International Energy Agency (IEA) Task 40

Sustainable International Bioenergy Trade: Securing Supply and Demand

Country Report—United States

2010

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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 population of the United States as of 2010 was 309,349,689,[1] and gross domestic product (GDP) was $14,256.5 billion (2010 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.[3]

1.2 Main Industries

Table 1 lists sales, receipts, and shipments for major U.S. industries. The top eight industries (in bold) represent approximately 90% of the total economic expenditure in the United States. Within the main industries shown in Table 2, 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).[4]

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**

Note: Data compiled every 5 years. Next census is due in 2012.

Table 2. U.S. industries with relevance to biomass.[5]

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 Reduction Requirements

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). Renewable fuels are considered carbon neutral, so 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.

The U.S. Environmental Protection Agency (EPA) reported in 2010 overall CO_2 emissions were 5,983.1 teragrams (Tg, 10^{12}g), an 15% increase over 1990 levels.[6]

1.4 Domestic Energy Production

Of the 75.031 quadrillion British thermal units (BTU) produced in the United States, 8.064 quadrillion BTU are produced from renewable energy (Table 3). Of that, 4.310 quadrillion BTU are produced from biomass sources, which comprises 53.45% of renewable energy and 5.74% of total energy produced (Table 3).

Table 3. Primary energy production ranked by source, 2010.[7]

Energy Type		**Quadrillion BTU**	**Production (%)**
Fossil Fuels	*Coal*	*22.077*	*29.424*
	Natural Gas (dry)	*22.095*	*29.448*
	Crude Oil	*11.669*	*15.552*
	NGPL[a]	*2.686*	*3.580*
		58.527	**78.004**
Nuclear Electric Power		**8.441**	**11.250**
Renewable Energy	*Hydroelectric Power*	*2.509*	*3.344*
	Geothermal	*0.212*	*0.283*
	Solar	*0.109*	*0.145*
	Wind	*0.924*	*1.231*
	Biomass	*4.310*	*5.744*
		8.064	**10.748**
Total		**75.031**	**100.00**

a. Natural gas plant liquids.

1.4.1 Renewable Energy

Renewable energy resources including hydroelectric, wind, solar, geothermal, and biomass provided about 8% of the total energy consumed in the United States in 2009. Hydroelectric contributes about 248,100 MW per year providing the largest contribution to the country's renewable energy.[8] Other sources of renewable energy continue to grow. As of 2011, the cumulative wind power capacity installed increased to 41,400 MW of generation capacity and 37 of the 50 states have some degree of utility-scale wind power. Geothermal capacity topped 3000 MW capacity in 2010 and solar for both heat (thermal solar) and electricity (photovoltaic solar) are also increasing in capacity. Biomass continues to be the largest consumed source of renewable energy consumed (~53%). 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 31.26% of total renewable energy consumed (**Error! Reference source not found.**).

Table 4. Primary energy consumption by source, 2010.[9] ,[10]

Energy Type		Quadrillion BTU	Consumption (%)
Fossil Fuels	*Coal*	*20.888*	*21.30*
	Natural Gas	*24.599*	*25.09*
	Petroleum	*36.010*	*36.73*
		81.489	**83.11**
Nuclear Electric Power		**8.441**	**8.61**
Renewable Energy	*Hydroelectric Power*	*2.509*	*2.56*
	Geothermal	*0.212*	*0.22*
	Solar/PV	*0.109*	*0.11*
	Wind	*0.924*	*0.94*
	Biomass	*4.272*	*4.36*
		8.027	**8.19**
Total		**98.045**	**100.00**

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. 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 like “flex-fuel” that can 85% ethanol. In 2011, Energy Information Administration (EIA) reported fuel ethanol capacity of 13.6 billion gallons per year, surpassing the 7.5 billion gallons required in the RFS that was enacted as part of the EPACT of 2005.[11] Based on current trends the RFS predicts, an expanding biofuel industry will have great economic implications providing jobs and creating capital investments.[12]

1.5 Electricity Production

Domestic electricity production is primarily drawn from coal-fired boilers (44.8% of total production), followed by nuclear power (19.6% of total production). A total of 10.4% of U.S. electric power comes from renewable resources, primarily from hydroelectric (6.3% of total U.S. electricity production) and biomass (1.4% of total U.S. electricity production) (Table 4).

Table 4. Electrical production in the United States, 2010.[13]

Power Source	Units in Operation	Total Nameplate Capacity (MW)	Total Capacity (%)	Annual Production (Thousand MWh)	Annual Production (%)
Coal	1396	342,296	30.06	1,847,290	44.75
Petroleum	3779	62,504	5.49	37,061	0.90
Natural Gas	5529	467,214	41.03	987,697	23.93
Other Gases	106	3,130	0.27	11,313	0.27
Nuclear	104	106,731	9.37	806,968	19.55

Power Source	Units in Operation	Total Nameplate Capacity (MW)	Total Capacity (%)	Annual Production (Thousand MWh)	Annual Production (%)
Hydroelectric	4,020	78,204	6.87	260,203	6.30
Wind	689	39,516	3.47	94,652	2.29
Solar/PV	181	987	0.09	1,212	0.03
Wood and Wood Derived	346	7,949	0.70	37,172	0.90
Geothermal	225	3,498	0.31	17,807	0.43
Biomass	1574	5,043	0.44	18,917	0.46
Pumped Storage	151	20,538	1.80	5,501	0.13
Other	51	1027	0.09	12,855	0.31

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 31% 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.[14,15]

Sector	Description	Major Uses[16]
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

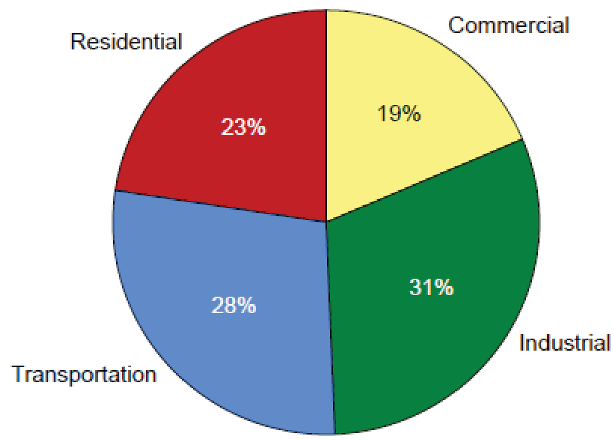

Figure 1. 2010 total energy consumption by sector.[17]

Currently, fossil fuels are used to produce roughly 83% of total energy consumed in the United States, while nuclear energy is used to produce almost 9% and renewable resources a little over 8% (Table 4).

1.6.1 Petroleum

In 2010 the United States consumed 19.1 million barrels of petroleum a day[18], of which 9 million barrels were used to produce motor gasoline. The transportation sector has the highest consumption rates, accounting for approximately 71.3% of the U.S. petroleum use in 2010.[19]Automobiles are the single largest consumer of oil, at 40%,[20] 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 2010 accounted for about 75% of total demand for crude oil—up from 36% in 1986.[21]

U.S. production of crude oil has dropped steadily over the past few decades from 8,140 thousand barrels per day in 1988 to 5,512 thousand barrels per day in 2010.[22]

Crude oil imports have increased steadily over the past 20 years from 7,402 thousand barrels per day in 1988 to11,753 thousand barrels per day in 2010.[23]

1.6.2 Coal

America is self-sufficient in coal.[24] Indeed, it has several hundred years' supply at the current use rate.[25,26] The United States' trend in coal use has been rising for decades. From 1950 through 2010, both coal production and coal consumption in the United States have more than doubled.[27] The U.S. population has almost doubled in this time period as well, while the per capita energy use has been declining since 1978.[28]

1.7 Further Country-Specific Energy-Related Information

The U.S. population is growing at a rate of 0.9%.[29] 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.

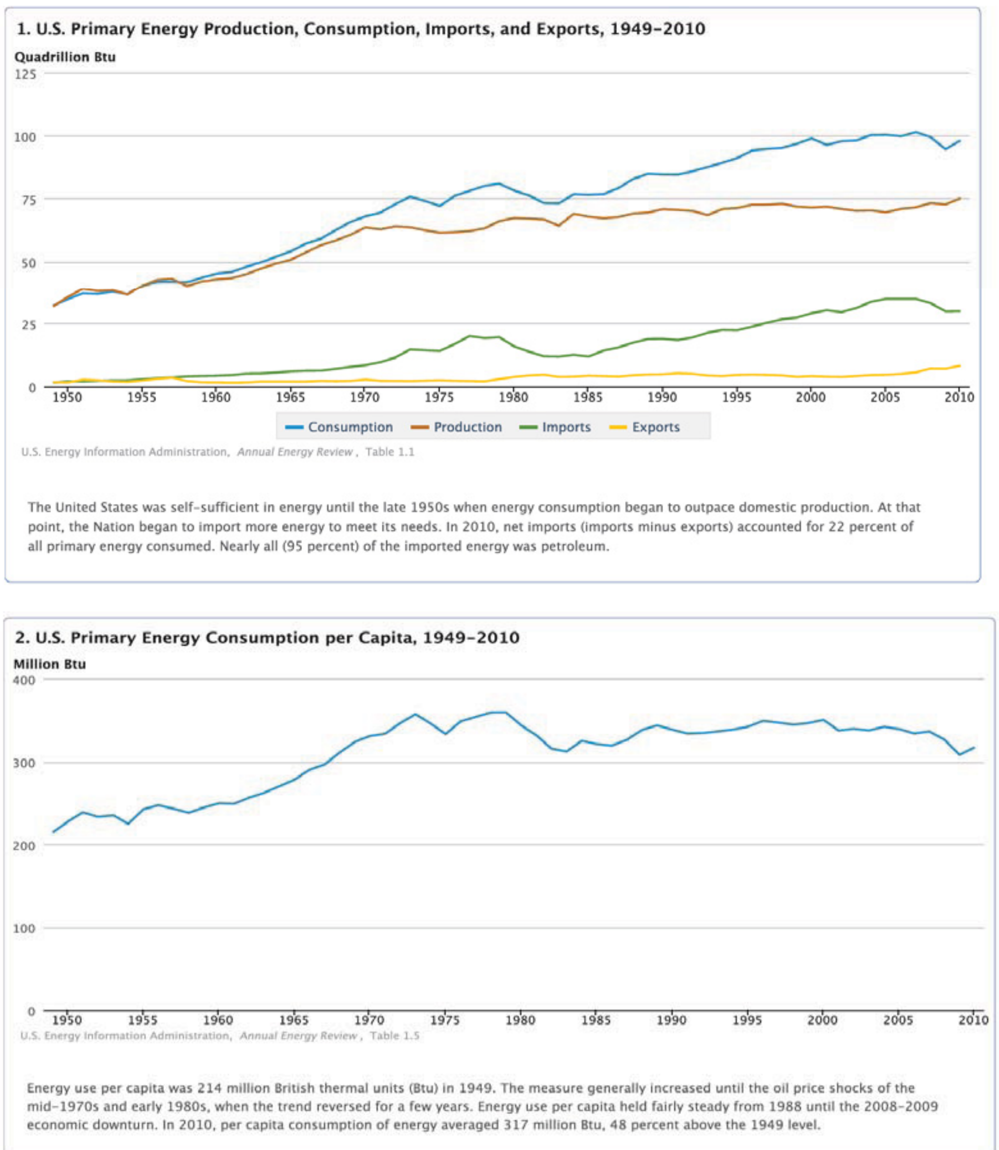

Figure 2. Overall energy consumption and consumption per capita in the United States over last half century.[30]

2. POLICY

2.1 Targets for Renewable Energy

The national renewable energy targets for the United States focus on biofuel production over the next 50 years. The first federal endorsement of biofuel 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).[31] With the exemption still in place, biofuel, 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.[32] 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.[33]

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.[34] 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.[35] 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.[36] EPACT also established an RFS that required that 7.5 billion gallons of ethanol and biodiesel be produced by 2012.[37] 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.[38]

Since EPACT, a variety of legislative, regulatory, and policy drivers have been established to help develop a sustainable market for bioenergy and biofuels. These efforts are summarized in Table 7.

2.1.1 Federal Targets for Biofuel Production

In his 2007 State of the Union address, President Bush announced a goal to reduce the nation's gasoline gasoline consumption by 20% by 2017.[39] Also in 2007, Congress passed the Energy Independence and Security Act of 2007 (EISA). The act amended the RFS established by EPACT 2005. Table 7. Federal biomass initiatives to support bioenergy industry development.

Date	Initiative	Roles/Objectives in Bioenergy Industry Development
Oct 2010	Biomass Crop Assistance Program (BCAP); Final Rule (Authorized by 2008 Farm Bill)	• Provides cost-share assistance to agricultural and forest land owners and operators for the establishment and production of eligible crops in selected project areas for conversion to bioenergy. • Provides matching funds for the collection, harvest, storage, and transportation of eligible material for use in a biomass conversion facility.
May 2009	Presidential Memorandum on Biofuels	• Establishes a Biofuels Interagency Working Group to consider policy actions to accelerate and increase biofuels production, deployment, and use. (Co-chaired by Secretaries of DOE and USDA and the Administrator of EPA.)
Feb 2009	American Reinvestment and Recovery Act (ARRA)	• Provides funds for grants to accelerate commercialization of advanced biofuels R&D and pilot-, demonstration-, and commercial-scale integrated biorefinery projects. • Provides funds to other DOE programs for basic R&D, innovative research, tax credits, and other projects.
May 2008	The Food, Conservation, and Energy Act of 2008 (2008 Farm Bill)	• Provides grants, loans, and loan guarantees for developing and building demonstration- and commercial-scale biorefineries. • Establishes a $1.01 per gallon producer tax credit for cellulosic biofuels. • Establishes the Biomass Crop Assistance Program (BCAP) to support the production of biomass crops. • Provides support for continuation of the Biomass R&D Initiative, the

		Biomass R&D Board, and the Technical Advisory Committee.
Dec 2007	Energy Independence and Security Act (EISA) of 2007	• Supports the continued development and use of biofuels, including a significantly expanded Renewable Fuels Standard, requiring production of 36 billion gallons per year by 2022, with annual requirements for advanced biofuels, cellulosic biofuels, and bio-based diesel.
Aug 2005	Energy Policy Act of 2005 (EPAct)	• Renews and strengthens federal policies fostering ethanol production, including incentives for the production and purchase of bio-based products; these diverse incentives range from authorization for demonstrations to tax credits and loan guarantees.

Table 6 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.[40] The U.S. EPA is revising its current RFS to reflect the changes in the EISA (Table 7. Federal biomass initiatives to support bioenergy industry development.

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Table 6).

2.1.2 Targets Set by Other Groups

In addition to biofuel 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 biofuel 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.[41] 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.[42]

Table 7. Federal biomass initiatives to support bioenergy industry development.

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Table 6. Biofuels targets mandated in the 2011 Renewable Fuel Standard (RFS2).

Year	Volume[a]	Conventional	Advanced	Cellulosic	Biomass-based diesel[b]	Undifferentiated Advanced
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	1.00	0.5
2013	16.55	13.8	2.75	1.00	≥1.00	0.75
2014	18.15	14.4	3.75	1.75	≥1.00	1.0
2015	20.50	15.0	5.50	3.00	≥1.00	1.5
2016	22.25	15.0	7.25	4.25	≥1.00	2.0
2017	24.00	15.0	9.00	5.50	≥1.00	2.5
2018	26.00	15.0	11.00	7.00	≥1.00	3.0
2019	28.00	15.0	13.00	8.50	≥1.00	3.5
2020	30.00	15.0	15.00	10.50	≥1.00	3.5
2021	33.00	15.0	18.00	13.50	≥1.00	3.5
2022	36.00	15.0	21.00	16.00	≥1.00	4.0

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

2.1.3 Federal Agency Role as Mandated by Congress

Many U.S. federal agencies administer programs that seek to expand the production and consumption of biofuel. 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[43]:

- 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 biofuel 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 biofuel. 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.[44] 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.[45] 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.[46] USDA's role was expanded with the passage of the Food Conservation and Energy Act of 2008. U.S. Customs and Border Protection (CBP) oversee 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.

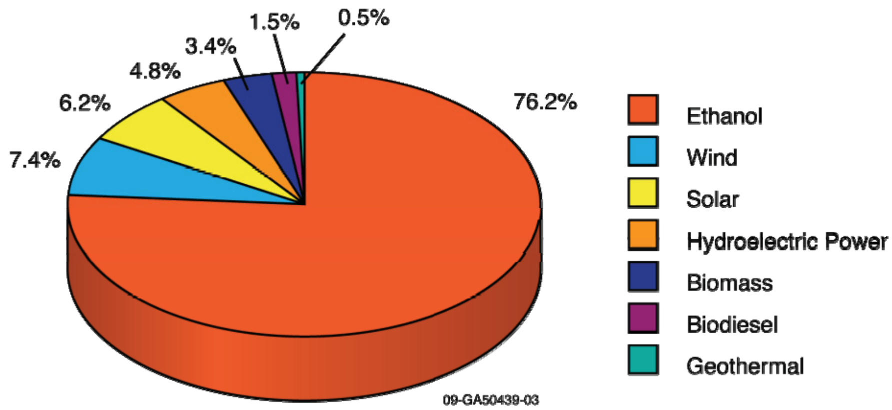

Figure 3. Estimated percent of total federal subsidies for renewable fuels in 2006, allocated by fuel source.[47]

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.[48] 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 7 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 7. Federal and state investments in lignocellulosic biorefineries awarded February 2007.[49,50]

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, LLCa	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 8 lists companies that, as of 2008, were selected for small-scale biorefinery projects totaling $240 million in federal investment over 4 years.

Table 8. Federal and state investments in lignocellulosic biorefineries awarded as of January 2008.[51,52]

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.

2.3.1 Feedstock Production-Focused Assistance

The Biomass Crop Assistance Program (BCAP) for USDA's Farm Service Agency (FSA) was created as part of the 2008 Farm Bill (The Food, Conservation, and Energy Act of 2008) to "reduce U.S. reliance on foreign oil, improve domestic energy security, reduce carbon pollution, and spur rural economic development and job creation.[53]

BCAP was set in place to help address bioenergy's "chicken-and-egg" challenge of establishing commercial-scale biomass conversion facilities and sufficient feedstock supply systems simultaneously:

- Conversion facilities must have reliable, large-scale feedstock supplies to operate, but there are no existing markets for accessing these materials
- Biomass feedstock producers do not have sufficient incentive to produce these materials because of the lack of existing markets to purchase their biomass.

BCAP provides financial assistance to agricultural residue producers in the form of matching Collection, Harvest, Storage, and Transportation (CHST) payments, $1 for each $1 provided by the conversion facility, up to $45 per ton, for a period of 2 years. Crop residues are only eligible if they are separated from the primary crop prior to delivery to the biorefinery (i.e., corn cobs qualify only if they are collected and harvested directly from the land, or separated from the grain, before arrival at the biorefinery). BCAP also provides cost share and annual payments to producers who enter into contracts with the Commodity Credit Corporation (CCC) to produce eligible biomass crops within selected BCAP project areas. For either program, producers must apply for the program and receive approval before delivering biomass to a conversion facility.

3. BIOMASS RESOURCES

In 2011, the U.S. Department of Energy released *The Billion-Ton Update,* a biomass resource assessment that projected biomass potential at conservative baseline yield increases and more optimistic yield increases driven by increased bioenergy industry demand.[54] Cropland and forestland have the potential to supply >1.1 billion dry ton (BDT) per year as projected from historical yield baselines and 1.3 to 1.6 BDT considering higher yield increases of 2 and 4%, respectively. Figure 4 and Figure 5 show the projected resource potential for both baseline and high-yield scenarios based on grower/stumpage payments of $60 per dry ton.

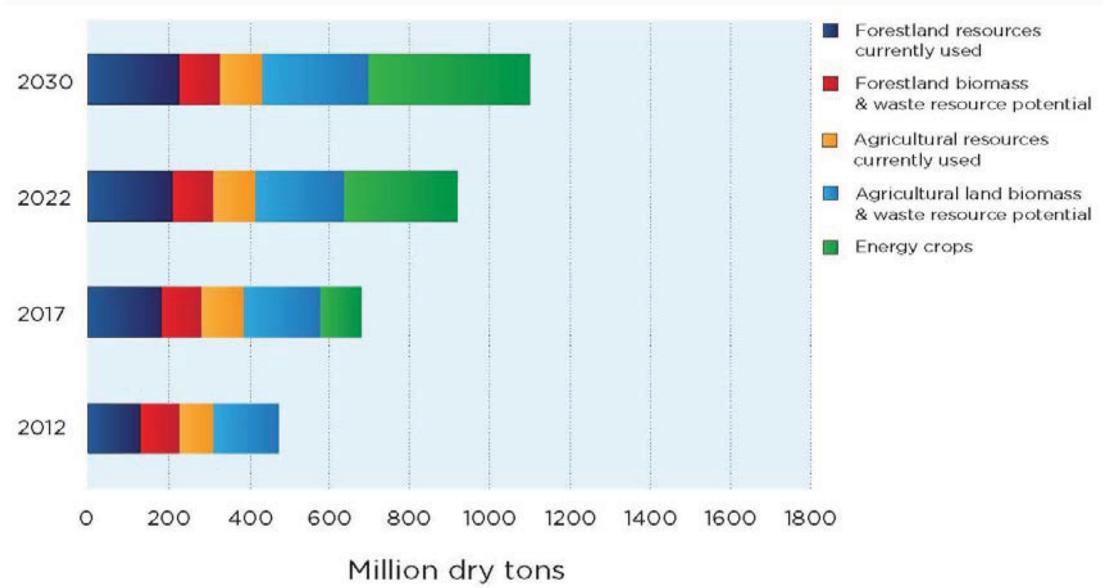

Figure 4. Summary of annual biomass resource potential from forest and agricultural resources under baseline assumptions.**Error! Bookmark not defined.**

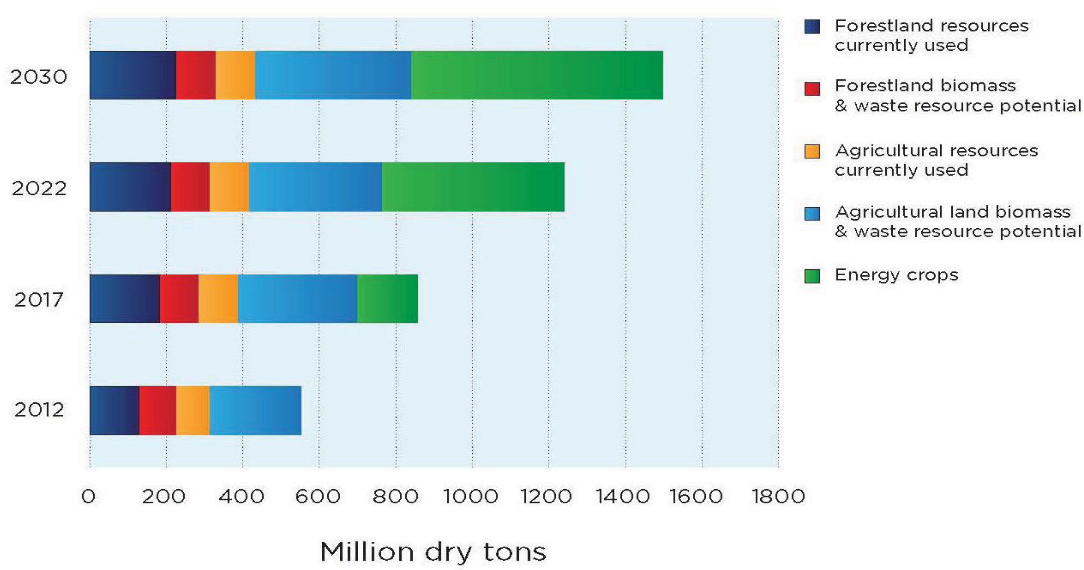

Figure 5. Summary of annual biomass resource potential from forest and agricultural resources under high-yield scenario assumptions.[55]

3.1 Geographical Biomass Resource Potential

The land base of the United States encompasses nearly 2,263 million acres. About 33% of the land area is classified as forestland, 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).[56,57] About one-half of this land has some potential for growing biomass for bioenergy feedstocks while continuing to meet food, feed, and fiber demands. Geographical biomass resource 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 6).

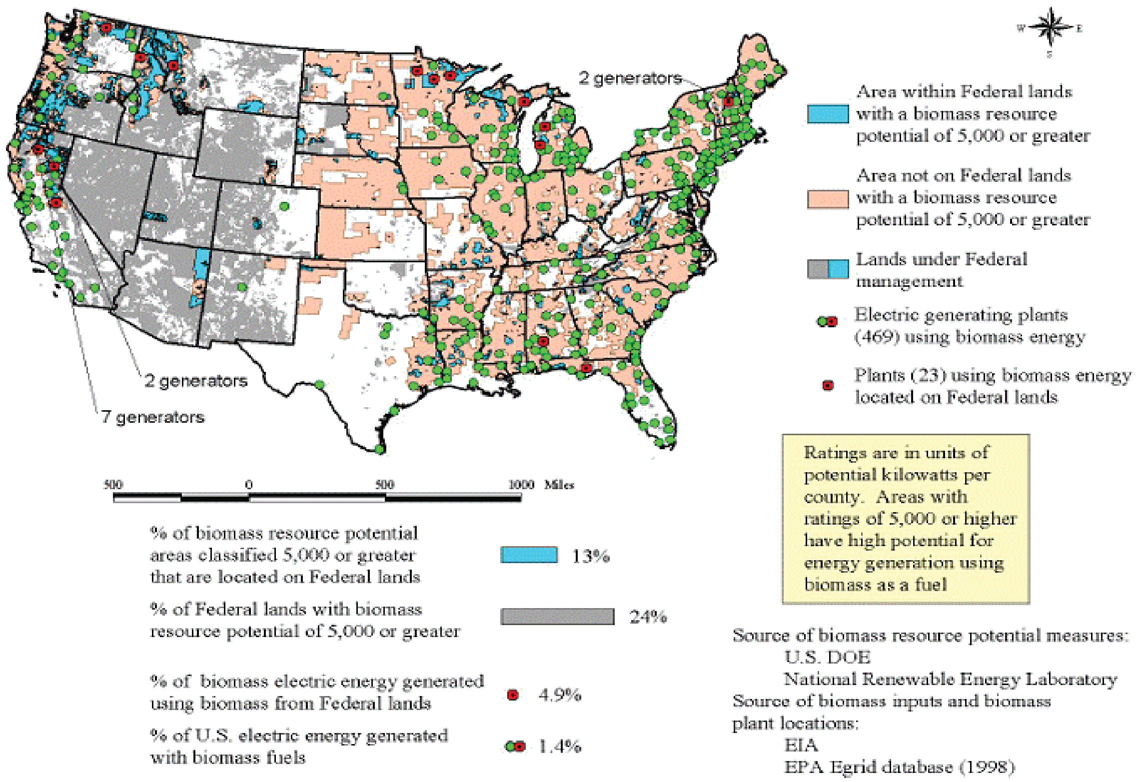

Figure 6. Geographical resource potential on federal lands in the continental United States.[58]

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 9).

Table 9. Gasoline and Ethanol: Comparison of current and potential production costs in North America (U.S. dollars per gasoline-equivalent liter).[59]

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

At baseline yield increase assumptions and $60 per dry ton, the amount of biomass that can be removed sustainably from agricultural lands is currently about 247 MDT per year. This amount can be increased fivefold to nearly 1.1 to 1.3 BDT within 20 to 30 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 energy crops. This high-yield scenario projection comprises 103 MDT of agricultural resources that are currently available, 404 MDT of agricultural biomass and waste resource potential, and 540 to 799 MDT of perennial energy crops.[60]

Figure 7 shows a breakdown of agricultural biomass resource availability at three different prices and four different time frames, projected from historical yield baselines.

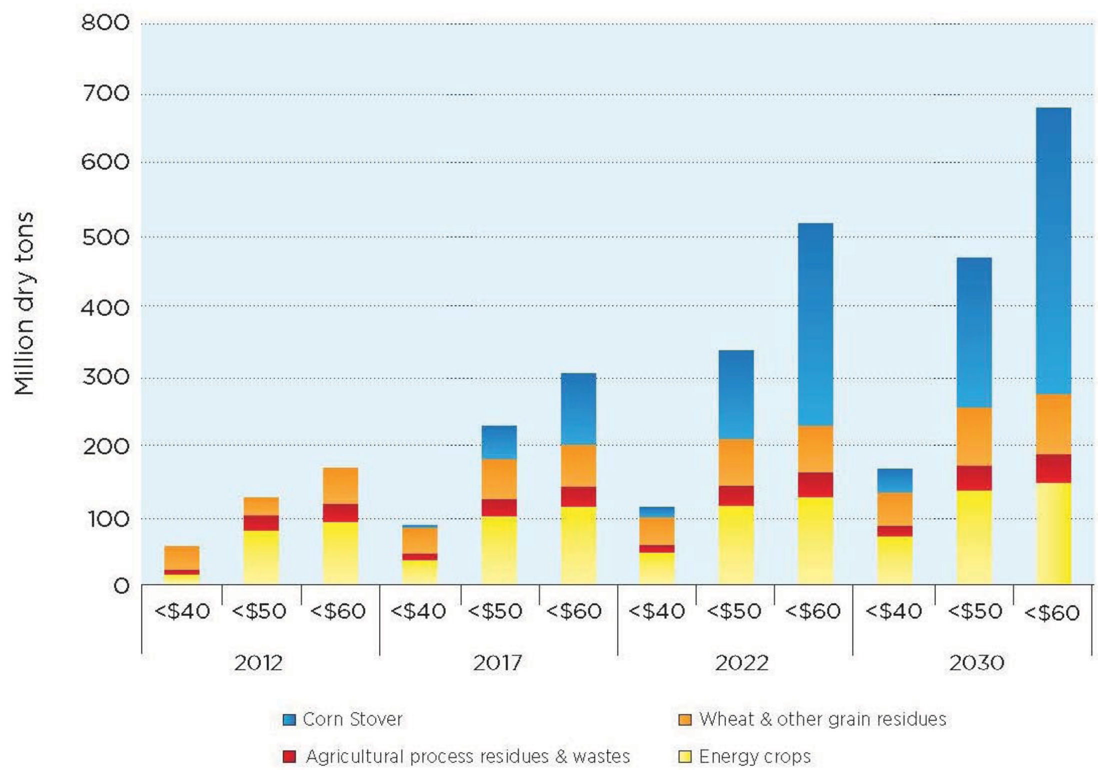

Figure 7. Estimated agricultural biomass resource availability projected at $40, $50, and $60 per dry ton, projected from historical yield baselines. High-yield projections (2 to 4% increases) are significantly higher.[61]

The Regional Feedstock Partnership was formed by the U.S. DOE, USDA, and Sun Grant initiative universities to address barriers associated with supplying a sustainable and reliable source of feedstock to a large-scale bioenergy industry. Figure 8 shows the 2010 energy crop field trial locations.[62]

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Figure 8. Regional Feedstock Partnership development work underway: 2010 Bioenergy Crop Trials (Updated May 2010).[63]

Corn stover provides the majority of crop residues currently available for biofuel production and accounts for 75% of total crop residues.[64] Most of the corn stover supply is concentrated in the Midwest region. Table 10 provides grain harvest statistics from the top five corn-producing states.

Table 10. Hectares under cultivation, average stover yields, and estimated residue produced for top corn-producing states (USDA-NASS, 2008).65

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

At baseline yield increase assumptions and $60 per dry ton, the amount of biomass that can be removed sustainably from privately owned forestlands is currently about 90 MDT per year. Based on the assumptions and conditions outlined in this analysis, including expansion of biomass accessibility to Federal lands, the amount of forestland-derived biomass that can be sustainably produced is approximately 102 MDT per year[66] (Figure 9). The 102 MDT potential availability from forest resources includes conventional pulpwood, urban wood wastes, mill residues, and forest residues.

Figure 9 shows a breakdown of forestland biomass resource availability at three different prices and four different time frames, projected from current industry practices and literature.

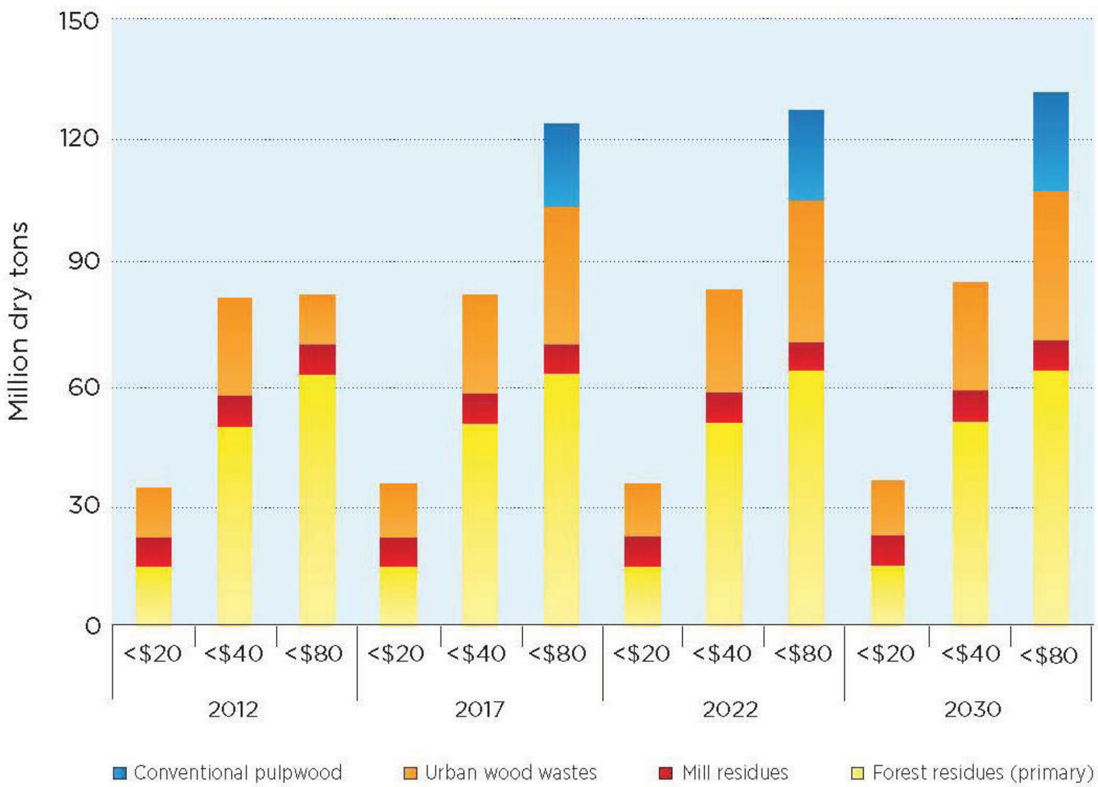

Figure 9. Estimated forestland biomass resource availability projected at $40, $50, and $60 per dry ton, projected from historical yield baselines.[67]

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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 10). 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 1.1 BDT (baseline projections) to 1.3 to 1.6 BDT (high-yield scenarios), as detailed in the Billion-Ton Update.[68]

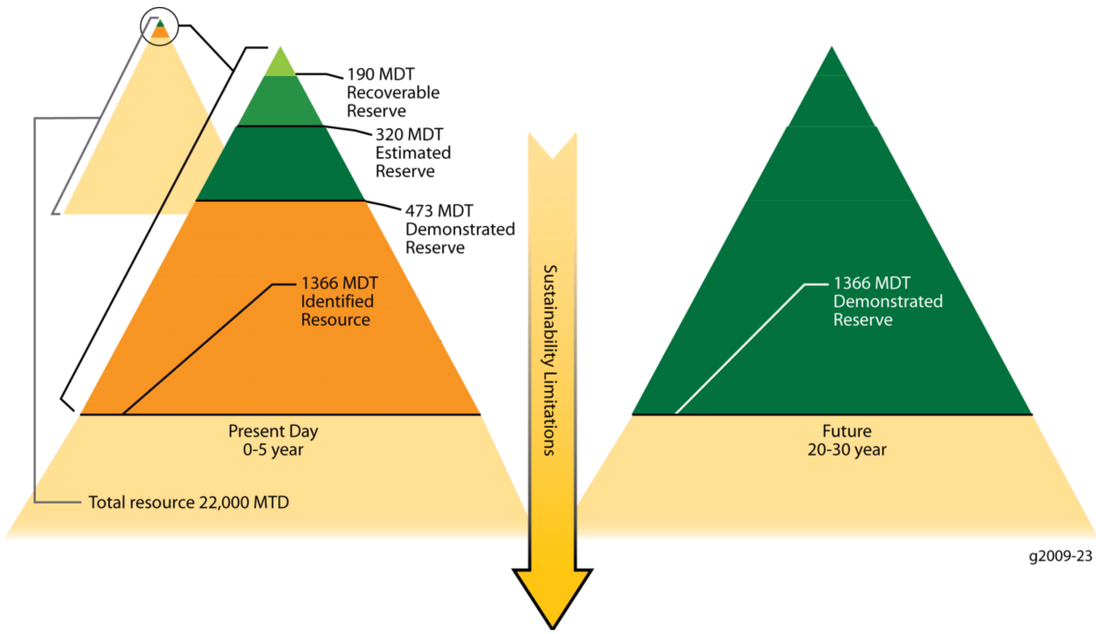

Figure 10. Current and projected biomass resource volume and potential availability for energy.

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.[69] 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.**Error! Bookmark not defined.**

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").[70] 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.[71]

4.3 Full Quantification of all Biomass Types in Use

Table 11. Industrial biomass energy consumption and electricity net generation by industry and energy sources for 2006.

		Biomass Energy Consumption (Trillion BTU)			
Industry	**Energy Source**	**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 Waste Solids	*363.462*	*107.182*	*256.280*	*8,768*

Table 13. (continued).

Industry	Energy Source	Biomass Energy Consumption (Trillion BTU) Total	For Electricity	For Useful Thermal Output	Net Generation (Million Kilowatt Hours)
	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]	*301.177*	*0.000*	*301.177*	*0*
	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[72]
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; [73] 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 2010, the total industrial biomass energy consumption in the United States was approximately 2,249 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 12 contains data from a survey of manufacturers that the EIA conducts every 4 years.

Table 12. Industrial biomass energy consumption and electricity net generation by industry for 2010.[74,75,76]

		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	**16.159**	**1.231**	**14.928**	**229**
Manufacturing	**Subtotal**	**1908.531**	**182.721**	**1725.810**	**27,233**
Food and Kindred Industry Products	*Agricultural Byproducts/Crops*	*15.819*	*0.160*	*15.659*	*33*
	Other Biomass Gases	*0.289*	*0.095*	*0.194*	*7*
	Other Biomass Liquids	*0.044*	*0.044*	*-*	*5*
	Sludge Waste	*0.243*	*0.055*	*0.188*	*8*
	Wood/Wood Waste Solids	*4.933*	*0.277*	*4.657*	*54*
	Subtotal	**21.328**	**0.631**	**20.697**	**107**
Lumber	*Sludge Waste*	*0.052*	*0.006*	*0.046*	*1*
	Wood/Wood Waste Solids	*225.676*	*10.676*	*215.001*	*1,286*
	Subtotal	**225.729**	**10.676**	**215.001**	**1,286**
Paper and Allied Products	*Agricultural Byproducts/Crops*	*1.335*	*0.036*	*1.300*	*5*
	Black Liquor	*787.380*	*112.361*	*675.019*	*17,152*
	Landfill Gas	*0.034*	*0.004*	*0.029*	*1*
	Municipal Solid Waste	*0.183*	*0.015*	*0.168*	*3*
	Other Biomass Liquids	*0.122*	*0.015*	*0.107*	*3*
	Other Biomass Solids	*9.477*	*1.762*	*7.715*	*326*
	Sludge Waste	*4.083*	*0.937*	*3.147*	*160*
	Wood/Wood Waste Liquids	*2.510*	*0.83*	*2.127*	*73*
	Wood/Wood Waste Solids	*311.180*	*55.395*	*255.785*	*8050*
	Subtotal	**1,116.304**	**170.909**	**945.396**	**27,039**

Table 14. (continued).

Industry	Energy Source	Biomass Energy Consumption (Trillion BTU)			
		Total	For Electricity	For Useful Thermal Output	Net Generation (Million)
Chemicals and Allied Products	*Other Biomass Liquids*	*0.061*	*0.005*	*0.056*	*1*
	Sludge Waste	*0.305*	*0.043*	*0.261*	*9*
	Wood/Wood Waste Solids	*3.953*	*0.104*	*3.849*	*18*
	Subtotal	**4.319**	**0.152**	**4.167**	**28**
Other	**Subtotal**	**8.810**	**0.349**	**8.461**	**37**
Nonspecified	*Ethanol*	*11.652*	-	*11.652*	-
	Landfill Gas	*92.233*	-	*92.233*	-
	Municipal Solid Waste Biogenic	*2.617*	-	*2.617*	-
Total		**2,031.193**	**183.953**	**1,847.20**	**27,462**

By sector, the largest consumer of renewable fuels in the United States is industrial. Following the industrial sector are the transportation, residential, and commercial sectors, in that order (Table 13).

Table 13. Renewable energy consumption by sector, 2010.[77]

Sector	Energy Source	Trillion BTU	Consumption (%)
Industrial	*Wood*	*1,307*	*33.95*
	Waste	*168*	*4.36*
	Fuel Ethanol	*15*	*0.39*
	Losses and Co-products	*742*	*19.27*
		2232	**57.97**
Transportation	*Fuel Ethanol*	*1042*	*27.06*
	Biodiesel	*29*	*0.75*
		1071	**27.82**
Residential	*Wood*	**420**	**10.91**
Commercial	*Wood*	*70*	*1.82*
	Waste	*34*	*0.88*
	Fuel Ethanol	*3*	*0.03*
		127	**3.30**
Total		**3850**	**100.00**

5.2 Quantitative List of Biomass Plants

5.2.1 U.S. Biorefineries by Location[78]

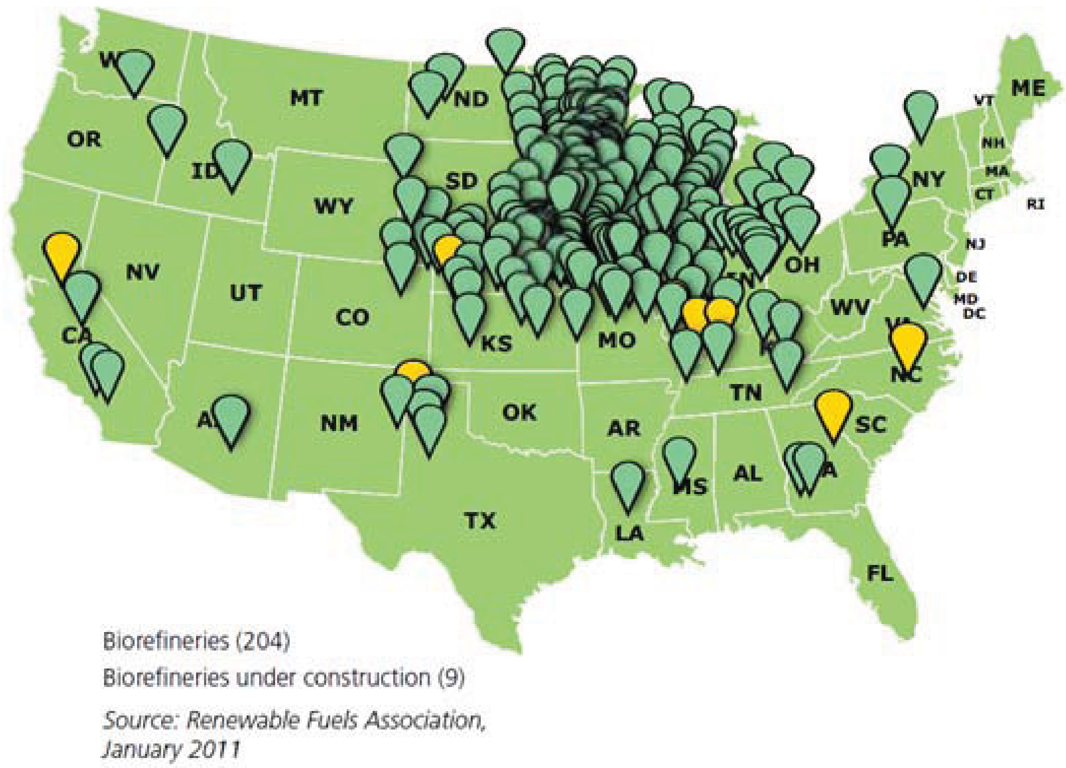

Figure 11. U.S. biorefineries by location (under construction and currently operational).

Table 14. 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)			**378**	**378**	**25**
Abengoa Bioenergy Corp	Fairmont, NE	Corn			
Abengoa Bioenergy Corp	Aberdeen, SD	Corn			
Abengoa Bioenergy Corp	Huron, SD	Corn			
Abengoa Bioenergy Corp.	Madison, IL	Corn			
Abengoa Bioenergy Corp.	Mt. Vernon, IN	Corn			

Table 16. (continued).

Company	Location	Feedstock	Nameplate Capacity (mgy)	Operating Production (mgy)	Under Construction / Expansion Capacity (mgy)
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			
Abengoa Bioenergy Corp.	Hugoton, KS	Corn residue/ cellulosic energy crops			
Absolute Energy, LLC*	St. Ansgar, IA	Corn	115.0	115.0	
ACE Ethanol, LLC	Stanley, WI	Corn	41.0	41.0	
Adkins Energy, LLC*	Lena, IL	Corn	45.0	45.0	
Advanced Bioenergy, LLC	Fairmont, NE	Corn			
Advanced Bioenergy, LLC	Aberdeen, SD	Corn			
Advanced Bioenergy, LLC	Huron, SD	Corn			
Advanced Bioenergy, LLC (Total)			198.0	198.0	
Aemetis	Keyes, CA	Corn	55.0	55.0	
Ag Energy Resources, Inc.	Benton, IL	Corn			5.0
AGP*	Hastings, NE	Corn	52.0	52.0	
Al-Corn Clean Fuel*	Claremont, MN	Corn	45.0	45.0	
Alchem Ltd. LLP	Grafton, ND	Corn	10.0		
AltraBiofuels Coshocton Ethanol, LLC	Coshocton, OH	Corn	60.0		
AltraBiofuels Phoenix Bio Industries, LLC	Goshen, CA	Corn	31.5		
Amaizing Energy, LLC*	Denison, IA	Corn	55.0	55.0	
Archer Daniels Midland (Total)			**1,750.0**	**1,7500.0**	**0.0**
Archer Daniels Midland	Wallhalla, ND	Corn/Barley			
Archer Daniels Midland	Cedar Rapids,	Corn			

Table 16. (continued).

Company	Location	Feedstock	Nameplate Capacity (mgy)	Operating Production (mgy)	Under Construction / Expansion Capacity (mgy)
	IA				
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	Columbus, NE	Corn			
Arkalon Energy, LLC	Liberal, KS	Corn	110.0	110.0	
Aventine Renewable Energy, LLC (Total)			**460.0**	**350.0**	
Aventine Renewable Energy, LLC	Pekin, IL	Corn			
Aventine Renewable Energy, LLC	Canton, IL	Corn			
Aventine Renewable Energy, LLC	Aurora West, NE	Corn			
Aventine Renewable Energy, LLC	Aurora East, NE	Corn			
Aventine Renewable Energy, LLC	Mount Vernon, IN	Corn			
Badger State Ethanol, LLC*	Monroe, WI	Corn	50.0	50.0	
Big River Resources Boyceville LLC	Boyceville, WI	Corn	40.0	40.0	
Big River Resources Galva, LLC	Galva, IL	Corn	100.0	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	110.0	
Blue Flint Ethanol	Underwood, ND	Corn	50.0	50.0	

Table 16. (continued).

Company	Location	Feedstock	Nameplate Capacity (mgy)	Operating Production (mgy)	Under Construction / Expansion Capacity (mgy)
Bonanza Energy, LLC	Garden City, KS	Corn/Milo	55.0	55.0	
BP Biofuels North America	Jennings, LA	Sugar Cane	1.5	1.5	
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	60	60	
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	195.0	195.0	
Cargill, Inc.	Ft. Dodge, IA	Corn			115
Cascade Grain	Clatskanie, OR	Corn	108.0		
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	
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	49.0	49.0	
Corn, LP*	Goldfield, IA	Corn	60.0	60.0	
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	24.0	
Didion Ethanol	Cambria, WI	Corn	40.0	40.0	

Table 16. (continued).

Company	Location	Feedstock	Nameplate Capacity (mgy)	Operating Production (mgy)	Under Construction / Expansion Capacity (mgy)
Dubay Biofuels Greenwood	Greenwood, WI	Cheese Whey			3
E Caruso (Goodland Energy Center)	Goodland, KS	Corn			20.0
E Energy Adams, LLC	Adams, NE	Corn	50.0	50.0	
East Kansas Agri-Energy, LLC*	Garnett, KS	Corn	35.0	35.0	
Flint Hills Resources LP	Fairbank, IA	Corn			
Flint Hills Resources LP	Iowa Falls, IA	Corn			
Flint Hills Resources LP	Menlo, IA	Corn			
Flint Hills Resources LP	Shell Rock, IA	Corn			
Flint Hills Resources LP (Total)			440.0	440.0	
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		
Gevo	Luverne, MN	Corn	21.0	21.0	
Glacial Lakes Energy, LLC - Mina	Mina, SD	Corn	107.0	107.0	
Glacial Lakes Energy, LLC*	Watertown, SD	Corn	100.0	100.0	
Golden Cheese Company of California*	Corona, CA	Cheese Whey	5.0		
Golden Grain Energy, LLC*	Mason City, IA	Corn	115.0	115.0	
Grain Processing Corp.	Muscatine, IA	Corn	20.0	20.0	
Grain Processing Corp.	Washington, IN	Corn	20.0	20.0	
Granite Falls Energy, LLC*	Granite Falls, MN	Corn	52.0	52.0	
Green Plains Renewable Energy	Fergus Falls, MN	Corn	60.0	60.0	
Green Plains Renewable Energy	Lakota, IA	Corn	100.0	100.0	
Green Plains Renewable Energy	Riga, MN	Corn	60.0	60.0	

Table 16. (continued).

Company	Location	Feedstock	Nameplate Capacity (mgy)	Operating Production (mgy)	Under Construction / Expansion Capacity (mgy)
Green Plains Renewable Energy	Shenandoah, IA	Corn	65.0	65.0	
Green Plains Renewable Energy	Superior, IA	Corn	60.0	60.0	
Green Plains Renewable Energy	Bluffton, IN	Corn	120.0	120.0	
Green Plains Renewable Energy	Central City, NE	Corn	100.0	100.0	
Green Plains Renewable Energy	Ord, NE	Corn	55.0	55.0	
Green Plains Renewable Energy	Obion, TN	Corn	120.0	120.0	
Guardian Energy	Janesville, MN	Corn	110.0	110.0	
Guardian Energy	Lima, OH	Corn	54.0	54.0	
Hankinson Renewable Energy LLC	Hankinson, ND	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	55.0	55.0	
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	60.0	60.0	
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	50.0	50.0	
Lincolnland Agri-Energy, LLC*	Palestine, IL	Corn	48.0	48.0	

Table 16. (continued).

Company	Location	Feedstock	Nameplate Capacity (mgy)	Operating Production (mgy)	Under Construction / Expansion Capacity (mgy)
Lincolnway Energy, LLC*	Nevada, IA	Corn	55.0	55.0	
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/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	
Murphy Oil	Hereford, TX	Corn/Milo	105	105	
Nebraska Corn Processing LLC	Cambridge, NE	Corn	45.0	45.0	
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	
NuGen Energy	Marion, SD	Corn	110.0	110.0	
One Earth Energy	Gibson City, IL	Corn	100.0	100.0	
Osage Bio-Energy	Hopewell, VA	Corn/Barley	65		
Pacific Ethanol	Madera, CA	Corn	40.0		
Pacific Ethanol	Stockton, CA	Corn	60.0	60.0	
Pacific Ethanol	Burley, ID	Corn	50.0	50.0	

Table 16. (continued).

Company	Location	Feedstock	Nameplate Capacity (mgy)	Operating Production (mgy)	Under Construction / Expansion Capacity (mgy)
Pacific Ethanol	Boardman, OR	Corn	40.0	40.0	
Parallel Products	Rancho Cucamonga, CA				
Parallel Products	Louisville, KY	Beverage Waste	5.4	5.4	
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	31.0	31.0	
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	
POET Biorefining - Chancellor	Chancellor, SD	Corn	110.0	110.0	
POET Biorefining – Cloverdale	Cloverdale, IN	Corn	92.0	92.0	
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	

Table 16. (continued).

Company	Location	Feedstock	Nameplate Capacity (mgy)	Operating Production (mgy)	Under Construction / Expansion Capacity (mgy)
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	
POET Biorefining - Marion	Marion, OH	Corn	68.0	68.0	
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			10.0
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	
Renova Energy	Torrington, WY	Corn	5.0	5.0	
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	

Table 16. (continued).

Company	Location	Feedstock	Nameplate Capacity (mgy)	Operating Production (mgy)	Under Construction / Expansion Capacity (mgy)
Southwest Georgia Ethanol, LLC	Camilla, GA	Corn	100.0	100.0	
Southwest Iowa Renewable Energy, LLC *	Council Bluffs, IA	Corn	110.0	110.0	
Spectrum Business Ventures Inc.	Mead, NE	Corn	25		
Sterling Ethanol, LLC	Sterling, CO	Corn	42.0	42.0	
Summit Ethanol, LLC	Cornelius, OR	Waste sugars	1.0		
Sunoco	Volney, NY	Corn	114.0	114.0	
Tate & Lyle	Loudon, TN	Corn	105.0	105.0	0
Tharaldson Ethanol	Casselton, ND	Corn	150.0	150.0	
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	53.0	53.0	
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	
Valero Renewable Fuels (Total)			**780.0**		

Table 16. (continued).

Company	Location	Feedstock	Nameplate Capacity (mgy)	Operating Production (mgy)	Under Construction / Expansion Capacity (mgy)
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	
Yuma Ethanol	Yuma, CO	Corn	40.0	40.0	
Total			**14,744.9**[a]	**14,217.4**	**271**

a. mgy for **209** nameplate refineries

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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, but has increased over the last few years. The price increase between may be due to the increase of demand caused by biofuel production (Figure 12). A comparison of 2002 operating expenses and net feedstock costs for undenatured ethanol production are shown in Table 15.

Figure 12. Corn: Price per bushel, 2002–2011.[79]

Table 15. Undenatured ethanol cash operating expenses and net feedstock costs for dry-milling process by plant size, 2002.[80]

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
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[81,82,83]

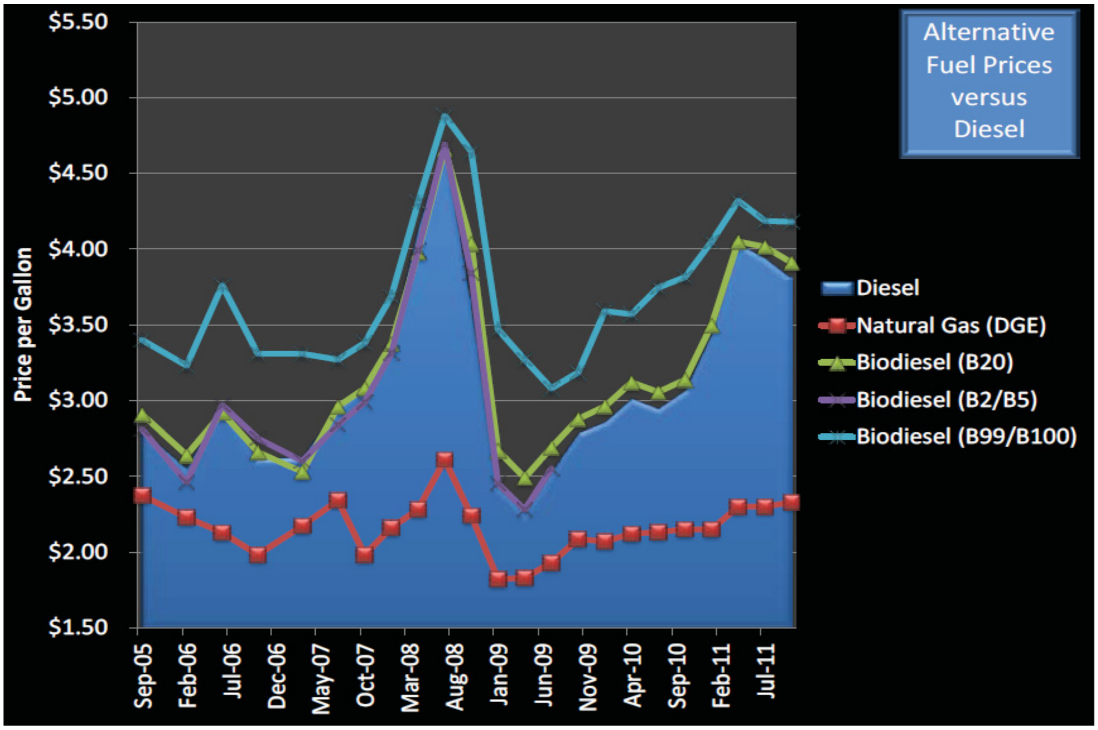

Figure 13. Price ranges per biofuel type (6-month average price)

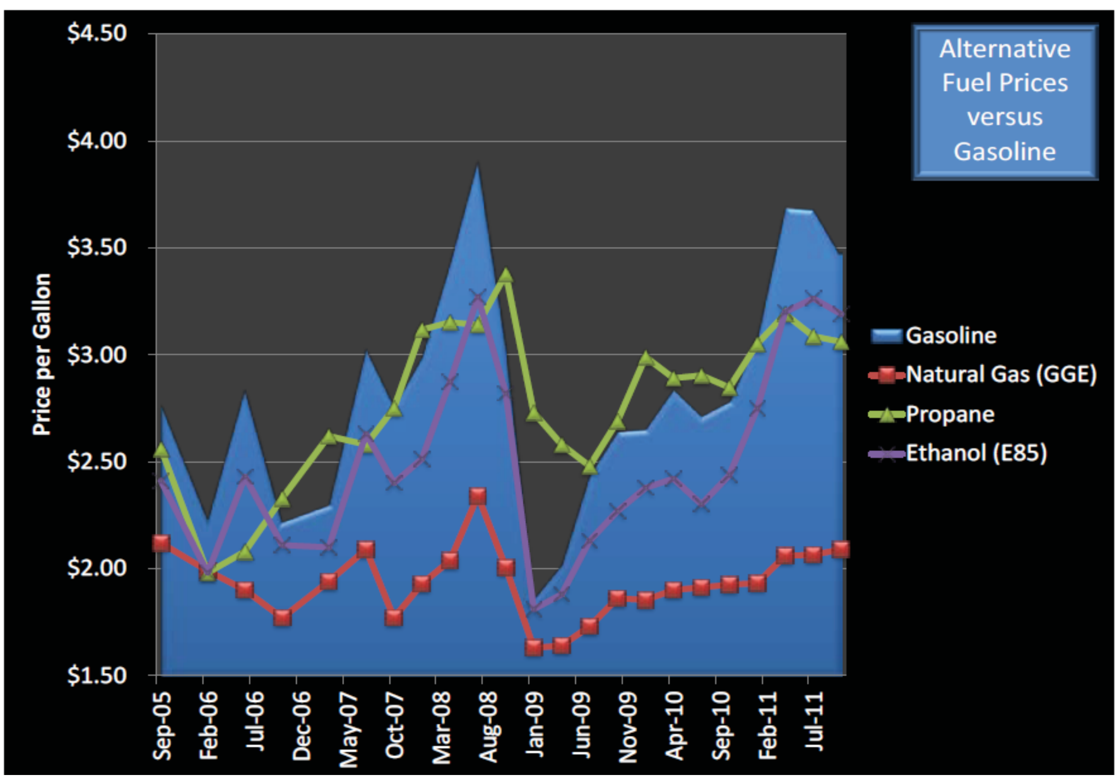

Figure 14. Price ranges per fossil fuel type (yearly average).

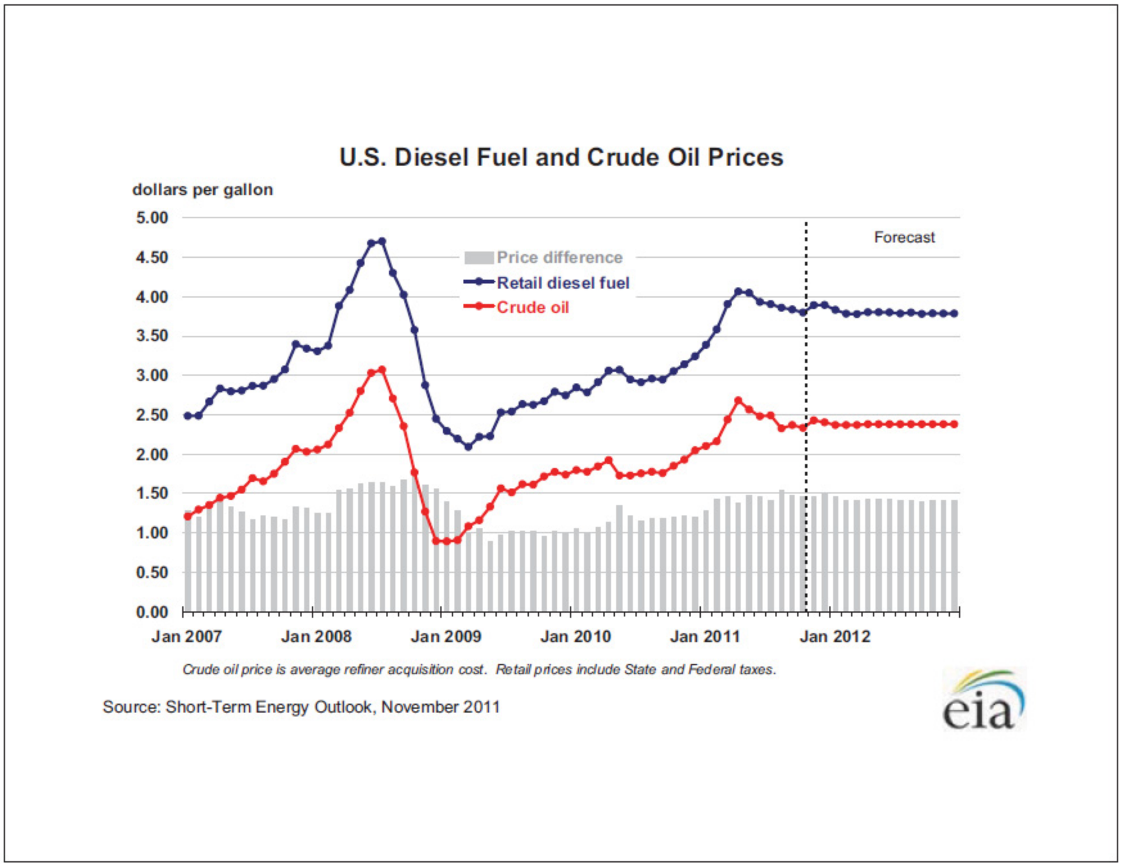

Figure 15. Price ranges for crude oil (yearly average).

7. BIOMASS IMPORT AND EXPORT

7.1 Ethanol

Recently importing amounts have decreased in the U.S. while exports remain minimal. In 2010, the United States imported 243 thousand barrels of fuel ethanol, greatly reduced from the 2006 high of 17,408 thousand barrels (Table 16).

Table 16. U.S. net imports of fuel ethanol (thousand barrels).[84]

2002	2003	2004	2005	2006	2007	2008	2009	2010
306	292	3,542	3,234	17,408	10,457	12,610	4,720	243

7.2 Biodiesel

The biodiesel production in the U.S. has decreased since its 2008 peak (Figure 16). Net exports have also decreased (Table 19).

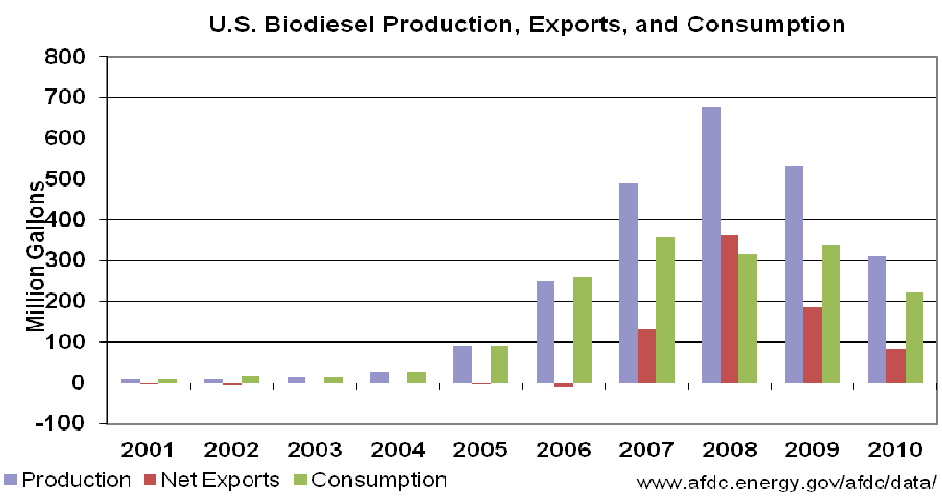

Figure 16. U.S. Biodiesel production, exports, and consumption.

Table 17. U.S. biodiesel exports and imports (million gallons, except shares).[85]

U.S Biodiesel (Mbbl)		
Year	**Imports**	**Exports**
2001	97	39
2002	191	56
2003	94	110
2004	97	124
2005	207	206
2006	1,069	828
2007	3,342	6,477
2008	7,502	16,128
2009	1,844	6,332
2010	*546*	*2,503*

7.3 Pellets

A small pellet industry came into existence in the 1930s. Its main growth began in the wake of the energy crisis in the 1970s, with an even greater acceleration of growth in the past decade, driven largely by renewable energy standards. In 2003, for example, world-wide production stood at roughly 1.1 million tonnes, which increased to 4.2 million tonnes in 2008.[86] Most plants in the U.S. in 2009 were small, relying on sawmill residue outputs for fiber and thus were typically limited to 100,000 tonnes or less per year. As of 2010, the total production capacity has again increased to just fewer than 6 million dry tonnes, with much of the recently added capacity intended for shipment to Europe (Table 20).

Table 18. U.S. Estimated wood pellet production capacity by sector.[92]

Estimated Capacity by Year	***2003***	***2004***	***2005***	***2006***	***2007***	***2008***	***2009***
U.S. Northeast	140	143	180	253	416	589	1056
U.S. West	281	308	354	458	473	589	711
U.S. North	122	122	158	344	502	964	1855
U.S. South	12	25	59	183	357	424	702
Total	**555**	**598**	**751**	**1238**	**1748**	**2566**	**4324**
	Capacity (*10^3 tonnes)						

The reliance on sawmill residues led to imbalances between supply and demand for biomass as the sawmilling sector retrenched in the 2008–2009 recession. This led pellet mills to turn to roundwood or other non-sawmill sources of biomass. In 2008, wood pellet production in the United States massed 1.8 million tonnes, just 66% of capacity as a result of limited mill residue availability which constrained plant activity output.[87]

A number of new mills have been built recently to process chipped roundwood. Their independence from the sawmill industry has allowed a focus on export of wood pellets, and some of the newer plants have capacities of 300,000-400,000 tonnes/year. In 2009, the U.S. pellet industry was projected to have a total capacity of over 4.3 million tonnes (see Table 8 and Figure 17), and recent additions have brought total capacity to around 6 million tonnes. The wood pellet industry and use of wood pellets as energy are in their relative infancy in North America and the recent growth of both has been fueled by increases in the cost of fossil energy as well as government policies that will continue to shape the renewable energy market. Policies aimed at reducing carbon dioxide emissions loom as bigger factors to rising pellet production in the future.[88]

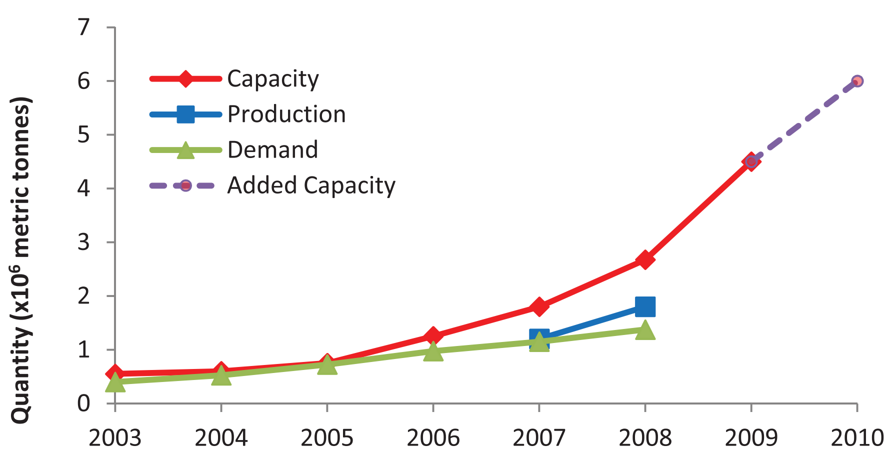

Figure 17. Capacity, production, and demand for wood pellets in the U.S. (Source[89] with added data).

In the New England States, for example, continually rising oil prices are responsible for the growth of pellets sales as private home owners look for more economical ways to heat their homes (Figure 18). In 2008 the cumulative sale of pellet appliances in U.S. was over 738,000 units, while the domestic pellet consumption was about 1,400,000 tons, almost entirely used for space heating (no industrial use or co-firing), equaling an average consumption of about 2 tons/y per unit. In 2010 the cumulative sale of pellet appliances was 824,000 units; assuming this value is close to the number of installed appliances, the U.S. domestic consumption of wood pellet for 2010 can be estimated slightly above 1,600,000 tons.

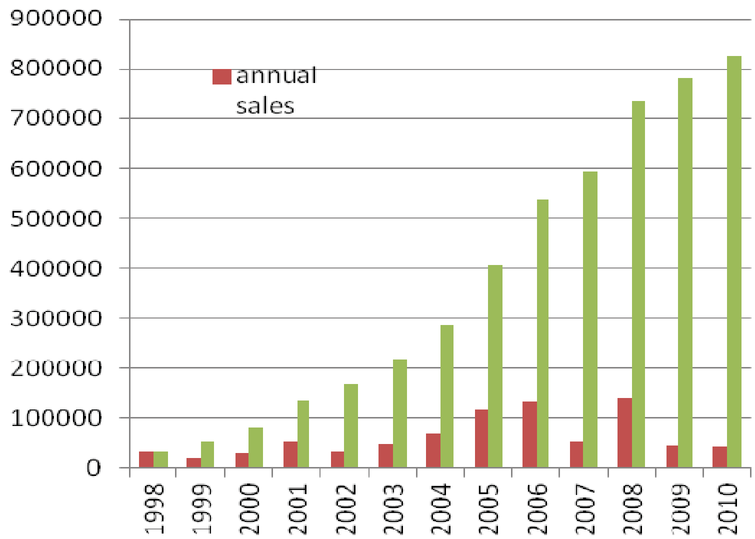

Figure 18. Annual and cumulative sales of pellet appliances in U.S. (Source: www.hpba.org)

7.3.1 Proposed Pellet Plants

As stated above, the U.S. pellet industry has grown rapidly in the past few years, and will continue to expand. More construction and new plants, or expansions will be built to support the push for an increase in renewable energy production. Figure 19 shows the location and relative size of pellet producers in the United States.

Figure 19. U.S. Wood pellet producers.[90]

The majority of pellet mills in the U.S. are small scale in comparison to the pulp and paper or power industry. The average pellet mill in the U.S. has a capacity of between 30,000–70,000 tonnes. Pellet plants are generally constrained due to a business model based on utilization of a waste product and residue provided by sawmills. However, in the U.S. southern region, some mills are moving to roundwood for their supply and these mills feature some of the largest mills in the U.S. Green Circle Bio Energy's 560,000-ton/year capacity plant, for example, is the largest wood pellet plant in the world. Its production is targeted mainly for export to the European Union.[91] Magnolia Bio Power, in Georgia also has plans for a plant that, when fully operational, will reach 900,000 tons of torrefied wood pellets annually and produce 30 MWh of electrical power. The first phase is scheduled for 2011 and will produce 300,000 tons of pellets.

7.3.2 Consumption and Exports

Renewable energy represents 8.0 quadrillion Btus of the nation’s 98.0 quadrillion Btu total energy consumption in 2010 (**Error! Reference source not found.**).[92] In 2009 (the most recent available data) wood and wood wastes generated in primary wood processing mills account for a third of the total industrial biomass energy consumption (**Error! Reference source not found.**). The U.S. biomass consumption profile has increased 8% from 2008 to 2009 and is forecasted to be the fastest-growing source of electricity through 2035 [12].[93]

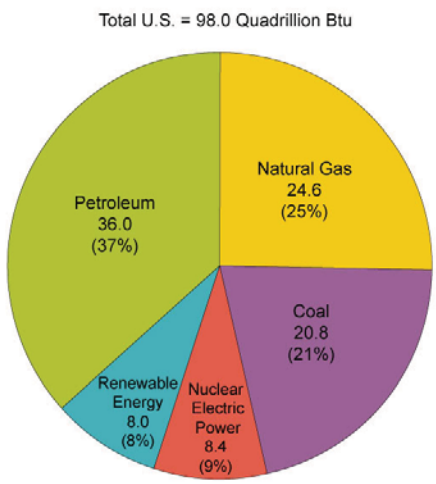

Figure 20. Primary energy use by Source, 2010. (Source: [12a]) (Quadrillion Btu and Percent)

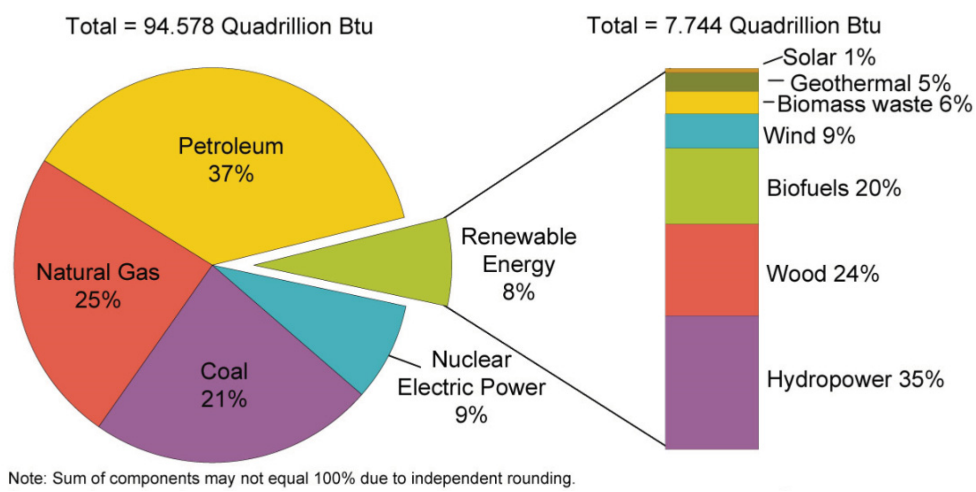

Figure 21. U.S. energy consumption by Energy Source, 2009. (Source: [12])

In 2008, over 80% of pellets produced in the U.S. were used domestically; of the remaining, about 19% were exported to Europe and 0.5% to Canada (Figure 22). By contrast, most Canadian pellets are shipped overseas [8].

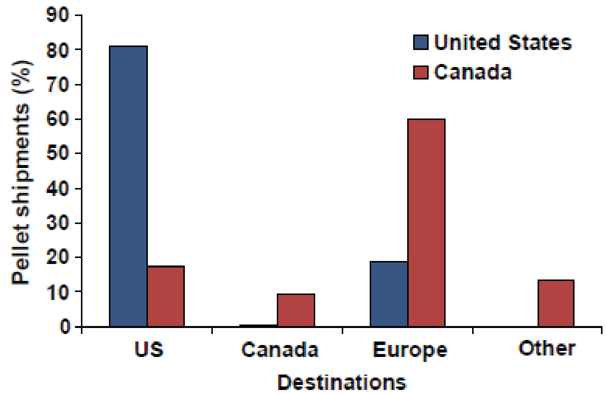

Figure 22. Destinations for Pellets Produced in U.S. and Canada. (Source: [8])

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 and that is attracting U.S. industries to expand their production of wood pellets explicitly for export to the EU. The demand in the European Union for wood pellets increased 7% in 2010, to 11 million tons [12]. North America has doubled its export volume to Europe over the past 2 years. In 2010, an approximately 1.6 million tons of pellets were shipped from the U.S. and Canada to the Netherlands, the UK, and Belgium [13], and exports are expected to continue to increase as the E.U. moves to obtain its mandates of 20% renewable energy by 2020.

Growth in North America put pressure on any new pellet production capacity for the Western Canadian Producers; as a result any extra volumes in the U.S. are directed towards this market rather than towards Europe. More stringent carbon emissions regulations could increase co-firing efforts for coal plants in the U.S. and Europe, resulting in a substantial need for pellets.

7.3.3 Prices

Prices for pellets in the U.S. vary by season, region, and supply and demand in the same way other heating fuels do. In the U.S., pellets are sold by the bag (40 lb), by the ton (50 bags), and by the skid (60 bags). The selling price currently ranges from $219 to 280 per ton ($4.60 to 5.60 per bag) and averages $250 per ton ($5.20 per bag).

Because bags of pellets stack and store easily, many prudent customers take advantage of lower off season prices and ensure their winter fuel supply by buying early. Selling price, of course, is only a part of the cost picture. The primary issue is the cost of energy, which is measured in dollars per million British thermal units. Pellets purchased at the average $150 per ton and burned in a typical pellet stove cost about $14.00 per million Btu, a figure that is less than the cost of electric heat (roughly $30 per million Btu) and competitive with average energy costs of some other fuels. Natural gas prices, however, are currently lower. Prices for natural gas range from $4.50 to 5.50 per million Btu, and are likely to remain low for the foreseeable future. This will continue to be the main impediment to large-scale adoption of biomass for home heating, except in areas where it is not available.

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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[94] 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.[95] Tables Table 2121, 22, and 23 show costs and targets for a modeled scenario (Scenario 1)[96] 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)".[97]

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)".[98]

		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
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)”.[99]

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
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 $.1427 per liter, or $.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.[100,101] The U.S. International Trade Commission has estimated that these assessments amounted to approximately $252.7 million in 2006.[102]

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.[103] 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.[104] This is called "duty drawback." There are no data regarding the amounts subject to this drawback,[105] but there are tax proposals at the federal level to repeal the exemption for ethanol-related export refunds.[106]

Almost every major oil-consuming country around the globe has projections for future ethanol consumption. This projected consumption (Figure 23), coupled with an increasing demand for a gasoline-type fuel, the international market for biofuels is expected to expand greatly over the next few decades. The major players in international trade of ethanol to meet these demands are the United States (U.S.), the European Union (EU), Japan, China, Brazil, and the "Rest of the World-Brazil" (ROW-BR).[107] 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 (Figure 23–Figure 25).

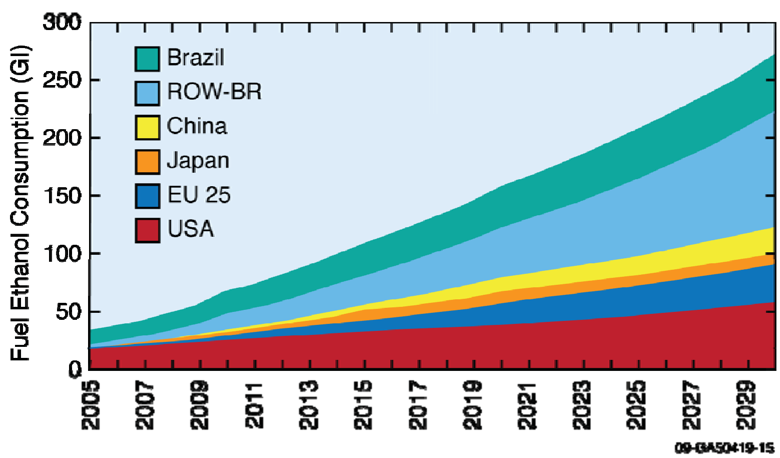

Figure 23. Estimated consumption of fuel ethanol from 2006 to 2030 (Scenario 1).[108] (Assumes ethanol displaces 10% of global gasoline production by 2030.)

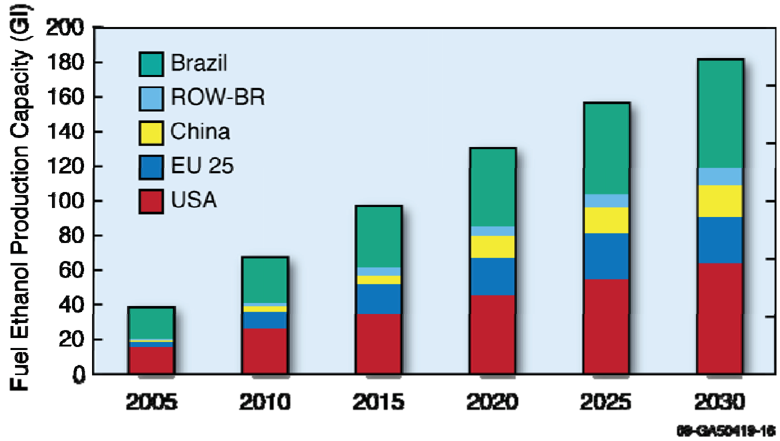

Figure 24. Estimated fuel ethanol capacity of production (conventional technologies).[109]

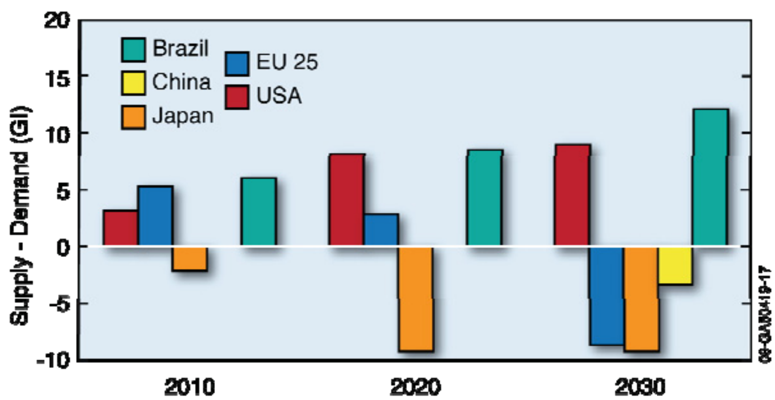

Figure 25. Estimated balance between potential supply and demand of fuel ethanol (Scenario 1 for U.S. [GI]).[110]

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.[111]

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 uses 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 be directly for biomass, but is also often focused 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[112]), 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 is dependent on an enhanced international biomass trade system that does not exist yet but will respond to ethanol import restrictions[113] 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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