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Viability Analysis of a Centralized Hydrogen Generation Plant for Use in Oil Refining Industry

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Abstract : The global energy system is experiencing a change of scenery. Unstable energy markets, an increasing focus on climate change and its sustainable development is forcing businesses to pursue new solutions in order to ensure future economic growth. This has led to the interest in using hydrogen as an energy carrier in transportation and industrial applications. As an energy carrier, hydrogen is accessible and holds a high gravimetric energy density. Abundant in hydrocarbons, hydrogen can play an important role in the shift towards low-emission fossil value chains. By combining hydrogen production by natural gas reforming with carbon capture and storage, the overall CO2 emissions are significantly reduced. In addition, the flexibility of hydrogen as an energy storage makes it applicable as a stabilizer in the renewable energy mix. The recent development in hydrogen fuel cells is also raising the expectations for a hydrogen powered transportation sector. Hydrogen value chains exist to a large extent in the industry today. The global hydrogen consumption was approximately 50 million tonnes (7.2 EJ) in 2013, where refineries, ammonia, methanol production and metal processing were main consumers. Natural gas reforming produced 48% of this hydrogen, but without carbon capture and storage (CCS). The total emissions from the production reached 500 million tonnes of CO2, hence alternative production methods with lower emissions will be necessary in future value chains. Hydrogen from electrolysis is used for a wide range of industrial chemical reactions for many years. Possibly, the earliest use was for the production of ammonia-based fertilisers by Norsk Hydro, with a test reactor set up in Notodden, Norway, in 1927. This application also claims one of the world’s largest electrolyser installations, at Sable Chemicals in Zimbabwe. Its array of 28 electrolysers consumes 80 MW per hour, producing around 21,000 Nm3/h of hydrogen. These electrolysers can compete if cheap sources of electricity are available and natural gas for steam reforming is relatively expensive. Because electrolysis of water produces oxygen as a by-product, a system of Autothermal Reforming (ATR) utilizing this oxygen has been analyzed. Replacing the air separation unit with electrolysers produces the required amount of oxygen to the ATR as well as additional hydrogen. The aim of this paper is to evaluate the technical and economic potential of large-scale production of hydrogen for oil refining industry. Sensitivity analysis of parameters such as investment costs, plant operating hours, electricity price and sale price of hydrogen and oxygen are performed.

Keywords : autothermal reforming, electrolyser, hydrogen, natural gas, steam methane reforming
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