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U.S. Pellet Industry Overview

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ABBREVIATIONS AND ACRONYMS

AFEX	Ammonia Fiber Expansion
ARA	Amsterdam, Rotterdam, Antwerp
BETO	U.S. Department of Energy's Bioenergy Technologies Office
C&D	Construction and Demolition
CIF	Cost, Insurance, Freight
dbh	diameter breast height
DDGS	Distiller's Dried Grains with Solubles
DOE	U.S. Department of Energy
EIA	U.S. Energy Information Administration
EN	European Norm
EU	European Union
FAME	Fatty Acid Methyl Ester
FAS	Free-Alongside-Ship
FDA	U.S. Food and Drug Administration
FOB	Free-On-Board
FY	Fiscal Year
ISO	International Standardization Organization
MYPP	Multi-Year-Program-Plan
OSB	Oriented Strand Board
USDA	U.S. Department of Agriculture
wt%	Weight percent
WTP	Willingness-To-Pay

1. REGULATORY FRAMEWORK, MARKET DRIVERS AND BARRIERS

This section provides an overview of federal policies that may have had an impact on the production, consumption or trade of U.S. pellets.

1.1. Drivers for domestic pellet consumption and production

Consumption

The main drivers for wood pellet consumption in the U.S. have been regional price competitiveness with residential heating oil and propane as well as replacements of fuelwood burners with respect to comfort and automatic feed-in. There are some incentives for bioheat (see Section 1.2) targeted at the residential and commercial building sector. Industrial use of wood pellets in heat and power is not incentivized. In fact, industrial consumption of wood pellets for heat and power production is marginal at best. The primary use of woody biomass is limited to direct by-product (residue) use in the forest products sector, e.g., pulp and paper. The Renewable Portfolio Standards (RPS) mandate the production of renewable electricity, including biopower, but wood pellets are usually not used in biopower facilities due to price. The Clean Power Plan (CPP) could increase domestic wood pellet consumption in the electricity sector, but its implementation is uncertain and its market impact unknown and potentially limited.

Production

U.S. wood pellet production started in the Northwest and Northeast, where small-scale production based on sawmill residues supplied regional residential heating markets. These markets grew but were ultimately limited by the expansion of the natural gas network and a limited price competitiveness of wood pellets. U.S. production grew exponentially over the past years due to demand from overseas markets. The expansion took place almost exclusively in the Southeast (with some production increases along the East Coast) due to strategic factors including proximity to EU markets, traditional wood basket including availability of biomass resources, labor, infrastructure, and know-how.

1.2. Bioheat

New Source Performance Standards (NSPS) by the EPA

In March 2015, the Environmental Protection Agency (EPA) issued New Source Performance Standards (NSPS) for new residential wood heaters, including pellet stoves.

Biomass Stove Tax Credit

The Biomass Stove Tax Credit is a federal incentive that gives a $300 tax credit for purchasing a fuelwood or wood pellet stove with a minimum 75% efficiency rating until December 31, 2016 (details of the law at: https://www.law.cornell.edu/uscode/text/26/25C).

Rebates through regional Woodstove Changeout Programs

Woodstove changeout programs are aimed at providing consumers with incentives to remove old, inefficient wood stoves or wood heating appliances, and replace them with clean, efficient new heating appliances. Incentives mainly include rebates for new stoves. 14 U.S. states currently provide such incentives. Details per state/region at: http://www.hpba.org/government-affairs/woodstove-changeout-program/current-changeout-programs.

1.3. Biopower

On federal level, there is significant uncertainty as to the potential implementation of the CPP, proposed by the U.S. EPA. In February 2016, the Supreme Court stayed implementation of the CPP Plan pending judicial review. Also, the exact role biomass can play in meeting CPP requirements is still unclear. Independent of the federal implementation of the CPP, individual states may push for the reduction of greenhouse gas emissions, e.g., via a phase-out of coal. In Colorado, for instance, the electricity company Xcel Energy is planning to pursue a phase-out plan for coal independent of the federal implementation of the CPP. Also, most states have renewable portfolio standards or goals in place (Figure 1). These standards require that utility companies generate a certain amount of energy from renewable resources by a certain date. For example, a certain percentage of the utility's electric power sales must be generated from renewable energy sources. Biomass is however only one from of renewable energy eligible to meet these targets – in addition to wind, solar, hydropower, etc.

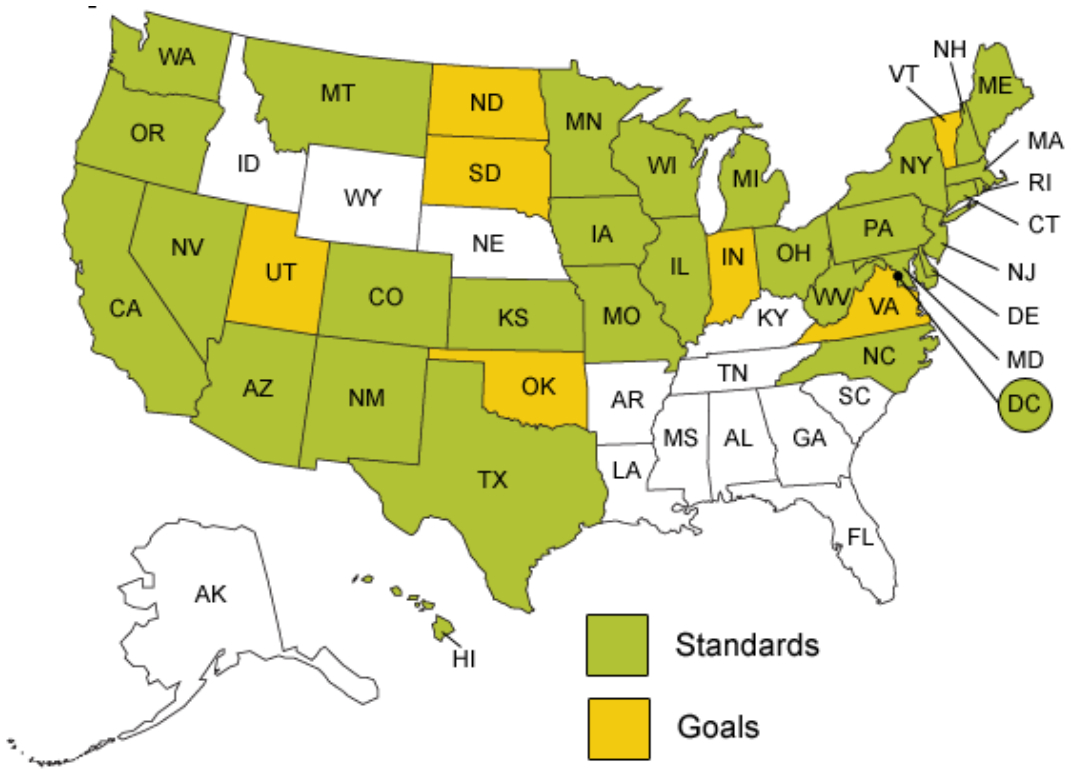

Figure 1. U.S. states with renewable portfolio standards (mandatory) or goals (voluntary) – by January 2012 (http://www.eia.gov/todayinenergy/detail.cfm?id=4850).

1.4. Biofuels and Biomass Crop Assistance Program (BCAP)

Wood pellets have the potential to become a key input feedstock to biorefineries producing advanced biofuels. At this point however, the nascent industry has not yet triggered a vast expansion of wood pellet production.

While tax credits for starch ethanol and FAME (biodiesel) have been terminated (ethanol at the end of 2011, biodiesel at the end of 2014), the biofuel industry is still able to benefit from indirect financing via agricultural and forest feedstock support programs, predominantly the Biomass Crop Assistance Program

(BCAP). It 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.[a] It is now in its 4th Amendment and supported by the 2014 Farm Bill.[b]

BCAP was initially put 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.

The BCAP provides two categories of financial assistance to owners and operators of agricultural and non-industrial private forest land who wish to establish, produce, and deliver biomass feedstocks:

First, establishment and annual payments may be available to certain producers who enter into contracts with the *Commodity Credit Corporation* (CCC) to produce eligible biomass crops on contract acres within BCAP project areas. In 2006, 20% of the U.S. corn harvest was used for ethanol production. The total agricultural subsidies through the CCC (under BCAP) for corn that year totaled $8.8 billion.[c] Thus, an estimated $1.8 billion went to subsidize corn destined for ethanol production.

Second, *matching payments* may be available to eligible material owners (EMO) for the sale and delivery of eligible material to qualified biomass conversion facilities (QBCF). Qualified biomass conversion facilities produce research, heat, power, biobased products, or advanced biofuels from biomass feedstocks. These payments are available to EMOs at the rate of $1 for each $1 per dry ton paid by QBCF to EMOs, limited to a maximum of $20 per dry ton and limited to a 2-year payment duration. All payment rates used in sales transactions between EMOs and QBCFs must reflect fair market values for the various types and varieties of eligible material biomass.

QBCF operations must register and be accepted as an eligible facility under BCAP. In FY16 (10/15-09/16), most accepted facilities were based on forest residues (followed by agricultural/orchard residues), including the following wood pellet plants[d]:

- Confluence Energy, CO (at locations in Walden and Kremmling), sourcing primarily dead (mountain pine beetle kill) trees: combined capacity 210,000 tons
- Forest Energy Corporation, AZ (Show Low location): 62,000 tons capacity
- Zilka Biomass, AL (Selma plant): 300,000 tons capacity

[a] http://www.fsa.usda.gov/Internet/FSA_File/bcapoctrules.pdf [October 8, 2016].

[b] http://www.fsa.usda.gov/Assets/USDA-FSA-Public/usdafiles/Energy/1bcap-a4.pdf [October 17, 2016]

[c] http://www.usda.gov/oce/newsroom/archives/testimony/2007files/Collins_011007.pdf [October 17, 2016]

[d] http://www.fsa.usda.gov/Assets/USDA-FSA-Public/usdafiles/Energy/bcap_facility_listing_FY2016.pdf [October 17, 2016].

2. NATIONAL AND REGIONAL PRODUCTION CAPACITY

The Biomass Magazine provides company information on Canadian and U.S. pellet mill plants (Biomass-Magazine 2016). The data was cross-checked with industry information gathered at the U.S. International Pellet Association (USIPA) Conference in Miami, FL. For example, Biomass Magazine (2016) states American Biocarbon to operate a 200,000 ton facility using sugarcane field residues in Louisiana. At present however, the facility is only producing at pilot scale (10,000 ton capacity) with plans to build a larger plant onsite later on (Cohn 2016). Therefore, it is expected that capacity numbers listed by Biomass Magazine (2016) are rather optimistic and should be interpreted with caution.

By the end of 2016, the industry has reached an operational production capacity (nameplate) of over 14 million tons with an additional 2.5 million tons under construction. Wood pellets represent the majority of this volume at 13.9 million tons of the nameplate capacity in operation. A complete list of all pelleting operations across the U.S. is provided in the Appendix.

Table 1. US pelleting capacity by feedstock.

Feedstock	Capacity (tons)	Subtotal
Agricultural residues	10,300	
Biomass Crops	40,000	
Crop Residue	10,000	
Subtotal herbaceous biomass		**60,300**
Hardwood	1,831,950	
Softwood	5,035,600	
Hardwood and Softwood	7,016,655	
Subtotal woody biomass		**13,884,205**
Paper Waste	170,000	
Unknown	311,015	
Subtotal other		**481,015**
TOTAL operational	**14,425,520**	
Under construction	*2,562,250*	
Planned	*4,722,800*	

The geographic distribution of U.S. pellet plants coincides with regional resource availability (Figure 2).

Small- and medium-scale plants, producing largely wood pellets for the domestic heating market are concentrated in the Northeast and Northwest. Large-scale, export-oriented wood pellet producers are located in the Southeast. The highest concentration of crop residues in the Midwest has little to no pelleting capacity (Figure 3).

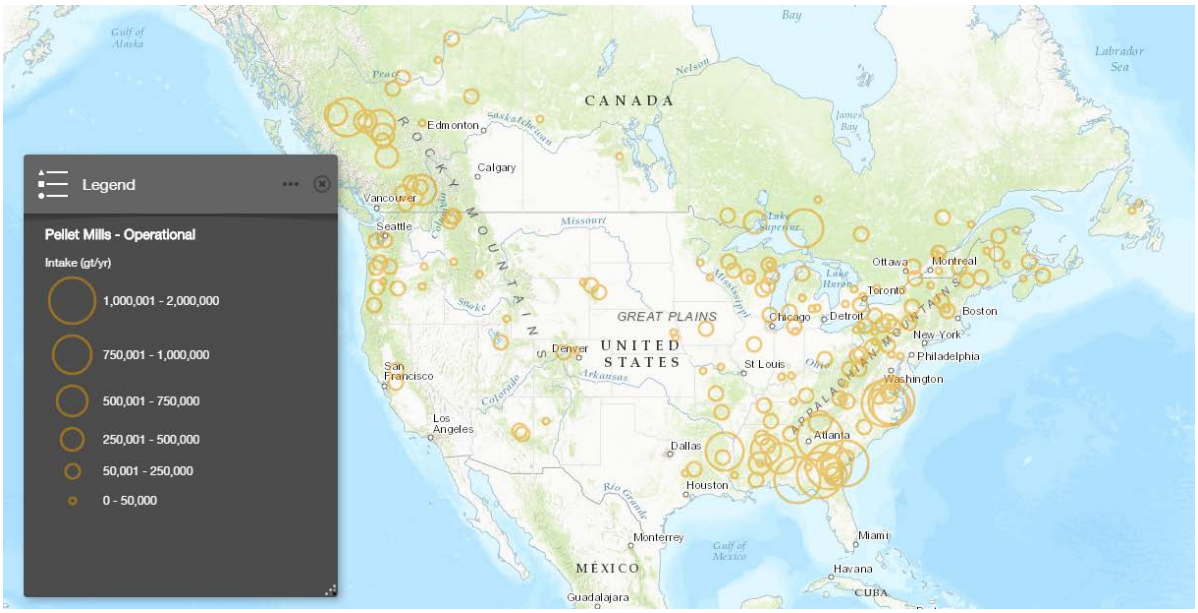

Figure 2. North American pellet mill locations (Source: Wood2Energy.org).

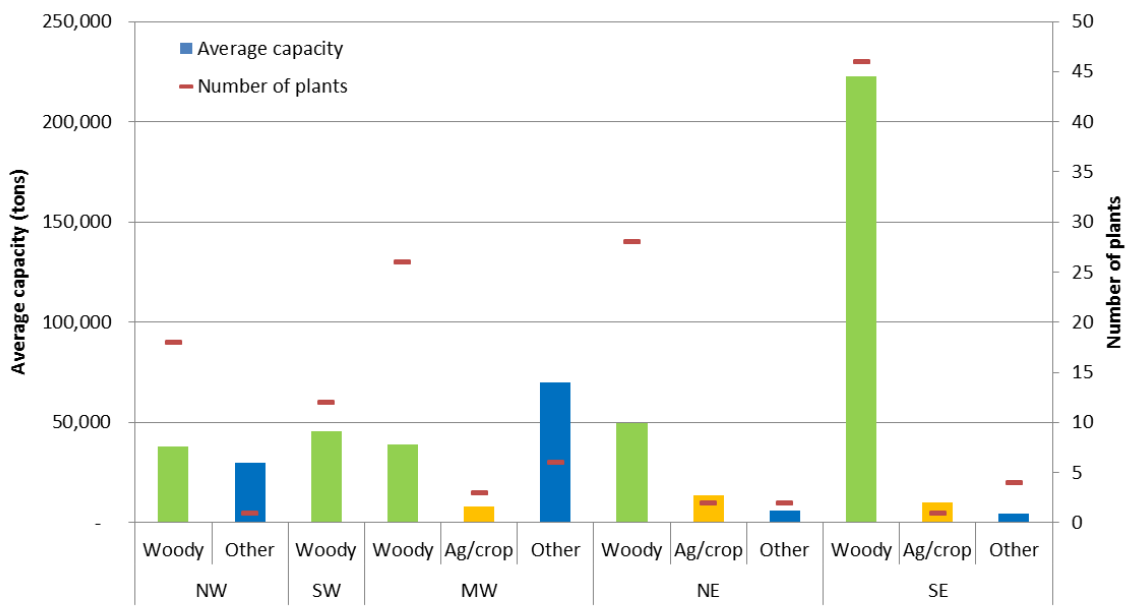

Figure 3. Regional distribution of feedstock choice, average plant size, and number of facilities. Note: The individual states included per region are presented in Table 8 in the Appendix.

3. WOOD PELLETS

3.1. Capacity trends

Wood pellet production has seen steady growth since 2004, with an exponential increase across the U.S. South (Figure 4). In the southern U.S., 119 mills consuming pulpwood and residual chip fiber were operating by 2015; the same number as in 2000 (Forest2Market 2015). However, there had been an internal shift in the sector from pulp and paper to wood pellet production. 16 new wood pellet facilities were built in the U.S. South since 2005. Between 1995-2015, 14 pulp and paper mills permanently closed across the southern U.S., (Forest2Market 2015). The panelboard and oriented-strand-board (OSB) sector had both openings and closings across the same period with a net loss of three panelboard and a net growth of four OSB facilities (Forest2Market 2015).

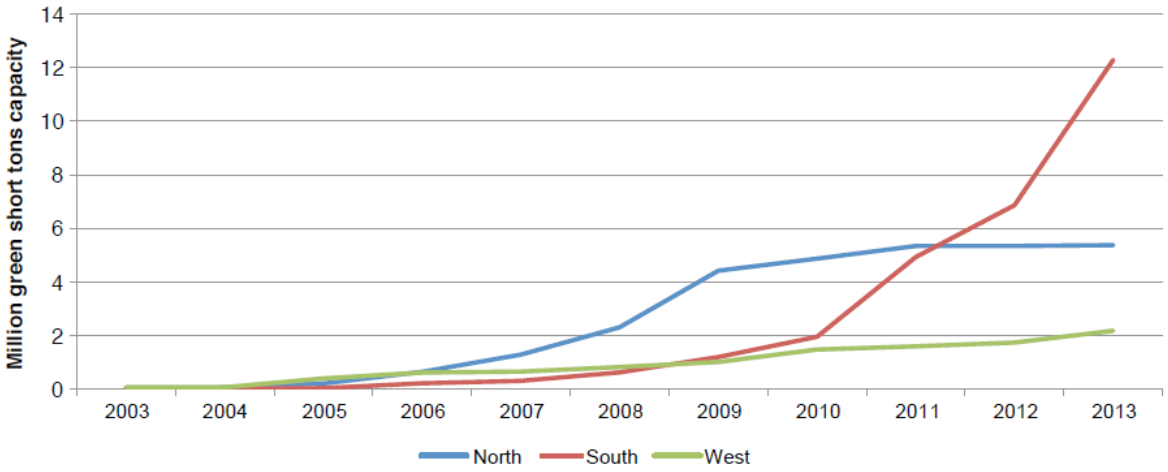

Figure 4. Growth in pellet production capacity by U.S. region from 2003 through 2013 (Forisk Consulting in Abt et al. 2014)

There are 14 wood pellet plant operations above 300,000 tons annual capacity; all located within the southeastern U.S. (Table 2). The main operations and market actors include:

- Enviva: most plants (seven) with a total capacity of 3 million tons
- Drax: a combined capacity of 996,000 tons with its Amite BioEnergy and Morehouse BioEnergy plants
- Georgia Biomass: largest single plant in the U.S. with 825,000 tons capacity, owned and operated by RWE Innogy
- German Pellets used to be a significant market actor, but filed for insolvency of two U.S. subsidiaries in 2016, reducing its overall production share

Plant operation times are usually in the range of 7,000 hours per year (Wild 2016), reducing actual annual production to about 80% of the nameplate capacity.

Table 2. U.S. wood pellet plants above 300,000 tons annual capacity (Biomass-Magazine 2016).

Plant	State	Feedstock	Capacity (tons)
Georgia Biomass (RWE)	GA	Softwood	825,000
Hazlehurst Wood Pellets	GA	Softwood	700,000
Enviva Pellets Cottondale	FL	Softwood	660,000
Highland Pellets*	AK	Softwood	600,000
German Pellets Louisiana	LA	Softwood	578,000
German Pellets Texas	TX	Hardwood and Softwood	551,155
Enviva Pellets Northampton	NC	Hardwood and Softwood	550,000
Enviva Pellets Southampton	VA	Hardwood and Softwood	550,000
Enviva Pellets Hamlet	NC	Woody Biomass	550,000
Blue Sky Biomass Georgia	GA	Woody Biomass	540,000
Amite BioEnergy (Drax)	MS	Hardwood and Softwood	500,000
Morehouse BioEnergy (Drax)	GA	Woody Biomass	496,000
Enviva Pellets Ahoskie	NC	Hardwood and Softwood	449,000
Westervelt Renewable Energy	AL	Softwood	309,000
Zilkha Biomass - Selma	AL	Hardwood and Softwood	303,000

*Note: Highland Pellets, Pine Bluff, AK, is currently still undergoing commissioning but is expected to start operation by the end of 2016[e].

3.2. Feedstock portfolio

Feedstock used in wood pellet mills ranges from primary (harvesting) to secondary (processing) residue streams and stemwood. Typical feedstock includes residual chip fiber and pulpwood, i.e., the same feedstock as panelboard, OSB or pulp and paper mills.

Small-size (< 150,000 tons) pellet mills derive most of their feedstock from sawmill operations in the form of dry sawdust and residue chips. As such they require proximity and logistical connection to these facilities. Also, since they rely on a residue stream of another industry, they are limited in output capacity and scale-up.

Medium- (150,000-300,000 tons) and large-size (>300,000 tonnes) pellet mills also use residue streams from the wood products sector, but this share declines with increasing pellet plant capacity. Larger plants derive an increasing fraction of their feedstock from silviculture operations directly, e.g., thinnings, salvage wood, and pulpwood.

Figure 5 shows the increase in silviculture by-products in total feedstock portfolios across the southern U.S. with the deployment of large-scale pelleting operations.

[e] http://www.biomassmagazine.com/articles/14001/highland-pellets-commissions-arkansas-pellet-plant [December 8, 2016].

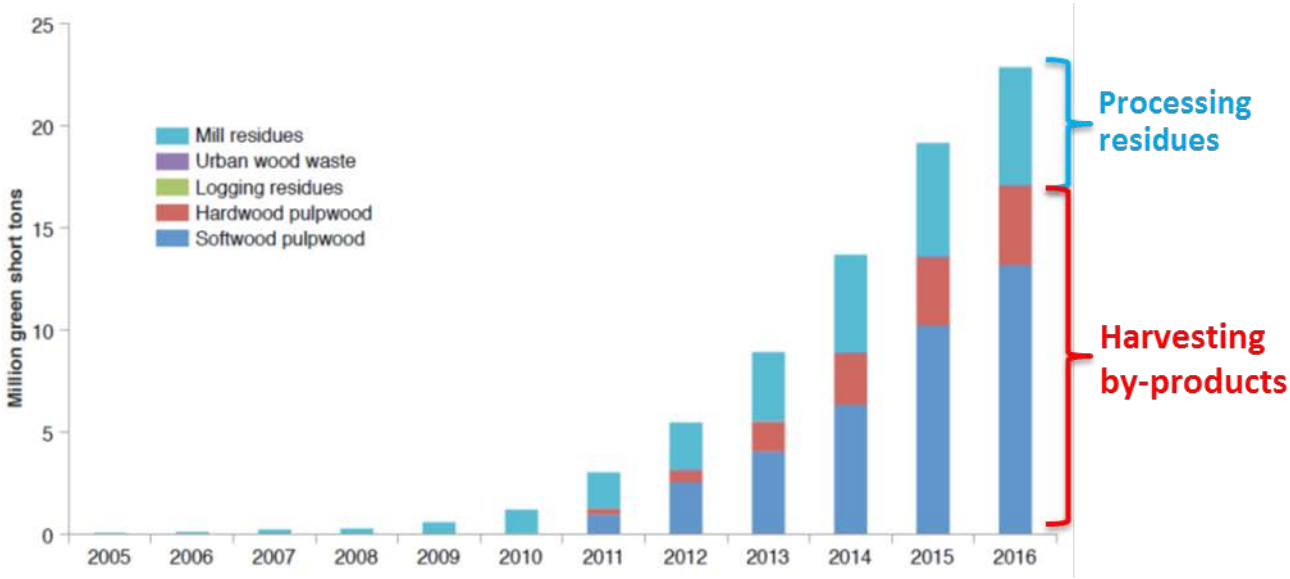

Figure 5. Actual and announced feedstock source for use in pellet production in the southern U.S. for 2005–2016 (Forisk Consulting in Abt et al. 2014).

Figure 6 shows the combined feedstock portfolio of two large pellet mills in the U.S. Southeast operated by Drax (Morehouse BioEnergy and Amite BioEnergy) with an individual capacity of 500,000 tons. Their plant level feedstock sourcing scheme reflects that of the wider U.S. Southeast pelleting industry.

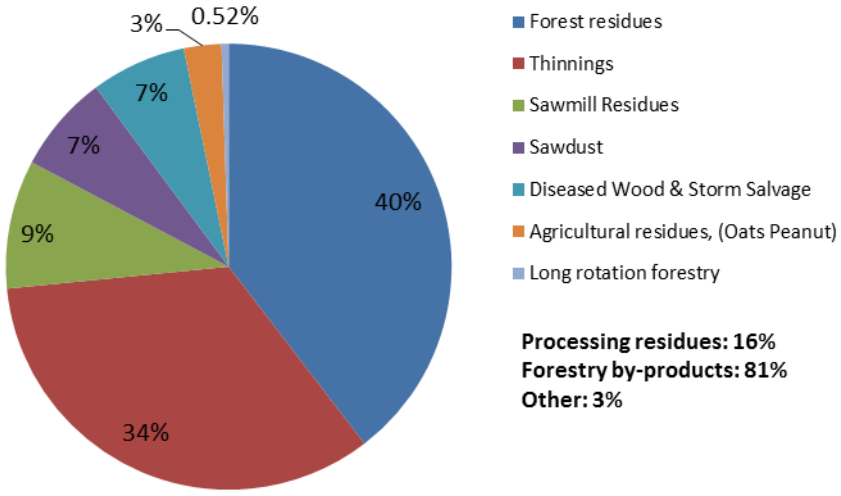

Figure 6. Drax US feedstock sourcing portfolio (http://www.drax.com/media/56583/biomass-supply-report-2014.pdf).

Enviva Biomass, the largest U.S. based producer with a portfolio of seven plants totaling a combined capacity of 3 million tons annually is about to disclose their feedstock sourcing data on their website (launch date not yet clear). According to Jennifer Jenkins, Enviva's Vice President and Chief

Sustainability Officer (*Personal Communication*), the company's sourcing stream is made up of 44% low-grade wood fiber from mixed pine-hardwood stands, 24% thinnings from pine plantations, 24% secondary residues (wood processing industry), plus 1% landscaping and other (7%) material. In total, the company sources 59% hardwood and 41% softwood through suppliers who deliver fiber from privately-owned forests and directly from sawmills and other wood industry manufacturers. The average age of the supplied wood is 36 years.

3.3. Feedstock value and price trends

Feedstock value

The most valuable harvest fraction in forestry is veneer logs, followed by sawtimber, chip-n-saw and pulpwood; respectively. Unless forests are owned by specific industry operations and grown solely for a specific assortment, e.g., short rotation pulpwood plantations, forest management and harvest timing are usually driven to maximize the most valuable fractions. Feedstock for pulp and paper, OSB or wood pellets are often not the most desired product of silviculture objectives, but can provide additional revenue streams. Thinning operations, e.g., specifically target the optimization of stands for sawtimber value.

During the decline of the U.S. housing market and following recession, available pulpwood and sawmill residual chip supply declined significantly in the U.S. South for both soft- and hardwood (Forest2Market 2015). This decline has increased demand (and stumpage prices) for pulpwood and residuals (Forest2Market 2015).

The value of these individual wood assortments are connected to the buying industry's willingness-to-pay (WTP), which is defined by plant economics and end product market value, e.g., sawn timber. It has been calculated that across the U.S. Southeast, the panelboard and pulp and paper industry can typically afford to pay a higher price for feedstock than wood pellet or bioenergy operations (Figure 7). Fiber costs including transport to the wood pellet plant gate usually range around $45 to $70 per dry ton and make up around a third of the total wood pellet production costs (at plant gate) (see also Table 3).

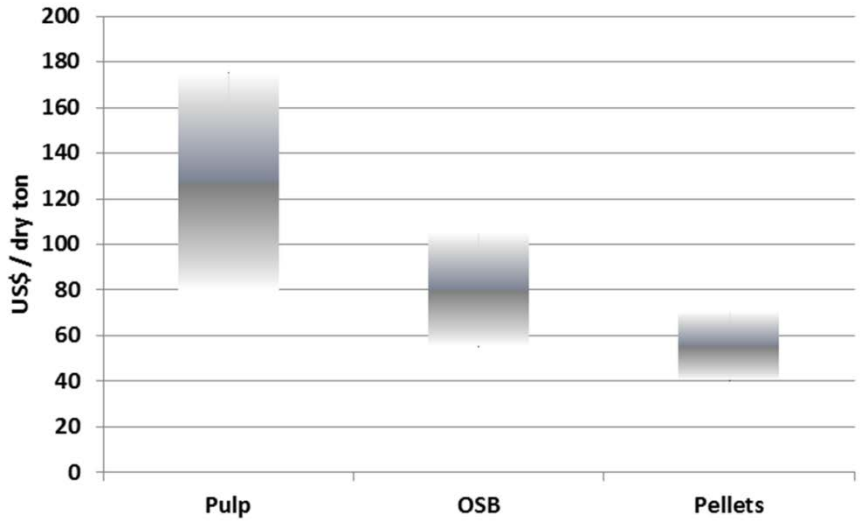

Figure 7. Upper ranges of the willingness-to-pay for feedstock of different wood product industries in the U.S. Southeast (Teir 2013).

Production costs

Table 3. Pellet supply costs based on US Southeast wood pellet data and herbaceous feedstock supply prices ($/ton).

	Average share	Wood pellet (lower range)	Wood pellet (upper range)	Corn stover pellets (lower range)	Straw pellets	Corn stover pellets (upper range)
Fiber cost	27%	$35	$45	$45	$68	$54
Fiber transport	11%	$15	$19			
Pelleting OPEX	15%	$20	$23	$22	$22	$22
Pelleting CAPEX	23%	$34	$34	$34	$34	$34
Plant gate	**76%**	**$105**	**$120**	**$101**	**$124**	**$110**
Mill to port	5%	$7	$7	$7	$7	$7
Port storage & handling	6%	$7	$11	$9	$9	$9
FOB	**88%**	**$120**	**$138**	**$117**	**$140**	**$127**
Ocean freight & handling	12%	$16	$20	$18	$18	$18
CIF-ARA	**100%**	**$136**	**$158**	**$136**	**$158**	**$145**

Residential wood pellet market - domestic

Residential markets are supplied by bagged pellets, stacked on pallets for bulk distribution. Prices vary, but are typically in the range of $5 (standard) to $7 (premium) per 40 pound bag (18.14 kg), equaling $250 to $350 per ton (excl. tax) at a final user distribution center, e.g., supermarket.

Industrial wood pellet market - export

Historically, industrial wood pellets sold for $130 to $160 per ton at Amsterdam, Rotterdam, or Antwerp (ARA) harbors (CIF-price: Cost, Insurance and Freight). U.S. FOB (Free-On-Board) or FAS (Free-Alongside-Ship) export prices have ranged between $115 and $140 per ton in main distribution harbors along the Southeast (e.g., Savanna, GA, and Mobile, AL) (Table 3).

Wood pellet supply contracts between U.S. producers and European utilities have fixed prices (potentially linked to a price adaptation formula), are negotiated in US$, and last typically 5-6 years (Keppler 2016, Peter-Paul Schouwenberg 2016). As such the recent drop in foreign exchange rates between the Euro and the US$ did not have a negative impact on U.S. pellet producers as much as it possibly could have. However, production has slumped outside of these long-term supply contracts and the market has seen an oversupply in 2016. Current spot prices (CIF-ARA) for U.S. produced wood pellets are close to production costs (Figure 8).

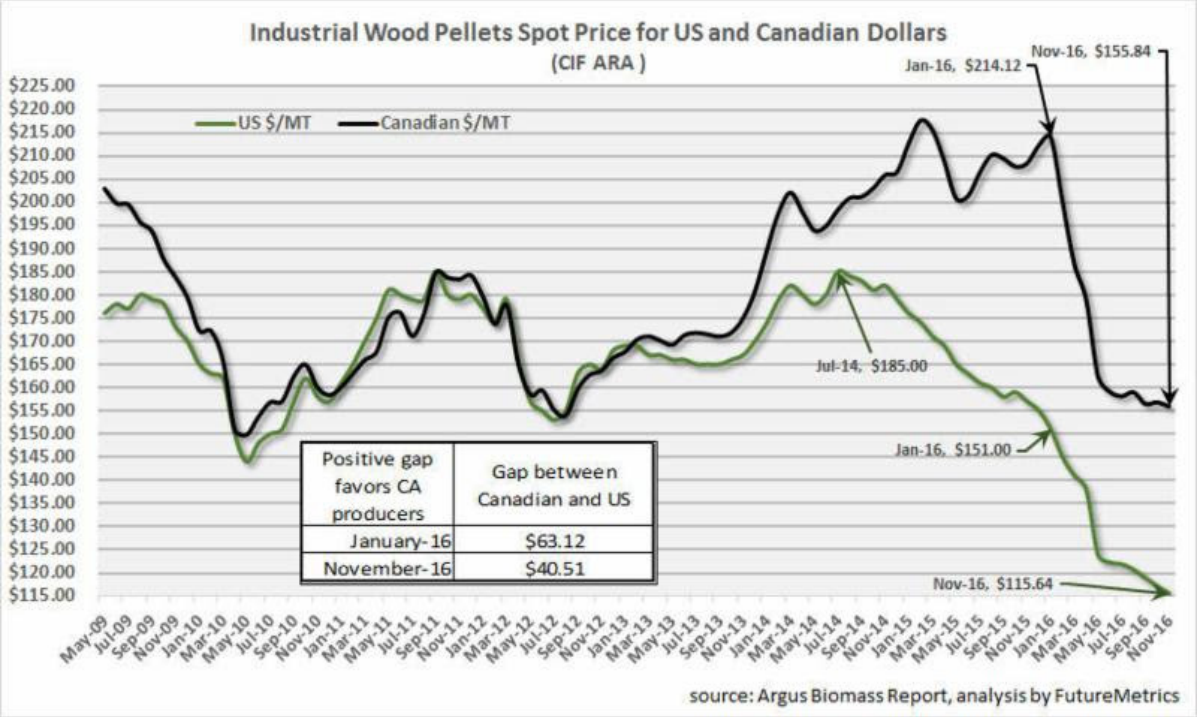

Figure 8. Industrial wood pellet spot prices in U.S. and Canadian Dollars (Source: FutureMetrics).

4. OTHER PELLETS

4.1. Herbaceous pellets

Despite the fact that many other industries besides biofuel producers also desire input material to be easy to handle, quality controlled/on-spec, etc., there is very little herbaceous pellet production across the U.S. at this point. Nine operations are currently operating with a total capacity of roughly 336,000 tonnes (Table 4). This number takes individual producer information into account and is slightly higher than the estimates presented by Biomass-Magazine 2016.

Table 4. Agricultural residue pellet operations sorted by feedstock sourcing strategy.

Company	State	Feedstock	Capacity (tons)*	Status*	Markets	Feedstock contracting
Golden Peanut Co.	AL	Peanut husks	n/a	O	Absorbent Animal feed Fertilizer Heat & power	Secondary waste stream from processing operation
Golden Peanut Co.	GA	Peanut husks	n/a	O		
International Pecan Co.	TX	Pecan shells	n/a	O	n/a	
American Biocarbon	LA	Sugarcane field residues	10,000 (200,000)	O (P)	Heat & power (biocoal, steam treated pellets)	
Enginuity Worldwide	MO	Crop residues	6,000	O	Animal feed Soil amendment Heat & power	Ag crop & residues (contracted & affiliated/member)
Pellet Technology USA	NE	Corn stover	30,000	O	Animal feed Heat & power	
Show Me Energy Coop	MO	Crop residues	90,000	O	Heating Animal bedding	
Ernst Biomass	PA	Switchgrass	25,000	O	Absorption Animal bedding	
Global Harvest Organics	MO	Agricultural residues	10,000	UC	Soil amendment Animal feed	
Iowa Biomass Pelleting	IA	Crop Residue	12,000	P	n/a	n/a
Enviro Energy	NY	Agricultural residues	2,000	O	n/a	n/a

*Note: not available (n/a), Operational (O), Under Construction (UC), Proposed (P),

Several distinctions can be made across the industry. Foremost, they differ in feedstock sourcing and contracting schemes. One line of operations relies on mill residues from the food processing industry (e.g., nuts and sugar). Others source agricultural harvesting residues directly through contracts with farmers. The end-markets are diverse and range from animal feed, to animal bedding (absorbents), soil amendment (fertilizer or biochar), and combustion processes (biocoal).

Show Me Energy[f] in Missouri is at present the largest operation. It is a farmer cooperative with a pelleting facility of 13.5 tonnes per hour (roughly 100,000 tons per year), which produces herbaceous pellets for energy use (heating of residential homes and broiler houses) and animal feed (cattle roughage extender). It had plans to also sell pellets (from cornstalks, grass straw, wheat and oat straw, milo stubble and

[f] http://www.showmeenergycoop.com; https://vimeo.com/7337437 [October 11, 2016].

soybean stubble) to Kansas City Power and Light where they were aimed at being co-fired with coal for the production of electricity and the generation of Renewable Energy Credits.[g]

Pellet Technology[h] of Nebraska currently has the second largest production and produces feed pellets made from corn stover and other herbaceous material (to improve digestability) for the domestic animal feed industry and combustion use. It contracts farmers within a 50 mile radius of the facility to supply 100,000 tons of stover annually.

American Biocarbon[i] in Louisiana is expected to become the largest herbaceous pelleting operation with a nameplate capacity of 200,000 tons per year. At present its pilot operation is at 10,000 tons annual capacity, producing torrefied pellets from sugarcane field residues. The future market for its large-scale facility would be European co-firing markets. Its geographic location allows access to large-scale oversea shipping routes. Its feedstock will be sourced in partnership with local sugar mills and their associated farmers.

4.2. Feedstock portfolio, value and willingness-to-pay

Current applications of corn stover are diverse but dominated by livestock co-feed. Due to the characteristics of corn stover (e.g., thick stalks), wheat straw is generally preferred as bedding material for larger animals. Other animal operations, e.g., poultry, do apply corn stover. However, the majority of US broiler production is outside the key corn producing states in the Midwest. Hence, different material is often applied (e.g., sawdust, shredded switchgrass, etc.)[j]. Other niche applications for corn stover include mushroom cultivation substrates.

The major use of corn stover is on-farm. As such, most material does not transfer via an official market (as compared to, e.g., hay) and thus lacks transparency and official statistics. A general, annual value for corn stover is not available. Corn stover is a valuable winter feed option for healthy cattle and its value will differ whether it is left standing the field for grazing or harvested, baled, and sold to replace alternative feed sources.

One way to derive corn stover value is via an estimation of co-feed value against alternatives. Calculations by Iowa State University[k] under the assumptions of $100/ton hay and $200/ton DDGS feed prices, suggest that harvested corn stover as a feed alternative can have a value of up to $63-77 per ton. Left standing in the field, the value is reduced to $20-30 per ton.

A second way to estimate corn stover value is via prices at auctions. These are also automatically an indicator for the industry's willingness-to-pay. Prices at auctions should however be interpreted carefully as they vary with alternative feed prices at the time of the auction, the quality of the auctioned material, the location and the time of year the auction is held, as well as the year itself (which influences the total amount of available herbaceous material).

[g] http://agebb.missouri.edu/agforest/archives/v12n2/gh4.htm [November 4, 2016].

[h] http://www.pellettechnologyusa.com [November 8, 2016].

[i] http://www.americanbiocarbon.com/ [October 11, 2016].

[j] https://youtu.be/xmZJw_1Mt5w [November 9, 2016]

[k] https://www.extension.iastate.edu/agdm/crops/html/a1-70.html [November 8, 2016].

Auction data (grower payment plus delivery to auction) from Rock Valley Hay[l] shows a weighted average price of $54/ton of straw and $45/ton (and a range of $20-70/ton) of corn stalk and a total sale quantity of 2,967 tonnes for the month of February 2016. This data is in-line with USDA Hay Feed and Seed Weekly price reports[m] indicating a range of $38-60/ton for corn stover. USDA Market Reports detail price structure for specific crops, e.g., wheat straw. Corn stalk was not available at the time this analysis was completed. Wheat straw prices vary significantly between years, as well as application and regions. For example, reported prices for 2014 erosion control material reached $138/ton in California. In Alabama, due to its scarcity, wheat straw has reached prices of $155/ton three consecutive years (2014-2016). Sale values of different feed options as presented in the USDA National Weekly Ag Energy Round-Up and the USDA National Hay, Feed & Seed Weekly Summary.[n]

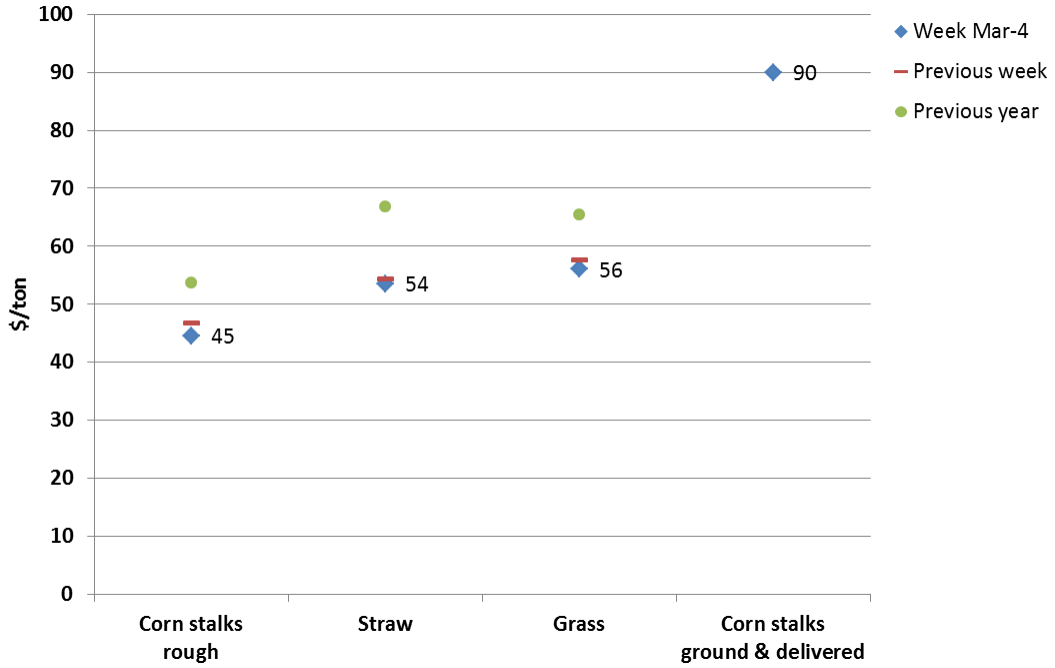

Figure 9. Average weekly sale values of different feed options reported for Iowa, Minnesota, Nebraska, South Dakota, Kansas, Missouri, and Illinois (Data: USDA).

[l] http://www.rockvalleyhay.com/site/mixedhay-bedding.html [November 2, 2016]

[m] https://www.ams.usda.gov/market-news/custom-reports ; https://www.ams.usda.gov/market-news/hay-reports ; https://www.ams.usda.gov/market-news/bioenergy-market-news-reports [November 9, 2016].

[n] https://www.ams.usda.gov/mnreports/lswfeedseed.pdf ; https://www.ams.usda.gov/mnreports/lswfeedseed.pdf [November 9, 2016].

5. U.S. TRADE BALANCE AND GLOBAL OUTLOOK

5.1. Domestic consumption

U.S. biomass consumption for energy has increased by almost 2 trillion Btu (roughly 2 EJ) over the last decade (Figure 10). This increase, however, was observed solely in the liquid biofuels sector. Woody and waste biomass for energy use remained stagnant (although this overall trend may not be reflected across all regions within the U.S.).

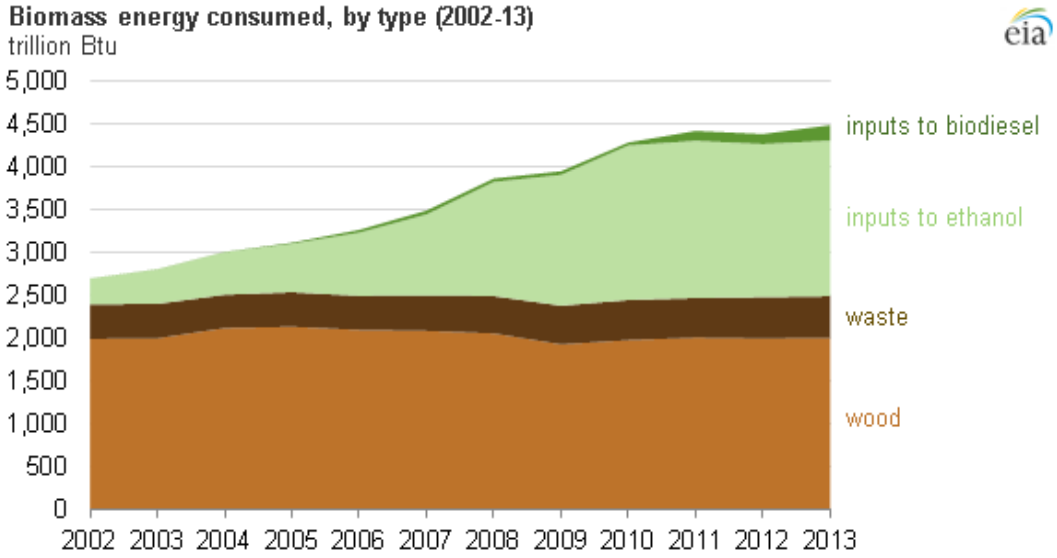

Figure 10. Biomass energy consumed by type between 2002-2013 (http://www.eia.gov/todayinenergy/detail.cfm?id=15451).

No official statistics on domestic wood pellet consumption exists. However, it can be approximated via the following formula: $C_i = P_i + I_i - E_i$

Where C_i: *Consumption in year i*
P_i: *Production in year* (Sources: Lamers *et al.* 2012, FAOSTAT 2016)
I_i: *Imports in year i* (Sources: Statistics-Canada 2016, USDA 2016)
E_i: *Exports in year i* (Sources: EUROSTAT 2015, USDA 2016)

Table 5. Estimated domestic consumption based on production, import and export statistics (metric tonnes).

	2008	2009	2010	2011	2012	2013	2014	2015
P_i	1,800,000	2,800,000	3,000,000	4,000,000	5,100,000	5,700,000	6,900,000	7,400,000
I_i	440,000	293,000	40,000	50,000	86,736	152,442	219,987	207,172
E_i	490,000	577,742	794,955	1,081,834	1,898,117	2,882,423	4,055,689	4,668,552
C_i	1,750,000	2,515,258	2,245,045	2,968,166	3,288,620	2,970,019	3,064,297	2,938,620

The primary consumers of U.S.-produced wood pellets are export markets, accounting for 63% in 2015. The remaining share is consumed domestically in residential heating. It is estimated that over 13 million wood heaters are in operational use across the U.S., the minority (roughly 10%) of which are wood pellet stoves (Figure 11). Commercial use is limited and expected at under 1% total consumption (Table 6).

U.S. biopower and/or -heat facilities are not known to use wood pellets in significant quantities. Rather, these installations are regionally integrated and make use of local wood waste fractions. A key reason is that – apart from state Renewable Portfolio Standards setting mandatory renewable electricity production levels for power companies – there are no U.S. incentive schemes which could close the gap between the oversea and domestic market willingness-to-pay (WTP). Hence, U.S. biopower and CHP installations are usually in the vicinity of wood processing industries or urban agglomerations where they can make use of construction and demolition wood (Figure 12, Figure 13).

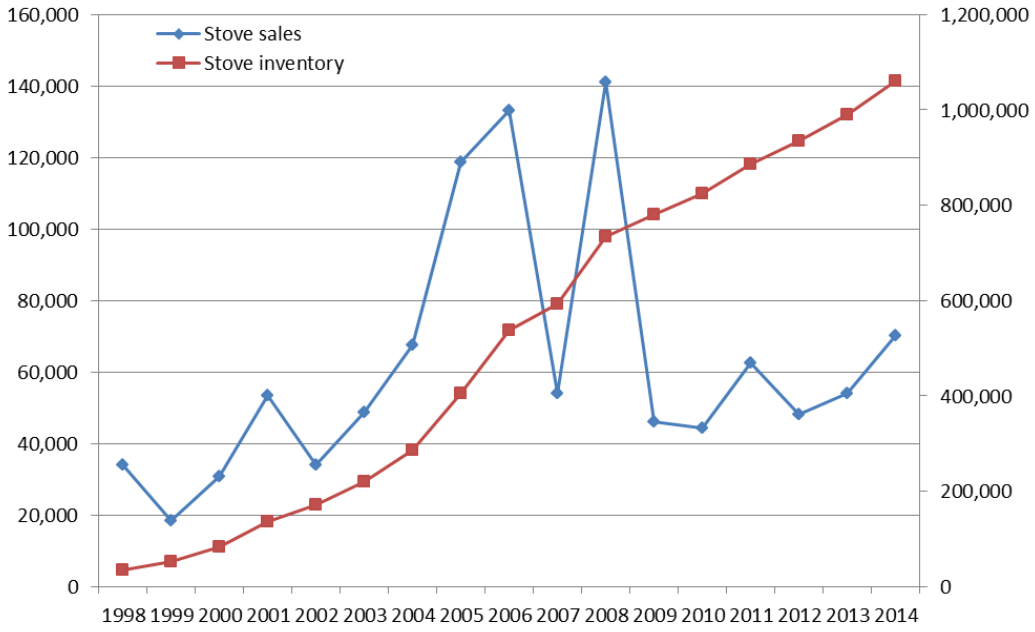

Figure 11. U.S. pellet stove sales (Source: Hearth, Patio, and Barbeque Association; http://www.biomassthermal.org/resource/PDFs/Fact%20Sheet%202.pdf; Personal Communication with Seth Walker, RISI).

Table 6. Wood and wood-derived fuel consumption by sector as projected in EIA 2016 (PJ).

Peta-Joule	**2012**	**2013**	**2014**	**2015**	**Comments**
Marketed Use (PJ)					
>> Residential: Wood: Reference case	468	615	646	498	Fuelwood dominates
>> Commercial: Biomass: Reference case	112	127	127	127	
Electric Power Generation (PJ)					
>> Dedicated Plants: Reference case	109	122	114	117	
>> Co-firing: Reference case	72	72	65	66	
Million tons (theoretical)					
Marketed Use (Million tons)					
>> Residential: Wood: Reference case	29.6	38.8	40.8	31.4	of which 10% wood pellets
>> Commercial: Biomass: Reference case	7.0	8.0	8.0	8.0	of which <1% wood pellets
Electric Power Generation (Million tons)					
>> Dedicated Plants: Reference case	6.9	7.8	7.2	7.3	of which <1% wood pellets
>> Co-firing: Reference case	4.6	4.6	4.1	4.2	of which <1% wood pellets
Calculated theoretical U.S. domestic wood pellet consumption (Million tons)	3.1	4.1	4.2	3.3	Sum of estimates

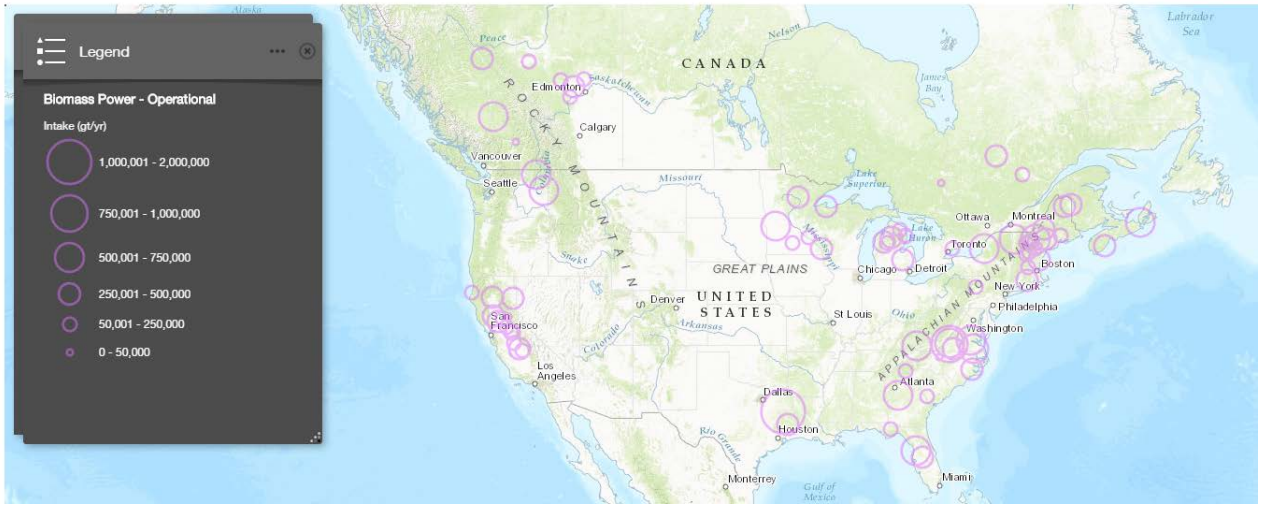

Figure 12. Biomass power operational (www.wood2energy.org).

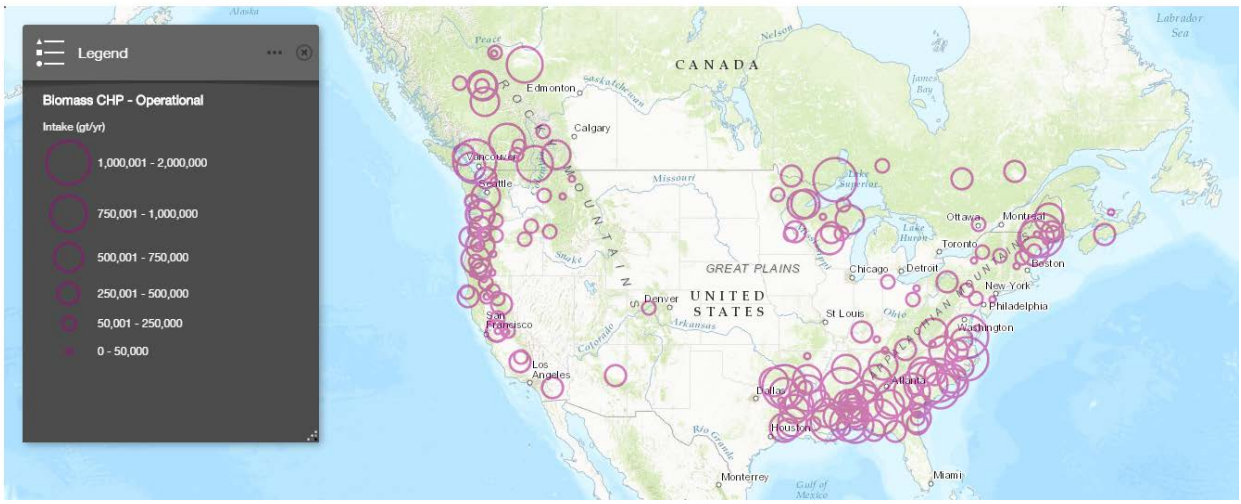

Figure 13. Biomass CHP operational (www.wood2energy.org).

5.2. U.S. trade balance until 2015

U.S. pellet production grew from around 2 million tons in 2008 to over 8 million tons by 2015 (Figure 14). Domestic consumption has remained relatively stable around 2-3.5 million tons. Annual cross-border trade with Canada is in the range of 250,000 tons and exports, 98% of which go to the EU, have reached almost two thirds of total production (Table 7).

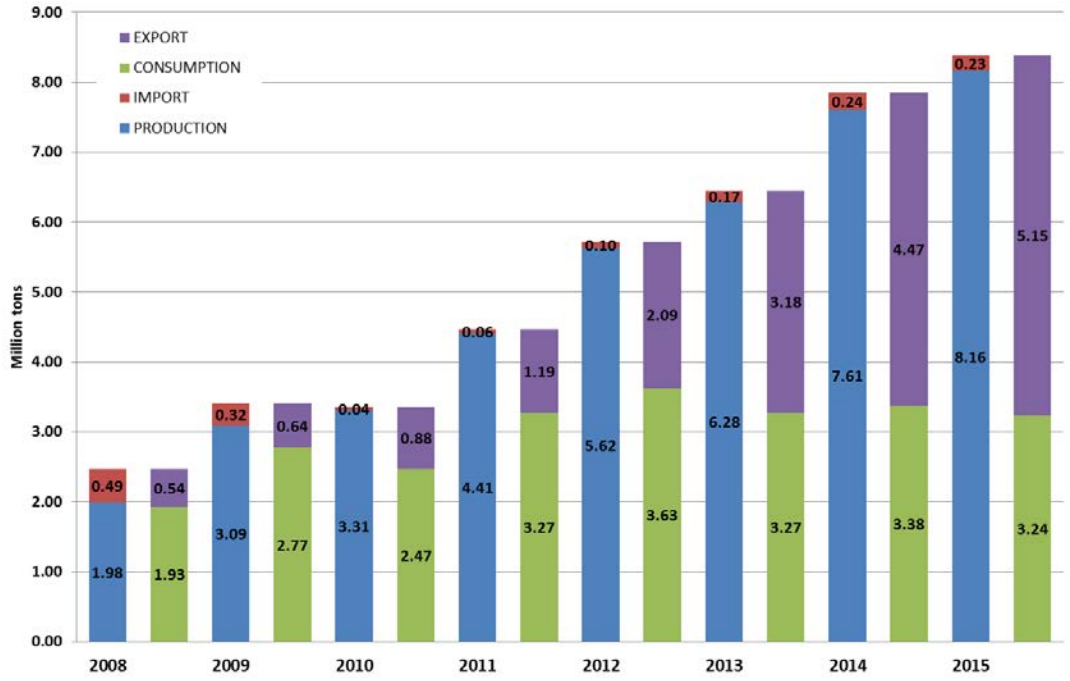

Figure 14. U.S. wood pellet production, consumption, imports and exports from 2008-2015. (Sources: Lamers et al. 2012, EUROSTAT 2015, FAOSTAT 2016, Statistics-Canada 2016, USDA 2016)

Table 7. U.S. wood pellet exports in tons (USDA 2016).

	2012	2013	2014	2015
United Kingdom	741,830	1,854,356	3,265,913	4,315,312
Belgium (and Luxembourg)	546,253	589,371	520,591	672,459
Netherlands	550,231	196,667	330,287	70,126
France	0	99	1,123	53,816
Canada	36,051	23,787	25,209	24,639
South Korea	28	37,038	60,578	4,186
Italy	14,969	165,698	131,986	1,975
Denmark	32,189	215,600	115,862	1,480
Sweden	50,631	24,639	16,279	0
Other	120,133	70,072	2,805	2,204
Total exports	**2,092,316**	**3,177,327**	**4,470,632**	**5,146,197**
of which to EU28	*93%*	*98%*	*98%*	*99%*

5.3. Global outlook until 2030

Global wood pellet production capacity was around 20 million tons in 2015 with an addition 2.2 million tons under construction. The expected global production by 2017 is around 18 million tons which is likely to be soaked up by the market by 2018 the latest. This means that the current global oversupply (2016) will turn into an undersupply by 2018/2019 (definitely 2020) if no additional capacity is brought online.

Global demand for industrial wood pellets by 2015 was roughly 14.4 million tons and could grow up to 28 million tons by 2020. Global demand in combustion markets however will plateau (between 2025-2030) and is expected to decline, depending on future policies for biopower in North America and Asia (Bingham 2016, Keppler 2016, Strauss 2016, Wild 2016).

At present, the primary markets are industrial-sized heat and power production facilities in Europe, including Denmark, the Netherlands, Belgium, UK, and to some degree Sweden. In addition to 2015 demand levels, the following increases are expected in the coming years:

- UK: + 3.9 million tons (Lynemouth, MGT Power, Drax full conversion unit 1, minus Eon Ironbridge)
- Belgium: + 1.8 million tons by 2018 (Langerloo)
- Netherlands: + 1.7 million tons from late 2016 until mid-2017 (RWE/Essent, Engie) plus an additional increase to a total of 3.9 million tons by the end of 2017 (capped and limited to 8 years of subsidies)
- Denmark: + 1.2 million tons (Dong)

The underlying policies (e.g., carbon tax and/or coal phase-out) however are limited as wood pellet combustion in retrofitted coal-fired power plants is only seen as a transition to a low-carbon energy future. As a result, the EU demand is expected to plateau around 2027 (Pöyry 2014, Pöyry 2015, Bingham 2016).

Demand increases in Asia are likely (Japan in particular), but the extent is yet unclear. Also, new demand markets will have suppliers compete for receiving long-term contracts. U.S. producers (from the Southeast) will need to compete with, e.g., Canadian producers in British Columbia, who already supply Asian markets today.

The future of wood pellet demand in North America is also somewhat uncertain. Canada has the potential to become a very large market as several provinces are aiming to phase-out coal (e.g., Alberta). If wood pellets are considered a viable option to reduce coal dependence and foster a respective phase-out by 2030, Alberta could have a demand of 25 million tons by 2029. Canada will likely consider supplying most of this demand from domestic producers.

Future U.S. demand will depend on state initiatives, as an implementation of the Clean Power Plan on Federal level is seen as unlikely. State initiatives and Renewable Portfolio Standards however could increase U.S. demand in the medium- (5yr) to long- (10 yr) term. Positive biomass activities in the U.S. include, e.g., Boardman, OR, the MISO Midwest grid operator foreseeing coal plant closures (and a capacity squeeze) by 2018, as well as developments in Maine where policy makers are starting to view biomass as a cost-efficient renewable strategy (Keppler 2016).

Figure 15 depicts one possible global demand outlook until 2030 taking into account information provided by utilities and pellet producers at the USIPA conference as well as market outlook studies by FutureMetrics and Hawkins Wright (Bingham 2016, Strauss 2016). The demand is lumpy as the individual demand parties are (partly very) large entities. Figure 16 breaks down the expected share of wood pellet production that would take place in the U.S. if the current supply shares to the respective demand countries are kept constant.

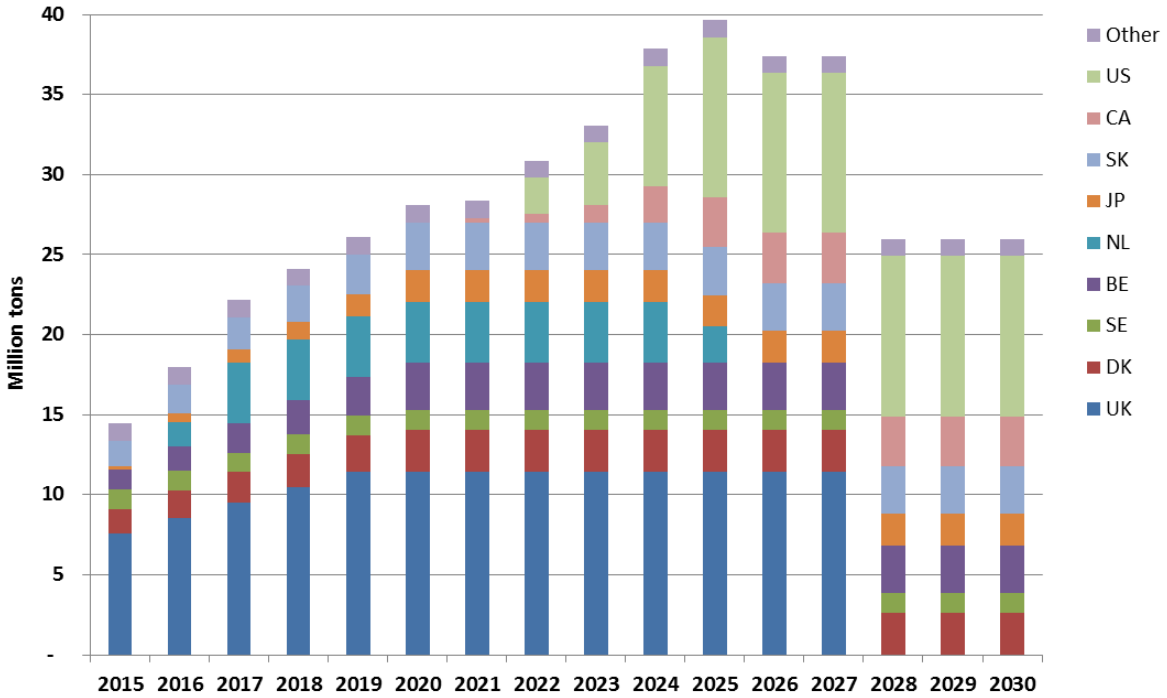

Figure 15. Past and expected global industrial wood pellet demand.

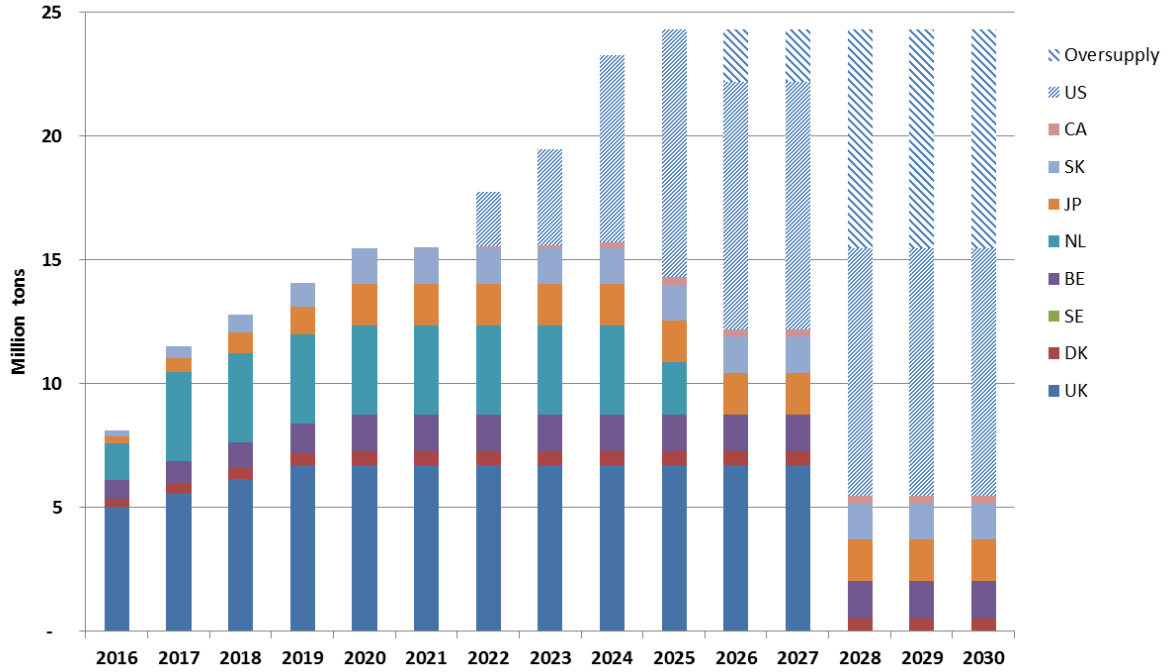

Figure 16. Expected U.S. industrial wood pellet production to fulfill part of the global demand.

6. CONCLUSIONS

The U.S. production of wood pellets has grown to over 8 million tons by 2015 (FAO 2016). The majority of the production capacity increase took place in the U.S. Southeast and is associated with industrial wood pellet production for export markets. In 2015, over 5 million tons were exported, 99% of which went to EU markets (84% to the UK alone) (EUROSTAT 2015, FAOSTAT 2016, USDA 2016). The production and consumption growth of U.S. residential wood pellets has been slow in comparison. The industrial and residential wood pellet markets are beginning to merge slowly, but production excess (e.g., in 2015 and 2016) in the industrial wood pellet segment could not be fully absorbed by domestic or oversea residential markets.

The main growth path for U.S. wood pellet production is still seen to lie in oversea markets (Bingham 2016, Strauss 2016). Demand increases for industrial pellets are projected to occur within the next years in Europe (Netherlands, Denmark, UK, Belgium) and Asia (predominantly Japan). At the same time, subsidy schemes in Europe are also bound to be phased out within the next decade. U.S. suppliers will have to compete with other supply regions (e.g., Western Canada to Asia) in the long-term, and are already focusing on selling more and more into non-subsidized markets such as biochemicals, absorbents, and soil amendments (Keppler 2016). An outlook of U.S. industrial wood pellet production under a potential growth in U.S. biopower demand and a lack thereof shows a wood pellet oversupply of 9-10 million tons by 2030, equaling roughly 12.5 million tons of production capacity, 20-30 large-scale plants, or 15 million green tons of woody biomass.

Once the U.S. production of wood pellets outgrows combustion market demand (which will plateau even with a domestic expansion of biopower) the industry will require additional outlets to avoid a structural

decline and bankruptcy. This will create a resource push and cost reduction, driving the development of a U.S. cellulosic biofuels industry.

Facing record level U.S. corn production and end-market saturation, the corn industry (in conjunction with a phase-out of MTBE and the RFS) essentially *pushed* the establishment of a corn ethanol market. It is expected that – in similar fashion – a cellulosic biofuel market can be pushed into existence through the necessity of a domestic feedstock supply industry to tap into additional market outlets for their product. Without a liquid (in market terms) intermediate cellulosic feedstock market, future conversion industries will have a tendency to attach themselves to other, already existing feedstock markets such as bio-oil, starch or sugar. The export-oriented wood pellet industry is seen as the most promising leverage point to grow a respective feedstock market which could create a resource push and facilitate the expansion of a domestic cellulosic biofuel industry. Several conditions point into this direction. First, wood pellets fulfill the basic requirements of a commodity good and respective market:

- Standardized product: chemical and physical homogeneity within specifications
- Bulk transport / logistics capability: Stable and storable, durable and flowable, high bulk density
- Intermediate good, fungible across multiple markets: combustion (heat and/or power, residential and industrial scale), absorbents (chemical, oil and gas industry, animal bedding), biochemical, biofuel
- Physical trade is based on a mix of long-term and spot market agreements; the market is in a transition to become more competitive and liquid (ease to match a buyer and seller)

Second, the primary markets for U.S. wood pellets are expected to plateau around 2027 (taking into account new market growth in Europe and Asia). Additional demand could come from within the U.S., depending on state-level implementation of the CPP and RPS. Canada is also expected to increase co-firing capacities but will most likely focus on regional biomass supply. To avoid stagnation and decline the industry will have to start supplying non-combustion markets and become more cost-competitive.

Also, a growth and continuation of the wood pellet industry is strongly supported from the grower/resource base. The USFS, forest industry associations, and forest owners alike state that the pellet industry creates additional demand needed to keep forests in working condition due to the structural decline in the wood products industry and the slow recovery of the U.S. housing market. The main alternative for private forest owners is land clearance for urbanization, which could reduce the socio-economic benefits associated with the forest industry in rural areas that have already suffered under the structural decline of the wood products sector. This aspect is relevant for constituents as well as policy makers.

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8. APPENDIX

Table 8. States per region.

Region	States
Northwest (NW)	AK; ID; MT; OR; WA
Southwest (SW)	AZ; CA; CO; NM; UT; WY
Midwest (MW)	IA; IN; MI; MN; MO; NE; SD; WI
Northeast (NE)	ME; NH; NY; OH; PA; VT
Southeast (SE)	AL; AR; FL; GA; KY; LA; MS; NC; SC; TN; TX; VA; WV

Table 9. Operational U.S. wood pellet plant list by capacity (Biomass-Magazine 2016).

Name	State	Feedstock	Capacity (tons per year)
Golden Peanut Co. - Headland	AL	Ag	Undisclosed
Golden Peanut Co. - Dawson	GA	Ag	Undisclosed
Wood Pellet Coop	MN	Hardwood	Undisclosed
Appalachian Wood Pellets	WV	Hardwood	Undisclosed
Woodgrain Millwork Inc.	OR	Softwood	Undisclosed
International Pecan Company	TX	Ag	Undisclosed
Snow Timber Pellets LLC	WI		15
Hearthside Wood Pellets	NY	Hardwood	700
Wolverine Hardwood Pellets	MI	Hardwood	750
Phoenix Resources LLC	MI	Hardwood and Softwood	900
Enviro Energy LLC	NY	Ag	1,800
Hannas Candle Company	AR		2,000
Pellet Technology USA	NE	Ag	2,500
Lemhi Valley Pellets	ID	Hardwood and Softwood	2,600
Pellheat Inc.	PA	Hardwood	5,000
Penn Wood Products Inc.	PA	Hardwood	5,000
Bearlodge Forest Products	WY	Softwood	5,000
Enginuity Worldwide LLC	MO	Ag	6,000
Mt. Taylor Manufacturing - Pellet Mill	NM	Hardwood and Softwood	6,000
Mt. Taylor Manufacturing	NM	Hardwood and Softwood	6,000
Essex Pallet & Pellet	NY	Hardwood and Softwood	6,000
Associated Harvest Inc.	NY	Hardwood	8,000
Log Hard Premium Pellets Inc.	PA	Hardwood	8,000
Alexander Energy Inc.	PA	Hardwood	8,500
Vulcan Wood Products	MI	Hardwood and Softwood	9,000

American Biocarbon - White Castle	LA	Crop Residue	10,000
Rocky Canyon Pellet Co.	ID	Hardwood and Softwood	10,000
Woodscape of Utah	UT	Hardwood and Softwood	10,000
American Pellet Company	MI	Hardwood and Softwood	12,000
Southern Kentucky Pellet Mill Inc.	KY	Hardwood	12,000
Kingdom Biofuels	PA		12,000
Southern Indiana Hardwoods	IN	Hardwood	13,000
Show Me Energy Cooperative	MO	Biomass Crops	15,000
Koetter & Smith Inc.	IN	Hardwood	15,000
Jensen Lumber Co.	ID	Softwood	15,000
Vermont Wood Pellet Co. LLC	VT	Softwood	16,600
Green Friendly Pellets LLC	MN	Hardwood	17,000
G-Pel International	FL		17,000
Southwest Renewable Resources	AZ	Softwood	18,000
Environmental Energy Partners LLC	CO	Softwood	18,000
Horizon Biofuels Inc.	NE	Hardwood and Softwood	20,000
Blue Mountain Lumber Products	OR	Hardwood and Softwood	20,000
Malheur Pellet Mill	OR	Softwood	20,000
Frank Pellets	OR	Softwood	21,000
Maeder Brothers Quality Wood Pellets Inc.	MI	Hardwood	22,000
American Wood Fibers - Wisconsin	WI	Hardwood and Softwood	25,000
Ernst Biomass	PA	Biomass Crops	25,000
Isabella Pellet	MI	Hardwood and Softwood	25,000
Turman Hardwood Pellets	VA	Hardwood	28,000
ProPellet	MN	Softwood	28,000
Hassell & Hughes Lumber Company	TN	Hardwood	30,000
West Oregon Wood Products - Banks	OR	Softwood	30,000
Phoenix Recycling	IA		30,000
EB Clean Energy Ltd. - Boardman	OR		30,000
Kirtland Products LLC	MI	Hardwood and Softwood	35,000
Superior Pellet Fuels LLC	AK	Softwood	35,000
Equustock - Clare	MI	Hardwood and Softwood	36,000
Wood Pellets C&C Smith Lumber	PA	Hardwood	36,000
Manke Lumber Company	WA	Softwood	38,000
Northeast Pellets LLC	ME	Hardwood and Softwood	40,000
Equustock - Troy	VA	Hardwood and Softwood	40,000
Dejno's Inc.	WI	Hardwood and Softwood	40,000
Pacific Pellet LLC	OR	Hardwood	40,000
Henry County Hardwoods Inc.	TN	Hardwood	40,000

O'Malley Wood Pellets	VA	Hardwood	40,000
Equustock - Montebrook	FL	Softwood	40,000
Western Wood Products Inc.	NM	Softwood	40,000
Bear Mountain Forest Products - Cascade Locks	OR	Softwood	40,000
Patterson Wood Products Inc.	TX	Softwood	40,000
Zilkha Biomass - Crockett	TX	Hardwood and Softwood	44,000
Barefoot Pellet Company	PA	Hardwood	45,000
American Wood Fibers - Circleville	OH	Hardwood and Softwood	50,000
Tri State Biofuels LLC	PA	Hardwood and Softwood	50,000
Fiber Resources Inc.	AR	Hardwood	50,000
Michigan Wood Fuels	MI	Hardwood	50,000
Instantheat Wood Pellets Inc.	NY	Hardwood	50,000
Greene Team Pellet Fuel Company	PA	Hardwood	50,000
PA Pellets	PA	Hardwood	50,000
Pellet America Corp.	WI	Paper Waste	50,000
North Idaho Energy Logs - Moyie Springs	ID	Softwood	50,000
West Oregon Wood Products - Columbia City	OR	Softwood	50,000
LowCountry Biomass	SC	Softwood	50,000
Potomac Supply LLC	VA	Softwood	50,000
Pacific Coast Pellets	WA	Softwood	50,000
Dover Resources Inc.	CA	Woody Biomass	50,000
Somerset Pellet Fuel	KY	Hardwood	55,000
Spearfish Pellet Co. LLC	SD	Softwood	58,000
Allegheny Pellet Corporation	PA	Hardwood	60,000
Hamer Pellet Fuel Elkins	WV	Hardwood	60,000
North Idaho Energy Logs - Hauser	ID	Softwood	60,000
Queston Wood Pellets	VT	Softwood	60,000
Forest Energy Corp.	AZ	Softwood	62,000
Marth Peshtigo Pellet Co. - Peshtigo	WI	Hardwood	64,000
Marth Wood Shavings Supply	WI	Hardwood	64,000
Northeast Wood Products LLC - Peebles	OH	Hardwood and Softwood	65,000
Fiber By-Products - White Pigeon	MI	Hardwood	65,000
Great Lakes Renewable Energy Inc.	WI	Hardwood and Softwood	70,000
Deadwood Biofuels LLC	SD	Softwood	71,000
American Wood Fibers - Marion	VA	Hardwood and Softwood	75,000
Fiber Recovery Inc.	WI	Hardwood	75,000
Nature's Earth Pellets NC LLC - Reform	AL	Softwood	75,000
Schuyler Manufacturing Facility	NY	Hardwood and Softwood	77,000
Equustock - Chester	VA	Hardwood and Softwood	80,000

Fiber Energy Products AR LLC	AR	Hardwood	80,000
Lignetics of Idaho Inc	ID	Softwood	80,000
Corinth Wood Pellets LLC	ME	Hardwood and Softwood	85,000
Jaffrey Manufacturing Facility	NH	Hardwood and Softwood	85,000
Deposit Manufacturing Facility	NY	Hardwood and Softwood	88,000
Varn Wood Pellets	GA	Softwood	88,000
Lignetics of Maine Inc	ME	Hardwood	90,000
Indeck Energy Ladysmith Biofuel Center LLC	WI	Hardwood and Softwood	90,000
Lignetics of Virginia Inc.	VA	Hardwood	90,000
Confluence Energy-Kremmling	CO	Softwood	90,000
Wood Fibers Inc.	WI		90,000
Nature's Earth Pellets NC LLC - Laurinburg	NC	Hardwood and Softwood	100,000
Dry Creek Products	NY	Hardwood	100,000
Maine Woods Pellet Company	ME	Hardwood and Softwood	105,000
Lee Energy Solutions	AL	Hardwood	110,000
Bayou Wood Pellets	LA	Hardwood and Softwood	120,000
Curran Renewable Energy LLC	NY	Hardwood and Softwood	120,000
Energex America Inc.	PA	Hardwood	120,000
Greenwood Fuels	WI	Paper Waste	120,000
Mallard Creek Inc.	CA	Softwood	120,000
Confluence Energy-Walden	CO	Softwood	120,000
Enviva Pellets Amory	MS	Hardwood and Softwood	121,000
Enviva Pellets Wiggins	MS	Hardwood and Softwood	121,000
Lignetics of West Virginia Inc.	WV	Hardwood	125,000
Bear Mountain Forest Products- Brownsville	OR	Softwood	125,000
Trae Fuels Ltd - Pellet Plant	VA	Hardwood and Softwood	130,000
Northeast Wood Products LLC - Ligonier	IN		130,000
Ozark Hardwood Pellets	MO	Hardwood	140,000
Nahunta Pellets	GA	Softwood	150,000
Telfair Forest Products LLC	GA	Softwood	150,000
Solvay Biomass Energy LLC	MS	Hardwood and Softwood	240,000
Appling County Pellets LLC	GA	Hardwood and Softwood	243,000
Zilkha Biomass - Selma	AL	Hardwood and Softwood	303,000
Westervelt Renewable Energy LLC	AL	Softwood	309,000
Enviva Pellets Ahoskie	NC	Hardwood and Softwood	449,000
Morehouse BioEnergy	GA	Woody Biomass	496,000
Amite BioEnergy	MS	Hardwood and Softwood	500,000
Blue Sky Biomass Georgia LLC	GA	Woody Biomass	540,000
Enviva Pellets Northampton LLC	NC	Hardwood and Softwood	550,000

Enviva Pellets Southampton LLC	VA	Hardwood and Softwood	550,000
Enviva Pellets Hamlet	NC	Woody Biomass	550,000
German Pellets Texas	TX	Hardwood and Softwood	551,155
German Pellets Louisiana LLC	LA	Softwood	578,000
Enviva Pellets Cottondale LLC	FL	Softwood	660,000
Hazlehurst Wood Pellets LLC	GA	Softwood	700,000
Georgia Biomass	GA	Softwood	825,000
SUM Operational Capacity (tons per year)			**14,425,520**