ROCKET SCIENCE

AIRPLANES WILL FLY ON WEEDS AND WASTE SOONER THAN YOU THINK

GEOFF MURRAY • ERIC NELSEN

"When, not if"

Developing these fuels is a question of "when, not if"

Will the aviation industry soon feel the winds of change when it comes to fuel? Ground transportation is transitioning to lower-emission fuels such as natural gas and electricity. But nearly all airplanes still run on petroleum-based jet fuel, due to a lack of commercial options. Many hands are at work on this pressing issue: Airlines, original equipment manufacturers, fuel suppliers, airports, government agencies, and researchers are coming together in working groups and coalitions with exotic monikers like SAFUG, CAAFI, MASBI, and SAFN to develop options that may finally enable the industry to move beyond its current predicament.

Airlines know that alternative fuels are essential for the industry's long-term viability. Presently, they are at the mercy of rising and volatile petroleum prices, spending as much as 40 percent of their annual budget on fuel. In addition, the industry will need to ramp up reductions of greenhouse gas emissions and pollution in response to regulatory pressures, given that the European Union has added domestic aviation to its Emissions Trading Scheme and the United Nation's International Civil Aviation Organization (ICAO) has set a goal of carbon-neutral growth for international aviation from 2020 on. Importantly, without alternative fuels, both fuel budget and emissions will continue to rise, given that aviation transport demand is projected to double in the next 20 years.

DISRUPTIVE TECHNOLOGIES

Increased focus and higher levels of government and private investment in fuel research and development in recent years are bearing some fruit: Two technologies have been approved to produce fuels that can be blended with petroleum for flight, known as hydroprocessed esters and fatty acids (HEFA) and Fischer-Tropsch technology. Some 1,500 commercial flights have been flown using such blended fuels, and airlines such as KLM, United, and Alaska Airlines have made multi-year commitments to buy biomass-based fuels.

We doubt the industry will switch to one, break-through alternative. Instead, after careful review of fuels in development, and based on our work with airlines, original equipment manufacturers, and suppliers, Oliver Wyman expects several alternative fuels could prove to be feasible in the next few decades. (See Exhibit 1.)

In the short term, HEFA and the Fischer-Tropsch processes that convert animal fats and biomass into fuel have potential as they are the only two fuels which are ASTM International-certified for use in flight. While both technologies face significant economic hurdles, large subsidies in developed markets are likely to remain in place for as long as five years, which will allow these processes to be economical. In addition, both are already currently producing small (but larger than pilot) levels of fuel for discrete offtake agreements.

EXHIBIT 1: POTENTIAL ALTERNATIVE FUELS FOR AVIATION

SHORT-TERM

HEFA PROCESS
(conversion of natural oils and animal fats into hydroprocessed esters and fatty acids)

Used at commercial scale at several biorefineries, but facilities tend to favor biodiesel production for subsidized ground transportation markets; jet fuels produced more opportunistically

Current issues include feedstock cost and availability, need to reduce conversion/refining costs

FISCHER-TROPSCH PROCESS
(synthetic fuel from biomass or fossil fuels)

Used at commercial scale, with coal and natural gas as feedstocks

Has not yet been proven at commercial scale using biomass as a feedstock

MEDIUM-TERM

ALCOHOL-TO-JET
(jet fuel from alcohols such as ethanol)

Feedstocks include corn, sugarcane, wood chips, and agricultural waste

First-generation feedstock supply chain is mature. Additional R&D needed to bring to economic viability; also may require sustainability-certified feedstocks in the future

CRYOGENIC FUELS
(such as liquefied natural gas)

Could cut aviation CO_2 emissions by about 15 percent and reduce nitrogen oxide pollution by 40 percent

Would require new engines and substantial infrastructure upgrades at airports

LONG-TERM

ELECTRICITY

Lower-cost option; could significantly reduce CO_2 and pollution from planes, depending on the fuel used to generate electricity

Would require development of electric propulsion systems, sufficiently powerful batteries, airport recharging systems

Source: Oliver Wyman

While fuels produced from both HEFA and Fischer-Tropsch processes currently have a competitive advantage due to technology maturity and established government subsides, however, both face scaling hurdles. Key challenges for converting oils and fats are feedstock cost and availability, in large part due to land competition with food crops, and competition between jet biofuel and other oil uses (such as in feed for cattle production). Research is ongoing on more sustainable feed stocks, such as those that could use brownfields or waste land, as well as algae as a feedstock. But economical scalability is a long way off. A sustainable Fischer-Tropsch process can use plant waste, but faces challenging economics due to high capital costs and large project sizes required to generate economies of scale.

In the medium term, we believe alcohol to jet technologies could have potential, due to the low cost and high availability of feed stocks. Alcohol-to-jet could use sustainable energy crops such as miscanthus and switch grass, low-cost agricultural and forest waste, and municipal solid waste. Cellulosic feed stocks such as forest waste prices are not correlated to food prices since they are not tied to existing farm land. In addition, the aggregate volume of feedstock is much larger and presents a greater opportunity to create meaningful quantities of fuel. Alcohol-to-jet produced fuel is expected to be certified for use in aircraft by ASTM

40 percent

The percentage of annual budgets that airlines spend on fuel

in 2014, according to the International Air Transport Association. Traditionally, however, alcohol (in the form of ethanol) has been more valuable to blend into gasoline than to convert to jet fuel. The use of cellulosic waste for alcohol-to-jet fuel also faces technology and economic hurdles that will need to be solved.

Longer-term, technologies such as alcohol-to-jet and pyrolysis may also provide impactful quantities of economically priced fuel. "Third generation" algal fuel and electricity could be viable future options as well.

Other possible fuel technologies could yet emerge from the depths of research and development labs. But based on what is known today, those listed above are likely to be the most viable options.

REACHING COMMERCIALIZATION

To reach commercialization, all require continuing research, investment, and a consistent, supportive policy environment. (See sidebar, Understanding Biorefinery Investment Risks on the following page.) Critically, feedstocks must be identified that are themselves sustainable, to reduce greenhouse gas emissions across the lifecycle of facilities and equipment. The industry will need new planes and engines to accommodate some alternative fuels, as well as changes to fueling infrastructure. Developing these fuels, however, is a question of "when, not if" to ensure the long-term health of the aviation industry.

GEOFF MURRAY
is a Chicago-based partner in Oliver Wyman's Aviation practice

ERIC NELSEN
is a Chicago-based partner in Oliver Wyman's Energy practice

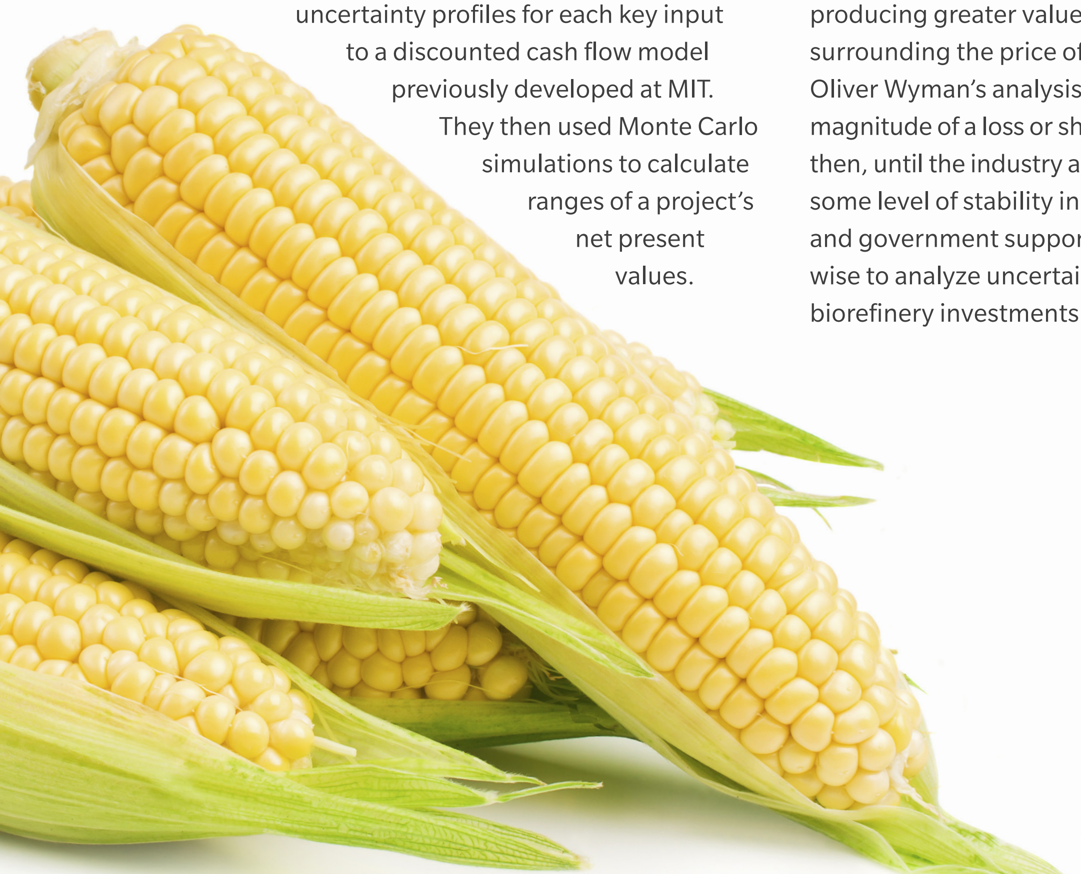
UNDERSTANDING BIOREFINERY INVESTMENT RISKS

ERIC NELSEN • DAMIAN BLAZY • MATTHEW PEARLSON • BRUNO MILLER

A corollary issue to which renewable fuels will likely be adopted by the airline industry – and indeed may be a driver of that adoption – is what fuels are likely to achieve competitiveness at commercial scale. Oliver Wyman, in conjunction with researchers at the Massachusetts Institute of Technology and Metron Aviation (a leader in air traffic management systems research), has been working to assess renewable fuel refineries from just such an investment perspective.

Recently, this team developed a methodology to value hydro-processing refineries producing aviation-grade biofuel and renewable diesel, which could aid prospective investors in determining under what market conditions a profitable refinery could be constructed. Most critically, this methodology includes an analysis of fuel price uncertainty and uncertainty around government mandates and support, using the United States Biodiesel Blender Tax Credit and Renewable Identification Numbers (RINs) as examples of the latter.

To "build in" uncertainty, the team constructed uncertainty profiles for each key input to a discounted cash flow model previously developed at MIT. They then used Monte Carlo simulations to calculate ranges of a project's net present values.



Scenarios were constructed around a potential facility's size, price correlation, and working cost of capital.

The analysis determined that a medium-sized refinery (producing 4000 barrels per day with a cost of capital of 16 percent and medium price correlation between commodity inputs) operating today would require government subsidies for a minimum of ten years to achieve an economic return (that is, for three years of construction and six years of operation). Otherwise, the risk of the refinery losing money over its 20-year lifespan would be large enough to make financing prohibitively expensive.

Indeed, after performing 20 million years of simulations, the team found that the likelihood of any discrete year showing positive value generation was less than 15 percent, indicating that some sort of financial externality would be required for the lifespan of the refinery – or it would close as soon as subsidies expire.

While larger facilities offer a greater likelihood of producing greater value, given the uncertainty surrounding the price of inputs and products, Oliver Wyman's analysis showed that the risk and magnitude of a loss or shortfall also increases. Clearly then, until the industry achieves critical mass and some level of stability in terms of supply, demand, and government support, investors would be wise to analyze uncertainty when considering biorefinery investments.

ERIC NELSEN
is a Chicago-based partner in Oliver Wyman's Energy practice

DAMIAN BLAZY
formerly with Oliver Wyman, is a research affiliate with MIT

MATTHEW PEARLSON
is a research specialist at MIT

BRUNO MILLER
is a principal, energy and environment, at Metron Aviation