Hydrogen Model V2

Demand:

Instead of doing the demand curves we’re doing now, lets just tell the model how much demand there is in a few different sectors. We don’t necessarily have to define the sector specifically, but could be a bit more generic. For example, transportation fuel and power generation would be good places to start.

The main differences between demands are the pressure, purity, and emissions benefits of switching to hydrogen.

Then, we tell the model how much of each demand there is, and it determines the price at each node that it can deliver hydrogen at.

Then, we can vary the amount of demand and the emissions benefits (carbon price) and maybe even the pressure for each sector to see how that changes prices.

The output is basically price curves or price points.

These outputs will need to be aligned with whatever scenarios we end up exploring as pathways. So, once we home in on some pathways, we’ll have a good idea of what the results need to look like.

Model:

Things to remove:

Carbon credits. Abandon this structure. It was designed with the idea that consumers might have different carbon preferences. But that idea is too difficult to implement from the supply side. An overall tracking of CI would be more straightforward.

Demand curves. Instead, we will come up with a few more generic sectors (export, transportation fuel (high quality with high, med pressure), fuel cells power (high quality, low pressure without needing fueling stations), and combustion (low quality, low pressure). We will require the model to meet demand, and then we’ll just show how increasing the demand in each of these sectors impacts the price at each node.

Might also be good to define storage needs (i.e., for 1 ton/day of demand, this segment requires 3 ton/day of storage).

Things to add:

Carbon tracking: this just needs to be done for the supply side and for any gas or electricity consumed for the other infrastructure technologies.

Hydrogen(pressure, quality): We need at least high/high, med/high, low/high, low/low, and liquid/high. The various technologies may play naturally into each segment. For example, electrolysis produces low/high, liquefaction turns things into liquid/high, etc.

Storage: this can just be calculated as a function of demand and seasonality. We need to keep track not only of the total amount of storage, but of whether a consumer is connected to centralized storage or not.

In this case, storage probably needs to be a commodity that is consumed, and which storage facilities can “produce”

Economies of scale: you need to do some slicker programming to do this better than you currently are. The y-intercept method is only useful if there is a minimum and maximum—i.e., for the part-load efficiency of a power plant. But for things like capital cost, that intercept (fixed portion) is quickly dwarfed by larger facilities. This is not really an economy of scale as much as a disincentive for very small plants.

Component-level: it might be more straightforward to define things like a compressor, storage, and fuel dispenser rather than a fueling station that includes all of those things. Then the model can optimize those services centrally or decentrally.

Pathways to $4/kg hydrogen for transportation.

1. Carbon pricing. This is pretty straightforward. It requires a carbon price in the model and then some demand-side assumptions about how demand would value that hydrogen.
2. Technology cost improvement. How much cheaper do the different systems and components need to get? This is pretty straightforward sensitivity/tornado analysis.
3. Centralized, high-purity pipelines. If compression and storage are centralized, then maybe they reach economies of scale and utilization much higher than individual fueling stations owning this underutilized assets.
   1. Probably the best outcome here is to focus on medium-duty regional distribution or local segments like port vehicles. Medium pressure is probably a big winner here. You just need to find transportation segments that are okay with refueling more often.
4. Liquid hydrogen intensive. Aligns with export-heavy focus. Basically explore how the cost advantages stack up if we focus on building a system with lots of liquefied hydrogen.
   1. Would require some new technologies. Namely 1) liquid hydrogen fuel tanks for trucks, and 2) liquid pipelines.
   2. One advantage may be siting electrolysis, wind, and liquefaction all nearby each there, thus centralizing the purification and liquefaction processes.
   3. Pipelines might not be necessary depending on the scale of demand desired to be achieved. But, it is likely that beyond 100 tons/day or so, that pipelines would begin to make much more sense than trucks. Especially if we’re talking hundreds of miles.
5. ??? Maybe these four ideas are enough. I am thinking about some ideas around coupling wind and solar farms directly to fuel some of the processes. Electrolysis is obvious, but you might also consider liquefaction and compression. This would be a capital cost intensive structure where variable costs are low b/c the electricity production is owned. I’m not sure how much impact this would actually have on the fueling station costs, though, since those are already very capital intensive. It might just be an added benefit, but not strong enough to be a pathway in and of itself.