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45V Hydrogen Tax Credit in the Inflation Reduction Act: The Role of New Clean Electricity

Issue Brief 23-06 by **Aaron Bergman** — September 2023

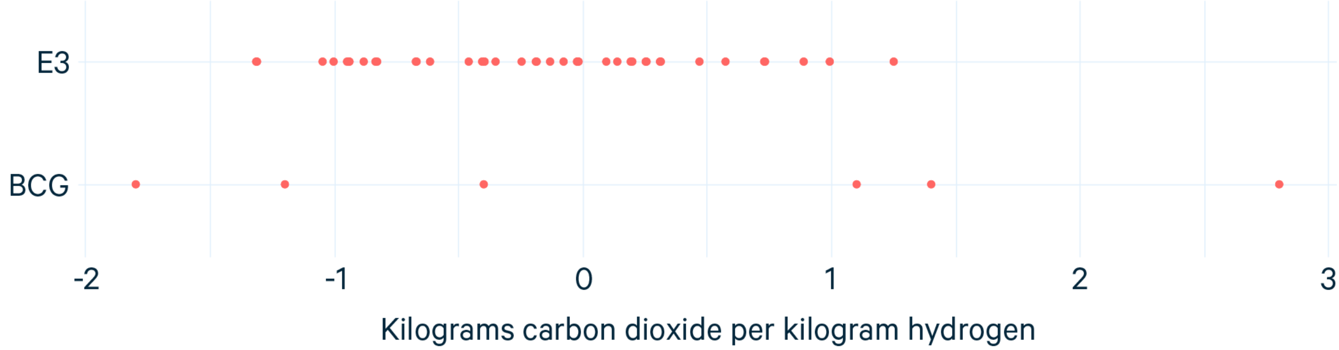
The central question in determining the emissions effect of new load on the electrical grid is whether the new generation is clean. In previous installments of this series, I reviewed studies that directly address this question, using optimizing models to look at the effect of the demand for electricity from electrolysis, the process of producing hydrogen by using electricity to split water. In this issue brief, I consider two studies that instead assume all the new generation built in response to the new demand from an electrolyzer is clean. The **study from Energy + Environmental Economics** (E3) was sponsored by the American Council on Renewable Energy, and the **Boston Consulting Group** (BCG) study was sponsored by NextEra Energy.

As I argued in the **opening blog post of this series**, not assuming that new generation is clean is the more defensible approach. Nonetheless, one can still obtain valuable insight from studies that assume the contrary. In this issue brief, I will discuss the findings from these studies and how I believe they should be interpreted.

1. Emissions Results

Figure 1 shows the emissions per kilogram of hydrogen produced from the BCG and E3 studies. Each study considers a variety of renewable energy portfolios built to meet the electrolyzer load. Each dot represents the difference in emissions between annual matching (meaning the total electricity consumed by the electrolyzer over the course of the year is the same as the total renewable generation in the portfolio over the year) and hourly matching (meaning the electrolyzer matches the renewable generation from the procured portfolio hour by hour). In contrast to the other studies examined in this series, the emissions rates are relatively small and even negative in a few scenarios. Since all the new generation is assumed to be clean, emissions arise solely from the different times at which the electrolyzer and clean generators operate. In my **paper with RFF Fellow Kevin Rennert**, we call this the **dispatch effect**. This is compared with the **capacity effect**, which arises from what is built, and is assumed away in these studies

Figure 1. Emissions Rate: Annual Matching Minus Hourly Matching



(but is addressed in the Princeton ZERO Lab, MIT Energy Initiative, and Evolved Energy studies).

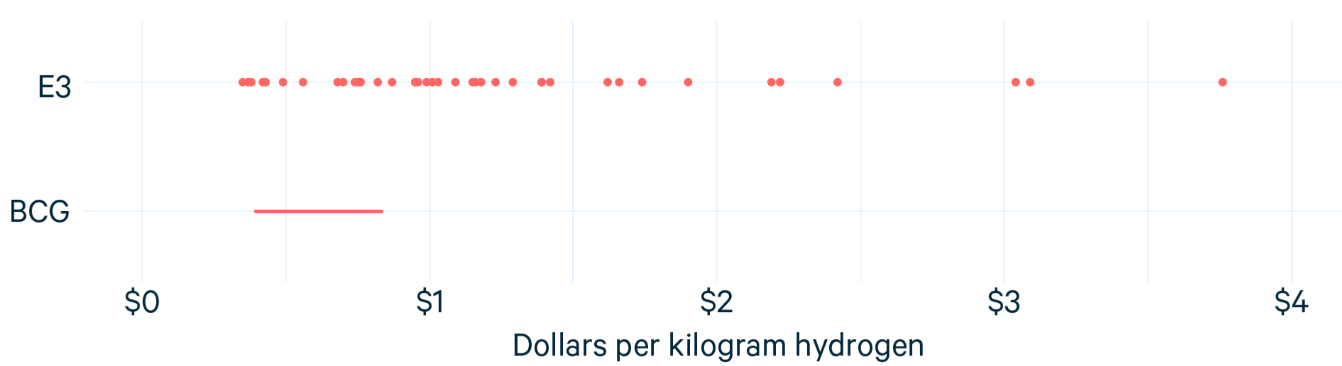
To quantify the emissions from electrolytic hydrogen production, the two studies use different versions of *marginal* emissions rates. A marginal emissions rate is the change in emissions due to a small change in electricity generation or consumption at a given location and time. The E3 study uses short-run marginal emissions rates projected using the Aurora model, and the BCG study uses long-run marginal emissions rates from **NREL's Cambium project**. The short-run marginal emissions rate refers to the change in emissions for the entire grid in response to the small change in generation or consumption at a given location and hour in a particular year and is calculated using the state of the grid in that year. The long-run marginal emissions rate instead looks across multiple years and is the change in emissions in response to a persistent (across years) change in generation or consumption and can include changes in the composition of the grid. The emissions are calculated by evaluating the combined effect of the chosen portfolio of clean energy and the operation of the electrolyzer. In each study, the scenarios (the dots in Figure 1) are different portfolios of renewable energy, chosen by the modelers rather than optimized, with the electrolyzer matching the renewable energy generation profile for hourly matching and operating at a relatively constant level for annual matching. For E3, the renewable portfolios are 0/100, 25/75, 50/50, 75/25 and 100/0 percent for solar or wind, for multiple regions and for the years 2025 and 2030. For BCG, the dots are national averages and include scenarios that allow a 10 percent overbuild of renewables and where the electrolyzer can shut down for 5 percent of hours.

2. Costs

The incremental costs of hourly matching over annual matching from each study are shown in Figure 2. For the E3 study, the scenarios are not exactly the same as in the emissions calculations. Instead, in each scenario, the portfolio of renewable energy in the annual matching scenario is sized to achieve an overall emissions rate of less than 0.45 kilogram s of carbon dioxide per kilogram of hydrogen, the level of emissions needed to receive the highest tier of the 45V tax credit. In many scenarios, this involves building less renewable energy because the emissions are already less than 0.45. In addition, a major driver of the cost difference is the reduction of the capacity factor of the electrolyzer in the hourly matching scenario. The BCG line indicates the range for the maturing markets scenario for hourly versus flexible annual matching. The methodology is not clear, but the authors indicate that the cost differences are driven by "reduced electrolyzer capacity factor, renewables overbuild and addition of energy storage."

Since these costs are based on prescribed portfolios of renewable energy and operation of the electrolyzer, they will be higher than what is seen in the optimization models used in the other studies in this series. Nonetheless, the BCG costs are not too different from the $0.10–$1.00 premium seen for hourly matching in the other studies, and many of the E3 results also fall within this range.

Figure 2. Costs: Hourly Matching Minus Annual Matching

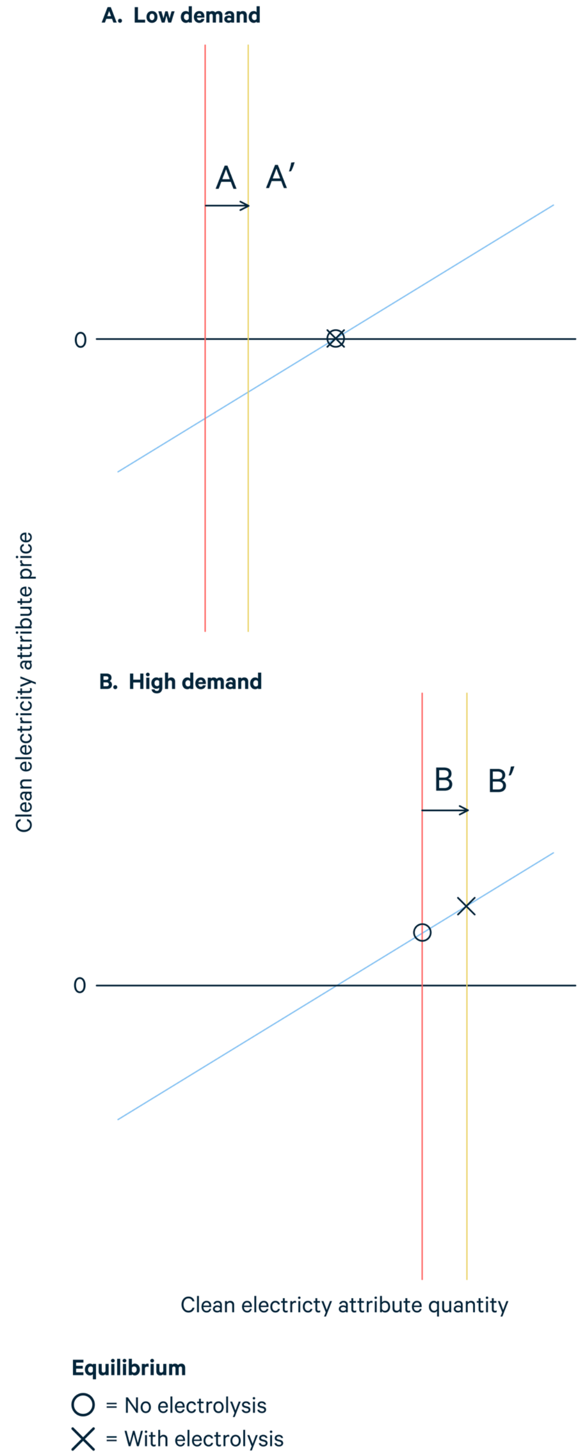


3. New Clean Electricity

I have emphasized in this series that the major effect on emissions arises from whether the choice of crediting policy incentivizes the construction of new clean energy. So, what does it mean that these studies simply assume that new clean energy is built to meet the demand from electrolyzers? To examine this, Figure 3 shows schematic supply and demand curves for clean energy—or, more properly, clean electricity attributes as represented by a renewable energy credit (REC) or, more generally, an energy attribute credit (EAC). The price on the vertical axis represents the amount that must be paid above and beyond the revenue the clean electricity generator would receive for selling electricity, which can be thought of as a proxy for an EAC price. Importantly, much of the supply curve has clean electricity available at a negative price. This represents clean electricity generators that will earn a profit from selling electricity with no need for additional revenue. In other words, all other things being equal, building that generation is profitable, so someone will build it even in the absence of additional incentives.

The first panel shows a scenario with low demand for clean electricity represented by the vertical line A.[1] Rather than being on the line A, however, the equilibrium amount of clean electricity is at the box, since all the negative-price clean electricity will be built. In this equilibrium, the EAC price is zero. Adding the additional demand from electrolysis moves the demand from A to A', but the supply of clean electricity remains the same. [2] In the second panel, the demand for clean electricity is higher and is represented by the vertical line B. Here, the clean electricity supply (shown by the circle on the chart) is higher than the value in the first panel, and there is a nonzero REC price because the equilibrium price is above zero. Adding the electrolyzer demand moves the demand to B', and the supply of clean electricity increases. Hence, in this high-demand scenario, the additional electrolyzer demand does induce new clean electricity.

Figure 3. Supply and Demand for Clean Electricity Attributes



1 These vertical lines are meant solely to represent levels of demand and are not demand curves, which would be sloped because of the price response of demand.

2 This is true in this schematic model, but in a more realistic model, the additional demand will change the price of electricity, which will shift the supply curve and change the equilibrium level of clean electricity. In other words, some of the new demand will be met with clean generation irrespective of the policy, just as is happening with clean energy being built now.

The questions then become, what does the current demand for clean energy look like, and what will it be going forward? If demand is at line A, adding new demand for clean electricity from electrolyzers will not induce new clean electricity to be built, whereas if demand is at line B, new clean electricity will be built, reducing emissions. The projections from the studies using optimizing models—which do not include demand from corporate procurement—project the future world at line A; the two studies reviewed here assume the line is at point B. A recent **op-ed**, written in part by many of the authors of the E3 study, argues that assuming that the world will be at line A entails that "(1) clean energy prices that are always lower than conventional energy (requiring a sharp reversal of recent trends), and (2) no change in clean energy demand despite lower prices." And "demand for clean energy," they state, "is strongly price elastic, meaning that low prices would lead to higher clean energy demand (and conversely that higher prices would shrink demand)."

Although REC prices in the voluntary market are currently nonzero, indicating that perhaps we are in a high-demand scenario (although there is **much controversy** on this question), the Inflation Reduction Act is likely to drive significant additional clean electricity, which would mean that the future looks more like the low-demand scenario, particularly if neither corporate demand nor demand from compliance with state policies increases commensurately. However, it is also possible that delays from permitting and from interconnection queues could mean that less clean electricity is deployed than expected.

4. Conclusion

The E3 and BCG studies show that even if all the new demand will be met by new clean electricity, there will still be changes in emissions, although of a much smaller magnitude than what is seen when the new demand is met in part by fossil fuel generation. But whether we will be in this world depends on the future supply and demand for clean energy. Modeling can help answer this question, but the demand for clean energy will also depend on the behavior of corporations and potential changes in state policies. One important advance that could inform the issue would be to find a way to **incorporate voluntary REC markets** into power sector modeling. The questions surrounding the 45V tax credit are incredibly complex, and without the modeling work that has been described in this series, it would be much more challenging to understand the countervailing forces that drive the emissions outcomes. It is this understanding, much more than the modeling results themselves, that will help Treasury set the policy for this tax credit.

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