Feedstock Doesn't Just 'Grow on Trees': Finding Available Feedstocks for Next-generation Biofuels and Biochemicals

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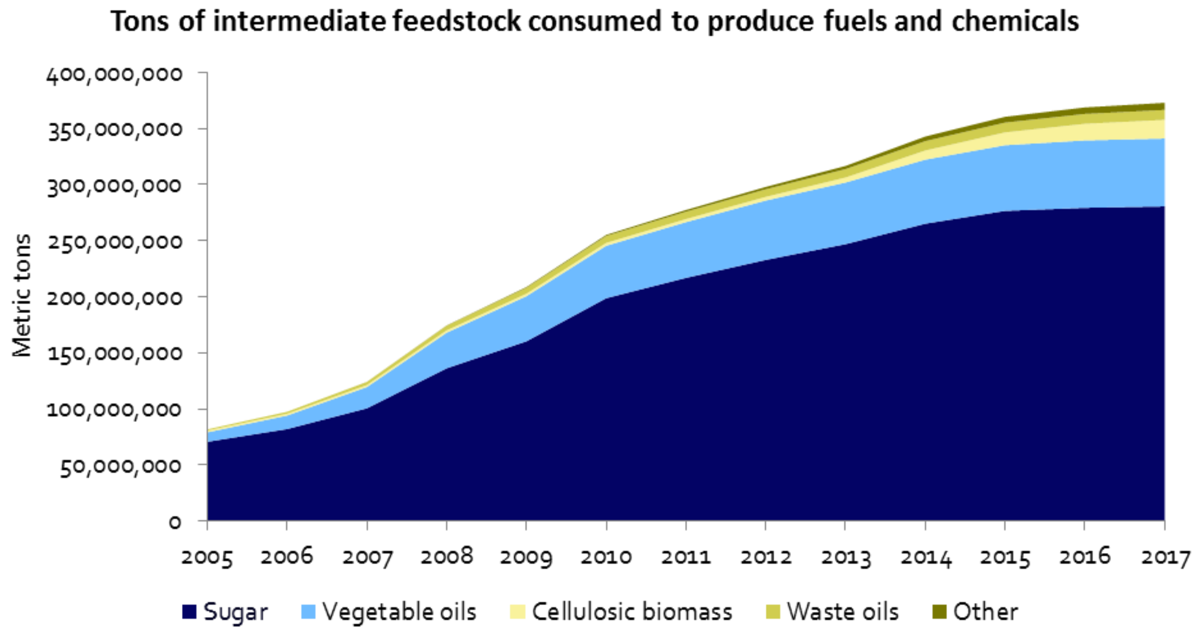
As capacity to convert biomass into fuels, chemicals, and materials increases, the competition for available and cheap biomass is consistently a key issue for companies aiming to commercialize novel production processes. In any of the processes we analyze – whether gasification, biomass to sugars, pyrolysis – feedstock cost is the largest component of overall production cost. In a bio-based industry where cost parity is a must, a secure feedstock supply is crucial for any producer.

The alternative fuels (AF) and bio-based materials and chemicals (BBMC) markets are growing rapidly and straining today's biomass value chain. The stress is seen today in indirect land-use change, volatile feedstock pricing, and competition with food, among other issues with today's feedstock supply. As the industry matures and develops, there is a long-term shift to next generation feedstocks, but first generation sugar crops and oilseeds dominate today (see figure).



Bio-based chemical production is dominated by sugar feedstocks

Global capacity to produce bio-based materials and chemicals today stands at 6.9 million MT and will grow 17.6% annually to reach 13.1 million MT in 2017, with production coming from 229 different production facilities. In terms of feedstock, sugar crops are the pacesetter in BBMC growth, with sugar-based chemicals growing 17.0% annually through 2017. Sugar crops will be the largest feedstock source for BBMC in 2017, as dozens of new production facilities ramp up making chemicals like butanol and succinic acid from first-generation sugars. Many of these sugar-based BBMC companies are exploring cellulosic sugars in R&D, but production capacity is based on sugars from crops like corn, sugarcane, and wheat. The sugars are fermented and chemically processed to obtain products as diverse as ethanol, aromatic chemicals like benzene, toluene, and xylene (BTX), flavor molecules, and organic acids, like adipic and succinic acid.

There was 247 million MT of sugar consumed in 2014 to produce fuels and chemicals, on pace to increase to 281 MT of consumption in 2017. About 78% of this consumption comes from the Americas, with the U.S. and Brazil leading the way – mainly as ethanol producers. The U.S. and Brazil are the two biggest markets making ethanol and other chemicals from corn and sugarcane, respectively. Behind the U.S. and Brazil are China (cassava and corn) and Indonesia (cassava, sugarcane). Though sugar feedstocks have the biggest potential product palatte, ethanol is by far the largest component of sugar consumption for biofuels and bio-based chemicals, consuming about 98% of sugars used to make fuels and chemicals.

Alternative fuels production is a move away from food feedstocks, with cellulosic, waste, and gas feedstocks growing

In Alternative Fuels, global production capacity will grow from 53.2 BGY in 2013 to 60.4 BGY in 2017, a mere 3.2% CAGR. The 2017 capacity is coming from 1,768 facilities spread across 82 countries. These biofuels are mainly produced from sugar crops (corn, sugarcane, wheat) and vegetable oils (palm, soy, rapeseed). While sugar crops and vegetable oil crops still control the vast majority of biofuel capacity in 2017, the growth through 2017 is a mere 2.9% and 1.5%, respectively. Growth is starting to accelerate from cellulosic biomass and other materials, such as municipal solid waste. Government policies aiming to combat food vs. fuel and the economic risks of using a food crop as feedstock are the main drivers pushing fuel producers to untraditional feedstock sources. And these pressures – economic, government, and public sentiment – will limit the growth of oilseed feedstocks.

Crops like soybean, canola/rapeseed, and palm are stalwarts of the oilseed crops, while growers are experimenting with less-known species like crambe, flax, jatropha, and Brassica carinata (Ethiopian mustard). These crops are the feedstocks for biodiesel, renewable diesel, and renewable drop-in jet fuel, as well as fatty acid esters and fatty acids and soaps. Oilseed consumption is much more geographically spread out than sugar consumption. Of the 2013 capacity to consume 55 million MT of vegetable oils, 41% is based in Europe (led by Germany and Spain), 19% in ASEAN (led by Indonesia and Malaysia), 18% in North America (mainly from the U.S.), and 16% in South America (Brazil and Argentina dominate). In terms of specific crops, rapeseed dominates in Europe, palm dominates in ASEAN, and soy dominates in the Americas. Biodiesel, renewable diesel, and fatty alcohols are the three largest products from vegetable oils, though biodiesel dominates with roughly 51 million MT of capacity.

Converting cellulosic feedstocks to fuels and chemicals comes with both technical and supply chain challenges

The biofuel and biochemical industries are slowly moving away from food-based feedstock, and cellulosic feedstocks will be the next step. There are a number of routes to unlock valuable products from lignocellulosic biomass – and several of these routes go through sugars. When mapping the economics of biomass-to-sugars for several different production processes, we found that feedstock cost was more than 60% of the operating costs to make cellulosic sugars.

Producers are developing supply chains for a long list of cellulosic feedstocks, including corn stover, sugarcane bagasse, palm residues, wheat straw, rice straw, wood, and energy crops. These feedstocks total more than 2.7 billion metric tons of feedstock globally, and about 1.5 billion metric tons of feedstock on a dry weight bases. But these feedstocks don't always come cheap – many of the start-ups we speak to expect feedstock for $40 per ton, but the reality is that these sources often cost more than twice that. Each of these biomass sources has a value – corn stover acts as a fertilizer when left in the field, sugarcane bagasse is burned to make power, palm empty fruit bunches are used as compost or for energy. As companies develop towards commercial scale, the harsh realities of feedstock logistics become apparent, and expectations on feedstock prices rise steadily.

For a number of reasons the biofuels industry is leading the transition into cellulosic biomass, with cellulosic ethanol being the leading fuel. Commercialization of cellulosic ethanol has faced many setbacks over the years, with numerous companies falling due to technological inefficiencies and financial stress. When the U.S. Environmental Protection Agency (EPA) expected first commercial volumes of cellulosic biofuels in 2010, it had high hopes for producers to meet the Renewable Fuels Standard (RFS) mandated volumes. However, the lack of commercialization forced the EPA to revise the RFS every year since 2010, dropping cellulosic biofuel mandate volumes far below the original plan. In 2012, it went as far as removing cellulosic biofuel mandate volumes for the year, and returned in 2013 and 2014 at 14 million gallons and 17 million gallons, respectively. As dozens of hopeful cellulosic ethanol companies ramp to commercialization, recent updates by POET-DSM, Abengoa, and DuPont Danisco have the turned the industry's eager eye to their facilities.

Waste: the final feedstock frontier?

Though methane has stolen the spotlight recently, waste feedstocks can be a very promising feedstock to make fuels and chemicals. No individual cellulosic feedstock matches the global availability and ubiquity of municipal solid waste (MSW). Globally, nearly 1.2 billion MT of municipal solid waste are produced, and – depending on the region – is commonly incinerated or landfilled. But a growing crop of companies can gasify or pyrolyze the waste into valuable products. All are working through technical and supply chain kinks, but the economics of waste can disrupt today's biofuel and biochemical markets. As waste and cellulosic producers ramp up new facilities today, the feedstock picture is far from finished, and all industry stakeholders should focus on supply chain logistics and replacement cost, as well as the performance of the various routes to convert these feedstocks.