USA

Top Trends & Techs

Jim Lane TheDigest November 2016

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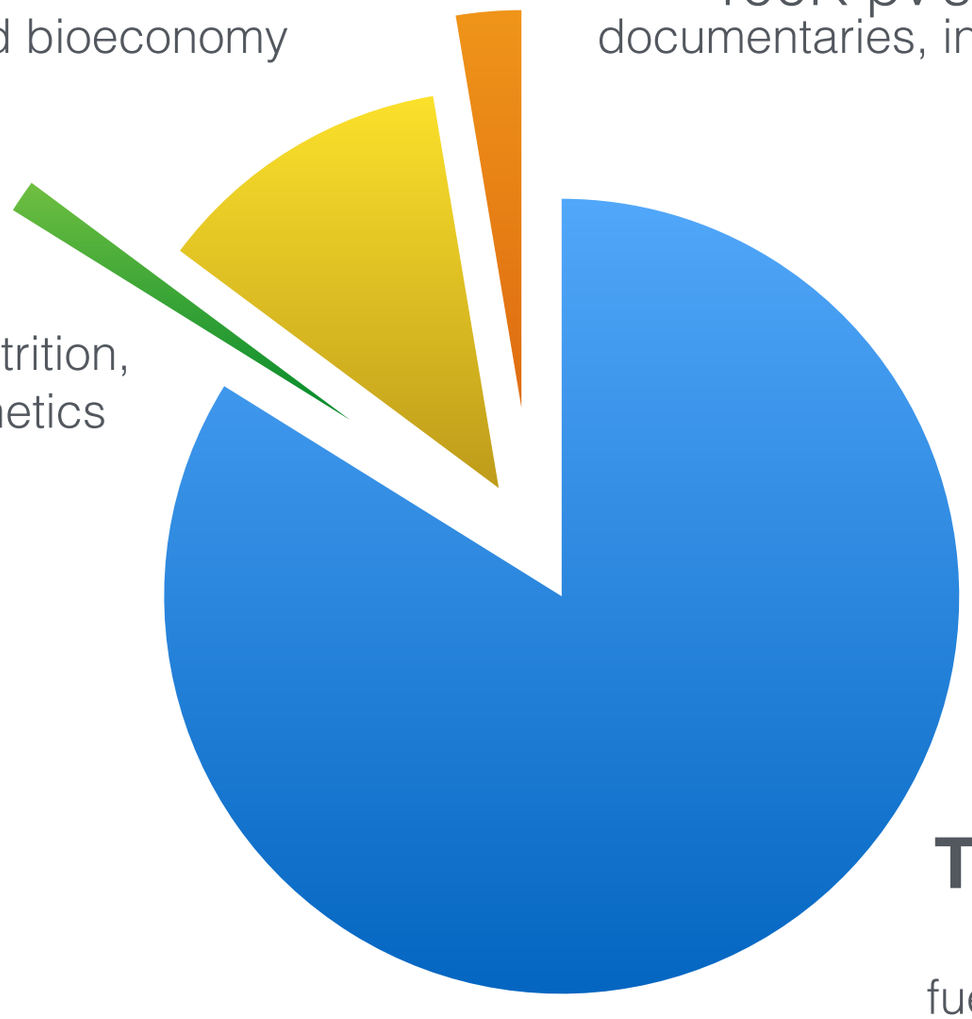

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10. Rise of Capital light technologies.

Here's a tech that exemplifies the flight to low-capex, especially in the cellulosic trade. It's **Edeniq.** Based on a 120 million gallon facility. net installation cost is $5.8M and an additional $1.15M in cost changes. Now, here are the economic gains.

Let's amortize the installation capex over 10 years. That gives us an annual cost of $1.695M and a net bottom line contribution of $10.21M. What's the change in the value of a public company with that kind of bump in earnings? The NASDAQ price/earnings ratio averages out to 25.75. And there's an implied added company value of $262M.

Because of economics like these, bolt-ons are the bomb. Corn oil extraction, cellulosic add-ons, tech to handle high free fatty acids for more biodiesel.

Pathway Economics

Impact on Annual Operating Margins for a 120 MGPY Plant

Revenue Changes		
Ethanol	$	10,400,000
DDGS (@ 10% Moisture)	$	(5,400,000)
Oil	$	1,500,000
Cellulosic RINs	$	3,900,000
Sub Total Revenue	**$**	**10,400,000**

Cost Changes		
Corn	$	-
Electricity & Natural Gas	$	-
Other Costs (Enzyme & Maintenance)	$	2,300,000
SubTotal Cost	**$**	**2,300,000**
Net Benefit	$	8,100,000

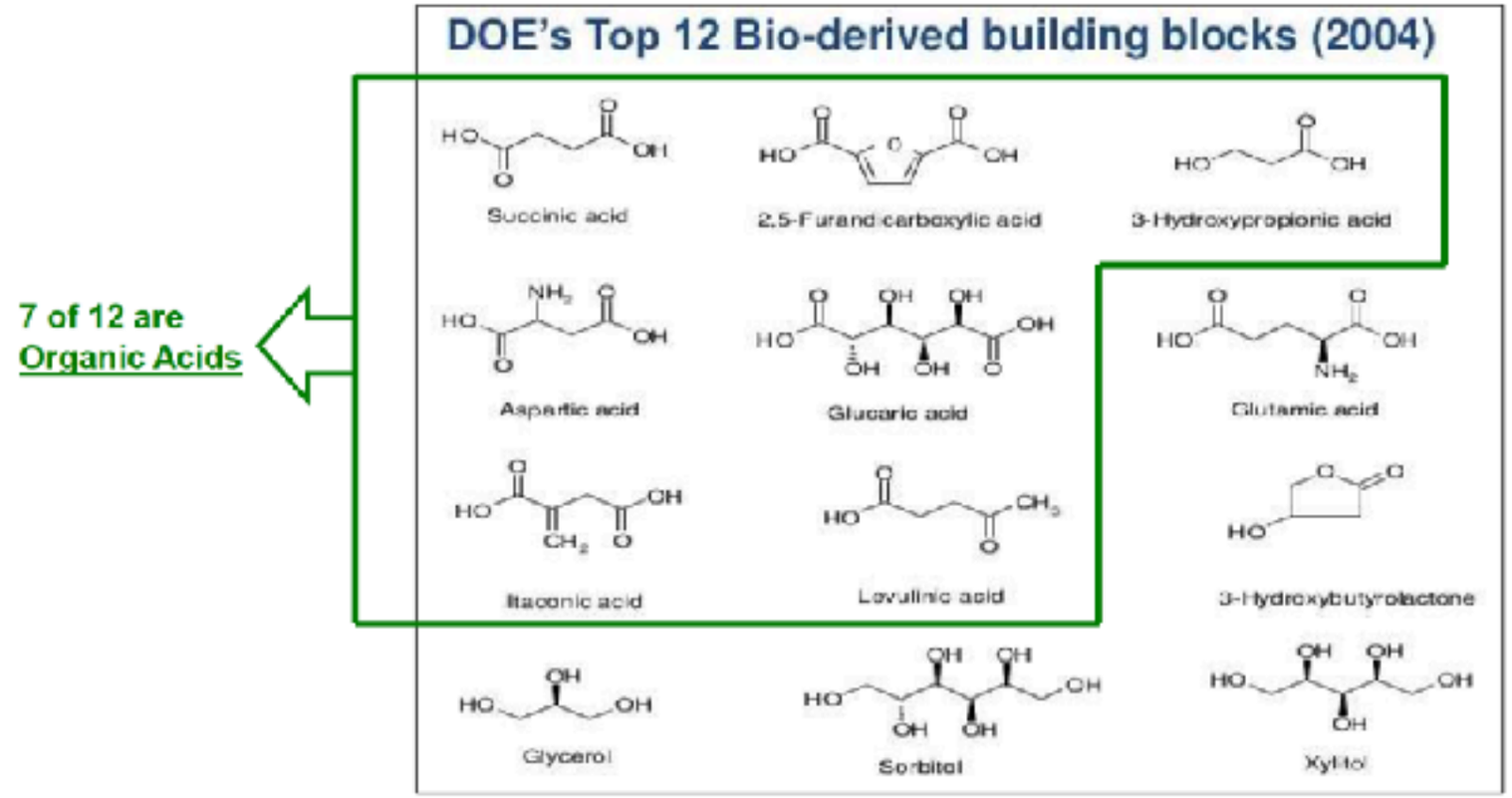
CapEx	**$**	**5,800,000**
Payback Period		**< 9 months**

Edeniq

9. Biotech hotties shift to organic acids

• Wide range of chemical compounds, myriad applications
• Produced from a multitude of fossil and renewable feedstock
- A sweet spot for industrial biotechnology resources
- Organic Acids at the Forefront of Displacing Petrochemicals:

1. Succinic Acid
2. Glucaric and Adipic Acids
3. Malonic Acid
4. FDCA
5. 5-KGA and Derivatives

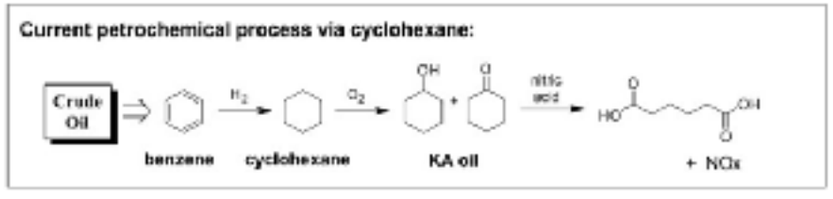


8. Synbio aims for big molecules in one step

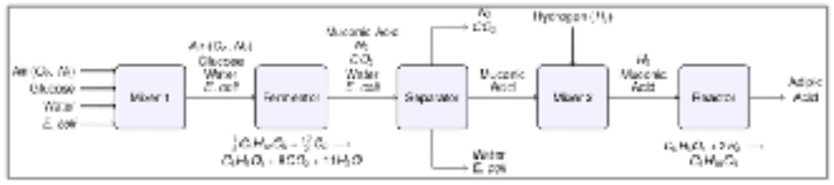
Organic Acids – Bio Advantaged Chemicals (2)

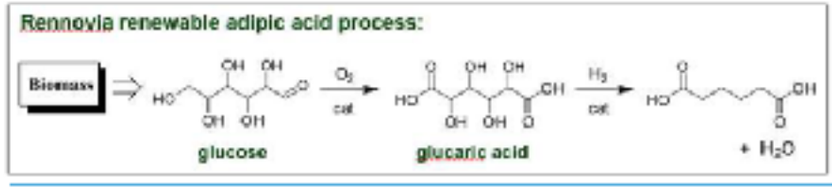
aka … simpler (= less process steps) from Renewable Resources than Fossil Fuels

Example: Production of Adipic Acid from Fossil Fuels vs. Renewable Resources



Route from Petrochemical Feedstock:
Disadvantaged





Route from Renewable Resources:
Advantaged!!

7. Rise of gas capture and conversion.

Methane, CO2, carbon monoxide, syngas

We mentioned natural gas as a feedstock, as with Calysta and Intrexon. But there's syngas, and it's hot. **Red Rock, Fulcrum** and **LanzaTech** see gas as the right way to unlock low-price carbon and make high-value jet fuel, chemicals, diesel and more. In part, because companies have revolutionized the back end, through fermentation advances, vastly improved microbes, and also through scaling down technologies like Fischer-Tropsch process as is the case with Velocys microchannel technology.

Intrexon's GTL pilot scale project in San Francisco.

6. Algae shifts to “anything but fuels”

For most people, ABFA has meant the Advanced Biofuels Association. Still does. But these days, it stands for Anything But Fuels, Almost. **Sapphire Energy** has refocused on omega-3s, and Heliae too. Qualitas continues in the omega-3 business with its Almega PL product line. In cyanobacteria, Meanwhile, Cellana keeps on with fuels, but in a product mix that includes nutraceuticals and protein too. **Algenol** has retreated to stealth mode. Joule Unlimited merged with **Red Rock Biofuels** and is focusing on the RRBs’ thermocatalytic tech. Elsewhere **Cellana** is working hard on a blend of fuels, nutraceuticals and fishmeal. **Aquafauna** and **Higashimaru** are targeting fishmeal. And **Earthrise** continues to be a star player in spirulina. Another product that has star power is astaxanthin. Producers include **Cyanotech**, **BGG**, **Alphy Biotech** and **Alga Technologies**. **Hy-Tek Bio** has been developing technology using “a unique strain of algae (HTB-1) – isolated from thousands of strains – to absorb up to 100 percent of the GHG emissions from flue gases. **Clearas** has been active in water treatment. Solazyme became **TerraVia**, and focused on advanced nutrition. **Fermentalg**’s hopes today ride to on DHA, and DHA+ omega-3s. .DHA, an essential fatty acid of the omega-3 family, is known for its role in the prevention of numerous illnesses.

Cellana’s demonstration algae farm in Kona, Hawaii.

5. Rise of renewable diesel and biodiesel.

Recently, in partnership with California's leading low-carbon fuel brand Propel Fuels, the City of Carlsbad is now fueling with the nation's cleanest and most advanced renewable diesel: Propel Diesel HPR (High Performance Renewable). We reported last November that consumer adoption of the Propel's HPR fuel has risen 300 percent compared to its former biodiesel product (B20).

And, **Tesoro** has unveiled its plan to foster the development of biocrude made from renewable biomass, which can be co-processed in its existing refineries, along with traditional crude oil. And the company has identified three new partners in the process: **Fulcrum BioEnergy, Inc.:** Fulcrum plans to supply biocrude produced from municipal solid waste to Tesoro to process as a feedstock at its Martinez, California Refinery. **Virent, Inc.:** Tesoro and Virent are working to establish a strategic relationship to support scale-up and commercialization of Virent's BioForming technology. **Ensyn Corporation:** Ensyn has applied for a pathway with the California Air Resources Board to co-process its biocrude, produced from tree residue – called Renewable Fuel Oil – in Tesoro's California refineries.

You might ask, why, and why now? Converting renewable biomass into biocrude is expected to enable existing refining assets to produce less carbon-intensive fuels at a significantly lower capital and operating cost. This approach could lower Tesoro's compliance costs with the federal renewable fuel standard and California's Low Carbon Fuel Standard by generating credits.

4. Strategics shifting to direct investment.

UPM, Cathay Pacific, Air BP, United Airlines, the US Navy, DuPont, POET-DSM, Raizen, Beta Renewables, Waste Management and **Canfor** — what unites these companies among strategics?

They are deploying technologies off the balance sheet to overcome the “no one invests in a first commercial plant” syndrome. Despite the availability of loan guarantees, it’s been tough sledding for technologies that lack a major strategic to provide the bulk of the equity.

Fulcrum, Red Rock, POET’s next-gen tech, **logen,** and **Licella** have been among the direct beneficiaries.

DuPont’s cellulosic ethanol project in Nevada, Iowa during its construction.

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3. First-gen growth slow; shift to new products, exports, M&A

More and more companies are targeting the California market. It's huge — and more importantly, there's the California Low Carbon Fuel Standard. As Michele Rubino pointed out in a March Madness webinar, California represents the Most Valuable Ethanol, with up to $4.06 per gallon in value as of March 2016.

And, then, what about the RFS slowdown?

In the past 3 years, the EPA has put a significant brake on the growth of the US biofuels market. Volume was expected by Congress in drafting RFS to increase by 7 billion gallons. Instead, the overall fuel volumes are mandated to increase by 2.54 billion gallons, reaching 18.8 billion gallons by 2017 instead of the once-expected 25 billion gallons. And much of that actual 2014-2017 increase comes as the gasoline pool itself expends owing to collapsed fuel prices.

Impact? With corn ethanol capped at 15 billion gallons and biomass-based diesel at 2 billion gallons (and 3-3.4 billion ethanol-equivalent gallons, owing to higher energy densities), there's not much room right now for cellulosic fuels, is there?

Bottom line, EPA says it will not aggressively increase ethanol volumes without a solution for the E10 ethanol saturation point, and sees the E15 and E85 voluntary markets growing very slowly.

2. Collapse of oil prices.

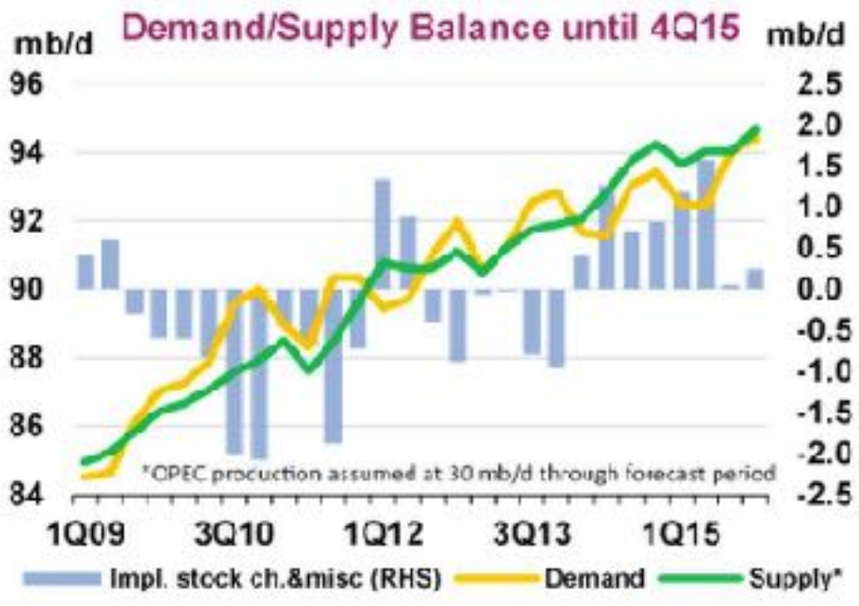
Uh, oil prices are down. Just saying.

Back in 2008-13, many assumed that high oil prices would shift attention towards renewable fuels. In fact, it shifted oil companies towards natural gas (for arbitrage opportunities), toward tight oil (for new production sources), shifted consumers towards fuel-efficient hybrids and electric cars. Even among investors in renewables, interest soared for high-margin chemicals rather than fuels.

Conversely, many assume that low oil prices will kill off advanced renewable fuels. In fact, it's shifted some refiners to use a time of strong margins to look for reliable opportunities in biocrude. It's killed off a lot of investment in tight oil extraction and choked off the natural gas boom. Renewable chemicals have strong opportunities, but more selectively than before. And electric cars are very hard pressed to compete on the economics of diesel.

These days differ from the oil price collapse of the 1980s and 1990s in one important aspect. Policies like the Renewable Fuel Standard and the Low Carbon Fuel Standard arrived. If they offered little effective support in the case of high oil prices, perhaps that can be understood in the context of legislators' desire to diversify beyond petroleum, not pick a winner in renewable fuel. But had there not been an RFS or an LCFS, the floor price for renewables would have collapsed along with every other fuel — and we would have been back to dependency on the single source, petroleum, from the lowest-cost providers — not always friendly regimes, and definitely offshore.

The old OPEC playbook of collapsing oil prices to kill off the competition, and raise them again when the monopoly is re-established? It's struggling worldwide. But also, for once, struggling in the US. lawmakers may well have learned a lesson, and got it right. And here we are with the US Navy enjoying $2.05 per gallon renewable fuel — 33% less than they paid for fossil fuels just over 2 years ago.



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1.

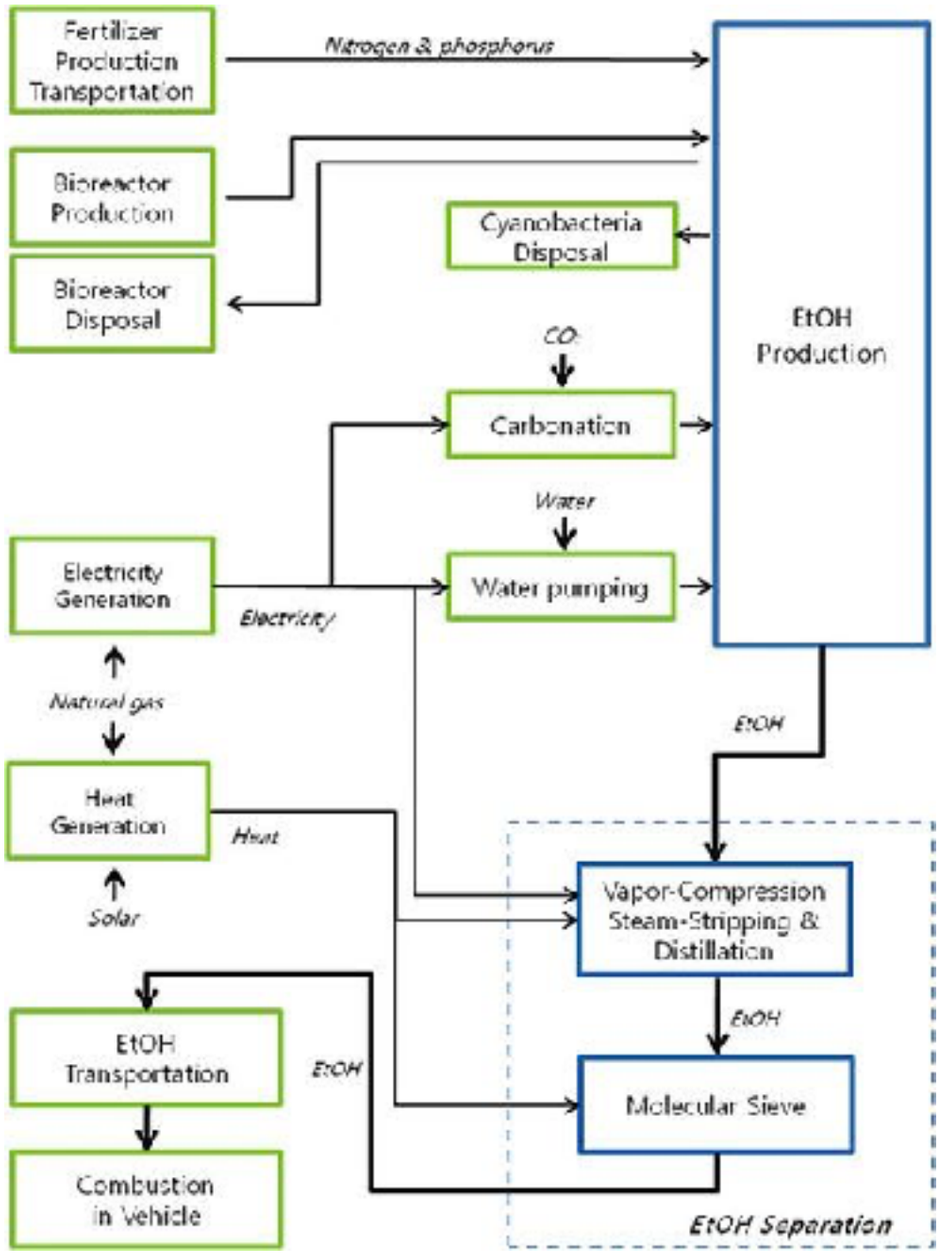
Swinging back to energy security.

Algenol

The Algenol Biofuel Process

Algenol in Fort Myers, Florida, is being recognized for developing a blue-green algae to produce ethanol and other fuels. The algae uses CO_2 from air or industrial emitters with sunlight and saltwater to create fuel while dramatically reducing the carbon footprint, costs and water usage, with no reliance on food crops as feedstocks. This is a win-win for the company, the public, and the environment. It has the potential to revolutionize this industry and reduce the carbon footprint of fuel production.

Algenol's hybrid algae are grown in saltwater in proprietary photobioreactors (PBRs) which minimize heterotrophic contamination and reduce water use. Photosaturation is a common limiting feature in aquatic photosynthesis and occurs when the rate of photon absorption exceeds the rate that the algae can use the energy for product formation (i.e., carbon fixation), such that the energy of the excess photons is wasted through non-photosynthetic processes. Algenol's vertical PBR system offers a productivity advantage over horizontal systems by delivering a more dilute irradiance over a greater surface area of the PBR, thereby limiting photosaturation.



Dimensional Energy

A Cornell team competes for the Carbon XPRIZE

Dimensional Energy converts CO2 into fuels, such as Methanol, through a novel nano-engineered catalyst and photocatalytic process. The Ithaca, NY-based group is combining technologies from two Cornell University labs, and is comprised of an interdisciplinary group of researchers and experienced entrepreneurs formed in the NEXUS NY Clean Energy Accelerator.

As NEXUS-NY explains:

The first technology is a high-density photobioreactor that optimizes light and CO2 delivery for efficient generation of algae. Developed by David Erickson, Associate Professor in the Sibley School of Mechanical and Aerospace Engineering at Cornell University, the technology delivers sunlight efficiently through low-cost, plastic, waveguides. This process increases efficiency and decreases water and energy use as compared to conventional algae reactors.

The second technology is a hybrid organic/inorganic nanofluid. Invented by Tobais Hanrath, Associate Professor of Chemical and Biomolecular Engineering at Cornell University, the technology has combined capabilities of CO2 capture and photocatalytic CO2 conversion.

“Right now we’re working together on a combined approach and testing with as much rigor as possible before we explore separate approaches for the university research,” explained Jason Salfi, NEXUS-NY EIR. “Everything we’re doing now can be applied to the technologies separately.. We’ve managed to take two unique technologies with separate applications and combine them together in a way that might actually have scalable promise”

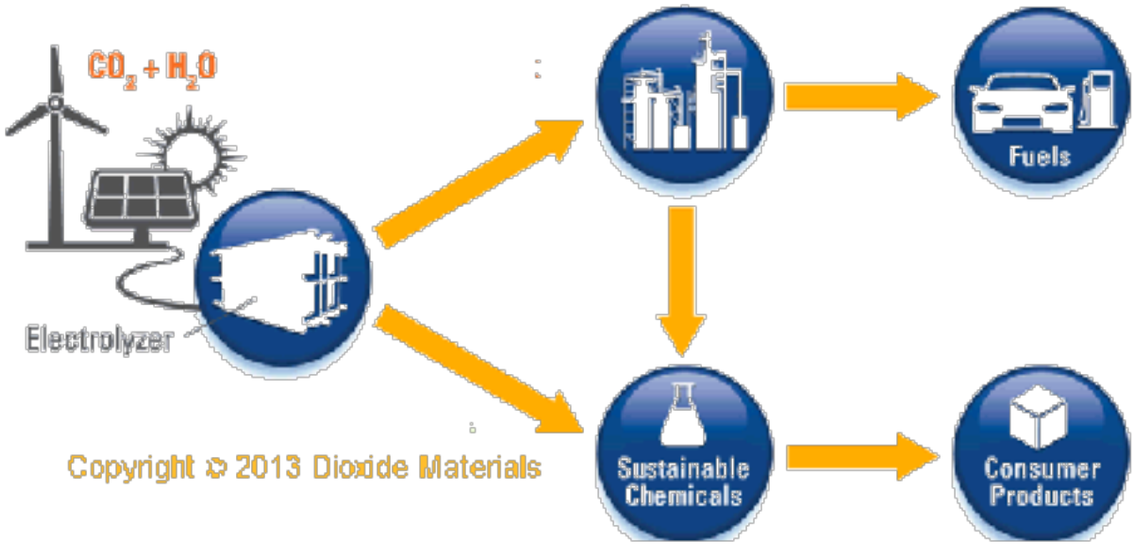
Dioxide Materials

Electrolyzer converts CO_2 into C_1 building blocks.

Dioxide Materials Inc. is a three year old startup based in Champaign IL that is developing products for CO2 sensing and CO2 utilization based on a patent pending catalyst that allows CO2 conversion to occur at record selectivity and energy efficiency (>97% selectivity and >80% overall energy efficiency).

Dioxide Materials is currently developing inexpensive carbon dioxide sensors that make heating, ventilation and air conditioning (HVAC) systems more efficient and cut electricity costs by automatically adjusting the thermostat and building ventilation based on occupancy. It is also developing methods to convert CO2 into high value chemicals
Dioxide Materials' long-term vision is to create a new chemical value chain using carbon dioxide feedstock and renewable energy (instead of oil and gas) to obtain high value fuels and chemicals.

Dioxide Materials' process uses an electrolyzer to convert CO2 into C1 building blocks. Subsequent chemical processes convert the C1 building blocks into high value fuels and chemicals. Dioxide Materials' patent pending catalysts lower the cost of converting carbon dioxide into C1 building blocks by a factor of 3. Dioxide materials also has patent pending processes to convert the C1 building blocks into high value chemicals, creating the first cost-competitive route to large volume, renewable fuels and chemicals.



Joule Unlimited

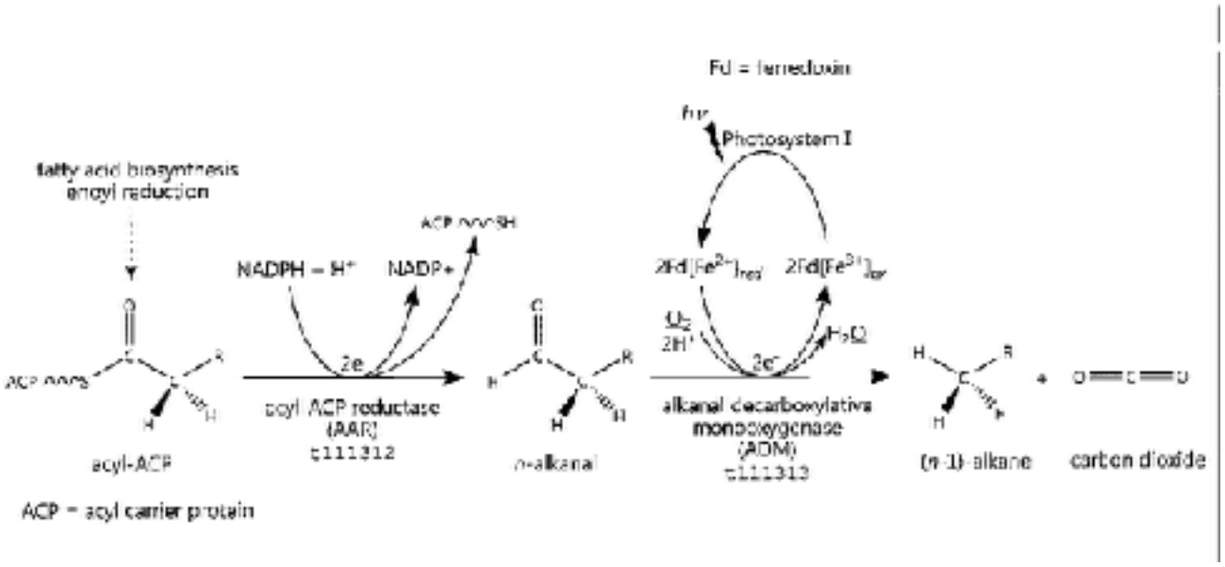
Fuel from thin air

For a number of years, readers all over the world have been following the fortunes of Joule Unlimited, in and out of stealth, and its goal of making hydrocarbons directly from CO2, sunlight and water — “fuel from thin air,” as we termed it several years ago.

The company has persevered as many have fallen by the wayside, and is now aimed at constructing a first commercial facility in 2017. Joule’s magic to some extent lies in the extravagantly low production costs, whereby Joule’s “solar fuels” (as they call them eschewing the term “biofuels”) could be competitive with $50 oil.

At right, that’s a Joule pathway. In this pathway, the secret sauce is ADM. No, not Archer Daniels Midland. Actually, it is alkane decaboxylative monooxygenase. Try saying that three times real fast. It’s an enzyme which, in the presence of CO2 and sunlight, converts an alkanal to an alkane. What’s an alkanal? You’d know it as a fragrance or flavoring, Vanilla is one.

By the way, we explained Joule’s magic, here.

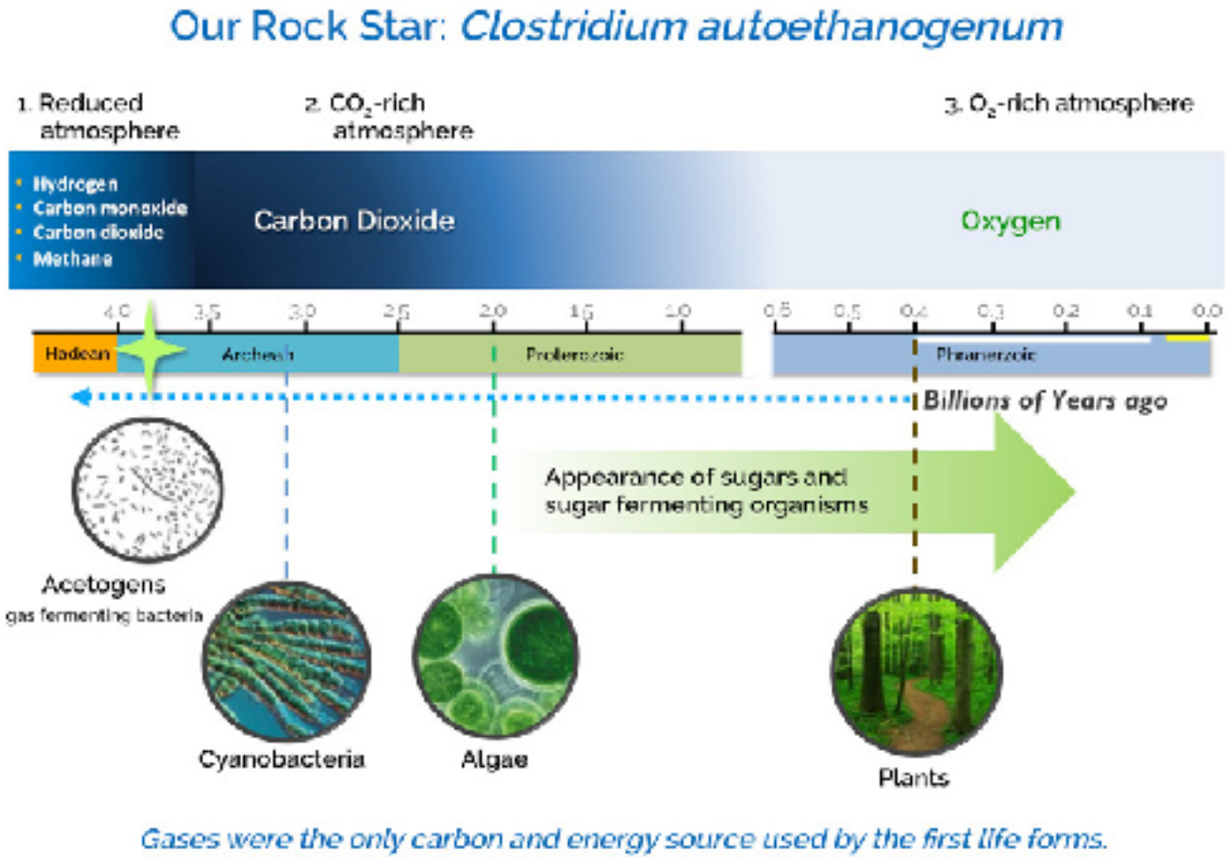


LanzaTech

Gas Fermentation Process

LanzaTech in Skokie, Illinois, is being recognized for the development of a process that uses waste gas to produce fuels and chemicals, reducing companies' carbon footprint. LanzaTech has partnered with Global Fortune 500 Companies and others to use this technology, including facilities that can each produce 100,000 gallons per year of ethanol, and a number of chemical ingredients for the manufacture of plastics. This technology is already a proven winner and has enormous potential for American industry.

LanzaTech developed a method to utilize gas streams with a range of CO and H_2 compositions to produce fuels such as ethanol and chemicals such as 2,3-butanediol at high selectivities and yields. While both CO/CO_2 and H_2 are utilized in the process, LanzaTech's proprietary microbes are also able to consume H_2-free CO-only gas streams, due to the operation of a highly efficient biological water-gas shift reaction occurring within the microbe. The process is facilitated by the enzyme-catalyzed chemistry of the Wood-Ljungdahl pathway whereby CO_2 and CO can be converted in a water-gas shift reaction catalyzed by carbon monoxide dehydrogenase (CODH). Through a series of intermediates, CO and CO_2 are ultimately fixed as acetyl-CoA by the CODH/ACS complex.



Newlight Technologies

AirCarbon: From CO2 to Plastics

Since scale-up in 2013, Newlight's sales volume has increased dramatically; today, Newlight is working with over 60 Fortune 500 companies across 9 major market segments to launch AirCarbon products. AirCarbon's value proposition is unique in the market: harnessing methane-based carbon emissions as a resource to displace oil and reduce the cost of plastics.

In March we reported that Newlight Technologies will supply IKEA with Newlight's AirCarbon and enable IKEA to produce AirCarbon thermoplastic under a technology license. Under the agreement, IKEA will purchase 50% of the material from Newlight's 23,000 tonne per year plant in the United States, and subsequently IKEA has exclusive rights

Newlight's technology aims to transform the economics of PHA-based plastics, since low yields and high production costs have kept PHA from competing strongly with petroleum-based plastics.
The AirCarbon production process begins with concentrated methane-based carbon emissions that would otherwise become a part of the air, rather than fossil fuels that would otherwise remain underground, including air-bound methane emissions generated from farms, water treatment plants, landfills, and energy facilities.

Last year, we reported that Newlight Technologies signed a 20-year take-or-pay off-take agreement with Vinmar International for 1 billion pounds of AirCarbon PHA — the first cost-competitive, carbon-negative plastic that will be available at scale.

Opus 12

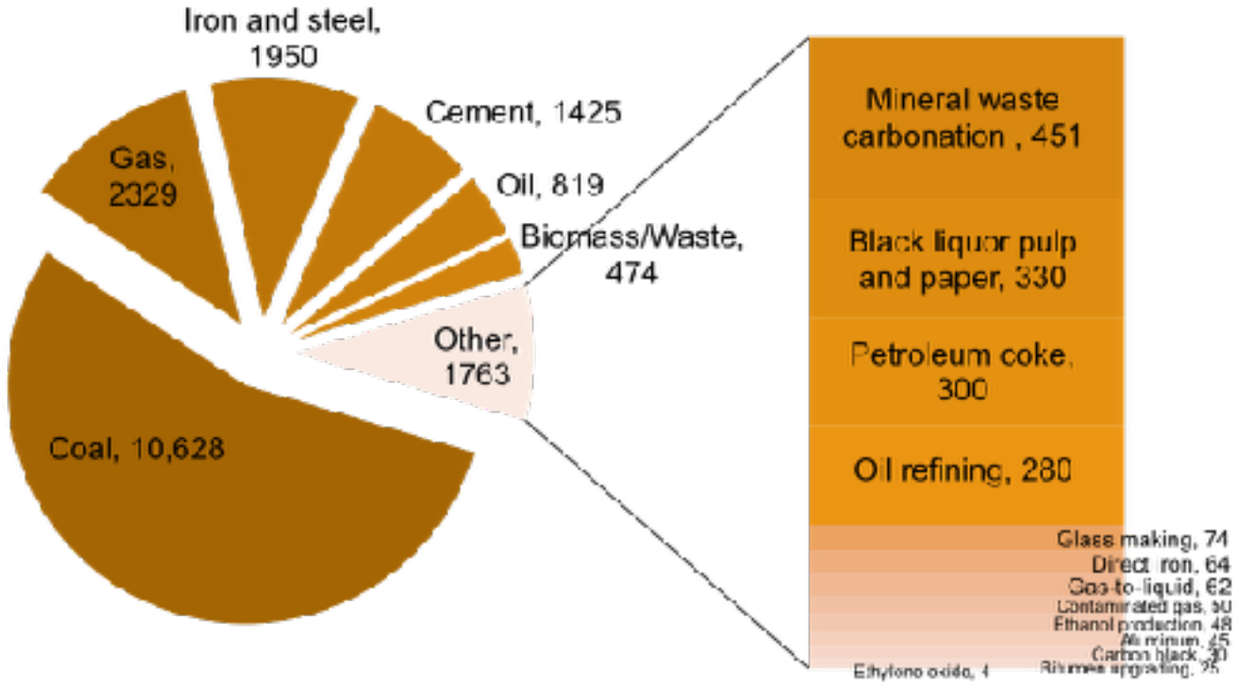
Reimagining Catalysts

Opus 12 utilizes a high-performance reactor as a platform technology capable of transforming CO2 – on the fly – into a wide range of products, depending on which catalyst is used. Many products, currently made from oil, could instead be made from recycled CO2 emissions and renewable electricity. The cleantech start-up is incubated in the Cyclotron Road program at Lawrence Berkeley National Lab.

Understanding of carbon dioxide conversion catalysis and reactor design has increased greatly in recent years. Product selectivity greater than 90% and energy efficiency above 50% have been demonstrated. However, these discoveries have yet to enable a commercial process due to difficulties integrating catalysts into a traditional electrolyzer reactor.

Key innovation: Opus 12 will incorporate cutting-edge catalysts into an electrochemical reactor with a novel gas diffusion layer in order to increase the concentration of carbon dioxide at the catalyst surface, which will lead to high reaction rates that are stable over time.

First market hypothesis: One of our initial targets will be CO production. The selective and energy efficient formation of CO is the first step towards liquid fuels production.



Cellana

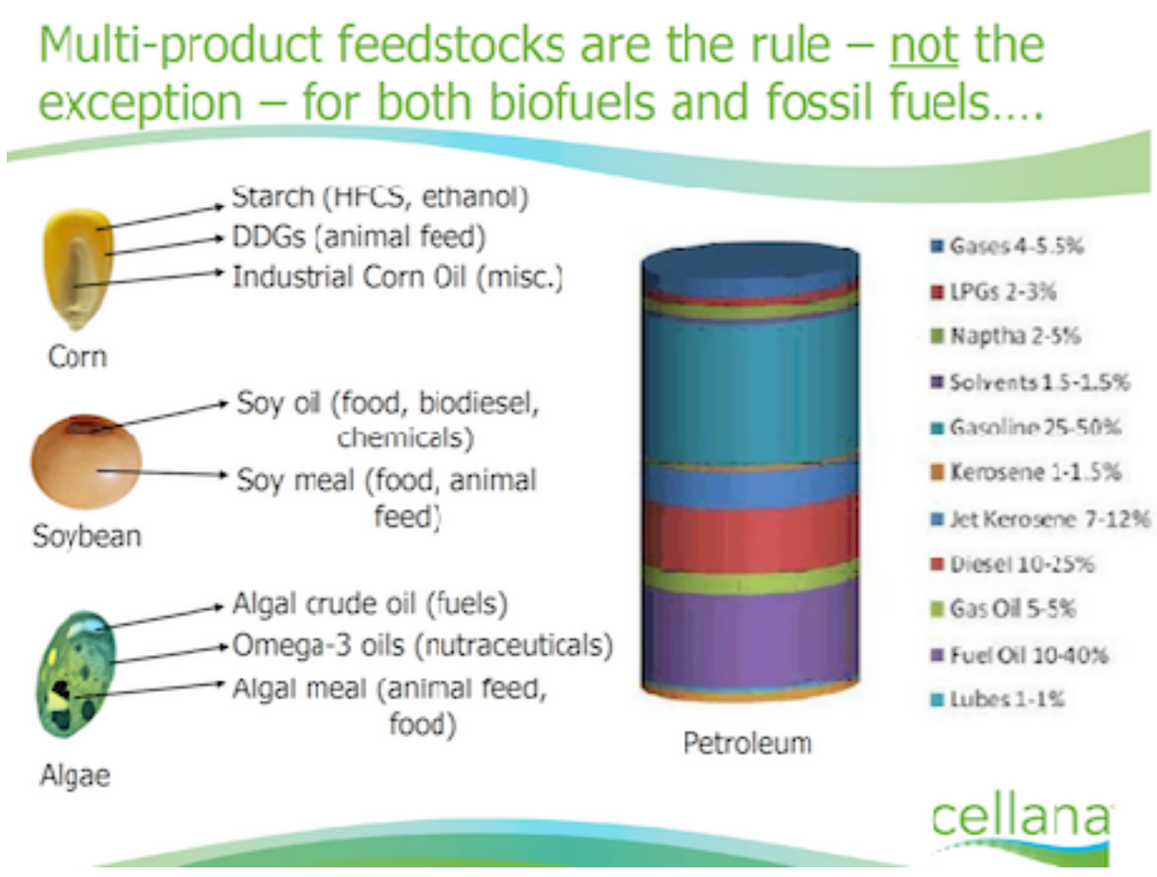
A multi-product strategy that cuts out the middlefish

Cellana, a leading developer of algae-based bioproducts, uses the most productive plants on earth — marine microalgae — to photosynthetically produce its ReNew line of Omega-3 EPA and DHA oils, animal feed/food, and biofuel feedstocks. Noting that people target fish oil not because fish make omega-3s, but because they aggregate them, they proclaim a goal of “cutting out the middlefish”.

Cellana’s ALDUO system enables economic, sustainable, and consistent production of photosynthetic, non-GMO algae at industrial scale. Cellana intends to construct and operate commercial facilities to produce these products as integrated algae-based biorefineries. To date, over $100 million has been invested in developing Cellana’s algae strains, production technologies, and its Kona Demonstration Facility.

In summer 2014, the US Department of Energy announced $3.5 million for a Cellana algae project aimed at accelerating the development of sustainable, affordable algal biofuels. Cellana was selected to develop a fully integrated, high-yield algae feedstock production system by integrating the most advanced strain improvement, cultivation, and processing technologies into their operations at their Kona Demonstration Facility.

Why significant? This is the first major grant award for algae to a multi-product biorefinery with Omega-3s as the high-value co-product. One observer noted, “DOE has come a long way in broadening their perspectives on how one can scale to achieve both commercial quantities of biofuels and profits simultaneously, rather than one at a time.”



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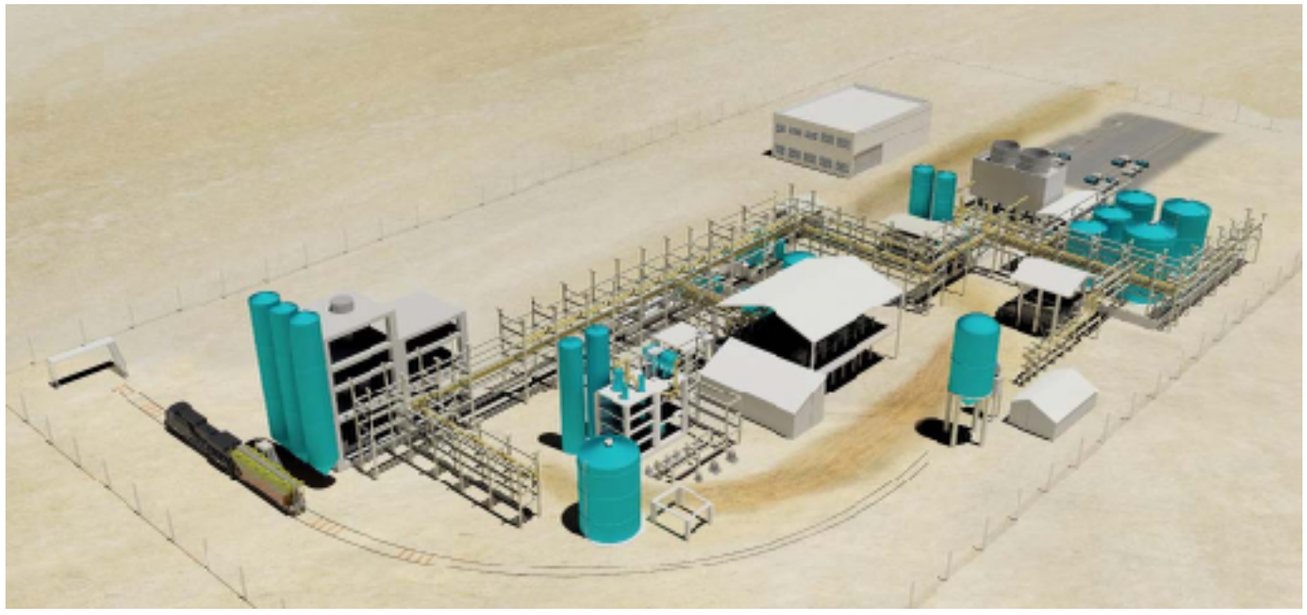
Skyonic

CO2 to baking soda and other solid products

Skyonic has developed patented technology solutions for the capture and utilization of carbon dioxide (CO2) in mineral form (carbonates) — making baking soda among other products, that make facilities built at industrial manufacturing and power plants profitable.



The first SkyMine facility opened October 2014 in San Antonio, Texas at Capitol Aggregates cement plant. The plant equipped with SkyMine technology will reduce its carbon emissions by 15 percent – 83,000 tons of CO2 annually.

The first SkyMine® facility opened October 2014 in San Antonio, Texas at Capitol Aggregates cement plant. The plant equipped with SkyMine® technology will reduce its carbon emissions by 15 percent – 83,000 tons of CO2 annually. Skyonic constructed, installed, and maintains the SkyMine equipment and systems at Capitol Aggregates. Capitol SkyMine is expected to generate approximately $48 million in revenue and $28 million in annual earnings – all from greenhouse gas emissions that previously would have been released into the atmosphere.

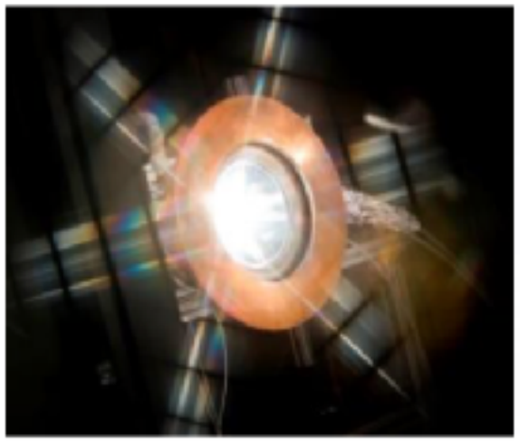
The introduction of this innovative technology could transform the carbon capture industry. Previously, captured carbon has been sequestered and injected into the ground. Now, using SkyMine technology, stationary emitters can convert greenhouse gasses into common industrial products.

Solar Jet

Air captured CO2 recycled for jets

It's an acronym, actually. It stands for "Solar chemical reactor demonstration and Optimization for Long-term Availability of Renewable JET fuel". And it's a partnership. The core team includes Bauhaus Luftfahrt, ETH Zürich, DLR-VT, Shell, and ARTTIC. Aviation industry advisors include IATA, Lufthansa, Airbus Group Innovations, and MTU Aero Engines.

Bottom line, Solar-Jet aims to ascertain the potential for producing kerosene from concentrated sunlight, CO2 captured from air, and water. Solar-Jet will optimize a two-step solar thermochemical cycle based on ceria redox reactions to produce synthesis gas (syngas) from CO2 and water, achieving higher solar-to-fuel energy conversion efficiency over current bio and solar fuel processes.



Reactor configuration for the two-step solar-driven thermochemical production of fuels? It consists of a cavity-receiver containing a porous monolithic ceria cylinder. Concentrated solar radiation enters through a windowed aperture and impinges on the ceria inner walls. Reacting gases flow radially across the porous ceria, while product gases exit the cavity through an axial outlet port. Red arrow indicates ceria reduction (oxygen evolution); blue arrow indicates oxidation (fuel production).

Bauhaus Luftfahrt Neue Wege. ETH Swiss Federal Institute of Technology Zurich DLR ARTTIC

Sunfire

Diesel from direct air CO2 capture

Sunfire's key technology is the Solid Oxide Power Core – a stack of high-temperature Solid Oxide Cells These convert chemical energy from a gaseous fuel into electricity and heat through a chemical reaction with an oxidizing agent (oxygen from air) in a continuous process. Unlike conventional fuel cells, which only run on hydrogen, Sunfire fuel cells can also be operated with different hydrocarbons, such as natural gas, bio gas, liquid petroleum gas (LPG) and several liquid hydrocarbon fuels (methanol, ethanol, diesel).

In a separate process, an electrolysis unit powered with green electricity splits water into hydrogen and oxygen. The hydrogen is then reacted with the carbon dioxide in two chemical processes conducted at 220 degrees Celsius and a pressure of 25 bar to produce an energetic liquid, made up of hydrocarbon compounds, which is called Blue Crude. This process is up to 70 percent efficient.

And not long ago, Audi and sunfire partnered with Climeworks on a pilot plant in Dresden that started production of the synthetic fuel Audi e diesel. It operates according to the power-to-liquid (PtL) principle and uses green power to produce a liquid fuel. As currently built, the pilot plant on the sunfire grounds in Dresden-Reick can produce approximately 160 liters of Blue Crude per day. Nearly 80 percent of that can be converted into synthetic diesel.

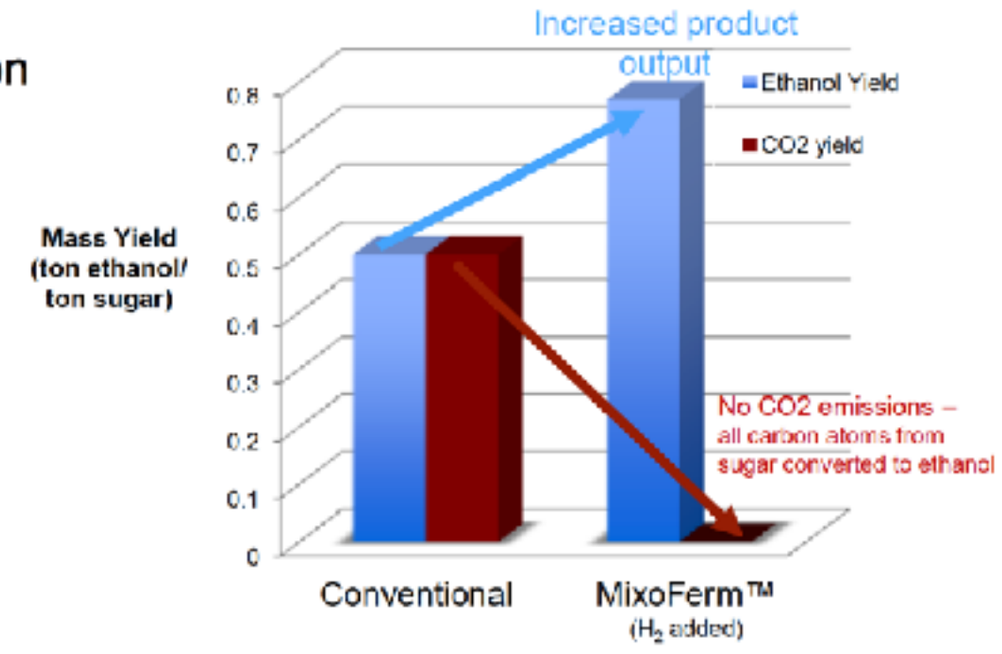
White Dog Labs

Using all that corn ethanol CO2 to boost yield 50%

White Dog Labs has developed a new process that eliminates the production of CO2, a potent greenhouse gas, during fermentation and instead shifts the carbon to added ethanol production, boosting fermentation yields by around 50 percent. The by-products are distillers grains, corn oil (if extracted from the grains) and water. The process can boost acetone production by 60%, all by its onesey, and half the CO2. Add supplementary hydrogen, and you get zero CO2 and a 50-60% percent boost in ethanol production and up to 120% increase if the process is optimized for acetone.

Through its acquisition of Elcriton, a biotech spin out from the University of Delaware, WDL researchers reported in the scientific literature that they have developed an organism that, contrary to common belief, is capable of consuming sugar and CO2 concurrently. So as opposed to yeast that consumes sugar and converts half of it to ethanol and emits the other half as CO2, this organism is capable of consuming the CO2 it initially produces. This breakthrough MixoFerm increases the product output (50% above what was previously theoretically possible) while reducing CO2 emissions.

The company has a biochemicals pathway based on the production of acetone and isopropyl alcohol (IPA), with a first commercial plant (75 kilotons per year) on the docket for 2020. In this slide, they describe, acetone and IPA as “decent markets” - acetone at 500 million gallons per year in the US and IPA at 150 million tons in the US — used in plastics, solvents and personal care.



Not a company yet, but we're watching…

USC

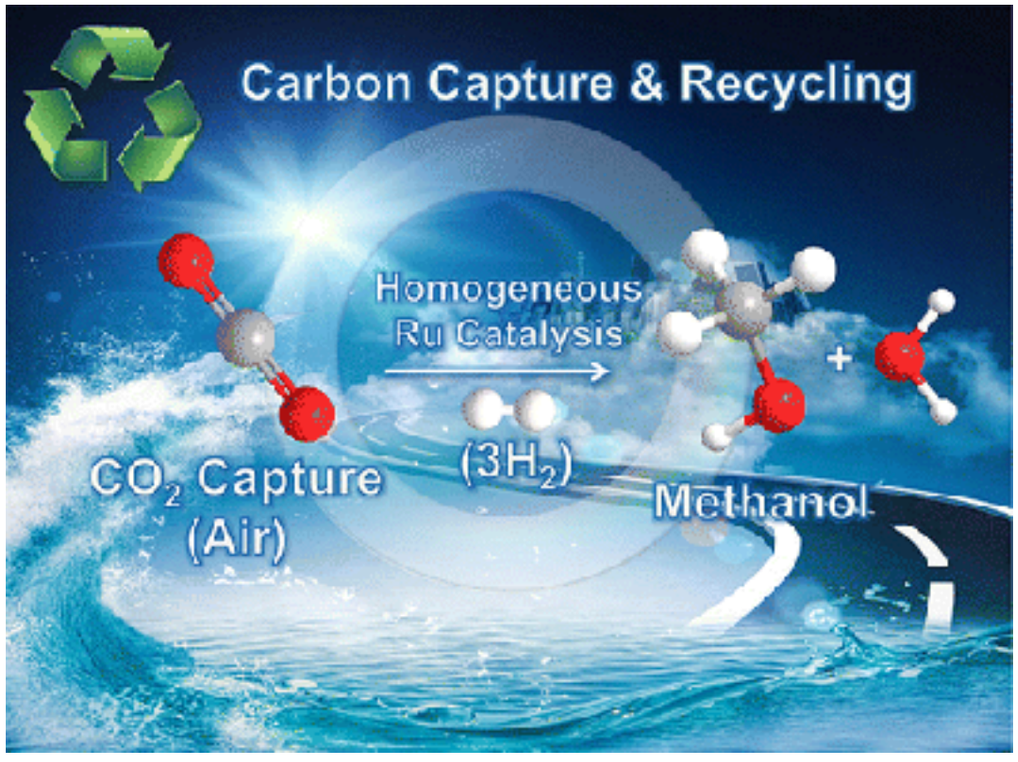
Airborne CO2 captured and converted to methanol

An article by G. K. Surya Prakash, a chemistry professor at the University of Southern California, along with the Nobel laureate and USC professor George A. Olah appeared this year in the Journal of the American Chemical Society, highlighting a pathway to making methanol from airborne CO2, via a homogeneous catalyst.

There they report:

For the first time, we have demonstrated that CO2 captured from air can be directly converted to CH3OH in 79% yield using a homogeneous catalytic system. A highly efficient homogeneous catalyst system for the production of CH3OH from CO2 using pentaethylenehexamine and Ru-Macho-BH (1) at 125–165 °C in an ethereal solvent has been developed (initial turnover frequency = 70 h–1 at 145 °C). Ease of separation of CH3OH is demonstrated by simple distillation from the reaction mixture. The robustness of the catalytic system was shown by recycling the catalyst over five runs without significant loss of activity (turnover number > 2000).

"Developing stable homogeneous catalysts for CO2 reduction to methanol was a challenge," Prakash told Phys.org. "Majority of the catalysts stopped at the formic acid stage. Furthermore, we needed a catalyst that could reduce carbamates or alkylammonium bicarbonates directly to methanol. We have achieved both with our catalyst. We will continue the studies to develop more robust catalysts that work around 100 to 120 °C, We would like to perform the chemistry in a preparatively useful way, wherein there are no solvent or reagent losses."

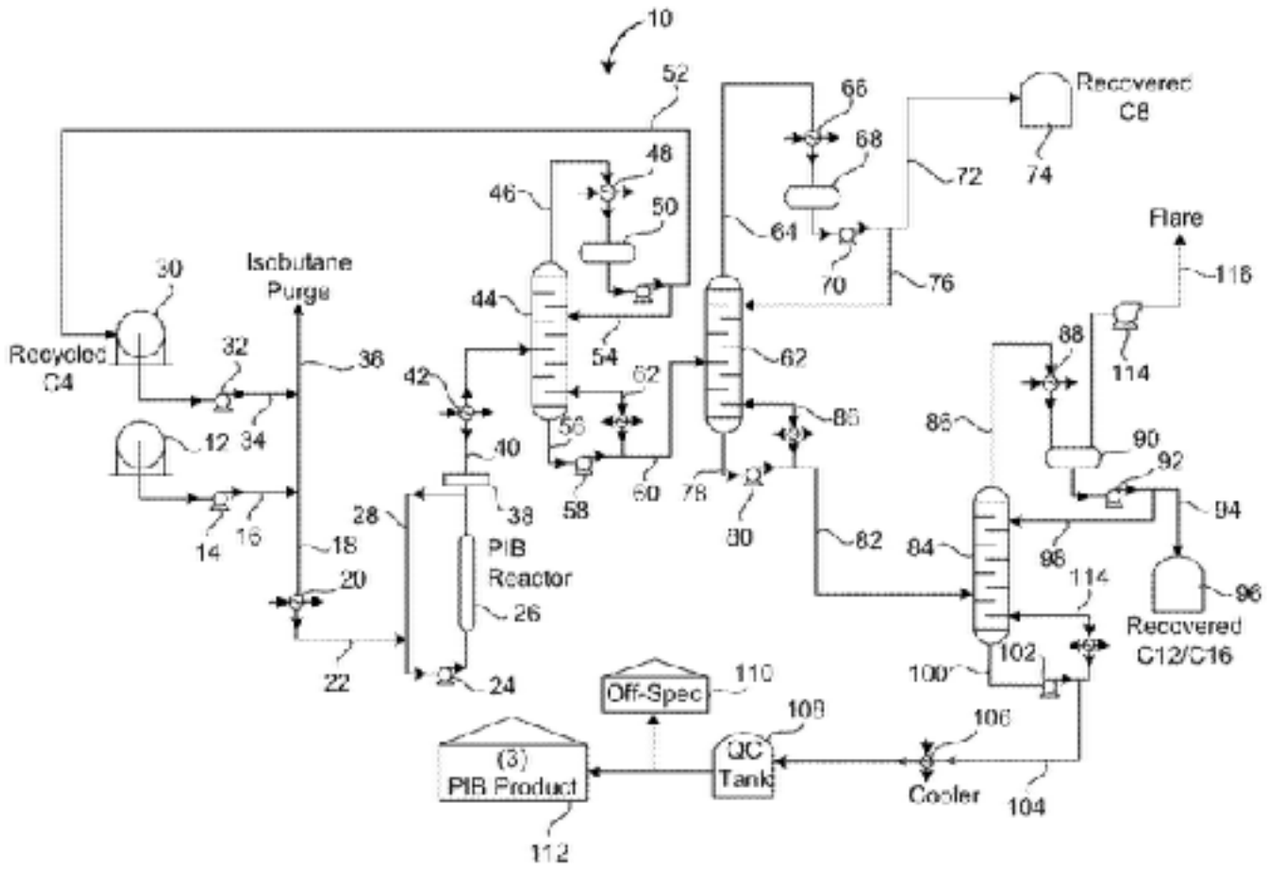


Soltex

Highly Reactive Polyisobutylene

SOLTEX (Synthetic Oils and Lubricants of Texas) in Houston, Texas, is being recognized for developing a new chemical reaction process that eliminates the use of water and reduces hazardous chemicals in the production of additives for lubricants and gasoline. If widely used, this technology has the potential to eliminate millions of gallons of wastewater per year and reduce the use of a hazardous chemical by 50 percent. separated. The separation process involves washing the neutralized catalyst complex from the reaction mixture with copious amounts of water to remove all catalyst residues.

Soltex's new process is based on a novel solid catalyst composition using a fixed-bed reactor system. A solid catalyst, in the form of a bead or other convenient geometrical shapes and sizes, is packed into a vessel to form a stationary, completely contained bed. Isobutylene monomer is fed to the reactor at a controlled rate and passes over the solid catalyst allowing the polymerization to occur. The polymer mixture exits the reactor at the same controlled rate. This reactor effluent contains minimal catalyst residues, therefore no subsequent catalyst separation or water wash is required.



Hybrid Coating Technologies Nanotech Industries

Non-Isocyanate Polyurethane/Green Polyurethane

Hybrid Coating Technologies/Nanotech Industries of Daly City, California, is being recognized for developing a safer, plant-based polyurethane for use on floors, furniture and in foam insulation. The technology eliminates the use of isocyanates, which cause skin and breathing problems and workplace asthma. This is already in production, is reducing VOC's and costs, and is safer for people and the environment.

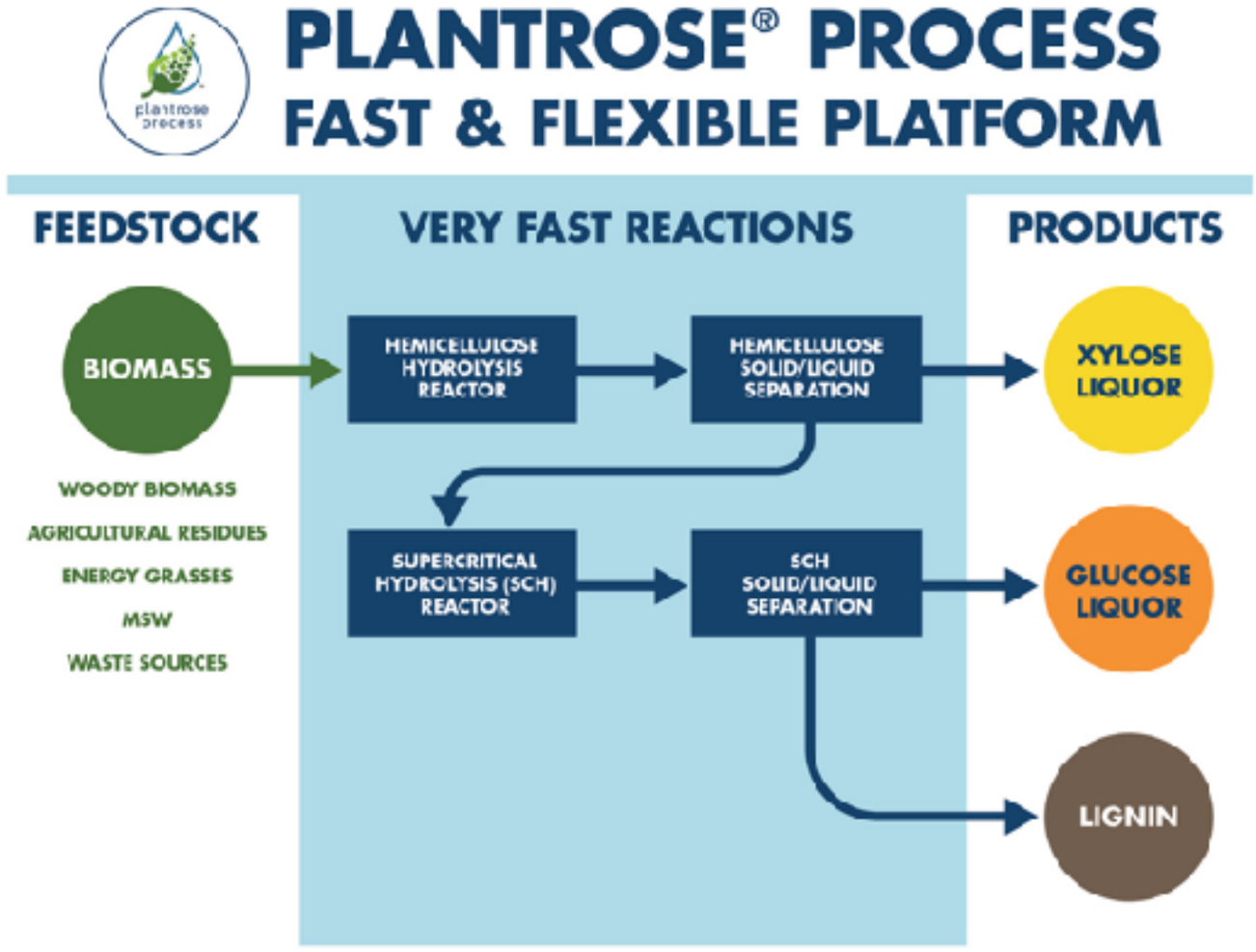
HCT developed a novel concept for generating new multifunctional modifiers for "cold" cure epoxy-amine compositions, namely hydroxyalkyl urethane modifiers (HUM), and subsequently developed HUMs based on renewable raw materials (vegetable oils), which are now used for SPF and UV-cured acrylic polymer based coatings. Utilizing HUM provides the cured composition with superior coating performance characteristics including pot life/drying times, strength-stress properties, bonding to a variety of substrates and appearance. Other characteristics, such as weathering and chemical resistance, are also strengthened while HNIPU is not sensitive to moisture in the surrounding environment. HCT also developed a version of its epoxyamine hydroxyurethane grafted polymer that replaces corrosive low-molecular weight amines with less hazardous high-molecular weight amines.

Renmatix

The Plantrose Process

Renmatix in King of Prussia, Pennsylvania, is being recognized for developing a process using supercritical water to more cost effectively break down plant material into sugars used as building blocks for renewable chemicals and fuels. This innovative low-cost process could result in a sizeable increase in the production of plant-based chemicals and fuels, and reduce the dependence on petroleum fuels.

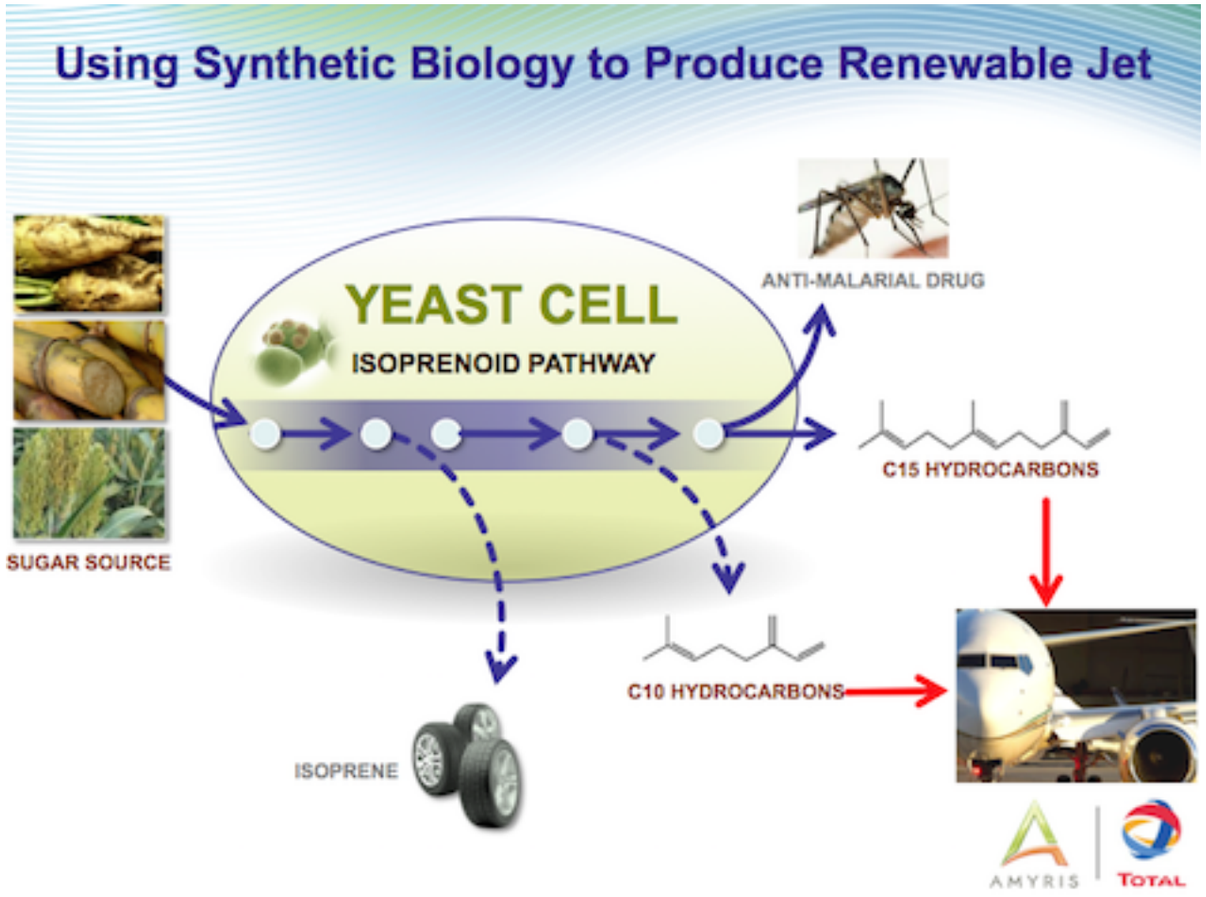
Renmatix's Plantrose process, which uses supercritical water to deconstruct biomass, provides cost–advantaged cellulosic sugars by using primarily water for conversion reactions. The two-step continuous process deconstructs a range of plant material into renewable feedstocks to produce separate streams of xylose and glucose. After sugar extraction, remaining lignin solids can be burned to supply the bulk of the heat energy required for the process (or utilized in higher-value applications like adhesives or thermoplastics).



Amyris

Farnesane for Use as Diesel and Jet Fuel

Renewable fuels are needed to help achieve global sustainability. Amyris took a step toward this goal by engineering yeast to make a chemical called farnesene instead of ethanol. Farnesene is a building block hydrocarbon that can be converted into a renewable, drop-in replacement for petroleum diesel without certain drawbacks of first-generation biofuels. Use of Amyris's renewable diesel may produce 82 percent less greenhouse gas emissions than use of petroleum diesel.



Amyris used state-of-the-art strain engineering to make yeast that converts sugars into the hydrocarbon farnesene rather than ethanol. Farnesene can then be hydrogenated to farnesane, a renewable drop-in replacement for petroleum diesel and a blend-stock for jet fuel. A recent lifecycle analysis estimated an 82 percent reduction in GHG emissions for farnesane, compared with the EPA baseline fossil diesel—including indirect effects. Farnesane can also have land-use benefits for heavy-duty transportation: a hectare of land growing soybeans to produce traditional biodiesel generates enough fuel for a bus to travel about 600 miles. If the same land is instead used to grow sugarcane to make ethanol, a bus adapted to run on ethanol could travel about 4,000 miles. However, if the sugarcane is used to produce farnesane, the unmodified diesel vehicle can travel about 5,500 miles. Breakthroughs in converting lignocellulosic biomass to fermentable sugars will further increase this benefit.

REG

Renewable Energy Group completed a quiet 506(b) exempt $4.25M cap raise in March, just before announcing Q1 revenues of $305.6M on 98.0 million gallons of fuel sold, a gain of 63.7% in gallons sold compared to Q1 2015. Adjusted EBITDA for the quarter was $9.9 million compared to negative $30.2 million in the prior year period, without any adjustments for the 2015 Biodiesel Mixture Excise Tax Credit (BTC). Adjusted EBITDA for the first quarter of 2015, after giving effect to the retroactive reinstatement of the BTC, was negative $14.5 million.

The cap raise was the first reg D filing by the company since a $26.2M raise in February 2014. At March 31, 2016, REG had cash and cash equivalents of $164.1 million, an increase of $117.0 million from the prior quarter end. This increase was largely the result of collections related to the retroactive reinstatement for 2015 of the biodiesel mixture excise tax credit.

For Q1, REG produced 86.2 million gallons of biomass-based diesel during the quarter, a 42.1% increase, while the average price per gallon sold of biomass-based diesel decreased by 7.9% to $2.92 which was due to lower heating oil and RIN prices.

Oil prices have plunged, but REG is getting stronger.
Diversification, high-tech paying off.
Will the market notice before the Ames Army owns it all?

Siluria

Just as CEO Ed Dineen exited to return to the petrochemical space, the company raised $25.742 million as 2015 drew to a close.

Siluria's latest financing round was led by National Petrochemical Industrial Company ("NatPet"), a producer of propylene and polypropylene in Saudi Arabia and a subsidiary of the Saudi joint stock company Alujain Corporation. The multifaceted partnership adds to Siluria's world-wide reach and expands a growing commercial portfolio in a massive target market, the company said.

NatPet from Saudi Arabia joins Fine-Teck from Oman, and Linde from Germany as Siluria's most recent strategic investors. Since its inception, Siluria has raised approximately $150 million.

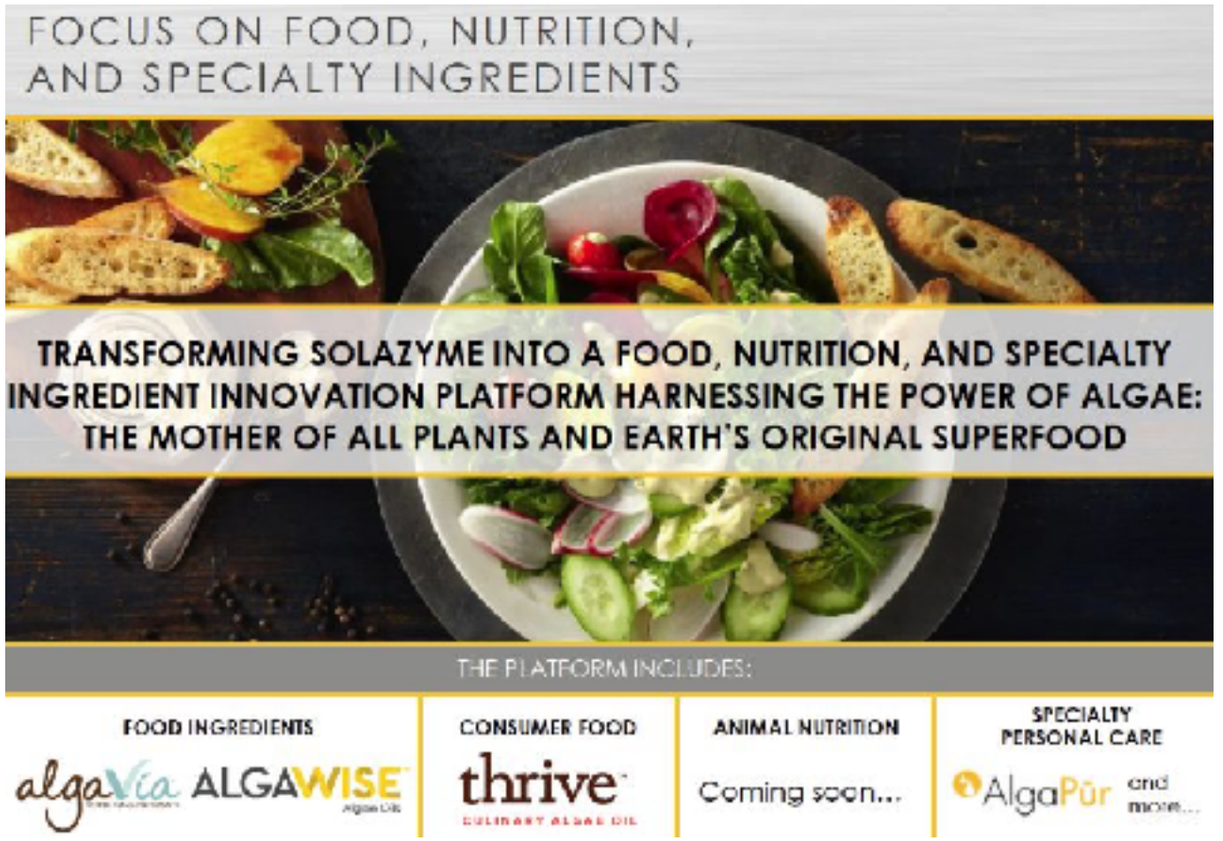
Siluria Technologies is pioneering the commercial production of fuels and chemicals made from natural gas.

TerraVia

In March, Solazyme refocused exclusively on food, nutrition and specialty ingredients, renaming the company TerraVia. and raised $28M from a group of foodie investors including Glenhill Capital, VMG Partners, PowerPlant Ventures, ARTIS Ventures, Simon Equities and several influential food industry CEOs.

The products, technology and market opportunities in industrial markets including fuels, industrial oils, and the oilfield/Encapso business will be spun-off. The company stated: "Moving forward, these initiatives will be grouped together as "Solazyme Industrials" and will not be part of TerraVia's refined focus.

TerraVia's portfolio of ingredients and products include: Specialty Food Ingredients, including the AlgaVia Whole Algae ingredients (lipid rich powder and protein) and AlgaWise Algae Oils (cooking and high stability oils). Consumer Food Products, including Thrive Culinary Algae Oil, Animal Nutrition Ingredients, a new area for the Company, and Specialty Personal Care Ingredients, including AlgaPur Oils.

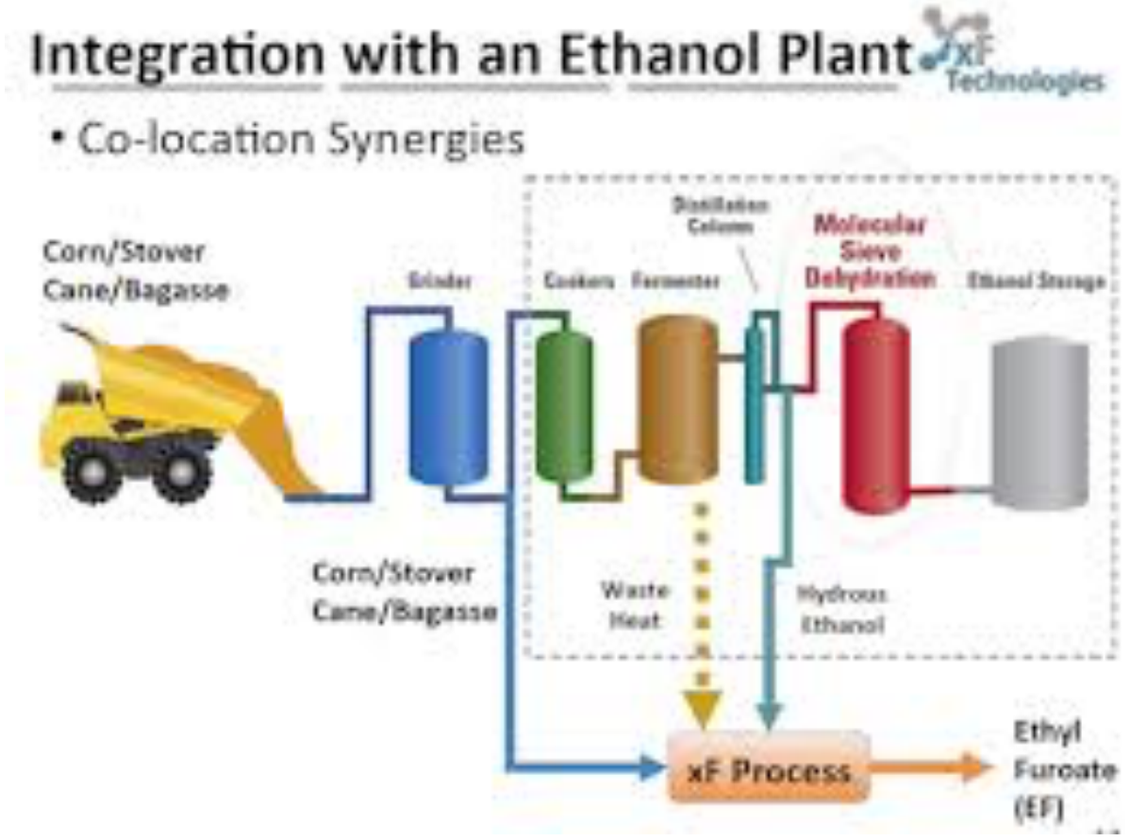


xF Technologies

USA
Top Trends & Techs

Bolt this on to an ethanol plant for advanced oxygenates

xF Technologies Inc. is an Albuquerque, NM based company that has developed a thermochemical process to convert biomass into an advanced oxygenate that is compatible with gasoline, diesel and heating oil. xF Technologies plans to license the process technology to third parties and will not produce biofuels for the commercial market. The process is ideally suited for co-location with a corn ethanol plant as ethanol is consumed in the conversion process. Additionally, excess heat generated in the ethanol plant is sufficient to operate the xF plant while high purity water produced in the xF plant can be utilized in the ethanol plant.
xF Technologies' alkyl furoates are expected to be approved by the EPA as an advanced biofuel and to be eligible RFS2 RIN credits.



Gevo

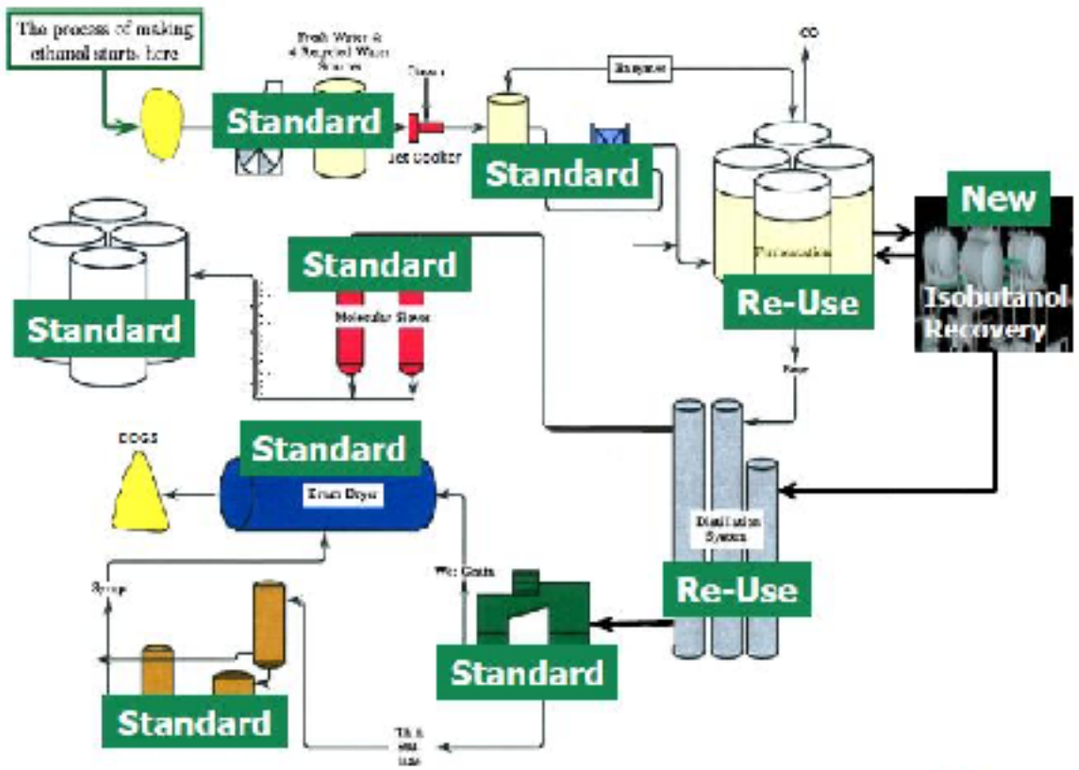
Ethanol, isobutanol side by side, and jet fuel, p-xylene too.

This week, Gevo signed an agreement with Musket Corporation to supply isobutanol for blending with gasoline. Musket is a national fuel distributor under the umbrella of the Love's Family of Companies. Initial target markets are expected to include the marine and off-road markets in Arizona, Nevada, and Utah.

The supply program is expected to begin with railcar quantities of isobutanol (a railcar holds approximately 28-29 thousand gallons). As isobutanol production ramps at Gevo's production facility in Luverne, Minn., and isobutanol-blended gasoline becomes more established at retail outlets, Musket expects to expand its purchase quantities. Musket is initially targeting retail pumps at Lake Havasu in Arizona, followed by other large marine markets such as Lake Powell, Lake Mead, as well as other large lakes in the western states. Later, Musket also anticipates expanding distribution into its core Oklahoma market.

Gasoline demand for the marine market in the U.S. is estimated to be approximately 1.7 billion gallons per year[1]. The National Marine Manufacturers Association has endorsed the use of Gevo's isobutanol in the marine fuel market because of the superior properties of isobutanol-blended gasolines, namely: prevent moisture absorption and phase separation; reduce engine corrosion; provide higher energy content; and contain a high octane rating.

"We believe Musket is an excellent partner to expand the use of isobutanol in gasoline blends, as our isobutanol production at Luverne builds. Musket and Love's are significant players in fuel distribution and retail in the U.S., so they have great reach to get our isobutanol into the market," said Dr. Patrick Gruber, Chief Executive Officer of Gevo.



Increases in yeast productivity and titer provides capacity upside

QCCP/Enogen

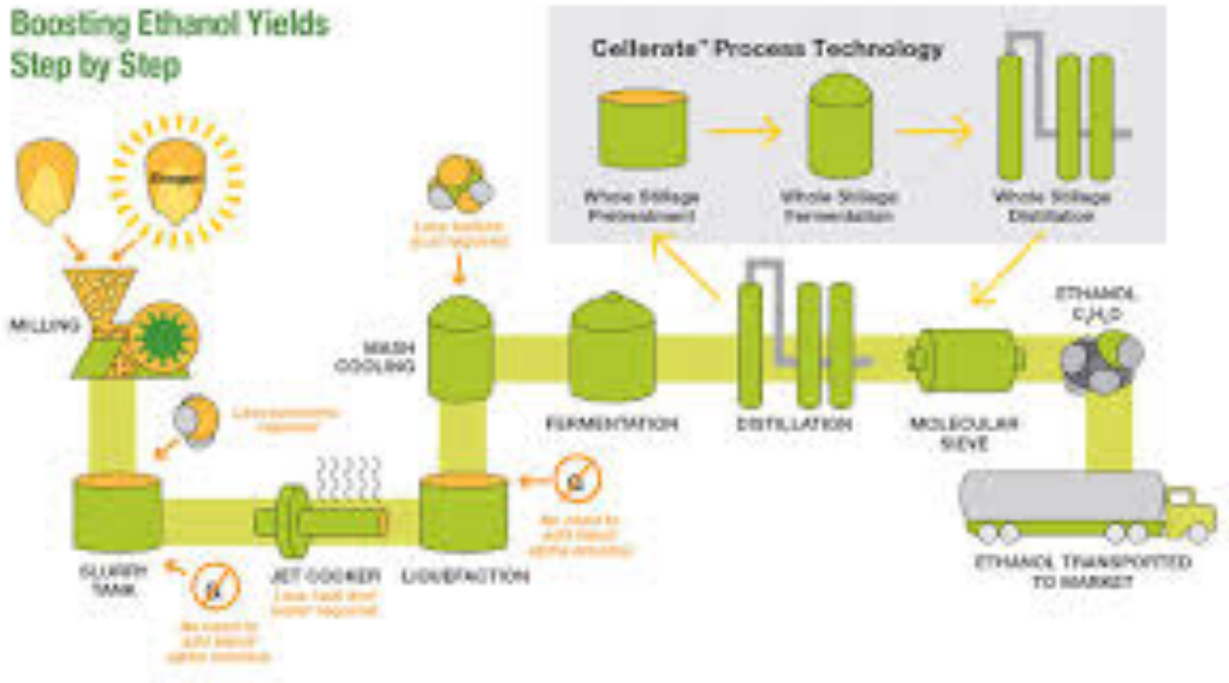
The enzyme grows inside the corn

In April, we reported that Quad County Corn Processors increased ethanol production by 20 percent in an 18-day trial using a combination of Cellerate process technology and Enogen corn.

To date, QCCP has produced over 3 million gallons of cellulosic ethanol via the Cellerate process.

The increase was achieved by realizing an additional 6 percent yield per bushel from converting corn kernel fiber into ethanol, plus a 14 percent throughput increase by combining Cellerate with Enogen. Developed at QCCP in Galva, Iowa, Cellerate is a collaboration between Syngenta and Cellulosic Ethanol Technologies, a subsidiary of QCCP. In 2014, Syngenta announced an agreement with CET to be the exclusive marketer of the Cellerate process technology to ethanol plants in North America.

“Cellerate can help ethanol producers improve the protein content of dried distillers grains to as much as 40 percent (DM) and boost total yield of distillers corn oil up to a potential 1.6 pounds per bushel (QCCP is currently achieving 1.1 pounds per bushel),” said Jack Bernens, head of Enogen at Syngenta. “We believe that not only will Cellerate process technology help make advanced and cellulosic ethanol a reality, but the combination of Cellerate and Enogen could represent the next step forward for ethanol production.”



Edeniq

Get more out the grind

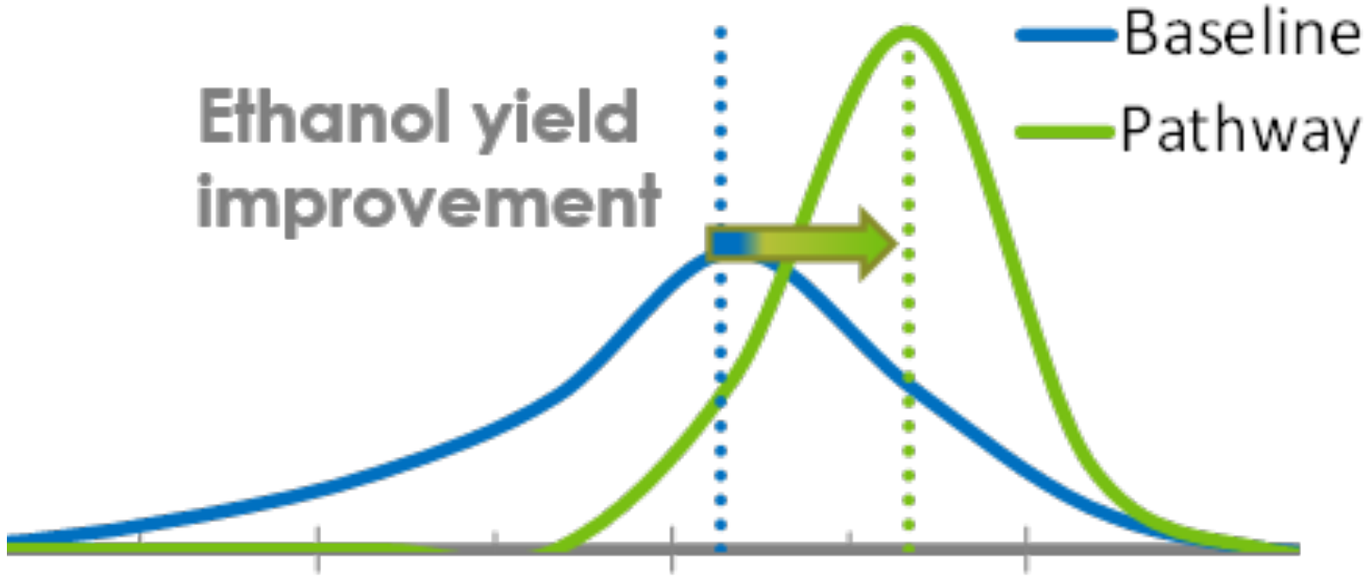
Edeniq is currently rolling out the company's complete PATHWAY Platform, which increases ethanol yield at existing plants by three to six percent through a more complete conversion of starch and cellulosic corn kernel fiber into ethanol.

The company's Cellunator pretreatment technology, a component of the PATHWAY Platform, has been operating commercially inside corn ethanol plants since 2009. The Cellunator enables ethanol plants to mill corn and other plant materials into a well-mixed slurry of small, uniformly-sized feedstock that can be more easily converted into sugars needed to produce biofuels and other biomaterials.

Last week, we reported that Siouxland Energy Cooperative licensed the Company's Cellunator and Pathway technologies for its 60 million gallon per year ethanol plant located in Sioux Center, Iowa.

The Pathway Technology integrates the Cellunator equipment with cellulase enzymes to convert corn kernel fiber to cellulosic ethanol. The Pathway Technology utilizes existing fermentation and distillation equipment to produce up to 2.5% cellulosic ethanol and up to a 7% increase in overall ethanol yield.

Siouxland Energy Cooperative expects to begin producing cellulosic ethanol in the fourth quarter of 2016. There is no capital investment associated with the enzymatic process for producing cellulosic ethanol.



Benson Hill Biosystems

The company. The company is using computation and biology to accelerate innovation in crop development. Benson Hill technologies will supply growers with more output from less input and increase sustainability and value throughout the agriculture and bioenergy sectors.

The raise. Benson Hill Biosystems secured an investment of $7.3 million in its Series A round of financing. Middleland Capital led the round, with co-investors Mercury Fund, Prelude Ventures, Prolog Ventures, Alexandria Venture Investments, Cultivation Capital, and TechAccel. Existing investors Missouri Technology Corporation and Biogenerator also participated in the round.

Transcriptic

The company. Transcriptic is the only cloud-based robotic bio lab in operation. The robotics lab arm of Emerald Therapeutics is a close competitor with a very similar end goal to run science experiments in the cloud. "We set out with the goal of giving the life sciences the same structural advantages that web has enjoyed, making it possible for two postdocs with a laptop in a coffee shop to run a drug company."

The raise. The robot-operated biolab startup Transcriptic raised $8.5 million in Series A funding. Data Collective led the round, with participation from IA Ventures, AME Cloud Ventures, Silicon Valley Bank, 500 Startups, MITS Fund, Y Combinator partner Paul Buchheit and several other angel investors.

Sweetwater Energy

The company. Sweetwater began as a producer of cellulosic sugars — but with the lack of cellulosic technology-based customers, it has extended its aim towards the production of renewable chemicals.

The raise. Sweetwater closed on a $10 million bridge loan, and opened its Series B investor round to begin construction of a first commercial facility. The company also landed $28 million in prospective project financing from the state of Minnesota.

USA
Top Trends & Techs

Caribou Biosystems

The company. Berkeley, Calif.-based Caribou is developing a genome editing platform based on an exclusive license to the foundational CRISPR/Cas9 work done in part by Doudna's lab at the University of California, Berkeley. Caribou's intellectual property is also based on work done at the University of Vienna.

The raise. Caribou Biosciences closed an $11 million Series A financing round in March. Investors included Fidelity Biosciences, Novartis, Mission Bay Capital, 5 Prime Ventures, and one undisclosed partner. Caribou co-founder and pioneering CRISPR/Cas9 researcher Jennifer Doudna has also joined as an investor, the firm said in a statement.

Fulcrum BioEnergy

USA
Top Trends & Techs

The company. Fulcrum BioEnergy converts municipal solid waste diverted away from landfills into diesel and jet fuel.

The raise. United Airlines announced a $30 million direct investment in advanced biofuels developer Fulcrum BioEnergy, obtained an option to invest in five future commercial-scale aviation biofuels plants, and signed offtake agreements for up 90 million gallons of biofuels per year. The offtake contracts are worth an estimated $1.58 billion over the 10-year offtake span, based on the current jet fuel price of $1.76 per gallon, according to Digest calculations.

Bolt Threads

The company. Bolt Threads uses proprietary technologies to create Engineered Silk fibers based on proteins found in nature. These programmable fibers, which can be tuned to provide superior comfort and performance, represent the most significant innovation the textile industry has seen for decades.

The raise. Bolt Threads, raised $32.3 million in Series B funding. Formation 8 and Foundation Capital led the round with participation from Founders Fund. Bolt Threads will use its Series B funding to increase production of better, smarter, more sustainable fibers and grow its team of technology and apparel experts.

Twist Biosciences

USA
Top Trends & Techs

The company. Twist has developed a proprietary semiconductor-based synthetic DNA manufacturing process featuring a 10,000-well silicon platform capable of producing synthetic biology tools, such as oligonucleotides, genes, pathways, chassis and genomes.

The raise. Twist completed a $37 million Series C financing. Led by Illumina, Inc., participants in the round include new investors Fidelity Management and Research Company and Foresite Capital Management LLC, as well as all existing investors including Nick and Joby Pritzker (through their family's firm Tao Invest), ARCH Venture Partners, Paladin Capital Group, Yuri Milner, and additional strategic corporate and venture investors.

Zymergen

The company. By applying its robotic automation, proprietary machine learning software, and deep computer analytics to the complex field of industrial microbiology, Zymergen can, cost-effectively, and predictably "program" microbes to produce high-value commercial molecules. Specifically, Zymergen works on strain development - engineering strains for partners, or creating new ones. What makes the company of high interest is the promise of a dramatic acceleration in the pace of strain optimization.

The raise. Zymergen completed a Series A investment round of $44 million. Data Collective led the Series A, with participation from AME Cloud Ventures (Jerry Yang), Draper Fisher Jurvetson, HVF (Max Levchin), Eric Schmidt's Innovation Endeavors, Obvious Ventures, True Ventures and Two Sigma Ventures.

Gingko BioWorks

The company. Ginkgo is currently under contract with 10 different corporate customers to produce 20 designer organisms for various products. Customers include many Fortune 500 companies, according to the startup. Ginkgo is moving beyond its original production of synthetic fragrances to cosmetics, nutritional products and health and consumer products. The move puts Ginkgo in direct competition with Silicon Valley-based synthetic biology startup Zymergen.

The raise. Ginkgo Bioworks raised a total of $54 million in two financings in 2015, $9M in March and another whopper, $45M towards the end of the year, led by Viking Global. YC joins other previous investors OS Fund and Felicis Ventures in the round.

Arcadia Biosciences

The company. Arcadia Biosciences develops and commercializes agricultural traits and products that bring value to growers, processors and consumers while benefitting the environment and enhancing human health. Using a variety of advanced screening, breeding and biotechnology techniques, Arcadia has created a diverse portfolio of late-stage traits across multiple crops.

The raise. Arcadia Biosciences priced its initial public offering, last May, at $8 per share and is offering 8.2 million shares, which will raise $65.6 million. The offering represents a 40% dip from the originally-expected offering range.

USA
Top Trends & Techs

Impossible Foods

The company. Impossible Foods was founded by Stanford professor Patrick Brown, vegan celebrity chef Tal Ronnen and cheesemaker Monte Casino. The company's synthetic food products include almond milk cheeses, ricotta, ravioli, and cream-cheese-like cheeses, sold in Whole Foods and elsewhere. Meats are on the horizon.

The raise. Impossible Foods raised $108 million in new round led by UBS, and included Viking Global Investors and earlier backers Khosla Ventures, Microsoft co-founder Bill Gates, and Horizons Ventures.

Also watch...

Arzeda

Vertimass

AgBiome

Matrix Genetics

Gen9

RedRock Biofuels

Mango Materials

Beyond Meat

PrecisionHawk

Green Plains

Ripple Foods

Oberon Fuels

Modern Meadow

AltAir

Industrial Microbes

Perfect Day

Clara Foods

Lygos