

# C2B2

Colorado Center for  
Biorefining and Biofuels

## SMALL COMPANIES ON THE VERGE OF BIG ADVANCEMENTS

Smaller entrepreneurial ventures can make a major impact if they have the right stuff — strong, marketable ideas, a shrewd business plan and the wherewithal to execute. Although they may not cast as long a shadow as their larger corporate counterparts, several members of C2B2 are proving just this, within the still-formative biofuels industry.

Of the 27 organizations under the C2B2 umbrella, companies such as Ceres, San Juan Bioenergy and LS9 are among those creating a buzz in the biofuels sector as they advance technologies toward commercialization. How close are these companies to bringing their products and services to market? And what makes their prospects especially promising? Executives from each of the companies offer their insights in the profiles below.

### LS9 - The Renewable Petroleum Company

Having dubbed itself “the renewable petroleum company,” San Carlos, California-based LS9 is pioneering “DesignerBiofuels,” the trade name for its portfolio of renewable hydrocarbon-based biofuels, including crude oil (biocrude) and biodiesel. LS9 doesn’t shy away from competition with the mainstream petroleum industry, nor from setting lofty expectations for the genetic manipulation technologies and processes it has developed.

Founded in 2005, LS9 is close to commercializing fuels produced through fatty acid biosynthesis. In this process, genetically fine-tuned enzymes serve as the catalysts in biphasic fermentations that convert the sugars (derived from feedstocks such as corn, sugar cane and biomass) to hydrocarbon fuels. These fuels have properties virtually indistinguishable

from those of gasoline, diesel and jet fuel. As Steve del Cardayré, LS9’s vice president of research and development, explains, what’s different about these fuels, is not only that they perform as well as the conventional formulations of ethanol and butanol, but they are also compatible with the existing petroleum distribution and consumer infrastructure, making for transparency along the various links of the supply and demand chain.

The metabolic pathways utilized in fatty acid biosynthesis make the fuel production process especially efficient, he says. “It’s an assembly line that really, really works and a way to get as many BTUs out of the land as we can.”

Fuels produced via those pathways are close to market-readiness. According to del Cardayré, LS9 is busy making “relatively subtle improvements” to yield and productivity in advance of scaling to and opening its first commercial production plant in mid-2010 at a yet-to-be-disclosed location. The goal, he adds, is to produce fuels that are price-competitive right from the outset, without subsidies; “if you want something to grow and gain widespread adoption, it needs to be profitable and economical.”

### San Juan Bioenergy LLC

The path traveled by San Juan Bioenergy LLC (SJB) during its formation, and its emphasis on local resources for both production and consumption make it an unusual company, even in the entrepreneurial world.

Based in the Four Corners town of Dove Creek in Southwest Colorado, the company has broken ground on a 2.5-million-gallon-per-year oil extrusion and biodiesel manufacturing facility that is slated to be operational later this year. While most of the oil it extrudes from sunflower crops initially has been earmarked for sale into food markets, plans call for a small but increasing share to be used to produce biodiesel. According to SJB’s CTO Nathan Morris, the company’s “take-it-slow” biodiesel production strategy reflects a strong emphasis on quality control. Controlling the amount of fuel introduced into the local supply chain will enable SJB to vigorously monitor fuel quality all the way to an end user’s fuel tank. This approach also allows SJB to refine its biodiesel production process while researching additional feedstocks, several of which are currently



A Scientist at LS9

being researched by C2B2.

SJB’s sunflower, safflower, and potential canola feedstocks will be grown locally by many Four Corners farms. As Morris explains, the goal is to market the bulk of the biodiesel produced at the plant to customers within a 200-mile radius of Dove Creek. With demand for diesel fuel within that area estimated at 500 million gallons of fuel per year, there’s a readymade market for SJB biodiesel among coal, oil and gas mining operations, ski resort, municipality, school, and farmers’ fleets.

Jeff Berman, an engineer by trade who is now the CEO, launched SJB in 2005 as a result of his work with the environmental not-for-profit Colorado Wild. This group, among other things, rates ski resorts based on the environmental impact of their operations, Morris recounts. In working with resorts to help them fulfill their “green” aspirations with biodiesel, Berman began to see promise in the idea of a biodiesel production facility in the area. A subsequent feasibility study funded by various public and private

# BIOMASS BREWING IN GOLDEN

As vital as feedstock analysis work is to the advancement of biofuels, the Biomass Analysis team of the National Bioenergy Center toils in relative obscurity. And while the team's supervisor, Edward J. Wolfrum, Ph.D., says he's happy to yield center stage to other biofuels organizations, he's quick to point out that the spotlight might never shine on those organizations without behind-the-scenes support from teams like his own.

The fastest route toward developing the most cost-, energy- and resource-efficient energy feedstocks may indeed run directly through the Center's facilities at the National Renewable Energy Laboratories in Golden. This is the place where public and private entities send feedstock samples for compositional analysis to determine their utility for the production of biofuels. It's a place that Wolfrum, a chemical engineer, playfully calls the "second-largest brewery in Golden," given all the activity at its pilot plant.

Analysis results obtained by the members of the Biomass Analysis team often figure prominently in the decisions researchers make regarding the specific feedstock production pathways they choose to explore for potential commercial development. Wolfrum, estimates his team has helped dozens of clients around the U.S; "We are service providers. We are the guys who measure things to facilitate research. Our job is to support current work using the best [analysis] techniques we have and to develop new and

improved techniques, so we help keep people from running down the wrong paths. We're always trying to stay one step ahead."

Staying a step ahead these days means that in addition to using classical wet chemical techniques, the team is also developing, validating, and deploying rapid-analysis methods based on near-infrared (NIR) spectroscopy, and working with other NREL researchers performing pyrolysis/molecular beam mass spectroscopy (py-MBMBS). These high-throughput techniques, when coupled with multivariate statistical analysis, can identify even the slightest chemical distinctions among different plant feedstock samples, including emerging energy crops that show promise for the production of biofuels.

Wolfrum summarizes the team's guiding credo as, "You can't control what you can't measure, and you can't understand what you can't measure." The more quickly clients are provided with accurate analysis, the faster they can deploy resources toward the most promising feedstocks. To that end, Wolfrum says the Biomass Analysis team stands ready to support C2B2 members in their goal of moving biofuels forward in Colorado and elsewhere via "informal and formal collaboration on any project that requires analysis."

Perhaps one of those projects will even someday earn the Center a few well-deserved headlines.



*The Biomass Analysis Team at work in Golden, Colo.*

## SMALL COMPANIES

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entities confirmed the viability of the concept and identified sunflowers as the best potential feedstock.

When the plant opens, Morris says it will be unique not only in what it produces, but in how it does so. It will meet much of its own energy needs through the gasification of sunflower hulls, a byproduct of SJB's oil production process, and glycerin, which is a byproduct of biodiesel production.

### Ceres - More Than a Decade in Biofuels

Eventually, biofuels producers such as SJB may look upstream to a company like Ceres for genetically optimized plant feedstocks. Ceres' work on plant genomics began more than a decade ago in the wake of the human genome project. Ceres is eyeing 2009 for the introduction of its first commercial energy crops, which include switchgrass. Denny Otsuga, Ph.D., manager of technology acquisition and licensing at Ceres, notes that the switchgrass project will be followed by the commercialization of high-biomass sorghum, miscanthus and a breed of sugar cane the company calls "energycane."

Freshly infused with \$75 million in capital, Ceres is collaborating with the Samuel Roberts Noble Foundation (to develop advanced agronomic processes and molecular breeding tools in switchgrass), Texas A&M University (to develop high-biomass sorghum) and South Dakota State University (to develop high-yield switchgrass cultivars better adapted to energy production in northern latitudes). Otsuga, who represents Ceres on the C2B2 steering committee, explains this is all part of the company's plan to carve out an upstream niche in the biofuels market; "We are positioning ourselves as a source material provider. We are really agnostic about what end products are made; all will require high densities of biomass produced in an environmentally sustainable way".

LS9, SJB and Ceres all hope to build on their involvement in C2B2 to enhance their commercial success. "Colorado is getting serious about bioenergy and C2B2 gives us a voice in how that market develops," says Otsuga. "It always helps when you can go to one place, meet all the players in the field, interact with people outside our area of expertise and review the exciting research that is going on."

## SPOTLIGHTS ON STUDENTS IN C2B2

**Tara Schumacher**, a PhD candidate at Colorado State University, is a Chicago native who arrived in Fort Collins seventeen years ago to attend CSU and explore the Front Range. After obtaining her B.S. in Zoology and Biology and then her teaching license, she enjoyed eight years of teaching at Windsor High School. Tara returned to CSU and is working on her PhD in the Cell and Molecular Biology Graduate Program. Tara's project is funded by a C2B2 seed grant, and focuses on using proteomics to investigate the mechanisms of lipid storage in microalgae for potential biodiesel use.



**Tanya Warnecke** is a PhD candidate in the Department of Chemical and Biological Engineering at the University of Colorado in Boulder. Her dissertation research employs genomic tools to engineer microbial strain development. Specifically, she has worked on improving the understanding of organic acid tolerance in *E. coli*. Tanya will be presenting her work at the Symposium on Biotechnology for Fuels and Chemicals in New Orleans and anticipates completion of her dissertation by May 2008.



**Margaret (Meg) Sobkowicz** left a successful and lucrative career with Schlumberger Oil Field Services with the specific intention of pursuing graduate studies in renewable technologies. Having graduated from Columbia University with her undergraduate degree in Chemical Engineering, Meg brought high standards of excellence to her graduate work. A third year student at the Colorado School of Mines, she won the 2007 graduate student poster competition at the Green Chemistry Conference of the American Chemical Society. Working in the field of bioplastic nanocomposites, she has quickly developed new isolation and functionalization process chemistries while mastering a wide suite of analytical methods. Her studies have already led to the submission of one journal article and she is in the process of completing a second.

**Jonathan Marda** is in his fourth year of his PhD program in Chemical Engineering at the Colorado School of Mines. His thesis is focused on the conversion of biomass fast pyrolysis oil (bio-oil) to hydrogen for distributed hydrogen production via a combination of non-catalytic partial oxidation and catalytic steam reforming and water-gas-shift reactions. Jonathan presented his research at the AIChE national meeting in Salt Lake City in November 2007 and will also discuss his work at the ACS spring national meeting in New Orleans in April 2008.



# C2B2 SEMI-ANNUAL MEETING AGENDA



## February 11 - 12, 2008 Fort Collins, Colorado

### Monday, February 11, 2008

- 3:00-5:00 PM ..... Tours of CSU Facilities on the CSU Campus
- 6:00 PM ..... Reception & Networking Event  
New Belgium Brewery
- 7:00 PM ..... Dinner  
New Belgium Brewery

### Tuesday, February 12, 2008

**Hilton Fort Collins**  
425 W. Prospect Road  
Fort Collins, CO 80526

- 7:30 AM ..... Breakfast
- 8:30 AM ..... Welcome  
Dr. Al Weimer, Executive Director
- 9:00-10:30 AM ..... Panel Discussion  
Business, IP & Technical Strategy
- 11:00-12:00 PM ..... Poster Session
- 12:00-1:00 PM ..... Lunch
- 12:45 PM ..... Guest Speaker  
Dr. Jan Leach, CSU
- 1:15-2:00 PM ..... Poster Session
- 2:00-2:30 PM ..... C2B2 Business Meeting
- 2:30-3:00 PM ..... Steering Committee Meeting  
Departures for  
Denver International Airport
- 3:00-5:00 PM ..... Sponsored Research  
Agreement Meetings



C2B2 is a cooperative research and educational center devoted to the conversion of biomass to fuels and other products, supported by state, institutional, and industry funds. The mission of C2B2 is to become the world's leading center in biorefining and biofuels research and education.

We provide private industry with one-stop access to researchers, laboratories, students, and educators from four innovative institutions, each having unique strengths in biofuel and biorefining application areas.

*Colorado Renewable Energy Collaboratory*

Created to develop energy technologies for rapid commercialization, the Collaboratory consists of the following institutions:

*University of Colorado at Boulder*  
Ranked in the top 25 nationally in Chemical and Biological Engineering, Molecular and Cellular Biology, and Biochemistry.

*Colorado State University*  
Ranked in the top 10 nationally in Agricultural Sciences with an internationally renowned Engines and Energy Conversion Laboratory.

*Colorado School of Mines*  
One of the few universities uniquely focused on energy research.

*National Renewable Energy Laboratory*

The only national laboratory dedicated to renewable energy and energy efficiency research and development (R&D).

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