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Global warming potential of electrochemical hydrogen production based on CSP/PV hybrid power plants

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Abstract
Global trade of green hydrogen and its derivatives is seen as an important factor in reducing global greenhouse gas emissions by replacing fossil fuels with chemically bound renewable energy. This could make the enormous potential of solar energy in the Earth's sunbelt available to industrialised countries with high energy needs. CSP/PV hybrid power plants are a promising approach to provide electricity for solar hydrogen production through electrochemical water splitting. Photovoltaics (PV) can provide electricity at very low cost. Thermal energy storage (TES), used in concentrated solar power (CSP) plants, offers a cost-effective way to store solar energy and thus adapt electricity production to demand. When needed, e.g. during night operation, the thermal energy is taken from the storage and used in a steam cycle to generate electricity. By combining CSP and PV, the full load hours of the electrolyser system can be significantly increased and standby operation can also be secured, which can increase the economic efficiency of solar hydrogen production. Based on an energy system model, the advantages of this concept were demonstrated before and the system design was optimised for minimum levelized cost of hydrogen.

However, the production process of the technologies under consideration also leads to greenhouse gas emissions, and careful consideration must be given to how these compare with the emissions of the fossil feedstocks used today. Only if a significant improvement in environmental impact is achieved, especially in terms of global warming potential (GWP), it makes sense to replace fossil fuels with solar hydrogen on a large scale.
To determine the specific GWP and the potential for reducing greenhouse gas emissions, the entire life cycle from “cradle to gate” of the produced solar hydrogen is analysed. In this way, it is possible to find out which processes or components have a major impact on the greenhouse gas emissions. The LCA study was conducted using openLCA software 2.0.2 and the ecoinvent database. In addition to electricity generation through PV and CSP, the electrolyser system and water supply are also considered. This study also examines the influence of the solar resource and shows how choosing a good location with increased solar irradiation leads to a lower GWP of the hydrogen produced.

Keywords: *solar hydrogen; life cycle assessment; global warming potential; photovoltaics; concentrated solar power; alkaline electrolysis*