

Once more we would like to thank the two reviewers for their comments on the manuscript. Below follows our responses to the comments by the reviewers and a description of how the manuscript has been modified. The original reviewer's comments are in black and our response in blue.

### **Anonymous referee #1**

#### General comments

Authors have addressed all comment and I think makes the paper much clearer and easier to follow. I've added a couple of specific comments to clarify a couple of points which aren't immediately clear from reading through.

Overall, I find the manuscript fit for publication and think it will be a valuable asset to the hydrogen community.

#### Specific comments

line 112: For clarity, please specify the impact of NO<sub>x</sub>:CO to OH e.g. a higher/lower NO<sub>x</sub>:CO ratio corresponds to a higher/lower OH availability

We have slightly rewritten this sentence, highlighting both the methane concentration and the NO<sub>x</sub> to CO emission ratio influence on OH, methane lifetime and atmospheric lifetime of OH.

For info, in the introduction there is a similar sentence as the original sentence near line 112: "The NO<sub>x</sub> to CO emission ratio has been shown to be important for explaining the OH time evolution and changes in methane lifetime over time (Dalsøren et al., 2016; Skeie et al., 2023)."

The new sentence near line 112 and the specification of the impact of the ratio as well as the methane concentration on OH and methane lifetime.

"The SSPs chosen were based on high and low methane concentration (Fig. 2a) and high and low NO<sub>x</sub> to CO emission ratio (Fig. 2b) as both drive changes in OH and methane lifetime and would also influence the atmospheric lifetime of hydrogen. Higher NO<sub>x</sub> to CO ratio and lower methane concentration corresponds to increased OH levels and a shorter methane lifetime, while lower ratio and higher methane concentration results in reduced OH levels and a longer methane lifetime."

line 195: Specify these are globally averaged hydrogen concentrations

We have added "globally averaged" to this sentence. "...larger increases in globally averaged hydrogen concentrations..."

line 208: I think it's worth adding a line to say that you had calculated the perturbation lifetime with respect to atmosphere and soil separately as this is not immediately clear until after reading the table.

We have added the following sentence:

“In Table 3, in addition to the total perturbation lifetime, the perturbation lifetime with respect to the atmospheric and soil sink are shown separately.”

Technical comments

lines 317: “Derwent also investigated”

Done.

## **Anonymous referee #2**

I have reread the revised manuscript and considered the authors responses, and I am satisfied that my concerns have been addressed and that the changes made have improved the manuscript. The upgraded Table 3 adds useful additional information, and the issues with the term "feedback factor" have been successfully resolved. I believe that the paper is now suitable for publication in ACP without substantial further changes, although I have suggested some minor technical corrections and clarifications below.

Minor corrections

The first line of the abstract is still awkward, and it would be better to reverse it: "Use of hydrogen as an energy carrier and reactant in metal production can reduce carbon dioxide emissions by replacing fossil fuel usage."

We have replaced the first sentence in the abstract with your suggestion. Thank you.

Line 15: "For methane the CH<sub>4</sub> GWP100" -> "The methane GWP100"

Done.

Line 43: "chemistry-climate model" not needed, as Earth system model is already stated

"chemistry-climate model" deleted.

Line 212: "is lower than" -> "is shorter than". The second half of this sentence would be more clearly phrased as: "... (7 years), it makes a greater contribution to the change in the total lifetime".

The full sentence is now rewritten as:

“As the soil sink lifetime (3.5 years) is shorter than the atmospheric lifetime (7.0 years), it makes a greater contribution to the change in the total perturbation lifetime (Table 3).”

Line 233: "have an extreme location relative to what can be expected" is somewhat unclear, perhaps better as "are remote from locations where hydrogen emissions may be expected to occur".

Thank you for your suggestion. We have rewritten the sentence: “One should note that these two sites are remote from locations where hydrogen emissions may be expected to occur.”

Line 254: "productions" -> "production"

Done

Line 313: "on how" -> "to how"

Done.

Line 558: The ACPD discussion paper Thornhill et al. 2020 should be updated to the final ACP paper Thornhill et al., 2021.

The reference is updated.