A circular economy
The waste-to-biofuel technology creating added-value products

Key to verification
How to achieve Low Carbon Fuel Standard verifications

Regional focus: ethanol in North America
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As this issue of Biofuels International is being prepared for publication in London, UK, across the Atlantic biofuel producers will no doubt be readying themselves for the world’s largest ethanol event: the International Fuel Ethanol Workshop, taking place from 10–12 June in Indiana, Indianapolis. The 35th edition of the event is offering five concurrent tracks for attendees, covering production and operations, leadership and financial management, coproducts and product diversification, infrastructure and market development, as well as a stream dedicated to advanced biofuels. It’s a chance for producers, suppliers and industry professionals across the US and globally to network and gain insights into the latest technologies and research findings.

Coincidently, the regional focus for this issue is ethanol in North America, with comments from associations including the American Coalition for Ethanol (ACE) and Growth Energy offering insider views into the state of the market in the US. Stiff political headwinds are impacting both domestic and international market share for US ethanol, including the uncertainty created by a US-China trade war and mismanagement of the Renewable Fuel Standard. ACE CEO Brian Jennings is, however, optimistic, noting that many ethanol producers are already reaping the benefits of selling ethanol into California’s Low Carbon Fuel Standard market. The recent decision by the European Commission to repeal the anti-dumping duty on the import of US ethanol to the European Union has also been enthusiastically welcomed by producers, with Growth Energy’s Craig Willis describing the move as a ‘win-win’ for the US and its European trading partners.

The US-China trade war situation is undoubtedly one to watch. In this edition’s regional report, Renewable Fuels Association president and CEO Geoff Cooper elaborates on the US industry’s ‘roller-coaster ride’ in selling ethanol to China over the past few years. A resolution of the trade war should be high on both sides’ agendas – and the sooner the better. “Today, not a drop is flowing there because China increased its already-punitive tariff to 70% last spring, in retaliation to new US tariffs on Chinese goods,” Cooper warns, adding that though the opportunity in China is enormous, without access to this Asian market, US ethanol producers will suffer from weak domestic demand and oversupply.

But despite the uncertainty of trade wars and tariffs, technology developments in biofuel production continue to make leaps and bounds, from biowaste valorisation to plant automation to yield maximisation. Canadian start-up Enerkem is developing and commercialising an advanced thermochemical process that chemically recycles carbon molecules contained in waste into added-value products, such as renewable methanol and ethanol. In fuelling a circular economy, the technology addresses both the challenge of waste management and the increasing need for low-carbon transportation fuels: a true ‘have your cake and eat it’ scenario.

In the next issue of Biofuels International we’ll take a closer look at a rapidly expanding new market for biofuels: the aviation sector. Earlier in May, I was one of 72 passengers invited on-board the ‘Perfect Flight’ from Halmstad City airport to Stockholm Bromma airport in Sweden, powered by sustainable aviation fuel supplied by Air BP and produced by Neste. The collaboration, which was led by Braathens Regional Airlines, resulted in the optimisation of every element of the flight management process to keep carbon emissions to a minimum and achieve the ‘Perfect Flight’ in Sweden, a country aiming to be carbon neutral by 2045. The result? Success on all counts, with a 46% reduction in carbon emissions compared with a regional jet flight. Sweden has sent a strong signal to the international aviation community with the ‘Perfect Flight’ and will continue to promote the use of renewable jet fuel in its drive to decarbonise aviation.

As ever, you can keep on top of the latest developments in the biofuels industry on the Biofuels International website: www.biofuels-news.com. And, in other exciting news, each magazine will now be delivered in entirely compostable packaging, which can be deposited with your food waste.

Katie Woodward
Managing Editor
Neste and Savonlinja roll out low emission bus service in Finland

Customers travelling on Savonlinja buses will be able to choose a lower emission journey from mid-May 2019, according to renewable diesel producer Neste.

Under a collaboration with Neste, Savonlinja will introduce a Green Travel surcharge in addition to a normal bus ticket price. Customers are able to choose the price they wish to pay for this additional charge.

The bus company intends to use the money collected through the surcharge to reduce greenhouse gas emissions, fuelling its buses with Neste’s MY Renewable Diesel.

The Green Travel surcharge will help passengers reduce greenhouse gas emissions by an average of 90% on their bus ride, compared to traditional diesel fuel.

“Climate change does not wait and solutions are needed right here and now,” said Tuomas Kulola, head of sales, marketing and services at Neste. “The key to fighting climate change is introducing innovations of all sizes to help bring about a more sustainable future. Developed in collaboration with Savonlinja, Green Travel is a good example of how important partnerships are to creating effective solutions. We are very proud to collaborate with Savonlinja on offering consumers the opportunity to reduce the carbon footprint of their bus trips.”

The surcharge will be available on all long distance bus trips and can be purchased for tickets via Savonlinja’s mobile app ‘Linjalla’ and at the company’s online store.

While customers are free to decide on the amount they pay for the surcharge, there is a minimum value of one euro. The low emission option is also available for customers using charter bus services.

“Customers have told us that they would like to have more climate and environmentally friendly transport options,” added Harri Leskinen, chief business officer at Savonlinja. “Green Travel is the answer to this. Our long-term goal is to be able to use only renewable fuel in our entire fleet.”

Savonlinja has announced that it will double the amount its customers pay for the Green Travel surcharge, using the funds to purchase Neste’s renewable diesel fuel.

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Aemetis lands biodiesel supply contract for Indian mining customer

Advanced renewable fuels producer Aemetis’ subsidiary in India, Universal Biofuels India, has landed a large biodiesel supply contract.

The customer is a multi-site mining company, which will use the biodiesel to fuel dump trucks and other heavy diesel equipment at mine sites in southern and central India. According to Aemetis, shipments to the customer have commenced and will be expanded to additional mines when onsite storage for biodiesel is installed.

“AWith the recent completion of our India plant pretreatment unit and expansion to 50 million gallons of capacity per year from low cost, high free fatty acid feedstock, the Aemetis team in India is executing on a rapid increase in production and revenues this year by continuing to expand domestic markets, which now include mining customers,” said Eric McAfee, chairman and CEO of Aemetis. “As the only US company producing biofuels in India, Aemetis’ India team continues to expand its market reach by winning new customers in innovative domestic markets.”

Earlier in May, Universal Biofuels India won a biodiesel supply contract with three government-owned oil marketing companies, with shipments of fuel to commence this month. Awarded under a public tender process, the contract covers the ongoing supply of biodiesel to a number of locations, totalling no more than $23 million (€20.5 million) during 2019.

Washington State Ferries commits to 10% biodiesel blend

Washington State Ferries (WSF) announced that it will be launching a Sustainability Action Plan that outlines objectives for more renewable ferries and terminals, which includes a commitment to using a 10% biodiesel mix.

The plan includes initiatives to protect orca whales, reduce greenhouse gas emissions, improve air quality and reduce waste.

“Because we operate our 23 ferries on Puget Sound and manage 20 terminals on its shores, we have an obligation to ensure WSF is doing everything we can to protect our environment,” said WSF assistant secretary Amy Scarton.

“WSF claims that it is the largest consumer of diesel fuel in the US state of Washington, burning over 18 million gallons each year. "WSF will use a 10% blend of biodiesel (B10) fleetwide. This is an increase in use of biofuels from the current 5% blend (B5) fleetwide," WSF stated in the plan.

WSF commits to using a 10% biodiesel mix fleetwide in its Sustainability Action Plan.
European Commission removes anti-dumping duties on US ethanol imports

The European Commission (EC) has chosen to repeal the anti-dumping duty on the import of ethanol from the US, overturning a decision made in 2013.

In announcing its decision, the EC concluded that removal of the duty would not increase the chance of dumping of US ethanol on the market in the European Union (EU).

The Commission announced a €62.9 per metric ton duty on all ethanol imports from the US in February 2013 for a period of five years.

The duties were due to expire in February 2018, however the EC launched an expiry review of the measures at that time, ensuring that current duties remained in place for the duration of the review.

The investigation has now concluded, with the Commission finding no evidence that removal of the US ethanol duties would encourage dumping in Europe.

“The decision today in the EU to allow more open access for US ethanol is very welcome by our industry and the members of the US Grains Council,” said Tom Sleight, president and CEO of USGC. “We look forward to working with our customers and counterparts in the EU to fulfil the ethanol demanded by their biofuels policy and environment and price-conscious consumers.”

“We welcome the European Commission’s decision to open the market to free and fair competition,” said Craig Willis, senior vice-president of global markets, Growth Energy. “By removing unjustified penalties were unjustified and unwarranted. The US ethanol industry is looking forward to resuming more open trade relations with the European Union.”

end
KATZEN wins Brazilian ethanol plant design contract

US-based KATZEN International has agreed to design a corn-based fuel ethanol plant in Brazil for Ethanol S. A. Bioenergia. The plant, which will be located in the Nova Mutum, Mato Grosso region of the South American country, broke ground in April.

The Ethanol S. A. Bioenergia facility is a joint venture project between Grupo O+ Participações and Grupo Infiniti. The plant will produce at least 800,000 litres per day of ethanol. As well as producing fuel ethanol, co-products of the production process will include distillers' grains with solubles and corn oil.

KATZEN's ethanol production process includes low-temperature cooking, high-yield simultaneous saccharification and fermentation, pressure cascade distillation and energy-integrated waste-heat evaporation.

California approves Edeniq customers for corn ethanol production

Biotechnology company Edeniq has announced that the California Air Resources Board (CARB) has approved two Intellulose 2.0 customers for cellulosic ethanol production from corn kernel fibre.

The two facilities, a 90 million gallon per year corn ethanol plant in Jackson, Nebraska and a 150 million gallon per year plant in Atlantic, Iowa, are owned by Siouxland Ethanol and Elite Octane, respectively. By using Edeniq’s Intellulose 2.0 technology, the two plants achieved average corn kernel fibre ethanol production of 3% of total production, almost three times the average performance achieved with Intellulose 1.0.

“Intellulose 2.0 is performing extremely well, and we are excited to bring the technology to more ethanol plants,” said Brian Thome, president and CEO of Edeniq. “We would also like to especially thank the teams at Siouxland Ethanol and Elite Octane for their collaboration and support, and the team at CARB for their communication and guidance during the evaluation process.”

“Siouxland Ethanol and Elite Octane are pleased to offer consumers access to low carbon liquid transportation fuels,” added Nick Bowdish, president and CEO of Siouxland Ethanol and Elite Octane. “We take pride in being leaders in the US ethanol industry and delivering results that satisfy both our investors and consumers. We appreciate the opportunity to work synergistically with Edeniq and CARB and will continue to make transportation fuels more environmentally friendly.”

The company’s Intellulose 2.0 technology achieves 2–4.5% cellulosic ethanol production from corn kernel fibre at existing ethanol plants without the need for upgrades or additional expenditure.

KATZEN wins Brazilian ethanol plant design contract

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KATZEN's ethanol production process includes low-temperature cooking, high-yield simultaneous saccharification and fermentation, pressure cascade distillation and energy-integrated waste-heat evaporation.
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Part of the climate solution

By Brian Jennings, CEO of the American Coalition for Ethanol

US ethanol industry plans for growing market share at home and abroad are up against some stiff political headwinds — from the uncertainty and export hurdles created by trade wars to mismanagement of our nation’s Renewable Fuel Standard (RFS) and the long-awaited anticipation over whether barriers will be lifted this summer to allow access to E15 blends with no strings attached.

These headwinds are wreaking havoc on rural America’s economy. The Environmental Protection Agency’s (EPA) small refinery waivers have collapsed Renewable Identification Number (RIN) values and reduced domestic ethanol blending, and the combination of trade uncertainty and barriers are depressing commodity markets for farmers. At the dawn of the 21st century, the ethanol industry forged a path out of the crushing economic conditions that besieged rural America, and it can and will again if given the opportunity.

During our organisation’s annual Washington, DC spring fly-in and government affairs summit, we prioritised three issues during our meetings on Capitol Hill with Members of Congress and the administration: 1) market access to E15 year-round (free of RIN reforms); 2) ensuring the EPA follows the rule of law when it comes to the RFS by reallocating blending obligations waived for small refineries and future refinery waivers; and 3) making the case that ethanol is part of the solution to reduce greenhouse gas (GHG) emissions.

By the time you’re reading this, we will most likely know if the EPA kept President Donald Trump’s promise of allowing year-round access to E15 nationwide by the 1 June start of the summer driving season. E15 use is currently restricted from 1 June to 15 September in most parts of the US because of the EPA’s volatility limits on gasoline during this period, even though E15 has slightly lower evaporative emissions than E10. At the direction of
the president, the EPA set forth a proposal to extend the 1-psi Reid vapor pressure waiver to E15 that currently applies to E10 during the summer months, along with reforms to the RIN market. The American Coalition for Ethanol (ACE) strongly supports year-round access to E15, but encouraged the EPA to abandon the unnecessary RIN reforms throughout the rulemaking process, which we believe would undermine ethanol use and negate the upside benefit of E15 year-round.

Another factor dampening the upside potential of greater access to E15 and higher ethanol blends is the EPA’s mismanagement of the RFS. The agency has waived RFS blending obligations for small refiners totalling 2.61 billion gallons for the 2016 and 2017 compliance year, as of the time of this writing, and there are more waiver requests for 2018 pending at the EPA. ACE has petitioned the agency to reallocate these blending obligations and joined litigation to reverse the blanket exemptions.

Our third priority issue on the domestic front is going on offense to proactively position ethanol as part of the solution to US congressional effort to address climate change. Congressional action on climate could be viewed as a significant cost that will penalise US farmers or a chance for new economic opportunities. ACE is focusing on making sure US elected leaders appreciate that any climate mitigation step they take must be balanced with economic opportunities. This is not an easy issue to navigate, as many people and businesses in rural America view the climate discussion with a sceptical eye. Our fear is that if rural America stands on the sidelines, because of political or philosophical opposition to climate science, the void we leave will be filled by extremists who will paint corn ethanol as part of the climate problem.

It is well-documented that corn ethanol today reduces GHGs by nearly 50% compared to gasoline, and the trend is ethanol’s friend; our emissions continue to drop while gasoline keeps getting worse. Rural America is becoming increasingly aware of the role it can play in mitigating climate change but will need to see concrete benefits from policies that provide a return on investment. Leveraging the existing GHG benefits of the RFS with new policies that make ethanol part of the solution to even greater climate improvements would be a win-win for the planet and rural America.

Already, many US ethanol producers have experienced the economic benefit of selling ethanol into the California Low Carbon Fuel Standard market. It is possible for a similar opportunity to unfold nationally as Congress considers ways to tackle climate change.

Internationally, exports have been the shining star for US ethanol producers over the last couple years. Artificial and political constraints to using more ethanol here at home, US ethanol’s favourable blending economics and octane value, and global policies to increase biofuel use are factors that helped contribute to another record year, with 1.6 billion gallons of ethanol exported in 2018.

ACE member plants are hopeful we can complete negotiations with China, because it is a market that represents game-changing potential. China aspires to produce nearly 2 billion gallons by 2020 to meet its plan of E10 nationwide, but that leaves another 2 billion gallons of long-term export volume. If talks prevail in reducing or tearing down the effective 70% tariff on US ethanol, China can develop into our top export market.

Likewise, we would like to maintain our strong economic and trading relationships with Canada and Mexico. As of this writing, the newly-negotiated United States–Mexico–Canada Agreement has not been sent to Congress for review and ratification. Canada has been our most consistent customer over the years, importing at least 200 million gallons of US ethanol annually since 2011. Mexico is also emerging as a potential export destination. Our neighbour to the south plans on E10 nationwide, which represents more than 1 billion gallons of ethanol demand. ACE’s own senior vice-president Ron Lamberty has practically taken up residence in Mexico doing educational workshops.

The political and market headwinds we face are not insurmountable, and with the backing of our members, ACE is working to position the US ethanol industry for some tailwind support in 2019.

It is well-documented that corn ethanol today reduces GHGs by nearly 50% compared to gasoline.”

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Setting standards

A critical element that supports the growth of the biofuels industry is the development of accurate fuel specifications. These specifications – like water content, denaturants and so forth – are important to ethanol companies across the globe because they ensure the proper characteristics of the fuel to facilitate successful performance under a wide range of engine technologies, as well as all ambient temperatures and geographies, from the urban areas of China to the countryside of Brazil. Fuel specifications must balance the needs of engines with varying combustion and emission control technologies used for on-road and off-road applications.

In order to spur biofuels expansion, a streamlined set of standards should exist to equalise the many unique factors in different nations. However, there is currently no standardisation in biofuels specifications, even for common blending targets of ethanol, and as the consumption of biofuels continues to rise, the immediacy for a technical assessment of international biofuel standards grows stronger.

In 2007, governments from the US, Brazil and the European Union (EU) asked biofuel experts to review the biofuels specifications to facilitate the global trade of biofuels. In that era, the US, Brazil and EU represented the largest markets for biofuel use. A tripartite taskforce was developed and robust discussions on the various properties of biofuels, specifically ethanol and biodiesel, were undertaken by experts from each country. Similarities and differences were mapped out for each parameter contained in each fuel composition specification. A criticism of these discussions would be the lack of consensus achieved in the limits of many of the critical parameters of ethanol blended fuel, such as the allowable ethanol, water and acidity contents. These variations in the specifications are still present today, even though similar ethanol blending rates are practiced.

While it seems rather obvious, it’s imperative the limits in each specification be based on scientific data that describes the characteristics of the fuel needed for the temperatures and altitudes where the fuel will be used. The most widely adopted specification around the world is the ASTM International specification for ethanol: D4806 Standard Specification for Denatured Fuel Ethanol for Blending with Gasolines for Use as Automotive Spark-Ignition Engine Fuel, which was first published in 1984. There are regulatory requirements communicated many times in the specification, for example, the minimum ethanol content. It’s also important to note that there are significant differences between the ASTM D4806 specification and other specifications for ethanol from global leaders.

An easy estimate is that the largest volume of ethanol that is blended globally is manufactured to meet ASTM specifications, but without streamlined standards, this falls short of portraying proper scientific accuracy.

Another significant factor of specifications is examining variations of ethanol content. Digging deeper into the variations, a minimum ethanol content is specified to ensure blenders of ethanol can accurately achieve targeted ethanol concentrations in the final gasoline/ethanol blend. There may also be a minimum ethanol content specified to ensure cheaper motor fuel components are not blended into ethanol that may compromise its successful use. Ethanol content can also vary due to denaturing requirements, or the materials added to ethanol to make it unsuitable for beverage consumption and to avoid any beverage alcohol tax liability. For example, countries like Brazil allow the use of a dye instead of a denaturant.

Other contributing factors inhibiting fungibility of biofuels globally are the current variations in the allowable maximum water content. Limits for water content should be based on concerns for water tolerance in the final gasoline blend. The maximum water content in the D4806 specification has been restricted to 1.0% by volume (1.25% by mass) since the first publication of this ASTM ethanol specification. Water content is restricted due to potential gasoline/water phase separation concerns with the final gasoline/ethanol blend, as ethanol and water are infinitely soluble.

For biofuels to succeed on the international market, open and fair trade is critical. A lack of a streamlined system only further prevents economic progress across the charts, which requires a full assessment of each specification for ethanol that should be reviewed for scientific accuracy. Standardisation in ethanol characteristics promotes global trade, improved safety, and greater fungibility of the biofuel supply. Sound, technical evidence for this process is long overdue.

Footnotes
2 This standard is available from ASTM International: https://www.astm.org/Standards/D4806.htm

For more information:
This article was written by Kristy Moore, principal scientist at KMoore Consulting and a well-known technical and regulatory expert on fuels. She serves as an advisor on regulatory affairs and global exports initiatives for ethanol trade association Growth Energy. Visit: www.kmooreconsulting.com

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<th>Parameter</th>
<th>United States ASTM D4806</th>
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<th>Canada CGSB 3.516</th>
<th>EU EN15376</th>
<th>China NG18</th>
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<td>30</td>
<td>70</td>
<td>0.005% wt.</td>
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Table 1: Comparison of global ethanol specifications
Campaigning for the reinstatement of the biodiesel tax credit remains a focus

**Federal policies impact the US biodiesel industry**

by Donnell Rehagen, CEO of the National Biodiesel Board

For most of 2019, advocacy in the nation’s capital has been our association’s main focus. Our top priority: the reinstatement of the biodiesel tax credit. The expiration of this tax incentive is leaving a feeling of uncertainty for biodiesel workers, producers and farmers nationwide, jeopardising our industry. If the tax incentive is not reinstated swiftly – it has been allowed to lapse for over 16 months – it will be an economic setback for many. Congress last addressed the biodiesel tax incentive in February 2018, retroactively extending it for 2017 but leaving it expired for 2018 and beyond.

The biodiesel tax credit, which has been in place since 2005, has become an expected part of the transactional cost of every gallon of biodiesel produced. Our producers’ customers downstream, who distribute biodiesel blends, expect the cost of biodiesel to be reduced in some way in recognition of this expected $1 (€0.89) per gallon tax credit. For over 16 months, our producers had to sell their fuel at ‘discounted’ prices because everyone in the supply chain has expected the tax credit to be reinstated. Many of our producers are carrying liabilities on their books and are getting to the end of their available cash waiting on the credit to return.

With plants in nearly every state, the US biodiesel and renewable diesel industry supports more than 60,000 jobs, paying more than $2.5 billion (€2.2 billion) in annual wages and generating more than $11 billion (€9.8 billion) in economic impact. Every 100 million gallons of biodiesel production supports 3,200 jobs.

The US biodiesel market has grown from about 100 million gallons in 2005 to more than 2.6 billion gallons annually since 2016. The biodiesel tax incentive helps producers across the country continue to invest in capacity for future growth and can provide some certainty in the competitive and unpredictable worldwide liquid fuel industry.

Collectively, as an association and industry we urge Congress to ensure these American jobs do not disappear and provide the biodiesel sector the certainty it needs. The National Biodiesel Board (NBB) will continue our advocacy efforts and fight for a multi-year extension of the tax incentive.

NBB is also opposing the Environmental Protection Agency’s (EPA) proposed modifications to Renewable Fuel Standard (RFS) Renewable Identification Number (RIN) market regulation rules. We disagree with the EPA's proposal to modify RIN market regulations without showing data-based evidence of problems with the RIN market and feel the reforms are unnecessary. These modifications can disrupt the system that obligated parties use to demonstrate compliance with the RFS. We are asking for transparency to the small refinery exemption process to prevent manipulation in the RIN market.

The EPA has been granting an unprecedented flood of retroactive exemptions to the RFS volumes over the past several years. The RFS rules allow small refineries to petition for relief from RFS obligations if they are facing an economic hardship. But the EPA has encouraged nearly every small refinery in the nation to claim a hardship, and the agency has granted exemptions to nearly everyone that petitioned. These retroactive small refinery exemptions are destroying demand for over 360 million gallons of biodiesel and renewable diesel, which is devastating to our industry and those workers we support.

I have always said the biodiesel industry is not for the faint of heart. It has always been challenging and always will be. We are simply asking that the rules established by the federal government, the biodiesel tax credit and the RFS, that have been the cornerstone to the exponential growth of our industry, not be changed in the middle of the game. Our producers took these signals of support many years ago and invested their hard-earned money to grow production and add value to the supply chain. We just need to see those same strong signals and rules applied consistently going forward so those investments can continue and we can experience the growth in our industry that so many count on.

With these critical issues facing our sector, advocacy is the key. It takes more than one voice to make a larger impact. Together we are leading the challenge to make a better, stronger biodiesel industry in the future.
The Biofuels Conference provided a great venue to hear about the latest developments in technology and the progress made in legislation to increase the application of biofuels in the transport sector. The presentations covered a large spectrum giving the right blend to create unforeseen networking opportunities at the event.”

Laszlo Domokos, SHELL

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Biodiesel demand on the up in Asia as tariffs continue to impact US prices

Biofuel feedstocks Trumped

Biomass-based diesel has found its pricing fundamentals once again hostage to developments outside its control across the international markets, with US President Trump’s trade manoeuvring versus China once again the culprit. Ramp ed up tariff blockades between the US and China briefly sent vegetable oil prices careering towards their lowest levels in over a decade, before the appalling state of US Midwest farm fields after devastating spring flooding pulled the bean oil market back from the brink after a disastrously slow start to the soy planting season.

For biodiesel producers, weak inputs versus a mineral oil market fretting ramped up US sabre rattling against Iran have left margins in reasonable health, although demand has yet to hit its full summer stride on either side of the Atlantic. European buying interest however has been ramping up for late 2019 dates, as obligated fuel distributors try to position themselves against huge 2020 mandated demand uplifts, a sentiment which will be felt in the US to a smaller degree given legislated uplift in the revised Renewable Fuel Standard biodiesel mandate next year. With most major European blending markets already either at or close to the blend wall, demand has been shifting into the high greenhouse gas saving barrels. These minimise the physical blends needed to stay on track towards obligated consumption, offering succour to the waste-based UCOME markets into Q1 2019 at a time of year when they would normally enter a seasonal funk, thanks to their relatively poor cold properties. Chinese resupply costs meanwhile have been rising, while US waste feedstock suppliers grapple with a potential mortal threat to their business, which could rob the import-dependent European market of some 300,000 tonnes of low carbon intensity feedstock later this year.

In Asia, biodiesel demand is also climbing, thanks to demand for PME barrels for discretionary blending into China, as well as to meet Indonesia’s expanded domestic demand in light of its B20 mandate. Given worries that Indonesian exporters still may be unable to balance rising output, some are anticipating an accelerated rollout of an unprecedented 30% mandated biodiesel blend in Indonesia, a move that would almost certainly rob the international market of the surplus barrels Indonesia has been able to sell overseas since last year. In ethanol, the exploded hopes of a quick US re-entry into China for US exporters thanks to Trump’s tariff uplift has been mitigated by a European Commission ruling re-opening the arbitrage into the European market. Vessels have already been placed on the water in anticipation of the move, which has largely been priced into European T2 pricing calculations. Demand uplift for US barrels will be cramped by remaining European tariffs against undenatured ethanol, low blend walls, the continent’s crop cap and the poor greenhouse gas ratings awarded to much US corn-based ethanol in a market increasingly conscious of the need to reduce the carbon intensity of its fuel blends to maximise throughput into conventional gasoline and diesel. US ethanol meanwhile continues to move to the Arab Gulf in size to satisfy demand for barrels to blend, based on economics alone, into the regional gasoline pool, an opportunity curtailed by the strict limitations on ethanol content in most regional gasoline specifications.

For more information:
This article was written by Matthew Stone, managing director at PRIMA. Please contact enquiries@prima-markets.com

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Producers margins for soy methyl ester (SME) biodiesel at US plants continue to move sharply higher amid a bulging supply of feedstock, although spot SME biodiesel prices were easing in the US midway through the second quarter, due to abundant inventory following a very cold winter that kept a lid on sales growth.

A lot of product remains in storage, which needs to be flushed out to support higher production rates. Demand remains steady, but excess inventory has dampened spot values. Delayed statistics from the Energy Information Administration (EIA), the data and analytical division of the US Department of Energy, show B100 inventory ending February at 73 million gallons, 13 million gallons above the previous year period, with stocks in January climbing 24 million gallons to 68 million gallons.

Production of biodiesel was up 21 million gallons during the first two months of 2019 at 274 million gallons against the comparable period year prior, and 87 million gallons above the same two months in 2017, according to EIA data.

Sales of pure biodiesel or B100 totalled 244 million gallons in January-February, but were only 6 million gallons above the first two months of 2018, although a sizeable 87 million gallons above the 2017 sales pace. Considering implied distillate demand during the first two months of the year at 172.7 million gallons per day was 1.86 million gallons per day, or 1.1%, above the same period in 2018, blending demand for B100 should have been higher. EIA data does show a modest increase in blending demand this year, which accounted for 149 million gallons of B100 sales during the first two months of this year, which was 11 million gallons more than in 2018 and 65 million gallons above the 2017 blend-in rate. B100 sales totalled 1.579 billion gallons in 2017, of which 924 million gallons were blended in petroleum-based diesel fuel, increasing to 1.858 billion gallons in 2018, with 1.093 billion gallons blended. For both 2017 and 2018, blending demand accounted for 59% of B100 sales.

Distillate demand growth against the previous year slowed late in the first quarter and reversed roughly midway through the second quarter, which could inhibit blending demand. Should US economic growth, which sizzled at a 3.2% annualised growth rate in the first quarter, according the Bureau of Economic Analysis, continue, blending demand should pick up pace.

Stricter sulphur regulations for marine fuels that take effect on 1 January 2020 could add a fillip for biodiesel demand later in the year and into 2020. The reduction in marine fuel sulphur requirements from 3.5% to 0.5% in ocean-going vessels globally under International Maritime Organization regulations requires producing a bunker fuel with equivalent specifications to on-road diesel. As such, prices for diesel fuel are increasing as suppliers scramble to ensure an adequate supply of compliant fuel to meet the new mandate. According to the International Energy Agency, marine vessels use about 4.3 million barrels per day of marine fuel, about 4% of global oil demand.

Regarding logistics, getting product to market has normalised according to trade sources, following extensive flooding in the US Midwest this year due to heavy rains exacerbated by melting snow.
following record snowfall. The Missouri and Mississippi rivers continue to swell however, frustrating the agriculture sector.

In addition to miserable weather in the Midwest, protracted trade tensions between the US and China have hit US growers of soybeans exceptionally hard. China was by a wide margin the largest importer of US soybeans in the world before the trade dispute. In retaliatory tit-for-tat acrimony, tariffs were lobbed by Washington and Beijing at the other’s imports, with soybeans an early target by China. Beijing imposed a 25% tariff on soybeans from the US, with Brazil now a major soybean exporter to China. News indicates Beijing will lift tariffs on US biodiesel exports from 10% to 25% amid the latest trade skirmish.

The US Department of Agriculture is projecting record inventory of soybeans that, along with a steep drop in buying from China, has pressed cash soybeans to near their lowest price point since 2007. Soybean futures that trade on the Chicago Board of Trade plumbed a better than 10-year low mid-May, recovering after US President Donald Trump said the federal government would assist farmers hurt by the trade impasse with federal aid.

Soybean oil remains the top feedstock for biodiesel production in the US. Data for the first two months of 2019 suggest soybean oil is growing its share in biodiesel production, accounting for 60% of output, according to EIA data. That compares with a 56% share for January-February 2017 and 53% share in early 2018, with the uptrend for soybean oil-produced biodiesel emerging in the latter part of last year.

EIA expects biodiesel production to average 5.59 million gallons per day this year, up 105,000 gallons per day, or 11.7%, against the 2018 output rate, increasing another 9% to 6.09 million gallons per day in 2020.

US imports of biodiesel and renewable diesel declined 42,000 barrels per day in 2018 from 2017 to 22,000 barrels per day, or 924,000 gallons per day, the second straight year with a drop in imports, which are down 64% from 2016 when they set a record. Declining US imports follow import duties imposed on supply from Argentina and Indonesia, which accounted for 60% of the imports in 2016. “When [Department of Commerce] announced its anti-dumping and countervailing investigations in March 2017, US imports of biodiesel from Argentina decreased from 29,000 barrels per day in 2016 to 19,000 barrels per day in 2017 and fell to zero in 2018. Indonesia did not export any biodiesel to the United States during 2018,” the EIA said.

When stripping out renewable diesel, US biodiesel imports averaged 11,000 barrels per day, or 462,000 gallons daily, in 2018, down 58% from 2017 and 76% from 2016. Canada exported 5,000 barrels per day to the US in 2018, with 6,000 barrels per day of US biodiesel imports originating from Europe.

For more information: Brian L. Milne is the energy editor with DTN, an independent, trusted source of actionable insights for 600,000 customers focused on feeding, protecting, and fuelling the world. Customer-centric and employee-driven, DTN focuses on empowering agriculture, oil and gas, trading, and weather-sensitive industries through continuous, leading-edge innovation. DTN is based in Minneapolis, with offices globally.
Despite challenges, the future for the US renewable fuels industry remains bright

**US ethanol ‘roller-coaster’ faces a big year**

by Colin Ley

There’s really no escaping international politics in the US at present, especially for businesses with softening domestic opportunities and that had been looking towards customers in China as a good way to keep sales and prices moving in the right direction.

This is certainly the case for North America’s ethanol producers, who find themselves at the front line of US President Donald Trump’s determination to secure a fairer trading relationship with China and who seems to be prepared to conduct a lengthy tariff war, if necessary, to achieve his objectives.

Renewable Fuels Association (RFA) president and CEO, Geoff Cooper, in recounting the US industry’s roller-coaster ride in selling ethanol to China over the last few years, steered clear of passing an opinion on how the current tariff dispute is being handled, when questioned by *Biofuels International*. His summary of events, however, shows how much all sides of the present US-China trade war need to find a solution, and the sooner the better.

“We need access”

“Prior to the sabre rattling on trade that began two years ago when China suddenly imposed a 35% duty on US ethanol, China was the fastest growing export market for the US ethanol industry,” he said.

“In 2014, we weren’t exporting anything to China, but by 2016 it was our third-largest export market at 200 million gallons.

“Today, not a drop is flowing there because China increased its already-punitive tariff to 70% last spring, in retaliation to new US tariffs on Chinese goods.”

Adding that reopening the Chinese market remains a top priority for US ethanol producers, Cooper continued: “Our industry ramped up production capacity with the expectation that exports to China would continue to grow. That excess supply, of course, backed up in our market when China closed its doors.

“In the longer term, the opportunity in China is enormous, as the country remains committed to transitioning to E10 nationwide as a way of addressing their air quality concerns. But we need access.

“As the US ethanol industry
suffers from softer domestic demand and an oversupply, building robust international markets, like China, is more important now than ever before.”

The Canadian view
Responding to similar questions on the impact of President Trump’s latest tariff moves, as viewed by the ethanol industry in Canada, industry consultant Jim Grey said he was really struggling to find any positives in the current situation.

“The Canadian ethanol market is priced out of the Chicago exchange and effectively follows the US trade, which has obviously been dramatically impacted by the US-China trade issue,” said Grey.

“From an ethanol perspective, it’s hard to imagine there are any positives at all about this trade war. Hopefully, therefore, it will get resolved in the not too distant future,” he continued.

Canadian producers already had enough on their hands, of course, before the latest escalation of the US-China dispute.

A terrible spring
The industry’s biggest problem, although hopefully a climate one-off, is due to corn growers being hit by a poor and wet spring this year, following on from a very bad crop year in 2018.

After struggling throughout the growing season last year, Canadian farmers were then hit by the development of toxins as the crop matured, a fact which made the dried distillers’ grains end of their business less attractive to livestock feed buyers. This inevitably hit total returns for processors.

“As for now, after a simply terrible spring, farmers are still waiting to plant their 2019 crops,” said Grey, adding that it remains to be seen how much impact this will have on new season ethanol production.

Federal and provincial positives
Not that it’s all bad news for the North American ethanol industry. Staying with Canada for the moment, there are positives to be taken from political developments at both federal and provincial levels.

“Our federal government is continuing to work towards introducing the country’s Low Carbon Fuel Standard, complete with the aim of reducing carbon output from the transport sector by 23 mega-tonnes,” said Grey, adding that the first draft of the new standard is expected to be released ‘very shortly’.

“The only way a carbon reduction of that kind could be achieved, of course, is through a major increase in the use of renewable fuels, which has to be a positive for the ethanol industry.”

It also needs to be pointed out, however, that Canada has a federal election looming within the next six months, with the jury definitely still out on whether or not the current administration will secure a fresh mandate. That could delay the country’s low carbon plans a little, although observers don’t think the ultimate carbon reduction goal would be harmed by a change of government.

E15 developments
On the provincial government front, meanwhile, Ontario is set to move towards a 15% ethanol blend by 2023. This compares with 5% at present, with the local administration already heading towards 10%.

“What the industry needs more than anything else is increased consumption,” said Grey, adding that Ontario’s E15 move will certainly help.

Signs of progress towards E15, at least for sale in the summer months, is also boosting market expectations in the US.

“The RFA has been working to secure parity in the way all ethanol blends are regulated since the EPA [Environmental Protection Agency] first began considering E15 approval nearly a decade ago,” said Cooper. “It has been a long fight, so we are pleased the agency is finally poised to provide a waiver allowing E15 to be sold in the summer months.

“However, we are also realistic with our expectations and realise it will take a while before E15 becomes as ubiquitous in the US gasoline market as E10 is today.”

While agreeing that it’s difficult to project how quickly E15 will “take flight” in the US market, Cooper’s ‘conservative estimate’ was that a year-round Reid vapor pressure waiver would create approximately 100 million gallons of new ethanol demand in the first 12 months following such a development.

Prospects remain incredibly bright
“Despite current policy and marketplace challenges, the future for the US renewable fuels industry remains incredibly bright,” Cooper added.

“For the first time in almost a decade, we’ve seen three or four new corn ethanol plants begin construction or start production in the last year. Some new capacity is also being added through expansions, although most of the industry’s recent incremental growth has come through efficiency gains at existing plants.

“Ethanol producers also continue to adopt new technologies that are making them more efficient and have removed bottlenecks throughout the process as a result.

“Ultimately, of course, ethanol remains a phenomenal product that has two unique properties that are indispensable; namely an extremely high octane and the ability to reduce carbon emissions.

“Carmakers around the globe are calling for higher octane fuels and governments around the world are taking action to reduce GHG [greenhouse gas] emissions from transportation. Ethanol has a central role to play in meeting both of those objectives.

“As such, ethanol’s low-carbon and high-octane attributes mean it will continue to have a growing role in the world’s liquid transportation fuel supply. But we need stable and certain policy to ensure ethanol is allowed fair access to these markets.

“While the industry faces a slew of near-term marketplace and policy challenges, I have no doubt that better days lie ahead.”

Investors are still out there
Grey, who was chair of the Board of Directors of Renewable Industries Canada until eight months ago and who is now applying his 40 years’ experience of the industry to a broad range of commercial projects, also ended on a definite up-note.

Asked to assess the level of investor interest in the industry at present, he said he believed that investors were ‘still out there’, although many were maybe keener today to commit to specific renewable fuel areas than in the past.

“I don’t think investors in general are that interested in first generation ethanol anymore, but they are still committed to renewable fuels in general,” he said.

“Developers in the biodiesel and drop-in renewable diesel sectors are likely to be the main winners, for example, in the current funding game.

“Biojet fuels also appear to be in prime position for significant growth and investment at present. They’re the bright stars currently and are certainly ahead of corn ethanol at the moment.”
Numerous biodiesel production facilities have been built in Europe over the past few years and KSB has been a key supplier, having installed several thousand pumps. The different processes employed to produce biodiesel all involve transesterification of oils and fats. In principle, the overall process for the production of biodiesel can be divided into three stages: it takes place without any pressure and at low temperatures, but each stage requires pumps specifically tailored to the particular requirements of the process.

**Standard water pumps and standard chemical pumps**

In the first stage, metal pumps with shaft seals are used to handle the feedstock. Standard chemical pumps, or pumps with standard hydraulic systems designed for water applications, can be used for this purpose. Both pumps function in the same way for this application, and the pump type selected is largely based on the biodiesel plant operator’s background: operators from the chemical sector are most likely to opt for a standard chemical pump, while investors with no chemical history will instead choose a lower cost pump with standard hydraulic system for water applications.

**No emissions: seal-less pumps**

For the second stage, special pumps are required to handle/recover methanol. In Germany, this process has to comply with the German Clean Air Act (TA Luft). Therefore, pumps used must feature a high level of tightness to prevent larger volumes of methanol or catalyst leakage. Standard chemical pumps – if provided with a double mechanical seal – may also be used at this stage, but this involves higher costs and more maintenance. Leakage can be avoided by using seal-less pumps, with magnetic drive pumps commonly employed as they offer the advantage of having only two static seals, ensuring a high degree of security against leakage.

**Pumps in duplex steel design for aggressive fluids**

High demands are placed, in particular, on the materials of pumps used in purification columns. Depending on the process, aggressive acids are used to separate water and glycerine from biodiesel, with the pumps partly exposed to pure hydrochloric acid. Special high-quality material must be used for the pumps as plain cast iron will not exhibit sufficient resistance to acids over the long term. In comparison, pumps made of cast super duplex stainless steel are resistant to even the most aggressive of fluids. The pumps installed in the corrosive environments of purification columns are therefore made of duplex steel. This material is resistant to all fluids containing chloride, including hydrochloric acid.

**Non-clogging impeller pumps resist abrasion**

The third stage in the biodiesel production process, the removal of glycerine, is yet another significant challenge to pump technology. At this stage, salts with a concentration weight of 35%, and partly present even in crystalline form, are separated from the fluid. In order to resist the abrasion caused by the crystalline solids, non-clogging impeller pumps are used. These centrifugal pumps in close-coupled or back pull-out design are specially designed for the handling of corrosive and abrasive fluids containing slurries. If necessary, the duplex steel used for the pumps can be subjected to a subsequent heat treatment to further increase their wear resistance.

**Growing market for bioethanol**

Over the past few years there has been a significant growth in the number of...
bioethanol refinery plants being built. The process can be divided into the ethanol production (fermentation) itself, ethanol purification and stillage treatment – a process that principally takes place in any brewery.

Europe’s main feedstocks for bioethanol production are cereals and sugar beet, which are ground and mixed with water. The mixture is then pumped to mash columns where the fermentation takes place. At this stage, non-clogging impeller pumps are again used to ensure safe handling of the solids-laden fluid. Because of the fluid’s high viscosity, the pumps require large impeller passages and correspondingly robust bearings.

**Keeping noise emissions down**

Once again, standard chemical pumps are used for the process following fermentation. They are designed to withstand temperatures up to 180°C, whereas standard water pumps can only be used up to approximately 120°C. Water plays an important role throughout the process, with an average of 1.5–2 tonnes of water produced through evaporation from every tonne of cereal. Consequently, pumps with standard hydraulic systems for water applications are normally used. To provide for the large flow rates required for cooling, cooling water pumps are also used. These are pumps usually designed for the handling of cooling water in power plants. They deliver up to 2,800m³ of water per hour, allowing for sufficient and fast cooling after the distillation phase.

In Germany, seal-less pumps with magnetic drives are typically used for alcohol storage tanks, as ethanol also falls under the provisions of the German Clean Air Act. Moreover, thanks to their drive concept, the seal-less pumps are particularly quiet when running, which is a great advantage given that ethanol production equipment is usually installed in the open air. With a view to applicable emission control regulations, it must therefore be ensured that noise emissions are kept low.

**Food approval**

A special characteristic in the production of bioethanol is that the plants must, at least in part, meet applicable food contact regulations. This means that the pumps must also comply with US Food and Drug Administration standards, which is why they are made of stainless steel. Another characteristic is that many operators wish to mount the pumps on feet made of stainless steel, so that the floor underneath can safely be hosed down with water without affecting the pumps.

**Pump technology for the fuel of the future**

As developments take place that allow a wider range of biomass feedstocks to be used for biodiesel or bioethanol, new processing technologies are emerging that are a challenge to the pump industry. The high temperatures and aggressive fluids experienced in the production of biofuels place special requirements on the materials used for the pumps, with pump manufacturers such as KSB developing products to meet these demands.

For more information:
This article was written by Christoph Pauly, press officer at KSB.
Visit: www.ksb.com/ksb-en

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Imagine giving your living room a makeover using a bright new coat of paint – made from rubbish. Fiction? Not anymore. As countries around the world look for ways to transition from a linear economy – in which we take, make, use and dispose – to a circular economy – where we reduce, reuse and recycle – one innovative Canadian start-up has come up with a revolutionary idea: to develop and commercialise a disruptive technology that uses an abundant resource available everywhere – non-recyclable waste – as a resource to manufacture renewable chemicals.

Communities all over the world are struggling with the often huge challenge of waste management, and they are often desperate to find new ways to reduce waste sent to landfills and incinerators. More than 2 billion metric tonnes of waste is generated around the world every year. Despite the efforts and programmes introduced to recuperate materials that can be recycled or composted, more than 50% of this volume is still landfilled, creating environmental problems and generating methane emissions, which are 25 times more harmful than carbon dioxide (CO₂).

While governments are developing policies to address the need for more sustainable energy, including low-carbon transportation fuels, global consumer goods manufacturers are also putting pressure on leading chemical manufacturers to replace hydrocarbon-based products with renewable chemical alternatives to meet the demand of their own customers. However, the challenge to reduce waste remains. Enerkem’s disruptive technology can help address these pressing environmental issues and fulfil the growing demand for greener products, or a ‘cradle to cradle’ solution in consumer products.

The technology is an advanced thermochemical process that chemically recycles carbon molecules in waste into added-value products.

Enerkem’s waste-to-biofuel technology chemically recycles carbon molecules in waste into added-value products.
advanced biofuels  biofuels

Figure 1: A circular economy uses waste as a resource

An Enerkem employee performing a series of tests at the Enerkem Innovation Center in Westbury, Québec

For more information:
This article was written by Mick Kopis, communications and marketing advisor at Enerkem. Visit: www.enerkem.com

contained in waste into added-value products, such as renewable methanol and ethanol. It takes waste in less than five minutes to produce a synthetic gas, and convert it into advanced low-carbon transportation biofuel – enough to fuel over 400,000 cars on a 5% ethanol blend. In turn, biofuels also help reduce greenhouse gas emissions by approximately 60% when compared to fossil fuel production and landfilling. Today, this technology is helping the City of Edmonton in Alberta, Canada increase its household waste diversion rate from about 50% to 90%.

In Europe, driven by the demands of the circular economy, Enerkem is developing its first European project in the Netherlands, with a consortium led by AkzoNobel, Air Liquid, the Port of Rotterdam and Shell. The consortium, which has set up a dedicated joint venture company, has already undertaken extensive preparatory work, covering detailed engineering and the permitting process. It aims to take a final investment decision later in 2019 as it pursues development work and finalises the selection of an engineering and procurement contractor.

The planned facility will convert up to 360,000 tonnes of waste into 220,000 tonnes (270 million litres) of bio-methanol – a chemical building block that is used to manufacture a broad range of everyday products, as well as being a renewable fuel. This represents the total annual waste of more than 700,000 households and represents estimated CO₂ emission savings of around 300,000 tonnes, when compared to the production of methanol from fossil fuels.

The facility will be built within the Botlek area of the Port of Rotterdam using Enerkem’s proprietary technology, and will convert non-recyclable mixed waste, including plastics, into syngas and then into clean methanol for use in the chemical industry and the transportation sector. This is a departure from today’s processes, in which methanol is generally produced from natural gas or coal.

Innovative clean technologies can help communities create value and meet local waste diversion objectives. While reducing pollution and greenhouse gas emissions, Enerkem’s technology can help the world shift from a linear economy to a circular economy that uses waste as a resource to produce sustainable products (Figure 1).

Since 2000, Enerkem has tested and validated several different feedstocks – from solid waste coming from several municipalities to dozens of other types of residues. Its exclusive process is environmentally sound and requires relatively low temperatures and pressures, which reduces energy requirements and costs. The technology was rigorously scaled up from pilot to demonstration to commercial stage over a 10-year period. Following the successful launch of its first facility, the company is now seeking to leverage its carbon recycling technology expertise to help solve the ever-growing issues related to ocean plastics waste.

Last year, Enerkem engaged in discussions with the Ocean Legacy Foundation, a Canadian non-profit organisation that carries out coastal clean-up expeditions, to explore ways in which soiled plastics can be recuperated from oceans to produce low carbon transportation fuels and chemicals, using the company’s technology.
New technologies for biowaste valorisation

Across the European Union (EU), the majority of urban waste produced, around 487kg per inhabitant and a total of 300 million tonnes per year in the EU, is still disposed of through landfilling (24%) or incineration (27%), with less than half (47%) recycled or composted. [1] Biowaste comprises around 30 to 50% of urban waste, being a complex and heterogeneous mixture, formed of a variety of waste streams including organic material from municipal solid waste (OFMSW), sewage sludge, HORECA (food service industry), pruning, garden waste, etc. Considering that around 100 million tonnes of biowaste is produced every year, the total cost of managing this waste is estimated to reach €143 billion. The need for additional management and comprehensive valorisation efforts throughout the entire supply chain is therefore essential, so that this type of waste can be categorised as a resource. Moreover, we must develop new technologies to serve as alternatives to current management systems, such as landfilling, energy recovery through the production of biogas and composting for agricultural use.

In order to support the most adequate management and valorisation routes of urban biowaste, the Biomass Department of the National Renewable Energy Centre of Spain (CENER) is aligned with and supports the need to move towards a circular bioeconomy, in which society is capable of valorising the wastes produced in an integral and cascade way. CENER is currently involved in four ongoing R&D and demonstration initiatives in cooperation with other European companies and institutions. A summary of the objectives and preliminary results obtained by CENER in European Horizon 2020 projects (PERCAL, SCALIBUR and NextGenRoadfuels), and the regional Urban Biorefinery project in Navarre, northern Spain, is presented below. All of the projects show promising routes for urban biowaste valorisation by means of biorefinery concepts into biobased products and advanced biofuels, and an encouraging opportunity for joining the waste and production sector in a future circular bioeconomy.

Supporting the valorisation of bioresidues, the SCALIBUR demonstration project [2] (H2020) aims at closing the gap between technological feasibility and industrial applications of urban biowaste valorisation by enhancing strategic cooperation between sectors. In the framework of this initiative, which promotes the valorisation of different biowaste materials such as OFMSW, sewage sludge or HORECA wastes, CENER leads the pathway related to OFMSW valorisation; executing the enzymatic hydrolysis and fermentation in its BIO2C – Biorefinery and Bioenergy Centre demonstration plant [3] (TRL7), for a later production of biopesticides and biobased polyesters. CENER will also develop a comprehensive environmental assessment of the entire valorisation process. Also at the European level, PERCAL research and innovation project [4] (H2020-BBI) will be highlighted, the main objective of which is to exploit OFMSW as feedstock to develop intermediate chemical products at high yield and low impurity level with considerable industrial interest, such as lactic acid, succinic acid and biosurfactants. In particular, CENER is leading the research line of biosurfactants production by valorising the fermentation by-product remaining after bioethanol, succinic acid and lactic acid production. The hydrolysis and extraction of both protein and lipid fractions contained in the fermentation by-product and their use for the synthesis of the biosurfactant, which is validated by the industry, are the main pillars of the research.

Moving towards other biowastes such as sewage sludge, the NextGenRoadfuels research and innovation project [5] (H2020) aims to prove the hydrothermal liquefaction technology pathway as a viable, sustainable and efficient route for production of liquid drop-in fuels for road transport, using low value aggregated urban wastes such as feedstock. For this project, CENER leads the research line related to the challenge of handling feedstocks with high organic nitrogen content. To overcome this barrier, firstly a pretreatment of feedstock using a mild and low temperature enzymatic hydrolysis with enzymes is executed. Secondly, extraction and purification...
processes are undergone for protein-derived amino acid and peptides valorisation.

At the national level, the Circular Urban Biorefinery in Navarre project, funded by the Regional Government of Navarre (Spain), is designing a new concept of integral and cascade valorisation of the different fractions that make up OFMSW to obtain bioproducts with greater added value. Going into more detail, CENER is developing processes for OFMSW fractionation, and carboidate, protein/lipid/ lignin fraction valorisation through a variety of biochemical and chemical processes, subsequent optimisation and upscaling, and upstream/downstream processes for the separation and purification of fractions. The ultimate objective is to obtain products such as bioplastics and their precursors, specifically polyhydroxyalkanoates (PHAs), and succinic acid, biodiesel, amino acids, bio-fertilisers and bio-stimulants, amongst others.

Interesting results have been obtained to date during this project. Samples of OFMSW waste from the fifth container (organic fraction) have been characterised. These samples were supplied by the Waste Collection Service of the District of Pamplona (Navarre) following a preliminary screening stage at the source. The initial work has been focused on determining the protocols for the treatment and handling of the waste, in order to minimise the action of microbial contamination, which is inherent in the nature of this material.

The protocols developed at this stage will subsequently be applied and adapted on an industrial scale. After this stage, the compositional result showed total lipids and protein contents of over 10 to 15% (w/w), meaning that these are fractions that can be recovered and valorised. The most appropriate methods and solvents for the recovery of the lipids fraction are being studied, while the first assays on the protein fraction have already been carried out using protease enzymes, and therefore, the first amino acid profiles have been obtained.

Regarding carbohydrates fraction, the OFMSW soluble sugars content ranges between 10 to 20% (w/w), making it important to focus on raw material stabilisation and conservation methods. The result of the characterisation of the different samples show glucan (mainly in the form of starch) contents of between 15 to 30% (w/w) of the composition. Therefore, the sugar potential of this waste is adequate as a carbon source for the production of bioplastics and their precursors, or to obtain building blocks through biochemical and/or biotechnological synthesis. Afterwards, in order to recover the sugars from OFMSW, enzymatic hydrolysis assays were performed with total solids content from 10 to 20%, obtaining a result of between 30 to 60g/L of sugars. Besides, the liquid fraction obtained from OFMSW hydrolysates is used as culture medium for the screening of microorganisms capable of producing PHA or succinic acid. The lignin can account for up to 10% (w/w) of the composition, with 90% being insoluble acid. Finally, it must be pointed out that this material contains a high quantity of extractives, and inhibitors were not detected.

It is important to emphasise that in all its developments, CENER carries out a global environmental assessment of the entire recovery process, through life-cycle assessment, as well as technical and economic feasibility studies.

The preliminary results of these initiatives show promising routes for urban biowaste valorisation by means of biowaste-refinery concepts into biobased products and advanced biofuels. Indeed, further research and demonstration activities are being executed and will be released in the coming years. With these and other upcoming initiatives and European level cooperation, CENER is developing technology to obtain new recovery paths for organic waste, on both laboratory and demonstration scales, for subsequent implementation on an industrial scale and launch into the market. In this way, CENER is contributing to the Circular Economy Action Plan proposed by the European Commission, and also to the wellbeing of society.

References
2. SCALIBUR demonstration project, http://www.scalibur.eu
4. PERCAL research and innovation project, http://www.percal-project.eu
5. NextGenRoadFuels research and innovation project, https://www.nextgenroadfuels.eu

For more information:
This article was written by Goizeder Barberena, biomass strategy and business development manager at CENER. Visit: www.cener.com
Understanding the changes to California’s Low Carbon Fuel Standard (LCFS) verification process is important for all ethanol and biodiesel producers, even if you do not currently sell fuels in California. Several other regions around the world are in various stages of planning to incorporate carbon impact scoring into their transportation fuels legislation. As a result, awareness of the LCFS procedures required to comply with carbon-impact verifications will help you stay competitive in the global marketplace, as you set long-range plans for your facility.

As of now (effective 1 January 2019), the new GREET 3.0 model applies to all new pathway applications. Current GREET 2.0 pathways are valid until 31 December 2020 and must be transitioned by this time to registration under the 3.0 model. All 2019 validations (for pathways under both models) are still performed directly by the California Air Resources Board (CARB), using their previously established validation procedures, but this is about to change.

From 1 January 2020, pathway validations and subsequent compliance verifications will be completed by independent parties known as verification bodies (VBs). Throughout 2020, every producer with a current or planned GREET pathway will need to select an accredited VB to perform validations for new pathways, as well as verification procedures to ensure compliance with the requirements for their pathways. These accredited VBs must be approved by CARB before you can begin working with them, so it is essential to allow plenty of time to obtain this approval before deadlines approach.

These new requirements use some new or redefined terminology, so a few definitions may be helpful to understand what they mean. Firstly, let’s go into a little more detail about verification bodies. VBs are firms accredited by CARB which will perform validations and verifications under the new process – these firms are essentially auditors. The VB team will consist of both financial and engineering professionals, to ensure compliance with all accounting and operational requirements.

Which firms are accredited as VBs? The short answer at the moment is none. The accreditation process for VBs is not complete; final training for providers who wish to offer VB services will begin this summer. A list of accredited providers will be available in September or October 2019. At that point, producers can and should review the list to select a provider. Keep in mind that your VB is not allowed to have any conflict of interest items with your organisation, to avoid concerns about impartiality.
in reviewing your data and other materials. This conflict of interest policy is very strict, and your relationship with a VB must be free of any conflict of interest for the previous five years. However, in order to give producers and VBs plenty of time to comply with this policy, certain high conflict activities may be granted a waiver for the first three years, so you’ll want to talk with your shortlisted providers if you feel you may have a conflict of interest. They will be able to tell you if your particular conflict is on the waiver list. CARB will need to approve your VB selection; they will also review conflicts of interest, so expect the approval process to take some time, and start early.

Next, what exactly is a validation? Validation is a review of the pathway application for acceptance (new pathway application or an existing pathway you wish to convert to the new version of the GREET model). As mentioned, all pathway validations will be performed by VBs beginning 1 January 2020.

Once your pathway validation is completed, you’ll need to prepare to provide data for your first verification. Verification is the ongoing review of required reports submitted to CARB; this can be compared to an audit. Those who are familiar with the Renewable Fuel Standard (RFS) attest process may find the processes are similar, but LCFS verification is much more detailed. Validation (pathway application) and verification (annual or quarterly reporting) procedures are essentially the same. Site visits to each facility by a lead verifier once a year are required (and to the central records location for the facility, if this differs). A site visit encompasses reviews of your accounting procedures and systems, as well as the equipment used for production and measurements. Supporting evidence for your reporting will be reviewed, and financial transactions will be examined for completeness and accuracy. Interviews with your key personnel responsible for reporting and tracking will be conducted, and all equipment and systems used for production, measurements and accounting will be observed. The goal of the site visit also includes ensuring that the reviewer understands your data management systems and processes, and assessing conformance with measurement accuracy. This comprehensive process must be conducted once a year, between March and August.

A sampling plan is also a required part of the verification and validation process; this plan is very similar to the process completed in preparation for a financial statement audit. Supporting documentation for your operating data and statistics will be examined to ensure accuracy and completeness. The data checks themselves focus, as you might expect, on data for any operations which have a high degree of uncertainty, or which have the largest impact on greenhouse gas emissions. The VB will trace the data to its origin, review the data collection procedures and calculation methodologies, and recalculate results and your carbon impact (CI) score for the two-year period, to compare with the data you have submitted and check for discrepancies.

The end result of the verification process is the verification statement. This is a final report that includes an opinion provided by the VB. The opinion can be one of three options. ‘Positive’ means that no material misstatements exist in the reporting. ‘Qualified Positive’ means that no material misstatements exist, but there are some errors that cannot be corrected. The final option, ‘Adverse’, means that material misstatements exist that affect CI. An ‘Adverse’ opinion on the verification statement disqualifies a plant from generating credits.

Note that although the VB verifies that the calculations performed to compute your CI score are correct, it does not actually compare against the requirements of your pathway. CARB will still complete that portion, so just because you get a ‘Positive’ verification report from your VB, this does not mean the approval process is completed. The data required for verification will encompass the two-year period prior to the verification date, so the first verification data under the new model will cover 2019–2020 data, and the verification statement for that period will be due 31 August 2021.

By now, you should have determined potential advantages under GREET 3.0 and decided when to make the shift to the 3.0 model. Whether you have determined to submit early or at the deadline, you should set plans in motion to develop a monitoring plan. Ethanol producers that utilise an EP3 under the RFS are already familiar with the compliance monitoring plan for that programme; this monitoring plan is similar. The monitoring plan outlines all the processes, procedures and equipment that your plant will use to collect your source data, how you will store that data and which documents should be reviewed to ensure that the VB has a comprehensive view of your plant’s data. The monitoring plan does not need to be turned in to CARB; however, it does need to be provided to your VB when you are ready to have them begin work, so you will want to start work on preparing it now if you have not already done so.

One final point to consider is whether you wish to complete verifications annually or quarterly. If you already do Renewable Identification Number attest procedures quarterly, you may find that incorporating the additional work of quarterly pathway verification into this workflow is more efficient. If you wish to do this, you’ll want to check the list of accredited verification bodies and select one as soon as it comes out in fall of 2019. ●

<table>
<thead>
<tr>
<th>LCFS key dates</th>
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<tr>
<td>September-October 2019</td>
<td>Accredited verification bodies list available – time to choose a VB and begin approval process</td>
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<tr>
<td>1 January 2020</td>
<td>Verification bodies begin performing pathway validations (no longer done by CARB)</td>
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<td>31 December 2020</td>
<td>Last day that GREET 2.0 pathways are valid</td>
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<tr>
<td>1 January 2021</td>
<td>All pathways must be GREET 3.0</td>
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<tr>
<td>31 August 2021</td>
<td>First verification statement due (2019–2020 data)</td>
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For more information: This article was written by Kari Buttenhoff, manager at Christianson PLLP. Visit: www.christiansoncpa.com
Lallemand offers a brief insight into the ever-changing world of industrial enzymes for alcohol production

An open door for innovation

What do enzymes do? Why do we need them?
Enzymes can be defined as any of a group of complex proteins or conjugated proteins that are produced by living cells and act as catalysts in specific biochemical reactions. What exactly are enzymes? So enzymes, despite ‘doing things’ in our process, are not living organisms, but they do come from living things. Typically they are a form of protein sourced from bacteria, fungi, or even plant based. Enzymes are biocatalysts (they increase the rate of biochemical reactions) that continue to function away from their host organism from which they are isolated. Each enzyme functions to increase the rate of specific biochemical reaction, similar to a lock and key, one enzyme for one reaction. So while not living, they do have environmental conditions in which they operate best, as well as conditions that they can be deactivated or ‘denatured’, especially temperature and pH.

Enzymes are important because they are utilised in many different applications. For example, they are used in home food preparation, household laundry detergents for stain removal, starch breakdown, etc. The type of enzyme(s) used depends on the type of reaction needed and the final product(s) desired. Enzymes are used in the fuel/beverage alcohol production process. Fuel ethanol facilities usually purchase their enzymes for specific parts of the process based on the feedstock used and conversion required, while most potable distilleries will use naturally occurring enzymes that are produced during grain processing (i.e. in barley malting). Before widespread enzyme utilisation in ethanol production, changes in process parameters, such as high heat or pH, were used to control reaction conditions. This type of process was not as efficient as the enzymatic process. To get ethanol from glucose, 12 enzymes are needed to function properly and at the right time to create alcohol. Simply put, enzymes are essential for alcohol production.

If you look at things from a yeast cell perspective, they need simple sugars (glucose) to be able to convert them into alcohol and carbon dioxide. The key to a good fermentation, which is the goal of any production facility, is to make the most amount of alcohol possible in the most efficient manner. If we look at the beginning of the process, dextrin formation, the most commonly used enzyme is called alpha-amylase (commonly called AA enzyme, or just AA). This enzyme is used for two things: to help water get into the exposed starch in your cooking process and to help break down starch to dextrin chains (chains of glucose molecules). After cooking/mashing, we cool and move to fermentation, at which point another key enzyme is added: a glucoamylase (commonly called GA enzyme, or just GA). This enzyme is what generates the consumable sugar for the yeast. The GA works by selectively ‘snipping’ or breaking bonds of dextrin chains to generate glucose as the targeted endpoint, but also maltose and maltotriose. The type of yeast strain will determine if all those sugar types can be used. From a yeast cell view, it will consume what it is equipped to do so and will not care what ‘brand’ of enzyme you use, just if it can utilise what is produced.

The last section of enzymes are those that can generate nutrition for the yeast from the mash itself. The enzymes typically used here are called proteases. They don’t work on all starch based mashes as there must be a protein content for the enzyme to work with. Not all proteases are created equal, especially in the ‘eyes’ of the yeast cell. Proteases cleave proteins to amino acids and peptides, which the yeast use to maintain themselves, but can also free up protein bound nutrients that the yeast can use. These enzymes can also potentially free up starches/sugars that are protein bound, as well as possibly bumping yield. Remember that yeast can’t touch these protein bound components otherwise.

All of these enzymes are essential in alcohol production and must be utilised to get the most out of your facility. Enzymes have been around for a long time, however over time they have become very efficient and productive. Advances in technology have evolved from the mass production/processing of enzymes from dedicated facilities to that of having alternative protein producers such as yeast cells within your operating system that can

“Each enzyme functions to increase the rate of specific biochemical reaction, similar to a lock and key, one enzyme for one reaction”

In basic terms, enzymes for alcohol production can be broken down into three main categories. The first is mashing/viscosity reduction to hydrolyse starch and convert to smaller starch chains (dextrins); the second is converting dextrin chains to fermentable sugar (glucose, maltose, etc.); and the third is nutrition generation.
produce some of the enzymes needed in the process.

**How enzymes are made for industrial uses**

As we know, enzymes are produced by microorganisms (yeasts, moulds or bacteria) under controlled fermentations. Most industrially produced microbial enzymes are secreted. However, in some cases, enzymes need to be extracted or released after cellular lysis. Figure 1 illustrates the front end of a typical enzyme production process.

Enzyme production begins with an inoculated agar slant of the chosen organism, which is then grown up in increasingly larger (multiple) stages to generate a substantial amount of cellular biomass. Once that occurs, the biomass is inoculated into larger agitated and aerated fermentation vessels that are controlled for temperature, pH, oxygen, foaming and nutrient additions, to produce the desired enzyme. This process is fairly similar to an aerobic yeast propagation or typical alcohol (non-aerobic) fermentation. Industrial enzymes are usually sold as concentrated, partially purified, or stabilised products that are ‘bug’ free. This means that there are no living organisms in the final product. Usually the enzymes are filtered and marketed as a clear liquid, although in some instances a non-clarified preparation can be produced. This will often contain the soluble components of the production medium. These components will not adversely affect the activity or function of the enzyme and in some cases may help stabilise the produced enzyme. Enzymes are usually sold on an activity (enzyme unit) basis, meaning the rate of substrate conversion that the enzyme has per unit of weight or volume.

However, recent advances have made it possible to secrete enzyme proteins directly within the yeast cell during fermentation. The result is production during fermentation of needed enzymes, such as glucoamylase, as a portion of the total protein produced by yeast cells over the course of their lifecycle. This allows for delivery of a large fraction of the total enzyme requirement as needed to the point of application, without enzyme production having to be carried out in a separate fermentation process.

Lallemand was one of the first companies to commercialise this type of organism and introduce it into the US fuel ethanol industry in 2012. The first product to do this was TransFerm. This yeast had glucoamylase producing genes inserted into its DNA to produce a high level of cell-associated protein, in order to produce the enzyme required for starch breakdown and fermentation.

Many years of research and development went into making this type of organism. For example, an exhaustive search was conducted for genes coding for enzyme proteins with activities of interest from bacterial and other fungal sources. The pool of potential genes were reviewed for safety (non-toxic) and chosen for optimal environmental conditions, such as pH and temperature, in which the enzymes would be expected to be most highly functional. These genes were inserted into the genome of Saccharomyces cerevisiae strains and the strains were screened for the ability to efficiently secrete active enzyme protein from the candidate gene, without negative impacts to the fermentation performance or stress tolerance of the host strain. Screening allowed for selection of the best combination of enzyme type and expression in order to achieve high levels of enzyme activity produced during fermentation, while maintaining levels of fermentation performance expected by the fuel ethanol industry. Other companies have subsequently come out with enzyme producing yeasts in this market and the bar continues to be raised to reach the full potential in terms of yield and efficiency.

There is no telling what will come next, but with the door wide open for producing various types of enzyme proteins in ways other than traditional methods, one can expect many more innovative enzyme expression products in the years to come.

**“Industrial enzymes are usually sold as concentrated, partially purified, or stabilised products that are ‘bug’ free”**

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**For more information:**

This article was written by Craig Pilgrim, vice-president, marketing and product development at Lallemand. Visit: www.lbds.com
Enzymatic hydrolysis of pre-treated lignocellulosic feedstocks is one of the most complex enzymatic processes applied on production scale today. It is not the conversion of a single, well-defined substrate into a single product by a single enzyme, but the hydrolysis of multiple and variable substrates (cellulose and hemicellulose interconnected with lignin, all present in lignocellulosic feedstocks) by a cocktail of enzymes. Three chain reactions, each with several enzymes, have been identified for this hydrolysis. Each enzyme shackles in these chains is crucial, and an issue with only one of these shackles, such as inactivation or absence of a co-factor, will have a significant effect on the overall hydrolysis result (Figure 1).

The first chain of reactions is dedicated to hydrolysis of hemicellulose or xylan into mainly xylose and arabinose. Enzymes involved in this chain of reactions are amongst others acetyl xylan esterase, arabinofuranosidase, endo-xylanase and beta-xylosidase.

The second chain reaction starts with hydrolysis of glucan by endo-glucanase (EG), followed by cellobiohydrolase (CBH1 and CBH2) action and finally beta-glucosidase (BG) action, into glucose. This chain of reactions is especially efficient in hydrolysing amorphous glucan. The third chain of reactions is involved in the hydrolysis of the most difficult part of the substrate, which is described in literature as crystalline glucan, into glucose. This type of glucan is first opened by an enzyme called lytic polysaccharide mono-xygenase (LPMO). Next, the cellolibiohydrolases and beta-glucosidase finish the job by a further hydrolysis into glucose.

Research at DSM laboratories on different pre-treated lignocellulosic feedstocks, such as corn stover, corn fibre, rice straw, wheat straw, bagasse, cane straw, etc. has discovered that all these feedstocks contain a substantial amount of crystalline glucan (30 to 40% in most feedstocks), which can only be hydrolysed efficiently by cellulase cocktails that contain an LPMO-type enzyme.

Noteworthy is the fact that LPMO-type enzymes need oxygen and electrons for their activity. A shortage of one of them clearly leads to a decreased LPMO performance and consequently a lower degree of glucan hydrolysis. Investigations at laboratory scale have revealed that electron supply is secured by the presence of lignin degradation products resulting from pre-treatment. These investigations also made clear that oxygen is abundantly present in incubations at laboratory scale in, for instance, shake flasks, however this is not the case at production scale. This is due to the enormous difference in the surface area/volume ratio between laboratory scale and production scale. In laboratory scale experiments, the surface area (where oxygen transfer takes place from the head space into the liquid) is large in relation to the volume, while this is very small at production scale (Figure 2).

Other aspects that facilitate oxygen transfer are mixing (normally much better in laboratory scale experiments) and the filling...
level of the reaction vessel (less head space and consequently less oxygen available on production scale due to asset utilisation).

In practice, the oxygen requirement is bigger than visualised in Figure 2, because degraded lignin in pre-treated feedstock gets easily oxidised and consumes significant amounts of oxygen. This auto-oxidation competes with LPMO for the available oxygen.

DSM has developed aeration technology at laboratory scale, and implemented and optimised dry matters and better usage of assets. In addition, lower viscosities give better heat transfer (cooling), mixing at low power input (good mass transfer for optimal hydrolysis) and better oxygen transfer (necessary for one of the enzymes in the cellulase cocktail as outlined above). Therefore, a good (hemi)cellulase cocktail not only results in high glucan and xylan hydrolysis yields, but also delivers a fast viscosity reduction. An example of viscosity reduction is shown in Figure 3.

A third important process aspect of enzymatic hydrolysis is microbial robustness, i.e. keeping out contamination as much as possible. Contamination is undesired, as lactic acid production and lower pH and higher temperatures are preferred to limit contamination and its negative effects.

An example proving that DSM’s cellulase performs well at high temperature is given in Figure 5, where hydrolysis curves are shown of pre-treated corn stover samples that had different severities in pre-treatment. The industrial challenge is not only to make it work on production scale, but for DSM it is also important to make a low cost and well balanced (hemi)cellulase cocktail applicable for multiple pre-treatment/biomass combinations. DSM has chosen to solve part of this challenge through its On-Site Manufacturing (OSM) of enzymes concept. The first OSM has been completed and is currently in its start-up phase. Through this concept, cost-effective whole broth enzyme production is feasible (using a local carbon source), which can be applied directly without any concentration, formulation or transport cost. This also means that this whole broth enzyme preparation may be somewhat less concentrated, but it avoids the yield losses that are inherent to ultra-filtration steps necessary for concentration.

It is clear that enzyme preparation does not only need to efficiently hydrolyse feedstock on laboratory scale, but also on production scale, and the process aspects related to that are key. The test results showed that growth coincided with lactic acid production and lower pH and higher temperatures are preferred to limit contamination and its negative effects. Contamination is undesirable, as lactic acid production by contaminants goes at the expense of valuable sugar and thereby ethanol yield. In addition, it may lead to downtime when extensive cleaning is required. Enzyme application conditions can help to limit contamination and its consequences. It is clear that enzyme preparation does not only need to efficiently hydrolyse feedstock on laboratory scale, but also on production scale, and the process aspects related to that are key.

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Figure 3: Viscosity reduction during the hydrolysis of pre-treated wheat straw

Figure 4: Results of challenge tests in enzymatically hydrolysed lignocellulosic feedstock

Figure 5: Hydrolysis of pre-treated lignocellulosic feedstocks at equal dry matter with different pre-treatment severities (Sekab = 0.75 combined severity factor (csf), M2 = 0.33 csf, M4 = 1.40 csf)
Showcasing the benefits of safety and production in cleaning ethanol evaporators

Automated tube bundle cleaning

You don’t have to look far to see that automation is an everyday occurrence in our lives. Your Keurig automatically brews you exactly eight ounces of coffee to start the day. Canary automatically activates your home-security system once you walk out the door. Pandora automatically picks your song of choice as you fight through rush hour. Your Ford sedan automatically parks itself once you arrive at work. If your java and music can be successfully automated to your liking, can your tools in the workplace function in the same manner?

As the importance of safety and production in the ethanol industry is being recognised, the need for automated tooling for cleaning is in high demand. The current process of cleaning ethanol evaporators, developed around high-pressure water, relies on the worker to clean by hand. This creates an extreme environment for the worker, who is:

- Physically holding the hose containing high-pressure water in his hands, and the sole source of delivering this high-pressure water from one tube to another.
- Constantly exposed to high-pressure water and hazardous working conditions.
- Faced with unavoidable worker fatigue accumulated through manual labour over a 12-hour shift, resulting in an inconsistent clean.

All of these problems can be solved by replacing the ‘hands-on worker’ with a ‘hands-free’ mechanised tool designed specifically for tube bundle cleaning. Standard solutions include a hose feeding device paired with a navigating apparatus (commonly referred to as an ‘indexer’ or ‘positioner’) to locate from tube to tube in order to clean. With these systems, safety is achieved by removing the worker from high-pressure water exposure. In terms of production, the worker efficiency is multiplied due to the hose feeding devices being able to feed multiple lances at once. With the former hands-on worker now operating the mechanised tool, a single worker can now double or triple his work production. Finally, the unavoidable physical fatigue of the worker over a 12-hour shift is replaced by the consistent feed of the hose feeding device, providing cleaning consistency throughout the entire bundle.

As a whole, mechanised hands-free tooling successfully provides a safe and efficient solution to the generalised waterblasting industry by replacing a manual worker’s inconsistent physical performance with controlled mechanised consistency, and by removing the said worker from hazardous cleaning conditions. When applied to the ethanol industry, however, multiple challenges arise in this attempt to achieve automation and production in the same scenario:

- Vertical orientation of ethanol evaporators and the limited enclosed area in which to work is always a challenge due to limited means of transport and the small working area outside of the blast zone.
- 24-inch man-ways restrict the sizes of entry, thus requiring tools to fit within the confined walls and to be lightweight for transport and setup.
- Navigation of a standard indexing system that travels on the X/Y axes inhibits full bundle coverage, dictated by the axial lengths and the location of the lance guide positioners. Consequently, the tool must be relocated several times within the evaporator, with the tubes along the walls ultimately still being cleaned by hand.
- The single angle view of the ‘blast zone’, the direct area on the tube sheet where the cleaning is performed is another obstacle. Within a confined entry clean of an ethanol evaporator, a single ‘line-of-sight’ is the only available view for the operator through the man-way, limiting his view of the tool to one angle and not providing multiple visual opportunities.
- Steam, lighting, debris – the elements that hinder the line-of-sight over the cleaning shift, many which are unavoidable. The steam, which is released by the high-pressure water, has only the man-way for escape. With more steam being created than...
escaping, it creates a visual mask over the mechanised tooling, resulting in minimal sight when navigating from tube to tube to clean. In light of an optimistic approach to hands-free cleaning in the ethanol industry that has been stifled by these limitations, a unique approach has been provided by Terydon, a designer and manufacturer of hands-free and automated tooling for over 20 years. Due to the restrictions of incorporating hands-free tooling in ethanol evaporators, Terydon has focused on each category in order to provide a solution.

**Hands-free safety**

The Terydon system uses an Android touch-screen tablet as its command surface to control the system. Through a standard Bluetooth wireless connection, this allows the operator to:

- Actively control the tool installed within the confined entry, all while being located outside the man-way, removing him from the hazardous working area known as the ‘blast zone’.
- Eliminate all cables and hoses through wireless control, which hinder the restriction of movement. This also limits the risk of slips, trips and falls.
- Control left/right/up/down navigational movements, as well as adjustable feed forward and reverse of the hose feeding device, all within the user-friendly app on the tablet.
- Signal the on/off control of the high-pressure water at the tablet, eliminating an additional worker that would typically control this feature.

**Increased production**

Terydon has developed all of its tooling with safety as its fore-most objective. However, where many see safety and production as conflicting objectives, the company has paired them to provide a safer and more productive solution:

- ‘Smart Indexing’, the branded term for Terydon’s Automated Indexing, allows the operator to automatically navigate from tube to tube by a single click of the button. This provides a consistent navigation that, much like the feed rate of the hoses, is reliable and accurate over the course of the cleaning process. This is the perfect solution for navigating with steam, low lighting and other ailments to the line-of-sight of the operator.
- With its patent-pending radial arm, the 3A Indexing System is capable of navigating to all the tubes along the walls so that a worker does not have to clean them by hand.
- With the incorporated radial arm, the 3A can clean 100% of the tubes within an ethanol evaporator while only having to relocate the indexer once.
- Software upgrades provided by Terydon for the Android app provides a data collection and recall feature, so that feedrates, percentage of clean, time to navigate, etc. can be applied to maximise efficiency.
- The 3A Indexing system cuts time when compared to an average indexing system. For example, when indexing between ¾-inch diameter tubes, the Terydon indexer requires 1.3 seconds for initial hole location and just 0.4 seconds to reach the next hole.

**User-friendly**

The 3A Smart Indexing system is easy to set up, with three easy-to-carry components that fit through a 24-inch man-way. It features a quick four-step teaching method to map the bundle pattern, and the user-friendly tablet interface is comparable to everyday use of smartphones.

For more information:
This article was written by Terry Gromes, automation specialist at Terydon. Visit: www.terydon.com
First-generation ethanol production has exhibited stable compounded annual growth for the last two decades, exemplified by the tenfold growth in production and fourfold expansion of production plants in the US, and primarily prompted by a sharp increase in oil prices during the first decade. By the middle of that decade, the world turned its attention towards cellulosic biofuels, due to large-scale availability of low-cost and sustainable cellulosic biomass, and claims that the technology was ready for investment and large-scale commercial operation. Ten years later, commercial large-scale plants have been developed and investments into cellulosic ethanol production are actively evaluated, primarily driven by either voluntary or mandated targets of lower greenhouse gas emissions, as well as technology advancements in enzyme and fermentation technology, of which the latter is discussed in this article.

Fermentation strategy development

Traditional fermentation strategies are often performed in batch mode. Thus, applying this strategy imposes significant downtime of the instruments and sub-optimal ethanol yield. The technology described here circumvents these challenges through the development of a new fermentation platform – the ‘Cost Reduction in yeast Fermentation for Commercial Production of Cellulosic Ethanol’ (CoRyFee). The platform takes advantage of a newly developed fermentation monitoring and control strategy, which makes it possible to keep the fermentation conditions at a ‘sweet spot’, thus allowing for optimal ethanol productivity and increased yields.

Additionally and importantly, the fermentation can be performed in continuous operation without fresh addition of yeast after the initial inoculum has been added to start the fermentation process. A direct productivity comparison between CoRyFee and traditional fermentation is illustrated in Figure 1.

Developed by a joint venture, the CoRyFee platform is the subject of a joint patent application filed by Terranol A/S and SEKAB E-Technology AB, as of 2018. At the time of writing, the platform has been demonstrated at fermentation scale of 10,000 litres fermentation volume with 50,000 litres of hydrolysate being fermented at 95% ethanol yield at the Biorefinery Demonstration Plant in Örnsköldsvik, Sweden, which is operated by SEKAB E-Technology. The main improvements achieved by using the CoRyFee platform are: 1) significantly improved yeast economy; 2) reduced need for tank volume, cleaning and sterilisation; and 3) increased tolerance towards an array of inhibitors released by the pre-treatment process from sugar and lignin degradation.

The CoRyFee process is currently optimised towards hydrolysates of soft and hardwood, with substantially higher productivity and ethanol yields compared to batch fermentations. Increase of productivity of four to sixfold on these soft and hardwood hydrolysates has been demonstrated in near industrial scale, and the technology is being evaluated by first and second generation ethanol producers.

Increasing fermentation rate and productivity of ethanol from xylose

Natural baker’s yeast Saccharomyces cerevisiae faces the challenge of comprehensive sugar utilisation, as it cannot ferment hemicellulose sugars (with the exception of mannose) in biomass, and thus needs engineering to ferment them. Xylose, the primary hemicellulose component in non-softwood biomass, is the primary target of such engineering work. Terranol’s latest proprietary commercially available yeast strain, the cV-110, has been optimised with respect to inhibitors such as lignin degradation products, furans and aliphatic acids, at low pH, by-product formation and higher growth rates for second generation ethanol production. It has, successfully, been evaluated on a wide range of biomasses, including hardwood, softwood, wheat straw and spent sulphite liquor. Fed-batch fermentations yielding 95% or more have previously shown scalability from 2 litres laboratory scale to 270,000 litres production scale, and vice versa.

Yeast propagation and storage

Another challenge is the production and propagation of the active biomass, i.e. the yeast needed to initiate the fermentation process. Yet another layer of complexity is added by the necessary storage for the produced yeast. A new approach, also related to the CoRyFee process, has been to develop a scalable, industrially relevant three-stage propagation protocol, which increases the biomass by more than a fifty or hundredfold over a period of less than three days, yielding close to 100 grams dry weight per litre. The propagation protocol, which has successfully been validated on a 120-litre scale, is designed in such a way that the last step induces the accumulation of intracellular trehalose, enabling the yeast to withstand severe desiccation. Strain cV-110 is suitable for storing as an active dry yeast product, and satisfactory viability after one year of storage has been demonstrated.

For more information:
This article was written by Birgitte Rønnow, co-founder and CEO of Terranol AS. Visit: www.terranol.com
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