

Review of the Renewable Energy Generation System in Switzerland

Background: Switzerland is situated in central Europe, requires significant energy to meet its population and economic needs. In 2019, Swiss energy-related CO2 emissions were around 44 Mt, with imports meeting about 70% of energy demand. [1] To reduce carbon emissions and dependence on imports, Switzerland is promoting renewable energy technologies such as hydropower, solar, wind, and biomass. The abundance of rivers in this country makes it an ideal location for hydropower generation, and the high reliability of plants makes it ideal for long-term energy planning. The mountainous terrain of the country also gives it great potential for solar and wind power, with high flexibility in wind power generation. In one strategy, Switzerland has set a target of increasing the share of renewable energy to 50% by 2030 and reducing transport CO2 emissions by 30% compared to 1990. [1] Switzerland is also closely following global climate change negotiations such as the COP26 summit and has implemented its own carbon tax. Over the last decade, Switzerland increased its share of renewable electricity from 58% to 66%, surpassing neighboring countries in renewable energy adoption. In 2020, Swiss greenhouse gas emissions per capita were 4.4 mt, compared to 8.9 mt in Germany and 5.5 mt in France. [1]

Technology Review

The electricity consumption demand in Switzerland in 2018 was approximately 75 TWh. [2] Table 1 shows the amount of electricity that can be provided by different renewable energy technologies, and the demand for electricity in 2018. Wind power provided the least amount of electricity, as wind turbines require a specific wind speed to operate effectively. There are currently only a few small wind turbines in Switzerland, with a total installed capacity of less than 20 MW. [2] Pumped storage systems are required to ensure a steady supply of wind power. Solar power provided more electricity than wind power, but also less because PV systems require a certain amount of solar radiation to generate electricity and only during daylight hours. Electronic devices such as inverters and rectifiers can convert the direct current generated by this energy source into alternating current that can be transmitted through the grid. [2] Hydropower is relatively well developed in Switzerland and is a major part of the renewable energy supply. For example, a large hydroelectric power plant, Linthal, with a capacity of 1,480 MW, was built in the Alps in 2015 and includes a new underground power plant and an extended reservoir, which significantly increased the capacity of the plant at the time. [3] The total installed capacity of hydroelectric power is currently over 15 GW and there are plans to increase this capacity in the future by upgrading and building new plants.

Tab. 1 Summary of electricity demand and supply by generation technology[2]

Scenario	0	1	2	3	4	5	6
Year	2017	2018	2018	2018	2018	2018	2018
Electricity demand							
Initial demand	62.9	62.6	62.6	62.6	62.6	62.6	62.6
Additional demand	-	-	-	-	12	12	12
Generation (TWh)							
Hydro	36.7	37.4	37.4	37.4	37.4	37.4	37.4
Nuclear	19.4	24.3	Phase out	Phase out	24.3	Phase out	out
PV	0.13	0.12	0.12	12	0.12	0.12	0.12
Wind	3.5	3.6	3.6	3.6	3.6	3.6	3.6

Overview of hydropower in Switzerland

Switzerland has a long history of using hydroelectric power, with its first hydroelectric power station built in 1886. [3] Today, hydropower is an important source of renewable energy in Switzerland, accounting for around 56% of the national electricity production. An example of a hydropower project is the hydroelectric power station at the Grande Dixence dam, which has an installed capacity of 2,070 MW. the plant consists of four Francis turbine generators for converting the potential energy of water into electricity. [3] The generators are connected to a substation which raises the voltage of the electricity to the level required for transmission to the grid. Figure 1 shows the schematic diagram of a hydroelectric power plant, the operation of which involves the controlled release of water from a dam into the turbines of the plant, which turn the generators to produce electricity, and finally the water is released into the river system downstream. [4] Hydropower efficiency in Switzerland ranges from 70% to 95%, contingent on factors like water height, turbine size, design, and transmission system efficiency. While modern turbines have increased conversion efficiency, some energy loss occurs due to friction. [4] Hydropower is generally reliable and efficient but has drawbacks, such as environmental impact and ecosystem damage due to dam construction.

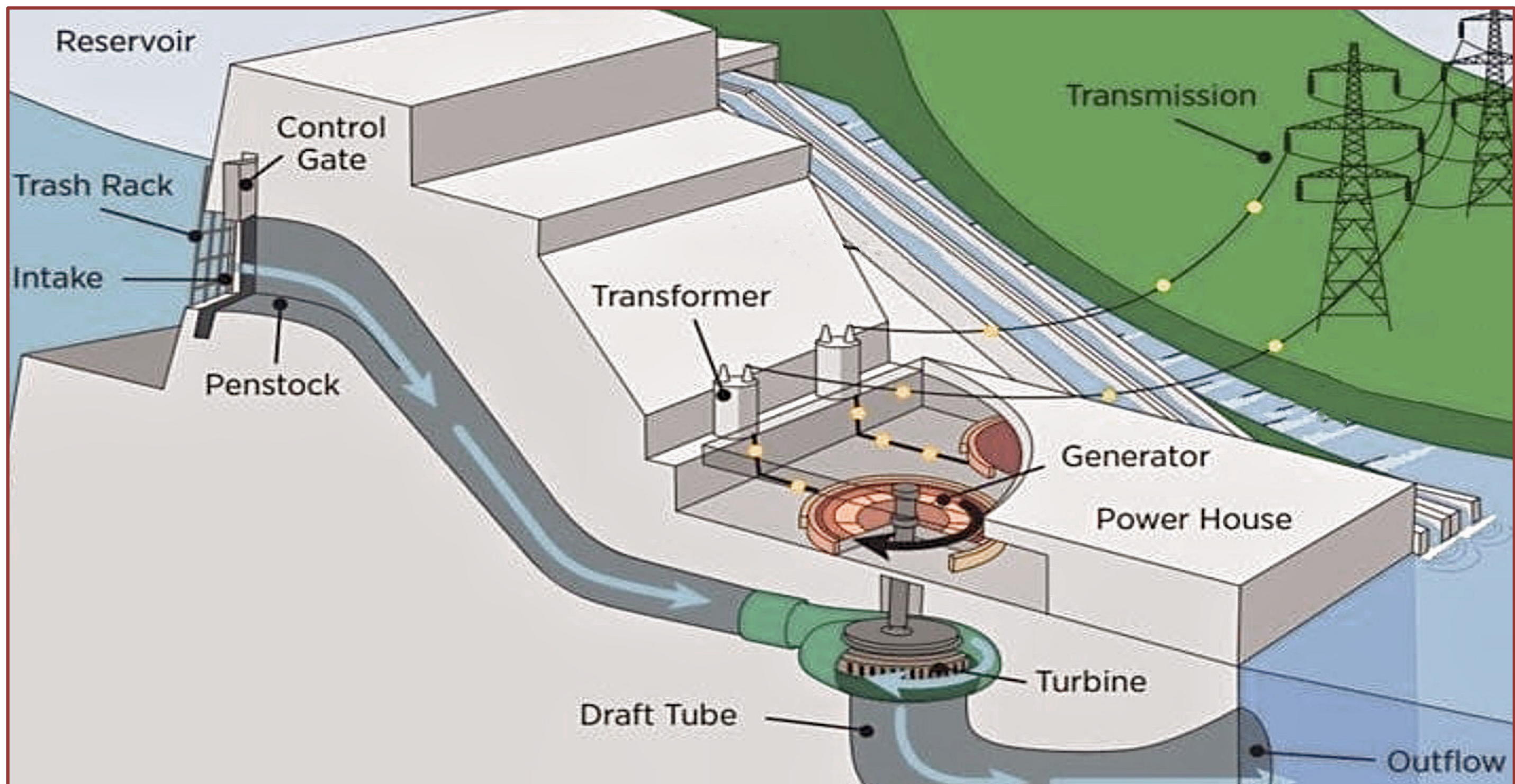


Fig. 1. Schematic diagram of a Swiss hydropower plant[4]

Overview of wind power in Switzerland

Wind power accounts for about 1.4% of electricity generation in 2019, a modest but growing contribution. [5] Figure 2 shows the growth in wind power production from 5 MW to 140 MW between 2002 and 2019. Wind turbines rely primarily on the wind to turn the blades and shaft, from which the generator is turned to produce electricity. The amount of electricity generated depends on the speed of the wind and the size of the turbine. Figure 2 also shows that in 1990 the turbine size could only produce 250 kW, whereas in 2019 an enlarged turbine could produce 10000 kW. The ratio of actual to maximum energy output of wind turbines in 2020 is 22.7%, which is relatively low compared to some other countries. [3]

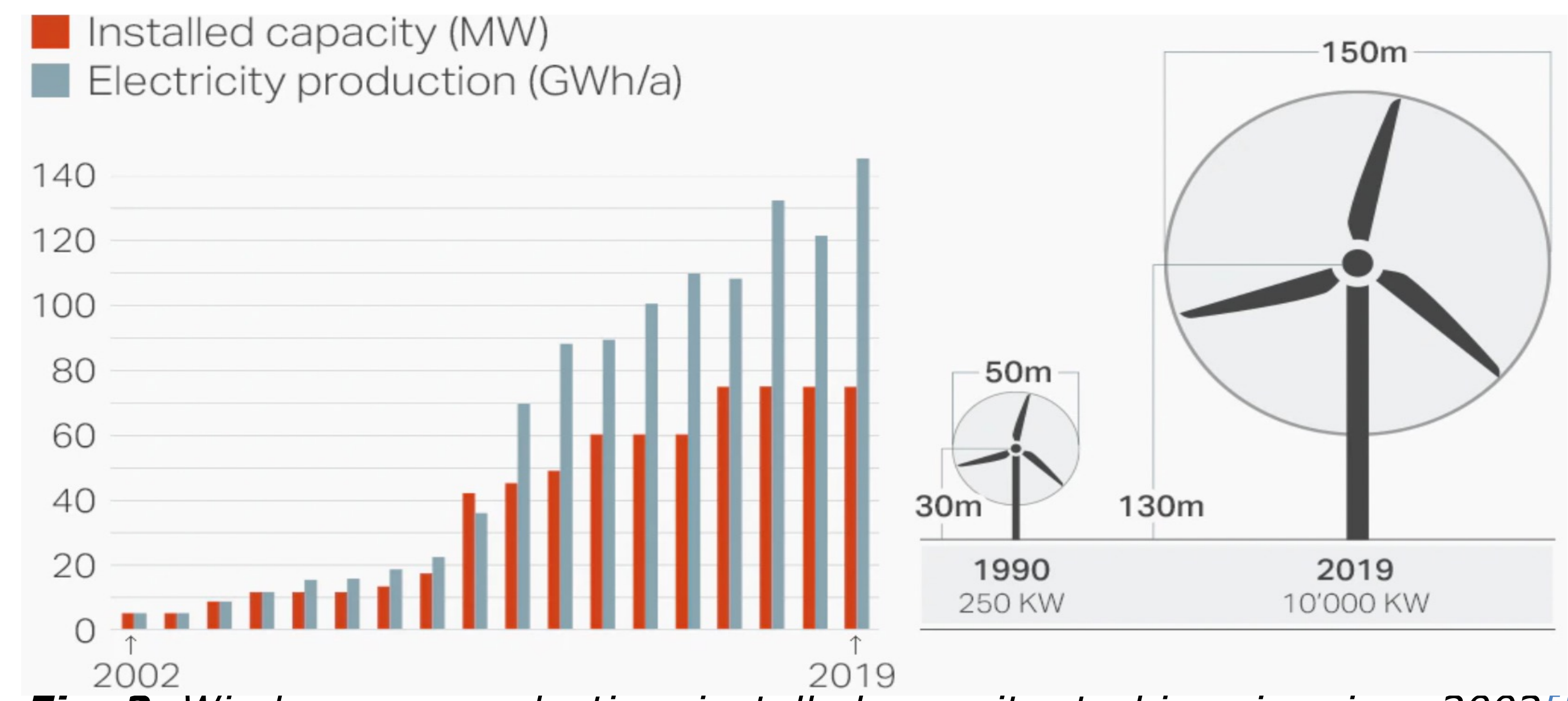


Fig. 2. Wind energy production, installed capacity, turbine size since 2002[5]

Potential for future expansion and Conclusions

In recent years, Switzerland has made good progress in renewable energy and several large-scale projects are being developed, such as the Jura wind project, which is expected to start construction in 2024 and consists of 22 turbines with a total capacity of 150 MW, making it one of the largest wind farms in Switzerland. [1] Government scheme to promote the installation of photovoltaic panels on buildings provides financial incentives for residential and commercial properties. This plan aims to add 300 MW of new solar capacity by 2025, equivalent to the electricity consumption of around 75,000 homes. [3] Switzerland aims to increase the share of renewable energy in the total energy mix to 43% by 2035 and commit to achieving carbon neutrality by 2050. [2] If Switzerland continues to make progress towards its energy goals, the contribution of renewable energy to the total energy mix is likely to continue to increase over the next 10 years. The share of wind power is currently relatively small, at around 1%, but is expected to increase as new wind power projects are developed. [5] In conclusion, Switzerland is making significant efforts to develop renewable energy technologies such as wind, water and solar energy to meet its environmental objectives. Considerable progress has been made in the past, but there are still goals to be achieved in the future.

References: [1] N. Lienhard, R. Mutschler, L. Leenders, and M. Rüdisüli, "Concurrent deficit and surplus situations in the future renewable Swiss and European electricity system," Energy Strategy Reviews, vol. 46, p. 101036, 2023/03/01/ 2023, doi: <https://doi.org/10.1016/j.esr.2022.101036>.
[2] M. Rüdisüli, E. Romano, S. Eggimann, and M. K. Patel, "Decarbonization strategies for Switzerland considering embedded greenhouse gas emissions in electricity imports," Energy Policy, vol. 162, p. 112794, 2022/03/01/ 2022, doi: <https://doi.org/10.1016/j.enpol.2022.112794>
[3] K. Schumacher, F. Krones, R. McKenna, and F. Schultmann, "Public acceptance of renewable energies and energy autonomy: A comparative study in the French, German and Swiss Upper Rhine region," Energy Policy, vol. 126, pp. 315-332, 2019/03/01/ 2019, doi: <https://doi.org/10.1016/j.enpol.2018.11.032>.
[4] <https://blueinfras.com/hp1-principles-of-hydropower-engineering> Online. Accessed 15/03/2023. Time 20.46
[5] <https://www.swissinfo.ch/eng/sci-tech/swiss-wind-power-held-up-by-legal-challenges/46027692> Online. Accessed 15/03/2023. Time 22.30