FIGURE 1 SAN GOTTARDO SITE (WWW.AET.CH)

SWITZERLAND

By the end of 2020, Switzerland had 42 large wind turbines in operation with a total rated power of 87 MW. These turbines produced 146 GWh of electricity in 2020. The construction of a new wind farm with a capacity of 12 MW began in 2019; it will be operational by end of 2020, increasing the total wind power capacity by 15%.

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LIONEL PERRET and MATTHIEU DUCRET, Planair SA, Switzerland

A cost-covering feed-in tariff (FIT) for renewable energy in Switzerland has been in place since 2009 [1]. This policy promotes wind energy and has led to an increase in new wind energy projects. Financing is currently requested for an additional 3.3 TWh under the FIT scheme

Internationally cross-linked research activities in 2020 focused on cold climates, complex terrain, aviation cohabitation, and social acceptance.

TABLE 1. KEY NATIONAL STATISTICS 2020: SWITZERLAND

Total (net) installed wind power capacity*	87 MW
Total offshore capacity	0 MW
New wind power capacity installed	12 MW
Decommissioned capacity (in 2020)	0 MW
Total electrical energy output from wind	146 GWh
Wind-generated electricity as percent of national electricity demand	0.2%
Average national capacity factor**	22%
Target (2050)	4.3 TWh/yr
National wind energy R&D budget	5.55 mil CHF (2019 most recent)

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

Only include turbines in operation the whole year: **(MWh production/8,760 hrs) / MW installed capacity
MWh total electrical production from wind turbines operating 1 January through 31 December divided by 8,760 hrs divided by the total installed wind capacity (in MW) at the beginning of the year.
[You can also use an estimate based on the average installed capacity during the year: (installed 1 Jan + installed 31 Dec)/2. But in that case, state that it is how the estimate is calculated.]

Market development

Targets and policy

The Energy Strategy foresees an additional 22.6 TWh/yr from renewable energy by 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).

Since the introduction of the FIT in 2009, wind projects with an estimated energy yield of 128.1 GWh are in operation and being supported under the scheme; additional projects with a potential energy yield of 1,739 GWh have been registered, and 1,594 GWh are on the waiting list. At the end of 2020, wind projects with an electricity production of 104.1 GWh are being supported using the direct commercialization subsidies, while 0.6 GWh still benefit of a reference market price.

The recent Energy Strategy 2050 has several implications for wind energy development in Switzerland. The new legislative package increases the budget for Switzerland's cost-covering feed-in tariff for renewable energy. Renewable resources include hydropower (up to 10 MW), photovoltaics, wind energy, geothermal energy, and biomass.

The cost of the FIT is financed by a levy on electricity consumption. The maximum levy is of 23 CHF/MWh (21.2 EUR/MWh; 23.8 USD/MWh). The FIT for newly installed wind turbines in 2020 was 230 CHF/MWh (corresponding to 212 EUR/MWh; 238 USD/MWh). Wind turbines built on locations 1,700 m above sea level or higher receive an altitude bonus of 25 CHF/MWh (23 EUR/MWh; 25.8 USD/MWh) in addition to the standard retribution [3]. The payment period expands over 15 years. 2019 was the last year of a transition period, after which the retribution scheme changes from feed-in tariffs to a direct commercialization scheme.

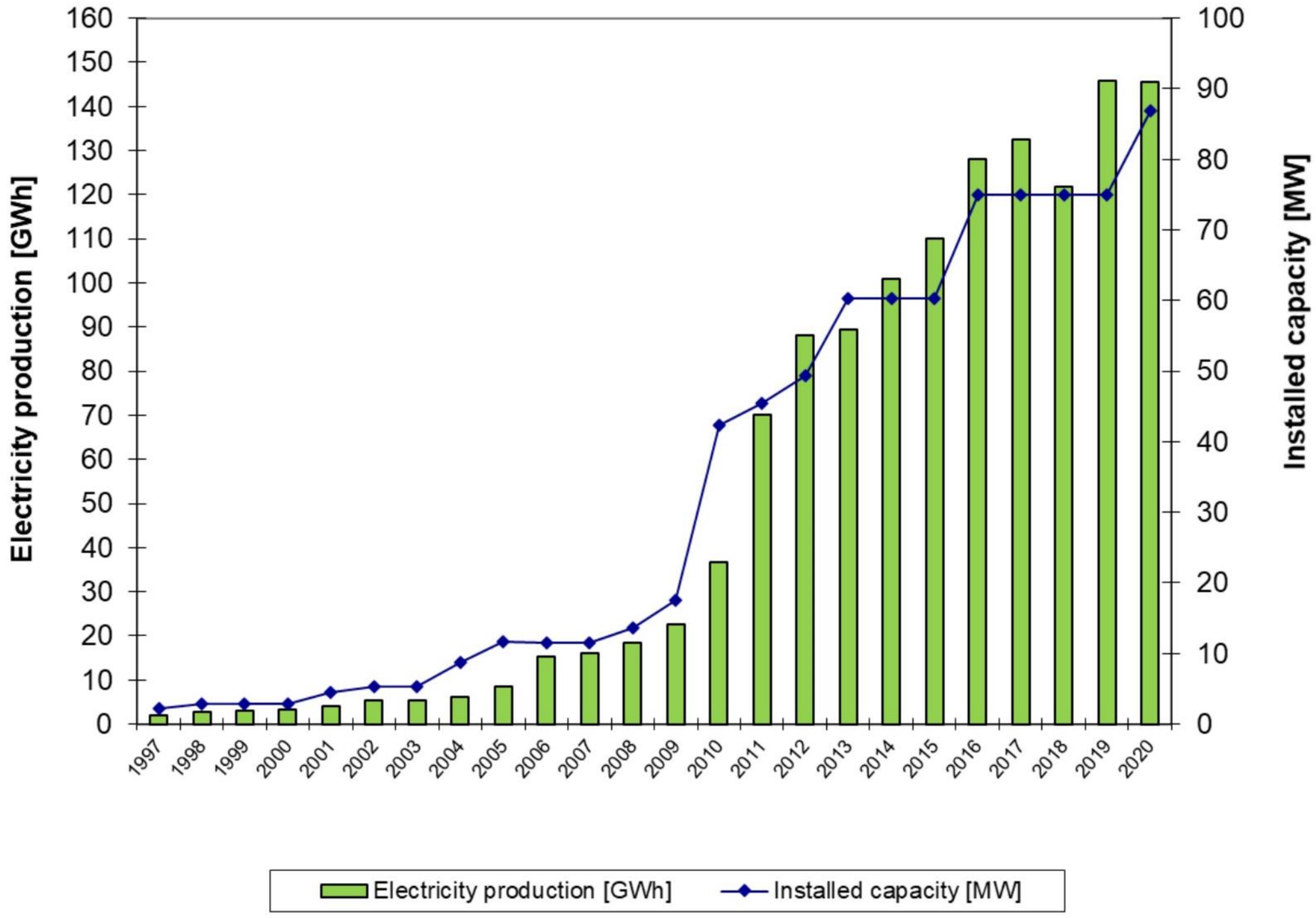
Progress and operational details

Approximately 59% of Switzerland's overall electricity production comes from renewable sources, with hydropower being by far the biggest contributor (95%). Wind power generation currently provides 0.2% of the Swiss electricity consumption. End of 2020, new turbines were installed; the production figure will grow by about 16-20 GWh in 2021 due to the commissioning of one high-altitude wind farm with estimated capacity factor of 15-20%. Projects that are already in advanced planning stages represent an additional 360 MW, while early-stage projects represent roughly 600 MW.

Matters affecting growth and work to remove barriers

Lengthy planning procedures are the greatest hindrance to Swiss wind energy growth. Stakeholders at different authority levels must first give their authorization, and specific projects must also be approved by voters in the local population.

In general, the Swiss population is favourable to wind energy as confirmed by votes at national and local levels. However, the opposition is very well organized, manages to polarize discussions on specific topics, and



systematically uses every possible channel of appeal, which slows down the planning procedures.

Some Cantons (provinces) opened combined procedure for land use planning and build permitting. Two to three wind farm projects will be following the new simplified process in 2021. Moreover, the role of the cantonal authorities in the planning process is now better defined and they are more able to assist project developers and communes with a project on their territory.

R,D&D activities

National R,D&D priorities and budget

The priorities of the research term 2017 to 2022 remain valid for 2020 [4]. These priorities are:

- Performance optimization per turbine and farm via turbine optimization, control optimization, and wind farm design;
- Reduction of turbine downtimes through technical optimization, icing protection, wind forecasts, and understanding of avifauna behaviour; and
- Acceptance of wind power. This includes accelerating research between wind power and other fields (such as ornithology or noise research) and promoting stronger cooperation between federal offices and institutes.

In 2020, the budget for wind energy-related R&D and demonstration projects from the Swiss Federal Office of Energy was approximately 0.5 million CHF (0.44 million EUR; 0.53 million USD). Within the national Swiss Energy programme, approximately 0.4 million CHF (0.37 million EUR; 0.45 million USD) were allocated to the wind energy sector for information activities, quality assurance measures, and for the support of regional and communal planning authorities [4]. Budget-wise, the 2021 trend is the same as for 2020, with hope of a slight increase in the Swiss energy programme for wind energy.

> After many years without new installed capacity, a new wind farm of 12 MW was commissioned in 2020.

National research initiatives and results

An ETH Zürich team of the Laboratory for Energy Conversion studied a novel comparative of the effectiveness of optimised nacelle using flaps to alleviate fatigue loads and to improve performance of wind turbines is experimentally conducted. Depending on upwind or downwind wind turbine mode, the stability or the energy yield results differ.

Using flaps in downwind configuration compensates for the adverse effect of wind turbine yaw

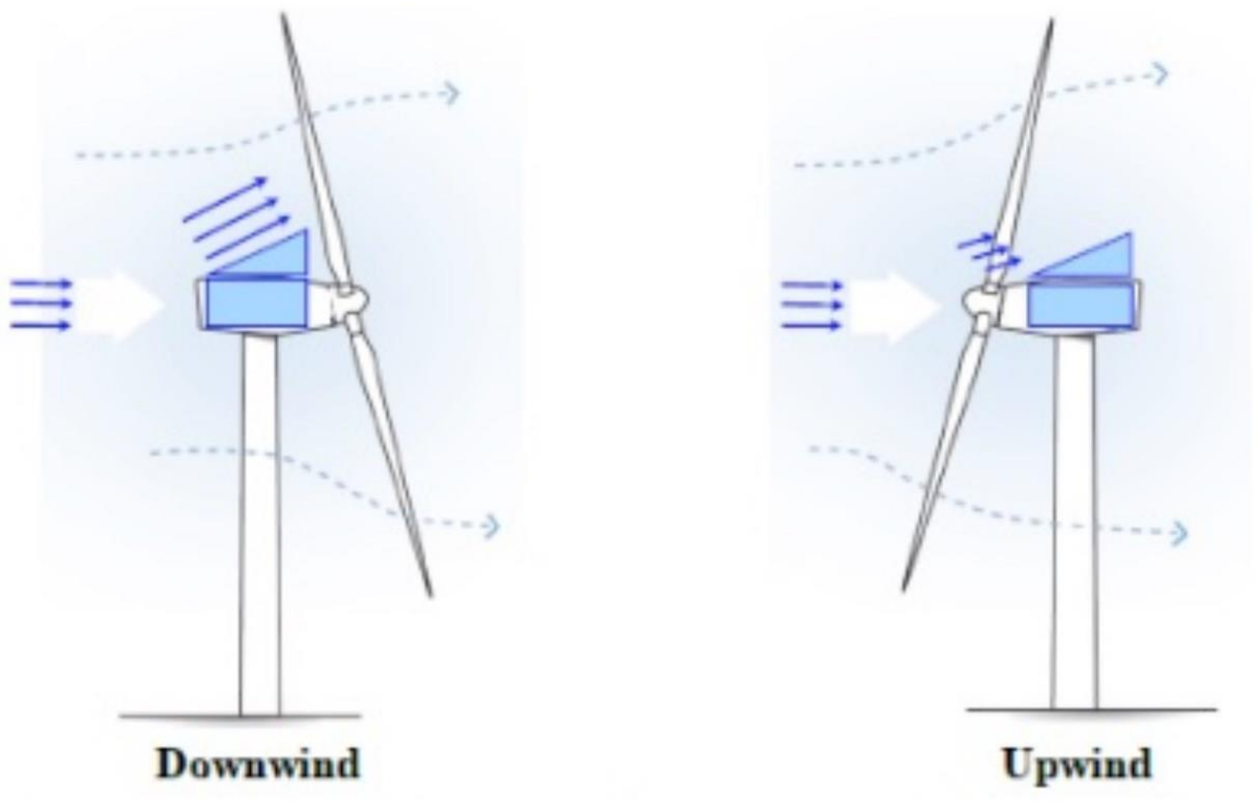


FIGURE 2 EFFECTIVENESS OF FLAPS SCHEMATIC

misalignment on the wind turbine performance and unsteady loads. Furthermore, using flaps decreases the cut-in speed and therefore increases the turbine annual energy yield by increasing wind turbine power generation for downwind configuration. "Improved Wind Turbine Performance Using Innovative Nacelle Design, 2020"

A team from the University of Geneva assessed the carbon footprint reduction of wind power installation by 1 MW increment. Based on country electricity import/export figures, it was possible to quantify the tons of carbon dioxide on a yearly basis per new 1 MW installation. As of today, the influence of any new 1 MW installed power results in 652 to 698 tons CO_2-eq per year, close to the emission figures of a gas-fired power plant production.

In order to bring together the wind energy research community of Switzerland, an initiative by HSR was concretized in 2019 with the launch of The Swiss Wind Energy R&D Network at a dedicated national forum which gathered 75 organizations. The concept developed is the first central collaboration platform in the wind energy industry that provides real incentives for participation. A very large interest was identified and high demand for a self-sustaining platform that provides a central location for wind energy industry and research to share and collaborate on reproducible workflows, data, and code whilst respecting confidentiality requirements.

Collaborative research

Switzerland is involved in the following IEA Wind TCP Tasks:

- Task 11 – Base Technology Information Exchange (Operating Agent)
  Switzerland co-hosted (online) a Topical Expert Meeting on Aviation system cohabitation in 2020.

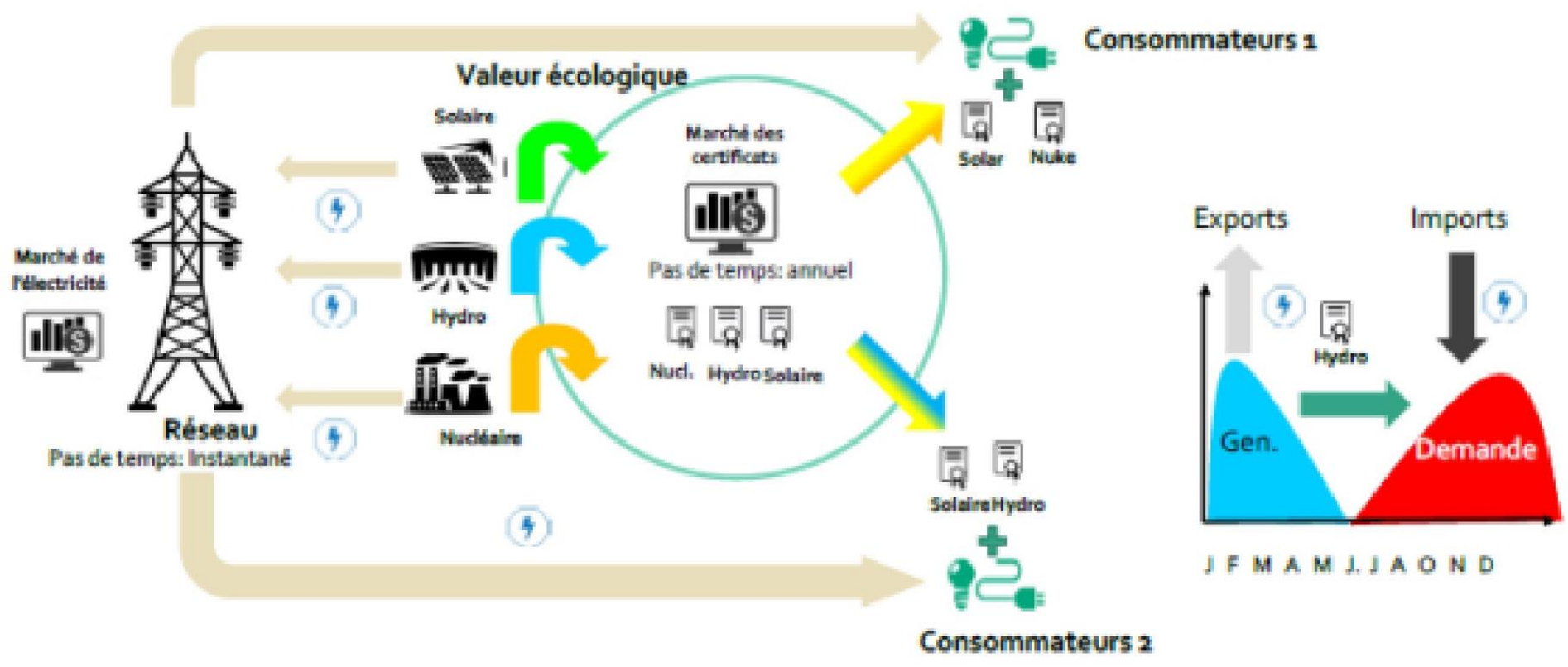


FIGURE 3 ENERGY MARKET (CARBOWIND, 2020. UNIVERSITÉ DE GENÈVE)

- Task 19 – Wind Energy in Cold Climates (with particularly active participation of Meteotest)
- Task 28 – Social Acceptance of Wind Energy Projects
- Task 29 – Mexnext III: Analysis of Wind Tunnel Measurements and Improvements of Aerodynamic Models
- Task 31 – International Wind Farm Flow Modelling WAKEBENCH
- Task 32 – LIDAR: Wind Lidar Systems for Wind Energy Deployment LiDAR
- Task 34 – Working Together to Resolve Environmental Effects of Wind Energy WREN

Impact of wind energy

[Possible figures include: market share of various companies, photos of turbines, factories, or parts, carbon or fossil fuel reduction.]

Environmental impact

With Carbowind study results mentioned above, the impact on carbon reduction with new installed wind power plants is encouraging, despite the almost completely carbon neutral electricity generation mix. Wind power generation, combined with solar power, is expected to replace power generated at nuclear power plants which are expected to be shut down at the end of their lifetime; the Mühleberg power plant was the first one to be effectively shut down in December 2019.

The Federal Council has developed the Energy Strategy 2050. This should enable Switzerland to make advantageous use of the new starting position and maintain its high supply standard. At the same time, the Strategy contributes to reducing Switzerland's energy-related environmental impact.

Economic benefits and industry development

A study estimated that the total turnover in wind energy in Switzerland in 2010 was about 38.9 million EUR (47.6 million USD) and that the wind industry employed about 290 people [5]. Another study from 2009 estimated the worldwide turnover of Swiss companies in wind energy is of 8.6 billion EUR (10.5 billion USD) by 2020.

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 (ABB)
- Development and production of power electronics such as inverters (ABB, VonRoll)
- Services in the field of site assessments and project development (Meteotest, Interwind, NEK, New Energy Scout, etc.)

Next term

Numerous Swiss wind farm projects are on hold due to complex and lengthy procedures. A study has been conducted at the University of Bern in 2020 to assess the factors speeding up or delaying wind energy projects and propose solutions towards a simplified development of wind energy. Results will be published.

In terms of deployment, seven projects are awaiting a statement of the Federal court.

The Comparison metrics simulation challenge (COMESI) project of the Ostschweizer Fachhochschule is ongoing. Its purpose is to help modelers to choose the best suitable model for a given wind energy project in complex terrain.

MaxWEP research project of the EPFL is ongoing, with the purpose of maximizing winter energy production by exploiting terrain potential.

References

List any references used directly in the text of the chapter.

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[3] Swiss Confederation (2017). Ordonnance sur l'encouragement de la production d'électricité issue d'énergies renouvelables OEneR. Download from: https://www.admin.ch/opc/fr/classified-compilation/20162947/201904010000/730.03.pdf

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[5] Rutter & Partner (2013). Volkswirtschaftliche Bedeutung Erneuerbarer Energien in der Schweiz.