



## Developments in Green Technology

by Jane Bratun

### REPLACING FOSSIL-BASED FUELS WITH CLEANER ALTERNATIVES

Renewable chemical and advanced biofuel company, **Gevo Inc.** [GEVO-NASDAQ], headquartered in Englewood, Colorado, is developing a product portfolio that replaces fossil-based fuels and harmful chemicals with low-carbon, cleaner alternatives. The Gevo process captures carbon dioxide from the atmosphere and converts carbohydrates to low-carbon chemicals and fuels. As noted by Patrick Gruber, Gevo's CEO, their processes generates inexpensive ingredients for food products and animal feed, as well as natural ingredients for consumer products, while promoting healthy soil. Also in the portfolio are cleaner jet fuel, gasoline, and ethanol-free fuel, replacing non-sustainable carbon-based chemicals and fuels with renewable carbon alternatives.

Gevo makes its products using fermentation technology, adding carbohydrates, such as corn, into its products. The Gevo process captures large quantities of protein from that corn, or most other carbohydrates, for animal feed. To that end, the Gevo plant in Luverne, Minnesota produces about 100 million pounds of animal feed, and about 20 million gallons of ethanol per year, with a production capacity of 1.5 million gallons per year, plus 3 million pounds of vegetable oil. The Luverne plant produces more animal feed on a tonnage basis than it does alcohols. For every gallon of Gevo fuel produced, the company expects to generate up to 11 pounds of animal feed and protein, which enables lower-cost food source production.

The advantage of using fermentation technology to produce products that cross over into what has traditionally been the petro-chemical world is that fermentation technology takes the complex agricultural-based raw materials and makes a simple alcohol that serves as a raw material to make jet fuel, isooctane and other products, using standard chemical industry techniques. When choosing a carbohydrate feedstock, the company considers cost, carbon footprint, contribution to food and feed, and availability. More and varied types of carbohydrate feedstocks will become available as feedstock technologies mature.

Jet fuel production is another part of the Gevo product portfolio. According to the International Air Transport Association, jet fuel demand is expected to grow at about 3 billion gallons per year. The aviation industry is expected to double its passengers

by 2034 and account for 2% of greenhouse gas (GHG) emissions (about the same as all of Germany), but jet fuel GHG emissions are expected to grow to 3% by 2050.

Gevo used its low-carbon renewable jet fuel (Gevo ATJ) throughout O'Hare International Airport in Chicago on November 8, 2017, for Fly Green Day. Over 20 companies participated. This proof of concept demonstrated that normal airport infrastructure can use cleaner, better, renewable jet fuel, which contains no sulfur or aromatics. Other properties of this low-carbon jet fuel are a freeze point below -80 degrees Centigrade, a higher overall energy density, a higher combustion heat, a lower physical weight, and lower particulate emissions than regular jet fuel.

The airline industry has committed to holding greenhouse gas emissions flat from 2020 and beyond and has promised self regulation, intended to avoid the high cost of compliance if governments regulate them instead. To meet this goal, the industry must use low-carbon jet fuels in significant quantity. Gevo has developed one of the few low carbon alternative jet fuels for commercial use specified by the American Society for Testing and Materials.

Gevo also provides a method to eliminate petroleum carbon from gasoline, making renewable gasoline with the potential, depending on the price of oil and carbon value, to be a gasoline for automobiles. Gevo produces isooctane from its isobutanol. Isooctane is the major hydrocarbon component in gasoline. Gevo's technology enables substituting fossil-based isooctane with renewable, low-carbon isooctane.

Gevo's isobutanol is being used to develop the "ethanol-free" gasoline market, particularly in regions where oxygen is required in the gasoline. The market size for ethanol-free gasoline is estimated by the U.S. Energy Information Administration to be about 5 billion gallons per year, outside of reformulated gas (RFG) regions, which are required to sell gasoline containing an oxygenate. Up to this point, ethanol was the only gasoline oxygenate available. Gevo's isobutanol enables use of ethanol-free gasoline in RFG areas. When RFG regions are included in the market size estimation, the total ethanol-free market is expected to be about 7 billion gallons per year for use in boats, small engines, sports cars, luxury cars, and farm machinery. This isooctane is already being

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used by Formula 1 Racing Teams in the European Union. And, as costs come down, this fuel will be more widely available.

Gevo has developed renewable carbon-based para-xylene, a key ingredient in converting petro-based polyester for fibers and bottles to 100% renewable content. This development work, sponsored by **The Coca-Cola Company** [KO-NYSE], and **Toray Industries, Inc.** [TRYIY-OTC] has proven the technology works. The company states this market will matter in the future when low-carbon chemical products and materials are valued like low carbon fuel.

Gevo's raw materials suppliers, for example corn plant suppliers, use sustainable growing methods wherever possible, building soil quality and carbon levels. The process captures the protein produced by the plants and supplies it to the feed markets and eventually to the food markets. They separate carbohydrates from the protein and ferment it via specially designed yeast to make low-cost alcohols like ethanol, isobutanol and or higher alcohols. The alcohols can be sold directly for chemical or fuel use. Around the Luverne plant, soil carbon is increasing because farmers use sustainable farming practices. Carbon is building in the soil, while crops are growing. Healthy soil also enables renewable, sustainable, carbon raw materials.

## ORCA RESEARCH FACILITY RUNS ON SOLAR POWER

Located on the coast of British Columbia, the not-for-profit **OrcaLab** recently made history by becoming the first Canadian orca research facility to run primarily on solar power. The facility can now examine orcas with minimal species interference. The solar project was made possible through Bullfrog Power, headquartered in Toronto, Ontario and their community of green energy supporters. Bullfrog is a provider of power from renewable energy sources, such as wind, low-impact hydro, and green natural gas. This is a unique use of solar power. It is not a solar-powered home or small factory – it is a research laboratory that can directly benefit the endangered orca (killer whale) population in British Columbia.

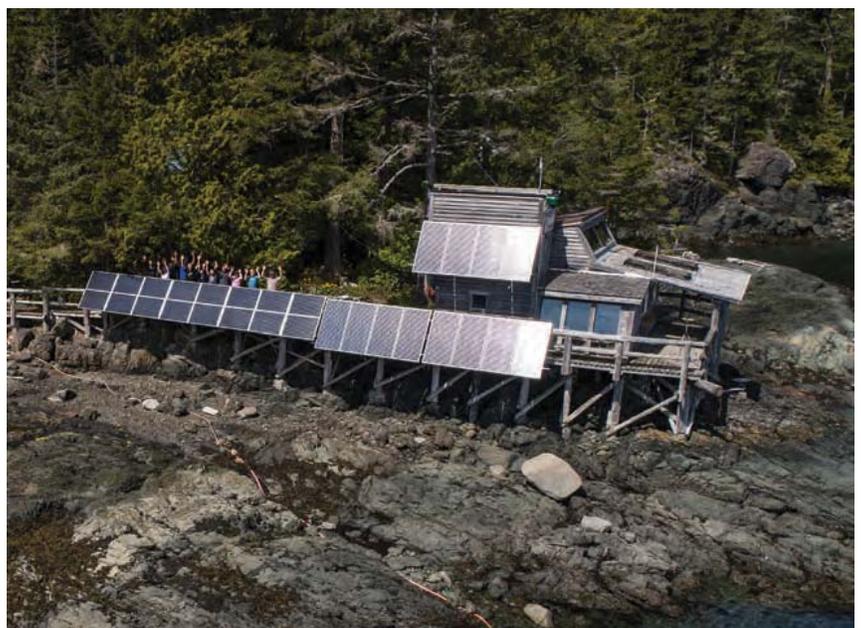
As noted on the OrcaLab website, orcas in North America are facing a decline in numbers and

are struggling to cope with the issues facing them. These issues include toxic contamination, noise and disturbances from boats and climate change (affecting the temperature and salinity of water, and ultimately limiting food supply). The southern pod has only 74 orcas left, according to the Center of Whale Research. This is particularly disturbing because the pod is not reproducing as it should.

In 1970, Dr. Paul Spong founded OrcaLab, a small land-based whale research station near the evergreen forest of Hanson Island in the waters of the Inside Passage of northern Vancouver Island. Supplementing the acoustic data are visual sightings of orcas as they pass OrcaLab, and reports from land observation sites during the summer, as well as reports from other researchers and whale watchers who share observations and information. Since 1994, OrcaLab has operated a video monitoring station on Cracroft Point in Johnstone Strait that allows the unobtrusive collection of both surface and underwater images of orcas and other ocean life.

A network of hydrophones, positioned around the orcas' "core habitat" helps the team monitor the orca's movements all year round. A network of remote video cameras streams live high-definition video from the orca habitat to the Internet, bringing live imagery as well as live sounds to a worldwide audience.

OrcaLab's energy needs began to change as they started developing the systems and capabilities to monitor the whales remotely. The goal is to get OrcaLab running on close to 100% renewable energy, using a mixture of solar panels and batteries. ■



The many solar panels powering the orca research laboratory, OrcaLab, on the coast of British Columbia, Canada. Photo courtesy OrCaLab.