A comprehensive grid impact analysis of developing zero-emission sustainable aviation fuel

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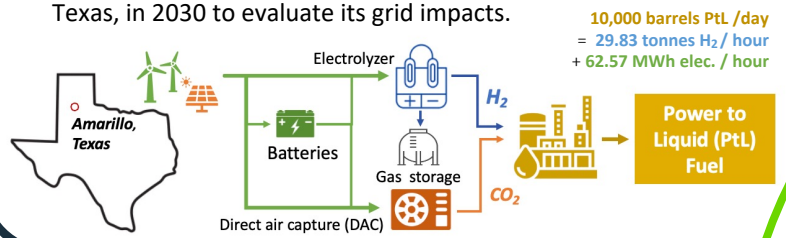
Introduction – *Sustainable aviation fuel from 100% renewable energy*

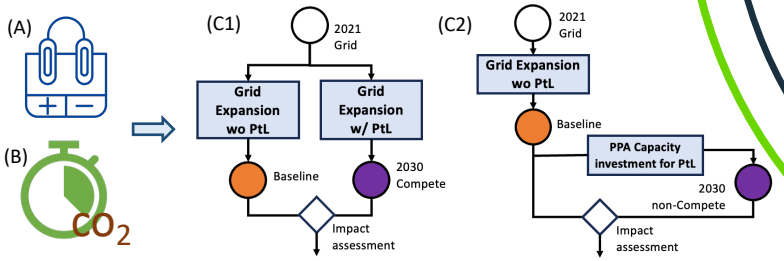
- Power-to-Liquid fuel (PtL) is a synthetic aviation fuel produced from **hydrogen** and **carbon dioxide**, aiming to achieve zero emissions using 100 % **renewable power**.
- We conduct a case study for a daily demand of 10,000 barrels PtL at Amarillo, Texas, in 2030 to evaluate its grid impacts.



Methods – *Grid expansion model for future scenarios*

We simulate the grid expansion in 2030 using an open-source model [1] and consider different future scenarios:

- (A) Hydrogen electrolyzer operations: ***flexible or inflexible operations*** if the hydrogen electrolyzer is operated with or without hydrogen gas storage.



- (B) Time-matching carbon policy: ***annual or hourly time-matching policy*** enforces 100% renewable power generation to match the PtL demand annually or hourly.
- (C) Capacity investment: the ***'compete' scenario*** (C1) represents grid expansion including the PtL demand (C1), while the ***'non-compete' scenario*** (C2) considers capacity investment exclusive for the PtL demand (i.e., PPA contracted capacity) [2].

Research Highlights

Compared to ERCOT 2030 without the PtL demand (represented as $\times 100\%$ baseline) - How significant is the change in carbon emissions and renewable curtailment?

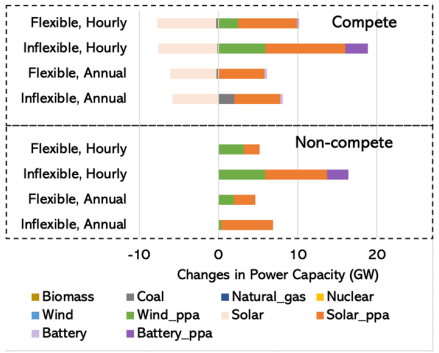
		Carbon Emission (%)	Renewable Curtailment (%)
Compete	*Inflexible, Annual*	9.24	-25.49
	Flexible, Annual	7.61	-37.48
	Inflexible, Hourly	-18.03	29.10
	Flexible, Hourly	-2.79	9.65
Non-compete	*Inflexible, Annual*	-1.35	42.28
	Flexible, Annual	-0.85	-2.86
	Inflexible, Hourly	-18.03	29.10
	Flexible, Hourly	-2.79	9.65

In the non-compete scenario, flexible and annual time-matching policy can reduce carbon emissions and mitigate curtailment.

Results – *How the grid will change with a daily demand of 10,000 barrels PtL ?*

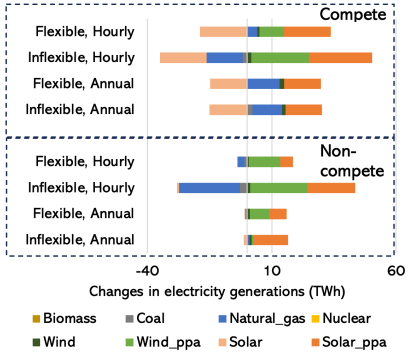
Power Capacity:

- In the compete scenario, the annual time-matching policy will prevent coal plant retirement.
- Under the inflexible operation, the hourly time-matching policy requires significant investments in renewable generations and batteries.



Electricity generation:

- In the compete scenario, natural gas electricity meets part of the PtL demand.
- In the non-compete scenario, renewable electricity can fully supply the PtL demand, except in the inflexible, annual time-matching case.



Conclusions:

1) Future development of PtL should consider its grid impacts systematically.
2) Flexible hydrogen operations avoid over-investment in renewables and mitigate curtailment, especially under the stringent hourly time-matching policy.

Reference:

[1] https://github.com/macroenergy/DOLPHYN, DOLPHYN
[2] Cybulsky, Anna, Michael Giovanniello, Tim Schittekatte, Dharik S. Mallapragada, and MIT Energy Initiative. "Producing Hydrogen from Electricity: How Modeling Additionality Drives the Emissions Impact of Time-Matching Requirements." (2023).