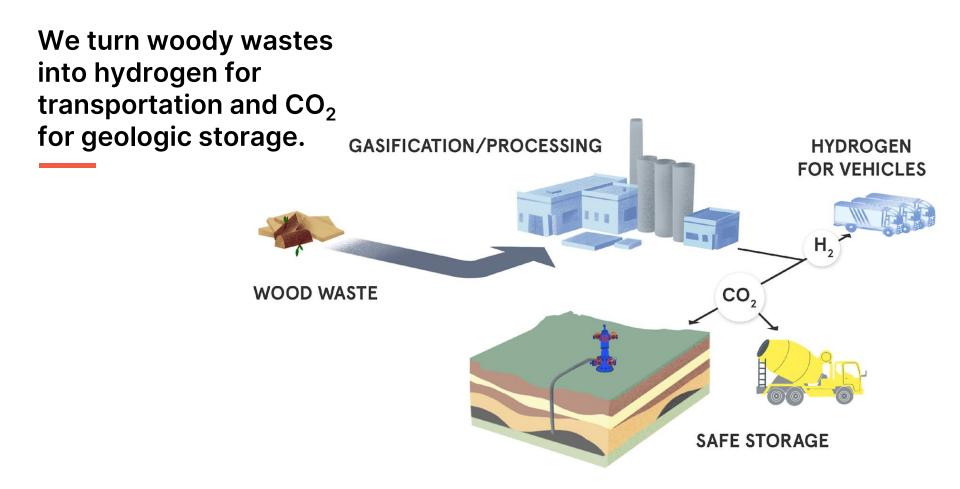
# Carbon-negative hydrogen from waste biomass

Joshuah Stolaroff

IEA Task 33 Meeting

April 19, 2023



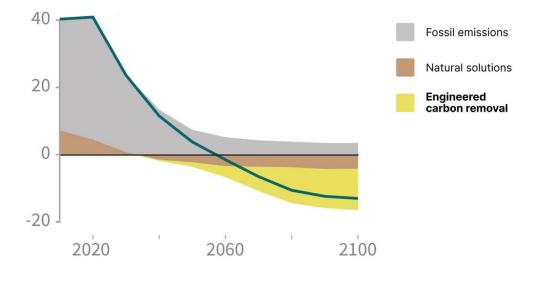




Carbon removal makes 1.5° possible

#### Gigatons of carbon removal are needed.

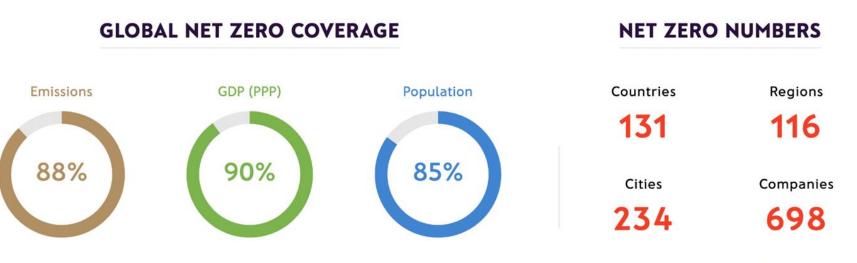
Billion tonnes CO<sub>2</sub> per year (GtCO<sub>2</sub>/yr)



Souce: IPCC "Middle of the road" scenario (2018)

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Net-zero by mid-century is now a widespread goal.



Country-level coverage only. We do not include sub-national net zero targets in countries without a target.

Out of 198 countries, 713 regions, 1,177 cities and 2,000 companies.

Source: zerotracker.net

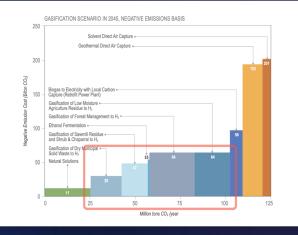


# A climate technology company spun out of work at LLNL



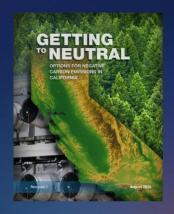


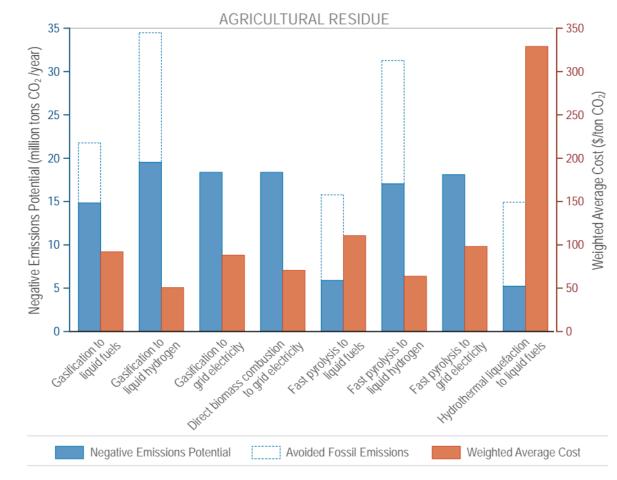




### At LLNL, we compared dozens of carbon removal pathways.

#### Mote's was the best.

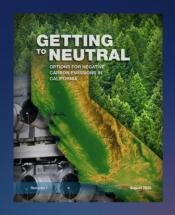


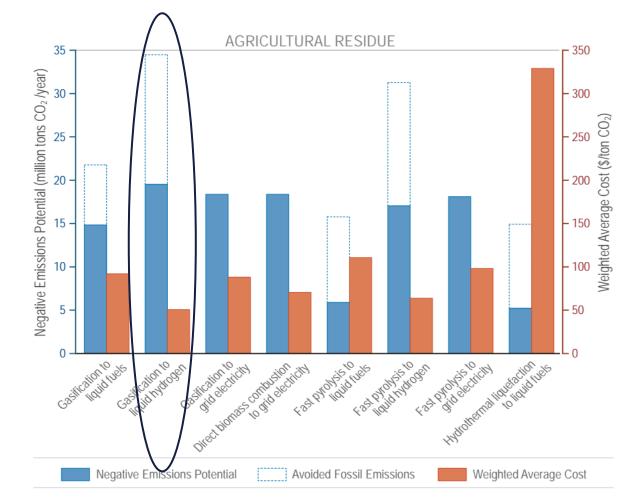


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### At LLNL, we compared dozens of carbon removal pathways.

#### Mote's was the best.





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Biomass gasification to H2 can meet the bulk of California's carbon removal needs.

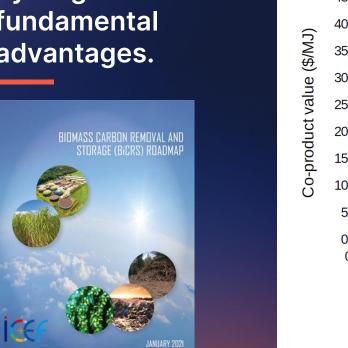


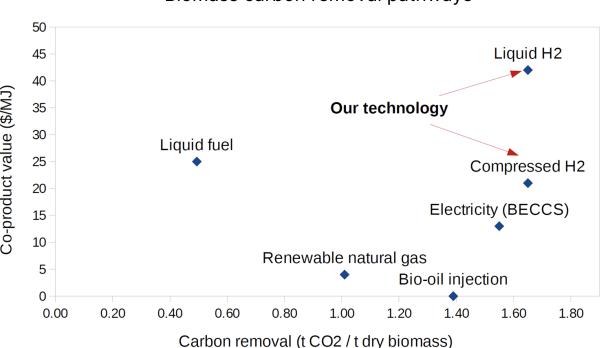
GASIFICATION SCENARIO IN 2045, NEGATIVE EMISSIONS BASIS



Biomass gasification to hydrogen has fundamental advantages.

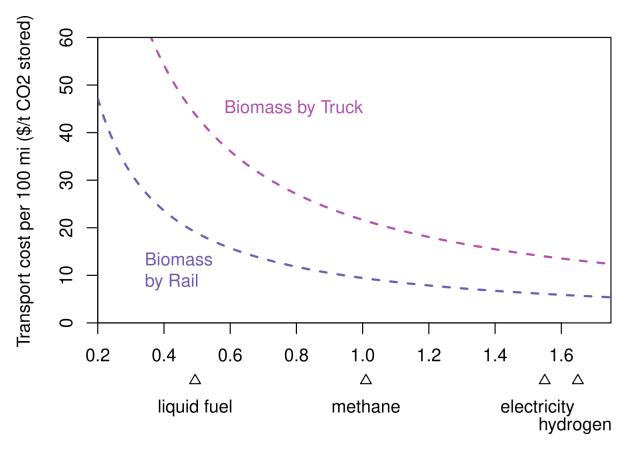
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#### Biomass carbon removal pathways

#### H<sub>2</sub>-BiCRS has better feedstock reach



CO2 storage factor (t CO2 / t biomass, dry basis)

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## Transport Cost for Carbon Removal Projects With Biomass and $\mathrm{CO}_2$ Storage

ORIGINAL RESEARCH

Case and

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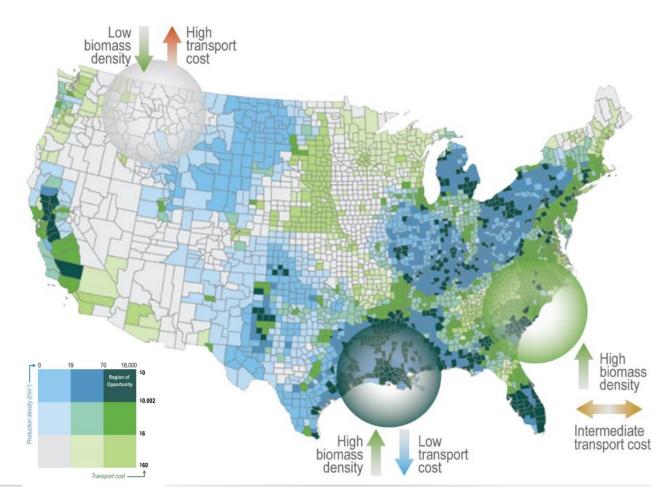
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frontiers

in Energy Research

Mai Bul, Imperial College London, goals. Permising strategies include the conversion of waste biomass to hydrogen, methane, liquid hale, or electricity coupled with CO<sub>2</sub> capture and storage (CS). A key challenge for these projects is the need to connect geographically dispersed biomass applies with geologic storage sites by either transporting biomass or CO<sub>2</sub>. We assess the cost of transport for biomass conversion projects with CO2 suity publicly weakble Enough waste biomass for ~1000 plants in the US.





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## **Entering Front-End Engineering Design for our first facility**

#### 400,000 ton/yr CO<sub>2</sub> remova

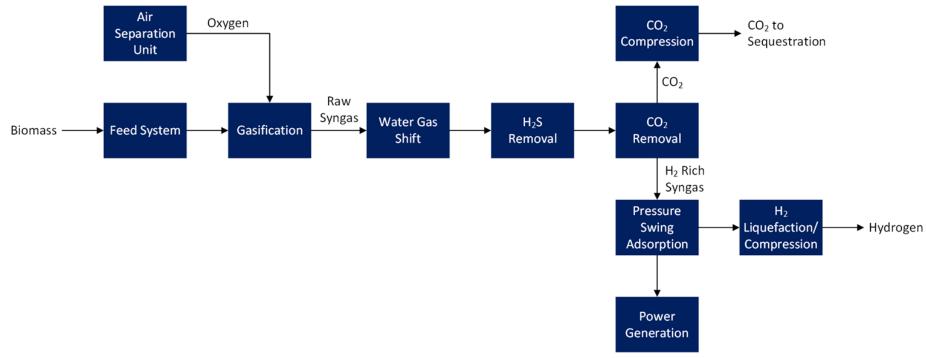
#### 60 ton/day hydrogen

#### **Operation in 202**

### Multiple projects in development



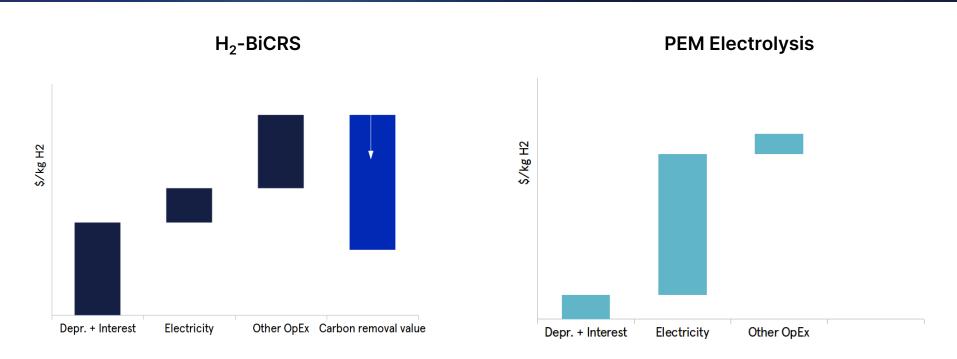
#### **Process Overview**



# Why biomass instead of electrolysis?

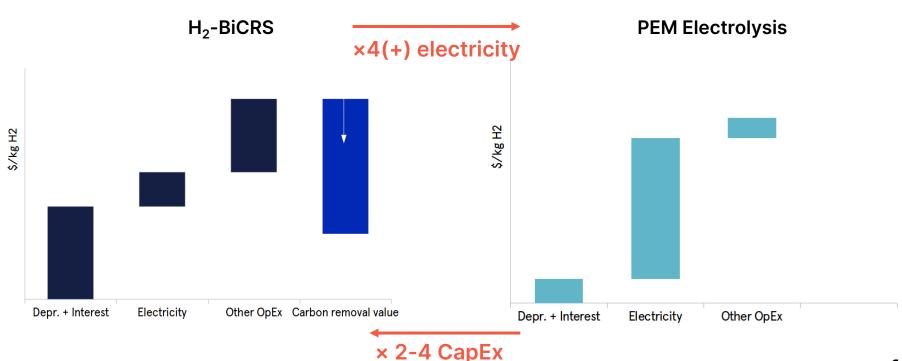


#### Unit Economics favor H<sub>2</sub>-BiCRS over H<sub>2</sub> electrolysis

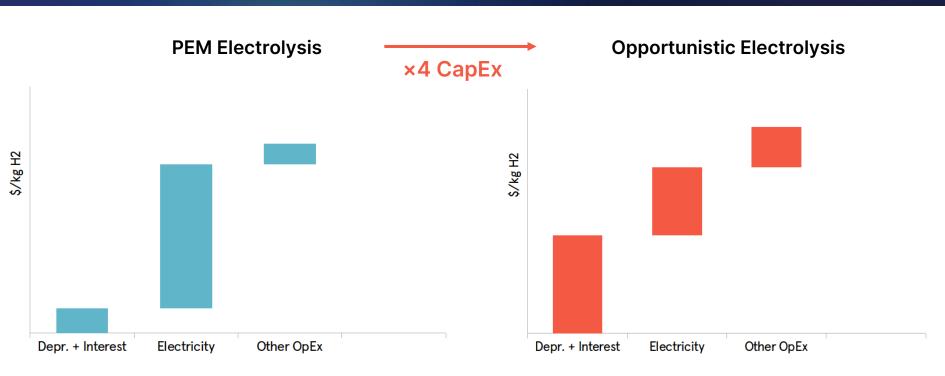


Souce: NREL. H2A: Hydrogen Analysis Model v. 3.2018 **19** 

#### Electrolysis is OpEx heavy, capital light



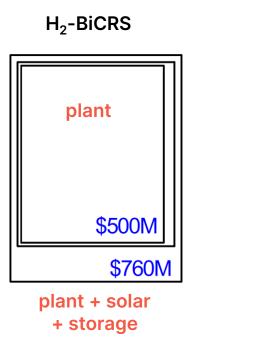
# Electrolysis with opportunistic renewables doesn't help on unit costs



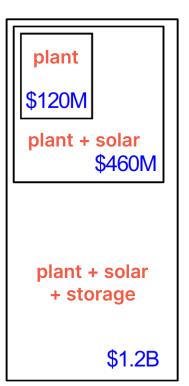
Big new projects need new electricity supply.



## Electrolysis CapEx is high when considering electricity



#### **PEM Electrolysis**

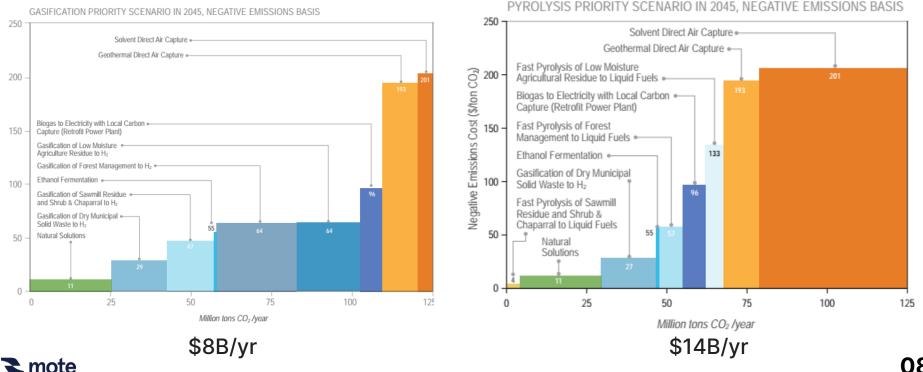


Solar source: NREL. U.S. Solar Photovoltaic System and Energy Storage Cost Benchmarks: Q1 2021

## Demand for carbon removal is rigid.

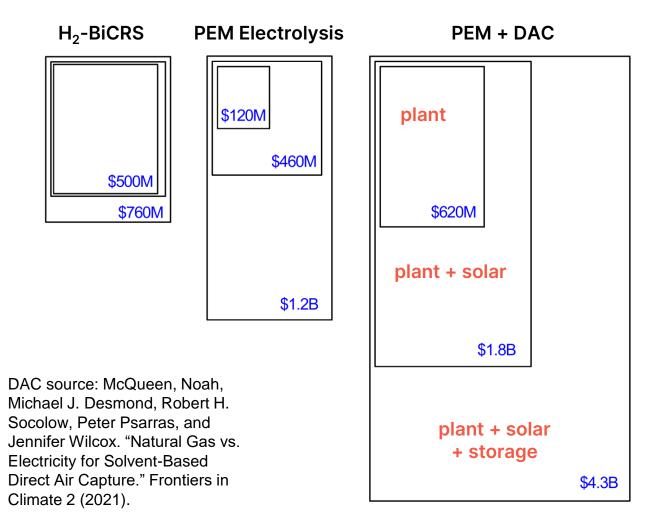


# Gaps left by less-expensive carbon removals will be met with Direct Air Capture



#### **08**

H<sub>2</sub>-BiCRS far less capital intensive than Electrolysis + DAC



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H<sub>2</sub>-BiCRS also saves huge swaths of land.

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H <sub>2</sub> -BiCRS	PEM Electrolysis	PEM + DAC
80 acres 450 acres	30 acres	110 acres plant
	1700 acres	
		plant + solar
		7000 acres

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#### Conclusions

Biomass gasification to hydrogen with CCS is an amazing opportunity to efficiently solve multiple problems.

- Carbon removal
- Clean energy

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• Waste management

Mote is forging partnerships to scale quickly.



# Thank you

Contact: josh@motehydrogen.com

