Scotia Capital™

Equity Research Industry Report

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Biofuels Outlook

Ethanol Margins Improve; Biodiesel Capacity Still Idle

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Fertilizers, Biofuels & Chemicals Research

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All figures in U.S. dollars unless otherwise stated.

Renewable Food- and Non-Food-Based Fuels

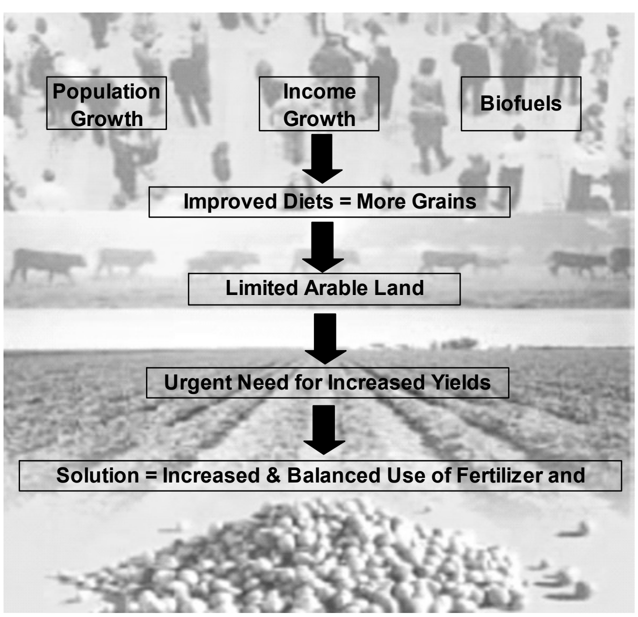
We separated renewable fuels prospects from our January 2010 Quarterly *Fertilizer, Biofuels, and Chemicals Outlook* into another stand-alone report that, for now, will be semi-annual. Numerous new advanced biofuel developments continue to be announced. We care particularly about fertilizer demand used for food-based fuels **as food-based fuel demand growth was a key reason why fertilizer stocks soared 500%-1,500% between 2003 and mid-2008.** Global biofuel production reached 22 billion gallons in 2009, with 19 billion gallons being ethanol production. In particular, we are interested in the following Canadian biofuel companies: Biox (just IPO'd with a C$50 million issue), GreenField Ethanol, Lignol, Ensyn, Iogen, and Enerkem (just raised C$53.8 million from Waste Management). All of these companies spoke at our November 2009 Bioenergy Day Conference.

Food Demand for Fuel

About 33% of the incremental 2006-2008 global food demand was used for food for fuel (according to Mosaic's CEO). U.S. corn-based ethanol demand soared as at May 5, 2005, when the U.S. government stopped protecting oil and gas refiners and distributors from class action MTBE lawsuit legal liability if they continued to spill gasoline containing methanol-based MTBE (methyl tert-butyl ether). Ethanol had only 15% market share at that time and MTBE had 85%. Since then ethanol captured most of MTBE's market share, which led to ethanol prices spiking from $2/gal to $5/gal. In turn, this led to the surge of U.S. ethanol IPOs, including Aventine, Pacific Ethanol, and VeraSun. They all went bankrupt in 2009 because of weak margins, leverage, and/or poor corn procurement or hedging practices. On March 16, 2010, Aventine emerged from bankruptcy.

Producers' mostly corn-based ethanol plants are now running again as margins have improved with April 2010 corn prices slumping to $3.50/bu from $4.25/bu in late December 2009, with oil still close to $80/bbl. A number of plants have and continue to be sold to others for as low as 25% replacement cost new (Valero bought seven ethanol plants from VeraSun at that price).

Exhibit 1: Key Drivers of Fertilizer Demand



Source: ICL.

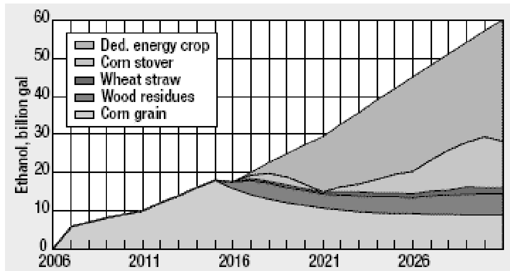
Biofuel Research

Fertilizer analysts and investors are now forced to understand the future of biofuels if they are to accurately assess the demand for food and, therefore, fertilizer (Exhibit 1). For more information on Scotia's effort to do so, please refer to our January 2009 report titled *The Choice of Next-Generation Biofuels* and our November 2009 report *Biofuels Outlook – Explosive Growth and Development Continue*. Our November 24, 2009, Bioenergy Day 2009 conference featured Canada's biggest renewable biofuels and renewable bio-power players. For details, refer to our November 2009 conference summary report *Bioenergy Day 2009 – "Bioenergy Opportunities"*.

Until 2012, generation one U.S. and Canadian food-based biofuels should still have good growth prospects of about 10%-15% annual growth for 2011 and 2012. This is, however, hugely dependent on the spot unleaded gasoline price differential with the spot corn-based ethanol price. Peak 2005-2008 growth levels were 30% per year for ethanol and 60% per year for biodiesel. **We and others continue to believe** that generation one biofuels may see their growth profiles ease further towards zero as of 2012 when the United States caps generation one food for fuel.

We have yet to see one statement from or have one interview with an oil and gas company that supports food-based biofuels. We believe they are, however, **all interested** in second-generation, more sustainable fuels. They already support myriad second- and third-generation fuel technologies. Active oil and gas biofuels leaders include Shell, Chevron, BP, Valero, Petrobras, and, more recently, ExxonMobil. This could negatively weigh on fertilizer-supported food demand for generation one biofuels, **and therefore on fertilizer stock valuations over time.**

Exhibit 2: Ethanol Production



Source: *Hydrocarbon Processing*.

Exhibit 2 shows a forecast by *Hydrocarbon Processing* that the U.S. use of corn-based **food for fuel may peak around 2014, and then start to decline**. The cap on U.S. food-based ethanol and biodiesel is still 15 billion gallons per year by January 2012 or about 5 billion bushels of corn/year for 14 billion ethanol gallons. After that, the 2007 U.S. Energy Bill targets second- and third-generation fuels to add another 21 billion gallons per year to 36 billion gallons per year by 2022. **So what will these fuels be made from, and how much fertilizer will they need, if any?**

Biofuel made from human garbage and human wastewater (algae), dead or living trees, wheat waste, corn waste, and jatropha trees **does not require fertilizer.** In the case of algae, **no potash is required,** but lots of carbon (CO_2), some nitrogen, and a little phosphate are needed if wastewater is not used. Some algae can clean non-potable water, which could get clean water credits. The question is **how much low-hanging biofuel fruit is there for recycled human waste before some fertilizer will be required for other types of advanced biofuel production?**

Biofuels Digest announced in late March 2010 that there are now 67 advanced biofuels projects aiming at 2.32 billion gallons of capacity by 2014. Appendix 1 includes a detailed table of advanced biofuels projects.

Global Food-For-Fuel Demand

Global demand for food-based biofuels is forecast to reach **7.2% of food grown in 2010.** The International Grains Council assumes **9% of all world vegetable oil consumption** will be used for biodiesel, with rapeseed oil accounting for 50%, soy oil for 25%, and palm oil for 12% of biofuel feedstock.

In biodiesel politics, the EU charged the United States with dumping its biodiesel into Europe after splash-blending it. **This cut 2009 U.S. biodiesel production for exports to Europe in half and weighed on U.S. soybean prices through March 2010**. The EU has made the commercial development of biofuels a priority in Europe, driven by legislation that targets a 10% use of renewable energy in transportation fuels by 2020. However, **this is not a mandate but a non-enforceable guideline.**

Biofuel Market Potential

In 2008, global fuel consumption was 85.43 million barrels per day at a refiner average cost of $2.95 trillion (U.S. EIA). The 2008 global biofuels market was only 1.7 million barrels per day, or only 2% of the total 2008 fuel market. **Royal Dutch Shell has estimated that alternative fuels could grow 500% to 10% of global fuel use by 2020, or $300 billion per year of revenue.**

Four key biofuel drivers are: (1) energy independence; (2) climate change remediation; (3) sustainable green economic development; and (4) the search for fuels that are lower in cost or in price volatility.

Some biodiesel feedstock will further diversify away from food-based to jatropha in 2013 and algae in 2015. Renewable jet biofuel (JP-8) is also expected to emerge **as a major new biofuel market** because of successful 2009 testing of algae and jatropha JP-8 blends in a variety of aircraft by a variety of carriers. All generation two (mostly cellulosic ethanol) and three (mostly algae) fuels are targeting sub-$2 per gallon variable cash costs to become competitive. **The airline industry has already concluded that 50% blends of algae and jatropha JP-8 jet fuel will be accepted, according to *Biofuels Digest*.**

The ease of drop-in non-food-based fuels into existing fuels **heavily favours** those that can pass fuel specs and have the same energy density as the fuels they are replacing or blending with. **This heavily favours renewable biodiesel over renewable ethanol and algae over cellulosic ethanol at this time.**

Carbon

A Canadian study published by the Global Renewable Fuels Alliance concluded that world biofuels production in 2009 **reduced global greenhouse gas (GHG) emissions by 123.5 million tonnes**, a 57% reduction compared to equivalent petroleum fuels.

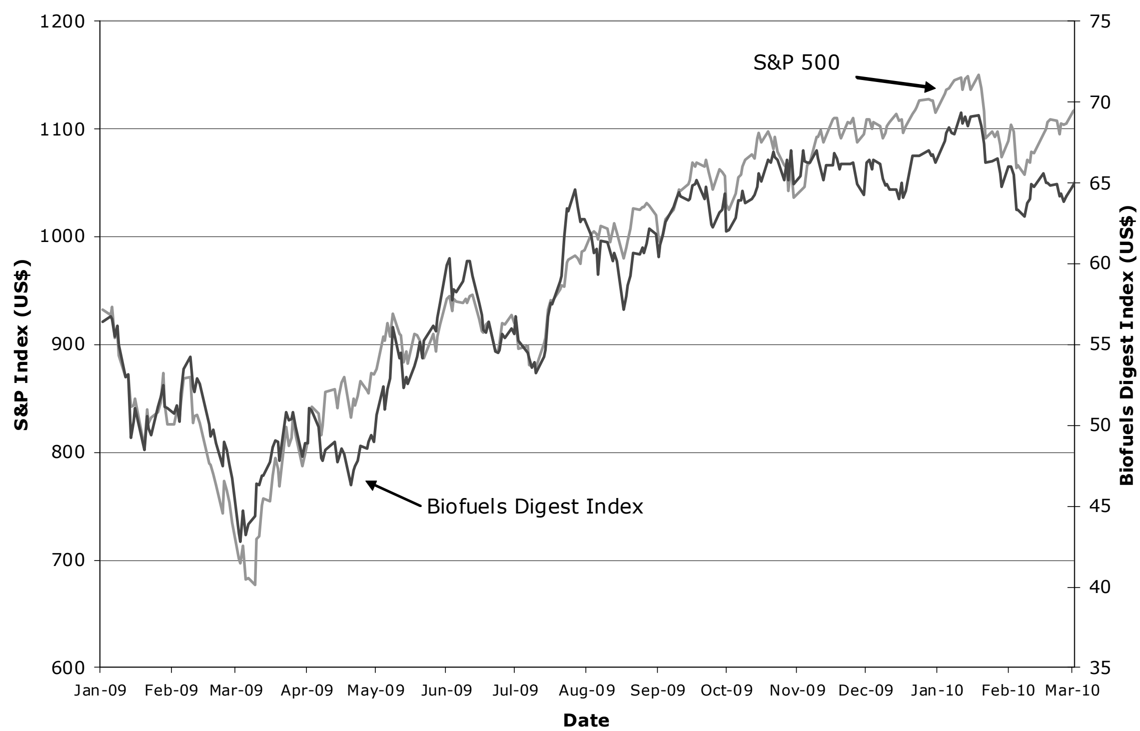
A recent study published by World Wildlife Fund estimates the adoption of second-generation biofuels in 20% of conventional fuels has the potential to **reduce emissions by 1 billion tonnes by 2030.**

Advanced second- and third-generation biofuels are likely to reduce 50% to 75% of GHG emissions.

Investment Index

The Biofuels Digest Index, comprised of 25 advanced and first-generation pure-play biofuel companies and oil and grain companies with significant biofuel investments and operations, gained 17.48% in 2009. The index outperformed the Dow Jones Industrial, and performed within 2% of the S&P 500 Index (Exhibit 3). The companies comprising the Biofuels Digest Index are included in Appendix 2.

Exhibit 3: Biofuels Digest Index vs. S&P 500



Source: *Biofuels Digest*.

Generation One Food-for Fuel-Arguments in Favour

Mosaic's estimate that **33% of incremental food demand from 2005 to 2008 was used for generation one biofuels. This created a furor among those negatively affected by soaring food costs.** Those in favour argued that only 7.2% of the world's grains and oilseeds were used for alternative and renewable fuel. However, that is only **3%** of the **net** total world's food production if one subtracts dried distiller grain and glycerine by-products used mostly to feed animals/poultry/fish. **Therefore, the net effect on food prices by food for fuel should be relatively small.**

U.S. corn yields for 2009 hit a record 165.2 bushels per acre, up 3% over 2004's record level. **This corn yield improvement is now up over 400% in 40 years**. Farmland efficiency using satellite technology, GPS (global positioning system), no-till farming, and genetically modified (GM) seeds have therefore increased the value added per acre of corn being converted into ethanol, according to supporters. Also, newer world-scale ethanol plants are raising ethanol yields/bushel towards 3 gallons/bushel versus only 2 gallons/bushel in 1980. Water use per ethanol gallon has also dropped sharply over time.

Supporters also cite that the Environmental Protection Agency (EPA) has defined corn-based ethanol as having a 21% GHG reduction.

Biofuels Revenue Rising

Clean Energy Trends 2010 stated biofuels reached $15 billion in revenue on 23.6 billion gallons of ethanol and diesel production. Their biofuels revenue forecast for 2019 is $112.5 billion.

Biofuels M&A Activity Rises

In 2009, there was $1.327 billion in biofuels M&A activity, up over 420% from 2008, making it the fastest growing alternative energy sector (Exhibit 4). Biofuels deals fell to 27 transactions in 2009 from 69 transactions in 2008.

Exhibit 4: 2009 Greentech M&A Activity

Transaction Value ($millions)	2009	2008	% Chg
Solar	$1,855	$3,461	–46.4%
Wind	3,056	2,016	51.6%
Biofuel	1,327	255	421.3%
Biomass	584	1,915	–69.5%
Smart Grid Distribution	96	166	–41.9%
Energy Storage	763	777	–1.8%
Energy Efficiency	1,258	164	664.7%
Hydro, Ocean and Tidal	177	274	–35.4%
Geothermal	0	291	–100.0%
Diversified Renewables	286	502	–43.1%
Carbon Capture and Sequestration	55	27	103.8%
Hydrogen and Fuel Cell Technology	50	62	–19.0%
Total	$9,506	$9,909	–4.1%

Source: Peachtree Green Advisors.

Oil Company Interest in Advanced Biofuels Rising

In 2009, there was a significant increase in multinational companies interested in biofuels, **especially oil companies**. A recent biofuel survey ranked BP (number four), Petrobras (18), Shell (27), ExxonMobil (29), and Chevron (51) in the "2009-2010 Hottest 100 Companies in Bioenergy," which had them **previously unranked in 2008-2009**. These rankings highlight the speed at which **big oil companies are entering the biofuels market.**

Shell just announced a $12 billion deal in Brazil with sugar-based ethanol partner Cosan. BP has invested $1 billion in ethanol expansions to date in Brazil, partnered with DuPont to construct a biobutanol demonstration plant in the United Kingdom, and entered a joint venture with Verenium, a cellulosic ethanol producer. Shell is working with Canadian-based Iogen to produce cellulosic ethanol from wheat straw, and with Codexis for ethanol-based enzymes. **Codexis has filed a prospectus to enter U.S. equity markets**.

In July 2009, ExxonMobil announced it will invest **$600 million in an algae biofuel company** with Synthetic Genomics to create genetically modified algae that continually "milk" the oil feedstock (fatty acids). Chevron has a joint venture with Weyerhaeuser to make fuel from biomass (Catchlight) and has invested in algae-based fuel producer Solazyme. Valero has also invested in algae, as well as generation one ethanol.

Old Non-Renewable Refinery Shutdowns

In October 2009, Sunoco Inc. **was the first major oil refiner to announce the shutdown of a U.S. refinery** during the 2009 economic downturn, closing its Eagle Point refinery in New Jersey. In November 2009, Valero announced its Delaware City refinery was closing. At our Bioenergy Day Conference in November 2009, AMEC suggested that bolt-on technology could be used **to transform mothballed refineries into biorefineries that can produce biofuel and many other valuable co-products**, while saving jobs. Similar add-on technology is beginning to be used in the ethanol industry with DuPont-POET, a U.S. ethanol producer, building a front-end processing step to its first-generation ethanol plant to produce second generation cellulosic ethanol in Iowa from corn cobs.

Government Funding Announcements

Of the $787 billion U.S. stimulus package, $100 billion will go to clean technology investments, including biofuels.

In March 2010, in Washington, the Renewable Fuels Reinvestment Act was introduced, proposing an extension of the $0.45 Volumetric Ethanol Excise Tax Credit, the $0.54 tariff on imported ethanol until December 31, 2015, and the $0.56 Small Producers Tax Credit and the Cellulosic Ethanol Production Tax Credit to January 1, 2016. These tax credits are scheduled to expire on December 31, 2010.

On October 27, 2009, U.S. Secretary of Energy Steven Chu announced that the DOE's Advanced Research Projects Agency-Energy (ARPA-E) awarded $151 million in funding for over 37 biofuel-related projects. Agrivida was awarded $4.6 million for on-cell-wall-degrading enzymes **grown within the plant itself** that are activated after harvest. This could **dramatically reduce the cost of cellulosic biofuels feedstock processing.** Ceres was awarded $5 million for its research on genes that enable energy crops to produce more biomass using less (lower quality) land, less water, **and less fertilizer than conventional energy crops.** DuPont was awarded $9 million for its project producing **biobutanol from seaweed.**

In December 2009, the ARPA-E opened its second funding application period with $100 million available for projects focusing on using microorganisms to convert CO_2 into fuel, carbon capture technologies, and battery technologies that would allow electric vehicles to compete with gasoline-powered cars and trucks.

In November 2009, the United States Department of Agriculture (USDA) and the Department of Energy (DOE) announced $24 million in bioenergy and bio-based products research and development (R&D) grants. GE Global Research was awarded $1.6 million to develop detailed kinetic models of biomass gasification. Gevo Inc. was awarded $1.78 million to develop a yeast fermentation organism that could **cost-effectively convert cellulosic material into isobutanol**.

In December 2009, the DOE announced **$564 million in funding for 19 integrated biorefinery projects.** Over 85% of the announced funding will go to 14 pilot-scale and four demonstration scale biorefinery projects in the United States. The remaining will focus on accelerating the construction of previously funded biorefinery projects. The DOE award is to be matched by over $700 million in private funding for a total investment of $1.26 billion. **Algenol Biofuels received $25 million for its algae-to-biofuels project with Dow in Texas.**

Exhibit 5: Biofuel Investments by Country, 2009

Brazil	$3,454 million
U.S.	$2,010 million
Papua New Guinea	$800 million
Canada	$589 million
India	$438 million
Rwanda	$250 million
Philippines	$197 million
South Africa	$190 million
Ethiopia	$84 million
Australia	$75 million
Sweden	$73 million
Kenya	$46 million
Argentina	$37 million
South Korea	$18 million
Peru	$12 million
Mosambique	$10 million
Poland	$4 million
Total	**$8,287 million**

Source: Biofuels Digest.

Globally, in 2009 $8.7 billion in biofuel investments were announced based on data from 18 countries (Exhibit 5). Overall, **Brazil led with $3.5 billion followed by the United States with $2.3 billion**. The largest reported investments were a $2.8 billion multi-year program for ethanol and biodiesel expansion by Brazil's Petrobras and a $600 million investment by ExxonMobil in algal-based fuels.

In October 2009, Canada announced it would invest C$1.5 billion over nine years through the ecoENERGY for Biofuels program. The program is investing C$110 million in Suncor Energy's St. Clair plant to strengthen the Canadian renewable fuel industry. Canada's Economic Action Plan also dedicates C$1 billion to the Clean Energy Fund and C$1 billion for the Green Infrastructure Fund.

The U.S. government will provide **an additional $5 billion in tax credits** to encourage new manufacturing associated with renewable energy sources.

Biofuels Impact on Water Supplies

Human-required fresh water plays an important role in food-for-fuel production. About 70% of the world's water use is for food. As global demand for water increases, **the effects of water use in biofuel production needs to be considered.** Corn is a resource-intensive crop that requires some irrigated water supply to grow in parts of North America. Next-generation feedstocks, such as algae, do not strain the water supply as much as first-generation crops, as algae can grow effectively in most wastewater. A U.S. study on water resources required to produce biofuels found that **corn-based ethanol used the largest amount of water per litre of ethanol produced while biodiesel required the least amount of water** (Exhibit 6).

Exhibit 6: Water Requirements for Biofuels

	Water Requirement per Litre of Product
Corn-based Ethanol	3-4 L
Cellulosic Ethanol	2-6 L
Biodiesel	1 L
Gasoline	1-2 L

Source: U.S. Government Accountability Office.

POET is expected to cut water consumption down to 2.33 gallons from three gallons of water per gallon of ethanol through the introduction of a proprietary cooling water recycling system. The company is targeting a 22% reduction in water consumption over the next five years. POET's current water usage rate of three gallons of water per gallon of ethanol is 80% less than the water usage when its operations started in 1988.

Low Carbon Fuel Standards (LCFS)

LCFS are performance measures based on the **total amount of carbon emitted per unit of fuel energy**, including all the carbon emitted in the production, transportation, and use of the fuel. **California has enacted into law a LCFS for 2020.** Each company is assigned a maximum level of GHG emissions per unit of fuel energy it produces. The level declines each year to put the country on a path to reducing total emissions. LCFS allow for the trading of emission credits among fuel suppliers. **LCFS are considered the most practical way to begin the transition to alternative fuels.**

Downside of LCFS renewable fuel standards: (1) it only targets biofuels and not other alternatives; and (2) prevents the innovation of other low carbon technologies.

Downside of carbon taxes: (1) they attract political opposition and public anger; and (2) have limited effectiveness. For example, a tax of \$25/ton of CO_2 would increase the retail price of electricity from coal by 17%, enough to motivate electricity producers to find low-carbon alternatives. However, a tax of \$50/ton CO_2 would raise the price of gasoline by only 45 cents per gallon. **This wouldn't be enough to induce drivers to switch to low-carbon fuel alternatives.**

Downside of carbon cap and trade. Refiners would likely increase the price of fuel to subsidize low-carbon fuels. This would cause consumers to drive less and auto companies would produce more fuel efficient vehicles.

To be more effective, LCFS must be coupled with other policies including: (1) efficiency and GHG emission standards for new cars, (2) infrastructure to support alternative fuels, and/or (3) incentives to reduce driving & promote transportation alternatives.

Design of LCFS. Three models could be included in the standards. (1) refiners can blend biofuels from cellulose or waste into gasoline and diesel, (2) refiners can buy natural gas, biofuels, electricity, and hydrogen, and (3) refiners can buy credits from other refiners or use banked credits from previous years.

Implementing LCFS: The LCFS process will require a system to record and verify GHG emission levels. One suggested approach involves "default and opt-in" where fuels are assigned a default value. The fuel producer can accept the default value or provide evidence it can produce significantly lower emissions. This places the burden of measuring and certifying GHG emissions on the oil distributors, biofuel producers, and electricity generators.

LCFS challenges: (1) Companies will often look for the easiest way to respond to LCFS requirements, which could involve shuffling production and sales in a way that meets the requirements of the LCFS **but do not actually result in any net change**; and (2) Indirect land-use changes – scientific studies **have not yet quantified the indirect land-use effect of biofuels.** Preliminary analysis suggests the ramp up of corn ethanol for the RFS targets will **add 40% more GHG emissions per unit of energy.** Cellulosic fuels would have a smaller effect. Biomass (crop and forestry residue and urban waste) would likely have no effect.

LCFS is more effective at the national level, or even at the international level. Efforts are ongoing in the EU to complement its biofuel directive with an LCFS standard that would require a 10% reduction in GHG intensity by 2020 for transport fuels.

In February 2010, the National Petrochemical & Refiners Association, American Trucking Associations, and other industry groups filed a lawsuit against the California Air Resources Board (CARB) for its LCFS. The suit claims the **LCFS regulates interstate and foreign commerce by discouraging the use of Canadian crude oil and ethanol produced in the American Midwest**, violating the commerce clause of the U.S. Constitution. Two other lawsuits against CARB over its LCFS have been filed by the ethanol industry.

U.S. Renewable Fuel Standard 2 (RFS-2)

On February 3, 2010, the United States reconfirmed its commitment to its Renewable Fuel Standard 2 (RFS-2) goals with energy policies that promote the production and use of biofuels. The EPA set 2010 blending volume targets for cellulosic ethanol at only 6.5 million gallons (as that is all the capacity that was built), significantly lower than the 100 million gallons proposed in May 2009. Biodiesel blending volume was increased to 1.15 billion gallons as the EPA combined the 2009 biodiesel volume requirement (0.5 billion gallons) and the previously proposed 2010 biodiesel volume requirement (0.65 billion gallons) and made the consolidated requirement mandatory. Soybean oil prices increased 12% in response. The total 2010 RFS volume was maintained at 12.95 billion gallons, increasing to 36 billion gallons in 2022.

Over the next 12 years the annual volume requirements under RFS-2 increase to 36 billion gallons from 13 billion gallons. The program has been expanded from RFS-1 to include off-road, locomotive, and marine gasoline and diesel fuel.

The RFS-2 mandates the **compulsory purchase** of four types of fuel rather than the single fuel as under RFS-1. The four types of fuels are: (1) cellulosic biofuels, including at least a 60% GHG reduction; (2) biomass-based diesel, including at least a 50% GHG reduction; (3) advanced biofuels, including at least a 50% GHG reduction; and (4) other renewable fuels, including at least a 20% GHG reduction.

A major part of the RFS-2 program is the requirement that the lifecycle GHG emissions of qualifying renewable fuels must be less than the GHG levels of the 2005 baseline average gasoline or diesel fuel it replaces. The threshold for cellulosic biofuel is 60%, and the threshold for advanced biofuel and biodiesel is 50%. In February 2009, the EPA determined that biodiesel made from soy, waste oil, fats, and greases complies with the 50% GHG threshold, allowing biodiesel to qualify for use under federal biofuels mandates.

The EPA retained its Renewable Identification Numbers (RINs) system of compliance under RFS-1 to track transactions. With the introduction of new fuels under RFS-2, there are now multiple types of RINs to correspond to the new types of fuels.

According to a white paper on the RFS-2 by Stoel Rives, one of the most dramatic changes under RFS-2 is the requirement **that all qualifying renewable fuels be produced with renewable biomass**. Renewable biomass includes: crops harvested from existing agricultural land, planted trees from a tree plantation on non-federal land, animal waste material, animal by-products, forestry residue, biomass, algae, and separated yard waste or food waste.

Stoel Rives' white paper mentioned that one point of criticism on RFS-2 by some industry participants was the limited recognition of municipal solid waste (MSW) under the Proposed Rule. The EPA resolved these issues in the Final Rule by allowing certain portions of MSW to be included as renewable biomass, provided that separation has occurred first.

The white paper also lists a key constraint with the RFS-2 is the requirement that all parties must register with the EPA prior to participating in the mandatory RIN program. The registration process must be completed by July 1, 2010, and could be the main constraint as the EPA implements the RFS-2.

Q4/09 & Q1/10 Biofuel Developments

On March 2, 2010, the U.S. DOE announced $100 million in Recovery Act funding to be made available to accelerate innovation in green technology. The funding was not directed at specific projects. This is the DOE's third round of funding for the Advanced Research Project's Agency-Energy (ARPA-E).

In December 2009, the U.S. Treasury Department initiated a project to determine the economic and environmental impacts of increasing biofuel production. The study will include an analysis of the incremental impact of additional biofuel production on U.S. grain crops, forest products, and fossil fuels, including the impact on prices.

In February 2010, the *New York Times* reported that the U.S Senate might put forward an energy and climate bill, which is more likely to pass the Senate than cap-and-trade legislation. The bill that is likely to emerge would include support for the development of nuclear and clean coal, which would help achieve the U.S. goal of reducing emissions by 17% from 2005 levels by 2050. There is some support for a carbon cap and dividend proposal.

The U.S. 2011 fiscal budget proposal released on February 1, 2010, included tax breaks for the domestic oil, natural gas, and coal industries. At the same time, the Obama administration proposed over $1 billion in new funding for fossil fuel R&D, including $668 million for the DOE "Clean Coal Power Initiative," which aims to develop and commercialize new environmental technologies for the coal industry.

On December 24, 2009 India reinstated its 20% blending target of biofuels in diesel and ethanol by 2017, along with financial incentives for second generation biofuels, including a national biofuel fund. The auto industry is booming in India as it is in China. All new cars in India are capable of running 20% ethanol blends.

The Health Care Bill passed in the U.S. House included: (1) an amendment to the term "qualified feedstock" for the $1.01/gallon cellulosic ethanol producer credit **to include any lignocellulosic or hemicellulosic matter that is renewable, and any cultivated algae, cyanobacteria, or lemma**; and (2) the removal of a $24 billion biofuel tax credit used by pulp and paper firms that recognizes black liquor as a biofuel, rather than as a biofuel feedstock. The biofuels provision in the bill is viewed as a positive for the non-pulp and paper biofuel industry, **supporting more cellulosic and algae biofuel production**.

The House passed the Waxman-Markey Climate Change Bill that the Senate has delayed its draft 950 page bill until later in 2010. In 2009, the U.S. government increased funding to the DOE's Office of Science by 18% to $4.76 billion to help advanced biofuels research. An additional $1.6 billion was allocated from stimulus spending to develop new electricity sources, more efficient cars, and to address climate change through renewable fuels.

Selected Q3/09 Biofuel Developments

ASTM International's aviations fuels committee approved the use of a 50/50 biofuel blend for aircraft. The airline industry is now looking for subsidies and allowances to be granted, as a result of the American Clean Energy and Security Act of 2009, to offset the price of standard jet fuel as the biofuel industry starts to grow. **The biggest obstacle for commercializing advanced biorefineries was the collapse of the 2009 venture capital financing market.**

The Obama administration committed to biofuels through loan guarantee and grant programs for integrated biorefineries. DuPont-Poet was first to commercialize second-generation corn waste ethanol in Iowa in early 2009 with its first expansion for 2011. Coskata was second in October 2009 using gasified waste to make ethanol. ZeaChem is expected to start its first non-food-based, 25 million gallon per year, commercial biorefinery in Boardman, Oregon, by 2013, and then build larger facilities capable of processing 100 million gallons per year. ZeaChem's process can utilize a variety of different biomass feedstocks and is projecting yields of 135 gallons per ton from poplar biomass, well above others looking at 100 gallons per ton from other biomass.

In July 2009, U.S. Energy Secretary Steven Chu announced up to $30 billion in new loan guarantees funded through the Recovery Act for the commercial use of new or improved energy technologies to help promote clean energy projects.

Many biofuel projects are progressing based on some form of government assistance such as grants, tariffs, subsidies, incentives, or mandates. Canada's $550 million in grants for bioenergy commercialization has been important in developing new products for Canada's lagging forest products industry and maintaining forward momentum on climate change.

In the United States, government subsidies for conventional fossil fuels **were over $72 billion between 2002 and 2008, but renewable fuel subsidies were only $29 billion over the same period** (half for corn-based ethanol).

First-Generation Ethanol Margins Improving

Oil spiking back to $80/bbl **is supportive** along with falling corn prices to $3.50/gal for ethanol operating margins. That is too late for VeraSun, which was number one in 2008 U.S. ethanol capacity. VeraSun had to sell most of its ethanol facilities in a bankruptcy auction to Valero at $0.25 on the replacement-cost-new dollar. Aventine's stock fell to pennies and it has gone off the NYSE as has Pacific Ethanol's stock. **The U.S. refining industry now owns over 7% of the U.S. ethanol industry.**

U.S. ethanol companies that had their ethanol plants up and running prior to mid-2005 **made a fortune in 2005.** This was due to the one-time elimination of U.S. methanol-based MTBE demand in favour of ethanol. 2005 was the heyday of U.S. ethanol IPOs, as spot ethanol prices hit $5 per gallon in 2005 temporarily versus a more normal $2 per gallon. Ethanol companies that levered themselves and built capacity ahead of the minimum U.S. requirements of the U.S. Energy Bill saw their economic spot market vanish during 2H/08. Some also pre-bought corn in mid-2008 at $6-$8 per bushel **without fixing ethanol selling prices or margins with refinery buyers, leading to their demise.**

The USDA's 2009-10 corn use for ethanol estimate is a 14% increase to 4.2 billion corn bushels of use. At early April 2010 with corn at only $3.50 per bushel and U.S. oil back near at $80/bbl, **ethanol margins north of $1/gal are sufficient for the ethanol industry to produce at maximum levels.**

U.S. ethanol production increased 25% between February and August 2009 because of the reopening of plants that were closed during the industry shakeout when oil prices were depressed. Ethanol capacity utilization in the United States and Brazil is expected to increase in 2010 because of lower corn and now sugar prices.

Does Corn-Based Ethanol Warm the Planet?

The amount of NO_X emissions (310 times worse than CO_2) and loss of nitrogen nutrients into the sky from applying nitrogen fertilizers to corn acres using a cradle-to-grave approach **may reveal that direct and indirect corn-based ethanol emissions are negative versus non-renewable fuel emissions.** This led, in part, to indirect land use and low-carbon fuel legislation for 2020 in California. The U.S. government and the EPA need to decide on life cycle GHG analysis for the 2007 Renewable Fuel Standard and/or amend the standard.

The U.S. biofuel industry is **suing California and lobbying to block the U.S. EPA** from assessing biofuel cradle-to-grave emissions, while **Canada has now started its scientific sustainable biofuel level study**. The EPA states that it wants to help define a fair process for evaluating land use.

Slashing and burning rain forests to plant soybeans or palm oil is responsible for up to 25% of global warming impacts annually**. It is this argument that has been considered in California's law.**

The RFS-2 requires that ethanol facilities currently exempt from GHG will be forced to make modifications upon any proposed expansion.

Ethanol Mandates

Canada: All of Canada is now on 5% ethanol-to-gasoline blends as of January 1, 2010. Alberta is spending C$439 million on renewable energy from organic materials and another C$4 billion for CO_2 reduction, sequestration, pipelines, and other programs. The federal government has C$500 million for production of next-generation renewable fuels such as cellulosic ethanol (not one project has yet to receive funding) and a C$550 million technology fund for supporting renewable fuel technologies (now mostly depleted after 17 rounds of semi-annual submissions).

United States: California mandated all its refineries to blend 10% ethanol into its gas supply as at January 1, 2010. The 15 billion gallon per year 2012 U.S. biofuels mandate is split between 14 billion gallons for ethanol and 1 billion gallons for biodiesel. The next 21 billion gallons after that to 36 billion renewable fuel gallons per year by 2022 in the United States is split for now as follows: a cellulosic ethanol mandate of 16 billion gallons by 2022 and a 5 billion gallon biodiesel segment. **This was reconfirmed by the U.S. DOE on February 3, 2010.**

India: India has reinstated a target biofuel blend level of 20%. On February 25, 2010, India's government announced that a three-year program to fix ethanol prices at $2.19/gallon for ethanol purchased by state oil companies to meet the 5% ethanol mandate could be limited to a six-month trial. Currently, state oil companies pay $1.73/gallon for ethanol. The increased price is in response to rising sugar prices that spiked in 2009 when India's sugar crop failed.

Brazil: Brazil's sugar-based ethanol production is forecast to increase to 13 billion gallons per year by 2015 from 9 billion gallons in 2009. Shell announced a $12 billion first- and second-generation sugar- and sugar waste-based ethanol investment in Brazil with Cosan in early February 2010.

EU: The **EU reduced** its soft biofuel targets by about 50% in 2008, **hurting** EU fertilizer stocks fell in response at that time.

2007 and 2010 RFS-2 U.S. Energy Bill Still Bullish for U.S. Corn-Based Ethanol But Only Until 2012

A U.S. cap was set on food-based ethanol in 2012 at 15 billion gallons per year. The minimum 2010 ethanol level is 10.5 billion gallons. This is **still supportive** for U.S. food-for-fuel demand for now. See our January 2009 report titled *The Choice of Next-Generation Biofuels* for details.

There are criticisms of the EPA's Renewable Fuels Standard, which uses 2022 higher assumed corn crop yields and higher assumed ethanol plant yields versus today's 2.8 gallons per bushel and 165 bushel per acre corn yields. There are also criticisms of the indirect land use penalty on corn-based ethanol that California is trying to implement in its lower carbon fuel standards. President Obama pledged his support to having "the most unbiased scientific information" on which to base U.S. federal policies, not the other way around. **As of early 2010, he continues on this path.**

Energy Secretary Steven Chu has called for research in gasoline and diesel-like biofuels generated from lumber, waste, crop wastes, solid waste, and non-food crops. His budget has been **doubled** to $400 billion per year for annual U.S. R&D government spending. **He has suggested carbon tariffs on imports that do not participate in emission reduction schemes by 2020.**

The U.S. EPA delayed its decision on allowing 15% ethanol blends in U.S. gasoline until late summer 2010 as the DOE tests are not yet complete. The field trials show that fuel, engines, and emission control systems on newer vehicles should be able to accommodate higher blends of ethanol. A ruling in favour of E15 would be positive for growth in the ethanol industry, which is currently stunted by the 10% "blending wall." A 15% versus 10% ethanol blend cap could allow the United States to more easily reach its mandated 14 billion gallons per year ethanol cap for January 1, 2012.

U.S. ethanol opposition believes the increased use of ethanol-based fuels **could hurt air quality and livestock producers**. The largest automobile club, AAA, also opposed the move to E15, and called for further in-depth research on the impact of E15 on fleet engines, vehicle performance, and fuel efficiency over long periods of time.

The National Renewable Energy Laboratory (NREL) stated research on E15 and E20 ethanol blends have shown **no major impact on vehicles.** NREL tests found vehicles reported a 7.7% loss in fuel economy using E20 blends compared to conventional gasoline, with no increase in NO_x emissions and reductions in carbon monoxide emissions.

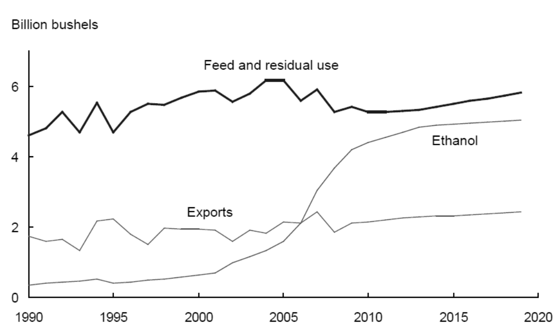
Ethanol Economics

U.S. corn prices dropped about 25% from the beginning of the year to about $3.20 per bushel in early October 2009, creating a 50 cent per gallon positive "crush spread" for ethanol producers at that time, up from 14 cents per gallon in April 2009. Both corn prices and oil prices have risen 10%+ since then.

Exhibit 7 shows the explosive growth in the use of corn to make ethanol in the United States.

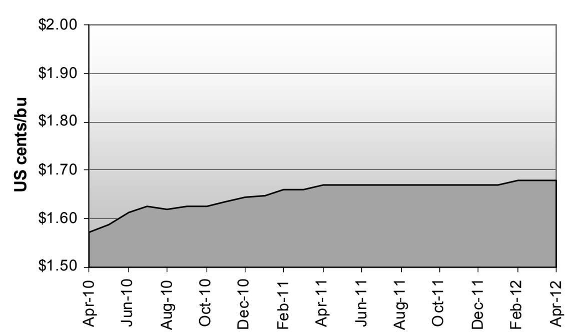
The forward U.S. ethanol price strip (Exhibit 8) shows **Q1/10 spot ethanol margins remain positive.** Exhibit 9, produced by *Price Perceptions,* showed that with oil above $60/bbl, corn has to move above $5/bu before U.S. corn-based ethanol production is curtailed at $2 per gallon ethanol prices. The 2008 corn price harvest low was $2.92/bu for front-month corn in mid-November 2008; the 2009 low was $3.20/bu in October 2009. **That was when most fertilizer stock values bottomed as companies bottomed.**

Exhibit 7: U.S. Corn Use for Ethanol



Source: USDA Agricultural Projections to 2019, February 2010; USDA; Economic Research Service.

Exhibit 8: CBOT Ethanol Forward Strip



Source: Bloomberg; Scotia Capital.

Exhibit 9: Corn Prices and Ethanol Margins

Hard to Price Out!
Corn Prices and Ethanol Margins

Cost of corn:						
Price/bushel	2.50	3.00	3.50	4.00	4.50	5.00
Cost/gallon:						
Corn 1/	.89	1.07	1.25	1.43	1.61	1.79
Mfg cost 2/	.39	.39	.39	.39	.39	.39
Total/gallon	1.28	1.46	1.64	1.82	2.00	2.18
DDG value 3/	.27	.32	.37	.42	.47	.52
Net cost/gallon	1.01	1.14	1.27	1.40	1.53	1.66
Ethanol price 4/	2.00	2.00	2.00	2.00	2.00	2.00
Margin/gallon	.99	.86	.73	.60	.47	.34

1/ Assumes 2.8 gallons of ethanol per bushel
2/ Average dry milling process (75% of plants)
3/ Based on DDG price of $120/ton at $3.00 corn – value of DDG advances with corn price
4/ Current price of ethanol

Source: *Price Perceptions.*

Spot ethanol and corn price relationships are shown in Exhibit 10.

U.S. ethanol cost. A Chevron-sponsored study claimed the average cost to the U.S. taxpayers of U.S. ethanol was $82/bbl on top of the gasoline retail price. The U.S. RFA strongly objected, claiming it was biased towards the oil industry.

Brazil ethanol cost. Brazil's cash break-even for its sugar-based ethanol production may be at about $35-$40/bbl oil prices, assuming $0.15/lb sugar prices (currently close to $0.25/lb, or the equivalent of $60-$65/bbl), **so it is no longer as economic short term to produce sugar-based ethanol**. Starch-based feedstock, like corn, has to be converted into sugar first, while raw sugar does not. Typically this creates a major advantage for sugar over corn and other starches. Since corn has only about 60% starch, and all other major ethanol feedstock (sugar beets, wheat, barley) have somewhat less, **sugar is normally the leader in first-quartile global ethanol production.**

Exhibit 10: Return over Variable Cost ($/Gal Ethanol)

Return Over Variable Cost ($ Gal Ethanol)

Conversion		Price of Ethanol fob Plant ($ Gal)								
2.8 Gal/Bu		$1.00	$1.25	$1.50	$1.75	$2.00	$2.25	$2.50	$2.75	$3.00
Cost of Corn del Plant ($ Bu)	$5.00	($0.78)	($0.55)	($0.32)	($0.09)	$0.15	$0.38	$0.61	$0.84	$1.08
	$4.50	($0.65)	($0.42)	($0.18)	$0.05	$0.28	$0.51	$0.75	$0.98	$1.21
	$4.00	($0.51)	($0.28)	($0.05)	$0.18	$0.41	$0.65	$0.88	$1.11	$1.34
	$3.50	($0.38)	($0.15)	$0.08	$0.32	$0.55	$0.78	$1.01	$1.25	$1.48
	$3.00	($0.25)	($0.01)	$0.22	$0.45	$0.68	$0.91	$1.15	$1.38	$1.61
	$2.50	($0.11)	$0.12	$0.35	$0.58	$0.82	$1.05	$1.28	$1.51	$1.75
	$2.00	$0.02	$0.25	$0.49	$0.72	$0.95	$1.18	$1.41	$1.65	$1.88
	$1.50	$0.16	$0.39	$0.62	$0.85	$1.08	$1.32	$1.55	$1.78	$2.01
		$2.08	$2.95	$3.81	$4.68	$5.55	$6.41	$7.28	$8.15	$9.02
		Maximum or Shut Down Cost of Corn ($ Bu)								

Source: Mosaic.

Brazil is the first country in the world to use more ethanol than gasoline at its fuel stations, **which should now be called ethanol stations and not gas stations!**

Exhibit 11: 2008 World Ethanol Production

Country	Millions of Gallons
USA	9000.0
Brazil	6472.2
European Union	733.6
China	501.9
Canada	237.7
Other	128.4
Thailand	89.8
Colombia	79.29
India	66
Australia	26.4
Total	**17,335.20**

Source: Renewable Fuels Association.

Ethanol Production Capacity

In 2008, world ethanol production reached over 17 billion gallons (see Exhibit 11) with the United States, Brazil, and Europe representing 93% of total global production.

U.S. capacity hit about 13 billion gallons during 2009 versus only 10.5 billion gallons required at minimum under the 2007 U.S. Energy bill. Most of this excess should get used up in 2010-2011. Few new generation one ethanol plants will be built from here on because of major uncertainty post 2012, and financing challenges after major ethanol company bankruptcies in 2008-2009.

Canada's ethanol. There will be 16 ethanol plants in Canada with a 400 million gallon per year capacity in 2010. To date, Canadian ethanol is 93% grain-based, split 73% from corn, 17% from wheat, and 3% from barley. The federal government passed its 5% ethanol legislation for 2010, of which a minimum of 2% must be biodiesel by 2012 (5% biodiesel in B.C. and 2% biodiesel in Alberta and Manitoba by 2010).

In September 2009, Greenfield Ethanol opened a 45 million gallon per year bioethanol plant in Johnstown, Ontario, that received C$119 million in federal funding. **This was 70% of the total project's budget, showing how serious Ontario and Canada are in supporting alternative fuel.** This is Greenfield's fourth ethanol plant in Canada and is its single largest facility to date, bringing its total capacity to 120 million gallons per year. In October 2009, Suncor received $110 million for its new Sarnia, Ontario, ethanol plant.

Internationally, Wilton International is set to start up its 400 million litre per year wheat-to-bioethanol facility in northeast England for 2010, the largest outside North America. The facility will produce high-protein animal feed, and CO_2 by-products that will be captured by Yara International and sold into the food and drink industry. The facility will require 1.2 million tonnes per year of wheat from U.K. farmers. The wheat used for ethanol will **not** be the high-protein milling wheat used in food production. The ethanol output is contracted to Shell for use in its gasoline blending.

Idle Ethanol Plants Being Bought

Valero purchased Renew Energy's 110 million gallon per year ethanol plant in Wisconsin for $72 million, and paid $200 million for two plants controlled by ASA Ethanol Holdings. This increases Valero's ethanol production capacity to 1.1 billion gallons per year, or 8% of U.S. capacity.

Nebraska Corn Processing purchased the 44 million gallon per year Mid-America Agri Products corn ethanol plant in Nebraska for $0.68 per gallon of ethanol capacity in a bankruptcy auction. The plant was built in 2007 and idled in 2009. The plant resumed production in Q1/10.

China Ethanol Developments

Effective January 1, 2010, China's import tax for alcohol will be 5%, down from 30%. It is unclear if this applies to fuel ethanol. Chinese buyers may not increase imports of ethanol because of lack of blending facilities, currently controlled by state-owned companies. China has mandated the use of ethanol in gasoline in one third of Chinese provinces, with the goal of blending 2 million tonnes of ethanol in gasoline by 2010 and 10 million tonnes of ethanol by 2020. Current Chinese ethanol production is only 1.35 million tonnes.

In mid-2007, China halted the incremental use of food for fuel for fear of food inflation and food shortages. Non-food materials like straw, switchgrass, jatropha, algae, sorghum, and other agricultural waste will still be allowed as biofuel feedstock. China's demand for biodiesel was last **forecast to grow over 100% per year from 2005 to 2010.** China's NDRC has set a target for **75% of the country's gasoline to be 10% ethanol-blended by 2010.**

Brazil Ethanol Developments

Brazil was the world's largest ethanol producer until the United States took over as number one in 2008. Brazil is still the number-one ethanol exporter. The United States exports none, and it blocks Brazilian ethanol imports via high import duties. **All of Brazil's cars can run on some blend of ethanol and gasoline, with 89% of new cars capable of running on 85% ethanol/15% gasoline blends.**

Sugar growers provide 45% of Brazil's fuel using only 1% of its arable land. The U.S. Senate extended its unfair $0.53 per gallon ethanol tariff against Brazil's ethanol to 2010 to protect its high-cost, corn-based domestic ethanol industry.

Brazil's ethanol production should reach 9 billion gallons per year by 2012, **double its 2006 level,** but only 60% of the United States' 15 billion gallon ethanol target from food-based feedstock for 2012. Brazil's current biodiesel blend mandate is 2%, with a long-term target of 20% by 2018.

As a result of heavy rains and lower-than-expected sugarcane harvest yields, Brazil has **lowered** its mandatory ethanol blending ratio in gasoline to 20% from 25% effective February 1, 2010 through May 1, 2010. Ethanol prices in Brazil rose 17 cpg in mid-January, with ethanol production down 8.3% to 5.86 billion gallons for the 2009-2010 harvest season.

Bunge Limited became the 100% owner of Usina Moema Participacoes S.A., which owns one sugarcane mill in Brazil with ownership interests in five other mills. With the purchase, Bunge would have a 60% share of sugarcane crushing capacity. Bunge's CEO stated that it is expanding into Brazil to "add significant scale to our current milling operations and enable us to vary production among multiple sugar and ethanol products, according to market conditions."

Sucral Engenharia e Processos Ltda. (Brazil) is planning to construct three fuel ethanol-producing facilities. The company will start up one plant per year, starting in April 2012.

Novozymes believes that Brazil could be exporting $4 billion per year of cellulosic sugar waste-based ethanol by 2020 (2 billion gallons per year) and that its cellulosic ethanol will be commercial by 2012.

Select Q1/10 and Q4/09 Ethanol Announcements

POET and Magellan Midstream Partners announced a joint venture to build a $4 billion 1,800 mile ethanol pipeline from the U.S. Midwest to the U.S. East Coast in Linden, New Jersey to be completed in 2014.

In October 2009, POET released a new ethanol co-product, Inviz, a biodegradable, low-nutrient protein found in corn that can be used as a gum base or in films, packaging, adhesives, coatings, and glazes. POET's process for extracting Inviz from corn is patent pending. The two key markets for POET's Inviz are **biodegradable plastics** and time-release capsules for pills.

On February 2, 2010, Shell announced a $12 billion deal with Brazil's Cosan for a sugar-based biofuel and biopower JV. The venture will be the third-largest fuel distributor in Brazil, with 4,500 fuel stations across the country. The joint venture hopes to more than double ethanol production to 5 billion litres per year from its current 2 billion litres per year.

On February 3, 2010, the United States reconfirmed its commitment to its RPS-2 goals with energy policies that promote the production and use of biofuels. The EPA set 2010 blending volume targets for cellulosic ethanol at 6.5 million gallons, significantly lower than the 100 million gallons proposed in May 2009. Biodiesel blending was increased to 1.15 billion gallons from the proposed 650 million gallons. The total 2010 RFS volume was maintained at 12.95 billion gallons, increasing to 36 billion gallons in 2022 (unchanged).

Second-Generation Cellulosic Ethanol

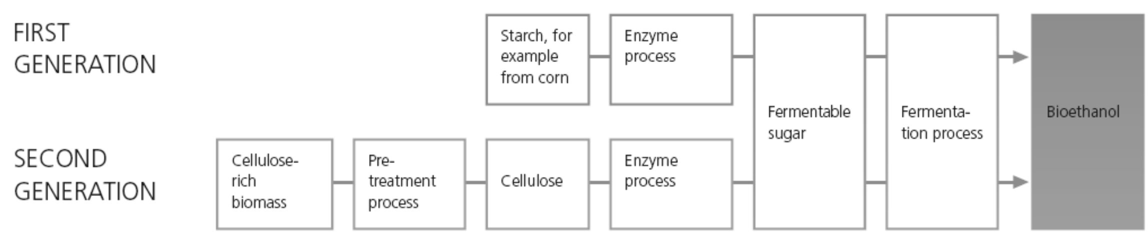
The 2008-2009 credit crisis delayed the development of cellulosic ethanol by at least a year. Seed investors are still unwilling to assume their technology risks. This led to Iogen's forecast, announced at Scotia's Bioenergy Day conference in November 2009, of closer to 10 million gallons of actual 2010 U.S. cellulosic ethanol production versus the 100 million gallon U.S. directive.

Success for cellulosic ethanol producers will depend on several factors: (1) access to a consistent supply of affordable feedstocks; (2) ability to access project finance and/or government grants, loan guarantees and tax credits; and (3) improved economies of scale with production methods.

Transition from Generation One to Generation Two Ethanol

The U.S. corn lobby also argues that generation one food-based ethanol plants could be readily converted to support generation two cellulosics plants over time. For example, the new DuPont-Poet corn waste Iowa cellulosics facility is attached to a generation one Poet ethanol plant. On September 29, 2009, Poet was awarded an additional $7 million in funding for its 25 million gallon per year cellulosic plant to help secure 700 tons of corn cob feedstock per day. The project will begin in 2011 **and has already received over $100 million in DOE funding**. See Exhibit 12 for bioethanol production processes, both first and second generation.

Exhibit 12: Bioethanol Production Processes



Source: The Novozymes Report.

Generation Two Ethanol Developments

We still believe that cellulosic ethanol from wood, plants, algae, or biomass/waste, or carbon-related biodiesels from algae, jatropha, switchgrass, miscanthus, cassava, or other plants like seaweed (Argentina) **could hit 1 million bbl/day or 10 billion gallons per year by 2018, especially with the increased emphasis expressed by President Obama on February 3, 2010**. The latest capacity estimate from *Biofuels Digest* is 2.32 billion gallons by 2014 for the United States alone (see Appendix 1).

Exhibit 13: Properties of Biofuel Feedstocks

	Composition		
	Cellulose (%)	Hemi-Cellulose (%)	Lignin (%)
Corn stover	35	28	16-21
Sweet sorghum	27	25	11
Sugarcane bagasse	32-48	19-24	23-32
Hardwood	45	30	20
Softwood	42	21	26
Hybrid poplar	42-56	18-25	21-23
Bamboo	41-49	24-28	24-26
Switchgrass	44-51	42-50	13-20
Miscanthus	44	24	17

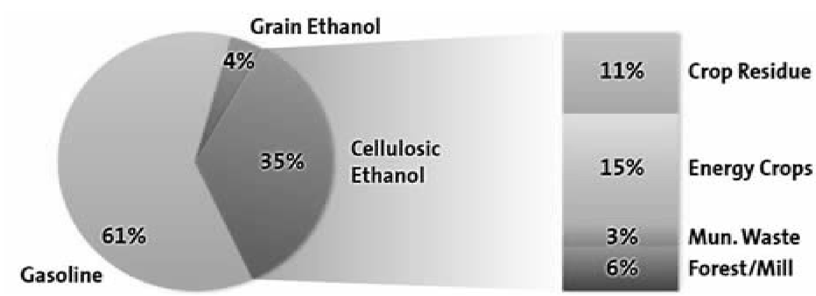
Source: U.S. Department of Energy.

The U.S. DOE forecast in Q1/09 of 90 billion gallons per year of non-food cellulosics-sourced fuels by 2030 (6 million bbl/day) and various 2008-2009 year-to-date breakthrough announcements support our view long term. Exhibit 13 shows the cellulosic component for several feedstocks.

The U.S.-based Environmental and Energy Study Institute estimated that there are 67 advanced biofuels projects complete, under construction, or in the planning stage in 31 states that could **get to 2.32 billion gallons per year of capacity by 2014.** In comparison, there are 171 first-generation U.S. ethanol plants (99% corn-based) that, with expansion plans, will have reached 13.6 billion gallons per year of capacity by the end of 2010.

The U.S. government gave six U.S. biorefineries an initial **$385 million** in start-up grants for corn stover, switchgrass, wheat straw, wood, and yard waste cellulosic processes. Collectively, they should produce **132 million gallons per year in three years**. GM stated it believes cellulosic ethanol could make up 35% of U.S. fuel requirements over time (see Exhibit 14).

Exhibit 14: Estimate of Potential U.S. Ethanol



Source: General Motors; Coskata.

Europe-based Novozymes and others have developed robust enzymes that can break down lignin, which acts like superglue in plants and trees, trapping sugars or starches. When sugars/starches are released, generation one ethanol plants can then process them into ethanol. **It was Novozymes' claims that prompted the U.S. DOE to speculate that the United States could eventually produce up to 90 billion gallons of cellulosics ethanol per year**. In Q1/10, Novozymes announced further cost breakthroughs for its cellulosic enzymes that take usage costs **down to $0.50/gal or below of cellulosic ethanol in 2010.**

U.S.-based Mascoma has a technology that could eliminate the cost of added enzymes by having the same organism convert biomass to simple sugars, and then to ethanol. Many other cellulosic ethanol processes require one enzyme to convert biomass to sugar and a second in ethanol production. Mascoma is aiming for yields of 70-85 gallons per ton from hardwoods, based on 70%-85% of the theoretical yield of 100 gallons per ton. Chevron announced a joint venture with Mascoma in September 2009.

Cellulosic Ethanol Cost per Gallon

Cellulosic ethanol capacity costs still range from $4-$8 per gallon of installed capacity, even at commercial scale. Projected production costs could eventually drop to $1 per gallon of ethanol according to Coskata. Cellulosic ethanol is expected to be competitive on a per-gallon cost basis. with oil around $80-$100 per barrel. Novozymes estimates that China could produce cellulosic ethanol for $2.50/gallon in 2010 and $1.50/gallon by 2015, based on China-specific costs, including raw material collection and transportation, ethanol production, logistics, and downstream distribution.

POET's cellulosic ethanol pilot plant has reduced its cost per gallon to $2.35 from $4.13 over the past year of production. POET's planned 25 million gallon per year commercial cellulosic plant in Iowa is expected to start up in late 2011 with **a goal of a $2 cost per gallon**.

On February 17, 2010, Novozymes introduced its new Cellic CTec2 enzyme, which is expected to allow manufacturers to produce cellulosic ethanol **below $2/gal** for initial commercial-scale plants scheduled to be in operation in 2011.

Novozymes has been working in partnership with Canada's Lignol to optimize the cellulosic ethanol production process while improving the process economics. Novozymes' Cellic CTec2 enzymes have helped Lignol achieve enhanced performance at its demonstration plant while reducing enzyme costs and increasing revenue. Pilot-scale tests with Cellic CTec2 enzymes will continue throughout 2010, with large-scale deployment of the enzymes to Lignol expected in 2011.

Canada's Lignol Energy Corporation (LEC)

Lignol is focused on the development of a bio-refining technology for the production of cellulosic ethanol and other high-value lignin co-products from wood waste. In mid-February 2010, we visited the company's 100,000 litre per year ethanol biorefinery pilot plant in B.C. that uses wood and agricultural residues as feedstock.

High-Value Lignin Co-Products

Lignol's patented wood biomass to ethanol process separates the components of biomass (cellulose, lignin, and hemicellulose) into clean streams for processing. Other cellulosic ethanol producers burn lignin for energy use on site. Lignol refines its lignin to produce highly valued HP-L lignin that can be blended into formaldehyde resins (adhesives, binders, insulation products), epoxy coatings (industrial, marine, automotive applications), and other resins. HP-L lignin-based resins can displace toxic, non-renewable formaldehyde resins. Technical lignin is a by-product of pulp and paper production. However, this lignin is contaminated with chemicals, which reduce its functionality.

Lignol believes its cost for its potential co-product range will be from $0.50/lb to over $0.75/lb, based on the price of ingredient being replaced. Long-term applications include: an additive in animal feed, low-cost carbon fibre, and an anti-oxidant for the replacement of petrochemicals in lubricants, metal working fluids, and rubber products.

Lignol's planned demonstration facility in the United States would produce 10,000-15,000 tonnes per year HP-L lignin. Its future commercial-scale biorefinery is expected to produce 50,000 tonnes per year of HP-L lignin using 1,000 tonnes per day of biomass feedstock. **Lignol has partnered with HA International, PPG Industries, and Huntsman** to provide HP-L lignin resins with an approximate 30% substitution rate.

Longer term, Lignol's HP-L product may also be used in the manufacture of carbon fibre. Lignol has been working with Oak Ridge National Laboratory (managed by the U.S. DOE, which has offered Lignol a $30 million grant) in testing its lignin product for use in carbon fibre applications, such as automotive parts. At the International Biotech Conference in 2009, Oak Ridge Lab stated that of all the lignin available for carbon fibre processing, **Lignol's lignin product was the only one that had a chance of making it over the finish line.**

In February 2010, Lignol announced with Novozymes that its HP-L lignin biomass plant uses less enzymes per ethanol gallon than its competitors because of the purity of its process.

Lignin Producers

Lignin has been produced as a by-product from the chemical pulping operations in the pulp and paper industry. As with cellulosic producers, most pulp mills burn the lignin for its energy value, **but a few companies process lignin for resale.**

Borregaard LignoTech, based in Norway, is the world's leading producer of lignin-based products at its eight plants. Over half its sales are in Europe, with the remaining split between the Americas and Asia-Pacific. LignoTech's only production facility in North America is based in Wisconsin and produces 95,000 tons of lignin per year.

Lignol Energy Corporation Comparables
Lignol is a unique company that produces both ethanol and high-value lignin using an enzyme-based process. Most other cellulosic ethanol companies either use chemical-based processing (e.g., Verenium) or gasify biomass to produce ethanol (e.g., Coskata, Range Fuels, and SunOpta). As mentioned earlier, ethanol producers burn the lignin by-product as fuel for its process. There are a few companies that have some similarities to Lignol, as listed below.

Burcon Nutrascience (TSX: BU) has a technology that separates protein from oil seeds, mainly canola and soy. Proteins are used in the food industry (beverages, baked goods, dressings and sauces, and protein powder). Burcon is similar to Lignol in that its extraction process does not use harsh chemicals and it produces a protein product with superior quality. Lignol's process produces a high-quality lignin product without using harsh chemicals. The key difference is that Lignol's product is used as a bio-chemical intermediate in resins and polymers. Lignol's HP-L lignin product can also be used as an animal feed additive, although Lignol is not targeting this as its primary lignin market.

BioExx Specialty Proteins (TSX: BXI) extracts oil and active ingredients from canola. Its process uses low temperatures compared to conventional processes that operate at high temperatures. The low temperature minimizes the damage to proteins, allowing for the separation of higher-value proteins for sale into the specialty feed and human food market. BioExx has a similar extraction process to Lignol in that it produces a high-quality, high-value product. The key difference is that BioExx uses petroleum-based heavy fuel oil in its extraction process, whereas Lignol uses enzymes and no harsh chemicals.

Abengoa Bioenergy (Spain: ABG) is developing an R&D program focused on integrated biorefineries. As part of the program it will identify and select potential added-value products (including lignin) along with ethanol using both enzymatic and thermochemical methods. This is currently only a small R&D segment of Abengoa's overall business. Abengoa was selected by the DOE to build an integrated biorefinery demonstration plant in Kansas. It will convert 400 tonnes per day of biomass into ethanol, lignin, and biomass animal feed. No timeline for completion has been set.

BlueFire Ethanol (OTCBB: BFRE) uses acid hydrolysis (chemical-based) technology to convert biomass into ethanol, a different production process from Lignol. BlueFire either burns lignin fuel for its process or further refines it for sale into markets. The amount of lignin burned for energy versus that refined and sold into the market was undisclosed.

Oil Companies in Second-Generation Ethanol/Biofuel

In 2008-2009, oil companies became active in myriad JVs with generation two and three cellulosics and algae companies. Chevron has JVs with Weyerhaeuser on switchgrass-based bioethanol (Catchlight Energy), algae-based Solazyme, and garbage-to-ethanol-based Mascoma. We briefly interviewed Catchlight Energy's CEO, who stated that the JV's focus is on the southeast U.S., where biomass grows the fastest in tracts of forest land owned by Weyerhaeuser.

Royal Dutch Shell owns 50% of Canada's Iogen and has an interest in Codexis, which is apparently developing better biocatalysts than Iogen is currently using. Codexis filed a preliminary prospectus for a $100 million IPO on the NYSE on December 28, 2009. In 2009, Shell doubled its financial support to $60 million for Codexis Inc.

BP and Verenium have a joint venture (Rangeland) to pursue the conversion of sugar-related grasses to cellulosic ethanol. A $250 million cellulosics plant was announced for Florida to produce 36 million gallons of cellulosic ethanol per year.

ExxonMobil announced a $600 million algae joint venture with Synthetic Genomics in early Q3/09. Dow Chemical announced a JV with Florida-based Algenol to produce algae on one of its Texas petrochemical sites.

It is clear that most oil companies are avoiding investments in food-based ethanol and are focusing on advanced technology, next generation non-food-based ethanol in places other than Brazil, where Shell's blockbuster $12 billion deal using sugar waste with Cosan will take place.

Pulp and Paper Mills Transitioning to Biofuels Production?

In our opinion, the forestry sector must transform its core business away from wood products to bioenergy or face extinction. AbitibiBowater could make the transition into biofuels as its mills are located in regions with substantial cutting rights (Ontario and Quebec). Shell and Iogen are looking to build an ethanol plant on part of Domtar's former Prince Albert pulp and paper mill, which is scheduled to be demolished, starting shortly. In late December 2009, Iogen confirmed that negotiations with Domtar were called off but are expected to restart in Q2/10. Iogen hopes to reach an agreement with Domtar before demolition of the mill begins.

In February 2010, the Forestry Products Association of Canada (FPAC) released the results of a study it conducted to determine the best path for the future of the forestry industry. The study focused on Canada's three main forestry regions: British Columbia, Ontario, and Quebec. Researchers analyzed 16 traditional forest products (lumber, pulp, newsprint) and 11 emerging technologies to determine how to ensure the forestry industry remains profitable into the future.

The study concluded that the future of the forestry industry involves an integrated biorefinery model. Lumber production should continue, with the residues from lumber (wood chips, sawdust) used in biorefineries to produce biochemicals and bioenergy. This new integrated model has the potential to power one-fifth of Canadian homes, the equivalent of nine nuclear reactors. The FPAC claims that higher economic returns are expected when the forestry industry integrates with the bioenergy industry, rather than as a stand-alone operation.

The second phase of the FPAC project (beginning in 2010) will explore new approaches to managing the value chain and opportunities to develop cross-sector partnerships. It will also estimate the market potential for wood-based bioproducts.

Verenium is expected to test its bolt-on C5 technology for the creation of cellulosic ethanol from the hemicelluloses generated by the pulp and paper process. **Vernium estimates a typical 1,500 ton per day kraft mill could produce 15 million gallons of ethanol per year.** The kraft pulping process used to make magazines and paper bags uses only 50% of the tree. The remainder ends up as sludge that is burned, spread on land, or landfilled. Verenium would use the leftover 50% of the tree sludge as feedstock for its process. Mechanical pulping used to make newsprint uses 90% of the tree, so less sludge is available.

Select Q4/09 and Q1/10 Announcements

Canada's Enerkem, a waste-to-biofuel producer, closed a C$53.8 million round of financing on February 24, 2010, with institutional investors that included a strategic investment by Waste Management Inc. (its third investment in waste energy). The funds will be used to support Enerkem's growth, including construction of its second waste-to-biofuels plant. According to Waste Management, the Enerkem investment complements its recycling, landfill, and waste-to-energy services.

Iogen's 23 million gallon commercial cellulosic ethanol plant in Prince Albert, Saskatchewan, has been stalled since it received C$500 million in government funding. The new CEO of Royal Dutch Shell, which is Iogen's part owner, does not expect advanced biofuels would be in widespread use for another decade. Iogen has said the Prince Albert project is making progress, but could not provide a timeline on a final investment decision. The project has not yet received a firm commitment from Iogen and Shell.

On January 6, 2010, Alter NRG announced its plasma gasification operation adjacent to Coskata's production facility is successfully supplying clean syngas to Coskata for conversion into fuel ethanol by its patented enzymes. Alter NRG's process gasifies up to 18 tons per day of non-food biomass into clean syngas.

In March 2010, Coskata stated the construction costs for its 55 million gallon per year commercial-scale plant were expected to be $275 million-$330 million, or $5-$6 per gallon of installed capacity. The company continues to confirm a fuel cost of $1.00-$1.50 per gallon (depending on final feedstock, power, and oxygen costs for the gasifier).

Valero announced its cellulosic ethanol plant will open in Georgia shortly, utilizing a proprietary process that co-produces pulp and ethanol from softwood chips in an integrated biorefinery application. The process can produce 22.6 million gallons of ethanol using 500 tons per day of pulp.

Iogen's cellulosic ethanol production reached 153,000 gallons in 2009, doubling its 2008 production.

SunOpta was awarded $5.5 million by the Canadian government to demonstrate its process to convert wood chips into ethanol, lignin, and a sugar substitute, xylitol, which is currently imported from China. The demonstration facility will be located at the Opta Minerals plant in Ontario.

BlueFire Ethanol has relocated its second planned 18 million gallon per year cellulosic ethanol biorefinery from California to Fulton, Mississippi. The feedstock for the plant will be green and wood wastes available from the surrounding area. It first biorefinery in Lancaster, California produces 3.9 million gallons of ethanol per year from post-sorted cellulosic wastes.

Inbicon opened its 1.4 million gallon per year, demonstration scale cellulosic ethanol plant in Demark using wheat straw as its initial feedstock. The plant is the largest cellulosic ethanol plant in Europe and is second in size to the KL Energy cellulosic ethanol project in Wyoming. Inbicon's plant also produces 13,000 tonnes of lignin pellets, which will be supplied to DONG Energy to replace coal.

TMO Renewables, based in the United Kingdom, has developed a process capable of cost-effectively converting at least 25 different biofeedstocks into ethanol, including corn stover, municipal waste, used newsprint, and wheat straw. TMO's process uses an enzyme supplied by Novozymes and requires only 10% of the standard amount of enzymes required for comparable processes.

Raven Biofuels Ltd. (RBL), a Canadian partner for Raven Biofuels International (RBIC), was established to develop technology and Canadian projects. RBL will pursue Canadian opportunities in bioenergy and clean technology. RBL received $170,000 in funding for the 11 million gallon per year ethanol biorefinery in Kamloops, British Columbia, in a joint venture with the Kamloops Indian Board. The biorefinery would require 500 dry tons of biomass per day.

In February 2010, Genera Energy opened its 250,000 gallon per year JV cellulosic plant, which will use corn cobs initially and eventually switchgrass, in Vonore, Tennessee. The $50 million plant uses a Dupont Danisco cellulosic ethanol (DDCE) process. The next step is to scale up to a 25 million-50 million gallon per year commercial facility (CEO of DDCE).

Select Q3/09 Announcements
Please refer to our November 2009 *Biofuels Outlook* report entitled "Explosive Growth and Development Continues" for Q3/09 announcements.

Canadian Players

In Canadian generation two cellulosic ethanol, **the frontrunner was wheat waste-based Iogen, which is now selling commercial cellulosic ethanol with Shell in Ottawa, Ontario**. Wood waste-based Lignol, Ensyn, and Nexterra are catching up, as is MSW waste-based Enerkem. Canada's Alter NRG has proven its plasma arc technology works on biomass at Coskata's Pittsburgh demonstration site.

E85 Ethanol-Blended Gasoline

To date, E85 ethanol is only compatible with flexible-fuel vehicles (FFV), which can run on any blend of ethanol gasoline fuel from 0% ethanol to 100% ethanol. North American and European FFVs can run with 85% ethanol (E85), as Brazil's cars do. U.S. and EU market sales of FFVs are still too low to make a difference to food-based fuel demand as a result of limited E85 fuelling locations. **If the number of FFVs on the road is forced to increase as a percentage of new car sales, it would lead to more E85 fuelling stations, and supporting infrastructure would follow.**

In Brazil, FFVs reached over 80% of January to November 2009's new car sales, leading to a total of over eight million FFVs on Brazil's roads. As a result, **Brazil now consumes 51% ethanol and 49% gasoline**, which Petrobras expects to increase to **75% ethanol by 2020.**

Sweden's FFVs comprised 25% of new car sales in 2008 and 35% in 2009. As at May 2009, there were 300,000 FFVs on the road in Sweden (4 million vehicles in total). The number of FFV vehicle models in Sweden has increased **to 28 from three in only two years**. The growth of FFVs in Sweden is supported by government incentives such as lower taxes and free parking. A $91 million government investment in E85 infrastructure will increase the number of E85 stations in Sweden to 2,000 by the end of 2009. As of August 2009, **there were 1,200 E85 fuelling stations in Sweden**.

The United States and Canada are still investigating FFV/E85 strategies that will emphasize production and sales of FFVs while enhancing their E85 infrastructure. The U.S. and Canadian E85 developments are therefore **way behind** Brazil and Sweden. At the end of August 2009, the U.S. auto industry announced it is **pushing to defeat** the Consumer Fuels and Vehicles Choice Act, which mandates auto manufacturers to produce FFVs for 50% of their U.S. vehicles by 2011, increasing to 90% by 2013. Without more FFVs on the roads, the United States may not expand its E85 infrastructure, **essentially stalling the development of the U.S. E85 fuel market.**

A University of Nebraska study concluded that E85 **increases engine efficiency by 14%** compared to E10 through improved energy conversion. Other tests have shown corn-based **E85 generates 30% lower CO_2 emissions** over an average car life compared to conventional gasoline. **Cellulosic-based E85 results in 36% lower CO_2 emissions.**

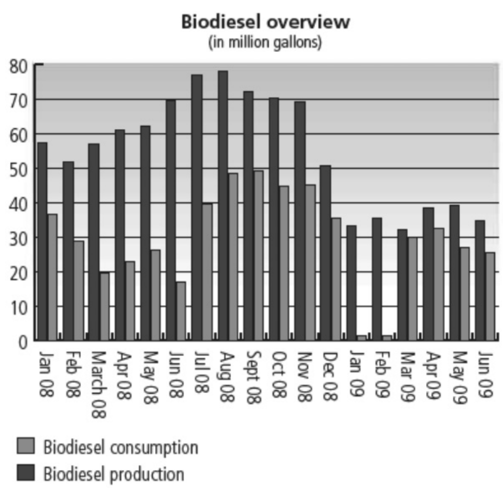
Biodiesel

Biodiesel demand growth tapering short term. In 2006, Archer Daniels had forecast 65% per year biodiesel demand growth through 2010. **Based on our calculations, this growth rate is now about 14% per year through 2012, assuming $80/bbl oil prices.** Soybean oil demand for 2008 biodiesel use reached 23% of all soybean oil demand. It takes 7.3 lb of soybean oil to make 1 gallon of biodiesel.

Biodiesel could see a supply/demand imbalance by 2015. Biodiesel demand is expected to reach almost 10 billion gallons by 2015, but the potential supply could reach 25 billion gallons. This could trigger future projects to be cancelled and/or keep utilization rates low.

In 2009, global biodiesel production reached 4.16 billion gallons. Worldwide use of biodiesel is expected to double from 2009 to 2015 **with the United States leading demand growth**. Indonesia and Malaysia are expected to double their production of palm oil biodiesel. Germany will continue to be the largest biodiesel producer in Europe.

Exhibit 15: Biodiesel Consumption and Production



Source: U.S. Energy Information Administration.

In 2009, the United States had about 175 biodiesel plants with the capacity to produce 7.5 billion litres of biodiesel. Many of these plants are idle and at least 20 have gone bankrupt. U.S. biodiesel production in 1H/09 was down 68% compared with the same period last year (Exhibit 15).

The U.S. EPA believes that biodiesel causes higher NO_x emissions (310 times worse than CO_2), especially as engine load increases. **If proved true, this could set back biodiesel demand growth further if biodiesel has to abide by upcoming U.S. climate change rules.**

The European Biodiesel Board (EBB) reported **European biodiesel production was up 35% to 7.76 million tonnes in 2008** over 2007. This was 65% of the global biodiesel market, even **though half the 276 biodiesel plants in Europe were idled**. For two years, EU biodiesel producers had to compete with heavily subsidized biodiesel from the United States sold in the EU at a discount below the soybean raw material price. Since the recent EU implementation of biodiesel import fees, **U.S. exports have dropped back to negligible levels.**

The U.S. biodiesel $1/gallon tax credit for producers expired on December 31, 2009. The Senate approved the American Workers, State, and Business Relief Act, which includes the extension of the $1/gallon biodiesel tax credit. The tax credit is retroactive, effective January 1, 2010, to December 31, 2010. Differences between the House and Senate versions of the bill still need to be reconciled before President Obama can sign it into legislation. The timing of this is uncertain. Until the tax credit is officially in place, the U.S. biodiesel industry should remain operating at reduced capacity. Without the incentive, **biodiesel would cost much more than petroleum diesel, killing biodiesel demand and causing some producers to shut down or go bankrupt, in our opinion.**

At the end of 2009, 85% of U.S. biodiesel production capacity was idle with production at only 50% of 2008's level. In 2009, 82% of the EU biodiesel production capacity was idle.

Biodiesel Mandates

European ethanol and biodiesel backtracking. The EU's 2008 biodiesel capacity hit 16 million tonnes per year as Germany set a 2008 tax on biodiesel that **backfired on demand.** Producers cut production by 60%, or 600,000 tonnes per year. Germany also **blocked** plans to raise ethanol blends to 10% from 5%, weakly, in our view, citing the 3.3 million German car engines that cannot function on it.

Brazil is moving toward a B20 biodiesel standard in major cities by 2015, and a countrywide B10 standard. Effective January 2010, Brazil requires 5% biodiesel blends, up from 4% previously. The B20 mandate would increase biodiesel demand by 661 million gallons. In 2009, Brazil's biodiesel capacity reached 952 million gallons per year at 43 facilities. **Almost 50% of capacity was off-line because of low demand**, with 2020 estimated production at about 630 million gallons.

South Korea is increasing its biodiesel blends to 2% from the current 1.5% blend, which would require 390 million litres of biodiesel in 2010. It plans on further increasing the biodiesel blends to 5% in 2011, and to 20% in the future. To facilitate this, the Korean government will waive the $0.45 per litre oil tax on diesel fuel. South Korea began blending biodiesel in July 2006.

In palm oil, Malaysia and Indonesia supply 90% of the world's palm oil. The majority of their palm oil exports for biodiesel go the EU. India has begun to compete against the EU for palm oil for its biodiesel programs, increasing its palm oil imports by 40%. **The 5.7% EU target for 2010 biofuels use is not mandatory, nor is the suggested 10% by 2020 target for now**.

The 418 page U.S. Renewable Fuel Standard (RFS-2) preamble (EPA) and 120 pages of regulations was reconfirmed by President Obama and DOE head Dr. Chu on February 3, 2010. It requires the use of 650 million gallons of biomass-based diesel in 2010, 800 million gallons in 2011, and a minimum of 1 billion gallons per year starting in 2012 and beyond.

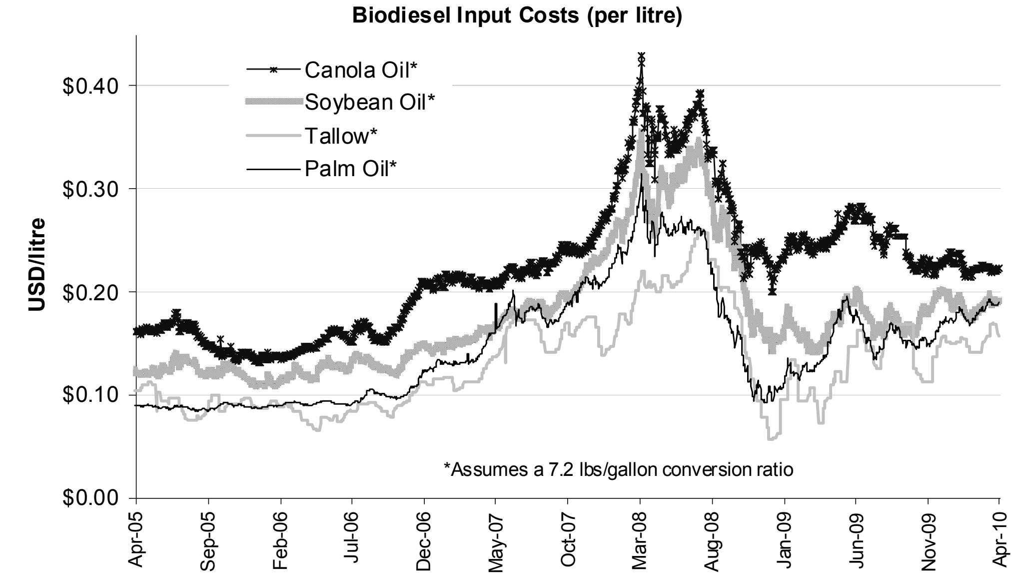
In Canada, Manitoba became the first Canadian province to mandate biodiesel when its B2 requirement was implemented on November 1, 2009. The provincial government is replacing the biodiesel fuel tax exemption with a 3.7 cent (Canadian) per gallon, five-year production grant for biodiesel produced in Manitoba starting in spring 2010.

Biodiesel Economics

There are three types of biodiesel feedstocks: (1) plant-derived oil (includes soybean, vegetable, cottonseed, canola, flax, sunflower, and peanut), which is the most expensive; (2) animal-derived oil (includes tallow, white grease, poultry fat, and yellow grease); and (3) recycled oils and grease mainly from restaurants and food processing plants.

Biodiesel feedstock costs peaked in the first half of 2008, causing numerous producers to slow down or stop production (Exhibit 16). In the first half of 2008, soybean oil prices soared 70% to a high of US$0.36 per litre before dropping in September 2009 to $0.16 per litre**. Biodiesel plants with the flexibility to process multiple feedstocks have fared the best**, as they can use lower-cost sources such as tallow and recycled cooking oil. In the United States starting on January 1, 2009, yellow grease biodiesel use became eligible for a credit of $1 per gallon (previously $0.50 per gallon).

Exhibit 16: Biodiesel Feedstock Costs



Source: Bloomberg; Scotia Capital estimates.

Free fatty acids (FFA), present in many biodiesel feedstock oils, cannot be processed in conventional biodiesel plants. FFA levels more than 0.5% weight in biodiesel feedstock results in a side reaction producing soap and ultimately decreases biodiesel yields. Refined vegetable oils have a FFA content of less than 2%, whereas restaurant grease and animal fat contain 15%-20% FFA content (Exhibit 17). In order to reduce the FFA levels in animal fat and recycled cooking oil to acceptable levels below 5%, **pre-treatment is required, increasing the overall processing costs.** Feedstock costs account for over 70% of the total biodiesel costs. Based on Exhibit 16, tallow has averaged approximately $0.04/litre less than soybean oil. **It is advantageous to use low-cost feedstocks with high FFA content (tallow, recycled cooking oil), as lower feedstock prices more than offset the additional pre-treatment processing costs**.

Exhibit 17: Free Fatty Acid Content in Biodiesel Feedstocks

Feedstock	FFA Content (wt %)
Soybean Oil	< 2%
Rapeseed Oil	< 2%
Palm Oil	8%
Yellow Grease	15% - 20%
Edible Tallow	15% - 20%
Camelina	2%
Jatropha	2%-30%

Source: Renewable Energy Group.

Many new biodiesel production facilities are capable of running multiple feedstocks in order to use the lowest-cost feedstock at any given time while still producing biodiesel that meets industry quality standards (e.g., Canada's Biox Corporation at its Hamilton plant).

Two important biodiesel quality tests are cloud point and cold filter plugging point. These characteristics refer to the temperature at which biodiesel begins to crystallize or gel, causing engine filters to clog. These two quality tests are **critical for biodiesel use in cold climates during the winter**. Both the cloud point and the cold filter plugging point **vary significantly by feedstock**.

Biodiesel produced from low-FFA canola oil has a cloud point of -3.3°C (meaning the biodiesel product will begin to crystallize or gel at temperatures below -3.3°C). The cloud points of soy-based biodiesel and tallow-based biodiesel are 0.9°C and 16°C, respectively, **making them less suitable for cold weather use** (Exhibit 18).

Exhibit 18: Biodiesel Cloud Point

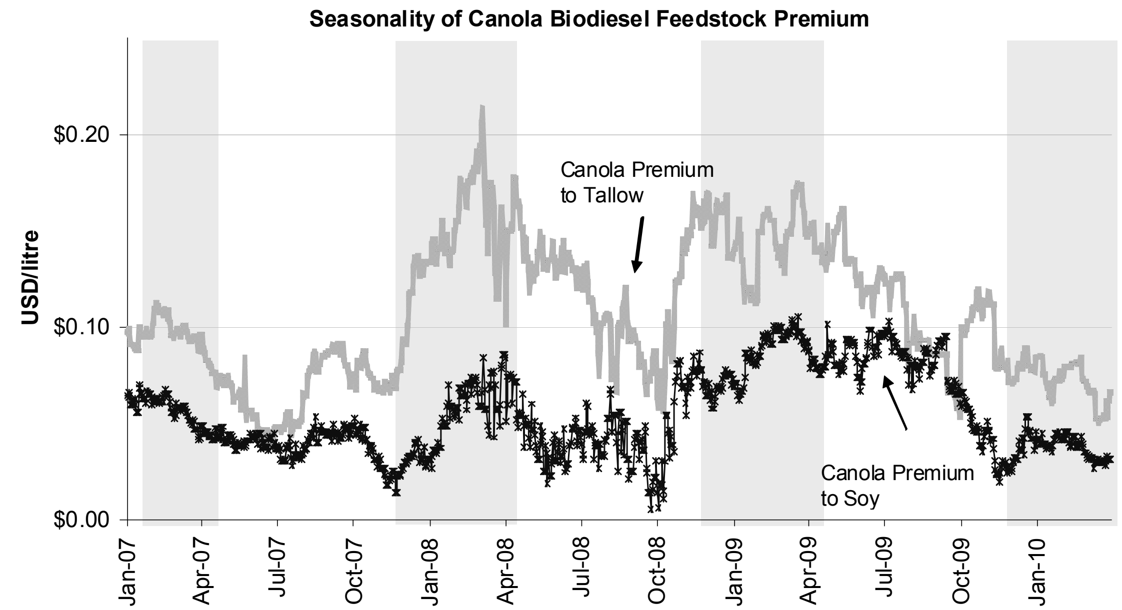
Biodiesel	Cloud Point (°C)	Biodiesel	Cloud Point (°C)
Algae 1	-5.2	Hepar, Low IV	6.7
Algae 2	3.9	Jatropha	2.7
Babassu	4.0	*Lesquerella fendleri*	-11.6
Beef Tallow	16.0	Linseed	-3.8
Borage	-1.3	*Moringa oleifera*	13.3
Camelina	1.5	Mustard	3.2
Canola	-3.3	Neem	14.4
Castor	-13.4	Palm	13.0
Choice White Grease	7.0	Perilla Seed	-8.5
Coconut	0.0	Poultry Fat	6.1
Coffee	0.2	Rice Bran	0.3
Corn, Distiller's	-2.8	Soybean	0.9
Cuphea viscosissima	Not enough sample	Stillingia	-8.5
Evening Primrose	-7.5	Sunflower	3.4
Fish	3.2	Tung	-10.0
Hemp	-1.3	Used Cooking Oil	2.4
Hepar, High IV	16.0	Yellow Grease	6.0

Source: Renewable Energy Group.

Several options are available to mitigate poor cold weather properties (cloud point and cold filter plugging point) in high-FFA-based biodiesel. Storage tanks and other biodiesel infrastructure can be heated to temperatures that will prevent gelling and crystallization of the biodiesel. Also, specialized additives can be mixed with the biodiesel fuel to lower the cloud point to enable the biodiesel to be used in cold weather. These options increase the cost of the tallow- and soy-based biodiesel compared to canola, which has a cloud point below 0°C.

As a result of the high FFA content and poor cold weather properties, **tallow feedstock has traded at an average $0.108/litre discount to canola since 2007**. Similarly, soy feedstock has traded at an average $0.056/litre discount to canola since 2007. This is a mainly seasonal trend. During the winter, cold weather properties are a major concern for biodiesel blenders. As a result, from November to April each year, the canola premiums to tallow and soy reach annual peaks (Exhibit 19).

Exhibit 19: Seasonality of Canola Biodiesel Feedstock Premium

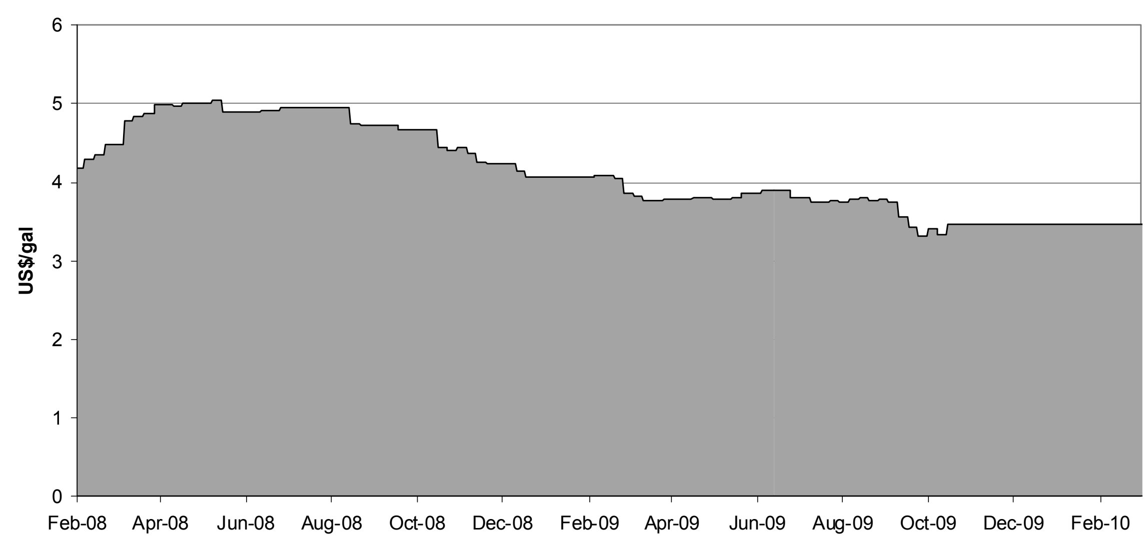


Source: Bloomberg; Scotia Capital.

Researchers from the University of California have discovered an enzyme that can produce fatty acid ethyl esters (another term for biodiesel) from hemicellulosic material. This could result in the future use of agricultural and forestry waste being used as a biodiesel feedstock.

With B100 prices just below $4 per gallon (Exhibit 20) and biodiesel feedstock prices down from 2008 peaks, **some low-cost biodiesel producers should be marginally profitable again.**

Exhibit 20: U.S. Biodiesel 100 Price



Source: Bloomberg.

The significant increase in food-based biodiesel feedstock costs has led to accelerated R&D in non-food second-generation feedstocks (algae, jatropha, and enzymes) that could, over time, be lower-cost alternatives to soy, palm, canola, and other first-generation food feedstocks.

First-Generation Related Biodiesel Topics

The glycerine market, a by-product from biodiesel production, is now oversupplied globally. The price of glycerine may **stay depressed** because of further oversupply from biodiesel production facilities. Typically glycerine is used for soap manufacturing, cosmetics, and other chemical products. An emerging use for glycerine is as a clean fuel to burn in boilers to produce steam and power. Raw glycerine, with 85% concentration, has an energy value of 65,000 BTU per gallon or **half that of fuel oil.**

On September 22, 2009, Kinder Morgan Energy Partners began commercial shipments of B2 biodiesel on its 115-mile Oregon Pipeline with a 100,000 barrel batch. Kinder Morgan's line is one of a few pipelines in the United States that can transport biodiesel, **as it does not transport jet fuel**, eliminating contamination risk for jet fuel batches. This biodiesel infrastructure has helped diesel fuel suppliers in Oregon meet the October 1, 2009, state biodiesel mandate.

First-Generation and Flexible Biodiesel Production Announcements

Canada
Biox Corporation (Flexible)

On February 25, 2010, the shareholders of JJR IV Acquisition Inc. approved the amalgamation of JJR with Biox Corporation. The amalgamation is effective March 1, 2010, with the new company called Biox Corporation. It began trading on the TSX (ticker: BX) at C$2.02/share on March 3, 2010, with 1.38 million shares traded on the first day. For its three months ending December 31, 2009, Biox reported C$11.6 million in sales and an operating loss (excluding non-cash items) of C$0.76 million.

Biox plans to use the equity proceeds to build a second biodiesel plant in Montreal, to be operational in the first half of 2011. The site will be at the end of the PetroCanada petroleum pipeline and next to the diesel distribution terminal.

Its first biodiesel IPO for $190 million **failed in** August 2007 because of collapsing equity and credit markets. Biox has a world-scale flexi-feed biodiesel plant in Hamilton operating at high capacity rates using mostly local chicken fat for feedstock, which is supplied by Sanamax.

On August 21, 2009, Biox Canada announced it will receive $72.4 million in funding for its 17 million gallon per year biodiesel plant in Hamilton from the Canadian government's ecoENERGY for Biofuels program. This is in place to help stabilize the Canadian renewable fuels industry. The program will provide **a total investment of up to $1.5 billion for 23 companies with payments made for up to seven years.**

Biox's business model includes: (1) technology that enables flexibility to use multiple feedstocks to lower operating costs (high free fatty acid tallow (20% FFA may not be used because of technology limitation)); (2) modular plant design that allows for quick construction times; and (3) locating biodiesel plants next to diesel distribution terminals. Biox currently has a 60 million litre per year biodiesel production facility in Hamilton, Ontario. In addition to plans for another 60 million litre per year production facility in Montreal, Biox is also looking at facilities in Chicago, Houston, and a second facility in Hamilton.

Canadian Bioenergy (First Generation)

Western-based Canadian Bioenergy could have been next with an IPO, but its preliminary prospectus did not get filed in 2007. It remains private currently. Canadian Bioenergy is looking for additional financing from Canadian farmers to ensure it qualifies for the C$14.25 million in government funding under its ecoABC program.

Canadian Bioenergy is focusing on the renewable diesel industry, with three projects in its development-stage project portfolio (one biodiesel and two green diesel projects). These projects require about C$200 million in capital and will generate C$500 million in annual revenues with a target IRR of 20%-30%. The company is also the largest Canadian wholesaler of biodiesel.

Canadian Bioenergy is in the process of raising capital from farmers to fund its joint venture 265 million litre per year biodiesel project with Archer-Daniels Midland (ADM) in Lloydminster, Alberta (40% Canadian Bioenergy, 60% ADM). The plant will be located adjacent to ADM's canola crushing plant in Alberta, to be commissioned in Q4/11. By building a biodiesel plant in an existing crushing plant, existing infrastructure can be used, reducing capital costs by 35%-40% and reducing operating costs by 35% compared to a greenfield stand-alone biodiesel plant (management estimates). Also, a secure canola feedstock source from ADM on site will reduce transportation costs and minimize supply risk.

Methes Energies' 1.3 million gallon per year biodiesel plant in Mississauga, Ontario will receive $5.4 million through Canada's ecoENERGY for Biofuels program. In September 2009, Methes Energies International filed a registration statement with the U.S. SEC relating to a proposed IPO.

United States

GreenHunter Energy Inc., the operator of the largest biodiesel refinery in the United States, stopped production at its facility in early 2009 and in June announced it may have to sell its Houston plant. The 180 million gallon per year Renewable Biofuels biodiesel plant in Texas, the largest in the United States, has been idled because of the expiration of the biodiesel tax credit on December 31, 2009. Many other new U.S. biodiesel plants have stopped operating as production is not economical for now. Most biodiesel businesses were based on high crude prices and government subsidies. Lower oil prices in 2009 and postponed blending mandates have hurt many U.S. producers.

HERO BX (previously Lake Erie Biofuels) produced more than 45 million gallons in 2009, with production expected to increase to 55 million gallons in 2010. The process ran 15 different feedstocks in 2009, ranging from fat and greases to fish oils and virgin oil, using less than 10% soybean oil in order to keep operating costs down. **HERO BX is testing the possibility of camelina and algae as feedstocks**. The company has been successful selling biodiesel into Asia and Eastern Europe, with half of its 2009 production sold internationally.

Darling International is considering a joint venture with a subsidiary of Valero Energy Corporation to build a 135 million gallon per year biodiesel plant using animal fat and used cooking oil as feedstocks. The facility is expected to be near Valero's St. Charles refinery in Louisiana. Darling and Valero are looking to secure a DOE loan under the Energy Policy Act.

U.S. Railroads Testing Biodiesel

The U.S. railroad industry consumed 3.6 billion gallons of diesel fuel in 2007, so it is a potential market for biodiesel. The Iowa Interstate Railroad has started testing B10 and B20 biodiesel blends supplied by Renewable Energy Group to measure engine performance and emission reductions. In January 2009, Disneyland Railroad trains were converted to biodiesel, and use waste oils from the resort's restaurants and hotels.

In Washington, Tri-City & Olympia Railroad established a subsidiary, Green Diesel, to make 1 million gallons per year for 100 cars on the 127-mile railroad. **This is the first biodiesel plant owned and operated by a railroad.**

In June 2008, Eastern Washington Gateway Railroad conducted a three-month biodiesel test for its 109-mile line, which mainly transports grain harvest. The test used a range of feedstocks including soy, canola oil, and grease.

Generation Two Biodiesel Developments

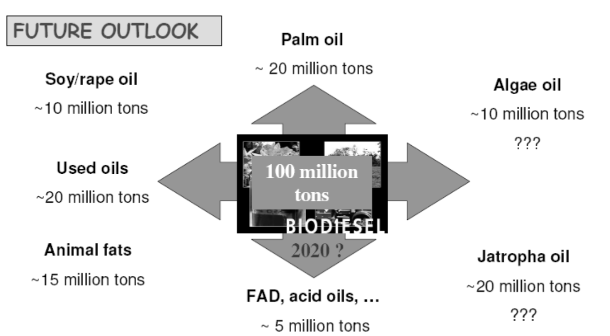
Generation two jatropha prospects: Negative press that actual jatropha yields are coming in well below expectations was **partly offset** by breakthrough news that certain jatropha trees can grow in colder climates (SG Biofuels). Tree fruit from jatropha is toxic, so it is not a food source.

Jatropha makes excellent biodiesel feedstock, along with algae oil (verified by Boeing and Continental's released flight data using a blend of both oils). **The labour cost to harvest jatropha fruit has to be really low** to make jatropha economics work. To date, all jatropha fruit has to be hand-picked. Jatropha's bushy trees have grown only 30° north or south of the equator to date.

A study published in June 2009 indicated jatropha required more than twice as much water as other biofuel feedstocks such as soybeans, and nearly **eight times as much water as corn and sugar cane**. This opens a new problem for this emerging biodiesel non-food-based feedstock, as water scarcity and conservation is becoming an important global issue.

In January 2010, S6 Biofuels announced up to $400 per acre profits using an elite jatropha cultivar in Guatemala at 350 gallons per acre and a $1.39 per gallon production cost.

Exhibit 21: Future Outlook for Biodiesel



Source: New Biofuels Production, DeSmet Presentation.

More new non-food crops like camelina, stinkweed, eucalyptus, and now olives have been announced as biodiesel alternatives lately, as their oil content is 30%-40%. Like soybeans, they can fix nitrogen in the soil, making them ideal swing crops, and many can grow in less-than-favourable conditions **without much fertilizer**. A range of biodiesel feedstock estimates for 2020 are found in Exhibit 21.

Camelina is a member of the mustard family, and is currently grown in the northern plains of the United States, particularly Montana. It is being tested in other areas of the United States and other countries such as Argentina. Similar to jatropha, camelina can be grown in low-rainfall areas that are unsuitable for food crops. The plant is also tolerant of cold weather.

Yields are double those of soybeans. The co-product meal left over after producing oil can be used for livestock feed. Studies have shown that a **wheat-camelina-wheat rotation produces more wheat than wheat-fallow rotations**, making camelina a potential second-generation biodiesel feedstock. It has also already been successfully tested in a commercial airline (Japan Airlines) test flight. The test showed camelina reduced carbon emissions by 80% compared to petroleum jet fuel. **This 80% emission reduction is in line with algae and jatropha CO_2 emission reductions.**

Salicornia is another emerging biodiesel feedstock that grows in salt marshes, on beaches, and near mangroves. The plant can tolerate immersion in salt water and inhospitable soils, reducing the fresh water requirement for growth. **Salicornia seeds contain 30% oil (similar to safflower oil) and 35% protein**, with test fields claiming yields between 225-250 gallons of biodiesel per hectare. The plant usually grows less than 30 centimetres tall. Studies have shown that **adding nitrogen fertilizer to the seawater increases the growth rate and height of the plant.**

Indian Biodiesel

India's Ministry of Renewable Energy targets 5% renewable fuels (mostly sugar- and molasses-based). In September 2008, India **raised the proportion of its biofuels target from non-edible plant sources from 5% to 20% by 2020 and 30% by 2030**. The government estimates 13.4 million hectares of barren land are available for jatropha farming for biodiesel production. This could potentially yield 15 million tonnes of biodiesel oil per year. India is claiming it **costs about $1.50 per gallon or $63 per barrel to produce jatropha oil. Currently, India imports over 70% of its petroleum.**

India is also targeting 50% or 30 million tonnes per year of second-generation non-food-based biodiesel from algae oil, **the boldest target we have yet seen for algae oil.** Cow dung is still used for up to 25% of the energy needs for India's rural poor, while firewood accounts for another 20%-25%.

Indian Railways, a big diesel user, is building a 2 million gallon per year biodiesel facility in Yelahanka, Karnataka state, for 2010 using jatropha feedstock. Indian Railway trains and 18,000 buses are targeted for biodiesel upon conversion of their engines.

Airline Interest in Renewable Jet Fuel

On February 15, 2010, British Airways, in partnership with Solena Group, announced that it will construct a 19 million gallon per year waste biomass gasification plant in East London to produce biojet fuel and 20 MW of excess renewable electricity annually. It will be the first biojet fuel plant in Europe and will process 500,000 tons per year of all types of biomass and residue feedstock sourced mainly from local waste management facilities. The plant is expected to begin operations in 2014.

In December 2009, Rentech signed an MOU with 13 airlines for the supply of alternative jet fuel, including Air Canada, American Airlines, FedEx Express, Lufthansa Airlines, United Airlines, and US Airways. Rentech's Natchez Project in Mississippi would produce 400 million gallons per year of alternative jet fuel using its patented biomass gasification technology, **using camelina oil as feedstock**. Rentech's "RenJet" is the only alternative jet fuel currently certified for use in commercial aviation, at up to a 50-50 blend with traditional jet fuel.

Boeing and UOP announced an initiative with the Sustainable Aviation Fuel Users Group consortium to examine the overall potential for sustainable, large-scale production of biofuels made from salicornia and saltwater mangroves, known as halophytes. The study will look at aquaculture management, land use, and energy requirements, and will identify the impacts of its use as an aviation biofuel.

Three airlines have completed flight tests using up to 50% renewable jet fuel. Air New Zealand completed a test flight on December 30, 2008 using 50% jatropha based biofuel in a Boeing 747. Continental Airlines used a 47.5% jatropha, 2.5% algae-based biofuel blend in its Boeing 737 test flight on January 7, 2009. Japan Airlines tested a Boeing 747 on January 30, 2009 with a 42% camelina and 8% jatropha/algae blend. **All three test flights had no operational issues** and the fuel met all ASTM performance specifications at a 50% blend with conventional jet fuel.

Generation Two Biodiesel Production Announcements

D1 Oils and BP have ended a jatropha joint venture, with D1 acquiring BP's 50% interest for under $1 million, paying a royalty of $49 per ton of the first 20,000 tonnes of jatropha oil up to a limit of $980,000 tonnes, and releasing BP from all claims associated with the venture. According to *Biofuels Digest*, **D1's unsuccessful attempt at raising $100 million in capital was a factor in ending the joint venture.** D1 is now restructuring its business to: (1) achieve value from existing planting; (2) build technology and service revenues; and (3) deliver focused science and technology.

Sustainable Oils, a camelina biodiesel producer, was awarded a contract by the Defense Energy Support Center for 40,000 gallons of camelina-based jet fuel, with an option to supply an additional 150,000 gallons. The fuel will support the Navy's ongoing alternative fuels testing program. **Sustainable Oils has the largest camelina research program in the United States** with over 140 trials across North America between 2005 and 2009.

BioJet Corporation announced a contract to sell 4 million barrels of bio-based jet fuel to E85 LLC. The two companies expect demand for biojet fuel to exceed 280 million barrels per year, **with jatropha** being the primary short-term feedstock.

Emerging Canadian Technologies

BioDiesel Reactor Technologies Inc. (BDR), based in Ottawa, is a clean energy technology company that has a membrane reactor technology that can make higher quality biodiesel at a lower cost. BDR is ready for commercial demonstration of its technology in a 4 million litre pilot plant adjacent to Greenfield Ethanol, scalable up to 400 million litres.

Algae Biofuel Still Very Promising

Algae remain among the most viable potential feedstocks in advanced renewable fuel if the cost of growing it comes down. Forty-six percent of the 2.32 billion gallons of advanced biofuels capacity by 2014 in the United States will be algae-based. It may be possible for algae to potentially replace some soybean, rapeseed, and corn, or take over for incremental RFS-2 as one of the main feedstocks for advanced biofuel production. **Algae growth also has great potential for carbon sequestration, as algae consume about 2 tonnes of CO_2 for each tonne of algae biomass growth.**

Algae oil is most comparable to conventional oil as most oil came from algae to begin with. It is believed that coal came from crushed plants and trees. Algae fuel will therefore not require specialized oil, refinery and distribution infrastructure. Algae farms are currently producing about 5,000-6,000 gallons per acre per year according to PetroAlgae (oil) and Algenol (ethanol). **This dwarfs soy (50 gallons of oil per acre per year), canola (150 gallons of oil per acre per year), and palm (650 gallons of oil per acre per year)** (Exhibit 22). Ethanol corn produces 450 gallons per acre per year currently.

Exhibit 22: Biodiesel Feedstock Oil Yields

Crop	Yield (gallon oil per acre)
Cotton	35
Soybean	48
Sun Flower	102
Rapeseed	127
Canola	155
Palm Oil	635
Jatropha	809
Algae	5,000 to 15,000

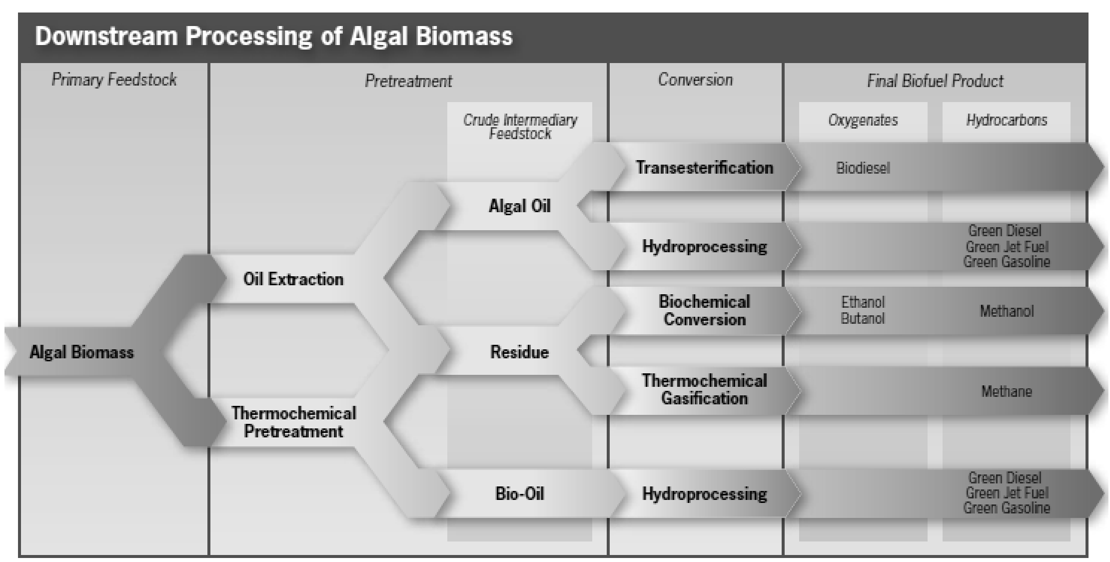
Source: Permaculture.

Algae can use only part of the incoming light in the wavelength range of 400-700 nanometres. Algae are able to convert 5%-10% of the incoming light into growth. Low-cost mixing of algae is imperative due to shading that occurs as the algae population increases towards harvest size.

In 2008-2009, more than $300 million was invested in algae fuel-based public/private partnerships, private companies, and first-stage commercial projects. 2010 is expected to see increased investment towards the acceleration and commercialization of algal biofuel technologies.

Once algae biomass is separated into oil and co-product biomass (nutrients, proteins, carbohydrates, ash), transesterification can convert algae oil into biodiesel, hydroprocessing can convert algae oil to renewable fuels, and most of the residue can be biochemically or thermochemically converted to several bioproducts, as seen in Exhibit 23.

Exhibit 23: Downstream Processing of Algal Biomass



Source: Natural Resources Defense Council.

The Natural Resources Defense Council (NRDC) issued a report in October 2009 that outlines potential environmental issues with respect to algae biomass production. The report concludes that future implementation of algae biofuel production will need to address core environmental impacts in order to develop and commercialize a sustainable product. The NRDC believes that **energy and water usage** should have the greatest potential impact on commercial-scale algae production, as both are significant algae production requirements.

Algae Breakthrough Details

The DOE stated it is "hard not to get excited about algae's potential," **as it could provide up to 500-1,000 times more fuel/acre/year than food-based feedstock.** Aside from CO_2, algae need about 5%-10% of the sun's power or artificial light (if grown indoors), water that can be fresh, salty, and/or non-potable, and some nitrogen, phosphate, and appropriate lesser minerals that can be derived from wastewater and effluent streams.

In five years, there could be thousands of algae biofuel companies versus over 100 today. China and India are the countries most likely to pursue the technology and produce hundreds of companies, as is currently being experienced in the solar industry. On February 3, 2010, President Obama coaxed the United States to more broadly support all forms of homegrown biomass like algae for U.S. energy independence.

Algae can also be used in production of bio-plastics as it has the same kind of physical and thermal property found in starches currently used in bio-plastic production. By 2020 the U.S. market for bio-plastics could reach $10 billion, up from its current value of $1 billion. Production of 1 kilogram of polypropylene creates 3.15 kilograms of CO_2. Production of 1 kilogram of bio-propylene creates only 1.4 kilograms of CO_2.

Cyanobacteria

Cyanobacteria is a blue-green algae with lower lipid content (25% lipids) than green algae that grows like a weed in the algae system. This type of algae can survive in an industrial setting, whereas green algae sometimes struggle to survive in open ponds. Three companies are currently working with cyanobacteria: BioLight Harvesting, Targeted Growth, and Synthetic Genomics. Cyanobacteria's superior photosynthesis abilities **can convert 10% of the sun's energy into biomass, compared to 1% by conventional energy crops such as corn or sugars, or 5%-10% by other types of algae.**

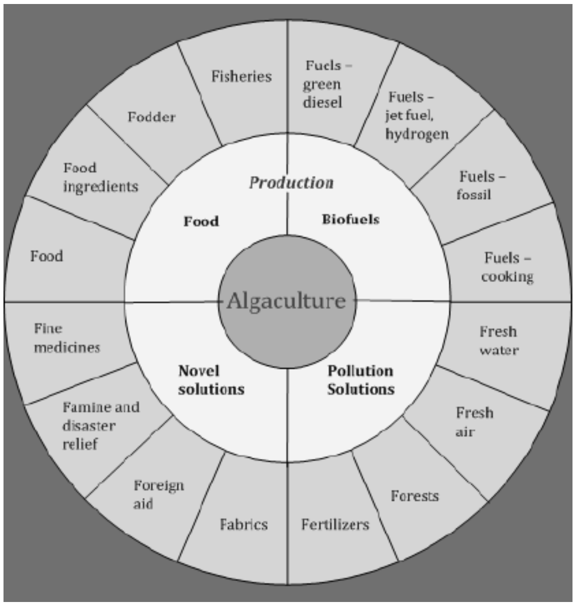
Algae Cost Per Gallon

Current algae oil cost net of co-product revenue may be as low as $1.30 per gallon over time (Algenol and Aurora Biofuels estimates). Rising credits for CO_2, NO_X, and renewable benefits will lower net algae oil feedstock or ethanol costs further over time. Net of algae oil, the carbohydrates and protein can be sold as high-protein fish food ($1,300-$1,600 per tonne currently), pharmaceuticals (omega 3-6-9 at $1,200 per tonne, estimated), and human food nutraceuticals ($10,000+/tonne), if extracted from a clean source of algae using clean, non-chemical methods.

The U.S. Department of Defense (DOD), which works on algae oil development with UOP at the University of Arizona, believes affordable algae oil means a price less than $5/gallon, and **that a target of $3/gallon appears viable**.

Algae are uniquely positioned to provide a value chain of products, including food, biofuels, pollution solutions, and novel solutions (medicines, fabrics, etc.). Exhibit 24 details the areas of algae's value chain. See Appendix 4 for more details on algae's value chain.

Exhibit 24: Algae's Value Chain

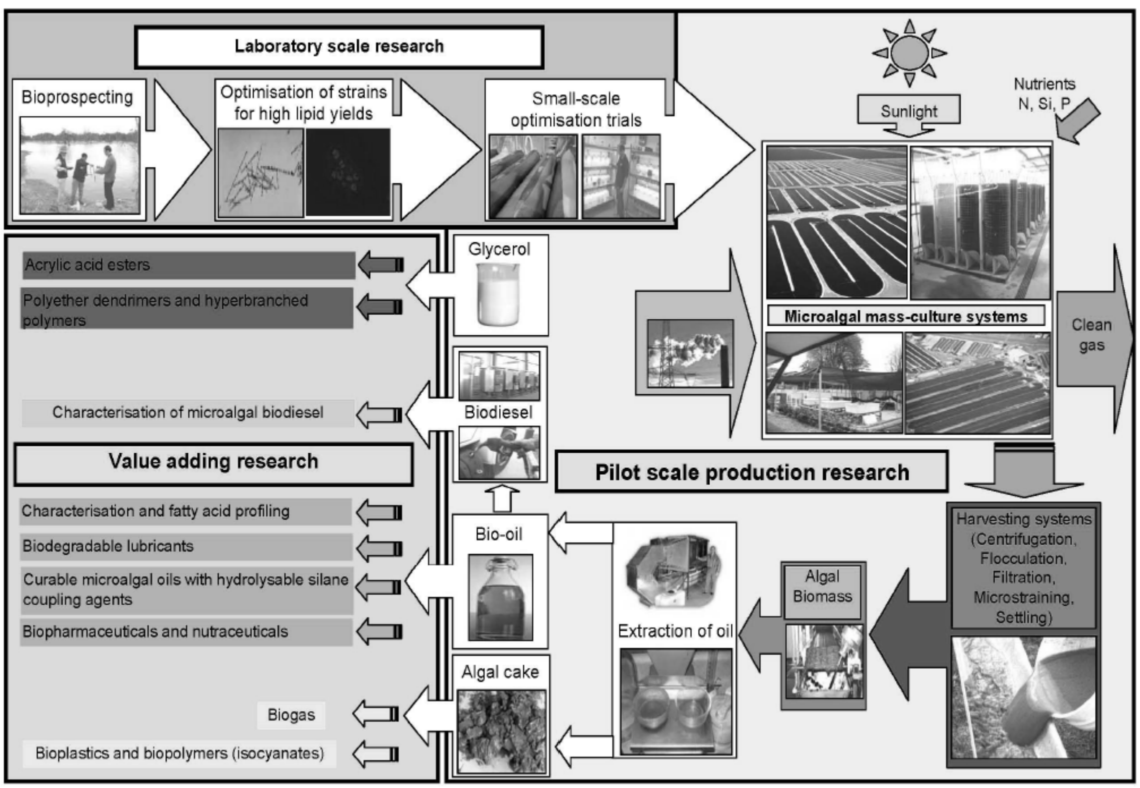


Source: Carbon2Algae.

Various algae can have various end algae products that also could include biopower (burning algae), nutraceutical specialties such as beta carotene, biofertilizers, and biochar (concentrated carbon from algal residues) (Exhibit 25).

The president of Sapphire Energy testified to the U.S. Senate that "algae is one of nature's most prolific and efficient photosynthetic organisms. Growing algae, and converting it into plastics, fuels, and or secondary feedstocks, could significantly help mitigate greenhouse gas emissions, reduce energy price shocks, reclaim wastewater, conserve fresh water, lower food prices, reduce the transfer of U.S. wealth to other nations, and spur regional economic development."

Exhibit 25: Algae Biofuel Process Flow Diagram



Source: South Australian Research and Development Institute.

Algae Impact on Potash Negative

Various algae can grow in waste effluent streams that are packed with nitrogen and phosphate run-off nutrition, with CO_2 emissions adding weight without fertilizer use. **The long-term algae impact on basic fertilizer demand is expected to be negative relative to food-based biofuels, particularly for potash, as algae need no potash to grow.** Some source of nitrogen and phosphorus will be required if algae is grown outside of waste or effluent streams.

Algae Mandates and Government Support

On July 31, 2009, a group of U.S. House lawmakers introduced legislation (H.R. 3460) to amend the Clean Air Act to: (1) **include algae-based biofuel in the renewable fuel program;** and (2) to amend the Internal Revenue Code to include algae-based biofuel in the cellulosic biofuel producer credit, **without** raising the 16 billion gallon per year 2022 volumetric cap on cellulosic fuels use under the RFS. **This legislation could potentially create competition between algae-based biofuels and cellulosic producers, and some cellulosic lobbyists are crying foul.**

The U.S. DOE announced an $80 million investment under the American Recovery and Reinvestment Act for advanced biofuels, including $78 million for two biofuels projects. The National Alliance for Advanced Biofuels and Bioproducts consortium received $44 million to develop a systems approach for sustainable commercialization of algal biofuel and bioproducts. The National Advanced Biofuels Consortium received $33.8 million to develop infrastructure compatible, biomass-based hydrocarbons.

The U.S. EPA will measure the GHG impacts of algae-based biofuels in its final rule to implement the renewable fuel standard in response to growing interest in algae, including recent algae project development announcements by oil majors ExxonMobil (SGI), Shell (HR Biopetroleum), Chevron (Solazyme), and Dow Chemical (Algenol), which are helping to commercialize various algae technologies.

Algae Economics

Biofuels Digest forecasts that **algae biofuel production could reach 1 billion gallons per year by 2014.** Targeted costs are $1.30/gal wholesale (Aurora Biofuels) and 1.6 billion gallons per year of 2014 algae oil capacity, **split 67% open pond and 33% indoor photobioreactor**. The current production split for microalgae is 99% open pond and 1% bioreactor.

In dewatering, AlgaeVentures claims it can reduce dewatering costs of algae **by 99%, which could lead to a $3/gallon drop** in operating costs to produce algae biodiesel or bioethanol.

Barry Cohen, Chairman of the National Algae Association, **firmly believes that if all of the best-in-class algae technologies for all the aspects of growing algae were put together, algae oil production would already be commercial.** GreenFuels went bankrupt in Q2/09 trying to do a complete algae growth system on its owns.

On fixed costs, the South Australian Research and Development Institute estimates the capital cost for indoor algae bioreactors is $1 million per hectare compared to outdoor open ponds at $100,000 per hectare.

High co-product values for algae by-products are critical to cut the net cost of algal biofuels. Some demonstrations like wastewater-to-algae biofuels (PetroSun and Gilbert Arizona JV) may have a lower cost structure, as certain wastewater has ideal nutrition for algae growth.

On CO_2 emissions, tests to date show full life cycle greenhouse gas emissions **are 85% to 93% lower using algae fuels.**

Oil Companies Like Algae Fuel

Indian Oil Company signed a MOU with PetroAlgae to licence microcrop technology for the production of algae-based biofuels at a future 60 million gallon per year pilot facility. **This is the fifth major oil company** and first national oil company to sign MOUs with PetroAlgae.

In Q3/09, ExxonMobil announced a $600 million algae joint venture investment in a partnership with Synthetic Genomics Inc. (SGI), a California-based genetics research company. Its objective is to find, optimize, and engineer superior strains of algae for renewable biofuels production. The partnership will also define and develop the best systems for large-scale algae cultivation and conversion into biofuels.

SGI plans to build a new research facility in San Diego for this project. SGI wants to engineer algal strains to produce lipids (oil) in a continuous process with algae that secrete hydrocarbons directly. ExxonMobil reviewed all biofuel options and concluded that algae had the best potential for positive algae strain development, production systems, and scalability. **The ExxonMobil partnership was a positive signal for the future of algae biofuels, as the world's largest and most sophisticated oil company chose algae over all other biofuel technologies.**

Other oil companies announcing investments in algae biofuels include: (1) Shell, which entered into a joint venture with HR BioPetroleum called Cellana that investigates different strains of algae appropriate for biofuel production; and (2) Chevron, which is a direct investor in Solazyme, which uses algae to produce biodiesel.

Airline Companies Like Algae Fuel

Boeing and Continental's jet fuel test used an **algae-jatropha blend** supplied by Sapphire (algae) and Terasol (jatropha) in a 737-600. Tests "met or exceeded all technical parameters for commercial jet aviation fuel. Those standards include freezing point, flash point, fuel density, and viscosity, among others."

Boeing now supports 50% biofuel blends, as do others including Japan Airlines and Pratt & Whitney. Cradle-to-grave greenhouse gas emission cuts from algae-jatropha jet fuel were estimated at 60%-80%. According to Boeing, **only about 5% of oil can be converted into jet fuel, while about 40% of vegetable oil, like algae oil, can be converted into jet fuel.**

KLM is targeting the use of biofuels in commercial flights starting in 2011. In November 2009, KLM completed a 1.5-hour test flight using a mixture of 50% biofuel and 50% conventional jet fuel.

The Pentagon Likes Algae Fuel

Consistent with India's 20 million tonne per year algae target, the U.S. Pentagon announced in February 2010 that it was only months away from producing algae biofuel for less than $3/gallon. The Defense Advanced Research Projects Agency (Darpa) is working on developing a facility that could produce 50 million gallons per year of algae fuel at a cost of $2/gallon, operational by 2011.

Algae Production Developments

Q4/09 & Q1/10 Developments

PetroAlgae entered into a $4 million Master Licence Agreement with Congoo for a non-exclusive licence to use PetroAlgae's proprietary technology to construct and operate algae production facilities in Egypt and Morocco. The licence expires on December 31, 2010.

Algenol and The Linde Group, an international gases and engineering giant, outlined a joint development project to develop cost-efficient technologies that capture, store, transport, and supply CO_2 for Algenol's proprietary process for the production of algae biofuels.

On October 14, 2009, Green Plains Renewable Energy announced that BioProcessAlgae, LLC completed the installation of Phase 1 of its multi-phase pilot project and algae production has begun. Over a four-month period, the company will gather production data, which will assist in scalability and functionality for future commercial operation.

SunEco is building a 1,320-acre open pond algae system in the Imperial Valley to produce 45 million gallons per year of algae crude oil by the end of 2010. Its technology uses 30 algae species and deeper ponds **at 6-8 feet to achieve yields of 33,000 gallon/acre-ft/year** with a target yield of 200,000 to 260,000 gallon/acre-ft/year.

W2 Energy Inc. has begun negotiations with organizations and governments in the Caribbean to build commercial-scale algae bioreactors to produce biofuel. The company has already developed the technology and expects to have several production units in the Caribbean by mid-2010.

On March 17, 2010, W2 Energy filed a U.S. patent on its algae harvesting and cleaning system that deals with common problems of tubular photobioreactors. W2's algae reactor is low cost, scalable, uses less water, and has higher productivity. Its modular system can be built from one cell up to multiple cells.

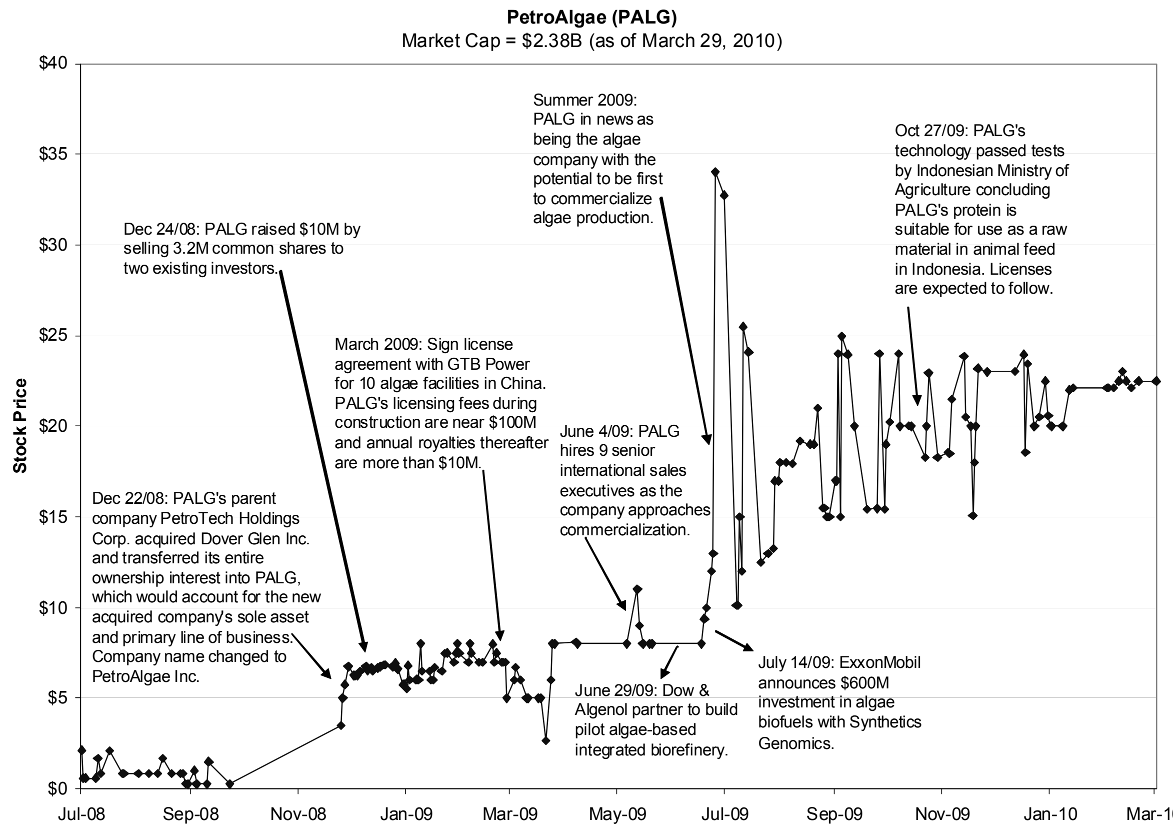
Q3/09 Developments

Please refer to our November 2009 *Biofuels Outlook* report entitled "Explosive Growth and Development Continues" for Q3/09 developments.

Publicly Traded Algae Companies

PetroAlgae's market capitalization increased from $50 million at the end of December 2008 to over $2.38 billion as at March 29, 2010 (Exhibit 26). The company claims it is the closest to commercialization of algae biofuels. PetroAlgae commenced licensing in early 2009 with an Asian deal focused on China and part of southern Japan. The company's model algae farm is 12,500 acres that produce 60 million gallons per year of algae fuel. PetroAlgae increased its international sales staff to 28 people in North America, South America, Europe, Asia, and the Middle East. PetroAlgae trades on the Nasdaq OTCBB exchange (ticker: PALG).

Exhibit 26: PetroAlgae (PALG) Market Capitalization



Source: Bloomberg, Scotia Capital.

Valcent Products owns 50% of the Vertigo Joint Venture, which has developed algae production technology using vertical algae bioreactors made from plastic sheeting. In March 2008, Valcent completed field testing of its bioreactor technology, which yielded 276 tons of algae per acre per year. Valcent's algae technology is being developed jointly with Global Green Solutions Inc., which will invest $3 million and commercialize the technology. Valcent is traded on the OTCBB exchange (ticker: VCTPF).

Odyssey Oil's main project with Xstrata PLC will capture and store CO_2 emissions from Xstrata's ferrochrome smelters in South Africa. Its technology will capture CO_2 emissions and relay them through gas-fired generators to produce electricity that can be recycled back to the ferrochrome plant or to the local power grid. The second phase of the project is to grow a selected algae strain in photobioreactors using the CO_2 flue gas from the exhausts of the generators to produce oil for biofuel and carbohydrates and protein for animal feed. Odyssey Oil & Energy trades on the Nasdaq OTCBB exchange (ticker: OOGI).

Based in India, Beckons Industries has developed a modular system of photosynthesis in a low-cost photobioreactor to produce biofuels and animal feeds and a process for mass culture of a selected strain of microalgae. Beckons plans for future testing of its prototype for flue gas sequestration in a coal-fired cement plant. Beckons Industries Limited trades on the Bombay Stock Exchange (ticker: BECI).

PowerGae is a development-stage company focusing on constructing and operating biodiesel production facilities and marketing biodiesel through existing petroleum manufacturers and distributors. The company has not developed its own proprietary technology and is not currently producing algae oil, but intends to produce 30,000 gallons per year of algae in 2010. PowerGae has an agreement with the Institute of the Biology of the Southern Seas (IBSS) from Ukraine on an industrial algae-growing research project. PowerGae, Inc. trades on the Nasdaq OTCBB exchange (ticker: PWGA).

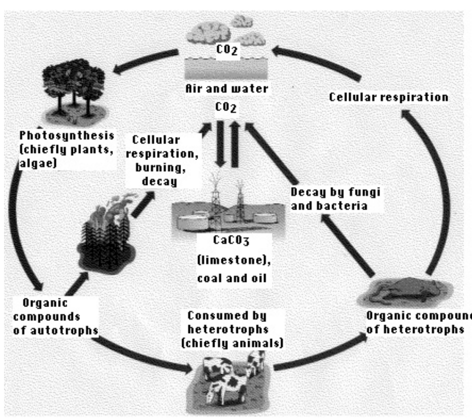
Algae Technology Developments

Algae's rapid four- to seven-day growth cycle (depending on strain) and CO_2 fixation capability (highest amongst all living matter at 1.7 to 1) point to theoretical production of 50,000 gallons/acre/year versus only 450 gallons/acre/year for corn-based ethanol, at best. Actual algae yields promised to date commercially are now in the 5,000-7,000 gallons/acre/year area (PetroAlgae, Algenol).

Exhibit 27: Algae Systems

Source: New Biofuels Production, DeSmet Presentation.

Exhibit 28: Carbon Cycle



Source: www.biology-pages.info.

Aside from water constraints, **the world also needs 10,000 CO_2 tonnes per day emission solutions at coal-fired cement, ethanol, petrochemical, or gasification plants.** Algae could be one of those CO_2 solutions, along with carbon sequestration (CCS) and enhanced oil recovery (EOR). See Exhibit 27 for current test algae systems.

Exhibit 28 shows the earth's carbon cycle, which shows humans have to stop emitting more carbon than the globe can absorb if runaway global temperatures are to be avoided. **Finding renewable fuels using CO_2 in algae and plants at or below fossil fuel prices would take out food-based fuels as well as fossil fuels.**

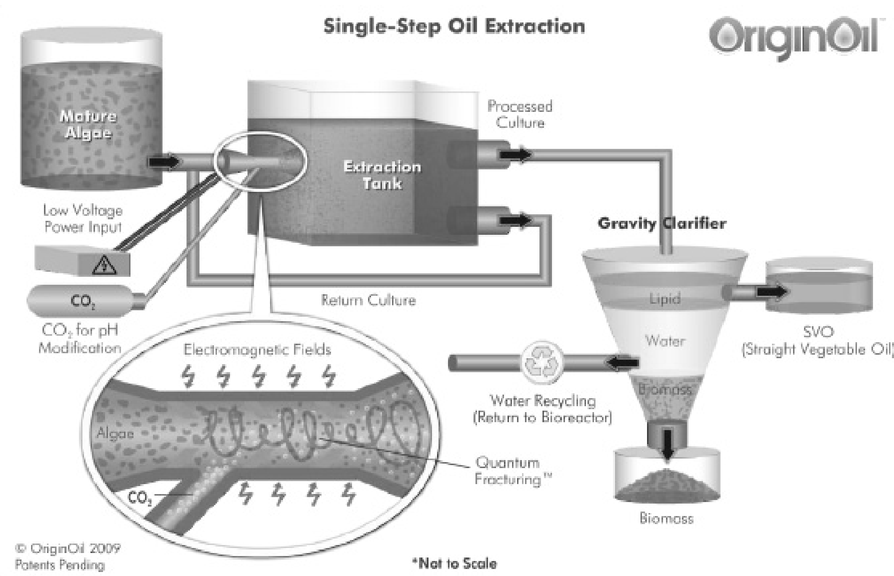
Optimally growing algae requires proper strain selection in proper salt water/fresh water, high-acid/low-acid water, high-temperature/low-temperature environments, indoor/outdoor, etc. **Genetically modified (GM) algae strains have little chance** of commercial success to date as Greenpeace, the Sierra Club, and others would pounce on any GM algae proposal.

Solazyme grows its algae in the dark, using plant waste cellulosic and other cellulosic materials containing sugar as food, and CO_2 to provide the energy that algae needs. Dark-growing algae need expensive food sources like sugars and vitamins to survive and reproduce. **By not obtaining energy from sunlight and using photosynthesis, dark-growing algae do not consume CO_2** and instead produce CO_2 like other burning processes. Solazyme's joint venture with Chevron is focusing on the development of a breakthrough algae strain that can reproduce itself without sunlight.

Ultrasound-based methods of algae harvesting are under development. They involve rupturing the algae cell wall using ultrasonic cavitation extraction, essentially eliminating the dewatering step for fuel feedstock extraction and reducing the time and energy for drying biomass. Ultrasonic cavitation rupture algae to get at their oil lipids via setting up a sonic wave at a certain.

In spring 2009, OriginOil announced a one-step process for algae dewatering and oil extraction (Exhibit 29). Its process uses ultrasound from intense fluid fracturing to break down algae cells, the same way a high-frequency sound wave breaks glass. Combined with electromagnetics and pH modification, OriginOil's process is claimed to maximize oil yields while using less energy. Algae oil lipids then rise to the surface for skimming while the residual algae biomass falls to the bottom for further processing. The company intends to commercialize the process for use by others.

Exhibit 29: OriginOil's Algae Process



Source: OriginOil.

Several algae companies, including the ExxonMobil/Synthetic Genomics partnership, are researching ways to **"milk" oil-rich algae to get at their oil without killing them**. Synthetic Genomics expects to have the first of this new species developed by the end of 2009.

The U.S. military, one of the world's biggest oil and gas users, is researching a specific type of algae found in oceans and lakes called diatoms, which can be engineered to not just secrete oil, but also gasoline. The U.S. military spent nearly $12 billion in 2008 on research and development, with numerous algae companies and universities receiving various military financial support.

A team of academics in North Carolina and PetroAlgae reported progress with other microcrops, **specifically duckweed**, realizing up to six times the average corn starch yield. The process cleans waste water and produces a high-yield biofuel, with the duckweed starch converted to ethanol at existing corn ethanol processors. Joule Biotechnologies in Massachusetts has used a modified version of **watermeal**, the smallest flowering plant, as a biofuel feedstock **yielding a potential record to date 20,000 gallons per acre,** with commercialization online as soon as 2010.

General Atomics awarded Algaeventure Systems an order for its algae harvesting, dewatering, and drying technology. General Atomics, supported by funding from the Defense Advanced Research Projects Agency (DARPA), is leading a group of corporate technology developers and universities in evaluating the potential of producing jet fuel from algae oil.

Sustainable Power has tested algal biomass for its fast pyrolysis process that uses nanobacteria as catalysts and aims to licence operators in Europe and Asia by the end of 2009. Its “Rivera Process” converts biomass into syngas, bio-oil, and biochar **in a matter of seconds, mirroring the geological process by which biomass is converted into fossil fuels.**

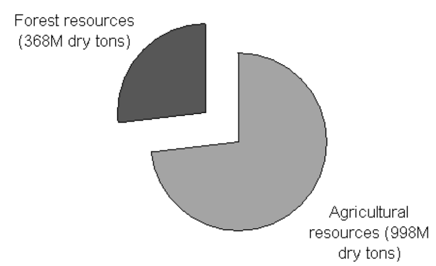
Sapphire Energy has over 230 patents or applications focused on the entire algae-to-fuel process. The company is developing industrial algae strains and building technology for CO_2 utilization, cultivation, harvesting, and refining at its New Mexico R&D centre. Sapphire Energy was ranked number five in the “2009-2010 50 Hottest Companies in Bioenergy” rankings by *Biofuels Digest*.

Sapphire Energy and the producers of the film *Fuel* announced the world’s first plug-in hybrid vehicle (a 2008 Toyota Prius) called “Algaeus” to travel the United States on algae-based fuel produced by Sapphire. The vehicle had an added battery pack, a plug, and an advanced energy management system. **It achieved 150 miles per gallon without any engine modifications in city driving.** The algae-based gasoline blend is a complete drop-in replacement to conventional gasoline.

Biomass

Please see our February 2009 report entitled *Biomass: Putting Waste to Good Use* for further information and developments.

Exhibit 30: Potential U.S. Biomass Resources



Source: USDA; DOE; Scotia Capital.

About 1.5 billion tonnes per year of biomass waste globally is from food production. By volume, biomass is **only 20%** of the weight of the food produced per m^3, so its light density makes it very expensive to transport. **Biomass is the number-four energy source on the planet** after oil, gas, and coal.

A joint USDA and DOE study estimates 1.3 billion dry tons of biomass annually that could displace 30% of U.S. liquid transportation fuels, **or 65 billion gallons per year** (Exhibit 30).

The U.S. National Research Council reported in a recent study that coal/biomass to liquids plants **would be cost competitive with conventional oil refineries if a $50/ton CO_2 tariff is imposed in the United States.**

Ensyn: Fast Pyrolysis Technology

Ensyn, a private company based in Ottawa, uses fast pyrolysis technology to gasify biomass to produce bio-oil and biochar **in less than two seconds**. We visited its demonstration plant outside of Ottawa, Ontario in December 2009, with a summary below.

Biomass pyrolysis demonstration plant in Renfrew, Ontario: The company currently has a 100 ton per day plant in Renfrew and a 1 ton per day test plant in the same location used for testing various biomass feedstocks, including switchgrass. The process feeds in woodchip and sawdust biomass into a fluidized catalytic cracker (FCC) using sand heated to 500°C and then cooled within seconds. The yield is 75% bio-oil by weight. The sand is regenerated and recycled back into the process. Ensyn is operating the FCC plant intermittently to meet the limited demand on its order book. Typically the plant is in operation on alternating weeks.

Established FCC technology: FCC is established technology widely used in petroleum refineries. Ensyn uses sand as a catalyst, which is a cost-effective option compared to typical active catalysts. The benefit of using existing FCC technology is that it can be easily scaled up. The facility is built in a modular structure, resulting in quick and easy construction.

Biomass supply: Ensyn is currently bringing in biomass feedstock from as far away as Washington State and shipping its bio-oil across North America (Texas, Wisconsin). Biomass costs range from $40-$100 per ton. Ensyn looks to source feedstock in the lower end of that range.

Ensyn's pyrolysis oil uses: Ensyn's bio-oil is currently being used in the food industry as "smoked flavouring." Bio-oil can be further processed into green gasoline, diesel, and jet fuel, or burned to produce biopower. It can also be used to produce adhesives, pharma/nutraceuticals, and intermediate chemicals.

Process flexibility to yield various products: Ensyn's process is versatile and can produce biochar, oil, and gas in varying quantities depending on the process conditions and what product is required. The biochar and gas produced are currently re-used in a dryer to pretreat the biomass feedstock to maintain the biomass moisture content at around 10%. Ensyn currently produces over 2,000 tons of biochar per year and has operating capacity to produce up to 4,000 tons per year.

DOE funding: On December 4, 2009, Honeywell's UOP was awarded $25 million from the DOE Next Generation Biofuels program to build an integrated demonstration unit in Hawaii using Ensyn's technology to produce gasoline and diesel from agricultural residue, woody biomass, dedicated energy crops, and algae. Ensyn's partnership with Honeywell's UOP should strengthen the credibility of its process as UOP has a long-standing history in the petroleum refining industry.

Ensyn's future scale-up plans: Ensyn has future plans to scale its process up to 400 tons per day and include a diesel generator set to produce electricity. A diesel generator set on a 100 ton per day plant would produce about 5 MW of electricity. Scale-up challenges that Ensyn will need to overcome are: (1) ensuring correct process parameters (temperature, size of reactor, reaction time) to ensure efficient production; and (2) supply and storage of biomass feed supply.

Q4/09 & Q1/10 Biomass Developments

Coskata, Zeachem, and Myriant stated 100 gallon per ton yields are being achieved at Coskata's Pennsylvania demonstration plant.

Canada's Nexterra Systems Corp. received C$7.7 million in funding from the Canadian federal and British Columbia provincial governments to support its effort to commercialize a new high-efficiency biomass power system in collaboration with GE Energy. The technology involves direct-firing syngas from Nexterra's biomass gasification process into GE's combustion engines. The first commercial demonstration project is expected to being in early 2010.

Southern Power acquired the 100 MW biomass Nacogdoches generating facility from American Renewables and is moving forward with construction, with production scheduled to begin in summer 2012. Total cost of the project is $475 million-$500 million and is expected to use 1 million tons of forest residue, wood waste, and clean municipal wood waste from a 75-mile radius of the plant. The output is committed to Austin Energy in a 20-year agreement to help Austin, Texas achieve its 30% renewable energy goal.

Zeachem claims 135 gallons per ton of biomass at pilot scale.

Q3/09 Biomass Developments

Please refer to our November 2009 *Biofuels Outlook* report entitled "Explosive Growth and Development Continues" for Q3/09 biomass developments.

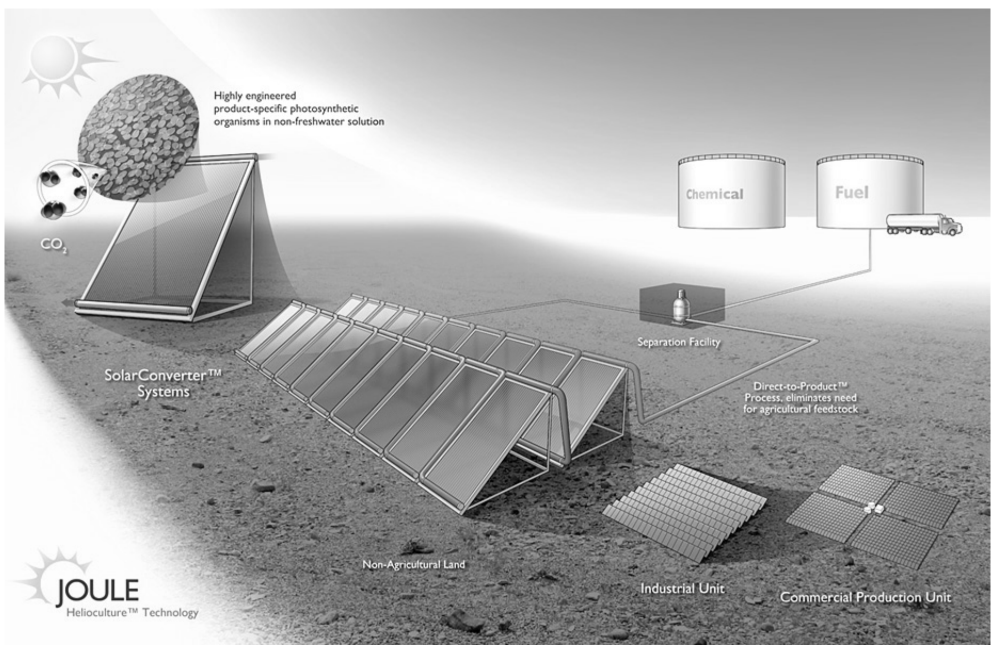
Advanced Biofuels

Generation Three Biofuels

The U.S. DOE launched a new "Energy Innovation Hub" focused on fuels from sunlight energy, and will award $122 million over five years to support the project to accelerate the development of a sustainable commercial process to convert sunlight into chemical fuels.

Joule Biotechnologies achieved direct microbial conversion of CO_2 into hydrocarbons using engineered organisms powered by solar energy and its Helioculture T technology (Exhibit 31). At the World Biofuels Market in March 2010, *Biofuels Digest* suggested that Joule's engineered organisms were, in fact, cyanobacteria. **Its process requires no agricultural land or fresh water and can produce more than 20,000 gallons of renewable ethanol per acre annually.** Joule does not require costly biomass production and pre-treating, eliminating numerous processing steps, and it can be customized depending on land size, CO_2 availability, and desired output. Joule's pricing is competitive with $40-$50 per barrel oil. Pilot development is scheduled for early 2011 with large-scale production by 2012. Joule is looking to achieve yields of up to 25,000 gallons per acre per year for ethanol and 15,000 gallons per acre per year for diesel. Commercial-scale operations in 2012 are expected to be 7.5 million to 75 million gallons per year (500-5,000 acres) and will require 120 tons per acre of CO_2 per year.

Exhibit 31: Joule Biotechnologies, Solar-to-fuels



Source: Joule Biotechnologies.

Researchers at UCLA have genetically modified cyanobacteria to produce **isobutanol directly from CO_2** and sunlight avoiding the need for biomass breakdown processing, a high-cost step in biofuel production. The technology could be placed next to power plants to eliminate CO_2 emissions. Researchers are still improving the rate and yield of production.

Researchers at Sandia National Labs developed a prototype for their "Sunshine to Petrol" machine that converts waste CO_2 to CO, and then to syngas, which could produce methanol, gasoline, or other liquid fuel, consuming only solar energy. The researchers believe the technology is still another 15 to 20 years away from being on the market.

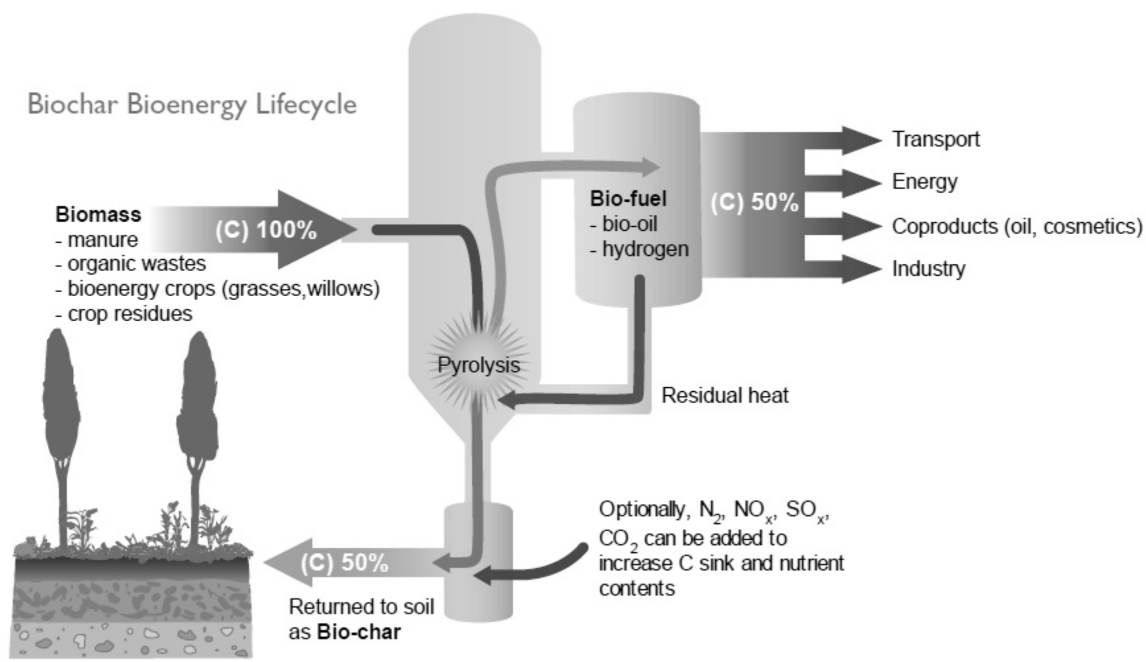
Sundrop Fuels, a solar gasification renewable energy company in Colorado, uses solar energy to gasify almost any kind of plant material into electricity or liquid transportation fuel. In a gallon of Sundrop fuel, 30% of the energy is solar, the remainder is from biomass. It can achieve production of up to 100 gallons per ton using woody biomass in its pilot operations, **with a potential 25% increase in yields at a cost of $2-$3 per gallon.** The company is developing a 5 million gallon per year commercial demonstration facility that will be in operation in mid-2012, targeting future expansion in sunny regions (North Africa, the Middle East, and parts of China).

Professor David Keith at the University of Calgary has developed a process to capture CO_2 from air using a patented 20-foot tower and caustic soda, **which can remove about 43% of the CO_2 from the air intake.** The carbon scrubber allows for the removal of CO_2 **after it has been emitted into the atmosphere** and removes the irreversibility of the CO_2 climate problem. The process is still in the early stages of development and is yet not ready for large-scale operation. **It would be ideal for algae producers as these towers could be put anywhere on the planet.**

Biochar

Biochar is the by-product of burning biomass in kilns in the absence of oxygen to capture combustible gases, a process called pyrolysis. Biochar is a porous, solid, carbon-rich residue, similar to charcoal, and is very stable due to its aromatic structure, making it difficult to break down. It contains up to 70 times more carbon than non-enriched soil. As a result, it can remain stable in soil for **hundreds of years**. Exhibit 32 illustrates the biochar bioenergy lifecycle.

Exhibit 32: Biochar BioEnergy Lifecycle



Source: Australia Commonwealth Scientific and Industrial Research Organization.

Biochar Production Process

There are three main bioenergy production processes that produce oil that is burned for power, syngas, and biochar: slow pyrolysis, fast pyrolysis, and gasification. The process conditions can be optimized to produce a desired ratio of syngas, oil, and biochar products (Exhibit 33).

Exhibit 33: Pyrolysis Processes and Output Ratios

Process	Liquid (bio-oil)	Solid (biochar)	Gas (syngas)
FAST PYROLYSIS Moderate temperature (~500 °C) Short hot vapour residence time (<2s)	75% (25% water)	12%	13%
INTERMEDIATE PYROLYSIS Low-moderate temperature, Moderate hot vapour residence time	50% (50% water)	25%	25%
SLOW PYROLYSIS Low-moderate temperature, Long residence time	30% (70% water)	35%	35%
GASIFICATION high temperature (>800 °C) Long vapour residence time	5% tar 5% water	10%	85%

Source: International Energy Agency.

Slow pyrolysis is the thermal conversion of biomass by heating it for a few hours at low temperatures (450°C to 650°C) without oxygen. **Biochar, oil, and syngas are produced in approximately equal proportions as a result of the slow combustion process.**

In a **fast pyrolysis** process, the time taken to reach the peak temperature is only a few seconds, rather than minutes or hours as in the slow pyrolysis process. **This leads to a much greater proportion of oil and less biochar.** The biochar produced in fast pyrolysis is granular with a lower energy value than slow pyrolysis.

Gasification converts biomass material into syngas (carbon monoxide and hydrogen) at high temperature and pressure. The process is designed to maximize syngas production, resulting in very low biochar production.

The three key advantages of the biochar process are: (1) it mimics the natural carbon cycle; (2) it is local, with the process working best on farms or forest areas where waste plant material is gathered locally, energy produced is used locally, and carbon fertilizer created can be returned to promote the growth of local crops; and (3) the technologies involved are not new and would be familiar to any chemist or engineer, with production methods that are tried, tested, small-scale, and cheap to manufacture.

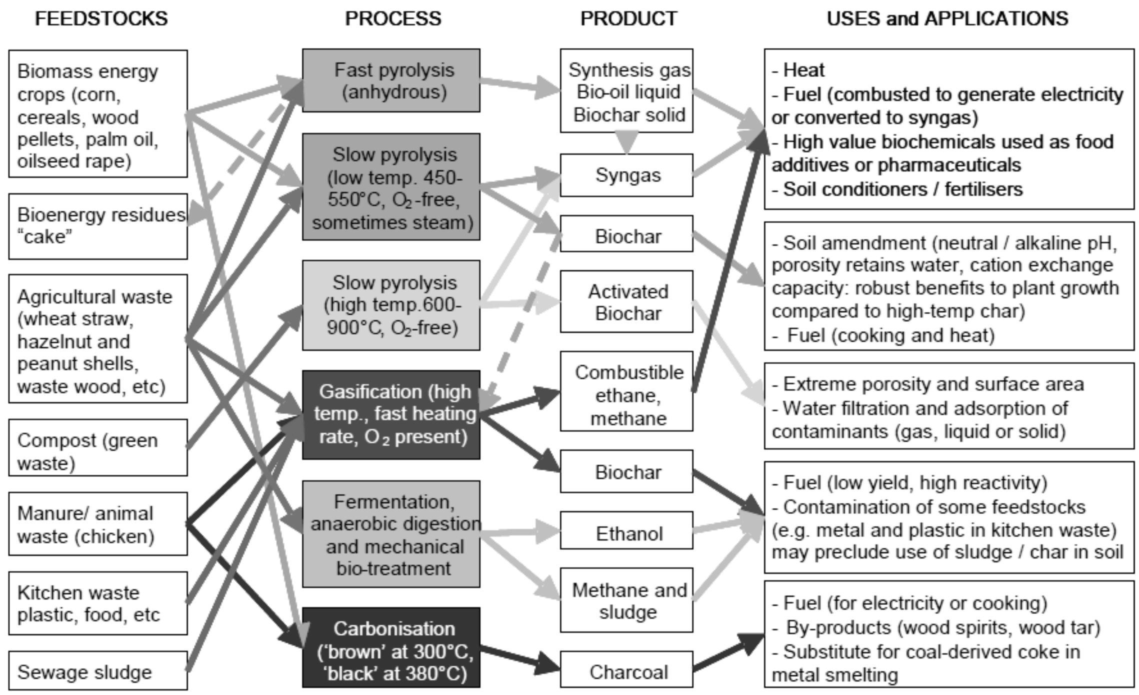
Biochar Feedstock

Biochar feedstocks currently include wood chips and wood pellets, tree bark, straw, nut shells, rice hulls, switchgrass, organic wastes including distiller's grain, bagasse, and manure. Ratios of carbon, oxygen, and hydrogen are important feedstock parameters in the quality of products.

An ideal feedstock has low mineral and nitrogen content such as wood and various grasses. A feedstock with high lignin content produces the highest yield when burned at moderate temperatures of approximately 500°C.

Chemical and physical properties of biochar **vary widely based on feedstock** and process conditions such as temperature and furnace residence time. For example, biochar produced from manure will have a higher nutrient content than biochar produced from wood waste. Wood waste would have a higher aromatic content, meaning it will be more stable. Biochar produced at high temperatures (700°C) will have a greater potential for adsorption of toxic substances. The properties of the biochar produced should be matched to an appropriate end application, but currently there is no screening process to match biochar products to a specific application. Exhibit 34 outlines various biochar feedstock and end-use applications.

Exhibit 34: Biochar Feedstock and End-Use Applications



Source: Australia Commonwealth Scientific and Industrial Research Organization.

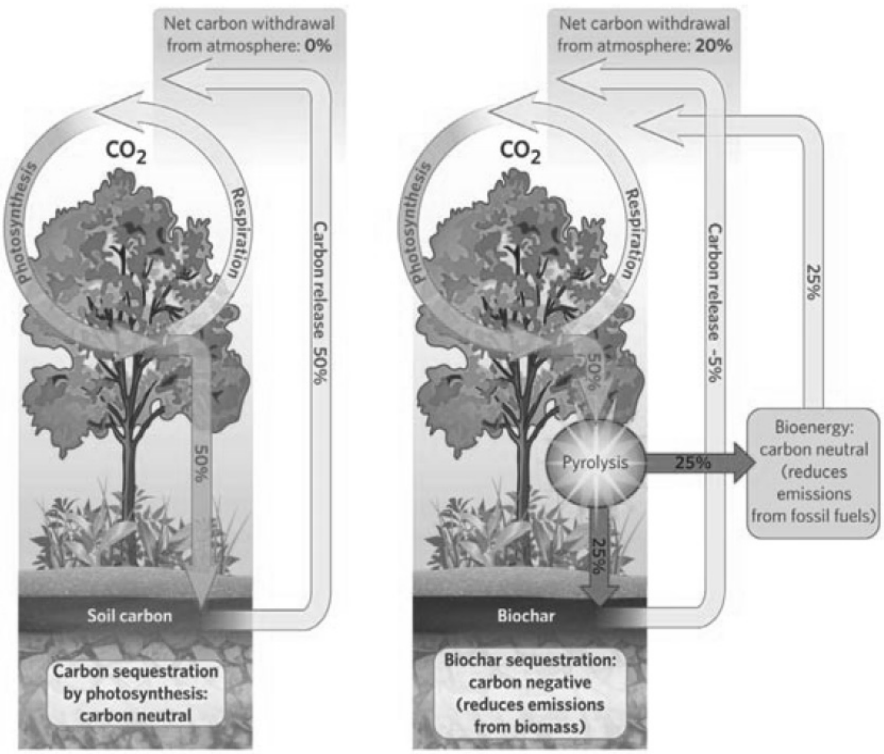
Biomass feedstock is expensive to transport, impacting biochar economics. In order to enhance process economics, **the pyrolysis units are portable** and ideally are located near the biomass source, instead of building large, centrally located facilities.

Biochar Applications

Biochar is used to enhance soil quality and crop yields. It helps with soil nutrient retention, improves soil structure, increases water-holding capacity, and decreases the release of non-greenhouse gases such as methane (CH_4) and nitrous oxide (N_2O). Research conducted at Delaware State University found that **biochar plus chemical fertilizer increased growth of winter wheat and several vegetables by 25%-50% compared with only chemical fertilizer use**. Enhanced crop production with biochar will work best in poor-quality, low-nutrient soils as in Brazil. Biochar used in fertile soil will have less positive effects. One small-scale producer of biochar was charging $600 per ton to U.S. farmers.

Biochar can also be used as a form of carbon capture and storage because of its stable structure. Biochar locks carbon in the soil for hundreds of years (Exhibit 35). Plants remove and store CO_2 in their cellulosic tissues through photosynthesis, which is later released after the plant tissues decay or are burned. **If the plant materials are burned to produce biochar the carbon is permanently stored in solid form.**

Exhibit 35: Carbon-Negative Biochar Process



Source: International Biochar Initiative.

Johannes Lehmann of Cornell University calculated that it is possible to capture **9.5 billion tonnes of carbon per year using biochar**. The International Biochar Initiative (IBI), a consortium of scientists advocating for research, development, and commercialization of biochar technology, estimates the potential for carbon storage in biochar is equivalent to removing approximately 1.2 billion tonnes of carbon from the atmosphere each year. **This could offset about 30% of the 4.1 billion tonne/year carbon emissions according to the U.S. Energy Information Administration.**

Lehmann calculated that up to 12% of the carbon emissions produced by human activity could be offset annually if slash-and-burn were replaced by slash-and-char.

The climate change bill currently being drafted in the U.S. Senate **will most likely involve biochar as a way to capture carbon on farmland.** A carbon-offset market that pays landowners and farmers could help reduce the U.S. dependence on foreign oil.

Scientists and policymakers are pushing for the post-Kyoto climate treaty, to be decided in Copenhagen later this year, to include conditions that biochar use be widely accepted in order to capture and store carbon emissions. This could make existing agricultural land more productive, and prevent further deforestation.

In December 2008, the United Nations Convention to Combat Desertification (UNCCD) placed biochar in consideration for use as a mitigation strategy during the second Kyoto Protocol commitment period beginning in 2013. If biochar is recognized under the Kyoto Clean Development Mechanism, **those who implement biochar technology could sell certified emission reduction (CER) credits for the proposed cap-and-trade system.**

In May 2009, Dynamotive Energy Systems, a second-generation Canadian biomass-to-biofuel producer, announced results of a biochar application testing program on commercial farming plots. **Overall, crop yields increased by 6% to 17% in biochar soil compared to control plots**. Biochar also yielded greater root depth (68%), lower plant leaf temperatures (-22%), and lower soil nutrient depletion rate (-44%). In total, 3,500 lb per acre of biochar was applied to the farm plots for the test. Dynamotive uses a fast pyrolysis process to produce its biochar.

Biochar Producers

Mantria Industries previously claimed to be producing 40,000 tons/year of commercial biochar at its facility in Tennessee, the largest biochar facility in the world. On November 16, 2009, the SEC charged four individuals and two companies (including Mantria Industries) **with operating a Ponzi scheme**. The SEC alleges that Mantria overstated the scope and success of its operations to solicit investors. Mantria claimed it was the world's leading manufacturer and distributor of biochar and had multiple facilities producing at a rate of 25 tons per day. **According to the SEC's press release dated November 16, Mantria had never sold any biochar and has just one facility testing biochar for possible future commercial production.**

Johannes Lehmann, Chairman of the Board for the International Biochar Initiative, stated the biochar industry is in the very early stages with very little biochar being produced in North America. He estimates less than 100 tons of biochar were produced in 2008 (no confirmed data reported). Currently, local farmers and researchers are buying biochar to test the product and with the limited supply, biochar is very expensive.

Canadian Biochar Players

As a by-product, Ensyn produces over 2,000 tons of biochar per year that is currently burned for power. Its operating capacity is 4,000 tons per year of biochar.

Alterna Energy, based in Prince George, B.C., is focused on manufacturing biocarbon from wood, municipal and agricultural waste, and tires. It has constructed a demonstration plant in McBride, B.C., to test its pyrolysis technology. Alterna has been supplying biochar to Australia for government-sponsored field testing.

On September 1, 2009, Canada's Dynamotive made its first of a minimum of 18 shipments of biochar to an undisclosed customer in the United States from its production facility in West Lorne, Ontario. It has a 130 tonne per day capacity.

Advanced Biorefinery Inc., based in Ottawa, Ontario, is working to develop and commercialize a transportable pyrolysis unit that will produce bioenergy, including biochar, at the source of biomass feedstock.

AirTerra builds stoves with a pyrolysis process, and a partially sealed container of biomass for second- and third-world countries to produce biochar while reducing CO_2 emissions caused from typical slash-and-burn farming practices. When the biomass is burned in the stove it produces heat and syngas used as fuel for cooking. The biochar residue can be used in fields to increase crop yield by 2x-8x. AirTerra stoves cost less than $50 and average 3.5 tonnes of biochar per year per stove with an average useful life of seven years. Each stove captures around 2-3 tonnes of CO_2 emissions per year.

Other International Biochar Players

Colorado-based Biochar Engineering Corp. is building a mobile pyrolysis biochar production unit called "Biochar 1000," capable of processing 1,000 pounds of biomass feedstock per hour while achieving yields of about 25%. The advantage of the Biochar 1000 is its ability to move to where the biomass is located, cutting down on expensive transportation costs. Biochar Engineering has sold two production units for $100,000 each.

Carbonscape, based in the United Kingdom, has built a 5 metre prototype of a proprietary industrial microwave technology using electricity to burn wood. **The company claims it can produce biochar for $65/tonne.**

Biobutanol

In January 2010, Cobalt Biofuels began producing biobutanol at its pilot plant in California and expects to complete a 1 million-2 million gallon per year demonstration scale plant by late 2011 or early 2012 co-located **with an existing pulp and paper mill**. A 12% blend of Cobalt biobutanol with gasoline complies with the requirements of California's Low Carbon Fuel Standard, and is already permissible under U.S. EPA guidelines.

Cobalt is looking for a partner to co-locate with ethanol plants. The company is working to produce more effective microbes that convert **both corn and cellulosic feedstocks to biobutanol**. Cobalt's technology is expected to produce biobutanol for about $1.40/gallon. Once the technology is commercialized, Cobalt plans to build a 1.5 million gallon plant, with the potential to increase to 10 million gallons.

DuPont and BP are seeking California regulatory approval to use biobutanol in gasoline as a potential replacement for corn-based ethanol in order to meet the state's GHG emission reduction regulations while boosting octane in gasoline.

In the past, biobutanol was abandoned because of its high production cost. In July 2009 DuPont and BP announced the development of a new process for making biobutanol using a microbe, **which they estimate will be at a cost equivalent of ethanol on an energy basis.** The biobutanol plant is under construction in the U.K., and **product is expected to be commercially available in 2013**.

Research engineers at Ohio State University have developed a new strain of bacteria that produced up to 30 grams of butanol per litre. Previously, concentrations above 15 grams per litre would result in a toxic environment for the bacteria in the fermentation tank. **The researchers claim they could bring the cost of butanol production below $3.00 per gallon.**

On October 6, 2009, *The Wall Street Journal* reported the first successful conversion of a first generation ethanol plant to biobutanol. Denver-based Gevo Inc. is now lining up financing for five more ethanol plants for conversion to biobutanol. New Gevo biobutanol capacity could be above 200 million gallons per year if it succeeds in raising financing. **BP and DuPont have also stated they want to roll out their biobutanol into U.S. ethanol plant retrofits**. San Francisco-based Cobalt biofuels also wants to make biobutanol, but from trees and other woody biomass. **This is shocking to us as it puts into play the possibility that post-2012 food-based fuels will actually fall, taking first generation U.S. corn-based ethanol capacity with it.**

Biobutanol can be blended in higher concentrations in gasoline than ethanol and should be competitive with oil above $45/bbl. However, like many other second-generation technologies, **scale-up could be a challenge.**

Ethanol Retrofits to Biobutanol

Gevo can retrofit an ethanol plant to produce biobutanol in only three months. The additional capital cost is $0.30/gallon of installed ethanol capacity. It is appropriate for ethanol plants, with capacity of between 25 million-100 million gallons per year.

Gevo uses a three part technology: (1) genetically modified biocatalyst that produces biobutanol rather than ethanol, (2) a method to separate isobutanol from the biocatalyst as it is produced; and (3) conversion from iosbutanol into a variety of end products.

Gevo's retrofits can use flexible feedstocks ranging from traditional food-based feedstocks to **cellulosic biomass**. Gevo will produce biobutanol from food-based feedstocks until cellulosic technology advances. The retrofitted biobutanol plants **can produce both ethanol and butanol** by simply replacing biocatalyst with traditional yeast.

Biobutanol Processes
There are two processes used to make biobutanol: (1) ABE fermentation; and (2) fermentation of syngas. ABE fermentation uses bacteria and a traditional fermentation process to produce butanol. The feedstocks used include sugar, corn, wheat, agricultural waste and algae biomass. The fermentation of syngas process involves the gasification of municipal solid waste or biomass to produce syngas. Special microorganisms called acetogens ferment the syngas to produce biobutanol. This process is similar to Coskata producing ethanol from gasifying MSW and other cellulosic feedstocks.

Bio-DME

DME is popular in China, Japan, and Sweden as a replacement for LPG and propane. This eliminates issues surrounding infrastructure, as it can use existing propane storage, pipelines, and other infrastructure. DME fuel is a non-toxic alternative to methanol, which is toxic.

In Europe, Topsoe and Sweden's Chemrec plan to produce 0.6 million gallons per year of renewable dimethyl ether (DME) from wood waste biomass (the world's first) at the Smurfit Kappa paper mill in Pitea, Sweden. Volvo is coordinating the bio-DME Europe project. The $20 million project is expected to come online in mid-2010. The bio-DME produced using Chemrec's black liquor gasification technology **uses 1,500 tons of residual forestry biomass per year as feedstock** (Exhibit 36).

Exhibit 36: Chemrec Bio-DME Plant (Pitea, Sweden)

Source: www.biodme.eu.

Chemrec submitted a $64 million grant application to the Swedish Energy Agency to help fund an industrial-scale black liquor gasification plant in Sweden, with total project costs estimated at €250 million with production expected in late 2012.

The Swedish Energy R&D Board awarded Chemrec $73 million to help implement its technology for the production of **40 million gallons per year of bio-DME and biomethanol** at its biorefinery in Sweden using black liquor gasification. Total project costs are estimated to be $440 million.

In 2010, Volvo Trucks will be the first truck manufacturer to begin bio-DME field tests to assess the potential of bio-DME as a vehicle fuel. Volvo is participating in the test project with 14 Volvo FH trucks that will be tested by select customers at four different locations in Sweden over the two-year test period. The evaluation in 2012 will determine whether the project will lead to full-scale industrial production of bio-DME modified trucks.

GV Energy has proposed to construct a 79 million gallon per year DME plant in British Columbia using 2,100 tonnes per day of wood fibre. **GV Energy claims its process can produce DME competitive with $75-$85/bbl oil.**

In July 2009, NewPage, an Ohio pulp and paper producer, **cancelled** its proposed biofuels gasification project in Escanaba, Michigan, with Sweden's Chemrec. The facility was to produce bio-methanol and bio-DME from the gasification of kraft pulp black liquor. The project was initially announced in August 2007 and cancelled as a result of poor pulp and paper markets and a lack of any DME vehicles or DME refuelling infrastructure.

Bio-Ammonia

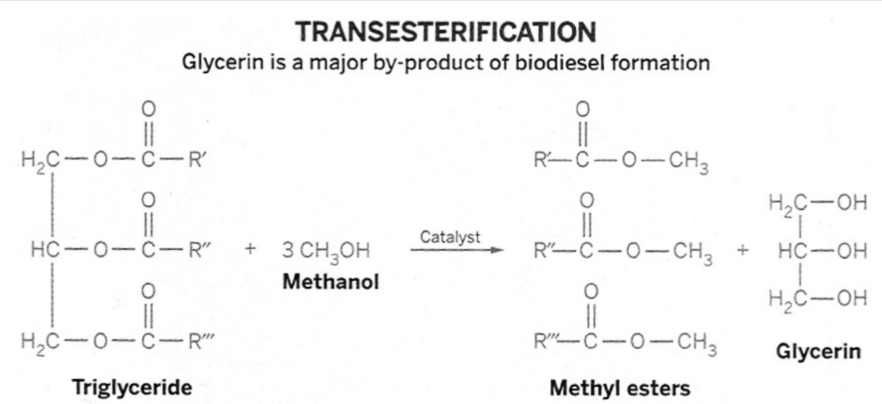
SynGest, a California-based gasification technology developer, and Heartland Co-Op in Iowa, proposed a deal to build a $105 million gasification plant producing **bio-ammonia fertilizer from syngas using corn cobs as feedstock.** Iowa could potentially accommodate up to 20 bio-ammonia plants in the future, each requiring about 400 tons of corn cobs per day. **The bio-ammonia is expected to be cost competitive at natural gas prices of $4 per thousand cubic feet.**

Renewable Methanol Potential

A UOP and USC partnership stated it will develop a process for the production of methanol, DME, and other chemicals from carbon dioxide (CO_2). Green Freedom's syngas production would use a new electrolytic stripping process that requires about **96% less energy** than a conventional thermal stripping process. It **apparently can capture 95% of the CO_2 at a single pass**. North Shore Energy Technologies **believes it can gasify wood into methanol at 165 gallons of biomethanol per 1 tonne of wood.** Cellulosic ethanol technologies to date are **yielding only 60-100 gallons per tonne of biomass**.

In Europe, Methanor operates the **world's first biomass-fed methanol plant ($450 million cost)**. Its proprietary process is similar to that for bioethanol, using glycerine that is a by-product of transesterification (i.e., biodiesel production; see Exhibit 37). The supply of glycerine from biodiesel plants in Europe is near endless for renewable methanol.

Exhibit 37: Transesterification



Source: Company reports.

Other Advanced Biofuel Developments

Archer Daniels Midland (ADM) announced it will start its new 100,000 tonne per year bio-based propylene glycol facility in Illinois using glycerine. Also, ADM will start its 50,000 tonne per year bioplastic facility in Iowa at the end of 2009 through a joint venture with Metabolix, a biotechnology company.

Biomass Waste Gasification

SITA UK, a subsidiary of Suez Environment, and Cyclamax are expected to convert over 600,000 tonnes of commercial and industrial waste into electricity in six gasification-based projects in the U.K. for $366 million.

Choren Biomass is building a 15,000 tonne per year commercial biomass-to-liquids plant in Freiberg, Germany, with production beginning in early 2010. Choren is working with German Pellets to provide 10,000 tons of dry wood feedstock per year, a small portion of the 1 million tons of dry wood feedstock required per year.

BIOENERGY CONCLUSIONS

We are increasingly convinced that the demand growth of food for fuel has limited life post-2012 as numerous new advanced-generation bioenergy technologies come to market and/or scale up to global commercial levels. **This will ultimately reduce the prospects for fertilizer use for food to make biofuels**.

Governments globally finally understand that society has limited life as we use up the heritage of 2 billion years of biomass decay into non-renewable oil, gas, and coal biomass. What should develop out of this is a sustainable energy business **that will need trillions in new investment dollars to shift the planet to a more sustainable energy path.** We hope this research report provides further details on the most promising renewable energy technologies and companies.

Appendix 1 – Advanced Biofuels Projects

Exhibit 1.1: Advanced Biofuels Projects

	2009	2010	2011	2012	2013	2014	Country	Fuel	Technology
Cobalt	0.01	0.01	2.01	102.01	102.01	102.01	USA	Biobutanol	Fermentation
Gevo	1.00	1.00	50.00	150.00	300.00	300.00	USA	Biobutanol	Fermentation
Butalco	0.01	0.01	0.01	0.01	0.01	0.01	Germany	Biobutanol	
Aurora Biofuels	0.01	0.01	0.01	0.01	0.01	0.01	USA	Biodiesel	Algae transesterification
ENN	0.01	0.01	0.01	0.01	0.01	0.01		Biodiesel	Algae transesterification
Kumho Petrochemical	0.00	0.00	0.39	0.39	0.39	0.39	Korea	Biodiesel	Algae transesterification
LiveFuels	0.01	0.01	0.01	0.01	0.01	0.01		Biodiesel	Algae transesterification
Seambiotic	0.01	0.01	0.01	0.01	0.01	0.01	Israel	Biodiesel	Algae transesterification
Solix	0.01	0.01	0.01	0.01	0.01	0.01	USA	Biodiesel	Algae transesterification
Chemrec	0.00	0.58	0.58	0.58	40.58	40.58	Sweden	BioDME	BLG
Abengoa	0.00	0.00	15.00	15.00	15.00	15.00	USA	Ethanol	EH
ADM	0.00	0.00	0.00	1.00	1.00	1.00	USA	Ethanol	EH
AE Biofuels	0.01	10.01	10.01	10.01	10.01	10.01	USA	Ethanol	EH
Algenol	0.01	0.30	0.30	0.40	250.40	750.40	Mexico	Ethanol	Algae fermentation
American Process	0.00	0.00	0.89	0.89	0.89	0.89	USA	Ethanol	EH
BlueFire Ethanol	0.01	0.01	3.91	3.91	22.91	22.91	USA	Ethanol	AH
Coskata	0.05	0.05	0.05	55.05	55.05	55.05		Ethanol	Gasification
DDCE	0.00	0.25	0.25	0.25	0.25	0.25	USA	Ethanol	EH
Enerkem	0.30	0.30	10.30	10.30	20.30	20.30	Canada	Ethanol	Gasification
Fulcrum	0.01	0.01	0.01	10.51	10.51	10.51	USA	Ethanol	Gasification
Haldor Topsoe	0.00	0.00	0.00	0.80	0.80	0.80		Ethanol	EH
Inbicon	1.40	1.40	1.40	19.40	19.40	19.40	Denmark	Ethanol	EH
IneosBIO	0.00	0.00	8.00	8.00	8.00	8.00	USA	Ethanol	Gasification-Fermentation
Iogen	0.48	0.48	23.48	23.48	23.48	23.48	Canada	Ethanol	EH
Kent BioEnergy	0.01	0.01	0.01	0.01	0.01	0.01	US	Renewable oils	Lipid extraction
KL Energy	1.30	1.30	1.30	1.30	1.30	1.30	USA	Ethanol	EH
LanzaTech	0.01	0.51	0.51	0.51	0.51	0.51	New Zeala	Ethanol	Gasification
Lignol	0.01	0.01	0.01	0.01	0.01	0.01	Canada	Ethanol	EH
Logos Technologies	0.00	0.00	0.00	0.80	0.80	0.80		Ethanol	EH
Mascoma	0.20	0.20	0.20	20.20	20.20	20.20	USA	Ethanol	CBP
POET	0.02	0.02	25.02	25.02	25.02	25.02	USA	Ethanol	EH
Range Fuels	0.00	4.00	4.00	4.00	4.00	4.00	USA	Ethanol	Gasification
Scottish Bioenergy	0.01	0.01	0.01	0.01	0.01	0.01	Scotland	Ethanol	EH
SEKAB	0.01	0.01	0.01	0.01	0.01	0.01	Sweden	Ethanol	EH
St1 Biofuels Oy	0.00	0.00	0.01	0.01	0.01	0.01	Finland	Ethanol	EH
Terrabon	0.00	0.10	0.10	0.10	0.10	0.10		Ethanol	Hydrogenation of carboxylic acids
TMO Renewables	0.01	0.01	0.01	0.01	0.01	0.01	UK	Ethanol	EH
UPM-Kymmene/Metso	0.00	0.00	0.00	0.68	0.68	0.68		Ethanol	EH
Verenium	1.40	1.40	1.40	37.40	37.40	37.40	USA	Ethanol	EH
Weyland / Statoil Hydro	0.00	0.01	0.01	0.01	0.01	0.01	Norway	Ethanol	EH
ZeaChem	0.00	0.25	0.25	0.25	0.25	0.25	USA	Ethanol	Gasification/fermentation
AltAir	0.00	0.00	0.00	100.00	100.00	100.00	USA	RDIF	Hydroprocessing
Amyris	0.01	0.01	0.02	1.02	27.02	27.02	USA	RDIF	CBP
British Airways	0.00	0.00	0.00	0.00	0.00	19.00	UK	RDIF	FT
Choren	0.00	4.10	4.10	4.10	4.10	4.10	Germany	RDIF	FT
Clearfuels	0.00	0.10	0.10	0.10	0.10	16.10	USA	RDIF	Steam reform
Dynamic Fuels	0.00	75.00	75.00	75.00	75.00	75.00	USA	RDIF	FT
Dynamotive	0.01	1.01	1.01	1.01	1.01	1.01	Canada	RDIF	Pyrolysis
Joule	0.00	0.01	0.01	0.01	0.01	0.01	USA	RDIF	CBP
LS9	0.01	0.10	10.10	10.10	10.10	10.10	USA	RDIF	CBP
PetroAlgae	0.12	0.12	0.12	70.12	140.12	210.12	USA	RDIF	Coking
REII	0.02	0.02	0.02	0.35	0.35	0.35	USA	RDIF	Gasification
Rentech	0.15	0.15	0.15	9.00	259.00	259.00	USA	RDIF	FT
Sapphire Energy	0.01	0.20	0.02	0.02	0.02	0.02	USA	RDIF	Hydroprocessing
Solazyme	0.10	0.10	0.10	100.10	100.10	100.10	USA	RDIF	Hydroprocessing
Greenfield Ethanol	0.00	0.00	0.01	0.01	0.01	0.01	Canada	Ethanol	EH
UK Carbon Trust Algae consortium	0.00	0.00	0.01	0.01	0.01	0.01	UK	RDFI/Biodiesel	Algae transesterification
UK Carbon Trust pyrolysis consortium	0.00	0.00	0.00	0.00	0.00	0.01	UK	Bio-oil	Pyrolysis
UOP-Aquaflow Bionomic	0.00	0.00	0.01	0.01	0.01	0.01	US	Bio-oil	Pyrolysis
Buckeye Technologies/University of Florida	0.00	0.00	0.01	0.01	0.01	0.01	USA	Ethanol	EH
National Technological University	0.01	0.01	0.01	0.01	0.01	0.01	Argentina	RDFI/Biodiesel	Algae transesterification
Praj MATRIX	0.00	0.01	0.01	0.01	0.01	0.01	India	Ethanol	EH
Virent	0.00	0.00	0.01	0.01	0.01	0.01	USA	RDIF	Bioforming
BioTfuel	0.00	0.00	0.00	0.02	0.02	0.02	France	RDIF	
Trenton Fuel Works	0.00	0.00	0.00	0.00	0.00	3.87	USA	Ethanol	AH
Pond Biofuels	0.00	0.01	0.01	0.01	0.01	0.01	Canada	Biodiesel	Algae transesterification
US Biofuels	0.12	3.80	5.90	10.50	25.30	25.30	USA		
	6.88	**107.05**	**256.22**	**883.90**	**1713.70**	**2322.58**			

Source: *Biofuels Digest*.

Appendix 2 – Biofuels Digest Index

Exhibit 2.1: Biofuels Digest Index

BIOFUELS DIGEST INDEX	SYMBOL	DIVISOR
Archer-Daniels-Midland	ADM	1.00
The Andersons	ANDE	0.33
Aventine Renewable Energy	AVR	0.33
Bluefire Ethanol	BFRE.OB	0.25
Biofuel Energy	BIOF	0.25
British Petroleum	BP	1.00
Cosan	CZZ	0.33
Earth Biofuels	EBOF.PK	0.10
Environmental Power	EPG	0.10
GreenShift	GERS.OB	0.10
Global Energy Holdings	GNH	0.10
Green Plains Renewable Energy	GPRED	0.10
Green Energy Resources	GRGR.PK	0.10
GreenHunter	GRH	0.20
Gushan Environmental Energy	GU	0.20
Lignol	LEC.V	0.10
Momentum Biofuels	MMBF.OB	0.10
OriginOil	OOIL.OB	0.10
PetroAlgae	PALG.OB	0.20
Pure Biofuels	PBOF.OB	0.10
Pacific Ethanol	PEIX	0.33
Raven Biofuels	RVBF.OB	0.20
Sustainable Power	SSTP.PK	0.10
SunOpta	STKL	0.10
Syntec Biofuel	SYBF.OB	0.10
Texcom	TEXC.PK	0.10
Tiger Ethanol	TGRW.OB	0.10
Valero	VLO	0.50
Verenium	VRNM	0.02

Source: *Biofuels Digest*.

Appendix 3 – Algae Companies

Exhibit 3.1: Algae Companies

A2BE Carbon Capture
Algae Biofuels Inc.
Algaedyne Corporation
AlgaeLab
AlgaeLink
Algafuel
Algenol
Algosource
Aquaflow Bionomic Corporation
Aquatic Biofuels
Aurorabiofuels
Bioalgene
Bionavitas
BioProcess Algae LLC
Biox Corporation
Blue Marble Energy
Bodega Algae
Canadian Pacific Algae
Canrex Biofuels Ltd.
Carbon Capture Corporation
Carbon2Algae
Catchlight Energy, LLC
Cellana
Columbia Energy Partners
Culturing Solutions, Inc.
Cyanotech
Diversified Energy
Energy Derived
Euglene Co., Ltd.
General Atomics
Genifuel
GenoFocus
Global Green Solutions, Inc.
Green Crude Production
GreenFire Energy
Greenfuel
GreenShift Corp.
GreenWater Energy
Hawaii Bio Energy
Independence Bio Products
Kai BioEnergy
Kegotank BioFuels
Kent Bioenergy
Kent Biosciences
Kent SeaTech
Kuehnle AgroSystems, Inc.
Lane Algae Group
Livefuels
Mana Fuels
Might Algae Biofuels
OriginOil
Pacific Sun Energy
PetroAlgae
PetroSun
Phycosource
Round River Technologies
Sapphire Energy
SarTec
SeaAg, Inc.
Seambiotic
Solix
Solray
SunEco Energy, Inc.
Sunflower Integrated Bioenergy, LLC
Sunrise Ridge Algae
Sunx Energy
Sylvatex Biofuels
Ternion Bio Industries
Tomorrow Biofuels
Valcent
XL Renewables

Source: Electric Power Research Institute.

Appendix 4 – Algae's Value Chain

Exhibit 4.1: Algae's Value Chain

1. **Food.** Algae supply high-protein, low-fat, nutritious, healthy and delicious human foods. Algae provide more vitamins, minerals and nutrients than land plants and are a natural health food. Algae do not provide a full solution for malnutrition due to their few calories.
   Note: Algae's food value will be suboptimal until solutions are found for a few key issues; making hard cell walls digestible and producing fewer nucleic acids. All other green promises await only macro and micro-scale algaculture production systems.
2. **Food ingredients.** Algal ingredients enhance about half the food products in a grocery store. Algae components support dairy products, beer, jams, bakery products, soups, sauces, pie fillings, cakes, frostings, colorings, ulcer remedies, digestive aids, eye drops, dental creams, skin creams and shampoos.
3. **Fodder.** Algae produce high-protein, low-cost, nutritious animal feed with numerous vitamins, minerals and nutrients. Replacing half the food grains fed to animals sold as U.S. exports would save 20 M acres of cropland and a trillion gallons of water. Local production in villages would feed millions of animals and would save 20 M acres a year of forests and grasslands from desertification due to animal forage.
4. **Fisheries.** Algae provide high-protein; low-cost, nutritious fish feed, vitamins and nutrients. Algae can be grown in-situ, in the water with the fin fish or shell fish. Fish tend to grow with more vitality on algae than land grains because they eat algae in their natural habitat.
5. **Fuels – biodiesel.** Algal oils pressed directly from algal biomass produce renewable and sustainable, high energy biofuel from sunshine, C02 and wastewater. Replacing U.S. ethanol production would take 2 M acres of desert, half of one Arizona county. Replacing corn as a biofuel feedstock would save 40 M acres of cropland, 2 trillion gallons of water, 240 M tons of soil erosion and extensive water pollution annually.
6. **Fuels – jet fuel, ethanol and hydrogen.** Algal production can be refined to a variety of high energy liquid transportation fuels including gasoline. While refining generally requires more energy input than squeezing out algal oil, the U.S. is likely to have a surplus of ethanol refinery capacity. Algal products can be refined in fossil fuel refineries into many of the products made from fossil fuels. Hydrogen gas production would occur in the algaculture system and need a refinery.
7. **Fossil fuels.** Replacing U.S. ethanol production also would save 7 B gallons of fossil fuel used to produce ethanol. Moving 1/10th of U.S. agricultural production from dirty diesel to clean algal-diesel would clean the environment and save 20 B gallons of fossil fuels annually. Even larger fossil fuel savings would accrue from using algal oils to substitute for a portion of the diesel used by trucks and trains.
8. **Fire &ndash cooking.** Black smoke from cooking fires and heating with wood, weeds and dung causes smoke death for 1.6 M and disability for 10 M mostly women and children every year. Clean-burning, high energy algal-oil can end smoke death and the many smoke disabilities. Substituting algal oil for wood and agricultural materials will save a tremendous amount of labor from gathering firewood and allow forests to be replanted.
9. **Fresh water.** Running wastewater through algaculture feeds the plants and cleans the water. Producing fuel, fodder or fertilizer using wastewater or brine water saves water that would otherwise be used for land-based crops. Replacing half of U.S. food exports with algaculture foods would save 30 M acres of cropland, 4 trillion gallons of water and 15 B gallons of fossil fuel.
10. **Fresh air.** Flueing smoke stack gasses through algaculture removes CO2, nitric oxides, sulfur and heavy metals such as mercury from power plant or industrial plants, sequesters greenhouse gasses and cleans the air. Algae represent only a partial solution since the plant only grows with sunshine and power plants operate 24 hours a day.
11. **Fertilizer.** Nitrogen-fixing algae may provide high nitrogen fertilizers at very low cost in both production and energy inputs. The product is natural and supports organic food production and could provide cheap local fertilizer to subsistence farmers globally. The ash retains fertilizer value after being burned in cooking fires.
12. **Forests.** High energy algal-oil fuel can end the need to denude forests and grasslands for cooking and heating fuel. Villagers may replant their forests with nut trees or legumes for food to offset the low calories provided by algal foods.
13. **Fabrics.** Algal carbohydrates are similar to wood and may be made into textiles, paper and building materials. Algal paper and building materials save forests and fabrics and provide warmth. Algal oils may be made into biodegradable plastics or other refined products.
14. **Foreign Aid.** American foreign aid provides subsidized U.S. food, undermines or destroys local food production because farmers cannot compete with U.S. subsidized food. Gifting food fails to address the root cause of hunger and poverty &ndash local control over food resources and community engagement. Algaculture foreign aid would transfer knowledge and some start-up materials to grow algal foods, fuels, fodder, fertilizer and medicines locally.
15. **Famine and disaster relief.** Algae, with its rich set of vitamins and minerals, may activate the immune system and ward off starvation while providing fuel, fodder, fabrics, fertilizers and fine medicines. Disaster relief with local algaculture production may prevent community starvation for millions. Local algal production solves the critical problem of food distribution.
16. **Fine medicines.** High-quality, affordable medicines, vaccines and pharmaceuticals may be made from algal coproducts or grown in algae bioengineered to produce advanced compounds such as antibiotics, vitamins, nutraceuticals and vaccines. These compounds are grown today in land plants and animals so algae offer significantly faster and lower cost production. Designer algae grown locally in villages could save millions of lives by providing low cost vaccines or other medicines that need no packaging or distribution. Fine medicines, especially personalized drugs tailored to an individual, may offer more value than all other algal coproducts combined.

Source: Carbon2Algae.

Notes

Notes

Appendix A: Important Disclosures

Company	Ticker	Disclosures (see legend below)*
Agrium Inc.	AGU	H3, I, U
Methanex Corporation	MX	J, P, S
Potash Corporation of Saskatchewan, Inc.	POT	N1, T, U

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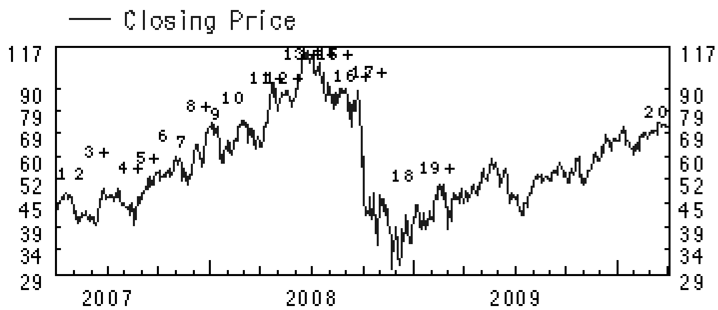
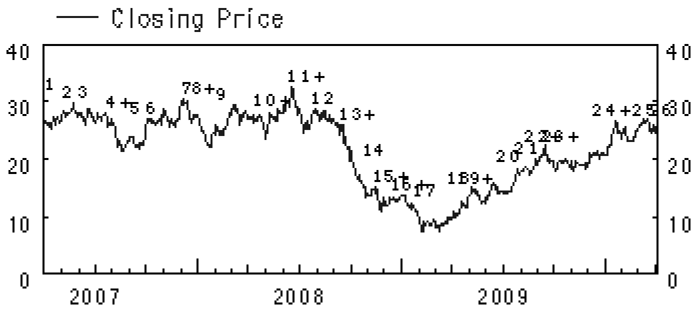


Numbers are located to the left of the lines they represent.
Numbers indicated with a plus sign (+) have more than one target or rating change in the given month.

Agrium Inc.				
#	**Date**	**Closing Price**	**Rating**	**Target-1YR**
1	7-Apr-07	$45.31	* 1-Sector Outperform	*$57.00
2	4-May-07	$41.08	1-Sector Outperform	*$55.00
3	7-Jun-07	$39.35	1-Sector Outperform	*$47.00
	15-Jun-07	$45.20	1-Sector Outperform	*$50.00
	20-Jun-07	$46.46	1-Sector Outperform	*$52.50
	23-Jun-07	$48.90	1-Sector Outperform	*$55.00
4	17-Aug-07	$40.20	1-Sector Outperform	*$47.50
	28-Aug-07	$44.92	1-Sector Outperform	*$53.00
5	5-Sep-07	$49.30	1-Sector Outperform	*$55.00
	13-Sep-07	$50.65	1-Sector Outperform	*$58.00
	26-Sep-07	$54.01	1-Sector Outperform	*$64.00
6	2-Oct-07	$53.28	1-Sector Outperform	*$67.00
7	2-Nov-07	$57.20	1-Sector Outperform	*$70.00
8	4-Dec-07	$62.75	1-Sector Outperform	*$73.00
	6-Dec-07	$64.09	1-Sector Outperform	*$76.50
	11-Dec-07	$60.60	Restricted	Restricted
	19-Dec-07	$58.14	* 1-Sector Outperform	*$75.00
9	8-Jan-08	$68.40	1-Sector Outperform	*$86.00
10	27-Feb-08	$72.51	1-Sector Outperform	*$90.00
11	5-Apr-08	$70.01	1-Sector Outperform	*$93.00
	16-Apr-08	$86.70	1-Sector Outperform	*$102.00
	17-Apr-08	$87.20	1-Sector Outperform	*$105.00
12	1-May-08	$79.60	1-Sector Outperform	*$98.00
	16-May-08	$89.56	1-Sector Outperform	*$111.00
13	12-Jun-08	$102.10	1-Sector Outperform	*$116.00
	14-Jun-08	$106.46	1-Sector Outperform	*$128.00
	26-Jun-08	$105.29	1-Sector Outperform	*$134.00
14	17-Jul-08	$95.24	1-Sector Outperform	*$128.00
	24-Jul-08	$83.75	* 2-Sector Perform	*$117.00
	31-Jul-08	$89.98	2-Sector Perform	*$123.00
15	6-Aug-08	$87.16	2-Sector Perform	*$112.00
	12-Aug-08	$82.13	2-Sector Perform	*$109.00
	15-Aug-08	$83.20	2-Sector Perform	*$114.00
16	4-Sep-08	$79.24	2-Sector Perform	*$109.00
	9-Sep-08	$71.29	Restricted	Restricted
	19-Sep-08	$89.00	* 2-Sector Perform	*$109.00
	20-Sep-08	$89.00	2-Sector Perform	*$114.00
17	3-Oct-08	$43.72	* 1-Sector Outperform	*$80.00
	28-Oct-08	$38.85	1-Sector Outperform	*$72.00
18	4-Dec-08	$31.27	1-Sector Outperform	*$66.00
19	12-Feb-09	$48.95	1-Sector Outperform	*$70.00
	26-Feb-09	$43.80	Restricted	Restricted
20	24-Mar-10	$72.55	* 2-Sector Perform	*$85.00
* represents the value(s) that has changed.				



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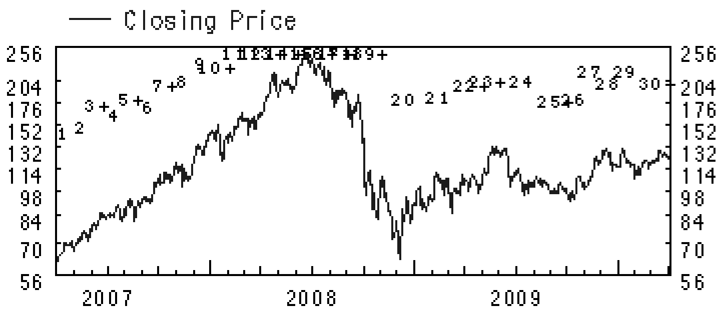
Methanex Corporation

#	Date	Closing Price	Rating	Target-1YR
1	7-Apr-07	$25.95	* 3-Sector Underperform	*$25.00
	27-Apr-07	$26.59	3-Sector Underperform	*$26.00
2	12-May-07	$27.81	3-Sector Underperform	*$27.00
3	7-Jun-07	$27.34	3-Sector Underperform	*$26.00
4	9-Aug-07	$22.05	* 2-Sector Perform	*$25.00
	17-Aug-07	$21.30	2-Sector Perform	*$23.50
	28-Aug-07	$23.05	2-Sector Perform	*$24.00
5	6-Sep-07	$23.38	2-Sector Perform	*$26.00
6	2-Oct-07	$26.91	2-Sector Perform	*$29.00
7	6-Dec-07	$30.00	* 3-Sector Underperform	*$30.00
8	8-Jan-08	$25.01	3-Sector Underperform	*$26.00
	16-Jan-08	$22.43	3-Sector Underperform	*$25.00
9	27-Feb-08	$28.01	3-Sector Underperform	*$27.50
10	1-May-08	$24.34	* 2-Sector Perform	$27.50
	7-May-08	$27.49	2-Sector Perform	*$28.50
	24-May-08	$28.25	2-Sector Perform	*$32.00
11	17-Jul-08	$25.10	2-Sector Perform	*$30.00
	24-Jul-08	$27.98	* 1-Sector Outperform	*$33.00
12	12-Aug-08	$27.40	1-Sector Outperform	*$32.00
13	24-Oct-08	$14.97	1-Sector Outperform	*$30.00
	29-Oct-08	$13.60	* 2-Sector Perform	*$27.50
14	15-Nov-08	$15.26	2-Sector Perform	*$22.50
15	4-Dec-08	$11.99	2-Sector Perform	*$20.00
	5-Dec-08	$12.00	2-Sector Perform	*$19.00
16	22-Jan-09	$11.00	2-Sector Perform	*$16.50
	30-Jan-09	$9.48	2-Sector Perform	*$15.00
17	12-Feb-09	$8.99	* 1-Sector Outperform	$15.00
18	18-Apr-09	$12.67	1-Sector Outperform	*$17.00
19	6-May-09	$15.06	1-Sector Outperform	*$19.00
	13-May-09	$13.92	* 2-Sector Perform	*$18.00
20	30-Jul-09	$17.55	2-Sector Perform	*$18.50
21	12-Aug-09	$18.13	2-Sector Perform	*$22.00
22	16-Sep-09	$21.30	2-Sector Perform	*$23.00
	17-Sep-09	$20.34	* 3-Sector Underperform	$23.00
23	14-Oct-09	$19.41	3-Sector Underperform	*$22.00
	29-Oct-09	$19.66	3-Sector Underperform	*$21.00
24	7-Jan-10	$22.18	3-Sector Underperform	*$25.50
	12-Jan-10	$23.89	* 2-Sector Perform	*$26.50
	29-Jan-10	$23.90	2-Sector Perform	*$28.00
25	23-Mar-10	$25.10	* 3-Sector Underperform	*$26.00
26	2-Apr-10	$25.56	3-Sector Underperform	*$27.00

* represents the value(s) that has changed.



Numbers are located to the left of the lines they represent.
Numbers indicated with a plus sign (+) have more than one target or rating change in the given month.

Potash Corporation of Saskatchewan, Inc.				
#	Date	Closing Price	Rating	Target-1YR
1	7-Apr-07	$64.50	* 1-Sector Outperform	*$218.00
	14-Apr-07	$69.62	1-Sector Outperform	*$240.00
2	12-May-07	$72.74	1-Sector Outperform	*$250.00
	18-May-07	$74.85	1-Sector Outperform	*$83.00
3	7-Jun-07	$75.99	1-Sector Outperform	*$87.00
	15-Jun-07	$82.97	1-Sector Outperform	*$92.00
4	13-Jul-07	$87.62	1-Sector Outperform	*$97.00
5	9-Aug-07	$87.86	* 2-Sector Perform	*$102.50
	17-Aug-07	$80.23	2-Sector Perform	*$91.00
	28-Aug-07	$88.43	2-Sector Perform	*$99.00
6	1-Sep-07	$93.58	2-Sector Perform	*$102.50
	26-Sep-07	$103.08	2-Sector Perform	*$113.00
7	2-Oct-07	$107.34	2-Sector Perform	*$118.00
	26-Oct-07	$112.59	2-Sector Perform	*$125.00
8	15-Nov-07	$108.09	2-Sector Perform	*$127.00
9	6-Dec-07	$131.00	2-Sector Perform	*$140.00
10	8-Jan-08	$138.32	2-Sector Perform	*$160.00
	16-Jan-08	$138.00	2-Sector Perform	*$169.00
	18-Jan-08	$125.50	* 1-Sector Outperform	$169.00
11	27-Feb-08	$156.02	1-Sector Outperform	*$178.00
12	26-Mar-08	$162.91	1-Sector Outperform	*$190.00
13	5-Apr-08	$172.57	1-Sector Outperform	*$210.00
	16-Apr-08	$198.50	1-Sector Outperform	*$222.00
	17-Apr-08	$196.88	1-Sector Outperform	*$240.00
	25-Apr-08	$210.40	1-Sector Outperform	*$250.00
14	1-May-08	$186.55	1-Sector Outperform	*$235.00
	16-May-08	$207.29	1-Sector Outperform	*$255.00
15	26-Jun-08	$222.49	1-Sector Outperform	*$275.00
16	17-Jul-08	$215.31	1-Sector Outperform	*$260.00
	24-Jul-08	$196.85	* 2-Sector Perform	*$237.00
	31-Jul-08	$210.37	2-Sector Perform	*$250.00
17	6-Aug-08	$189.30	2-Sector Perform	*$225.00
	15-Aug-08	$179.90	2-Sector Perform	*$237.00
18	4-Sep-08	$160.37	2-Sector Perform	*$214.00
	20-Sep-08	$182.98	2-Sector Perform	*$237.00
19	3-Oct-08	$102.21	2-Sector Perform	*$150.00
	29-Oct-08	$97.97	* 1-Sector Outperform	$150.00
20	4-Dec-08	$62.89	1-Sector Outperform	*$130.00
21	12-Feb-09	$107.52	* 2-Sector Perform	$130.00
22	24-Apr-09	$101.59	2-Sector Perform	*$125.00
	29-Apr-09	$102.61	Restricted	Restricted
23	7-May-09	$109.77	* 2-Sector Perform	*$155.00
	13-May-09	$120.51	* 1-Sector Outperform	*$150.00
	21-May-09	$124.02	1-Sector Outperform	*$165.00
24	11-Jul-09	$99.12	1-Sector Outperform	*$153.00
25	22-Sep-09	$100.70	1-Sector Outperform	*$143.00
	24-Sep-09	$98.92	Obscured	Obscured

	25-Sep-09	$97.86	* 1-Sector Outperform	*$143.00
26	14-Oct-09	$95.89	1-Sector Outperform	*$136.00
27	19-Nov-09	$120.76	1-Sector Outperform	*$146.00
28	23-Dec-09	$116.98	1-Sector Outperform	*$140.00
29	7-Jan-10	$129.29	1-Sector Outperform	*$150.00
30	10-Mar-10	$121.30	1-Sector Outperform	*$155.00
	16-Mar-10	$128.75	1-Sector Outperform	*$160.00
* represents the value(s) that has changed.				

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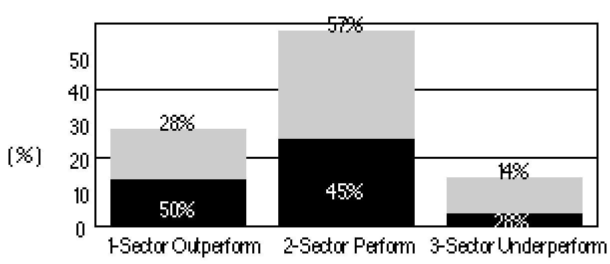

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