THE POTENTIAL OF POWER-TO-GAS

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Technology review and economic potential assessment

Executive summary

Massive development of renewable electricity production from intermittent sources (i.e. wind and solar) is underway in some European countries (e.g. Denmark and Germany) and is expected in a larger extent in Europe in the future decades. Increased capacities of power production from intermittent sources lead to periods of low spot prices of electricity, offering an opportunity for the development of flexible electro-intensive processes, and power-to-gas (hydrogen and synthetic methane) processes in particular.

This perspective has recently been fostering the R&D activity and interest in power-to-gas in Europe and more specifically Germany. Around 50 pilot and demonstration projects have been launched worldwide since 2004, most of them being announced in the 3 past years, with a significant level of activity in grid injection applications.

This study assesses the economic potential of power-to-gas and other power-to-X applications with a technical-economic modelling of six case studies targeting energy markets (i.e. gas injection into the grid, green mobility, heat production). For each case study, we compared the levelized cost of the final product with the market prices of alternative products on the target markets. This comparison was performed for three time horizons (2015, 2030 and 2050) offering different set of assumptions regarding prices of electricity and cost of technologies, in order to identify conditions required for business cases to be viable.

Green mobility is the most promising market for power-to-gas (with hydrogen fuel) and should be the first target for large scale deployment of the technology. Already competitive with other green fuel options, competitiveness with fossil fuels will likely remain out of reach without financial incentives. Methanol could prove an interesting alternative as well with different deployment constraints[1].

With a levelized cost of 8 to 10 €/kg_{H2} of distributed hydrogen[2], hydrogen produced from power already competes with bioCNG on the “green fuel” market on a fuel cost per kilometer basis. This optimal cost is reached for high load factors (i.e. from 6,000 to 8,000 hours/year) and does not rely on very low electricity prices (average final purchase price between 40 to 70 €/MWh). To become competitive with fossil fuels (ex: gasoline) on a fuel cost per kilometer basis, power-to-hydrogen will have to be delivered at a levelized cost of 3 to 4 €/kg. This could be achieved for instance if CAPEX and cost of electricity were more than halved. However, halving CAPEX is an ambitious target, and having access to electricity at a final purchase price of 20 €/MWh during more than 6,000 hours appears unlikely. As a result, hydrogen from power will have a hard time competing with fossil fuels on a fuel cost per kilometer basis without financial incentives.

Conclusions on the competitiveness of methanol produced from power (power-to-liquids route) are very similar. The methanol option is however very different from a technical perspective, being a potential drop-in replacement of traditional fuels when used in blend. Nevertheless, many other options are already in competition for this market such as biofuels, other synthetic fuels from power-to-liquids, fuels from biomethane (CNG, LNG) or batteries.

Power-to-gas for grid injection will likely not meet viability without strong financial support, due to its high CAPEX and the low market value of the produced gas.

Based on current costs and advantageous electricity prices (average final purchase price of 40 €/MWh), the levelized cost of gas-from-power injected into the grid is 100 and 170 €/MW_{HHV} for hydrogen and synthetic methane respectively. Power-to-gas for grid injection is thus far from competitiveness with natural gas (about 20 €/MWh_{HHV}) and remains more costly than biomethane (60 to 100 €/MWh_{HHV}), in particular for synthetic natural gas.

At the 2030 or 2050 horizons, it is likely that hydrogen produced from power can reach costs comparable to current biomethane production costs; it however appears unlikely for synthetic natural gas.

[1] Many other aspects and mobility options out of the scope of the present study would need to be taken into account to draw a comprehensive green mobility perspective (cost of vehicles, CO_2 emissions and air pollution, autonomy, technology readiness, ease of implementation…)

[2] Power-to-methane for mobility is considered in this study as a downstream market of synthetic methane grid injection with CNG filling stations connected to the gas grid.

Power-to-heat with an electric boiler at an industrial site appears as a potentially competitive option, able to develop in contexts exhibiting short periods of low-cost electricity (typically 1,000 or 2,000 hours per year), but very sensitive to the spread between electricity and natural gas prices.

Such a spread in favour of electricity becomes likely with possible future increase of taxes on fossil fuels and CO_2 and increased shares of renewable electricity. The use of more efficient assets (i.e. heat pump) for power-to-heat would offer a higher resilience to the price of electricity but would require higher duration of operation.

Based on the case studies considered and the various scenarios analyzed, this study shows that power-to-gas technologies have most potential when applied to green mobility markets. As such, their fate will be strongly correlated to policies and incentives implemented in the much broader perspective of the transport sector decarbonisation.