How Green is Blue Hydrogen ?

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The paper referenced above was published on August 12th has generated a lot of comments in the wider media. These comments are generally taking this paper and using it a bit out of context and without looking at the technical detail.

The paper is one of the first I have seen that tries to model the fugitive methane issue associated with making hydrogen from natural gas (ie. Methane). The basic premise of the paper (apologies for oversimplifying) is that the more energy you use to make the hydrogen by steam reforming, the more fugitive methane will be emitted. As methane is many times more pernicious as a greenhouse gas than CO2, this additional methane emission more than offsets the carbon capture benefits associated with blue hydrogen over grey due to the increased energy demand of the carbon capture processes.

Certainly, there will be more energy needed to run the CO2 capture and storage processes, the expectation that this will, of necessity increase fugitive methane emissions is perhaps not correct. The paper really highlights the need to address the methane leakage from gas field, pipeline systems and processing plants. It is of course naïve to think these will be eliminated, but there is a more general need for these to be aggressively addressed by operating companies and regulators. The issue as it related to blue hydrogen or CO_2 capture in general is really looking at treating the symptoms rather than the cause.

As a secondary technical observation, I also think the paper was not very clear on the issues of CO_2 capture efficiency within the hydrogen production process and from flue gas in the hydrogen plants, it seems to be driven by the existing characteristics of operating hydrogen plants (steam reformers). A more interesting look at this would be to consider the same process as applied to the production of ammonia; in the production of ammonia the same steam reforming of light hydrocarbons is used to produce the synthesis gas as in a typical hydrogen plant. The difference is that ammonia plants employ secondary reformers to drive the near total conversion of methane to CO, CO_2 and H_2. This is followed by a shift reactor to convert the CO + H_2O to CO_2 and more H_2, eliminating all the CO down to ppm levels. The CO_2 is then removed, again down to near ppm levels in the resulting syngas. This is much more aggressive than a typical hydrogen plant. The main reason is cost optimization. Typical non-ammonia use for hydrogen is for desulfurization of petroleum products, chiefly gasoline and diesel. In this application high purity hydrogen is not needed and some CO_2 and CO is left as its removal is not economically justified.

In the ammonia production case CO and CO_2 are poisons for the ammonia synthesis reactor catalyst and must be totally removed.

It's also worth noting that the most likely large scale uses for hydrogen are in heavy transport, ships, trains, mining and agriculture. The most efficient storage and transport vehicle for hydrogen is to convert it to ammonia and back to hydrogen at point of use. So, in that context it's reasonable to compare blue hydrogen production to that of ammonia. In this case the recovery efficiency of CO_2 from the process streams is near 100%, much higher than the paper assumed.

Finally, the paper has two dominant scenarios for blue hydrogen, one without flue gas CO_2 capture and one with, in my view if there is no flue gas CO_2 capture, then it's not blue hydrogen, around 50% of the total CO_2 created in the reforming process is from burning gas for energy, this must be treated, or the process simply doesn't qualify as "blue".