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Cellulosic Ethanol-The System is Not Ready

See Attached

Additional submitted attachment is included below.

What Happened to Cellulosic Ethanol?

The year 2022 was supposed to be a landmark year for the circular bioeconomy. In 2007, the United States had set itself the goal of producing 16 billion gallons per year of ethanol from cellulosic biomass by 2022. Over $10 billion in public and private funds were invested in the U.S. to achieve the goal.

The result? Less than about 10 million gallons of cellulosic ethanol were produced in 2022, much less than one tenth of one percent of the goal.

What happened?

If cellulosic biomass is ever to become a cornerstone of the bioeconomy, we need to understand what happened.

We can first ask: "What is required to achieve a very large-scale industry involving feedstock processing to commodity products?". Asked this way, the answers become more obvious. For a large-scale industry producing fuels from cellulosic biomass, we require five functioning subsystems.

- Large scale feedstock production (involving the agricultural/forestry sector)
- Large scale transport systems to move feedstock to the biorefinery
- Large scale biorefining systems to produce the biofuels
- Large scale systems to transport biofuels to end markets
- Large scale end markets for the biofuels

Not one of the five required subsystems for cellulosic ethanol was in place in 2007…nor are they in place now (at least in the U.S.).

Cellulosic biomass production is a sideline for most farmers. It will need to be a major focus of farmers if it is to be produced at scale. Likewise, large-scale systems for gathering, transporting, and storing the required biomass are needed. Biomass supply systems turned out to be quite expensive to implement—in one case about twice as much was invested to set up the supply chain as was expended on the biorefinery itself.

While some technologies for biorefining to cellulosic ethanol were in place, most of these were decades old even in 2007. New methods have been developed since 2007, but most of these are not investment-ready even now and they were certainly not investment-ready in 2007.

Unit trains have been developed to transport corn starch-derived ethanol to market and these were probably available to transport cellulosic ethanol also. However, at least in the U. S., the market for ethanol as an octane booster was already saturated by corn ethanol, so there was limited room for cellulosic ethanol in the market, even if it had been produced at scale.

Therefore, it appears that cellulosic ethanol production was not primarily limited by conversion technology, instead, the overall system was not ready.

This tentative conclusion is supported by the relative* success of renewable natural gas (RNG) produced from waste cellulosic biomass in the U. S. in response to the federal and state financial and policy incentives. It appears that no one predicted the success of the RNG industry in those early years immediately after 2007.

And yet it happened. Why?

Let's consider again the five subsystems needed to achieve scale.

First the waste materials for RNG production were already gathered at some reasonable scale. Second and third, the scale of anaerobic digestion was appropriate for many on-site wastes and anaerobic digestion technology is well developed. Fourth and fifth, biogas resulting from anaerobic digestion is easily burned to produce electricity or purified to biomethane (RNG) and the resulting electricity and/or biomethane are readily moved using existing large-scale distribution systems to large final markets.

In other words, cellulosic RNG met most or all the five subsystem requirements while cellulosic ethanol met few or none of these requirements. In retrospect, perhaps we should not be surprised at the success of cellulosic RNG and the failure of cellulosic ethanol.

Our need for large scale alternatives to fossil fuels is stronger than ever. We need renewable fuels and electricity to meet climate objectives as well as energy security objectives. If we are to achieve these objectives using (at least in part) cellulosic biomass, we will need to pay more careful attention to the required five subsystems for a large-scale cellulosic biofuels system…starting with the farmers and foresters.

*We are currently producing annually about 0.8 billion gallons of gasoline equivalent of RNG, a respectable number but still far short of the 16 billion gallon per year national goal set by Energy Independence and Security Act of 2007. Furthermore, most of the RNG has been produced from already-gathered waste materials, an important but nonetheless limited supply.