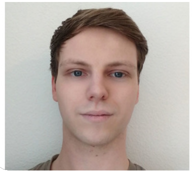
Coupling of PtG and the Requirements for the Electrical Energy Grid

Student



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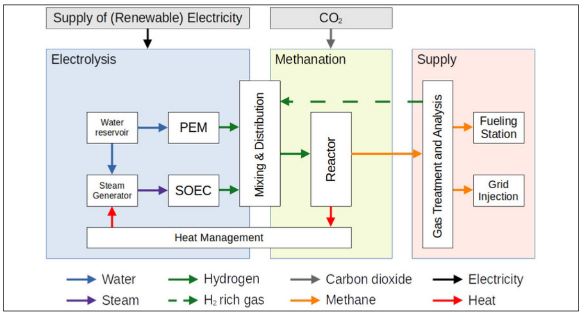
Introduction: Fossil fuels are a major plague on the power generation and transport sectors. Electrification would allow the transport sector to become CO2-neutral, but it would also shift the burden of the transition from fossil fuels completely onto the power generation sector. An interesting variant to simple electrification is the coupling of this two sectors. The technology that would facilitate this is called “Power-to-Gas (PtG)”, which is a system that allows converting electricity into artificial methane. This technology has also the potential to store energy as a seasonal battery and would have a synergy with the increased photovoltaic power generated, since the production happen mostly during the summer while the consumption is higher in winter.
The main purpose of this project is to check whether a Power-to-Gas system is able to quickly activate to absorb the excess of power that is fed into the electric grid. When more power is generated than is consumed, the power grid becomes unstable and the frequency drop to dangerously low levels. The grid operators use tolls called Power Controller that can quickly activate to re-stabilize the grid and the PtG could theoretically be included in this tool set.

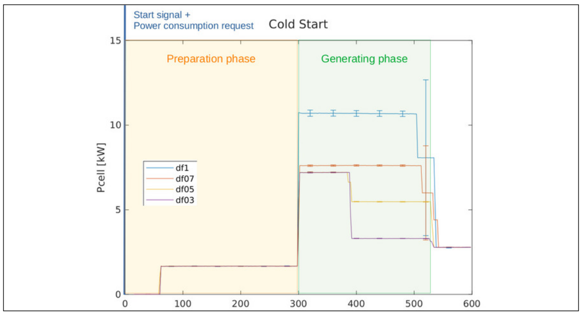
Definition of Task: The OST university's Power-to-Gas plant uses both a PEM (Proton Exchange Membrane) and a SOEC (Solid Oxide Electrolyzer Cell) to perform water electrolysis. The resulting hydrogen is then fed into a reactor with CO2 and nickel as a catalyst, generating methane and water vapor in an exothermic reaction. Initially, only the PEM is active as the SOEC is deployed using the heat generated during the reaction to increase the overall efficiency of the system. The reactor takes a couple of hours to prepare before it can contain the reaction, therefore if the plant were required to quickly draw power from the grid to stabilize it, only the PEM would theoretically be able to react with sufficient speed.
To test how fast the system can react the PEM was operated with different power draws and condition: The first condition is "Cold Start", i.e. while the system is not in generating mode and need to prepare itself, while the second is "Stand-by", i.e the system is already in generating mode and should theoretically instantly react.

Result: In "Cold Start" the system took 60 seconds before it started adsorbing a limited amount of power from the grid and an extra 240 seconds to consume the desired amount. This delay would categorize the system only as a tertiary Power Control, the slower kind. In "Stand-by" the system was able to instantly react, reaching therefore the speed of a primary Power Controller, but the power-adsorption-capacity was reduced by 30%.
The system is only capable of taking away extra power from the grid and can not yet generate it. Today this ability is not quite useful as the majority of generators are controlled by the grid operators and the main problem is the lack of power generation. With the transition to renewable energy, mainly solar power, a percentage of the power generation would become privately owned and unregulated. To balance unregulated generators regulated power-consumer are needed and the PtG of the OST as proven itself capable of covering this role.

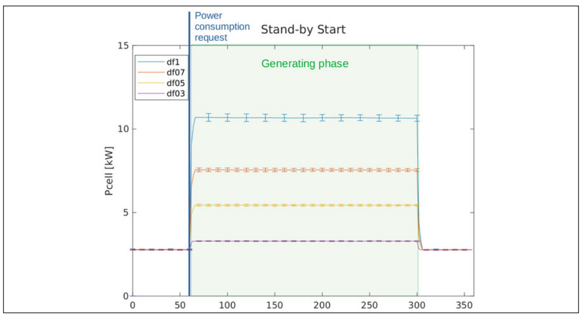
Operation Schematic of the Power-to-Gas plant installed at the OST
Own presentment



Power Consumption of the Electrolyzer Cells during "Cold Start"
Own presentment



Power Consumption of the Electrolyzer Cells during "Stand-by Start"
Own presentment



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Electrical Engineering, Energy and Environment