PROSPECTS FOR SECTOR COUPLING BETWEEN ELECTRICITY AND TRANSPORT BY MEANS OF PRODUCING HYDROGEN

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Overview

The European Commission has set ambitious targets to increase the use of electricity from renewable energy sources (RES-E) in electricity generation as well as in the transport sector. Due to the supporting policy measures in the EU the share of RES in total energy supply is continuously increasing. In the last years, especially high PV and wind penetration in some regions has been noticed.
However, the increasing use of variable RES for electricity production caused requires better balancing activities between supply and demand to meet the so-called residual load, see Fig. 1.

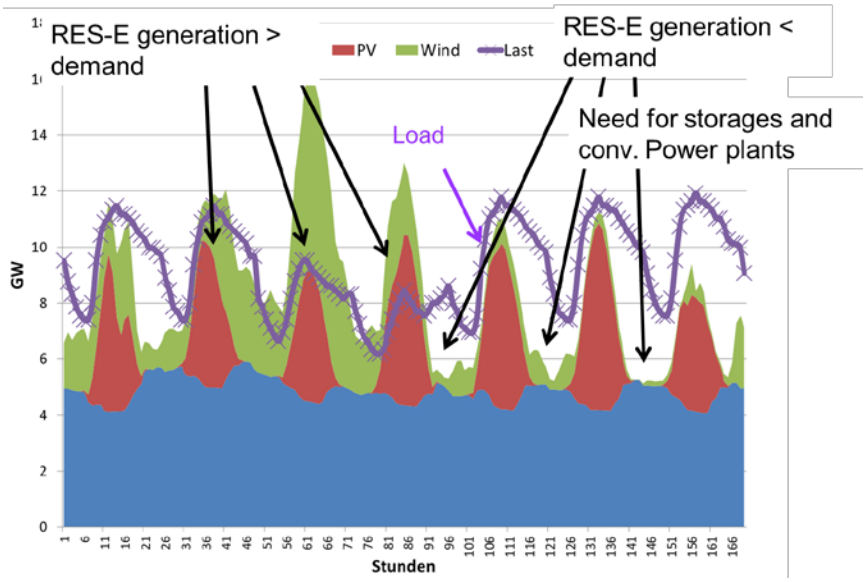

Figure 1. Example: electricity generation from variable renewables (wind, PV and run-of-river hydro) over a summer week on an hourly base in comparison to demand

To balance electricity supply and demand over time new market mechanisms and storage options will be needed, e.g. EC (2011). In this paper special focus is put on long-term electricity storage options.
The core objective of this paper is to investigate the market prospects of long-term electricity storage options (such as hydro pump storages, hydrogen and methane from power-to-gas (PtG) conversion technologies) which are able to balance fluctuations over longer periods, months or years .

Methods

Our method of approach is based on simple levelized cost calculations for different electricity storage options. Equation (1) describs the calculation of the storage cost C_{STO}:

$$C_{STO} = \frac{\frac{IC \cdot C.R.F + C_{OM}}{T} + C_E}{\eta_{STO}} \quad \text{(EUR/kWh)} \qquad (1)$$

Where C_{OM} are operating and maintenance costs, IC are investment costs, C.R.F is capital recovery factor, T is the number of full-load hours per year, and η_{SP} is efficiency of the storage. The most crucial parameters in this equation

are the full-load hours (T) and the cost of electricity (C_E). The problem is that usually the full-load hours of storage are very low.

Next, the analysis of future prospects is based on technological learning regarding the future development of investment costs of long-term storages. This analysis is based on quantities for technologies described in IEA (2011).

On the electricity market side we use a fundamental approach where the intersection of supply and demand at every point-of-time gives the corresponding electricity market price. It is important to note that the quantity of storage has a feedback on the market price for charging storages as well as discharging and, hence, on the price spread.

Results

The current economic performance of all investigated long-term storage options is far from competitiveness. However, until 2050 decreases in the prices of the PtG-technologies are expected to take place mainly due to learning effects. By 2030 under most favorable learning conditions the costs of hydrogen and methane for 2000 full-load-hours per year will be between 0.15 EUR/kWh and 0.20 EUR/kWh.

This leads to the conclusion that re-electrification of hydrogen and methane produced from RES is too expensive (and also very inefficient, see corresponding chain in Fig.2) and consequently not economically competitive.

Yet, for hydrogen and methane there are prospects for use in the transport sector. Fuel prices in transport in recent years have rather increased compared to stagnation or decreases in electricity spot markets. Consequently, and given in addition the lack of environmentally benign fuels for mobility hydrogen and methane from renewable electricity might become an economically alternative for fueling passenger cars.

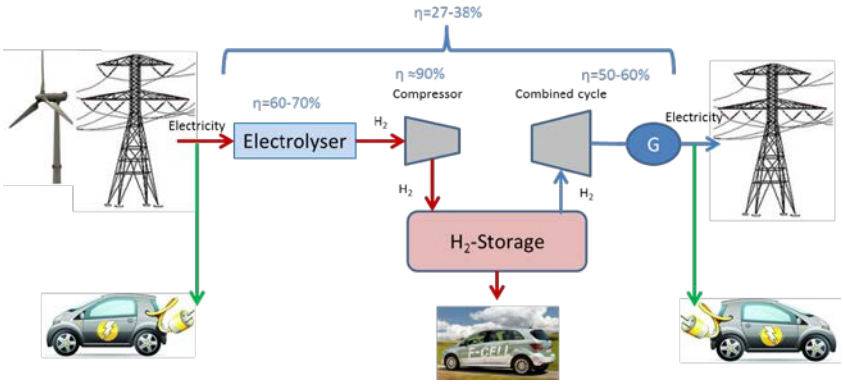

Figure 2. Energy supply chains with hydrogen as a storage for electricity and as a fuel to use RES for mobility

Conclusions

The major conclusions are: (i) with respect to all centralized long-term storage technologies the future perspectives will be much less promising than currently indicated in several papers and discussions; (ii) For PtG-technologies it will also become very hard to compete in the electricity markets despite a high technological learning potential; (iii) In the long-term the most promising option for the use of hydrogen will be by sector coupling with transport.

However, investments in new long-term storage capacities should be conducted only in a coordinated way and if there is a clear sign for new excess production, in this case of electricity from RES.

References

EC: Electrical Energy Storage, White paper, IEC, 2011
IEA: Energy Technology Perspectives, OECD/IEA, Paris 2011