

FEATURE

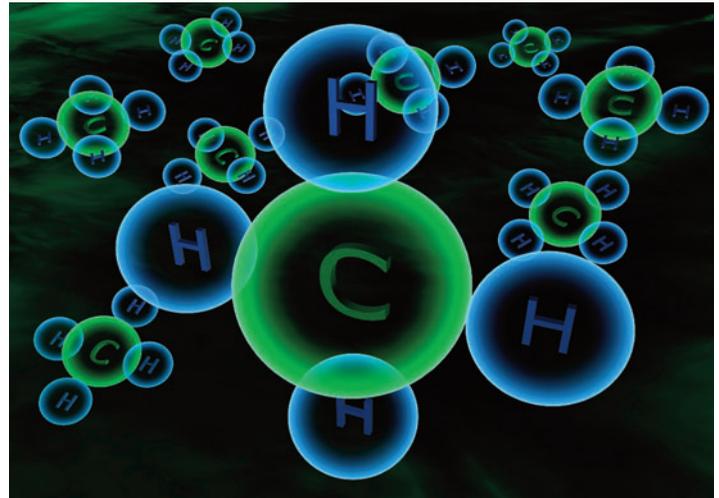
Calysta Sees Natural Gas as ‘Advantaged’ Feedstock for Fuel/Chemical Production

Menlo Park, Calif.-based Calysta Energy announced October 22 it intends to capture methane – the primary alkane component in natural gas – and use it as feedstock for the production of fuels and high-value chemicals via a novel biological gas-to-liquids (GTL) technology platform – trademarked “BioGTL.”

The company, a spin-out of DNA 2.0, the largest U.S.-based provider of synthetic genes for industrial and academic use, is headed by Alan Shaw after spending over a decade serving as president and CEO of Codexis Inc., a California-based biotech outfit biotech that’s developing industrial biotechnological routes for biofuels, bio-based chemicals and other bioproducts with global customers that include Merck, Pfizer, Chemtex and Raizen.

“I’m fundamentally an industrialist,” Shaw told Ethanol & Biofuels News (EBN). “My career has followed a very common theme. I’ve been very successful in commercializing green technologies. The secret of that success is not necessarily recognizing the technology, but in identifying the market opportunity.”

Leading Calysta Energy alongside Shaw is chief scientific officer and co-founder Josh Silverman, a technology leader with broad expertise in biotechnology start-up ventures.



Previously, Silverman established and led research and development (R&D) partnerships and product development collaborations for five biotechnology companies, including Avidia through acquisition by Amgen.

Together, Shaw and Silverman firmly believe their young company’s novel “BioGTL” platform is ripe to become a viable, disruptive technology that can cost-competitively produce a range of fuels and chemicals derived from methane found in both conventional and unconventional sources of natural gas.

EBN caught up with Shaw and Silverman to find out how the company’s novel Bio-GTL technology works, how it might economically and efficiently compete with

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conventional forms of GTL platforms in operation today and how inherent dynamics within the natural gas sector might impact the company's business strategy going forward.

EBN: *Several biofuel firms - those that originally targeted using biomass as feedstock - appear to be turning their attention now to natural gas as the starting material for the production of fuels/chemicals, primarily because it's cheap and abundant now. Specifically, for Calysta Energy, why does the company see natural gas as an "advantaged" feedstock?*

Shaw: There is a real demand for hydrocarbons - molecules that consist of hydrogen and carbon - in the world. Biomass is principally carbohydrate, which most people know as sugar. Carbohydrates have carbon, hydrogen and oxygen in them. In fact, there is a lot of oxygen in carbohydrates. One hundred tons of sugar - or carbohydrate - has 52 tons of oxygen in it. In other words, 52% of biomass is something you don't want and, to get rid of it, it has to be vented off in the form of carbon dioxide. It doesn't leave as elemental oxygen so it strips off some of what you don't want. By the time you have converted your biomass into a hydrocarbon fuel or chemical, the maximum theoretical yield you could ever hope for is 30%, and that's terrible.

For the last 10 years, the industry has been forging ahead trying to create what was known as the "new sugar economy" and, now, I think a lot of people are waking up to the fact that this isn't going to work. The economics don't stack up... the numbers just don't make sense. And, that's assuming that biomass is readily available. The problem is that it's not readily available because it has to be collected, it's not where you need it, it's seasonal, has propensity to rot, and transporting it expends more energy. The whole thing is energy intensive, and even if you get it to the refinery your maximum yield of a hydrocarbon is capped at about one-third. If you can change the feedstock and start with something that doesn't have oxygen in it and it only has carbon and hydrogen, it's the perfect feedstock to produce hydrocarbons.

Mind you, I'm not talking necessarily about ethanol. I'm talking about hydrocarbons [those derived from carbohydrates]. Ethanol has one oxygen atom in it for every two carbon atoms. The Brazilians have proven that you can make money fermenting sugar to ethanol. I'm specifically talking about hydrocarbons such as diesel. In my opinion, there is no viable alternative to diesel today at large scale. It's an unmet market need. The industry also needs cheaper sources of feedstock for chemicals - not necessarily renewable chemicals, but cheaper sources of



Alan Shaw, president, chairman and CEO of Calysta Energy.

Source: Calysta Energy

feedstock for building blocks for polymers that are growing at 7%-10% per annum because of [population] growth in SE Asia.

Silverman: Diesel is absolutely the biggest market. There is a wide variety of other petrochemicals that are also going to be very difficult to make biomass sourced replacements

EBN: *As you know, the Renewable Fuels Standard (RFS) was crafted around the robust utilization of biomass for production of biofuels for the incumbent fuel infrastructure. With more companies like Calysta Energy now making the shift to natural gas as a feedstock for fuels and chemicals, how do you see public policy changing - irrespective of who wins the election this year - to reflect this growing trend?*

Shaw: I don't think it matters who wins the election - whether it's the Democrats or the Republicans - everybody admits now that natural gas is front and center of this country's energy future. There's no confusion about the role of natural gas. Everybody gets the relevance of natural gas. So, what does that mean?

If we can deliver a liquid transportation fuel from an energy source that this country has enough of itself then we just nailed the energy security box. Granted, it doesn't do anything for emissions necessarily and it doesn't have a renewable label, but you've just solved probably the biggest issue that this country faces and that's energy security and I think that could trump saving the planet in the near-term. Regardless of politics, energy security is very important. We've also saved about US\$300 billion a year because that's how much this country hemorrhages every year buying imported oil from people who don't necessarily like us very much. \$1 billion per day leaves this country to pay for imported hydrocarbons.

Think about this for a moment: If we could then redirect that \$300 billion into alternate energy - not necessarily just for the transportation sector - we can address the renewables aspect and solve our transportation fuels at the same time. I don't think we need to look to wind, solar, hydro and nuclear to fix the internal combustion engine because it's not broken. Like my father used to always tell me, "Son, if it's not broken, don't fix it."

I'm not so sure whether we need to put a renewables tag on liquid transportation fuel or industrial chemicals. We can save money there and fix energy security and then give the U.S. Department of Energy [DOE] the means to go and

solve carbon emissions in different areas. I would welcome working with the DOE regardless of who wins the election on helping them fix this. There's a lot that can be done and we can help.

EBN: *Companies like Royal Dutch Shell, ExxonMobil, DuPont and others are looking at potentially capturing stranded gas – methane being the primary alkane – at sites that typically get flared during fracking/shale operations and making value-added products out of it, but transporting the gas - either via compression or liquefaction - makes it cost-prohibitive. How does Calysta Energy intend to work with these companies to address this glaring deficiency?*

Silverman: No doubt the stranded gas is a big opportunity. Lots of people are going after it right now. The main issue that they have is that the current technologies for converting gas to liquids are based on the Fischer-Tropsch platform. It's a 90-year-old technology. While it's very well optimized at the scale that it works at, trying to scaling it down does not work. People have been trying to scale it down economically for the last 80 years with no success. The benefit of the BioGTL is that it operates at lower temperature, lower pressure, and has significantly lower capital requirements getting the process to work and it should scale down significantly better than the F-T process. We think this will be the premier technology for utilizing stranded gas sources that operate at that small-to-medium-scale and will be a preferred way going forward.

EBN: *Can you briefly describe how the biological portion performs within company's novel GTL pathway?*

Silverman: We're basically working with an organism that natively metabolizes methane in natural gas to grow. It uses the methane as a sole carbon and energy source and it combines that methane with oxygen to create its own biomass. For example, for the diesel application, we can take the lipids that are produced by the cell, hydrotreat those to alkanes and then those can get dropped into a refiner essentially as a "crude", which then the refinery can take and treat as if it was a barrel of crude oil. The cells do all the work. We simply do an extraction and a small clean-up to make sure that the crude meets the specifications that the refinery needs so we don't poison their catalysts – making sure all the phosphate, nitrogen and water and so on are low enough - but that's well-established chemistry.

For more specialty chemicals, we're looking at biocatalysis to convert some of the higher molecular weight compounds in natural gas - such as ethane, propane and butane – being able to biocatalytically oxidize those directly to alcohols on site to allow for easy transport. That's a biocatalysis approach where we're using the same

enzymes that the cell normally uses for metabolism and growth – via the incorporation of methane – using those as a single step to transform light hydrocarbons to alpha alcohols, which can be easily transported and then easily processed to other high-value chemicals at a refinery site.

At the high level, it's taking the various components of natural gas and converting them to liquid form. The benefit of biology is that we can very specifically address all the components of natural gas and turn them each into the most highly valuable oxidized version of that component. We have enough control and specificity that we can increase the value chain as opposed to the chemical method where everything gets mixed together and you get a mixture with little control over composition.

EBN: *Aside from the biological component, how does Calysta Energy's GTL technology differ from conventional GTL schemes like F-T? Is it adept at processing conventional and unconventional sources of gas into liquids?*

Silverman: It's certainly much more specific and less capital intensive. The other benefit we have versus F-T technology is that BioGTL has a much lower sensitivity to contaminants in the natural gas. Most people don't really talk about this, but especially as we go into more unconventional sources of natural gas – things like the shale gas, fracking off-gases, etc. – the contaminant profiles of these unconventional sources are wildly different than what the industry has been used to seeing in the past and, in order for these plants to actually utilize this new source of gas, they have to put in a lot of infrastructure and capital just to scrub the contaminants out of the gas and get it to something that looks more like conventional gas. Most of the normal contaminants in natural gas are actually nutrients for the cells – the nitrogen, phosphorus and sulfur. These contaminants will poison the catalyst immediately in F-T technology, but our cells actually grow better in the presence of those contaminants. By reducing the need for gas-scrubbing technology we drive down the costs of capital and reduce the scale at which we can be economical, and that expands the number of sources of gas we can go after.

EBN: *Is Calysta Energy considering transesterifying the lipid oil into a fatty acid methyl ester (FAME) biodiesel, or is it firmly targeting a straight diesel substitute?*

Silverman: Rather than hydrotreating the oil you can transesterify to a FAME. That might be a little bit cheaper. We're still working through the economics there. But, the down side is then you're left with biodiesel and that has certain limitations. Everyone likes petroleum diesel. That molecule works. It has a very high energy density, it has very good properties and the refiners know how to make

that to a variety of specifications whether that's Europe's diesel, JP-8...there's a lot of very fine details that go into that specification. Biodiesel works in some cases, but it still has a fairly low market penetration relative to petroleum diesel. Being able to go after the petroleum diesel market directly we think has a lot of advantages.

EBN: What are some of the economic highlights of the "BioGTL" technology compared to F-T or other routes to biofuels or chemicals – i.e. thermochemical or biological?

Silverman: We're not going to compete with Shell's Pearl facility any time soon. At the smaller scale, however, we can be economical where large-scale F-T technology cannot. We've seen estimates that 90% of gas deposits are not going to be able to be accessed by F-T. The technologies are essentially not in direct competition in that BioGTL can access feedstocks that F-T plants can't access. As long as we can be competitive with petroleum diesel, there's going to be an opportunity there.

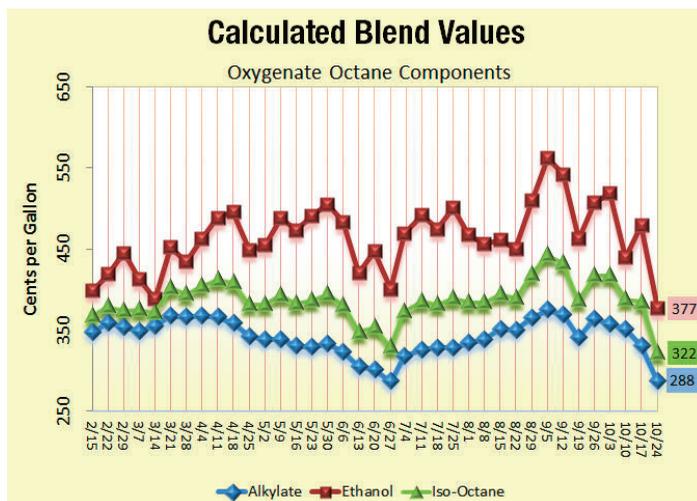
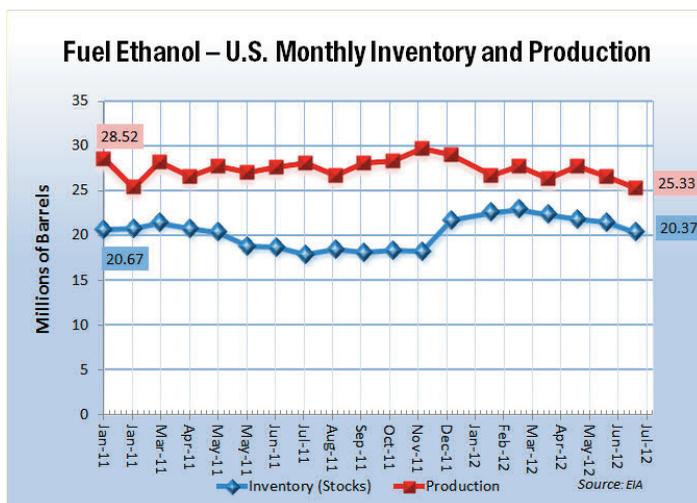
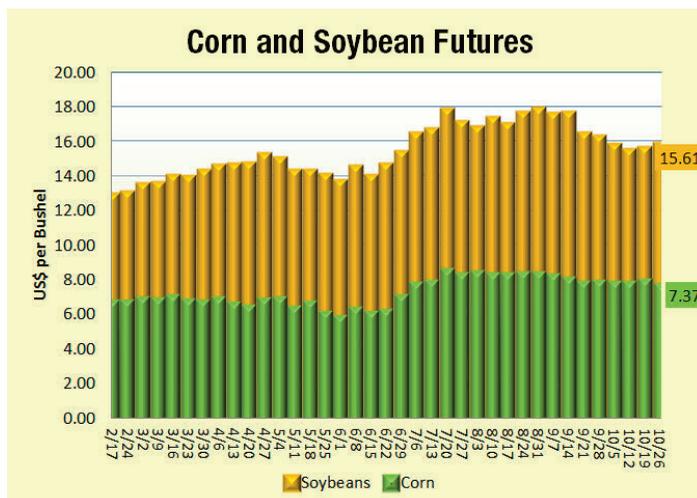
Looking at other hydrocarbon biofuel approaches, it's really the cost of biomass, the cost of gathering the biomass and the low efficiency due to the high oxygen content basically make it a non-starter as far as we can tell. The quotes we've seen for current hydrocarbon biofuels coming from sugar are on the order of \$20-\$30 per gallon, so that's no where close to be viable from a cost-competitive view.

The one that may be a little closer is the algae-to-biofuel processes. Even so, there are a lot of hidden costs in that industry as well, such as water, carbon dioxide feed-in and collection costs to name a few. If we plug our process into the current algae model, our best estimates right now suggest about six times cheaper than an algae open pond process.

Our current estimates show us to be cost-competitive with petroleum-based diesel, which is the benchmark that we're pushing against and as long as we can meet those requirements and be cost-competitive there we think everything else will fall into place.

EBN: What is Calysta Energy's strategy going forward with its BioGTL technology? Is the intent to strictly co-locate its technology on site where stranded gas is present, license the technology, a combination of both, etc.?

Silverman: There are lots of ways you could go about it. We can have the technology on site to convert the gas on the stranded location, turn the gas into something that's easily transportable and then collect the liquids from a variety of sources at a central processing location, which can be a traditional refinery using more standard chemistry. The key is really in that first step of how do you convert the gas to a form that can be transported and do that efficiently at medium-to-small-scale.



Shaw: We are talking to the oil majors as you might expect us to be. One of the benefits is that we can take advantage of all that downstream processing and all the chemistry that's in place. I think co-location could make a lot of sense because a lot of the infrastructure is on the downstream processing of these gases to liquids and so we could take advantage of infrastructure that's already in place.

Silverman: One place where a lot of other new fuel start-ups have fallen down is meeting the specifications for the final consumer. The last thing we want to do is reinvent the wheel. Current refiners are very good at meeting specifications. They know exactly what every customer wants. To the extent we can bolt onto that and use the existing infrastructure, that takes a huge amount of risk off our plate.

Shaw: I really don't see Calysta Energy in the long-term as an independent company. It's just not realistic. We're a technology company. We can work hand-in-hand with industry helping them to produce their chemicals cheaper and help them open up new markets. We can take our technology to the gas so I think we've got to be working with the gas producers and refiners. We've opened up a number of very positive discussions with oil refiners and you can expect us doing deals with people in that sector in the short-term. This isn't something we'll be trying to do ourselves.

EBN: *Natural gas prices are currently hovering between \$3.40-\$3.50/MMBtu (million British Thermal Units). As oil and natural gas prices become increasingly decoupled from one another, does Calysta Energy anticipate natural gas prices will inevitably increase due to glut in supply?*

Silverman: We expect it to go up from here, but not significantly. We modeled it to go up about two-fold from current prices because it's not expected to stay as low as it is, but it is expected to be disassociated from oil prices going forward. If you look from the last 20 years up to about five years ago, the price of oil and the price of natural gas go in lock-step together. But, over the last five years, they've now diverged and that's because, before five years ago, basically all of the natural gas came off of oil wells. Now that we have access to fracking technology and shale gas you have people producing gas for the sake of producing gas independently from oil, which supports why those prices have separated and why they're expected to stay separated for the time being.

Interestingly, pretty much all of the bio-based feedstocks are now tied directly to oil. If you look over the last five to 10 years, sugar, soybeans, corn oil and so forth are all now



Josh Silverman, chief scientific officer,
Calysta Energy.
Source: Calysta Energy

moving exactly in lock-step with petroleum oil; further reinforcing the idea it's not going to be possible to make petroleum replacements from a bio-based feedstock because you can't make something cheaper than oil if your feedstock keeps changing at the same pace as oil.

And, if you look at the gas reserves, the shale gas throughout the world is ten-fold what the conventional reserves are, and that's not even starting to get into other sources like the gas hydrates that are at the bottom of the ocean. Just the sheer mass of unconventional gas sitting there; you can drive huge price changes very quickly in the downward direction.

EBN: *Is Calysta Energy looking at potentially tapping into the biogas market as well?*

Silverman: I absolutely think that's an opportunity. Most of the biogas producers in the U.S. are really hurting right now because the price of their product has fallen through the floor. We're not working for renewable story right now. In the short-term, we're now just trying to make sure the economics work on the merits of the technology itself. However, longer-term, having a biogas as a source really would bring in a renewable story by being able to take in a renewable stream from an anaerobic digester or landfill and feeding it into our system. But, for now, we're more focused on the pragmatic approach.

EBN: *Finally, how does the company intend to approach the remainder of 2012 heading into 2013 being an early-stage start-up?*

Shaw: I view Calysta Energy as a first-mover and it's a great position to be in because you attract the best people. It's resonating that we're at the right place at the right time, but as a first-mover we have to keep moving. We're a spin-out of a company called DNA 2.0 and they've committed enough funding to last through 2013, which is quite good for a small company. We have sufficient funds for our current level of operations, but I want to accelerate deployment of this technology and I'd love to triple the number of staff. We're in the market, we're looking for funding and ideally I'd like to have that funding come from industry. We've got to keep ahead of the curve. Other people will see this and try to jump on this bandwagon with us. That's okay. That's the nature of innovation. We can't afford to rest on our laurels and that requires obtaining the necessary funding and resources to keep moving.

– Bryan Sims