Semester project:

Life Cycle Assessment of Hydrogen Generation by Proton Conducting Ceramic Cell Electrolyzers

The European Union uses 9.7 million tonnes of hydrogen annually. 95% of this hydrogen is generated from natural gas and coal, which pollute a lot. Only 5% comes from electrolysis [1]. Hydrogen is mainly used as an energy storage medium for renewable energy sources in the chemical industry (to produce ammonia), metal treatment, semiconductor production, and other applications. Since many renewable energy sources are intermittent, too much electricity is sometimes available. Storage with hydrogen can help save this surplus of electricity and avoid wasting it.

There are different types of electrolyzers: Alkaline Electrolyzers (AEM), Polymer Electrolyte Membrane Electrolyzers (PEM), and Solid Oxide Electrolyzers (SOE) [2]. However, there is some ongoing research to study another potential type of electrolyzer, as AEL is limited by its low efficiency, its critical material usage limits PEM, and its degradation issue limits SOE. Recently, there has been an ongoing research interest in learning Proton Conducting Ceramic Cells (PCC). Unlike well-established oxygen-ion-conducting electroceramics such as yttria-stabilized zirconia (YSZ), protonic ceramics primarily transport H+ through the dense electrolyte. This feature greatly increases protonic-ceramic cell performance and efficiency.

Another electrolyzer type is the Anion Exchange Membrane (AEM). It is one technology is likely the combination of these two technologies. In principle, it allows for the utilization of cost-efficient catalysts and hardware as the Alkaline electrolyzer, and it can produce high-quality H_2 at a high current level as the PEM, thus showing a great promising future. Since the AEM emerged this decade, more efforts based on materials design, component optimization and performance evaluation still need to be developed to make it commercially competitive.

Concerning size, efficiency, and cost, AEM and PCC are considered intermediate options for energy storage, particularly for small-scale power plant applications. Therefore, building an LCA model on AEM and PCC manufacturing production is critical first to understand which manufacturing steps can be improved to reduce emissions. After detecting the key process, sensitivity analysis can be carried out on material recycling rate, energy replacement, etc.

LCA model will be conducted through OPENLCA software. The work will be done in collaboration with the GEM and IPESE.

Your Tasks:

- Understanding H_2 production technologies, particularly for AEM and PCC systems.
- Conducting AEM and PCC manufacture process LCA.
- Detecting the key process via the results and carrying out the sensitivity analysis for different scenarios.

Skills

- Understanding of energy concept and life cycle assessment
- Results interpretation and report writing
- Lectures: Life cycle assessment in energy systems, Energy Conversion and/or Renewable Energy

Administrative

This project is a part of collaborative research work between IPESE (EPFL) and GEM (EPFL). The project will be supervised by Xinyi (IPESE, GEM), and co-supervised by Du Wen (IPESE). If interested, please send your CV, with short motivation letter, to Xinyi and Du.

Location

This research work will be conducted at EPFL, Sion.

Supervisors

Xinyi Wei, mailto: xinyi.wei@epfl.ch; Du Wen: du.wen@epfl.ch

References

1. Georgia Kakoulaki et al. "Green hydrogen in Europe–A regional assessment: Substituting exist ing production with electrolysis powered by renewables". In: *Energy Conversion and Manage ment* 228 (2021), p. 113649.
2. Jun Chi and Hongmei Yu. "Water electrolysis based on renewable energy for hydrogen produc tion". In: *Chinese Journal of Catalysis* 39.3 (2018), pp. 390–394.