

ON THE FUTURE ROLE OF HYDROGEN: STORAGE FOR ELECTRICITY AND FUEL FOR MOBILITY?

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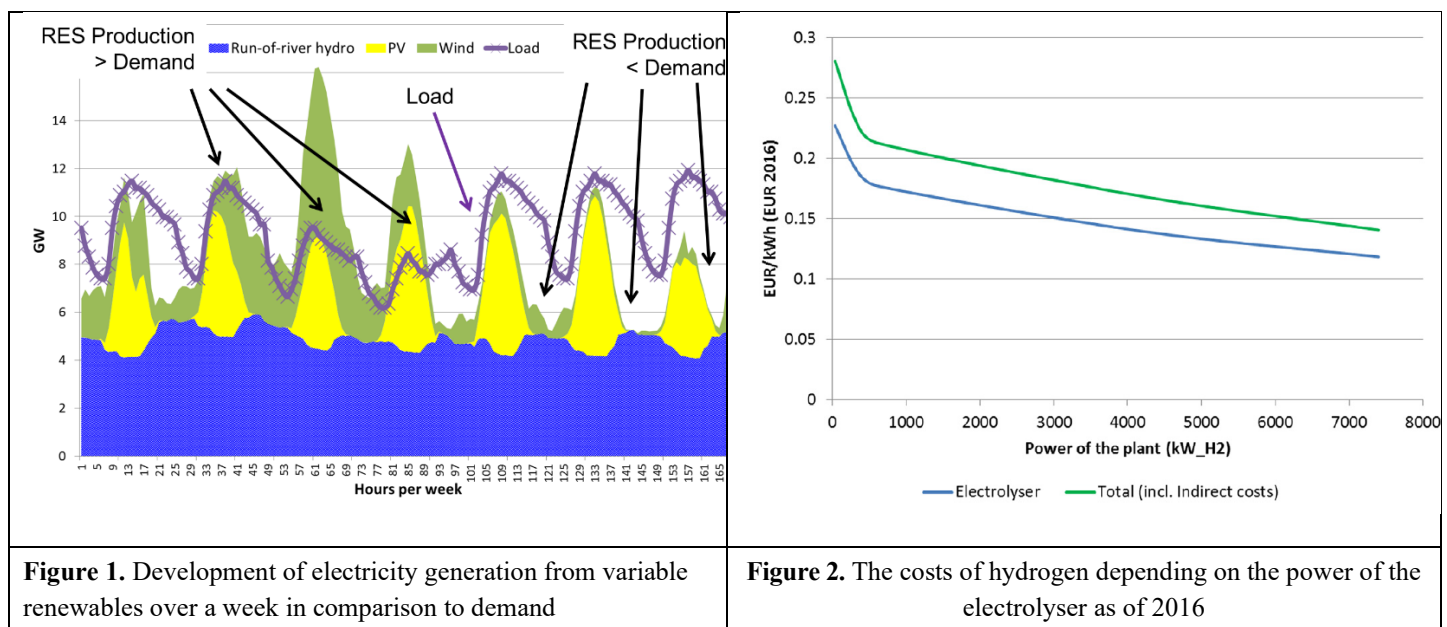
Overview

Since many decades hydrogen has been considered as a universal environmentally benign energy carrier. So far, high production costs stated a major barrier for a broader market penetration. However, the European Commission has set the ambitious targets to increase the share of renewable energy sources (RES) in electricity generation to 27% by 2030 opening a new prospects for hydrogen. The reason is that an increasing share of these new RES comes from variable sources like wind and solar. This leads to the need for increased balancing activities between supply and demand, see Fig. 1, including the demand for long-term electricity storage options.

The core objective of this paper is to investigate the future market prospects of hydrogen as a storage for excess electricity and its possible more competitive use in the transport sector as a renewable fuel.

Method

Our method of approach is on the supply side based on technological learning for the future development of investment costs of long-term storage options based on expected future quantities for technologies described in various IEA reports. 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.



Results

The major results of our investigations are:

An important aspect, relevant to the cost of hydrogen production, is the size of the production system. It is obvious that small-size electrolysers are rather expensive, leading to higher hydrogen costs. Corresponding total costs of hydrogen production are depicted in Fig. 2. Using small-size electrolysers (ca. 100–500 kW), hydrogen costs are above 0.23 EUR per kWh. In the case of the large-size electrolysers (above 4000 kW) total hydrogen costs are below 0.15 EUR/kWh. As shown in Fig. 4 hydrogen can be used as storage for electricity from volatile RES but the efficiency of the whole energy supply chain including re-electricification of hydrogen is very low. However, up to 2050 decreases in the costs of hydrogen production will take place mainly due to learning effects. In a dynamic market framework the costs of large centralized and smaller decentralized long-term hydrogen storage will finally be too high to become competitive in the electricity sector alone. By 2030 under most favorable learning conditions the costs of hydrogen for 2000 full-load-hours (FLH) per year will be between 0.07 EUR/kWh and 0.11 EUR/kWh, see Fig. 3. An additional reason for the unfavorable economic conditions of long-term storage options is the self-cannibalism of storage in electricity markets. This means that every additional storage reduces the price spread and, hence, its own economic performance. Other reasons are competition with demand response options, demand

–side management, power-to-heat and decentralized storages. The costs of the latter will not decline significantly faster but they will compete on end-user price level which is (and will remain) remarkably higher.

Next we discuss whether the use of hydrogen in transport could be a solution. An alternative could be hydrogen use directly in the transport sector. Since in this sector GHG emissions are continuously increasing, one of the major challenges for the EU is to find policies and measures with which this trend can be stopped. One important target is to increase use of RES and zero-emission vehicles (ZEV) (such as battery electric vehicles (BEV) and fuel cell vehicles (FCV)) in car passenger transport. Although these technologies have already environmental advantages, they are still not economically competitive (especially FCV).

To reduce the relatively high costs of hydrogen cheap surplus electricity from variable RES can be used for electrolysis. The major problem of the economics of all storage options are their low FLH. Currently, a figure of about 2000 hours per year is considered to be the minimum. For example, costs are about four times higher if the FLH are reduced to 500 h/yr. Moreover, at current price spreads of about 3 to 5 cents/kWh in the Western European market no type of storage is economically attractive at FLH below 4000 h/yr. Hence, the number of full-load hours, which are dependent on availability of surplus electricity from wind and PV, have a crucial impact on the total hydrogen costs.

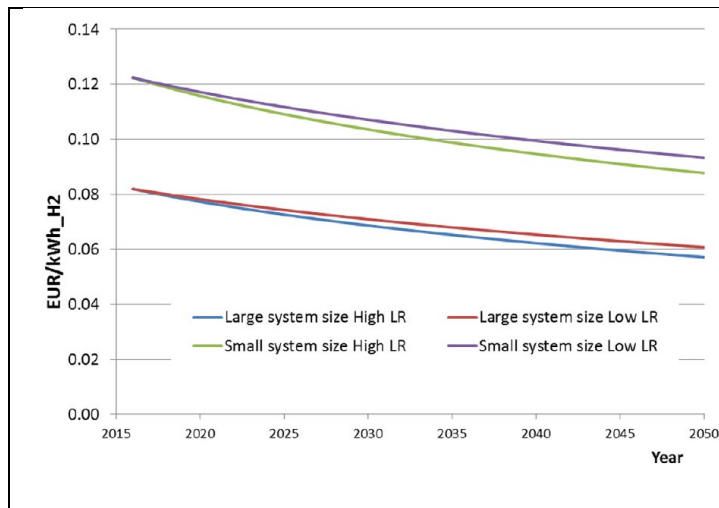


Figure 3. Development of costs of hydrogen from small and large electrolysis plants depending on Technological Learning up to 2050.

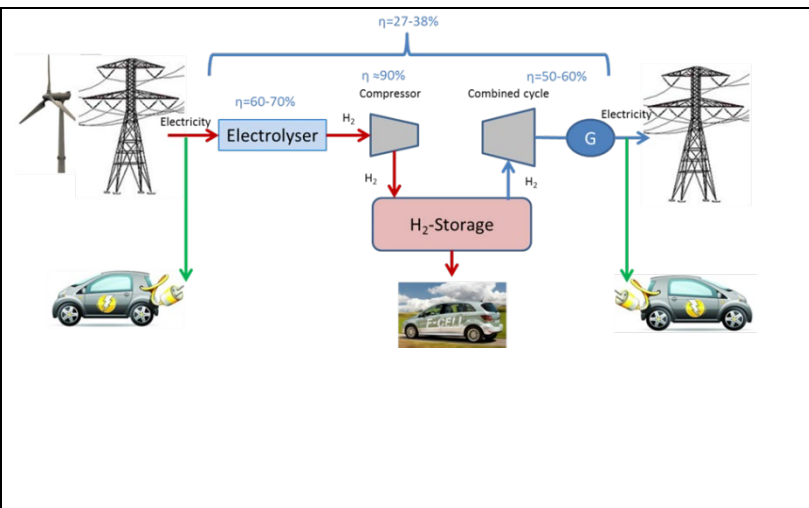


Figure 4. Energy supply chains with hydrogen as a storage for electricity and as a fuel to use RES for mobility

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. Yet, for hydrogen, 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 from renewable electricity might become in the future an economically alternative for fueling passenger cars.