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Editorial

Seasonal Energy Storage with Power-to-Methane Technology

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To have a sustainable society, the need to use renewable sources to produce electricity is inevitable. Due to the weather dependence of some of these sources (wind, solar), utility-scale energy storage has to be used. These fluctuations range from minutes (passing cloud) to whole seasons (Winter/Summer solar availability). Short-time storage can be solved (at least theoretically) with batteries. However, seasonal storage—due to the amount of storable energy and the self-discharging of some storage methods—is still a challenge to be solved in the near future.

Recently, novel methods are available among the classical long-term storage technologies (such as pumped hydro storage). Batteries are becoming better and better with less self-discharge and bigger energy density; therefore, they can be used for seasonal storage, although they cannot cover the total need. Therefore, Power-to-Gas methods (mainly Power-to-Hydrogen, P2H, and Power-to-Methane, P2M) play a bigger and bigger role in the storage mix. In these methods, surplus electricity is used to electrolyze water and produce hydrogen; this can then be stored and used later to recover electricity. Due to technical difficulties related to long-term hydrogen storage, alternative methods (such as Power-to-Methane or Power-to-Ammonia) can also be attractive solutions.

In Power-to-Methane technology, the hydrogen—with added carbon dioxide—can be turned to methane through chemical or biochemical methods. The methane can be stored and used later to recover electricity. Comparing the P2H and P2M methods, the energy recovery ratio is better for P2H; nonetheless, loss-free storage and recovery needs special equipment. By contrast, for P2M—being the produced methane SNG, i.e., synthetic natural gas—existing gas-storage facilities can be used for storage, and recovery can be achieved through the existing mature methods (such as gas engines). Although electricity recovery is associated with carbon dioxide emission, the amount of emitted CO_2 is equal to the one used for the synthesis; therefore, this technology can also be considered carbon-free.

There are two well-established ways for hydrogen-to-methane conversion: chemical and biochemical. The chemical way (the so-called Sabatier reaction) is fast and efficient, but it is a high-pressure and high-temperature reaction, which can be performed in special equipment; additionally, it might require hardly accessible metals for catalysis. Although sometimes it can be slower, the biochemical method is a low-temperature and low-pressure method utilizing microorganisms; some can be found even in biogas facilities. An additional advantage for the biochemical method is that it can be used on CH_4/CO_2 mixtures, i.e., it can enrich biogas to SNG.

This Special Issue is dedicated to biochemical Power-to-Methane technology. P2M technology is now on the verge of full-scale industrial use; therefore, a Special Issue dedicated to this method is very timely. The topics covered here range from basic biochemical research through comparison of various storage methods to complete energy storage solutions.

The increasing percentage of weather-dependent renewables in the energy mix forced researchers to find novel solutions for energy storage to fulfil the need for temporal balancing. In their paper, Sterner and Spechts [1] portrayed the 30-year-long history that led to Power-to-Everything (including Power-to-Methane and other Power-to-Fuel) technologies.

Szuhaj et al. [2] described the development of stable mixed microbiota for high yield Power-to-Methane conversion. This is a significant result because, with this method, it is unnecessary to use special strains for biomethanation; still, it was possible to enrich the initial biogas up to 95% of CH_4.

Kummer and Imre [3] compared other methods available for seasonal energy storage. They developed a simple function to help the ranking of various energy storage methods using their combined losses during unloaded and loaded time intervals.

P2M is not only a methane-producing technology; it has unique attributes because of renewable gas production, high-capacity grid balancing, and combined long-term energy storage with decarbonization, representing substantial innovation. Due to these points, the expected impact of P2M technology will be remarkable; the potentials hidden in this technology were outlined in the paper of Pörzse et al. [4].

For historical reasons, Visegrad countries (Czech Republic, Slovakia, Poland, and Hungary) have high-capacity gas storage and distribution networks, primarily built in the 1960s to the 1980s. Due to these capacities, P2M technology is a very attractive seasonal storage method in these countries because the produced methane can be stored and transported in their existing gas network. A case study to use P2M technology on the V4 countries in the regulation of Photovoltaic Power Plants were given by Pintér [5].

Concerning applicability, the biochemical P2M method can be appealing for countries with existing biogas production facilities. The paper of Csedő et al. [6] analyzes the financial side of the application of P2M technology in wastewater treatment plants as a seasonal energy storage facility, using Hungarian data.

Finally, Zavarkó et al. [7] reviewed the status of the technology by giving a critical review of closed, running, and planned biomethanation facilities in Europe. According to their results, future projects should have an integrative view of (chemical) hydrogen storage and utilization with carbon capture and utilization (HSU&CCU). In this way, the enhanced decarbonization potential would increase sectoral competitiveness.

We believe that biological Power-to-Methane technology—especially combined with biogas refinement—will be a significant player in the energy storage market within less than a decade. The ease of storage and use of methane as well as the effective carbon-freeness can make it a competitor for batteries or hydrogen-based storage, especially for storage times exceeding several months.

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