RIFS-Blogpost

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[The Role of Hydrogen Emissions for a Climate-neutral Industry]

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Hydrogen could help with the decarbonisation of steel production.

Hydrogen is an important energy carrier that will be essential for decarbonizing our economies, in particular for industrial sectors like steel and chemical production. But hydrogen itself is an indirect

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greenhouse gas (GHG), and emissions along the hydrogen value chain – including those of methane and CO_2 if blue hydrogen is part of the mix – have the potential to reduce the climate benefits of hydrogen if not properly managed. In a recent study, we evaluated the potential impact of climate-warming emissions in Germany's future hydrogen economy and provide recommendations for German and EU policymakers on how to avoid them.

1.1 Germany's National Hydrogen Strategy

Germany has adopted a National Hydrogen Strategy as part of its wider plan to achieve climate neutrality (net zero GHGs) by 2045. Between now and 2030, Germany wants to ramp up its domestic production to 30 - 56 TWh, focusing on 'green' hydrogen produced by electrolysis powered by renewable energy sources; imports will also be important to meet future demand. Germany's hydrogen strategy emphasizes four areas of action: ensuring hydrogen availability, building an efficient infrastructure (including the development of a "core network" of pipelines for domestic distribution), implementing hydrogen applications, and creating effective framework conditions. Amid this focus on the challenging task of ramping up domestic green hydrogen production and associated infrastructure – aspired to within Germany as well as the EU – little attention has been paid to the need for minimizing emissions from the hydrogen value chain.

In our study, we asked ourselves the question: how significant can we expect emissions from a future hydrogen economy to be? We approached this question by looking forward to the year 2045, by which time Germany should have achieved climate neutrality (i.e., net zero greenhouse gas emissions). Germany's scenarios for climate neutrality in 2045 assume the use of 300-600 TWh of exclusively green hydrogen. In 2045, Germany projects that it will continue to have 63 million tonnes of CO2 equivalents (63 Mt CO2e) in residual GHG emissions, which will then require offsetting via an equivalent amount of carbon dioxide removal (CDR) to reach net-zero. Importantly, these residual emissions projected for 2045 do not account for any emissions of hydrogen gas (H2), an indirect greenhouse gas that is more than 11 times more potent than CO_2 over a 100-year timescale. (We use the value for GWP100 of 11.6 from Sand et al. [2023].)

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1.2 Emissions in a scenario with green hydrogen

We calculated the H2 emissions that can be expected in a future hydrogen economy, using a range of illustrative scenarios for Germany in 2045 as our case study. Emission intensities along the hydrogen value chain during production, conversion, transport and storage were selected based on a review of current literature. Assuming high demand for hydrogen and high H2-emission rates, we calculate that H_2 emissions resulting from an all-green German hydrogen economy in 2045 amount to 11 Mt CO_2e. These emissions largely stem from production, driven by current operational practices in which gases are intentionally released (vented) to the atmosphere during certain purification steps. The good news is, these emissions can be nearly eliminated with a change in operational practices (to instead capture the vented hydrogen and recombine it with oxygen to make water), something which industry representatives have told us is feasible.

This will be important for achieving climate neutrality: 11 Mt CO_2e in H2 emissions is equivalent to 17% of Germany's projected residual emissions for 2045 (though production emissions for imported hydrogen would not formally be assigned to Germany's balance sheet). But in the context of present-day emissions – Germany reported 673 Mt CO_2e of greenhouse gas emissions in 2023 – this amount of H2 emissions would contribute only a relatively minor amount to additional warming today. For the moment, overall H2 use - and hence related H2 emissions - remains negligible. However, as hydrogen consumption increases, the relevance of associated emissions will also increase.

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1.3 Recommendations for a climate-neutral hydrogen economy

In our study we also consider the warming impact if blue hydrogen (i.e., fossil hydrogen combined with Carbon Capture and Storage) is considered in the mix. In addition to emissions of H2, production of blue hydrogen leads to emissions of methane (from the reforming process and upstream natural gas production) and CO2 (especially considering that current CO2 capture rates are low). These emissions would significantly increase the climate-warming impact of a future hydrogen economy. Assuming that blue hydrogen accounts for one third of projected imports in a high demand scenario and meets the EU standard for low-carbon hydrogen, this would bring the combined GHG-emissions to an equivalent of 37 percent of projected residual emissions in a German net-zero economy in 2045.

Based on our findings, we developed recommendations and published them in an additional RIFS policy brief. The most effective way to minimize H2 emissions related to the hydrogen value chain is the reduction of hydrogen use – by prioritizing its use in sectors where electrification is not possible, and direct electrification for other end-uses. Aside from this, the most important lever for managing emissions along the hydrogen value chain for green hydrogen is at the point of production. To address H2 emissions in a future hydrogen economy, EU Member States should define maximum emission rates for electrolysers and prescribe the implementation of best available techniques (e.g., minimizing or eliminating venting) for emission reduction. To underpin effective implementation, the EU should also mandate comprehensive monitoring of H_2 emissions by the European Environmental Agency. Within and beyond the EU, it will be important to promote formal recognition of hydrogen's role as an indirect GHG, including by reviewing and updating its global warming potential in next IPCC report to reflect the latest science. This will support future monitoring and reporting efforts and create a clear reference point for researchers and policy makers.

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1.4 EU must set standards

For controlling the additional GHG emissions from blue hydrogen, standards for both domestic production and imports into Europe are needed. The EU standard for low-carbon hydrogen – requiring a GHG savings of at least 70% - provides an important starting point for this. This threshold value should be increased over time to ensure that GHG emissions are minimized. Furthermore, it will be essential to develop and maintain high levels of transparency and ensure robust certification schemes to verify compliance both in the EU and in countries exporting to the EU. Additional recommendations can be found in both the study and policy brief.

Currently in the EU and Germany, policy makers are trying – and struggling – to establish a fledgling hydrogen industry. From the side of the policy makers, there is concern that too much regulation is only going to hurt the efforts to establish an industry that will be important for achieving our climate targets. It is true that in the case of green hydrogen, regulating and controlling H2 emissions will be important for achieving net zero in 2045 and beyond – but that additional H2 emissions right now would have a relatively small impact. Nonetheless, it is important to recognize hydrogen's impact as an indirect GHG now, and to avoid path dependencies that establish emission-intensive practices as the standard (which might then be more expensive to "fix" later on).