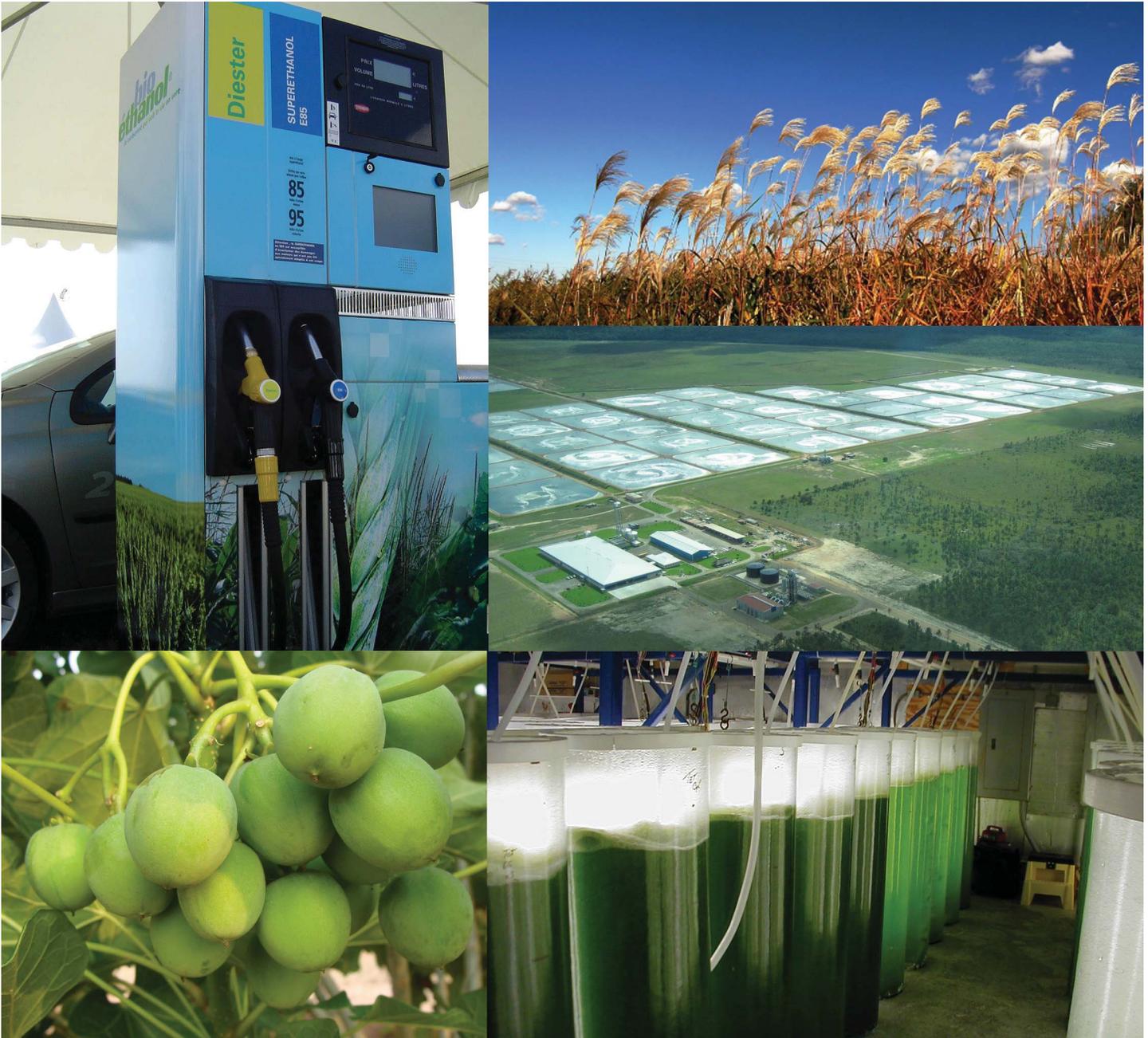


BIOFUELS 2010: SPOTTING THE NEXT WAVE

JOSHUA KAGAN THE PROMETHEUS INSTITUTE | TRAVIS BRADFORD THE PROMETHEUS INSTITUTE



EXECUTIVE SUMMARY

TABLE OF CONTENTS

1 EXECUTIVE SUMMARY	16
2 FIRST-GENERATION– ETHANOL	21
2.1 Introduction to Alcohol-Based Fuels	21
2.2 Ethanol in the United States	22
2.2.1 Overview	22
2.2.2 Ethanol's Strengths	23
2.2.2.1 Displaces Petroleum Gasoline	23
2.2.2.2 Corn Ethanol Environmental Benefits	25
2.2.2.3 Infrastructure Available for E85 Rollout	26
2.2.3 Limitations of Corn Ethanol	26
2.2.3.1 "Food vs. Fuel" Debate	26
2.2.3.2 Transportation Limitations	28
2.2.3.3 Infrastructure Limitations	29
2.3 U.S. Ethanol Feedstocks	30
2.3.1 Corn	30
2.3.1.1 Corn Feedstock Costs	31
2.4 Corn Ethanol Production Process	32
2.4.1 Dry Mill Process	32
2.4.2 Wet Mill Process	33
2.4.3 Conversion Economics	33
2.4.4 Plant Site Considerations	34
2.5 Policy Considerations	35
2.5.1 Historical Overview	35
2.5.2 Energy Policy Act of 2005	36
2.5.2.1 Renewable Fuels Standard	36
2.5.2.2 Blenders and Producer Credits	37
2.5.3 Import Duty on Fuel Ethanol	37
2.5.4 California's Air Resource Board "Low Carbon Fuel Standard"	37
2.5.5 Proposed E15 Blends	38
2.6 U.S. Corn Ethanol Market Overview	39
2.6.1 Ethanol Capacity by State	39
2.6.2 Majors Dominate the U.S. Ethanol Industry	40
2.6.3 U.S. Ethanol Industry Shakeout	41
2.7 U.S. Corn Ethanol Unit Economics	42
2.7.1 Cost Structure	42
2.7.2 U.S. Ethanol Prices and Margins	43
2.8 Brazilian Ethanol	47
2.8.1 Brazil Overview	47
2.8.2 Feedstocks– Sucrose (Sugar)	49
2.8.2.1 Sugarcane Yields and Production	50
2.8.2.2 Global Sugar Markets	51
2.8.3 Brazilian Ethanol Production Process	53
2.8.3.1 Conversion Process Overview	53
2.8.3.2 Co-Generation, Downstream Logistics, and Other Brazilian Efficiencies	54
2.8.4 Brazilian Ethanol Policy Overview	54
2.8.4.1 Proalcool	54
2.8.5 Brazilian Ethanol Market Overview	56
2.8.5.1 Production Capacity	56
2.8.5.2 Flex Fuel Vehicles as the Main Driver of Domestic Consumption	57
2.8.5.3 Exports	57
2.8.5.4 Consolidated Industry	58

2.8.6.1 Price of Ethanol vs. Gasoline	59
2.8.6.2 Cost structure	60
2.9 Other Ethanol Regions	61
2.9.1 European Ethanol Production	61
2.9.2 Central American Ethanol Production	62
2.9.3 Asian Ethanol Production	62
2.9.4 Global Sugar Ethanol Potential	63
2.10 Is First-Generation Ethanol Worth It?	65
3 FIRST-GENERATION BIODIESEL	66
3.1 Biodiesel Overview	66
3.2 Global Biodiesel Feedstocks	68
3.2.1 Edible Oils	68
3.2.1.1 Rapeseed (EU)	69
3.2.1.2 Soybean (U.S)	69
3.2.1.3 Palm (Southeast Asia)	70
3.2.2 Inedible Oils	71
3.2.2.1 Waste Vegetable Oil (WVO)	72
3.2.2.2 Animal Tallow	72
3.2.3 Advanced Feedstocks (<i>Jatropha</i>)	72
3.3 Biodiesel Technology	74
3.3.1 Transesterification	74
3.3.2 Blending	75
3.4 European Union (EU-27) Biodiesel	76
3.4.1 EU Biodiesel Policy	76
3.4.1.1 Blending Mandates	76
3.4.1.2 Tax Incentives	77
3.4.1.3 2009 Trade War with the United States	77
3.4.2 E.U Biodiesel Market Overview	77
3.4.2.1 European Biodiesel Companies	81
3.4.3 E.U Biodiesel Unit Economics	82
3.4.3.1 Cost Structure	82
3.4.3.2 Prices and Competitiveness with Diesel	83
3.5 U.S. Biodiesel	84
3.5.1 U.S. Biodiesel Policy	84
3.5.1.1 Renewable Fuel Mandates	84
3.5.1.2 VEETC Tax Credit	84
3.5.1.3 Small Biodiesel Producer Tax Credit	85
3.5.1.4 Alternative Fuel Refueling Infrastructure Tax Credit	85
3.5.1.5 Ultra-low Sulfur Diesel (ULSD)	85
3.5.2 U.S Biodiesel Market Overview	85
3.5.2.1 Production and Capacity	85
3.5.2.2 U.S Biodiesel Industry Shake-Out	87
3.5.2.3 U.S Biodiesel's Limited Potential to Displace Petroleum Diesel	89
3.5.3 U.S. Biodiesel Unit Economics	89
3.5.3.1 Costs	89
3.5.3.2 Prices and Competitiveness with Diesel	91
3.6 Other Biodiesel Markets	93
3.6.1 Palm Oil	93
3.6.2 Production, Consumption, and Prices	94
3.6.3 Countries With Substantial Biodiesel Programs	96

3.6.3.1 Malaysia	96
3.6.3.2 Indonesia	96
3.6.3.3 Argentina	96
3.6.3.4 Brazil	96
3.6.3.5 First-Generation Biofuels Reconsidered	97
4 SECOND-GENERATION BIOFUELS – CELLULOSIC ETHANOL	98
4.1 Introduction to Cellulosic Ethanol	98
4.1.1 Cellulosic Ethanol's Strengths	98
4.1.2 Cellulosic Ethanol's Challenges	99
4.2 Cellulosic Feedstocks	99
4.2.1 Cellulose, Hemicellulose, and Lignin Explained	99
4.2.2 Cellulosic Feedstocks Considerations	100
4.2.2.1 Feedstock Availability	100
4.2.2.2 Feedstock Yields	102
4.2.2.3 Feedstock Costs	103
4.2.2.4 Logistics	105
4.2.3 Agricultural Residues, Grasses, and Energy Crops	106
4.2.3.1 Notable Agricultural Crops	106
4.2.4 Woody Biomass	107
4.2.4.1 Forestry Residues	108
4.2.4.2 Forest Thinning	108
4.2.4.3 Primary and Secondary Mill Residues	109
4.2.5 Municipal and Other Urban Waste	109
4.2.6 U.S. Cellulosic Ethanol Feedstocks Aggregated	110
4.3 Cellulosic Ethanol Conversion Technologies	111
4.3.1 Bio-chemical	111
4.3.1.1 Pretreatment	112
4.3.1.2 Hydrolysis	112
4.3.1.3 Fermentation	113
4.3.1.4 Lignin Recovery	113
4.3.2 Thermo-chemical	113
4.3.2.1 Gasification	114
4.3.2.2 Pyrolysis	115
4.3.3 Funding Disparities Between Bio-Chemical and Thermo-Chemical Demonstration Facilities	116
4.4 Cellulosic Ethanol Policy	116
4.4.1 Energy Independence and Security Act of 2007	116
4.4.2 Department of Energy (DOE)	117
4.4.2.1 Integrated Cellulosic Biorefineries	117
4.4.2.2 Small-Scale Cellulosic Biorefineries	118
4.4.2.3 Bioenergy Research Centers	118
4.4.2.4 Ethanologen Projects (Bio-chemical)	118
4.4.2.5 Enzyme Systems Solicitation	118
4.4.2.6 Thermo-chemical Solicitation	119
4.4.2.7 American Recovery and Reinvestment Act of 2009	119
4.4.3 U.S. Department of Agriculture (USDA)	120
4.4.3.1 Demonstration-Scale Grants	120
4.4.3.2 Volumetric Cellulose Ethanol Excise Tax Credit	120
4.4.4 Internal Revenue Service (IRS)	120
4.4.5 State Initiatives	120
4.5 Cellulosic Ethanol Industry Overview	121
4.5.1 Current Capacity	121

4.5.2 Future U.S. Cellulosic Ethanol Production and Capacity	121
4.5.2.1 The Path Towards 16 Billion Gallons Per Year	123
4.6 Cellulosic Ethanol Unit Economics	125
5 THIRD-GENERATION BIOFUELS – ALGAE AND OTHER EXOTIC BIOFUELS	132
5.1 Algae Biofuels	132
5.1.1 Algae Biofuel Policy	133
5.1.2 Growth and Harvesting Technologies	134
5.1.2.1 Open Ponds	135
5.1.2.2 Closed Ponds, Photo-bioreactors, Hanging Bags, and Fermentation	136
5.1.2.3 List of Companies and Their Growth Methods	138
5.1.2.4 Harvesting and Extraction	139
5.1.3 Algae Biofuel Industry Overview	140
5.1.3.1 Algae Yields	142
5.1.3.2 Co-Products and Co-Services	143
5.1.4 Algae Biofuel Unit Economics	144
5.1.4.1 Costs	144
5.1.4.2 Opportunities and Constraints for Algae Biofuels	152
5.2 Designer Biofuels	156
5.2.1 Overview	156
5.2.2 Advanced Bio-Chemical Methods	157
5.2.3 Advanced Thermo-Chemical	160
5.2.3.1 Pyrolysis	162
5.2.4 Hybrid Bio-Chemical and Thermo-Chemical Processes	162
5.2.5 Biobutanol	165
6 MARKET AND INDUSTRY ANALYSIS	170
6.1 Global Liquid Transportation Market Overview	170
6.2 Petroleum Volumes, Prices, and Forecasts	174
6.2.1 Transportation Petroleum Demand 2009-2015	174
6.2.2 Transportation Petroleum Supply	177
6.2.3 Transportation Petroleum Prices 2009-2015	181
6.3 Biofuels (Volumes, Projections, Regions 2009-2022)	183
6.3.1 U.S. Ethanol	183
6.3.2 Brazilian Ethanol Production	185
6.3.3 Other First-Generation Ethanol Production	188
6.3.4 Second- Generation Cellulosic Ethanol	191
6.3.5 First-Generation Biodiesel	197
6.3.5.1 India, China, Jatropha and Other Forms of Biodiesel	205
6.3.6 Algae Biofuels	205
6.3.7 Algae Market Segments	210
6.3.8 Exotic Biofuels and other Hydrocarbon Imposters	212
6.3.8.1 Biobutanol	213
6.3.8.2 Advanced Diesel	214
6.3.8.3 Synthetic Jet Fuel	216
6.3.8.4 Petroleum-like Hydrocarbons	217
6.3.8.5 Third-Generation Designer Biofuels Aggregated	219
6.4 Biofuels Capacity to Displace Petroleum 2009-2022	222
6.4.1 The Grand Bargain: Why The Future of Biofuels Is Algae	228
6.4.2 Do Not Throw First-Generation Biofuels Under the Bus	232

7 EIGHT QUESTIONS FOR THE FUTURE OF BIOFUELS	234
7.1 What are the implications of the First-Generation market shake-out?	234
7.2 What are the prospects that the U.S. will adopt downstream infrastructure that facilitates the mainstream adoption of E85 ethanol?	235
7.3 What are the consequences if RFS mandates for Advanced Biofuels are not met?	236
7.4 If the U.S. increases ethanol blends from E10 to E12 (or E13) who is liable for any problems that occur to gasoline engines?	237
7.5 How will the cellulosic ethanol industry overcome logistical challenges?	238
7.6 What will be the cost of cellulosic biomass (feedstocks) when second-generation biofuels reach commercialization?	239
7.7 Will public and private support for third-generation algae biofuels reach parity with second-generation cellulosic ethanol?	240
7.8 What are the potential Black Swans that could alter the trajectory of biofuels?	241
8 BIOFUEL RESOURCE GUIDE	244
8.1 Biofuel Industry Associations	244
8.2 Online Biofuel Resources	245
8.3 Online Clean Technology Resources (with biofuel coverage)	246
8.4 Salient Biofuel Reports	247
8.5 Relevant Biofuel Books	248
8.6 Biofuel Magazines	249
8.7 Relevant Government and NGO Resources	250
9 COMPANY PROFILES	252
9.1 First-Generation Ethanol	253
<i>Abengoa Bioenergy</i>	253
<i>Archer Daniels Midland</i>	255
<i>Cosan</i>	256
<i>Osage Bio Energy</i>	257
<i>Poet</i>	258
9.3 First-Generation Biodiesel	259
<i>Bunge/Diester Industrie</i>	259
<i>Neste Oil</i>	260
<i>Renewable Biofuels (RBF)</i>	261
9.5 Second-Generation Cellulosic Ethanol	262
<i>Biogasol</i>	262
<i>Bluefire Ethanol</i>	263
<i>Coskata</i>	264
<i>DuPont Danisco Cellulosic Ethanol (DDCE)</i>	265
<i>Enerkem</i>	267
<i>Fulcrum Bioenergy</i>	268
<i>Ineos Bio</i>	269
<i>logen</i>	270
<i>KL Energy</i>	271
<i>Mascoma</i>	272
<i>QTeros</i>	273
<i>Range Fuels</i>	274
<i>Vercipia Biofuels</i>	275
<i>Zeachem</i>	276
9.4 Third-Generation Algae	277
<i>Algenol Biofuels</i>	277
<i>Aurora Biofuels</i>	278
<i>Origin Oil</i>	279

<i>Petroalgae</i>	280
<i>Sapphire Energy</i>	281
<i>Solazyme</i>	282
<i>Solix Biofuels</i>	283
9.2 Third-Generation Synthetic Fuels	284
<i>Amyris Biotechnologies</i>	284
<i>Choren Industries</i>	285
<i>Cobalt Biofuels</i>	286
<i>Gevo</i>	287
<i>LS9</i>	288
<i>Virent</i>	289
9.6 Suppliers	290
<i>Ceres</i>	290
<i>Edenspace</i>	291
<i>Genencor</i>	292
<i>ICM</i>	293
<i>Novozymes</i>	294
10 APPENDICES	295
11 REFERENCES	301

LIST OF FIGURES

Figure 1-1: 2008 Global Biofuel Production in Billions of Gallons	17
Figure 1-2: 2008 Regional Crop Displacement by Biofuel Production)	17
Figure 1-3: Global Biofuel Production in 2022, in Billions of Gallons	19
Figure 1-4: % of Global Transportation Products Displaced by Biofuels in 2022	20
Figure 2-1: Global Ethanol Production in Millions of Gallons (Mgal)	21
Figure 2-2: Growth in U.S. Ethanol Production 1990-2008	23
Figure 2-3: U.S. Petroleum Consumption Statistics	23
Figure 2-4: Crude Oil, Gasoline, and Ethanol Conversions	24
Figure 2-5: U.S. Farming Gross Income vs. Expenses in Billions of Dollars 1990-2009E	24
Figure 2-6: The Lifecycle of Ethanol	25
Figure 2-7: E85 Refueling Stations in Continental U.S.	26
Figure 2-8: U.S. Corn Prices (Cents/Bushel) 2003-2008	27
Figure 2-9: U.S. Corn Harvests in Billions of Bushels 1990-2009E12	27
Figure 2-10: U.S Ethanol Transportation Methods	28
Figure 2-11: U.S. Distribution of E85 Service Stations	29
Figure 2-12: U.S. Corn Yield 1974-2008	30
Figure 2-13: Relationship between Corn Prices and Delivered Cost per Gallon ¹⁸	31
Figure 2-14: Cost Structure of U.S. Dry Mill Corn Ethanol Facility, 1Q 2008 (courtesy BCurtis)	31
Figure 2-15: Traditional Dry-Mill Ethanol Process	32
Figure 2-16: Diagram of Wet Mill Process	33
Figure 2-17: Corn Ethanol Cost Detail \$/Gal	34
Figure 2-18: Construction Costs of Dry Mill Ethanol Plant	35
Figure 2-19: Renewable Fuels Standard Per Energy Independence and Security Act of 2007	36
Figure 2-20: Relationship Between Ethanol Blends and Capacity	38
Figure 2-21: Growth of U.S. Ethanol Industry 1999-2009	39
Figure 2-22: Ethanol Capacity and Production by State in Millions of Gallons	40
Figure 2-23: Leading U.S. Ethanol Companies by Production Capacity 2009 and 2010 in MGY	41
Figure 2-24: Ethanol's Value Chain	42
Figure 2-25: Dry Mill Ethanol Cost Details 2007-2012E	43
Figure 2-26: Relationship Between Corn Prices and Levelized Costs Per Gallon	43
Figure 2-27: U.S. Retail Prices of Ethanol and Gasoline 2008-2009	44
Figure 2-28: United States Vehicle Driving 1997-2009 in Billions of Miles	45
Figure 2-29: Price Relationship Between Crude Oil and Corn 2004-2008	45
Figure 2-30: Ethanol Crush Spread 2005-2008	46
Figure 2-31: U.S. Ethanol Operating Margins 2006-2009 ²⁰	47
Figure 2-32: Brazilian Cane Cutter Working in the Field ²²	48
Figure 2-33: Brazilian Sugarcane Production in Millions of Tons 1975-2005	49
Figure 2-34: Brazilian Land Mass and Crop Harvests 2007	50
Figure 2-35: Brazilian vs. U.S. Ethanol	50

Figure 2-36: Brazilian Sugarcane Production – Food vs. Fuel 2004-2009E	50
Figure 2-37: Global Sucrose Producers (Average from 2006-2008) in '000 Metric Tons	51
Figure 2-38: Global Sugar Consumers (Average from 2006-2008) in '000 Metric Tons	52
Figure 2-39: Largest Sugar Exporters (Average from 2006-2008) in '000 Metric Tons	52
Figure 2-40: Brazilian Sugar, Ethanol, and Electricity Plant	53
Figure 2-41: Gasoline and Ethanol Demand in Brazil and U.S.	55
Figure 2-42: Brazilian Ethanol Production in Million Gallons 2004-2009E Anhydrous vs. Hydrrous	56
Figure 2-43: Expansion of Brazilian Ethanol Demand – Flex Fuel Vehicles 2003-2008	57
Figure 2-44: Brazilian Exports by Destination 2006-2008	58
Figure 2-45: Estimated 2009 Brazilian Production Capacity by Major Company in Millions of Gallons	59
Figure 2-46: Brazilian Ethanol Unit Economics	60
Figure 2-47: Price of Crude Oil vs. Price of Sugar 1986-2009 - Index = 100	61
Figure 2-48: 2007 Largest Chinese Ethanol Producers	62
Figure 2-49: Conversions of Global Sugar Supply to Ethanol Volumes	63
Figure 2-50: Global Potential for Sugar-Based Ethanol Based on Yield of 169 Gallons of Ethanol per Metric Ton	64
Figure 2-51: Global Potential for Sugar-Based Ethanol to Displace Global Gasoline Supplies	65
Figure 3-1: Biodiesel Energy Density Compared to Other Energy Sources BTU/G	66
Figure 3-2: Global Consumption of Diesel by Region, 2005	67
Figure 3-3: Total Potential for Conventional Oilseed Feedstocks Converted into Biodiesel to Displace Global Petroleum Diesel in BGY	68
Figure 3-4: Global Rapeseed Oil Production 2004-2008	69
Figure 3-5: Global Processing of Soybeans 2004-2008	70
Figure 3-6: Vegetable Oil Yields in Liters/Hectare	71
Figure 3-7: U.S Biodiesel Capacity By Feedstock in 2007 (2.2BGY)	71
Figure 3-8: Chinese and Indian Jatropha Potential in BGY	73
Figure 3-9: Jatropha Seeds	74
Figure 3-10: Transesterification of Oils and Fats	75
Figure 3-11: Diagram of European Biofuel Policy Changes from 2008 to 2010	76
Figure 3-12: Largest Biodiesel Producing Countries in 2008	78
Figure 3-13: EU-27 Biodiesel Production in 2008	78
Figure 3-14: German Biodiesel Production 2007 vs. 2008 in Millions of Gallons	79
Figure 3-15: European Biodiesel Production by Member State in MMT 1998-2008	80
Figure 3-16: U.S. Biodiesel Exports to EU 2006-2007 in MT	80
Figure 3-17: Fact vs. Fiction – U.S. Biodiesel Exports vs. Idle E.U. Capacity	81
Figure 3-18: Largest Biodiesel Producing Companies in Europe in Millions of Gallons per Year of Production Capacity	82
Figure 3-19: Rapeseed Prices FOB Rotterdam in \$/MT 2004-2009	82
Figure 3-20: Retail Price of Diesel in Germany, France, and U.K. in Dollars 2002-2009	83

Figure 3-21: Biodiesel Mandates Under RFS	84
Figure 3-22: U.S. Biodiesel Production 2000-2009 in Mgal/Y	86
Figure 3-23: U.S. Biodiesel Production vs. Capacity in MGY	86
Figure 3-24: 2006 U.S. Production vs. 2007 U.S. Exports	87
Figure 3-25: U.S. Biodiesel Plants as of July 2009	88
Figure 3-26: Largest U.S. Biodiesel Producers in January, 2009	88
Figure 3-27: Prices of Soybean Oil, Tallow, and Grease in Cents per Gallon	90
Figure 3-28: Crude Oil vs. Soybean Prices 2003-2008	90
Figure 3-29: U.S. Retail Prices of B100 vs. Diesel 2007-2009 in Cents per Gallon	91
Figure 3-30: Break-Even Analysis of Biodiesel Prices vs. Soybean Oil Prices	92
Figure 3-31: Total Levelized Cost of Producing a Gallon of Biodiesel Using Soybeans and Waste Vegetable Oil	92
Figure 3-32: Weekly Retail Diesel Prices Europe vs. U.S. 2008-2009 ⁷⁴	93
Figure 3-33: Comparison of Global Feedstocks (\$/ton) 2001-2008	94
Figure 3-34: Production of Palm Oil by Country in Million Tons 2003-2008	94
Figure 3-35: Biodiesel Feedstock Cost Per Gallon August 2009	95
Figure 4-1: The Lignin, Hemicellulose, and Cellulose Composition of a Traditional Biomass Crop	100
Figure 4-2: U.S. Biomass Inventory Based on Billion Ton Study	101
Figure 4-3: Biomass Availability in United States 2005	102
Figure 4-4: Theoretical Yields of Various Feedstocks in Gallons/Ton	103
Figure 4-5: Cost Structure of Cellulosic Ethanol Feedstocks 2004-2012E	104
Figure 4-6: Relationship Between Cost Per Dry Ton and Per Gallon Equivalence	105
Figure 4-7: Perennial Energy Crops by U.S Location	106
Figure 4-8: % of Cellulosic Material from Selected Biomass	107
Figure 4-9: U.S. Availability of Various Types of Forestry Biomass	108
Figure 4-10: Total MSW Generation By Material 2007	109
Figure 4-11: Per Year Ethanol Yields from Various Cellulosic Sources	110
Figure 4-12: The Relationship Between 39.1 Billion Gallons of Cellulosic Ethanol and 139 Billion Gallons of Petroleum Gasoline	111
Figure 4-13: Bio-chemical Cellulosic Ethanol Production Process	112
Figure 4-14: Example of Enzymatic Hydrolysis	113
Figure 4-15: Thermo-chemical Conversion Process – Gasification	114
Figure 4-16: Gasification and Pyrolysis Thermo-chemical Conversion Processes	115
Figure 4-17: Discrepancy Between USDA and DOE Funding for Bio-Chem and Thermo-Chem Cellulosic Demonstration and Commercial Plants	116
Figure 4-18: Advanced Biofuel Provision Under Energy Independence and Security Act of 2007	117
Figure 4-19: Geography of DOE Funded Second- Generation Biofuel Projects	119
Figure 4-20: Estimated Cellulosic Ethanol Production in 2010 in Millions of Gallons	122

Figure 4-21: Plant Construction Roll-Out to 16 Billion Gallons per Year of Cellulosic Ethanol Capacity	123
Figure 4-22: EPA Feedstock Roadmap to 16BGY of Cellulosic Ethanol	124
Figure 4-23: Feedstock Land Use Requirements for 16BGY of Cellulosic Ethanol in 2022	125
Figure 4-24: Estimated Installed Capital Costs 2007-2012	126
Figure 4-25: Levelized Cellulosic Ethanol Production Cost 2007-2012	126
Figure 4-26: Estimated Current Capital Costs for Second- Gen Cellulosic Production via Thermo-Chemical and Bio-Chemical Routes \$/Gal	127
Figure 4-27: Estimated Current Feedstock Costs for First-and Second- Generation Ethanol	128
Figure 4-28: Estimated Current Conversion Costs for Bio-Chemical Cellulosic Ethanol Facilities	128
Figure 4-29: Estimated Current Conversion Costs for Thermo-Chemical Cellulosic Ethanol Facilities	129
Figure 4-30: Estimated Total Levelized Costs for Thermo and Bio-Chemical Cellulosic Ethanol Production	130
Figure 5-1: Experimental Photo-Bioreactor93	133
Figure 5-2: Cyanotech's Open Pond System in Hawaii	135
Figure 5-3: Algae Grown in Dishes	136
Figure 5-4: Diagram of PBR Systems	137
Figure 5-5: Solix Biofuels PBR Tubes at Pilot Facility	138
Figure 5-6: Algae Production Methods By Company	138
Figure 5-7: Example of Algal Centrifuge	139
Figure 5-8: PetroSun's 1000-Acre Algae Farm in Rio Hondo, TX	140
Figure 5-9: Calculation of Yields for Naturally Occurring Algae in American Southwest	142
Figure 5-10: Estimate of Algae Oil Yields in Photo-Bioreactor Growth System in Gallons per Acre per Year	143
Figure 5-11: Algae Co-Product Opportunities at Various Price Points	143
Figure 5-12: Aggregate Algae Biofuel Cost Comparison via Any Growth Method	146
Figure 5-13: Solix Biofuels PBR Total Levelized Production Cost 2008	147
Figure 5-14: Three Scenarios for PBRs Target Cost \$/Gal in 2009 and 2019	148
Figure 5-15: Solix Biofuels PBR Total Levelized Production Cost 2019	148
Figure 5-16: Three Cases of Algae PBR Cost Reduction Trajectories to 2020 in \$/gal on an Equivalent Btu Basis with Retail Diesel Prices	149
Figure 5-17: Breakdown of Capital and Operating Costs of Producing a Gallon of Algae Biofuels via Open Pond in 2009	150
Figure 5-18: Three Scenarios for Algae Biofuels from Open Ponds Target Cost \$/Gal in 2019	151
Figure 5-19: Three Cases of Algae PBR Cost Reduction Trajectories to 2020 in \$/gal on an Equivalent Btu Basis with Retail Diesel Prices	152
Figure 5-20: Graphic Representation of Algae's Capacity to Displace 50% of U.S. Petroleum Diesel Consumption Compared to Corn or Soy Biodiesel	153
Figure 5-21: Average Annual Sun Hours in United States - Contiguous 48 States	154
Figure 5-22: U.S. CO ₂ Emission Sources Tons per Year	154
Figure 5-23: U.S. CO ₂ Emission Sources '000 Tons in 2008	155
Figure 5-24: Water Consumption for Various Sectors in Southwest U.S. Compared to Evaporative Loss from Algae Biofuel via Open Pond Methods Million MGY	156
Figure 5-25: Cellulosic Biofuels vs. Advanced Biofuels Requirements Per RFS under EISA	157

Figure 5-26: Second- and Third-Generation Cellulosic Ethanol Processes Compared	158
Figure 5-27: Qteros "C3" Simultaneous Bio-Chemical Conversion Mechanism	159
Figure 5-28: LS9 Fermentation Process --- Results in Petroleum Hydrocarbons and Alternative Chemicals	160
Figure 5-29: Choren Gasification Diagram	161
Figure 5-30: Schematic Diagram of Pyrolysis Process Linked with Gasification	162
Figure 5-31: Coskata's Three Part Conversion Process	163
Figure 5-32: ZeaChem's Conversion Technology	164
Figure 5-33: Terrabon's "MixAlco" Conversion Technology	164
Figure 5-34: Comparison of Cobalt Continuous Fermentation vs. Other Processes	166
Figure 5-35: Gevo Butanol Production Diagram	166
Figure 5-36: Next Generation Feedstocks Compared	167
Figure 5-37: Next Generation Processes Compared	168
Figure 5-38: Next Generation Molecules Compared	169
Figure 6-1: Energy and Oil Metrics and Equivalents in 2005103	170
Figure 6-2: Composition of Barrel of Oil in Gallons from U.S. Refineries	171
Figure 6-3: Motor Gasoline, Diesel, and Jet Fuel's Composition the Portion of Oil Used for Transportation in 2005	171
Figure 6-4: Oil Consumption by Product and Region, 2005, in Million Barrels Per Day Equivalency	172
Figure 6-5: Oil Consumption by Product and Region, 2005, as a Percentage of Total Consumption	173
Figure 6-6: Global Motor Gasoline, Diesel, and Jet Fuel's Equivalence on Barrels and Gallons Equivalence, 2005	173
Figure 6-7: Projected Global Consumption (Million Barrels Per Day) Using Population Method	174
Figure 6-8: Pre-recession Estimated Petroleum Consumption in Millions of Barrels Per Day OECD vs. Non-OECD	175
Figure 6-9: Projected Global Oil Demand Growth Based on Increase of 1.39% Per Year (Million Barrels Per Day) 2010-2015	175
Figure 6-10: OECD Petroleum Consumption 2010-2015	176
Figure 6-11: Non- OECD Petroleum Consumption 2010-2015	176
Figure 6-12: Various Global Petroleum Fuels Projections 2010-2015 and 2022 Assuming 42gal=1bbl	177
Figure 6-13: Global Supply and Demand of Oil in Millions of Barrels per Day	178
Figure 6-14: Largest Oil Producing Nations in 2007 in Millions Barrels per Day	178
Figure 6-15: Top 10 Oil Producers' Reserves 1988-2008 in Billions of Barrels	179
Figure 6-16: Top 10 Oil Producers' Reserves 1988-2008 in Billions of Barrels and on a Percentage Basis	180
Figure 6-17: Global Oil Reserves 1988-2008 in Billions of bbls on a Regional Basis	180
Figure 6-18: Average WTI Spot Prices \$\$\$ by Year vs. Oil Supply (Millions of Barrels Per Day) 1997 – 2008	181
Figure 6-19: Future Oil Prices – 3 Case Scenarios Illustrating Price Sensitivity to Increases in Demand Using Historical Ratios – 2010-2015	182
Figure 6-20: Prospective Changes to U.S. Blend Rates and Implications on Consumption and Corn Crop	183

Figure 6-21: U.S. Corn Ethanol Production and Capacity 2009-2015 in Billions of Gallons	184
Figure 6-22: Projected U.S. Ethanol Production vs. Gasoline Equivalency 2009-2015 in Billions of Gallons	185
Figure 6-23: Brazilian Ethanol Consumption and Exports (Billion Gallons) 2005/2006-2014/2015	186
Figure 6-24: Projected Brazilian Ethanol Production (Billion Gallons) 2007/2008 – 2014/2015 Based Upon 2008/2009 Sugarcane Harvests and Assuming 9% Annual Growth	186
Figure 6-25: Brazilian Ethanol Capacity 2007/2008 – 2014/2015 in Billions of Gallons per Year Assuming Sucrose Production Levels Increase 7% Per Year	187
Figure 6-26: Brazilian Exports in Billions of Gallons 2008/2009 – 2014/2015	188
Figure 6-27: 2008 Global Ethanol Production in Millions of Gallons	188
Figure 6-28: Projected Growth of First-Generation Ethanol Production from Marginal Producers 2008-2015 in Billions of Gallons	189
Figure 6-29: Global Ethanol Exported to U.S. (Non-Brazilian) in Billions of Gallons	189
Figure 6-30: Aggregate Global Ethanol Production 2008-2015 in Billions of Gallons	190
Figure 6-31: Global First-Generation Ethanol Production Estimates and Gasoline Equivalency in Billions of Gallons per Year	190
Figure 6-32: Estimated Cellulosic Ethanol Capacity 2009-2015 in Millions of Gallons	192
Figure 6-33: U.S. Cellulosic Production 2009-2015 in Millions of Gallons	193
Figure 6-34: U.S. Cellulosic Ethanol Production vs. RFS Mandates 2009-2015 in Millions of Gallons	194
Figure 6-35: Projected Disparity Between Production and Capacity of U.S. Cellulosic Ethanol 2009-2015	194
Figure 6-36: U.S. Cellulosic Ethanol Production vs. Rest of the World 2009-2015 in Millions of Gallons	196
Figure 6-37: Total U.S. Ethanol Supply and Gasoline Equivalency 2009-2015 in Billions of Gallons	196
Figure 6-38: Combined Sources of U.S. Ethanol Supply and the Amount of Gasoline and Imports it Displaces 2009-2015	197
Figure 6-39: Estimated Global Diesel Consumption 2009-2015 in Million Barrels Per Day	198
Figure 6-40: 2009E Global Diesel Consumption By Region in Million Barrels Per Day (MBD)	198
Figure 6-41: 2008 Global Biodiesel Production in Millions of Gallons	199
Figure 6-42: U.S. Biodiesel Production 2008-2015	199
Figure 6-43: U.S. Biodiesel Capacity Projections through 2015 in Millions of Gallons	200
Figure 6-44: Projected E.U. Biodiesel Imports in Millions of Gallons through 2015	202
Figure 6-45: Projected E.U. Biodiesel Imports in Millions of Gallons through 2015	202
Figure 6-46: Global Aggregate Biodiesel Production 2008-2015 in Millions of Gallons	203
Figure 6-47: Global Biodiesel Production and Capacity 2008-2015	204
Figure 6-48: Displacement of Global Diesel By First-Generation Biodiesel 2009-2015	204
Figure 6-49: U.S. Algae Biofuels Production Capacity 2009-2015 in Millions of Gallons	206
Figure 6-50: U.S. Algae Biofuel Production Capacity 2016-2022 in Billions of Gallons	208
Figure 6-51: Projected Regional Market-Shares of Algae Biofuel Industry 2009-2022	209
Figure 6-52: Global Algae Biofuel Production Capacity 2022 in Billions of Gallons	209
Figure 6-53: Global Algae Biofuel Production vs. Capacity 2022 in Billions of Gallons	210
Figure 6-54: Projected Global Applications of Algae Biofuels 2022	211
Figure 6-55: Global Algae Production Capacity in 2022 by Market Segment	211

Figure 6-56: Algae Biofuel Displacement of Various Petroleum Products in 2022	212
Figure 6-57: BioButanol Nameplate Capacity 2009-2015 in Millions of Gallons	214
Figure 6-58: BioButanol Production 2009-2015 in Millions of Gallons	214
Figure 6-59: Advanced Diesel Capacity 2009-2015 in Millions of Gallons	215
Figure 6-60: Advanced Diesel Production 2009-2015 in Millions of Gallons	215
Figure 6-61: Synthetic Jet Fuel Production Capacity 2009-2015 in Millions of Gallons	217
Figure 6-62: Petroleum Substitute Hydrocarbon Capacity 2009-2015 in Millions of Gallons	218
Figure 6-63: Petroleum Substitute Hydrocarbon Production 2009-2015 in Millions of Gallons	219
Figure 6-64: Global Capacity of Third-Generation Biofuels in 2015, in Millions of Gallons	220
Figure 6-65: Global Production of Various Third-Generation Biofuels in 2015, in Millions of Gallons	221
Figure 6-66: Global Production of Total Third-Generation Synthetic Biofuels 2016-2022 (Not Including Algae) in Millions of Gallons	221
Figure 6-67: % of Harvests Dedicated to Various Biofuels in 2008	222
Figure 6-68: Global Production of Biofuels that Replace Gasoline 2009-2022 in Billions of Gallons	223
Figure 6-69: % of Global Gasoline Replaced by First-, Second-, and Third-Generation Biofuels 2009-2022	224
Figure 6-70: Global Production of Biofuels that Replace Diesel 2009-2022 in Billions of Gallons	224
Figure 6-71: % of Global Diesel Replaced by First-, Second-, and Third-Generation Biofuels	225
Figure 6-72: Global Biomass-based Jet Fuel Substitute Production 2009-2022 in Billions of Gallons	225
Figure 6-73: % of Global Jet Fuel Replaced by Third-Generation Biofuels 2009-2022	226
Figure 6-74: Global Production of Biofuels by Generation in Billions of Gallons 2009	227
Figure 6-75: Global Production of Biofuels by Generation in Billions of Gallons 2015	227
Figure 6-76: Global Production of Biofuels by Generation in Billions of Gallons 2022	228
Figure 6-77: Algae Biofuels' Capacity to Displace U.S. Petroleum	229
Figure 6-78: Snapshot of U.S. Transportation Petroleum Consumption 2009	230
Figure 6-79: U.S. Petroleum Production and Consumption 1970-2008 in Million Barrels per Day	230
Figure 6-80: Relationship between Price of Crude Oil (\$/bbl) and Annual U.S. Imports of Petroleum for Transportation (in Billions of Dollars)	231
Figure 7-1: 2008 Global VC Funding of Cellulosic Ethanol, Algae Biofuels, Third-Generation Synthetic Biofuels in Millions of dollars	241
Figure 10-1: Biofuel Abbreviations and Definitions	295
Figure 10-2: Biofuel Technological Pathways	295
Figure 10-3: Major Oil Companies' Investment in Biofuels	296
Figure 10-4: List of VC Investors In Biofuels	296
Figure 10-5: Second- and Third-Generation Biofuel VC Investments in 2008	298
Figure 10-6: Venture Capital Funding of U.S. Second- and Third-Generation Biofuel Companies in Millions of Dollars	298
Figure 10-7: 2009 First and Second Quarter VC Investment in Advanced Biofuels	299

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1 EXECUTIVE SUMMARY

Oil is a problematic energy source for reasons other than volatile prices and diminishing supplies. In recent years, the consensus in the scientific community is that climate change is real and is driven largely by carbon emissions that stem from human behaviors. One response to the threat of climate change would be to regulate the use of carbon fossil fuels with an externality tax or some other policy measure. Taxing fossil fuels would drive up the price of petroleum products, making alternative fuels more economically attractive. Yet, can alternative fuels compete without policy initiatives?

This report is an inquiry into the role of biofuels as a legitimate substitute to displace the primacy of petroleum transportation fuels. Our research was guided by the following questions:

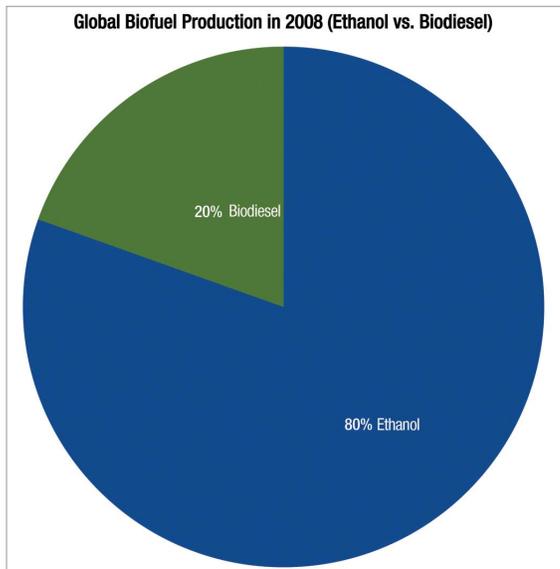
- » What are the different types of biofuels and to which of them should more attention be paid?
- » Will biofuels ever be price-competitive with fossil fuels without subsidies? If so, when?
- » When, if ever, will biofuels displace significant volumes of liquid petroleum products?

The findings of this report are the results of a comprehensive research project, as well as a series of fact-finding interviews of scientists, policymakers, academics, and more than 40 first-, second-, and third-generation biofuel companies. As a result of this extensive research and analysis undertaking, this report provides insights and accurate information on the following biofuel subject areas:

- » Regional and global **market dynamics**
- » Established and experimental **technology** pathways
- » Recent and future biofuel **policies** and their market implications
- » The strengths and weaknesses of **feedstock** choices
- » The **economics** of each generation of biofuel
- » **Profiles** of 40 of the most interesting global biofuel companies

Our research revealed that the global biofuels paradigm is poised to dramatically shift in the coming years. First-generation biofuels (consisting of grain or sucrose-based ethanol and oil seed-based biodiesel) are currently the only commercially viable and available forms of biofuel. Of the 21.5 billion gallons of biofuel produced in 2008, 80% was ethanol (17.3Bgal), while biodiesel accounted for the other 20% (4.1Bgal).

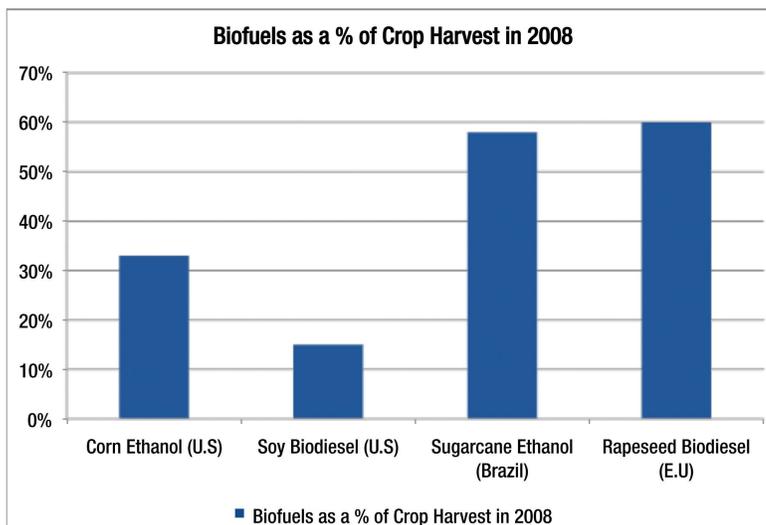
FIGURE 1-1: 2008 GLOBAL BIOFUEL PRODUCTION IN BILLIONS OF GALLONS



Source: The Prometheus Institute

In 2008, ethanol production displaced 3.7% of global gasoline consumption, while biodiesel accounted for 1.5% of the global diesel market (on equivalent Btu levels). When we consider the amount of cropland consumption that was required to displace a relatively minor amount of petroleum, we find that current first-generation biofuels are highly problematic. For example, the United States is the largest corn producer in the world. In 2008, the U.S. allocated approximately 33% of its entire corn crop to displace about 5% of its gasoline needs. Similarly, in 2008, the EU used about 60% of its rapeseed harvest to replace 3% of its diesel consumption.

FIGURE 1-2: 2008 REGIONAL CROP DISPLACEMENT BY BIOFUEL PRODUCTION



Source: The Prometheus Institute

Given the land-use constraints that face the current generation of biofuels, there is significant enthusiasm from policymakers and entrepreneurs for the commercialization of “advanced” biofuels whose production will not compete with food crops. Based on our analysis of the strengths, weaknesses, and opportunities for advanced biofuels, prospects for the production of significant amounts of biofuel from non-food feedstocks are appealing, but they remain limited by complicated logistics. For example, it is estimated that a cellulosic ethanol plant with a production capacity of 50MGY would require a truckload of biomass to be delivered every six minutes, 24 hours per day and 365 days per year. Furthermore, this biomass will most likely come from unconventional energy crops whose growth, harvest, collection, and transportation methods will differ from the well-established practices of mainstream crops like corn, wheat, soybeans, etc.

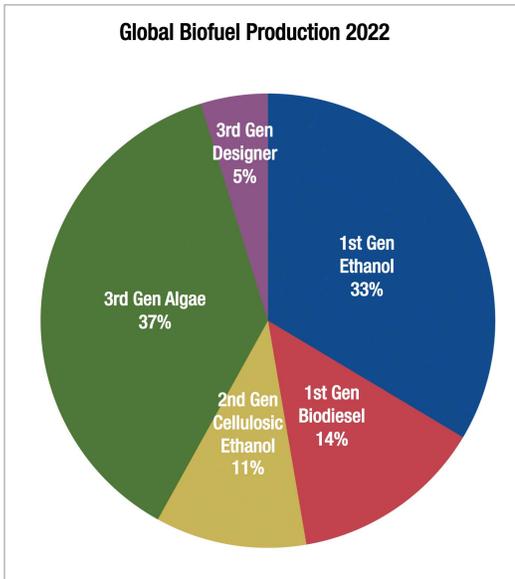
Based on the findings of this report, we forecast that although second-generation cellulosic ethanol will likely achieve commercialization around 2011, its prospects will be limited due to land-use issues, logistical challenges, and fresh-water constraints. Although third-generation technologies such as algae lag behind second-generation cellulosic biofuels by several years, algae biofuels are truly revolutionary and will almost certainly become an unsubsidized economic inevitability around 2016. However, this conclusions will materialize only if algae can achieve the following operational parameters:

- » Algae yields reach 5,000-10,000 gallons of diesel per acre per year (compared to corn, which yields 350 gal/acre/year of ethanol, and soybean oil which provides 50gal/acre/year of biodiesel)
- » Algae is grown on marginal or desert land using brackish or salt water (thus eliminating the need for scarce agricultural land or freshwater)
- » It consumes CO₂ as a feedstock, resulting in the production of algae biofuels being close to carbon neutral
- » Using algae for biofuel production does not compete with human or animal food sources

Algae oil can be refined into gasoline, diesel, or jet fuel (as opposed to other biofuels that are limited to a specific transportation application) as well as a number of nutritional and cosmetic supplements, animal feed, and other by products.

We project that by 2022, third-generation biofuels will be the largest global biofuel source, accounting for 37% (40 billion gallons) of total biofuel production (on a volumetric basis).

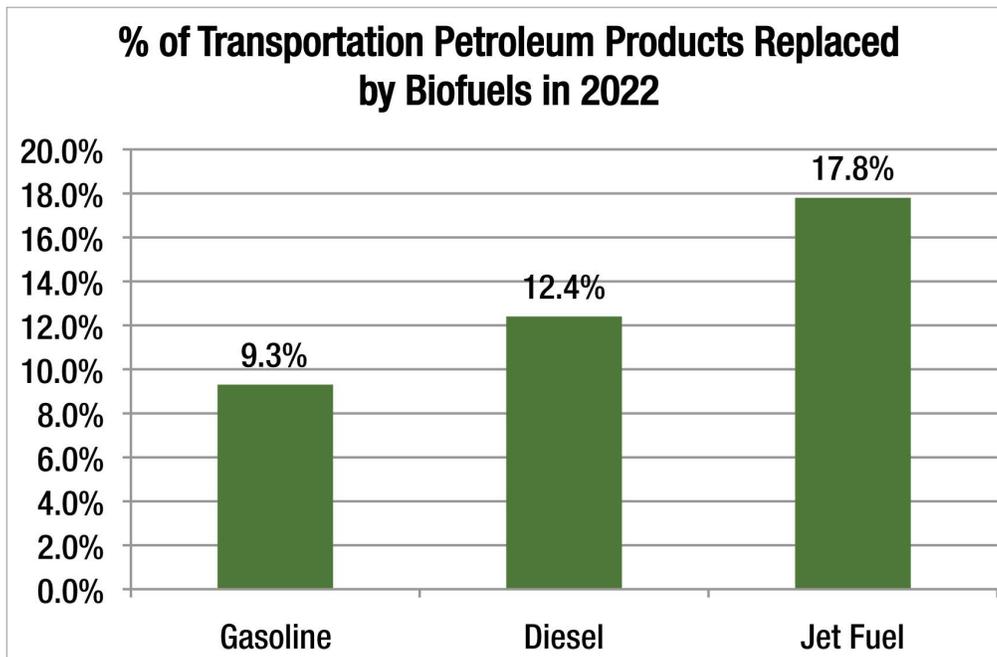
FIGURE 1-3: GLOBAL BIOFUEL PRODUCTION IN 2022, IN BILLIONS OF GALLONS



Source: The Prometheus Institute

In extrapolating our projections in transportation petroleum demand growth in emerging economies throughout the world, we estimate that in 2022, 834 billion gallons of gasoline, diesel, and jet fuel-like products will be consumed globally -- 169 billion gallons more than in 2009. Biofuel production is expected to make up 109 billion gallons of this amount, accounting for 9.3% of the global gasoline market, 12.4% of diesel, and 17.8% of all jet fuel consumed.

FIGURE 1-4: % OF GLOBAL TRANSPORTATION PRODUCTS DISPLACED BY BIOFUELS IN 2022



Source: The Prometheus Institute

This report is intended to be a comprehensive, holistic, and nuanced overview of the global biofuel industry designed for a target audience of investors, entrepreneurs, policymakers, academics, research institutions, and companies with an interest in the field. In the coming years, we believe the global biofuel industry will develop into a market measured in the hundreds of billions of dollars, and a major sector in the cleantech space. Though the near-term prospects of biofuel firms remain uncertain, the industry is full of potential and should be watched closely as its technologies and companies continue to evolve and emerge over the next few years.

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