NREL
Transforming ENERGY

Low-Cost, Dispatch-Constrained Electricity for H_2 Production

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Solar-Derived Hydrogen: Understanding and Implementing the Cost Reduction Drivers Panel

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A Changing Grid

The electric grid is changing, creating new challenges…

- Declining value of renewable electricity generation as penetration increases
- Price volatility
- Need for additional grid services (e.g. capacity, flexibility)

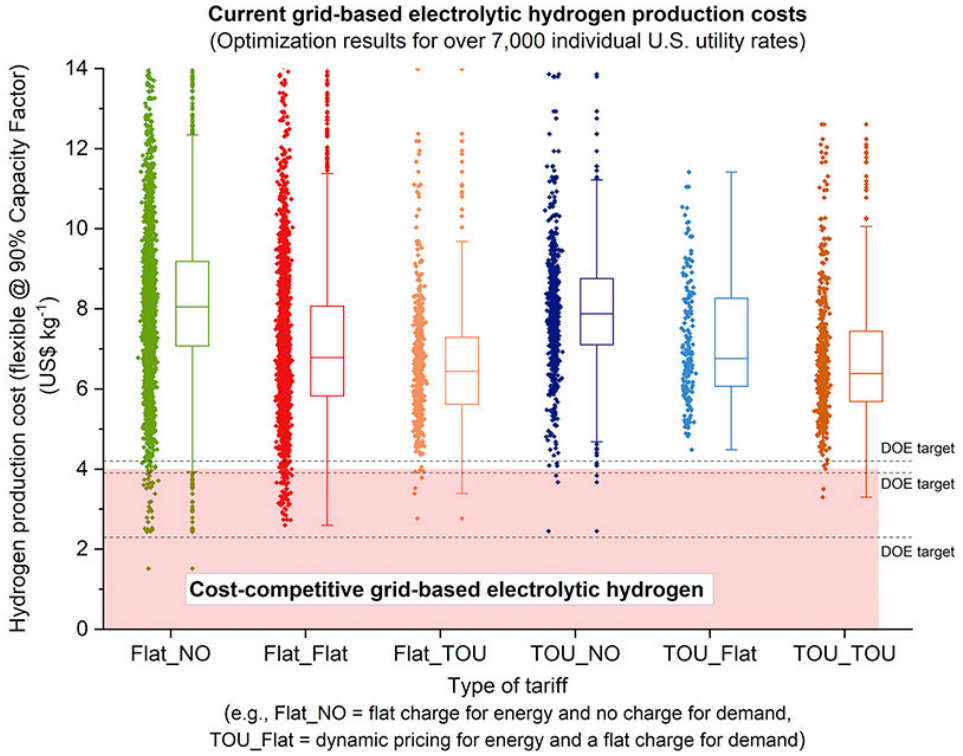
…and opportunities

- Low price PPAs
- Availability of **low-cost, dispatch-constrained electricity (LDE)**

Current Opportunities

- Some locations already have tariffs that are sufficient for electrolyzers today[1] (at high capacity factors)

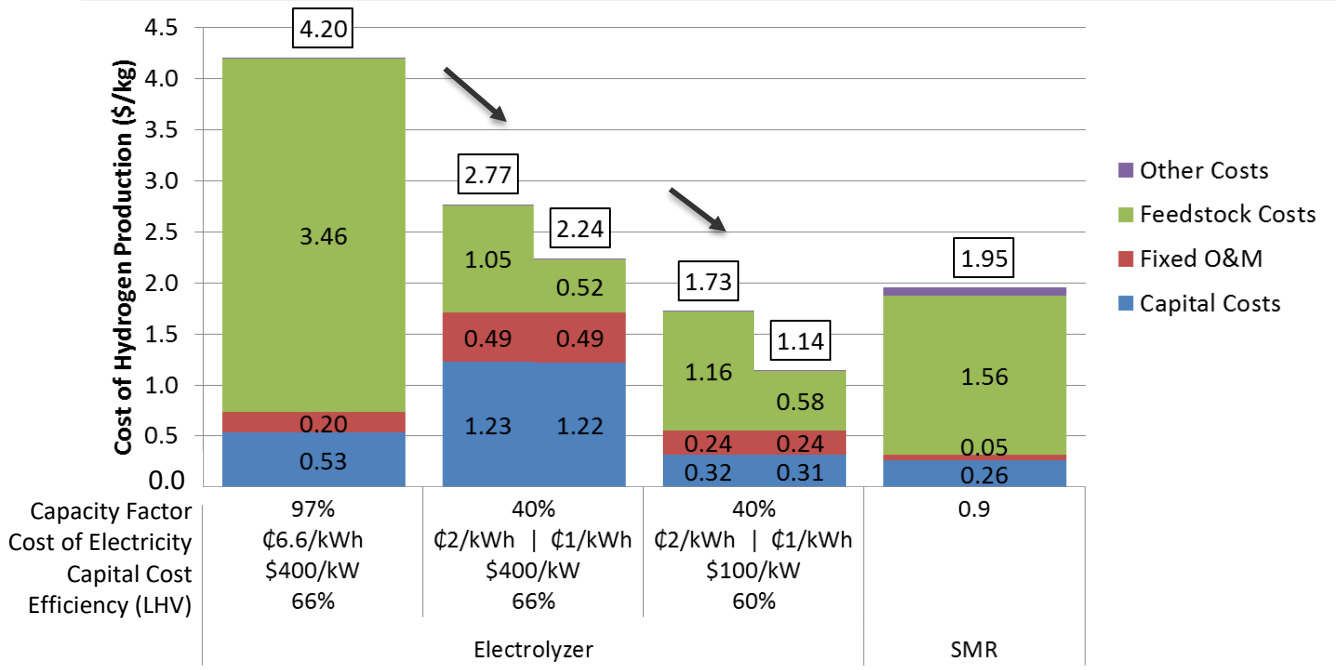
- Other locations may inherently have lower electricity prices, however prices may be more *volatile*…



[1]Guerra, Omar J., Joshua Eichman, Jennifer Kurtz, and Bri-Mathias Hodge. 2019. "Cost Competitiveness of Electrolytic Hydrogen." *Joule*, July. https://doi.org/10.1016/j.joule.2019.07.006.

Potential Opportunity: Low Temperature Electrolysis

Potential Levelized Costs of H_2 Production

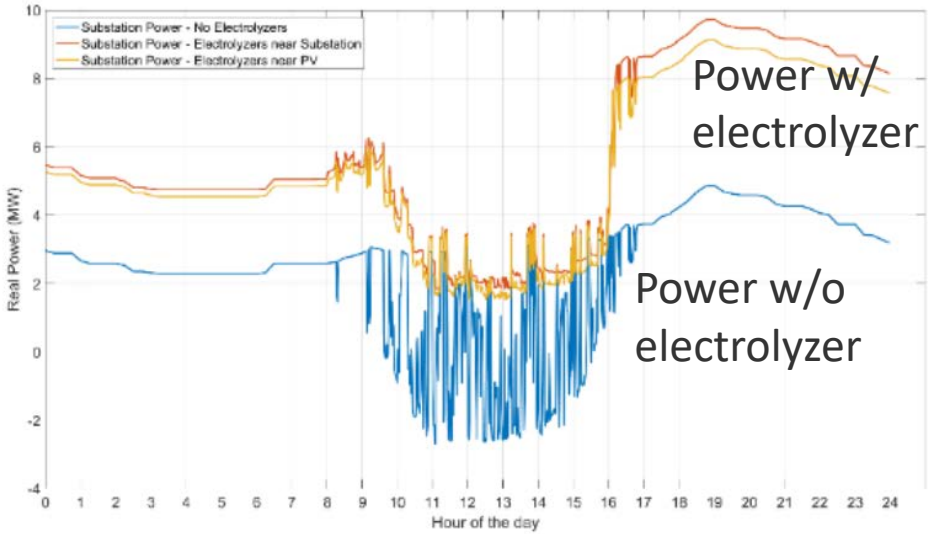


Source: Bryan Pivovar & Josh Eichman

Availability of low-cost electricity can help enable ***low-cost hydrogen*** production at ***lower capacity factors***

Do We Have the **Technologies** and Mechanisms?

- Electrolyzer technologies have been tested to provide grid services (e.g. reduce power fluctuations and voltage deviations)
- Flexibility of electrolytic hydrogen production can provide:
  - Ancillary services (contingency, spinning, and non-spinning reserves)
  - Demand response (increased opportunity with hydrogen storage)



https://www.hydrogen.energy.gov/pdfs/review19/ta015_hovsapian_2019_o.pdf

Do We Have the Technologies and **Mechanisms**?

- Can potential buyers access wholesale markets?
- Can electrolyzer operators be compensated for providing grid services?
  - Large enough buyers should be able to get prices ~$20/MWh above wholesale prices
  - How much can this be reduced by supplying grid services?

Table 1-8 Total price per MWh by category: 2015 and 2016[58]

Category	2015 $/MWh	2015 Percent of Total	2016 $/MWh	2016 Percent of Total	Percent Change Totals
Load Weighted Energy	$36.16	63.6%	$29.23	58.5%	(19.2%)
Capacity	$11.12	19.6%	$10.96	21.9%	(1.5%)
Transmission Service Charges	$7.09	12.5%	$7.81	15.6%	10.1%
Transmission Enhancement Cost Recovery	$0.51	0.9%	$0.52	1.0%	2.1%
PJM Administrative Fees	$0.44				5%
Reactive	$0.37				9%
Energy Uplift (Operating Reserves)	$0.38				%)
Regulation	$0.23				%)
Transmission Owner (Schedule 1A)	$0.09				3%
Black Start	$0.08				3%
Day Ahead Scheduling Reserve (DASR)	$0.10				%)
Synchronized Reserves	$0.11				%)
NERC/RFC	$0.03				0%
Load Response	$0.02				%)
Non-Synchronized Reserves	$0.02				%)
RTO Startup and Expansion	$0.01				%)
Transmission Facility Charges	$0.00	0.0%	$0.00	0.0%	(59.2%)
Capacity (FRR)	$0.13	0.2%	$0.00	0.0%	(100.0%)
Emergency Load Response	$0.00	0.0%	$0.00	0.0%	(100.0%)
Emergency Energy	$0.00	0.0%	$0.00	0.0%	0.0%
Total Price	$56.88	100.0%	$49.99	100.0%	(12.1%)

PJM reports the total cost of electrical energy at ~$20/MWh greater than the cost of load weighted energy

Source: Monitoring Analytics, LLC "State of the Market Report for PJM 2016 Volume 2: Detailed Analysis" (March 9, 2017)

Thank You

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Additional information on H2@Scale can be found at:

https://www.hydrogen.energy.gov/pdfs/review18/h2000_pivovar_2018_o.pdf
https://www.hydrogen.energy.gov/pdfs/review19/sa171_ruth_2019_o.pdf
http://energy.gov/eere/fuelcells/downloads/h2-scale-potential-opportunity-webinar

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