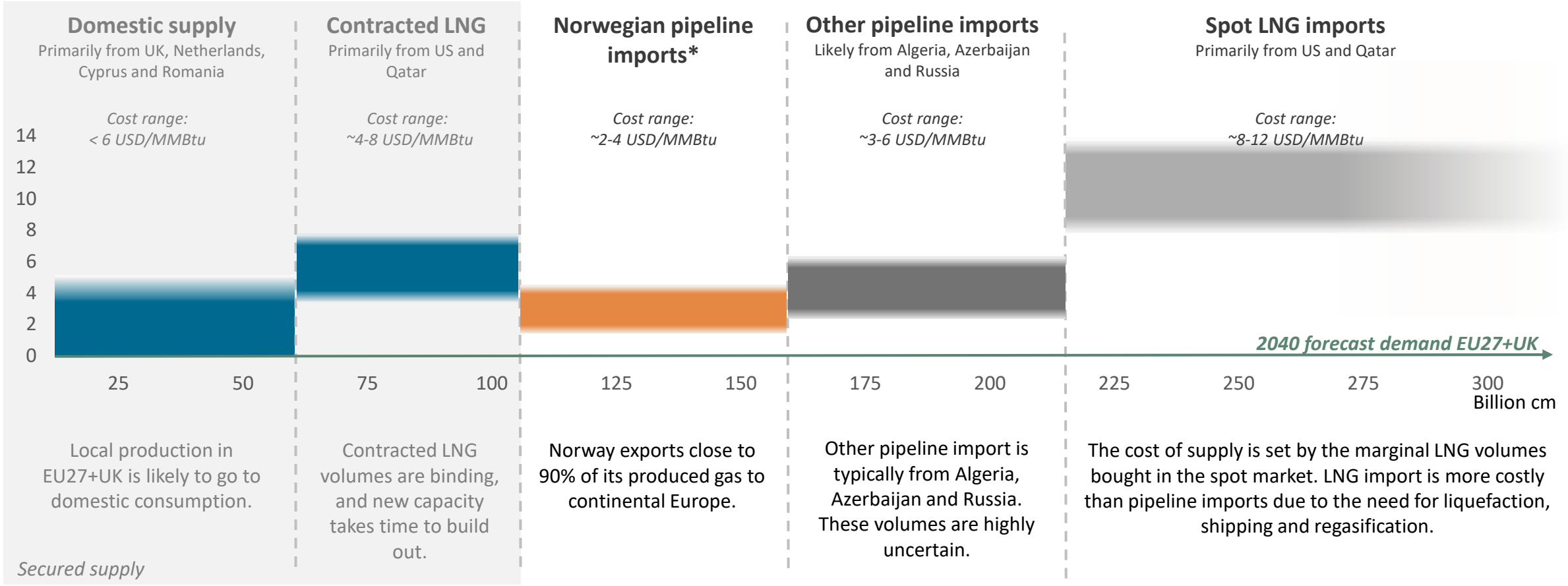


- EU27 industrial output declined after Russia's invasion of Ukraine.
- The post-invasion energy price surge significantly affected consumption. If the high prices persists, gas demand curtailment may be necessary.

Source: Rystad Energy research and analysis; Rystad Energy GasMarketCube

Pipeline import is the preferred supply source to EU27 and UK due to low cost

Indicative cost of supply curve for natural gas delivered to EU27 and UK in 2040 by supply source
USD/MMBtu

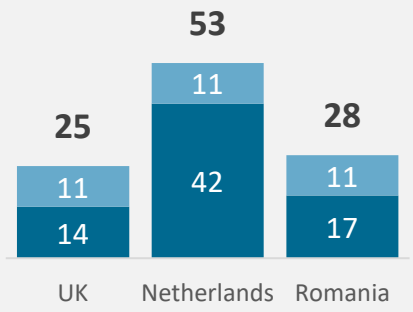


* Includes production from not yet sanctioned gas fields.
Source: Rystad Energy research and analysis; Rystad Energy GasMarketCube

LNG imports with higher emission intensity than piped gas supply

Emission intensity along the value chain for gas delivered to EU27+UK by supply source
Kg CO_2/boe

Domestic supply
Primarily from UK, Netherlands, Cyprus and Romania



Domestic supply has lower emission intensity than imported LNG.

Secured supply

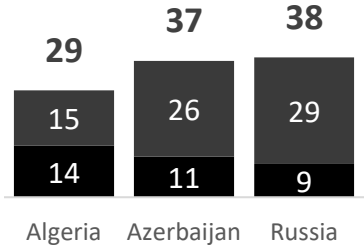
Contracted LNG
Primarily from US and Qatar

Contracted LNG volumes from US and Qatar will have relatively high emission intensity.

Norwegian pipeline imports

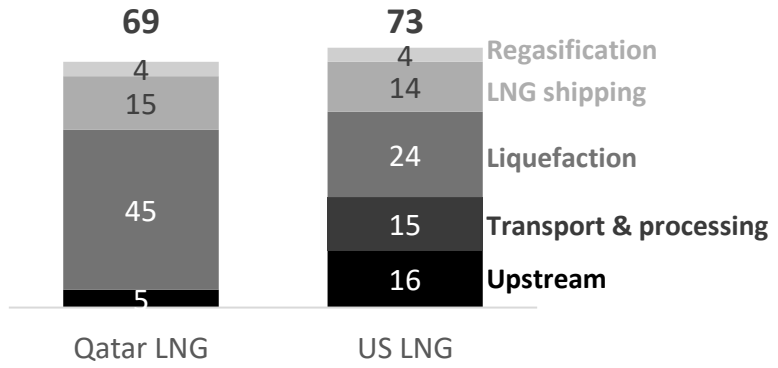
Norwegian piped gas has low intensity partly due to electrification and energy efficiencies.

Other pipeline imports
Primarily from Algeria, Azerbaijan and Russia



Other piped gas has lower emissions than LNG, yet higher than Norwegian piped gas.

Spot LNG imports
Primarily from US and Qatar

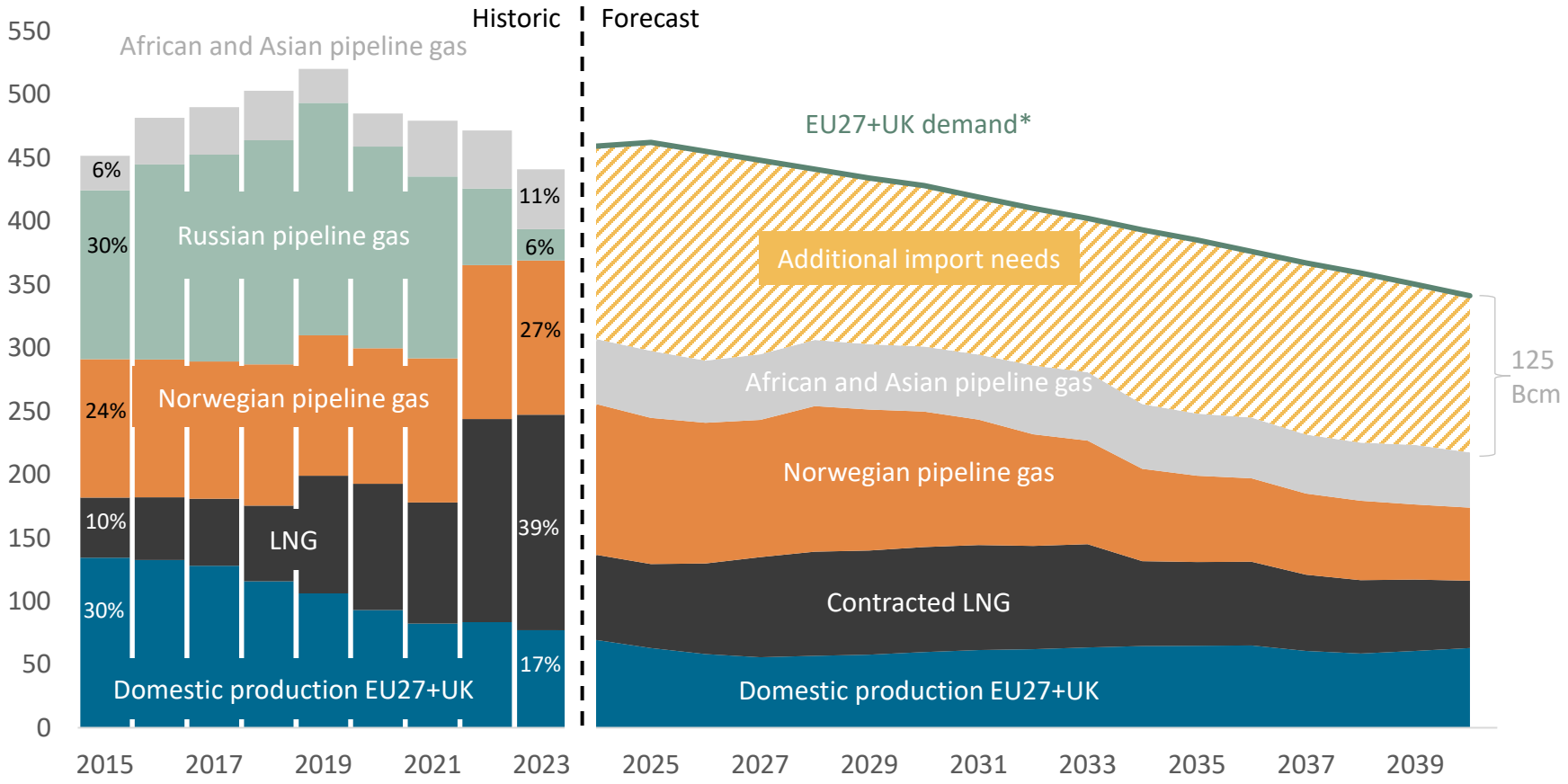


LNG must be liquefied for transportation, and prior to this, the gas must be thoroughly purified. Emissions related to long-distance shipping and regasification also lead to higher emission intensity.

Source: Rystad Energy research and analysis; Rystad Energy GasMarketCube; Rystad Energy EmissionCube

Norwegian piped gas likely to be crucial to fill EU27 and UK's long-term gas import gap

EU27+UK gas sources
Billion cm



- The graph shows the largest sources of gas imports to EU27 and UK. Before Russia's invasion of Ukraine in 2022, Russian piped gas was the largest gas supply source to EU27+UK.
- After the loss of Russian piped gas, large volumes of LNG have been imported to cover demand. Going forward, EU27 and UK are highly dependent on further gas imports.
- Norwegian piped gas will play a crucial role in supplying Europe with gas going forward.
- The significant import gap points to that there will be limited opportunities for utilizing natural gas to produce blue hydrogen, as the need for gas as-is is significant. In addition, the import gap gives incentives to expand Norwegian gas production.

* EU pre-FF55 baseline + UK high electrification.
Source: Rystad Energy research and analysis; Rystad Energy GasMarketCube

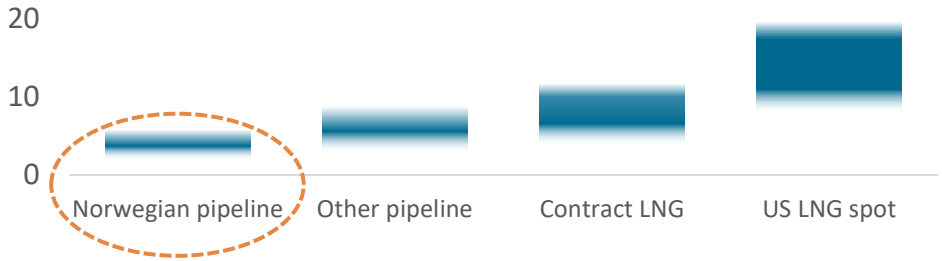
Norwegian gas supply has highly competitive cost and low emission intensity

Reasons for longevity of NCS gas supply

1. **Highly competitive on cost**
2. **Emission intensity among the lowest in the world**
3. Stable supplier with growing European market share
4. The call for additional Norwegian gas is strong

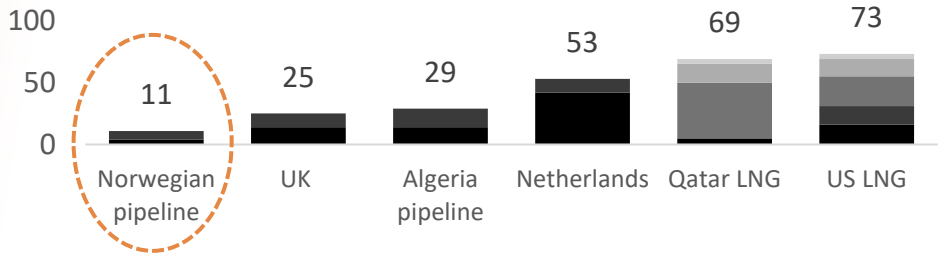
Indicative cost of gas delivered to EU27+UK

USD/MMBtu



Emission intensity for gas delivered to EU27+UK

Kg CO_2/boe



Source: Rystad Energy research and analysis; Rystad GasMarketCube

Norwegian gas supply is stable and will become more important to European energy security

Reasons for longevity of NCS gas supply

1. Highly competitive on cost
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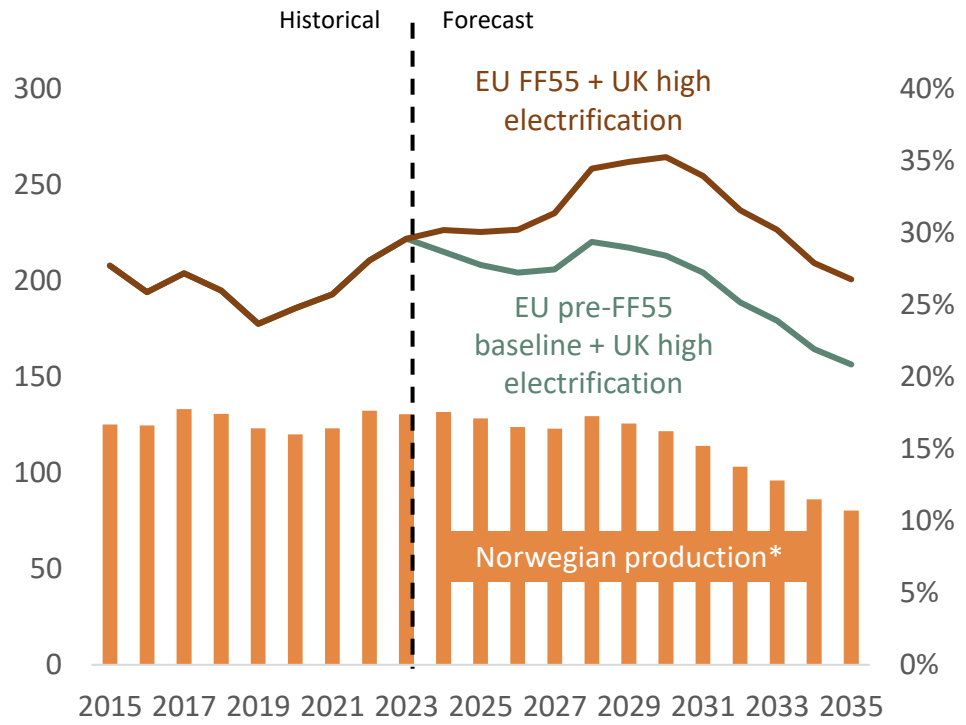
3. **Stable supplier with growing European market share**
4. The call for additional Norwegian gas is strong

EU27+UK gas demand and Norwegian production

Billion cm (LHS), Norwegian production share of EU27+UK demand (RHS)



* Forecasted Norwegian gas production also includes production from not-yet sanctioned fields.
Source: Rystad Energy research and analysis; Rystad GasMarketCube

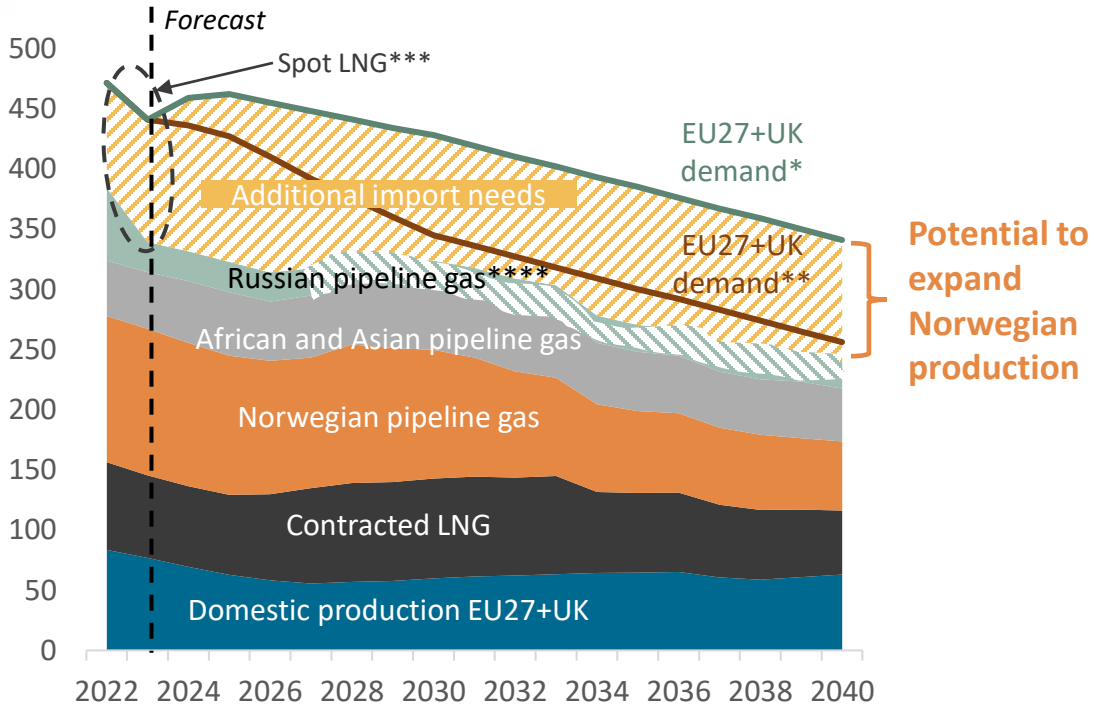
High demand for Norwegian gas supply

Reasons for longevity of NCS gas supply

1. Highly competitive on cost
2. Emission intensity among the lowest in the world
3. Stable supplier with growing European market share
4. **The call for additional Norwegian gas is strong**

EU27+UK future gas import sources

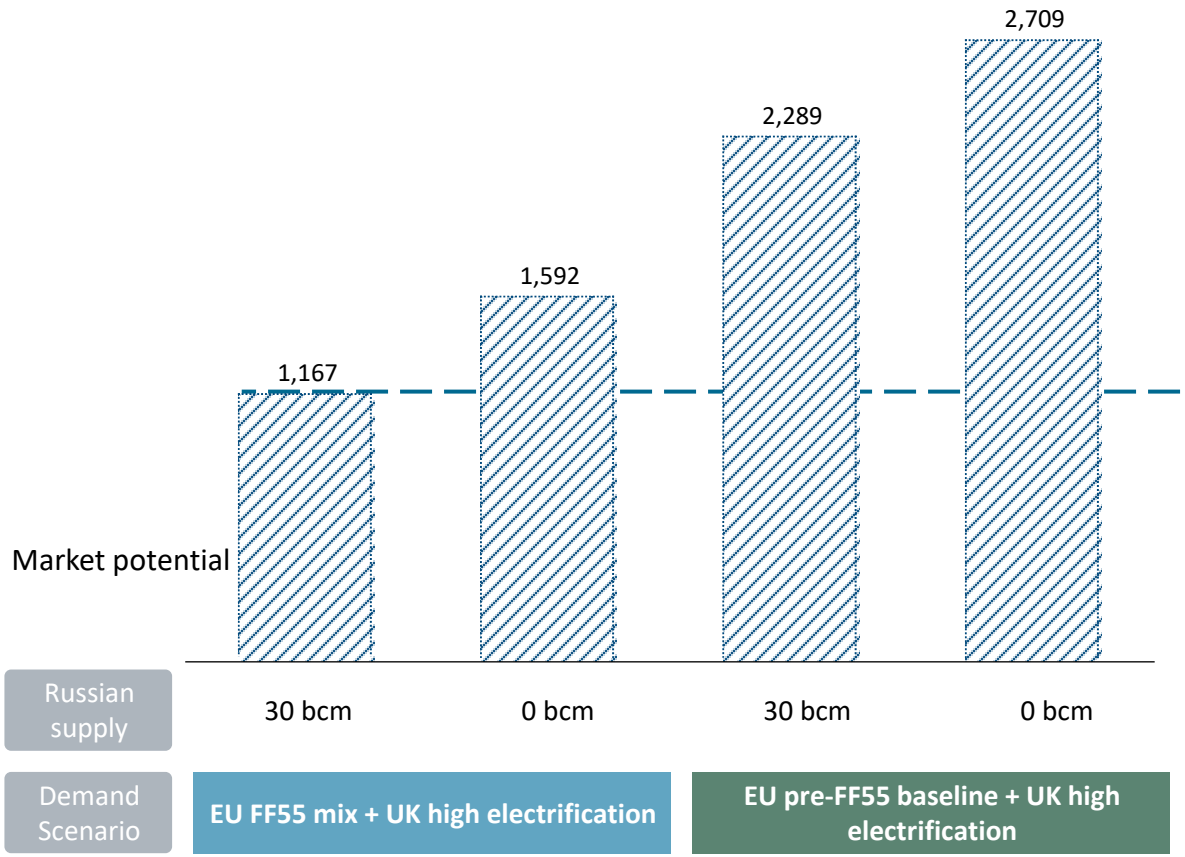
Billion cm



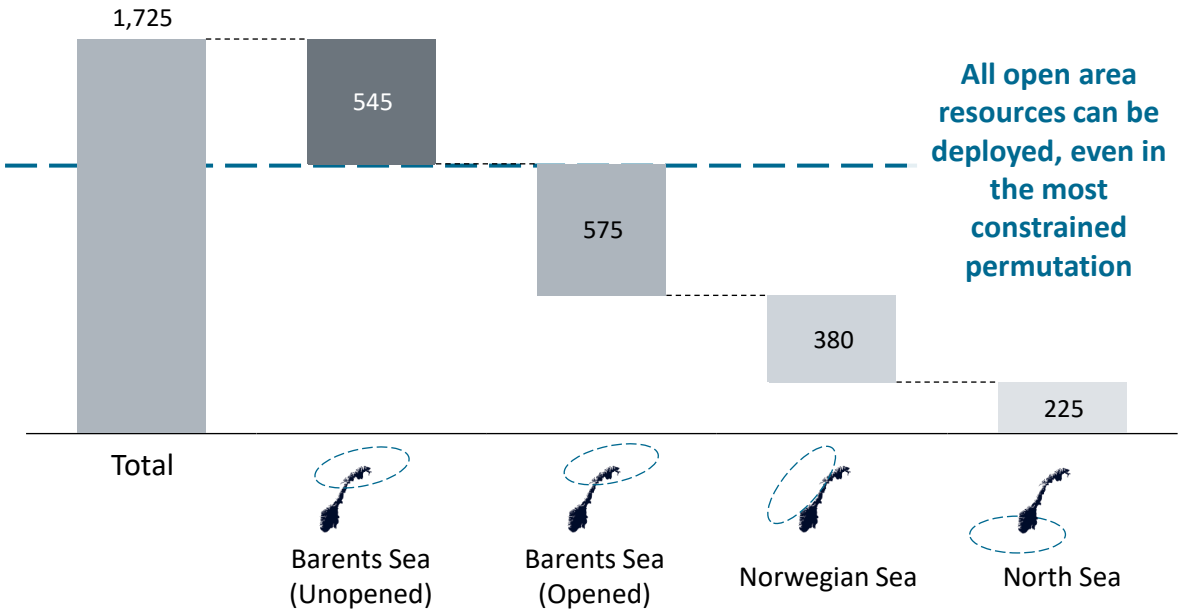
* EU pre-FF55 baseline + UK high electrification; ** EU FF55 + UK high electrification; *** Large volumes of spot LNG filled the demand gap.; **** EU aims to end use of Russian gas by 2027, such that these volumes are highly uncertain.
Source: Rystad Energy research and analysis; Rystad Energy GasMarketCube

Norway have potential to increase gas deliveries through development of undiscovered volumes

Cumulative market potential 2027-2040
Billion cm



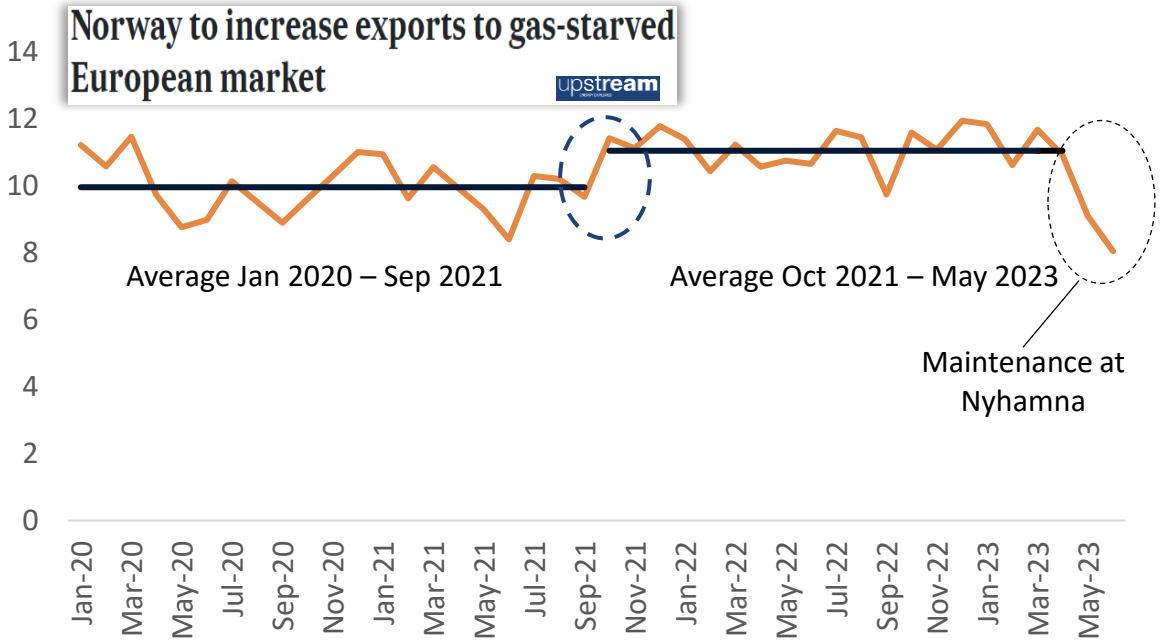
Undiscovered NCS resources according to NPD
Billion cm



Source: Rystad Energy research and analysis, NPD

Recent events have shown that production from existing NCS gas fields can be increased

Monthly Norwegian gas production, Jan 2020 - Jun 2023
Billion cm



- The Norwegian government approved additional production from the gas fields Troll, Heidrun and Oseberg in September 2021 following the gas market crunch.
- After Russia's invasion of Ukraine, the Norwegian government extended the permits for additional gas production. The measures made it possible to keep Norwegian gas export at record highs through the usual maintenance periods.

Methods to increase production from existing gas fields

LPP

Low-pressure production on Ormen Lange

Gas injection

Gas re-injected into Gina Krog oil field is exported instead

Brownfield expansion

Equinor to unlock 45-year-old gas discovery to boost supplies to Europe

- Low-Pressure Production (LPP) extends field life by extracting gas from lower-pressure reservoirs as they mature. Operators may prioritize gas production over oil by exporting previously reinjected gas. Brownfield expansion involves prolonging the life of existing fields by integrating new discoveries

Source: Rystad Energy research and analysis; NPD; Upstream; Bloomberg

Table of content

EU has very aggressive hydrogen targets intended to be used primarily in industry and transportation

	EU	UK
Solar PV	***592 GW*** *capacity required by 2030 (REPowerEU)*	***70 GW*** *installed capacity by 2035 (Powering Up Britain)*
Wind	***510 GW*** *capacity required by 2030 (REPowerEU)*	***50 GW*** *offshore wind by 2030 (Powering Up Britain)*
Hydrogen H2	***20 mtpa*** *of renewable hydrogen consumed annually by 2030 (REPowerEU)*	***0.9 mtpa*** *Low-carbon hydrogen production by 2030* (Powering up Britain)*
CCUS CO_2	***50 mtpa*** *of carbon injection capacity in the EU by 2030 (Net-Zero Industry Act)*	***20-30 mtpa*** *of captured and stored CO_2 by 2030 (Powering up Britain)*

Targets are set to decrease fossil fuel consumption

Targets for renewable power and consumption of hydrogen are intended to reduce the fossil fuel demand. Short-falls in reaching these targets mean that fossil fuel demand will not be reduced as much as it could be if goals were met.

"With the measures in the REPowerEU plan, we could gradually remove at least 155 bcm of fossil gas use"
European Commission

"Gas will continue to play a declining but still significant role in our energy system for decades to come"
Powering up Britain

* Assuming 50% electrolyzer capacity on the 10 GW hydrogen capacity target.
Source: Rystad Energy Research and Analysis; EU Commission; UK HM Government

EU regards green hydrogen to be the future, while blue plays a transitional role

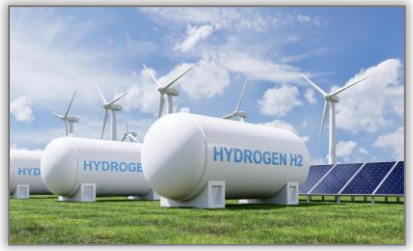
EU view on hydrogen in the medium- and long-term

Green hydrogen (Renewable hydrogen)*

Renewable hydrogen production volumes are currently limited both by electrolyzer and renewable power capacity.

Post-2030, the EU communication and initiatives focus on renewable hydrogen, through for example the REPower EU initiative communicating consumption targets for renewable hydrogen.

There are therefore strong indications that renewable hydrogen (green hydrogen) is EU's preference in the medium- to long-term.



Renewable hydrogen is defined by the energy sources it uses, such as wind, hydro and solar power.

EU Commission

Blue hydrogen (Low-carbon hydrogen)*

Low-carbon blue hydrogen can play a transitional role in ramping up the hydrogen economy, especially as long as green hydrogen is only available in limited quantities and at a high cost.

However, it is expected that EU will introduce a stricter GHG reduction threshold for low-carbon hydrogen than the 70% threshold that currently is in place post-2030.

Hydrogen produced from natural gas with CCS is therefore at risk of being faced out in the EU post-2030.

Low-carbon hydrogen is defined by the amount of GHG emissions it produces and is neutral to the method used.

EU Commission

* The EU Commission and EU Parliament are moving away from a color classification scheme to one where hydrogen is classified based on the source of the electricity used and the achieved GHG reduction compared to fossil alternative.
Source: Rystad Energy research and analysis; Rystad Energy HydrogenCube; EU Commission

Europe will struggle to reach its production goal with current pipeline, import goal more likely

REPowerEU targets 20 million tonnes of green hydrogen consumption by 2030, where half is produced domestically, and the rest is imported

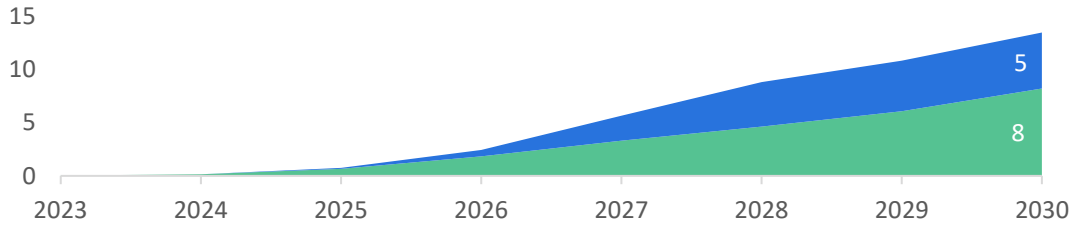
1

EU's goal is to produce 10 mtpa of green hydrogen by 2030

Europe will have roughly eight million tonnes of green and five million tonnes of blue hydrogen production capacity by 2030 based on known projects.

However, it is important to separate capacity from production, where the latter is lower due to ramp-up periods and utilization. Realistic hydrogen output based on known projects are therefore significantly lower than known capacity by 2030.

Cumulative capacity in million tonnes of H_2 (Excluding grey)*



Domestic production of 10 mtpa of green hydrogen appears unrealistic given current project pipeline

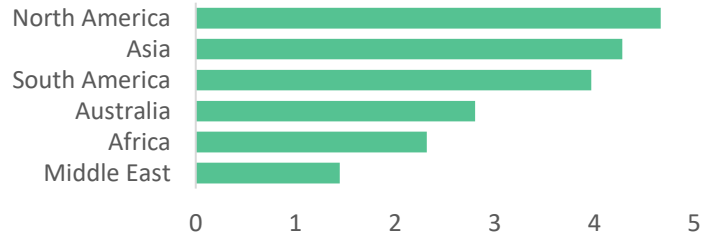
2

EU's goal is to import 10 mtpa of green hydrogen by 2030

The global green hydrogen production capacity is estimated to be roughly 20 million tonnes by 2030, excluding Europe.

However, due to difference between capacity and production, and that not all these volumes are intended for Europe, the likelihood of EU being able to get its hands on 10 million tonnes of green hydrogen seems unlikely.

Cumulative capacity in million tonnes of green H_2 per region(Excluding blue and grey)*



~ 20
million tonnes of green H_2 by 2030*

The likelihood of EU being able to get its hands on 10 million tonnes of green hydrogen seems unlikely given the global project pipeline

* Unrisked volumes, so actual production will likely be lower
Source: Rystad Energy research and analysis; Rystad Energy HydrogenCube; EU Commission

Hydrogen a key tool for EU's decarbonization and it is likely room for both green and blue hydrogen

1

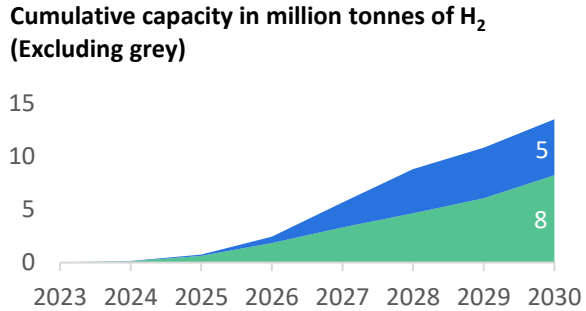
EU wants green hydrogen for their decarbonization efforts ...

*Consume 20 million tonnes of **renewable** hydrogen by 2030, of which 10 million tonnes are domestic production and 10 million tonnes are imported.*

EU Commission

2

... however, uncertain if green hydrogen production can scale up quickly enough ...



3

... yielding potential for blue hydrogen to cover shortfall in green production

Low-carbon blue hydrogen can play a transitional role in ramping up the hydrogen economy, especially as long as green hydrogen is only available in limited quantities and at a high cost.

EU Commission

EU has set clear goals related to consumption, domestic production and import of renewable hydrogen. The hydrogen is intended to replace natural gas, coal and oil in hard-to-decarbonise industries and transport sectors.

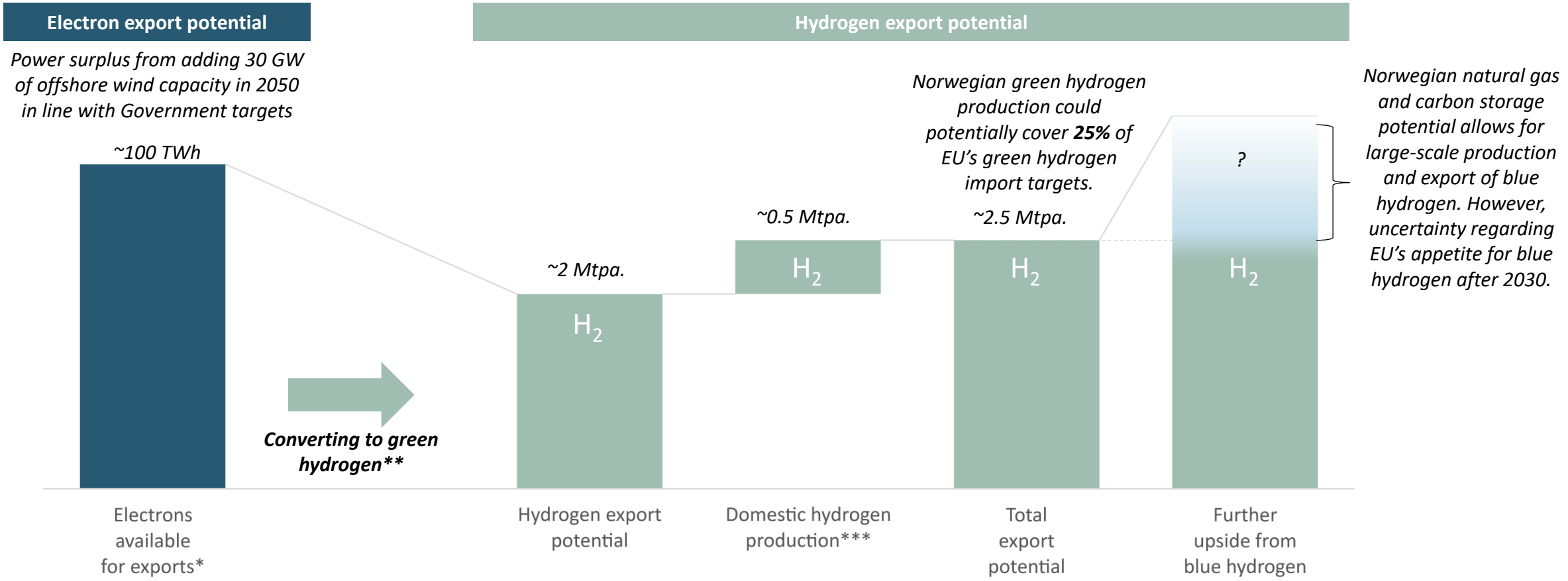
Current project pipeline for green hydrogen projects in Europe leave doubt if production is able to scale up quickly enough to match ambitious targets. Also uncertainties if import target is possible to meet.

Shortfall in green hydrogen production yields a upside potential for blue hydrogen to be welcomed back into the warmth to ensure EU are able to reach its consumption targets.

Source: Rystad Energy research and analysis; Rystad Energy HydrogenCube; EU Commission

Norway can achieve considerable hydrogen export potential from offshore wind or natural gas...

Norwegian electron and hydrogen export potential
TWh and million tonnes of hydrogen

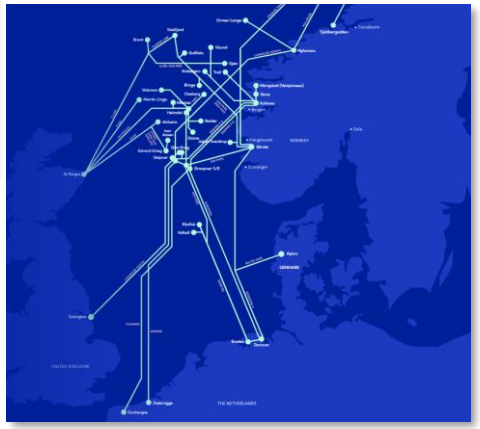


* Based on Statnett's base scenario + 30 GW offshore wind with 50% capacity factor.; ** Rule of thumb: 50 TWh electricity produces appr. 1 Mt H_2.; *** Statnett's 2050 power balance includes 28 TWh for domestic green H_2 production.
Source: Rystad Energy research and analysis; Statnett

… but hydrogen exports should be avoided because of high conversion losses

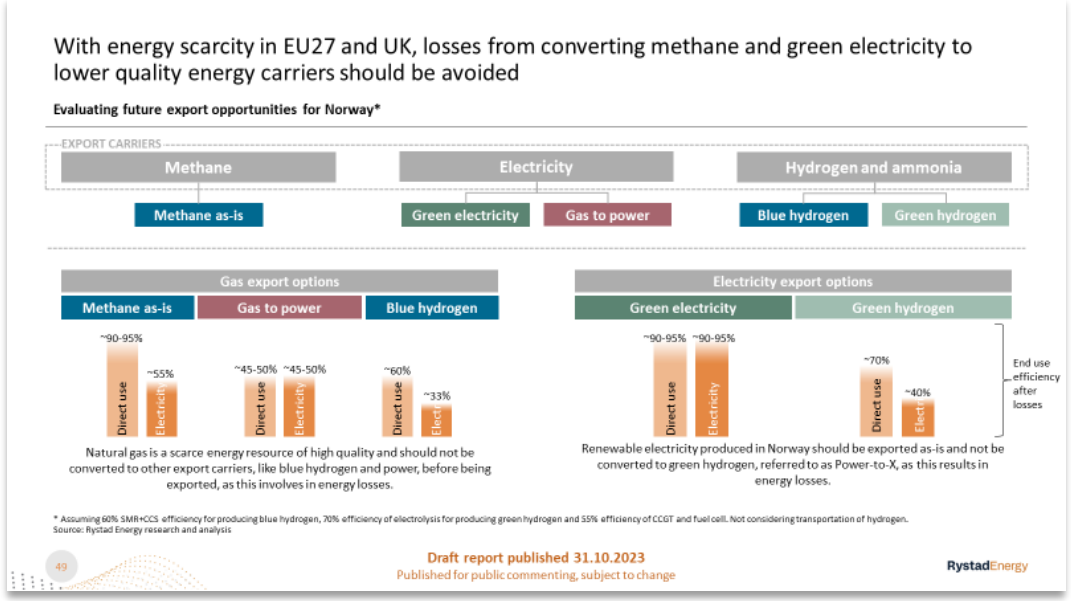
Norway is favorably located close to the European market…

Norway is located close to core markets in Europe. This allows for relatively low transportation costs, either by ship or pipeline. Furthermore, Norway can potentially benefit from retrofitting of existing natural gas pipelines, depending on technological feasibility.



…but hydrogen exports should be avoided because of high conversion losses

Conversion of natural gas or electrons to hydrogen will entail large efficiency losses. Taking into account the scarce energy situation in Europe, Norway should export natural gas and electricity directly in order to supply more energy to Europe.



Source: Rystad Energy research and analysis; Norwegian Petroleum; Regjeringen.no; Equinor

UK has significantly more aggressive CCS targets than EU considering the size of the economy

	EU	UK
Solar PV	***592 GW*** *capacity required by 2030 (REPowerEU)*	***70 GW*** *installed capacity by 2035 (Powering Up Britain)*
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Targets are set to decrease fossil fuel consumption

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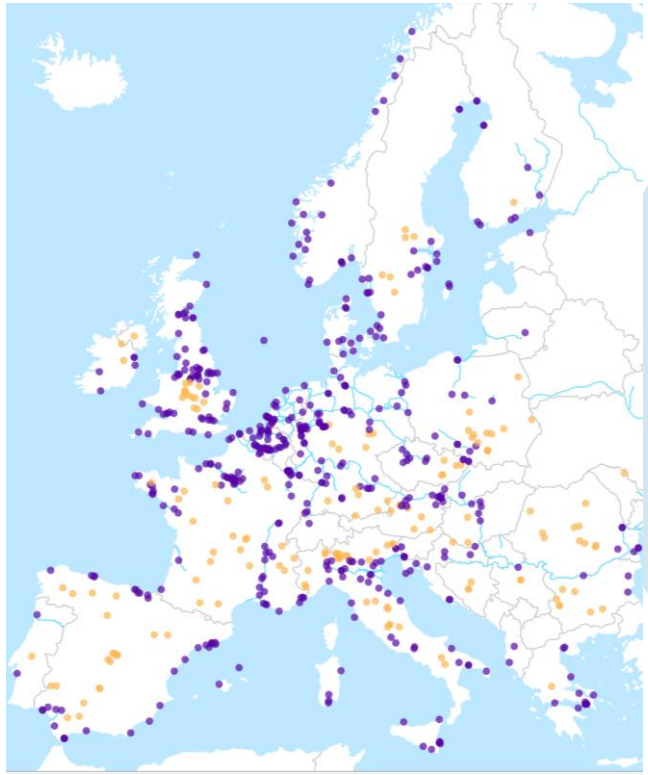
European Commission

"Gas will continue to play a declining but still significant role in our energy system for decades to come"
Powering up Britain

* Assuming 50% electrolyzer capacity on the 10 GW hydrogen capacity target.
Source: Rystad Energy Research and Analysis; EU Commission; UK HM Government

Significant need for carbon capture within hard-to-abate industries and hydrogen production

Point source emitters in the EEA and UK



Less than 50km from a river or coast

or

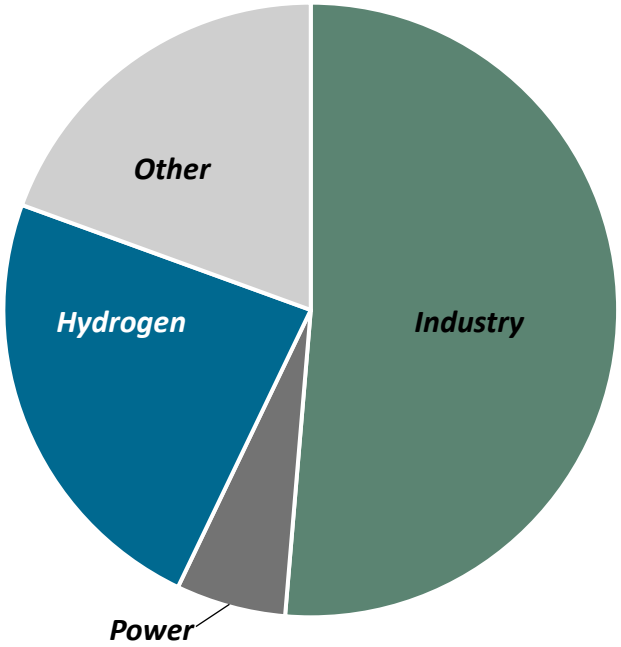
5Mt CO_2 in a 50km^2 cluster

covers

85% of emissions

2030 CO_2 capture capacity in EU27 based on announced projects*

Hard-to-abate industries *and* ***hydrogen production*** *are expected to account for* ***75%*** *of EU's carbon capture capacity in 2030.*

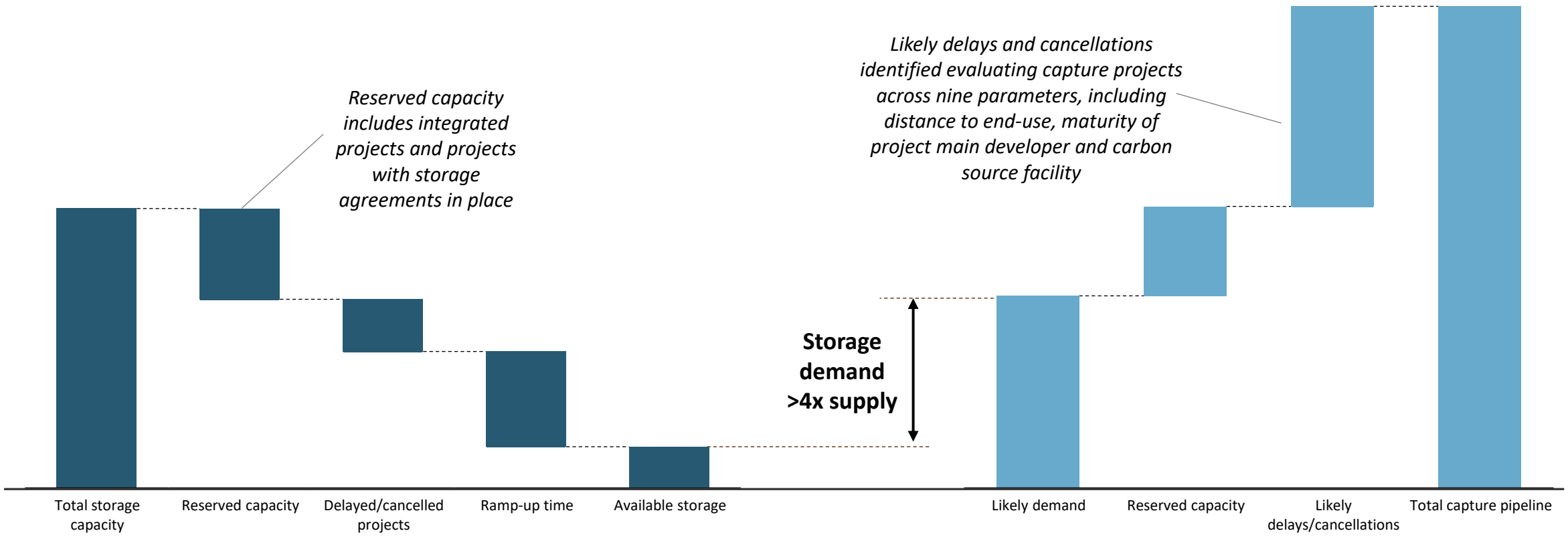


* Based on announced maximum capture capacity, not accounting for ramp-up.
Source: Rystad Energy research and analysis; Rystad Energy CCUSCube

Large expected undersupply of CO_2 storage, requiring emitters to act quickly to secure capacity

European carbon storage capacity by 2030
Mtpa. of CO_2

European carbon capture capacity by 2030
Mtpa. of CO_2



Source: Rystad Energy research and analysis

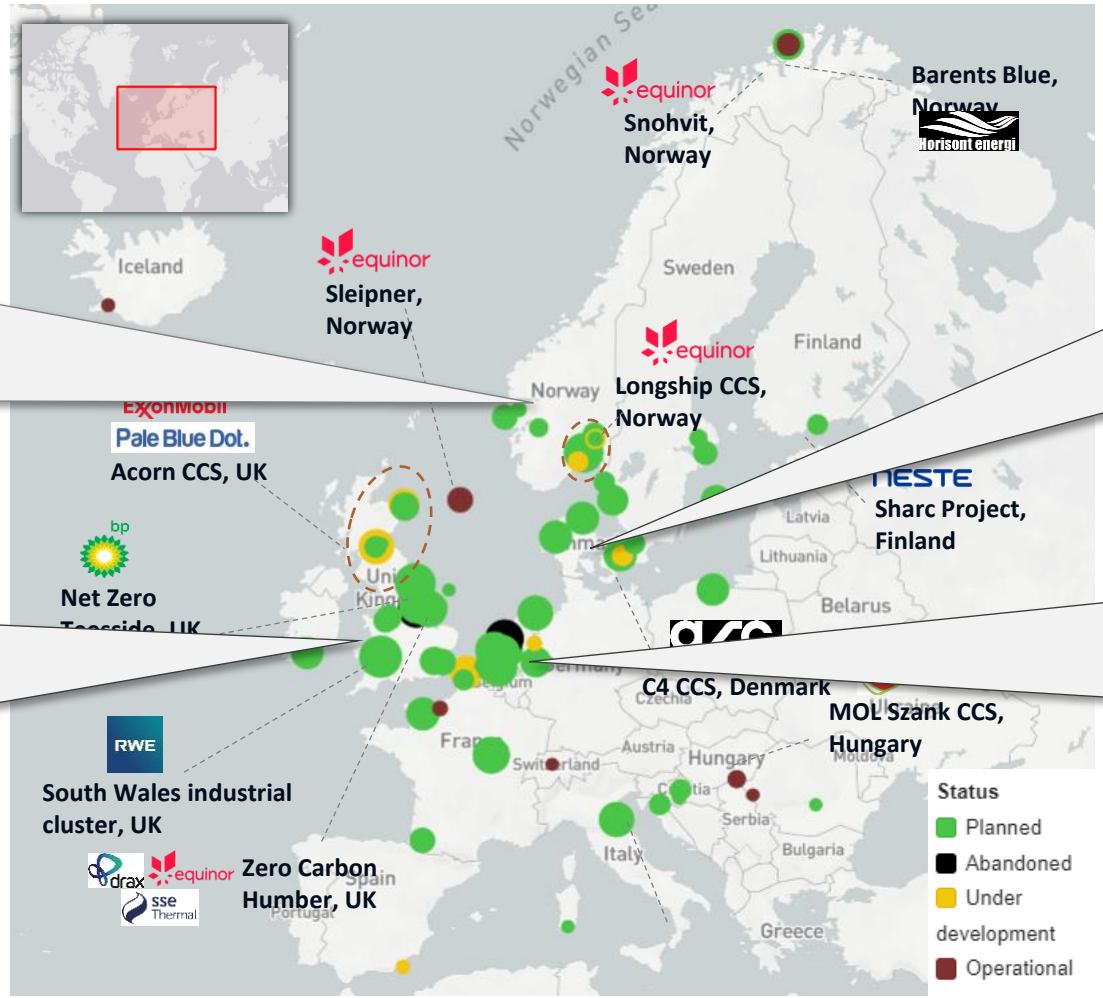
Norway likely to benefit from first-mover advantage for storing ship-borne CO_2

Norway
Offshore storage potential in depleted O&G fields and in saline aquifers.
Ambitious governments and first-mover advantage with Northern Lights.
Small domestic CO_2 capture, ***able to store large volumes from abroad***.

> Northern Lights CCS project in full swing with all CO2 storage tanks installed
> CARBON CAPTURE USAGE & STORAGE

United Kingdom
Large offshore storage potential in depleted O&G fields and in saline aquifers.
Ambitious government targets, ***but UK CCUS storage licenses are set to only address UK emissions.***

> Oil companies granted licences to store carbon under the North Sea
> Government hopes companies including Shell will be able to store up to 10% of the UK's annual carbon emissions



Denmark
Large potential, but low experience.
High government ambitions.
Recently awarded support scheme of EUR 1.1 billion from the EU to support roll-out of CCS in Denmark.

> Press release | 12 January 2023 | Brussels
> State aid: Commission approves €1.1 billion Danish scheme to support roll-out of carbon capture and storage technologies

Netherlands
Very large storage potential in depleted O&G, both onshore and offshore. Limited access to saline aquifers. Low experience.
Antwerp@C already under development with EU backing, expected to store CO_2 in the Netherlands by 2027.
Located close to major emitters.

> NEWS ARTICLE | 26 June 2023 | European Climate, Infrastructure and Environment Executive Agency
> CEF Energy: Antwerp@C CO2 Export Hub receives 144.6 million of EU

Source: Rystad Energy research and analysis

Existing CCS experience and positive authorities make NCS an attractive storage location…

The Norwegian Continental Shelf has existing experience with CCS

Carbon has been stored on the NCS since 1996 when Equinor started to separate CO_2 from the gas stream at Sleipner Vest and store it in the Utsira formation at volumes up to one million tonnes per year.
From 2008 and onwards, the Snøhvit facility also captures and store CO_2 from the gas stream, up to 0.7 million tonnes per year.

The Longship project and the CO_2 Technology Centre Mongstad (TCM) also contribute valuable experience.

Longship

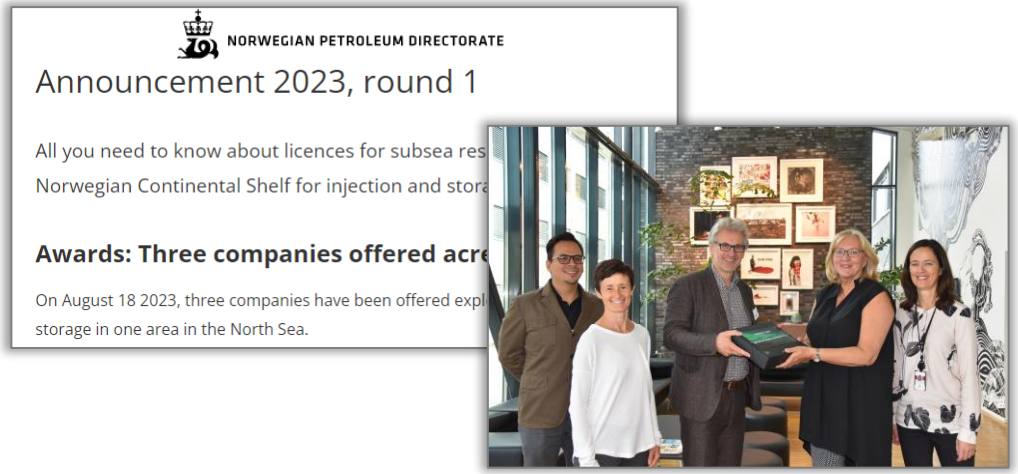
Northern Lights

TECHNOLOGY CENTRE MONGSTAD

Norwegian authorities have showed willingness to conduct permitting activity

Storage of CO_2 is seen as a climate initiative, and as such the Norwegian authorities are responding to increase interest to store CO_2 on the NCS.

Companies can apply to the Ministry of Petroleum and Energy for a permit to store CO_2, and by mid-2023, six permits have been granted, primarily for exploration licenses.



Source: Rystad Energy research and analysis; Norwegian Petroleum; Regjeringen.no; Equinor

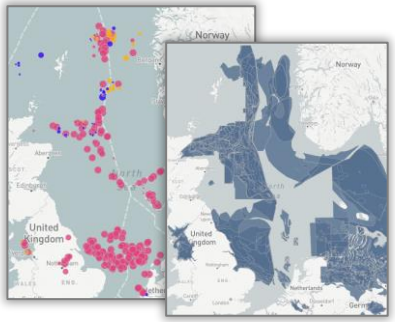
…but sites are not significantly better from a geological perspective and further away from Europe

The NCS does not offer significantly better storage sites from a geological perspective

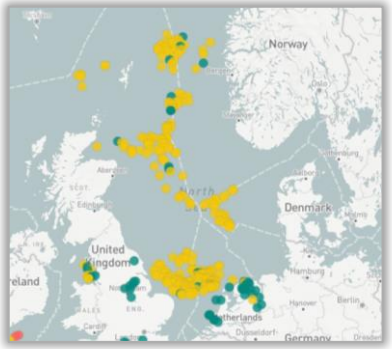
Storage sites can be ranked on multiple characteristics, that yield an assessment of how attractive the site is for storage of CO_2.

Depleted oil and gas fields are attractive storage locations as characteristics are well known and existing infrastructure can often be utilized. Saline aquifer are also attractive as they can generally store significant larger volumes than depleted oil and gas fields, but usually requires higher investments.

However, there are attractive depleted oil and gas fields and saline aquifer sites on the Dutch, the British and the Danish continental shelf, in addition to the Norwegian one.



Overview of depleted oil and gas field (left) and saline aquifer (right)

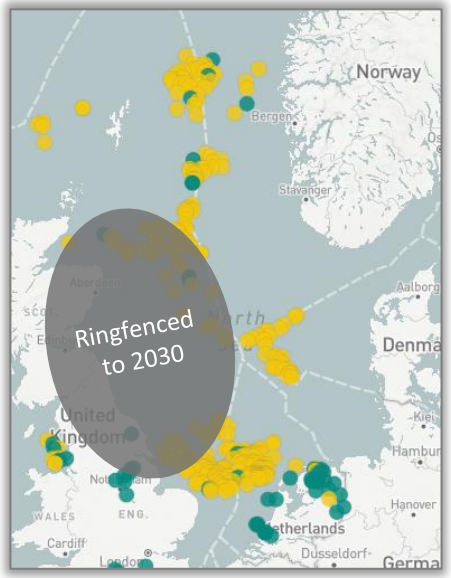


Storage site assessment (Yellow medium, green good)

The NCS is further from the continent than many alternative storage sites

Storage sites in the in the Netherlands and Denmark are closer to main point-source emitters in Europe.

The potential storage sites on the NCS are therefore at a disadvantage when the CO_2 is transported to the storage location compared to alternative sites on for example the Danish continental shelf.



Source: Rystad Energy research and analysis; Rystad Energy CCUSCube; Norwegian Petroleum; Regjeringen.no; Equinor

Norway can have an important role in the CCS value chain, enabling a pathway to reach European emission targets

CCS' role in the future energy system

1 Slower development of renewables and hydrogen in Europe increases the call for carbon capture from emitters in Europe

- Renewables development is lagging compared to stated targets, while hydrogen development is challenged by commerciality due to immature technology and high gas prices.
- Given natural gas' relevance as a transition fuel in the European energy mix, the importance of carbon capture on flue stacks in industrial clusters and gas power plants is increased given EU's climate ambitions.

2 An integrated natural gas and CCUS approach is a strong hedge if responsibility of scope 3 emissions becomes a requirement

- Most oil and gas companies currently only include scope 1 emissions in their decarbonization targets.
- There is a push to make companies report and take responsibility of their scope 1, 2 and 3 emissions. If this becomes a requirement, CCUS in combination with natural gas consumption in Europe can be an important measure for companies to reduce scope 3 emissions.

3 Current developments towards CCS in industrial clusters in Europe, shows the relevance of CCS in the future energy system

- Several industrial clusters in Europe are currently looking towards CCS as the solution to reduce emissions. The UK government has ringfenced the CCS industry, making carbon storage at the UKCS available only to domestic emissions up to 2030.
- This leaves an opportunity for Norway as an early mover to take benefit and secure imports of European emissions through developing infrastructure and offshore storage.

Norway's role in the CCS value chain can be to develop transport infrastructure and offshore storages to enable a decarbonized natural gas value chain in Europe and provide a pathway to reach European emission targets.

Source: Rystad Energy research and analysis

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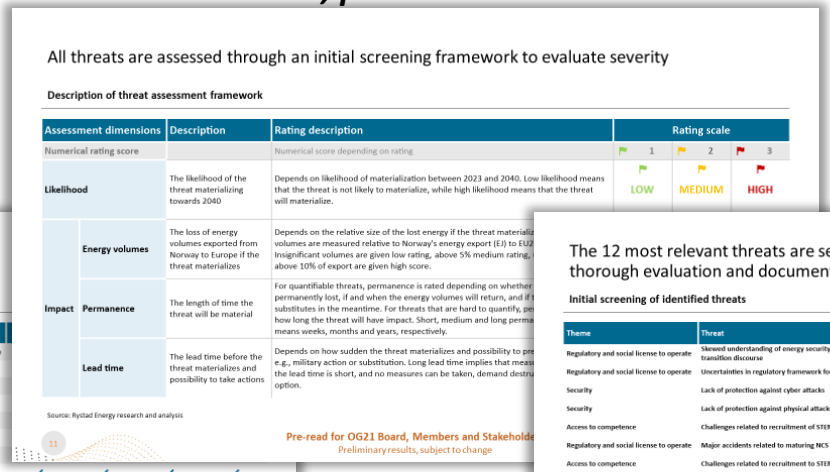
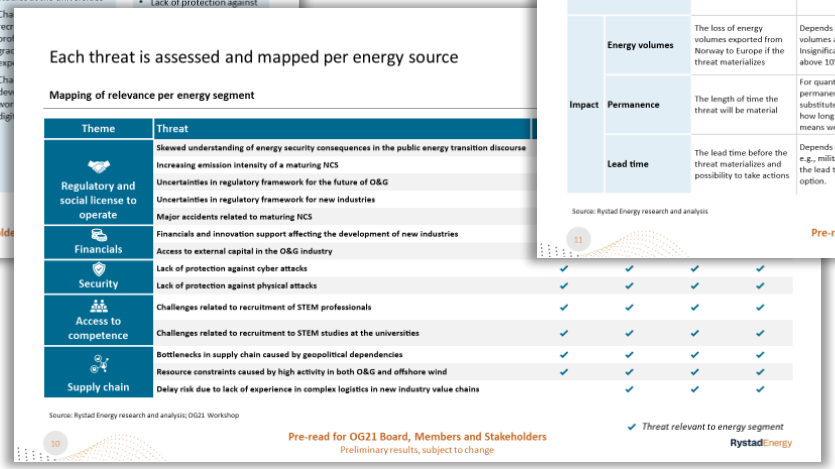
Process from identifying threats in workshop 1 to evaluation of threats in pre-read for workshop 2

Identified threats in workshop 1

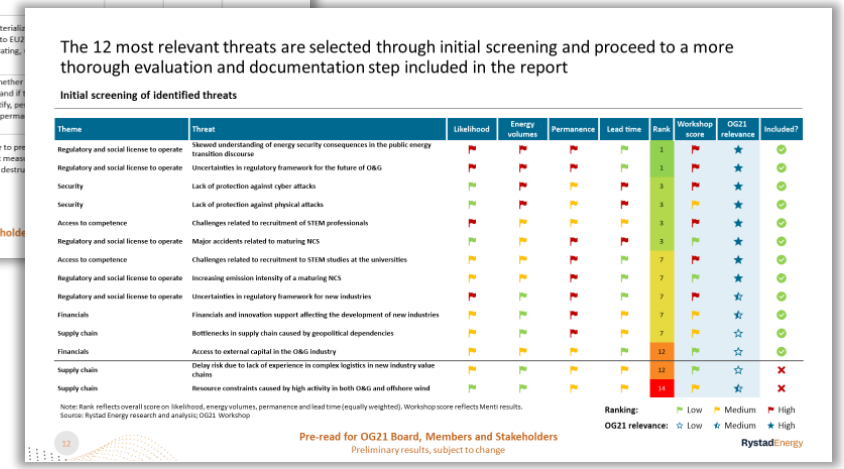
Threats were grouped and merged to create a MECE list, and some threats outside what was discussed in Workshop 1 was added

All threats were screened based on likelihood of materializing and impact on European energy security measured in energy volumes at risk, permanence and lead time





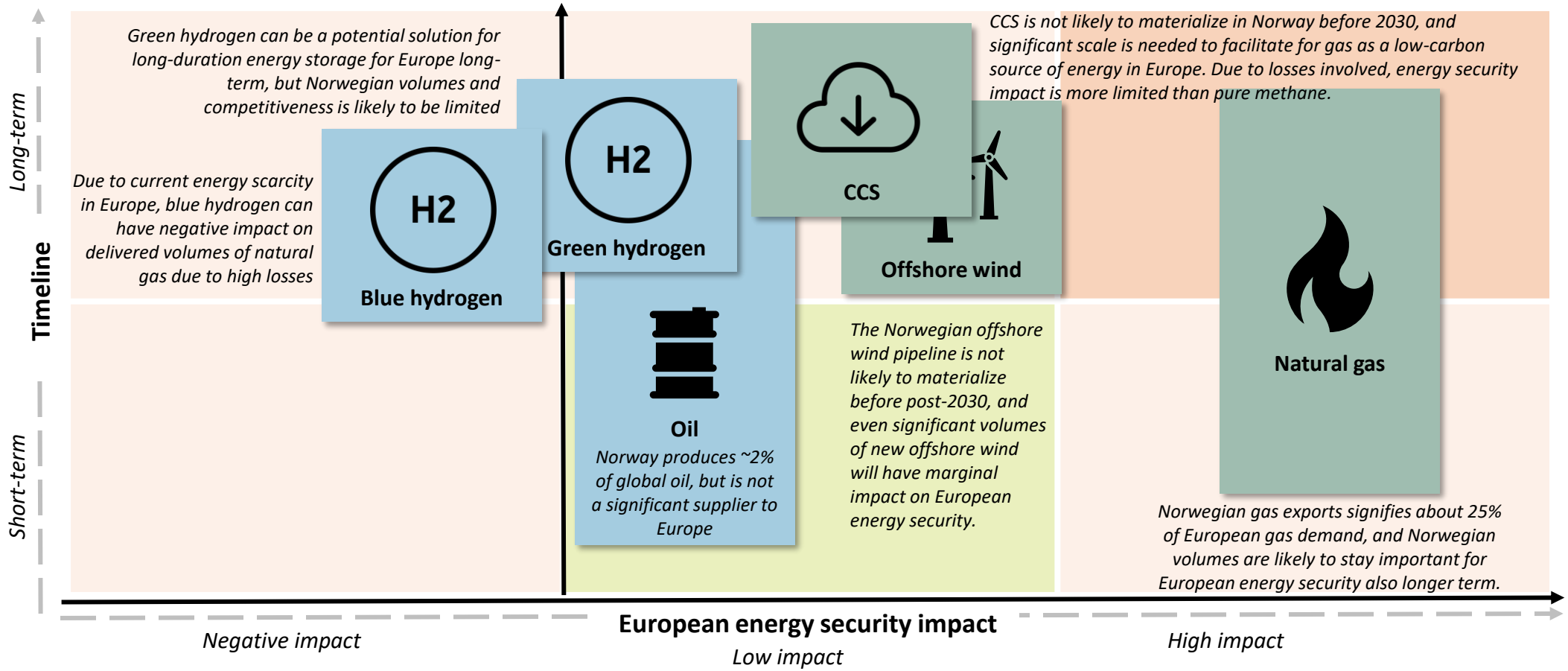
All threats were mapped towards relevant energy sources, identifying potential volume impact



12 threats with highest overall score selected and further documented in pre-read for workshop 2

Threats to natural gas deliveries to Europe can have high volume impact both short- and long-term

Ranking of energy sources with regards to time criticality and energy volume impact on European energy situation*



*Background analysis on energy security impact per energy source can be found in the pre-read material provided for Workshop 1
Source: Rystad Energy research and analysis; OG21 Workshop

Focus on documenting energy security impact for natural gas, offshore wind and CCS

Evaluation of threats focuses on documenting energy security impact for the most important industries based on the background analysis

Natural gas	Offshore wind	CCS
Norwegian gas exports signifies about 25% of European gas demand, and Norwegian volumes are likely to stay important for European energy security also longer term.	The Norwegian offshore wind is likely to have marginal impact on European energy security even with significant volumes, but is an important enabler for electrification of O&G.	CCS can facilitate for gas as a low-carbon source of energy in Europe, and is as such an important enabler for long-term Norwegian gas deliveries to Europe.
Volumes at risk from European energy security perspective		
Norwegian natural gas deliveries to Europe at risk compared to European total gas consumption	*Offshore wind volumes at risk compared to Norway's 30 GW target*	*Norwegian offshore carbon storage industrialization at risk*

Source: Rystad Energy research and analysis

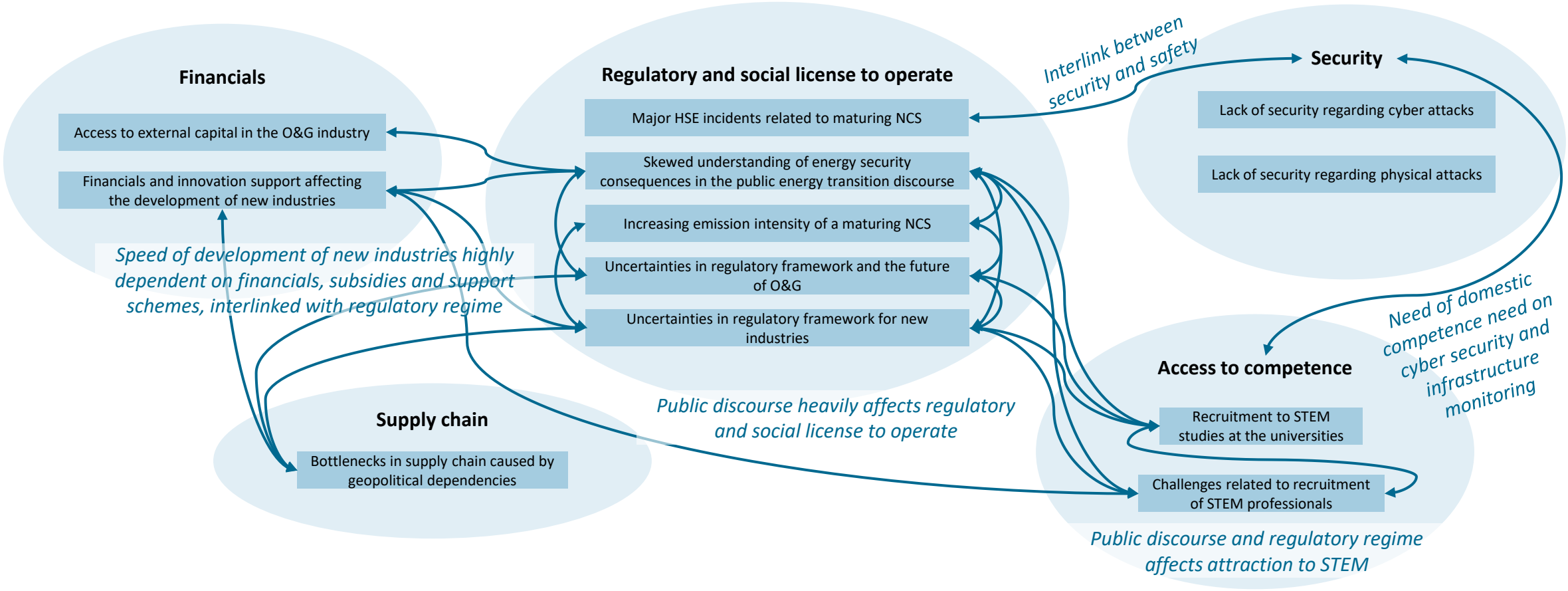
Overview of threats to Norwegian energy supply for European energy security

Theme	Threat	Threat description
Regulatory and social license to operate	**Skewed understanding of energy security consequences in the public energy transition discourse**	*Public opinion on energy production impacts future policy development and social lciense to operate, referring to e.g. onshore wind or O&G exploration.*
	Increasing emission intensity of a maturing NCS	*Higher overall emissions intensity due to tail production going forward. These volumes can be at risk due to emission reduction targets.*
	Uncertainties in regulatory framework for the future of O&G	*Regulatory uncertainty related to future developments, exploration licenses and phase-out strategy.*
	Uncertainties in regulatory framework for new industries	*Regulatory uncertainty related to support schemes, contract structures, subsidies, tax regimes,national strategy related to energy exports, etc.*
	Major accidents related to maturing NCS	*Infrastructure reaching design lifetime can lead to increased risk of serious accidents with high impact on social license to operate.*
Financials	**Financials and innovation support affecting the development of new industries**	*Uncertainties related to support schemes, in addition to limited R&D funding in commercialization can affect speed of development of new industries.*
	Access to external capital in the O&G industry	*Banks are restricting funding to O&G due to increased focus on ESG.*
Security	**Lack of protection against cyber attacks**	*Technology development in the O&G sector increases risk of cyber attacks.*
	Lack of protection against physical attacks	*Norwegian O&G infrastructure exposure to physical attacks.*
Access to competence	**Challenges related to recruitment of STEM professionals**	*The competition for STEM professionals is expected to be harder going forward.*
	Challenges related to recruitment to STEM studies at the universities	*Educating the required number of STEM professionals is likely an increasing challenge going forward.*
Supply chain	**Bottlenecks in supply chain caused by geopolitical dependencies**	*Geopolitical tensions causes increased risk in supply chain with potential bottlenecks caused by trade wars and following price increases.*

Source: Rystad Energy research and analysis

Most threats are heavily interlinked and development along one parallel affects others

Dependencies between selected threats



Source: Rystad Energy research and analysis

Overall evaluation of threats to Norwegian energy supply in light of European energy security

Theme	Threat	Evaluation
Regulatory and social license to operate	Skewed understanding of energy security consequences in the public energy transition discourse	Lack of fact-based energy transition discourse today can have a large impact on Norwegian energy exports in the long term.
	Increasing emission intensity of a maturing NCS	Increasing emission intensity may challenge the social license to operate, potentially impacting future Norwegian energy exports.
	Uncertainties in regulatory framework for the future of O&G	Slows down investment decisions both on new projects and emission reduction measures, with potential large impact.
	Uncertainties in regulatory framework for new industries	Regulatory uncertainty slows down renewables development, which has low export impact, but affects electrification of O&G.
	Major accidents related to maturing NCS	A major accident would potentially impact the social license to operate, but the likelihood is still considered very low.
Financials	Financials and innovation support affecting the development of new industries	Potentially large impact on development of offshore wind and CCS in Norway, which also affects e.g. O&G electrification.
	Access to external capital in the O&G industry	Restrictions to O&G financing mainly impacts smaller companies, but can have large impact on exploration activity.
Security	Lack of protection against cyber attacks	Likelihood of high-impact attack is relatively small, but potential volume effect and HSE risk can be significant.
	Lack of protection against physical attacks	The likelihood of such an event is considered very low, but with potential fatal consequences to export volumes.
Access to competence	Challenges related to recruitment of STEM professionals	O&G already struggles to attract STEM professionals in competition with other industries, limiting future O&G activity.
	Challenges related to recruitment to STEM studies at the universities	Already observing less interest and capacity for STEM education, which can impact long term energy volumes.
Supply chain	Bottlenecks in supply chain caused by geopolitical dependencies	High concentration and geopolitical tension increases likelihood, with a moderate potential effect on energy volumes.

Source: Rystad Energy research and analysis

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Process from identifying mitigations in workshop 2 to evaluation threat mitigation potential

Identified mitigations in workshop 2

The 13 most relevant mitigations are selected through initial screening and grouping of suggestions from Workshop 2

Initial screening of identified mitigations

Category	Mitigation	Description	Relevant stakeholder
Technology	Technologies for emission reduction	Alternative technologies to reduce emissions can be electrification with offshore wind, CCS to some extent and other technologies.	OG21, Energi21
Technology	Technologies for industrializing floating offshore wind	Improve technologies for floating offshore wind to enable industrialization and the commercial viability of offshore wind.	OG21, Energi21
Technology	Technologies for increased production from existing fields	New technologies to increase gas production in existing fields, especially in tail production. This can also contribute to reduce emission intensity in maturing fields.	OG21
Technology	Smart engineering to reduce future needs for STEM professionals	Improve and implement technologies that can reduce the labor-intensity, especially for processes that are highly STEM-intensive. An example of technology is autonomous engineering.	OG21
Technology	Technologies for improved infrastructure surveillance	Technologies and digital tools for better and more efficient infrastructure surveillance targeting maintenance and anomaly detection.	OG21
Competence	Better risk understanding and management	Risk understanding and management is important in a changing geopolitical world to promote resilience. Integrated OT and IT systems, sabotage, cyber threat, and plans for swift recoveries after external disruptions are examples of key focus areas.	OG21, PSA
Competence	Improve competence on AI, big data and machine learning applications in O&G	Using AI, big data and machine learning can benefit multiple processes in O&G. Examples include subsurface understanding, decision support, improved cyber security, maintenance scheduling and overall efficiency gains.	OG21
Competence	Improve competence on circular economy	Improve competence on circular economy for reuse and recycling of equipment and materials to limit supply chain dependencies and emissions.	OG21
Competence	Improve collaboration with universities and academia to ensure future competence needs are met	Strong collaboration with academia is important to ensure that future competence requirements are covered.	OG21
Communication	Communicate the need for training and developing the existing workforce	Training and development to adapt to new competence requirements.	OG21
Communication	Communicate the need for a holistic energy roadmap	Communicate the need for a roadmap describing the entire future Norwegian energy system. The roadmap should provide a stable and predictable regulatory framework in addition to clear targets for the future energy mix.	OG21, MPE
Communication	Collaborative modes across energy system verticals	Ensure collaboration and integration between various energy system verticals to facilitate a more holistic approach.	OG21, Energi21
Communication	Communicate need for addressing funding in industrialization of offshore wind	Emphasize the need for alternative funding of offshore wind from demonstration through commercialization.	Offshore Norge, Konkraft, Norsk Industri

Source: Rystad Energy research and analysis; OG21 Workshop

OG21 feasibility: ✕ None ☆ Low ★ Medium ★ High

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Published for public commenting, subject to change

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Mitigations discussed during workshop 2 were grouped and merged to create a MECE list of 13 mitigations.

Mitigations and the threats they address

The mitigations address the presented threats to the energy security

		Regulatory and social license to operate					Financials		Security		Access to competence		Supply chain
Category	Mitigation	Skewed understanding of energy security consequences in the public energy transition discourse	Increasing emission intensity of a maturing NCS	Uncertainties in regulatory framework for O&G	Uncertainties in regulatory framework for new industries	Major accidents related to maturing NCS	Financials and innovation support affecting the development of new industries	Access to external capital in the O&G industry	Lack of protection against cyber attacks	Lack of protection against physical attacks	Challenges related to recruitment of STEM professionals	Challenges related to recruitment of STEM studies at the universities	Bottlenecks in supply chain caused by geopolitics
Communication	Communicate the need for a holistic energy roadmap	■	■	■	■	■	■	■			■	■	■
Technology	Technologies for improved infrastructure surveillance					■			■	■			
Technology	Technologies for autonomous engineering to reduce future needs for STEM professionals					■					■	■	
Technology	Technologies for industrializing floating offshore wind		■				■						
Technology	Technologies for emission reduction		■										
Technology	Technologies for increased production from existing fields		■										
Competence	Better risk understanding and management			■	■	■			■	■			
Competence	Improve competence on AI, big data and machine learning applications in O&G		■			■			■	■	■	■	
Competence	Improve collaboration with universities and academia to ensure future competence needs are met		■			■			■	■	■	■	■
Competence	Improve competence on circular economy		■										■
Communication	Collarborative modes across energy system verticals	■	■	■	■		■				■	■	
Communication	Communicate the need for training and developing the existing workforce										■	■	
Communication	Communicate need for addressing funding in industrialization of offshore wind		■		■		■						■

Source: Rystad Energy research and analysis; OG21 Workshop

■ Mitigation option relevant to reduce risk from threat

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Published for public commenting, subject to change

RystadEnergy

The 13 identified mitigations were then assessed on the identified threats they address.

* Technology development, competence development or communication
Process from identifying threats in workshop 1 to evaluation of threats in pre-read for workshop 2

The 13 most relevant mitigations are selected through initial screening and grouping of suggestions from Workshop 2

Initial screening of identified mitigations

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Communication	**Communicate the need for a holistic energy roadmap**	Communicate the need for a roadmap describing the entire future Norwegian energy system. The roadmap should provide a stable and predictable regulatory framework in addition to clear targets for the future energy mix.	OG21, MPE
Communication	**Collaborative modes across energy system verticals**	Ensure collaboration and integration between various energy system verticals to facilitate a more holistic approach.	OG21, Energi21
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OG21 feasibility: ✖ None ☆ Low ★ Medium ★ High

Source: Rystad Energy research and analysis; OG21 Workshop

The mitigations address the presented threats to the energy security

		Regulatory and social license to operate					Financials		Security		Access to competence		Supply chain
Category	**Mitigation**	Skewed understanding of energy security consequences in the public energy transition discourse	Increasing emission intensity of a maturing NCS	Uncertainties in regulatory framework for O&G	Uncertainties in regulatory framework for new industries	Major accidents related to maturing NCS	Financials and innovation support affecting the development of new industries	Access to external capital in the O&G industry	Lack of protection against cyber attacks	Lack of protection against physical attacks	Challenges related to recruitment of STEM professionals	Challenges related to recruitment of STEM studies at the universities	Bottlenecks in supply chain caused by geopolitics
Technology	**Technologies for emission reduction**		■										
Technology	**Technologies for industrializing floating offshore wind**		■				■						
Technology	**Technologies for increased production from existing fields**		■										
Technology	**Smart engineering to reduce future needs for STEM professionals**					■					■	■	
Technology	**Technologies for improved infrastructure surveillance**					■			■	■			
Competence	**Better risk understanding and management**	■		■	■	■			■	■			
Competence	**Improve competence on AI, big data and machine learning applications in O&G**		■			■			■	■	■	■	
Competence	**Improve competence on circular economy**		■										■
Competence	**Improve collaboration with universities and academia to ensure future competence needs are met**		■			■			■	■	■	■	■
Communication	**Communicate the need for training and developing the existing workforce**										■	■	
Communication	**Communicate the need for a holistic energy roadmap**	■	■	■	■	■	■	■			■	■	■
Communication	**Collaborative modes across energy system verticals**	■	■	■	■		■				■	■	
Communication	**Communicate need for addressing funding in industrialization of offshore wind**		■		■		■						■

Source: Rystad Energy research and analysis; OG21 Workshop

■ Mitigation option relevant to reduce risk from threat

A holistic energy roadmap works as an enabler to help mitigate many of the identified threats

		Regulatory and social license to operate					Financials		Security		Access to competence		Supply chain
Category	**Mitigation**	Skewed understanding of energy security consequences in the public energy transition discourse	Increasing emission intensity of a maturing NCS	Uncertainties in regulatory framework for O&G	Uncertainties in regulatory framework for new industries	Major accidents related to maturing NCS	Financials and innovation support affecting the development of new industries	Access to external capital in the O&G industry	Lack of protection against cyber attacks	Lack of protection against physical attacks	Challenges related to recruitment of STEM professionals	Challenges related to recruitment of STEM studies at the universities	Bottlenecks in supply chain caused by geopolitics
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Communication	Communicate the need for training and developing the existing workforce												
Communication	Communicate the need for a holistic energy roadmap	■	■	■	■	■	■	■			■	■	■
Communication	Collaborative modes across energy system verticals	■	■	■	■		■				■	■	
Communication	Communicate need for addressing funding in industrialization of offshore wind		■		■		■						■

A holistic energy roadmap is key to address uncertainties in most of the identified threats and can act as an enabler for other mitigations.

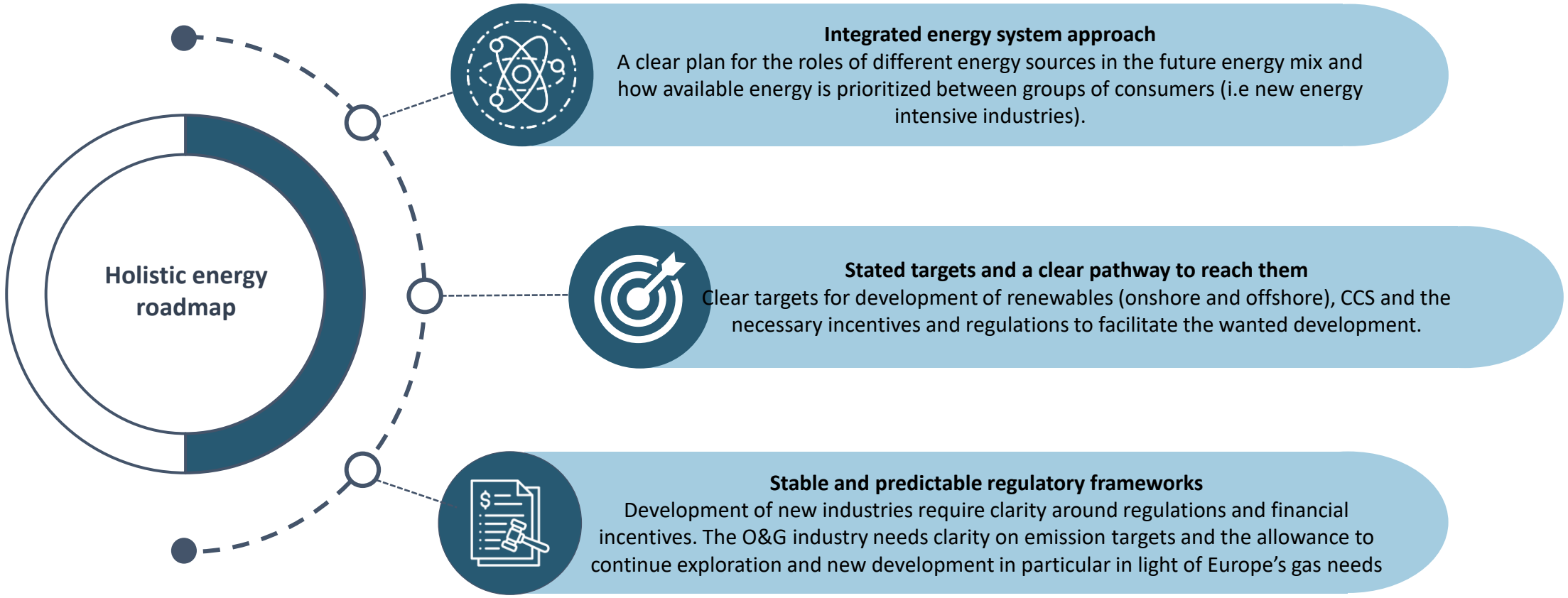
- *There is a clear need of an integrated energy system approach, instead of planning for the different energy verticals separately as they are inter-dependent*
- *OG21, together with other important stakeholders like Energy21, has a role in communicating the importance and need of a holistic energy system approach, as well as providing fact-based information on technology and competence development needs in order to achieve targets and ambitions.*
- *A holistic energy roadmap is an important tool to mitigate risks related to uncertainties in regulatory framework for both O&G and new industries by creating comfort around the regulatory and social license to operate giving clarity around the ambitions on role of the different energy sources in the future energy system, including exploration for gas.*
- *Such clarity would also enable planning and competence development according to future needs, reducing recruiting challenges, development of domestic supply chains and a clear mandate for new financial mechanisms and innovation support for new technologies/industries through stable and predictable frameworks.*

■ Mitigation option relevant to reduce risk from threat

Source: Rystad Energy research and analysis; OG21 Workshop

A holistic energy roadmap needs to plan for a future integrated energy system

Illustration of what the holistic energy roadmap should cover



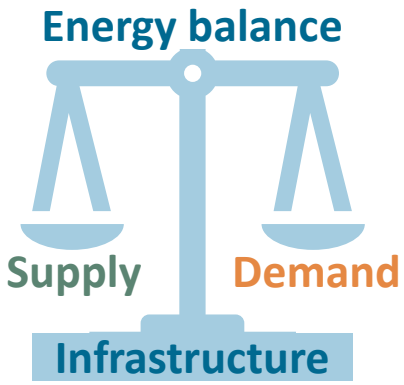
Source: Rystad Energy research and analysis

Planning for the future energy system involves a clear pathway for all components

A holistic energy roadmap needs to include a clear pathway for all components in the domestic energy balance

Supply

- Future energy system planning need clear targets on primary energy production: oil, gas and electricity.
- Ambitions on energy carrier level also need to be clearly stated, prioritizing between oil, gas, electricity, blue hydrogen, green hydrogen and CCS.
- The necessary primary energy production is a function of domestic energy demand needed to meet emission targets and export ambitions, but also of the losses defined by the energy carriers used to deliver the primary energy.
- Ambitions related to import reliance affect the need for domestic production and is an important component in the future energy balance.
- The supply side of the equation must consider daily, weekly and seasonal variations in energy production levels. In addition, balancing different energy sources and weather systems is key to avoid unnecessary storage demand and potential losses for Norway and possibly also for Europe.



Infrastructure

The targets and prioritizations give implications for the infrastructure required to distribute and balance the energy system. Some examples:

- Export of electricity requires significant new interconnector capacity and potentially a North Sea grid to balance offshore energy production and demand.
- New gas infrastructure like the Barents pipeline is an important measure to unlock new gas volumes.
- Prioritization amongst competing energy carriers for repurposing of gas infrastructure, relevant for both blue and green hydrogen, as well as CO2.

Demand = Domestic use + Exports

- Future energy system planning needs clear targets and prioritization between energy for domestic use and energy exports. This is a balance of pathways to provide the highest national GDP, employment considerations, climate targets and other societal factors.

Domestic use

- Ambitions includes prioritizing which consumers and industries have the right to access new consumption, including prioritization between electrification of O&G, new energy intensive industries*, etc.
- The availability of cheap and reliable energy affects new industries' growth opportunities, national decarbonization efforts and ability to keep existing energy intensive industries competitive.
- Increased domestic use implies securing employment and GDP growth outside the energy industry.

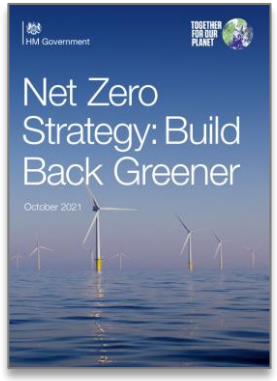
Export

- Export ambitions per energy carrier will require a strategic surplus of domestic energy production for selected energy sources.

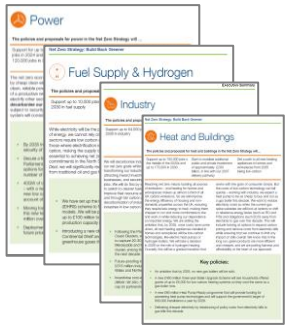
*Battery manufacturing, data centers, hydrogen production, etc.
Source: Rystad Energy research and analysis

UK roadmaps give a clear direction of government policy for relevant stakeholders

The UK Government publishes holistic plans for the entire energy system



The UK plans are taking a holistic view on the entire energy system, covering energy producers and consumers for all relevant energy carriers.



Consumers of energy
What sort of energy should be consumed, policies to achieve targets.

Producers of energy
Targets and policies for the different energy production method, such as offshore wind and oil and gas in the UK North Sea

Infrastructure for energy
Infrastructure targets to realize production and consumption targets, e.g., grid investments to facilitate electrification of the car fleet

Documents give information on the direction of government policy and government's commitment to delivery

> *"Together these plans set out the actions we are taking, and the timeline for issues that need further work, **providing certainty** to the industry, to investors and to the British public **on the direction of government policy** and our commitment to delivery."*
>
> Powering up Britain – Energy Security Plan

> *"[…] and we **remain absolutely committed** to maximizing the **vital production of UK oil and gas** as the North Sea basin declines"*
>
> Powering up Britain – Energy Security Plan

> *"Energy security necessarily entails the smooth transition to low carbon energy in line with Net Zero, even as we **acknowledge the vital role natural gas will play for years to come**."*
>
> Powering up Britain – The Net Zero Growth Plan

Source: Rystad Energy research and analysis; HM Government UK; BEIS UK

Adoption of new technologies is essential to increase production from existing fields

		Regulatory and social license to operate					Financials		Security		Access to competence		Supply chain
Category	**Mitigation**	Skewed understanding of energy security consequences in the public energy transition discourse	Increasing emission intensity of a maturing NCS	Uncertainties in regulatory framework for O&G	Uncertainties in regulatory framework for new industries	Major accidents related to maturing NCS	Financials and innovation support affecting the development of new industries	Access to external capital in the O&G industry	Lack of protection against cyber attacks	Lack of protection against physical attacks	Challenges related to recruitment of STEM professionals	Challenges related to recruitment of STEM studies at the universities	Bottlenecks in supply chain caused by geopolitics
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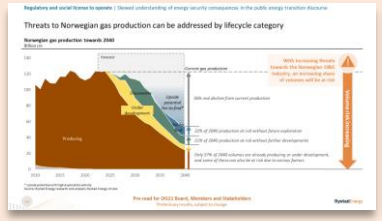
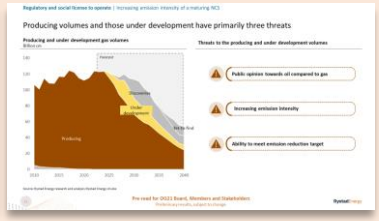
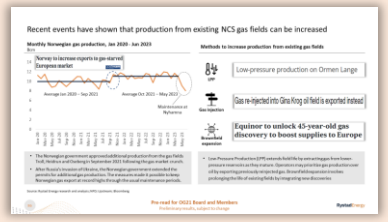
Communication	Communicate the need for training and developing the existing workforce												
Communication	Communicate the need for a holistic energy roadmap												
Communication	Collaborative modes across energy system verticals												
Communication	Communicate need for addressing funding in industrialization of offshore wind												

Increased production from existing fields is key to minimize decline in gas production n the NCS

- *The gas production on the NCS is expected to decline steeply in the coming years. Increased competence on operationalizing new digital tools, in addition to new technologies for increased production from existing fields, can help to extend the lifetime of existing fields.*
- *Increased production from existing fields targets several of the identified threats. Firstly, as there is high uncertainty regarding the regulatory and social license for exploration and new developments, maximizing the production from existing fields is important to maintain Norwegian energy exports. Furthermore, increased production from existing fields will contribute to reducing emissions intensity and improving the business case for emission-reducing measures such as electrification which need a certain life-time as basis for the investment.*
- *Options for increased gas production from existing fields include low-pressure production, stop gas reinjection, infill drilling, subsea tie-backs and near-field exploration. Frontier exploration will need new infrastructure to support build-out (i.e. Barentspipe)*







Source: Rystad Energy research and analysis; OG21 Workshop

Mitigation option relevant to reduce risk from threat

Collaborative modes across energy verticals can strengthen mandates and foster ideas

		Regulatory and social license to operate					Financials		Security		Access to competence		Supply chain
Category	**Mitigation**	Skewed understanding of energy security consequences in the public energy transition discourse	Increasing emission intensity of a maturing NCS	Uncertainties in regulatory framework for O&G	Uncertainties in regulatory framework for new industries	Major accidents related to maturing NCS	Financials and innovation support affecting the development of new industries	Access to external capital in the O&G industry	Lack of protection against cyber attacks	Lack of protection against physical attacks	Challenges related to recruitment of STEM professionals	Challenges related to recruitment of STEM studies at the universities	Bottlenecks in supply chain caused by geopolitics
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Technology	Technologies for industrializing floating offshore wind												
Technology	Technologies for increased production from existing field												
Technology	Smart engineering to reduce future needs for STEM professionals												
Technology	Technologies for improved infrastructure surveillance												
Competence	Better risk understanding and management												
Competence	Improve competence on AI, big data and machine learnin applications in O&G												
Competence	Improve competence on circular economy												
Competence	Improve collaboration with universities and academia to ensure future competence needs are met												
Communication	Communicate the need for training and developing the existing workforce												
Communication	Communicate the need for a holistic energy roadmap												
Communication	Collaborative modes across energy system verticals	■	■	■	■	■	■	■	■	■	■	■	
Communication	Communicate need for addressing funding in industrialization of offshore wind		■		■		■						■

Increased collaboration across energy system verticals can strengthen mandate and align initiatives

Collaboration between OG21 and Energi21 can strengthen both organizations. Three alternative collaboration modes suggested below:

Collaboration through forums/workshops and shared call for proposals

Partial integration through a shared TG addressing integrated energy thinking

Fully integrated with Energi21 to facilitate for more holistic energy system approach and R&D

Source: Rystad Energy research and analysis; OG21 Workshop

■ Mitigation option relevant to reduce risk from threat

Better risk understanding and management is key to create resilience towards new security threats

		Regulatory and social license to operate					Financials		Security		Access to competence		Supply chain
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Competence	Improve competence on AI, big data and machine learning applications in O&G		■			■			■	■	■	■	
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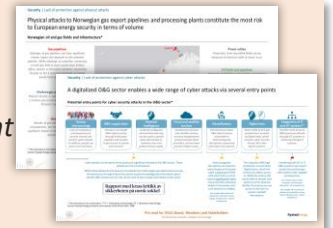
Communication	Communicate the need for training and developing the existing workforce												
Communication	Communicate the need for a holistic energy roadmap	■	■	■	■	■	■	■			■	■	■
Communication	Collaborative modes across energy system verticals	■	■	■	■		■				■	■	
Communication	Communicate need for addressing funding in industrialization of offshore wind		■		■		■						■

Risk understanding and management creates resilience towards external attacks and major accidents

- *Better risk understanding and management creates resilience towards external attacks and safety incidents. Examples of measures to improve resilience are improved cyber competence especially in light of increased digitalization, utilizing new technologies for inspections and surveillance.*



Improved data foundation and applications can contribute to reduced uncertainty in decisions and policy-making

- *Having fact-based discussions with good understanding of results and implications of decisions that are made could benefit discussions regarding frameworks for both O&G and new industries. This can in turn reduce the uncertainties and therefore mitigate these threats.*

Source: Rystad Energy research and analysis; OG21 Workshop

■ Mitigation option relevant to reduce risk from threat

Security risks can benefit from synergies with data gathering maintenance purposes

		Regulatory and social license to operate					Financials		Security		Access to competence		Supply chain
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Improved infrastructure condition data enables more optimized and cost-efficient maintenance

- *Technologies and digital tools can provide improved data volume and quality for infrastructure condition. This have benefits for optimizing maintenance and anomaly detection.*
- *Improved data enables optimized maintenance through scheduling based on infrastructure condition rather than only fixed intervals. Predictive maintenance is important to maintain the high safety standard as the NCS matures in a cost-efficient way.*

Better infrastructure and system overview improves anomaly detection

- *Technologies and digital tools can improve anomaly detection through better information.*
- *More frequent overview of the system will improve the ability to detect anomalies and harmful external intervention. This can limit the impact if anomaly is discovered early.*

Source: Rystad Energy research and analysis; OG21 Workshop

▣ Mitigation option relevant to reduce risk from threat

People-less technologies have the possibility to ease some of the recruitment pressure

		Regulatory and social license to operate					Financials		Security		Access to competence		Supply chain
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Automation of workflows (engineering, planning, applications, subsurface, etc.) and other digital tools can play an important role to ease STEM recruitment pressure

- *Advancement in technology have already shown promising results in automating tasks, reducing the need for personnel. Improved competence on the possibilities of new technologies such as AI and big data applications and implementing these technologies can therefore benefit the O&G industry. Collaboration with academia and development of existing workforce to ensure the required competence is developed to utilize new digital tools are important steps towards unlocking these benefits.*
- *A key application would be to reduce the recruitment need for STEM professionals through for example implementation of more automated engineering and integration of workflows between different verticals in the O&G companies.*

Source: Rystad Energy research and analysis; OG21 Workshop

▣ Mitigation option relevant to reduce risk from threat

Closing the funding gap to industrialize floating offshore wind is important to reduce emissions from the NCS

		Regulatory and social license to operate					Financials		Security		Access to competence		Supply chain
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Industrialization of floating offshore wind is required to reach emission targets from O&G

- *Further electrification of O&G requires new renewable power generation. Floating offshore wind has significant potential to generate energy to the grid to ensure there is enough energy for electrification of O&G installations.*
- *However, there is a funding gap to industrialize and scale current technologies. The funding gap can be illustrated by ENOVA spending ~50% of funds on the Hywind Tampen project.*

Source: Rystad Energy research and analysis; OG21 Workshop

▣ Mitigation option relevant to reduce risk from threat

Table of content

The OG21 strategy focuses on cost-efficiency, de-carbonizing and offshore industries synergies

The OG21 strategy 2021 focuses on three dimensions…

"Successfully compete for market shares in the oil and gas markets.
…production needs to be highly cost-efficient, and the industry needs to deliver on the ambitious GHG emissions targets…"

"Secure deliverables to the European market for natural gas by de-carbonizing the gas. CCS is a key technology to decarbonize natural gas, either into low-emission hydrogen or electrical power."

"Contribute with competencies and solutions to the development of new industries…
…should take place in parallel with the further development of the petroleum industry to leverage synergies."

- In short, the OG21 strategy focus on three dimensions, namely; emissions, de-carbonizing and synergies between O&G and new industries.
- The three dimensions illustrate how OG21 believes that the NCS and Norwegian O&G can continue to deliver value to the Norwegian society going forward.

… emphasizing five important elements

Emission reduction

Cost-efficiency

Existing production and near-field exploration

Secure deliveries to the European market for natural gas by de-carbonizing the gas

New industry opportunities (e.g., offshore wind and CCS) building on O&G competence

- The five important elements that were addressed in the OG21 strategy led to an emphasis on eight different technologies, three innovations to promote and a focus on synergies between O&G and new industries.

Source: Rystad Energy research and analysis; The OG21 Strategy: "A new chapter" (2021)

The OG21 strategy describes prioritized technologies and new industries with large potential

Summary of the OG21 strategy from 2021

8 technologies and knowledge areas are identified to have high priority:

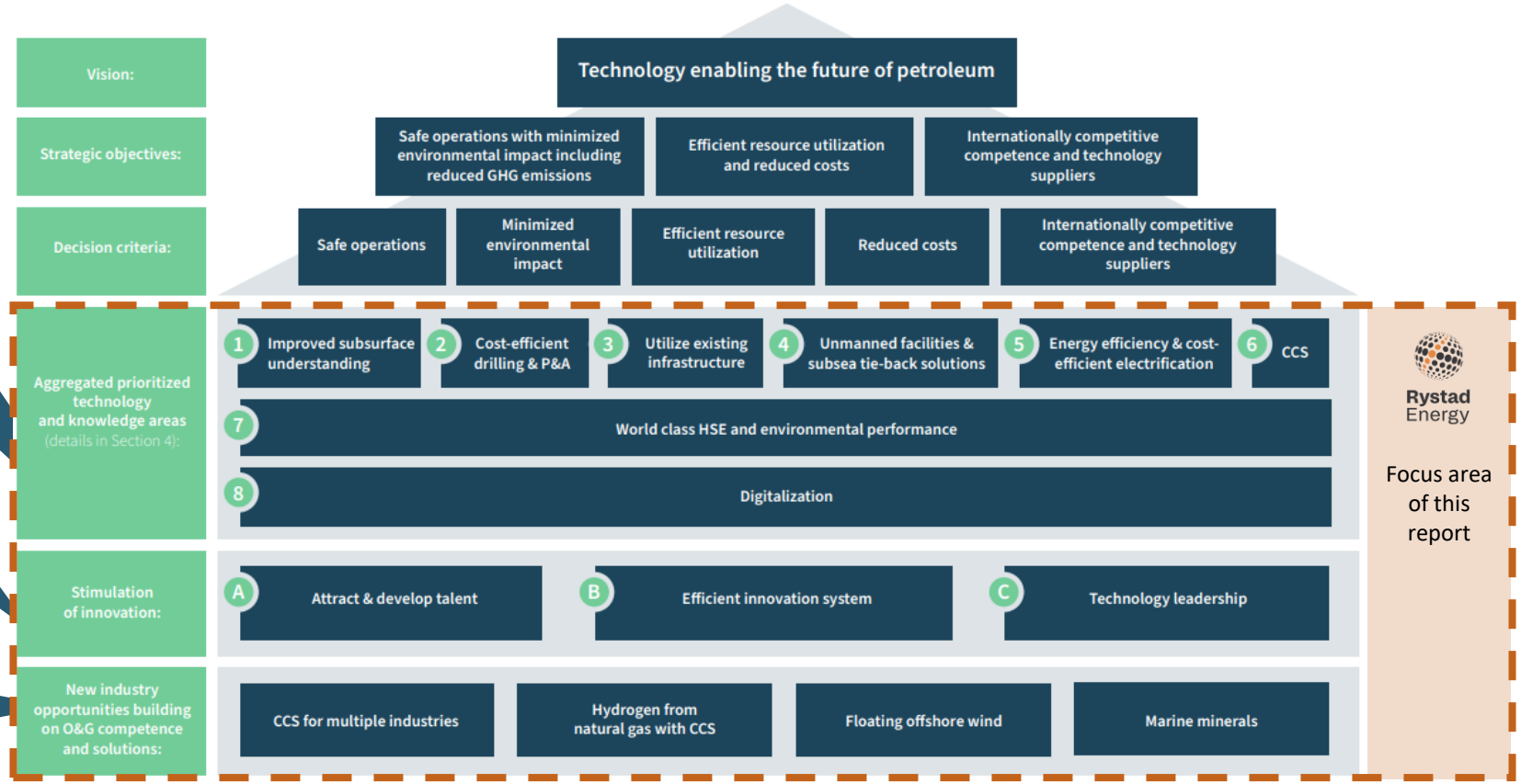
1. Improved subsurface understanding
2. Cost-efficient drilling and P&A (plugging and abandonment)
3. Utilizing existing infrastructure efficiently
4. Unmanned facilities and subsea tie-back solutions
5. Energy efficiency and cost-efficient electrification
6. Carbon capture and storage
7. World leading HSE and environmental performance
8. Digitalization

3 critical elements are crucial to stimulate the required innovation:

A. Attract and develop talent
B. Efficient innovation system
C. Technology leadership

4 new industries are identified to have significant market potential and leverage from existing O&G competence and solutions:

- CCS for multiple industries
- Hydrogen from natural gas with CCS
- Floating offshore wind
- Marine minerals



Source: Rystad Energy research and analysis; The OG21 Strategy: "A new chapter" (2021)

External events have changed dramatically after the OG21 strategy was published in 2021

Overview of external events after the OG21 strategy was published in November 2021

November 2021
OG21 strategy published

September 2022
The Nord Stream pipeline explodes

March 2023
Supply chain bottlenecks caused by geopolitical tension and COVID19 effects lead to EU's critical raw materials act.

May 2023
Increasing supply chain costs contribute to the decision to cancel the Trollvind project

August 2023
Norwegian Government approves Hammerfest LNG electrification

November 2023

February 2022
Russia attacks Ukraine

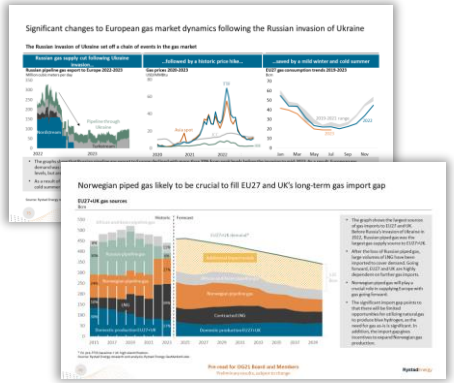
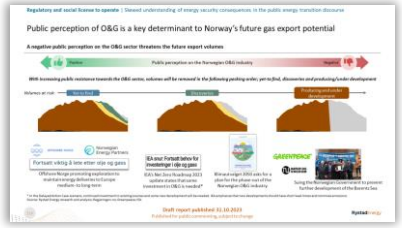
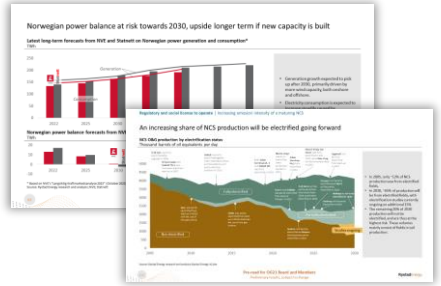
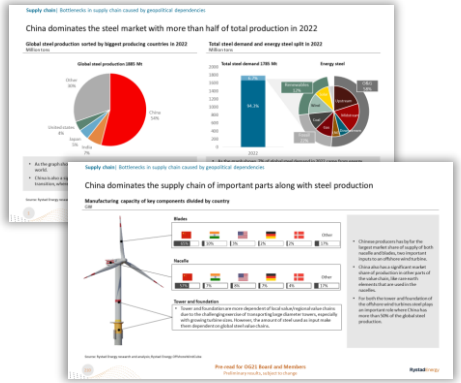
January 2021 - February 2023
High power prices cause public resistance towards export cables. In the wake of the Ukraine invasion, prices soared even higher.

February through October 2023
Demonstrations against onshore wind in Norway have been ongoing since 2019. Exemplified by the Fosen demonstrations in 2023.

Source: Rystad Energy research and analysis

Market environment impacted by recent events affecting R&D needs

Recent external events have had implications for the Norwegian offshore industries

Norwegian gas has increased in importance for Europe after Russia's invasion of Ukraine	Nord Stream pipeline attack has increased security awareness	Increasing conflict levels in energy questions accelerate the decline in NCS O&G exports	Melkøya electrification debate illustrate the uncertainty regarding NCS electrification	Supply chain dependencies and higher costs
EU's ambition to become independent of Russian pipeline gas by 2027 has made the EU become more dependent on Norwegian gas exports. Norway's share of EU gas imports increased from 22% to 27% in 2023.	The attack on the North Stream pipeline has increased the focus on security. Considerable preventive measures have been taken on the NCS, both for physical risks and cyber risks.	The public opinion is divided in the view on O&G, creating uncertainty for exploration and new developments. This can potentially limit new volumes from the NCS, accelerating the decline in Norwegian energy exports and increases importance on continuing to reduce emissions.	The Norwegian power balance will decline towards 2030, potentially turning negative. Amongst other, this threatens electrification of O&G, which are required to reach emission targets, and other industries that require power. Development of offshore wind has become more important to offset power balance decline.	Chinese dominance in renewable supply chains and increased geopolitical tensions imply a potential risk for new projects. This increases the importance of building domestic supply chains to reduce supply chain dependencies.
				

Source: Rystad Energy research and analysis

OG21 strategy recommended focus changes based on impact on European energy security

Evaluation of OG21 strategy considering impact on European energy security

		Focus area from current OG21 strategy	Importance in light of European energy security	Comment
Aggregated prioritized technology and knowledge areas	1	Improved subsurface understanding	→	Improved subsurface understanding remains important. In light of European energy security, a focus shift towards prioritizing gas as a more important than oil in technology and competence development should be considered.
	2	Cost-efficient drilling and P&A	→	Due to gas production being less drilling intensive than oil, with less focus on infill drilling, however cost-efficient drilling is important from a commercial perspective when evaluating future drilling targets.
	3	Utilize existing infrastructure	→	Maintaining high utilization and reducing operational costs to enable long-term operations of existing gas infrastructure remains important. However, facilitating new gas infrastructure to enable new volumes is of increasing importance due to the European gas situation.
	4	Unmanned facilities and subsea tie-back solutions	↑	Extending possible subsea tie-back distances has become more important for enabling discoveries at longer distance from existing infrastructure, to increase Norwegian gas supply utilizing existing infrastructure.
	5	Energy efficiency & cost-efficient electrification	↑	Electrification is currently the most important emission reduction measure on the NCS. Due to increased focus on emission reduction, cost-efficient electrification and new technologies to electrify using e.g. offshore wind is of key importance to ensure continued social license to operate.
	6	CCS (to decarbonize gas)	↓	Decarbonizing natural gas from Norway using CCS to produce hydrogen or low-carbon power (gas-to-power) has negative consequences for the total energy volumes delivered due to losses, and hence challenges current energy scarcity in Europe.
	7	World class HSE and environmental performance	→	A continued focus on HSE and environmental performance is important as the NCS is in a maturing phase. Data analysis and inspections to identify anomalies for HSE purposes also has potential synergies with improved risk management related to security.
	8	Digitalization	↑	Digitalization has increased importance as it can mitigate several threats such as cyber security and challenges related to recruitment of enough STEM professionals. Also, the use of AI and digital tools can help increase the resource base.
Stimulation of innovations	A	Attract & develop talent	→	A continued focus on attracting and developing the existing workforce is important to mitigate negative effects from an aging workforce and handle new technologies.
	B	Efficient innovation system	→	An efficient innovation system with sufficient governmental funding is still important. However, the focus towards new industries should be emphasized in the revised strategy.
	C	Technology leadership	→	A continued focus on technology leadership is important for proper implementation of new technologies along with knowledge on how the technologies should be communicated to suppliers.
New industry opportunities building on O&G competence and solutions		CCS for multiple industries	↑	Competence and knowledge from the O&G industry is important for implementing CCS technologies that can be used by other industries. Especially infrastructure, transport and offshore carbon storage are viewed as important.
		Hydrogen from natural gas with CCS	↓	Hydrogen from natural gas with CCS produced domestically is less important given the gas scarcity situation in Europe and the conversion losses that come from transforming natural gas to blue hydrogen.
		Floating offshore wind	↑	Floating offshore wind will play a role in ensuring electrification of O&G installations with minimal negative effects for the onshore energy balance.
		Marine minerals	→	Marine minerals have not been directly addressed in the work by Rystad Energy in 2023, but it is relevant for developing domestic supply chain and long-term reduced geopolitical dependency.

Importance in light of European energy security: ↓ Reduced → Continued ↑ Increased

Source: Rystad Energy research and analysis; OG21

Disruptions in the European energy market creates need for changed priorities

Evaluation of OG21 strategy technology and knowledge areas considering impact on European energy security

4 Unmanned facilities and subsea tie-back solutions

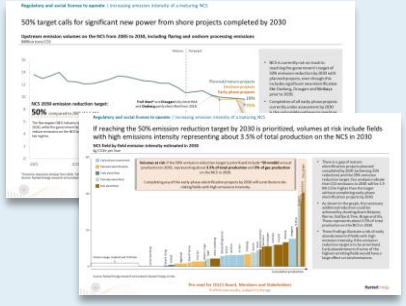
Increased importance

As there have been very few large gas discoveries on the NCS in recent years, technologies for developing smaller discoveries has become more important. Subsea tie-backs offer a cost-efficient way of realizing smaller discoveries, and extending possible tie-back lengths are important to unlock future volumes.

5 Energy efficiency & cost-efficient electrification

Increased importance

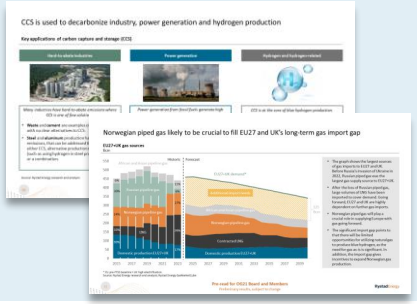
Energy efficiency and cost-efficient electrification are essential to have Norwegian gas production with as low emission intensity as possible. Electrification also plays an important role for the social license to operate and Norway reaching the identified emission targets for the future.



6 CCS (to decarbonize gas)

Lower importance

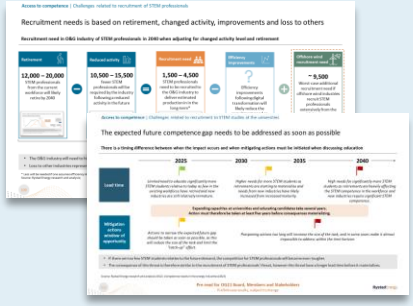
The uncertain demand outlook for Norwegian natural gas has changed since the OG21 strategy was published. In 2022, gas was labeled as a sustainable activity in the EU taxonomy*. Additionally, following reduced appetite for Russian gas,, the importance of de-carbonizing gas is lowered.



8 Digitalization

Increased importance

The use of digital tools and AI offers a great opportunity for the O&G industry going forward. The use of such tools may help in mitigating the threats of a lack of STEM professionals, cyber attacks and major accidents. Further, the use of big data can enhance exploitation from existing fields.



* Under strict emission threshold regulations
Source: Rystad Energy research and analysis; OG21; EU Commission

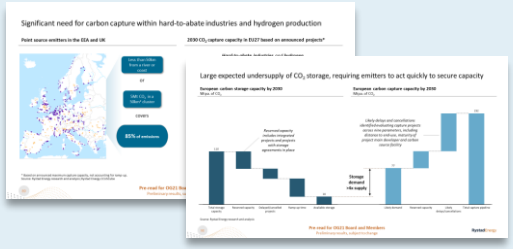
Increased focus on CCS and floating offshore wind is necessary considering European energy security

Evaluation of OG21 strategy new industry opportunities building on O&G competence and solutions considering impact on European energy security

CCS for multiple industries

Increased importance

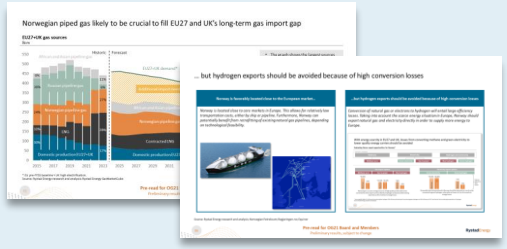
A Norwegian CCS industry, through infrastructure to transport and store carbon in offshore storages on the NCS, can play an important role in reducing European emissions related to natural gas consumption in Europe. Continued use of natural gas increases the need to reduce emissions from hard-to-abate industries through capture from flue stack or in gas power plants. Continued use of natural gas also increases the relevance of the O&G industry to take responsibility in scope 3 emissions. Existing CCS experience and positive authorities make NCS an attractive storage location and synergies from the O&G industry is especially viable.



Hydrogen from natural gas with CCS

Lower importance

As blue hydrogen production results in large efficiency losses, blue hydrogen production in Norway in the short-to medium-term adds to the risk of European energy shortage. In light of European energy security, direct use of gas should be preferred as long as Europe is in a position of energy scarcity. Since Norwegian pipeline gas is also very competitive both on cost and emissions compared to LNG imports, Europe's demand for Norwegian pipeline gas is likely to remain strong even if Europe's total gas demand is reduced. Also, EU policies only consider blue hydrogen as a transition fuel.



Floating offshore wind

Increased importance

Floating offshore wind has potential to increase Norwegian power generation and can as such be a key enabler for new O&G electrification projects. Through its significant emissions and large power demand, O&G companies have a responsibility to contribute to the development of floating offshore wind to ensure that enough electricity is available for electrification of the NCS. Increased focus from OG21 and the O&G industry can also contribute to communicating the need to cover the funding gap on industrialization of floating offshore wind.

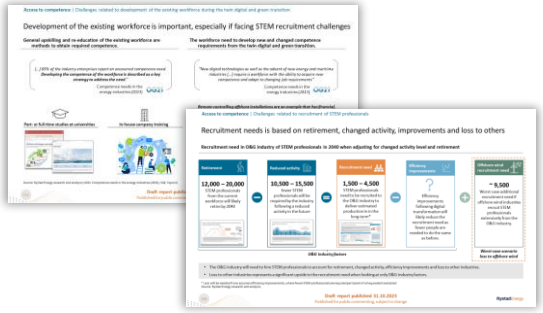
Source: Rystad Energy research and analysis; OG21

Four additions to the strategy are recommended considering European energy security

Recommended elements added to strategy with the goal of reducing risk to Norwegian security of supply towards Europe

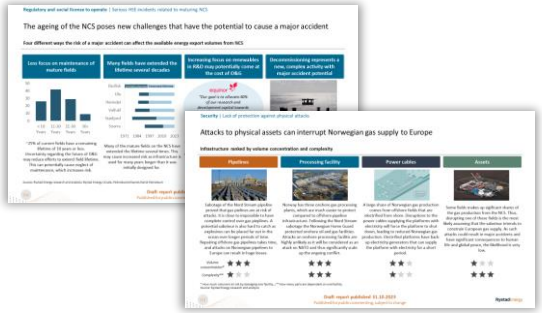
Digitalization to stem up for the shortage in STEM graduates and professionals

In light of challenges in recruiting STEM professionals, technologies to reduce the need for labor, both for skilled workers and engineering and development should receive increased focus. This include digital toolsets particularly for desktop work processes (enginnering, planning, applications, subsurface). Increased focus on digitalization can also enable improved risk understanding and management.



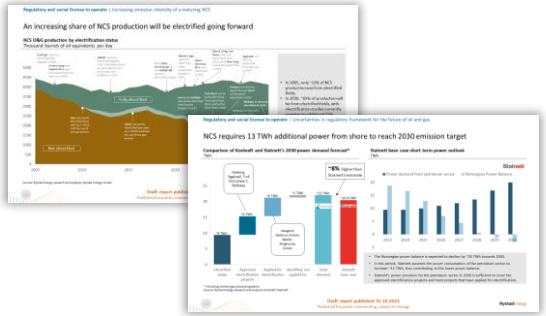
Building on synergies between maintenance and security workstreams

Recent events have put security on top of the agenda, which has previously gotten little focus. There is a clear synergy potential between maintenance and security workstreams through both inspections and anomaly detection in data analysis. Examples include infrastructure surveillance, gathering important data for both maintenance and security applications.



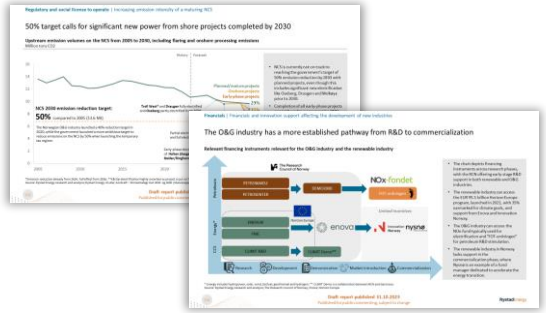
Communicating the need for increased collaboration between energy sources

The future energy system will be more integrated, which creates a need for collaboration across energy system verticals. OG21 would benefit from increasing focus on collaboration, e.g. with Energy21 and other relevant stakeholders. Communicating the need for a holistic energy roadmap is a key collaboration platform.



Communicating the role O&G companies should take in developing new industries

The target to reduce emissions from O&G by 50% by 2030 is under pressure, partly because of uncertainty regarding the access to electricity from shore and a high risk of negative power balance in Norway by 2030. This calls for efforts from the O&G industry to contribute to industrializing offshore wind and CCS through collaboration, industrialization projects, in addition to technology and competence synergies.

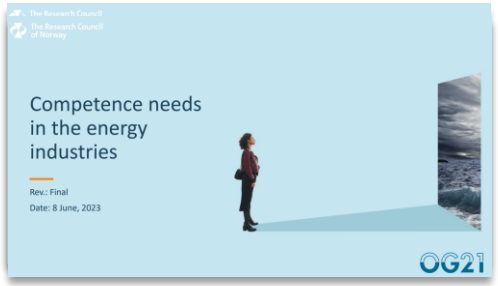


Source: Rystad Energy research and analysis

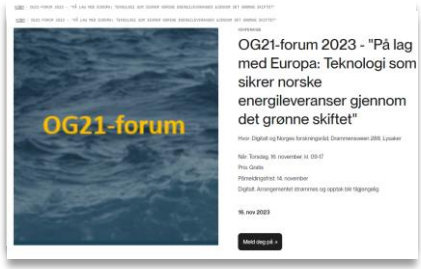
OG21 communication should benefit the development of the energy system of tomorrow

OG21 communication should provide facts and objective information to the discourse on O&G
OG21 can provide fact-based reports and other information to the discourse on the O&G industry.

Publish reports
OG21 can provide fact-based reports and information to the public discourse on the energy system.



Forums/workshops
The OG21 have a broad reach in the energy industries and can use forums or workshops to address and focus on relevant topics to improve competence sharing and collaboration across the industry.



Collaboration with others
Collaborating with others on communicating topics can be beneficial. Especially OG21 and Energi21 can benefit from collaboration on certain topics, especially related to the entire energy system.

New initiatives
OG21 could also have a role in communicating new initiatives, such as voicing the need for a holistic energy roadmap. This could be done in collaboration with Energi21 and others.

The motivation behind OG21's communication should be to accelerate the development of the energy system of tomorrow, and to identify technology and competence needs of relevance to the OG21 strategy.

Source: Rystad Energy research and analysis

Table of content

Overview of threats to Norwegian energy supply for European energy security

Theme	Threat	Threat description
Regulatory and social license to operate	**Skewed understanding of energy security consequences in the public energy transition discourse**	*Public opinion towards energy impacts future developments of the industry, referring to e.g. onshore wind or O&G exploration.*
	Increasing emission intensity of a maturing NCS	*Higher overall emissions intensity due to tail production going forward. These volumes can be at risk due to emission reduction targets.*
	Uncertainties in regulatory framework for the future of O&G	*Regulatory uncertainty related to future developments, exploration licenses and phase-out strategy.*
	Uncertainties in regulatory framework for new industries	*Regulatory uncertainty related to support schemes, contract structures, subsidies, tax regimes, strategy related to energy exports, etc.*
	Major accidents related to maturing NCS	*Infrastructure reaching design lifetime can lead to increased risk of serious accidents with high impact on social license to operate.*
Financials	Financials and innovation support affecting the development of new industries	*Financial uncertainties related to subsidies/support schemes, in addition to limited R&D funding can affect speed of development of new industries.*
	Access to external capital in the O&G industry	*Banks are restricting funding to O&G due to increased focus on ESG.*
Security	Lack of protection against cyber attacks	*Technology development in the O&G sector increases risk of cyber attacks.*
	Lack of protection against physical attacks	*Norwegian O&G infrastructure exposure to physical attacks.*
Access to competence	Challenges related to recruitment of STEM professionals	*The competition for STEM professionals is expected to be harder going forward.*
	Challenges related to recruitment to STEM studies at the universities	*Educating the required number of STEM professionals is likely an increasing challenge going forward.*
Supply chain	Bottlenecks in supply chain caused by geopolitical dependencies	*Geopolitical tensions causes increased risk in supply chain with potential bottlenecks caused by trade wars and following price increases.*

Source: Rystad Energy research and analysis

Lack of facts in public discussions is a major threat to Norwegian energy exports in the long run

Skewed understanding of energy security consequences in the public energy transition discourse

- The Norwegian public discourse often discusses how the oil and gas industry can be replaced. New industries like offshore wind, hydrogen and carbon capture and storage are often described as “the new oil”.
- One central element missing in the public discourse is the relative energy export potential from offshore wind compared to oil and gas, and how small the contribution from offshore wind actually is compared to the energy contents of oil and gas. This skewness can influence investment decisions today with large impact on future energy export potential.

Criteria		Evaluation	Comment
Likelihood		🚩	Skewed public discussions does already occur and is likely to impact decisions regarding the future of the NCS. Examples include the relative energy content of O&G vs. renewables, and the distinction between oil and gas
Impact	**Energy volumes at risk**	🚩	Lack of awareness around the relative importance of O&G compared to renewables may lead to lower investments in O&G, with high volume impact
	Permanence	🚩	Lack of fact-based discussions today will impact investment decisions that have long-term effects because of the long investment cycles in both O&G and new industries.
	Lead time	🚩	Lack of awareness in public discussions does not impact production today, but several years into the future.
OG21 relevance		★	OG21 can contribute by supporting research on the topic and communicating the need for a more nuanced public discourse about the topic.
Mitigation options		Technology	**Competence**	**Communication**

The skewed understanding of consequences in public climate and energy debate is likely to affect investment decisions with large long-term impact on Norwegian O&G exports.

OG21 relevance: ☆ Low ★ Medium ★ High

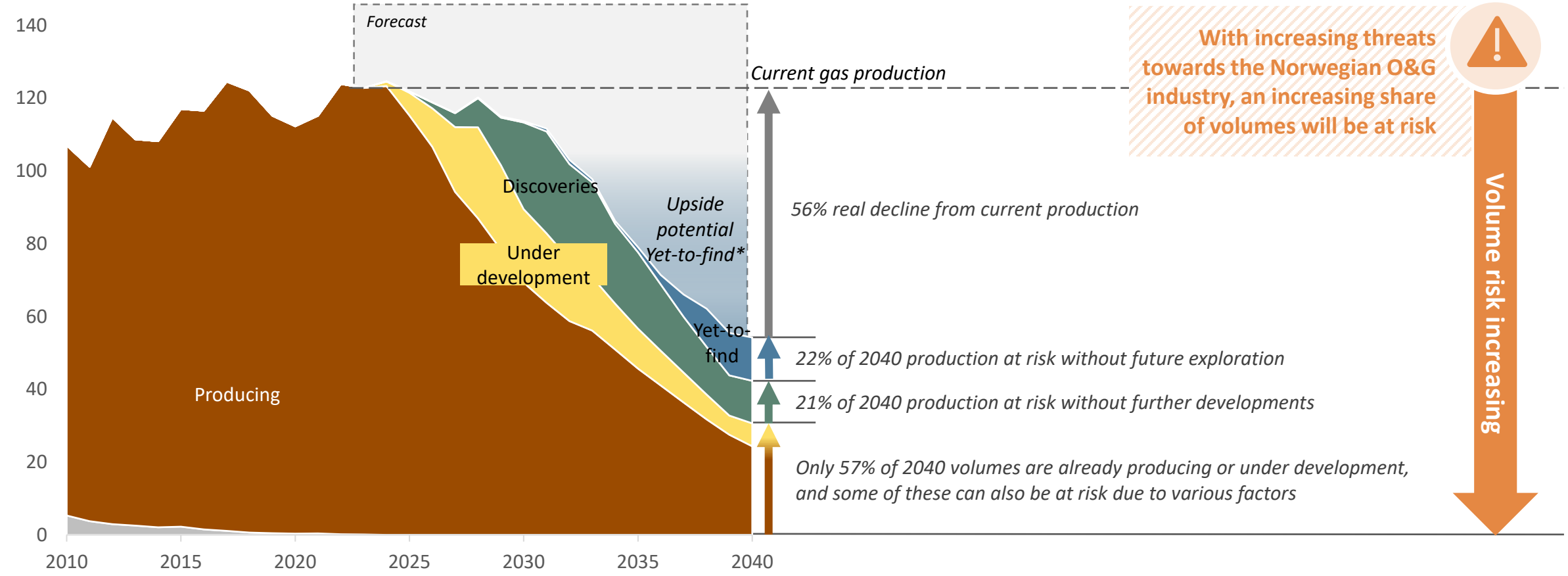
Ranking: 🚩 Low 🚩 Medium 🚩 High

Color filled if mitigation option is relevant

Source: Rystad Energy research and analysis

Threats to Norwegian gas production can be addressed by lifecycle category

Norwegian gas production towards 2040
Billion cm



* Upside potential with high exploration activity
Source: Rystad Energy research and analysis; Rystad Energy UCube

Public perception of O&G is a key determinant to Norway's future gas export potential

A negative public perception on the O&G sector threatens the future export volumes

Positive — Public perception on the Norwegian O&G industry — Negative

With increasing public resistance towards the O&G sector, volumes will be removed in the following pecking order; yet-to find, discoveries and producing/under development

Volumes at risk: Yet to find → Discoveries → Producing and under development

OFFSHORE NORGE — Norwegian Energy Partners

Fortsatt viktig å lete etter olje og gass

Offshore Norge promoting exploration to maintain energy deliveries to Europe medium- to long-term

IEA snur: Fortsatt behov for investeringer i olje og gass

IEA's Net Zero Roadmap 2023 update states that some investment in O&G is needed*

Klimautvalget 2050 asks for a plan for the phase-out of the Norwegian O&G industry.

GREENPEACE — NATUR OG UNGDOM

Suing the Norwegian Government to prevent further development of the Barents Sea

* In the Delayed Action Case scenario, continued investment in existing sources and some new development will be needed. IEA emphasize that new developments should have short lead-times and minimize emissions.
Source: Rystad Energy research and analysis; Regjeringen.no; Greenpeace; IEA

This threat has a large impact on the following threats and is therefore not evaluated separately

Examples of how a *"Skewed understanding of energy security consequences in the public discourse"* affects the three following threats

Increasing emission intensity of a maturing NCS	Uncertainties in regulatory framework for the future of oil and gas	Uncertainties in regulatory framework for new industries
• Lack of understanding for how much Norwegian energy exports would be reduced by reducing O&G activity. • Lack of understanding for how much electricity is required for O&G electrification. • Lack of understanding for how much renewable capacity would need to be built to replace the energy exports from O&G.	• Lack of understanding for how much Norwegian energy exports would be reduced by reducing O&G activity. • Lack of understanding for how much renewable capacity would need to be built to replace the energy exports from O&G. • Lack of understanding for how rapid Norwegian O&G exports will decline if exploration and new developments are not allowed.	• Lack of understanding for how much renewable capacity would need to be built to replace the energy exports from O&G. • Lack of understanding for the variability of renewable energy sources compared to fossil fuels, and the associated need for energy storage solutions.

Impact of this threat cannot be evaluated separately and is hence evaluated as part of the following three threats

Source: Rystad Energy research and analysis

Increasing emission intensity from mature fields may challenge the social license to operate

Increasing emission intensity of a maturing NCS

- A maturing NCS will experience higher emission intensity caused by fields in tail production. Even though Norwegian upstream emissions will still be lower than most peers, there is a risk that this increasing emission intensity can cause challenges related to the social license to operate. This may in turn be a threat to Norwegian energy export potential.
- One possible reaction to the increasing emission intensity is electrification, but this depends on availability of electricity.
- Early abandonment of the most emission intensive fields is also to be considered. However, these fields could be valuable in the future if new discoveries are made, allowing for extensions.

Criteria		Evaluation	Comment
Likelihood		⚑	Higher emission intensity from mature fields can threaten the the social and regulatory license to operate. However, Norwegian upstream emissions will still be among the lowest in the world, making this threat unlikely to impact volumes.
Impact	**Energy volumes at risk**	⚑	The increasing emission intensity can impact the regulatory and social license to operate. This may in turn impact exploration and newbuilds, with potentially high impact on long-term volumes.
	Permanence	⚑	If increased resistance towards the O&G sector causes lower exploration activity, halt in newbuilds or early abandonment of existing fields, these decisions would have long-term impact on energy supplied from the NCS.
	Lead time	⚑	Likely long lead time as the decisions today require several years to materialize in changed production volumes.
OG21 relevance		★	OG21 can play an important role both in communicating the comparably low emission intensity of Norwegian O&G, and by supporting R&D to further reduce emissions.
Mitigation options		**Technology**	**Competence**	**Communication**

The increased emission intensity of Norwegian fields can challenge the social license to operate. This may, in the extreme, cause lower Norwegian energy exports. However, this threat is only considered moderately likely.

OG21 relevance: ☆ Low ★ Medium ★ High

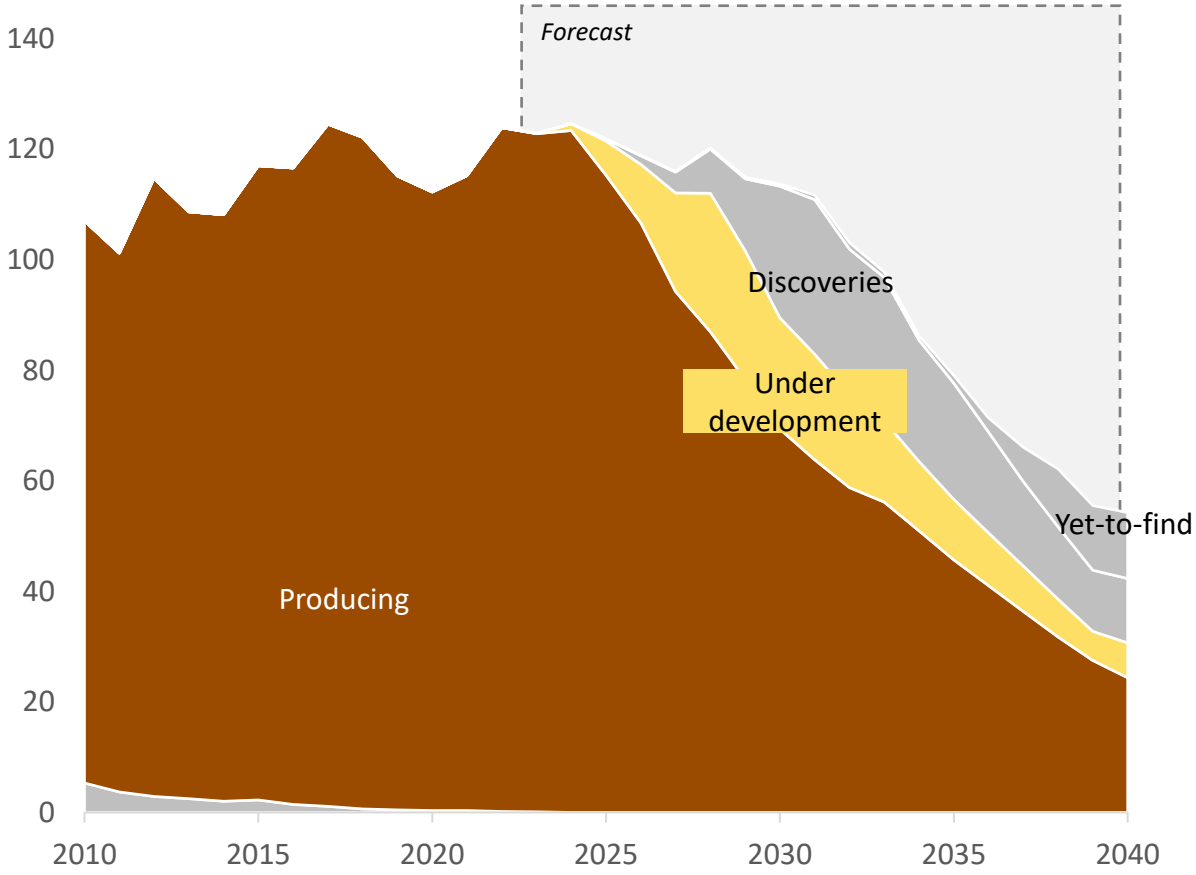
Ranking: ⚑ Low ⚑ Medium ⚑ High

Color filled if mitigation option is relevant

Source: Rystad Energy research and analysis

Producing volumes and those under development have primarily three threats

Producing and under development gas volumes
Billion cm



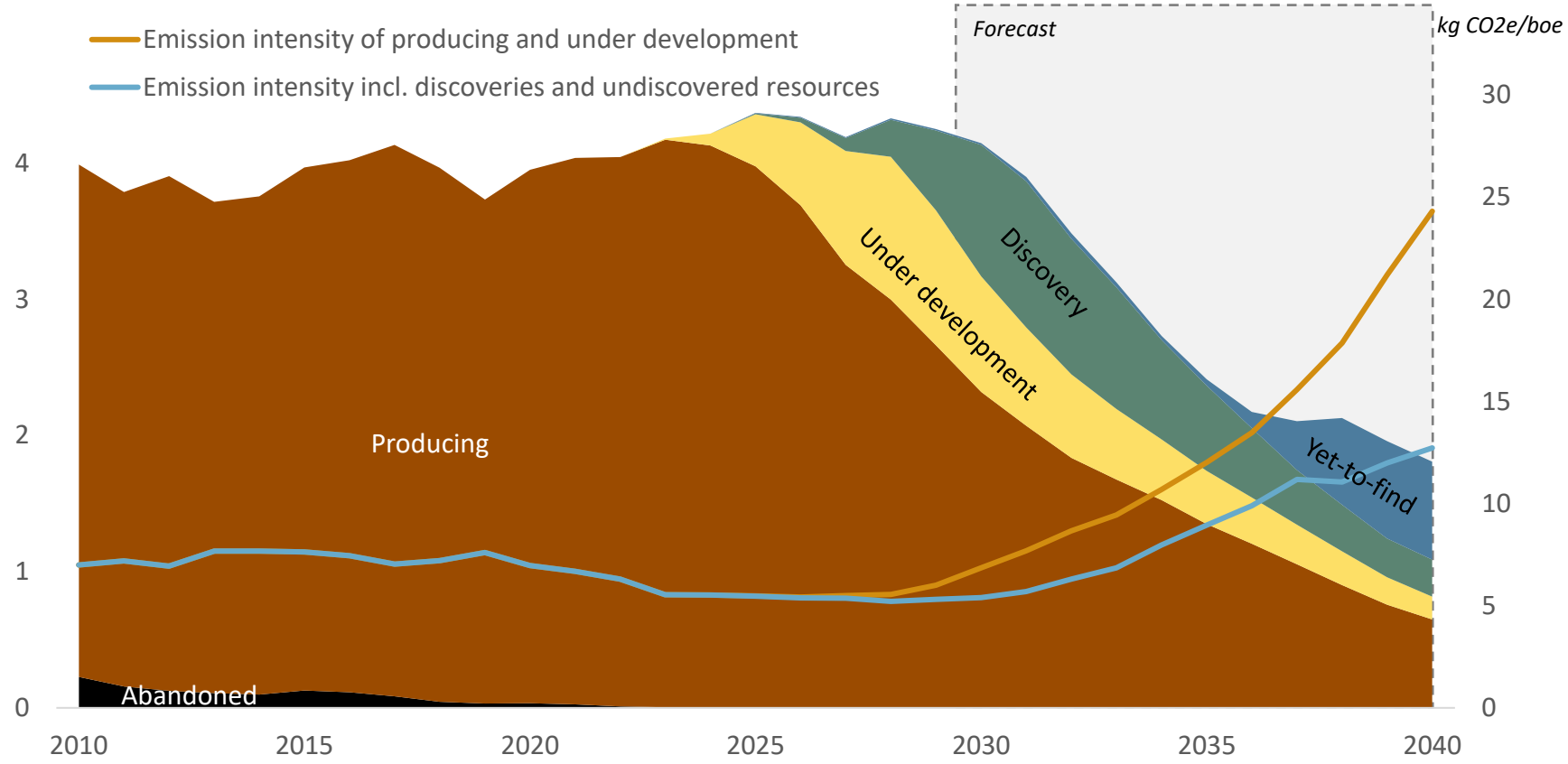
Threats to the producing and under development volumes

- **Public opinion towards oil compared to gas**
- **Increasing emission intensity**
- **Ability to meet emission reduction target**

Source: Rystad Energy research and analysis; Rystad Energy UCube

Emission intensity increases dramatically in tail production, raising questions on social license to operate

NCS production and upstream emission intensity
Million barrels of oil equivalents per day (RHS), kg CO2e per boe (LHS)

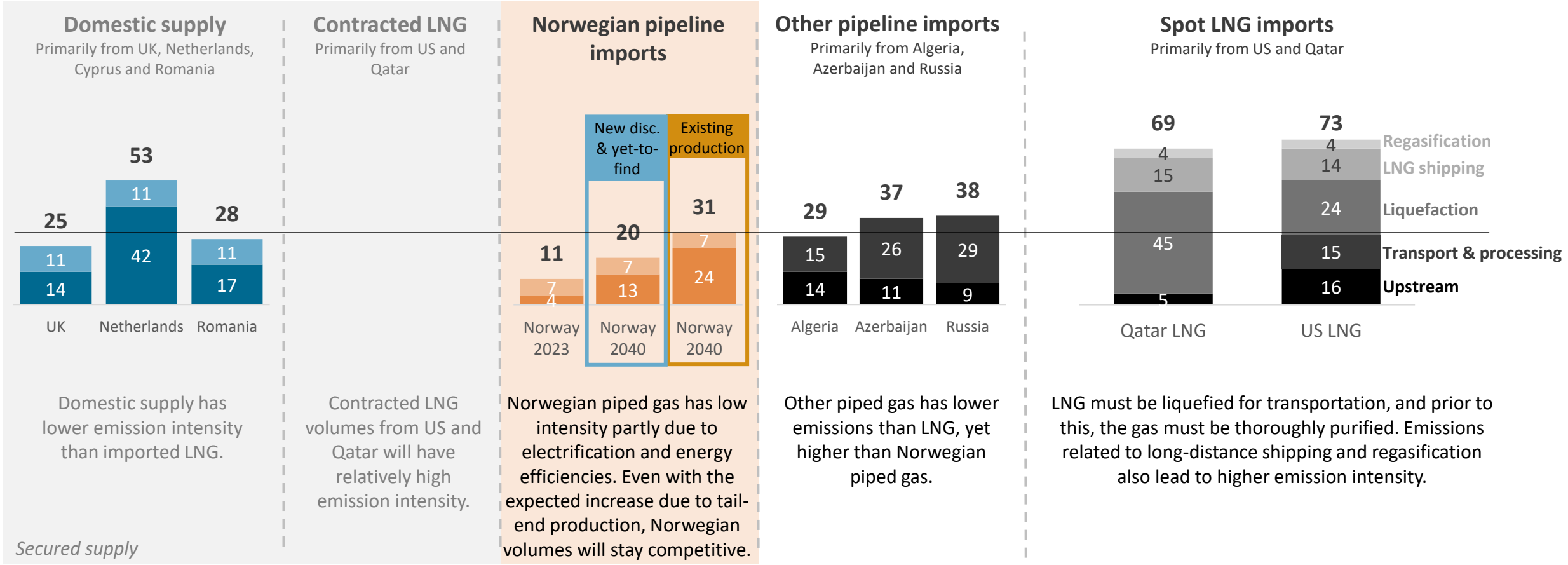


- The increasing emission intensity raises questions regarding the social license to operate and Norwegian gas competitiveness towards other supply sources.
- Production from the NCS is expected to decline towards 2040 due to a more mature continental shelf.
- As more fields are entering tail production, the average emission intensity will increase.
- Emissions intensity for fields that are already sanctioned towards 2040, this is expected to increase from about 4 kg CO2e per boe today to almost 25 kg CO2e per boe by 2040.
- If new volumes from discoveries and exploration activity comes online as expected, the emissions intensity will be limited to ~13 kg CO2e per boe in 2040.

Source: Rystad Energy research and analysis; Rystad Energy UCube

Norwegian gas will still be competitive on emissions compared to other supply sources

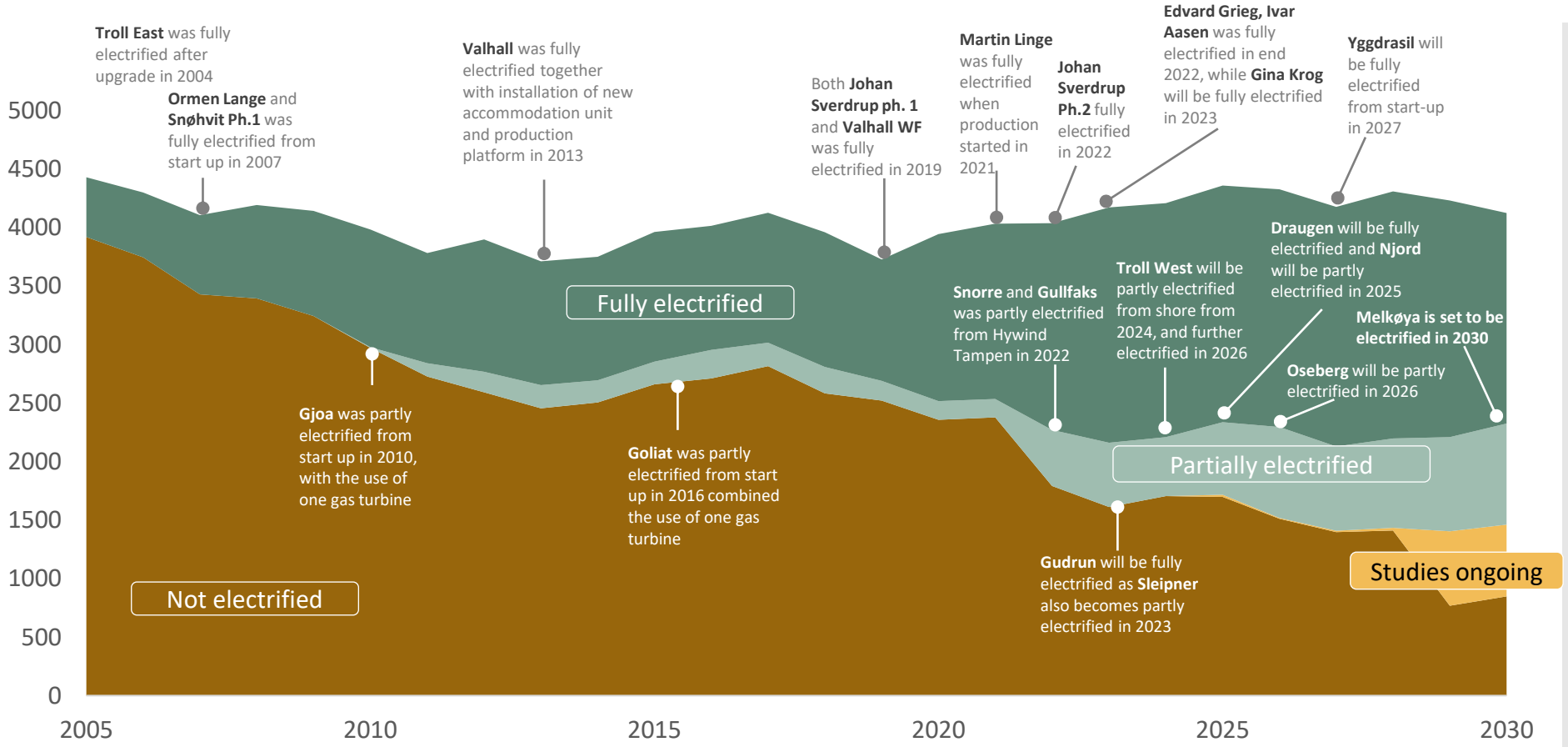
Emission intensity along the value chain for gas delivered to EU27+UK by supply source
Kg CO_2/boe



Source: Rystad Energy research and analysis; Rystad Energy GasMarketCube; Rystad Energy EmissionCube

An increasing share of NCS production will be electrified going forward

NCS O&G production by electrification status
Thousand barrels of oil equivalents per day

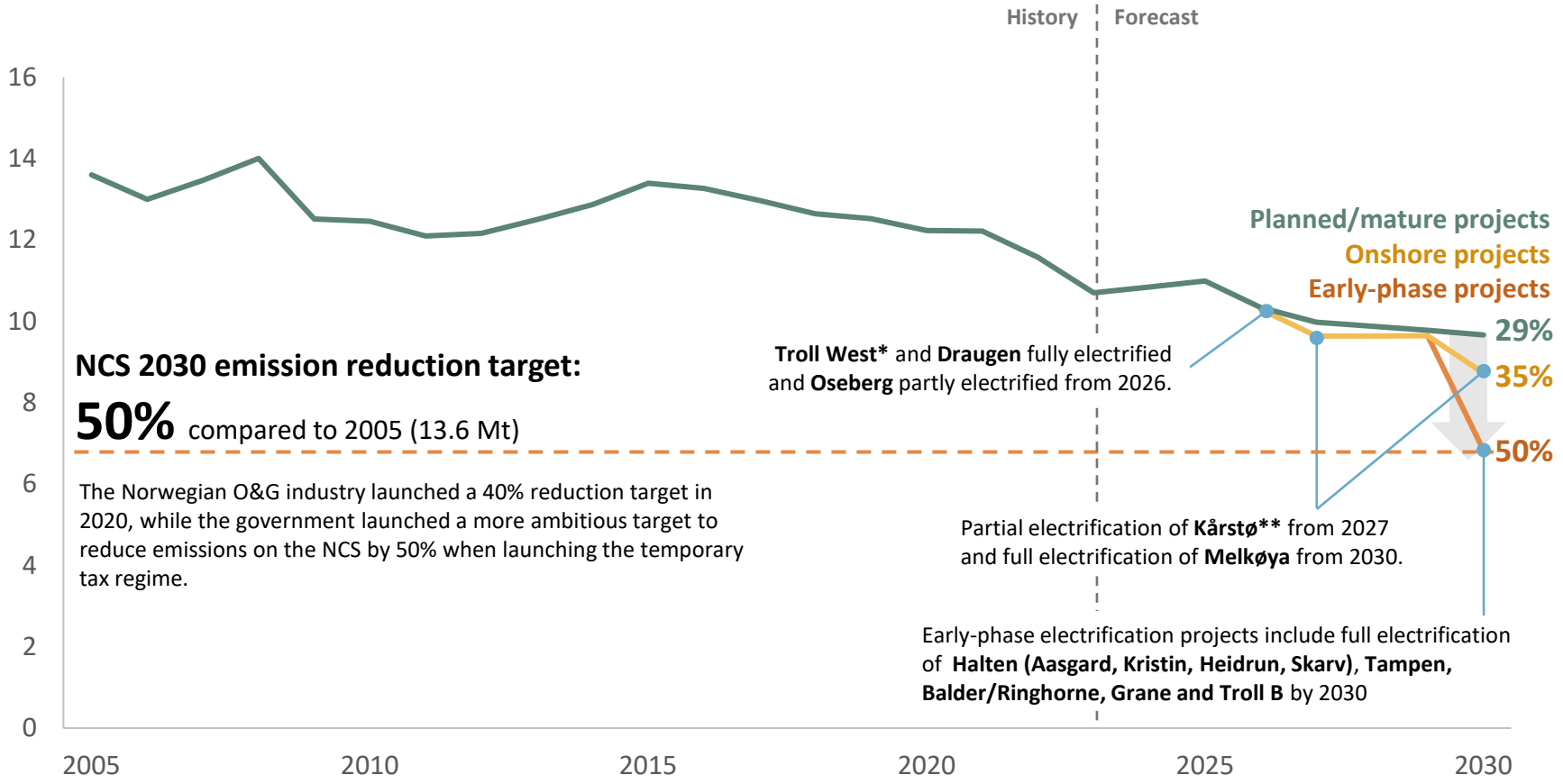


- In 2005, only ~12% of NCS production was from electrified fields.
- In 2030, ~65% of production will be from electrified fields, with electrification studies currently ongoing on additional 15%.
- The remaining 20% of 2030 production will not be electrified, and are thus at the highest risk. These volumes mainly consist of fields in tail production.

Source: Rystad Energy research and analysis; Rystad Energy UCube

50% target calls for significant new power from shore projects completed by 2030

Upstream emission volumes on the NCS from 2005 to 2030, including flaring and onshore processing emissions
Million tonnes CO2

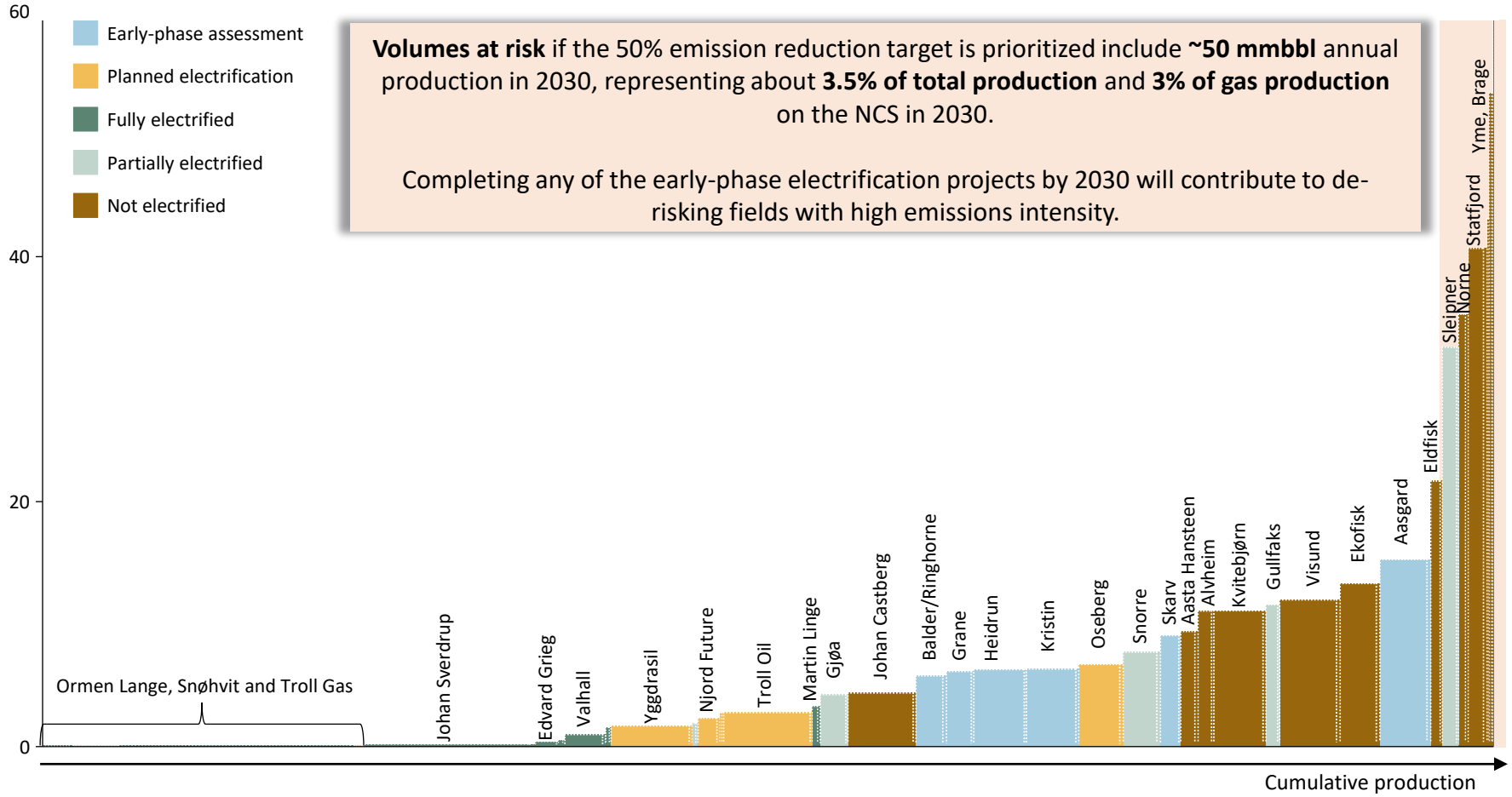


- NCS is currently not on track to reaching the government's target of 50% emission reduction by 2030 with planned projects, even though this includes significant new electrification like Oseberg, Draugen and Melkøya prior to 2030.
- Completion of all early-phase projects currently under assessment by 2030 is the only viable pathway to reaching the 2030 target. Most of these are electrification projects and calls for significant new power from shore.
- There are few other alternatives to power from shore prior to 2030, but initiatives like Trollvind or partial electrification with offshore wind has potential longer term.

* Emission reduction already from 2024, full effect from 2026; ** Kårstø electrification highly uncertain as project is put on hold
Source: Rystad Energy research and analysis; Rystad Energy UCube; Konkraft – Klimastrategi mot 2030 og 2050 (Statusrapport 2023)

If reaching the 50% emission reduction target by 2030 is prioritized, volumes at risk include fields with high emissions intensity representing about 3.5% of total production on the NCS in 2030

NCS field by field emission intensity estimated in 2030
kg CO2e per boe

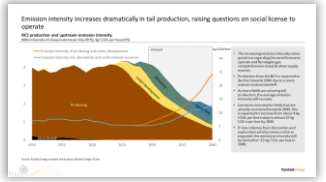
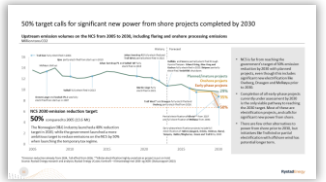
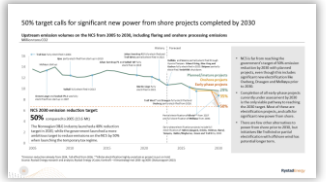
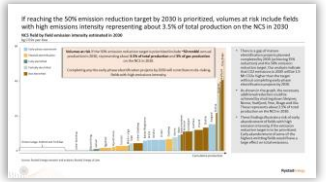


- There is a gap of mature electrification projects planned completed by 2030 (achieving 35% reduction) and the 50% emission reduction target. Our analysis indicate that CO2 emissions in 2030 will be 1.9 Mt CO2e higher than the target without completing early-phase electrification projects by 2030.
- As shown in the graph, the necessary additional reduction could be achieved by shutting down Sleipner, Norne, Statfjord, Yme, Brage and Ula. These represents about 3.5% of total production on the NCS in 2030.
- These findings illustrate a risk of early abandonment of fields with high emission intensity, if the emission reduction target is to be prioritized. Early abandonment of some of the highest-emitting fields would have a large effect on total emissions.

Source: Rystad Energy research and analysis; Rystad Energy UCube

Electrification is the industry's desired solution, but early abandonment may be a viable option

Summary of challenges related to increasing emission intensity on the NCS

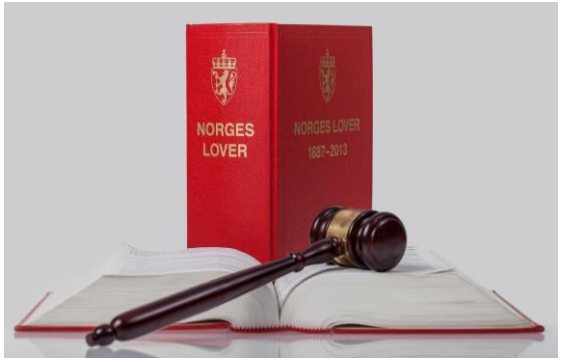
Key takes	Comments	Evaluation*	Exhibits
The emission intensity of the NCS will increase in the coming years as more fields are entering tail production.	• Fields in tail production generally have higher emission intensity as the production is low while the energy consumption does not decline in line with the decline in production. • As the NCS is becoming more mature, more fields will be in tail production, thus increasing the average emission intensity on the NCS.		
The O&G industry has an ambition to reduce emissions by 50% in 2030.	• The O&G industry's ambition to reduce emissions by 40% was increased to 50% following the negotiations regarding the temporary changes in the petroleum tax in 2020.		
The most important measure is to electrify onshore and offshore installations.	• Konkraft tracks the development towards this goal. The main identified emission reduction potential is through electrifying offshore fields and onshore processing plants. • Konkraft's tracking shows that there is still a long way to go to reach the target by 2030.		
An alternative solution is early abandonment of the fields with the highest emissions intensity.	• Some fields on the NCS have very high emission intensity. One alternative way of reducing emissions, with less electrification, is early abandonment of the most emission intensive fields.		

* Overall evaluation depending on likelihood and impact if applicable, otherwise indicating severity.
Source: Rystad Energy research and analysis

Uncertainties regarding the future of O&G threaten Norwegian long-term energy export capacity

Uncertainties in regulatory framework for the future of oil and gas

- Uncertainty regarding the future regulatory framework for oil and gas in Norway, caused by changes in the political landscape, may affect long-term investments, and thereby volumes.
- The uncertainty is mainly related to the social and regulatory license to:
  a) Continue operations at current activity level at currently operating fields. One central point of uncertainty here is whether electrification of mature fields is necessary to maintain the social license to operate, and the availability of this electricity.
  b) Exploration and new production to replace maturing fields. The ageing of the NCS requires high investments in exploration and new production just to maintain current production volumes. However, this is a highly controversial political topic.



Criteria		Evaluation	Comment
Likelihood		🚩	There is already considerable uncertainty regarding the future of O&G and political parties have various opinions. This is very likely to affect investment decisions that impact future energy export potential from the NCS.
Impact	**Energy volumes at risk**	🚩	A maturing NCS will experience a large production decline unless this is counteracted by exploration and newbuilds. Uncertainty regarding the future of O&G may impact investment decisions, which will have a large impact on future volumes.
	Permanence	🚩	Uncertainty leading to lower investments in O&G will have long-term effects for Norwegian O&G exports
	Lead time	🚩	The threat will have a long lead time as the investment decisions of today impact production volumes several years into the future
OG21 relevance		★	OG21 can help mitigating the threat by highlighting the need for Norwegian O&G going forward and communicating the need for a more predictable framework.
Mitigation options		Technology	Competence	**Communication**

The uncertainty related to the future of O&G is very likely to impact investment decisions today. This can have large long-term effects on Norwegian energy export volumes. However, the consequences will not be seen in several years.

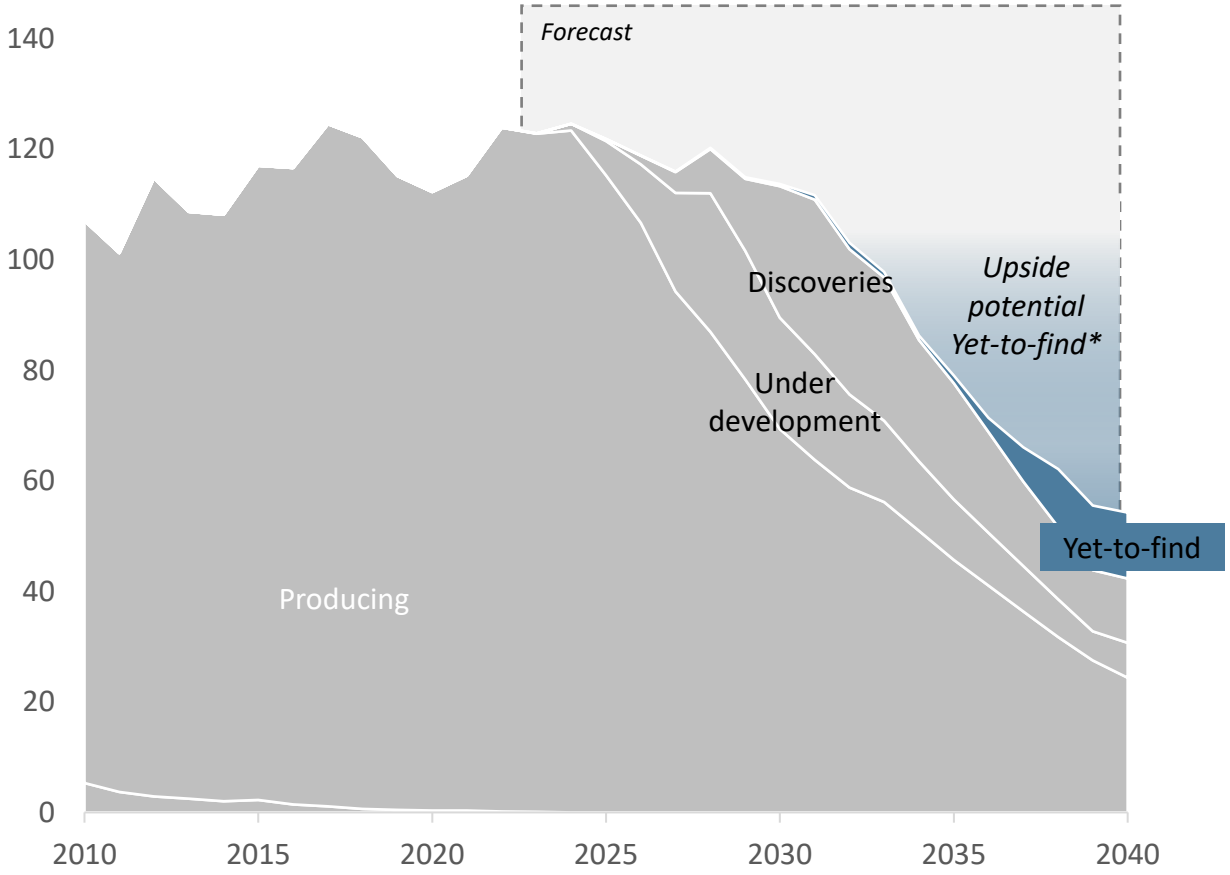
Source: Rystad Energy research and analysis

OG21 relevance: ☆ Low ★ Medium ★ High **Ranking:** 🚩 Low 🚩 Medium 🚩 High

Color filled if mitigation option is relevant

Yet-to-find volumes have primarily three threats, all related to the operating environment

Yet-to-find gas volumes
Billion cm



Threats to the yet-to-find volumes

- **Access to area to explore**
- **Public opinion towards O&G exploration**
- **Access to capacity or need of new infrastructure to develop gas**

* Upside potential with high exploration activity
Source: Rystad Energy research and analysis; Rystad Energy UCube

Most of the undiscovered resources are in the Barents Sea, which is only partly opened for O&G

Undiscovered gas resources on NCS according to NPD

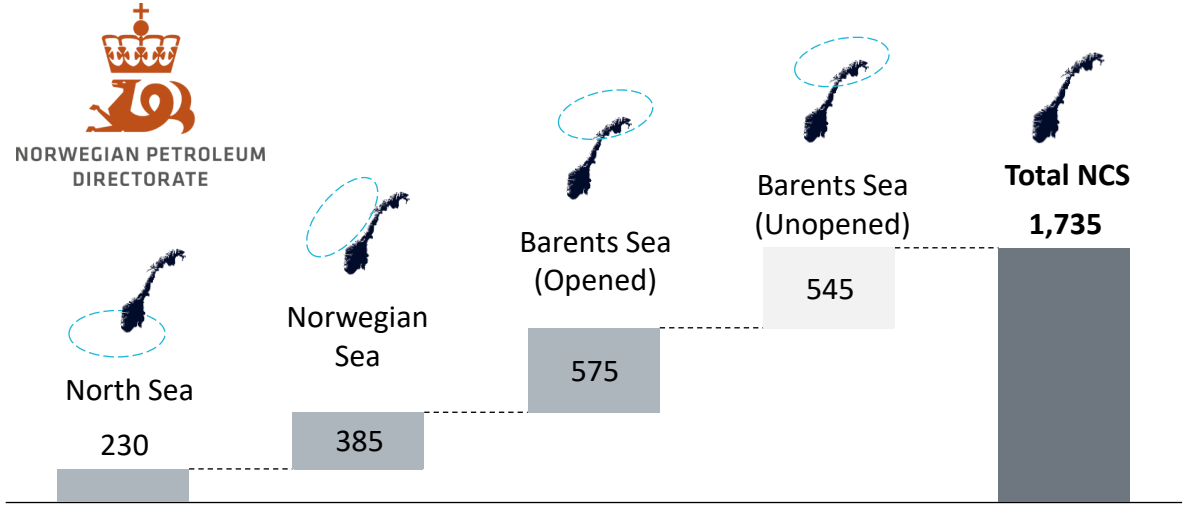
Billion cm

"The Barents Sea is like a kind of little brother, but when we look into the future at the resource potential that is out there, it could be a big brother on the Norwegian continental shelf in the future, that means leaving no stone unturned to find more gas in the Barents and that work on expanding export capacity continues."

Terje Aasland

Petroleum and Energy Minister

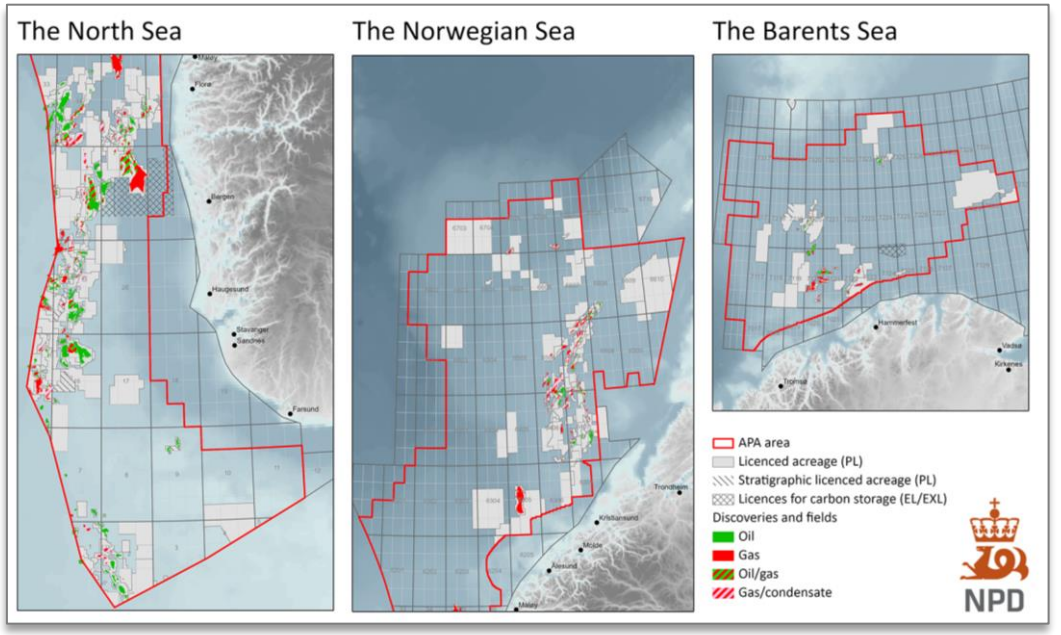
NORWEGIAN PETROLEUM DIRECTORATE



Map of area available for application in predefined areas 2023

The Norwegian Government announced that 92 blocks are added to the 2023 Awards in Pre-defined Areas, of which 78 are in Barents Sea.

Regjeringen vil ha mer leting etter gass – lyser ut 92 blokker i årets TFO

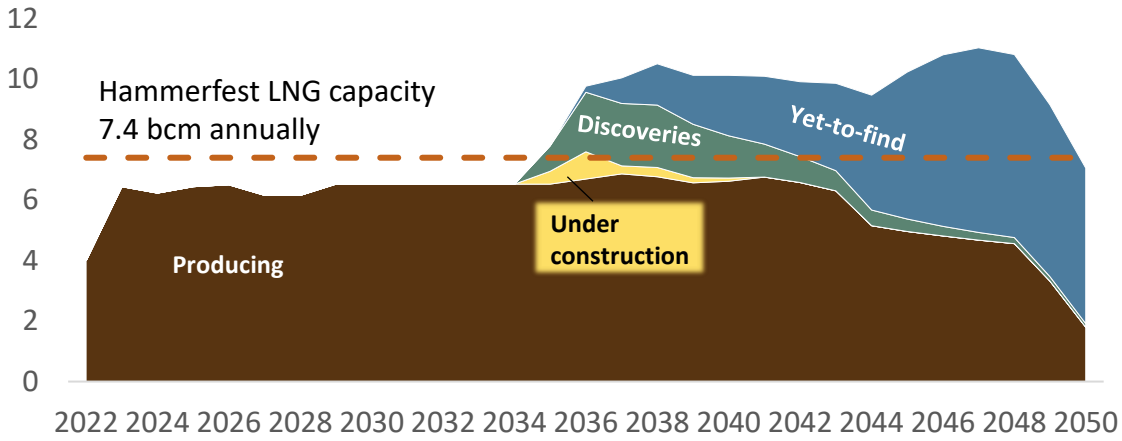


Source: Rystad Energy research and analysis; NPD; Regjeringen.no

The ability to transport gas to the markets from Barents is key to enable further development

Gas capacity evaluation of the Barents Sea

Gas volumes in the Barents Sea split by life-cycle measured in billion cm

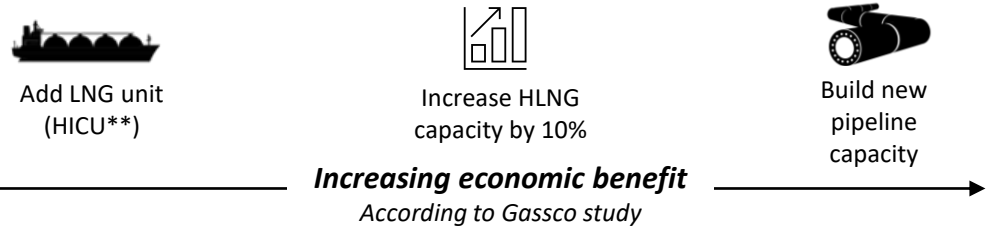


- The graph above shows the gas volumes split by life-cycle in the Barents Sea and the transportation capacity at Hammerfest LNG to get the gas volumes to markets.
- There is low spare capacity, which have primarily three implications. First, operators are hesitant to develop discoveries if the gas is stranded. Secondly, it dampens the exploration willingness in an area that has proved to be more successful than the other areas on NCS. Lastly, an inability to extract the gas have negative effects on the amount of oil one can recover from oil fields.
- To summarize, absence of gas transportation options acts as a barrier for further development of Barents Sea.

Investments in transportation infrastructure as a solution

In April 2023, Gassco published an evaluation of transportation options for gas in the Barents Sea that concluded that investing in additional transportation capacity for gas is profitable. Three (four) alternatives were considered:

1. Add LNG unit with medium capacity (HICU*)
2. Increase capacity at HLNG** with 10%
3. Build pipelines to the Norwegian Sea with high capacity
4. Blue ammonia production and transportation***

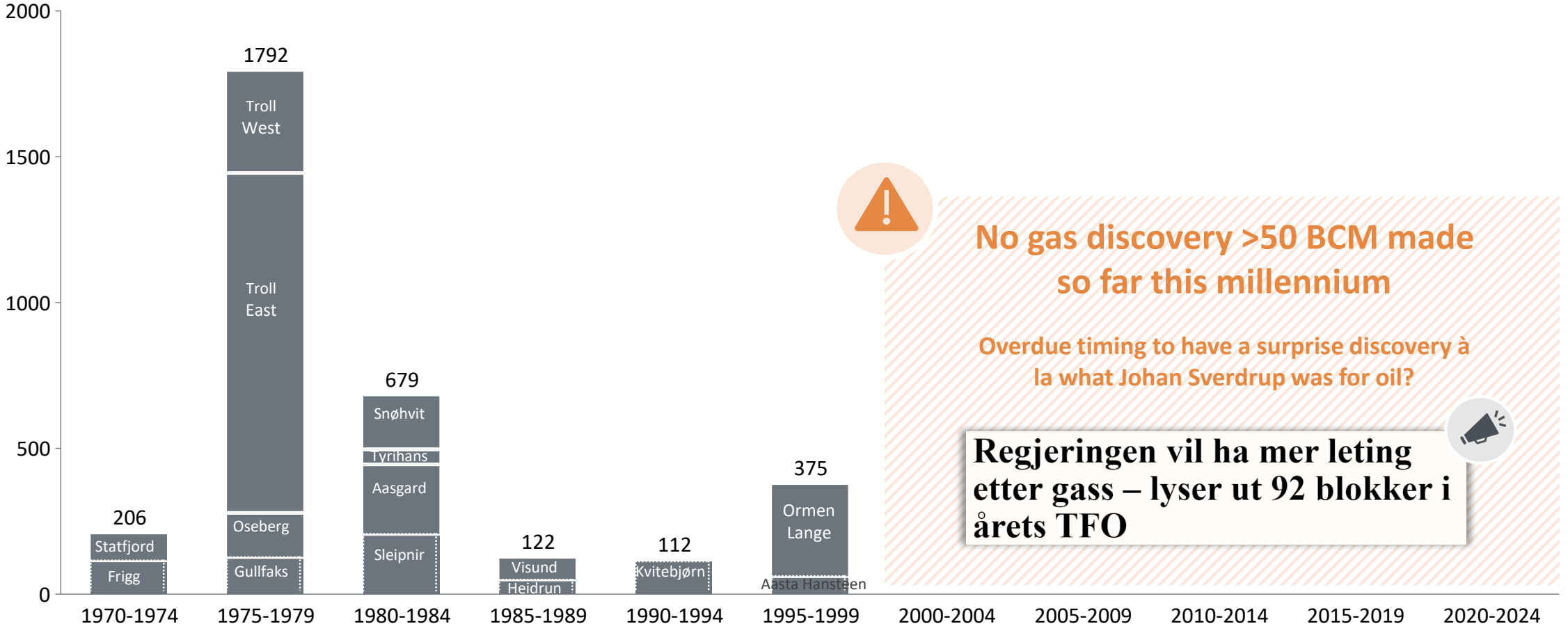


The study found that building new pipeline capacity has the highest economic benefits, partly because it adds most capacity. This can in turn incentivize companies to increase exploration activity in the Barents Sea.

* HICU refers to Hammerfest Increased Capacity Unit; ** HLNG refers to Hammerfest LNG; *** The ammonia option was not included in the evaluation given the uncertainties related to the Barents Blue project.
Source: Rystad Energy research and analysis; Gassco

No sizeable gas discoveries made in Norway this millennium – plenty of discovery potential

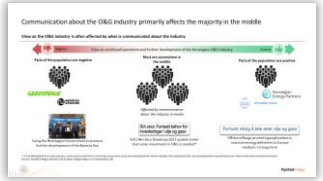
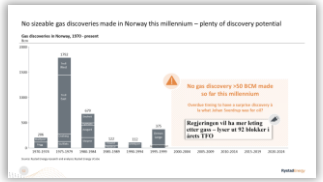
Gas discoveries in Norway, 1970 - present
Billion cm



Source: Rystad Energy research and analysis; Rystad Energy UCube

Future potential uncertainty in external factors can threaten development and production

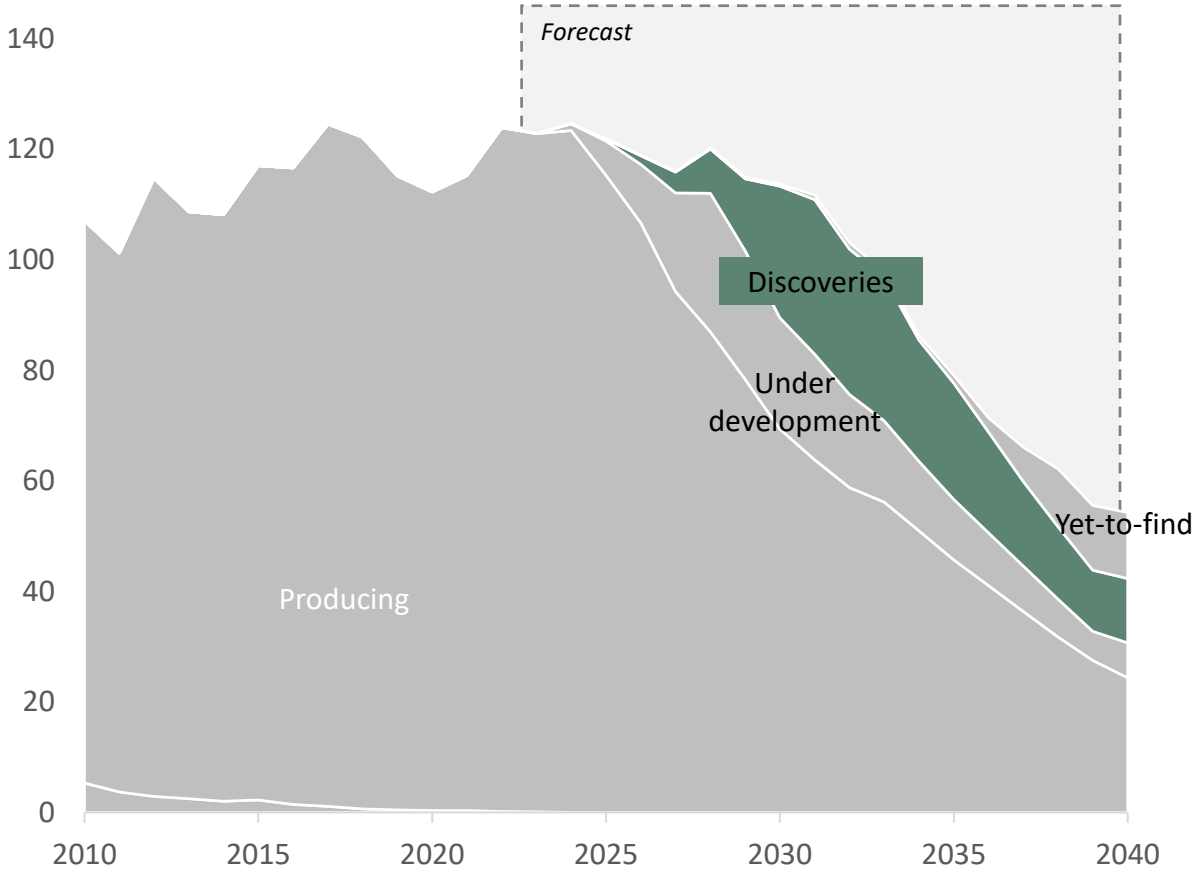
Summary of threats to uncertainties in regulatory framework for the future of oil and gas related to yet-to-find volumes

Key takes	Comments	Evaluation*	Exhibits
Limiting access to areas for exploration reduce the resource potential.	• There are significant undiscovered resources on the Norwegian Continental Shelf according to NPD estimates. • The majority of the volumes are in the Barents Sea, followed by the Norwegian Sea and then the North Sea. • Almost one-third of all undiscovered volumes are located in the unopened parts of the Barents Sea.		
Development and especially exploration are reliant on social acceptance.	• Social acceptance amongst the public is key for continued O&G activity. • Exploration and development activity are most vulnerable to changes social acceptance. • A negative public perception will threaten future volumes.		
Absence of available infrastructure will hinder development, and threaten future volumes.	• Available capacity and infrastructure to transport hydrocarbons to markets is key for development. • Barents Sea is an example, where the low available gas transportation capacity hinders future development.		
No sizeable gas discoveries this decade.	• Development of new production is dependent on favorable project economics, where the volume is a key contributor to project economics. • Unfortunately, there has been no sizeable gas discoveries this decade.		

* Overall evaluation depending on likelihood and impact if applicable, otherwise indicating severity.
Source: Rystad Energy research and analysis

Discovered volumes have primarily three threats

Discovered gas volumes
Billion cm



Threats to the discovered volumes

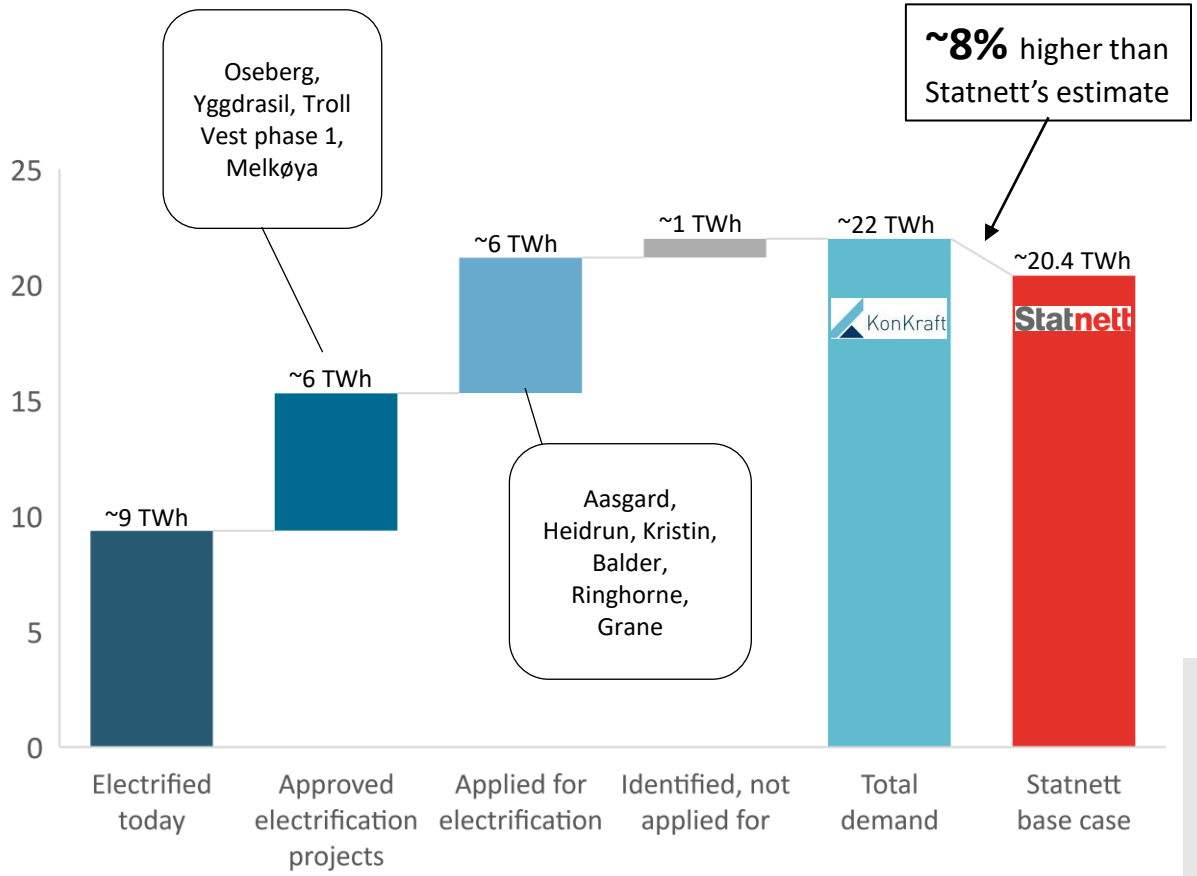
- **Access to electricity**
- **Regulatory allowance to develop with electrification from shore or find other electrification solutions**
- **Public opinion towards O&G**

Source: Rystad Energy research and analysis; Rystad Energy UCube

NCS requires 13 TWh additional power from shore to reach 2030 emission target

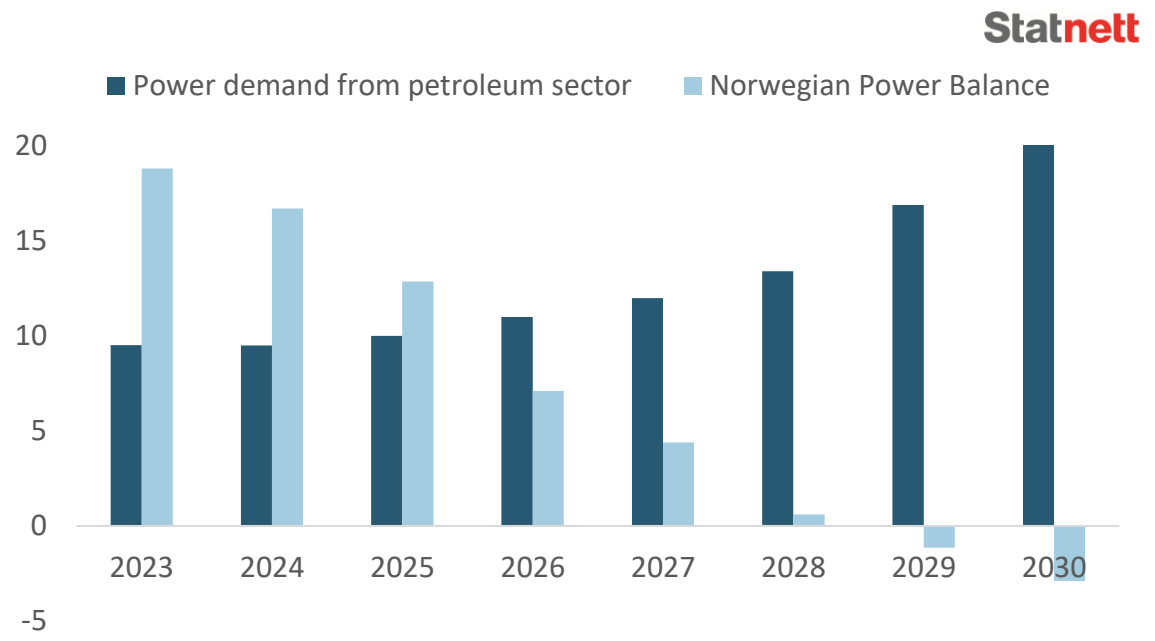
Comparison of Konkraft and Statnett's 2030 power demand forecast*

TWh



Statnett base case short term power outlook

TWh



- The Norwegian power balance is expected to decline by ~20 TWh towards 2030.
- In this period, Statnett assumes the power consumption of the petroleum sector to increase ~11 TWh, thus contributing to the lower power balance.
- Statnett's power provision for the petroleum sector in 2030 is sufficient to cover the approved electrification projects and most projects that have applied for electrification.

* Including onshore gas processing plants.
Source: Rystad Energy research and analysis; Konkraft; Statnett

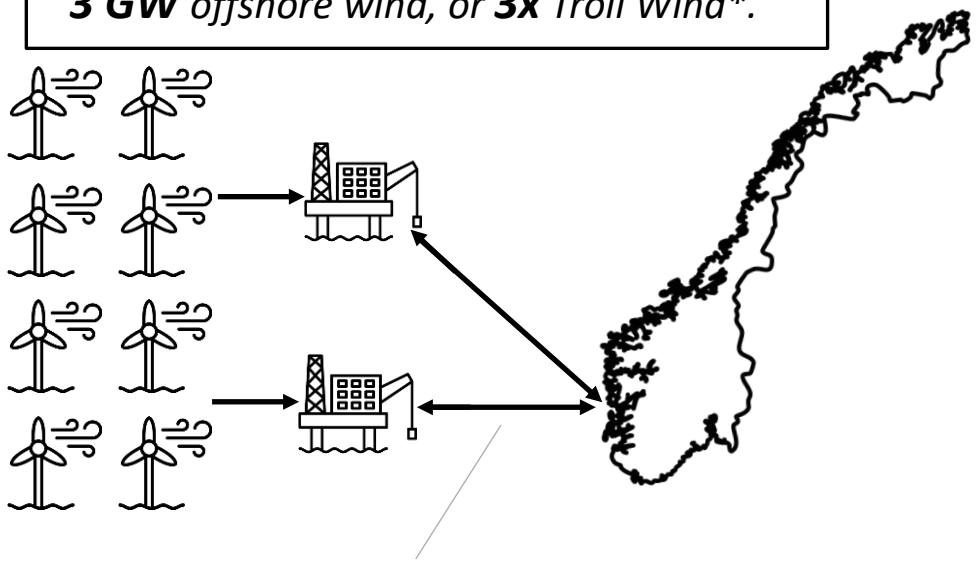
Offshore wind can play an important role in ensuring access to electricity for the O&G sector

Assessment of various technologies for green electricity generation

	Public perception	Government involvement	Generation potential	Competitiveness	Total assessment
Offshore wind	✓	✓	✓	?	✓
Onshore wind	−	?	✓	✓	?
Solar PV	?	−	−	?	?
Hydro	✓	?	−	✓	?

* Assuming 50% capacity factor.
Source: Rystad Energy research and analysis

***~13 TWh** additional power demand from the O&G sector by 2030 can be supplied by **~3 GW** offshore wind, or **3x** Troll Wind*.*



Variable wind power generation requires platforms to also be connected to the onshore power grid. In the long run, new technologies for offshore energy storage may allow electrification without onshore connection.

The O&G will need large amounts of electricity to reach emission targets

Summary of challenges related to uncertainty in regulatory framework for new industries

Key takes	Comments	Evaluation*	Exhibits
The O&G industry requires large amounts of renewable power in the coming years to reach emission targets.	• Konkraft estimates that the O&G industry requires 13 TWh of additional electricity in 2030 to reach emission targets, mainly for electrifying existing fields. • New developments will also require electrification, thus increasing the power demand from the O&G industry going forward.		

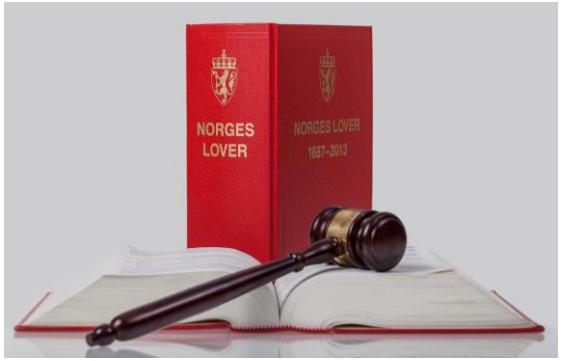
Remaining threats related to development of new discoveries handled in the following material (access to electricity)

* Overall evaluation depending on likelihood and impact if applicable, otherwise indicating severity.
Source: Rystad Energy research and analysis

Regulatory uncertainty threatens Norway's long-term export potential of renewable energy

Uncertainties in regulatory framework for new industries

- A clear and predictable regulatory framework and legislation is highly important for the speed of development of new industries on the NCS, like offshore wind and CCS.
- One example of a new industry with regulatory uncertainty is offshore wind. Among other issues, this industry lacks clarity around the level of subsidies and regulations related to export/hybrid cables.
- Other countries have responded quick and put in place comprehensive frameworks for new industry development. If Norway wants to become a leading exporter of renewable energy, the government must ensure that the Norwegian framework is predictable and competitive in order to attract investments.



Criteria		Evaluation	Comment
Likelihood		🚩	The high level of uncertainty is already impacting future energy export potential. An example is the lack of offshore wind initiatives caused by high uncertainty regarding subsidies, export cables etc..
Impact	**Energy volumes at risk**	🚩	High relative impact on renewables volumes, but very small volumes compared to O&G.
	Permanence	🚩	High uncertainty and its negative consequences of new industry development in Norway will have large impact on renewables volume. However, these volumes are small compared to O&G volumes.
	Lead time	🚩	Long lead time as new industries require long time to build up.
OG21 relevance		★	The lead time of this threat will be long as the limited investments in new industries today only affect energy export potential several years into the future.
Mitigation options		Technology	**Competence**	**Communication**

The lack of a comprehensive framework will likely have a large impact on renewables development. However, the volume effect is still small compared to O&G volumes.

Source: Rystad Energy research and analysis

OG21 relevance: ☆ Low ★ Medium ★ High **Ranking:** 🚩 Low 🚩 Medium 🚩 High

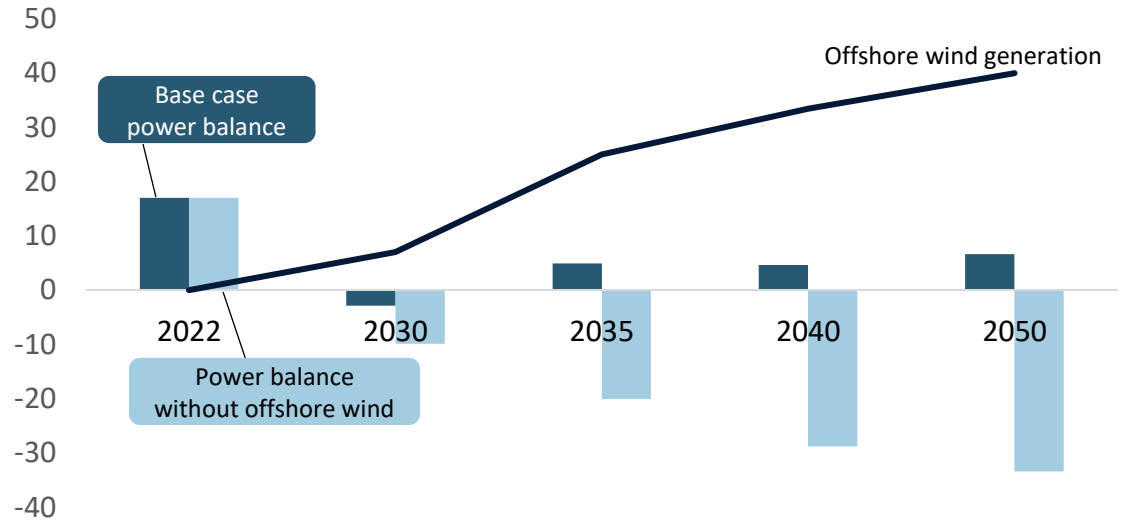
Color filled if mitigation option is relevant

The pace of offshore wind development will have a large impact on the Norwegian power balance

Indicative timeline for Sørlige Nordsjø II

The role of offshore wind in Statnett's power balance outlook

TWh



- Statnett expects ~1.6 GW* of offshore wind to be installed by 2030, equaling the combined capacity of Hywind Tampen and Sørlige Nordsjø II. The 2050 capacity is only expected to be 9 GW, considerably lower than the 30 GW government target.
- The development of offshore wind has a large impact on the power balance. Slow processes threaten the O&G sector's access to power for electrification projects.
- As Statnett's forecast is only ~30% of the government target, there is also a large upside potential if the processes are sped up.

* Assuming 50% capacity factor.
Source: Rystad Energy research and analysis; Regjeringen; Statnett

Central sources of uncertainty still need to be addressed to facilitate further growth

Main sources of uncertainty in regulatory framework for offshore wind in Norway

Cable type

- After a period of high uncertainty, Sørlige Nordsjø II phase 1 is announced to be built with a radial, with opening for hybrid cables in phase 2.
- Terje Aasland has announced that hybrid cables may be a possibility for Utsira Nord and SN II phase 2, while Trygve Slagsvold Vedum has stated that SP will not support hybrid cables.
- Several opposition parties have announced that they support hybrid cables, also for SN II phase 1.


Sp vant første runde om hybridkabler. Kan bli omkamp til høsten.

ENERGI

Havvind-utlysning kommer denne uka: NVE peker på hybridkabler

Høyre trekker seg fra havvind-forhandlinger – krever nytt forslag fra regjeringen

Connection to O&G installations

- The decision to use a radial for Sørlige Nordsjø II implies that O&G installations cannot be connected directly to the offshore wind farm.
- Several O&G companies have expressed a desire to use electricity from offshore wind farms to electrify platforms, e.g., ConocoPhillips wanting to electrify Ekofisk with electricity from Sørlige Nordsjø II.


ConocoPhillips

Olje- og energidepartementet
Postboks 8148, Dep
0033 Oslo

Ved: Anette Vehus Smedsvig

Kopi: Gaute Erichsen

ENERGI

ConocoPhilips ser på muligheten for havvind til Ekofisk

ConocoPhilips har valgt ikke å bygge ut vindkraft til Ekofiskfeltet i Nordsjøen selv, men kan melde sin interesse for en strøm fra en havvindpark i området.

Opening of new areas

- New areas for offshore wind will not be announced before **2025**. Unless public processes are considerably optimized, it is unlikely that capacity beyond Sørlige Nordsjø II and Utsira Nord will be realized before **2035**.
- NVE have identified 20 areas suitable for offshore wind. After the next announcement round in 2025, Norway will only have opened for offshore wind development in three out of these 20 areas.


Tre nye havvindområde aktuelle for opning og utlysing i 2025

Pressemelding | Dato: 14.09.2023

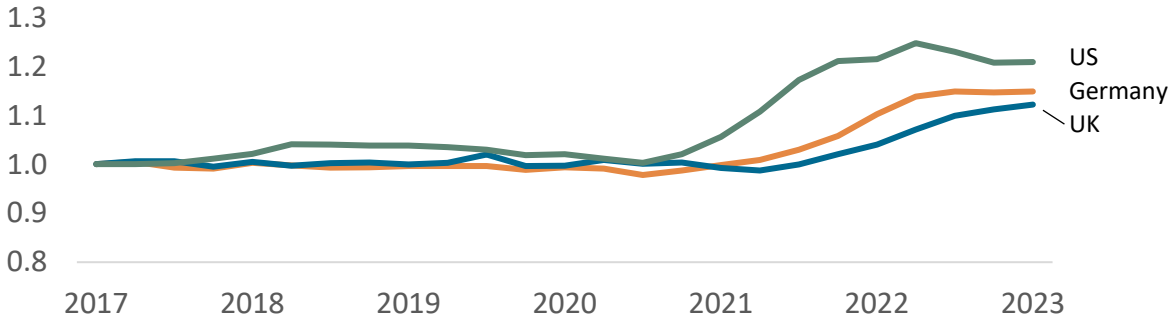
Regjeringa gir Noregs vassdrags- og energidirektorat (NVE) i oppdrag å starte strategiske konsekvensutgreiingar av tre havvindområde som kan vere aktuelle for opning og utlysing i 2025.

Source: Rystad Energy research and analysis

Higher supply chain costs and cost of capital threaten the profitability of offshore wind projects

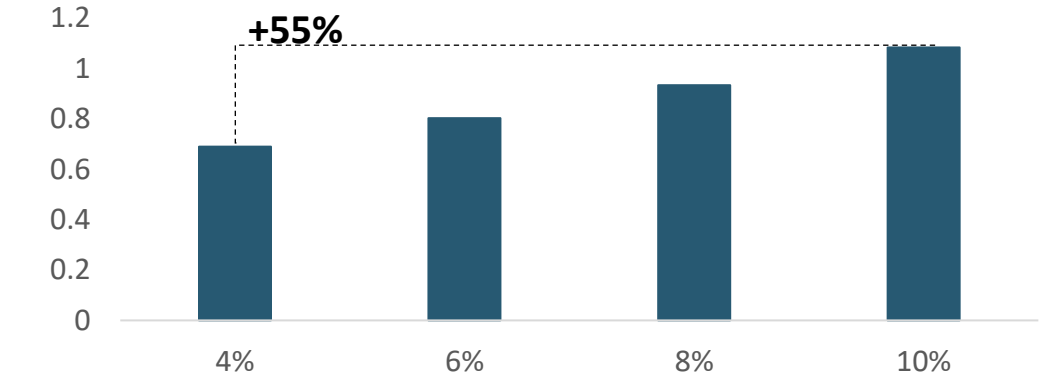
Offshore wind component price inflation

Indexed to 1 in March 2017



Post-tax LCOE of a 900 MW offshore wind farm by WACC*

NOK/KWh



Potential consequences of increasing supply chain and capital costs

Increasing supply chain costs and cost of capital in an industry with already low margins can strongly slow down offshore wind development in Norway

The renewable industry is characterized by high up-front investments, with a long repayment period. The margins are typically low, especially when comparing to oil and gas projects. This way, offshore wind projects are more prone to cost increases.

The offshore wind industry has experienced rising supply chain costs over the past few years caused by higher raw materials prices and high demand for wind turbine components. Some of the cost components with the highest inflation are nacelle, cables and installation vessels.

The long repayment period of renewable energy projects also make these projects more exposed to changes in the cost of capital, compared to oil and gas projects. With the rapid interest rate hikes in recent years, there is a risk that offshore wind projects that were previously considered profitable are now considered unprofitable, thus delaying the development of offshore wind.

* Based on a simulation using Rystad Energy Renewables Economic Model. Assuming capital intensity to be 2.2 mill GBP/MW_{AC}. WACC = weighted average cost of capital.
Source: Rystad Energy research and analysis; Rystad Energy Renewables Economic Model

Even though the subsidies for SN II have been raised, it may still not be sufficient

Support scheme for Sørlige Nordsjø II has been altered several times

February 2022

Not announced if and to what extent financial support would be give. However, as the Government decided to use radial instead of hybrid cable, it accepted that this could require higher subsidies.

Vindkraft i Norge

Regjeringen åpner for å subsidiere havvind: – Det er en investering

Regjeringen vil subsidiere havvind på norsk sokkel for å unngå kabler til dyrere strømmarkeder. Hva det vil koste skal bestemmes i en auksjon.

March 2023

Government announces that it will support projects through a contract for difference. The maximum support is set to bNOK 15 and the reservation price to NOK 0.66/KWh.

Forslag om tosidig differansekontrakt for støtte til havvind fra første fase av Sørlige Nordsjø II

Pressemelding | Dato: 31.03.2023

May 2023

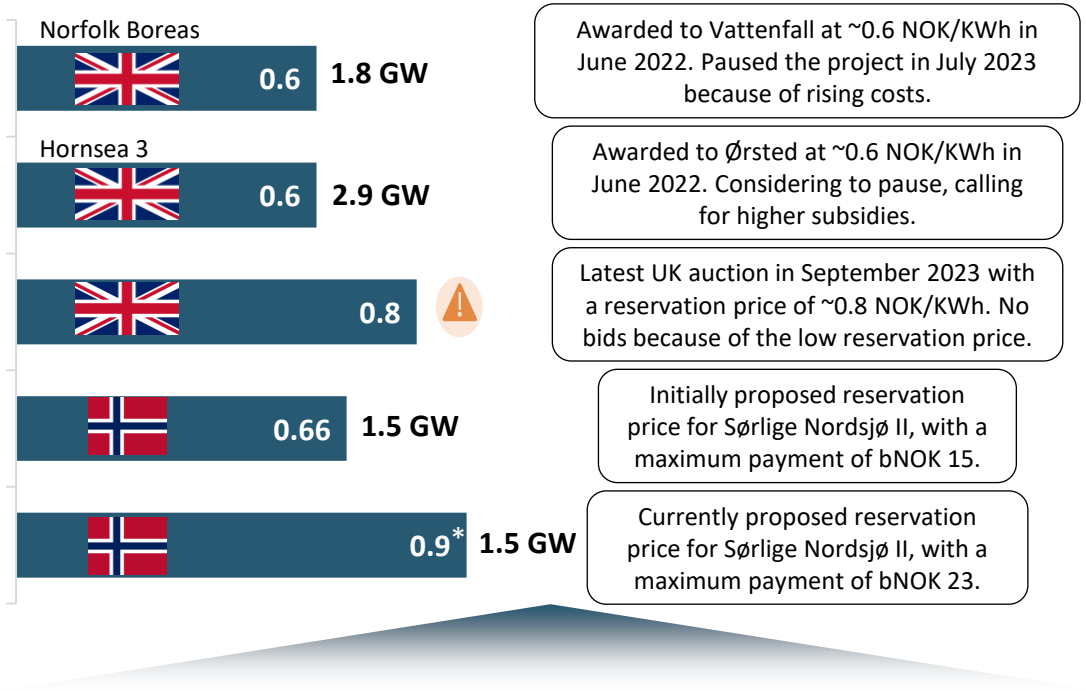
Government announcing that the maximum support will be increased to bNOK 23 and the proposed reservation price increased to 0.9 NOK/KWh.

Regjeringen jekker opp subsidieanslaget for havvindsatsingen med åtte milliarder

Regjeringen mener nå et tak på 23 milliarder kroner for statsstøtte til Sørlige Nordsjø II er fornuftig.

Sørlige Nordsjø II reservation price compared to other projects

NOK/KWh*

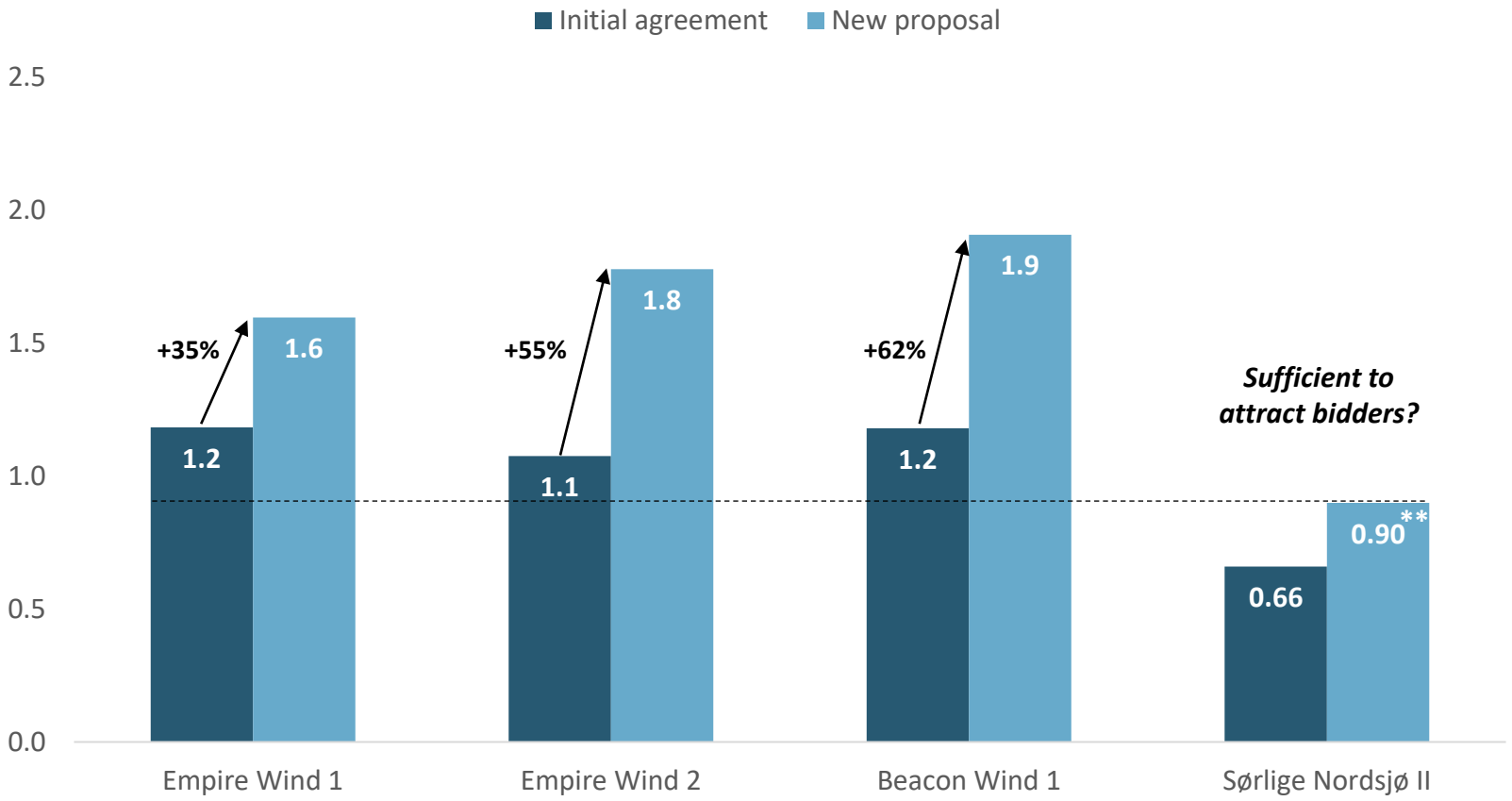


Even though the subsidies for Sørlige Nordsjø II have been raised in recent months, it is only slightly higher than other projects that have called for higher subsidies. Thus, there is a risk that there will be few or no bidders for Sørlige Nordsjø II, potentially delaying the development of Norwegian offshore wind.

* Not officially announced, only indicated
Source: Rystad Energy research and analysis

Equinor and BP's New York offshore wind farms are the latest projects to be threatened by rising costs

Strike price of offshore wind projects*
NOK/KWh



- Equinor and BP won the auctions for two US projects in January 2023. The contracts were offshore wind renewable energy certificates (OREC) with strike prices equaling 1.1-1.2 NOK/kWh.
- In 2023, Equinor and BP plead to increase the strike price by 35-62%. The plea was declined, meaning that Equinor and BP will have to either complete the project at strike prices they deem uneconomical or to pay a cancellation fee.
- The reservation price of Sørlige Nordsjø II is only to some degree comparable to the OREC used in the US auction. Yet, the development in the US projects illustrate the inflation in the offshore wind market. With the application deadline for Sørlige Nordsjø II coming up, the development in US projects raise uncertainty to whether Sørlige Nordsjø II will receive bids below the reservation price.

*The US offshore wind projects are based on offshore wind renewable energy certificates (OREC), that are only to some extent comparable to the European contract for difference system.** Not officially announced, only indicated.
Source: Rystad Energy research and analysis;

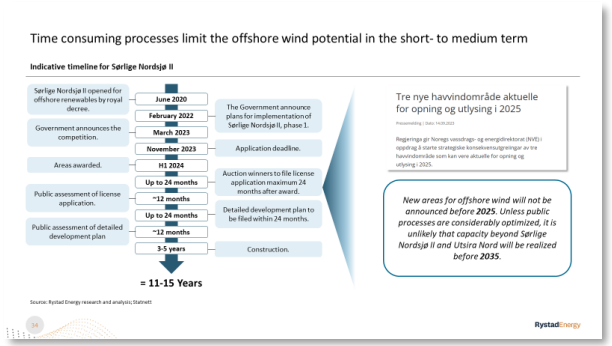
Time-consuming processes, uncertain profitability and lack of predictable framework threaten the growth potential of offshore wind

Three factors threatening the growth of offshore wind in Norway

Time-consuming processes

The Utsira Nord and Sørlige Nordsjø II projects have experienced long political processes and delays, and the goal of completing these projects before 2030 seems unlikely.

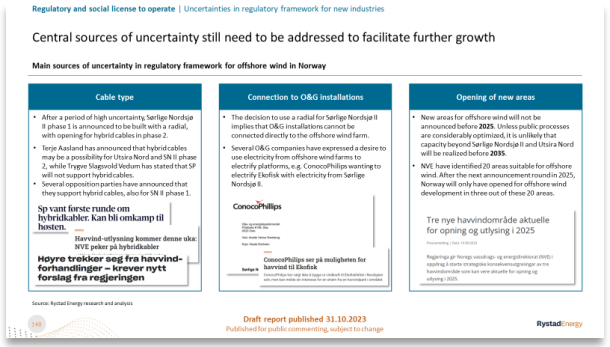
Political processes and approvals constitute a large part of the timeline. Streamlining these processes will be key to further offshore wind development.



Lack of predictable framework

Uncertainty regarding cable types, potential connections to O&G installations, and the announcement of new areas have delayed the processes of Utsira Nord and Sørlige Nordsjø II.

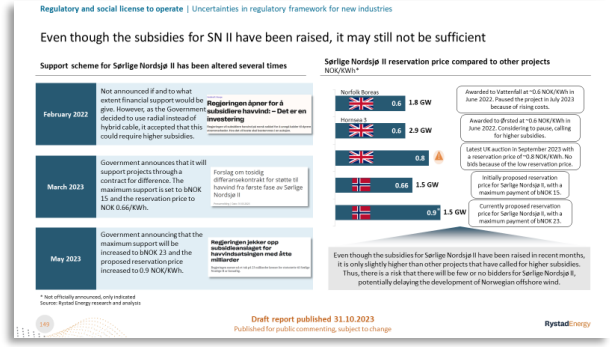
Many of these points of uncertainty are not clarified for future developments. This threatens the development of offshore wind in Norway as it causes a high level of uncertainty for future projects.



Uncertain profitability

In recent years, offshore wind projects have experienced increasing supply chain costs and cost of capital. This threatens the profitability of projects and calls for higher subsidies.

Renewable energy sources are dependent on cost improvements to compete with fossil fuels. The uncertain profitability of offshore wind projects is a threat to the future access to renewable energy in Norway.



Source: Rystad Energy research and analysis

Slow development of offshore wind can force Norway to prioritize power between O&G electrification and other purposes

The Norwegian power balance will be under pressure towards 2030...

Demand	Konkraft expects the power demand from the petroleum sector to increase by ~13 TWh towards 2030. Statnett estimates that electrification of transport, industry (not incl. O&G), data centers, batteries and hydrogen production will require additional ~27 TWh towards 2030.	**+ ~40 TWh**
Supply	Statnett expects Norwegian power production to increase ~18 TWh. Of these, 7 TWh are from offshore wind, and thereby highly uncertain. Based on the discussion above, these volumes are not assumed to be ready by 2030.	**+ ~11 TWh**
Balance	If offshore wind projects are not completed before 2030, and the development of onshore wind and other sources follows Statnett's trajectory, the Norwegian power balance can potentially decrease by 29 TWh, this yielding a power deficit in 2030.	**= ~29 TWh** lower power balance

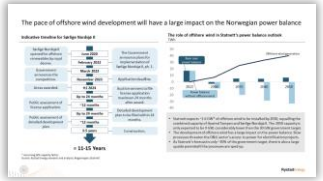
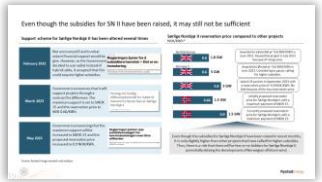
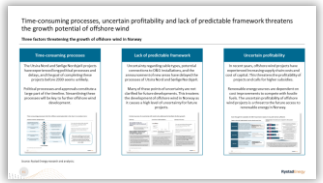
... causing high uncertainty for electrification of the O&G industry

Electrification of the NCS is highly dependent on the public willingness to prioritize renewable electricity to the O&G sector

Source: Rystad Energy research and analysis; Konkraft; Statnett

Offshore wind may hold the largest potential for development of renewable energy in Norway

Summary of challenges related to uncertainty in regulatory framework for new industries

Key takes	Comments	Evaluation*	Exhibits
The Norwegian power balance will decline towards 2030, with the development in offshore wind being a main driver.	• The demand for electricity will increase due to electrification of O&G, traditional industry and transport, in addition to new industries like batteries and green hydrogen. • The supply growth of electricity is limited, among other because of public resistance towards onshore wind. Offshore wind can be an important contributor, but the long lead times cause uncertainty.		
The development of offshore wind in Norway is threatened by uncertain regulatory framework and increasing costs.	• The Norwegian government has announced an ambitious target of 30 GW offshore wind in Norway. • However, the development is threatened because of uncertainty regarding regulations and subsidies. • Increasing supply chain costs and costs of capital have paused other offshore wind projects recently, causing uncertainty for the upcoming auctions in Norway.		
The slow pace in offshore wind development is a threat to the future of the O&G industry.	• There is a high likelihood that Norway will be in a power deficit in 2030. This can potentially limit the O&G industry's opportunity to electrify and cut emissions. • Lack of electrification is likely to affect the social license to operate, threatening both current production and new volumes of O&G.		

* Overall evaluation depending on likelihood and impact if applicable, otherwise indicating severity.
Source: Rystad Energy research and analysis

Norway has benefitted from being a first mover in CCS

Norway benefits from being a first mover in carbon storage ...

Carbon has been stored on the NCS since 1996 when Equinor started to separate CO_2 from the gas stream at Sleipner Vest and store it in the Utsira formation at volumes up to one million tonnes per year.
From 2008 and onwards, the Snøhvit facility also captures and store CO_2 from the gas stream, up to 0.7 million tones per year.

The Longship project and the CO_2 Technology Centre Mongstad (TCM) also contribute valuable experience.

Longship

Northern Lights

CO_2 TECHNOLOGY CENTRE MONGSTAD

... but competition strengthens the need for a competitive framework

Examples of European countries with high CO_2 storage ambitions

Large storage potential, but limited experience.
High government ambitions. Recently awarded support scheme of EUR 1.1 billion from the EU to support roll-out of CCS in Denmark.

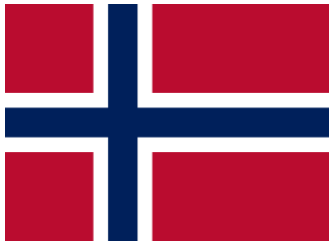
Very large storage potential in depleted O&G, both onshore and offshore. Limited access to saline aquifers. Low experience.
Antwerp@C already under development with EU backing, expected to store CO_2 in the Netherlands by 2027.
Located close to major emitters.

Large offshore storage potential in depleted O&G fields and in saline aquifers. Ambitious government targets, ***but UK CCUS storage licenses are set to only address UK emissions short- to mid-term*** *and the UK is therefore not a direct competitor to Norway.*

Source: Rystad Energy research and analysis

Norway's regulatory framework is good, but lacking a clear target going forward

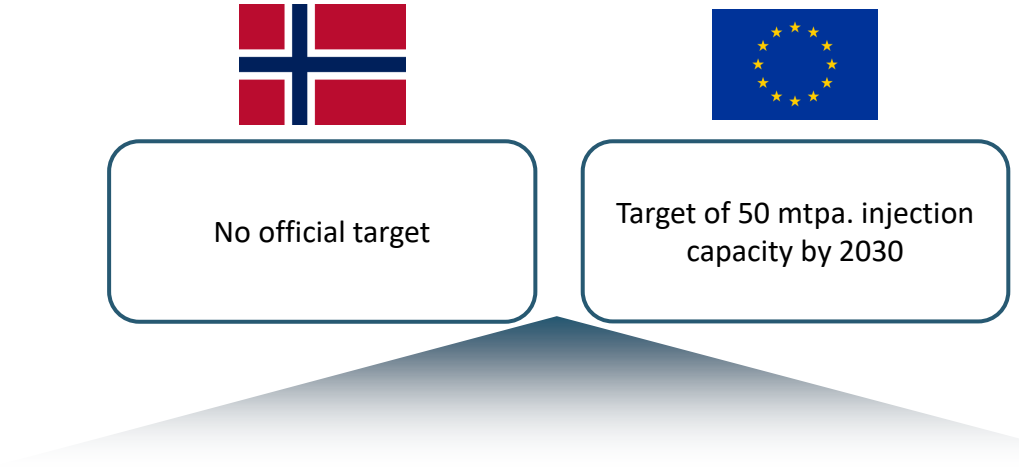
Regulations and legislation



Norway's pioneer role in CO_2 storage has resulted in a well-developed framework. The CO_2 storage regulation (CO2-lagringsforskriften) regulates permits for exploration and utilization of areas, CO2 transport, storage operations and abandonment of wells. The regulation was first introduced in 2014.

In the EU, CO_2 storage is regulated by the CCS directive, introduced in 2009. This directive regulates how CO_2 should be transported and stored. The award of licenses for exploration and utilization of areas is not covered by the CCS directive, but by local regulations. Thus, the maturity of the regulatory framework differs between countries.

Norway lacks a CO_2 storage target



OFFSHORE NORGE

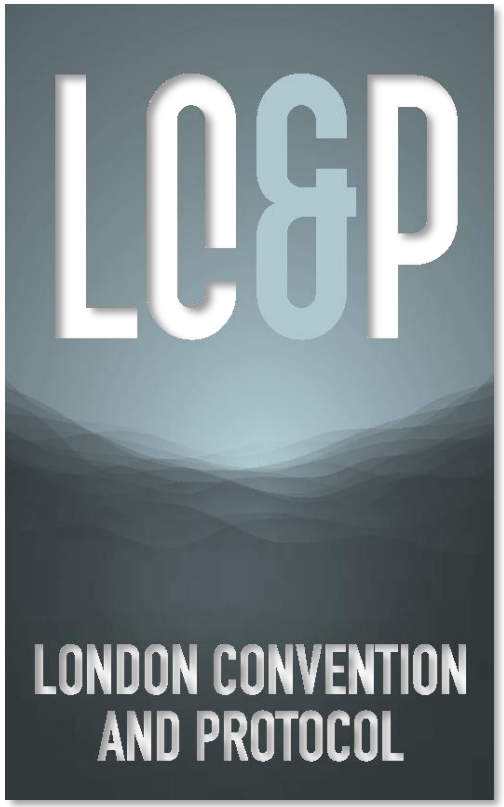
ZERO

«We need a national target for storage of CO_2 on the Norwegian continental shelf.»

Source: Rystad Energy research and analysis; Regjeringen; European Commission

The Norwegian CO_2 storage industry depends on bilateral agreements to secure emissions

The London Protocol requires bilateral agreements for transport of CO_2 for offshore storage



Transport of CO_2 for **offshore storage** purposes is regulated under the London Protocol. Following a decision from 2019, CO_2 can now be exported or imported for offshore storage purposes if there is a provisional application and a **bilateral agreement** between the two countries.

Only one such agreement has been signed, opening a major potential for Norway if action is taken quickly

Second, we need to enable cross-border transport of CO2 for storage. Then we need bilateral agreements, as required by the London protocol. This topic is very high on our agenda!

An important task at hand is therefore to encourage countries to ratify the 2009-amendment of the London protocol, so that we ensure predictability and a long-term framework.

Terje Aasland speech at Climmit Summit

The only signed bilateral agreement for transport of CO_2 for offshore storage is between Denmark and Belgium. Norway has not signed any agreements yet, but it is known that Norway and Belgium have started negotiations. Signing similar agreements with main European emitters should be a top priority for Norway to ensure a stable demand for CO_2 storage in Norway.


Home › Subsea ›

Denmark and Belgium sign landmark agreement for CO2 transport

CARBON CAPTURE USAGE & STORAGE


Belgium and Norway will work closer on cross-border transport and storage of CO2

Press release | Date: 24/04/2023

Source: Rystad Energy research and analysis; IMO; Regjeringen

A major accident is still very unlikely, but would have large consequences on energy exports

Major HSE incidents related to maturing NCS

- The Norwegian continental shelf is entering a more mature phase, with aging installations and infrastructure.
- The ageing of installations and infrastructure can potentially pose a higher likelihood of catastrophic accidents. Examples include issues with well integrity, structural weaknesses, corrosion and leakages.
- A catastrophic accident would have direct impact on Norwegian energy exports. Furthermore, there would likely be a large indirect long-term impact on Norwegian oil and gas production as a catastrophic accident would threaten the social license to operate.

Criteria		Evaluation	Comment
Likelihood		⚑	The NCS is entering a more mature phase. However, the likelihood that this will cause catastrophic accidents or other events affecting volumes is still low because of regulations and HSE focus on the NCS are the highest globally.
Impact	Energy volumes at risk	⚑	In the worst case, a maturing NCS can cause a catastrophic accident. The direct volume impact on gas exports will only be large if it hits a large field or a processing plants, but a major accident have a long-term negative effect on the public opinion.
	Permanence	⚑	A catastrophic accident would have long-lasting effects on the production from the field subject to the incident. An accident could also cause problems with the social license to operate, affecting the future of the O&G industry.
	Lead time	⚑	Even though the ageing of NCS, and related challenges, has been foreseen for many years, a potential major accident would happen unexpectedly and have an immediate effect on energy volumes.
OG21 relevance		★	OG21 can contribute by supporting research on the topic and communicating the need for increased awareness of the challenges related to a maturing NCS.
Mitigation options		Technology	Competence	Communication	

The potential impact of a catastrophic accident on the NCS would be dramatic. However, the Norwegian NCS is known for its world-leading safety level, so the likelihood is still extremely low.

OG21 relevance: ☆ Low ★ Medium ★ High

Ranking: ⚑ Low ⚑ Medium ⚑ High

Color filled if mitigation option is relevant

Source: Rystad Energy research and analysis

The risk of major accidents on an aging NCS can affect export volumes in four ways

Four different ways the risk of a major accident can affect the available energy export volumes from NCS

Increased monitoring and maintenance

The NCS is already world-leading in safety. The aging infrastructure requires even stronger emphasis on safety through increased monitoring and control routines. This will likely lead to increased downtime for maintenance and preventive measures when irregularities are discovered.

Volume impact ★☆☆

The direct effect of a major accident

If a major accident occurs, there will be an immediate drop in production volumes from the fields directly affected. This effect is likely to be long-term as it could take several years to restore the facilities. In many cases, the field would be closed down as a result of the accident.

★☆☆

The short-term indirect effect of a major accident

A major accident would indirectly affect the production from other fields as activity would be reduced or stopped in await of investigations. If investigations reveal that other fields may be exposed to the same type of accident, these fields would likely be shut down for an extended period.

★★☆

The effect of a major accident on the social license to operate

The O&G industry is already facing considerable resistance, which would be further strengthened by a major accident with high death tolls and potentially large petroleum spills. This could affect investments and political decisions, with large effect on Norwegian energy exports.

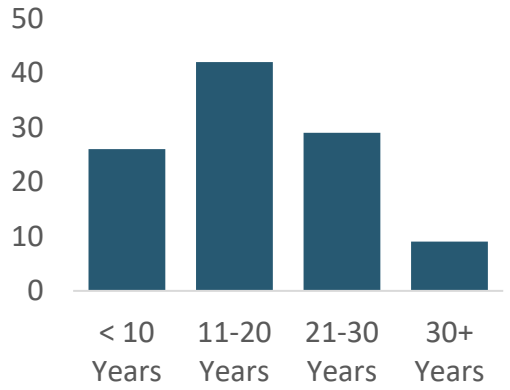
★★★

Source: Rystad Energy research and analysis; Petroleumstilsynet

The ageing of the NCS poses new challenges that have the potential to cause a major accident

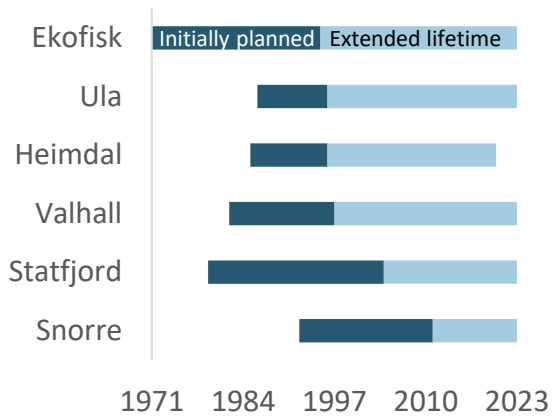
Four different ways the risk of a major accident can affect the available energy export volumes from NCS

Less focus on maintenance of mature fields



~25% of current fields have a remaining lifetime of 10 years or less. Uncertainty regarding the future of O&G may reduce efforts to extend field lifetime. This can potentially cause neglect of maintenance, which increases risk.

Many fields have extended the lifetime several decades



Many of the mature fields on the NCS have extended the lifetime several times. This may cause increased risk as infrastructure is used for many years longer than it was initially designed for.*

Increasing focus on renewables in R&D may potentially come at the cost of O&G

equinor

"Our goal is to allocate 40% of our research and development capital towards renewables and low-carbon solutions by 2025."

The world-leading safety level on the NCS is partly caused by high R&D focus within safety. The uncertainty regarding the future of O&G leads companies to prioritize R&D spending within renewables, which may halt the safety development in O&G.

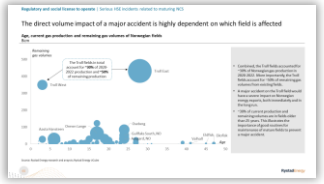
Decommissioning represents a new, complex activity with major accident potential

Many fields will be decommissioned in the coming years. This is a complex operation that Norwegian companies have limited experience with, representing a new type of major accident risk.

*Note that some of the fields with lifetime extensions have replaced parts of the old infrastructure. E.g. Ekofisk and Valhall fields have both gone through significant upgrades.
Source: Rystad Energy research and analysis; Rystad Energy UCube; Petroleumstilsynet; Norsk Petroleum

A major accident is still very unlikely, but the potential effect on energy volumes can be dramatic

Summary of challenges related to the risk of a major accident

Key takes	Comments	Evaluation*	Exhibits
Major accidents have happened at the NCS before, and continuous efforts are needed to reduce the risk of new accidents.	• Several major accidents have occurred in the Norwegian petroleum industry. These accidents can both lead to deaths and have large impact on Norwegian energy exports. • From a energy security perspective, the recent fire at Hammerfest LNG illustrates the importance of preventive measures to maintain Norwegian energy supplies to Europe.		
A major accident would directly impact export volumes, but the impact on social license to operate is more important.	• The direct impact of a major accident describes the deaths and loss of energy volumes caused by the physical damage to the asset affected by the accident. • Indirect effects describes the effect an accident would have on other fields. The most important indirect effect would be the negative impact on the social license to operate.		
An accident on the Troll fields or on the onshore processing plants would have the highest direct volume effect.	• The Troll fields account for approximately 30% of current Norwegian gas production, and 50% of remaining volumes. In addition, there is high concentration in the onshore processing plants. • The effect of a major accident on energy volumes is highly dependent on which asset is affected.		
Ageing, less focus on R&D for O&G HSE and new activities like decommissioning pose new risks going forward.	• Many mature fields have extended their lifetime dramatically. Older installations may pose a higher major accident risk because of wear and tear and less sophisticated technology. • In the coming years, decommissioning will become an increasingly important activity on the NCS. As this is a complex operation, it is possible that this will increase the major accident risk.		

* Overall evaluation depending on likelihood and impact if applicable, otherwise indicating severity.
Source: Rystad Energy research and analysis

Evaluation of threats: Financials

Theme	Threat	Threat description
Regulatory and social license to operate	Skewed understanding of energy security consequences in the public energy transition discourse	*Public opinion towards energy impacts future developments of the industry, referring to e.g. onshore wind or O&G exploration.*
	Increasing emission intensity of a maturing NCS	*Higher overall emissions intensity due to tail production going forward. These volumes can be at risk due to emission reduction targets.*
	Uncertainties in regulatory framework for the future of O&G	*Regulatory uncertainty related to future developments, exploration licenses and phase-out strategy.*
	Uncertainties in regulatory framework for new industries	*Regulatory uncertainty related to support schemes, contract structures, subsidies, tax regimes, strategy related to energy exports, etc.*
	Major accidents related to maturing NCS	*Infrastructure reaching design lifetime can lead to increased risk of serious accidents with high impact on social license to operate.*
Financials	**Financials and innovation support affecting the development of new industries**	*Financial uncertainties related to subsidies/support schemes, in addition to limited R&D funding can affect speed of development of new industries.*
	Access to external capital in the O&G industry	*Banks are restricting funding to O&G due to increased focus on ESG.*
Security	Lack of protection against cyber attacks	*Technology development in the O&G sector increases risk of cyber attacks.*
	Lack of protection against physical attacks	*Norwegian O&G infrastructure exposure to physical attacks.*
Access to competence	Challenges related to recruitment of STEM professionals	*The competition for STEM professionals is expected to be harder going forward.*
	Challenges related to recruitment to STEM studies at the universities	*Educating the required number of STEM professionals is likely an increasing challenge going forward.*
Supply chain	Bottlenecks in supply chain caused by geopolitical dependencies	*Geopolitical tensions causes increased risk in supply chain with potential bottlenecks caused by trade wars and following price increases.*

Source: Rystad Energy research and analysis

Reducing financial uncertainties for new industries is key for development

Financials and innovation support affecting the development of new industries

- The financial attractiveness of new industries have implications for the development as it affects R&D spending and access to project financing.
- The financial attractiveness is affected by maturity of technology and concepts, subsidy schemes and operating framework for new industries. This also affects the funds allocated to R&D for new industries.
- Uncertainties regarding the financial attractiveness and the lack of incentives for investment in R&D for renewable industries may impact the industrial development on the NCS.

Criteria		Evaluation	Comment
Likelihood			Medium likelihood since uncertainties are already affecting attractiveness, exemplified through no bids on the latest offshore wind auction in the UK.
Impact	**Energy volumes at risk**		Lack of financing may threaten electrification of O&G operations if there is no surplus power, which in turn can reduce O&G output which is dominating the energy export from Norway.
	Permanence		Reduced R&D spending and project development can potentially have long-term effects of the development of new industries, and thereby also the Norwegian export potential, both electrons and molecules.
	Lead time		New industries take time to build up, and proving financial attractiveness is key in this process. Should therefore be acted on sooner rather than later.
OG21 relevance			Relevant for the OG21 in primarily three ways. First, through its CCS mandate. Secondly, for members of OG21 that intends to develop new industries. And lastly, relevant when considering electrification of O&G fields.
Mitigation options		Technology	Competence	**Communication**	

There is a medium likelihood that the development of new industries will be negatively affected by uncertain financials. An important impact will likely be a threat to electrification of O&G, that in turn can reduce exports of oil and gas.

OG21 relevance: ☆ Low ★ Medium ★ High

Ranking: Low Medium High

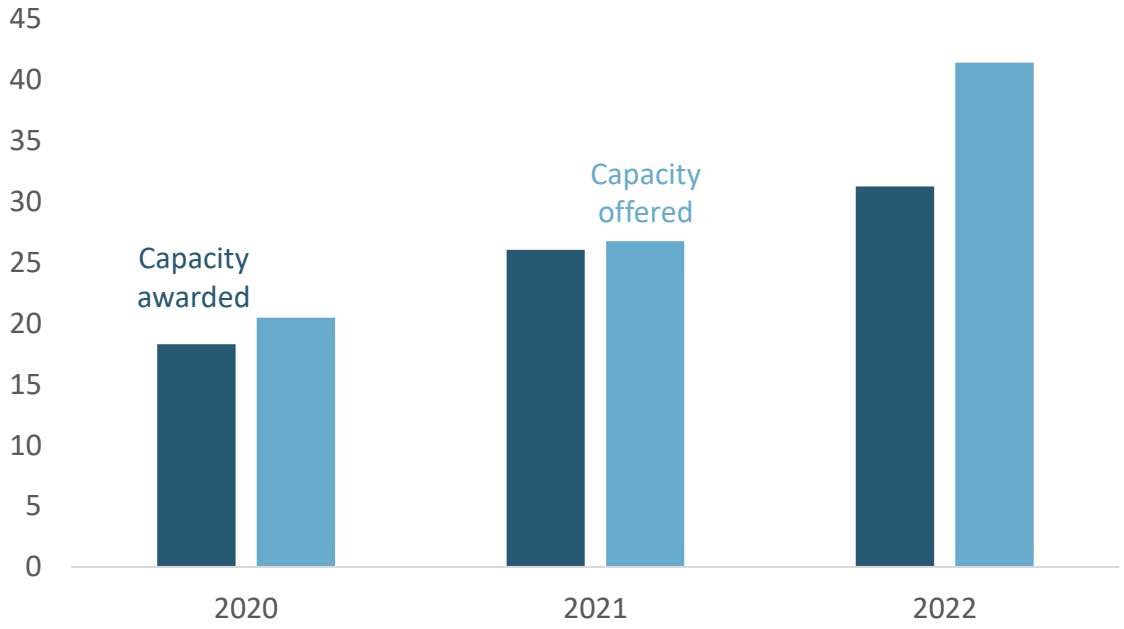
Color filled if mitigation option is relevant

Source: Rystad Energy research and analysis

Capacity offered in European renewable projects outnumber capacity that is bid on

Renewable capacity offered and capacity awarded in Europe

GWac



- As the graph shows the renewable capacity offered in Europe is significantly larger than the capacity that companies are inclined to invest in.
- One potential explanation is that the terms and conditions offered along with the projects are not good enough for companies to find them profitable.

Example of failed auctions and delays in renewable projects

Capacity awarded

No bids

Offshore wind drops out of UK auction on costs, risking climate goals — REUTERS

~3 GW

Orsted says huge UK Hornsea 3 wind project at risk without government action — REUTERS

1.4 GW

Vattenfall says it is stopping British Norfolk Boreas offshore wind farm — REUTERS

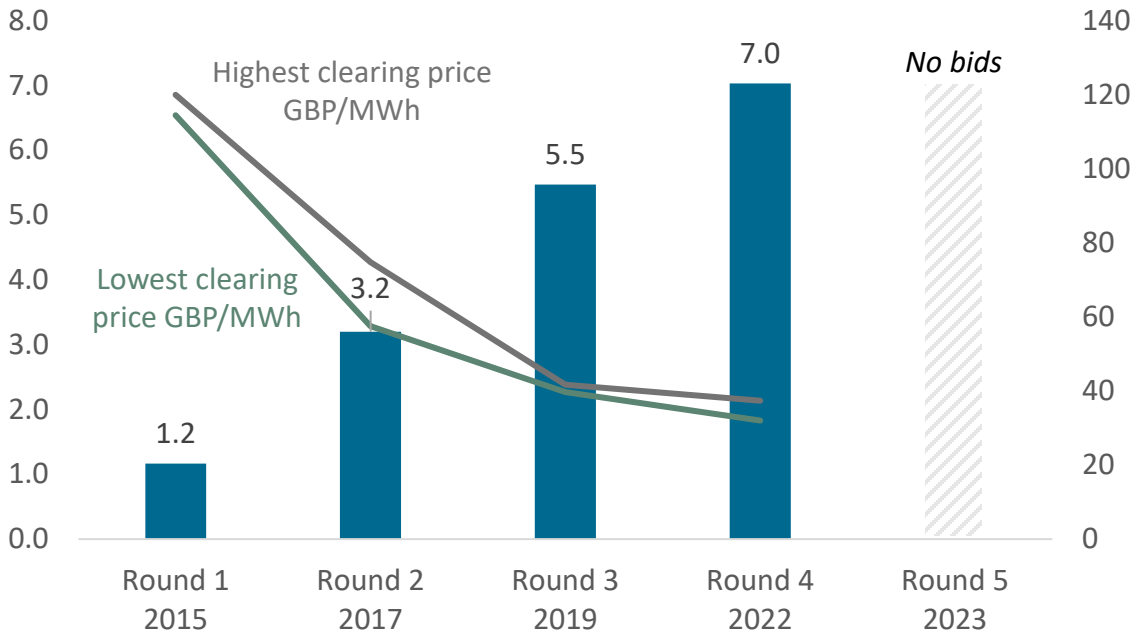
- In September 2023, the latest UK auction received zero bids for offshore wind projects.
- Ørsted is expected to take a final investment decision later this year.
- In July 2023, Vattenfall halted development in the British Norfolk Boreas offshore wind project.

Source: Rystad Energy research and analysis; Rystad Energy PowerCube; Reuters

The failure to attract bidders puts upcoming projects in Norway at risk

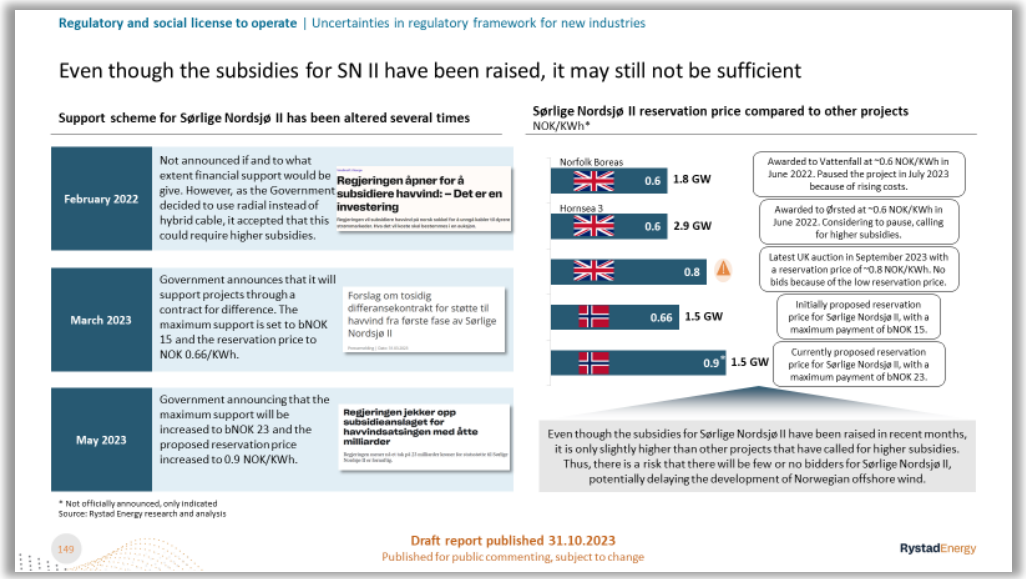
Headwind for UK offshore wind in the latest CfD round…

GW (LHS), GBP/MWh in 2012 prices (RHS)



- The UK CfD rounds which started in 2015 began with a high price but dropped a lot over the years with advancements in technology and the use of larger wind turbines.
- However, the last auction in September 2023 received zero bids for offshore wind projects and a share of the awarded capacity in 2022 has been halted.

…may reflect to the auction soon to start in Norway



- The first auction for an offshore wind project in Norway is closing in with an anticipated auction round in February 2024. The Norwegian government has yet to disclose a final decision on subsidies.
- Due to rising costs within the offshore wind industry and technology development not moving quick enough, the project may be at risk.

Source: Rystad Energy research and analysis; Rystad Energy Renewables and Power Analytics; UK Government

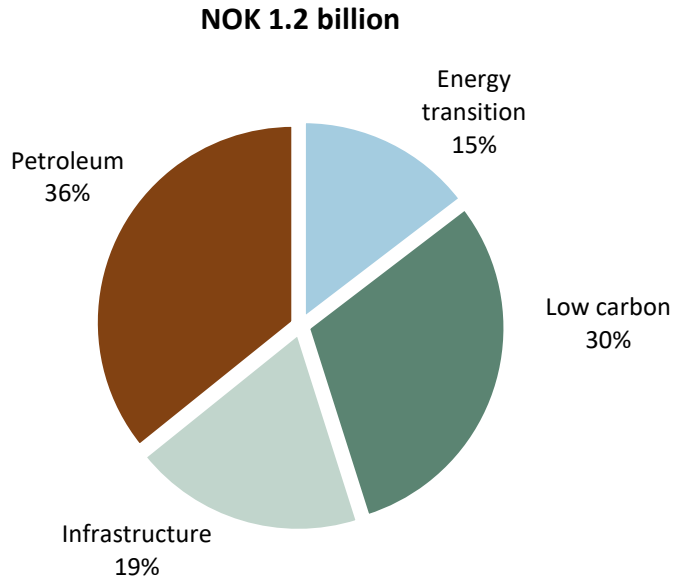
The Research Council offers important R&D programs for both renewable energy and O&G

Key energy R&D programs from the Research Council of Norway (RCN)

Sustainability	
FME	Renewable energy, energy efficiency and CO_2-handling
ENERGIX	Generate new knowledge and new solutions that promote the long-term, sustainable development of the energy system.
CLIMIT	Supports the research, development and demonstration of CO_2 capture and storage (CCS).
Petroleum	
PETROMAKS2	Overall responsibility for research to promote responsible, optimal management on the NCS, limited to upstream activities.
PETROSENTER	Centers that develop expertise to solve key challenges for the management and value creation on the NCS.
DEMO2000	Demonstrate and qualify innovative products and systems in close collaboration with industry participants.

- Even though the centers are split into the two categories sustainability and petroleum it is worth mentioning that many of the R&D projects under the petroleum category are towards making the operation of the O&G industry more environmentally friendly.

Research Council of Norway distribution of R&D energy funds* in 2021

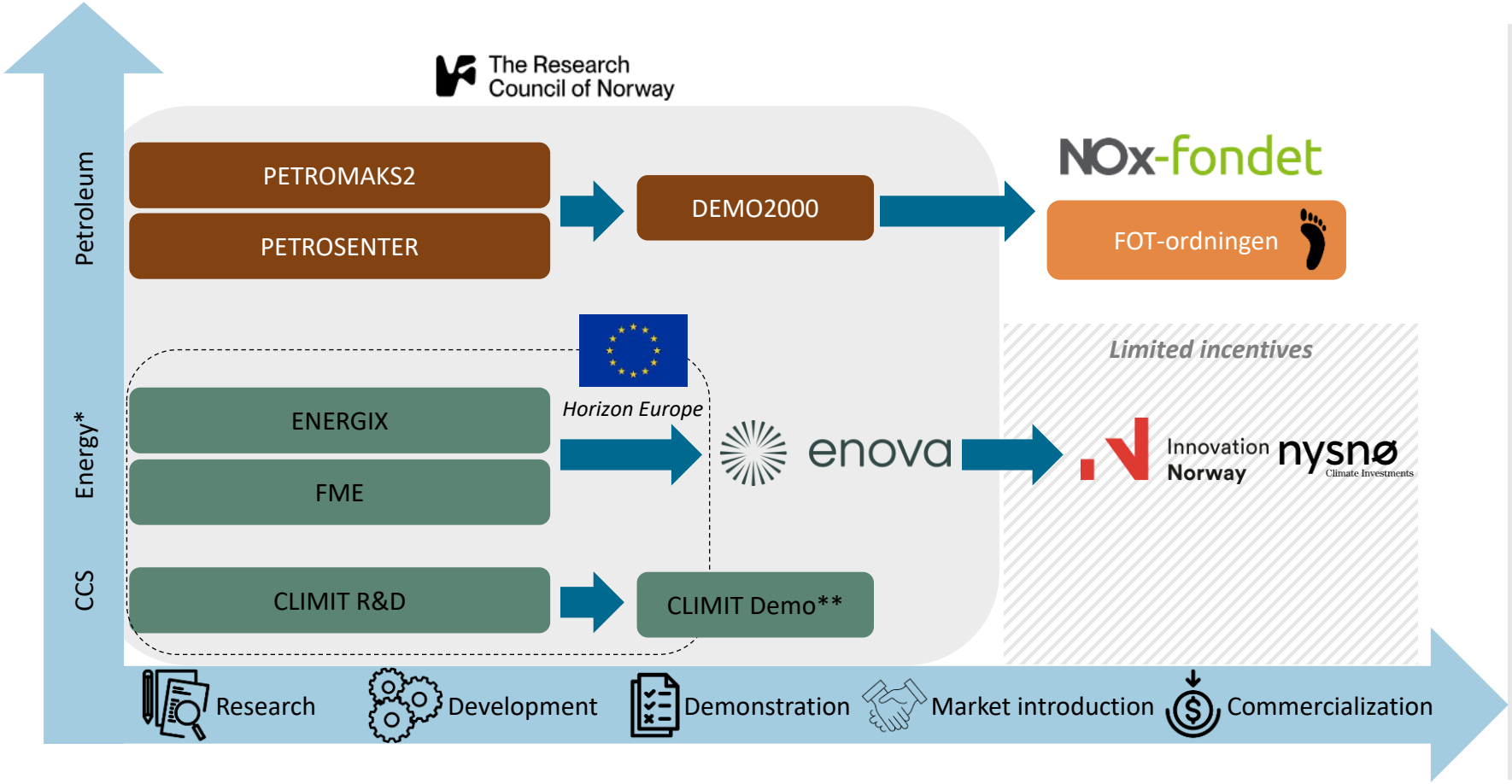


- The chart shows the total distribution of RCN's energy funds split into the relevant categories.
- The RCN is a Norwegian government agency that funds research and innovation projects. The RCN's budget is announced in the National budget and in 2022 the RCN had a total budget of NOK 11.4 billion.

* Energy transition includes energy transition, batteries and electrical transport. Low carbon includes renewable energy, CO_2-handling, biofuel and hydrogen. Infrastructure includes infrastructure and energy consumption.
Source: Rystad Energy research and analysis; The Research Council of Norway

The O&G industry has a more established pathway from R&D to commercialization

Relevant financing instruments relevant for the O&G industry and the renewable industry



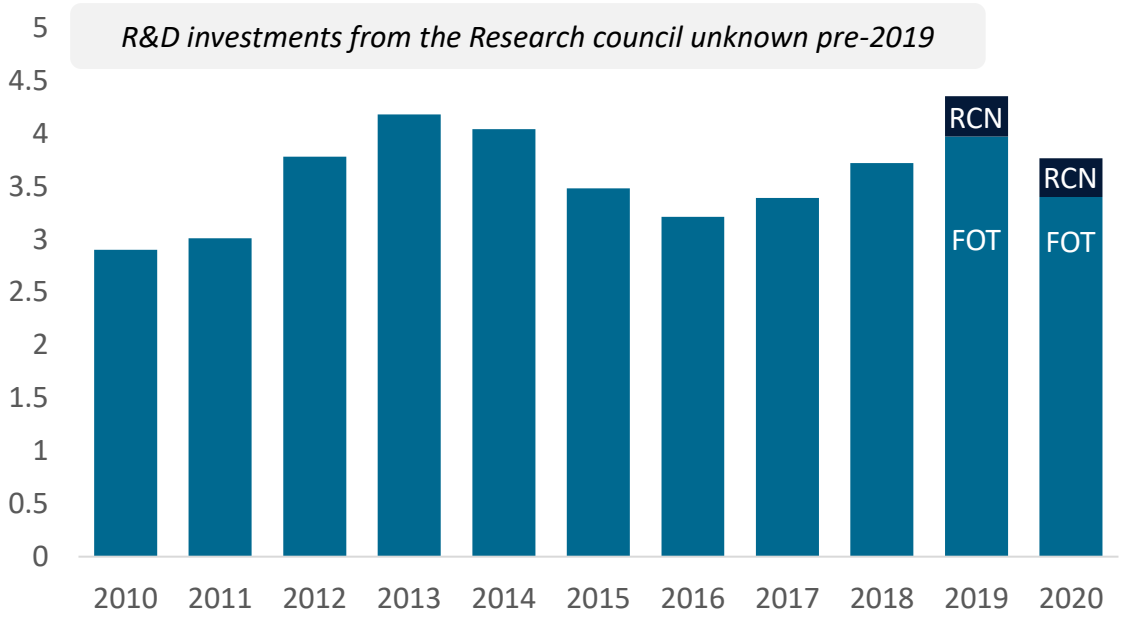
- The chart depicts financing instruments across research phases, with the RCN offering early-stage R&D support in both renewable and O&G industries.
- The renewable industry can access the EUR 95.5 billion Horizon Europe program, launched in 2021, with 35% earmarked for climate goals, and support from Enova and Innovation Norway.
- The O&G industry can access the NOx-fund typically used for electrification and "FOT-ordningen" for petroleum R&D stimulation.
- The renewable industry in Norway lacks support in the commercialization phase, where Nysnø is an example of a fund manager dedicated to accelerate the energy transition.

* Energy includes hydropower, solar, wind, biofuel, geothermal and hydrogen; ** CLIMIT Demo is a collaboration between RCN and Gassnova.
Source: Rystad Energy research and analysis; The Research Council of Norway; Enova; Horizon Europe

The FOT arrangement is a success story in the O&G industry in promoting R&D

R&D investments in O&G through RCN and the FOT arrangement

Billion NOK

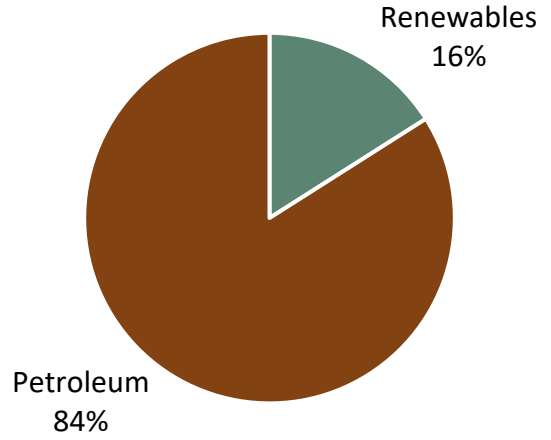


- The FOT arrangement significantly enhances R&D investments in the petroleum industry, as illustrated in the graph comparing its contributions to available funding for petroleum R&D from the RCN.
- Under the FOT arrangement license operators can charge the production licenses a certain percentage of the license's revenue for R&D.

R&D investments in petroleum is significantly larger than renewables*

"The qualification criteria should be broadened to include the applicant's annual investment plans in education, research, and innovation. This is inspired by the successful FOT arrangement in the oil and gas sector and will enhance the competitiveness of the Norwegian industry and offshore wind farm development."

SINTEF



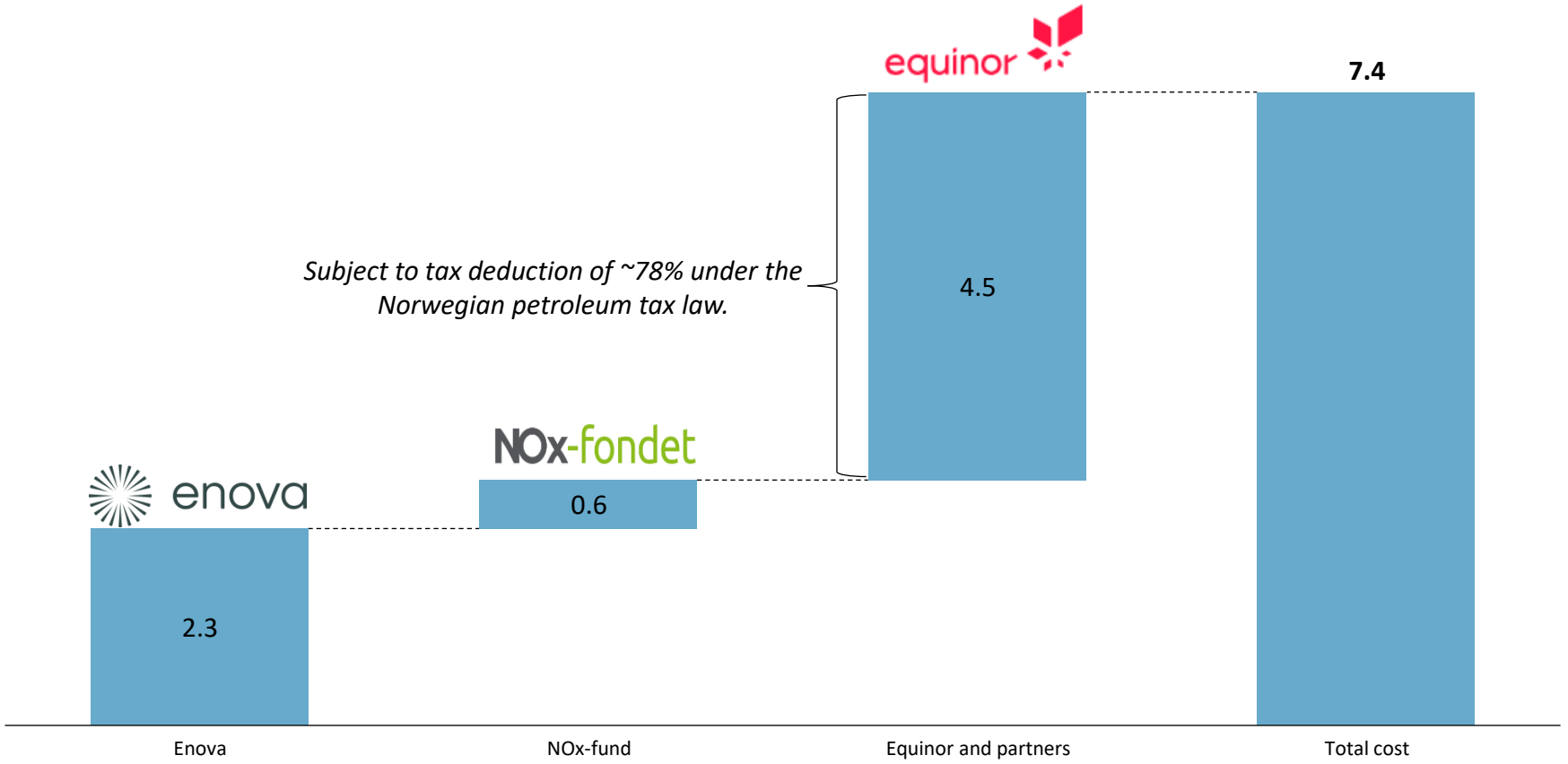
The petroleum industry outnumbers renewables R&D with the FOT arrangement

- The success of the FOT arrangement is potentially transferrable to other industries like the offshore wind industry. The pie chart shows the amount spent on R&D supported by Enova and the RCN renewables compared to the FOT arrangement and the RCN petroleum.

* Enova here is only the money distributed to energy systems in 2020, while RCN for renewables is the low carbon category which includes: renewable energy, CO2-handling, biofuel and hydrogen. Petroleum is the FOT-arrangement and RCN.
Source: Rystad Energy research and analysis; Sintef; The Research Council of Norway; Enova

Favorable financial instruments helped the execution of the Hywind Tampen project

Cost split of the Hywind Tampen project*
Billion NOK

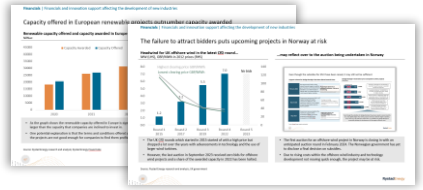
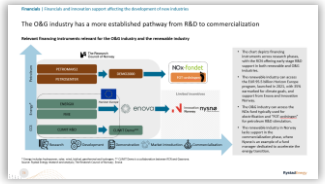
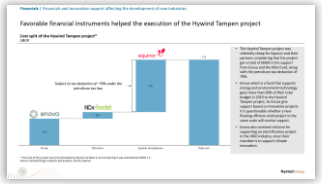


- The Hywind Tampen project was relatively inexpensive for Equinor and their partners considering that the project got a total of NOK 2.9 billion in support from Enova and the NOx-fund, along with the petroleum tax deduction of 78%.
- Enova which is a fund that supports energy and environment-technology gave more than 60% of their total budget in 2019 to the Hywind Tampen project. As Enova give support based on innovative projects it is questionable whether a new floating offshore wind project in the same scale will receive support.
- Enova also received criticism for supporting an electrification project in the O&G industry, since their mandate is to support climate innovation.

* The cost of the project was first estimated by Equinor at NOK 5 billion, but once completed, the total cost was NOK 7.4 billion.
Source: Rystad Energy research and analysis; Enova; Equinor

Lack of financial attractiveness and R&D incentives poses a threat to the energy transition

Summary of the threat financials and innovation support affecting the development of new industries

Key takes	Comments	Evaluation*	Exhibits
Reduced willingness to participate in European wind auctions. This may reflect over to Norway's upcoming auction.	• The willingness to participate in auctions for wind acreage has reduced from previous highs. • The renewable industry may be seen as unattractive due to a combination of too slow technological development, increased interest rates and inflation and a lack of government subsidies. • Government subsidies may be displaced in the future by advancements in technology.		
More established and better R&D incentives for the O&G industry than the renewable industry.	• The O&G industry has a more established financial pathway especially when it comes to later stages of the developments of new innovations.		
The FOT arrangement has been a significant success in promoting R&D in the O&G industry, might be transferrable to other industries.	• The success of the FOT arrangement in the O&G industry may be applicable to the renewable industry, but measures must be taken sooner rather than later.		
Equinor and the partners in the Hywind Tampen project benefitted from financial support and favorable tax regime.	• Hywind Tampen received extensive support for primarily two reasons: It was ground-breaking as an early-mover in floating wind and it was within the Petroleum Law and therefore eligible for tax returns. • Enova received criticism for the size of its support to the project as Enova gave more than 60% of its funds in 2019 to the project.		

* Overall evaluation depending on likelihood and impact if applicable, otherwise indicating severity.
Source: Rystad Energy research and analysis

Banks are restricting funding for new oil and gas projects, but no immediate threat

Access to external capital in the O&G industry

- Increased ESG focus from banks and investors makes it harder for O&G companies to access external capital with good terms.
- Many banks have stated policies that financial services towards new O&G projects are either excluded or limited to not take on any new clients. Exploration funding is typically excluded at an earlier point than developments.
- Smaller companies are at risk of missing out if favorable lending options are removed especially on the NCS where suitable arrangements have attracted smaller companies.

Criteria		Evaluation	Comment
Likelihood		⚑	Medium likelihood as some banks already have stated policies that they will not finance new projects. However, its impact is expected to primarily impact smaller O&G companies, with larger companies not as affected now.
Impact	**Energy volumes at risk**	⚑	Policies on financing new oil and gas projects may curb future energy supplies. However, it's crucial to note that today's investment decisions will impact production in the years ahead, meaning that new energy volumes will enter the market.
	Permanence	⚑	The stricter the policies that banks implements, the harder it will be to access capital for the O&G industry. Higher permanence on exploration and expansion.
	Lead time	⚑	The investment decisions of today impact production volumes several years into the future.
OG21 relevance		☆	Given that the trend of banks moving away from providing capital to the O&G industry is happening worldwide, the threat is not within OG21s scope. However, it is important for OG21 to communicate the threat to relevant market players.
Mitigation options		Technology	Competence	**Communication**	

There is a medium likelihood that it will be difficult for the O&G industry to attain external capital in the future. As the investment decisions of today impact production volumes several years in the future, the impact is moderate.

OG21 relevance: ☆ Low ★ Medium ★ High

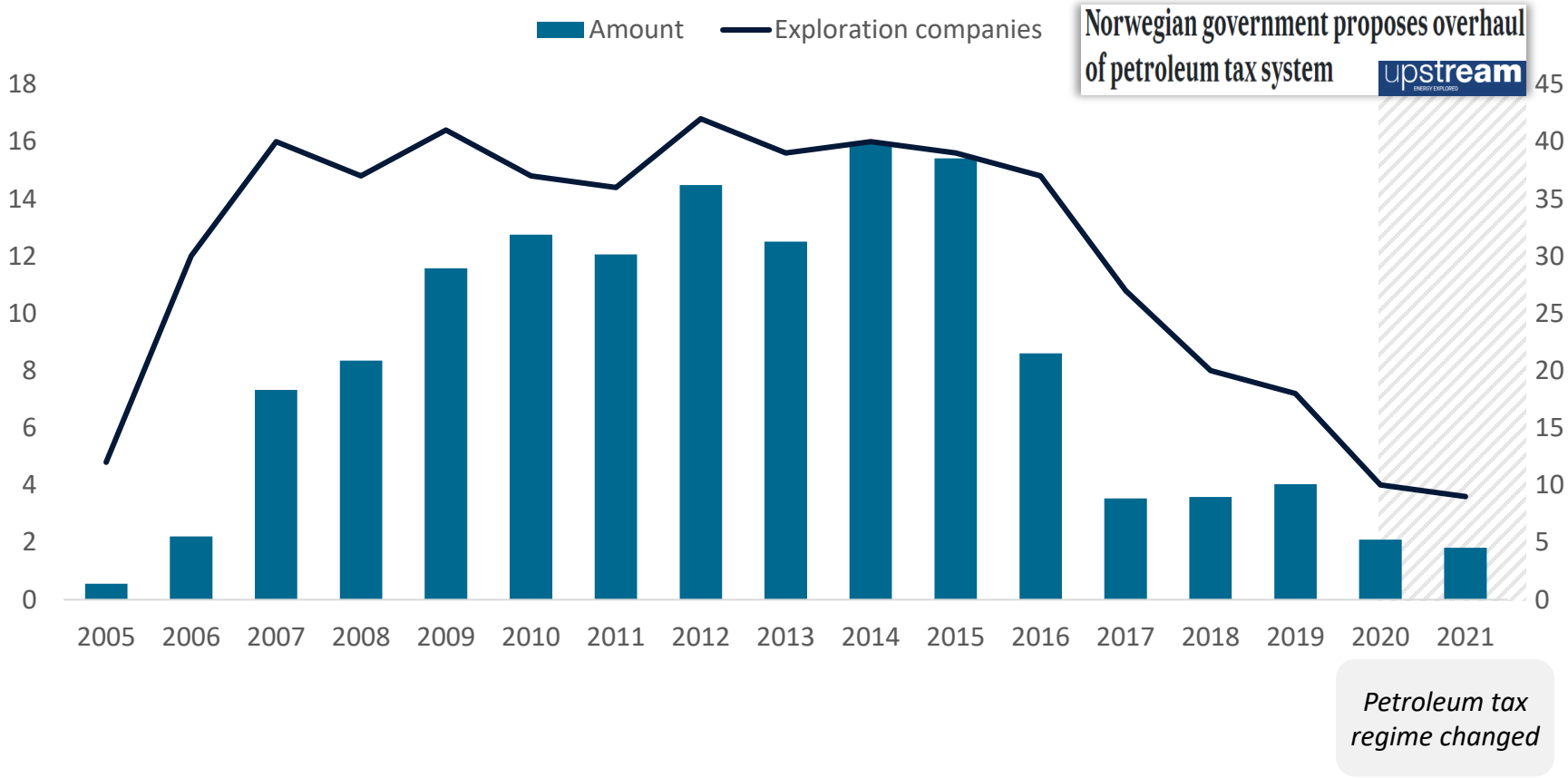
Ranking: ⚑ Low ⚑ Medium ⚑ High

Color filled if mitigation option is relevant

Source: Rystad Energy research and analysis

Significant payments made under the cash-back system after it was introduced in 2005

Payment of petroleum tax to exploration companies
Payment in billion NOK (LHS), number of exploration companies (RHS)

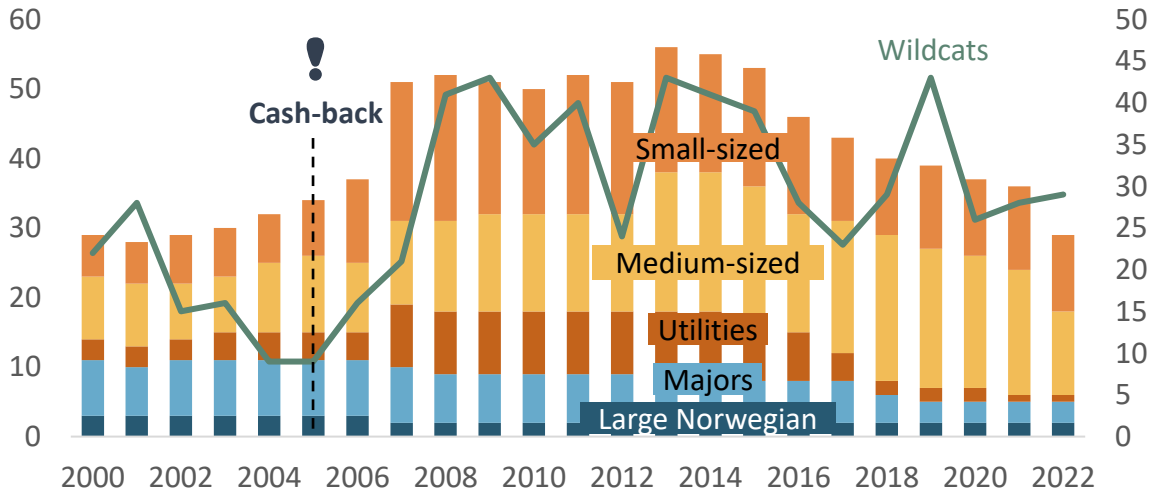


- The graph shows the amount that the government has paid out to exploration companies yearly after the cash-back system was introduced in 2005 along with the number of companies that has received money through the cash-back system.
- In 2022, the government changed the petroleum tax system and reduced the cash-back from 78% to 71.8%, while the remaining 6.2% must be carried forward without interest against future profits.
- On the positive side, the 71.8% now includes both exploration losses and other losses.

Source: Rystad Energy research and analysis; The Norwegian Tax Administration

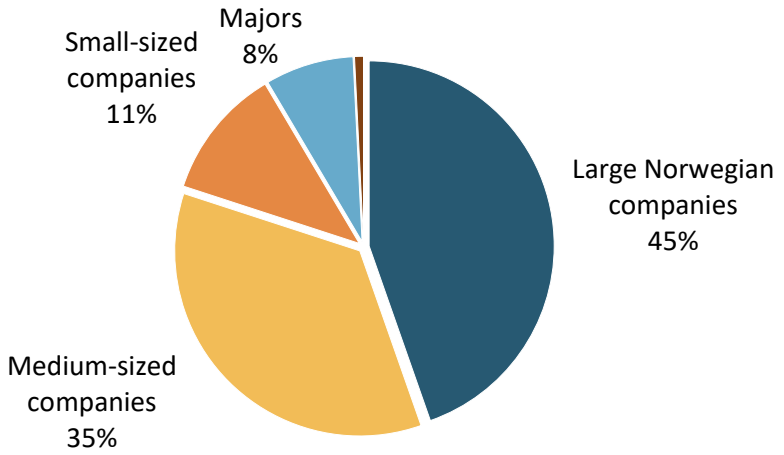
History shows that a high number of active companies on the NCS is important for new volumes

The cash-back system boosted activity and number of small companies
Number of companies (LHS), number of wildcats drilled (RHS)



- The figure shows the number of companies split based on their size measured by production and global reach.
- A relatively larger share of small- and medium-sized companies entered the NCS as the cash-back system made it easier to enter the NCS without having to purchase shares in production or discoveries from other companies.
- The overall trend since 2016 is that fewer companies are active on the NCS, and especially smaller companies are moving away from the NCS.

Historical discoveries (2010-2023), volume weighted with participation in each discovery per company group



- The figure shows the volume weighted share of historical discoveries on the NCS in the period 2010-2023 for each representative company.
- The figure shows that the small companies on the NCS contribute with a relatively large share of discoveries. There is a correlation between the number of wells drilled and the number of discoveries, driven by the chance of success.
- Trends show that more active companies contributes to more wildcats drilled, meaning that the number of active companies on the NCS is important for exploration activity and hence also new volumes.

Source: Rystad Energy research and analysis; Rystad Energy UCube; NPD

Financing options are getting tighter in the O&G industry, hurting small companies first

The banking sector is committing to the net zero target

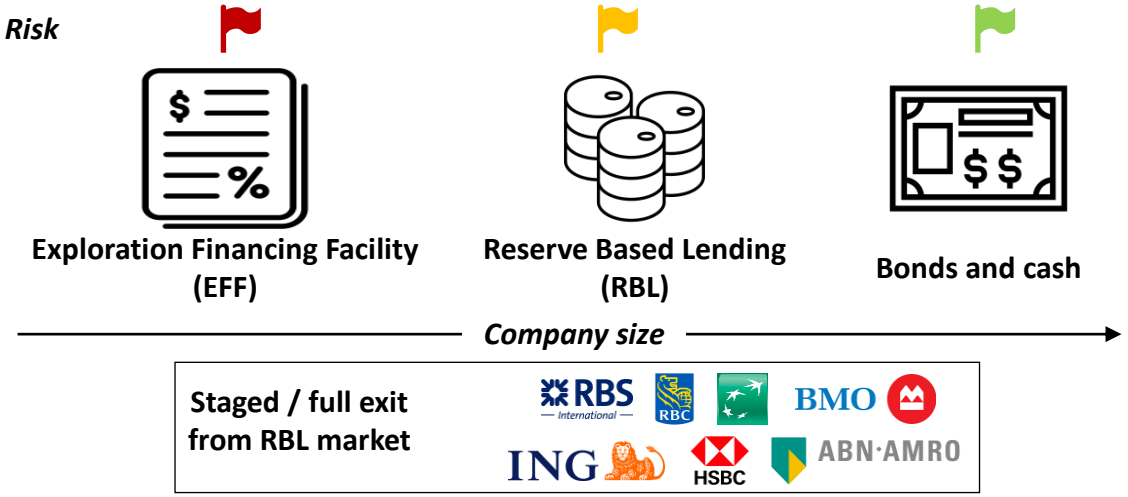
Danske Bank drops fossil fuel finance to support energy transition

BNP Paribas: will no longer finance development of new oil and gas fields

HSBC to end funding for new oil and gas fields

- Banks are implementing policies pledging to stop financing of new oil and gas fields.
- Many banks are also pledging to be in line with the climate goals undertaken by the EU with more impactful policies being implemented in the future.
- Some banks have stated that they will continue to serve their existing clients, but that they will not take on new clients.

Typical financing methods of O&G companies varies with size

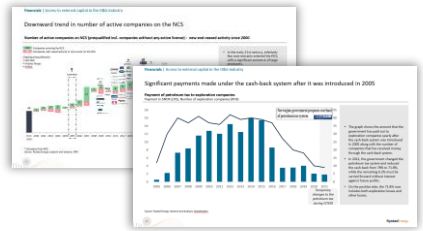
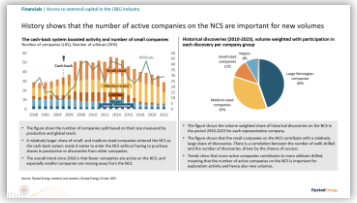


- EFF's are typically used by small O&G companies that typically either have some resources or none. The financing is used purely for discovery of new oil fields where banks have collateral in the cash-back system and is therefore at risk when banks are introducing new ESG policies.
- RBL's are typically used by small- and medium-sized companies that have some resources that they can use as collateral to achieve financing. RBL's are often used to expand or acquire new projects and is therefore at a medium risk.
- Big O&G companies often use cash or bonds to finance their projects. The bonds market is currently not evaluated to be at risk by new policies.

Source: Rystad Energy research and analysis; Fossil Fuel Finance Report 2023

A changing financial environment may be harmful for future discoveries on the NCS

Summary of the threat access to external capital in the O&G industry

Key takes	Comments	Evaluation*	Exhibits
The cash-back system attracted many companies to the NCS, especially smaller, helping diversity among the active companies.	• The number of active companies on the NCS went up after the cash-back system was introduced by the Norwegian government. The cash-back system levelled the playing field and made it easier for small O&G companies to participate. • The cash-back system has been a huge success, but it was overhauled in 2022 covering a smaller share of exploration losses.		
Small- and medium-sized O&G companies have boosted exploration activity on the NCS and contributed with discoveries historically.	• The importance of having a diverse company base can be reflected in the historical discoveries made by the active companies. The loss of this diversity may be impactful for the future of the NCS.		
Banks are implementing policies that reduce the ability to finance oil and gas projects. The impact will first be seen among small companies.	• Banks are making it harder for O&G to obtain debt financing, affecting small O&G companies first. • A result of a tighter debt market may be higher interest rates from the banks who are willing to lend out money to the O&G industry which will affect the companies appetite for new investments.		

* Overall evaluation depending on likelihood and impact if applicable, otherwise indicating severity.
Source: Rystad Energy research and analysis

Evaluation of threats: Security

Theme	Threat	Threat description
Regulatory and social license to operate	Skewed understanding of energy security consequences in the public energy transition discourse	*Public opinion towards energy impacts future developments of the industry, referring to e.g. onshore wind or O&G exploration.*
	Increasing emission intensity of a maturing NCS	*Higher overall emissions intensity due to tail production going forward. These volumes can be at risk due to emission reduction targets.*
	Uncertainties in regulatory framework for the future of O&G	*Regulatory uncertainty related to future developments, exploration licenses and phase-out strategy.*
	Uncertainties in regulatory framework for new industries	*Regulatory uncertainty related to support schemes, contract structures, subsidies, tax regimes, strategy related to energy exports, etc.*
	Major accidents related to maturing NCS	*Infrastructure reaching design lifetime can lead to increased risk of serious accidents with high impact on social license to operate.*
Financials	Financials and innovation support affecting the development of new industries	*Financial uncertainties related to subsidies/support schemes, in addition to limited R&D funding can affect speed of development of new industries.*
	Access to external capital in the O&G industry	*Banks are restricting funding to O&G due to increased focus on ESG.*
Security	**Lack of protection against cyber attacks**	*Technology development in the O&G sector increases risk of cyber attacks.*
	Lack of protection against physical attacks	*Norwegian O&G infrastructure exposure to physical attacks.*
Access to competence	Challenges related to recruitment of STEM professionals	*The competition for STEM professionals is expected to be harder going forward.*
	Challenges related to recruitment to STEM studies at the universities	*Educating the required number of STEM professionals is likely an increasing challenge going forward.*
Supply chain	Bottlenecks in supply chain caused by geopolitical dependencies	*Geopolitical tensions causes increased risk in supply chain with potential bottlenecks caused by trade wars and following price increases.*

Source: Rystad Energy research and analysis

Norwegian O&G infrastructure is exposed to physical attacks

Lack of protection against physical attacks

- Recent events have put energy security on the European agenda, and Norwegian gas supply will be key to ensure energy security in Europe going forward. The sabotage of the Nord Stream pipelines brought attention to the fact that NCS oil and gas infrastructure is exposed to physical attacks, which would likely result in reduced NCS supply to Europe.
- Physical O&G infrastructure includes platforms, pipelines, onshore processing plants and supply bases, and power cables.
- Measures have been put in place to mitigate the risk of physical attacks such as preparing contingency plans and routines and increasing surveillance and protection. However, the level of physical security measures currently in place to protect the O&G infrastructure might not be sufficient taking the severe impact of an attack into consideration.

Criteria		Evaluation	Comment
Likelihood		⚑	Physical attacks of O&G infrastructure are unlikely. However, recent events show that Russia, considered as the biggest threat, can be willing to scale up the conflict with NATO and the West. Security measures are in place to mitigate the risk.
Impact	Energy volumes at risk	⚑	An attack can result in significant lost energy volumes and/or reduced export capacity.
	Permanence	⚑	Damages to infrastructure can take months or years to repair. However, contingency plans and routines will reduce the downtime.
	Lead time	⚑	Likely very short lead time as an attack would be intentional and aiming to cause severe damage that is hard to mitigate on short notice.
OG21 relevance		★	OG21 can contribute by supporting technology research to improve infrastructure surveillance and develop competence on the topic, in addition to communicate the need for proper contingency plans and measures to the relevant bodies.
Mitigation options		Technology	Competence	Communication	

The likelihood of a physical attack of O&G infrastructure is very low as some security measures are in place and an attack would have significant geopolitical consequences. However, damages to O&G infrastructure could have severe volume impact.

OG21 relevance: ☆ Low ★ Medium ★ High

Ranking: ⚑ Low ⚑ Medium ⚑ High

Color filled if mitigation option is relevant

Source: Rystad Energy research and analysis

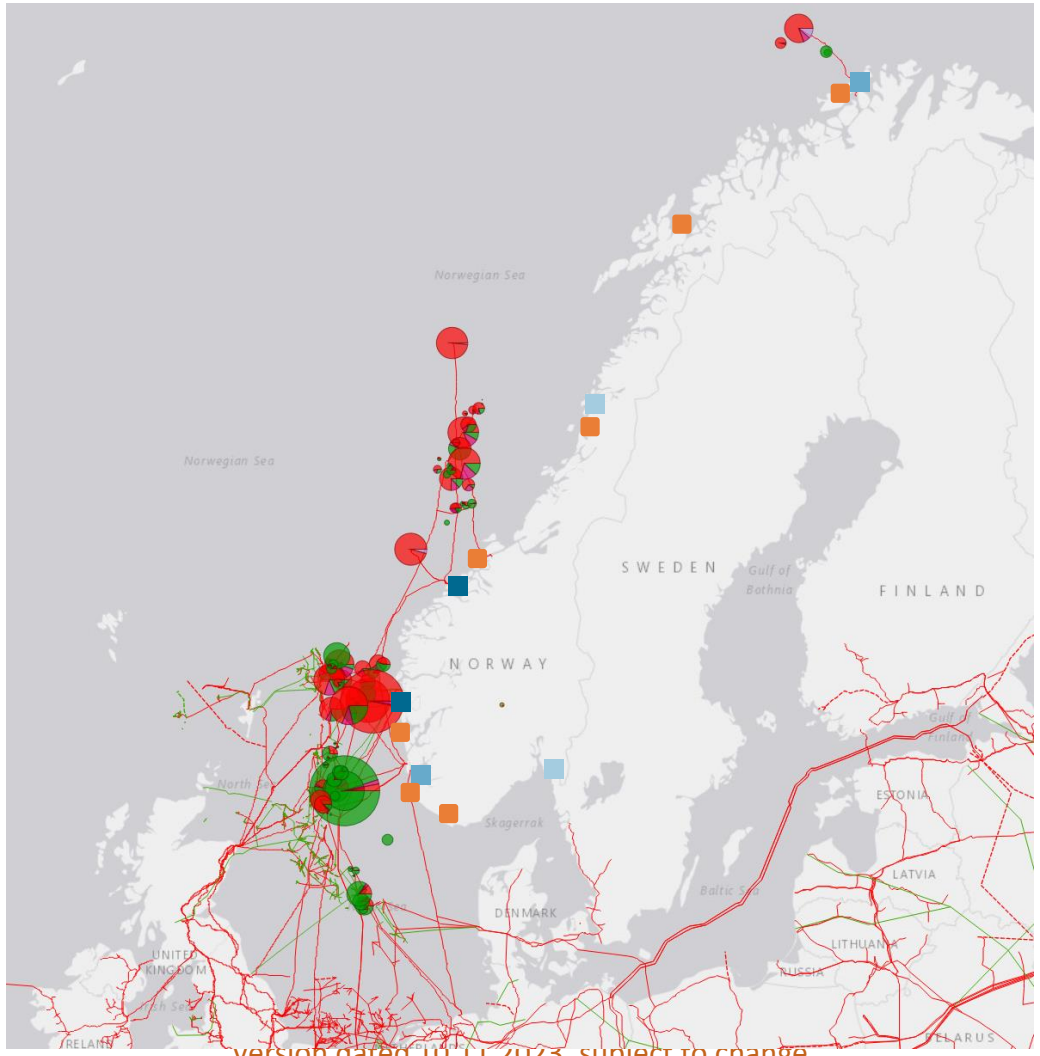
Physical attacks to Norwegian gas export pipelines and processing plants constitute a risk to European energy security

Norwegian oil and gas fields and infrastructure*

Gas pipelines
Sabotage of gas pipelines can have significant volume impact but depends on the attacked pipeline.

Onshore gas processing plants
Physical attacks or sabotage of one of Norway's onshore gas processing plants would weaken Norway's export capability.

Gas fields
Attacks of gas fields could have severe consequences, but not necessarily have direct significant impact to Norway's export.



Power cables
Production from electrified fields can be tampered if electrical cable to shore is cut.

Oil fields and pipelines
Sabotage of oil fields or oil pipelines would have significant negative consequences, but not necessarily that considerable in the context of European energy security.

LNG import and export terminals
Most of Norwegian gas is exported to Europe through pipelines, such that attacks to LNG terminals would not significantly weaken Norway's export capability.

Supply bases
Attacks to Norwegian supply bases would not pose significant threat European energy security.

* The overview is not exhaustive.
Source: Rystad Energy research and analysis

Attacks to physical assets can interrupt Norwegian gas supply to Europe

Infrastructure ranked by volume concentration and complexity

Pipelines

Sabotage of the Nord Stream pipeline proved that gas pipelines are at risk of attacks. It is close to impossible to have complete control over gas pipelines. A potential saboteur is also hard to catch as explosives can be placed far out in the ocean over longer periods of time. Repairing offshore gas pipelines takes time, and attacks on Norwegian pipelines to Europe can result in huge losses.

*Volume concentration**: ★★★

*Complexity***: ★☆☆

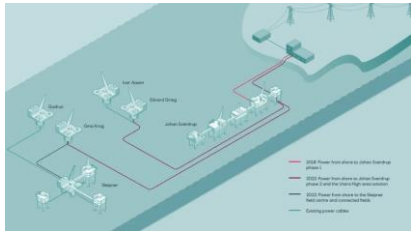
Processing facilities

Norway has three onshore gas processing plants, which are much easier to protect compared to offshore pipeline infrastructure. Following the Nord Stream sabotage the Norwegian Home Guard protected onshore oil and gas facilities. Attacks on onshore processing facilities are highly unlikely as it will be considered as an attack on NATO and thus significantly scale up the ongoing conflict.

*Volume concentration**: ★★★

*Complexity***: ★★★

Power cables



A large share of Norwegian gas production comes from offshore fields that are electrified from shore. Disruptions to the power cables supplying the platforms with electricity will force the platform to shut down, leading to reduced Norwegian gas production. Electrified platforms have back-up electricity generators that can supply the platform with electricity for a short period.

*Volume concentration**: ★★☆

*Complexity***: ★☆☆

Assets

Some fields makes up significant shares of the gas production from the NCS. Thus, disrupting one of these fields is the most likely assuming that the saboteur intends to constrain European gas supply. As such attacks could result in major accidents and have significant consequences to human life and global peace, the likelihood is very low.

*Volume concentration**: ★☆☆

*Complexity***: ★★★

* How much volume is at risk by damaging one facility.; ** How many parts are dependent on one facility.
Source: Rystad Energy research and analysis

Norwegian gas export pipelines exposed to the highest risk of physical attacks

Summary of the threat lack of protection against physical attacks

Key takes	Comments	Evaluation*	Exhibits
Physical attacks on Norwegian O&G infrastructure would have significant consequences but are not very likely.	• Recent events have brought attention to the fact that Norwegian O&G infrastructure is exposed to physical attacks. Sabotage of Nord Stream pipelines and Balticonnector are relevant examples. • Physical attacks will likely have significant consequences, such that the risk is low. However, if Russia, considered as the most significant threat, is willing to escalate the conflict with NATO and the West, Norwegian gas facilities are highly relevant targets.		
Attacks on gas export pipelines would directly weaken Norway's ability to supply Europe with gas.	• Norwegian gas flows to receiving terminals in continental Europe and UK through offshore gas export pipelines. Sabotage of one of these pipelines would directly impact European gas supply.		
Attacks on onshore processing plants would weaken Norway's export ability but is not likely due to the extensive consequences.	• Attacks on one of Norway's processing plants would directly affect Norway's ability to supply Europe with gas. Physical attacks of an onshore processing plant would threaten human life and potentially cause a major accident, in addition to create significant geopolitical tension, such that an attack is unlikely.		
Attacks on power cords supplying electricity to fields is more likely but volume impact will in most cases be quite small.	• Cutting an electrified offshore field's power cord to shore will force production to shut down. If the affected field is large, or several fields are connected to the cord that is cut, the impact can be quite large. However, in most cases, the volume impact would likely be small relative annual Norwegian production.		
Platform attacks are not likely and would in most cases have limited volume impact.	• Norway has many producing gas fields and an attack could limit Norway's export potential to Europe. However, an attack would have similar consequences as an attack of onshore gas processing facility, such that the likelihood is low.		

* Overall evaluation depending on likelihood and impact if applicable, otherwise indicating severity.
Source: Rystad Energy research and analysis

Technology development in O&G sector increases the risk of cyber attacks

Lack of protection against cyber attacks

- With the fast-paced technology development in the oil and gas sector, data and information security are becoming more important. Technological development enables efficient systems and better control, but also increased complexity and uncertainty regarding cyber security. Lack of knowledge and awareness, integration of OT and IT system and digital twins pose significant threats.
- The O&G sector is already exposed to cyber attacks today, but no large-scale attacks have succeeded yet. The severity of cyber attacks span from smaller attacks, for instance ransomware and phishing, to cyber surveillance and theft aimed at acquiring information, to rarer large-scale attacks with the potential to interfere with systems and operations causing significant damage.
- Cyber security research, competence and risk mitigations are not sufficient given the severity of a NCS cyber attack.

Criteria		Evaluation	Comment
Likelihood			Smaller cyber attacks happen quite often in Norway, while disruptive and large-scale attacks are less common. However, according to NSM, the frequency of serious cyber attacks towards Norway has significantly increased the past years.
Impact	Energy volumes at risk		A large-scale attack interfering with the central systems of large fields or other O&G infrastructure can result in lost energy volumes and/or reduced export capacity.
	Permanence		Current contingency plans and back-up systems likely reduce the downtime in the event of an attack, but it can take some time regain system control. In the event of a large-scale attack causing physical damages, repair can increase downtime.
	Lead time		Likely very short lead time as an attack would be intentional and aiming to cause damage that is hard to mitigate on short notice.
OG21 relevance			OG21 can contribute by supporting technology research to improve cyber security and develop competence on the topic, in addition to communicate the need for comprehensive security assessment and further research to the relevant bodies.
Mitigation options		Technology	Competence	Communication

The technology development make industries more prone to cyber attacks, but the likelihood of a successful large-scale attack targeting important O&G infrastructure is still low. In the case of a successful attack of central systems, the impact can be significant.

Source: Rystad Energy research and analysis; NSM Risiko 2023

OG21 relevance: ☆ Low ★ Medium ★ High

Ranking: Low Medium High

Color filled if mitigation option is relevant

A digitalized O&G sector enables a wide range of cyber attacks via several entry points

Potential entry points for cyber security attacks in the O&G sector*

Human shortcomings

Lack of competence and awareness of security threats can result in cyber attacks. In addition, people can have cruel intentions.

O&G supply chain

Attackers can target O&G infrastructure through third-party suppliers and vendors to get access to system and network.

Artificial intelligence

Artificial intelligence and machine learning can be used to spread false information or malware over time without being caught.

Cloud and satellite services

Introduction of cloud and satellite services increase independence of international cloud providers, and we leave sensitive digital traces.

Electrification

Electrification makes O&G infrastructure vulnerable to electromagnetic disruptions, tampering with data and systems.

Digital twin

Almost 90% of NCS gas production is covered by Digital twin, which involves cyber security threats like other digital systems.

Integration of IT and OT systems**

Interfere with physical O&G processes directly through OT systems or indirectly through IT systems.

Phishing attacks
E-mails to trick employees to reveal sensitive information or download malware

Espionage
Espionage seeking to gain insights

Ransomware attacks
Data tampering and demanding ransom for decrypting key. Similar to Hydro attack

Spread of false information
AI, for instance, can be trained to spread information that is hard to tell if is right or wrong

Insider threats
Employees or contractors with access to systems and data

Infiltrating system and networks
Access to information and potentially systems

Data manipulations
Manipulated data can lead to incorrect decision-making that can impact physical operations

Data theft
Theft of sensitive information, for instance gas deliveries and security measures

Unauthorized access
Enables data manipulation or sabotage of the physical O&G infrastructure

Electromagnetic disruptions
Interrupting electronics, causing poorer performance or damage. Data can also be interrupted, changed, manipulated or sabotaged.

Disruptions to OT system
Directly controlling physical O&G operations, like production and/or security systems

Disruptions to IT system
Indirectly interfering with physical O&G operations, like production and/or security systems

* The overview is non-exhaustive. ; ** IT = Information technology, OT = Operation technology
Source: Rystad Energy research and analysis; NSM Risiko 2023; ABB; Petroleumstilsynet

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Integration of IT and OT systems**

Interfere with physical O&G processes directly through OT systems or indirectly through IT systems.

High-level impact evaluation

Cyber attacks via the above entry points are significant threats to the O&G sector. These attacks are the most frequent.

While these attacks do not pose an immediate risk to Norwegian gas deliveries to Europe, the enemy can through these entry points acquire knowledge and information about specific O&G infrastructure, that can be used to plan a large-scale attack a later point.

Rapport med krass kritikk av sikkerheten på norsk sokkel

Electromagnetic disruptions can have the same impact as if a power cable supplying the field with electricity is cut but require significantly higher resources than a physical attack to the power cord, such that this is unlikely.

See chapter about physical attacks for potential volume impact of large-scale system interference.

The majority of NCS gas production is covered by Digital twins, which the enemy can obtain access to. While the enemy will not be able to tamper with systems on the physical facility, the enemy can use access to the twin to acquire valuable information.

Interfering with OT or IT O&G systems can impact production and tamper with systems with negative consequences.

See chapter about major accidents for thorough description of consequences.

See chapter about physical attacks for potential volume impact of large-scale system interference.

* The overview is non-exhaustive.; ** IT = Information technology, OT = Operation technology
Source: Rystad Energy research and analysis; NSM Risiko 2023; ABB

Previous cyber attacks have caused significant damage but also forced security improvements

Overview of historical cyber attacks

In 2010, Iranian nuclear facilities were attacked. The attack involved at sophisticated computer worm that targeted and damaged centrifuges used in Iran's uranium enrichment program, causing significant disruptions to their nuclear ambitions.

Stuxnet 'hit' Iran nuclear plans

Shipping company Maersk says June cyberattack could cost it up to $300 million

The Maersk cyberattack in 2017 was a massive ransomware attack that affected the Danish shipping and logistics company, Maersk. The ransomware encrypted their computer systems and disrupted their operations. Maersk incurred significant financial losses, and the attack affected their customers and global supply chains.

This incident highlighted the consequences of a large-scale ransomware attack on critical business operations.

The cyberattack on Norsk Hydro in 2019 was a major ransomware The attack encrypted the company's computer systems, disrupting its operations and demanding a ransom for the decryption key. Hydro declined to pay the ransom and, instead, worked to restore its systems and recover from the incident.

Cyber-attack on Hydro

Hydro became victim of an extensive cyber-attack in the early hours of Tuesday, March 19, 2019, impacting operations in several of the company's business areas.

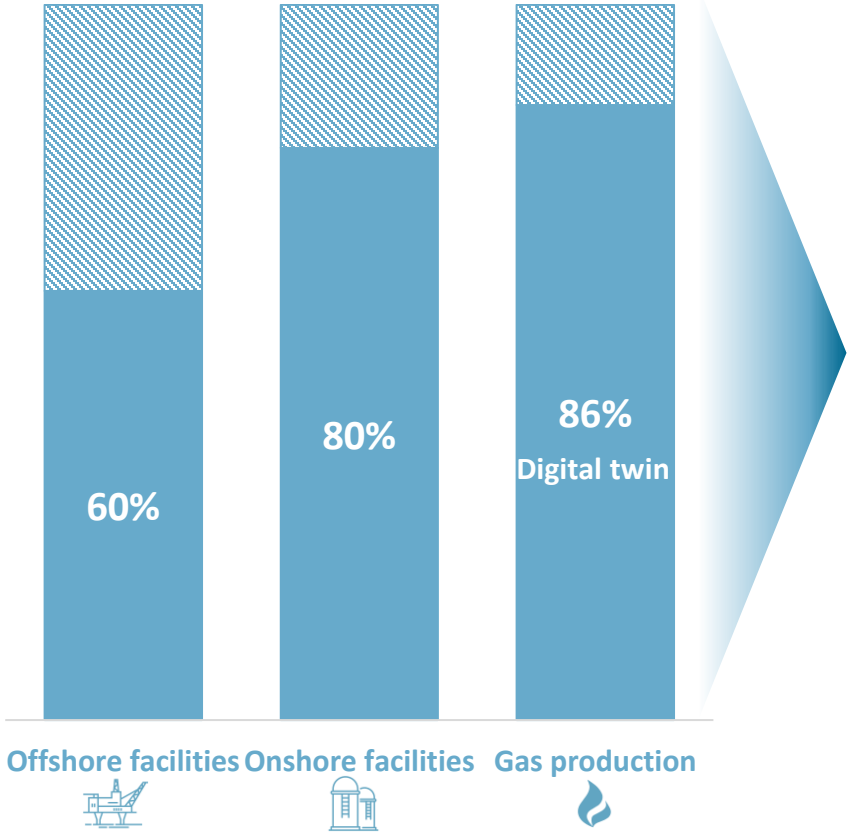
Biden Order To Require New Cybersecurity Standards In Response To SolarWinds Attack

The SolarWinds attack was a major cybersecurity breach in 2020. The attack involved hackers infiltrating SolarWinds' software updates, allowing them to access and compromise the computer networks of many customers, including US Government agencies. It was a supply chain attack and had serious implications for cybersecurity.

Source: Rystad Energy research and analysis; Hydro

Almost 90% of NCS gas production is covered by Digital twins, which opens for cyber attacks

Share of the NCS covered by Digital Twins
Percentage



Onshore and offshore assets with digital twins

Norway leads the digital asset race with more twins than any other country and more digital O&G assets than the rest of the world combined.

While this is beneficial for optimizing O&G operations, the reliance on a digital system enables cyber attacks.

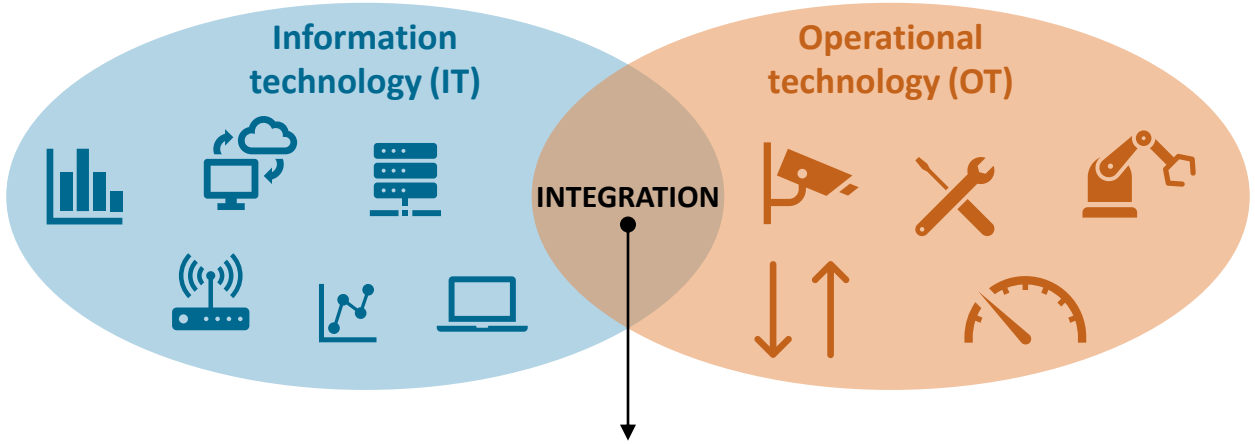
If an enemy gets access to the Digital twin of a gas platform, the enemy can have access to valuable information about that platform that can be misused with negative consequences.

Source: Rystad Energy research and analysis; NSM Risiko 2023; ABB

Integration of IT and OT systems in the O&G sector is a significant threat to Norwegian gas export

Risks related to the integration of IT and OT systems – the IT/OT converge

IT systems are designed for managing digital information, supporting operations and processing data.



OT systems monitor and perform physical processes and equipment in real-time and are commonly used for production and processing in the O&G industry.

OT systems are built to be efficient and historically without protective mechanisms.

To share information from the O&G processes performed by the OT systems, IT systems must be connected. The information share between the systems enables optimization, automatization and increased efficiency.

However, integrating IT and OT systems creates an opening for cyber attacks. The enemy can obtain access to, and tamper with, the OT systems on a platform or processing facility by hacking into the IT systems. Hence, the enemy can damage physical operations, such as gas production or processing, without being there physically. Rebuilding the systems can take time.

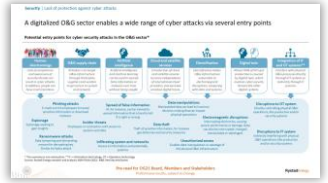
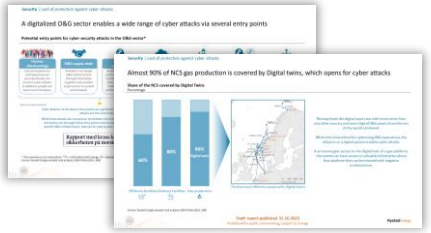
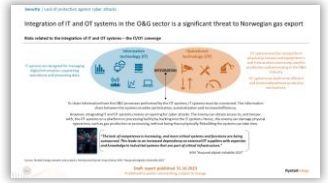
"The lack of competence is increasing, and more critical systems and functions are being outsourced. This leads to an increased dependency on external OT suppliers with expertise and knowledge in industrial systems that are part of critical infrastructure."

NSM "Nasjonalt digitalt risikobilde 2023"

Source: Rystad Energy research and analysis; Petroleumstilsynet; Sopra Steria; NSM "Nasjonalt digitalt risikobilde 2023"

Long-lasting access to sensitive O&G information and IT/OT converge can result in cyber attacks

Summary of the threat lack of protection against cyber attacks

Key takes	Comments	Evaluation*	Exhibits
Increasing digitalization in the O&G sector enables cyber attacks via several entry points.	• The technology development in the O&G sector creates vulnerabilities and potential entry points for a wide range of cyber attacks. Entry points include people, supply chain, AI and cloud services, electrification, digital twins and integration of OT and IT systems. • The impact of cyber attacks depends on the data, systems and processes the enemy gets access to. • Large-scale cyber attacks require significant amounts of time, resources and competence. • In most cases, the enemy is only able to get access to information about O&G systems and processes and is not able to interfere with systems or operations.		
Unauthorized access to sensitive O&G information about systems and processes over time can be used by the hacker to plan large-scale cyber attacks.	• Small-scale cyber attacks, such as phishing, are likely the most common. These attacks are not immediate threats to gas production. However, the enemy can use such methods to obtain access to sensitive and valuable information over time, which can be used to plan a large-scale attack. • If the enemy hacks into the digital twin of a gas field, the enemy will not be able to do any changes to physical processes on the gas field but will get access to valuable information. • Cyber attacks on power cords supplying fields with electricity is possible in theory but unlikely as this would require extensive amounts of resources.		
IT and OT system integration creates infrastructure vulnerabilities that can be exploited by the enemy and enable interference with critical O&G operations.	• The integration of IT and OT systems in the O&G sector creates an opportunity for the enemy. The enemy can get access to the operational systems and processes on O&G infrastructure by hacking into the IT systems and thus damage production without being there physically. • The volume impact from such an attack will depend on the magnitude of the output from the specific field or processing plant. If one of the Troll fields or one of the gas processing plants is attacked, the impact on Norwegian gas supply to Europe can be significant.		

* Overall evaluation depending on likelihood and impact if applicable, otherwise indicating severity.
Source: Rystad Energy research and analysis

Evaluation of threats: Access to competence

Theme	Threat	Threat description
Regulatory and social license to operate	Skewed understanding of energy security consequences in the public energy transition discourse	*Public opinion towards energy impacts future developments of the industry, referring to e.g. onshore wind or O&G exploration.*
	Increasing emission intensity of a maturing NCS	*Higher overall emissions intensity due to tail production going forward. These volumes can be at risk due to emission reduction targets.*
	Uncertainties in regulatory framework for the future of O&G	*Regulatory uncertainty related to future developments, exploration licenses and phase-out strategy.*
	Uncertainties in regulatory framework for new industries	*Regulatory uncertainty related to support schemes, contract structures, subsidies, tax regimes, strategy related to energy exports, etc.*
	Major accidents related to maturing NCS	*Infrastructure reaching design lifetime can lead to increased risk of serious accidents with high impact on social license to operate.*
Financials	Financials and innovation support affecting the development of new industries	*Financial uncertainties related to subsidies/support schemes, in addition to limited R&D funding can affect speed of development of new industries.*
	Access to external capital in the O&G industry	*Banks are restricting funding to O&G due to increased focus on ESG.*
Security	Lack of protection against cyber attacks	*Technology development in the O&G sector increases risk of cyber attacks.*
	Lack of protection against physical attacks	*Norwegian O&G infrastructure exposure to physical attacks.*
Access to competence	**Challenges related to recruitment of STEM professionals**	*The competition for STEM professionals is expected to be harder going forward.*
	Challenges related to recruitment to STEM studies at the universities	*Educating the required number of STEM professionals is likely an increasing challenge going forward.*
Supply chain	Bottlenecks in supply chain caused by geopolitical dependencies	*Geopolitical tensions causes increased risk in supply chain with potential bottlenecks caused by trade wars and following price increases.*

Source: Rystad Energy research and analysis

The competition for STEM professionals expected to be tougher going forward

Challenges related to recruitment of STEM* professionals

- There will be an increased competition for STEM professionals going forward driven by primarily three factors.
- Firstly, the competition for STEM professionals will tighten as society will require a higher more STEM competence, driven by new industries and the digital and green transition.
- Secondly, the O&G industry has a declining reputation, especially internationally, where STEM professionals prefer other industries than O&G.
- Lastly, the ability to attract and retain international competence, and the complications of having international competence given the geopolitical situation and the inclusion of parts of the petroleum industry in the Security Act.

Criteria		Evaluation	Comment
Likelihood		🚩	The competition for STEM professionals are expected to toughen. This coincides with O&G industry having a decreased job attractiveness, partly due to industry repetition. This leaves the O&G industry in a challenging position.
Impact	**Energy volumes at risk**	⚑	Too low recruitment will affect the industry's ability to execute operations and development. Maintaining current production is less STEM intensive than development, and will therefore likely be prioritized if there is a shortfall of competence.
	Permanence	⚑	Competition for STEM professionals can be won short-term, but the underlying problem of too little STEM competence available takes more time to address.
	Lead time	⚑	Bottlenecks in STEM competence is already felt, but will primarily hit in the medium- to long-term when the competition for STEM professionals are higher due to increased demand from other sectors.
OG21 relevance		★	Highly relevant for OG21, which conducted a dedicated competence workshop in 2023 where recruitment of STEM professionals was identified as one of the main threats.
Mitigation options		Technology	**Competence**	**Communication**

Offshore energy industries are at high risk of experiencing recruitment and retention challenges of STEM professionals, driven by increasing competition combined with reduced attractiveness of the O&G industry. Shortfall of STEM competence can put current and future energy volumes at risk.

* Science, technology, engineering and math
Source: Rystad Energy research and analysis; OG21 Competence needs in the energy Industries (2023)

OG21 relevance: ☆ Low ★ Medium ★ High

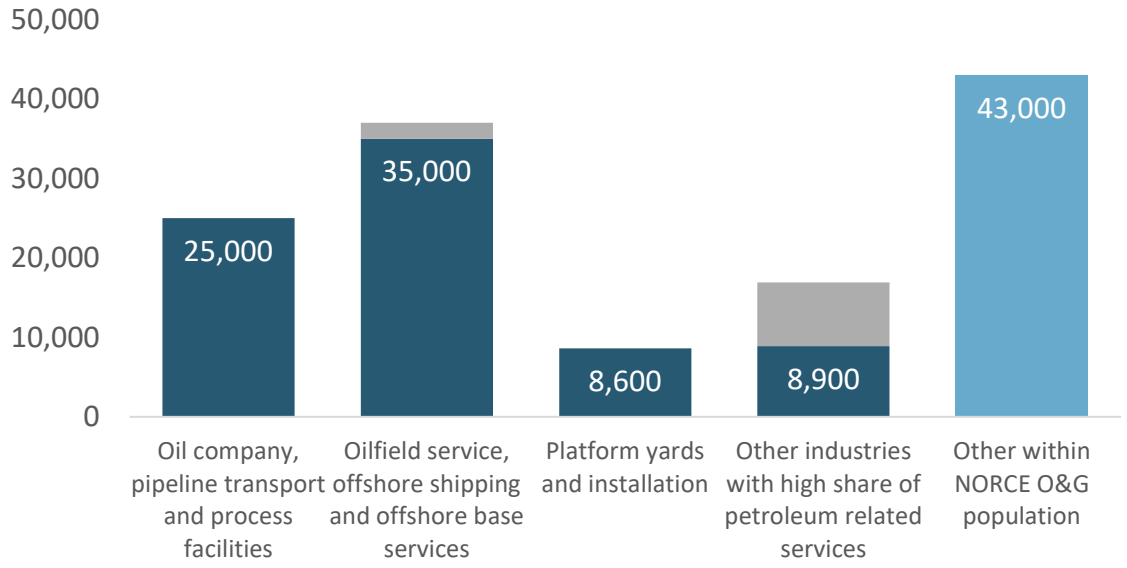
Ranking: ⚑ Low ⚑ Medium ⚑ High

Color filled if mitigation option is relevant

Around 120,000 work directly or indirectly with O&G in Norway, of which ~30% are STEM educated

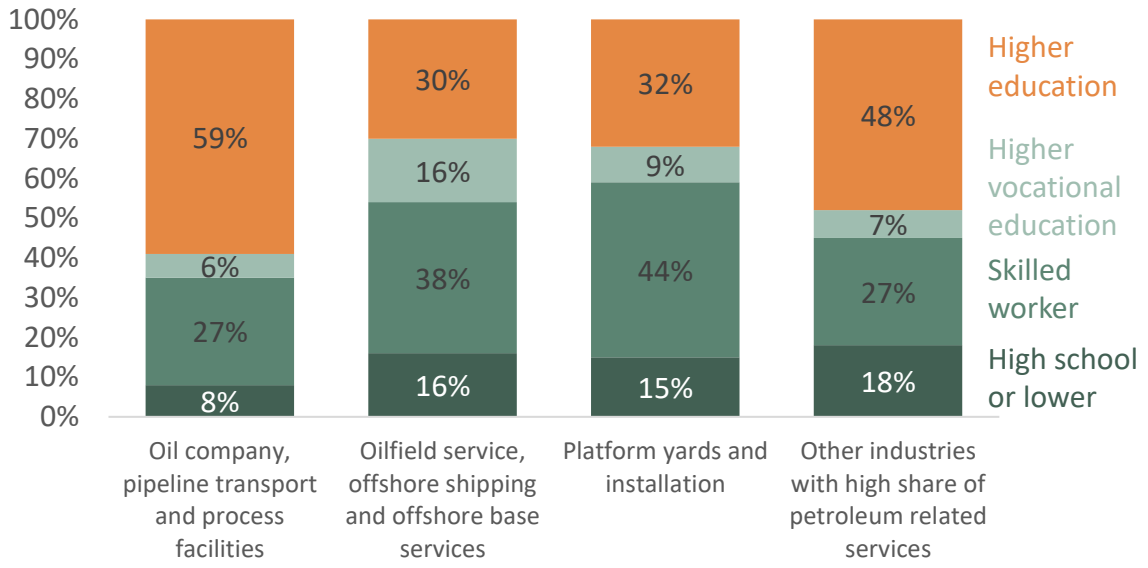
Employees directly and indirectly employed in the O&G industry

Number of employees (2021)



Education distribution of the O&G workforce

Percentage of employees with different education (2021)



- There were approximately 120,000 people employed directly or indirectly in the oil and gas industry in 2021 according to a NORCE report from 2022*.
- Other industries with high share of petroleum related services mean that deliveries to the O&G industry is more than 50%
- Other represents the sum of employees in petroleum serving industries with less than 50%.

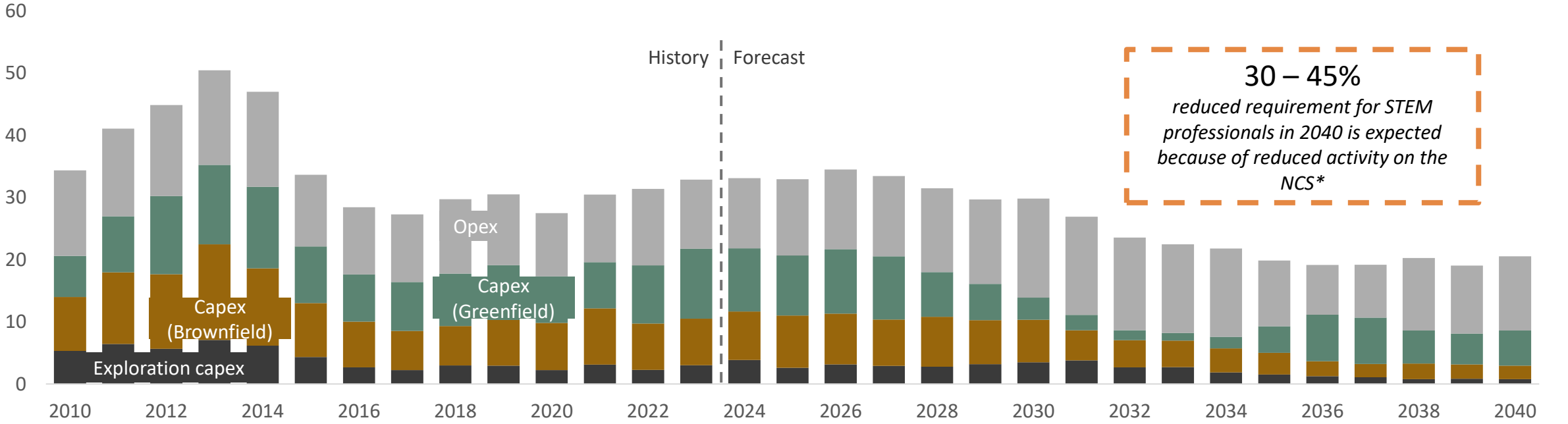
- The graph above shows the education distribution of employees in the four industries from the chart to the left that are directly involved in the O&G industry.
- Most of the employees with higher education holds STEM competence*, yielding approximately 30% of the work force involved in the O&G industry.

* Based on the NORCE (2022) report "Utvikling i sysselsetting relatert til petroleum, sokkelelektrifisering og nye havnæringer, 2018-2026"

Source: Rystad Energy research and analysis; NORCE (2022) "Utvikling i sysselsetting relatert til petroleum, sokkelelektrifisering og nye havnæringer, 2018-2026"; SSB; Microdata.no

Less spending results in reduced need for STEM professionals in 2040 compared to historically

Spending on the Norwegian Continental Shelf 2010 – 2040
Billion USD

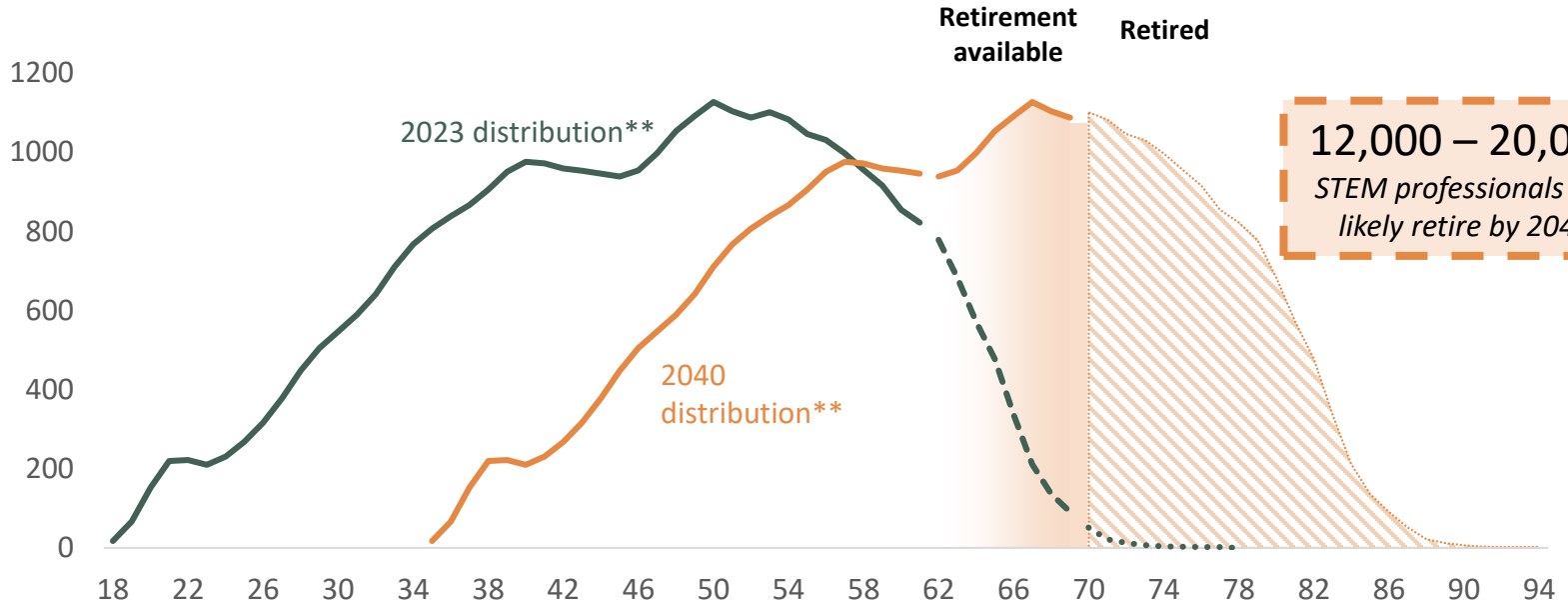


- The graph above displays the spending profile on the Norwegian Continental Shelf split by exploration capex, capex and opex in the period 2010 to 2040.
- Total spending is a good indicator of activity, which is expected to experience a short-term increase, before declining in the medium- and long-term. Reduced activity will decrease the demand for STEM professionals, where especially development is likely to require a lot of STEM competence.
- Spending in 2040 compared to 2021 numbers implies a reduced need for STEM competence between 30 – 45%, depending on weighting to capex compared to opex*

* Capex spending is more STEM intensive than opex spending. Using an equal weighting between capex and opex yields a 30% decrease, while a 75% capex and 25% opex weighting yields a 45% decrease in STEM competence requirement.
Source: Rystad Energy research and analysis; Rystad Energy UCube

Between 12,000 and 20,000 STEM professionals will likely retire from the O&G industry by 2040

Age distribution for STEM educated employees in the O&G industry*
Number of employees with STEM education at a given age in 2023, 2035 and 2040



12,000 – 20,000
STEM professionals will likely retire by 2040

Employees are protected from being fired on the basis of old age until they reach 70 years
Regjeringen.no

*To be eligible for AFP, you must be at least 62 years old****
Fellesordningen for AFP

"[…] pension drawing options from the age of 62"
equinor

- The graph above displays the age distribution of the employees in the O&G industry in 2023 and the how the same workforce would be in 2040.
- Several companies make retirement available from 62 years old, while the Government have imposed regulations that prevent employers from firing employees on the basis of old age until they reach 70 years old. It is therefore likely to see some retirement from 62 years old, but the majority when employees reach 70 years old.
- In 2040, between 12,000 and 20,000 of the STEM professionals in the workforce will have retired.

* Assuming 30% of the workforce have STEM education, based on NORCE (2022) report; ** Obtained through shifting the 2021 distribution from SSB out in time; *** And must fulfill the requirements laid down by the statutes.
Source: Rystad Energy research and analysis; Regjeringen.no; Equinor; SSB; NORCE; Microdata.no; Fellesordningen for AFP

Offshore wind industry ambitions will likely require more than 9,000 STEM professionals

The Government have high ambitions for the offshore wind industry

Regjeringen.no

Havvind blir Norges neste eksporteventyr

Pressemelding | Dato: 01.12.2022

The Norwegian authorities have ambitious goals for offshore wind with regards to both power generation and supply chain market shares.

Announced in May 2022 that 30 GW of offshore wind capacity will be rewarded by 2040

Announced in December 2022 that offshore wind is within the export reform "Hele Norge eksporterer" and targeting 10% of the global offshore wind market by 2030.

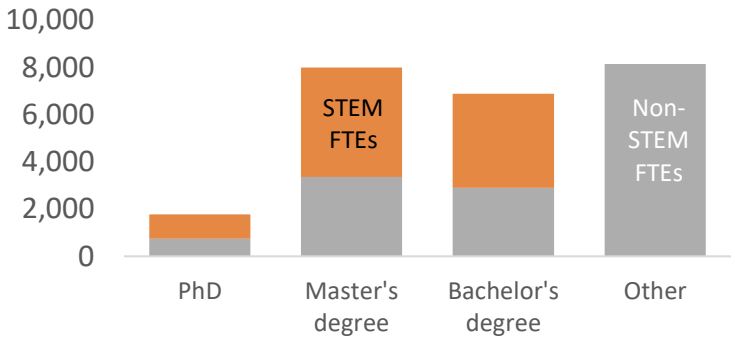
Offshore wind will have a significant STEM professionals need

Hired by Norwegian Offshore Wind and Tekna, Menon Economics conducted a study looking at the competence requirements for the offshore wind industry.

"Within higher education, there will be a particular need for engineering competence"

MENON ECONOMICS

Employment needs from the offshore wind industry
Number of employees split on education level in 2035



~ 9,500
*STEM professionals likely demanded by the offshore wind industry in 2035**

* The average expected competence requirements for employees with higher education according to a survey conducted by Menon Economics states that roughly 60% of higher educated should have STEM competence.
Source: Rystad Energy research and analysis; Menon Economics (2023) "Gigawatt krever megaløft"; Regjeringen.no

Development of the existing workforce is important, especially if facing STEM recruitment challenges

General upskilling and re-education of the existing workforce are methods to obtain required competence.

[…] 65% of the industry enterprises report an uncovered competence need. ***Developing the competence of the workforce is described as a key strategy to address the need****."*

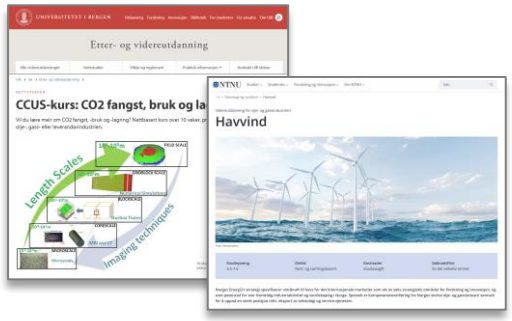
Competence needs in the energy industries (2023) OG21

The workforce need to develop new and changed competence requirements from the twin digital and green transition.

"New digital technologies as well as the advent of new energy and maritime industries […] require a workforce with the ability to acquire new competence and adapt to changing job requirements"

Competence needs in the energy industries (2023) OG21

Part- or full-time studies at universities



In-house company training

Remote-controlling offshore installations are an example that has financial, environmental and safety benefits.

Valemon and Martin Linge are examples of remote-controlled platforms

Nov 2018, E24

Source: Rystad Energy research and analysis; OG21 Competence needs in the energy Industries (2023); E24; Equinor

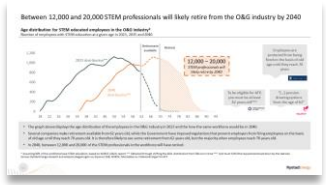
Recruitment needs is based on retirement, changed activity, improvements and loss to others

Recruitment need in O&G industry of STEM professionals in 2040 when adjusting for changed activity level and retirement

Retirement

12,000 – 20,000

STEM professionals from the current workforce will likely retire by 2040



Reduced activity

10,500 – 15,500

fewer STEM professionals will be required by the industry following a reduced activity in the future

Recruitment need

1,500 – 4,500

STEM professionals need to be recruited to the O&G industry to deliver estimated production in in the long-term*

Efficiency and developments

?

Efficiency improvements following digital transformation and development of existing workforce will likely reduce the recruitment need.

O&G industry factors

Offshore wind recruitment need

~ 9,500

Worst-case additional recruitment need if offshore wind industries recruit STEM professionals extensively from the O&G industry.

Worst-case scenario loss to offshore wind

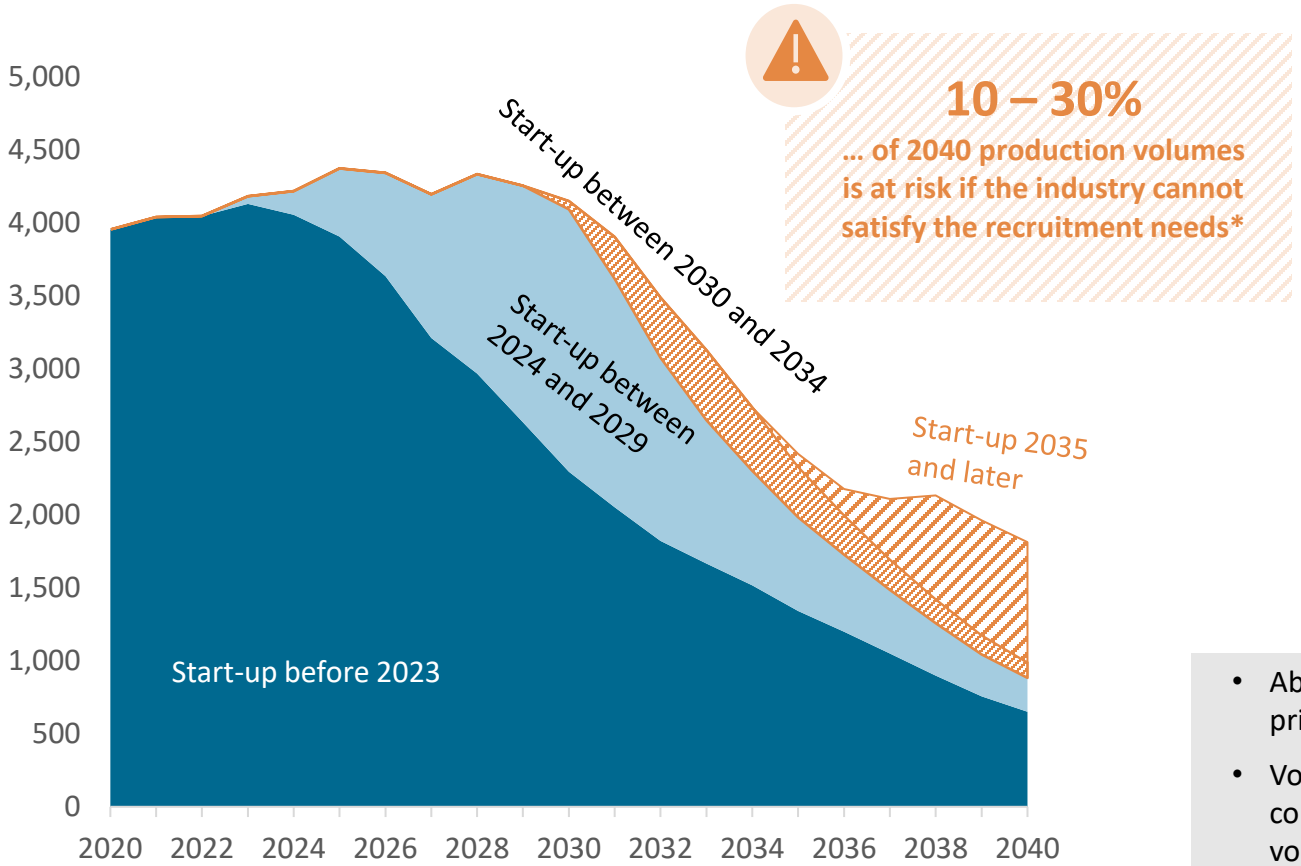
- The O&G industry will need to hire STEM professionals to account for retirement, changed activity, efficiency improvements and loss to other industries.
- Loss to other industries represents a significant upside to the recruitment need when looking at only O&G industry factors.

* Less will be needed if one assumes efficiency improvements, where fewer STEM professionals are required per barrel of oil equivalent extracted
Source: Rystad Energy research and analysis;

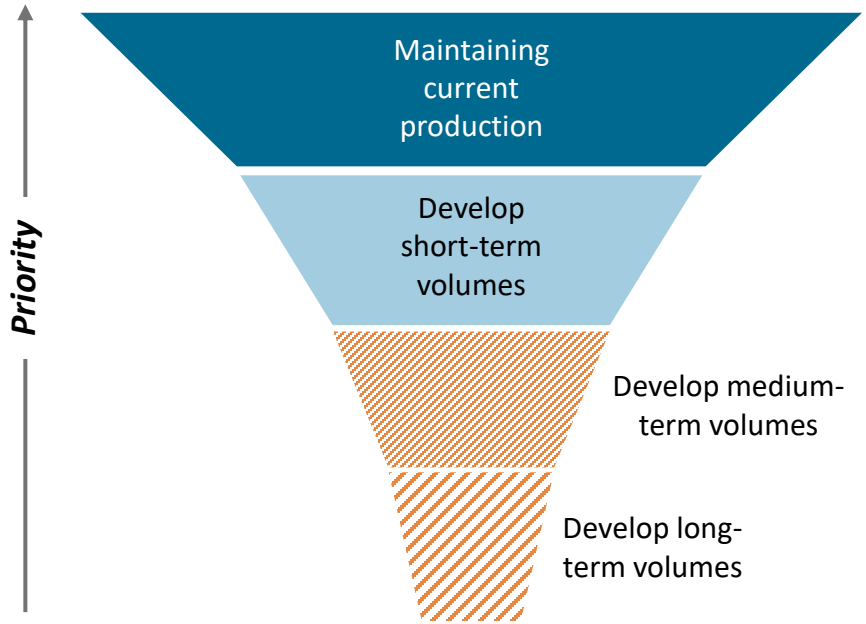
Future production at risk if the O&G industry fails to recruit enough STEM professionals

Production of oil and gas on the NCS split by start-up year

Thousand boe/d



Activity prioritization in the event of STEM competence shortfall



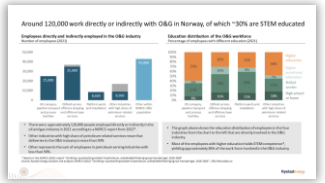
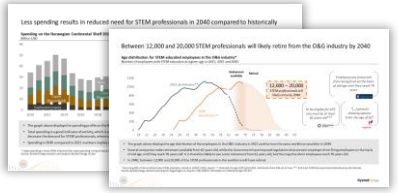
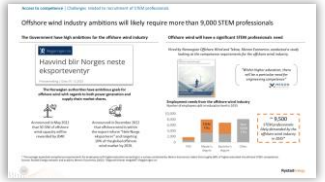
- Above is a prioritizing scheme outlining how operators and developers will likely prioritize their activities in the event of a STEM competence shortfall.
- Volumes at risk is therefore dependent on the scale and timing of STEM competence shortfall, where a more extensive shortfall will put a higher level of volumes at risk.

* Number reflects volumes at risk related to recruitment need of 1,500 to 4,500 STEM professionals, which is the number when only looking at the O&G industry isolated. If one includes loss of STEM professionals to new industries, the recruitment number is higher, and more volumes is at risk. A counter-effect of this underestimation is the assumption of same STEM intensity per volume developed today as in 2040, which likely overestimates the volumes at risk.

Source: Rystad Energy research and analysis; Rystad Energy UCube

Recruitment of STEM professionals should be a focus area going forward

Summary of challenges related to recruitment of STEM* professionals

Key takes	Comments	Evaluation*	Exhibits
The oil and gas industry are reliant on a workforce with a high share of STEM professionals.	• There are approximately 120,000 people directly or indirectly working within the O&G industry. • Of these, around 30% have STEM competence. • The O&G industry is therefore relatively STEM intensive in order to operate.		
Recruitment need from retiring workforce are to some extent offset by reduced activity going forward.	• The Norwegian Continental Shelf is maturing, and the activity on the shelf is expected to reduce going forward, both spending and production. This will reduce the need for STEM professionals as less projects are developed. • The O&G industry has an ageing workforce. A high share of the current employees will therefore be retired by 2040.		
Loss of STEM professionals to other industries will increase the recruitment need in O&G.	• Other industries will have STEM recruitment need too. Especially other offshore industries can benefit from recruiting O&G STEM professionals. • There is therefore a high upside risk to the recruitment need if other industries recruit STEM professionals from the O&G industry.		
Recruitment need of STEM professionals in the O&G industry is moderate, but high upside.	• When looking at O&G industry effects isolated, the recruitment need is less then 5,000 STEM professionals. • However, there is a high risk of other industries recruiting STEM professionals currently employed in the O&G industry which will increase the recruitment need.		

* Overall evaluation depending on likelihood and impact if applicable, otherwise indicating severity.
Source: Rystad Energy research and analysis

Educating the required number of STEM professionals is likely to be an issue going forward

Challenges related to recruitment to STEM* studies at the universities

- Being able to educate enough STEM students going forward is expected to face challenges.
- Firstly, too few of the upcoming generation select natural science and mathematics in high school. They therefore lack important qualifications to pursue a STEM education that must be obtained.
- Secondly, the number of STEM study places offered at the universities is too low compared to future expectations regarding required STEM professionals.
- Lastly, the ability to attract international students, and the complications of having international students given the geopolitical situation and the inclusion of parts of the petroleum industry in the Security Act.

Criteria		Evaluation	Comment
Likelihood			Capacities at universities are reducing for some STEM educational programs, however, positive outlooks with current application numbers.
Impact	**Energy volumes at risk**		Low recruitment to STEM studies can put future energy volumes at risk if required competence is not available. However, the likely improved efficiency and a lower activity level going forward will probably reduce the impact somewhat.
	Permanence		Expanding capacities at universities and educating more candidates take several years.
	Lead time		Application trend positive in the short-term, but too low capacity and potential changes to application trends will yield problems in the medium- to long-term.
OG21 relevance		★	Highly relevant for OG21, which conducted a dedicated competence workshop in 2023 where recruitment to STEM studies at the universities was identified as one of the main threats.
Mitigation options		Technology	Competence	**Communication**

Reduced interest for STEM topics in high school and not enough university capacity will likely cause problems with too few STEM students. This can impact energy volumes in the medium- to long-term, and will take time to address.

* Science, technology, engineering and math
Source: Rystad Energy research and analysis; OG21 Competence needs in the energy Industries (2023)

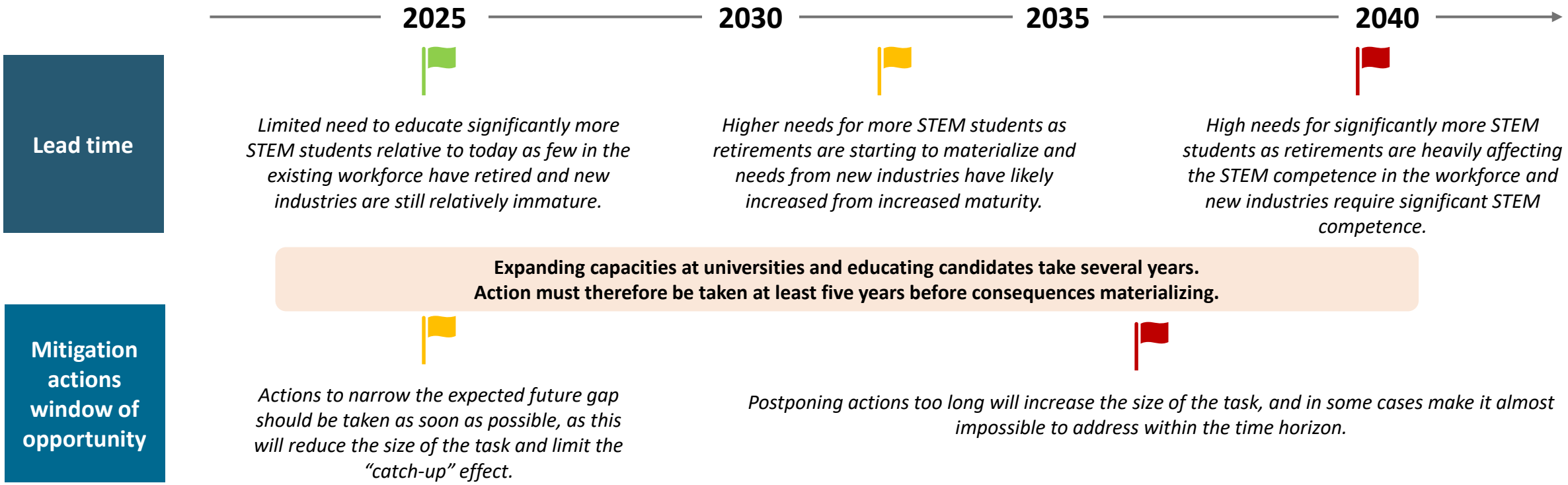
OG21 relevance: ☆ Low ★ Medium ★ High

Ranking: Low Medium High

Color filled if mitigation option is relevant

The expected future competence gap needs to be addressed as soon as possible

There is a timing difference between when the impact occurs and when mitigating actions must be initiated when discussing education



- If there are too few STEM students relative to the future demand, the competition for STEM professionals will become even tougher.
- The consequence of this threat is therefore similar to the recruitment of STEM professionals' threat, However, this threat have a longer lead time before it materializes.

Source: Rystad Energy research and analysis; OG21 Competence needs in the energy Industries (2023)

Evaluation of threats: Supply chain

Theme	Threat	Threat description
Regulatory and social license to operate	Skewed understanding of energy security consequences in the public energy transition discourse	*Public opinion towards energy impacts future developments of the industry, referring to e.g. onshore wind or O&G exploration.*
	Increasing emission intensity of a maturing NCS	*Higher overall emissions intensity due to tail production going forward. These volumes can be at risk due to emission reduction targets.*
	Uncertainties in regulatory framework for the future of O&G	*Regulatory uncertainty related to future developments, exploration licenses and phase-out strategy.*
	Uncertainties in regulatory framework for new industries	*Regulatory uncertainty related to support schemes, contract structures, subsidies, tax regimes, strategy related to energy exports, etc.*
	Major accidents related to maturing NCS	*Infrastructure reaching design lifetime can lead to increased risk of serious accidents with high impact on social license to operate.*
Financials	Financials and innovation support affecting the development of new industries	*Financial uncertainties related to subsidies/support schemes, in addition to limited R&D funding can affect speed of development of new industries.*
	Access to external capital in the O&G industry	*Banks are restricting funding to O&G due to increased focus on ESG.*
Security	Lack of protection against cyber attacks	*Technology development in the O&G sector increases risk of cyber attacks.*
	Lack of protection against physical attacks	*Norwegian O&G infrastructure exposure to physical attacks.*
Access to competence	Challenges related to recruitment of STEM professionals	*The competition for STEM professionals is expected to be harder going forward.*
	Challenges related to recruitment to STEM studies at the universities	*Educating the required number of STEM professionals is likely an increasing challenge going forward.*
Supply chain	**Bottlenecks in supply chain caused by geopolitical dependencies**	***Geopolitical tensions causes increased risk in supply chain with potential bottlenecks caused by trade wars and following price increases.***

Source: Rystad Energy research and analysis

Geopolitical supply chain dependencies leave project delays at risk if situation escalates

Bottlenecks in supply chain caused by geopolitical dependencies

- The current geopolitical situation poses a risk to the supply chain in both O&G and for new industries. With a significant number of suppliers and essential materials being concentrated in China, the development of new projects is at risk if the geopolitical situation gets worse.
- Without having enough capacity domestically, a deterioration in the geopolitical climate may lead to bottlenecks across different supply chains. However, China plays an important role in reaching global climate targets due to their ability to ramp up capacity, making low-carbon technologies accessible at affordable costs.
- The O&G industry is exposed due to the sourcing of important materials like steel, and through limited yard capacities.

Criteria		Evaluation	Comment
Likelihood		⚑	Medium likelihood due to the current geopolitical situation and the concentration of both key suppliers and essential materials.
Impact	**Energy volumes at risk**	⚑	Bottlenecks in the supply chain may significantly affect the timeliness of new oil and gas projects and the emergence of new industries, but their impact on current exports is not as significant.
	Permanence	⚑	Should the geopolitical situation deteriorate it is likely that supply chains will be severely disrupted and that projects will be impacted, especially those that are newly started.
	Lead time	⚑	Medium lead time as it as it would require a prolonged deterioration in the geopolitical situation over time for suppliers to stop delivering goods to their customers.
OG21 relevance		☆	Low relevance for OG21 as countries have already taken measures to become more autonomous. However, supply chain dependencies can be limited with technology development and with good communication to relevant authorities.
Mitigation options		**Technology**	Competence	**Communication**	

Key suppliers and essential materials for both the O&G industry and new industries are concentrated, increasing the likelihood for supply chain disruptions. The geopolitical uncertainties poses a moderate risk to the impact of future energy volumes.

OG21 relevance: ☆ Low ★ Medium ★ High **Ranking:** ⚑ Low ⚑ Medium ⚑ High

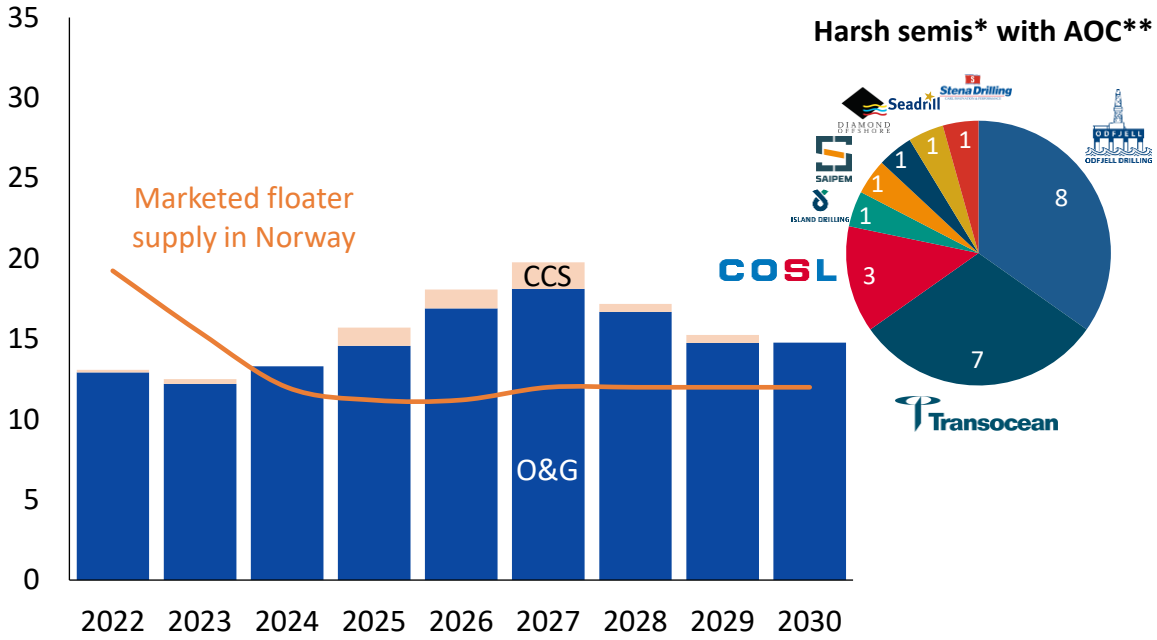
Color filled if mitigation option is relevant

Source: Rystad Energy research and analysis

Security concerns after contracts awarded to Chinese drilling operator on the NCS

Harsh-environment semisub demand-supply balance in Norway

Rig years



- A tight offshore rig market in Norway for harsh-environment with relatively few players servicing the market makes it hard to avoid the importance of the recently disputed COSL, who entered a contract with Equinor.

Criticism after Equinor awarded contracts to rig owner COSL

Two COSL rigs awarded drilling contracts

equinor

Equinor at centre of security storm over deals with Chinese drilling giant

upstream

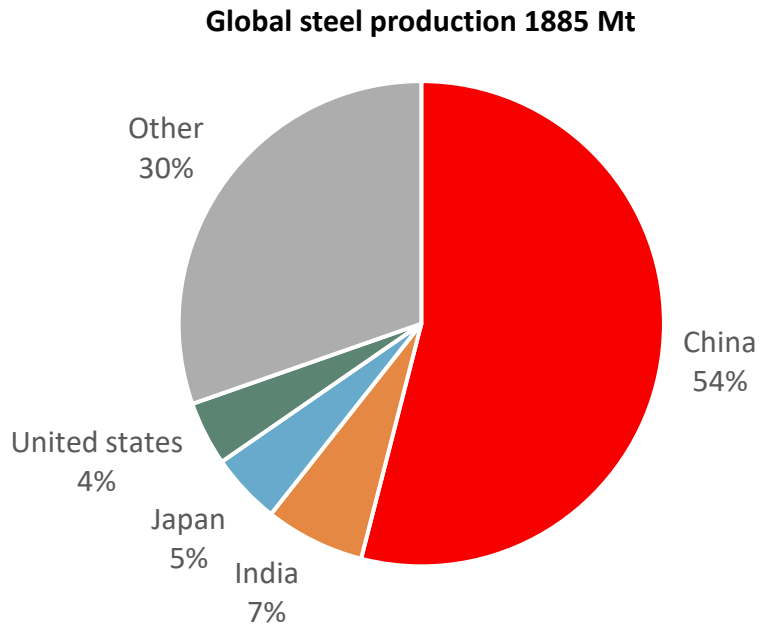
"One key focus of concern is that, as with other rig companies contracted to work offshore Norway, COSL has been granted access to an overview of the seabed in the areas where it will be working, including data for anchorage analysis and everything that lies on the seabed within a defined area."

- At the end of August 2023, Equinor awarded contracts to the Chinese contractor COSL. The process has sparked debate concerning giving a Chinese operator access to critical Norwegian infrastructure on the NCS.

* Do not include cold stacked rigs or rigs under construction.; ** AOC - Acknowledgement of compliance - Petroleum operations can be conducted by the mobile facility concerned in accordance with the regulations in Norway.
Source: Rystad Energy research and analysis; Rystad Energy OffshoreRigCube; Equinor; Upstream

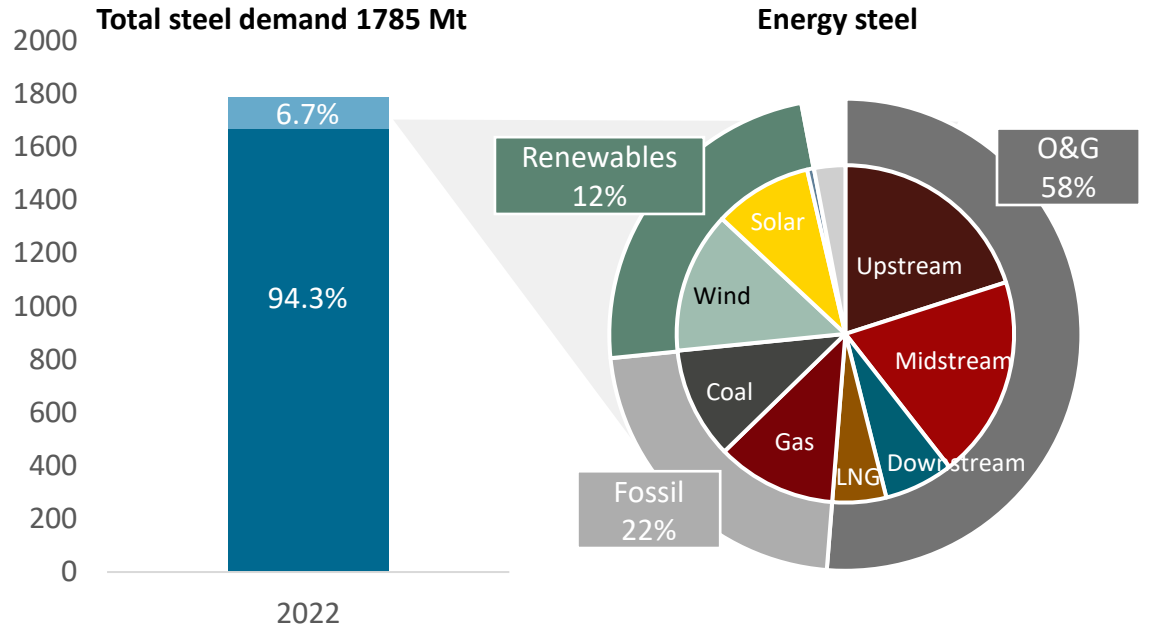
China dominates the steel market with more than half of total production in 2022

Global steel production sorted by biggest producing countries in 2022
Million tonnes



- As the graph shows China has more than half of the total steel production in the world.
- China is also a significant producer of other metals important for the energy transition, where China has more than 70% of the global production.

Total steel demand and energy steel split in 2022
Million tonnes

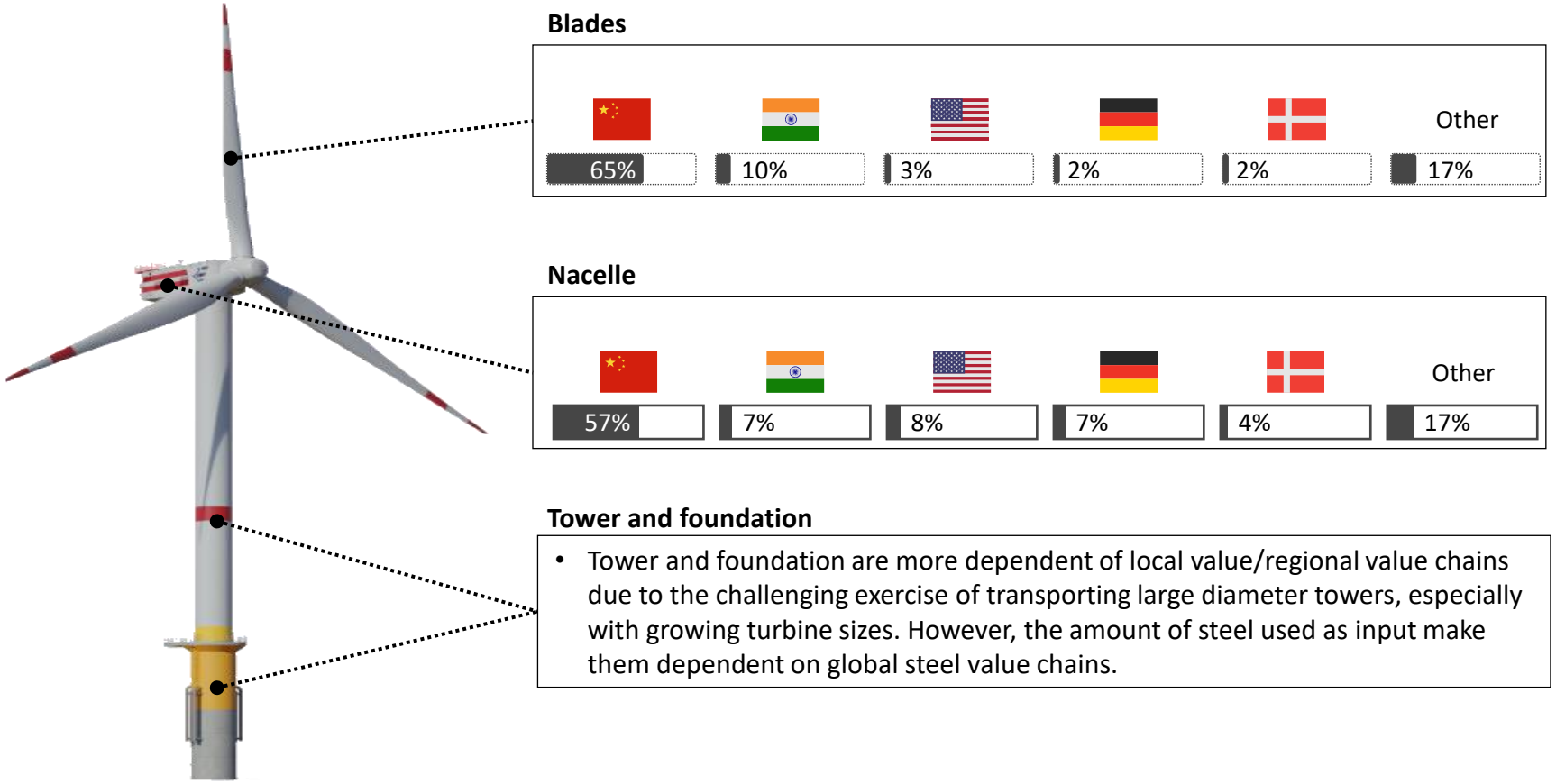


- As the graph shows, 7% of global steel demand in 2022 came from energy industries, and demand from renewables are expected to grow significantly in the next decades with the energy transition.
- The energy industry demand a large share of high-quality steel, which can be more exposed to price variations challenging low-margin renewable projects.

Source: Rystad Energy research and analysis; Rystad Energy Steel dashboard; World Steel

China dominates the supply chain of important parts along with steel production

Manufacturing capacity of key components divided by country
GW

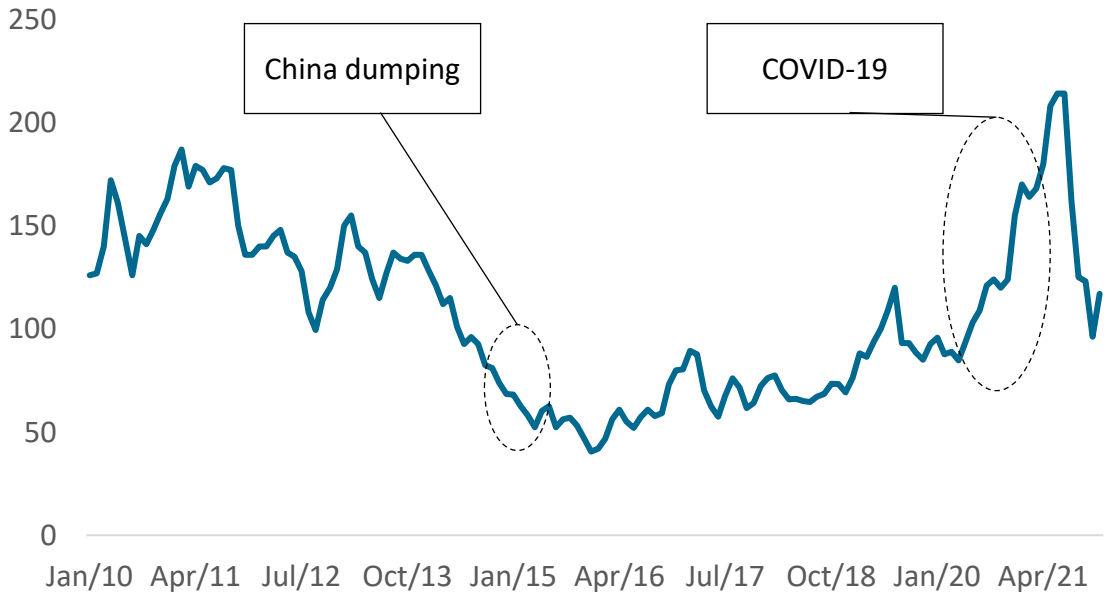


- Chinese producers has by far the largest market share of supply of both nacelle and blades, two important inputs to an offshore wind turbine.
- China also has a significant market share of production in other parts of the value chain, like rare earth elements that are used in the nacelles.
- For both the tower and foundation of the offshore wind turbines steel plays an important role where China has more than 50% of the global steel production.

Source: Rystad Energy research and analysis; Rystad Energy OffshoreWindCube

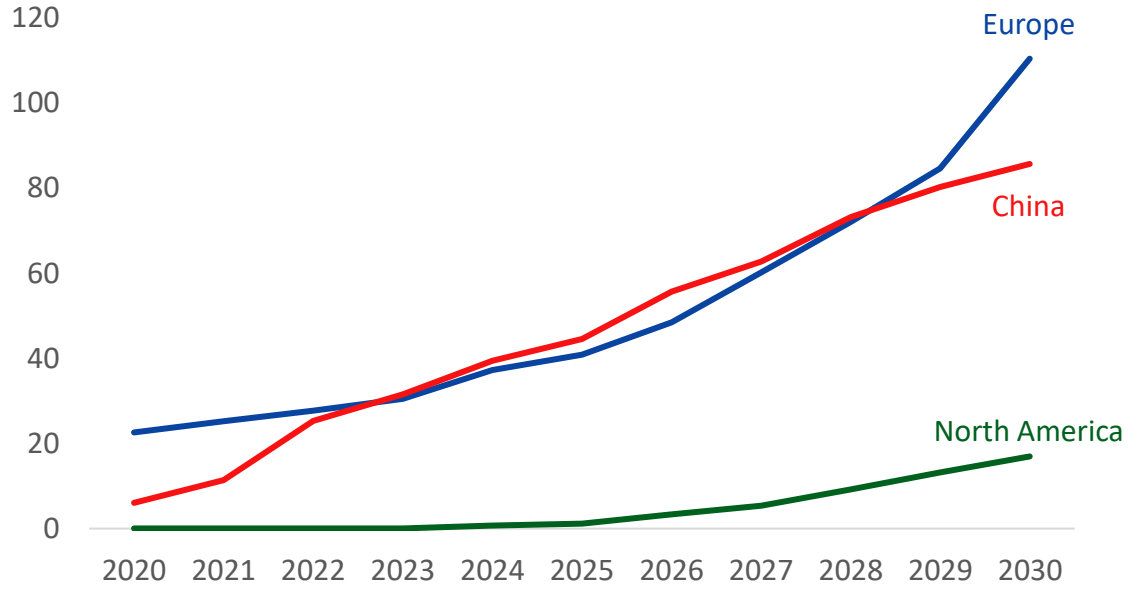
China's own plan to develop its offshore wind industry may interfere with the global market

Historical steel price 2010-2021
USD per Million ton (Dry)



- Recent steel market price fluctuations have been influenced by developments in China.
- The offshore wind industry have relatively slim margins and fluctuations in the steel price are very impactful for the profit of the industry.

Installed capacity of offshore wind in China and Europe
GW

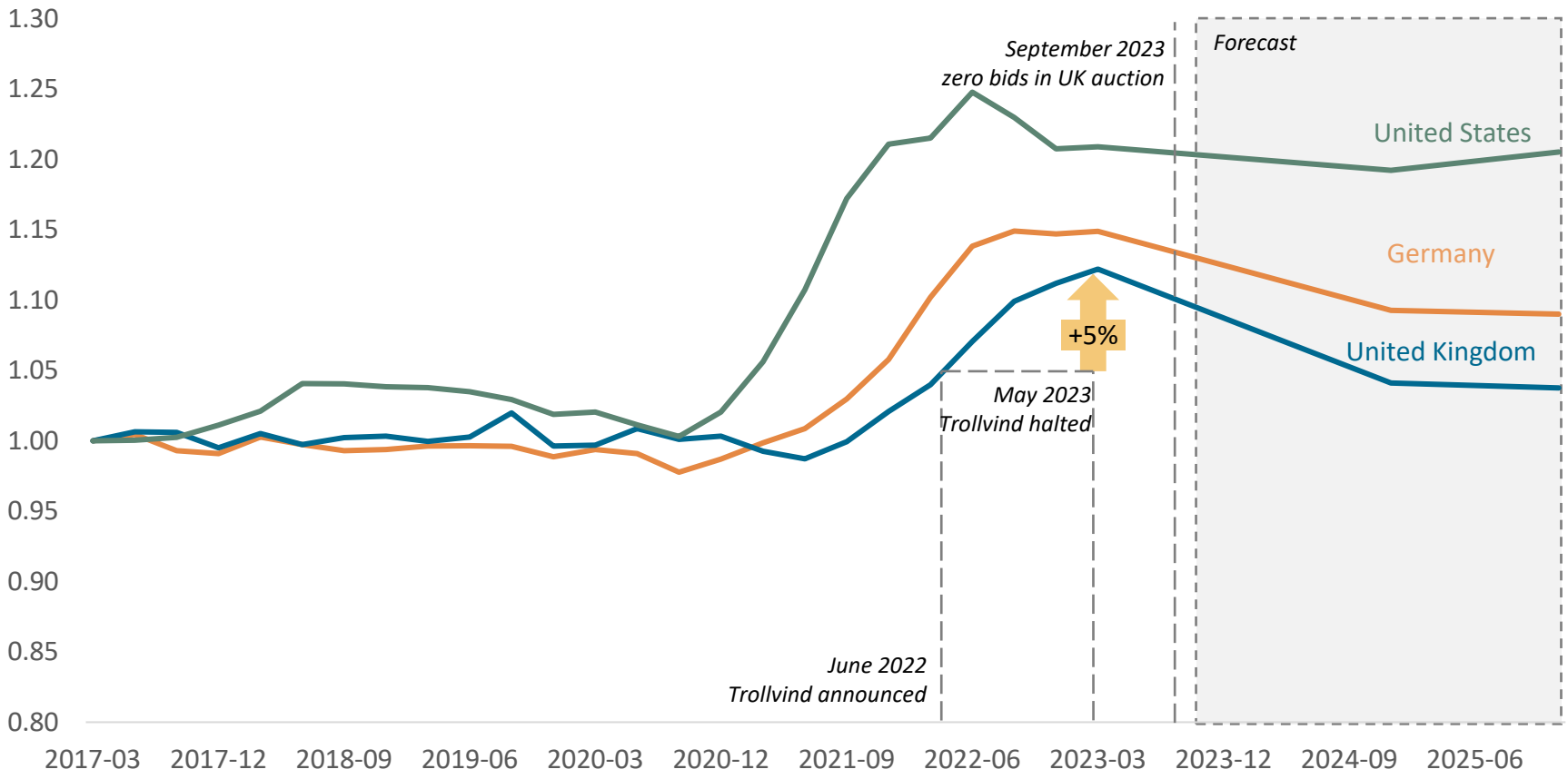


- China is along with Europe the fastest growing market for installed capacity in offshore wind.
- As China has the biggest concentration of the nacelle and blade production an escalation of the geopolitical situation could mean that they will focus on their domestic market which will put the global market at risk.

Source: Rystad Energy research and analysis; Rystad Energy OffshoreWindCube; WorldSteel

The offshore wind industry is hit by price increases all over the value chain

Offshore wind component price inflation
Average price inflation, indexed to 1 in March 2017

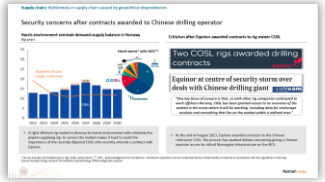
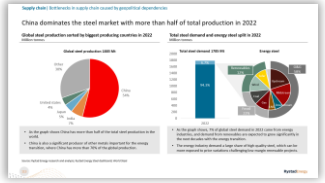
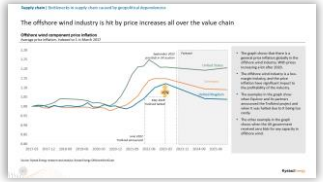


- The graph shows that there is a general price inflation globally in the offshore wind industry. With prices increasing a lot after 2020.
- The offshore wind industry is a low-margin industry, and the price inflation have significant impact to the profitability of the industry.
- The examples in the graph show when Equinor and its partners announced the Trollvind project and when it was halted due to it being too costly.
- The other example in the graph shows when the UK government received zero bids for any capacity in offshore wind.

Source: Rystad Energy research and analysis; Rystad Energy OffshoreWindCube

The renewable and the O&G industry may be increasingly more dependent on China in the future

Summary of the threat bottlenecks in supply chain caused by geopolitical dependencies

Key takes	Comments	Evaluation*	Exhibits
China's presence is hard to avoid in the rig market as seen in the recent debate with Equinor and COSL	• A limited supply of harsh environment semisubs in Norway in the future shows the need for Chinese market players. • The outcome of the Equinor - COSL debate may affect future market conditions.		
Geopolitical dependency is seen in the materials market where China is the most dominant steel producer globally	• The geopolitical dependency can be seen in the global steel market where China has more than 50% of the global production, China is also a significant producer of other important rare earth metals. • Energy steel demand accounts for 6.7% of global steel demand with renewables growing quickly. • Steel is used as example of an industry that O&G is exposed to, that also has a handful of important supplying countries. Other countries could expose a risk when looking at different materials.		
Sourcing of important parts in the offshore wind industry at risk due to China's own growth plans	• China is a major producer of important parts like nacelle and blades used in offshore wind turbines. Steel is also an important input. • Europe and China are the two fastest growing markets within the offshore wind industry. However, China could prioritize themselves making Europe's growth trajectory harder to achieve.		
Price inflation in the offshore wind industry is costly and leads to projects being cancelled. A sign that more capacity in the supply chain is needed to support the energy transition	• The offshore wind industry is a low-margin industry and the price inflation seen in the last years has contributed to several projects being halted or cancelled.		

* Overall evaluation depending on likelihood and impact if applicable, otherwise indicating severity.
Source: Rystad Energy research and analysis

RystadEnergy

Navigating the future of energy

Rystad Energy is an independent energy consulting services and business intelligence data firm offering global databases, strategic advisory and research products for energy companies and suppliers, investors, investment banks, organizations, and governments.

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