Annual Report 2024

Switzerland

Photo: *Mont-Crosin Wind farm – Juvent/BKW. Turbine type: Vestas V112 - 3,3MW. (Photo credit: © BKW)*

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By the end of 2024, Switzerland had 47 large wind turbines in operation with a total rated power of 100.637 MW (Table 1). These turbines produced 170.506 GWh of electricity in 2024. 6 wind turbines were built in 2023 (Wind farm Sainte-Croix) but started producing energy only at the beginning of 2024.

A cost-covering feed-in tariff (FIT) for renewable energy in Switzerland has existed since 2009 (Swiss Federal Office of Energy (2023) [1].

A new scheme with an investment subsidy of 60% has also entered into force in 2022. These policies offer an attractive economic framework for wind energy, but the authorisation process is causing a long delay, in worst cases up to 25-years. About 2 TWh of projects are under development.

In autumn 2023, Parliament approved the Federal Act on a Secure Electricity Supply Based on Renewable Energies. The bill lays the foundations for a rapid increase in domestic electricity production from renewable energy sources such as water, sun, wind and biomass. On June 9, 2024, the Swiss people approved the project with 68.7%. Internationally cross-linked research activities in 2024 focused on cold climates, complex terrain, aviation cohabitation and acceptance.

Total (net) installed wind power capacity*	100.637 MW
Total offshore capacity	0 GW
New wind power capacity installed	0 GW
Decommissioned capacity (in 2023)	0 GW
Total electrical energy output from wind	170.506 GWh
Wind-generated electricity as percent of national electricity demand	0.3 %
Average national capacity factor**	19.1 %
Target	4.3 TWh
National wind energy R&D budget	EUR 5.73 mio. (2023 most recent)
*Including the 6 wind turbines at Ste-Croix **Including the 6 wind turbines at Ste-Croix that start operation in 2024	

***Table 1**. Key Statistics 2024: Switzerland*

Highlights

- The very long approval process still delays wind energy deployment.

- The last federal court has positively judged six projects with 133 MW / 274 GWh.

- On June 9, 2024, the Federal Act on a Secure Electricity Supply Based on Renewable Energy was approved, with Swiss citizens voting 68.7% in favour.

- The AES (Association of Swiss Electricity Companies) considers wind power generation of 21 TWh, including 15 TWh in winter, to be optimal, which would represent around a third of current electricity consumption.

- After Axpo in 2023, BKW and other electricity producers have emphasized in 2024 the importance of wind power in Switzerland.

- The federal government approved the adaptation of the master plan for the canton of St. Gallen. The 15 zones suitable for wind power are now definitively included in the master plan.

- The federal government also approved the masterplan for the canon of Lucerne, with a significant acceleration of procedures and a framework promoting social acceptance.

- The population of the town of Chur clearly approved the construction of a second wind turbine with 83.10% of votes “in favour”. Local authorities support extension project.

Market Development

Targets and Policy

The Energy Strategy foresees an additional 39 TWh from renewable energy by 2050. The new proposed law also anticipates even 35 TWh in 2035 and 45 TWh in 2050. Wind energy should contribute 4.3 TWh/yr to this target (with intermediate goals of 0.3 TWh in 2025 and 1.2 TWh in 2035), the Swiss Wind Association aims at 9 TWh for 2050.

A levy on electricity consumption finances the cost of the FIT. The maximum levy is EUR 24,5/MWh, which is used to develop a fund to support renewable energies in Switzerland. The FIT for newly installed wind turbines in 2022 was between EUR 138,5/MWh and EUR 245/MWh. The payment period expands over 15 years. The FIT system was limited to the period up to the end of 2022. Projects that are built in the next few years and have been approved for FIT can continue to benefit from it.

In 2023 and 2024, the system of investment contributions was introduced. The investment contribution amounted to 60% of the eligible investment costs. From 2025, there will again be new funding instruments: on the one hand, the sliding feed-in tariff (floating market premium) and, on the other, investment contributions based on the reference system principle.

The new version of the Energy Act adapts existing instruments and creates new ones, such as the floating market premium and contributions for project studies.

Floating market premium: There is now a floating market premium for hydroelectric plants, wind farms and certain photovoltaic and biomass plants. It guarantees revenue for electricity fed into the electricity grid. If earnings are lower than the feed-in tariff, the fund financed by the grid surcharge pays the difference to the plant operator. If revenues exceed the feed-in tariff, the plant operator pays the difference into the grid supplement fund. The term of remuneration is 20 years.

Investment contributions: The minimum period of operation for wind power plants and photovoltaic systems receiving investment contributions is being extended from 15 to 20 years, to bring it into line with the period of remuneration under the floating market premium.

Investment contribution rates: Wind power plants are divided into three categories according to the altitude at which they are built (Table 2).

Project study contributions: Project owners of wind, hydroelectric or geothermal power plants with project study costs of at least EUR 31,950 can apply for a contribution of 40% of the attributable project study costs. In the case of wind turbines, contributions for project studies are awarded per project, not per turbine and amount to a maximum of EUR 1,065 million.

CATEGORY	RATE IN EUR KW
category I: < 1000 m above sea level	1385
category II: 1000 to 1700 m above sea level	1598
category III: > 1700 m above sea level	1757

Table 2. *Investment contribution rates. (Source: BFE Publikationen [10].)*

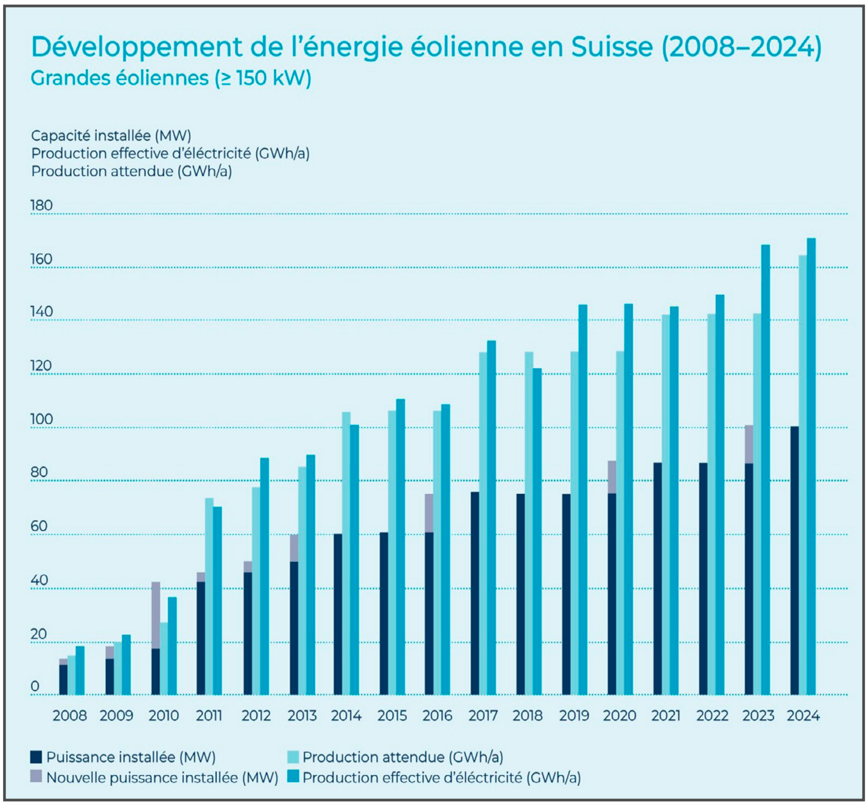

Figure 1. *Annual installed capacity, cumulative capacity and energy production in Switzerland from 2008 to 2024. (Source: Suisse Eole)*

Progress and Operational Details

Approximately 68.7% of Switzerland's electricity production comes from renewable sources, with hydropower being the biggest contributor (88%). Wind power generation currently provides 0.3% of Swiss electricity consumption. The 47 turbines produced 170.506 GWh of electricity in 2024 (Figure 1). Projects already in advanced planning stages represent an additional 550 MW, while early-stage projects represent roughly 1'300 MW. These projects should be realized in the next 3-8 years.

Matters Affecting Growth and Work to Remove Barriers

Lengthy planning procedures significantly hinder Swiss wind energy growth. Stakeholders at different authority levels must first give their authorization, and voters must (typically) also approve specific projects in the local areas.

Generally, the Swiss population favours wind energy, as confirmed by votes at national and local levels. However, the opposition is very well organized and manages to polarize discussions on specific topics while systematically using every possible channel of appeal, which slows down the planning procedures.

Most of the Cantons (provinces) opened combined procedures for land use planning and building permitting. With the energy crises, several improvements in permitting processes are discussed on the national level. The most advanced is about reducing the number of courts involved in the last step of wind energy authorisations.

RD&D Activities

National RD&D Priorities and Budget

The Swiss R&D priorities are organised around the plant, the turbine and innovative wind energy technologies.

The Plant:
Development of data-related methods for the planning, layout and operation of wind parks.
Development and validation of control strategies for optimising overall oper-

ational performance (e.g., concerning forecasts and shut-down algorithms).

The Turbine:
Component optimisation, especially for the use of wind energy in complex terrain.
Development and validation of components for use in cold climates and for accurate forecasting of ice formation.
Noise abatement strategies.

Alternative wind energy technologies above 1 MW.

In 2023, the budget for wind energy-related R&D and demonstration projects was approximately EUR 5.59 million. The total budget includes the national Wind Program of the Swiss Federal Office of Energy, with approximately EUR 0.426 million allocated to the wind energy sector for information activities, quality assurance measures, and supporting regional and communal planning authorities [2].

The *Energiestatistiken* 2024 (Energy Research Statistic 2024) is available end of 2025. Budget cuts are very likely for 2025 and the following years.

National Research Initiatives and Results

WindSPORES: The Policy-relevant wind power deployment scenarios for Switzerland [3] project has focused on showing the value of wind energy by studying the correlation of wind patterns in between Swiss regions.

COSMO-REA2 is the most suitable dataset for analysing Swiss wind power potential and turbine performance alongside other wind patterns in Europe.

Figure 2 shows wind speeds at 100 m, averaged spatially and temporally. Both datasets resolve the impact of Swiss orography on wind speeds, with highest average speeds on alpine peaks and along the upper Rhone and Rhine valleys (Figure 2a). However, the smoothing effect of NEWA's coarser resolution is also apparent.

Although there are no locations in Switzerland where the two datasets fundamentally contradict each other - i.e., there are no anticorrelated timeseries in any location - NEWA does not perform as well as COSMO-REA2 in representing valley flows.

The central panel in Figure 2a highlights the lack of correlation between the two datasets in all valleys and valley outlets, which is driven by the inability of NEWA to capture the summertime mid-afternoon increase in wind speeds experienced in the valleys. We can verify this by focusing on a specific site where we know this phenomenon exists. Although it does not capture the strength of summer valley flows, NEWA depicts a higher average annual Swiss wind speed than COSMO-REA2 (Figure 2b).

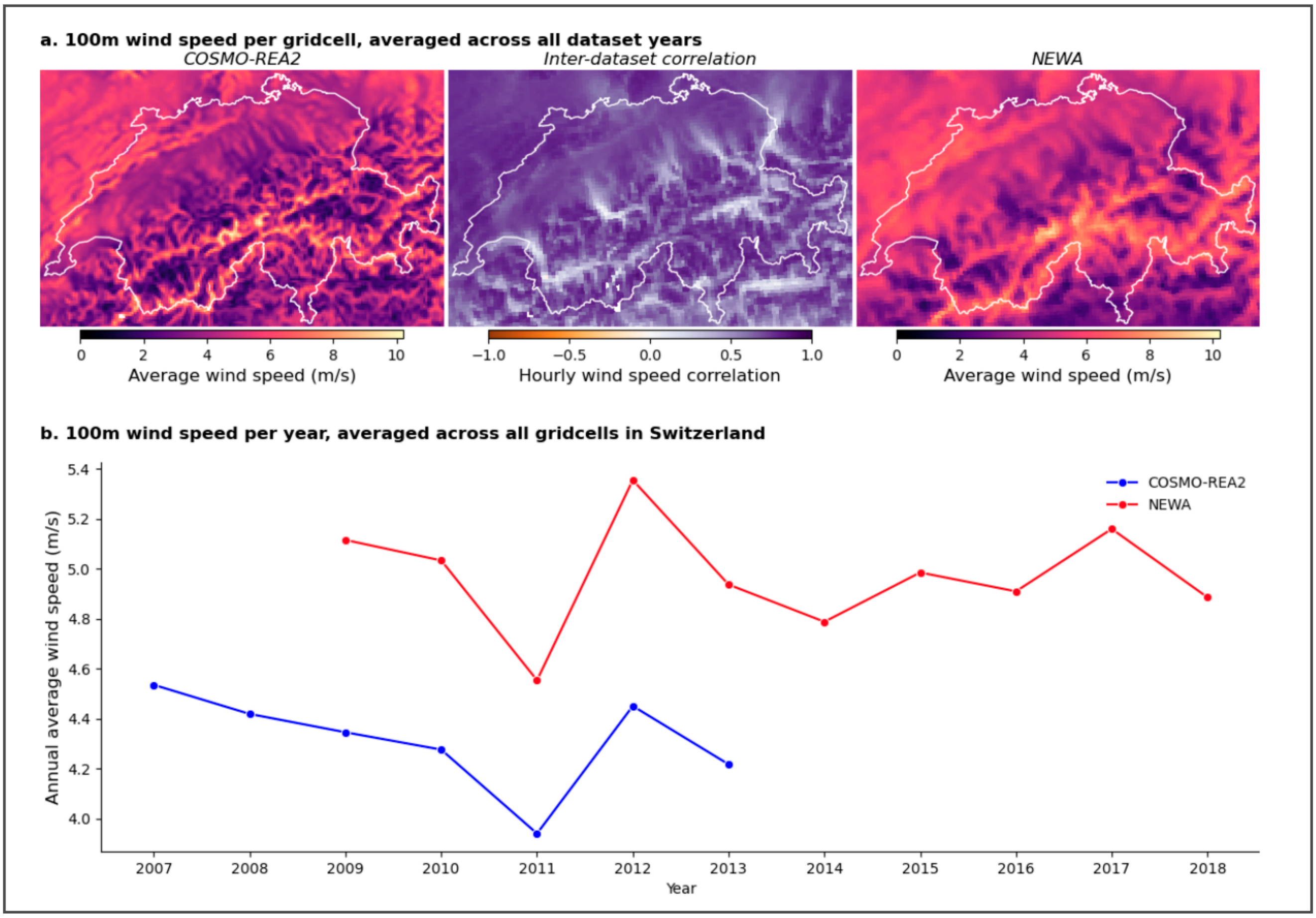

Figure 2. *Comparison of simulated wind speeds from NEWA and COSMO-REA2 datasets. (Source: WindSPORES)*

As a result of the WindSPORES project, we have demonstrated the potential of wind power in reducing reliance on solar, storage and electrolysis. Figure 3 ascertains that wind power experiences a strong anticorrelation with electrolyser deployment and a moderate anti-correlation with solar power, battery storage and synfuel imports.

At the same time, solar power has a positive moderate correlation with electrolyser deployment and battery storage.

Replacing solar power capacity with wind power will result in an energy system which is less subject to strong daily fluctuations and marked seasonal variations and requires less storage, green hydrogen production capacities and synfuel imports.

The final report was published on December 4, 2023 by the SFOE [5] and is available here: *WindSPORES – Policy-relevant wind power deployment scenarios for Switzerland*

AMM-Fauna: The Autonomous multi-sensor monitoring of birds to assess collisions and flight avoidance near wind farms project [4] developed an optical monitoring system for wind turbines to detect possible collisions with bats.

The developed system also documents the context of the collisions and proximity flights of bats. The system is based on an IR sensor, a camera with an intermediate spectrum sensor and an infrared (IR) camera. All mounted together in a mobile system, with two operation modes: tracking mode and high-speed scan mode.

This technology overcomes the limitations of existing IR cameras in terms of spatial resolution, coverage of the rotor surface, detection sensitivity and target identification. A detection software and scanning mechanism is integrated in the system.

The final report was published on July 1, 2024, by the SFOE. [6]

WindMet: Deriving the spatio-temporal wind energy yield in mountainous terrain - Recommendations of methods for practitioners.

Complex mountain winds provide a wind energy potential, which is still largely unknown. Mountainous terrain forces air flow to react by e.g., wind flow sheltering, strong ridge acceleration, channeling, deflections, blocking and even recirculation. Thermally driven circulations add to that complexity and are almost always connected with topography-modified wind flows [7].

Diurnal changes in winds, due to horizontal temperature differences, lead to characteristic mountain wind systems such as the "slope wind" system or the "mountain-valley wind" system. The impact of these complex topography effects on annual energy production (AEP) has not been thoroughly quantified yet and may be considerable. For instance, compared to the lowlands, wind speeds were found to generally increase with

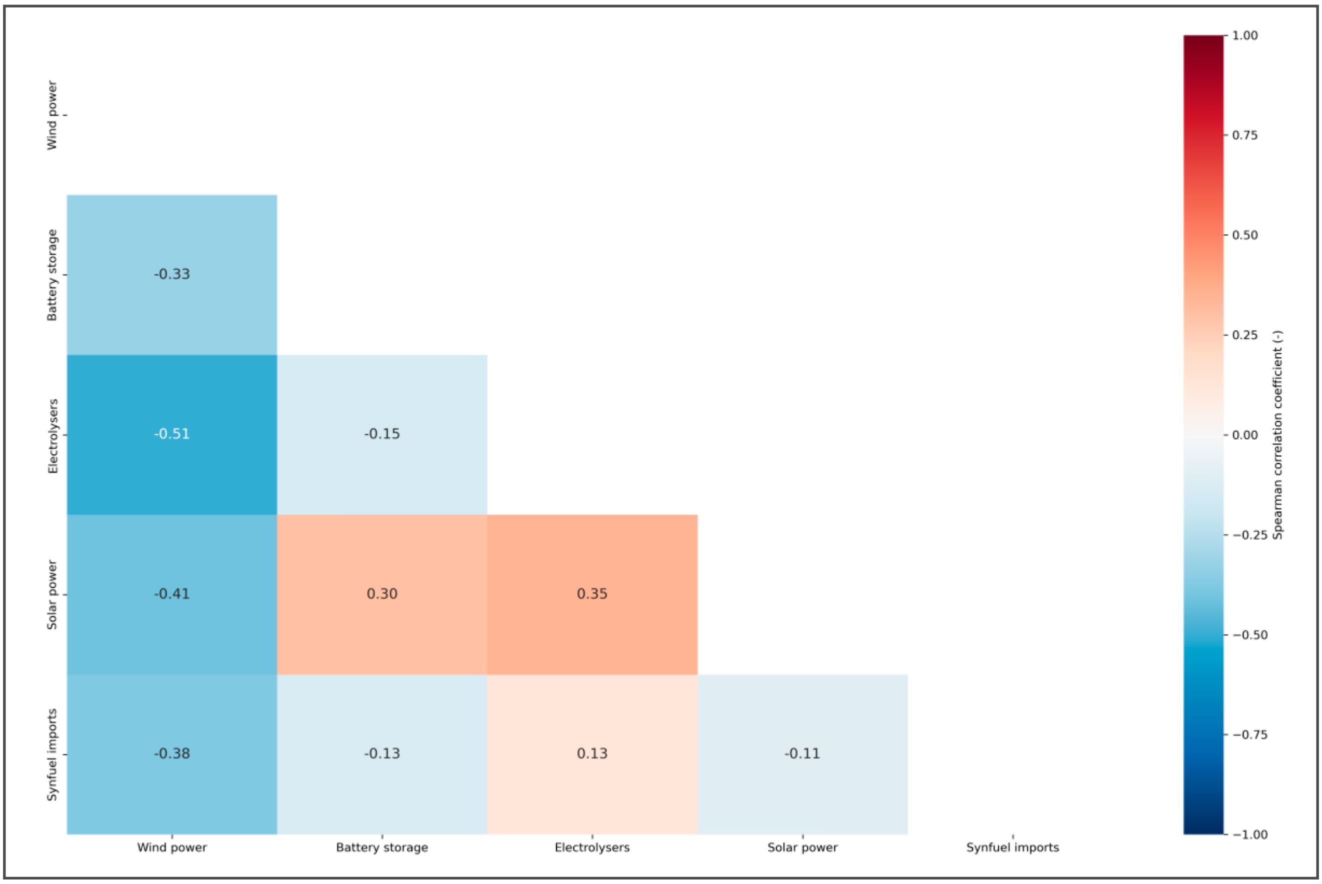

Figure 3. *Correlation of key energy system design components; calculated in the WindSPORES project. (Source: WindSPORES)*

terrain elevation in mountainous terrain, and this is even more prominent in the winter, when more energy production is required [8].

Life cycle inventory models on wind power production in the Swiss and European context.

The project envisages an update of the existing life cycle inventory data regarding wind power production. There is a strong need for up-to-date wind power data for Life Cycle Assessment, in order to improve consistency, comparability and transparency between LCA studies. The activities include an update of the existing inventory data regarding wind power in Switzerland and Europe, the integration of the life cycle inventory models into the UVEK database, as well as their possible transfer to the ecoinvent database. Activities further include the development of new life cycle inventory models for large-scale wind farms, in order to fill the void of standard reference cases.

The following three projects were launched at the end of 2024: **CODEWIND**, Community-centred wind energy in Switzerland, which is developing a digital co-de-sign framework for collaboration and planning; **PARTI-DYNACCEPT**, which is focusing on the role of financial participation in shaping the dynamics of community acceptance of wind energy, and **WindCoEconomy,** which is developing models for participation and economic involvement. As these projects run for 3 years, first results can be expected in 2026.

Collaborative Research

Switzerland is involved in the following IEA Wind TCP Tasks:

Task 11 - Base Technology Information Exchange (Operating Agent)

Task 43 - Wind Energy Digitalization (Co-Operating Agent)
Task 47 - Aerodynamics (TURBINIA)

Task 52 - Large-Scale Wind Lidar

Task 54 - Cold Climate Wind Power

Task 59 - Working Together to Resolve Environmental Effects of Wind Energy (WREN)

Task 60 - Harmonised Life Cycle Assessment for Wind Power (Co-Operating Agent)

Impact of Wind Energy

Environmental Impact

Carbowind study results [9] indicated that the impact on carbon reduction with new installed wind power plants is significative with 378 g/kWh, despite the almost completely carbon neutral electricity generation mix. This study considers the relevant import of carbon-based electricity during winter in Switzerland. Wind power generation, combined with solar power, is expected to replace power generated by nuclear power plants which are expected to be shut down at the end of their lifetime.

Economic Benefits and Industry Development

The Swiss industry is active in several wind energy fields:

- Development and production of chemical products for rotor blades, such as resins or adhesives (Gurit Heberlein, SIKA, Huntsman, Clariant).
- Grid connection (Hitachi Energy, ABB).
- Development and production of power electronics such as inverters (ABB, VonRoll).
- Services in the field of site assessments and project development (Meteotest, Interwind, Basler & Hofmann, Emch + Berger etc.).

Next Term

New energy laws were discussed and adopted in 2023 aiming at accelerating the energy transition. In June 2023, a new dedicated law for Wind Energy was adopted, reducing the permitting time for wind projects in an advanced status, resulting in reductions from the previous situation with 25 years average permit process duration. With this new law, 6 wind energy projects in the planning phase will benefit from this regulation change, and it is estimated that they will be built in 2025-2026, three years before originally planned.

On November 13, 2024, the Federal Council specified the implementation of the new legal provisions in various ordinances. The first package will come into force on January 1, 2025. The second package, comprising the remaining amendments, will probably be adopted by the Federal Council in the first quarter of 2025, and will come into force on January 1, 2026.

References

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[2] Swiss Federal Office of Energy (n.d.). Energy 2050+; *bfe.admin.ch/bfe/en/home/policy/energy-perspectives-2050-plus.html*

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[7] Whiteman, 2000; *researchgate.net/publication/226579958_Charles_David_Whiteman_Mountain_Meteorology_Fundamentals_and_Applications*

[8] Kruyt et al., 2017; *researchgate.net/publication/315732931_Potential_contributions_of_wind_power_to_a_stable_and_highly_renewable_Swiss_power_supply*

[9] UNIGE Carbowind (2020); *archive-ouverte.unige.ch/unige:144762*

[10] Baréme Annex 2.4; *pubdb.bfe.admin.ch/fr/publication/download/11921*