Optimised operations of green hydrogen production

Hydragonix is looking for dedicated master's students to work on advanced real-time control of water electrolysis systems - a cornerstone in removing greenhouse gas emissions from industry and heavy mobility.

Start date: Flexible
Industrial supervisor: Anton Frisk @ Hydragonix
Academic supervisor: To Be Determined

Background:

For green hydrogen to be able to out-compete fossil-based alternatives in the market, the cost of producing hydrogen through electrolysis needs to be reduced. Typically 70-80% of the green hydrogen cost is due to the cost of electricity, and there-fore it is of great importance to use the cheapest available electricity when operating the electrolyzers. The power output of Renewable Energy Sources (RES), such as wind and solar power, varies over time resulting in volatile electricity market prices. At the same time the demand for hydrogen can vary greatly depending on the use-case (e.g. industrial use, mobility or seasonal energy storage).

Combined, this leads to a tough case to solve for any control system designed to optimise the cost of green hydrogen production in real-time. In it simplest form a controller can set up basic rules (eg. "If electricity price goes <40€/MWh, turn on hydrogen production") but these methods are very limited. In order to optimise further, novel control methods such as Receding Horizon Control (RHC) or Model Predictive Control (MPC) have been suggested [1], and these methods can be combined with forecasts of the relevant time-series data.

In this project we are interested in control of complete electrolyzer systems (commercial electrolyzers) in response to both internal (thermodynamics, gas flows etc) and external factors (hydrogen demand, electricity prices, RES input etc). By solving these complex questions in real-time we can boost the profitability of green hydrogen production and empower the sustainable energy transition.

Project proposals:

This master's thesis project aims to create and evaluate an MPC controller for real-time optimization of a green hydrogen production system. Building upon our controller blueprint, the aim is to create new capabilities to respond to additional

market signals and benchmark these methods of operations against a base-line. The project involves model development, simulation testing and verification on hardware data. We have three relevant focus areas to choose from:

A. Focus on electrolyzer health and risk of degradation during operations. The challenge is to develop models on how operational features (such as ramp-times, start/stop-cycles and overloading) affect the electrolyzer stack degradation and include these models in real-time control systems.
B. Focus on electrolyzer participating in demand-side flexibility bidding on a European energy market. Balancing rewards for flexibility with demand security will be key in tackling this challenge.
C. Focus on using market forecasts as inputs for controllers. Both forecasting algorithms and the controller can be part of the project. Quantifying forecast uncertainty can be a tool to tune the risk-reward balance of the control system.

About our Hydragonix:

Hydragonix is a start-up company with the mission to support democratization of green hydrogen. Hydragonix develops a platform for operational performances of green hydrogen plants. For this purpose we have developed a prototype MPC controller that contains a model of an electrolyzer system. We are a fast growing company, with tremendous potential for reducing global greenhouse gas emissions, and expect to recruit for several new job positions during 2022.

Qualifications:

We're looking for students with a drive to contribute to sustainable energy transition and make use of their skills in control, energy, engineering, and programming to do that. We believe that your willingness to learn and tackle new challenges are the most important success factors. In addition to that, it's a bonus if you have experience in: Programming, Python, Model Predictive Control, Convex optimization, Industrial Automation, Energy and/or Finance.

Apply: Send an email to anton@hydragonix.com. Please mention which project proposal you want to work on, and include a CV and/or course transcript.

Relevant Literature:

[1] Flamm, Benjamin, Christian Peter, Felix N. Büchi, and John Lygeros. "Electrolyzer Modeling and Real-Time Control for Optimized Production of Hydrogen Gas." *Applied Energy* 281 (January 2021): 116031. https://doi.org/10.1016/j.apenergy.2020.116031.

[2] Guinot, Benjamin, Florent Montignac, Bénédicte Champel, and Didier Vannucci. "Profitability of an Electrolysis Based Hydrogen Production Plant Providing Grid Balancing Services." *International Journal of Hydrogen Energy* 40, no. 29 (August 2015): 8778–87. https://doi.org/10.1016/j.ijhydene.2015.05.033.