



Report 2023

Norway

Øyfjellet wind power plant. Photographer: Stig Storheil, NVE.

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Wind power deployment in Norway has effectively paused in 2023 compared to recent years. The result is 14 MW of new installed capacity in 2023 and a net total installed capacity of 5,083 MW at the end of the year.

The standstill was driven by the lack of public support for onshore wind power that caused a pause in licensing from 2019 until 2022 and a shift from incentives to taxation.

The electrical energy produced by the 65 active wind farms – one of which is offshore – in 2023 was 14 TWh. That is a decrease of 5.4% compared to the year before, pri-

marily caused by fluctuations in the wind resource.

Highlight(s)

- Hywind Tampen was fully commissioned. This is currently the world's largest floating offshore wind farm with a system capacity of 88 MW and an installed

Table 1. Key National Statistics 2023: Norway

Total (net) installed wind power capacity	5.083 GW
Total offshore capacity	0.006 (0.01) GW
New wind power capacity installed	0.014 GW
Decommissioned capacity (in 2023)	0.004 GW
Total electrical energy output from wind	14 TWh
Wind-generated electricity as percent of national electricity demand	9.1%
Average national capacity factor	32.3%
Target	N/A
National wind energy RD&D budget	17.6 mill. EUR

turbine capacity of 94.6 MW. The wind farm is not grid connected.

- 20 new areas for offshore wind have been identified by the government.

Market Development

Targets and Policy

The Norwegian government has set an ambition of allocating offshore areas for wind power development that can facilitate 30 GW of deployment of offshore wind. The allocation shall be made stepwise and completed by 2040. The exclusive rights to the first project will be given through a CFD auction in Q1 2024. In line with this ambition, 20 suitable areas for offshore wind have been identified. These areas are going through a strategic impact assessment and will be ranked by attractiveness. Two areas have previously been opened and are in the process of being allocated.

There are no specific targets for onshore wind power in Norway.

Progress and Operational Details

In 2023, there was a modest fourteen megawatts of new installed capacity. The net total installed grid connected capacity in Norway was 5,083 MW at the end of the year. The electrical energy produced by this installed capacity was 14 TWh, this was 9.1 percent of Norwegian power production. This is a decrease of 5.4 percent in production compared to the year before. The overall share of wind power in Norwegian power production decreased by one percentage point in overall Norwegian power production. The decrease was primarily caused by lower-than-normal wind resources. The value factor of Norwegian wind power in the electricity market was 0.92 and the capacity factor was 32 percent in 2023.

There were 65 active grid connected wind farms, where one is placed offshore and consists of two floating demonstrator turbines. In addition, there is Hywind Tampen which is a floating wind farm that is connected to oil and gas infrastructure. Hywind

Tampen has eleven turbines and an installed capacity of 94.6 MW.

Unfortunately, there is no cost data available for 2023. In real terms, 2022 cost data shows an increase in LCOE of 8.1 percent since 2020. This trend is expected to have continued in 2023. These numbers are based on wind farms commissioned in the given year, and as such do not represent the cost at the time of the financial investment decision and therefore show a significant lag in time compared to market data.

Matters Affecting Growth and Work to Remove Barriers

The lack of public acceptance for onshore wind has effectively slowed down and stopped the considerable deployment seen in the previous five years, to the point where very little new onshore deployment is expected towards 2030. It has also led to a rework of the licensing scheme for onshore wind. The outcome of this work is a parallel licensing process that includes the planning and building act and the energy act. The

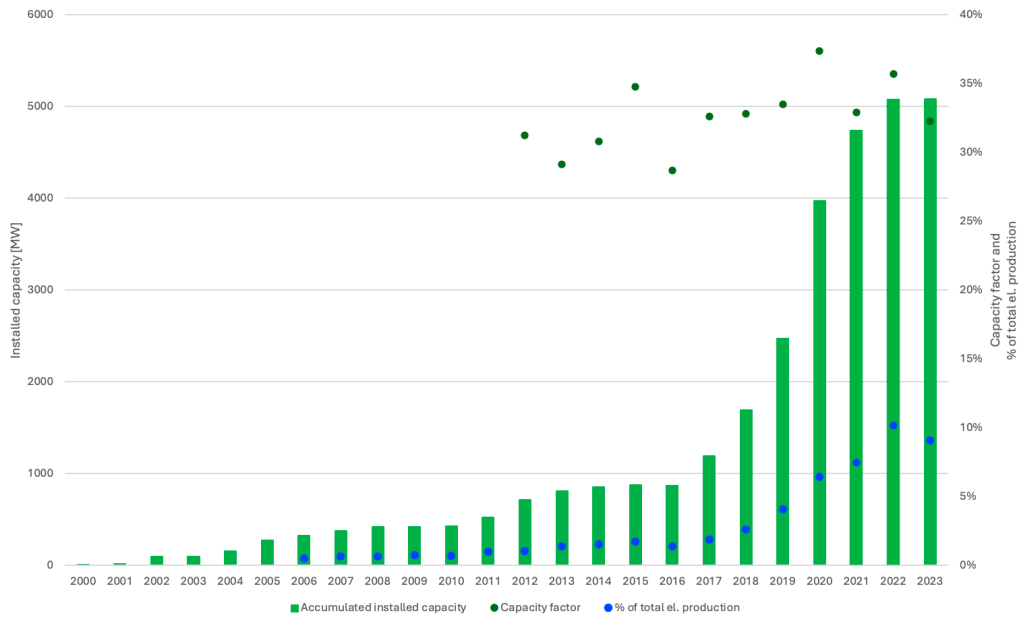


Figure 1: Accumulated installed capacity, capacity factor and percentage of total electricity production for Norwegian wind power.

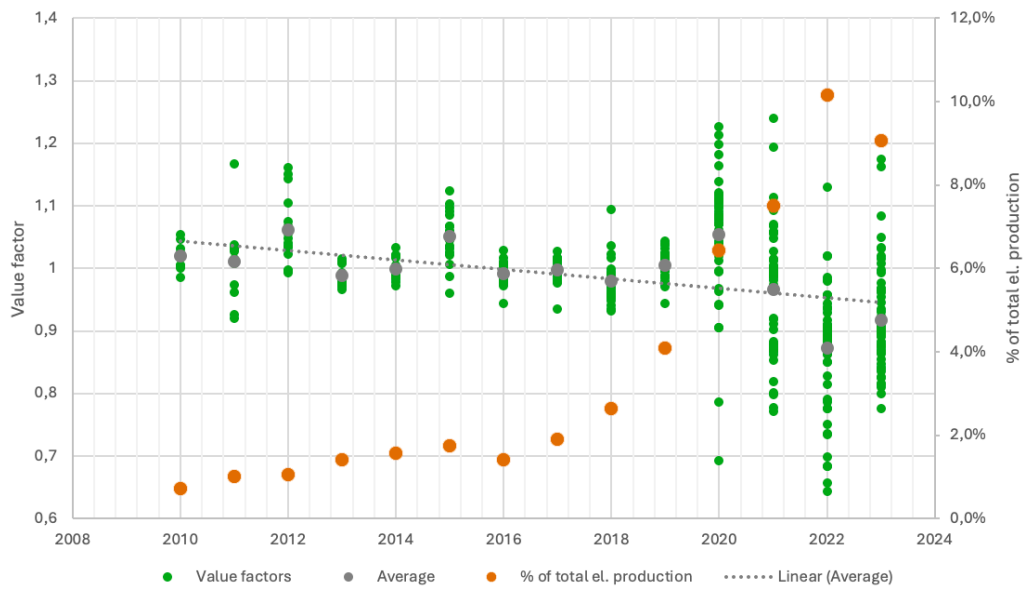


Figure 2: Value factors from electricity market and percentage of total electricity production for Norwegian wind power plants.

change effectively gives the municipalities veto power and makes licensing in general slower for onshore wind power.

In 2021, a consequential court case presented for the Norwegian Supreme Court ruled that two licenses for wind power development were invalid because the construction violates Sami reindeer herders' right to practice their culture [9]. This conflict has now been resolved by mediation and a compromise where alternative areas for the reindeers are made available, a financial compensation is given, and the herders get veto powers over possible repowering of the sites at the end of the concession period [10].

There has been a large shift in policy on onshore wind power going from support schemes and favourable depreciation rules to taxation. The following taxation changes are now in effect:

- A ground rent tax of 32.1 percent with an effective rate of 25 percent on onshore wind power, effective by the 1st of January 2024 [13].
- An increase in the production tax introduced in 2021 from 2 Øre/kWh (1.9 EUR/MWh; 2 USD/MWh) in 2023 to 2.3 Øre/kWh (2.2 EUR/MWh; 2.3 USD/MWh) in 2024 [12]. This will be deductible from the ground rent tax.
- Normal corporate income tax of 22 percent.

The introduction of the ground rent tax can affect investor confidence in future Norwegian wind power projects.

Following the energy crisis of 2022, a temporary windfall tax for onshore wind power of 23 percent on power sales exceeding power prices of 70 øre/kWh (66.5 EUR/MWh; 71.4 USD/MWh) was introduced, this tax was ended on the first of October 2023 [11].

RD&D Activities

The Research Council of Norway administers a public research program for sustainable energy, ENERIGX. This program covers renewable energy, energy efficiency, energy systems, and sustainable transport (hydrogen, fuel cells, biofuels, and batteries). Industry, research institutes, and universities can receive funding for their research based upon proposals to regular calls.

Enova, a state enterprise, offers capital grants for full-scale demonstration projects of ocean renewable energy production including offshore wind. While up to 50% of eligible costs can be covered, Enova's funding measured in absolute figures is limited. Innovation Norway runs a program supporting prototypes within environmentally friendly technology. Wind energy is included in this definition. Projects are supported with up to 45% of eligible costs.

National RD&D Priorities and Budget

Energi21 is the Norwegian national strategy for research, development, demonstration and commercialisation of new energy technology.

Selected key research and innovation topics are:

- *Offshore wind power plants* – efficient production, installation, operation and maintenance of floating and fixed turbines, methods and technology for cutting costs.
- *Offshore infrastructure and integrated systems* – flexible grids with upscaling 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 and 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 budget for the **ENERIGX** program (see above) in 2023 was NOK 540 million (EUR 51 million; USD 55 million) and the same budget is expected in 2024. In total, the Research Council granted NOK 186 million (EUR 17.6 million; USD 19 million) to wind energy research in 2023. In 2023, the ENERIGX program granted funding to the following wind energy R&D projects:

- Nylon ropes for mooring of floating wind turbines, Sintef Ocean (Competence building project).
- Bottom Fixed Offshore Wind Turbines in Extreme Waves, Sintef Ocean (Competence building project).
- WINDREG - Offshore wind and regional futures: Challenges and opportunities for energy justice in regional transitions, University of Agder, (Competence building project).
- Impacts of wind turbines on flying nocturnal wildlife, NMBU, (Competence building project).

ENOVA launched a competition for allocating of up to 2 billion NOK (190 million EUR; 204 million USD) to small-scale commercial floating wind projects. The funds were won by GoliatVind for a 75 MW demonstrator project, similar to Hywind Tampen but with the aim of utilising a semi-sub foundation and 15 MW turbines.



Photo 1: Tellnes wind power plant. *Photographer: Simon Oldani, NVE.*

National Research Initiatives and Results

FME NorthWind – the Norwegian Research Centre on Wind Energy – is a research cooperation co-financed by the Research Council of Norway, industry, and research partners. The Centre started in June 2021 and is scheduled to continue for 8 years with a total budget of about NOK 350 million (EUR 33.3 million; USD 35.7 million), of which NOK 120 million (EUR 11.4 million; USD 12.2 million) is from the Research Council of Norway. The Centre is hosted by SINTEF and includes research partners, NTNU (Norwegian University of Science and Technology), UiO (University of Oslo), NGI (Norwegian Geotechnical Institute), NINA (Norwegian institute for nature research) and additional international partners.

Research and innovation are carried out by the research partners in collaboration with 43 industry partners, covering the full value chain of the Norwegian wind industry including developers and energy companies, supply industry and service companies. The Centre also includes a PhD

programme and educational activities at a bachelor and master's level, carried out by the university partners.

In 2023, NorthWind engaged an external consulting firm, Impello, to analyse the innovations in development so far with regards to maturity, potential for commercialisation and benefit to the industry. The industry partners are engaged in the work through participation in specific user studies enabling them to use and develop knowledge and innovation from the Centre in their activities.

30 innovations, ranging from TRL 1 to 6, have been identified. Examples include hybrid welding (Aker Offshore Wind and Aibel), wind farm design optimisation (Norconsult) and digital twin technology (DNV). Examples also include tools for LCA-assessment and models for diffusion and innovation of offshore wind technology. The assessment of the innovations forms the basis for further prioritisation of the continued research to bring the innovations towards industrial use.

Test Facilities and Demonstration Projects

The Norwegian Marine Energy Test Centre (MetCentre) – already housing two floating wind turbine demonstrators – was rewarded a license to increase their allowed installed capacity to 82.7 MW and a new grid connection with 66 kV transmission voltage. A part of this grid connection shall be a subsea collector provided by Aker Solutions. This will be the world's first of its kind, providing a subsea grid connection point for the planned expansion of the test center [6].

The Hywind Tampen floating offshore wind farm was completed in 2023. The wind farm has a system capacity of 88 MW, but the turbine capacity was increased to 94.6 MW. The wind farm will supply five offshore oil platforms with approximately 35% of their annual electricity demand. The project pioneers the use of offshore wind energy combined with gas turbines to supply offshore oil installations with renewable electricity. It is currently the largest floating offshore wind farm constructed [7].

Collaborative Research

In 2023, 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 34: WREN - Working Together to Resolve Environmental Effects of Wind Energy (WREN).
- Task 43: Wind Energy Digitalisation.
- Task 44: Flow Farm Control.
- Task 45: Recycling of Wind Turbine Blades.
- Task 46: Erosion of Wind Turbine Blades.
- Task 48: Airborne Wind Energy.
- Task 49: Integrated Design on Floating wind Arrays (IDEA).
- Task 50: Hybrid Power Plants.
- Task 53: Wind Energy Economics.

Impact of Wind Energy

Environmental Impact

In 2023, the Norwegian electrical energy production was 154 TWh, where wind and hydro power produced 98% of total power output. The Norwegian electrical energy consumption was 136 TWh, and there was 17 TWh of net export to other countries [2]. This means that new electricity generation from wind power does not, to a large extent, displace electricity produced from fossil fuels in the Norwegian electricity supply. In 2022, the calculated CO₂ emissions for electricity used in Norway was 19 g CO₂ per kWh [3]. Therefore, the direct effect of new

wind power capacity on greenhouse gas emissions from electricity generation in Norway is limited. On the other hand, Norwegian total energy consumption still consists of approximately 50 percent fossil fuels [4], and larger volumes of affordable renewable energy coupled with CO₂ reduction targets helps to drive the electrification of transport and industry. These are the sectors responsible for most of Norwegian fossil fuel consumption. Norwegian power demand is expected to increase due to this electrification of transport and industry, along with the establishment of new energy intensive industries. Wind power, onshore and offshore, is well suited to meet that rise in demand, based on resource availability and the relatively low LCOE of onshore wind power. However, there are high levels of concern and resistance in the public tied to onshore wind power development's impact on the local environment.

Economic Benefits and Industry Development

The latest available evaluation of the economic impact from wind energy in Norway is based on the year 2022. Revenue from wind energy related businesses that year was NOK 44.7 billion (EUR 4.2 billion; USD 4.6 billion), where NOK 34.4 billion (EUR 3.3 billion; USD 3.5 billion) came from the offshore sector and NOK 10.4 billion (EUR 1 billion; USD 1.1 billion) were from the onshore wind sector. The domestic revenue where NOK 7.5 billion (EUR 713 million, USD 765 million) and NOK 5.3 billion (EUR 504 million; USD 541 million) for the offshore and onshore business respectively. This activity generated 7,061 man-years, 68 percent of which were in the offshore sector. The offshore wind sector saw an increase in revenue by 18 percent while the land-based sector saw a decrease of 29 percent in revenue, compared to 2021 [1].

We see several industry initiatives focused on offshore wind. Companies with experience in the offshore oil and gas industry have widened their scope of interest and increased their

engagement with the offshore wind industry. These companies normally offer expertise in marine operations, offshore structures, mooring solutions, logistics, consulting, and more. Some notable companies are Equinor, Fred. Olsen Windcarrier and Aibel. Equinor develops, owns and operates offshore wind farms. Fred. Olsen Windcarrier have installed 20% of offshore wind turbines globally – excluding China [8]. Aibel is an EPCI contractor for offshore substations that cooperates with Hitachi to deliver HVDC platforms for the Dogger Bank projects and Dolwind Epsilon for Tennet.

Fitting of the electrical infrastructure is performed in Haugesund, Norway. The Doggerbank offshore substations are the first unmanned HVDC substations to be made [5]. There are also offshore cable manufacturing facilities in Norway, such as Nexans Norway in Halden.

Next Term

The first auction and allocation of an offshore project was completed in 2024. In 2025, three floating offshore wind projects will be given exclusive rights within the Utsira Nord area, pending ESA approval of the subsidy scheme. One bottom fixed project in the Sørilige Nordsjø II area was up for auction in Q1 2024 with a strike price of 99 EUR/MWh (115 øre/kWh). These projects represent 3,000 MW. In the short term, new onshore wind capacity is expected to be very limited.

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