Leaked hydrogen fuel could have small negative effects on atmosphere

Using hydrogen as an energy carrier can help reduce air pollution and greenhouse gas (GHG) emissions associated with fossil fuels, according to recent research. However, if used on a large-scale, it is important that hydrogen does not leak significantly into the atmosphere as it might have some negative environmental effects, such as increasing the lifetime of methane, increasing climate effects and causing some depletion of the ozone layer.

The precise impact of extensive hydrogen use on the chemistry of the atmosphere is uncertain. Hydrogen, when used extensively, would have to be produced, transported and stored on a large scale and could leak into the atmosphere at any of these stages. In addition, air pollutants could be emitted to the atmosphere during production of the hydrogen, depending on how it was generated. For example, pollution could occur if hydrogen was produced from fossil fuel sources.

The study investigated the potential impact on air pollution of the large-scale use of hydrogen as a fuel in a future mix of energy sources, using a combination of two modelling systems. A range of future scenarios of hydrogen use from a global energy model was linked with a global atmospheric model that simulated changes in air pollutants (carbon monoxide, nitrogen oxides, sulphur dioxide and hydrogen) in the atmosphere. It was assumed that hydrogen would be produced from methane, coal or biomass feedstocks.

Hydrogen leakage from the production, distribution and end-use of hydrogen fuel varied from 0.3% to 10%, depending on the estimated levels of leakage throughout the hydrogen fuel chain. In absolute terms, the lower level is comparable to the amount of hydrogen currently released to the atmosphere from the combustion of fossil fuels, and the upper limit is five times today’s total hydrogen emissions.

Overall, air quality in the lower atmosphere (the troposphere) was found to improve if hydrogen was introduced into the future mix of energy sources. This improvement would occur as a result of the avoided use of fossil fuels and reduced emissions of carbon monoxide (especially in tropical regions), nitrogen oxides and sulphur dioxide, despite an increase in nitrous oxide and volatile organic compound emissions if coal was used to produce the hydrogen. High levels of hydrogen use also reduce the development of ground-level ozone, another air pollutant, partly formed from fossil fuel emissions.

There may also be some climate change impacts, other than through the reduced use of fossil fuels as a major energy source. The hydrogen could also potentially act as a GHG itself, and it could cause atmospheric chemical reactions that extend the lifetime of methane (a GHG) in the atmosphere, especially under high levels of hydrogen leakage.

A further impact comes from chemical reactions of hydrogen in the stratosphere (the layer of atmosphere above the troposphere). Especially under high hydrogen leakage, stratospheric ozone becomes slightly depleted. However, the overall effect would be small since, under those conditions, some tropospheric ozone is produced as a result of additional precursor emissions in leaks.

The findings of this study highlight the importance of minimising hydrogen leakage if used at large scale and suggest that additional policies on hydrogen emissions and air pollutants would need to accompany policies that promote hydrogen energy technologies, according to its authors.


Contact: vruijven@ucar.edu

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