Title
Power-to-gas and Power-to-liquids for Managing Renewable Electricity Intermittency in the Alpine Region

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Abstract
Large-scale deployment of renewable energy sources (RES) can play a central role in reducing CO2 emissions from energy supply systems, but intermittency from solar and wind technologies present grid integration challenges. High temperature co-electrolysis of steam and CO2, in the so-called power-to-gas (PtG) and power-to-liquid (PtL) configuration, could provide a path for utilizing the excess intermittent electricity from a power system by converting it into chemical fuels that can be directly utilized in other sectors, such as transportation and heating. The chemical fuels could also be used in the power sector during periods of deficit in supply.

Here, we study the economic and engineering potential of PtG/PtL systems deployment as storage for intermittent renewable electricity and as a source of low-carbon heating and transportation energy among the different energy sectors in the Alpine region, using the BeWhere model, a geographic explicit cost minimization model. Preliminary results indicate large-scale deployment of the PtG/PtL technologies for producing chemical fuels from excess intermittent electricity is feasible, particularly when incentivized by carbon prices. In addition, large volumes of captured CO2, as much as 30 Mt CO2/year are utilized in the synthesis of the chemical fuels, providing as much as 23% of liquid transportation fuels. In this context, it can be concluded that PtG/PtL technologies can enable greater integration of RES into the energy supply chain, with application worldwide.
Power-to-gas and power-to-liquids for managing renewable electricity intermittency in the Alpine Region

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Background

Large scale deployment of renewable energy sources (RES) can play central role in reducing CO2 emissions from energy supply systems, but intermittency from solar and wind technologies present grid integration challenges. High-temperature co-electrolysis of steam and CO2 in the so-called power-to-gas (PtG) and power-to-liquids (PtL) configuration, could provide a path for utilizing the excess intermittent electricity from a power system by converting it into chemical fuels that can be directly utilized in other sectors, such as transportation and heating.

Aim of the study

The main focus of this work is to emphasize on the impacts of temporal and spatial intermittency of RES in power dispatch systems as well as on the utilization of excess intermittent electricity via PtG and PtL processes into other energy sectors (such as transportation, heating or power, in the context of long-term storage).

Power-to-gas/liquids

Recent development and performance improvements have demonstrated efficient co-electrolysis of H2O(g) and CO2 in Solid Oxide Electrolysis Cell (SOEC). The ohmic resistance as well as the cell degradation rates and mechanisms are rather similar as in the electrolysis of steam alone. In the light of such developments of SOECs, an overall conversion efficiency of 70% are to be expected. This efficiency refers to the calorific value of the final product to be expected. This efficiency refers to the efficiency of the overall conversion process in the SOEC, which includes the electrical input to the process.

Methodology

The study is carried out using BeWhere model [1]. BeWhere is a geographic explicit cost optimization model, based on mixed integer linear programming (MILP), written in GAMS and used CPLEX as solver.

Preliminary results

Figures 5 through 8 present the power generation mix and the resulting over-generation potential for the sample year at carbon price €150/CO2.

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