Comment to LCFS

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Disclaimer

Opinions expressed in this document are entirely my own and nothing to do my employer. This study was conducted exclusively during my personal time.

Summary

Hydrogen LCFS strategy must carefully consider constraining factor, without which it is guaranteed to fail in supporting the liftoff. Solar and wind have seasonal fluctuation therefore solar/wind based green hydrogen generation have seasonal fluctuation. Without developing seasonal storage, forcing only green hydrogen will face massive curtailment therefore there will not be any business cases. CARB must coordinate the effort with the utility to make sure that green hydrogen could be produced without wasting it, which requires seasonal storage capacity corresponding to about 15% of yearly hydrogen consumption. Note: electrify everything will face exactly the same challenge since the root cause is seasonal fluctuation of solar and wind.

1. Comments to hydrogen LCFS

Regarding current requirement of green hydrogen mix time frame, I would like to remind CARB staff members that major renewable sources in California are solar and wind which have seasonal fluctuation. Accordingly, if we are to accept only green hydrogen produced from solar and wind, the green hydrogen production will naturally have seasonal fluctuation.

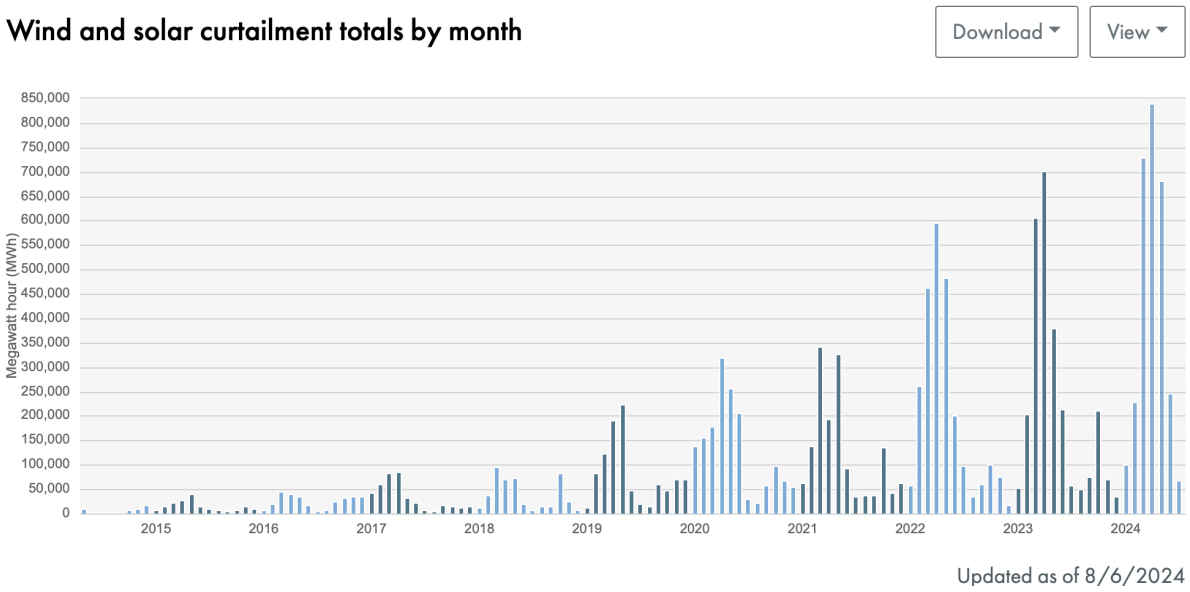
Consequence: without having seasonal hydrogen storage, there will be significant fluctuation in output, which according to market principles, will lead to huge fluctuation in price.

CARB staffs must be reminded that we have at least two analogous problems.

1. Curtailment of CO_2 free electricity in California, which shows clear seasonal fluctuation reflecting fluctuation in solar and wind output (see next page).
2. Why we have 15% of natural gas storage capacity to yearly consumption in the US? Seasonal fluctuation of demand. People use heater when it is cold.

Curtailment from the California grid

Attached below is the curtailment data published by California Independent System Operator (CAISO: the grid operator of California) found at https://www.caiso.com/about/our-business/managing-the-evolving-grid



As one can see, curtailment increase from January to June then decrease from July to December. Maximum output of solar takes place in June (summer solstice) and minimum output takes place in December (winter solstice). On the other hand, atmospheric temperature warm up and cool down with delay. As one should be aware of, hot summer days rather take place in July, August and sometime continues to September. We use AC when it is hot and use heater when it is cold. Naturally, supply-demand will reflect the seasons. ***This can be addressed only if we have seasonal storage, which we don't.*** I encourage CARB staffs to look up these values. Generally speaking, stationary battery way more than $100/kWh. Tesla Powerwall is sold about $10k for 13.5kWh, which translates to $740/kWh. Hydrogen underground storage costs about a few dollar/kWh. Note: one must take the device lifetime into consideration. Lifetime of battery is usually less than 10 years. Gas storage could last a few decades. One can divide these costs by the number of households in California (~13M), which will give you how much a household need to pay in order to build and maintain the storage to address seasonal fluctuation of solar and wind. Please be reminded that curtailment means solar and wind station operators do not have profit out of curtailed electricity. ***One can store it and sell it when supply is below demand, however, only if the storage solution is affordable for majority.***

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Now, why this is relevant (critical in my opinion) for LCFS strategy?

1. Without having seasonal storage, we cannot fully decarbonize power sources, then it does not matter how many BEV or FCEV people bought them. Either electricity or hydrogen need to be on-demand sources which is unfortunately fossil based (natural gas). ***Please remember solar and wind are NOT on-demand power supplies.***

Solution: build hydrogen underground storage, H_2 pipeline and facilitate H_2 market expansion

With the hydrogen underground storage as affordable seasonal storage, we can introduce sufficient amount of solar and wind. Keep in mind that for the large scale energy transfer, pipeline offers close to 10x lower cost compared to HVDC line (this is also related to surface to volume ratio) enabling us to connect solar and wind generated at geographically separated. The relevance of this is following: generally speaking wind power output in high latitude peaks rather in winter, which is opposite of solar output. Therefore, there will be averaging effect, which will reduce the required amount of storage size.

As the analogous scale of infrastructure, let us look at natural gas pipeline. As you may be aware of, California import significant amount of natural gas from Wyoming via the natural gas pipeline owned by Berkshire Energy (https://www.brkenergy.com/our-businesses/kern-river-gas-transmission-company). Very interestingly, Wyoming is known to have significant amount of wind power generation capacity. If we retrofit their natural gas pipeline to H_2 pipeline, we are going to have huge amount of renewable power supplies connected each other: solar in south west and wind in north west.

Note: H_2 pipeline technology already exist. See
https://www.energy.gov/eere/fuelcells/hydrogen-pipelines

I point out that ***there is a large scale underground hydrogen storage project in Delta Utah***, which is co-developed by Chevron and Mitsubishi Heavy Industry (https://aces-delta.com). Delta Utah is very close to the Kern River Pipeline so it seem conceivable that such large scale hydrogen storage and distribution infrastructure can be built some time in near future.

Relation to LCFS: timeline is crucial

Forcing hydrogen industry to switch to 100% green makes sense ***only if such a large scale hydrogen storage and pipeline are already in place.*** If not, there will be significant amount of curtailment (waste) and the entire energy transition effort is going to fail.

Message to CARB

Instead of specifying the specific year without explaining why 2030, please use more reasonable language (ex. when the necessary infrastructure is complete).
Let me ask the CARB staffs: is it hydrogen producers' responsibility to develop such a massive infrastructure? I suppose the public institutions roles should include facilitating coordination of effects in different industry sectors: energy production, storage and distribution, and various users including transportation sector.