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Sustainable International Bioenergy Trade: Securing Supply and Demand

Country Report—United States

June 2009

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CONTENTS

ACRONYMS viii

1. GENERAL INTRODUCTION 1
   - 1.1 Country Characteristics 1
   - 1.2 Main Industries 1
   - 1.3 CO_2 Reductions 3
   - 1.4 Energy Production 3
     - 1.4.1 Renewable Energy 4
   - 1.5 Electricity Production 5
   - 1.6 Energy Consumption 6
     - 1.6.1 Petroleum 7
     - 1.6.2 Coal 7
   - 1.7 Further Country-Specific Energy-Related Information 8

2. POLICY 10
   - 2.1 Targets for Renewable Energy 10
     - 2.1.1 Background 10
     - 2.1.2 Federal Targets for Biofuels Production 10
     - 2.1.3 Targets Set by Other Groups 10
     - 2.1.4 Federal Agency Role as Mandated by Congress 11
   - 2.2 Financial Support Measures for Biomass 12
   - 2.3 Other Measures to Stimulate Biomass/Biofuels 14

3. BIOMASS RESOURCES 16
   - 3.1 Geographical Biomass Resource Potential 16
   - 3.2 Economic Biomass Resource Potential 17
   - 3.3 Agricultural Resources 17
   - 3.4 Forest Resources 19

4. CURRENT AND PROJECTED USE OF BIOMASS FOR ENERGY 20
   - 4.1 Current and Projected Use of Biomass Resources 20
   - 4.2 Trend Analysis of Domestic Production/Consumption 21
     - 4.2.1 Biopower 21
     - 4.2.2 Biobased Transportation Fuels 21
     - 4.2.3 Biobased Products 21
     - 4.2.4 “20 in 10” Goal 21
   - 4.3 Full Quantification of all Biomass Types in Use 22

5. CURRENT BIOMASS USERS 24
   - 5.1 Main Users 24
   - 5.2 Quantitative List of Biomass Plants 26
     - 5.2.1 U.S. Biorefineries by Location 26

6. BIOMASS PRICES 36
   - 6.1 Average Prices of Main Biofuels for Large-Scale Users 36

6.2 Fuel Price Comparisons over Time for Large-scale Users" ... 38
7. BIOMASS IMPORT AND EXPORT ... 40
7.1 Ethanol ... 40
7.2 Biodiesel ... 40
7.3 Biomass Pellets ... 42
8. BARRIERS & OPPORTUNITIES ... 46
8.1 General Barriers and Opportunities for Biomass ... 46
8.2 Barriers and Opportunities for International Biomass Trade ... 49
8.2.1 Economic ... 51
8.2.2 Technical ... 51
8.2.3 Logistical ... 51
8.2.4 International ... 51
8.2.5 Ecological ... 52
8.2.6 Competing Markets ... 52
8.2.7 Legal ... 52
8.2.8 Information ... 52
8.3 U.S. Participation in International Biomass Trade ... 52
9. REFERENCES ... 54

FIGURES

Figure 1. Total energy consumption by sector. ... 6
Figure 2. Overall energy consumption and energy consumption per capita in the United States over last half century. ... 8
Figure 3. Estimated percent of total federal subsidies for renewable fuels in 2006, allocated by fuel source ... 12
Figure 4. Annual biomass resource potential from forest and agricultural resources. ... 16
Figure 5. Geographical resource potential on federal lands in the continental United States. ... 16
Figure 6. Summary of cropland uses, idle cropland, and cropland pasture in the contiguous United States. ... 17
Figure 7. Regional Biomass Energy Feedstock Partnership development work underway: 2008 Bioenergy Crop Trials. ... 18
Figure 8. Summary of potentially available forest resources. ... 19
Figure 9. Current and projected biomass resource volume and potential availability for energy ... 20
Figure 10. U.S. biorefineries by location (under construction and currently operational) ... 26
Figure 11. Corn: Price per bushel, 1975–2007 (2007 Dollars). ... 36
Figure 12. Price ranges per biofuel type (yearly average). ... 38
Figure 13. Price ranges per fossil fuel type (yearly average). ... 38
Figure 14. Price ranges for crude oil (yearly average). ... 38
Figure 15. Estimated consumption of fuel ethanol from 2006 to 2030 (Scenario 1). (Assumes ethanol displaces 10% of global gasoline production by 2030.) ... 50

Figure 16. Estimated fuel ethanol capacity of production (conventional technologies). 50
Figure 17. Estimated balance between potential supply and demand of fuel ethanol (Scenario 1 for USA [GI]). 50

TABLES

Table 1. U.S. industries ranked by total economic expenditure (2007). 2
Table 2. U.S. industries with relevance to biomass. 2
Table 3. Primary energy production ranked by source, 2006. 3
Table 4. Electrical production in the United States, 2006. 5
Table 5. Sector summaries.' 6
Table 6. Primary energy consumption by source, 2006. 7
Table 7. Renewable energy consumption by source, 2006. 8
Table 8. Biofuels targets mandated by EISA. 11
Table 9. Federal and state investments in lignocellulosic biorefineries awarded February 2007.' 13
Table 10. Federal and state investments in lignocellulosic biorefineries awarded January, as of 2008.' 13
Table 11. Gasoline and Ethanol: Comparison of current and potential production costs in North America (U.S. dollars per gasoline-equivalent liter). 17
Table 12. Hectares under cultivation, average stover yields, and estimated residue produced for top corn-producing states (USDA-NASS, 2008). 18
Table 13. Industrial biomass energy consumption and electricity net generation by industry and energy sources, 2006. 22
Table 14. Industrial biomass energy consumption and electricity net generation by industry." 24
Table 15. Renewable energy consumption by sector, 2006. 25
Table 16. U.S. fuel ethanol industry biorefineries and capacity. 26
Table 17. Undenatured ethanol cash operating expenses and net feedstock costs for dry-milling process by plant size, 2002. 36
Table 18. U.S. fuel ethanol imports by country, 2002–2007 (millions of gallons). 40
Table 19. U.S. biodiesel exports and imports (million gallons, except shares) 41
Table 20. Biodiesel annual statistics (million gallons). 42
Table 21. Contributing costs (2007$) and technical targets for "Process Concept: Herbaceous Biomass Production (Resource Standing in Field)." 46
Table 22. Contributing costs (2007$) and technical targets for "Process Concept: Dilute Acid Pretreatment, Enzymatic Hydrolysis, Ethanol Fermentation and Recovery, Lignin Combustion for CHP (Corn Stover)." 47
Table 23. Contributing costs (2007$) and technical targets for "Process Concept: Feedstock Collection, Preprocessing, and Delivery to Conversion Reactor Inlet (Dry Herbaceous Biomass)." 48

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ACRONYMS

BDT	billion dry ton
bgy	billion gallons per year
BRDI	Biomass Research and Development Initiative
CBI	Caribbean Basin Initiative
DOE	Department of Energy
DOT	Department of Transportation
EERE	Energy Efficiency and Renewable Energy
EIA	Energy Information Administration
EISA	Energy Independence and Security Act of 2007
EPA	Environmental Protection Agency
EPACT	Energy Policy Act
EU	European Union
GBEP	Global Bioenergy Partnership
GDP	gross domestic product
IEA	International Energy Agency
INL	Idaho National Laboratory
IRS	Internal Revenue Service
MDT	million dry ton
MTBE	methyl tertiary butyl ether
MYYP	multi-year program plan
NGPL	natural gas plant liquids
NREL	National Renewable Energy Laboratory
RD&D	research, development, and demonstration
RFS	Renewable Fuels Standard
RGGI	Regional Greenhouse Gas Initiative
USDA	United States Department of Agriculture
WCI	Western Climate Initiative

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International Energy Agency (IEA) Task 40 Country Report—United States June 2009

1. GENERAL INTRODUCTION

1.1 Country Characteristics

The United States' population as of August 2008 was 304,967,620,[1] and the gross domestic product (GDP) was $14,256.5 billion (2008 dollars).[2] The United States has a total land area of nearly 2.3 billion acres with an approximate breakdown of land use as follows:

- Forest land, 651 million acres (28.8%)
- Grassland pasture and range land, 587 million acres (25.9%)
- Crop land, 442 million acres (19.5%)
- Special uses (primarily parks and wildlife areas), 297 million acres (13.1%)
- Miscellaneous other uses, 228 million acres (10.1%)
- Urban land, 60 million acres (2.6%).[3]

The most consistent trends in major uses of land (1945 to 2002) have been upwards in special-use and urban areas and downwards in total grazing lands. Forest-use area generally declined from 1949 to 1997 but increased by about 1% from 1997 to 2002. Total cropland area has declined over this 57-year period, but it has not done so consistently. Total cropland area increased in the late 1940s, declined from 1949 to 1964, increased from 1964 to 1978, and then declined again from 1978 to 2002.[4]

1.2 Main Industries

Table 1 lists sales, receipts, and shipments for major U.S. industries. The top 8 industries (in bold) represent approximately 90% of the total economic expenditure in the United States. Within the main industries shown in Table 1, several sub-industries exist that have specific relevance to biomass. These industries are shown in Table 2.

Table 1. U.S. industries ranked by total economic expenditure (2007).[5]

Description	Sales, Shipments, or Receipts ($1,000)	Total Economic Expenditure (%)
Wholesale trade	603,922,7184	20.9
Manufacturing	5,339,345,058	18.5
Retail trade	3,932,027,444	13.6
Finance and insurance	3,641,082,600	12.6
Construction	1,781,778,684	6.1
Healthcare and social assistance	1,697,230,614	5.8
Professional, scientific and technical services	1,344,760,849	4.7
Information	1,075,153,974	3.7
Transportation and warehousing	655,857,245	2.3
Administrative and support and waste management and remediation services	636,657,422	2.2
Accommodation and food services	612,949,468	2.1
Utilities	581,553,952	2.0
Real estate, rental, and leasing	493,911,736	1.7
Other services (except public administration)	417,512,388	1.4
Mining, quarrying, oil and gas extraction	368,191,012	1.3
Arts, entertainment, and recreation	188,975,642	0.7
Management of companies and enterprises	173,120,738	0.6
Educational services	47,241,063	0.2
Totals	**29,026,577,073**	**100.0**

Table 2. U.S. industries with relevance to biomass.[6]

Industry/Sub Industry	Relevance to Biomass
Forestry, logging, fishing, hunting, trapping, and agricultural support activities	Biomass collection, harvesting, and other forest and agricultural services are resources whose byproducts are used to produce biofuels, bio-power, and bio-based products.
Electric power generation, transmission, and distribution	Biomass and Municipal Solid Waste are used for production of electric power.
Water, sewage, and other systems	Possible opportunity for anaerobic digestion.
Food manufacturing	Waste products from food manufacturing can be used for biofuels and bio-based products. Grain and oilseed milling would be obvious forms of food manufacturing that are relevant to biomass.
Paper manufacturing	Waste streams from paper manufacturing, such as black liquor, can be used to produce biofuels and biopower. Pulp, paper, and paperboard mills would be an example of a sub-industry of paper manufacturing that is relevant to biomass.
Petroleum and coal products manufacturing	Biomass inputs could be used for fuels blends and chemical production.
Pesticide, fertilizer, and other agricultural chemical manufacturing	Biomass could be used as an input to some of these chemical productions.
Plastics and rubber products manufacturing	Biomass can be an input for bio-based products and other alternatives to plastics, etc.
Wood product manufacturing	Waste products from wood manufacturing can be used for biofuels and biopower.
Farm Product Raw Material Wholesalers	This industry group comprises establishments primarily engaged in wholesaling agricultural products (except raw milk, live poultry, and fresh fruits and vegetables), such as grains, field beans, livestock, and other farm product raw materials (excluding seeds). Grain and field-bean wholesalers would be an example of a sub-industry of wholesale trade that is relevant to biomass.

1.3 CO_2 Reductions

Although a number of state and regional programs exist to limit carbon dioxide emissions (e.g., the northeastern Regional Greenhouse Gas Initiative [RGGI] and the Western Climate Initiative [WCI]), no *federal* limits exist on such emissions. In the absence of federal limits and as the economy has expanded, CO_2 emissions have increased over the years. The U.S. Environmental Protection Agency (EPA) reports that in 2006 overall CO_2 emissions were 5,983.1 teragrams (Tg, 10^{12}g), an 18% increase over 1990 levels.[7]

There are requirements at the federal level, however, that are intended to reduce overall carbon dioxide emissions, as well as those of certain air pollutants, without directly limiting such emissions. For example, the Energy Policy Act (EPACT) of 2005 mandated that the EPA establish a Renewable Fuels Standard (RFS) program. In response, EPA set a statutory default requiring that, in 2006, 2.78% of all gasoline sold is derived from renewable sources (e.g., ethanol). Because renewable fuels are carbon neutral, their use equates with a reduction in the total amount of carbon dioxide that would have been emitted to the atmosphere if all gasoline sold was petroleum derived. EPA estimates that the RFS will reduce annual CO_2-equivalent emissions of greenhouse gases from 8.0 to 13.1 Tg.

Although the United States signed and ratified the United Nations Framework Convention on Climate Change and signed the Kyoto Protocol, it has not, to date, ratified the latter agreement. Doing so would commit the country to reducing its greenhouse gas emissions to 93% of its 1990 levels during the commitment period of 2008 to 2012, and the magnitude of that challenge has grown over the years as overall emissions have increased as indicated above. As of 2006, a reduction of 1,269.4 Tg would have been needed to comply with the Kyoto Protocol target.[8] Therefore, achieving such a reduction will offer significant technical and economic challenges even in the absence of expected population growth.

1.4 Energy Production

Of the 71.025 quadrillion British thermal units (BTU) produced in the United States, 6.872 quadrillion BTU are produced from renewable energy (Table 3). Of that, 3.324 quadrillion BTU are produced from biomass sources, which comprises 48.37% of renewable energy and 4.68% of total energy produced (Table 3).

Table 3. Primary energy production ranked by source, 2006.[9]

Energy Type		**Quadrillion BTU**	**Production (%)**
Fossil Fuels	*Coal*	*23.790*	*33.495*
	Natural Gas (dry)	*19.022*	*26.7821*
	Crude Oil	*10.801*	*15.207*
	NGPL[a]	*2.356*	*3.317*
		55.968	**78.801**
Nuclear Electric Power		**8.214**	**11.565**
Renewable Energy	*Hydro Electric Power*	*2.869*	*4.039*
	Geothermal	*0.343*	*0.483*
	Solar	*0.072*	*0.101*
	Wind	*0.264*	*0.371*
	Biomass	*3.309*	*4.658*
		6.857	**9.654**
Total		**71.039**	**100.00**

a. Natural gas plant liquids.

1.4.1 Renewable Energy

Renewable energy resources provide just over 6% of the total energy used in the United States today. Making the largest contribution to the country's renewable energy, hydroelectric plants produce 300,000 MW per year,[10] three times as much as any other renewable source and 150 times that of wind power. The Pacific Northwest and the Middle Atlantic states lead the way in hydroelectricity production, most of which is produced for electric utilities.

Wind power is a growing industry in the United States. In 2008, wind power capacity increased by 50% with the installation of 8,358 MW of generation capacity. Wind is especially site-specific; areas in Colorado, Idaho, Wyoming, Montana, the Dakotas, and along the Appalachian Mountains on the East Coast have been identified as having high wind potential. In order for wind power to become a more substantial contributor to the renewable energy market, the U.S. Department of Energy (DOE) Energy Efficiency and Renewable Energy (EERE) program has identified the need to improve technology, infrastructure, and siting capabilities.

Solar and geothermal energy production industries are limited by current technology, but development is progressing. Geothermal energy has been identified as a potentially significant source of electricity and heat, primarily in the Western United States. Solar power is used for both heat (thermal solar) and electricity (photovoltaic solar). Thermal solar power is used for a variety of applications, from heating swimming pools to producing steam for electricity. Photovoltaic solar power has been growing steadily in the United States since the late 1990s. Further development for both solar and geothermal energy production is being pursued through government agencies, laboratories, and universities.

Biomass is the largest source of renewable energy consumed (~49%). The largest type of biomass consumed is wood, followed by biofuels (mainly ethanol and biodiesel) and waste. Hydroelectric power is another large contributor to renewable energy consumption, at 41.45% of total renewable energy consumed (Table 7).

1.4.1.1 Biofuels

In recent years there has been an increased interest in biofuels—bioethanol and biodiesel derived from common agricultural staples or waste. Increased domestic production of these fuels could reduce U.S. expenditure on foreign oil and improve energy security if methods of producing and transporting the fuels do not involve heavy inputs of fossil fuels, as current agricultural systems do.

In *Annual Energy Outlook 2007*, the Energy Information Administration (EIA) predicts that ethanol consumption will reach 11.2 billion gallons by 2012, surpassing the 7.5 billion gallons required in the RFS that was enacted as part of the EPACT of 2005.[11]

Most cars on the road today in the United States can run on blends of up to 10% ethanol, and motor vehicle manufacturers already produce vehicles designed to run on much higher ethanol blends. Portland, Oregon, recently became the first U.S. city to require all gasoline sold within city limits to contain at least 10% ethanol.[12] Ford, Chrysler, and General Motors are among the automobile companies that sell "flexible-fuel" cars, trucks, and minivans that can use gasoline and ethanol blends ranging from pure gasoline up to 85% ethanol (E85). By mid 2006, there were approximately six million E85-compatible vehicles on U.S. roads.[13]

The Renewable Fuels Association reports 113 U.S. ethanol distilleries in operation and another 78 under construction, with capacity to produce 11.8 billion gallons within the next few years.

Expanding ethanol fuel (and biodiesel) industries provides jobs in plant construction, operations, and maintenance, mostly in rural communities. According to the Renewable Fuels Association, in 2005 alone, the ethanol industry created almost 154,000 U.S. jobs, boosting household income by $5.7 billion.[14] It also contributed about $3.5 billion in tax revenues at the local, state, and federal levels.[15]

There is growing international criticism about the production of ethanol fuel from food crops.[16,17,18,19]

1.5 Electricity Production

Domestic electricity production is primarily drawn from coal-fired boilers (49.1% of total production), followed by nuclear power (19.4% of total production). A total of 9.4% of U.S. electric power comes from renewable resources, primarily from hydroelectric (7% of total U.S. electricity production) and biomass (1.3% of total U.S. electricity production) (Table 4).

Table 4. Electrical production in the United States, 2006.[20]

Power Source	Units in Operation	Total Nameplate Capacity (MW)	Total Capacity (%)	Annual Production (Billion kWh)	Annual Production (%)
Wind Power	341	11,603	1.08	30.3	0.7
Solar Energy	31	411	0.04	2.1	0.1
Petroleum Coke Fueled Boiler	31	1,754	0.16	46.4	1.1
Oil Fired Boiler	327	34,975	3.25	7.8	0.2
Nuclear Power	104	105,584	9.82	787	19.4
Natural Gas Fueled Boiler	776	97,632	9.08	159	3.9
Diesel Generators	4,514	8,563	0.8	13.8	0.3
Incinerators	96	2,671	0.25	12.3	0.3
Hydroelectric	4,138	96,988	9.02	282	7.0
Geothermal	215	3,170	0.29	13.5	0.30
Fuel Oil	13	956	0.09	8.5	0.2
Combustion Turbine Generators	2,882	155,227	14.4	147	3.6
Combined Cycle Natural Gas	1,686	216,269	20.1	505	12.4
Coal Fired Boilers	1,460	333,115	30.9	1,995	49.1
Biomass	270	6,256	0.58	53.5	1.3

1.6 Energy Consumption

The U.S. DOE tracks national energy consumption in four broad sectors: industrial, transportation, residential, and commercial. The industrial sector has long been the country's largest energy user, currently representing about 33% of the total. Next in energy use is the transportation sector, followed by the residential and commercial sectors (Table 5 and Figure 1).

Table 5. Sector summaries.[21,22]

Sector	Description	Major Uses[23,24]
Industrial	Facilities and equipment used for producing and processing goods.	22% Chemical production 16% Petroleum refining 14% Metal smelting/refining
Transportation	Vehicles that transport people/goods on ground, air, or water.	61% Gasoline fuel 21% Diesel fuel 12% Aviation
Residential	Living quarters for private households.	32% Space heating 13% Water heating 12% Lighting 11% Air conditioning 8% Refrigeration 5% Electronics 5% Wet-clean (mostly clothes dryers)
Commercial	Service-providing facilities and equipment (businesses, government, other institutions).	25% Lighting 13% Heating 11% Cooling 6% Refrigeration 6% Water heating 6% Ventilation 6% Electronics

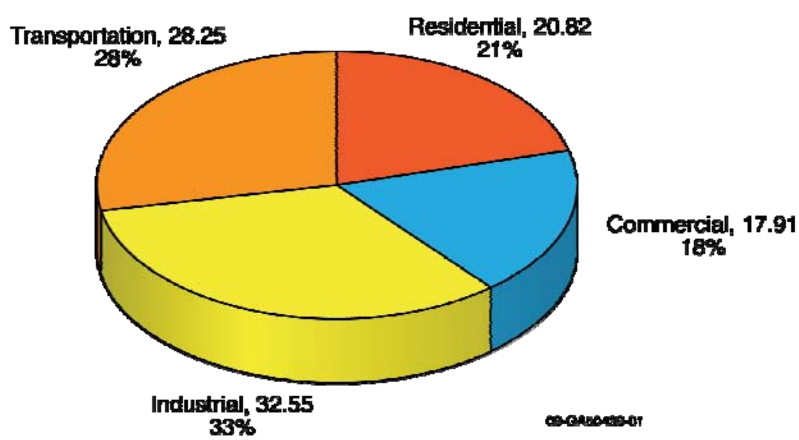

Figure 1. Total energy consumption by sector.[25]

Currently, fossil fuels are used to produce almost 85% of total energy consumed in the United States, while nuclear energy is used to produce roughly 8% and renewable resources about 7% (Table 6).

Table 6. Primary energy consumption by source, 2006.[26]

Energy Type		Quadrillion BTU	Consumption (%)
Fossil Fuels	*Coal*	*22.447*	*22.50*
	Natural Gas	*22.224*	*22.28*
	Petroleum	*39.958*	*40.06*
		84.629	***84.84***
Nuclear Electric Power		**8.214**	**8.23**
Renewable Energy	*Hydro Electric Power*	*2.869*	*2.88*
	Geothermal	*0.343*	*0.4*
	Solar	*0.072*	*0.07*
	Wind	*0.264*	*0.26*
	Biomass	*3.361*	*3.37*
		6.909	**6.93**
Total		**99.752**	**100.00**

1.6.1 Petroleum

The United States consumes 20.8 million barrels (3,310,000 m^3) of petroleum a day,[27] of which 9 million barrels (1,400,000 m^3) are used to produce motor gasoline. The transportation sector has the highest consumption rates, accounting for approximately 68.9% of the U.S. petroleum use in 2006,[28] and 55% of worldwide oil use,[29] as documented in the Hirsch report. Automobiles are the single largest consumer of oil, at 40%,[30] and are also the source of 20% of the nation's greenhouse gas emissions.

The United States is increasingly dependent on imports to meet its energy needs. Crude oil imports for 2007 accounted for about 66% of total demand for crude oil—up from 36% in 1986.[31]

U.S. production of crude oil has dropped steadily over the past 20 years from 248,629 thousand barrels in 1988 to 154,867 thousand barrels in 2008—a decrease of 37.7%.[32]

Crude oil imports have increased steadily over the past 20 years from 1.7 billion barrels in 1987 to 3.65 billion barrels in 2007, an increase of 115%.[33]

1.6.2 Coal

America is self-sufficient in coal.[34] Indeed, it has several hundred years' supply at the current use rate.[35,36] The United States' trend in coal use has been rising for decades. From 1950 through 2006, both coal production and coal consumption in the United States have more than doubled.[37] The U.S. population has almost doubled in this time period as well, while the per capita energy use has been declining since 1978.[38, 39]

Table 7. Renewable energy consumption by source, 2006.[40]

Energy Type		Trillion Btu	Consumption (%)
Hydroelectric Power		**2,869.04**	**41.45**
Biomass	*Wood*	*2,171.73*	*31.38*
	Waste	*407.23*	*5.88*
	Biofuels	*794.99*	*11.49*
		3,373.95	**48.74**
Geothermal		**342.88**	**4.95**
Solar		**72.22**	**1.04**
Wind		**263.74**	**3.81**
Total		**6,921.82**	**100.00**

1.7 Further Country-Specific Energy-Related Information

The U.S. population is growing at a rate of 0.85%, adding nearly three million people every year (based on growth rate from 2007 to 2008).[41] The U.S. Census projects that this growth rate will slow over the coming decades to a projected population growth rate of 0.5% by 2050. However, this does not reflect the raw growth of the United States, which is projected to reach 392 million people by 2050, assuming current rates of immigration and trends regarding birthrates. Figure 2 correlates U.S. population and energy consumption, illustrating that while overall energy consumption in the United States has grown, the per capita energy consumption has actually slowed and leveled off in the past decade. The EIA projects a gradual decline in energy consumption per capita through 2030 due to improved technology, government mandates and initiatives, and continuing high oil prices. Total consumption will continue to rise slowly if current trends hold constant, while per capita consumption should go down over the next few decades.

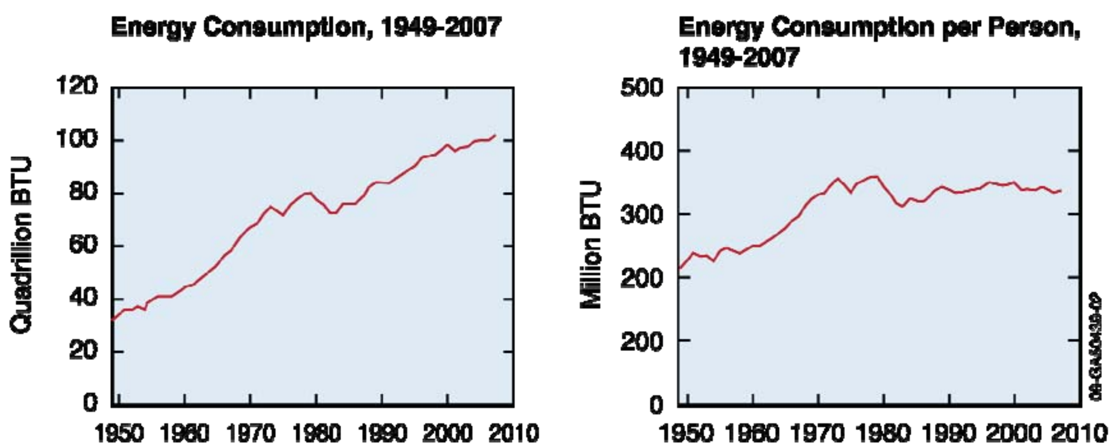

Figure 2. Overall energy consumption and energy consumption per capita in the United States over last half century.[42]

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2. POLICY

2.1 Targets for Renewable Energy

2.1.1 Background

The national renewable energy targets set by the United States focus on biofuels production. The first federal endorsement of biofuels came with the passage of the 1978 Energy Tax Act. The act introduced a 100% exemption of the gasoline tax for alcohol fuel blends (which was $.04 at the time).[43] With the exemption still in place, biofuels, particularly ethanol, received more attention as a possible oxygenate to be used in reformulated gasoline as outlined in the Clean Air Act Amendments of 1990, which directed the U.S. EPA to establish a standard for reformulated gasoline.[44] Another possible oxygenate defined in the Clean Air Act was methyl tertiary butyl ether (MTBE). Until recently, MTBE was the preferred oxygenate because it was less expensive and easier to distribute than ethanol.[45] However, concerns over MTBE's affect on ground water quality has resulted in many states adopting laws that ban or significantly limit its use in gasoline sold in those states. Twenty-five states have laws that phase out MTBE partially or completely.[46] In light of the MTBE bans in these states, one element of the EPACT of 2005 repealed the oxygenate requirement as described in the 1990 Clean Air Act Amendments.[47] A provision of the repeal required refiners to blend gasoline so that they still maintain the Clean Air Act-mandated emissions reductions achieved in 2001 and 2002.[48] EPACT also established an RFS that required that 7.5 billion gallons of ethanol and biodiesel be produced by 2012.[49] Prior to EPACT, Congress passed the American Jobs Creation Bill of 2004, which established a $.51 blender's tax credit for ethanol. The bill also established a comparable credit for biodiesel production.[50]

2.1.2 Federal Targets for Biofuels Production

In his 2007 State of the Union address, President Bush announced a goal to reduce the nation's gasoline consumption by 20% by 2017.[51] Also in 2007, Congress passed the Energy Independence and Security Act of 2007 (EISA). The act amended the RFS established by EPACT 2005. Table 8 lists the new targets for biofuels production as prescribed by EISA. By 2022, the United States shall produce 36 billion gallons of biofuels. Of that, 21 billion gallons shall be advanced biofuels (derived from feedstock other than corn starch). Of the 21 billion gallons, 16 billion shall come from cellulosic ethanol. The remaining 5 billion gallons shall come from biomass-based diesel and other advanced biofuels.[52] The U.S. EPA is revising its current RFS to reflect the changes in the EISA.

2.1.3 Targets Set by Other Groups

In addition to biofuels targets set by Congress through the RFS, other organizations have set targets that while not mandatory, have helped drive federal policy. One such group is the Biomass Research and Development Initiative's (BRDI) Technical Advisory Committee, which was established by the Biomass Research and Development Act of 2000 and has diverse representation from industry, academia, non-governmental organizations, and state governments. In its 2006 Vision Statement, the committee set a goal that by 2030 biofuels consumption would be equivalent to 5 billion gallons of gasoline, roughly 20% of the total market share, and biopower consumption would be 3.8 quadrillion BTU, or 7% of the market share. By 2030, the committee envisions bioproducts consumption to be 55.3 billion pounds.[53] Another organization, 25×'25, whose steering committee is comprised of leaders from industry and state government, has released policy recommendations and strategies aimed toward producing 25% of America's energy needs by 2025 by utilizing the country's agricultural and forest resources, while still meeting demands for food and feed.[54]

Table 8. Biofuels targets mandated by EISA.[55]

Year	Volume (Billion Gallons)	Conventional Biofuels	Advanced Biofuels	Cellulosic Biofuels	Biomass-Based Diesel[a]	Undifferentiated Advanced Biofuels
2006	4.00	4.0				
2007	4.70	4.7				
2008	9.00	9.0				
2009	11.10	10.5	0.60		0.50	0.1
2010	12.95	12.0	0.95	0.10	0.65	0.2
2011	13.95	12.6	1.35	0.25	0.80	0.3
2012	15.20	13.2	2.00	0.50	1	0.5
2013	16.55	13.8	2.75	1.00	≥1.000	0.75
2014	18.15	14.4	3.75	1.75	≥1.000	1.0
2015	20.50	15.0	5.50	3.00	≥1.000	1.5
2016	22.25	15.0	7.25	4.25	≥1.000	2.0
2017	24.00	15.0	9.00	5.50	≥1.000	2.5
2018	26.00	15.0	11.00	7.00	≥1.000	3.0
2019	28.00	15.0	13.00	8.50	≥1.000	3.5
2020	30.00	15.0	15.00	10.50	≥1.000	3.5
2021	33.00	15.0	18.00	13.50	≥1.000	3.5
2022	36	15	21	16	≥1.000	4

a. EPA Administrator determines minimum use allocation for "biomass-based diesel" beginning in 2013.

2.1.4 Federal Agency Role as Mandated by Congress

Many U.S. federal agencies administer programs that seek to expand the production and consumption of biofuels. In most cases, federal responsibility was legislated by Congress. The BDRI board of directors, created by the Biomass Research and Development Act of 2000, is comprised of high-level officials from various agencies and offices within the federal government. The board is co-chaired by the U.S. Department of Agriculture (USDA) and the U.S. DOE. The other board member agencies include[56]:

- The National Science Foundation
- The Environmental Protection Agency
- The Department of the Interior

- The Office of Science and Technology Policy
- The Office of the Federal Environmental Executive
- The Department of Transportation
- The Department of Commerce
- The Department of the Treasury
- The Department of Defense.

In addition to serving as BRDI board members, these agencies also perform specific duties that further the advancement of biofuels research, production, and use within the United States. For example, the U.S. EPA is responsible for administering the RFS as prescribed by EPACT 2005 and as amended by EISA. The Internal Revenue Service (IRS) is responsible for overseeing the various tax credits given to blenders and producers of biofuels. For example, the IRS oversees the $.51 volumetric ethanol excise tax credit established by the American Jobs Creation Act of 2004 as amended by the Food, Conservation, and Energy Act of 2008.[57] The IRS also administers a biodiesel producer's tax credit that was established by the American Jobs Creation Act of 2004. The USDA and the U.S. DOE are responsible for distributing loans and grants to stimulate biomass-related projects and research. For instance, the U.S. DOE announced in 2007 that it will provide up to $385 million to fund six biorefinery projects over 4 years that could produce 130 million gallons of cellulosic ethanol per year.[58] In addition, the U.S. DOE Office of Science operates three bioenergy research centers as part of the Genomics to Life Program. These centers are intended to further the basic research needed in order to cost-effectively produce cellulosic ethanol and other advanced biofuels.[59] USDA's role was expanded with the passage of the Food Conservation and Energy Act of 2008. U.S. Customs and Border Protection (CBP) oversees the import duty for fuel ethanol.

2.2 Financial Support Measures for Biomass

The Texas Comptroller of Public Accounts Subsidies estimates that subsidies totaling $6.2 billion were given for renewable energy producers. Ethanol had the largest share of the subsidies at $4.7 billion (76.2% of total subsidies for renewables). The share of federal subsidies for renewables by fuel source is shown in Figure 3.

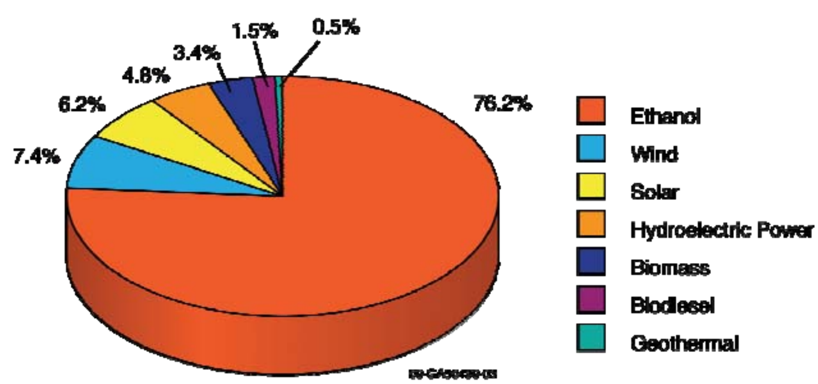

Figure 3. Estimated percent of total federal subsidies for renewable fuels in 2006, allocated by fuel source.[60]

In 2006, 20% of the U.S. corn harvest was used for ethanol production, and total agricultural subsidies through the Commodity Credit Corporation for corn in that year totaled $8.8 billion.[61] Thus, an estimated $1.8 billion went to subsidize corn destined for ethanol production.

The United States has also invested substantially in lignocellulosic fuel production projects. Table 9 lists companies that were awarded DOE contracts in February 2007 totaling $385 million in federal investment over 4 years. All projects are cost-shared by the private industry partner and other investors, and some projects also receive state support.

Table 9. Federal and state investments in lignocellulosic biorefineries awarded February 2007.[62,63]

Company Name	Location	Size MGY*	Products	Feedstocks
Range Fuels[a]	Soperton, GA	40.0	Ethanol, methanol	Wood residues and crops
BlueFire Ethanol, Inc.	Corona, CA	19.0	Ethanol	Green & wood wastes diverted from landfills
Abengoa Bioenergy	Hugoton, KS	11.4	Ethanol & power	Ag residues & switchgrass
Poet, LLC[a]	Emmetsburg, IA	125.0	Ethanol; 25% cellulosic	Corn fiber, cobs, stalks
ALICO, Inc.	LaBelle, FL	13.9	Ethanol & power (project abandoned)	Urban residues & energycane
Iogen Biorefinery Partners, LLC	Shelley, ID	18.0	Ethanol & power (project abandoned)	Straws from wheat, barley, rice, corn and switchgrass

a. Listed on www.ethanolrfa.org Web site as under construction.

Table 10 lists companies that, as of 2008, were selected for small-scale biorefinery projects totaling $240 million in federal investment over 4 years.

Table 10. Federal and state investments in lignocellulosic biorefineries awarded January, as of 2008.[64,65]

Company Name	Location	Size MGY*	Products	Feedstocks
ICM Incorporated	St. Joseph, MO	1.5	Ethanol & other	Corn fiber & stover switchgrass, sorghum
Ecofin, LLC	Nicholasville, KY	1.0	Ethanol & other	Corn cobs
Mascoma Corp.[a]	Vonore, TN	2.0	Ethanol & other	Corn cobs & switchgrass
Pacific Ethanol	Boardman, OR	2.7	Ethanol & other	Wood & crop residues
Verenium Corp[b]	Jennings, LA	1.5	Ethanol & other	Ag & wood residues & energy crops
Lignol Innovations, Inc	Commerce City, CO	2.0	Ethanol, lignin, furfural	Wood residues
(formerly Stora Enso, N America)	Wisconsin Rapids, WI	5.5	Fischer-Tropsch liquids	Mill and forest residues
RSE Pulp & Chemical, LLC	Old Town, ME	2.2	Ethanol & other	Hemicelluloses extract from wood
Flambeau River Biofuels, LLC	Park Falls, WI	6.0	Fischer-Tropsch liquids, heat	Mill and forest residues

a. Dupont Danisco Cellulosic Ethanol, LLC has replaced Mascoma Corporation as the technology partner on the Vonore, TN project.

b. Listed on www.ethanolrfa.org Web site as operational.

2.3 Other Measures to Stimulate Biomass/Biofuels

The United States requires a 10% ethanol blend for its gasoline. A few major U.S. corporations are investing substantially in biofuel research, including British Petroleum, Chevron, and Shell Oil. These companies are pursuing research and development for many types of biofuels, including cellulosic and algae-derived ethanol. Chevron partners with research universities (i.e., University of California Davis) and national laboratories (i.e., National Renewable Energy Laboratory [NREL]) to pursue these ends.

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3. BIOMASS RESOURCES

The land base of the United States encompasses nearly 2,263 million acres. About 33% of the land area is classified as forest land, 26% as grassland pasture and range, 20% as cropland, 8% as special use (e.g., public facilities), and 13% as miscellaneous use (e.g., urban areas, swamps, and deserts).[67,68] About one-half of this land has some potential for growing biomass.

Cropland and forestland have the potential to supply >1.3 billion dry ton (BDT) per year based on reasonable assumptions. Agricultural resources could produce 998 MDT per year, and forest resources could produce 368 MDT per year (Figure 4).

The Billion Ton Study projects that, from agricultural and forest resources, the United States can produce nearly this amount of biomass feedstock annually and continue to meet food, feed, and export demands.

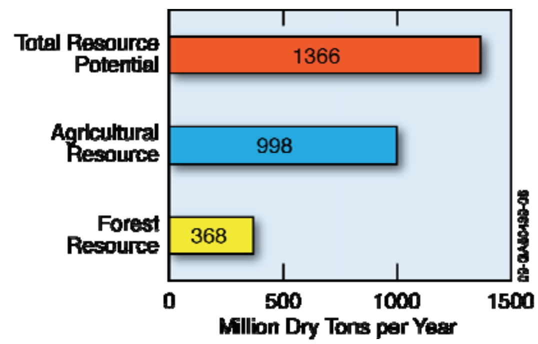

Figure 4. Annual biomass resource potential from forest and agricultural resources.[66]

3.1 Geographical Biomass Resource Potential

Geographical potential is the theoretical potential of land area available for the production of biomass energy from residues (forestry and agriculture) and dedicated energy crop plantations (Figure 5).

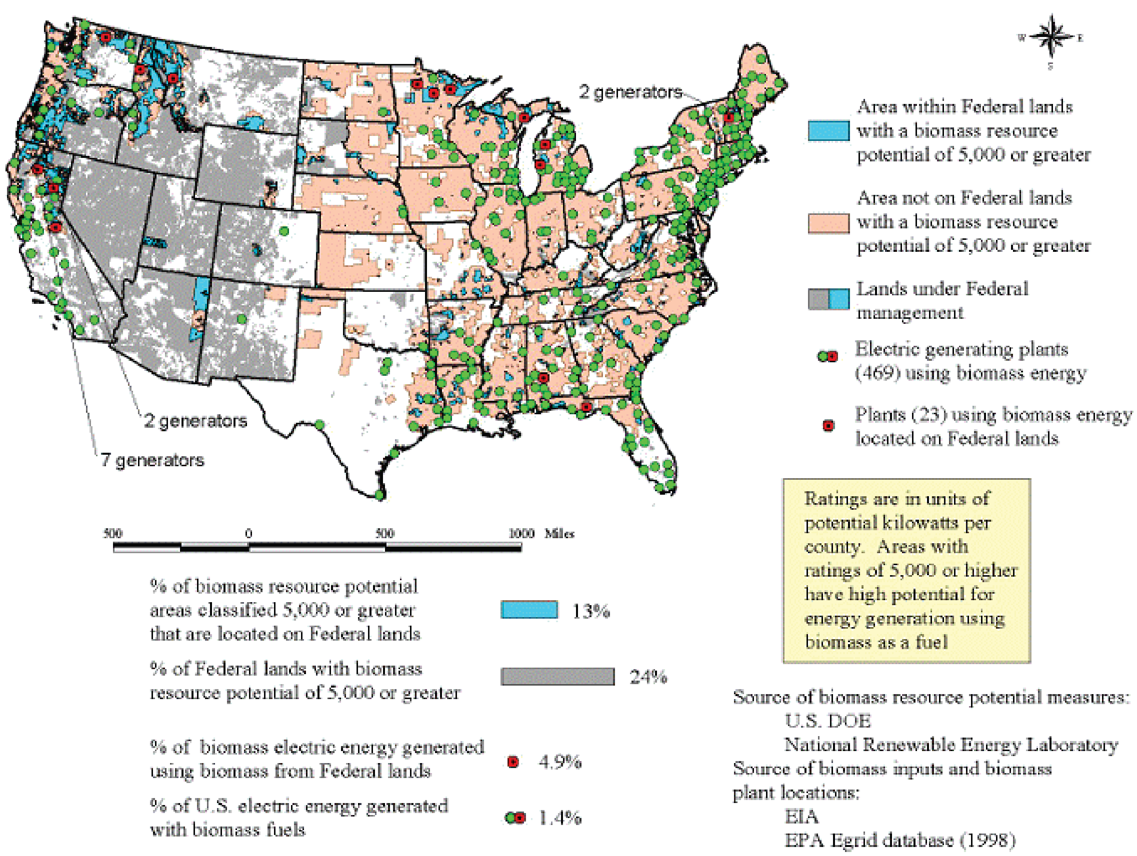

Figure 5. Geographical resource potential on federal lands in the continental United States.[69]

3.2 Economic Biomass Resource Potential

The economic potential is the technical potential that can be realized at profitable levels. This may be depicted by a cost-supply curve of secondary biomass energy.

As gas costs rise and expected ethanol costs are reduced, cellulosic ethanol costs are expected to drop below those of gasoline (Table 11).

Table 11. Gasoline and Ethanol: Comparison of current and potential production costs in North America (U.S. dollars per gasoline-equivalent liter).[70]

Fuel Type	2002	2010	Post-2010
Gasoline	$0.21	$0.23	$0.25
Ethanol from corn	$0.43	$0.40	$0.37
Ethanol from cellulose (poplar)	$0.53	$0.43	$0.27

Note: Gasoline gate cost based on $24/barrel oil in 2002, $30/barrel in 2020; corn ethanol from IEA, with about 1% per year cost reduction in future; cellulosic costs from IEA based on NREL estimates.

3.3 Agricultural Resources

The amount of biomass that can be removed sustainably from agricultural lands is currently about 194 MDT per year. This amount can be increased fivefold to nearly 1 BDT within 35 to 40 years through a combination of technology changes (e.g., higher crop yields and improved residue collection technology), adoption of no-till cultivation, and changes in land use to accommodate large-scale production of perennial crops.[72]

This projection includes 428 MDT of annual crop residues, 377 MDT of perennial crops, 87 MDT of grains used for biofuels, and 106 MDT of animal manures, process residues, and other miscellaneous feedstocks.[62] Figure 6 shows a summary of cropland allocation in the United States

The Regional Biomass Energy Feedstock Partnership was formed by the U.S. DOE and USDA, in partnership with Sun Grant universities and the National Biomass State and Regional Partnership, to develop biomass feedstock resources and realize the 1.3 BDT annual feedstock goal (Figure 7).

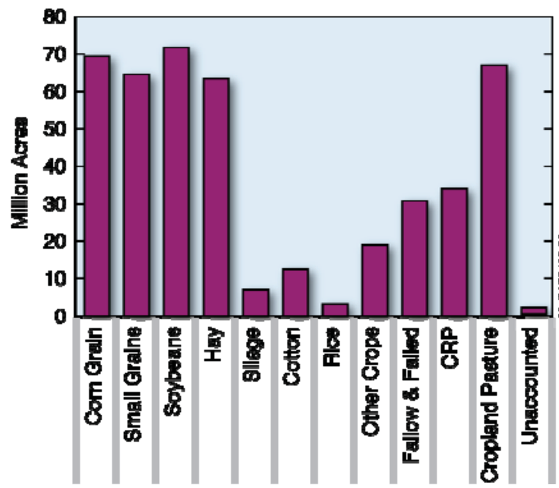

Figure 6. Summary of cropland uses, idle cropland, and cropland pasture in the contiguous United States.[71]

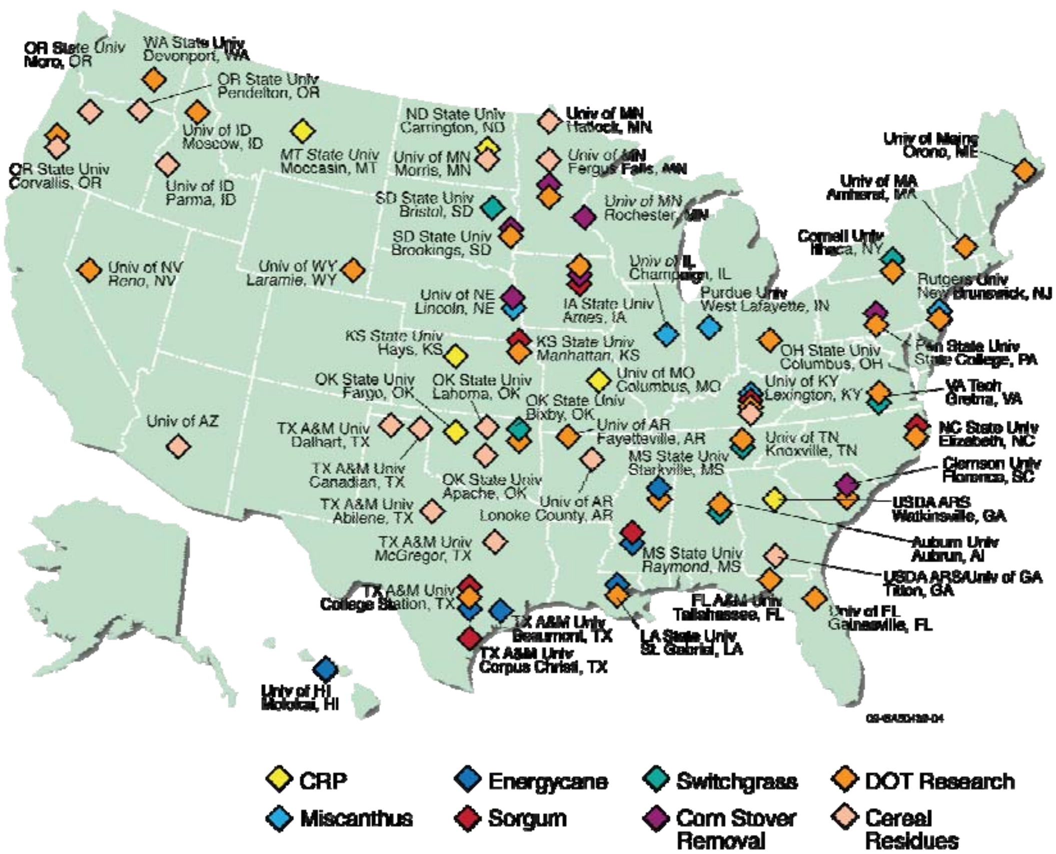

Figure 7. Regional Biomass Energy Feedstock Partnership development work underway: 2008 Bioenergy Crop Trials.[73]

Corn stover provides the majority of crop residues currently available for biofuel production and accounts for 75% of total crop residues.[74] Most of the corn stover supply is concentrated in the Midwest region. Table 12 provides grain harvest statistics from the top five corn-producing states.

Table 12. Hectares under cultivation, average stover yields, and estimated residue produced for top corn-producing states (USDA-NASS, 2008).[75]

Rank	State	Hectares under Cultivation (million)	Estimated Average Residue Yield (Mg/ha)[a]	Estimated Residue Produced (Mg*1e6)
1	Iowa	5.75	9.08	52.2
2	Illinois	5.35	9.29	49.7
3	Nebraska	3.81	8.49	32.3
4	Minnesota	3.40	7.75	26.4
5	Indiana	2.63	8.23	21.6

a. Assumes a 1:1 corn grain to residue weight ratio. **Note:** These estimates are for gross corn stover produced and do not account for what can actually be collected.

3.4 Forest Resources

Biomass derived from forestlands currently accounts for ~142 MDT of the total annual U.S. consumption of 190 MDT. Based on the assumptions and conditions outlined in this analysis, the amount of forestland-derived biomass that can be sustainably produced is approximately 368 MDT per year, more than 2.5 times the current consumption[77,78] (Figure 8).

The 368 MDT potential availability from forest resources includes 64 MDT of residues from logging operations and site clearing and 60 MDT from fuel treatment operations involved in reducing fire hazards. The availability estimates for these two key primary forestland resources take into account environmental concerns by assuming (1) sufficient biomass is left onsite for nutrient recycling purposes, (2) steep-sloped and inaccessible areas (i.e., roadless areas) are avoided, and (3) collection frequency is accounted for. The forestland potential also considers the allocation of recovered resources to both energy wood and higher-valued forest products.

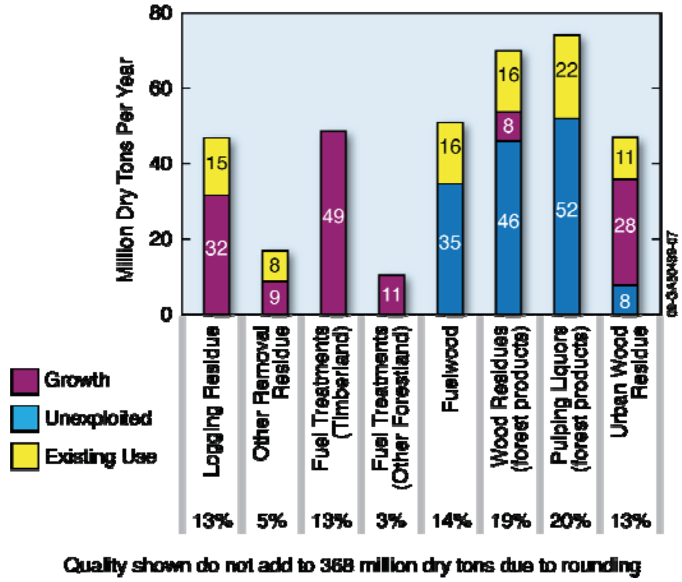

Figure 8. Summary of potentially available forest resources.[76]

4. CURRENT AND PROJECTED USE OF BIOMASS FOR ENERGY

4.1 Current and Projected Use of Biomass Resources

The EIA defines an entire resource volume as the "Total Resource." With regard to feedstock resources, this would include both annually renewable and stock resources plus future potential. It is estimated that the biomass Total Resource will be greater than 22,000 MDT per year (Figure 9). The "Recoverable Reserve" is that portion of the Total Resource that is currently within the market. The biomass feedstock Recoverable Reserve equates to 190 MDT per year. The "Estimated Reserve" is that portion of the Total Reserve that can be recovered with current and foreseeable technology both economically and in an environmentally sustainable manner. The feedstock Estimated Reserve is 320 MDT per year. The "Demonstrated Reserve" is that portion of the Total Reserve that has been measured. For the biomass feedstock resources, the Demonstrated Reserve is estimated to be 473 MDT per year. Finally, "Identified Resources" are a qualitative estimate based on measured, indicated, and inferred resources levels. For biomass feedstocks, the Identified Resources equate to 1366 MDT, as detailed in the Billion Ton Study.[79]

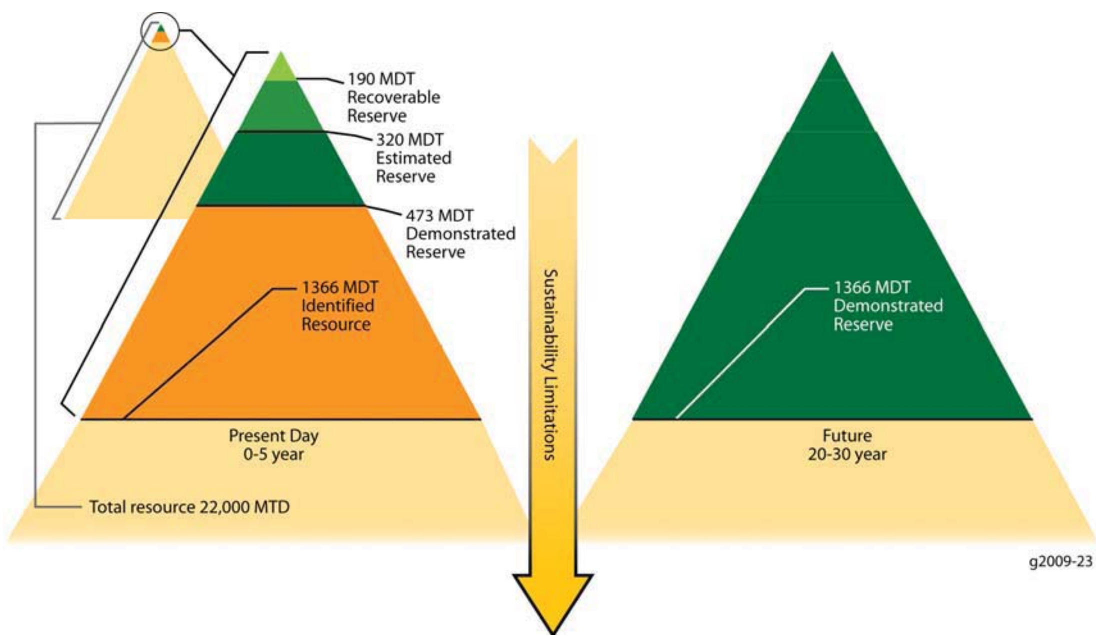

Figure 9. Current and projected biomass resource volume and potential availability for energy.

Currently, biomass accounts for approximately:

- 13% of renewably generated electricity
- Nearly all (97%) the industrial renewable energy use
- Nearly all the renewable energy consumption in the residential and commercial sectors (84% and 90%, respectively)
- 2.5% of transport fuel use.

A relatively significant amount of biomass (~6 to 9 MDT) is also used in the production of a variety of industrial and consumer bioproducts that directly displace petroleum-based feedstocks. The total annual consumption of biomass feedstock for bioenergy and bioproducts together currently approaches 190 MDT.

An important factor affecting the future use of biomass is sustainability. The Global Bioenergy Partnership (GBEP) states that bioenergy is sustainable only if its entire production chain (feedstock production, refining, and conversion) and end use practices are sustainable.[80] Sustainability includes environmental, social, and economic considerations. The main environmental issues to be considered are responsible use of agro-chemicals and fertilizers, prevention of soil erosion, protection of biodiversity, reduction of greenhouse gas emissions, improvement of air quality, and sustainable management of surface and ground water. Social sustainability can be achieved by addressing issues such as indoor air pollution, rural jobs and development, labor conditions, gender, and access to land and water. Economic sustainability means that the policy environments and the government incentives to encourage bioenergy should target technologies that are economically and commercially viable in the medium and long term.

4.2 Trend Analysis of Domestic Production/Consumption

4.2.1 Biopower

Biomass consumption in the industrial sector is projected to increase at an annual rate of 2% through 2030, from 2.7 quadrillion BTU (quads) in 2001 to 3.2 quads in 2010, 3.9 quads in 2020, and 4.8 quads in 2030. Additionally, biomass consumption in electric utilities is projected to double every 10 years through 2030. Combined, biopower will meet 4% of total industrial and electric generator energy demand in 2010 and 5% in 2020.

4.2.2 Biobased Transportation Fuels

Transportation fuels from biomass will increase significantly from 0.5% of U.S. transportation fuel consumption in 2001 (0.0147 quads) to 4% of transportation fuel consumption in 2010 (1.3 quads), 10% in 2020 (4.0 quads), and 20% in 2030.

4.2.3 Biobased Products

Production of chemicals and materials from biobased products will increase substantially from 5% of the current production of target U.S. chemical commodities in 2001 (~12.5 billion pounds) to 12% in 2010, 18% in 2020, and 25% in 2030.[66]

4.2.4 "20 in 10" Goal

In the *2007 State of the Union Address*, U.S. President Bush recognized the United States' "addiction to oil" and asked that America reduce its gasoline use by 20% over the next 10 years ("20 in 10").[81] A major element of that commitment is to increase the supply of renewable and alternative fuels to 35 billion gallons per year (bgy) by 2017. The current RFS requires 7.5 bgy of renewable fuel be blended with gasoline by 2012. A more aggressive RFS is needed to meet the "20 in 10" goal. The Office of the President continues to back this commitment by increasing research, development, and demonstration (RD&D) funding for the Biomass Program in the Budget Request. DOE, EPA, and Department of Transportation (DOT) are evaluating intermediate ethanol blends (e.g., E15 and E20) to accelerate displacement of gasoline while addressing the challenges of building a new biofuels infrastructure in a sustainable manner.[82]

4.3 Full Quantification of all Biomass Types in Use

Table 13. Industrial biomass energy consumption and electricity net generation by industry and energy sources, 2006.

Industry	Energy Source	Biomass Energy Consumption (Trillion BTU) Total	For Electricity	For Useful Thermal Output	Net Generation (Million Kilowatt Hours)
Agriculture, Forestry and Mining	*Agricultural Byproducts/Crops*				
	Subtotal	**13.199**	**2.888**	**10.310**	**181**
Manufacturing	**Subtotal**	**1868.156**	**354.767**	**1513.389**	**28,716**
Food and Kindred Products	*Agricultural Byproducts/ Crops*	*34.687*	*0.937*	*33.750*	*29*
	Other Biomass Gases	*0.610*	*0.042*	*0.568*	*8*
	Other Biomass Liquids	*0.069*	*0.069*	*0.000*	*6*
	Wood/Wood Waste Solids	*2.668*	*0.278*	*2.390*	*56*
	Subtotal	**38.034**	**1.325**	**36.708**	**98**
Lumber	*Sludge Waste*	*0.073*	*0.015*	*0.058*	*2*
	Wood/Wood Waste Solids	*251.865*	*16.824*	*235.041*	*1,326*
	Subtotal	**251.939**	**16.839**	**235.099**	**1,327**
Paper and Allied Products	*Agricultural Byproducts/ Crops*	*1.381*	*0.065*	*1.316*	*6*
	Black Liquor	*853.151*	*220.683*	*632.467*	*17,949*
	Landfill Gas	*0.046*	*0.007*	*0.039*	*1*
	Municipal Solid Waste Biogenic[a]	*1.362*	*0.272*	*1.089*	*24*
	Other Biomass Gases	*0.267*	*0.031*	*0.237*	*4*
	Other Biomass Liquids	*0.004*	*0.001*	*0.003*	*0*
	Other Biomass Solids	*4.319*	*0.570*	*3.749*	*112*
	Sludge Waste	*5.331*	*2.275*	*3.056*	*171*
	Wood/Wood Waste Liquids	*26.976*	*3.831*	*23.146*	*154*
	Wood/Wood	*363.462*	*107.182*	*256.280*	*8,768*

Industry	Energy Source	Biomass Energy Consumption (Trillion BTU) Total	For Electricity	For Useful Thermal Output	Net Generation (Million Kilowatt Hours)
	Waste Solids				
	Subtotal	**1256.298**	**334.917**	**921.381**	**27,190**
Chemicals and Allied Products	*Landfill Gas*	*0.160*	*0.078*	*0.082*	*4*
	Municipal Solid Waste Biogenic[a]	*0.790*	*0.079*	*0.711*	*10*
	Other Biomass Liquids	*0.161*	*0.014*	*0.146*	*3*
	Other Biomass Solids	*0.005*	*0.000*	*0.005*	*0*
	Sludge Waste	*0.389*	*0.000*	*0.389*	*0*
	Wood/Wood Waste Solids	*3.016*	*0.689*	*2.328*	*17*
	Subtotal	**4.521**	**0.860**	**3.661**	**34**
Biorefineries *Biofuel Losses and Coproducts*[b]	*Biodiesel Feedstock*	*0.441*	*0.000*	*0.441*	*0*
	Ethanol Feedstock	*300.736*	*0.000*	*300.736*	*0*
	Subtotal	**301.177**	**0.000**	**301.177**	**0**
Other[c]	**Subtotal**	**16.187**	**0.824**	**15.363**	**66**
Nonspecified[d]	*Ethanol*	*9.429*	*0*	*9.429*	*0*
	Landfill Gas	*72.996*	*0*	*72.996*	*0*
	Municipal Solid Waste Biogenic[a]	*2.263*	*0*	*2.263*	*0*
	Subtotal	**84.688**	**0**	**84.688**	**0**
Total		**1966.043**	**357.655**	**1608.388**	**28,897**

a. Includes paper and paper board, wood, food, leather, textiles and yard trimmings[83]

b. Losses and coproducts from production of biodiesel and ethanol calculated as the difference between energy in feedstocks and production.

c. Other includes Apparel; Petroleum Refining; Rubber and Misc. Plastic Products; Transportation Equipment; Stone, Clay, Glass, and Concrete Products; Furniture and Fixtures; and related industries.

d. Primary purpose of business is not specified.

- = Not Applicable.

Note: Totals may not equal sum of components due to independent rounding. Government Advisory Associates, Resource Recovery Yearbook and Methane Recovery Yearbook; U.S. Environmental Protection Agency, Landfill Government Advisory Associates, Resource Recovery Yearbook and Methane Recovery Yearbook; U.S. Environmental Protection Agency, Landfill Methane Outreach Program estimates; Ethanol and biofuel losses and coproducts: Table 2 of this report; and analysis conducted by the Energy Information Administration, Office of Coal, Nuclear, Electric and Alternate Fuels.

5. CURRENT BIOMASS USERS

5.1 Main Users

In 2003, the total industrial biomass energy consumption in the United States was approximately 1,533 trillion BTU. Most of the biomass energy consumed is derived from forestlands. Black liquor accounts more than half of this amount. Wood and wood wastes generated in primary wood processing mills account for another third of the total industrial biomass energy consumption. Table 14 contains data from a survey of manufacturers that the EIA conducts every 4 years.

Table 14. Industrial biomass energy consumption and electricity net generation by industry.[84,85,86]

		Biomass Energy Consumption (Trillion BTU)			
Industry	**Energy Source**	**Total**	**For Electricity**	**For Useful Thermal Output**	**Net Generation (Million)**
Agriculture, Forestry, and Mining	*Agricultural Byproducts/Crops*				
	Subtotal	**9.010**	**2.720**	**6.290**	**167**
Manufacturing	**Subtotal**	**144.208**	**375.986**	**1,068.222**	**28,834**
Food and Kindred Industry Products	*Agricultural Byproducts/Crops*	*37.153*	*4.073*	*33.079*	*28*
	Other Biomass Gases	*0.278*	*0.217*	*0.062*	*8*
	Other Biomass Liquids	*0.067*	*0.067*	*-*	*5*
	Tires	*0.379*	*0.179*	*0.201*	*14*
	Wood/Wood Waste Solids	*3.441*	*0.641*	*2.801*	*49*
	Subtotal	**41.318**	**5.176**	**36.142**	**104**
Lumber	*Sludge Waste*	*0.058*	*0.019*	*0.039*	*3*
	Wood/Wood Waste Liquids	*0.248*	*0.080*	*0.168*	*12*
	Wood/Wood Waste Solids	*1.131*	*16.265*	*199.872*	*1,483*
	Subtotal	**216.422**	**16.364**	**200.078**	**1,499**
Paper and Allied Products	*Agricultural Byproducts/Crops*	*1.131*	*0.092*	*1.040*	*7*
	Black Liquor	*814.120*	*239.340*	*574.780*	*18,311*
	Landfill Gas	*0.310*	*0.063*	*0.247*	*7*
	Municipal Solid Waste	*2.274*	*0.427*	*1.848*	*53*
	Other Biomass Liquids	*0.071*	*0.034*	*0.037*	*2*
	Other Biomass Solids	*0.741*	*0.586*	*0.155*	*59*
	Sludge Waste	*10.136*	*3.536*	*6.600*	*251*
	Tires	*7.540*	*2.627*	*4.913*	*253*
	Wood/Wood Waste Liquids	*21.019*	*4.697*	*16.322*	*416*
	Wood/Wood Waste Solids	*293.439*	*100.738*	*192.701*	*7,679*
	Subtotal	**1,150.781**	**352.138**	**798.643**	**27,039**

Industry	Energy Source	Biomass Energy Consumption (Trillion BTU) Total	For Electricity	For Useful Thermal Output	Net Generation (Million)
Chemicals and Allied Products	*Landfill Gas*	*0.214*	*0.041*	*0.173*	*4*
	Municipal Solid Waste	*1.398*	*0.122*	*1.276*	*12*
	Other Biomass Liquids	*0.073*	*0.014*	*0.059*	*0*
	Other Biomass Solids	*0.004*	*0.001*	*0.003*	*0*
	Sludge Waste	*0.300*	*0.072*	*0.228*	*9*
	Wood/Wood Waste Solids	*1.881*	*0.496*	*1.385*	*18*
	Subtotal	**3.870**	**0.745**	**3.125**	**43**
Other	**Subtotal**	**31.787**	**1.564**	**30.233**	**149**
Nonspecified	*Landfill Gas*	*74.730*	-	*74.730*	-
	Municipal Solid Waste	*5.000*	-	*5.000*	-
	Subtotal	**79.730**	**-**	**79.730**	**-**
Total		**1,532.947**	**378.706**	**1,154.242**	**29,001**

By sector, the largest consumer of renewable fuels in the United States is commercial, consuming 2.45 quads. Following the commercial sectors are the industrial, transportation, and residential sectors, in that order (Table 15).

Table 15. Renewable energy consumption by sector, 2006.[87]

Sector	Energy Source	Trillion BTU	Consumption (%)
Industrial	*Wood*	*1,515*	*51.39*
	Waste	*147*	*4.99*
	Fuel Ethanol	*10*	*0.34*
	Losses and Co-products	*300*	*10.17*
		1,972	**66.89**
Transportation	*Fuel Ethanol*	*451*	*15.30*
	Biodiesel	*33*	*1.12*
		484	**16.42**
Residential	*Wood*	**390**	**13.23**
Commercial	*Wood*	*65*	*2.21*
	Waste	*36*	*1.22*
	Fuel Ethanol	*1*	*0.03*
		102	**3.46**
Total		**2948**	**100.00**

5.2 Quantitative List of Biomass Plants

5.2.1 U.S. Biorefineries by Location[88]

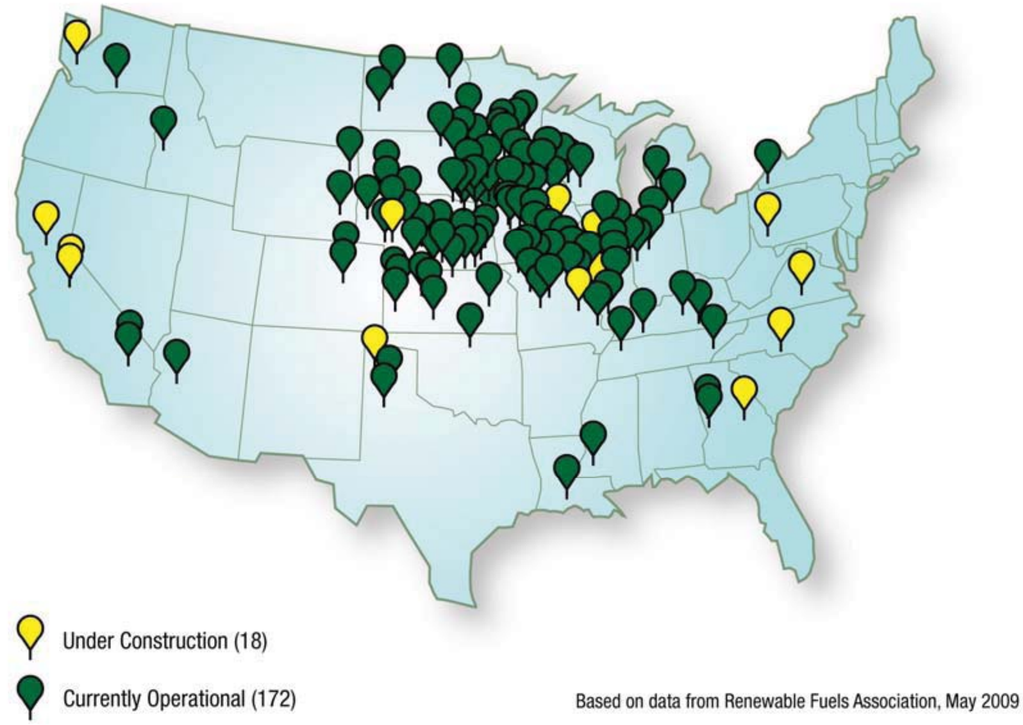

Figure 10. U.S. biorefineries by location (under construction and currently operational).

Table 16. U.S. fuel ethanol industry biorefineries and capacity.

Company	Location	Feedstock	Nameplate Capacity (mgy)	Operating Production (mgy)	Under Construction/ Expansion Capacity (mgy)
Abengoa Bioenergy Corp. (Total)			**198.0**	**168.0**	**176.0**
Abengoa Bioenergy Corp.	Madison, IL	Corn			
Abengoa Bioenergy Corp.	Mt. Vernon, IN	Corn			
Abengoa Bioenergy Corp.	Colwich, KS	Corn/Milo			
Abengoa Bioenergy Corp.	Ravenna, NE	Corn			
Abengoa Bioenergy Corp.	York, NE	Corn			
Abengoa Bioenergy Corp.	Portales, NM	Corn			
Absolute Energy, LLC*	St. Ansgar, IA	Corn	100.0	100.0	
ACE Ethanol, LLC	Stanley, WI	Corn	41.0	41.0	

Company	Location	Feedstock	Nameplate Capacity (mgy)	Operating Production (mgy)	Under Construction/ Expansion Capacity (mgy)
Adkins Energy, LLC*	Lena, IL	Corn	40.0	40.0	
Advanced Bioenergy, LLC	Fairmont, NE	Corn	100.0	100.0	
Advanced Bioenergy, LLC	Aberdeen, SD	Corn	50.0	50.0	
Advanced Bioenergy, LLC	Huron, SD	Corn	32.0	32.0	33.0
Ag Energy Resources, Inc.	Benton, IL	Corn			5.0
AGP*	Hastings, NE	Corn	52.0	52.0	
Agri-Energy, LLC*	Luverne, MN	Corn	21.0	21.0	
Al-Corn Clean Fuel*	Claremont, MN	Corn	42.0	42.0	
Alchem Ltd. LLP	Grafton, ND	Corn	10.0		
AltraBiofuels Coshocton Ethanol, LLC	Coshocton, OH	Corn	60.0		
AltraBiofuels Indiana, LLC	Cloverdale, IN	Corn	92.0		
AltraBiofuels Phoenix Bio Industries, LLC	Goshen, CA	Corn	31.5	31.5	
Amaizing Energy, LLC*	Atlantic, IA	Corn			110.0
Amaizing Energy, LLC*	Denison, IA	Corn	48.0	48.0	
Appomattox Bio Energy	Hopewell, VA	Corn			65.0
Archer Daniels Midland (Total)			**1,070.0**	**1,070.0**	**550.0**
Archer Daniels Midland	Cedar Rapids, IA	Corn			
Archer Daniels Midland	Clinton, IA	Corn			
Archer Daniels Midland	Decatur, IL	Corn			
Archer Daniels Midland	Peoria, IL	Corn			
Archer Daniels Midland	Marshall, MN	Corn			
Archer Daniels Midland	Walhalla, ND	Corn/Barley			
Archer Daniels Midland	Columbus, NE	Corn			
Arkalon Energy, LLC	Liberal, KS	Corn	110.0	110.0	
Aventine Renewable Energy, LLC (Total)			**207.0**	**207.0**	

Company	Location	Feedstock	Nameplate Capacity (mgy)	Operating Production (mgy)	Under Construction/ Expansion Capacity (mgy)
Aventine Renewable Energy, LLC	Pekin, IL	Corn			
Aventine Renewable Energy, LLC	Aurora, NE	Corn			
Badger State Ethanol, LLC*	Monroe, WI	Corn	48.0	48.0	
Big River Resources Galva, LLC	Galva, IL	Corn			100.0
Big River Resources, LLC*	West Burlington, IA	Corn	92.0	92.0	
BioFuel Energy - Buffalo Lake Energy, LLC	Fairmont, MN	Corn	115.0	115.0	
BioFuel Energy - Pioneer Trail Energy, LLC	Wood River, NE	Corn	115.0	115.0	
Bional Clearfield	Clearfield, PA	Corn			110.0
Blue Flint Ethanol	Underwood, ND	Corn	50.0	50.0	
Bonanza Energy, LLC	Garden City, KS	Corn/Milo	55.0	55.0	
Bridgeport Ethanol	Bridgeport, NE	Corn	54.0	54.0	
Bunge-Ergon Vicksburg	Vicksburg, MS	Corn	54.0	54.0	
Bushmills Ethanol, Inc.*	Atwater, MN	Corn	50.0	50.0	
Calgren Renewable Fuels, LLC	Pixley, CA	Corn			55.0
Carbon Green Bioenergy	Lake Odessa, MI	Corn	50.0		
Cardinal Ethanol	Union City, IN	Corn	100.0	100.0	
Cargill, Inc.	Eddyville, IA	Corn	35.0	35.0	
Cargill, Inc.	Blair, NE	Corn	85.0	85.0	
Cascade Grain	Clatskanie, OR	Corn	108.0		
Castle Rock Renewable Fuels, LLC	Necedah, WI	Corn	50.0	50.0	
Center Ethanol Company	Sauget, IL	Corn	54.0	54.0	
Central Indiana Ethanol, LLC	Marion, IN	Corn	40.0	40.0	
Central MN Ethanol Coop*	Little Falls, MN	Corn	21.5	21.5	
Chief Ethanol	Hastings, NE	Corn	62.0	62.0	
Chippewa Valley Ethanol Co.*	Benson, MN	Corn	45.0	45.0	

Company	Location	Feedstock	Nameplate Capacity (mgy)	Operating Production (mgy)	Under Construction/ Expansion Capacity (mgy)
Cilion Ethanol	Keyes, CA	Corn			50.0
Clean Burn Fuels, LLC	Raeford, NC	Corn			60.0
Commonwealth Agri-Energy, LLC*	Hopkinsville, KY	Corn	33.0	33.0	
Corn Plus, LLP*	Winnebago, MN	Corn	44.0	44.0	
Corn, LP*	Goldfield, IA	Corn	55.0	55.0	
Cornhusker Energy Lexington, LLC	Lexington, NE	Corn	40.0	40.0	
Dakota Ethanol, LLC*	Wentworth, SD	Corn	50.0	50.0	
DENCO, LLC	Morris, MN	Corn	24.0		
Didion Ethanol	Cambria, WI	Corn	40.0	40.0	
E Caruso (Goodland Energy Center)	Goodland, KS	Corn			20.0
E Energy Adams, LLC	Adams, NE	Corn	50.0	50.0	
E3 Biofuels	Mead, NE	Corn	25.0		
East Kansas Agri-Energy, LLC*	Garnett, KS	Corn	35.0	35.0	
ESE Alcohol Inc.	Leoti, KS	Seed Corn	1.5	1.5	
Front Range Energy, LLC	Windsor, CO	Corn	40.0	40.0	
Gateway Ethanol	Pratt, KS	Corn	55.0		
Glacial Lakes Energy, LLC - Mina	Mina, SD	Corn	107.0	107.0	
Glacial Lakes Energy, LLC*	Watertown, SD	Corn	100.0	100.0	
Global Ethanol/Midwest Grain Processors	Lakota, IA	Corn	97.0	97.0	
Global Ethanol/Midwest Grain Processors	Riga, MI	Corn	57.0	57.0	
Golden Cheese Company of California*	Corona, CA	Cheese Whey	5.0	5.0	
Golden Grain Energy, LLC*	Mason City, IA	Corn	115.0	115.0	
Golden Triangle Energy, LLC*	Craig, MO	Corn	20.0	20.0	
Grain Processing Corp.	Muscatine, IA	Corn	20.0	20.0	
Granite Falls Energy, LLC*	Granite Falls, MN	Corn	52.0	52.0	

Company	Location	Feedstock	Nameplate Capacity (mgy)	Operating Production (mgy)	Under Construction/ Expansion Capacity (mgy)
Greater Ohio Ethanol, LLC	Lima, OH	Corn	54.0		
Green Plains Bluffton	Bluffton, IN	Corn	110.0	110.0	
Green Plains Obion	Obion, TN	Corn	110.0	110.0	
Green Plains Renewable Energy	Shenandoah, IA	Corn	55.0	55.0	
Green Plains Renewable Energy	Superior, IA	Corn	55.0	55.0	
Hawkeye Renewables, LLC	Fairbank, IA	Corn	120.0	120.0	
Hawkeye Renewables, LLC	Iowa Falls, IA	Corn	105.0	105.0	
Hawkeye Renewables, LLC	Menlo, IA	Corn	110.0	110.0	
Hawkeye Renewables, LLC	Shell Rock, IA	Corn	110.0	110.0	
Heartland Corn Products*	Winthrop, MN	Corn	100.0	100.0	
Heron Lake BioEnergy, LLC	Heron Lake, MN	Corn	50.0	50.0	
Highwater Ethanol LLC	Lamberton, MN	Corn			50.0
Homeland Energy	New Hampton, IA	Corn	100.0	100.0	
Husker Ag, LLC*	Plainview, NE	Corn	75.0	75.0	
Idaho Ethanol Processing	Caldwell, ID	Potato Waste	4.0	4.0	
Illinois River Energy, LLC	Rochelle, IL	Corn	100.0	100.0	
Iroquois Bio-Energy Company, LLC	Rensselaer, IN	Corn	40.0	40.0	
KAAPA Ethanol, LLC*	Minden, NE	Corn	40.0	40.0	
Kansas Ethanol, LLC	Lyons, KS	Corn	55.0	55.0	
KL Process Design Group	Upton, WY	Wood Waste	1.5	1.5	
Land O' Lakes*	Melrose, MN	Cheese Whey	2.6	2.6	
Levelland/Hockley County Ethanol, LLC	Levelland, TX	Corn	40.0	40.0	
Lifeline Foods, LLC	St. Joseph, MO	Corn	40.0	40.0	
Lincolnland Agri-Energy, LLC*	Palestine, IL	Corn	48.0	48.0	
Lincolnway Energy, LLC*	Nevada, IA	Corn	50.0	50.0	

Company	Location	Feedstock	Nameplate Capacity (mgy)	Operating Production (mgy)	Under Construction/ Expansion Capacity (mgy)
Little Sioux Corn Processors, LP*	Marcus, IA	Corn	92.0	92.0	
Louis Dreyfus Commodities	Grand Junction, IA	Corn	100.0	100.0	
Louis Dreyfus Commodities	Norfolk, NE	Corn	45.0	45.0	
Marquis Energy, LLC	Hennepin, IL	Corn	100.0	100.0	
Marysville Ethanol, LLC	Marysville, MI	Corn	50.0	50.0	
Merrick & Company	Aurora, CO	Waste Beer	3.0	3.0	
Mid America Agri Products/Horizon	Cambridge, NE	Corn	44.0		
Mid America Agri Products/Wheatland	Madrid, NE	Corn	44.0	44.0	
Mid-Missouri Energy, Inc.*	Malta Bend, MO	Corn	50.0	50.0	
Midwest Renewable Energy, LLC	Sutherland, NE	Corn	25.0	25.0	
Minnesota Energy*	Buffalo Lake, MN	Corn	18.0	18.0	
NEDAK Ethanol	Atkinson, NE	Corn	44.0	44.0	
Nesika Energy, LLC	Scandia, KS	Corn	10.0	10.0	
New Energy Corp.	South Bend, IN	Corn	102.0	102.0	
North Country Ethanol, LLC*	Rosholt, SD	Corn	20.0	20.0	
Northwest Renewable, LLC	Longview, WA	Corn			55.0
One Earth Energy	Gibson City, IL	Corn			100.0
Otter Tail Ag Enterprises	Fergus Falls, MN	Corn	57.5	57.5	
Pacific Ethanol	Madera, CA	Corn	40.0		
Pacific Ethanol	Stockton, CA	Corn	60.0		
Pacific Ethanol	Burley, ID	Corn	50.0		
Pacific Ethanol	Boardman, OR	Corn	40.0	40.0	
Panda Ethanol	Hereford, TX	Corn/Milo			115.0
Parallel Products	Rancho Cucamonga, CA				
Parallel Products	Louisville, KY	Beverage Waste	5.4	5.4	

Company	Location	Feedstock	Nameplate Capacity (mgy)	Operating Production (mgy)	Under Construction/ Expansion Capacity (mgy)
Patriot Renewable Fuels, LLC	Annawan, IL	Corn	100.0	100.0	
Penford Products	Cedar Rapids, IA	Corn	45.0	45.0	
Pinal Energy, LLC	Maricopa, AZ	Corn	55.0	55.0	
Pine Lake Corn Processors, LLC	Steamboat Rock, IA	Corn	30.0	30.0	
Platinum Ethanol, LLC*	Arthur, IA	Corn	110.0	110.0	
Plymouth Ethanol, LLC*	Merrill, IA	Corn	50.0	50.0	
POET Biorefining - Alexandria	Alexandria, IN	Corn	68.0	68.0	
POET Biorefining - Ashton	Ashton, IA	Corn	56.0	56.0	
POET Biorefining - Big Stone	Big Stone City, SD	Corn	79.0	79.0	
POET Biorefining - Bingham Lake	Bingham Lake, MN		35.0	35.0	
POET Biorefining - Caro	Caro, MI	Corn	53.0	53.0	5.0
POET Biorefining - Chancellor	Chancellor, SD	Corn	110.0	110.0	
POET Biorefining - Coon Rapids	Coon Rapids, IA	Corn	54.0	54.0	
POET Biorefining - Corning	Corning, IA	Corn	65.0	65.0	
POET Biorefining - Emmetsburg	Emmetsburg, IA	Corn	55.0	55.0	
POET Biorefining - Fostoria	Fostoria, OH	Corn	68.0	68.0	
POET Biorefining - Glenville	Albert Lea, MN	Corn	42.0	42.0	
POET Biorefining - Gowrie	Gowrie, IA	Corn	69.0	69.0	
POET Biorefining - Hanlontown	Hanlontown, IA	Corn	56.0	56.0	
POET Biorefining - Hudson	Hudson, SD	Corn	56.0	56.0	
POET Biorefining - Jewell	Jewell, IA	Corn	69.0	69.0	
POET Biorefining - Laddonia	Laddonia, MO	Corn	50.0	50.0	5.0
POET Biorefining - Lake Crystal	Lake Crystal, MN	Corn	56.0	56.0	
POET Biorefining - Leipsic	Leipsic, OH	Corn	68.0	68.0	
POET Biorefining - Macon	Macon, MO	Corn	46.0	46.0	

Company	Location	Feedstock	Nameplate Capacity (mgy)	Operating Production (mgy)	Under Construction/ Expansion Capacity (mgy)
POET Biorefining - Marion	Marion, OH	Corn			65.0
POET Biorefining - Mitchell	Mitchell, SD	Corn	68.0	68.0	
POET Biorefining - North Manchester	North Manchester, IN	Corn	68.0	68.0	
POET Biorefining - Portland	Portland, IN	Corn	68.0	68.0	
POET Biorefining - Preston	Preston, MN	Corn	46.0	46.0	
POET Biorefining - Scotland	Scotland, SD	Corn	11.0	11.0	
POET Biorefining- Groton	Groton, SD	Corn	53.0	53.0	
Prairie Horizon Agri-Energy, LLC	Phillipsburg, KS	Corn	40.0	40.0	
Quad-County Corn Processors*	Galva, IA	Corn	30.0	30.0	
Range Fuels	Soperton, GA	Wood Waste			20.0
Red Trail Energy, LLC	Richardton, ND	Corn	50.0	50.0	
Redfield Energy, LLC *	Redfield, SD	Corn	50.0	50.0	
Reeve Agri-Energy	Garden City, KS	Corn/Milo	12.0	12.0	
Renew Energy	Jefferson Junction, WI	Corn	130.0	130.0	
Renova Energy	Torrington, WY	Corn	5.0	5.0	
Riverland Biofuels	Canton, IL	Corn	37.0	37.0	
Show Me Ethanol	Carrollton, MO	Corn	55.0	55.0	
Siouxland Energy & Livestock Coop*	Sioux Center, IA	Corn	60.0	60.0	
Siouxland Ethanol, LLC	Jackson, NE	Corn	50.0	50.0	
Southwest Georgia Ethanol, LLC	Camilla, GA	Corn	100.0	100.0	
Southwest Iowa Renewable Energy, LLC *	Council Bluffs, IA	Corn	110.0	110.0	
Sterling Ethanol, LLC	Sterling, CO	Corn	42.0	42.0	
Sunoco	Volney, NY	Corn	114.0		
Tate & Lyle	Ft. Dodge, IA	Corn			105.0

Company	Location	Feedstock	Nameplate Capacity (mgy)	Operating Production (mgy)	Under Construction/ Expansion Capacity (mgy)
Tate & Lyle	Loudon, TN	Corn	67.0	67.0	38.0
Tharaldson Ethanol	Casselton, ND	Corn	110.0	110.0	
The Andersons Albion Ethanol LLC	Albion, MI	Corn	55.0	55.0	
The Andersons Clymers Ethanol, LLC	Clymers, IN	Corn	110.0	110.0	
The Andersons Marathon Ethanol, LLC	Greenville, OH	Corn	110.0	110.0	
Trenton Agri Products, LLC	Trenton, NE	Corn	40.0	40.0	
United Ethanol	Milton, WI	Corn	52.0	52.0	
United WI Grain Producers, LLC*	Friesland, WI	Corn	49.0	49.0	
Utica Energy, LLC	Oshkosh, WI	Corn	48.0	48.0	
Valero Renewable Fuels	Albert City, IA	Corn	110.0	110.0	
Valero Renewable Fuels	Charles City, IA	Corn	110.0	110.0	
Valero Renewable Fuels	Ft. Dodge, IA	Corn	110.0	110.0	
Valero Renewable Fuels	Hartley, IA	Corn	110.0	110.0	
Valero Renewable Fuels	Welcome, MN	Corn	110.0		
Valero Renewable Fuels	Albion, NE	Corn	110.0	110.0	
Valero Renewable Fuels	Aurora, SD	Corn	120.0	120.0	
VeraSun Energy Corp. (Total)			**805.0**		
VeraSun Energy Corp.	Dyersville, IA	Corn			
VeraSun Energy Corp.	Linden, IN	Corn			
VeraSun Energy Corp.	Janesville, MN	Corn			
VeraSun Energy Corp.	Hankinson, ND	Corn			
VeraSun Energy Corp.	Central City, NE	Corn			
VeraSun Energy Corp.	Ord, NE	Corn			
VeraSun Energy Corp.	Bloomingburg, OH	Corn			
VeraSun Energy Corp.	Marion, SD	Corn			

Company	Location	Feedstock	Nameplate Capacity (mgy)	Operating Production (mgy)	Under Construction/ Expansion Capacity (mgy)
Verenium	Jennings, LA	Sugar Cane Bagasse	1.5	1.5	
Western New York Energy LLC	Shelby, NY		50.0	50.0	
Western Plains Energy, LLC*	Campus, KS	Corn	45.0	45.0	
Western Wisconsin Renewable Energy, LLC*	Boyceville, WI	Corn	40.0	40.0	
White Energy	Russell, KS	Milo/Wheat Starch	48.0	48.0	
White Energy	Hereford, TX	Corn/Milo	100.0	100.0	
White Energy	Plainview, TX	Corn	110.0		
Wind Gap Farms	Baconton, GA	Brewery Waste	0.4	0.4	
Xethanol BioFuels, LLC	Blairstown, IA	Corn	5.0	5.0	
Yuma Ethanol	Yuma, CO	Corn	40.0	40.0	
Total			**12,638.4**[a]	**10,797.4**	**1,892.0**

a. mgy for **196** nameplate refineries

6. BIOMASS PRICES

6.1 Average Prices of Main Biofuels for Large-Scale Users

The price per bushel of corn has decreased greatly over the last 30 years as technologies have improved and supply has increased. The price increase between 2005 and 2007 may be due to the increase of demand caused by biofuel production (Figure 11). A comparison of 2002 operating expenses and net feedstock costs for undenatured ethanol production are shown in Table 17.

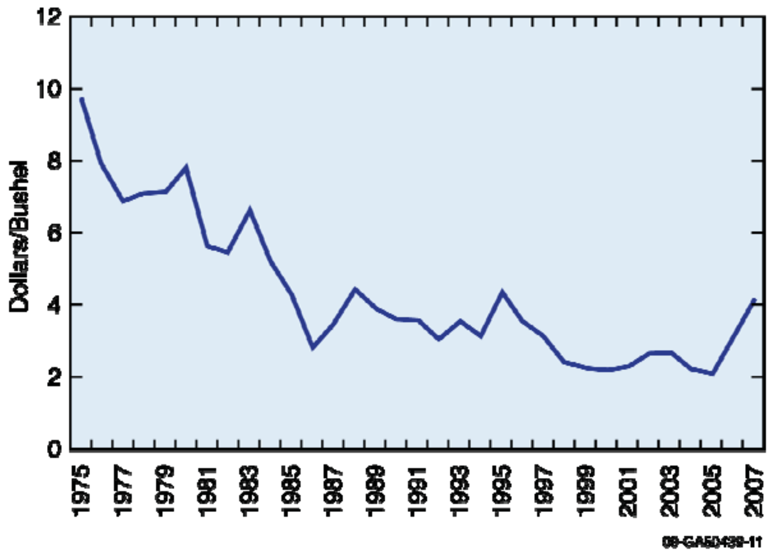

Figure 11. Corn: Price per bushel, 1975–2007 (2007 Dollars).[89]

Table 17. Undenatured ethanol cash operating expenses and net feedstock costs for dry-milling process by plant size, 2002.[90]

Feedstock	Unit	All Dry Mills	Small	Large
Corn	1,000 bu	193,185	103,213	89,972
Sorghum	1,000 bu	10,409	N/A	10,409
Other	1,000 ton	44.9	N/A	44.9
Alcohol Production				
Fuel	1,000 gal	548,684	275,900	272,784
Industrial	1,000 gal	1,000	1,000	
Total	1,000 gal	549,684	276,900	272,784
Ethanol Yield	Gal./bu	2.6623	2.6828	2.649
Feedstock Costs	Dol./gal	0.8030	0.7965	0.8095
Byproducts Credits				
Distiller's Dried Grains	Dol./gal	0.2520	0.2433	0.261
Carbon Dioxide	Dol./gal	0.0060	0.0038	0.008
Net Feedstock Costs	Dol./gal	0.5450	0.5494	0.5405

Feedstock	Unit	All Dry Mills	Small	Large
Cash Operating Expenses				
Electricity	Dol./gal	0.0374	0.04	0.0349
Fuels	Dol./gal	0.1355	0.1607	0.1099
Waste Management	Dol./gal	0.0059	0.0077	0.0041
Water	Dol./gal	0.0030	0.0044	0.0015
Enzymes	Dol./gal	0.0366	0.0377	0.0365
Yeast	Dol./gal	0.0043	0.0039	0.0046
Chemicals	Dol./gal	0.0229	0.0231	0.0228
Denaturant	Dol./gal	0.0348	0.0356	0.03399
Maintenance	Dol./gal	0.0396	0.0319	0.0474
Labor	Dol./gal	0.0544	0.0609	0.0478
Administrative Costs	Dol./gal	0.0341	0.0357	0.0325
Other	Dol./gal	0.0039	0.0035	0.0043
Total	**Dol./gal**	**0.4124**	**0.4451**	**0.3802**
Total Cash Costs/Net Feedstock Costs	**Dol./gal**	**0.9574**	**0.9945**	**0.9207**

6.2 Fuel Price Comparisons over Time for Large-scale Users[91,92,93]

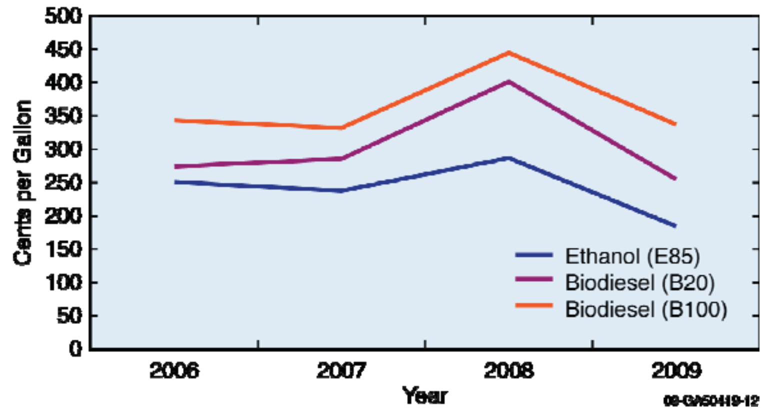

Figure 12. Price ranges per biofuel type (yearly average).

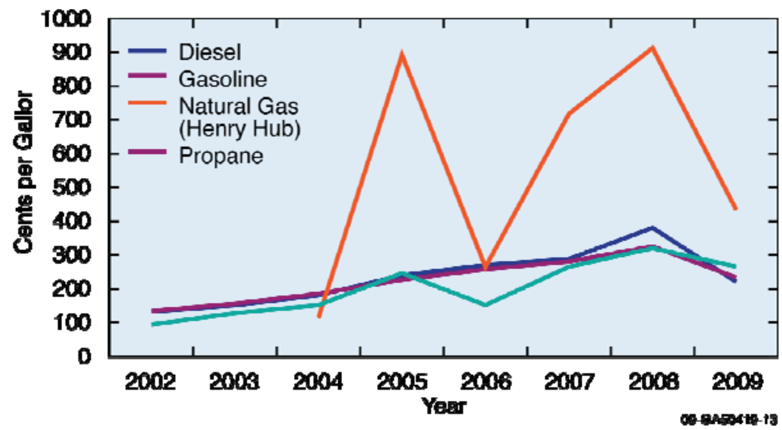

Figure 13. Price ranges per fossil fuel type (yearly average).

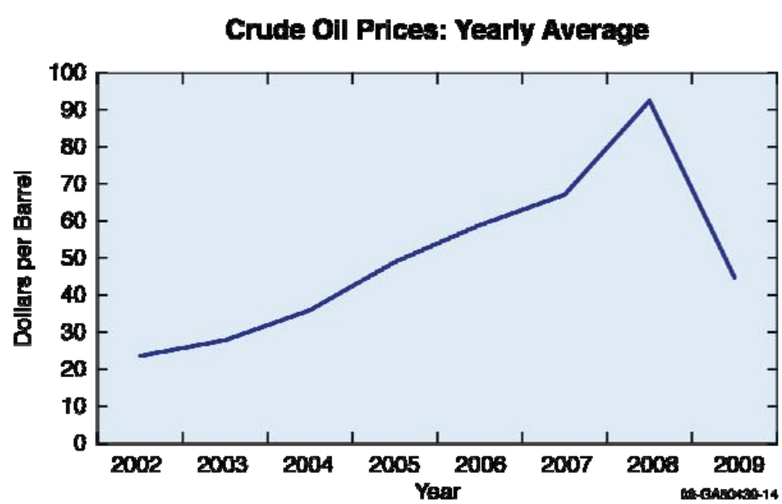

Figure 14. Price ranges for crude oil (yearly average).

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7. BIOMASS IMPORT AND EXPORT

7.1 Ethanol

The U.S. currently does not export ethanol. It uses all of the ethanol it produces and imports some from other countries. In 2006, the United States imported 599.7 million gallons of ethanol. About 66% of the ethanol imported came from Brazil (Table 18).

Table 18. U.S. fuel ethanol imports by country, 2002–2007 (millions of gallons).[94]

Country	2002	2003	2004	2005	2006	2007
Brazil	0	0	90.3	31.2	433.7	188.8
Costa Rica	12	14.7	25.4	33.4	35.9	39.3
El Salvador	4.5	6.9	5.7	23.7	38.5	73.3
Jamaica	29	39.3	36.6	36.3	66.8	75.2
Trinidad & Tobago	0	0	0	10.0	24.8	42.7
Canada						5.4
China						4.5
Total	**45.5**	**60.9**	**158**	**134.6**	**599.7**	**429.2**

7.2 Biodiesel

U.S. biodiesel production and export has recently grown significantly. This increase is driven mainly by the Renewable Fuel Standard (RFS) program that was established in the Energy Policy Act of 2005. The RFS program objectives, coupled with increasing fuel prices, led to a surge in biodiesel production capacity and production (Figure 15). Much of the increase in production in 2007 and 2008 was not consumed within the United States but was exported because of the incentives provided by the biodiesel tax credit (Tables 19 and 20).

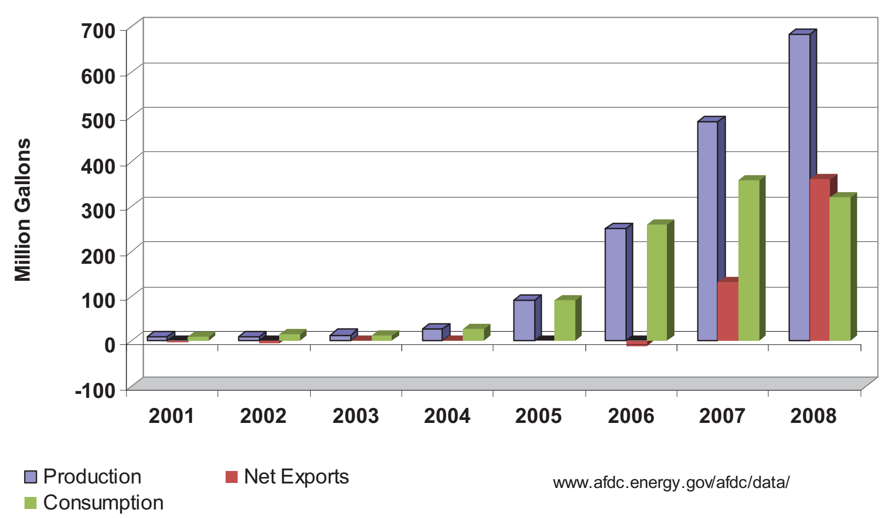

Figure 15. U.S. biodiesel production, exports, and consumption.[95]

Table 19. U.S. biodiesel exports and imports (million gallons, except shares).[96]

Exports[a] to:	World	North America		European Union	
Year	Volume	Volume	Share of world total	Volume	Share of world total
2003	4.61	1.28	28%	0.82	18%
2004	5.19	0.98	19%	0.74	14%
2005	8.64	1.58	18%	3.78	44%
2006	34.76	11.91	34%	16.48	47%
2007	272.04	18.20	7%	237.01	87%
2008	677.38	6.82	1%	645.96	95%

Imports from:	World	North America		Asia	
Year	Volume	Volume	Share of world total	Volume	Share of world total
2003	3.93	0.16	4%	2.53	64%
2004	4.08	0.49	12%	1.61	39%
2005	8.68	1.10	13%	4.94	57%
2006	44.91	7.74	17%	24.19	54%
2007	140.37	20.81	15%	100.67	72%
2008	315.07	25.45	8%	129.43	41%

a. Exports include re-exports.

Current export levels may be temporary as the European Union contests the claimed dumping practice of U.S. biodiesel on EU markets. The European Commission is investigating placing tariffs on U.S. biodiesel. This would significantly reduce the amount of biodiesel that the United States would export to Europe.

Table 20. Biodiesel annual statistics (million gallons).[97]

Year[a]	Production (BDPRPUS [b])	Exports[c]	Imports	Net Imports (BDNIPUS[b])	Imputed Consumption[d] (BDTCPUS[b])
2001	8.57	1.65	3.29	1.64	10.20
2002	10.50	2.33	8.02	5.68	16.18
2003	14.20	4.61	3.93	-0.68	13.52
2004	27.97	5.19	4.08	-1.10	26.87
2005	90.80	8.64	8.68	0.04	90.84
2006	250.43	34.76	44.91	10.14	260.58
2007	489.83	272.04	140.37	-131.67	358.17
2008	682.53	677.38	315.07	-362.31	320.22

a. Through 2000, data are not available. Beginning in 2001, data are estimates.

b. BDPRPUS = Biodiesel plant production; BDNIPUS = Biodiesel net imports; BDTCPUS = Biodiesel product supplied (consumption).

c. Exports include re-exports

d. Imputed consumption = production + imports – exports

7.3 Biomass Pellets

Biomass pellets can be used as an alternative to, or in combination with, coal, making them an excellent substitute for coal-fed systems. Pellets can also be used in home heating or highly efficient combined heat and power (CHP) plants. Biomass pellets are quickly becoming cost competitive with fossil fuels and even coal. In fact, in some areas in Europe biomass pellets are less expensive that coal, which is prompting increased demand. Biomass pellets are a viable energy solution for heating, as one ton (1,000 kg) of biomass (wood) pellets produces the same amount of BTUs as 3.36 barrels of oil or 20.5 GJ (gigajoule) of gas.

The demand for biomass pellets in Europe has been rapidly increasing in recent years. In 2005, the European Union experienced a 16% growth in electricity produced from biomass. This growth is expected to continue, which is motivating U.S. industries to expand their production of biomass pellets explicitly for export to the European Union.

One challenge the biomass pellet industry faces is that demand can be volatile. In 2008, Europe's warm winter caused a drastic reduction in demand for biomass pellets, which subsequently reduced demand for pellet imports.

Figure 16 shows the location of biomass pellet plants in the United States in 2006. In 2007, the U.S. biomass pellet production capacity was approximately 1.4 million tons with 1.2 million tons additional capacity under construction.[98]

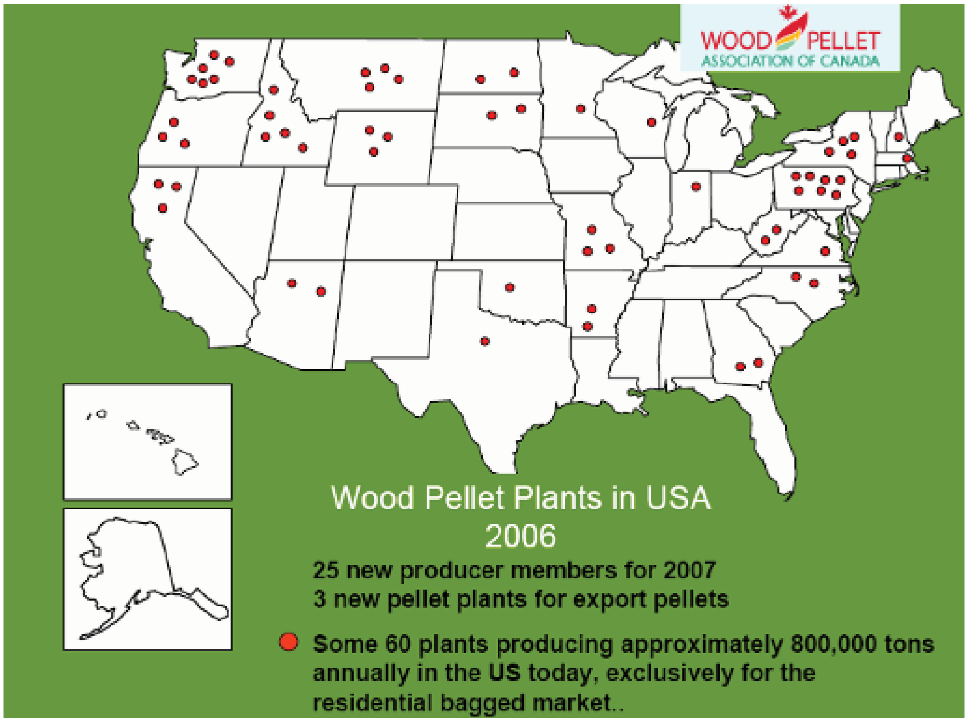

Figure 16: Pellet plant locations in the United States in 2006.[99]

The main cost factors for exporting wood pellets are transportation and supply logistics, among which sea transportation alone contributes 35 to 38% of the total cost, depending on the distance of the export countries. These costs are followed by the pellet production cost, which amounts to about 30%. Raw material followed by drying costs are the main cost contributors for pellet production. Pelletization processing and personnel costs are also of great relevance.

At the end of 2006, pellet demand in the United States was around 1.4 million tons, a greater than 200% increase over the 2002 demand. Pellets in the United States are used mostly in residential and small-scale applications and very little, if at all, in large-scale power generation. Although pellet popularity is growing, the U.S. market remains comparatively small.

In Europe, renewable power generation and greenhouse-gas emissions regulations have triggered a boom in wood pellet use. Current EU commitments call for 20% of final energy consumption to come from renewables by 2020 and the meeting of the Kyoto Protocol's targets. It is estimated that the EU currently supplies about 4% of its total electricity from wood waste (versus 2% in the United States) and this number is expected to double by 2010. Current consumption is now greater than 6 million tons annually.[100]

In 2006, EU nations consumed around 5.5 million tons of pellets but produced only 4.5 million tons, an 18% “deficit.” Canada is currently the largest pellet exporter to the EU, but there is also significant export potential in the United States, as evidenced by the fact that pellet manufacturing capacity has been expanding rapidly.

In the United States, the low price of coal and its prominence in power generation (coal accounted for roughly 48% of U.S. electricity generated in 2008) present the biggest challenges to the growth of the wood pellet market. However, greenhouse gas emissions regulations being developed could change this. Because wood pellets are considered greenhouse gas neutral, co-firing them with coal reduces CO_2 emissions on a 1:1 basis.

Greenhouse gas emissions regulation has been one of the major pellet industry drivers in Europe and can represent a relatively low-cost means of transitioning toward cleaner power generation technologies in the United States and other countries. Given the relative abundance of biomass across North America, (especially Canada, the biomass superstore of the continent) federally regulated limitations on greenhouse gas emissions could jump start the wood pellets market here.

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8. BARRIERS & OPPORTUNITIES

8.1 General Barriers and Opportunities for Biomass

The main barrier for biomass is sustainable production of feedstocks. While national assessments[101] identify sufficient biomass resource to meet the production targets, much of that resource is inaccessible because of unfavorable economics that result from agronomic systems that are not designed for commercial-scale biomass production, material handling and environmental constraints, and limited market access.[102] Tables 21–23 show costs and targets for a modeled scenario (Scenario 1)[103] that are driving current R&D in feedstock supply system design.

Note: Positive balance for the U.S. is wholly dependent upon getting away from corn as a sole source of biomass. If corn is the only source used, the U.S. would have a substantial deficit, even if it only displaced 7% of gasoline with ethanol.

Table 21. Contributing costs (2007$) and technical targets for "Process Concept: Herbaceous Biomass Production (Resource Standing in Field)."[104]

Cost Contributions/ Technical Parameters	**Metric**	**Corn Stover**			**Cereal Straw**			**Switchgrass**		
		2007	2012	2017	2007	2012	2017	2007	2012	2017
Year $ Basis		2007	2007	2007	2007	2007	2007	2007	2007	2007
Grower Payment	$/dry ton	13.10	13.10	26.20	13.10	13.10	26.20	13.10	13.10	26.20
Tonnage Potential at or Below Grower Payment	MDT/yr	1.4	58.0	96.6	12.8	19.7	19.7	0	10.9	52.0
Percent Dry Feedstock (<15% Moisture)	%	100	4	2	100	100	100	0	60	29
Agronomic and Environmental Practice Factors	MDT/yr	—	13.0	51.5	—	8.0	8.0	—	10.9	52.0
New crop development factors	MDT/yr	—	—	—	—	—	—	—		
Stumpage Fee	$/Dry ton	13.10	13.10	26.20	13.10	13.10	26.20	13.10	13.10	26.20
Tonnage Potential at or Below Stumpage Fee	MDT/yr	0.0	1.1	10.0	0.0	2.7	7.0	0.0	37.2	65.0
Percent Dry Feedstock (<15% Moisture)	%	0	0	0	0	0	0	0	0	0
Agronomic and Environmental Practice Factors	MDT/yr	—	—	—	—	—	—	—	2.0	7.6
New Crop Development Factors	MDT/yr	—	—	—	—	0.1	0.5	—	—	—

a. Feedstock Production Case Reference: Threshold Tonnage Analysis

Table 22. Contributing costs (2007$) and technical targets for "Process Concept: Dilute Acid Pretreatment, Enzymatic Hydrolysis, Ethanol Fermentation and Recovery, Lignin Combustion for CHP (Corn Stover)."[105]

		Corn Stover		
Cost Contributions/Key Technical Parameters	**Metric**	**2005**	**2009**	**2012**
Year $ Basis		2007	2007	2007
Minimum Ethanol Production Processing Cost	$/gal EtOH	1.59	1.35	0.82
Total Project Investment per Annual Gallon	$	5.11	4.46	3.17
Plant Capacity (Dry Feedstock Basis)	tonnes/day	2000	2000	2000
Ethanol Yield	gal EtOH/dry U.S. ton	65.3	74.3	89.8
Prehydrolysis/Treatment				
Total Cost Contribution	$/gal EtOH	0.44	0.31	0.25
Capital Cost Contribution	$/gal EtOH	0.20	0.17	0.14
Operating Cost Contribution	$/gal EtOH	0.24	0.13	0.11
Solids Loading	wt%	30	30	30
Xylan to Xylose	%	68	75	90
Xylan to Degradation Products	%	13	6	5
Xylan Sugar Loss	%	13	7	0
Glucose Sugar Loss	%	12	6	0
Enzymes				
Total Cost Contribution	$/gal EtOH	0.32	0.33	0.10
Capital Cost Contribution	$/gal EtOH	NA	NA	NA
Operating Cost Contribution	$/gal EtOH	0.32	0.33	0.10
Saccharification and Fermentation				
Total Cost Contribution	$/gal EtOH	0.31	0.27	0.10
Capital Cost Contribution	$/gal EtOH	0.12	0.11	0.05
Operating Cost Contribution	$/gal EtOH	0.19	0.17	0.05
Total Solids Loading	wt%	20	2	20
Combined Saccharification/Fermentation Time	days	7	7	3
Overall Cellulose to Ethanol	%	86	86	86
Xylose to Ethanol	%	76	80	85
Minor Sugars to Ethanol	%	0	40	85
Distillation and Solids Recovery				
Total Cost Contribution	$/gal EtOH	0.18	0.17	0.15
Capital Cost Contribution	$/gal EtOH	0.15	0.13	0.12
Operating Cost Contribution	$/gal EtOH	0.04	0.04	0.03
Steam Use	lb stm/gal EtOH	54		45
Moisture Content of Solids	% water by weight	15		15
Balance of Plant				
Total Cost Contribution	$/gal EtOH	0.34	0.27	0.22
Capital Cost Contribution	$/gal EtOH	0.39	0.33	0.26

Cost Contributions/Key Technical Parameters	Metric	Corn Stover 2005	2009	2012
Operating Cost Contribution	\$/gal EtOH	-0.05	-0.06	-0.04
Co-product Credit: Electricity	\$/gal EtOH	-0.17	-0.14	0.11
Co-product Credit: Other	\$/gal EtOH	0	0	0
Electricity Production	KWHr/gal EtOH	4.4	3.5	2.4
Water Consumption	gal H_2O/gal EtOH	10.2		6.2
Fuel Ethanol Case Reference (Model Run #)		J0507B	I0610F Y09	J0601A .Throat. 2000.35

Table 23. Contributing costs (2007\$) and technical targets for "Process Concept: Feedstock Collection, Preprocessing, and Delivery to Conversion Reactor Inlet (Dry Herbaceous Biomass)."[106]

Cost Contributions/Technical Parameters	Metric	Dry Herbaceous 2007	2009	2012	2017
Year \$ Basis		2007	2007	2007	2007
Total Cost of Feedstock Logistics	\$/dry ton	47.00	32.80	32.80	32.80
Overall Logistics Efficiency (output/input)	% (dry matter basis)	95	95	95	95
Harvest and Collection					
Total Cost Contribution	\$/dry ton	18.40	10.60	10.60	10.60
Capital Cost Contribution	\$/dry ton	7.80	4.70	4.70	4.70
Operating Cost Contribution	\$/dry ton	10.60	5.90	5.90	5.90
Collection Efficiency	% improvement over baseline	25	40	40	40
Single-pass Capacity	dry ton/hr	—	—	—	—
Selective Harvest Feedstock Quality	change in \$/dry ton	—	—	—	1.50
Storage and Queuing					
Total Cost Contribution	\$/dry ton	6.10	3.70	3.70	3.70
Capital Cost Contribution	\$/dry ton	0.20	0.10	0.10	0.10
Operating Cost Contribution	\$/dry ton	5.90	3.60	3.60	3.60
Shrinkage	% dry matter loss	<5	<5	<5	<5
Storage Quality	change in \$/dry ton	—	—	—	—
Preprocessing					
Total Cost Contribution	\$/dry ton	7.80	6.20	6.20	6.20
Capital Cost Contribution	\$/dry ton	1.50	1.20	1.20	1.20
Operating Cost Contribution	\$/dry ton	6.30	5.00	5.00	5.00
Capacity	dry ton/kW-hr	0.034	0.043	0.043	0.043
Bulk Density	dry lb/ ft^3	12	14	14	14
Preprocessing Quality	change in \$/dry ton	—	—	—	\$3.00
Transportation and Handling					
Total Cost Contribution	\$/dry ton	14.70	12.30	12.30	12.30
Capital Cost Contribution	\$/dry ton	3.10	2.70	2.70	2.70
Operating Cost Contribution	\$/dry ton	11.60	9.60	9.60	9.60

Cost Contributions/Technical Parameters	Metric	Dry Herbaceous			
		2007	**2009**	**2012**	**2017**
Plant Conveying Bulk Density	dry lb/ft^3	4.4	9	9	9
Plant Storage Bulk Density	dry lb/ft^3	10	12	12	12
Field Bulk Density	dry lb/ft^3	—	—	—	—
Balance of Feedstock Logistics					
Total Cost Contribution	$/dry ton	47.00	32.80	32.80	32.80
Capital Cost Contribution	$/dry ton	12.60	8.70	8.70	8.70
Operating Cost Contribution	$/dry ton	34.40	24.10	24.10	24.10
Value-added Contribution (increased margin/more feedstock available)	$/dry ton	0.00	0.00	0.00	4.50

Feedstock case reference (Model Run #): INL Feedstock Model x2-12-07 ctw

8.2 Barriers and Opportunities for International Biomass Trade

Other countries that produce ethanol and import it into the United States may be subject to import tariffs or duties, depending on trade agreements. A general *ad valorem* tax of 2.5% is assessed on imports.

Two other trade policies affect imports. Some countries can import ethanol without a tariff as long as they import less than the quota set by the U.S. International Trade Commission each year. In addition, a tax of $0.1427 per liter, or $0.54 per gallon, is assessed on imports that are not exempt from the tariff or that exceed the limits allowed by other countries. Brazil, a large producer and exporter of ethanol, is subject to the tariff, thus the tariff is frequently called the Brazilian ethanol tariff.[107,108] The U.S. International Trade Commission has estimated that these assessments amounted to approximately $252.7 million in 2006.[109]

However, some imported ethanol from Caribbean Basin Initiative (CBI) countries can enter the United States without paying duties, even if the ethanol was actually produced in a non-CBI country. Ethanol can be dehydrated in a CBI country and then shipped to the United States to avoid the duty.[110] In addition, current law allows duties that are paid when ethanol is imported to be refunded if a related product (e.g., jet fuel) is exported.[111] This is called "duty drawback." There are no data regarding the amounts subject to this drawback,[112] but there are tax proposals at the federal level to repeal the exemption for ethanol-related export refunds.[113]

Almost every major oil-consuming country around the globe has projections for future ethanol consumption. Projected consumption (Figure 15), coupled with an increasing demand for a gasoline-type fuel, are expected to expand the international market for biofuels greatly over the next few decades. The major players in international trade of ethanol to meet these demands are the United States (USA), the European Union (EU), Japan, China, Brazil, and the "Rest of the World-Brazil" (ROW-BR).[114] While Brazil is not a one of the leading consumers of gasoline, it will be a major ethanol producer. Other countries that have similar production capacities (ROW-BR) will also have a significant role in biomass trade (Figures 16 and 17).

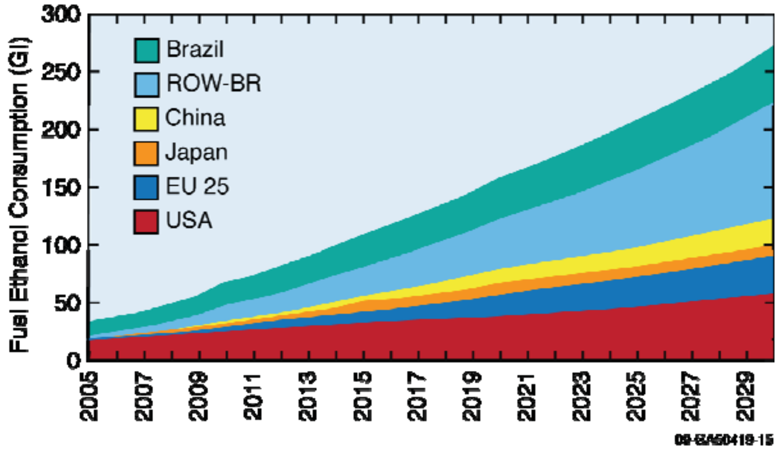

Figure 15. Estimated consumption of fuel ethanol from 2006 to 2030 (Scenario 1).[115] (Assumes ethanol displaces 10% of global gasoline production by 2030.)

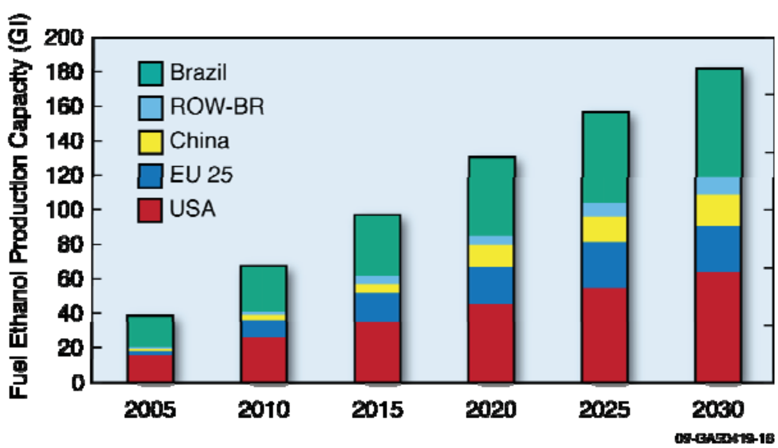

Figure 16. Estimated fuel ethanol capacity of production (conventional technologies).[116]

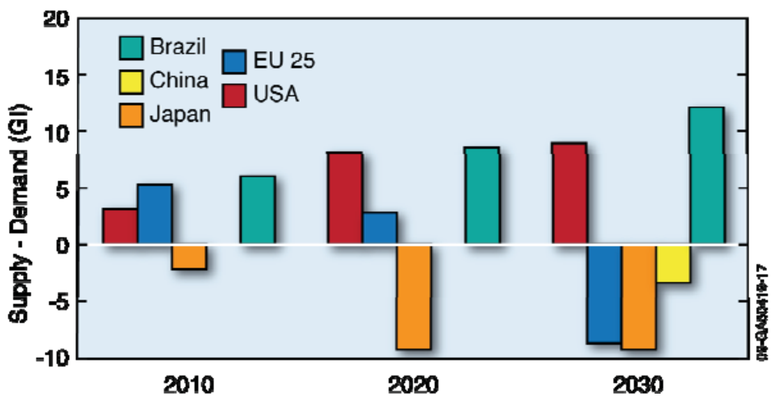

Figure 17. Estimated balance between potential supply and demand of fuel ethanol (Scenario 1 for USA [GI]).[117]

In considering barriers and opportunities that will impact U.S. participation in international biomass trade, it is worthwhile to emphasize relevant issues identified by earlier IEA Bioenergy Task 40 efforts and include recommendations for addressing them.[118]

8.2.1 Economic

One of the principal barriers for the use of biomass energy in general is the competition with fossil fuel on a direct production cost basis (excluding externalities). The limiting factor in biomass supply often is not the amount available, but rather the investment required to gather and pre-treat or densify the biomass to make transportation economical. Capital for investment in these regions may be limited, or investment may be deemed too risky until markets show some long-term stability and growth. In summary, while the strong increase in overall biomass demand is a positive development in itself, the market is hampered at this moment by many factors such as its dependence on (short-term) policy support measures and typical problems of emerging markets such as small bilateral volumes, lacking market transparency, etc.

8.2.2 Technical

A general problem of some biomass types is variety in physical properties (e.g., low density and bulky nature) and chemical properties, such as high ash, moisture, nitrogen, sulfur, or chlorine content. These properties make it difficult and expensive to transport and often unsuitable for direct use, say, for co-firing with coal or natural gas power plants. Power producers are generally reluctant to experiment with new biomass fuel streams (e.g., bagasse or rice husks). As shipments within these streams often fail to meet the required physical and chemical properties, power producers are afraid to damage their installations (designed for fossil fuels), especially the boilers.

8.2.3 Logistical

Related to technical barriers are logistical barriers. One of the problems of logistical barriers is a general lack of technically mature pre-treatment technologies in compacting biomass at low cost to facilitate transportation, although fortunately this is improving. Densification technology has recently improved significantly (e.g., for pellets), although this technology is only suitable for certain biomass types. Also, the final density per cubic meter is still far less than oil, given the nature of biomass.

When setting up biomass fuel supply chains for large-scale biomass systems, logistics are a pivotal part in the system. Various studies have shown that long-distance international transport by ship is feasible in terms of energy use and transportation costs, but availability of suitable vessels and meteorological conditions (e.g., winter time in Scandinavia and Russia) need to be considered. However, local transportation by truck (both in biomass exporting and importing countries) may be a high-cost factor, which can influence the overall energy balance and total biomass costs.

8.2.4 International

As with other traded goods, several forms of biomass can face technical trade barriers. As some biomass streams have only recently been traded, so far no technical specifications for biomass and no specific biomass import regulations exist. This can be a major hindrance to trading. For example, in the EU, most residues containing traces of starches are considered potential animal fodder, and thus it is subject to EU import levies.

A major constraint is that countries with large markets (the United States, Japan, and the EU) are completely or partially closed due to trade barriers. The United States applies *ad valorem* duties of 2.5% for imports from most-favored-nations (MFN) and 20% for imports from other countries. Japan applies *ad valorem* duties of 27% (MFN treatment). At present, these duties represent a significant barrier to trade, influencing the competitiveness of foreign imports.

Other international barriers include import transportation tariffs and risk of pathogens or pests in bioproducts.

8.2.5 Ecological

Large-scale biomass-dedicated energy plantations may in principle pose various ecological and environmental issues that cannot be ignored (e.g., monocultures and associated [potential] loss of biodiversity, soil erosion, fresh water use, nutrient leaching, pollution from chemicals).

8.2.6 Competing Markets

Various types of biomass can be used for end products other than energy (i.e., as raw material for the pulp and paper industry, as raw material for the chemical industry [e.g., tall oil or ethanol], as animal fodder [e.g., straw], or for human consumption [e.g., ethanol or palm oil]). This competition can occur directly over biomass resources, but it also often focuses indirectly on land availability.

8.2.7 Legal

Before large-scale international trade of bioenergy can be implemented, clear rules and standards need to be established, such as who is entitled to the CO_2 credits. Another related issue concerns the methodology that should be used to evaluate the avoided emissions throughout the fuel life cycle.

8.2.8 Information

The benefits of sustainable biomass energy in general, and specifically the need for international biomass trade, are still largely unknown to many stakeholders such as industrial parties, policy makers, non-governmental organizations, and the general public. More active dissemination of information by the IEA Bioenergy Program, various United Nation institutions, national governments, and other organizations is required.

8.3 U.S. Participation in International Biomass Trade

International fuel ethanol trade is still in its infancy, and there are many barriers to overcome before the industry is self-sustaining. On the other hand, from the results presented in Section 8.1 (Case Scenario 1[119]), it is clear that the only way to accomplish the U.S. target of displacing 10% of the gasoline demand in 2030 is by enhancing international ethanol trade.

Long-term U.S. participation in international biomass trade depends on an enhanced international biomass trade system that does not exist yet but will respond to ethanol import restrictions[120] that impact all participating countries. This enhanced system will meet key sustainability requirements:

- Standardized products
- Sustainability of production
- Environmentally conscious production from all sources
- Net energy balance when importing is considered.

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