Report 2022
Norway

Havøygavlen wind power plant. *Photo: Marte Nyheim, NVE.*

Authors *Magnus Wold, NVE, Norway; Harald Rikheim, Norwegian Research Council, Norway; Birgit Hernes, Norwegian Research Council, Norway; Ann Myher Østenby, NVE, Norway.*

In 2022, 374 MW of new capacity was installed, resulting in a net total installed capacity of 5,073 MW by the end of the year.

The electrical energy produced by Norway's 65 active wind farms, including one offshore farm, was 14.8 TWh for 2022. This is an increase of 25% compared to the year before. The decrease in LCOE of wind power projects, alongside favourable depreciation rules and the final years of the electricity certificate scheme, are factors which have driven the more recent deployment of wind power in Norway. However, the closure of support schemes at the end of 2021, new taxation rules and lack of public acceptance have contributed to the declining support for additional onshore wind projects.

Both offshore and onshore wind power regulations are undergoing significant developmental processes. Several ongoing projects surround a licensing scheme for onshore wind power. Meanwhile,

Table 1. Key National Statistics 2022: Norway

Total (net) installed wind power capacity*	5.073 GW
Total offshore capacity	0.0059 GW
New wind power capacity installed	0.374 GW
Decommissioned capacity (in 2022)	0 GW
Total electrical energy output from wind	14.8 TWh
Wind-generated electricity as percent of national electricity demand	11.1%
Average national capacity factor**	35.7%
Target	N/A
National wind energy RD&D budget	12 million USD

a framework for commercial-scale offshore wind is under development. However, only technology demonstrations have been deployed offshore so far, of which Hywind Tampen is the largest (88 MW). Each project is still in progress throughout the end of 2022. The first CfD auctions for offshore wind are expected to be held in 2023. Similarly, the first onshore wind farms are expected to commence via the new licencing scheme in 2023.

Highlight(s)

- Wind energy generation increased by 25%.
- First power produced by Hywind Tampen, the world's largest floating offshore wind farm (88MW).
- Government ambition to allocate offshore areas for an additional 30 GW of wind power.

Market Development

Targets and Policy

As of now, Norway does not have any specific energy goals to meet or dedicated support mechanisms in place for wind energy development. However, the Norwegian government has an ambition of allocating offshore areas for wind power development that can facilitate an additional 30 GW of offshore wind. Through a phased approach to the project, it is planned to be completed by 2040. The exclusive rights to the first four phases will be given in 2023.

In addition, a highly successful joint support scheme with Sweden, which aimed to finance 28.4 TWh of new renewable energy production, ended in 2021, along with favourable depreciation rules. No new support mechanisms were introduced in 2022.

In 2019 the licensing process for onshore wind power was terminated. After a revision of the regulatory framework, the licensing process was reopened for new project applications in 2022 upon approval by the municipality of the project location.

Progress and Operational Details

The deployment of wind power in Norway increased dramatically in the last five years, making it the strongest growth on record. In 2022, 374 MW of new capacity was commissioned, all of which occurred onshore. Wind turbines installed in 2022 have nameplate capacities in the range of 2.35 MW to 5.7 MW, with the majority of them in the 4.3 MW to 5.7 MW range.

The Hywind Tampen project is excluded from the statistics as it is not connected to the grid. Upon completion, this project will be the world's largest floating offshore wind farm (94,6 MW). In 2022 seven out of eleven wind turbines were installed and the initial power produced was delivered on the 13th of November 2022 [3].

Regarding the 2022 financial costs of Norwegian onshore wind power, no data is available. However, according to real terms data from 2021, there was an increase in capital expenditure for new installations compared

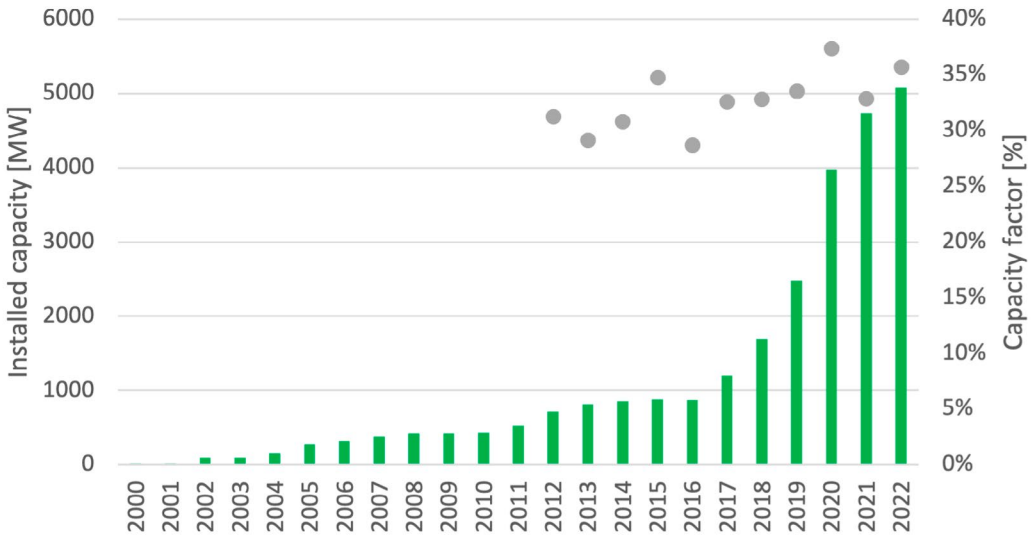

Figure 1: The columns represent accumulated onshore wind power capacity in Norway from 2000 – 2022. The dots represent the corresponding capacity factor in the given year.

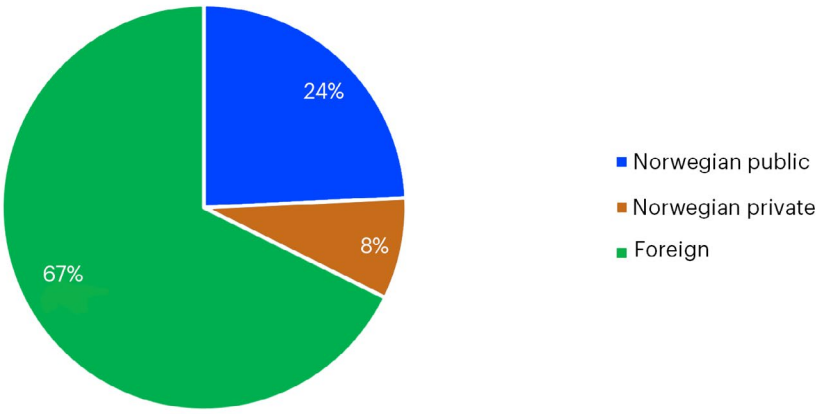

Figure 2: Ownership of Norwegian wind power installations based on average AEP [1].

to 2020 and 2019. Similarly, operating expenditure shows a slight increase from 2019 towards 2021. This trend is expected to continue into 2022.

The majority of Norwegian wind power assets are owned by foreign investors. This trend has expanded from 62% of the fleet in 2019 to 67% in 2022 [1].

Matters Affecting Growth and Work to Remove Barriers

Public acceptance of onshore wind power in Norway has been an issue for several years. This problem has persisted through the European energy crisis and does not show signs of weakening in the near future. A consequential example of this resistance is the Fosen ruling. In this case, the Norwegian Supreme Court ruled that two licenses for wind power development were invalid because the construction violates the Sami reindeer herders' right to practice their culture [6].

This lack of public acceptance has effectively decelerated and stopped the expansive deployment seen in the previous five years to the point where little new onshore deployment is expected towards 2030. It has furthermore led to the licensing scheme for onshore wind power to be reworked. The outcome of this revision will be a parallel licensing process which will include the planning and building act and will likely render licensing increasingly cumbersome and time-consuming for onshore wind power.

As a result of challenges in public acceptance, there has been a significant shift in policy concerning wind power in Norway. In 2021, support schemes and favourable depreciation rules aimed to aid the continued development of the industry. This changed in 2022 to new taxation proposals which specifically inhibit the development of onshore wind power.

The proposed taxation changes are as follows:

- A doubling of the production tax, introduced in 2021, from 1 Øre/kWh to 2 Øre/kWh (1.9 EUR/MWh; 2.08 USD/MWh) [7].
- A tax on natural resources for onshore wind power of 1.3 Øre/kWh (1.235 EUR/MWh; 1.35 USD/MWh) [7].
- A ground rent tax of 40% on onshore wind power [7].
- A temporary windfall tax for onshore wind power of 23% on power sales exceeding power prices of 70 Øre/kWh (66.5 EUR/MWh; 72.73 USD/MWh) [8].

All taxes are suggested to be introduced in 2023. However, they are still subject to change.

Furthermore, the production tax and natural resource tax will be deductible from the ground rent tax. In essence, the overall climate supporting new onshore wind power has become significantly less accommodating.

RD&D Activities

Several public actors help enable RD&D activities in Norway. The Research Council of Norway administers ENERGIX, which is their public research program for sustainable energy. The program covers renewable energy, energy efficiency, energy systems, and sustainable transport from sources such as hydrogen, fuel cells, biofuels, and batteries. Additionally, industry, research institutes, and universities may receive funding for their research based upon proposals to regular calls. Furthermore, Enova offers capital grants for full-scale demonstration projects of ocean renewable energy production, including offshore wind. The Hywind Tampen project is included among these. While up to 50% of eligible costs can be covered, Enova's funding measured in absolute figures is limited. Finally, Innovation Norway runs a program supporting prototypes within environmentally friendly technology, of which wind energy is included. Projects are supported with up to 45% of their eligible costs.

National R,D&D Priorities and Budget

The Norwegian national strategy for research, development, demonstration, and commercialisation of new energy technology is named Energi21. This strategy was revised in 2022. Selected key research and innovation areas in this strategy surround offshore wind, these are:

- Offshore wind power plants: Efficient production, installation, operation, and maintenance of floating and fixed turbines. As well as methods and technology for cutting costs.
- Offshore infrastructure and integrated systems: Flexible grids with scaling opportunities and solutions for system integration and interaction with storage, production, and transmission technologies.
- Market design and legal issues: Design of energy auctions and tenders and interaction between production onshore and offshore.
- Environment and society: Methods for investigating and assessing environmental impacts, area and resource management, as well as offshore planning and overall effects.
- Digitalisation and cyber security: Weather monitoring and prediction models, interaction with the energy system, system security, and big data management.

The prementioned ENERGIX program had a budget of 540 million NOK (51 million EUR; 55 million USD) in 2022. The budget for 2023 is expected to be of a comparable size. In total, the Research Council granted 117 million

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NOK (11 million EUR; 12 million USD) to wind energy research in 2022.

The following R&D projects were granted funding through ENERGIX in 2022:

- Secure operation of wind farms in winter climates by Norconsult AS.
- Yaw control of single-point moored floating wind turbines by Salar AS.
- Adaptive control for robotic prefabrication by Aker Solutions AS.
- WindBarge: Low-cost floating wind energy production by GFMS AS.
- 4SWIND: Advancing seismic seabed survey techniques and optimising site-selection for offshore wind farms by the University of Bergen.

In 2020, NorthWind was established. This centre for offshore wind will be run by Sintef Energy and has 20 industrial partners along with five academic partners. The centre has obtained a grant for eight years and a yearly budget of approximately 44 million NOK (4.4 million EUR; 5.0 million USD). Public funding constitutes 50% of the budget.

National Research Initiatives and Results

No research projects came to fruition in 2022. Nevertheless, several knowledge-building projects (KSP) were initiated at Norwegian research institutions which have significance for offshore wind development. The projects are realised through funding from the ENERGIX programme. These are large research projects with budgets of 20-25 million NOK, a duration of 4-5 years and include the education of PhD students.

The following KSP-projects started in 2022:

- VisAviS: This project concerns the development of a bird migration visualisation tool to facilitate impact assessments of coastal and offshore wind projects. It aims to support the sustainable development of these projects. Duration: 2022-2026. Project lead: NINA.
- SeaConnect: This project looks at high-voltage subsea connections for resilient renewable offshore grids. It will develop new materials and designs for the subsea components that currently have the highest risk of failure in offshore power grids. It also aims to increase the breakdown voltage and service life for subsea cable terminations and connectors. Duration: 2022-2026. Project lead: SINTEF Energy Research.
- WindSys: This project will assess the impact of floating wind farms on marine life and look at co-existence with the fishing industry. Its focus lies on the impacts of the placement of wind turbines at sea on pelagic fish. Duration: 2022-2025. Project lead: NINA.
- Grid (in Norwegian: Havnett): This Green Platform project will develop new technology, knowledge, and solutions to enable the profitable development of offshore wind in Norwegian waters. This includes how to connect power from offshore wind to the existing grid concerning both bottom-fixed and floating wind farms. It includes a KSP led by SINTEF Energy Research. Duration: 2022-2024. Project lead: Equinor. Green Platform is a financing scheme supported by several Norwegian governmental organisations that support RD&D.

Test Facilities and Demonstration Projects

The Hywind Tampen floating offshore wind farm was partially completed and delivered its first power in 2022. The 88 MW wind farm will supply five offshore oil platforms with approximately 35% of their annual electricity demand [9]. The project pioneers the use of offshore wind energy combined with gas turbines to supply offshore installations with electricity.

Collaborative Research

In 2022, Norwegian actors participated in collaborative research through the following IEA Wind Tasks:

Task 11: Base Technology Information Exchange, Task 19: Wind Energy in Cold Climates, Task 25: Power Systems with Large Amounts of Wind Power, Task 30: Offshore Code Comparison Collaboration Continuation with Correlation (OC5), Task 33: Reliability Data, Task 34: WREN, Task 37: Wind Energy Systems Engineering, Task 43: Digitalisation, Task 44: Wind Farm Control, Task 45: Recycling Wind Turbine Blades, Task 46: Erosion of Wind Turbine Blades, Task 48: Airborne Wind Energy, Task 49: Integrated Design of Floating Wind Arrays, Task 50: Hybrid Power Plants and Task 53: Wind Farm Economics.

Impact of Wind Energy

Environmental Impact

In 2022, Norway had an electrical energy production of 146 TWh, where wind and hydropower produced 98% of total power output. The Norwegian electrical energy consumption constituted 133.4 TWh, while 12.5 TWh were exported to other countries. Hence, new electricity generation from wind power does not displace electricity produced from fossil fuels in Norway. In that regard, new wind power capacity has a limited direct effect on greenhouse gas emissions from electricity generation in Norway. Nevertheless, larger

volumes of affordable renewable energy, coupled with CO2 reduction targets, are driving further electrification of transport and industry. These furthermore represent the sectors responsible for the majority of Norwegian fossil fuel consumption. Due to the electrification of these sectors, and the establishment of new industry, Norwegian power demand is expected to increase. Considering its resource abundance and the relatively low LCOE of onshore wind power, both onshore and offshore wind power is well suited to meet that rise in demand. However, the public concern tied to the impact of wind power development on the local environment, which led to the stop in licensing of onshore wind power in 2019. This still limits the organisation for new onshore projects.

Economic Benefits and Industry Development

The economic turnover in the Norwegian wind industry in 2021 was 3.8 billion EUR (4.2 billion USD), where 27.5% was attributed to onshore wind power and 72.5% to offshore wind power. The two sectors required approximately 2,300 and 4,300 man-years, respectively [2]. Numbers for 2022 are unavailable.

Several industry opportunities regarding offshore wind have been identified, especially in the floating offshore wind industry. For example, companies with experience in the offshore oil and gas industry have broadened their scope of interest and increased their engagement with the offshore wind industry. These companies usually offer expertise in marine operations, offshore structures, mooring solutions, logistics, consulting, among others. Some notable companies include Equinor, Fred. Olsen Windcarrier, and Aibel. Equinor develops, owns, and operates offshore wind farms. Fred. Olsen Windcarrier account for the installation of 20% of offshore wind turbines globally, excluding China [4]. Aibel was awarded the contract for HVDC platforms for the Dogger Bank projects by Equinor, among others. The project management and completion for these will take place in Haugesund, Norway. These platforms are dedicated to the first unmanned HVDC substations to be made [5]. Furthermore, there are opportunities for offshore cable manufacturing facilities in Norway, such as Nexans Norway in Halden.

Next Term

The recent regulatory work is anticipated to commence for both onshore and offshore wind. The new licensing process for onshore wind will be set into effect, and new projects will be presented. The first auctions, as well as the allocation of offshore projects, will be completed. Additionally, four projects will be given exclusive rights within the areas previously opened for offshore wind. These projects will add 3,000 – 3,750 MW of additional capacity, comprising of three floating offshore wind projects and one bottom fixed project. In the near future, the installation of new onshore capacity is expected to be very limited.

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Sørfjord wind power plant #1. *Photographer: Catchlight, NVE*.

Sørfjord wind power plant #2. *Photographer: Catchlight, NVE*.