

Life cycle assessment of green ammonia production at a coastal facility in South Africa

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Abstract

A just energy transition (JET) to low-carbon fuels, such as green hydrogen, is critical for mitigating climate change. Countries with abundant renewable energy resources are well-positioned to meet the growing global demand for green hydrogen. However, to improve the volumetric energy density and facilitate transport and distribution over long distances, green hydrogen needs to be converted into an energy carrier such as green ammonia. This study conducted a comparative life cycle assessment (LCA) to evaluate the environmental impacts of green ammonia production, with a particular focus on greenhouse gas (GHG) emissions. The boundary of the study was from cradle-to-production gate, and the design was based on a coastal production facility in South Africa, which uses renewable energy to desalinate seawater, produce hydrogen, and synthesise ammonia. The carbon intensity of production was 0.79 kg CO₂-eq per kg of ammonia. However, if co-products of oxygen, argon and excess electricity are sold to market and allocated a portion of GHG emissions, the carbon intensity was 0.28 kg CO₂-eq per kg of ammonia. Further, without the sale of co-products but excluding the embodied emissions of the energy supply system, as defined in the recent international standard (ISO/TS 19870), the carbon intensity was 0.11 kg CO₂-eq per kg of ammonia. Based on the hydrogen content of ammonia, this is equivalent to 0.60 kg CO₂-eq per kg of hydrogen, which is well below the current threshold for certification as a low-carbon fuel. The process contributing most to the overall environmental impacts was electrolysis (68%), with particulate matter (55%) and global warming potential (33%) as the dominant impact categories. This reflects the energy intensity of electrolysis and the carbon intensity of the energy used to manufacture the infrastructure and capital goods required for green ammonia production. These findings support the adoption of green ammonia as a low-carbon fuel to mitigate climate change and help achieve net-zero carbon emissions by 2050. However, achieving this goal requires the rapid decarbonisation of energy supply systems to reduce embodied emissions from manufacturing infrastructure.