

World Biofuels Report Ed 1 2011

Market Intelligence

2009 was a hard year for the biofuels sector with low oil prices and reduced demand for transport fuels. Investment was down by just over a third compared to the previous year. Plants were idle or operating at less than capacity. The industry in the EU, US, Malaysia and Indonesia were particularly feeling the effects; both the US and EU were struggling to compete with cheaper fuels from Latin America. The projects that did receive investments mainly used mixed feedstocks and thus could adapt to changing commodity prices and supply shortages. Projects using sugar cane or next generation feedstocks such as jatropha, cellulosics or algae received significant investments.

Petrobras and Amyris made the biggest investments in sugar cane. The former to produce pure and blended fuels for both the domestic and export market, and the latter to create high value products from sugar cane such as farnesene. High value products, rather than biofuels themselves, seemed to drive investment in next generation feedstocks. The three top algae developers in terms of investments have developed a range of high value products derived from algae, and two of the top three cellulosic ethanol producers have disclosed that they are developing other products. These products would provide revenue for developers in the short term before the commercialisation of next generation fuels.

Key investors in next generation biofuel projects are the oil and gas incumbents. The majority of which have covered their bases across all the next generation feedstocks. With the exception of jatropha which has performed poorly in field trials, and subsequently few investments have been made by the industry in it. BP also sold its stake in D1 Oils, a major jatropha developer, last year. A key market for biodiesel producers is likely to be the aviation sector. In 2012 flights entering into and out of the EU have to join the emissions trading scheme. Biofuels are likely to be a part of meeting emissions targets. Other emissions and biofuel blend mandates are planned both compulsory and voluntary. To date eight test flights have been conducted using Biojet derived from petroleum and biomass blends; a further four flights are in the planning stages. Feedstocks used for Biojet include Camelina, algae, jatropha, coconut oil and babassu oil. The military has announced supply investments in biofuels, especially in fuels derived from Camelina.

Brazil is likely to overtake the US and become the biggest ethanol producer again after receiving significant foreign investments last year. The country is also investigating the feasibility of operating biorefineries in countries with duty free trade agreements with the EU and US such as Haiti and El Salvador. Elsewhere in Latin America, Argentina will continue to be strong this year and will continue to export biodiesel to the EU until the implementation of EU sustainability criteria for biofuels. NRG EXPERT feels that the industry is likely to be successful in challenging the EU's criteria for sustainability for 2010 which excludes biodiesel derived from soy beans. Producers of biodiesel from palm oil are likely to use methane capture at their plants to meet the sustainability criteria or will focus on growing domestic demand. Following the implementation of EU anti-dumping legislation on US biodiesel imports, exports of US biodiesel has been down. While there is some evidence that producers are flouting the legislation, this is unlikely to compensate for the legislation. Accusations of the US dumping biodiesel have moved to Australia, where the government may impose emergency anti-dumping rulings in the short term.



Highlights

NRG EXPERT believes that US biodiesel producers will not recover in the short term. US ethanol producers may also be affected by the expiration of subsidies at the end of the year, unless legislation can be passed in time.

Japan will become a growing market for the sector following the expected implementation of new biofuels legislation in the short term. China and India may also become significant biofuel markets.

NRG EXPERT expects the latter part of 2011 and 2012 to be a good year for the sector, with new countries entering the sector on a commercial scale, such as the Philippines, Thailand. The EU market may contact slightly with the removal of subsidies in some key member states, e.g. the Netherlands.

Price - £850

Code - NRGWBR1

*Please note - prices are also available in US Dollars and Euros. Please consult

www.nrgexpert.com.

For further information on these products or future editions please contact us at:

Tel: + 44 (0) 20 8432 6378 Fax: +44 (0) 20 8328 7117 OR info@nrgexpert.com



Table of Contents

| Pub | olished E | Зу | | 2 | |
|------|--|-----------|--|----|--|
| Cop | yright N | lotice | | 2 | |
| Tab | le of Co | ntents | | 3 | |
| List | of Figu | res | | 7 | |
| List | of Table | es | | 11 | |
| 1 | Execu | ıtive Sum | mary | 15 | |
| 2 | Introd | uction | | 17 | |
| 3 | First generation biofuels | | | 21 | |
| | 3.1 | Ethano | ol (Bioethanol) | 21 | |
| | | 3.1.1 | Corn | 22 | |
| | | 3.1.2 | Sugar beet | 23 | |
| | | 3.1.3 | Sugar cane | 23 | |
| | | 3.1.4 | Sorghum | 25 | |
| | 3.2 | Biodies | sel | 26 | |
| | | 3.2.1 | Palm oil | 26 | |
| | | 3.2.2 | Soy beans (Soya; Soya beans) | 28 | |
| | | 3.2.3 | Rapeseed | 28 | |
| 4 | Energ | y Crops | | 31 | |
| | | 4.1.1 | Jatropha | 31 | |
| | | 4.1.2 | Camelina | 35 | |
| | | 4.1.3 | Croton trees | 36 | |
| | | 4.1.4 | Miscanthus (Miscanthus giganteus) | 37 | |
| | | 4.1.5 | Poplar trees | | |
| | | 4.1.6 | Salicornia (Salicornia Bigelovii, Dwarf saltwort, Dwarf glasswort) | | |
| | | 4.1.7 | Switch grass | 38 | |
| 5 | Waste | e vegetab | le oil and tallow | 39 | |
| | | 5.1.1 | Fuel: Biodiesel | | |
| 6 | Cellulosic biofuels (lignocellulosic biofuels) | | | | |
| | 6.1 | Second | d generation | | |
| | | 6.1.1 | Fuel: Ethanol | | |
| 7 | Algae | | | | |
| | 7.1 | | eneration biofuel | | |
| | | 7.1.1 | Fuel: Diesel substitute | | |
| 8 | | | | | |
| 9 | | - | cess | | |
| 10 | | | Impact | | |
| 11 | | | el debate | | |
| 12 | Market | | | | |
| | 12.1 Financials | | | | |
| | 12.2 | - | nies | | |
| | 12.3 Petroleum transport fuels | | | | |
| 13 | | • | ion | | |
| 14 | • | | | | |
| | 14.1 | EU Bio | fuels Directive | 85 | |



| | 14.2 | Renewable Energy Directive | 87 |
|----|--------|---|-----|
| | 14.3 | REACH | 90 |
| | 14.4 | Import and export regulations | 91 |
| | 14.5 | Biofuel production | 93 |
| | | 14.5.1 Biodiesel | 93 |
| | 14.6 | Ethanol | 98 |
| | 14.7 | Biofuel consumption | 108 |
| | 14.8 | Next generation biofuels | 109 |
| | 14.9 | Job creation | 110 |
| | 14.10 | Factors affecting the market | 111 |
| | 14.11 | EU competitiveness | 113 |
| 15 | Europe | ean countries | 114 |
| | 15.1 | Austria | 114 |
| | 15.2 | Belgium | 114 |
| | 15.3 | Bulgaria | 115 |
| | 15.4 | Denmark | 116 |
| | 15.5 | Estonia | 117 |
| | 15.6 | Finland | 117 |
| | 15.7 | France | 117 |
| | 15.8 | Germany | 118 |
| | 15.9 | Ireland | 124 |
| | 15.10 | Latvia | 125 |
| | 15.11 | Luxembourg | 125 |
| | 15.12 | Netherlands | 126 |
| | 15.13 | Norway | 126 |
| | 15.14 | Poland | 126 |
| | 15.15 | Portugal | 127 |
| | 15.16 | Romania | 127 |
| | 15.17 | Spain | 127 |
| | 15.18 | Sweden | 131 |
| | 15.19 | Switzerland | 134 |
| | 15.20 | Turkey | 136 |
| | 15.21 | UK | 137 |
| 16 | USA | | 138 |
| | 16.1 | Incentives | 138 |
| | 16.2 | Renewable Fuel Standard | 139 |
| | 16.3 | Food, Conservation, and Energy Act of 2008 (Farm Bill 2008) | 142 |
| | 16.4 | State legislation | 142 |
| | 16.5 | Biofuel imports and exports | 144 |
| | 16.6 | Market | 145 |
| | 16.7 | Next generation biofuels | 156 |
| | 16.8 | Economic downturn | 161 |
| | 16.9 | Animal feed | 162 |
| | 16.10 | Biodiesel | 163 |
| 17 | Brazil | | 171 |
| | 17.1 | Sugar production | 172 |



| | 17.2 | Sugar ca | ane production | 173 |
|----|---------------|------------------------------|----------------|-----|
| | 17.3 | Ethanol | plants | 173 |
| | 17.4 | Ethanol | | 176 |
| | 17.5 | Blending | g mandates | 179 |
| | 17.6 | Export n | narket | 179 |
| | 17.7 | Biodiese | ıl | 181 |
| | 17.8 | Investme | ent | 183 |
| | 17.9 | Foreign | Investment | 185 |
| 18 | Latin America | | | 186 |
| | 18.1 | Argentin | a | 186 |
| | 18.2 | Colombi | a | 191 |
| | 18.3 | Hondura | ıs | 192 |
| | 18.4 | Paragua | y | 194 |
| | 18.5 | Peru | | 195 |
| | 18.6 | Uruguay | , | 195 |
| 19 | North A | America | | 198 |
| | 19.1 | Canada | | 198 |
| | 19.2 | Biodiese | ıl | 204 |
| | 19.3 | Ethanol | | 204 |
| | 19.4 | Mexico. | | 205 |
| 20 | Ocean | ia | | 208 |
| | 20.1 | Australia | 1 | 208 |
| | 20.2 | 20.2 New Zealand21 | | |
| 21 | ASIA | | | |
| | 21.1 | China | | 222 |
| | 21.2 | Chinese | Taiwan | 226 |
| | 21.3 | India | | 226 |
| | 21.4 | Indones | a | 231 |
| | 21.5 | Japan | | 234 |
| | 21.6 | Korea, S | South | 236 |
| | 21.7 | Malaysia | a | 236 |
| | 21.8 | Pakistar | 1 | 238 |
| | 21.9 | Thailand | l | 239 |
| | 21.10 | The Phil | ippines | 248 |
| | 21.11 | Vietnam | | 251 |
| 22 | Russia | Russia and the CIS countries | | |
| | 22.1 | Russia | | 252 |
| | 22.2 | Ukraine | | 252 |
| | 22.3 | Other co | ountries | 253 |
| 23 | Africa | | | 254 |
| | 23.1 | South A | frica | 254 |
| | 23.2 | Sudan | | 255 |
| | 23.3 | Other co | ountries | 255 |
| | | 23.3.1 | Kenya | 255 |
| | | 23.3.2 | Mozambique | 255 |
| | | 23.3.3 | Tanzania | 255 |



| 24 | Aviation | on sector | 256 |
|----|----------|--------------------------------------|-----|
| | 24.1 | Carbon emissions | 256 |
| | 24.2 | Bio-jet fuels | 257 |
| | | Air force and the military | |
| 25 | | Gas Involvement | |
| 26 | Biofue | el targets, subsidies and incentives | 279 |
| 27 | Conve | ersion units | 297 |
| 28 | Ackno | owledgements | 298 |



List of Figures

| Figure 2.1. | Development of biofuels |
|----------------------------|---|
| Figure 2.2. | Products from biofuel feedstocks |
| Figure 3.1. | World corn price projections, US \$ per tonne |
| Figure 3.2. | World sugar price projections, US \$ per tonne |
| Figure 3.3. | Fuel yield for biofuel feedstocks, gasoline equivalent, gallons per acre |
| Figure 3.4. | World vegetable oil prices, US \$ per tonne |
| Figure 3.5. | World oil seed prices, US \$ per tonne |
| Figure 4.1. | Jatropha curcas |
| Figure 4.2. | Scale of jatropha projects (hectares) and number of projects, 2008 and 2015 |
| Figure 4.3. | Camelina* |
| Figure 4.4. | Salicornia (Salicornia Bigelovi) |
| Figure 6.1. | Breakdown of operating costs for a cellulosic plant using enzyme pre-treatment |
| Figure 6.2. | Status of cellulosic ethanol plants as of February 2010 |
| Figure 6.3. | Adjusted feedstock potential for cellulosic feedstocks |
| Figure 6.4. litres | Planned development of cellulosic ethanol capacity by the top ten developers, million |
| Figure 7.1. | Microalgae and macroalgae. Microalgae (left) Macroalgae (right) |
| Figure 8.1. | Role of biotechnology in biofuel production |
| Figure 9.1. | Levelised cost of energy for transport fuels, US \$ per litre |
| Figure 9.2. | Conversion pathways to produce biofuels |
| Figure 10.1. | Greenhouse gas savings of biofuels by feedstock and country of origin, % - Biodiesel |
| Figure 10.2. and Biogas | Greenhouse gas savings of biofuels by feedstock and country of origin, % - Ethanol |
| Figure 10.3. | Future research challenges for assessing the environmental impacts of biofuels |
| Figure 10.4. | Global average water footprint for ethanol feedstocks, m³/GJ |
| Figure 10.5. | Global average water footprint for biodiesel feedstocks, m³/GJ |
| Figure 12.1. | New investment by technology, 2009, US \$billion |
| Figure 12.2. | Global Asset Financing (GAF), US \$ million, Q1 2009 – Q2 2010 |
| Figure 12.3. | Global Asset Financing (GAF) per biofuel project, US \$ million, Q1 2009 – Q2 2010 |
| Figure 12.4. | Biofuels New Build Asset Investment Waves, US \$ billion |
| Figure 12.5. | Investments in terms of feedstocks, US \$ million, 2009 |
| Figure 12.6. | VC/PE investments in biofuels, US \$ million, Q1 2009 – Q2 2010 |
| Figure 12.7. | Average VC/PE investments in biofuels per deal, US \$ million, Q1 2009 – Q2 2010 |
| Figure 12.8. | Top ten companies in 2009 in terms of investments, US \$ million |



| Figure 12.9. 2008, US \$ billi | Corporate and government R&D investment by technology, 2009, and total growth on on |
|-----------------------------------|--|
| Figure 12.10. | Average crude oil import costs, US \$/barrel* |
| Figure 12.11. | Short term oil price forecast, West Texas Spot price, US\$ per barrel |
| Figure 12.12. | DOE EIA World oil price projections, US \$ per barrel |
| Figure 14.1. | Biofuel chain and supply measures in the EU |
| Figure 14.2. | Proportion of biofuel meeting sustainability standards |
| Figure 14.3. | Idle and used biodiesel capacity in the EU, million litres |
| Figure 14.4. | Average installed capacity of biodiesel plants in the EU, million litres |
| Figure 14.5. | Biodiesel production in the top six EU countries, million litres |
| Figure 14.6. 2011 (right) | Market share of biodiesel production in the top six EU countries, %, 2009 (left) and |
| Figure 14.7. | Feedstock used for biodiesel production, thousand tonnes |
| Figure 14.8. | Idle and used ethanol capacity in the EU, million litres |
| Figure 14.9. | Average installed capacity of ethanol plants in the EU, million litres |
| Figure 14.10. | Ethanol production in the top six EU countries, million litres |
| Figure 14.11. 2011 (right) | Market share of ethanol production in the top six EU countries, %, 2009 (left) and |
| Figure 14.12. | Balance of ethanol trade, net exporters +and net importers -, million litres |
| Figure 14.13. | Feedstock used for ethanol production, thousand tonnes |
| Figure 14.14. | Fate of ethanol produced in the EU, million litres |
| Figure 14.15. | Imports of biofuels into the EU, million litres |
| Figure 14.16. | Production of DDGS during ethanol production in the EU, thousand tonnes |
| Figure 14.17. | Consumption of biofuels in the EU, 2006 - 2011 |
| Figure 14.18. | Biodiesel consumption in the EU, 2009 - 2011, million litres |
| Figure 14.19. | Ethanol consumption in the EU, 2009 - 2011, million litres |
| Figure 15.1. | Projections on the production of biodiesel and ethanol in Bulgaria, 2008 – 2020 |
| Figure 15.2. many, gCO2eq | Standard greenhouse gas emissions for biofuels, established by the UFOP in Gerper MJ, $\%$ |
| Figure 15.3. | Ethanol market in Sweden, thousand litres |
| Figure 15.4. | Biodiesel market in Sweden, thousand litres |
| Figure 15.5. | Quantity of feedstock used in biofuel production in Sweden, thousand tonnes |
| Figure 15.6. | Biodiesel consumption in Switzerland, million litres |
| Figure 15.7. | Ethanol consumption in Switzerland, million litres |
| Figure 16.1. | Renewable fuel volume obligation as established in the RFS program, billion litres |
| Figure 16.2. | Blending mandates in the US, launch dates |
| Figure 16.3. | Historical US ethanol imports, million litres |



| Figure 16.4. | Growth of the ethanol industry in the US, billion litres |
|-------------------------------|---|
| Figure 16.5. | Average production capacity of ethanol plants in operation in the US, million litres |
| Figure 16.6. | Top ten states for ethanol production, million litres |
| Figure 16.7. | US Ethanol biorefinery locations |
| Figure 16.8. | Top ten ethanol producers in terms of installed capacity, million litres |
| Figure 16.9. million | Breakdown of funding for advanced biorefinery projects, December 2009, US \$ |
| Figure 16.10. | Fate of corn harvested for ethanol production in the USA, 2009 |
| Figure 16.11. the US, % | Breakdown of feedstocks for biodiesel plants in operation and under construction in |
| Figure 16.12. | Breakdown of biodiesel production costs |
| Figure 16.13. | Top ten biodiesel manufacturers in the US, million litres |
| Figure 16.14. | Production and consumption of biodiesel in the US, million litres |
| Figure 17.1. | Sugar producing regions and ethanol plants in Brazil |
| Figure 17.2. | Sugar cane and sugar production in Brazil for each crop harvest, million tonnes |
| Figure 17.3. | Balance of cane products and by-products, 1,000 kg of planted cane |
| Figure 17.4. | Ethanol production in Brazil for each crop harvest, million litres |
| Figure 17.5. | Average price of Brazilian ethanol exports, US \$ per litre |
| Figure 18.1. installed capaci | Anticipated fate of biodiesel produced by the ten largest biodiesel producers by ty, million litres, 2010 |
| Figure 18.2. | Map showing biofuel production and blending terminal locations in Argentina |
| Figure 18.3. government, mi | Supply commitments for ethanol producers for the Argentinan market from the illion litres, 2010 |
| Figure 18.4. government, mi | Supply commitments for biodiesel producers for the Argentinan market from the illion litres, 2010 |
| Figure 18.5. | Fate of palm oil produced in Honduras, tonnes |
| Figure 18.6. | Development of the biofuel market in Paraguay, million litres |
| Figure 18.7. | Quantity of feedstock used in biofuel production in Uruguay, tonnes |
| Figure 19.1. | Ethanol and biodiesel plants in Canadian provinces, million litres |
| Figure 19.2. | Feedstocks used by Canadian biofuel plants, million litres |
| Figure 19.3. | Map of potential areas for biofuel feedstock cultivation in Mexico |
| Figure 20.1. | Ethanol production capacity in operation in Australia, million litres |
| Figure 20.2. | Biodiesel production capacity in operation in Australia, million litres |
| Figure 20.3. | Breakdown of biodiesel sold on the Australian market, million litres |
| Figure 21.1. | Fuel ethanol plants in China |
| Figure 21.2. | Sugar cane feedstocks in India, thousand tonnes |
| Figure 21.3. | Production and consumption of ethanol in India, 2006 – 2011, million litres |
| Figure 21.4. | Breakdown of fate of biodiesel produced by manufacturers in Indonesia, million litres |



| Figure 21.5. | Map of installed ethanol plants in Indonesia |
|--------------------------------|--|
| Figure 21.6. | Map of installed biodiesel plants in Indonesia |
| Figure 21.7. | Annual and forecast of crude palm oil production in Malaysia, million tonnes |
| Figure 21.8. | Main feedstock used to produce ethanol in Thailand, thousand litres per day |
| Figure 21.9. litres per day | Anticipated production of ethanol from cassava and molasses in Thailand, million |
| Figure 21.10. | Prices of ethanol blends and gasoline in Thailand, 2005 – 2009, THB per litre |
| Figure 21.11. | Prices of biodiesel blends and gasoline in Thailand, 2005 – 2009, THB per litre |
| Figure 21.12. | Feedstocks used in biodiesel plants in Thailand |
| Figure 21.13. | Projections on domestic demand for biodiesel in Thailand, million litres |
| Figure 21.14. | Breakdown of manufacturers of biodiesel in Thailand, thousand litres per day |
| Figure 21.15. | Projections of idle and operating ethanol capacity in the Philippines, million litres |
| Figure 21.16. | Projections of ethanol production and imports in the Philippines, million litres |
| Figure 21.17. | Projections of biodiesel production and consumption in the Philippines, million litres |
| Figure 24.1. | Timeline of proposed legislation and voluntary targets for the aviation sector |
| Figure 24.2. | Aviation fuel demand and supply scenarios |
| Figure 24.3. | CAAFI R&D roadmap for biofuel feedstocks |



List of Tables

| Table 2.1. | Production processes for first generation biofuels |
|-----------------------------|---|
| Table 3.1. | Advantages and disadvantages of ethanol compared to gasoline |
| Table 3.2. | Yields of ethanol per feedstock |
| Table 3.3. | Monthly prices for corn, US \$ per tonne |
| Table 3.4. | Products from sugar cane production |
| Table 3.5. | Monthly sugar prices, US \$ cents per pound |
| Table 3.6. | Advantages and disadvantages of biodiesel compared to petroleum diesel |
| Table 3.7. | Monthly prices for feedstocks for the production of biodiesel, US \$ per tonne |
| Table 4.1. | By-products from jatropha |
| Table 4.2. | The advantages and disadvantages of jatropha |
| Table 4.3. | Key companies involved in jatropha projects |
| Table 4.4. | Main developers of biodiesel from Camelina |
| Table 6.1. | Cellulosic waste materials of food crops |
| Table 6.2. | Top cellulosic ethanol manufacturers in terms of installed capacity in 2009 |
| Table 6.3. generation biofu | The advantages and disadvantages of cellulosic ethanol as an alternative to first- uels feedstocks on the market |
| Table 7.1. | The biodiesel yield per acre for different feedstocks |
| Table 7.2. | Production capacity for algae biofuel developers, million litres, 2010 and 2012 |
| Table 7.3. | Products derived from algae |
| Table 7.4. biofuels feedsto | The advantages and disadvantages of algae as an alternative to first-generation ocks on the market |
| Table 9.1. | Description of Conversion Pathway |
| Table 10.1. | Emissions Lifecycle for each Feedstock |
| Table 10.2. | How green are biofuels? |
| Table 12.1. | Business model of the top ten biofuel companies in terms of investments last year |
| Table 12.2. | Estimates of subsidies for different energy sources |
| Table 12.3. | Transport fuel prices and taxes per litre, June 2010 |
| Table 12.4. | Transport fuel prices, May 2010, US dollars per litre |
| Table 12.5. | Relationships between crude oil, gasoline, ethanol and break-even corn prices |
| Table 12.6. | Average oil price projections, US \$ per barrel |
| Table 13.1. | Biodiesel production, million litres |
| Table 13.2. | Ethanol production, million litres |
| Table 13.3. | Biodiesel projections |
| Table 13.4. | Bioethanol projections |
| Table 14.1. | Energy content of marginal transport fuel – pure and blends, MJ/litre |
| Table 14.2. | Energy content of marginal transport fuel blends, MJ/litre |



| Table 14.3. use | EU Member States goals for the use of biofuels as transportation fuel, % of total fuel |
|------------------------|--|
| Table 14.4. | Road transportation fuels consumption in the EU, 2006 – 2011, ktoe |
| Table 14.5. | Renewable Energy Directive targets |
| Table 14.6. mission | Greenhouse gas emissions for biofuel feedstocks according to the European Com- |
| Table 14.7. | Milestones for the biofuel industry in the EU |
| Table 14.8. | REACH costs |
| Table 14.9. | Development of biodiesel plants in the EU, thousand litres |
| Table 14.10. | EU 2008 and 2009 biodiesel capacity estimates |
| Table 14.11. | Production capacity of the main biodiesel producers in Europe |
| Table 14.12. | Development of ethanol plants in the EU, million litres |
| Table 14.13. | Production capacity of the main ethanol producers, 2010 |
| Table 14.14. | Ethanol plants in the EU, million litres, March 2010 |
| Table 14.15. | Advanced biofuel plants in the EU |
| Table 14.16. | Jobs created by the sector in key European countries |
| Table 15.1. | Fuel Taxes |
| Table 15.2. | Breakdown of transport fuels in Bulgaria |
| Table 15.3. | Quota for Biodesel and Bioethanol from 2003-2010 |
| Table 15.4. | Quotas and taxes for biofuels in Germany |
| Table 15.5. | Tax exemptions in € per litre of biofuels |
| Table 15.6. | Land use criteria for sustainable biofuels in Germany |
| Table 15.7. | Energy tax on pure biodiesels, € per litre |
| Table 15.8. | Consumption of biofuels in Germany, thousand tonnes |
| Table 15.9. | Average price at the filling station for biodiesel and diesel in Germany, June 2010 |
| Table 15.10. | Biodiesel plants in operation in Germany, end 2009 |
| Table 15.11. | Incentives for Irish farmers producing energy crops |
| Table 15.12. | Financial support for production facilities |
| Table 15.13. | Albengoa Bioenergy global presence |
| Table 15.14. | Biodiesel plants in operation, under construction and planned in Spain |
| Table 15.15. | Ethanol plants in Spain, excluding Abengoa's plants |
| Table 15.16. | Ethanol plants in Sweden |
| Table 15.17. | Biodiesel plants in Sweden |
| Table 15.18. | Planned biodiesel projects in Switzerland, million litres |
| Table 16.1. | History of ethanol subsidy legislation in the US |
| Table 16.2. | State fuel taxes |
| Table 16.3. | Biofuel blends and car manufacturing compatibility in the US |
| Table 16.4. | Ethanol plants in the USA, July 2010 |
| Table 16.5. | Business structure of the top 5 ethanol producers in the US |
| | |



| Table 16.6. | US cellulosic ethanol projects under development and construction |
|-----------------------------|---|
| Table 16.7. December 200 | Awardees of US Department of Energy and Department of Agriculture funding, 9 |
| Table 16.8. | Valero Renewables' ethanol plants |
| Table 16.9. stocks | DDGS produced for a 20 million gallon (91 million litres) plant using different feed- |
| Table 16.10. | Business models for the top five biodiesel producers in the US |
| Table 16.11. | Biodiesel plants in the USA, July 2010 |
| Table 17.1. | Production costs for ethanol in the USA, Germany and Brazil, € per 1,000 litres |
| Table 17.2. | Installed biofuel capacity and targets in Brazil |
| Table 17.3. | Top ten sugar cane facilities in Sao Paulo State for the 2008/2009 harvest |
| Table 17.4. | Key Companies using SCA Brazil Ethanol brokerage |
| Table 17.5. | Biodiesel plants in operation in Brazil |
| Table 17.6. | Investment in renewable energies |
| Table 17.7. | Ethanol plants owned by Cosan in Brazil |
| Table 18.1. | Argentina Renovables' list of biodiesel plants in operation, large scale |
| Table 18.2. | Ethanol plants in operation in Colombia |
| Table 18.3. | Biodiesel plants in operation in Colombia |
| Table 18.4. | Top five biodiesel plants in operation in Honduras |
| Table 19.1. | Blending mandates in Canadian provinces, target dates |
| Table 19.2. | Incentives for biofuels in Canadian provinces |
| Table 19.3. | Federal programmes to promote a domestic renewable fuels industry in Canada |
| Table 19.4. | Ethanol plants in operation or under construction in Canada |
| Table 19.5. | Biodiesel plants in operation or under construction in Canada |
| Table 19.6. | Tax exemptions for E10 by Canadian province |
| Table 19.7. | Ethanol pilot project in Mexico |
| Table 20.1. | Biodiesel plants in Australia, January 2010 |
| Table 20.2. | Ethanol plants in operation in Australia, January 2010 |
| Table 20.3. | Biofuels Excise Rates for Australia |
| Table 20.4. | Effective fuel tax rates for alternative fuels in Australia |
| Table 20.5. | Blending mandates in Australia, target dates |
| Table 20.6. Australia | Second generation Biofuels Research and Development Programme projects in |
| Table 20.7. | Leading biofuel players in New Zealand, as of August 2009 |
| Table 21.1. | China investment in renewable energy markets |
| Table 21.2. | Ethanol plants in operation in China, million litres |
| Table 21.3. | Cities with the E10 blend mandate in China |
| Table 21.4. | Cost analysis of using different feedstocks for ethanol using 2006 prices in China |
| Table 21.5. | Major biodiesel facilities in China |



| Table 21.6. | Project financing for biofuel projects in India |
|--------------------------------|--|
| Table 21.7. | Blending mandate for biodiesel in Indonesia |
| Table 21.8. | Blending mandate for ethanol in Indonesia |
| Table 21.9. | Biodiesel projects in operation in Malaysia |
| Table 21.10. litres per day | Fifteen year Renewable Energy Development Plans for biofuels in Thailand, million |
| Table 21.11. | Ethanol plants in Thailand, March 2010 |
| Table 21.12. | Breakdown of retail prices for B2 and B5 biodiesel in Thailand as of May 2010 |
| Table 21.13. | Biodiesel plants in operation in Thailand, March 2010 |
| Table 21.14. | Comparison different feedstocks for ethanol in the Philippines |
| Table 24.1. | Aviation ground rules for 2nd and 3rd generation biomass fuelling |
| Table 24.2. | US military supply contracts for biofuels |
| Table 24.3. | Biofuel manufacturers with contracts to develop or supply fuel for the aviation sector |
| Table 25.1. | Oil and gas company investments in biofuels |
| Table 26.1. | Biofuel targets, subsidies and incentives for biofuels for EU member states |
| Table 26.2. | Biofuel targets, subsidies and incentives outside the EU |
| | |



Table of Contents

| Pub | olished E | Зу | | 2 | |
|------|--|-----------|--|----|--|
| Cop | yright N | lotice | | 2 | |
| Tab | le of Co | ntents | | 3 | |
| List | of Figu | res | | 7 | |
| List | of Table | es | | 11 | |
| 1 | Execu | ıtive Sum | mary | 15 | |
| 2 | Introd | uction | | 17 | |
| 3 | First generation biofuels | | | 21 | |
| | 3.1 | Ethano | ol (Bioethanol) | 21 | |
| | | 3.1.1 | Corn | 22 | |
| | | 3.1.2 | Sugar beet | 23 | |
| | | 3.1.3 | Sugar cane | 23 | |
| | | 3.1.4 | Sorghum | 25 | |
| | 3.2 | Biodies | sel | 26 | |
| | | 3.2.1 | Palm oil | 26 | |
| | | 3.2.2 | Soy beans (Soya; Soya beans) | 28 | |
| | | 3.2.3 | Rapeseed | 28 | |
| 4 | Energ | y Crops | | 31 | |
| | | 4.1.1 | Jatropha | 31 | |
| | | 4.1.2 | Camelina | 35 | |
| | | 4.1.3 | Croton trees | 36 | |
| | | 4.1.4 | Miscanthus (Miscanthus giganteus) | 37 | |
| | | 4.1.5 | Poplar trees | | |
| | | 4.1.6 | Salicornia (Salicornia Bigelovii, Dwarf saltwort, Dwarf glasswort) | | |
| | | 4.1.7 | Switch grass | 38 | |
| 5 | Waste | e vegetab | le oil and tallow | 39 | |
| | | 5.1.1 | Fuel: Biodiesel | | |
| 6 | Cellulosic biofuels (lignocellulosic biofuels) | | | | |
| | 6.1 | Second | d generation | | |
| | | 6.1.1 | Fuel: Ethanol | | |
| 7 | Algae | | | | |
| | 7.1 | | eneration biofuel | | |
| | | 7.1.1 | Fuel: Diesel substitute | | |
| 8 | | | | | |
| 9 | | - | cess | | |
| 10 | | | Impact | | |
| 11 | | | el debate | | |
| 12 | Market | | | | |
| | 12.1 Financials | | | | |
| | 12.2 | - | nies | | |
| | 12.3 Petroleum transport fuels | | | | |
| 13 | | • | ion | | |
| 14 | • | | | | |
| | 14.1 | EU Bio | fuels Directive | 85 | |



| | 14.2 | Renewable Energy Directive | 87 |
|----|--------|---|-----|
| | 14.3 | REACH | 90 |
| | 14.4 | Import and export regulations | 91 |
| | 14.5 | Biofuel production | 93 |
| | | 14.5.1 Biodiesel | 93 |
| | 14.6 | Ethanol | 98 |
| | 14.7 | Biofuel consumption | 108 |
| | 14.8 | Next generation biofuels | 109 |
| | 14.9 | Job creation | 110 |
| | 14.10 | Factors affecting the market | 111 |
| | 14.11 | EU competitiveness | 113 |
| 15 | Europe | ean countries | 114 |
| | 15.1 | Austria | 114 |
| | 15.2 | Belgium | 114 |
| | 15.3 | Bulgaria | 115 |
| | 15.4 | Denmark | 116 |
| | 15.5 | Estonia | 117 |
| | 15.6 | Finland | 117 |
| | 15.7 | France | 117 |
| | 15.8 | Germany | 118 |
| | 15.9 | Ireland | 124 |
| | 15.10 | Latvia | 125 |
| | 15.11 | Luxembourg | 125 |
| | 15.12 | Netherlands | 126 |
| | 15.13 | Norway | 126 |
| | 15.14 | Poland | 126 |
| | 15.15 | Portugal | 127 |
| | 15.16 | Romania | 127 |
| | 15.17 | Spain | 127 |
| | 15.18 | Sweden | 131 |
| | 15.19 | Switzerland | 134 |
| | 15.20 | Turkey | 136 |
| | 15.21 | UK | 137 |
| 16 | USA | | 138 |
| | 16.1 | Incentives | 138 |
| | 16.2 | Renewable Fuel Standard | 139 |
| | 16.3 | Food, Conservation, and Energy Act of 2008 (Farm Bill 2008) | 142 |
| | 16.4 | State legislation | 142 |
| | 16.5 | Biofuel imports and exports | 144 |
| | 16.6 | Market | 145 |
| | 16.7 | Next generation biofuels | 156 |
| | 16.8 | Economic downturn | 161 |
| | 16.9 | Animal feed | 162 |
| | 16.10 | Biodiesel | 163 |
| 17 | Brazil | | 171 |
| | 17.1 | Sugar production | 172 |



| | 17.2 | Sugar ca | ane production | 173 |
|----|---------------|------------------------------|----------------|-----|
| | 17.3 | Ethanol | plants | 173 |
| | 17.4 | Ethanol | | 176 |
| | 17.5 | Blending | g mandates | 179 |
| | 17.6 | Export n | narket | 179 |
| | 17.7 | Biodiese | ıl | 181 |
| | 17.8 | Investme | ent | 183 |
| | 17.9 | Foreign | Investment | 185 |
| 18 | Latin America | | | 186 |
| | 18.1 | Argentin | a | 186 |
| | 18.2 | Colombi | a | 191 |
| | 18.3 | Hondura | ıs | 192 |
| | 18.4 | Paragua | y | 194 |
| | 18.5 | Peru | | 195 |
| | 18.6 | Uruguay | , | 195 |
| 19 | North A | America | | 198 |
| | 19.1 | Canada | | 198 |
| | 19.2 | Biodiese | ıl | 204 |
| | 19.3 | Ethanol | | 204 |
| | 19.4 | Mexico. | | 205 |
| 20 | Ocean | ia | | 208 |
| | 20.1 | Australia | 1 | 208 |
| | 20.2 | 20.2 New Zealand21 | | |
| 21 | ASIA | | | |
| | 21.1 | China | | 222 |
| | 21.2 | Chinese | Taiwan | 226 |
| | 21.3 | India | | 226 |
| | 21.4 | Indones | a | 231 |
| | 21.5 | Japan | | 234 |
| | 21.6 | Korea, S | South | 236 |
| | 21.7 | Malaysia | a | 236 |
| | 21.8 | Pakistar | 1 | 238 |
| | 21.9 | Thailand | l | 239 |
| | 21.10 | The Phil | ippines | 248 |
| | 21.11 | Vietnam | | 251 |
| 22 | Russia | Russia and the CIS countries | | |
| | 22.1 | Russia | | 252 |
| | 22.2 | Ukraine | | 252 |
| | 22.3 | Other co | ountries | 253 |
| 23 | Africa | | | 254 |
| | 23.1 | South A | frica | 254 |
| | 23.2 | Sudan | | 255 |
| | 23.3 | Other co | ountries | 255 |
| | | 23.3.1 | Kenya | 255 |
| | | 23.3.2 | Mozambique | 255 |
| | | 23.3.3 | Tanzania | 255 |



| 24 | Aviation | on sector | 256 |
|----|----------|--------------------------------------|-----|
| | 24.1 | Carbon emissions | 256 |
| | 24.2 | Bio-jet fuels | 257 |
| | | Air force and the military | |
| 25 | | Gas Involvement | |
| 26 | Biofue | el targets, subsidies and incentives | 279 |
| 27 | Conve | ersion units | 297 |
| 28 | Ackno | owledgements | 298 |



List of Figures

| Figure 2.1. | Development of biofuels |
|----------------------------|---|
| Figure 2.2. | Products from biofuel feedstocks |
| Figure 3.1. | World corn price projections, US \$ per tonne |
| Figure 3.2. | World sugar price projections, US \$ per tonne |
| Figure 3.3. | Fuel yield for biofuel feedstocks, gasoline equivalent, gallons per acre |
| Figure 3.4. | World vegetable oil prices, US \$ per tonne |
| Figure 3.5. | World oil seed prices, US \$ per tonne |
| Figure 4.1. | Jatropha curcas |
| Figure 4.2. | Scale of jatropha projects (hectares) and number of projects, 2008 and 2015 |
| Figure 4.3. | Camelina* |
| Figure 4.4. | Salicornia (Salicornia Bigelovi) |
| Figure 6.1. | Breakdown of operating costs for a cellulosic plant using enzyme pre-treatment |
| Figure 6.2. | Status of cellulosic ethanol plants as of February 2010 |
| Figure 6.3. | Adjusted feedstock potential for cellulosic feedstocks |
| Figure 6.4. litres | Planned development of cellulosic ethanol capacity by the top ten developers, million |
| Figure 7.1. | Microalgae and macroalgae. Microalgae (left) Macroalgae (right) |
| Figure 8.1. | Role of biotechnology in biofuel production |
| Figure 9.1. | Levelised cost of energy for transport fuels, US \$ per litre |
| Figure 9.2. | Conversion pathways to produce biofuels |
| Figure 10.1. | Greenhouse gas savings of biofuels by feedstock and country of origin, % - Biodiesel |
| Figure 10.2. and Biogas | Greenhouse gas savings of biofuels by feedstock and country of origin, % - Ethanol |
| Figure 10.3. | Future research challenges for assessing the environmental impacts of biofuels |
| Figure 10.4. | Global average water footprint for ethanol feedstocks, m³/GJ |
| Figure 10.5. | Global average water footprint for biodiesel feedstocks, m³/GJ |
| Figure 12.1. | New investment by technology, 2009, US \$billion |
| Figure 12.2. | Global Asset Financing (GAF), US \$ million, Q1 2009 – Q2 2010 |
| Figure 12.3. | Global Asset Financing (GAF) per biofuel project, US \$ million, Q1 2009 – Q2 2010 |
| Figure 12.4. | Biofuels New Build Asset Investment Waves, US \$ billion |
| Figure 12.5. | Investments in terms of feedstocks, US \$ million, 2009 |
| Figure 12.6. | VC/PE investments in biofuels, US \$ million, Q1 2009 – Q2 2010 |
| Figure 12.7. | Average VC/PE investments in biofuels per deal, US \$ million, Q1 2009 – Q2 2010 |
| Figure 12.8. | Top ten companies in 2009 in terms of investments, US \$ million |



| Figure 12.9. 2008, US \$ billi | Corporate and government R&D investment by technology, 2009, and total growth on on |
|-----------------------------------|--|
| Figure 12.10. | Average crude oil import costs, US \$/barrel* |
| Figure 12.11. | Short term oil price forecast, West Texas Spot price, US\$ per barrel |
| Figure 12.12. | DOE EIA World oil price projections, US \$ per barrel |
| Figure 14.1. | Biofuel chain and supply measures in the EU |
| Figure 14.2. | Proportion of biofuel meeting sustainability standards |
| Figure 14.3. | Idle and used biodiesel capacity in the EU, million litres |
| Figure 14.4. | Average installed capacity of biodiesel plants in the EU, million litres |
| Figure 14.5. | Biodiesel production in the top six EU countries, million litres |
| Figure 14.6. 2011 (right) | Market share of biodiesel production in the top six EU countries, %, 2009 (left) and |
| Figure 14.7. | Feedstock used for biodiesel production, thousand tonnes |
| Figure 14.8. | Idle and used ethanol capacity in the EU, million litres |
| Figure 14.9. | Average installed capacity of ethanol plants in the EU, million litres |
| Figure 14.10. | Ethanol production in the top six EU countries, million litres |
| Figure 14.11. 2011 (right) | Market share of ethanol production in the top six EU countries, %, 2009 (left) and |
| Figure 14.12. | Balance of ethanol trade, net exporters +and net importers -, million litres |
| Figure 14.13. | Feedstock used for ethanol production, thousand tonnes |
| Figure 14.14. | Fate of ethanol produced in the EU, million litres |
| Figure 14.15. | Imports of biofuels into the EU, million litres |
| Figure 14.16. | Production of DDGS during ethanol production in the EU, thousand tonnes |
| Figure 14.17. | Consumption of biofuels in the EU, 2006 - 2011 |
| Figure 14.18. | Biodiesel consumption in the EU, 2009 - 2011, million litres |
| Figure 14.19. | Ethanol consumption in the EU, 2009 - 2011, million litres |
| Figure 15.1. | Projections on the production of biodiesel and ethanol in Bulgaria, 2008 – 2020 |
| Figure 15.2. many, gCO2eq | Standard greenhouse gas emissions for biofuels, established by the UFOP in Gerper MJ, $\%$ |
| Figure 15.3. | Ethanol market in Sweden, thousand litres |
| Figure 15.4. | Biodiesel market in Sweden, thousand litres |
| Figure 15.5. | Quantity of feedstock used in biofuel production in Sweden, thousand tonnes |
| Figure 15.6. | Biodiesel consumption in Switzerland, million litres |
| Figure 15.7. | Ethanol consumption in Switzerland, million litres |
| Figure 16.1. | Renewable fuel volume obligation as established in the RFS program, billion litres |
| Figure 16.2. | Blending mandates in the US, launch dates |
| Figure 16.3. | Historical US ethanol imports, million litres |



| Figure 16.4. | Growth of the ethanol industry in the US, billion litres |
|-------------------------------|---|
| Figure 16.5. | Average production capacity of ethanol plants in operation in the US, million litres |
| Figure 16.6. | Top ten states for ethanol production, million litres |
| Figure 16.7. | US Ethanol biorefinery locations |
| Figure 16.8. | Top ten ethanol producers in terms of installed capacity, million litres |
| Figure 16.9. million | Breakdown of funding for advanced biorefinery projects, December 2009, US \$ |
| Figure 16.10. | Fate of corn harvested for ethanol production in the USA, 2009 |
| Figure 16.11. the US, % | Breakdown of feedstocks for biodiesel plants in operation and under construction in |
| Figure 16.12. | Breakdown of biodiesel production costs |
| Figure 16.13. | Top ten biodiesel manufacturers in the US, million litres |
| Figure 16.14. | Production and consumption of biodiesel in the US, million litres |
| Figure 17.1. | Sugar producing regions and ethanol plants in Brazil |
| Figure 17.2. | Sugar cane and sugar production in Brazil for each crop harvest, million tonnes |
| Figure 17.3. | Balance of cane products and by-products, 1,000 kg of planted cane |
| Figure 17.4. | Ethanol production in Brazil for each crop harvest, million litres |
| Figure 17.5. | Average price of Brazilian ethanol exports, US \$ per litre |
| Figure 18.1. installed capaci | Anticipated fate of biodiesel produced by the ten largest biodiesel producers by ty, million litres, 2010 |
| Figure 18.2. | Map showing biofuel production and blending terminal locations in Argentina |
| Figure 18.3. government, mi | Supply commitments for ethanol producers for the Argentinan market from the illion litres, 2010 |
| Figure 18.4. government, mi | Supply commitments for biodiesel producers for the Argentinan market from the illion litres, 2010 |
| Figure 18.5. | Fate of palm oil produced in Honduras, tonnes |
| Figure 18.6. | Development of the biofuel market in Paraguay, million litres |
| Figure 18.7. | Quantity of feedstock used in biofuel production in Uruguay, tonnes |
| Figure 19.1. | Ethanol and biodiesel plants in Canadian provinces, million litres |
| Figure 19.2. | Feedstocks used by Canadian biofuel plants, million litres |
| Figure 19.3. | Map of potential areas for biofuel feedstock cultivation in Mexico |
| Figure 20.1. | Ethanol production capacity in operation in Australia, million litres |
| Figure 20.2. | Biodiesel production capacity in operation in Australia, million litres |
| Figure 20.3. | Breakdown of biodiesel sold on the Australian market, million litres |
| Figure 21.1. | Fuel ethanol plants in China |
| Figure 21.2. | Sugar cane feedstocks in India, thousand tonnes |
| Figure 21.3. | Production and consumption of ethanol in India, 2006 – 2011, million litres |
| Figure 21.4. | Breakdown of fate of biodiesel produced by manufacturers in Indonesia, million litres |



| Figure 21.5. | Map of installed ethanol plants in Indonesia |
|--------------------------------|--|
| Figure 21.6. | Map of installed biodiesel plants in Indonesia |
| Figure 21.7. | Annual and forecast of crude palm oil production in Malaysia, million tonnes |
| Figure 21.8. | Main feedstock used to produce ethanol in Thailand, thousand litres per day |
| Figure 21.9. litres per day | Anticipated production of ethanol from cassava and molasses in Thailand, million |
| Figure 21.10. | Prices of ethanol blends and gasoline in Thailand, 2005 – 2009, THB per litre |
| Figure 21.11. | Prices of biodiesel blends and gasoline in Thailand, 2005 – 2009, THB per litre |
| Figure 21.12. | Feedstocks used in biodiesel plants in Thailand |
| Figure 21.13. | Projections on domestic demand for biodiesel in Thailand, million litres |
| Figure 21.14. | Breakdown of manufacturers of biodiesel in Thailand, thousand litres per day |
| Figure 21.15. | Projections of idle and operating ethanol capacity in the Philippines, million litres |
| Figure 21.16. | Projections of ethanol production and imports in the Philippines, million litres |
| Figure 21.17. | Projections of biodiesel production and consumption in the Philippines, million litres |
| Figure 24.1. | Timeline of proposed legislation and voluntary targets for the aviation sector |
| Figure 24.2. | Aviation fuel demand and supply scenarios |
| Figure 24.3. | CAAFI R&D roadmap for biofuel feedstocks |



List of Tables

| Table 2.1. | Production processes for first generation biofuels |
|-----------------------------|---|
| Table 3.1. | Advantages and disadvantages of ethanol compared to gasoline |
| Table 3.2. | Yields of ethanol per feedstock |
| Table 3.3. | Monthly prices for corn, US \$ per tonne |
| Table 3.4. | Products from sugar cane production |
| Table 3.5. | Monthly sugar prices, US \$ cents per pound |
| Table 3.6. | Advantages and disadvantages of biodiesel compared to petroleum diesel |
| Table 3.7. | Monthly prices for feedstocks for the production of biodiesel, US \$ per tonne |
| Table 4.1. | By-products from jatropha |
| Table 4.2. | The advantages and disadvantages of jatropha |
| Table 4.3. | Key companies involved in jatropha projects |
| Table 4.4. | Main developers of biodiesel from Camelina |
| Table 6.1. | Cellulosic waste materials of food crops |
| Table 6.2. | Top cellulosic ethanol manufacturers in terms of installed capacity in 2009 |
| Table 6.3. generation biofu | The advantages and disadvantages of cellulosic ethanol as an alternative to first- uels feedstocks on the market |
| Table 7.1. | The biodiesel yield per acre for different feedstocks |
| Table 7.2. | Production capacity for algae biofuel developers, million litres, 2010 and 2012 |
| Table 7.3. | Products derived from algae |
| Table 7.4. biofuels feedsto | The advantages and disadvantages of algae as an alternative to first-generation ocks on the market |
| Table 9.1. | Description of Conversion Pathway |
| Table 10.1. | Emissions Lifecycle for each Feedstock |
| Table 10.2. | How green are biofuels? |
| Table 12.1. | Business model of the top ten biofuel companies in terms of investments last year |
| Table 12.2. | Estimates of subsidies for different energy sources |
| Table 12.3. | Transport fuel prices and taxes per litre, June 2010 |
| Table 12.4. | Transport fuel prices, May 2010, US dollars per litre |
| Table 12.5. | Relationships between crude oil, gasoline, ethanol and break-even corn prices |
| Table 12.6. | Average oil price projections, US \$ per barrel |
| Table 13.1. | Biodiesel production, million litres |
| Table 13.2. | Ethanol production, million litres |
| Table 13.3. | Biodiesel projections |
| Table 13.4. | Bioethanol projections |
| Table 14.1. | Energy content of marginal transport fuel – pure and blends, MJ/litre |
| Table 14.2. | Energy content of marginal transport fuel blends, MJ/litre |



| Table 14.3. use | EU Member States goals for the use of biofuels as transportation fuel, % of total fuel |
|------------------------|--|
| Table 14.4. | Road transportation fuels consumption in the EU, 2006 – 2011, ktoe |
| Table 14.5. | Renewable Energy Directive targets |
| Table 14.6. mission | Greenhouse gas emissions for biofuel feedstocks according to the European Com- |
| Table 14.7. | Milestones for the biofuel industry in the EU |
| Table 14.8. | REACH costs |
| Table 14.9. | Development of biodiesel plants in the EU, thousand litres |
| Table 14.10. | EU 2008 and 2009 biodiesel capacity estimates |
| Table 14.11. | Production capacity of the main biodiesel producers in Europe |
| Table 14.12. | Development of ethanol plants in the EU, million litres |
| Table 14.13. | Production capacity of the main ethanol producers, 2010 |
| Table 14.14. | Ethanol plants in the EU, million litres, March 2010 |
| Table 14.15. | Advanced biofuel plants in the EU |
| Table 14.16. | Jobs created by the sector in key European countries |
| Table 15.1. | Fuel Taxes |
| Table 15.2. | Breakdown of transport fuels in Bulgaria |
| Table 15.3. | Quota for Biodesel and Bioethanol from 2003-2010 |
| Table 15.4. | Quotas and taxes for biofuels in Germany |
| Table 15.5. | Tax exemptions in € per litre of biofuels |
| Table 15.6. | Land use criteria for sustainable biofuels in Germany |
| Table 15.7. | Energy tax on pure biodiesels, € per litre |
| Table 15.8. | Consumption of biofuels in Germany, thousand tonnes |
| Table 15.9. | Average price at the filling station for biodiesel and diesel in Germany, June 2010 |
| Table 15.10. | Biodiesel plants in operation in Germany, end 2009 |
| Table 15.11. | Incentives for Irish farmers producing energy crops |
| Table 15.12. | Financial support for production facilities |
| Table 15.13. | Albengoa Bioenergy global presence |
| Table 15.14. | Biodiesel plants in operation, under construction and planned in Spain |
| Table 15.15. | Ethanol plants in Spain, excluding Abengoa's plants |
| Table 15.16. | Ethanol plants in Sweden |
| Table 15.17. | Biodiesel plants in Sweden |
| Table 15.18. | Planned biodiesel projects in Switzerland, million litres |
| Table 16.1. | History of ethanol subsidy legislation in the US |
| Table 16.2. | State fuel taxes |
| Table 16.3. | Biofuel blends and car manufacturing compatibility in the US |
| Table 16.4. | Ethanol plants in the USA, July 2010 |
| Table 16.5. | Business structure of the top 5 ethanol producers in the US |
| | |



| Table 16.6. | US cellulosic ethanol projects under development and construction |
|-----------------------------|---|
| Table 16.7. December 200 | Awardees of US Department of Energy and Department of Agriculture funding, 9 |
| Table 16.8. | Valero Renewables' ethanol plants |
| Table 16.9. stocks | DDGS produced for a 20 million gallon (91 million litres) plant using different feed- |
| Table 16.10. | Business models for the top five biodiesel producers in the US |
| Table 16.11. | Biodiesel plants in the USA, July 2010 |
| Table 17.1. | Production costs for ethanol in the USA, Germany and Brazil, € per 1,000 litres |
| Table 17.2. | Installed biofuel capacity and targets in Brazil |
| Table 17.3. | Top ten sugar cane facilities in Sao Paulo State for the 2008/2009 harvest |
| Table 17.4. | Key Companies using SCA Brazil Ethanol brokerage |
| Table 17.5. | Biodiesel plants in operation in Brazil |
| Table 17.6. | Investment in renewable energies |
| Table 17.7. | Ethanol plants owned by Cosan in Brazil |
| Table 18.1. | Argentina Renovables' list of biodiesel plants in operation, large scale |
| Table 18.2. | Ethanol plants in operation in Colombia |
| Table 18.3. | Biodiesel plants in operation in Colombia |
| Table 18.4. | Top five biodiesel plants in operation in Honduras |
| Table 19.1. | Blending mandates in Canadian provinces, target dates |
| Table 19.2. | Incentives for biofuels in Canadian provinces |
| Table 19.3. | Federal programmes to promote a domestic renewable fuels industry in Canada |
| Table 19.4. | Ethanol plants in operation or under construction in Canada |
| Table 19.5. | Biodiesel plants in operation or under construction in Canada |
| Table 19.6. | Tax exemptions for E10 by Canadian province |
| Table 19.7. | Ethanol pilot project in Mexico |
| Table 20.1. | Biodiesel plants in Australia, January 2010 |
| Table 20.2. | Ethanol plants in operation in Australia, January 2010 |
| Table 20.3. | Biofuels Excise Rates for Australia |
| Table 20.4. | Effective fuel tax rates for alternative fuels in Australia |
| Table 20.5. | Blending mandates in Australia, target dates |
| Table 20.6. Australia | Second generation Biofuels Research and Development Programme projects in |
| Table 20.7. | Leading biofuel players in New Zealand, as of August 2009 |
| Table 21.1. | China investment in renewable energy markets |
| Table 21.2. | Ethanol plants in operation in China, million litres |
| Table 21.3. | Cities with the E10 blend mandate in China |
| Table 21.4. | Cost analysis of using different feedstocks for ethanol using 2006 prices in China |
| Table 21.5. | Major biodiesel facilities in China |



| Table 21.6. | Project financing for biofuel projects in India |
|--------------------------------|--|
| Table 21.7. | Blending mandate for biodiesel in Indonesia |
| Table 21.8. | Blending mandate for ethanol in Indonesia |
| Table 21.9. | Biodiesel projects in operation in Malaysia |
| Table 21.10. litres per day | Fifteen year Renewable Energy Development Plans for biofuels in Thailand, million |
| Table 21.11. | Ethanol plants in Thailand, March 2010 |
| Table 21.12. | Breakdown of retail prices for B2 and B5 biodiesel in Thailand as of May 2010 |
| Table 21.13. | Biodiesel plants in operation in Thailand, March 2010 |
| Table 21.14. | Comparison different feedstocks for ethanol in the Philippines |
| Table 24.1. | Aviation ground rules for 2nd and 3rd generation biomass fuelling |
| Table 24.2. | US military supply contracts for biofuels |
| Table 24.3. | Biofuel manufacturers with contracts to develop or supply fuel for the aviation sector |
| Table 25.1. | Oil and gas company investments in biofuels |
| Table 26.1. | Biofuel targets, subsidies and incentives for biofuels for EU member states |
| Table 26.2. | Biofuel targets, subsidies and incentives outside the EU |
| | |



Table of Contents

| Pub | olished E | Зу | | 2 | |
|------|--|-----------|--|----|--|
| Cop | yright N | lotice | | 2 | |
| Tab | le of Co | ntents | | 3 | |
| List | of Figu | res | | 7 | |
| List | of Table | es | | 11 | |
| 1 | Execu | ıtive Sum | mary | 15 | |
| 2 | Introd | uction | | 17 | |
| 3 | First generation biofuels | | | 21 | |
| | 3.1 | Ethano | ol (Bioethanol) | 21 | |
| | | 3.1.1 | Corn | 22 | |
| | | 3.1.2 | Sugar beet | 23 | |
| | | 3.1.3 | Sugar cane | 23 | |
| | | 3.1.4 | Sorghum | 25 | |
| | 3.2 | Biodies | sel | 26 | |
| | | 3.2.1 | Palm oil | 26 | |
| | | 3.2.2 | Soy beans (Soya; Soya beans) | 28 | |
| | | 3.2.3 | Rapeseed | 28 | |
| 4 | Energ | y Crops | | 31 | |
| | | 4.1.1 | Jatropha | 31 | |
| | | 4.1.2 | Camelina | 35 | |
| | | 4.1.3 | Croton trees | 36 | |
| | | 4.1.4 | Miscanthus (Miscanthus giganteus) | 37 | |
| | | 4.1.5 | Poplar trees | | |
| | | 4.1.6 | Salicornia (Salicornia Bigelovii, Dwarf saltwort, Dwarf glasswort) | | |
| | | 4.1.7 | Switch grass | 38 | |
| 5 | Waste | e vegetab | le oil and tallow | 39 | |
| | | 5.1.1 | Fuel: Biodiesel | | |
| 6 | Cellulosic biofuels (lignocellulosic biofuels) | | | | |
| | 6.1 | Second | d generation | | |
| | | 6.1.1 | Fuel: Ethanol | | |
| 7 | Algae | | | | |
| | 7.1 | | eneration biofuel | | |
| | | 7.1.1 | Fuel: Diesel substitute | | |
| 8 | | | | | |
| 9 | | - | cess | | |
| 10 | | | Impact | | |
| 11 | | | el debate | | |
| 12 | Market | | | | |
| | 12.1 Financials | | | | |
| | 12.2 | - | nies | | |
| | 12.3 Petroleum transport fuels | | | | |
| 13 | | • | ion | | |
| 14 | • | | | | |
| | 14.1 | EU Bio | fuels Directive | 85 | |



| | 14.2 | Renewable Energy Directive | 87 |
|----|--------|---|-----|
| | 14.3 | REACH | 90 |
| | 14.4 | Import and export regulations | 91 |
| | 14.5 | Biofuel production | 93 |
| | | 14.5.1 Biodiesel | 93 |
| | 14.6 | Ethanol | 98 |
| | 14.7 | Biofuel consumption | 108 |
| | 14.8 | Next generation biofuels | 109 |
| | 14.9 | Job creation | 110 |
| | 14.10 | Factors affecting the market | 111 |
| | 14.11 | EU competitiveness | 113 |
| 15 | Europe | ean countries | 114 |
| | 15.1 | Austria | 114 |
| | 15.2 | Belgium | 114 |
| | 15.3 | Bulgaria | 115 |
| | 15.4 | Denmark | 116 |
| | 15.5 | Estonia | 117 |
| | 15.6 | Finland | 117 |
| | 15.7 | France | 117 |
| | 15.8 | Germany | 118 |
| | 15.9 | Ireland | 124 |
| | 15.10 | Latvia | 125 |
| | 15.11 | Luxembourg | 125 |
| | 15.12 | Netherlands | 126 |
| | 15.13 | Norway | 126 |
| | 15.14 | Poland | 126 |
| | 15.15 | Portugal | 127 |
| | 15.16 | Romania | 127 |
| | 15.17 | Spain | 127 |
| | 15.18 | Sweden | 131 |
| | 15.19 | Switzerland | 134 |
| | 15.20 | Turkey | 136 |
| | 15.21 | UK | 137 |
| 16 | USA | | 138 |
| | 16.1 | Incentives | 138 |
| | 16.2 | Renewable Fuel Standard | 139 |
| | 16.3 | Food, Conservation, and Energy Act of 2008 (Farm Bill 2008) | 142 |
| | 16.4 | State legislation | 142 |
| | 16.5 | Biofuel imports and exports | 144 |
| | 16.6 | Market | 145 |
| | 16.7 | Next generation biofuels | 156 |
| | 16.8 | Economic downturn | 161 |
| | 16.9 | Animal feed | 162 |
| | 16.10 | Biodiesel | 163 |
| 17 | Brazil | | 171 |
| | 17.1 | Sugar production | 172 |



| | 17.2 | Sugar ca | ane production | 173 |
|----|---------------|------------------------------|----------------|-----|
| | 17.3 | Ethanol | plants | 173 |
| | 17.4 | Ethanol | | 176 |
| | 17.5 | Blending | g mandates | 179 |
| | 17.6 | Export n | narket | 179 |
| | 17.7 | Biodiese | ıl | 181 |
| | 17.8 | Investme | ent | 183 |
| | 17.9 | Foreign | Investment | 185 |
| 18 | Latin America | | | 186 |
| | 18.1 | Argentin | a | 186 |
| | 18.2 | Colombi | a | 191 |
| | 18.3 | Hondura | ıs | 192 |
| | 18.4 | Paragua | y | 194 |
| | 18.5 | Peru | | 195 |
| | 18.6 | Uruguay | , | 195 |
| 19 | North A | America | | 198 |
| | 19.1 | Canada | | 198 |
| | 19.2 | Biodiese | ıl | 204 |
| | 19.3 | Ethanol | | 204 |
| | 19.4 | Mexico. | | 205 |
| 20 | Ocean | ia | | 208 |
| | 20.1 | Australia | 1 | 208 |
| | 20.2 | 20.2 New Zealand21 | | |
| 21 | ASIA | | | |
| | 21.1 | China | | 222 |
| | 21.2 | Chinese | Taiwan | 226 |
| | 21.3 | India | | 226 |
| | 21.4 | Indones | a | 231 |
| | 21.5 | Japan | | 234 |
| | 21.6 | Korea, S | South | 236 |
| | 21.7 | Malaysia | a | 236 |
| | 21.8 | Pakistar | 1 | 238 |
| | 21.9 | Thailand | l | 239 |
| | 21.10 | The Phil | ippines | 248 |
| | 21.11 | Vietnam | | 251 |
| 22 | Russia | Russia and the CIS countries | | |
| | 22.1 | Russia | | 252 |
| | 22.2 | Ukraine | | 252 |
| | 22.3 | Other co | ountries | 253 |
| 23 | Africa | | | 254 |
| | 23.1 | South A | frica | 254 |
| | 23.2 | Sudan | | 255 |
| | 23.3 | Other co | ountries | 255 |
| | | 23.3.1 | Kenya | 255 |
| | | 23.3.2 | Mozambique | 255 |
| | | 23.3.3 | Tanzania | 255 |



| 24 | Aviation | on sector | 256 |
|----|----------|--------------------------------------|-----|
| | 24.1 | Carbon emissions | 256 |
| | 24.2 | Bio-jet fuels | 257 |
| | | Air force and the military | |
| 25 | | Gas Involvement | |
| 26 | Biofue | el targets, subsidies and incentives | 279 |
| 27 | Conve | ersion units | 297 |
| 28 | Ackno | owledgements | 298 |



List of Figures

| Figure 2.1. | Development of biofuels |
|----------------------------|---|
| Figure 2.2. | Products from biofuel feedstocks |
| Figure 3.1. | World corn price projections, US \$ per tonne |
| Figure 3.2. | World sugar price projections, US \$ per tonne |
| Figure 3.3. | Fuel yield for biofuel feedstocks, gasoline equivalent, gallons per acre |
| Figure 3.4. | World vegetable oil prices, US \$ per tonne |
| Figure 3.5. | World oil seed prices, US \$ per tonne |
| Figure 4.1. | Jatropha curcas |
| Figure 4.2. | Scale of jatropha projects (hectares) and number of projects, 2008 and 2015 |
| Figure 4.3. | Camelina* |
| Figure 4.4. | Salicornia (Salicornia Bigelovi) |
| Figure 6.1. | Breakdown of operating costs for a cellulosic plant using enzyme pre-treatment |
| Figure 6.2. | Status of cellulosic ethanol plants as of February 2010 |
| Figure 6.3. | Adjusted feedstock potential for cellulosic feedstocks |
| Figure 6.4. litres | Planned development of cellulosic ethanol capacity by the top ten developers, million |
| Figure 7.1. | Microalgae and macroalgae. Microalgae (left) Macroalgae (right) |
| Figure 8.1. | Role of biotechnology in biofuel production |
| Figure 9.1. | Levelised cost of energy for transport fuels, US \$ per litre |
| Figure 9.2. | Conversion pathways to produce biofuels |
| Figure 10.1. | Greenhouse gas savings of biofuels by feedstock and country of origin, % - Biodiesel |
| Figure 10.2. and Biogas | Greenhouse gas savings of biofuels by feedstock and country of origin, % - Ethanol |
| Figure 10.3. | Future research challenges for assessing the environmental impacts of biofuels |
| Figure 10.4. | Global average water footprint for ethanol feedstocks, m³/GJ |
| Figure 10.5. | Global average water footprint for biodiesel feedstocks, m³/GJ |
| Figure 12.1. | New investment by technology, 2009, US \$billion |
| Figure 12.2. | Global Asset Financing (GAF), US \$ million, Q1 2009 – Q2 2010 |
| Figure 12.3. | Global Asset Financing (GAF) per biofuel project, US \$ million, Q1 2009 – Q2 2010 |
| Figure 12.4. | Biofuels New Build Asset Investment Waves, US \$ billion |
| Figure 12.5. | Investments in terms of feedstocks, US \$ million, 2009 |
| Figure 12.6. | VC/PE investments in biofuels, US \$ million, Q1 2009 – Q2 2010 |
| Figure 12.7. | Average VC/PE investments in biofuels per deal, US \$ million, Q1 2009 – Q2 2010 |
| Figure 12.8. | Top ten companies in 2009 in terms of investments, US \$ million |



| Figure 12.9. 2008, US \$ billi | Corporate and government R&D investment by technology, 2009, and total growth on on |
|-----------------------------------|--|
| Figure 12.10. | Average crude oil import costs, US \$/barrel* |
| Figure 12.11. | Short term oil price forecast, West Texas Spot price, US\$ per barrel |
| Figure 12.12. | DOE EIA World oil price projections, US \$ per barrel |
| Figure 14.1. | Biofuel chain and supply measures in the EU |
| Figure 14.2. | Proportion of biofuel meeting sustainability standards |
| Figure 14.3. | Idle and used biodiesel capacity in the EU, million litres |
| Figure 14.4. | Average installed capacity of biodiesel plants in the EU, million litres |
| Figure 14.5. | Biodiesel production in the top six EU countries, million litres |
| Figure 14.6. 2011 (right) | Market share of biodiesel production in the top six EU countries, %, 2009 (left) and |
| Figure 14.7. | Feedstock used for biodiesel production, thousand tonnes |
| Figure 14.8. | Idle and used ethanol capacity in the EU, million litres |
| Figure 14.9. | Average installed capacity of ethanol plants in the EU, million litres |
| Figure 14.10. | Ethanol production in the top six EU countries, million litres |
| Figure 14.11. 2011 (right) | Market share of ethanol production in the top six EU countries, %, 2009 (left) and |
| Figure 14.12. | Balance of ethanol trade, net exporters +and net importers -, million litres |
| Figure 14.13. | Feedstock used for ethanol production, thousand tonnes |
| Figure 14.14. | Fate of ethanol produced in the EU, million litres |
| Figure 14.15. | Imports of biofuels into the EU, million litres |
| Figure 14.16. | Production of DDGS during ethanol production in the EU, thousand tonnes |
| Figure 14.17. | Consumption of biofuels in the EU, 2006 - 2011 |
| Figure 14.18. | Biodiesel consumption in the EU, 2009 - 2011, million litres |
| Figure 14.19. | Ethanol consumption in the EU, 2009 - 2011, million litres |
| Figure 15.1. | Projections on the production of biodiesel and ethanol in Bulgaria, 2008 – 2020 |
| Figure 15.2. many, gCO2eq | Standard greenhouse gas emissions for biofuels, established by the UFOP in Gerper MJ, $\%$ |
| Figure 15.3. | Ethanol market in Sweden, thousand litres |
| Figure 15.4. | Biodiesel market in Sweden, thousand litres |
| Figure 15.5. | Quantity of feedstock used in biofuel production in Sweden, thousand tonnes |
| Figure 15.6. | Biodiesel consumption in Switzerland, million litres |
| Figure 15.7. | Ethanol consumption in Switzerland, million litres |
| Figure 16.1. | Renewable fuel volume obligation as established in the RFS program, billion litres |
| Figure 16.2. | Blending mandates in the US, launch dates |
| Figure 16.3. | Historical US ethanol imports, million litres |



| Figure 16.4. | Growth of the ethanol industry in the US, billion litres |
|-------------------------------|---|
| Figure 16.5. | Average production capacity of ethanol plants in operation in the US, million litres |
| Figure 16.6. | Top ten states for ethanol production, million litres |
| Figure 16.7. | US Ethanol biorefinery locations |
| Figure 16.8. | Top ten ethanol producers in terms of installed capacity, million litres |
| Figure 16.9. million | Breakdown of funding for advanced biorefinery projects, December 2009, US \$ |
| Figure 16.10. | Fate of corn harvested for ethanol production in the USA, 2009 |
| Figure 16.11. the US, % | Breakdown of feedstocks for biodiesel plants in operation and under construction in |
| Figure 16.12. | Breakdown of biodiesel production costs |
| Figure 16.13. | Top ten biodiesel manufacturers in the US, million litres |
| Figure 16.14. | Production and consumption of biodiesel in the US, million litres |
| Figure 17.1. | Sugar producing regions and ethanol plants in Brazil |
| Figure 17.2. | Sugar cane and sugar production in Brazil for each crop harvest, million tonnes |
| Figure 17.3. | Balance of cane products and by-products, 1,000 kg of planted cane |
| Figure 17.4. | Ethanol production in Brazil for each crop harvest, million litres |
| Figure 17.5. | Average price of Brazilian ethanol exports, US \$ per litre |
| Figure 18.1. installed capaci | Anticipated fate of biodiesel produced by the ten largest biodiesel producers by ty, million litres, 2010 |
| Figure 18.2. | Map showing biofuel production and blending terminal locations in Argentina |
| Figure 18.3. government, mi | Supply commitments for ethanol producers for the Argentinan market from the illion litres, 2010 |
| Figure 18.4. government, mi | Supply commitments for biodiesel producers for the Argentinan market from the illion litres, 2010 |
| Figure 18.5. | Fate of palm oil produced in Honduras, tonnes |
| Figure 18.6. | Development of the biofuel market in Paraguay, million litres |
| Figure 18.7. | Quantity of feedstock used in biofuel production in Uruguay, tonnes |
| Figure 19.1. | Ethanol and biodiesel plants in Canadian provinces, million litres |
| Figure 19.2. | Feedstocks used by Canadian biofuel plants, million litres |
| Figure 19.3. | Map of potential areas for biofuel feedstock cultivation in Mexico |
| Figure 20.1. | Ethanol production capacity in operation in Australia, million litres |
| Figure 20.2. | Biodiesel production capacity in operation in Australia, million litres |
| Figure 20.3. | Breakdown of biodiesel sold on the Australian market, million litres |
| Figure 21.1. | Fuel ethanol plants in China |
| Figure 21.2. | Sugar cane feedstocks in India, thousand tonnes |
| Figure 21.3. | Production and consumption of ethanol in India, 2006 – 2011, million litres |
| Figure 21.4. | Breakdown of fate of biodiesel produced by manufacturers in Indonesia, million litres |



| Figure 21.5. | Map of installed ethanol plants in Indonesia |
|--------------------------------|--|
| Figure 21.6. | Map of installed biodiesel plants in Indonesia |
| Figure 21.7. | Annual and forecast of crude palm oil production in Malaysia, million tonnes |
| Figure 21.8. | Main feedstock used to produce ethanol in Thailand, thousand litres per day |
| Figure 21.9. litres per day | Anticipated production of ethanol from cassava and molasses in Thailand, million |
| Figure 21.10. | Prices of ethanol blends and gasoline in Thailand, 2005 – 2009, THB per litre |
| Figure 21.11. | Prices of biodiesel blends and gasoline in Thailand, 2005 – 2009, THB per litre |
| Figure 21.12. | Feedstocks used in biodiesel plants in Thailand |
| Figure 21.13. | Projections on domestic demand for biodiesel in Thailand, million litres |
| Figure 21.14. | Breakdown of manufacturers of biodiesel in Thailand, thousand litres per day |
| Figure 21.15. | Projections of idle and operating ethanol capacity in the Philippines, million litres |
| Figure 21.16. | Projections of ethanol production and imports in the Philippines, million litres |
| Figure 21.17. | Projections of biodiesel production and consumption in the Philippines, million litres |
| Figure 24.1. | Timeline of proposed legislation and voluntary targets for the aviation sector |
| Figure 24.2. | Aviation fuel demand and supply scenarios |
| Figure 24.3. | CAAFI R&D roadmap for biofuel feedstocks |



List of Tables

| Table 2.1. | Production processes for first generation biofuels |
|-----------------------------|---|
| Table 3.1. | Advantages and disadvantages of ethanol compared to gasoline |
| Table 3.2. | Yields of ethanol per feedstock |
| Table 3.3. | Monthly prices for corn, US \$ per tonne |
| Table 3.4. | Products from sugar cane production |
| Table 3.5. | Monthly sugar prices, US \$ cents per pound |
| Table 3.6. | Advantages and disadvantages of biodiesel compared to petroleum diesel |
| Table 3.7. | Monthly prices for feedstocks for the production of biodiesel, US \$ per tonne |
| Table 4.1. | By-products from jatropha |
| Table 4.2. | The advantages and disadvantages of jatropha |
| Table 4.3. | Key companies involved in jatropha projects |
| Table 4.4. | Main developers of biodiesel from Camelina |
| Table 6.1. | Cellulosic waste materials of food crops |
| Table 6.2. | Top cellulosic ethanol manufacturers in terms of installed capacity in 2009 |
| Table 6.3. generation biofu | The advantages and disadvantages of cellulosic ethanol as an alternative to first- uels feedstocks on the market |
| Table 7.1. | The biodiesel yield per acre for different feedstocks |
| Table 7.2. | Production capacity for algae biofuel developers, million litres, 2010 and 2012 |
| Table 7.3. | Products derived from algae |
| Table 7.4. biofuels feedsto | The advantages and disadvantages of algae as an alternative to first-generation ocks on the market |
| Table 9.1. | Description of Conversion Pathway |
| Table 10.1. | Emissions Lifecycle for each Feedstock |
| Table 10.2. | How green are biofuels? |
| Table 12.1. | Business model of the top ten biofuel companies in terms of investments last year |
| Table 12.2. | Estimates of subsidies for different energy sources |
| Table 12.3. | Transport fuel prices and taxes per litre, June 2010 |
| Table 12.4. | Transport fuel prices, May 2010, US dollars per litre |
| Table 12.5. | Relationships between crude oil, gasoline, ethanol and break-even corn prices |
| Table 12.6. | Average oil price projections, US \$ per barrel |
| Table 13.1. | Biodiesel production, million litres |
| Table 13.2. | Ethanol production, million litres |
| Table 13.3. | Biodiesel projections |
| Table 13.4. | Bioethanol projections |
| Table 14.1. | Energy content of marginal transport fuel – pure and blends, MJ/litre |
| Table 14.2. | Energy content of marginal transport fuel blends, MJ/litre |



| Table 14.3. use | EU Member States goals for the use of biofuels as transportation fuel, % of total fuel |
|------------------------|--|
| Table 14.4. | Road transportation fuels consumption in the EU, 2006 – 2011, ktoe |
| Table 14.5. | Renewable Energy Directive targets |
| Table 14.6. mission | Greenhouse gas emissions for biofuel feedstocks according to the European Com- |
| Table 14.7. | Milestones for the biofuel industry in the EU |
| Table 14.8. | REACH costs |
| Table 14.9. | Development of biodiesel plants in the EU, thousand litres |
| Table 14.10. | EU 2008 and 2009 biodiesel capacity estimates |
| Table 14.11. | Production capacity of the main biodiesel producers in Europe |
| Table 14.12. | Development of ethanol plants in the EU, million litres |
| Table 14.13. | Production capacity of the main ethanol producers, 2010 |
| Table 14.14. | Ethanol plants in the EU, million litres, March 2010 |
| Table 14.15. | Advanced biofuel plants in the EU |
| Table 14.16. | Jobs created by the sector in key European countries |
| Table 15.1. | Fuel Taxes |
| Table 15.2. | Breakdown of transport fuels in Bulgaria |
| Table 15.3. | Quota for Biodesel and Bioethanol from 2003-2010 |
| Table 15.4. | Quotas and taxes for biofuels in Germany |
| Table 15.5. | Tax exemptions in € per litre of biofuels |
| Table 15.6. | Land use criteria for sustainable biofuels in Germany |
| Table 15.7. | Energy tax on pure biodiesels, € per litre |
| Table 15.8. | Consumption of biofuels in Germany, thousand tonnes |
| Table 15.9. | Average price at the filling station for biodiesel and diesel in Germany, June 2010 |
| Table 15.10. | Biodiesel plants in operation in Germany, end 2009 |
| Table 15.11. | Incentives for Irish farmers producing energy crops |
| Table 15.12. | Financial support for production facilities |
| Table 15.13. | Albengoa Bioenergy global presence |
| Table 15.14. | Biodiesel plants in operation, under construction and planned in Spain |
| Table 15.15. | Ethanol plants in Spain, excluding Abengoa's plants |
| Table 15.16. | Ethanol plants in Sweden |
| Table 15.17. | Biodiesel plants in Sweden |
| Table 15.18. | Planned biodiesel projects in Switzerland, million litres |
| Table 16.1. | History of ethanol subsidy legislation in the US |
| Table 16.2. | State fuel taxes |
| Table 16.3. | Biofuel blends and car manufacturing compatibility in the US |
| Table 16.4. | Ethanol plants in the USA, July 2010 |
| Table 16.5. | Business structure of the top 5 ethanol producers in the US |
| | |



| Table 16.6. | US cellulosic ethanol projects under development and construction |
|-----------------------------|---|
| Table 16.7. December 200 | Awardees of US Department of Energy and Department of Agriculture funding, 9 |
| Table 16.8. | Valero Renewables' ethanol plants |
| Table 16.9. stocks | DDGS produced for a 20 million gallon (91 million litres) plant using different feed- |
| Table 16.10. | Business models for the top five biodiesel producers in the US |
| Table 16.11. | Biodiesel plants in the USA, July 2010 |
| Table 17.1. | Production costs for ethanol in the USA, Germany and Brazil, € per 1,000 litres |
| Table 17.2. | Installed biofuel capacity and targets in Brazil |
| Table 17.3. | Top ten sugar cane facilities in Sao Paulo State for the 2008/2009 harvest |
| Table 17.4. | Key Companies using SCA Brazil Ethanol brokerage |
| Table 17.5. | Biodiesel plants in operation in Brazil |
| Table 17.6. | Investment in renewable energies |
| Table 17.7. | Ethanol plants owned by Cosan in Brazil |
| Table 18.1. | Argentina Renovables' list of biodiesel plants in operation, large scale |
| Table 18.2. | Ethanol plants in operation in Colombia |
| Table 18.3. | Biodiesel plants in operation in Colombia |
| Table 18.4. | Top five biodiesel plants in operation in Honduras |
| Table 19.1. | Blending mandates in Canadian provinces, target dates |
| Table 19.2. | Incentives for biofuels in Canadian provinces |
| Table 19.3. | Federal programmes to promote a domestic renewable fuels industry in Canada |
| Table 19.4. | Ethanol plants in operation or under construction in Canada |
| Table 19.5. | Biodiesel plants in operation or under construction in Canada |
| Table 19.6. | Tax exemptions for E10 by Canadian province |
| Table 19.7. | Ethanol pilot project in Mexico |
| Table 20.1. | Biodiesel plants in Australia, January 2010 |
| Table 20.2. | Ethanol plants in operation in Australia, January 2010 |
| Table 20.3. | Biofuels Excise Rates for Australia |
| Table 20.4. | Effective fuel tax rates for alternative fuels in Australia |
| Table 20.5. | Blending mandates in Australia, target dates |
| Table 20.6. Australia | Second generation Biofuels Research and Development Programme projects in |
| Table 20.7. | Leading biofuel players in New Zealand, as of August 2009 |
| Table 21.1. | China investment in renewable energy markets |
| Table 21.2. | Ethanol plants in operation in China, million litres |
| Table 21.3. | Cities with the E10 blend mandate in China |
| Table 21.4. | Cost analysis of using different feedstocks for ethanol using 2006 prices in China |
| Table 21.5. | Major biodiesel facilities in China |



| Table 21.6. | Project financing for biofuel projects in India |
|--------------------------------|--|
| Table 21.7. | Blending mandate for biodiesel in Indonesia |
| Table 21.8. | Blending mandate for ethanol in Indonesia |
| Table 21.9. | Biodiesel projects in operation in Malaysia |
| Table 21.10. litres per day | Fifteen year Renewable Energy Development Plans for biofuels in Thailand, million |
| Table 21.11. | Ethanol plants in Thailand, March 2010 |
| Table 21.12. | Breakdown of retail prices for B2 and B5 biodiesel in Thailand as of May 2010 |
| Table 21.13. | Biodiesel plants in operation in Thailand, March 2010 |
| Table 21.14. | Comparison different feedstocks for ethanol in the Philippines |
| Table 24.1. | Aviation ground rules for 2nd and 3rd generation biomass fuelling |
| Table 24.2. | US military supply contracts for biofuels |
| Table 24.3. | Biofuel manufacturers with contracts to develop or supply fuel for the aviation sector |
| Table 25.1. | Oil and gas company investments in biofuels |
| Table 26.1. | Biofuel targets, subsidies and incentives for biofuels for EU member states |
| Table 26.2. | Biofuel targets, subsidies and incentives outside the EU |
| | |



| Please complete the following information: Title: Mr./Mrs./Miss./Ms./Dr./Other: |
|---|
| |
| |
| Last Name: |
| Job TitleDepartment |
| Company |
| Address |
| Postal Code City |
| Country: E-mail |
| Tel:Fax: |
| |
| Product Name Product Code Price |
| |
| |
| |
| |
| |
| 20% VAT (if applicable) |
| Total |
| VAT Number (EU Businesses only) |
| Where applicable, UK VAT at 20% should be added for all purchases made from the United Kingdom or European Union. V. Registered business customers within the European Union (Excluding UK) may enter a valid VAT number above and exclude VA |
| Delivery Options |
| Hard Copy □ ^{1, 2} Electronic Download □ ¹ Both □ ^{1, 2} |
| ¹ Additional Charges: Secure Electronic Download (1-3 users only): No Extra Cost Electronic Enterprise internal license (>3 users): Cost + 100% For all other multiple user licenses and for external use please contact sales @NRGExpert.com. |
| ² Hard Copy: UK - £120, Europe - £180/€200 Rest of World - £240/\$330 (all prices include delivery and are subject to change) |
| Payment Options |
| Cheque enclosed (made payable to NRG Smarts Limited) Credit Card Bill me |
| Visa ☐ MasterCard ☐ American Express ☐ |
| Card Number Expiry date |
| CVC/Signature code (last 3 numbers on back of card) |
| |
| Date:Signature |

Our Usual Terms & Conditions shall apply to this order. Please see www.NRGExpert.com. NRGExpert is a trading name of NRG Smarts Limited, incorporated in England & Wales under company number 7468718.

E&OE