SOLENCO POWERBOX: REVOLUTIONIZING THE WORLD OF ENERGY TODAY

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ABSTRACT
Solenco Power NV is a fast-growing SME innovator in the field of cleantech and specializes in energy storage systems for residential and industrial sectors. The Solenco Powerbox (SPB) is the company's first disruptive commercial energy storage product, which is approaching commercial readiness. Dr. Hugo Vandenborre, the founder of Solenco Power and an authority in the field of hydrogen, is convinced that energy storage and the SPB will unlock the true potential of full-scale renewable energy sources (RES). SPB is a whole chain 0% carbon solution, that contributes to a 100% renewable energy adoption, validated in this paper.
Keywords: renewable energy, energy storage, seasonal storage, hydrogen, proton exchange membrane.

1. INTRODUCTION
Mid-September 2020, the European Commission (EC) announced that will boost its goals to reduce greenhouse gas emission to at least a 55% reduction by 2030. In addition, it aims to reach at least a 32% share of renewable energy and a minimum improvement in energy efficiency of 32.5%. Furthermore, the EC's new program Green Deal, outlines its ambition for Europe to become the first Carbon-neutral continent by 2050, with a reduction of the greenhouse gas emissions by 80-95% compared to 1990 levels.
The European Union (EU) and its strategy in energy policy against the climate change proofs that changes are about to come. Ideas and initiatives to support the accomplishment of the highly demanding targets are expected and supported by programs like Innovation Action call. Last 27th of January 2021, the EC received the submission of 1550 applications in topics targeting the goals above mentioned. Several of these calls were mainly related to the deployment of existing and new renewable energy sources (RESs).
The EC has declared its ambition of making the EU the world leader in renewable energy. It has shifted from an energy system dominated by centralized fossil fuel generation to a model with increasing roll out of RES. But RESs are unpredictable.
As a simplification, an energy network consists in generation, transmission, distribution, and loads. Mostly centralized generation, in the form of power plant such us thermal based on gas, nuclear, coal within others. The network of conductors that serve to transport the electrical power from the generating power station to substations are englobed in the transmission system. In the last part on this network, electrical power from the substations to the end consumers or loads, done by the distribution system.
To accomplish the target of decarbonization, one of the EC approaches consist on increasing the share of renewable consumption, by means of installing more RESs and make use of that energy. This means RES becoming a generation actor in the energy network. But due to the nature of their inputs, RESs cannot be controlled. The solution just does not relay on installing more and more RESs. It is about finding a way to balance their output.
The figure 1 taken from Elia website, shows the price imbalance in a quarter-hour basis. One can see that unforeseen events, could have a relevant effect in the cost of energy.

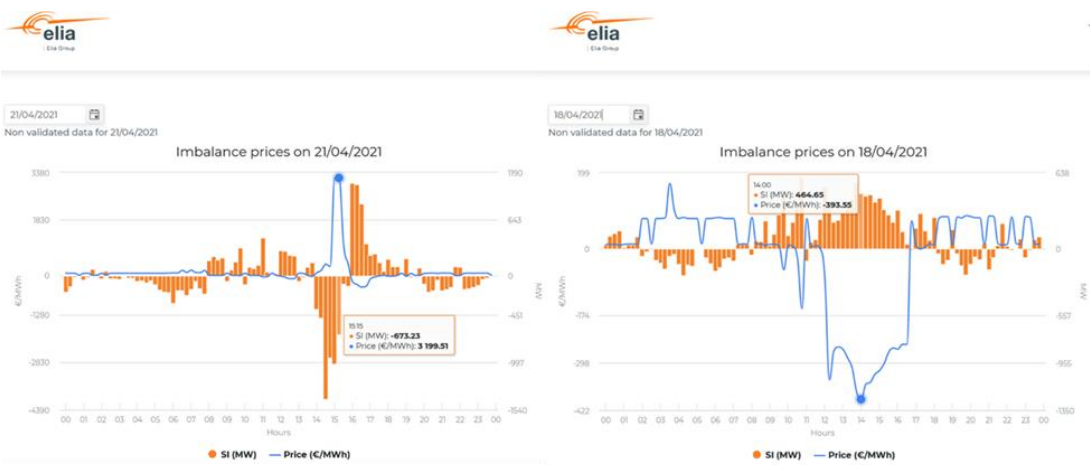


Fig.1. Peaks in electricity prices - Price Imbalance.

In the figure 1 on the left, one can see prices per megawatt hour (MWh) rising to 3.199,51€. The lack of electricity supply, make prices rise. This event introduces a problem as well as several opportunities. One of these opportunities is an economical benefit. For the one able to supply electricity during that period, there is a business opportunity. If the difference between this benefit compared to their costs of investment, operation and availability is positive, a business model could be drawn.
In the figure 1 on the right, reverse scenario. Prices per MWh go down to -393,55€. The overproduction during this period makes the price go negative. As well as before, this event indicates a problem as well as a business opportunity. One able to consume electricity at that period could get an economical befit.
Coming back to the problem revealed in these charts, one of the conditioning factors for this imbalance between supply and demand is the lack of elasticity in the electricity market. Demand-response take place in a very short period. If that combination cannot be compensated in the given period, prices will peak consequently. Although this information has been taken choosing specific dates with interesting information, that plot does not represent a standard, but it could expose an upcoming challenge.
From the discussion initiated after figure 1, one can see that the decarbonization does not just relay on installing more and more renewable energy source. As mentioned before, RESs are unpredictable so the control over them is practically impossible; but its balance can be achieved with the integration of energy storage systems (ESSs).
EESs are being considered and applied for their full integration in the current and future energy market architecture. They can act as a buffer of energy to store it when available, and use it when needed. For Solenco Power NV, hydrogen is identified as a potential candidate to be part of front the meter and behind the meter ESSs applications:
Front of the meter energy storage: energy storage facilities in the EU-27, operational or in project, that are connected to the generation and the transmission grid with their characteristics.
Behind the meter energy storage: installed energy storage systems in the residential, commercial, and industrial infrastructures.

2. MATERIAL AND METHODS

Under this section, the SPB and figure 2 will be further explored. When used in a residential home, electricity is produced during the day through solar photovoltaic (PV) panels and the generated power goes to its home appliances. Excess electricity can be directed to the SPB. Water is circulated over the PEM electrolysis side while feeding power. Water will split in oxygen, normally release to the atmosphere, and hydrogen that will be stored under pressure. During this process, useful heat is released. The electrolysis process can be initiated within seconds.

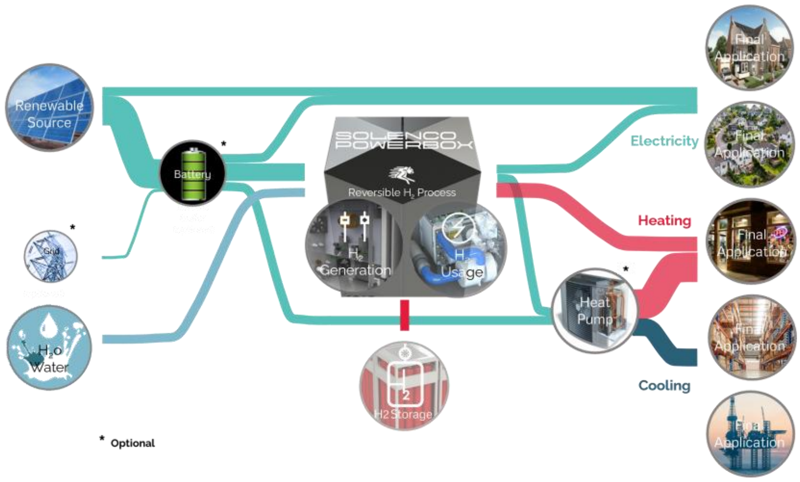


Fig.2. Peaks in electricity prices - Price Imbalance.

At night or when there is a lack of electricity, the stored hydrogen can be transformed by the reversible PEM fuel cell principle into electricity and heat. The electricity goes to appliances and the heat is used for low temperature heating systems as well as sanitary water heating.
The SPB at its hydrogen can store energy for undefined periods without losses. Storage from day to night-time hours is only part of the challenge to increase the share of renewables. Solar and wind are both typically seasonal. In terms of direct use, in the more irradiated parts of Europe, PV production could be sufficient to power installations during the summer months, but inadequate for winter. For installations in isolated areas,

storage solution that can easily shift energy from summer to winter must be developed. The SPB can make hourly, weekly, monthly, or so-called seasonal storage a reality. Figure 3 introduces a simplification between the load and the solar PV production, experience in a residential building, in a daily and yearly scope.

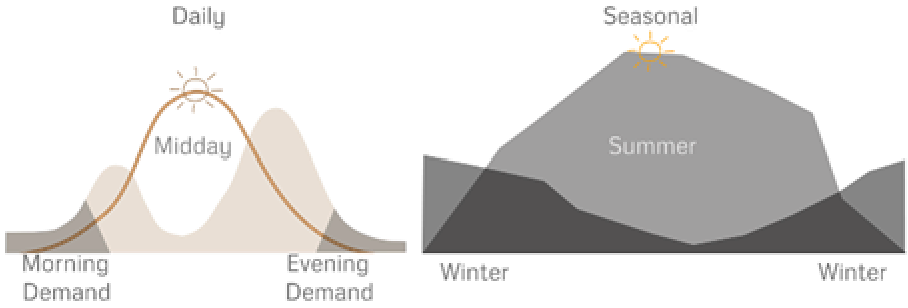


Fig.3. Photovoltaic production - Daily and seasonal renewable energy balancing challenge.

Due to its low density in volume, hydrogen is often compress after the electrolysis process. In this case, mobile applications are determining the standards for pressures, being in the United States 10.000 psi and 5.000 psi translated in Europe in 700 bar and 350 bar, respectively. In just few cubic meters of space, megawatts of energy can be stored. The novelty of Solenco's solutions and more precisely of the SPB relies in its reversible principle. A single system that combines energy storage and power cogeneration of electricity and heat.

2.1. Use case

As a practical example, it is introduced a use case where the topology described under table 1, in synergy with the SPB is integrated in a residential building, for electricity, heating and colling purposes. In this case, the goal is to optimize the use of RESs in a residential environment, by introducing the SPB and its hydrogen storage to compensate the mismatch between the generation profile of RESs and the consumption profile of the user, shown in figure 3. The following equipment is considered in this use case:

Table 1. Use case – Residential building.

Electricity demand (kWh)	*Heating demand (kWh)*	*Solar PV (kWp)*	***SPB** PEM Fuel Cell process (kW)*	***SPB** PEM Electrolysis process (kW)*	***SPB** Hydrogen storage (kWh)*	*Battery (kWh)*	*Heat pump (kW)*
2,500	7,500	12.5	5	5	3000	12	4

All those elements have been taken into consideration, making them interact with a real consumer profile, by using the control logic of the SPB, implemented in a SPB's simulation tool. The results of a yearly simulation have been plotted under the following section.

3. RESULTS AND DISCUSSION

The following figures 4, 5 and 6 summarize the results of the SPB's simulation tool applying the operational logic of the SPB, under the given user consumer profiles and dimensions of the installation.

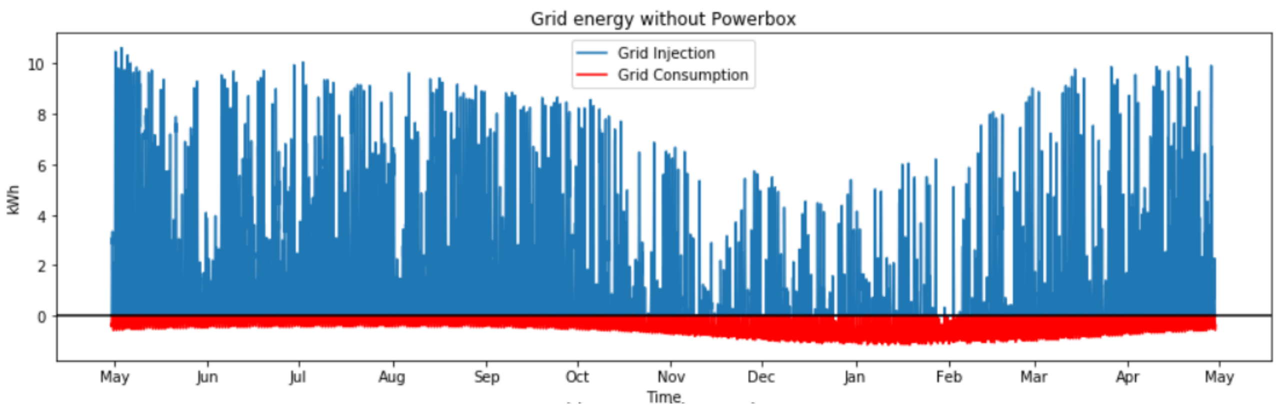


Fig.4. Electric grid profile - Injection and consumption without SPB

Fig.5. Breakdown of the energy flows

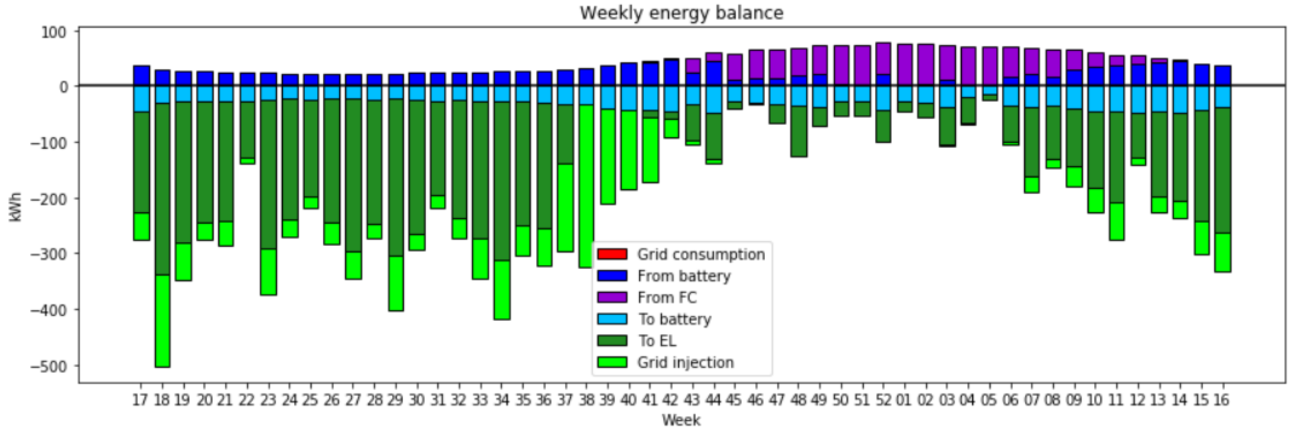
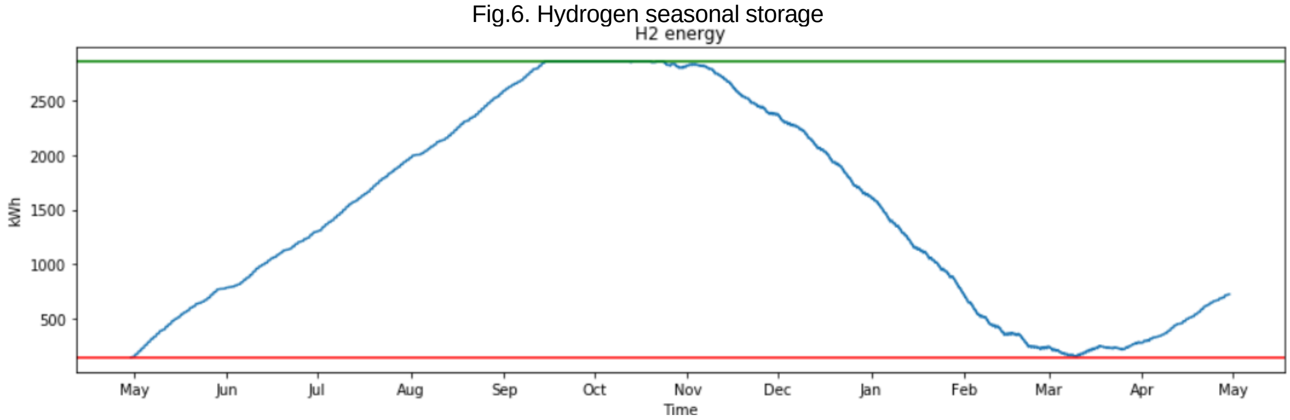


Fig.6. Hydrogen seasonal storage



One can see that despite a short period when grid consumption was required during the commissioning of the system (fig. 4, month of May), the installation become self-sufficient. It proofs seasonal storage at residential scale by the use of hydrogen storage, supporting the penetration of RESs.

4. CONCLUSIONS

The SPB contributes to the mass uptake of RES. Its purpose can be destinated from grid connected installations behind the meter and front the meter, to isolated areas. It shows the potential of smothering the energy transition that is taking place nowadays. SPB provides to their users a tool to decide how and when use their energy. The first prototypes of the SPB have been installed in the field under a Horizon 2020 European Commission funded project, referred to as Netfficient, on the German island of Borkum. Hydrogen technologies and the SPB can provide a way to store energy as well as cogenerate electricity and heat under demand.
The EC has recently published its hydrogen strategy as part of its wider energy system integration strategy. The European hydrogen strategy foresees the production of 1 Million tons of clean hydrogen by 2024 and 10 million tons by 2030. This requires a massive and rapid action from all stakeholders along the clean hydrogen value chain. The European Commission has also emphasized hydrogen as an energy carrier. It outlines a clear roadmap in the 'Clean Energy' section of the Green Deal.
Solenco Power NV will further develop the SPB solution towards a scalable product and greater market penetration.

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