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Comments on Hydrogen sections of the TIAX report,

"Full Fuel Cycle Assessment — Well toTank Energy Inputs, Emissions, and Water Impacts"

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This memo contains a detailed technical review of the hydrogen sections of the TIAX report, "Full Fuel Cycle Assessment — Well toTank Energy Inputs, Emissions, and Water Impacts".

General comments.

The hydrogen section (3.5) reads like a rough draft and could benefit greatly from further editing, fact checking and "cleaning up". There were many repetitions of the same information, typos, inconsistent units (mixed SI and English) and numbered references to unknown publications. It seemed as though the section was synthesized in a hurry from raw material in the H2 Highway Network Blueprint Plan and other sources. The H_2 section also does not seem complete with major omissions in discussion of other feedstocks beyond natural gas, no discussion of liquefaction and refueling stations.

Specific Comments

Aside from the rough draft quality of the document, there were some technical issues that should be corrected.

p. 3-16. "Nuclear power can be used to produce hydrogen generally through thermochemical water splitting".

Thermochemical water splitting is still at the basic research stage. Far from being generally used it has not yet been successfully demonstrated at the bench scale. The only commercially available way to use nuclear power to make H2 is through electrolysis.

p. 3-16, paragraph that begins "Hydrogen can be produced at large- " **This discussion of storage and transport is muddled and hard to follow. The discussion should briefly describe ways of storing H2, Then proceed to common ways of transporting hydrogen.**

p. 3-16, Figure 3.3. **Does not allow for central electrolysis with delivery. It is unlikely that biomass or coal would be used to make electricity and then electrolytic hydrogen (shown as a solid line). This would be both inefficient and expensive. Gasification is a much preferable route (shown as a dotted line).**

p. 3-16 final sentence. **Which pathways were judged more promising for analysis and why? Add Table showing pathways and criteria used to choose among hydrogen pathways?**

p. 3-17, 2nd paragraph. The authors should mention the National Academies' Hydrogen Economy study and the H2A project of the DOE.

Overall, the introductory section 3-15 to 3-17 is very rough. There are many reports that do a better job of describing H2 technologies.

p. 3-17, section 3.5.1, First paragraph. Report mentions that most hydrogen is made from natural gas multiple times. Only need to say it once. The second paragraph largely repeats earlier material, as well.

p. 3-18 paragraph below Figure 3.4 . Not necessarily true that reformers are only suited to constant H2 demand. Time varying demand is handled by running the reformer at a constant rate and filling up H2 storage. This is how industrial H2 systems operate today, and most designs for H2 energy systems use this concept.

Table 3.10 . This table seems to refer to characteristics of small onsite reformers in terms of start up, and purity. Not as applicable to large scale reformers.

p.3-19, "Steam reformer" section begins with repeat material

p.3-19, 3-20, numbered references given. What are these?

p. 3-22. Misspellings. "carries" should be "carrier" "waster" should be "water"

p, 3-22. last sentence. "Energy consumption for electric power generation corresponds to 0.24 J/J of hydrogen produced" **The electricity consumption varies considerably depending on the H2 pathway, as a later table shows. Which pathway does this refer to?**

Table 3-11, not clear from the text whether this table is talking about "electricity" or the primary energy needed to make the electricity. The table entries are OK for electricity, but should be approximately doubled, if you want to represent the primary energy used to make electricity depending upon the grid mix.(as described in the text).
Other entries in table look reasonable.

Table 3-12 looks fine.

Section 3.5.2 is too cursory. See excellent NREL reports on biomass H2.

There is no mention of coal to hydrogen and carbon sequestration. Understood that coal may not be the first choice for H2 production, but the technology still needs to be described. This is a major omission.

Section 4.
There isn't any description of liquefiers for H_2 and the liquefaction energy required for LH2 truck transport.

Table 4-11
Not clear what units energy intensity is in. or why H_2 is so high compared to other gaseous fuels.

Section 5.3.4
There isn't any description of liquefiers for H_2 and the liquefaction energy required for LH2 truck transport.
No description of refueling station and the required energy inputs.
The information on Table 3-11 should be broken out into these separate components (production, distribution/transport, refueling).

Table 5-16 H_2 delivery table
It's not clear where the distances came from or what they mean.
Where is the liquefaction energy input? It's not very complete.