Solar battery program in Austria – innovative solutions for increasing solar coverage

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ABSTRACT

Upper Austria is one of Austria's nine federal states with a population of 1.4 million. Renewable energy currently supplies more than 32% of the total energy demand. Photovoltaics are an important element, currently 21.5 million ft² are installed, equalling an installed capacity of 14.8 ft² per inhabitant. To take sustainable energy market development to the next level, the state implemented a support program for solar batteries with the aim to support innovation and kick-start market development. It supports households with an existing PV system to store the generated electricity in a battery storage, thus increasing the share of solar electricity that can be used on site. In the Austrian climate, on average, households with a typical PV system can only use 30-40% of the electricity generated, with a solar battery this can be increased to 60-70%. The program was very well received and in total more than 800 households participated. A scientific evaluation of the performance of the systems is in place.

Keywords: solar energy, solar battery, storage, photovoltaics, support program

1 BACKGROUND

1.1 Upper Austra – a leading energy state

Upper Austria is one of Austria's nine federal states with a population of 1.4 million. It is located in the northern part of the country, bordering Germany and the Czech Republic. Since the mid-90s, the government of Upper Austria has prioritized energy efficiency and renewable energy. Renewable energy currently supplies more than 32% of the total energy demand in the state, of which 16% comes from modern wood biomass, 11% from hydropower and about 5% from solar and other renewable energy sources. The high share of renewables in the energy mix was achieved through comprehensive state energy action plans. In these plans, the state follows a "sticks, carrots and tambourines" approach, a combination of regulatory, financial and information measures.

Most of the energy programs are managed by the OOe Energiesparverband, the state energy agency. The strategic approach to sustainable energy has also resulted in a robust growth of sustainable energy businesses. Over 250 companies collaborate in the energy and environment business network, the Cleantech-Cluster.

2 SOLAR ENERGY STORAGE

2.1 Solar energy – an important element in the energy transition

Photovoltaics are an important element in the energy transition, the process of phasing out fossil fuels from the energy system. The state has provided support to market development in the past decade, making Upper Austria a leading PV market. Currently 21.5 million ft² are installed, equalling an installed capacity of 14.8 ft² per inhabitant.

2.2 The solar battery program

To take sustainable energy market development to the next level, the state implemented a support program for solar batteries. The aim of the program was to support innovation and kick-start market development in a very early phase. It supported households with an existing PV system to install a solar battery, thus increasing the share of solar electricity that can be used on site.

The decision was taken to support only batteries with lithium technologies, which at the time of the program start offered the most interesting options (now a wider choice of technologies is available).

2.3 Increasing self-consumption of solar PV

A solar battery in conjunction with a PV systems enables the intermediate storage of the electricity generated on site. With intelligent battery solutions, households can consume their own PV electricity even when the sun is not shining. Without a battery storage, the generated electricity must either consumed immediately or fed into the grid. However, the very low feed-in tariff renders this option economically uninteresting for PV plant operators.

The practical benefits of a solar power storage for a household can be described with the following two parameters:

- The "self-consumption rate" indicates the share of on-site generated PV electricity that can be consumed, also by means of the battery storage system.
- The "solar coverage rate" indicates the share of the household's electricity consumption that can be

covered by the self-generated solar electricity, also by means of the battery storage system.

An average household with a typical-sized 5 kWp PV system uses approximately 30% of the generated electricity in the Austrian climate. The rest is usually fed into the grid as excess supply. The remuneration for PV feed-in is economically very unattractive, thus the large interest of PV plant operators to use as much of the solar electricity as possible.

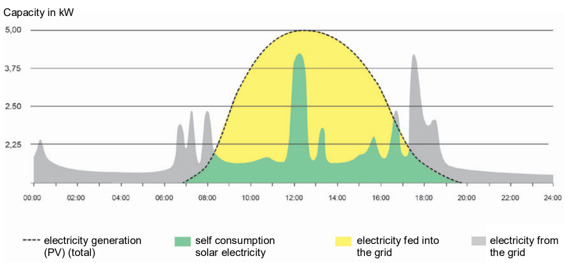

Figure 1: PV self-consumption withtout battery storage

The typical electricity consumption of a 4-person household is 3,500-4,000 kWh/year in Austria, compared to around 10,000 kWh/year in the US (Source: US Energy Information Administration).

2.4 How does solar energy storage work

A PV battery sytem collects the solar electricity generated during the day that is not directly consumed. When the sun is not available during the day or due to weather conditions, the PV electricity can be taken out of the battery storage. Intelligent equipment controls the flow of electricity between the PV system, consumers in the household, storage system and public grid.

If the PV system generates electricity, the current electricity demand in the household is firstly covered. If the current generation exceeds the present demand, the battery is charged. The excess electricity is fed into the grid only when the battery is fully charged.

The storage capacity can be chosen in such a way that the battery can supply the household with stored electricity until the next charging cycle, that is, when the PV system generates electricity again (see consumption diagram, example for July). If, in the meantime, a higher peak load occurs, additional power is obtained.

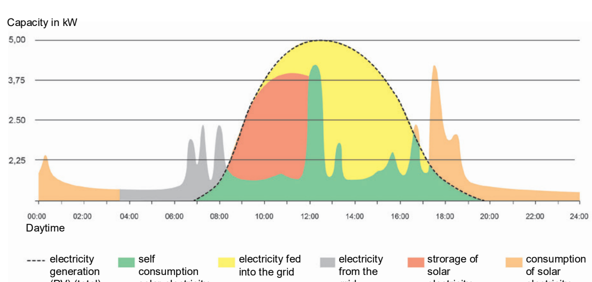

Figure 2: PV self-consumption with battery storage

2.5 System components

Genreally, a residential PV system consists of the following components:

- PV modules
- conversion components (inverters)
- battery
- monitoring and metering equipment

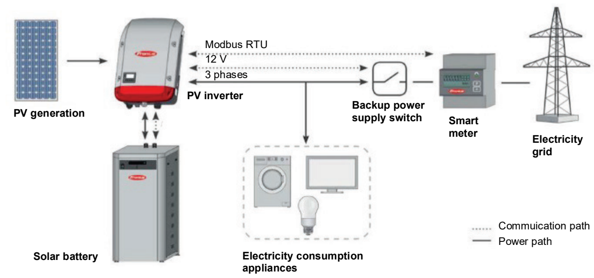

Figure 3: Example of system components

2.6 Lithium-Ion technology

Lithium-ion batteries have not yet been available on the market for as long as lead-acid batteries. They are currently more expensive than lead-acid batteries. However, lithium-ion batteries can be charged/discharged significantly more often (up to 7,000 full cycles), achieve higher efficiencies and discharge depths and are maintenance-free. In addition, they are smaller and lighter than lead-acid batteries.

In a lithium-ion battery, the anode consists of a copper foil coated with a graphite compound or lithium titanate. The cathode, the positive electrode, is a lithium compound. The electrolyte is a dissolved lithium salt. Depending on whether the electrolyte is liquid or gel-like, they are called lithium-ion batteries or lithium-polymer batteries.

The various lithium-ion batteries differ primarily in the material used for the cathode, which consists of cobalt, manganese, nickel or iron phosphate and their compounds (common types of lithium-ion batteries: lithium-nickel-manganese-cobalt batteries, lithium-iron-phosphate batteries, lithium-manganese batteries, lithium-cobalt batteries). The different materials influence the energy density, power density, nominal voltage, calendar life and charging cycles.

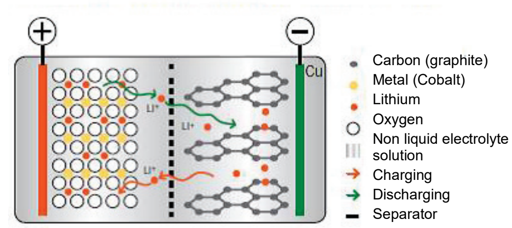

Figure 4: Scheme of a lithium ion accumulator

2.7 AC/DC concepts

Battery systems typically operate with direct current, which is also the form of current generated by PV systems. In order to use the solar electricity in the household or feed it into the grid, it must be converted into alternating current. A range of legal requirements and standards must be complied with.

The following concepts are typically used for the technical installation of storage systems:

- connection of the storage system to the alternating current (AC) circuit of the building
- connection to the direct current (DC) circuit of the PV plant

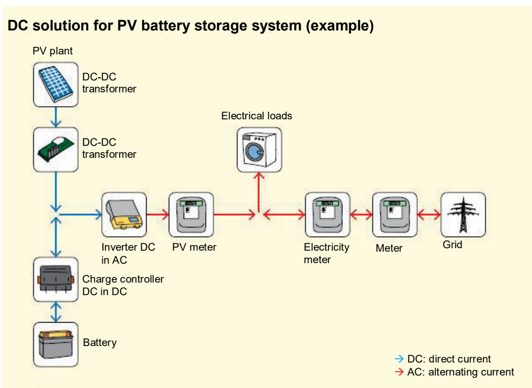

Figure 5: Example of DC installation concept

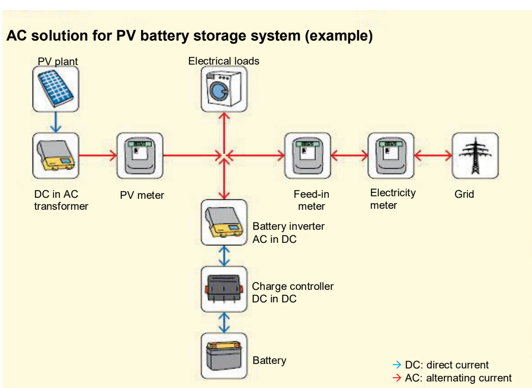

Figure 6: Example of an AC installation concept

2.8 Integration of electric vehicles and Smart Home concepts

Stationary PV storage helps to increase the share of generated PV electricity that can be used on site. The self-consumption rate can also be increased through the use of an electric vehicle (EV).

In the current Smart Home concepts, the PV plant, electricity storage system and EV work together. The electricity generated by the PV plant is either used immediatly by household appliances or e-vehicles or stored in the battery system. When no PV electricity is generated, required electricity is taken from the battery storage system.

Smart charging stations can use the electricity generated by the household's PV plant to charge an EV. Excess PV electricity is passed on to the household appliances and is also used to recharge the EV. An intelligent energy monitoring and management system measures, at every given moment, the exact amount of excess PV electricity and passes it on to the EV charging station.

Figure 7: Vehicle-to-Home (V2H)

In the future, more "Vehicle-to-Home" (V2H) are likely to used when an EV is fully integrated into a Smart Home System. When the sun shines, the EV is charged with PV electricity from the on-site PV plant. As an integrated part of the system, the battery of the EV absorbs the excess energy and returns it when it is required. This is especially suitable for households where the electric car is not used for daily commutes to work and available when the sun is shining during the day.

2.9 Dimensioning

For an average household with a self-consumption rate target of 60-70% in Upper Austria (3,400 heating days, average annual household electricity consumption of 3,500 kWh/year), the following rule of thumb applies:

Usable storage capacity in kWh = 1.2 – 1.5 times the kWpeak capacity of the PV plant

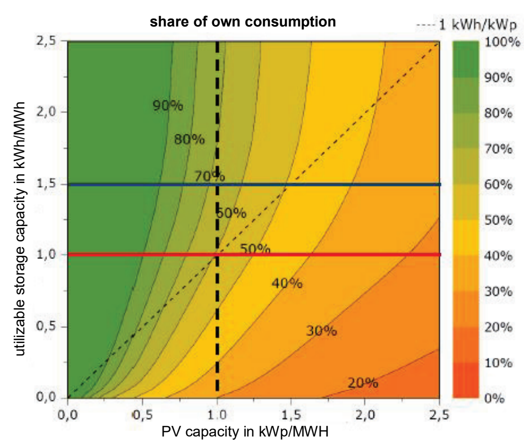

Figure 8: Example of dimensioning: 5,000 kWh annual electricity demand, 5 kWp PV system, storage capacity 4 kWh to 6 kWh

3 PROGRAM RESULTS AND MONITORING

The support program gave an incentive that reduced the price of a stored kilowatt-hour of electricity to about 20 Cent/kWh (= 21 US Cent/kWh), which is an average household electricity price in Austria.

The program was very well received. In total 890 households participated. At the beguinning of 2017, more than 600 batteries were already installed.

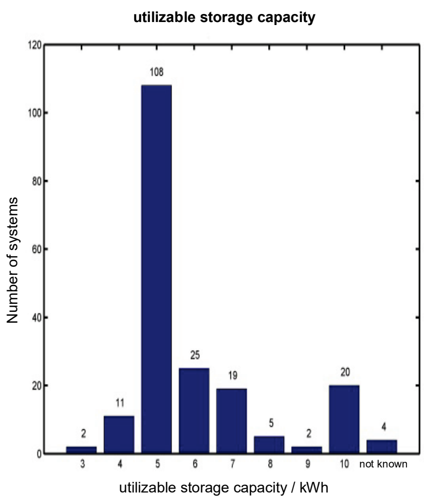

Figure 9: Installed usable storage capacity of monitored installations

The following graphic from the evaluation shows the increase in self-consumption rate as a function of the battery size.

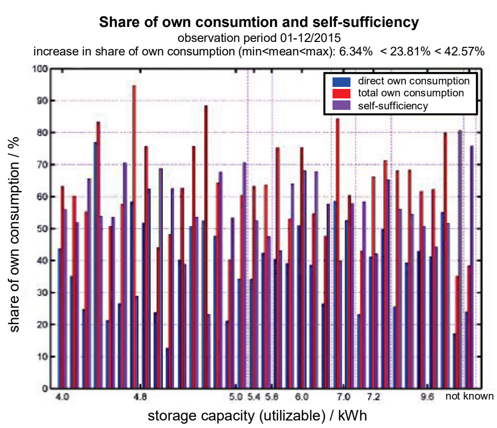

Figure 10: Self-comsumption through increased storage

In addition to the technical analysis, also selected households were visited and interviewed by a trained energy consultant and additional energy efficiency potentials were assessed. The most important conclusions arizing from these personalized energy advice sessions can be summarized as follows:

- There is a very high level of awareness among the households participating in the program (they are typical "early adopters"). In overall terms, their handling of electricity is very responsible.
- Nevertheless, there was at least 10% efficiency potential identified (mostly standby consumption) for all households.
- The dimensioning of the PV and storage systems was not always ideal - the degree of capacity utilization could be improved by the future use of an electric vehicle.
- Many homes showed a surprisingly high baseload during night hours, which partly consumed the stored energy. Causes were often the high electricity demand of the central heating circulation pumps and the standby demand of home office equipent.
- The most important efficiency measures proposed in the advice sessions were: lighting replacement (LED) and replacement of cirulating pumps.

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