Is Utility Scale Hydrogen Energy Storage of Solar Electricity Ready for Prime Time on the North American Grid? A Guide for Bankers and Investors

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WHY SOLAR (PV) ELECTRIC ENERGY STORAGE?

The sun does not always shine when there is demand for PV electricity

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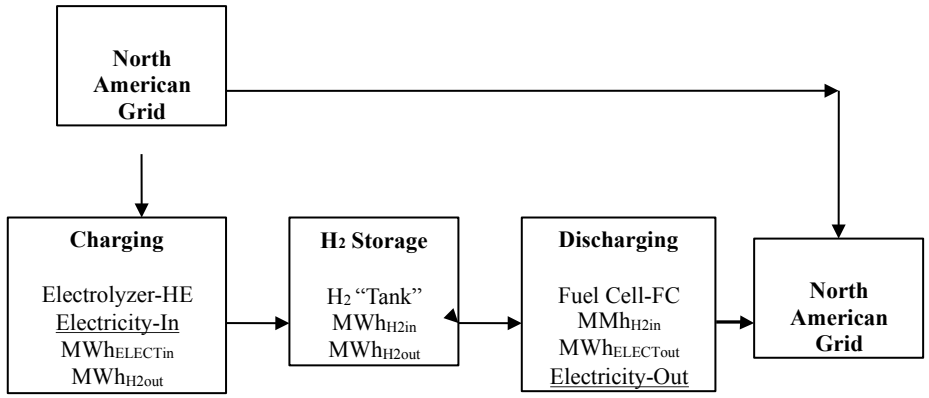

Schematic of a Hydrogen Storage Plant (HSP)

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A HSP is just "like" a rechargeable battery.

- PV electricity from the grid charges the HSP by converting the electricity into H_2
- the HSP the stores the electricity as H_2
- the HSP then discharges by converting the H_2 back into electricity and putting it back on the grid

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PAPER Summary

*A **bulk electric** (**utility scale**[1]) hydrogen energy storage plant can be used on the North American electric grid for the daily, weekly or seasonal storage of **solar (PV) electricity (energy)**. The goal of my paper is to help bankers (investors) determine whether hydrogen (H_2) energy storage is ready for prime time[2] on the North American grid.*

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[1] in the range of 100-3,000/MWh/day

[2] is currently commercially viable

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- Average American home uses 1-1.5 MWh/mth (≈1,000 kWh/mth)
- You can download my paper right here at the SOLAR 20/20 Virtual Convention

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EXCEL WORKBOOK Summary

I have developed a H_2 storage plant (**HSP**) levelized cost of storage (LCOS)[3,4] financial algorithm for a model HSP. To compute the LCOS, the paper's HSP LCOS financial algorithm requires 22 HSP specifications (specs) [metrics]. The 22 HSP specs [independent variables] and the 76 dependent variables are all defined using a standard set of SI electric and H_2 energy units. I used the HSP LCOS algorithm to do sensitivity analysis and to confirm "published" HSP specifications (specs).

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[3] not to be confused with the levelized cost of energy (LCOE)

[4] my JSEE PV LCOE paper was published in Aug 2002

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My HSP LCOS algorithm is presented on my paper's Excel[5] HSP LCOS Financial Algorithm Workbook.

- You can download my paper's Excel HSP LCOS Financial Algorithm Workbook right here at the SOLAR 20/20 Virtual Convention
- My Excel HSP LCOS Algorithm Workbook works.
- In the workbook, you can replace the 22 HSP spec values in my base case with your own compiled 22 HSP spec values and compute your own LCOS.

[5] a fully functioning Excel Workbook

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EFFECT OF THE COLORADO AND ILLINOIS "SHELTER-IN-PLACE ORDERS ON MY PAPER

I have not updated certain of the 22 HSP spec values in my base case.

- For example, I used US$50.16/MWh (US¢5.02/kWh) as the cost of the PV electricity to be stored instead of US$40.00/MWh (US¢4.00/kWh). OOPS!

- *Another example, I set the MWh_{ELECT} a day of Solar Electricity that charges HSP at 3,000 MWh/day. A 75 MW PV plant with 4 sun hours a day only produces 300 MWh/day.* WOW! OOPS! again!
- The lack of spec value updating does not affect my conclusion
- I will update the 22 HSP spec values my base case in the next version of my paper

NO HSP SPEC DATABASE

- My goal is not the presentation of a public database of HSP specs for use by a banker (investor).

- I have the much more modest goal of presenting a recognized standard LC methodology, a model HSP, a realistic base case and an accurate "back of the envelope" LCOS financial algorithm.

HSP Energy storage cycle

Grid → HE → H_2 "Tank" → FC → Grid

- the same SI energy units (MW; MWh) are used through the complete HSP energy storage cycle
- 1 $MW_{ELECT} \equiv 1\ MW_{H2}$
- 1 $MWh_{ELECT} \equiv 1\ MWh_{H2}$
- This does not mean the HSP is 100% efficiency (η)

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Details-The Standard SI (Système International d'Unités) Electric and H_2 Energy Units

- In the US, electric energy is already measured in the SI energy units MW_{ELECT} and MWh_{ELECT}
- In the US, H_2, as an industrial gas, is measured in the English units: lbs_{H2} (mass); scf_{H2} (volume) or in the SI units: kg_{H2} (mass); $Nm^3{}_{H2}$ (volume)
- In the US, H_2, as an energy carrier, can be measured in the English energy unit, $mmBtu_{H2}$, or in the SI energy unit, MWh_{H2}

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- Since MWh_{ELECT} are charging the HSP and since MWh_{ELECT} are being discharged from the HSP, I have measured the energy that the HSP stores as H_2 in MWh_{H2}.

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CONCLUSION

If you are a banker (investor) asking me, is hydrogen energy storage ready for prime time on the North American grid?

My answer is **NO!**

I base my answer on the following facts.

1. There are no commercial HSP on the North American grid.

2. I did not find the 22 HSP specs for a commercial North American HSP in any current authoritative data base.

3. I complied my 22 base case specs for a model HSP.

4. I computed the LCOS, using my 22 base case specs and my LCOS algorithm, but it was too high for any current commercial HSP development on the North American grid.

5. I did sensitivity analysis with my Excel LCOS Workbook.

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6. In my base case, I did not realistically present the HSP Round Trip efficiency. I was too optimistic. HSP Round Trip efficiency was too high. It should currently be in the 60% range; not the 72.9% that I computed.

7. In my base case, the Total HSP CapEx that I computed was also not realistic. I was again too optimistic. My computed Total HSP CapEx was too low.

8. I computed the LCOS in my base case to be US$142.21/MWh (€124.08). This 183.5% increase from US$50.16/MWh cost of PV electricity to be stored. It is too high for the market.

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9. Perhaps a carbon constrained North American grid would accept a time of day 20% increase to US$60.19 (€52.46) for stored PV electricity but not much higher.

10. There is not enough time to review my actual paper or to go over my Excel HSP LCOS Financial Algorithm Workbook line by line.

11. READ my paper on your own.

12. GET "hands on experience" in HSP LCOS sensitivity analysis. Enter your own 22 complied HSP specs on my Excel HSP LCOS Financial Algorithm Workbook and see the results

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THANK YOU FOR LISTENING TO MY PRESENTATION!

SORRY, I ONLY HAD 10 MINUTES