The future prospects of sector coupling

Electricity and heat generation and storage

Jasmine RAMSEBNER[1] , Reinhard HAAS
TU Wien, EEG

Motivation

The Paris Agreement to reduce greenhouse gas (GHG) emissions is one of the most significant recent international political signs for the urgency towards more environmentally friendly energy supply (IEA, 2015). Robinius et al. (2017) make clear that “sector coupling” (SC) could be an approach to transform all energy sectors towards the targeted reduction in GHG emissions increasing the use of Renewable Energy Sources (RESs) in energy generation. Since the nature of RESs use, however, is very volatile it inherits various challenges in balancing the supply according to demand and providing appropriate flexibility.

In the following, we aim at describing the state of the art and range of SC possibilities as well as giving an outlook on the future prospects of SC.

The range of SC options

The BDEW (2017) defines SC as follows: “the energy engineering and energy economy of the connection of electricity, heat, mobility and industrial processes, as well as their infrastructures, with the aim of decarbonisation, while simultaneously increasing the flexibility of energy use in the sectors of industry and commercial/trade, households and transport under the premises of profitability, sustainability and security of supply”.

SC can be performed in different stages along the energy supply chain either centrally, close to the generation farm or decentrally, close to - or at the customer location. An example of central SC is the storage of excess wind energy through electrolysis and further use of this power in other sectors. With an increase in small-scale PV systems for households, however, decentralised options for SC represent a substantial chance for future flexibilities.

Apart from structuring SC in central and decentral applications, a classification through the sectors that are combined can be made. From the frequently described approaches of Power to Gas (P2G) (Ajanovic and Haas (2015)) or Power to Heat (P2H) (Bloess et al. (2018)), literature offers further applications such as Power to Liquids, Fuel, Industry etc… (Blanco et al. (2018), Schlemme et al. (2017), Zerrahn et al. (2018))

The future prospects of SC

Already Armaroli and Balzani (2011) claim that the local intermittence of wind and solar energy is uncorrelated with demand. This circumstance implies options for flexibility, such as storing or providing excess power to other sectors directly at the site of generation or more distributed at the customer location through, e.g. charging vehicle batteries from solar power at peak generation times. Robinius et al. (2017) draw up a range of SC options described in this chapter in figure 1.

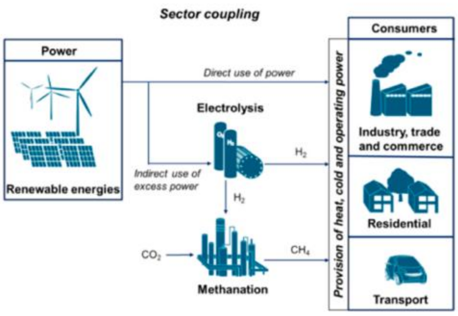

Figure 1 Principles of sector coupling, Source: Robinius et al. (2017)

[1] Jungautorin, Gusshausstrasse 25-29/370-3, 1040 Wien, Tel: +43(0)-1-58801-370347, ramsebner@eeg.tuwien.ac.at, Web: http://eeg.tuwien.ac.at/

Ajanovic and Haas (2015) point out that the increasing amount of volatile electricity generation from sun and wind asks for long-term storage technologies to balance supply with demand throughout the year. One very promising option is the conversion of excess power into hydrogen for further use in industry, transport or heating as either gas (P2G), liquid (P2L) or fuel (P2F). In general long-term storage options, however, still are far from being economically feasible due to high investment cost and low overall efficiency in a long conversion chain.

Figure 2 shows the generation from VER as an example of solar, wind and hydropower. Whereas there is excess generation in summer, in particular due to high availability of solar energy, these sources cannot offer sufficient supply in winter. It can, therefore be concluded that solely sector coupling will not solve all challenges with VER, but seasonal storage is required. Further research, hence, especially needs to derive solutions and technologies for long-term storage of solar energy for the winter. Studies have already been conducted for long-term liquid heat storage from solar energy e.g. by Lennartson (2015) on “molecular solar thermal energy storage” MOST, to guarantee for a further transmission of the electricity supply towards RESs.

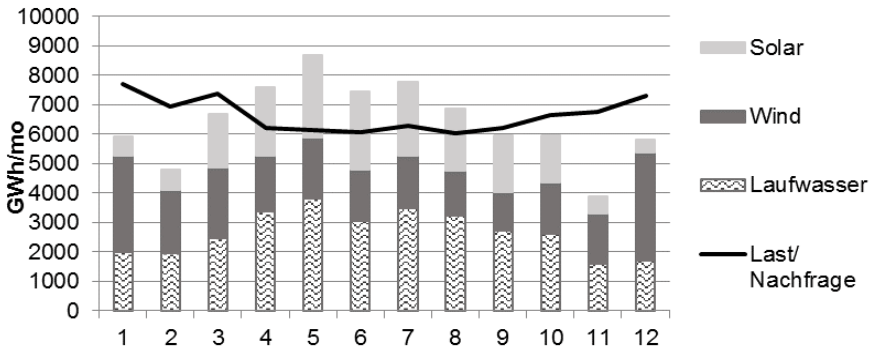

Figure 2 Energy generation from VERs water, wind and sun compared to average demand throughout the year

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