Achieving 100% Renewable Electricity in Austria – Analysing the EAG-Goals

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Abstract: According to the Renewable Expansion Act, Austria must generate 100% of its electrical energy from renewable sources (national balance). Renewables include biomass, wind, solar and hydropower. To achieve this goal, the installed capacity of wind and solar power plants must be increased significantly. In this work, the LEGO model is used, which is a very flexible and modular simulation model for the energy sector. First, the Austrian electricity system for the year 2020 is modelled and updated to the current state. Then, the EAG target for the year 2030 is simulated. Based on these simulation results, it is possible to assess how high the addition of the various generation technologies will be and at which locations additions should be made. 4.8 GW of wind and 10.4 GW of PV will be added and 6 lines will be needed in addition to known plans.

Keywords: EAG, #mission2030, renewable energy sources, energy transition

1 Introduction

Austria's electrical energy system faces new challenges through its expansion of renewable energies. The Renewable Energy Expansion Act (Erneuerbaren Ausbau Gesetz; EAG) stipulates that from the year 2030, electricity consumption is to be covered 100% nationally on balance from renewable energy sources [1]. To achieve this goal, the EAG prescribes an increase in electricity production from biomass by 1 TWh, hydropower by 5 TWh, wind by 10 TWh, and photovoltaics by 11 TWh to meet the expected demand of 82 TWh in 2030 purely from renewable energy sources. This addition of renewables is transforming our electricity system with currently a few large and on-demand power plants to one with many small generators with volatile generation. Despite the massive change, system stability must continue to be ensured in the future.

This paper is dedicated to the analysis of the Austrian electricity system in 2030 by replicating the electricity sector in the open source "Low-carbon Expansion Generation Optimization" (LEGO) model available on GitHub[1]. How will the planned expansion affect the system? A further analysis is made comparing the expansion targets set in the EAG with results of a cost-minimizing expansion of renewables to achieve the goal of 100% renewable electricity generation (national balance) in 2030.

[1] https://github.com/wogrin/LEGO

The remaining of the paper is structured as follows: In Section 2 the LEGO model and the implementation of the Austrian electricity system is explained, Section 3 details the EAG scenario and the modifications to the LEGO model to simulate it. Section 4 shows the results of the base year 2020 and compares it with data from Statistics Austria as well as the results from the simulation of the EAG scenario. Finally, section 5 concludes the paper with a summary.

2 Simulation model LEGO and implementation of Austria

The LEGO model is an optimization model for cost minimization - depending on the selection of modules to be treated. It provides a wide range of results. The model is flexible in two ways: (i) in terms of time and (ii) in terms of thematic modelling blocks that can be combined with each other. Figure 1 shows a schematic representation of various modelling blocks. These can be added depending on the study. The existing model is described in more detail in [2]. For the implementation of the Austrian electricity system, the data from the ATLANTIS model [3] are converted into a format compatible with LEGO. This involves a total of 911 lines, 184 transformers, 2 phase shifting transformers, 1 304 power plants and 468 nodes. For each node, there are solar and wind profiles over an entire year that reflect the hourly generation coefficient. These profiles were provided by Renewables Ninja [4]. Water inflows for each pumped storage, reservoir, and run-of-river power plant were calculated using data from APG [5] and E-Control [6] and incorporated into the model. As a further step, candidate power plants are included in the model. For this purpose, studies of the Austria wind [7] and solar potentials [8] are integrated. In Austria, the renewable power supply is expected to increase by 27 TWh by 2030. Of this, 11 TWh will be generated from photovoltaics and 10 TWh from wind power [9].

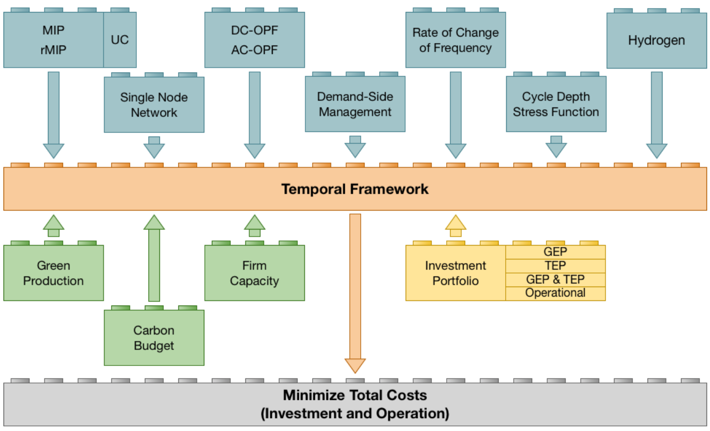

Figure 1: model description

Figure 2 shows the spatial distribution of power plants within Austria for the year 2020. Geographically, there are two distinctive distributions of power plants in Austria. The large pumped-storage and storage power plants are mainly located in the western part of Austria. In contrast, the large wind farms are located in the northeaster area. This poses a great challenge for the grid. The run-of-river power plants are located on along the larger rivers in Austria.

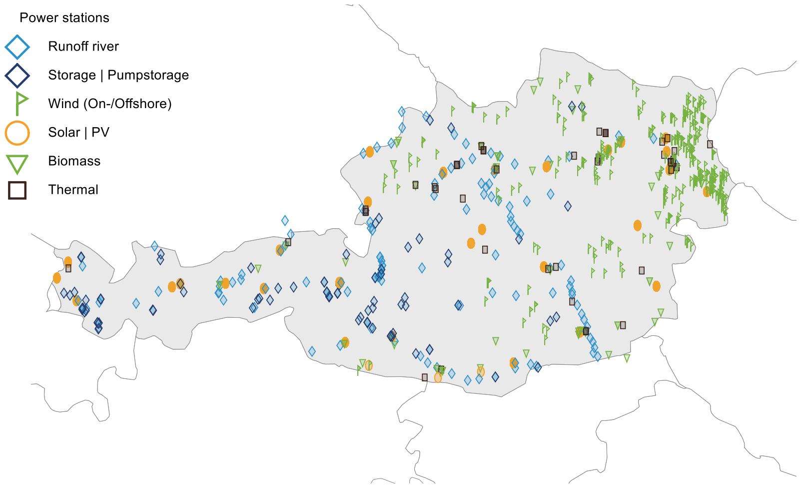

Figure 2: Power stations of 2020

3 Future scenario EAG 2030

In order to implement new climate policy goals and requirements of the European Union, the Renewable Energy Expansion Act was passed by the Austrian Parliament on July 7, 2021 [10]. The law provides for the conversion of the electricity supply to 100% electricity from renewable energy sources (national balance) by 2030, to become climate-neutral by 2040 and to fundamentally modernize the Austrian subsidy system for green electricity. Austrian electricity generation from renewable energy sources is therefore to be increased by 27 TWh by 2030. The electricity generation is made up of the following technologies:

- 11 TWh photovoltaics
- 10 TWh wind power
- 5 TWh hydropower
- 1 TWh biomass

With the currently installed capacity of renewables, the 2030 target of the EAG cannot be implemented. Therefore, it is necessary to invest in renewable energy power plant capacities until 2030. In order to study the effects of this large implementation of variable renewable energy sources into the Austria electricity system, a simulation with the LEGO model is made. For this, so called candidate power plants are added to the system of LEGO Austria 2020. These are integrated into the model on the basis of potentials and are only added by the model if they are needed.

Figure 3 shows the modification of the LEGO model for the EAG scenario 2030. For this, some changes have to be made. First, power plants that will be shut down by then must be removed from the model. Fuel prices and CO_2 prices have to be assumed for the year 2030. The consumption of Austria is increased to 82.6 TWh. Based on potentials, so-called candidate power plants are implemented into the model. The generation targets of wind, solar and biomass is given based on the EAG target.

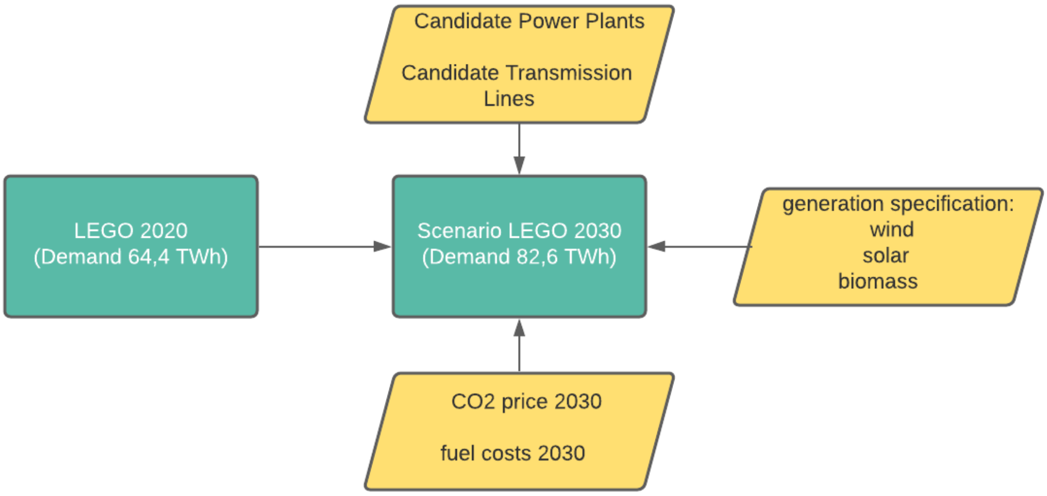

Figure 3: Scenario 2030 in LEGO

A wind power potential analysis shows that there is a residual potential of about 20 GW in Austria [7]. According to the solar potential study, the residual potential of solar power plants in Austria is about 53.6 GW [8]. Figure 4 shows the wind and solar potentials of the Austrian federal states. High wind potentials are in Upper and Lower Austria. As Burgenland already uses much of its wind power potential and national parks are excluded from the study, the remaining potential is low. High solar potentials are in Tyrol, Styria and Carinthia. These potentials are included in the model as candidate power plants.

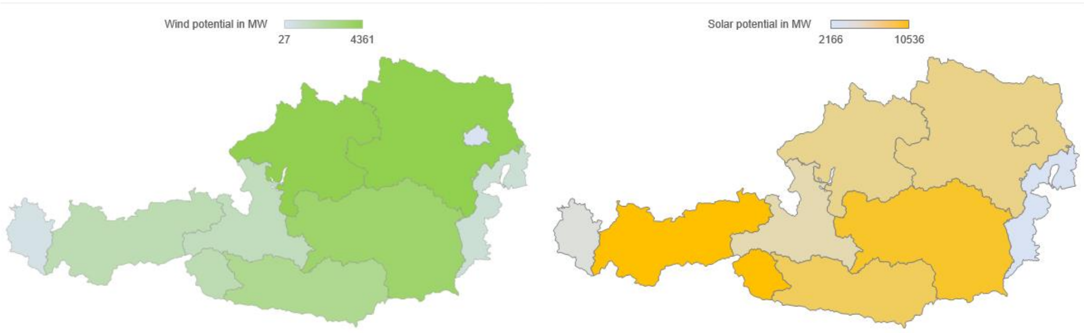

Figure 4: Solar and wind potential of the federal states of Austria

Figure 5 shows the distribution of the potential of biomass, solar, wind and hydropower plants. The existing potentials of wind and solar are allocated to the nodes from the studies mentioned above. Two pumped storage power plants with a total capacity of 1.6 GW are implemented. For the run-of-river power plants, 12 power plants with a capacity of 1.7 GW are included, mainly on the Danube. For biomass, 24 power plants with a capacity of 156 MW will be integrated across Austria.

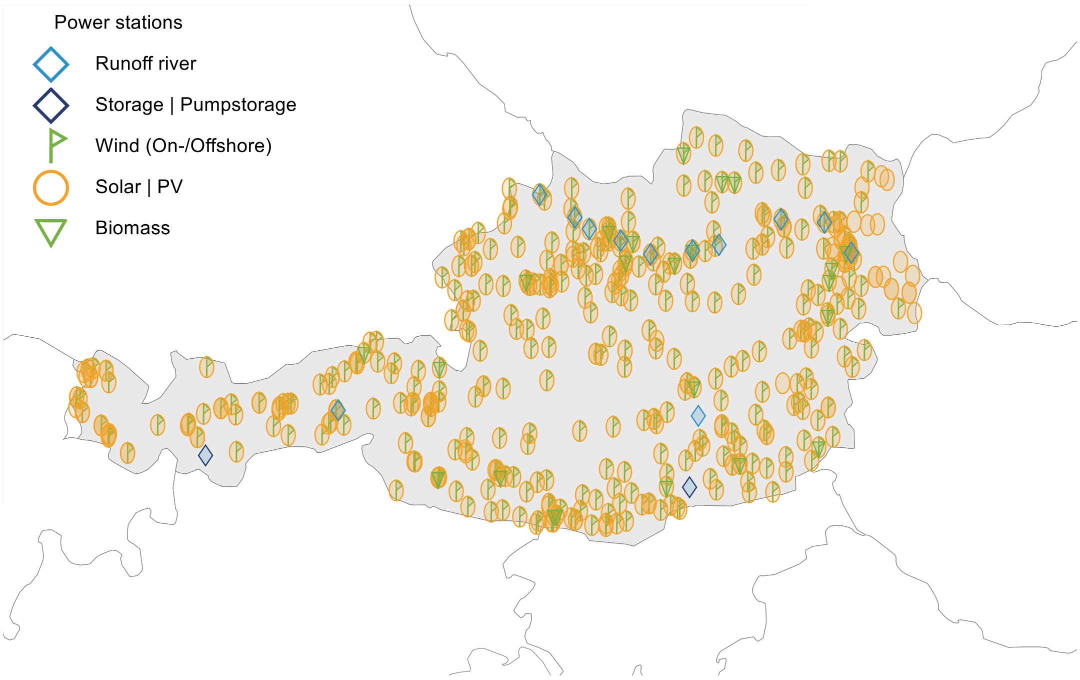

Figure 5: Candidate power stations for 2030

4 Simulation results

In this section, two scenarios are simulated and then compared with other results. First, the 2020 baseline scenario is simulated and a comparison with data from the Statistics Austria is made to calibrate the model. Then, the 2030 scenario is simulated with the specifications of the EAG. The two results are checked for plausibility and then analysed. Both scenarios were calculated with seven representative periods.

4.1 Comparison Statistics Austria and LEGO for 2020

The first simulation is used to integrate the Austrian electricity system into the LEGO simulation model and to eliminate errors. The year 2020 is simulated and then compared with data from Statistics Austria and adjusted if necessary. The consumption of Austria is assumed to be 64.4 TWh. For this scenario, import is fixed at 25.5 TWh and export at -22.3 TWh. Biomass power plant generation is set to a minimum of 3.6 TWh. Pumping consumption is fixed at 3.36 TWh, this value is taken from Statistics Austria [11].

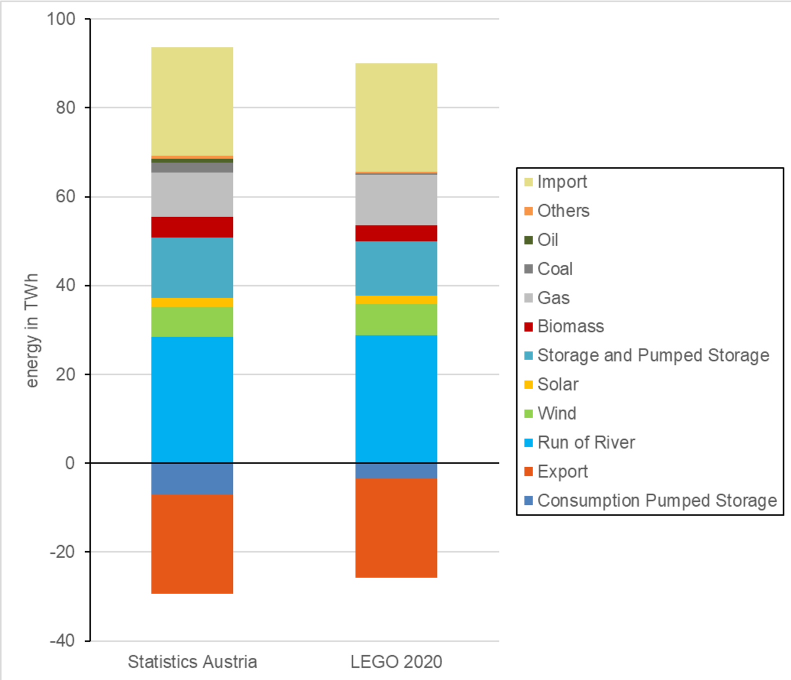

Figure 6: Comparison of produced electricity between Statistics Austria and LEGO for 2020

The result, as shown in Figure 6, is very similar to the values of Statistics Austria. The largest share of Austria's generation is generated from hydropower plants. In relation to the consumption of 64.4 TWh, this amounts to 58%. In total, 78% is generated from renewable energy sources.

4.2 Comparison EAG and LEGO for 2030

The year 2030 is calculated with candidate power plants and candidate lines as described in section 3 of this paper. Consumption is increased to 82,6 TWh. To meet the EAG target, minimum generation is set for Wind to 16.3 TWh, Solar to 12.4 TWh and Biomass to 5 TWh

To meet this requirement, the model must add power plants and possibly transmission lines. Some power plants will be shut down by 2030, and these are removed from the model. These include all coal power plants and some gas power plants. The transmission grid in Austria is also changing, including the 380 kV Salzburg transmission line and some other projects that are included for the simulation of 2030.

In Figure 7 the simulations of LEGO for the scenario 2020 and 2030 can be seen. In the 2030 scenario, the entire consumption is covered by 100% renewable energies. For this, some power plants have to be added.

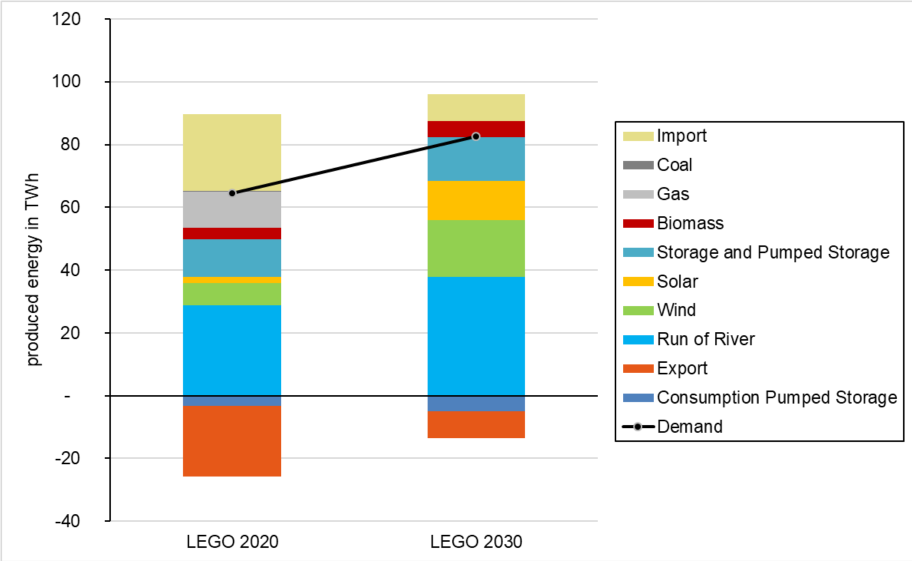

Figure 7: Comparison between LEGO 2020 and LEGO 2030

To cover the demand, the amount of capacity is increased by the model as follows:

- 4 861 MW of wind
- 10 441 MW of solar
- 156 MW of biomass
- 1 738 MW of run of river
- 1 616 MW of pumped storage

Figure 8 shows the installed capacity for the year 2020 and 2030. Photovoltaics will take the largest share of installed capacity. Wind power will more than double. The number of gas power plants decreases; thus, the installed capacity also decreases. Since the last coal power plant was closed in 2020, there will be none left in 2030. Overall, the bottleneck capacity for the year is about 42 GW. In comparison, this is only 25 GW in 2020.

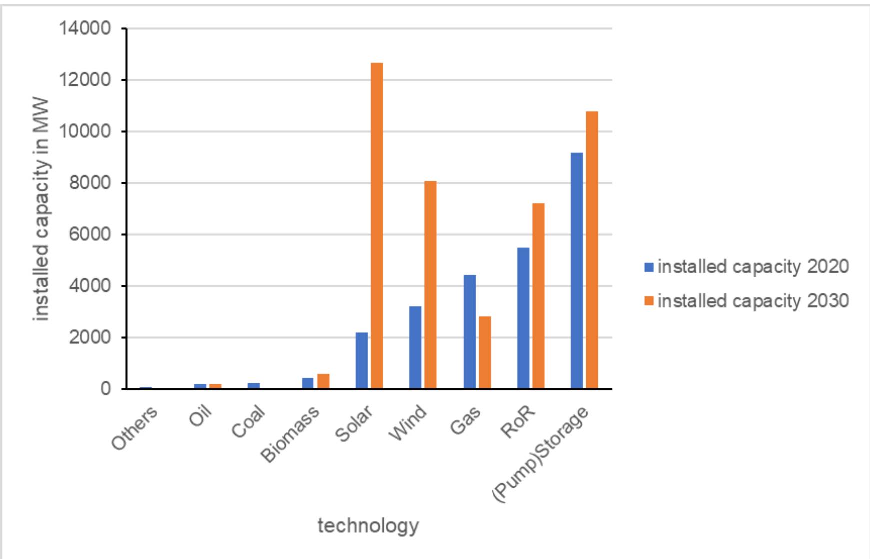

Figure 8: Comparison of the installed capacity of the LEGO 2020 and 2030 scenario.

Figure 9 shows the generation from renewable energy sources. Three scenarios are compared. Statistics Austria 2020, LEGO Simulation 2020 and 2030 with EAG specifications. The share of renewables increases to 100%. The generation from wind and solar increase very strongly.

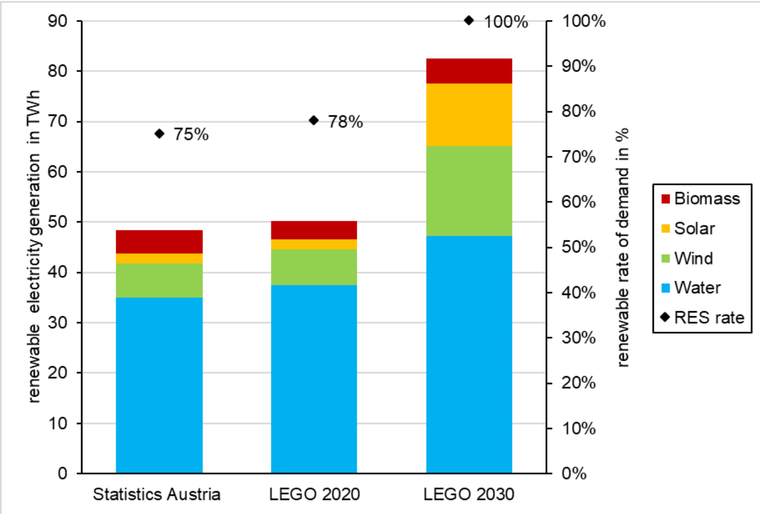

Figure 9:Comparison of the energy production by different scenarios and the rate of renewable production in relation to the consumption.

Based on the potentials, the candidate power plants are added as shown in Figure 10. Due to the high solar potentials in Tyrol, a lot of solar power plants are added here. Wind power plants are added mainly in Lower and Upper Austria.

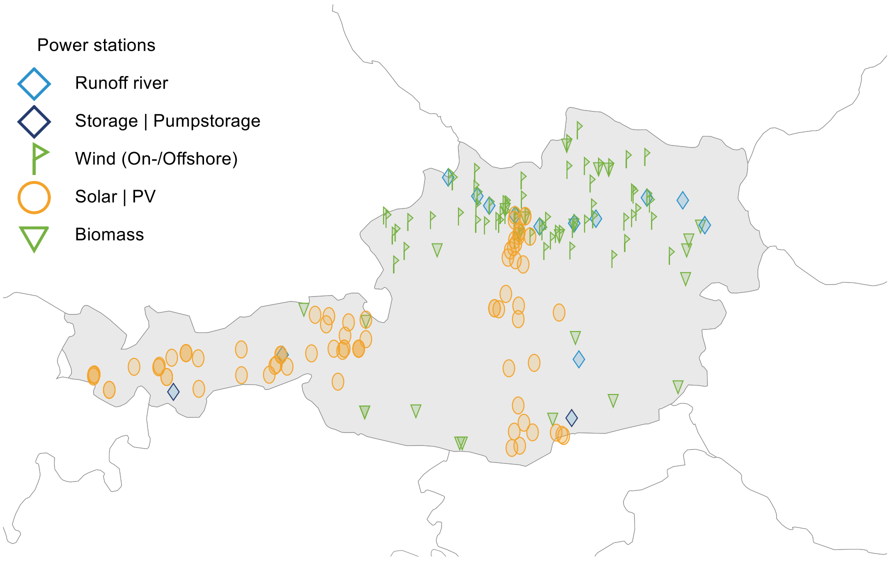

Figure 10: Addition of the power plants for the year 2030

5 Summary

Electricity consumption will increase to about 82.6 TWh by 2030. This increase is assumed to be due to increase in Electromobility, electrification of industry and heating among others. Some conventional power plants will be shut down by 2030. According to the simulation a total of 17 040 MW of supply-dependent power plants (PV, wind, run-of-river) will be integrated into the grid. This transformation of the electric power system is not easily manageable and brings some challenges. Among other things, grid reliability is very critical during bad weather conditions. In these phases, large-scale storage facilities have to cover the electrical energy demand or import from other countries is needed.

In order to cope with this strong expansion of renewables, some hurdles have to be overcome. Among other things, building permits must be simplified, grid infrastructure must be strengthened, storage must be installed.

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