Greenhouse effects of fugitive hydrogen emissions during pipeline transport

Introduction

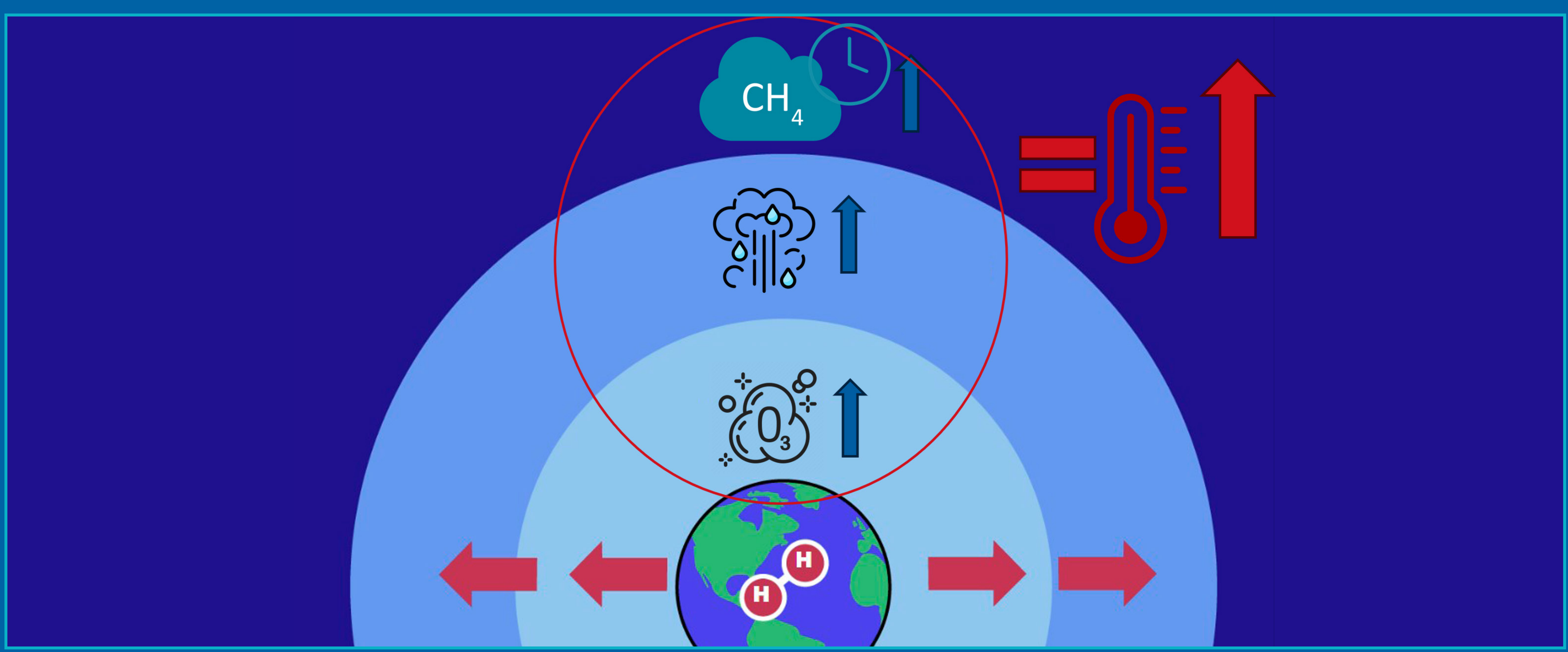
Peer reviewed literature indicates that hydrogen is an indirect greenhouse gas[1,2,3]. This might have implications on the transport of hydrogen through (repurposed) grids. It is an inescapable fact that transportation of energy comes with losses. In a gas grid part of these losses are fugitive emissions, i.e. gasses that escape from the confinement of the transportation grid.

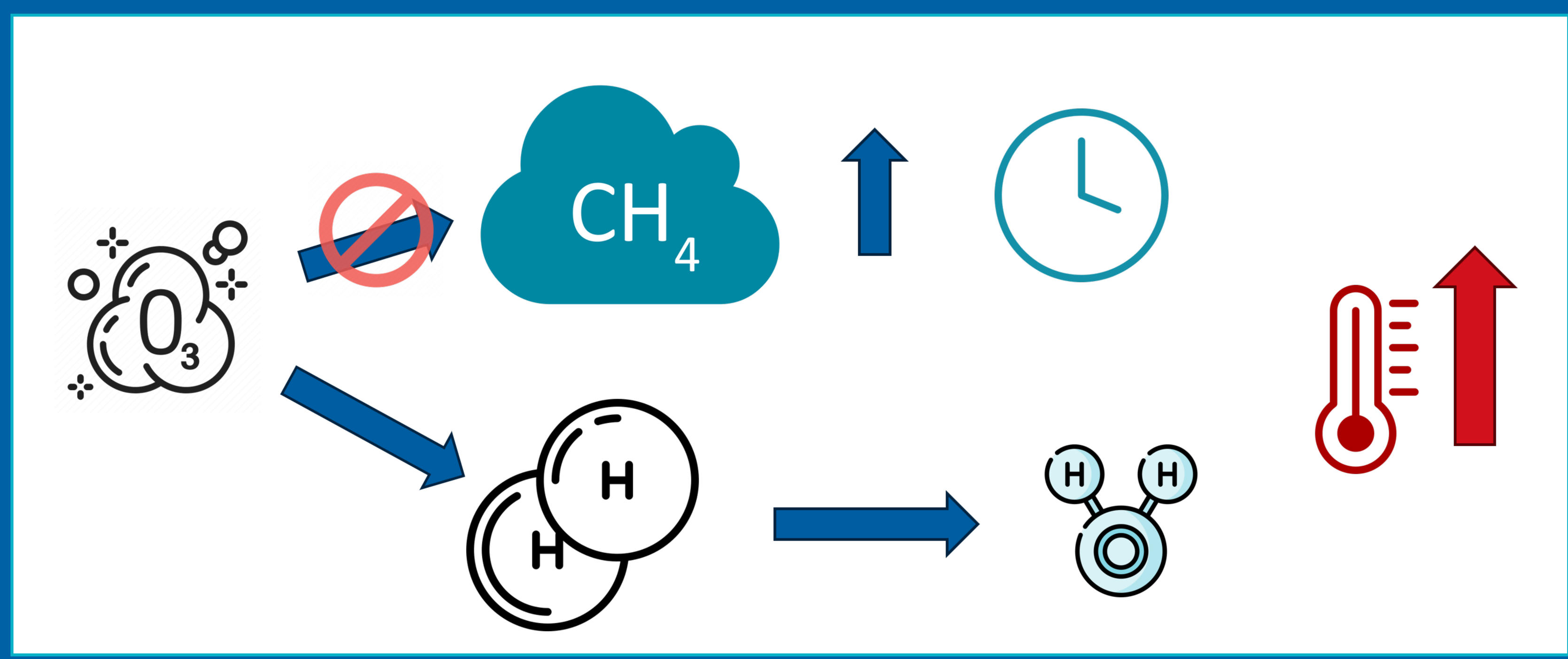
In a recent, yet unpublished study, the forecasted effects of transporting hydrogen through repurposed grids are examined. This study focused on the fugitive emissions of the gas grids, and the relative climate impact of these emissions. Different factors are assessed: leak rates, grid sizes and global warming potentials of hydrogen.

Methodology

A lot is known about emissions of gasses from gas grids; due to recent developments, European legislation is becoming more stringent to take emission mitigating measures. This legislation has led to to more research on (fugitive) methane emission. The outcome from this research is used as a basis for calculating the greenhouse effects of hydrogen emission.

Hydrogen is not a greenhouse gas by itself as it does not absorb infrared radiation because it lacks a dipole moment. However atmospheric hydrogen alters the chemical reactions with other gasses, increasing the lifetime of greenhouse gases like methane (CH_4) stratospheric water vapor and aerosols. Therefore hydrogen is called an indirect greenhouse gas.





Results

In the study it was found that there is at least 90% reduction in CO_2 equivalent emissions compared to the current natural gas grid. Table 1 shows the volumetric leak rates of hydrogen, which are a factor 1.5 – 4 higher than for methane[4]. However, global warming potentials are usually calculated on a mass basis and because of the difference in density between the two gasses, the mass based leakage rate is a lot lower for hydrogen.

Table 1: Volumetric and mass based hydrogen leak rates compared to methane[4].

	Volume based (-)	Mass based (-)
Permeation	4	0.43
Laminair leaks	1.5	0.16
Turbulent leaks	3	0.32

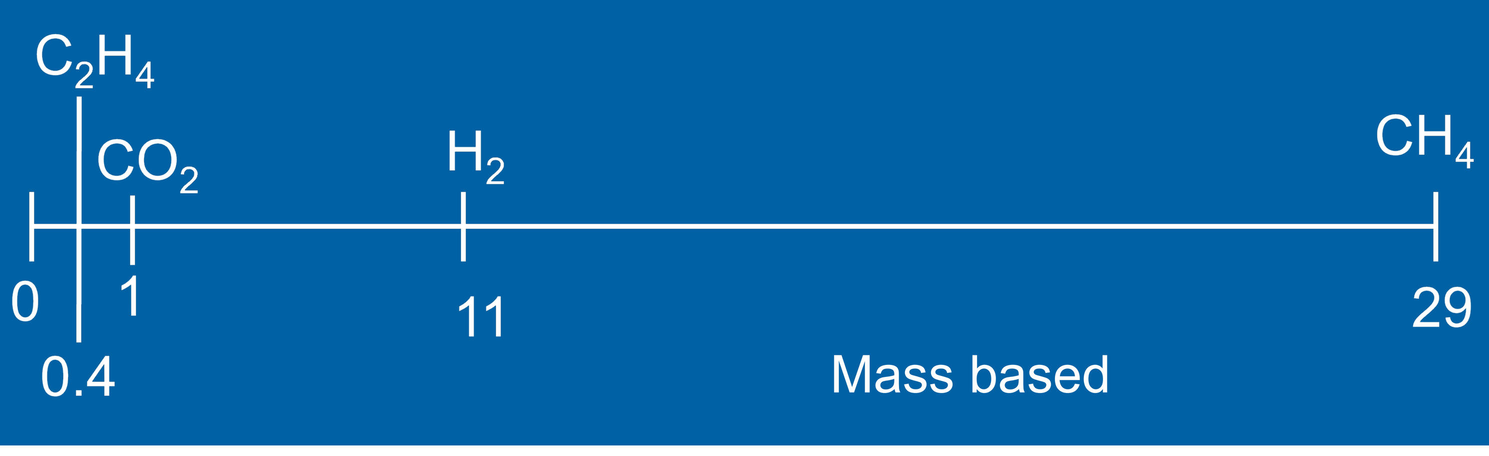
Permeation is the effect of molecules traveling through a solid material. An exact number on permeation is hard to give as there are many variables and different papers publish different results on the same type of tests. However a reasonably well-founded assumption is that hydrogen permeates four times as much as methane for PE/PVC pipelines, which are most common in distribution grids[5].

The second type consists of laminar leaks. Literature indicates that a factor of 1.5 can be used for this type of leaks[4]. These kind of leaks can develop over time due to corrosion, material degradation, alteration of the surrounding soil, etc.

The third type is a turbulent leak, these are typically large leaks. The typical volumetric leakage rate is around 3 depending on several factors[4]. In a grid, such large leakages are typically caused by third party damages. These leaks are typically uncommon but can emit a large volume in a relatively short time.

There is no consensus on the global warming potential of hydrogen

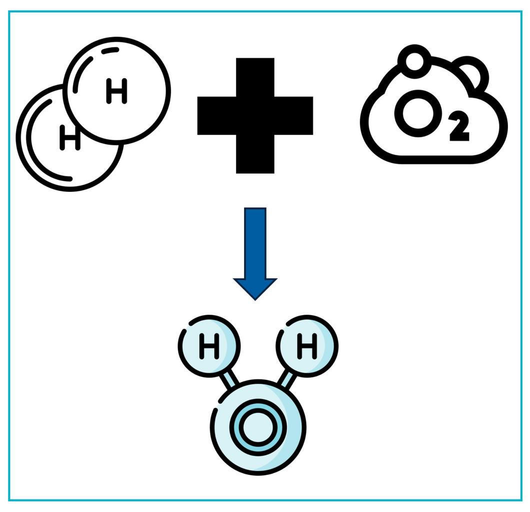
There is no consensus on the Global Warming Potential (GWP) for hydrogen. As the indirect effects can only be modeled, different climate prediction models give different reactions to an increase in hydrogen concentration. The global warming potential values over a 100-year timescale typically vary between 5 and 13. It should be noted that although there is no consensus on the exact value, there is a strong agreement that hydrogen has a GWP greater than 1.



Conclusion

To decrease harmful hydrogen emissions even further it is important that all procedures should be made to be leak-free in hydrogen grid operation. This can be done by using flaring instead of venting, or (even better) using recompression. Kiwa can help grid operators and industry with finding the most optimal solution for leak-free hydrogen operation and utilization.

The research underlines the necessity to keep a close watch on the amount of hydrogen in the atmosphere around the entire globe. Such a measuring system exists for gasses like methane and should also be implemented for hydrogen as soon as possible.



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