Report 2021

Finland

Lakiakangas wind farm (in Isojoki municipality) will operate 20 wind turbines with 145m hub height and 150m diameter. It is a representative modern wind farm in Finland. *Photo: Ville Suorsa and the Finnish Wind Power Association*

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The year 2021 showed a sustained boom in wind power installations. The boom of wind deployment in Finland continues with 671MW new capacity in 2021, more than doubling the capacity additions from the previous year. The cumulative wind capacity at the end of 2021 increased by 26%, reaching 3,257MW

THE WIND SHARE of electricity consumption stayed at 9.3%, similar to the previous year's 9.6% ([2] Finnish Energy (12.01.2022) "The energy year 2021". Energiateollisuus). Wind generated electricity reached 8.2TWh, a 5% increase compared to the previous year despite the 26% increase in capacity. The reason is the relatively normal year in terms of wind power index (0.98, close to the long term average of 1.00), compared to the exceptional previous year (index 1.17, meaning 17% over the long term average), which has compensated for the new wind capacity made available ([3] Finnish Meteorological Institute (5.4.2022), Wind and wind power indices in Finland for 2016-2021 based on ERA-5 100-meter wind speed.).[HH1]

In 2021 Finland consumed 86.5 TWh of electricity, similar to pre-pandemic 2019 (86.1TWh). This represents a recovery from the 6% drop in electricity demand registered in 2020 due to the pandemic.

Table 1. Key National Statistics 2021: Finland

Total (net) installed wind power capacity*	3.257 GW
Total offshore capacity	0.073 GW
New wind power capacity installed	0.671 GW
Decommissioned capacity (in 2021)	0 GW
Total electrical energy output from wind	8.19 TWh
Wind-generated electricity as percent of national electricity demand	9.3%
Average national capacity factor**	32%
Target	51% RES in 2030
National wind energy R&D budget	0.58 million EUR (2021)

*Installed wind power capacity: Use nameplate power ratings of the installed wind turbines

Highlight(s)

The year 2021 saw a new record in wind installations with 671MW added capacity, more than double the previous year. The wind deployment boom is in full swing with double-digit growth in new capacity for the third year.

Wind farms are gradually getting bigger, with the average wind farm using 13 wind turbines, each with a capacity 4.5MW. Larger turbines and high towers allow the rotor to emerge above the forest canopy and capture high wind resources.

Market Development

Targets and Policies

The existing target sets a 51% share of RES of Finland's gross final energy consumption in 2030. In connection with this target, the estimated share of electricity consumption from renewables (RES-E) will increase to 50% in 2027 and 53% in 2030 ([4] Ministry of Economic Affairs and Employment. "Finland's Integrated Energy and Climate Plan" (20.12.2019). https://julkaisut.valtioneuvosto.fi/handle/10024/161977).

The target to reach carbon neutrality by 2035 was already set in 2019 by the government. In connection with this target, the government has proposed ([5] Ministry of Environment press release (3.3.2022) https://valtioneuvosto.fi/en/-//1410903/new-climate-change-act-to-be-submitted-to-parliament-carbon-neutrality-target-2035-included-in-the-act-emission-reduction-targets-for-coming-decades-as) to reform the Climate Change Act by setting emission reduction targets -60% in 2030, -80% in 2040 and -90% in 2050, all versus 1990.

Criticism of government plans by members of the parliament refers to (i) economic impact as a result of tax losses, (ii) effect of increased fuel prices in the context of Russia's military action, and (iii) inequality of citizens due to increases in the price of necessities ([6] Finnish Parliament, Opinion of the Committee TaLV 19/2022 https://www.eduskunta.fi/FI/vaski/Lausunto/Sivut/TaVL_19+2022.aspx).

Further, a working group on energy taxation aims at increasing taxes levied on heating fuels, including peat and fossil fuels, and at discontinuing the energy tax rebate for energy intensive industries, among other measures ([7] " Report of the working group on energy taxation reform: A proposal for implementing the intentions and goals of the Government Programme and for further development of energy taxation " VN/11347/2019 http://urn.fi/URN:ISBN:978-952-367-508-7).

Progress and Operational Details

The newly installed wind turbines reach 150m diameter and 150m hub height ([1]). The industry has overcome size and logistics challenges for this size of turbines, which suit well the Finnish landscape with forested areas in flat terrain and gentle hills. The 70+ meter full-sized blades have routinely been transported across the country.

The average capacity factor in 2021 was 31.9%, similar to [HH1] the average in the period 2018-2021, namely 33.2%.

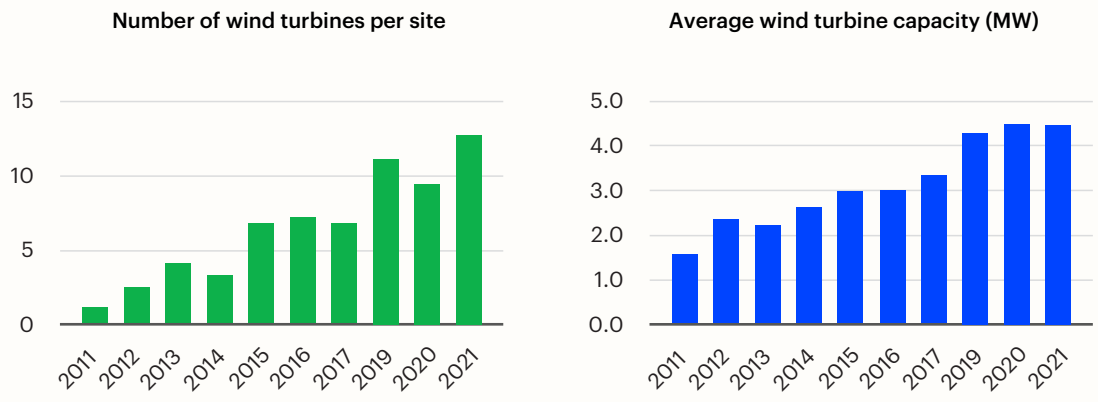

Figure 1. Turbine and wind farm sizes are gradually increasing in Finland [1].

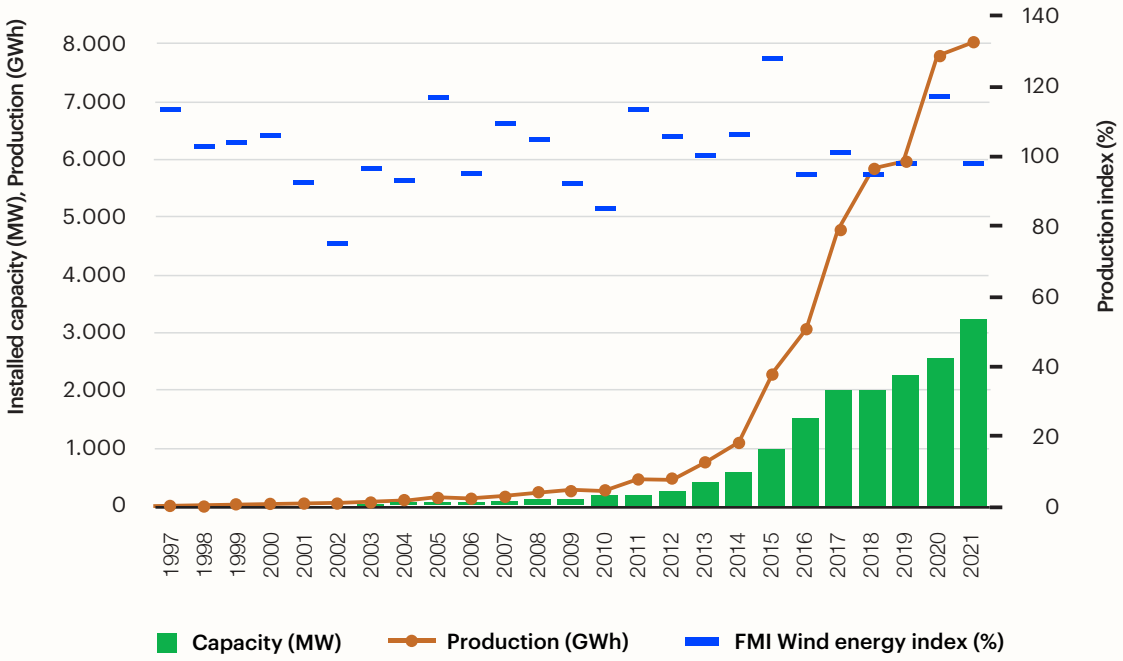

Figure 2. Development of wind power capacity and production in Finland. The wind power index gives the yearly generation compared to the long-term average (100%) provided by the Finnish Meteorological Institute (FMI).

Matters Affecting Growth and Work to Remove Barriers

The demand for wind power continues to be strong in Finland, but installations progressed slower than originally anticipated due to several reasons, including the pandemic context, which affected the availability of workforce and components ([8] Finnish Wind Power Association, press release 12.1.2022 "Finnish wind power statistics 2021: A record year behind the construction of wind power").

The average spot price increased to a new all-time high in 2021, reaching a 72.34€/MWh (2021 average) [2]. Higher electricity prices continue to favor the deployment of wind energy.

The state-owned agency responsible for forests, Metsähallitus, which administers more than 12 million hectares of state land and water areas, continues to support wind development. The pipeline of projects on state-owned land includes 400MW to be built and an additional potential of 900MW ([9] Metsähallitus website https://www.metsa.fi/en/responsi-

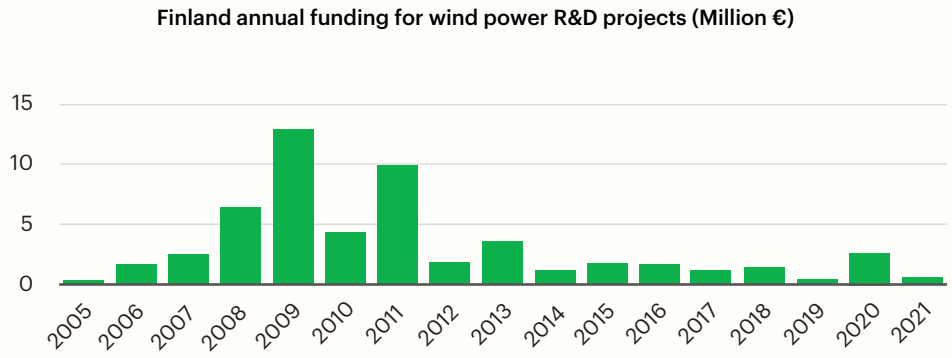

Figure 3. Public R&D funding in Finland has averaged 1.6 Million € annually during the past decade *(source: Business Finland)*

ble-business/wind-power/). This is relevant considering the fragmentation of land ownership, which may sometimes slow development.

Regarding offshore wind, the low profitability has been flagged as a challenge in Finland. The government expects that modern larger wind turbines will make the case more attractive for commercial offshore wind in Finnish waters.

In this context, Metsähallitus is currently planning the Korsnäs offshore wind farm with a capacity 1.3GW. The development process will consider protected areas, merchant shipping routes, and national defense requirements. This will be the first large-scale offshore wind farm in Finland [HH1] ([10] Metsähallitus "Korsnäs Offshore Wind Farm" https://www.metsa.fi/en/responsible-business/wind-power/korsnas-offshore-wind-farm/). The government estimates that the first auction could take place in 2023 and 2024 ([11] Press release 710/2021 "Ministerial Committee on Economic Policy supports auction model for leasing public water areas for offshore wind power production" https://vnk.fi/en/-/ministerial-committee-on-economic-policy-supports-auction-model-for-leasing-public-water-areas-for-offshore-wind-power-production).

R,D&D Activities

National R,D&D Priorities and Budget

The Finnish Funding Agency for Technology and Innovation, Business Finland (BF), continues to fund research and innovation in the country. Wind power is aligned with the key aspects of sustainability and economic growth, which define the Business Finland strategy for 2025.

Public R&D funding in Finland has averaged 1.6 Million € annually during the past decade ([12] Business Finland).

National Research Initiatives and Results

A research study[BHJ1] on estimating the possibility for offshore wind energy development by processing a multitude of data layers representing eventually ecological, societal, and economic factors was carried out [13]. One of the key results of the study is a generic model for spatial prioritization when the potential economic benefit is to be balanced with many ecological and societal factors. The work was supported by the Strategic Research Council of the Academy of Finland project SmartSea, by the Finnish Ministry of Environment project (also through project MetZo-III), the Finnish Inventory Programme for Underwater Diversity (VELMU), by the Kone Foundation.

R&D on Probabilistic forecasting of spatially aggregated wind power generation that was started in 2020 continued in 2021 as part of the HOPE (Highly Optimized Energy Systems) project funded by Business Finland. Further, R&D on Estimating thrust coefficients of a wind turbine for wake effect calculation was conducted as part of the BC-DC project.[BHJ2]

A Ph.D. thesis aimed at developing meteorological solutions to support wind energy production was presented [BHJ3] [14].

Collaborative Research

VTT is active in several EU, Nordic, and IEA research project frameworks. Within the IEA Wind TCP, Finland takes part in:

- **Task 11** Base Technology Information Exchange, which produces valuable information in identifying issues important for wind R&D in Finland
- **Task 25** Design and Operation of Energy Systems with Large Amounts of Variable Power Generation (Finnish organizations VTT and Recognis serve as co-operating agents).

- **Task 36** Forecasting for Wind Energy: Vaisala is a lead provider of weather instrumentation, and the Finnish Meteorological Institute conducts research related to wind forecasting (e.g., in Business Finland project HOPE) and is responsible for operational numerical weather prediction and model development as part of joint international efforts (MetCoOp).
- **Task 44** Farm flow control. VTT as a participant.
- **Task 46** Erosion of wind turbine blades. Finland serves as a co-operating agent in this approved in 2020.
- **Task 54** Cold Climate wind power (Operating agent VTT): Finland has a national interest in addressing the challenges of adapting wind energy to cold climate. The Task has been instrumental in the deployment of wind energy in harsh environments.

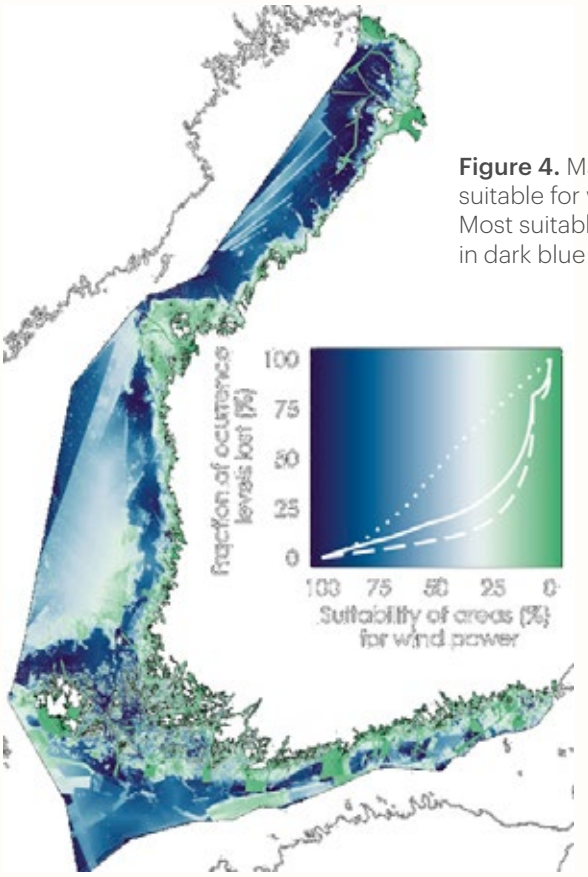

Figure 4. Marine areas suitable for wind power. Most suitable areas appear in dark blue [13].

Impact of Wind Energy

Environmental Impact

In the ten-year period since 2012, renewables (wind, hydro, wood, and other) increased gradually from 28% of total energy consumption to 42%. The wind has been a relevant contributor growing from 0.1% to 2.2% of Total Energy Consumption, with an upward trend but still behind wood and hydro. At the same time, fossil fuels, including peat, gradually decreased from 50% down to 34% of total energy consumption. ([15] Official Statistics of Finland (OSF): Energy supply and consumption [e-publication]. [referred:21.4.2022]).

Economic Benefits and Industry Development

The estimated economic benefit of wind power capacity built in Finland was assessed in 2018 ([16] H. Savikko, J. Hokkanen, V.-P. Alkula, M. Rautiainen, H. Koutonen (2019) Tuulivoiman aluetalousvaikutukset: aluetalousvaikutukset eri elinkaaren eri vaiheissa [in Finnish]. https://www.tuulivoimayhdistys.fi/filebank/1380-Tuulivoiman_aluetalousvaikutukset_2_5_2019.pdf). During the entire life cycle, each GigaWatt of wind power capacity will bring a turnover of 6.3 billion euros (7.2 billion USD) in Finland, including the value of the sold electricity during the operational phase. The tax revenues are estimated to be 1.7 billion euros (1.9 billion USD), including 787 million EUR (895 million USD) value added tax, 320 million EUR (364 million USD) municipality tax, 200 million EUR (228 million USD) real estate tax.

A representative wind farm such as Lakiakangas (86 MW) generates 300-400k€/year as real estate tax to the municipality, in addition to rental income to land owners [17].

Installed wind capacity in Finland is shared by many owners. The largest owner is Exilion Tuuli, with 12% capacity[BHJ1] . 14 organizations are owning 2%-12% capacity. Nearly half (48%) of the capacity is owned by foreign investors [1][BHJ2] . A single wind turbine manufacturer (Vestas) represents 59% of cumulative capacity and 97% of 2021 capacity additions.

Next Term

Onshore wind deployment is expected to continue at full speed in Finland. A total of 4.2GW of new wind is under construction and expected online in 2022-2025, including a remarkable 1866MW in 2022 [1]. The challenging international context due to pandemic and geopolitical changes may affect wind supply chains and workforce availability.

At the same time, large scale offshore wind is also moving forward. Several offshore projects have been announced, with Tahkoluoto extension expected in 2024-25. First tender for a government site anticipated - The nature surveys in the Korsnäs wind farm are continuing in 2022. Also, wind resource measurements in the nearby island of Bergö (Maalahti) are being performed as of April 2022 [10].