Biofuels 2.0: investment opportunities and risks

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Demand for biofuels is rapidly increasing as governments respond to climate change concerns. For the investor such a rapidly growing market is attractive, but current demand depends heavily on government incentives. Newer "second-generation" technologies offer the potential for improved performance but involve a relatively high degree of technology risk. This article explores the issues for investors, and considers some possible strategies for success.

Global demand for biofuels is increasing as governments respond to climate change. Political incentives now drive a burgeoning market but current production processes may not deliver the necessary increases in production capacity or decreases in product cost. So-called "second-generation" technologies which have yet to reach the market at industrial scale may be necessary to address these issues, but may face significant barriers to entry set by incumbent technologies. What are the future technology trajectories that an investor must consider? Is it better to focus on current technologies, or should investors already be looking towards the next generation? Are there some guiding principles and strategic insights that investors can use in deciding on an entry strategy? In this article we try to shed some light on these questions.

Biofuels – a developing market driven by legislation and government support

Biofuels – liquid transport fuels derived from organic materials – are the only direct substitute for oil-based fuels that are available on a significant scale. They have attracted renewed attention from legislators and industry in recent years, particularly in Europe and the USA. Biofuels are seen as sustainable supplements to petrol and diesel, which may reduce greenhouse gas emissions and improve the security of fuel supplies. At the same time, the two major biofuels in current use – bioethanol and biodiesel – are compatible with existing fuel distribution networks and vehicle fleets when blended at a 5 percent level.

Biofuel markets have been stimulated by legislation. The EU biofuels directive sets a target of a 5.75 percent market share for transport use by 2010 and it is likely that this will rise to 10 percent by 2020. A similar situation exists in the USA where biofuels are seen as integral to proposals for a 20 percent reduction in petroleum consumption by 2017. In the EU, member states have had free rein in how they meet the 5.75 percent target. A variety of incentives

for producers have been applied in different ways in different member states, including production/retail quotas, tax incentives and mandatory regulation of the inclusion level for biofuels. As a whole, the European biofuels market is extremely heterogeneous, both in terms of application of regulations and uptake of products.

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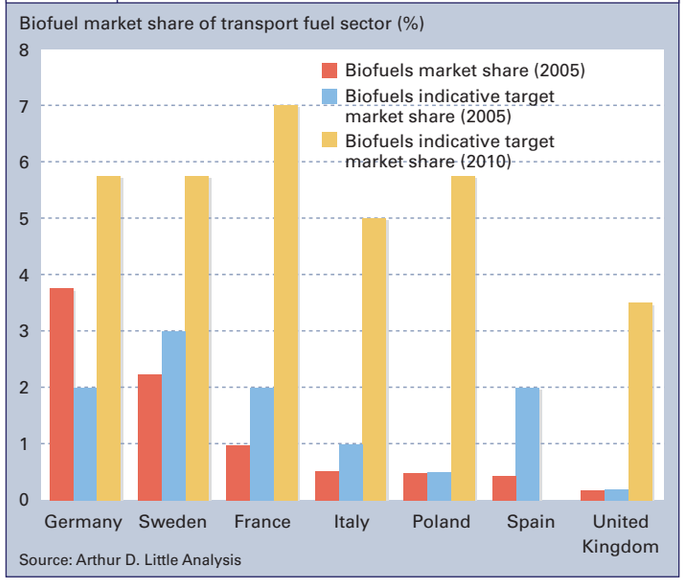
Germany has the strongest biodiesel market in the world, and this is built on a significant tax rebate making biodiesel cheaper than fossil fuel alternatives. France has allocated mandatory production quotas, and designated specific agricultural consortia to meet them. Some EU member states including France, Austria and Germany have obligations in force for the blending of biofuels, which are reinforced with financial penalties on petrol and diesel suppliers if they are not met. The UK will enforce the use of biofuels in this way in 2008.

The USA, the world's second-largest bioethanol market after Brazil, is still debating how to achieve its recently imposed substitution targets, with tax breaks for oil producers revoked and emissions trading schemes currently under consideration.

Exhibit 1 **World biofuels market (2005)**



Most countries fall short of meeting national biofuel substitution mandates (Exhibit 1). In the EU, only Germany and Malta have met targets for 2005. To achieve future targets for 2010 and beyond, a step change in production capacity will be required.

Driving the demand for biofuels

Arguably, the key driver of the biofuels market is that of reducing atmospheric carbon emissions with a view to mitigating climate change. Vehicle fuels account for over 20 percent of global man-made carbon dioxide emissions; sourcing low-carbon alternatives is a high priority. During photosynthesis, plants fix carbon dioxide from the atmosphere into sugars, starches and oils, which can then be used for biofuel production. When biofuels are burnt, this carbon is released back to the atmosphere, suggesting that they are "carbon neutral". A large number of studies have been undertaken to determine the environmental impacts of biofuel production, with inconclusive results as net carbon dioxide emissions may well occur as a result of farming methods, shipping and manufacturing processes.

Opportunities for investment in biofuels remain attractive, but over the very long term it seems likely that they will form only part of the vehicle fuel solution.

In addition to the climate change arguments put forward for biofuels, many governments are supporting their development as a means of increasing fuel security and decreasing reliance on crude oil imports from areas of political instability. But even if the EU target of 10 percent inclusion by 2020 were met, the true contribution of biofuels to fuel security would be small.

Taken together, these two drivers suggest that biofuels present only a temporary solution, yet credible alternatives such as fuel cells and hydrogen power remain a long way from widespread commercial use. With legislation giving an indication of the market potential through to 2020, opportunities for investment in biofuels remain attractive, but over the very long term it seems likely that they will form only part of the vehicle fuel solution.

Today's market conditions

For much of 2006 high oil prices contributed to wide interest in biofuels. As oil prices have declined – and the prices

of raw materials increased – the biofuels industry faces significant challenges. In the UK, for example, biodiesel plants are operating below full capacity but, with the Renewable Transport Fuels Obligation (RTFO) coming into effect in 2008, biofuel producers remain confident that the financial penalties on fuel suppliers for failing to blend their products with biofuels will reinvigorate the market.

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Production technologies used at present are very much "first-generation". For bioethanol, this involves the fermentation of sugars derived from crops such as sugar cane, corn and wheat; for biodiesel it involves the conversion of oils to diesel by a "transesterification" process. Feedstocks for biodiesel include rape seed (canola), soya bean and oil palm, as well as animal tallows and waste vegetable oils. Alternative feedstocks such as *Jatropha* are currently being investigated by biodiesel producers (see case study 1) and the use of woody materials and straw (lignocellulosic feedstocks) is attracting great interest amongst bioethanol producers.

Stepping up – can incumbent technologies meet future demand?

Achieving future substitution targets will pose significant challenges for the incumbent biofuel manufacturing and technology base. Current demand is being met, in part, by constructing more manufacturing plants. New facilities are being commissioned at a phenomenal rate, on top of the significant global capacity expansion that occurred in 2005 and 2006. However, current production methods will be constrained by requirements for arable land and relative costs between fossil fuels and biofuel alternatives.

I. Unrealistic requirement for arable land

Large land areas are needed to grow the energy crops from which biofuels are produced. For the market to expand, more land will be required, and this will result in greater competition with food crops. Sourcing of feedstocks is an international bulk-commodity trading activity, and the short-term impact of the growing demand for energy crops is already being observed, with rising prices and concerns over deforestation in tropical areas such as Brazil and Borneo.

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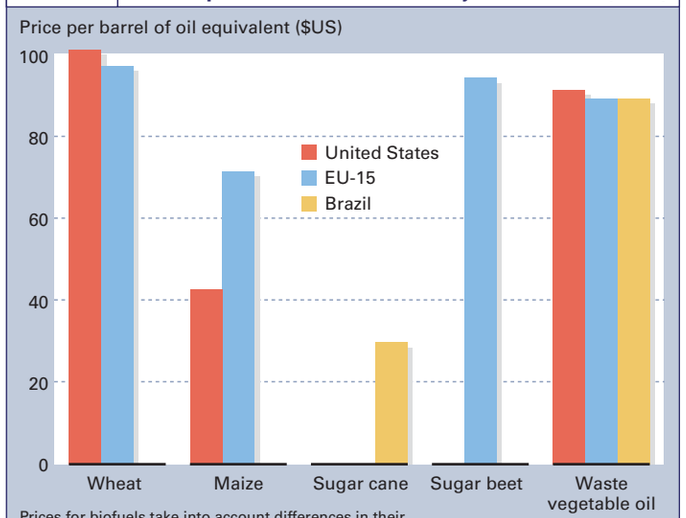
II. Cost base and competition with oil prices

Market expansion in many countries is driven by tax breaks and subsidies. The countries leading the field are those that have the most favourable political incentives to meet government-set targets. Without such incentives, biofuels cannot compete on cost with fossil fuels at current oil prices (Exhibit 2).

In Brazil, where the bulk availability of sugar cane has created the world's largest bioethanol market, the size of the market has fluctuated substantially over the last five years

Exhibit 2 **Biofuel production costs from major feedstocks (2004)**



Prices for biofuels take into account differences in their energy content for the most recently available data (2004).
Source: Adapted from OECD, 2005. Agricultural market impacts of future growth in the production of biofuels

depending on the price of oil. In many European countries, current demand for biofuels has been adversely affected by a combination of the reduced cost of crude oil and high feedstock prices. The long-term success of biofuels will depend on competition between biofuels and fossil fuels without subsidies or tax incentives.

Existing producers are already responding to these challenges. In the case of D1 Oils, a UK-based biodiesel producer, plant breeding and supply chain management are being used to improve the cost and quality of biodiesel feedstocks (see Case Study 1).

Case Study 1: D1 Oils

D1 Oils is a UK-based producer of biodiesel. As well as having developed a pioneering "modular" biodiesel refinery that allows production to grow with market demand without the need for significant up-front investment in major infrastructure, D1 Oils is actively involved in a crop improvement programme to secure high-quality oil from developing countries.

D1 Oils has focussed a large-scale breeding and planting programme on *Jatropha*, a tree that produces seeds with high oil content, has a broad climate tolerance, and has the potential to be grown widely in the developing world, providing farmers with a sustainable income from growing an energy crop that does not compete for land with food crops. By late 2006, D1 Oils had planted or secured the rights to offtake from over 100,000 hectares of *Jatropha* plantation in southern Africa, India and South East Asia.

These improvements must be viewed in light of the anticipated step changes in biofuel production volumes which are required to meet the politically-driven future demand for biofuels. In this light, some areas of the incumbent manufacturing and technology base may still be inadequate to achieve national targets. A new, "second-generation" base may be required to meet this need.

Biofuels 2.0 – the next generation

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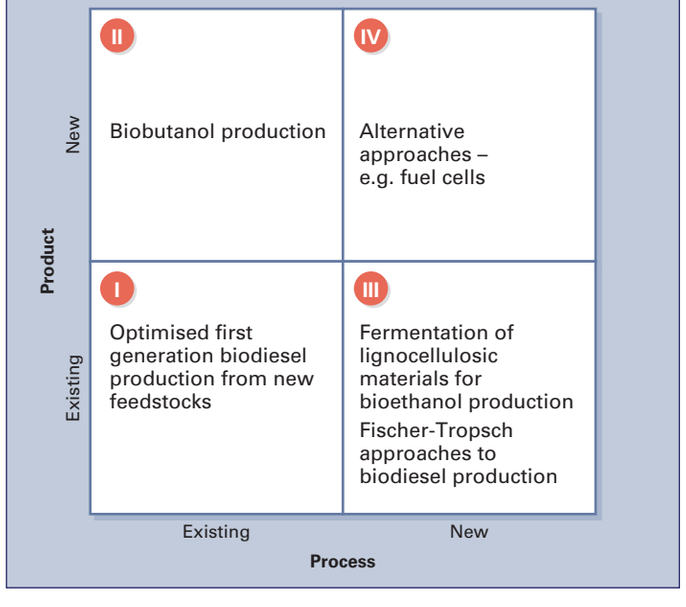
For second-generation technologies to successfully replace incumbents, they must show the clear benefits of improved production volumes, reduced costs and requirements for arable land. Existing processes may also be modified (e.g. through using new feedstocks), and the relative advantage of new production methodologies is not necessarily clear. However, second-generation production methods should also seek to improve the net energy balance of the fuel – the ratio of energy used in production to the energy released on combustion. Biodiesel production by current methods has a net energy balance of 1 to 3.3, indicating a relatively efficient process, whereas bioethanol production from corn requires higher energy inputs, with a ratio of 1 to 1.4, indicating a less efficient

Exhibit 3 **Opportunities for biofuel production**



process with significant potential for improvement. Energy balance considerations have previously discouraged some of the oil majors from investing in biofuels.

A consideration of the alternative opportunities presented by new product and process development in the biofuels field is provided in Exhibit 3, and the four corresponding strategies for investment in biofuels are considered in further detail below.

I. Use new feedstocks in existing production processes

In the UK, the rising cost of feedstocks coupled to a falling oil price has led to the paradoxical situation of biodiesel production falling in advance of the implementation of the Renewable Transport Fuels Obligation RTFO and the legal requirement for 5 percent biofuel inclusion in transport fuels. Prices for food-grade oils such as rapeseed and soya are close to all-time highs, and even with generous government subsidy, biofuel manufacturers are struggling to maintain profitability.

An alternative strategy is to use oils from non-food crops such as *Jatropha*, which give high yields and avoid the cost pressures and competition for land that come with using food-grade oils. D1 Oils is pursuing a programme of *Jatropha* breeding in developing countries to develop this as a sustainable feedstock for first-generation production processes.

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II. Develop new products from existing production processes

Although the production process for biobutanol is well known, it has not yet been exploited commercially for biofuel use. This is an area of active research and development for a number of major corporations, including DuPont and BP (see Case Study 2). Biobutanol production is based on bacterial fermentation of sugars (either derived directly from sugar beet, or from the hydrolysis of starches from corn or wheat). As a fuel, it is considered to have a number of advantages over bioethanol, in that it offers a more improved fuel economy than ethanol/petrol. Biobutanol and bioethanol have similar production routes

and use similar feedstocks, and it is possible to retrofit existing ethanol production capacity for the fermentation of biobutanol. However, biobutanol presents two major drawbacks. Firstly, in most markets it is seen as "untested" whereas bioethanol has been in use in markets such as Brazil for several decades. Secondly, because of its relatively low gelling temperature, biobutanol cannot be used in high concentrations in vehicle fuels, whereas ethanol can be used in 85 percent blends with petrol.

Case Study 2: BP, DuPont and British Sugar

In collaboration with DuPont and British Sugar, BP has developed biobutanol, a fuel additive with a higher energy content than bioethanol. The rationale behind this product is that more energy can be produced from a smaller volume of biofuel, thereby improving the net energy balance when biobutanol is used in vehicle engines.

III. Seek new methods to produce existing products

Existing feedstocks and production methods for bioethanol and biodiesel leave much to be desired. In the case of fermentation for bioethanol production, yields are comparatively low, and feedstocks are generally high-value, whereas biodiesel is produced by an efficient process, but requires expensive feedstocks. Both biofuels are subject to competition with food uses for their key feedstocks. Alternative production processes for alternative feedstocks are already in development for the production of bioethanol and biodiesel.

Incumbent technologies only use a small proportion of the whole crop plant to make biofuels. For example, the existing process for biodiesel manufacture is well optimised, but only uses the seeds of the oil crop, with the remainder being used for animal feed, or for low-value co-products. Second-generation manufacturing processes will need to be able to convert the whole plant to biofuel, or use waste materials, such as those derived from forestry activities.

Bioethanol manufacture has significant scope for future improvement using alternative feedstocks. Yeasts and bac-

teria currently used in bioethanol fermentation can only metabolise starch and hexose sugars, and cannot access the more recalcitrant cellulose polymers that make up wood. Biotechnology is being used to engineer microorganisms capable of fermenting these complex polymers to bioethanol.

Pyrolysis (heating in the absence of oxygen) can also be used to convert wood biomass into synthesis gas (a mixture of hydrogen and carbon monoxide), which can subsequently be converted into biodiesel using the Fischer-Tropsch reaction, although this is not yet used on an industrial scale.

Biofuels bring with them the benefits of compatibility with existing vehicle fleets and fuel distribution networks. The strong political support for biofuels in many markets means that they are potentially attractive propositions for investors.

IV. Seek alternatives to biofuels

Although alternatives to biofuels, including hydrogen power and fuel cells, are in development and offer the potential of reduced carbon emissions and security of fuel supply, these are many years from widespread commercial application. In the meantime, biofuels offer the potential of some improvement in carbon emissions, and a slight improvement in fuel security, and bring with them the benefits of compatibility with existing vehicle fleets and fuel distribution networks. The strong political support for biofuels in many markets means that they are potentially attractive propositions for investors.

Insights for the investor

Notwithstanding the future beyond biofuels, many investors are asking whether or not they should invest in first-generation technologies in the short term, begin investment in second -generation technologies now, or hedge their bets and invest at a later date. There is no single "biofuels market" in which to invest. Markets – determined by geopolitical boundaries – are extremely heterogeneous in terms of political support, feedstocks and commercial activities, but some general principles may well apply.

Politically imposed fiscal incentives are the core drivers of the adoption of biofuels. Without these, biofuels produced using incumbent technologies are not price-competitive with fossil alternatives. Second-generation manufacturing processes are currently under development and have the potential to increase production volumes and reduce costs while diversifying feedstocks, but they remain a long way from market.

Successful investment in bioethanol will undoubtedly require looking to the future. Existing production methods for bioethanol are relatively inefficient and in themselves offer limited potential for carbon reduction. Indeed, some bioethanol manufacturers are actively discussing expensive "carbon capture" technologies to improve the environmental impacts of existing production methods. A more holistic approach to feedstock use would see the fermentation of materials such as straw and wood waste. Using the whole crop would drive up the efficiency of the production process, and reduce reliance on high value-added food-crops. Fermentation of this lignocellulosic material is likely to dominate bioethanol production in the medium term, and technology development in this area is relatively well advanced.

But the competitive position of bioethanol is potentially uncertain. Despite its current leading position in Europe and the USA, biobutanol may pose a significant competitive threat, and this is more than hinted at by the interests of companies such as BP and DuPont. The improved energy content of biobutanol and its greater compatibility with petrol at low concentrations make it a very attractive fuel substitute, yet questions remain over the wider acceptance of biobutanol and its use in high concentrations. Only time will tell if bioethanol has a sustainable first-mover advantage.

The position with biodiesel with respect to first and second-generation production technologies is less clear cut, but potentially more interesting. Current production processes for biodiesel are relatively efficient, and some companies such as D1 Oils and the US-based CTI Biofuels have already developed modular plants that allow outputs to be quickly scaled to market demand with limited up-front capital investment. In the case of D1 Oils, competitive advantage and long-term sustainability of supply may well be achieved through their agronomy programmes to

develop high-yielding, low-cost feedstocks that do not compete with oils for food use.

Existing methods of biodiesel production are relatively straightforward and avoid the need for the high temperature and pressure chemistry of the Fischer-Tropsch process. It is unclear whether second-generation technologies for biodiesel production will deliver significantly improved energy balances when compared to existing methodologies. Second-generation technologies for biodiesel are arguably further from market than those for bioethanol. It is highly likely that, with a greater diversity of feedstocks, existing biodiesel production methods set the barriers to entry for second-generation technologies too high for them to compete effectively.

The international biofuels markets are complex and heterogeneous with respect to products, legislation and production technologies. If political support for these markets continues, prospects for investors are interesting. But any investor must undertake a thorough due diligence of their chosen markets, their chosen biofuel and the technologies used for its production.

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