Developing a Wood Pellet/Densified Biomass Industry in Washington State: Opportunities and Challenges

Technical Assessment

Prepared by:
David Sjoding, Erin Kanoa, Pauline Jensen

Winter 2013

WASHINGTON STATE UNIVERSITY
EXTENSION ENERGY PROGRAM

905 Plum Street SE, P.O. Box 43165, Olympia, Washington 98504-3165

WSUEEP13-033 • August 2013

Disclaimer: This report is intended to provide general strategic direction for the development and growth of the densified biomass/pellet mill industry. It is not to be used as a substitute for an investment-grade business plan and feasibility study.

Contents

Introduction

The Energy Economies of Washington State

From an energy perspective, Washington can be viewed as having two economies:

- Urban areas of the state, where there is access to relatively cheap natural gas, and
- Rural areas of the state, where natural gas is not readily available.

Typical energy sources in rural areas include fuel oil, residual oil, propane, electricity, wood and other renewable resources. We have the opportunity to develop densified biomass as a less expensive alternative to petroleum products.

A set of natural gas maps, provided later in this document, indicate where markets for densified wood have a higher opportunity for development. This can be viewed as a “Washington grown, owned and used” economic development/business case.

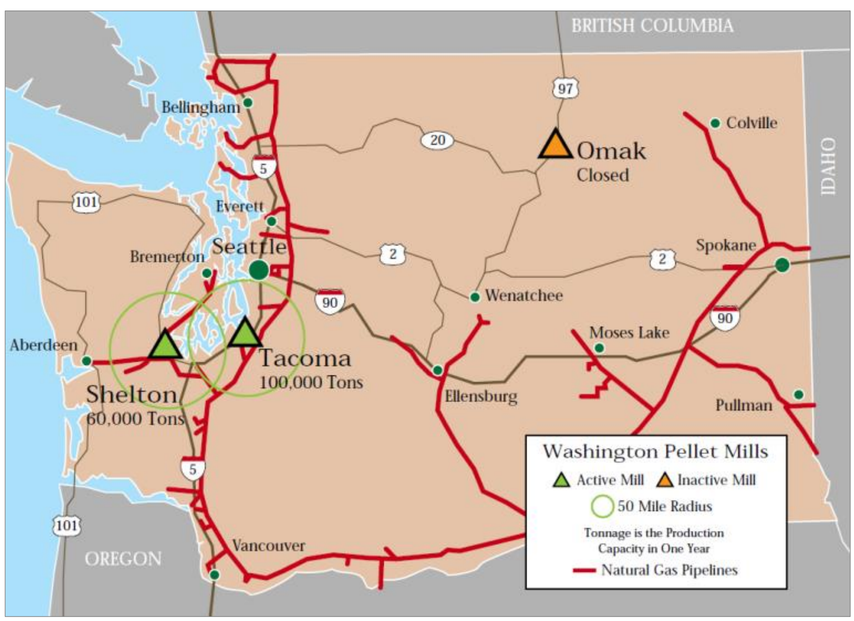
This report is intended to provide general strategic direction for the development and growth of the densified biomass/pellet mill industry in our state. It is not to be used as a substitute for an investment-grade business plan and feasibility study. However, it provides a broad and strong context for specific business plan/feasibility plan development.

Pellet Mill Capacity

The capacity of Washington pellet mills has shrunk in recent years. In 2009, three mills had a capacity of 180,000 tons per year. In 2010, the state had two mills and a capacity of 120,000 tons per year. In 2011, with the re-opening of the mill in Shelton as Olympus Pellets, capacity was up to 160,000 tons per year.

British Columbia, Oregon and Idaho all have strong pellet mill industries.

Rural Washington is the best area of the state to develop the pellet mill industry due to the prices of available alternative energy supplies (where natural gas is not available) and abundance of woody biomass feedstock.



Wood Pellet Basics

What is Densified Biomass?

Raw biomass materials are irregular in shape, low in energy density, are greatly affected by temperature and moisture, and can be difficult to transport. If biomass is to be treated as a common fuel, it must have the main characteristics of a common fuel, which can be achieved through densification. Densification creates a regular shape, increases energy density, reduces the effects of temperature and moisture, and increases ease of transport.

In addition, densification increases the energy density of the biomass; that is, densification increases the amount of energy stored per unit volume (typically defined as BTU/lb). Wood in its raw form has an energy density of about 7,600-9,600 BTU/lb, wood pellets are about 8,200 BTU/lb. Torrefied pellets have an energy density range of 9,000 -10,800 BTU/lb.

> **What is biomass densification?**
>
> Wood fuel pellets, briquettes, pucks and other forms of densified fuel are created by compressing and heating sawdust or chipped wood so they are a solid biofuel with consistent quality – low moisture content, high energy density and homogenous size and shape.

What Can be Made from Biomass?

A biorefinery makes multiple products from biomass, such as liquid fuel, power, heat and bio-based chemicals. These varied product streams can improve the financial resiliency of a facility.

Biomass Feedstock

Fuel pellets can be manufactured from various types of biomass feedstocks, from corn stover to hard woods. Ideally, biomass used to make wood pellets is sourced from an established biomass waste stream such as sawdust from a mill, trees killed by pine beetles, or clean waste wood from construction or furniture making. In Washington state, wood waste from logging and mill residues make up the majority of feedstocks used for pelletizing.

The type of raw material determines the amount of grinding and drying needed before the conditioning process. If a feedstock is not in a raw state, such as with reclaimed wood, only grinding and minimal drying may be necessary. Purchasing the biomass feedstock is the most costly aspect of pellet production. Drying the raw materials is the most energy-intensive aspect of pellet production.

Pellet Manufacturing

Raw biomass is densified to increase the energy content of the biomass per unit weight so it can compete with oil, propane and other fuels. The biomass densification process includes:

- Feeding the feedstock into a dryer;
- Grinding it to the required size;
- Conditioning the mixture, which involves reducing moisture of the feedstock for efficient use with pellet equipment;
- Pelletizing, cooling and screening the pellets; and
- Packaging the product for storage, shipping and sales.

Pellets are graded by bulk density in kg/m3 with an energy content unit of MJ/kg^{-1}, when converted to BTU/lb the energy ranges from 7,500 – 8,700 BTU/lb. Hardwood, softwood and switchgrass pellets are in the higher range.

Heating value is not described in the requirements, but required testing at a lab will notify the mill and potential consumer how the pellets tested with regard to their MJ kg-1 rating.

Energy Balance

The energy balance is the energy inputs and outputs of a process or system. For pellet production, the energy balance can be divided into three sections: harvesting forest byproduct feedstock – which includes transportation to the sawmill; producing the pellets; and transporting the finished product to the point of sale.

The net energy balance for wood pellets is strongly positive. The energy embedded in the wood pellets significantly exceeds the energy used to create them.

U.S. Pellet Standards

To help standardize pellet production across the industry in the U.S. and adhere to the U.S. Environmental Protection Agency (EPA) wood-burning emissions requirements, the Pellet Fuels Institute (PFI) developed standards for pellet fuel producers. At this time, adherence to these standards is voluntary.

Due to the variability of feedstocks and proprietary production techniques of individual manufacturers, wood pellets are defined by their feedstock source, density, moisture levels and ash content, and are then categorized as Premium, Standard or Utility. This information helps consumers understand what to expect from the pellets they purchase to heat their homes, businesses or schools.

So far, 40 U.S. pellet mills have agreed to adhere to these standards, but none of the pellet mills in Washington have yet agreed to follow them. The PFI standards are provided in Appendix A, along with the European standards and a brief comparison. The main differences of the PFI Standard compared to the European Standard are in materials origin, additives, net energy value (calorific) and regulated contaminants. The ability to enforce quality along the entire supply chain would require compliance from each producer from raw material to delivery.

European Pellet Standards

The main differences between the PFI standards and the European standards are in material origins, additives, net energy value and regulated contaminants. The European standards are provided in Appendix A.

The voluntary European pellet standards[1] were created to ensure a reliable biomass commodity and consistent quality standards along the entire supply chain, from raw material to delivery. The primary emphasis was to provide a product with quantified energy content and validated origin source information that consumers could use to help make informed purchasing decisions. These standards also address source and quality concerns that exist around products made from biomass, which had led to earlier market volatility.

The U.S. has long restricted oil exports. This fact, along with the dampening effect of a slower economy, has softened oil prices in the U.S. One of the competitive risks for developing a densified biomass industry is more competitive pricing from fuel oil.

Energy Content

The energy content of pellets can vary based on moisture and the energy content of different types of wood and binders, if used. Bark content will also significantly affect energy content.

Feedstock variables include moisture content and particle size, shape, and distribution. As with process variables, these have a significant influence on pellet quality.[2]

Energy Content of Northwest Wood Species (in BTU)

Lodgepole Pine	Western Red Cedar	Ponderosa Pine	Douglas Fir	Red Alder	Big Leaf Maple	Western Hemlock
10,760	9,700	9,616	8,950	8,860	8,400	8,370

Source: *Wood to Energy in Washington: Imperatives, Opportunities, and Obstacles to Progress*, University of Washington

Binding agents, such as inherent starches, are released from the feedstock during the pelletization process. The need for additional binders may be necessary if the amount of natural agent produced is less than desired. These agents may include vegetable oil, clay, starch cook oil or wax.[3]

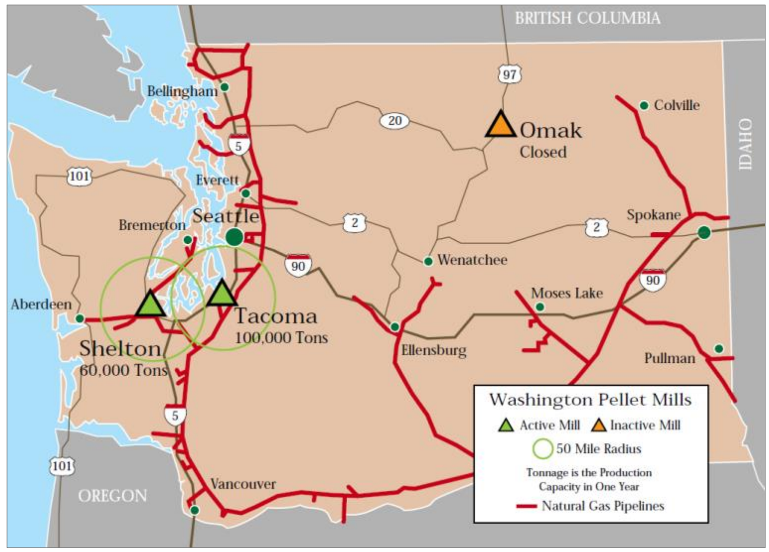
To deal with variability in energy content, one mill, the Superior Pellet Fuels of Fairbanks, Alaska,[4] established a premium standard of energy content of at least 8,100 BTU/lb with a moisture content of 6.25 to 6.5 percent (average BTU content is around 8,200 BTU/lb). The wood recipe is adjusted to meet this standard.

[1] http://biowatt.ru/files/docs/gost/pellets-standarden14961-1.pdf
[2] Idaho National Laboratory
[3] Biomass Densification for Energy Production
[4] http://www.superiorpelletfuels.com/

Opportunities for the Pellet Mill Industry

Rural Users

Where natural gas is not available, densified biomass has a significant market opportunity. It is principally in the rural areas of the state where natural gas is not available; these are considered prime areas to develop densified biomass/pellet markets. These areas are indicated on the map, which shows natural gas pipelines and pellet mills that were in operation as of December 2012.



Rural Washington has a variety of fuel sources available for commercial, institutional and industrial facilities, including:

- Fuel oil
- Residual oil/waste oil
- Propane
- Wood pellets
- Wood waste
- Electricity

Coal as an energy source has essentially disappeared as a generated energy source in Washington, although is still exists in the fuel mix of state utilities.

In-State Anchor Tenants

Commercial, institutional and industrial facilities that currently use fuel oil, residual oil/waste oil and propane are potential anchor tenants to support the development of the pellet mill market. These include food processing facilities; Department of Corrections facilities; asphalt, concrete and petrochemical companies; and schools.

Information about the primary fuel sources used by commercial, institutional and industrial facilities is available from Department of Ecology Industrial Section (very large boilers) and regional clean air agencies. The WSU Energy Program collected this information as part of this study,[5] which provides a starting point for developing business plans and expanding anchor tenants that would use wood pellets.

The wood pellet industry tends to be very seasonal, peaking in the winter when heating needs are highest. An ideal anchor tenant would be summer seasonal or year-round to balance winter heating.

[5] Available upon request

The Sealaska Approach: Build Demand Then Build Supply

Sealaska, an economic development corporation for Southeast Alaska Native Americans, has an interesting approach for developing a pellet mill industry in Southeast Alaska. It is first focusing on building baseload demand in larger facilities. When volume reaches sufficient levels, a pellet mill will be developed to meet that demand. Early steps have included:

- Sealaska's four-story headquarters building was converted to wood pellets, eliminating the need for 35,000 gallons per year of heating oil. The building uses a Viessman Kob boiler with 85 percent efficiency and a circulating hot water system. The system uses two flue gas filters to improve air quality.
- This approach is now supported by the Alaska Energy Authority, the U.S. Coast Guard and the U.S. Forest Service. An interagency agreement has been signed between the U.S. Coast and the U.S. Forest Service.
- A second major facility considering conversion to wood pellets is the U.S. Coast Guard Station in Ketchikan, AK.

Facilities like these can build regional demand. This strategy could be applied to Washington state.

Applying the Sealaska Strategy to Washington State

The north Olympic Peninsula has several major commercial, industrial and institutional facilities that could switch from fuel oil to wood pellets. These include Clallam Bay Corrections Center, Lakeside Industries in Port Angeles and the U.S. Coast Guard Group in Port Angeles. Taken together, these facilities would build market demand that, in turn, would allow a forest products/pulp and paper mill to establish local pellet mill production. Residential wood pellet stoves and pellet sales would build on this foundation.

Export Markets

Wood pellets could also be exported to Asian or European markets, but this is a tougher, more complex market to enter than the in-state market.

Tough competition already exists with the southeastern U.S. and Canada, which are well established in the export market and have lower price structures than Washington. The southeastern U.S., with a faster-growing timber cycle and less rugged terrain, has competitive advantages that have allowed its export market to expand.

International pellet standards (principally defined by established European standards) are significantly more stringent[6] than the voluntary U.S. standards developed by the Pellet Fuels Institute.[7] To enter the international market, U.S. pellet mills will need to meet these international standards.

[6] The European wood pellet standards test for additives, energy content and heavy metals that are not currently specified in the U.S. wood pellet standards.

[7] http://pelletheat.org/pfi-standards/

An additional challenge is commodity purchase expectations ("We buy what is on the market today") versus the need for multi-year contracts between buyer and seller to enable capital investment in pellet mill production facilities.

For these reasons, the export market for wood pellets does not currently look as promising as the domestic market.

Challenges Facing the Pellet Industry

The wood pellet industry in rural Washington faces a variety of competitive forces, including:

- Cheap and plentiful oil and natural gas,
- Reduced need for fuels due to enhanced energy efficiency, and
- Competition for biomass feedstock.

Cheap and Plentiful Oil and Natural Gas

For the first time in decades, U.S. oil prices are below world market prices as fracking technology is used to produce large volumes of oil and natural gas. The U.S. demand for foreign oil is also dropping, which frees significant global oil resources for Asia and Europe, dampening the potential export market for densified biomass products.

This trend is very likely to continue. It has also triggered – for the first time in over 30 years – a split in the price of U.S. West Texas Intermediate oil compared to the European Brent price. The U.S. has long restricted oil exports. This, along with the dampening effect of a slower economy, has softened oil prices in the U.S.

The strategy to build a densified biomass industry in Washington by developing large anchor tenants that have significant demand for thermal energy and could use wood pellets instead of fuel oil, residual oil or propane could be frustrated by the availability of cheap natural gas. These large rural industrial/institutional facilities in areas that are not served with natural gas pipelines could switch to liquefied natural gas (LNG) delivered by truck.

Competition for Biomass Feedstock

Pellet mills need a cheap and reliable source of wood waste materials. Competition and prices for this feedstock fluctuate as emerging uses compete for this resource:

- **Alternative wood products** – Recycle One of Tacoma is developing a composite wood fiber/plastic board for construction uses. Other facilities appear to be getting traction in Grays Harbor.
- **Aviation biofuel** – The market demand for aviation biofuel and other advanced biofuel alternatives has triggered a race to complete research and develop these biofuels from woody biomass.

Alaska Airlines, based in Seattle, is an industry leader in using biofuel

- **Biochar** – Biochar made from woody biomass – an alternative to activated carbon make from petroleum coke – is used to restore disturbed soils and remediate soil and stormwater contamination. The Washington State Department of Ecology is supporting research at WSU to develop engineered biochars.[8] In addition, the Northwest Biochar Working Group brings together stakeholders to identify opportunities for biochar, develop demonstration projects, and identify best practices that will set the standard for effective use of this technology.

- **Bioproducts and nutraceuticals** – This emerging industry aims to offset petrochemicals used to produce fragrances, foodstuffs and dietary supplements, and promises to be the most lucrative market for woody biomass.

Feedstock Harvesting and Transportation Costs

New techniques and equipment for rapidly pulling logging slash out of the woods promise to improve access to forest biomass and the speed of its removal. For example, chip trucks with log truck frames and rear-wheel steering provide better access to forest biomass supplies, and new methods of chipping the wood allow for faster loading and higher-quality chips.

To reduce the costs of transporting biomass to pellet mills, Washington state legislators are invited to consider a remedy that has been successfully employed in British Columbia and Idaho, where higher weight limits on the roads significantly improve efficiencies of hauling feedstock materials. This approach is also supported by proposed federal legislation that would allow trucks with an extra axle to haul heavier loads of agricultural and forest products. (Truck length is not increased with this proposal.)

Volatility in the Wood Pellet Marketplace

Pellet fuel manufacturers should secure their supply of feedstock years in advance to avoid price fluctuations due to dips in feedstock availability and increases in use, such as during a cold snap. This will also enable pellet mills to stabilize their product supplies so consumers feel confident relying on this fuel source as a viable alternative to electricity, propane or fuel oil.

Enhanced Energy Efficiency

By reducing the need for energy, technologies such as variable refrigerant flow (VRF) heat pumps become an alternative fuel source – and a significant competitive risk for the wood pellet market. Energy efficiency is always viewed as a companion to fuel source shifting to reduce end-user costs.

On a cost per MMBTU basis, wood pellets compete extremely well against a wide range of options, with the key exception being heat pumps. VRF heat pumps have come to commercial maturity in the marketplace. One caution for heat pumps is that below 0°F, VRF heat pumps

> The WSU Energy Program developed a small spreadsheet calculator to underpin this data. It was designed for rural areas of the state where natural gas is not available to compare the cost of energy, taking into consideration the efficiencies of different heating systems. It does not include capital costs.

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[8] For additional information, see the Pacific Region Biomass Partnership website (http://pacificbiomass.org/Library.aspx#Introduction) and *Biochar: Background & Early Steps to Market Development* (http://pacificbiomass.org/documents/Biochar%20Backgound%20and%20Early%20Steps%20to%20PNW%20Market%20Development%2010%202012%201207.pdf).

have reduced ability to keep a building warm. Harsher winter climates, such as northeastern Washington, would need backup heating or very high levels of insulation.

VRF heat pumps draw energy from the outside air, water or the ground, and are very energy efficient. These systems can range from 150 to 400 percent efficiency, with a typical efficiency of 250 percent. This efficiency reflects the federal minimum efficiency for air source heat pumps (7.7 heating seasonal performance factor). More details about VRF heat pumps are provided in the factsheet provided in Appendix C.

The table below compares the cost to produce a specific amount of heat using various fuels.[9] At $18.94 per unit of heat delivered, The heat produced from wood pellets is significantly less expensive than heat produced by electric baseboard heaters, fuel oil and propane, and more expensive than heat produced using heat pumps and firewood.

Fuel	Units	MMBTU per unit [a]	Fuel cost per unit	Efficiency %	Cost MMBTU
Heat pump	$/kWh	.003147	$.11	200% [b]	$13.78
Cord wood	$/Cord	18	$175.00	60%	$16.20
Wood pellets	**$/ton**	**16.5**	**$250.00**	**80%**	**$18.94**
Baseboard electric	$/kWh	.003147	$.11	100%	$31.14
#2 Fuel oil	$/gal	.1396	$3.50	80%	$31.34
Propane	$/Gal	.0915	$2.50	80%	$34.15

[a] MMBTU is the abbreviation for one thousand thousand British thermal units, which is a unit of heat required to raise the temperature of one pound of water by one degree Fahrenheit.

[b] Variable refrigerant flow heat pump systems can range from 150 to 400 percent efficiency, with a typical value of 250 percent. However, below 0°F, these heat pumps have reduced ability to keep a building warm. In harsher winter climates, such as northeastern Washington, a backup heating system is needed.

Competition for Feedstock

Competition for feedstock is shifting, as are prices. Pellet mills need a cheap and reliable source of wood waste materials. During 2012, the Puget Sound biomass market was affected by the closure of the Kimberly-Clark paper mill, which had a 52 MW biomass combined heat and power (CHP) system and used 400,000 tons of woody biomass per year. This closure triggered a glut of wood waste in the Puget Sound region, and prices fell considerably (40 percent or more). In contrast, in areas of the state beyond the Puget Sound, where pulp mills are actively buying, feedstock costs are significantly more.

The cheaper prices in the Puget Sound area are not expected to hold. The Cosmo Specialty Fibers pulp mill is back on-line in the Grays Harbor area. In addition, wood chips are shipped around Puget Sound,

[9] This cost is a function of the cost of the fuel and the efficiency of the device used to create heat from that fuel, such as a stove. Data used to compile this table is from the U.S. Department of Energy's heating fuel comparison calculator (as of 11/26/12).

which expands the Puget Sound woodshed to include Port Townsend Paper (permitted for a 25 MW biomass CHP system) and Nippon Paper (a 20 MW biomass CHP system).

Alternative woody biomass uses are emerging that will increase competition – and prices – for wood waste/wood chips:

- **Alternative wood products** – Recycle One of Tacoma is producing a composite wood fiber/plastic board for construction uses. Other facilities that use this resource may open soon.
- **Aviation biofuel** – The market demand for aviation biofuel and other advanced biofuel alternatives has triggered a race to complete research and develop these biofuels from woody biomass. In our state, WSU leads a five-year, $40 million research and development effort called the Northwest Advanced Renewables Alliance.[10] This effort focuses on a broad range of wood biomass feedstocks. As such, when this technology emerges, it will provide an alternative pathway for using woody biomass. A parallel study called Advanced Hardwood Biofuels Northwest[11] led by the University of Washington is focusing on plantation-grown hybrid poplar. It, too, is a five-year, $40 million research and development effort. Due to its plantation-grown feedstock, it should have less impact on the pellet mill industry.
- **Biochar** – Biochar is another emerging use for woody biomass. Market uses include soil toxics and stormwater remediation, an alternative to activated carbon from petroleum coke, agriculture and restoration of disturbed soils. The Washington State Department of Ecology is supporting research at WSU to develop engineered biochars.[12]
- **Bioproducts and nutraceuticals** – An additional emerging market for biomass is offsetting petrochemicals and producing fragrances and nutraceuticals. This set of markets has the highest prices/best economics in terms of market competition.

Biomass is an active market; despite the cautions cited here, there are marketing opportunities that investors in our state are advised to investigate.[13]

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[10] http://www.nararenewables.org/
[11] http://ahb-nw.com/
[12] For additional information see the Pacific Region Biomass Partnership website (http://pacificbiomass.org/Library.aspx#Introduction) and *Biochar: Backgound & Early Steps to Market Development* (http://pacificbiomass.org/documents/Biochar%20Backgound%20and%20Early%20Steps%20to%20PNW%20Market%20Development%2010%202012%201207.pdf).
[13] http://cleanburnfuel.com/index.html

Environmental Considerations

A number of environmental aspects and cross-currents are involved with developing a densified biomass/pellet mill industry in Washington.

Air Emissions

How does a pellet stove's emissions profile compare to fuel oil or propane or wood heat? Table 1, from *The Pellet Handbook*,[14] describes the emission factors of final energy supply of different residential heating systems. Carbon dioxide emissions from biomass are considered climate neutral.

The Olympic Regional Clean Air Agency with funding from the U.S. Environmental Protection Agency developed a report titled *Greenhouse Gas and Air Pollutant Emissions of Alternatives for Woody Biomass Residues,* November 2010. This report did a comparative analysis of the emissions profile of 15 different uses for woody biomass starting from when the tree hits the ground. This is a comprehensive inventory of emissions that are profiled from the wood waste through the use of the final product. The following is extracted for wood pellets (pages 62-64):

> **3c. Pelletization & Combustion in Pellet Stove**
> ***Life cycle description***
> The system emissions for the production of pellets and combustion in a pellet stove includes emissions associated with woody biomass preprocessing, pellet processing, packaging, distribution and combustion in pellet stove. The net emissions are the system emissions minus the avoided use emissions of minus displaced emissions from fuel wood or fossil fuel heat usage, as shown in Figure 25.

[14] *The Pellet Handbook*, table 9.7, page 314.

Table 1. Total Emissions from Specific Fuels

	Pellets from Wood Shavings			Pellets produced from sawdust			Heating oil			Natural gas		
Emissions Factor [mg/MJ_{FE}]	Fuel supply	Auxiliary energy supply	Thermal utilization	Fuel supply	Auxiliary energy supply	Thermal utilization	Fuel supply	Auxiliary energy supply	Thermal utilization	Fuel supply	Auxiliary energy supply	Thermal utilization
CO_2	2,324	699	0	3,787	699	0	7,000	599	75,000	3,300	300	55,000
CO	4.5	.7	101.9	22.2	.7	101.9	27	.6	18	93	.3	19
C_xH_y	7	2.9	7.9	14.7	2.9	7.9	42	2.4	6	490	1.2	6.
NO_x	14.4	.7	100	48.6	.7	100.0	54	.6	39	12	.3	15
SO_2	1.7	.8	11	6.4	.8	11	29	.7	45	5	.3	0.0
Dust	.8	.1	23.6	7.7	.1	23.6	4	.05	1.6	1	<0.05	0.0

Source: *Pellet Handbook,* table 9.7, page 314.

Fuel supply includes transport emissions to get the fuel to the furnace.

Auxiliary energy supply is typically electricity, used to operate the pumps, fans and other equipment involved with furnace operation.

Thermal utilization is the actual emissions from burning the fuel.

Life Cycle Emissions Data

Table 14. Pelletization and combustion in pellet stove life cycle emissions estimates. System, displaced and net emissions are presented. Data presented assume the chip-then-transport woody biomass preprocessing approach, 50 mile transport distance, 100 mile distribution distance and a fixed market demand. Values that are approximately zero (<0.005 or >-0.005) are indicated by ~0.

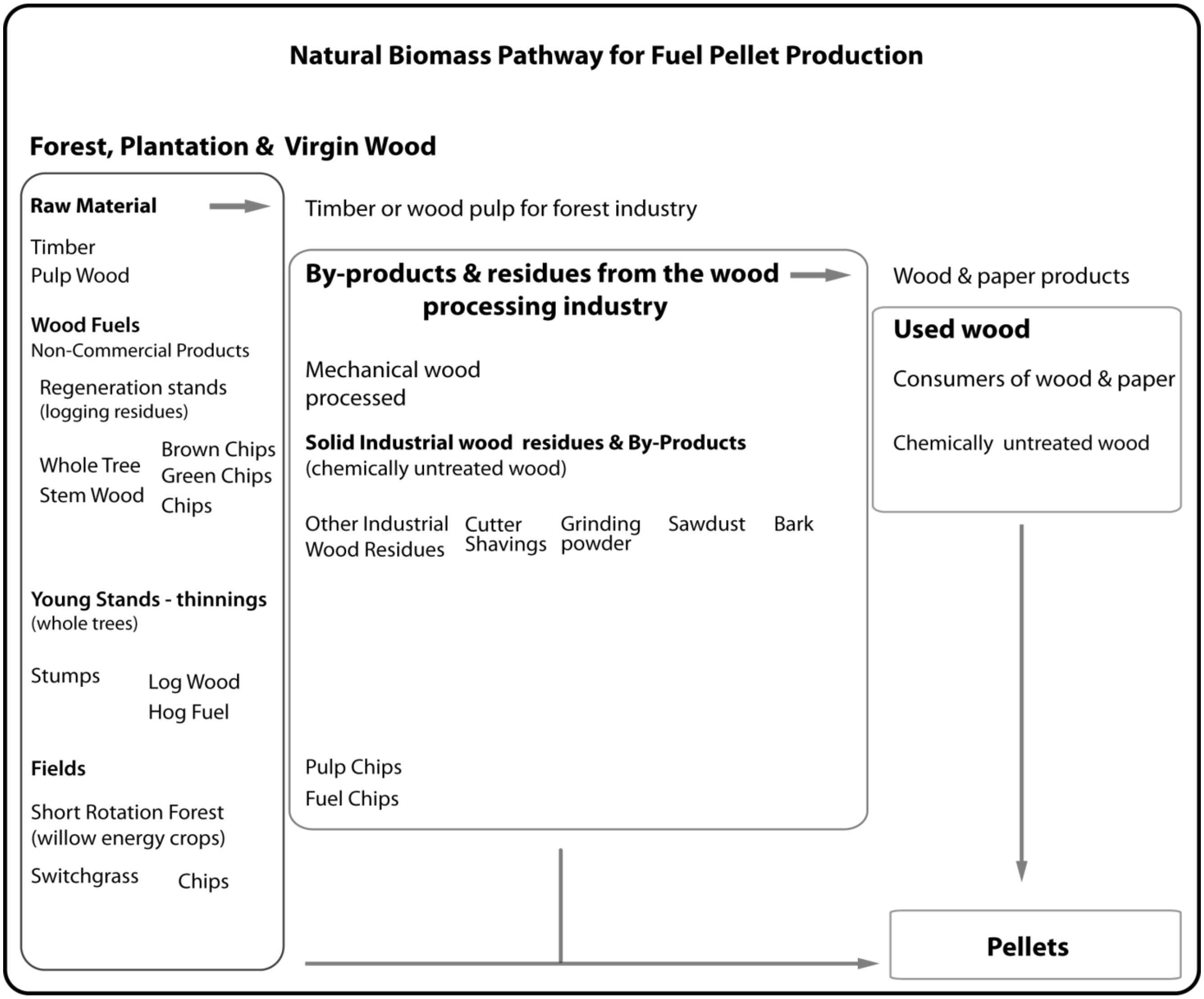
	CO_2	N_2O	CH_4	CO	$PM_{2.5}$
	(t CO_2e/bdt)			(lb/bdt)	
system					
woody biomass preprocessing	0.03	~0	~0	0.29	0.03
pelletization and packaging	0.43	~0	~0	0.83	0.16
distribution (100 mi)	0.01	~0	~0	0.11	0.01
combustion	1.33	0.01	~0	21.16	2.34
system emissions	1.80	0.01	~0	22.39	2.54
displaced: fuel wood					
alternate use: EPA-certified stove	--	--	--	--	--
net emissions	1.80	0.01	~0	22.39	2.54
alternate use: on-site combustion	0.01	0.04	-0.13	-18.32	-6.11
net emissions	1.81	0.05	-0.13	4.07	-3.57
alternate use: on-site decomposition	-0.12	-0.01	-0.16	-75.05	-12.24
net emissions	1.68	~0	-0.15	-52.66	-9.70
displaced: fossil fuel heat					
avoided: natural gas (in furnace)	-0.76	~0	-0.01	-0.63	-0.09
net emissions	1.04	0.01	-0.01	21.75	2.45
avoided: fuel oil (in furnace)	-1.25	~0	-0.01	-0.81	-0.06
net emissions	0.55	0.01	-0.01	21.58	2.48
avoided: electric heat	-1.02	-0.01	~0	-0.34	-0.16
net emissions	0.78	~0	~0	22.05	2.38

If transport-then-chip preprocessing approach were used, the woody biomass preprocessing emissions would be: CO_2 - 0.04 t CO_2e/bdt, N_2O - 0.00 t CO_2e/bdt, CH_4 - 0.00 t CO_2e/bdt, CO 0.29 lb/bdt and $PM_{2.5}$ 0.03 lb/bdt.

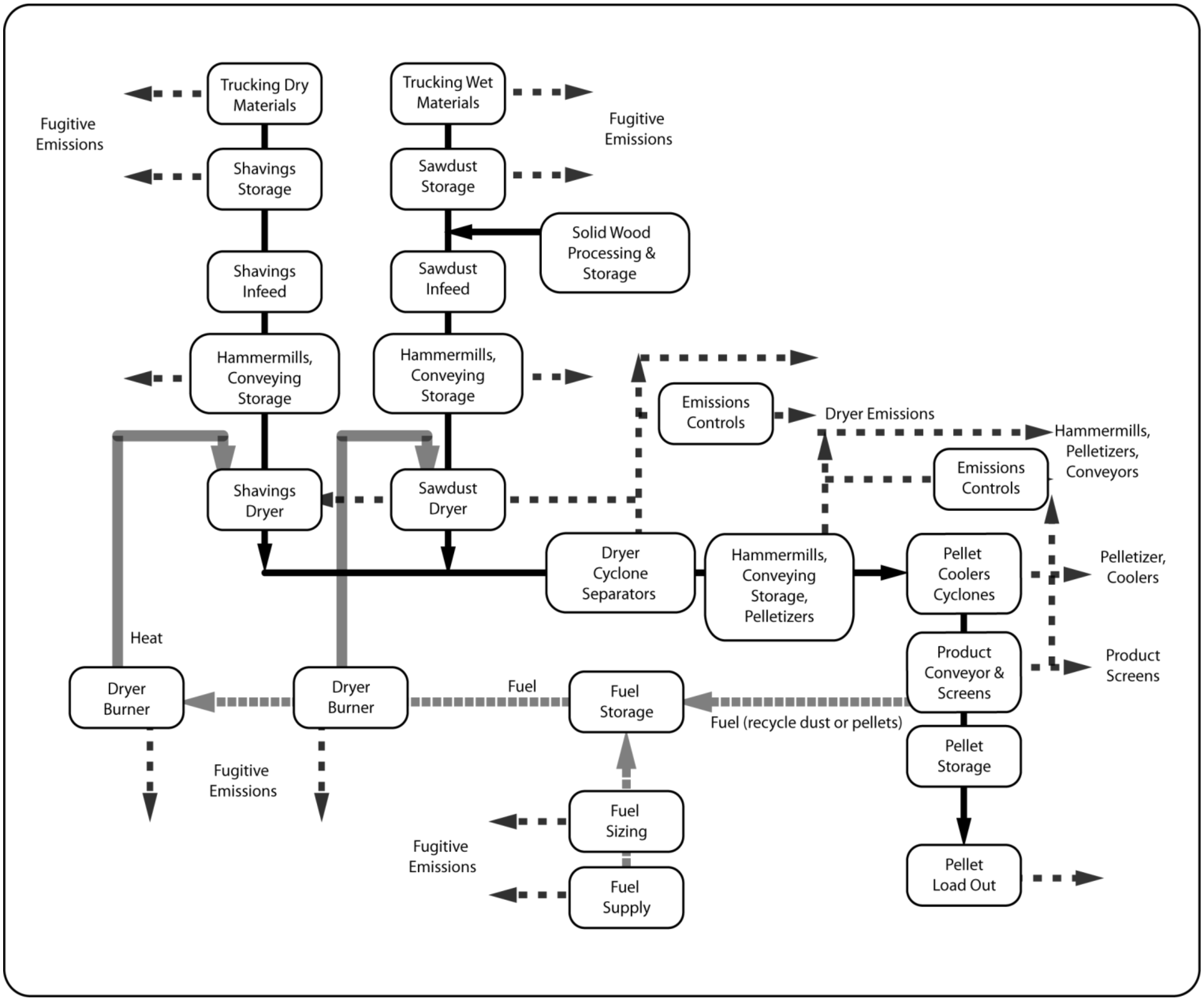
Bdt = bone-dry tons of timber

Emission factor data assumptions and considerations

This analysis assumes that pellets produced are not packaged and instead are distributed in bulk. Distribution is assumed to be via heavy duty trucks. It is assumed that 10% of residues gathered do not meet the quality requirements for pellet production and are diverted to combustion in an industrial hog fuel boiler.



The diagram above describes the pathway for fuel pellet production. Along each pathway energy is used and emissions are created.



Emissions sources during pellet production

Drying comprises the majority of energy used in the production of pellets from wood shavings. According to the sub-study incorporated into the *Pellet Handbook*, the total specific energy consumption of pellet production is 1.315 kWh/t (w.b.)p (there of around 114 kWhel/t (w.b.)p and 1,200 kWhth/t (w.b.)p). Thermal energy needed for drying constitutes 93% of the energy consumption (cf. Figure 7.4). The other 7% are the electricity demands of grinding, pelletization, cooling and peripheral equipment, whereby pelletization makes up the greatest amount with 3.9% of the total.

Explanations: total energy consumption of pellet production of 1,315 kWh/t (w.b.)p;calculation of the specific energy consumption. general framework conditions: around 8,000 annual full operating hours (continuous operation); annual production of around 40,000 t (w.b.)p; electric power output 670 kW, specific heat demand for drying 1,200 kWh/t of evaporated water; drying from M55 to M10"

Energy Balance

Energy balance for pellets can be broken down into three sections:

- Harvesting of forest byproduct feedstock, including transportation to the sawmill,
- Production of the pellets, and
- Transportation to consumer.

Tree harvesting includes all the processed of gathering of wood residues and transportation to the sawmill for processing. The energy required for this task is estimated to be .385GJ to harvest and collect wood logs, transport them over an average distance of 70 miles and then converted into 1 ton of sawdust. [18]

Total energy consumed for the production of sawdust in saw mills	
Type of energy	MJ tonne^{-1} wood pellets
Electricity	140.3
Natural gas	86.15
Heavy fuel oil	9.680
Middle distillates	14.46
Propane	.2967
Steam	2.32
Wood waste	131.4
Total	385.0

Table from [18]

The energy consumed to transport 1 ton raw materials by truck for an average distance of about 17 miles is around 0.044 GJ. For every ton of wood pellets to be produced 1.56 ton of raw material are needed. Therefore, 0.07 GJ of energy is used for the truck transportation. [18]

Total energy used for biomass densification		
Energy	Wet Sawdust (MJ tonne^{-1} pellet)	Natural Gas (MJ tonne^{-1} pellet)
Electricity	404	404
Fuel	3168	2364
Diesel .05	206	206
Total	3778	2974

It is seen that the energy used to produce 1 ton wood pellets is around 3.8 GJ using wet sawdust as the fuel for drying, and around 3 GJ when natural gas is used for drying. [18]

Summary of emission factors for each process in gtonne-1 wood pellets						
Energy & Pollutant	Harvest	Truck 17 miles	Production		Train 485 miles	Ocean Vessel (BC to Europe) 9,626 miles
			Sawdust as Fuel	Natural Gas as fuel		
Energy Consumed	.53	.07	3.78	2.97	.26	2.6
CO2	29,850	4675	27,800	193,000	12,785	206,440
CO	494	26.5	222	239	33.6	420
CH4	24.3	0.39	5.3	924	n.a	23
N2O	2.6	0.062	0.177	3.01	n.a	5
NOx	357.2	54.7	482	514	246	5280
VOC	6.5	3.9	4.84	220	14.05	140
PM	41.1	2.61	14.2	22.6	8.59	430
SOx	35.6	4.34	127	209	10.9	2780
Aldehyde	n.a.	1.73	n.a.	n.a	n.a.	n.a
NH3	n.a.	n.a.	0	3.81	n.a.	6

Only 4.6 GJ (4,359,959 BTUs) of energy (or 25% energy content) is consumed for each ton of wood pellets from harvesting, truck and train transportation and production, if the wood pellets are to be used domestically. [18]

General energy content of wood pellets

2.8 x 5,800,000 14,500, 000 BTU/ ton of wood pellets

(7450 BTU/ lb) x (1lb/.000454 tons) = 16,409,691 BTU/ton

Forest Health

Major portions of the forests of the western U.S. and Canada have become very unhealthy. Forests have become overgrown, weakened and subject to being killed by pine bark beetles and the western spruce bud worm. Phrases like “red zones” (large swathes of standing dead trees with the needles turned red) have entered our vocabulary. The risk of catastrophic forest fires is greatly increased. In Washington, legislation has been passed (Revised Code of Washington 76.06) to address forest health issues. The Commissioner of Public Lands has issued forest health hazard warnings for areas of the counties of Yakima, Klickitat, Okanogan, and Ferry. The state of Oregon in response to the deepening crisis has developed in cooperation with the U.S. Forest Service and others a statewide Forest Restoration Economic Assessment. A core shift is needed in how we manage our forests. We need to manage them by policy objects and not by constraints only. What has occurred over the last several decades is not working.

In this context, finding new economic uses of forest materials (sustainably managed) provides an economic base for helping to restore forests to health. Region 6 of the U.S. Forest service has estimated that providing an economic base for selling overgrown merchantable logs increased the acreage covered by forest health treatments within available funds by 6-7 fold (presentation at re-opening ribbon cutting ceremony of Springdale Lumber in Stevens County).

Adding additional economic value through pellet mills/biorefineries will extend the acreage covered by forest health treatments. Maximizing economic value from dead and dying forests can be a significant help in forest health restoration. A textbook example of the value of forest health treatments occurred near Sisters, Oregon (Deschutes National Forest) in the summer of 2012. This area had significant forest health treatment work done is some areas of the national forest. A wildfire occurred in untreated forest land and burned to the edge of the treated forest land and stopped.

Forest Sustainability

DNR provides key leadership regarding forest biomass uses for renewable energy.[15] From the beginning, this effort has insisted on sustainable management of our forest for biomass resources. Two key steps have been taken:

1) A major review was conducted of the state’s forest practices rules with a focus on including forest biomass with the framework of the rules. A major stakeholder review (The Forest Practices Biomass Work Group)[16] developed a set of recommendations that were submitted to Forest Practices Board in August 2012.
2) A second major effort has been led by the DNR in cooperation with the University of Washington and TSS Consultants to develop a very detailed sustainable forest biomass supply

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[15] http://www.dnr.wa.gov/ResearchScience/Topics/OtherConservationInformation/Pages/em_biomass.aspx

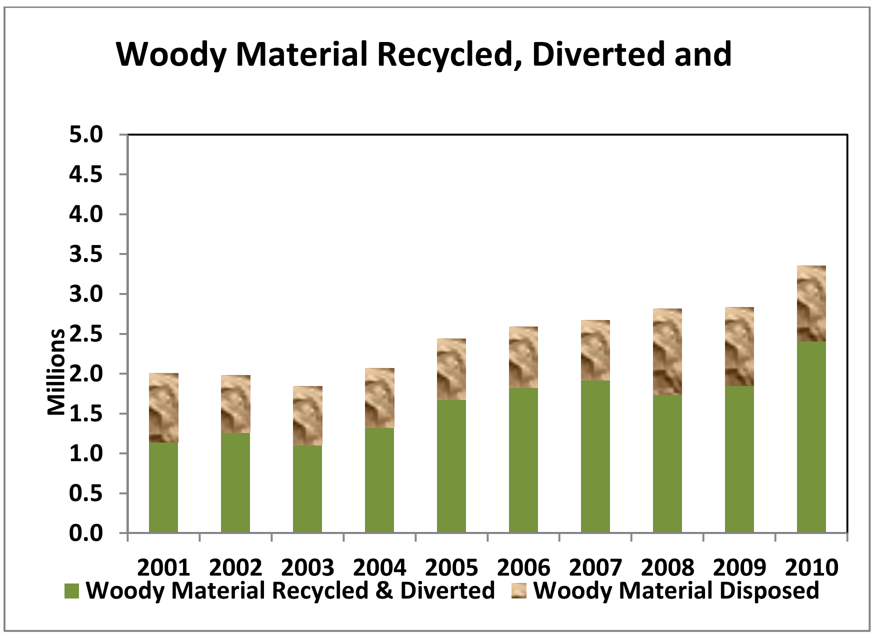
[16] http://www.dnr.wa.gov/ResearchScience/Topics/OtherConservationInformation/Pages/em_forest_practices_workgroup_resources.aspx

assessment.[17] The final report was issued in March 2012 and is titled *Washington Forest Biomass Supply Assessment*.[18] This report is "near investment grade" in its quality and as such is far superior to any other forest biomass supply study depicting the state of Washington. This study comes with a forest biomass supply calculator[19] that provides a deep window into the data.

Within this context, DNR is proceeding to develop and issue biomass supply contracts for sale of biomass materials.

Urban Biomass

A second major source of wood fiber for pellets is urban wood waste including clean construction and demolition debris (no lead paint or metals). Recycling of organic materials is a long standing policy goal of Washington. . The Department of Ecology tracks solid waste data in its annual *Solid Waste Status Report*.[20] The following two graphs from these reports highlight the urban wood waste opportunity:

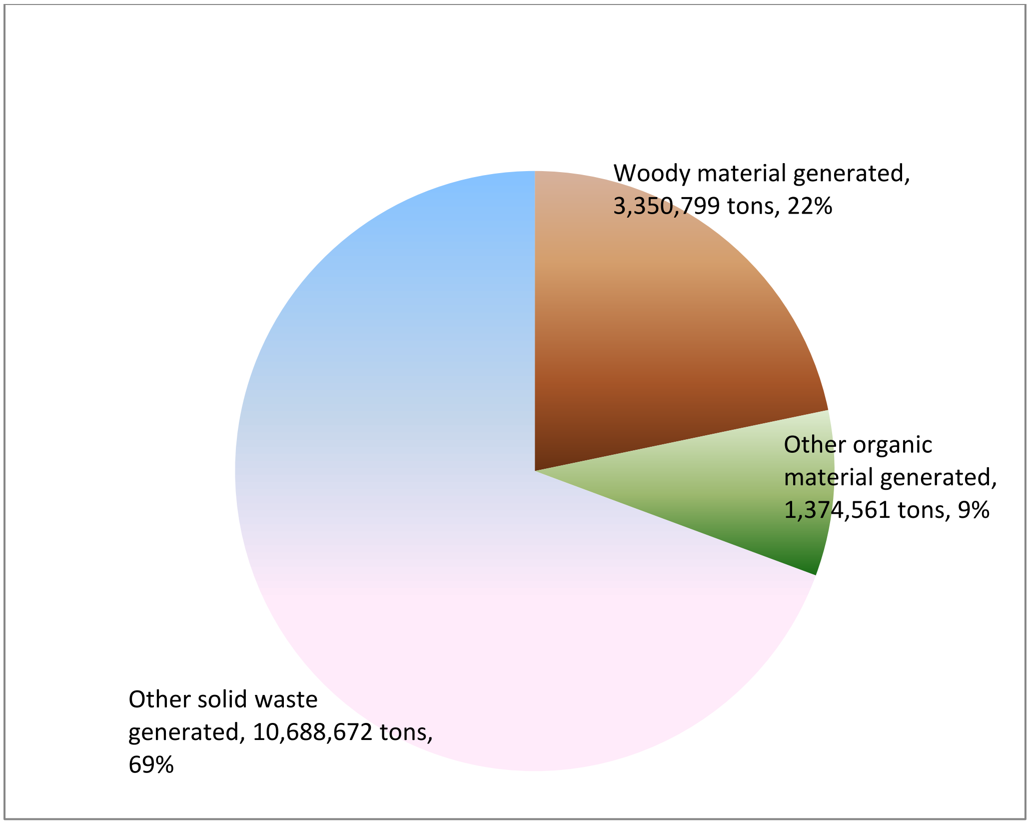


17 http://www.dnr.wa.gov/ResearchScience/Topics/OtherConservationInformation/Pages/em_forest_biomass_assessment.aspx

18 http://www.dnr.wa.gov/Publications/em_finalreport_wash_forest_biomass_supply_assess.pdf

19 http://www.dnr.wa.gov/ResearchScience/Topics/OtherConservationInformation/Pages/em_forest_biomass_supply_study.aspx

20 http://www.ecy.wa.gov/programs/swfa/solidwastedata/report.asp


Woody material generated, 3,350,799 tons, 22%
Other organic material generated, 1,374,561 tons, 9%
Other solid waste generated, 10,688,672 tons, 69%

Economics – Supply & Demand

Feedstock Transportation Costs

It is a common understanding that all biomass is local. Transportation costs for feedstock materials can significantly reduce the profit margin for using biomass materials. A standard rule of thumb is a maximum of 50 miles for hauling forest biomass materials. Equipment for rapidly pulling logging slash out of the woods can improve both access to forest biomass and the speed of removal. For example, Hermann Brothers Logging & Construction of Port Angeles uses chip trucks with a log truck frame and rear wheel steering via a joystick from the cab. In addition, they use a grinder with knives (not knuckles) to slice the wood chips for faster loading and higher quality chips. Both British Columbia and Idaho have higher weight limits on their roads significantly improving efficiencies feedstock hauling of materials. At the national level, federal legislation has been proposed to allow trucks with an extra axle to haul heavier loads of agricultural and forest products. Truck length is not increased with this proposal.

Pellet Mill Economics

All fuels are impacted by price volatility and wood based pellet fuels are not immune to this. The price of the feedstock for pellets impacts downstream the price of pellets to the manufacturer and on to the consumer. Several winters ago in Europe, the price of pellets almost doubled from the prior heating season. The timing of this was in conjunction with an increase in residential pellet stove users. The result was disastrous to producers and consumers alike, but shed light on how to make pellets a reliable fuel source both in cost and in performance. All pellet fuel manufacturers were made aware of the need to secure their supply of feedstock for years in advance, and creating a supply structure that the end consumer would then grow to trust. It became clear that if pellets were to compete with electricity and coal, they must perform with the same marks.

Costs Associated with Setting Up a Pellet Mill

The basic cost for setting up a pellet mill, as verified by actual examples detailed in the *Pellet Handbook*,[21] are:

- Raw material: 43 percent
- Drying equipment: 35 percent
- Pelletization equipment: 7 percent
- Personnel: 6 percent
- Storage facilities: 3 percent
- Peripheral equipment: 2.5 percent
- Grinding equipment: 2 percent
- General investments: 1 percent
- Cooling equipment: 0.5 percent

[21] Cite specific pages in the *Pellet Handbook*

When the availability of free sawdust from a forest products mill is considered, this cost array changes dramatically, with drying equipment consuming 93 percent of the set-up costs.

Estimated total pellet production costs for a plant that produces 40,000 tons per year are $177.49/ton. The biggest costs – at least 80 percent – are associated with the price of the feedstock and drying.

This analysis highlights the importance of the feedstock price. In the Northwest, timber affected by pine beetle kill is an excellent candidate for providing a constant near-term supply of feedstock and residual sawdust from mills around the state.

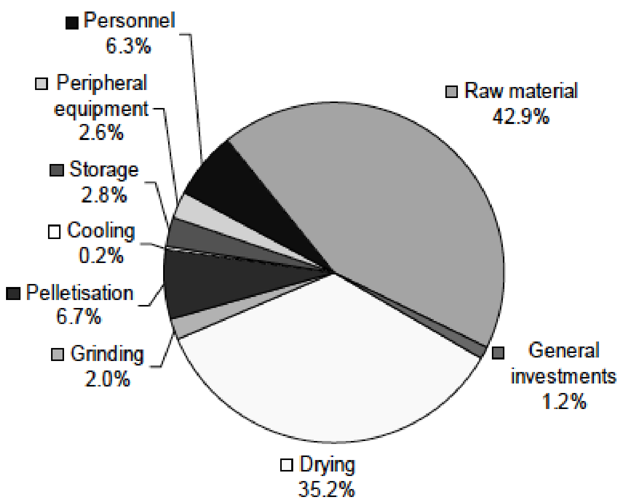


Figure 7.2: Pellet production costs and their composition according to the different cost factors when sawdust is used as raw material

Explanations: total specific pellet production costs of 136.6 €/t (w.b.)p; calculation of the specific production costs of process steps and cost factors as per Sections 7.2.1 to 7.2.9; general framework conditions: around 8,000 annual full operating hours (continuous operation); annual production of around 40.000 t (w.b.)p/a

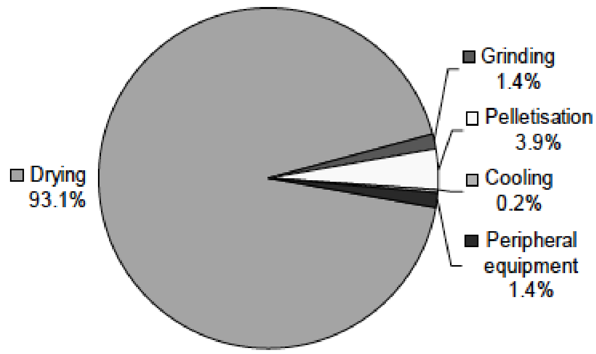


Figure 7.4: Energy consumption of pellet production when sawdust is used as raw material

Explanations: total energy consumption of pellet production of 1,315 kWh/t $(w.b.)_p$; calculation of the specific energy consumption of process steps and cost factors as per Sections 7.2.1 to 7.2.9; general framework conditions: around 8,000 annual full operating hours (continuous operation); annual production of around 40,000 t $(w.b.)_p$; electric power output 670 kW, specific heat demand for drying 1,200 kWh/t of evaporated water; drying from M55 to M10

The capital costs for a new pellet mill should include the categories planning, infrastructure construction, and a miscellaneous category. Every mill site will have its own unique requirements for completion and the numbers below for capital cost offered are for a general information and do not replace a pro forma assessment for each mill.

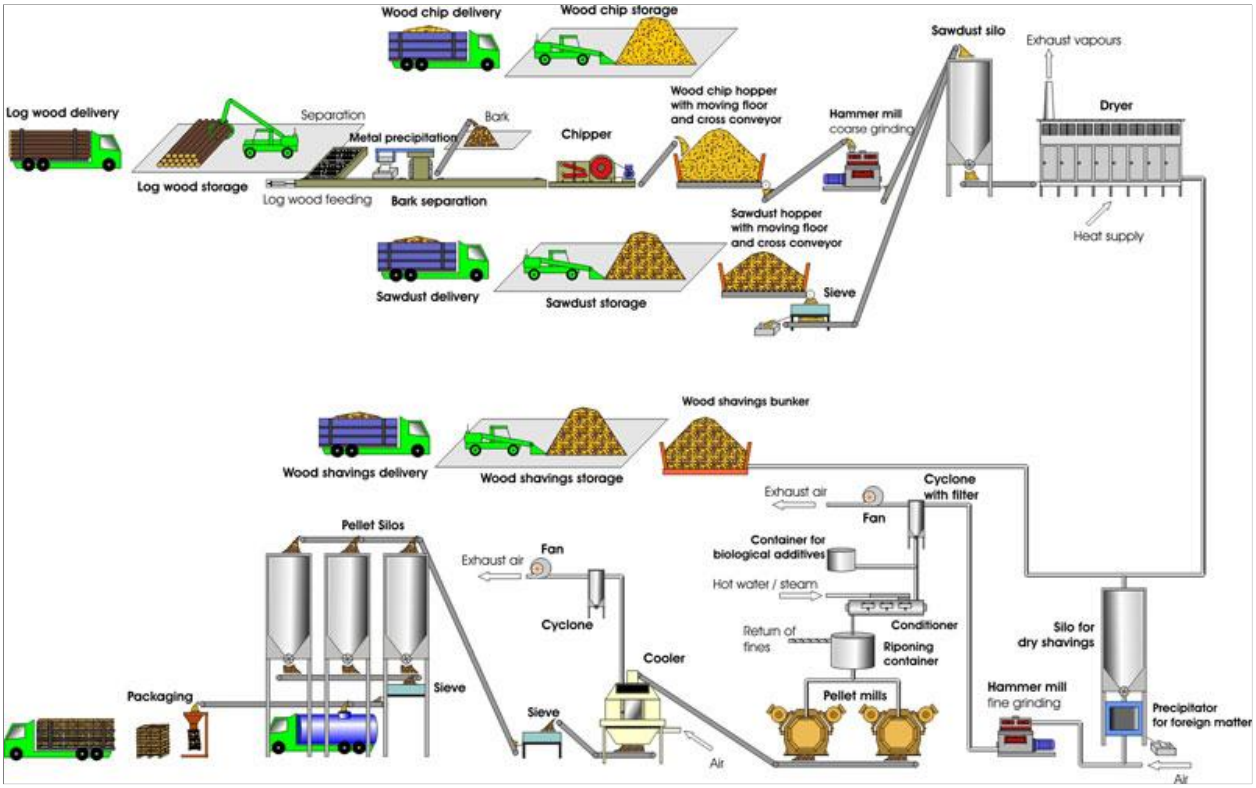
Capital Costs of a 40,000-ton-per-year Pellet Mill (rounded)	
Dryer	$130,000
Hammer mill	$ 30,000
Pellet machine	$65,000
Cooler	$5,000
Storage conveyors, separators	$115,000
Peripheral equipment	$60,000
Buildings	$900,000
Total:	$ 1,350,000

Equipment

The basic equipment for a pellet mill in order of use includes:

1. A feedstock grinder or mill brings the feedstock particle size down to no more than 3mm;
2. A drying oven with a cyclone separator - All sawdust comes with moisture that must be removed, the drying oven reduces the moisture to levels which allow further processing without clogging the downstream hoppers;
3. An in-feed hopper collects the materials for loading to a screw auger;
4. The screw auger moves the materials to the die extruder;
5. The die extruder heats and compresses the materials to the form of pellets;
6. A pellet dryer reduces most moisture for preparation of packaging; and
7. Bagging device collects the final product into appropriate portions for the consumer.

The following schematic provides a visual perspective of a pellet mill.



Source: BIOS Bioenenergiesysteme GmbH, http://www.bios-bioenergy.at/en/pellets/pellet-production-plants.html

Supporting the Pellet Mill Industry

Despite the cautions mentioned above, investors in Washington are finding many promising opportunities in the densified biomass/pellet mill industry. The pellet mill industry has an opportunity to increase demand for its products, provide a clean energy alternative to industries and homes in rural areas of our state, and convert wood waste into a valuable commodity while reducing landfill impacts. Like other emerging bioenergy industries, it needs on-going technical and programmatic support to achieve these goals.

The next step is to guide the pellet mill industry as it works to develop market demand.

Wood pellets, packaged for market, Olympus Pellet Mill in Shelton, Washington

Washington Tax Incentives

Further exploration and follow-up analysis is needed to explore the opportunity to use New Market Tax Credits and Industrial Revenue Bonds administered by the Washington Economic Development Finance Authority.

Washington has three tax incentives that support development of the pellet mill industry:

- A reduction of the business and occupation tax rate to 0.138 percent on gross revenues from manufacture of wood biomass fuel [RCW 82.04.260(1)(F)]. This tax rate compares of a manufacturing rate of 0.484 percent (RCW 82.04.240). No expiration date.
- A six-year property and leasehold tax exemption on buildings, equipment and property used to manufacture wood biomass fuel [RCW 84.36.640 and 82.29A.135]. This tax exemption is scheduled for expedited Tax Preference Performance Review in 2013 by the Joint Legislative Audit and Review Committee. The deadline for applications for this tax incentive is December 31, 2015.
- While Washington taxes logging slash coming from the forests as a forest product (“stumpage value”), it also provides a business and occupation tax credit for forest-derived biomass sold or used to produce electricity, steam, heat or biofuel. The credit is $3.00 per green ton through June 30, 2013 and $5.00 per green ton though June 30, 2015.

Federal Tax Incentives

There are no residential or commercial federal tax incentives for converting to wood pellet heat from fuel oil, residual oil or propane .[22] The residential energy credit for this conversion expired in 2011.

[22] http://www.irs.gov/uac/Energy-Incentives-for-Individuals-in-the-American-Recovery-and-Reinvestment-Act

The federal business development programs under the U.S. Department of Agriculture Rural Development Agency are a source of federal incentive funding. For developing a new pellet mill, possibilities to explore include:

- **Industrial Revenue Bonds –** These are the equivalent of tax-free municipal bonds that do not loan the full faith and credit of the state. They function under federal tax law and are administered by the Washington Economic Development Finance Authority. Montana is pursuing this tax pathway for a pellet mill (export market).
- **New Market Tax Credits**[23]

Carbon Credits

Carbon credit markets continue to emerge and develop, presenting promising opportunities to support the development of the pellet mill industry. Financial incentives based on carbon emission reductions are continuing to develop. An on-going analysis of this opportunity is needed in conjunction with developments in climate change policy.

- British Columbia established a carbon tax on a revenue-neutral basis. This system does not need a carbon market.
- Oregon established a non-profit organization called The Climate Trust,[24] which directly funds projects around the Northwest that reduce greenhouse gases. The Climate Trust funded the Fuels for Schools program to shift rural schools off of fuel oil to wood waste boilers or pellet boilers. This program has been discontinued as cap and trade markets have emerged.
- The California carbon cap and trade system held its first auction of "tradable carbon allowances" in October 2012. Each allowance – selling for $10.09 – represents the right to emit one ton of carbon. This market is governed by the California Air Resources Board under the Global Warming Solutions Act of 2006 (AB 32). A key current lawsuit hinges on whether buyers are paying a fee to emit or are being taxed.
- Voluntary carbon markets, such as the Climate Action Reserve,[25] also bear watching for market incentives. Rigorous ground rules have been developed in recent years to establish greater market discipline.

State Policies

While Washington state has not yet clearly focused on developing the densified biomass/pellet mill industry, a number of policies are in place that support this stance:

- **Beyond Waste**[26] – Development of new landfills is very difficult and expensive. Alternatives such has recycling, composting organics and developing beneficial uses of materials otherwise

[23] http://www.irs.gov/pub/irs-utl/atgnmtc.pdf
[24] http://www.climatetrust.org/index.html
[25] http://www.climateactionreserve.org/

heading to landfill has been part of state law since 1971 (RCW 70.93). Organics materials management in particular focuses wood recycling.

- **Sustainable forest biomass** – DNR has taken the lead on developing forest biomass policy (RCW 79.150). This legislation was preceded by forest biomass energy demonstration project legislation in 2009. The statewide sustainable forest biomass supply assessment fits in this policy context.
- **Forest health** – Forest health issues are also a policy driver to encourage the development of economic uses for wood biomass. Oregon is the most aggressive state in dealing with this problem. Governor Kitzhaber's 2013-2015 budget includes $4 million in state funds to support forest health restoration work on state forest lands.
- **State energy policy** – For over three decades, Washington state energy policy has principally, but not exclusively, focused on electricity energy policy. RCW 43.21F.010 (3) states in part "to promote energy self-sufficiency through the use of indigenous and renewable energy sources, consistent with the promotion of reliable energy sources, the general welfare, and the protection of environmental quality."
- In addition, RCW 43.21F.088 sets forth principles to guide development and implementation of the state's energy strategy. Subsection (10 (d) states: "Reduce dependence on fossil fuel energy sources through improved efficiency and development of cleaner energy sources, such as bioenergy, low-carbon energy sources, and natural gas, and leveraging the indigenous resources of the state for the production of clean energy." Within this legislative context, densified biomass and use of wood pellets promotes energy self-sufficiency and reduces dependence on fossil fuels. The *2012 State Energy Strategy* established a framework for this report.
- **Climate change** – Greenhouse gases emissions are limited to 1990 levels by 2020, with further reductions in 2035 and 2050 (RCW 70.235.020). In addition, Chapter 163, laws of 2009, states in section 1: "Utilizing forest biomass to generate energy can reduce the greenhouse gases emitted by burning forest biomass." The use of wood pellets to offset petroleum products reduces greenhouse gases. Carbon pricing policy options were developed in the *2012 State Energy Strategy*, Chapter 6.[27]

Several additional state policies and programs would further enhance the development of a densified biomass/pellet mill industry.

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[26] http://www.ecy.wa.gov/beyondwaste/
[27] http://www.commerce.wa.gov/Documents/EO2012WAEnergyStrategy.pdf

Thermal Energy Policy

Building on the *2012 State Energy Strategy*, there has been a growing awareness of the need to develop thermal energy policies. The Cascade Power Group developed the *Clean Energy Roadmap: Washington State*.[28] This work and the thermal energy baseline[29] developed by the WSU Energy Program provide an analytical basis to further develop thermal energy policy with the goal of further reducing our dependence on petroleum products for key thermal energy needs.

A number of state and local facilities use petroleum products (principally fuel oil) to provide heat and/or steam. Shifting from these sources to wood pellet systems will not only reduce operating budget costs; these facilities will also become anchor tenants for the pellet mill industry. Funding for this shift in fuel use would be provided in the capital budget.

[28] http://www.northwestcleanenergy.org/NwChpDocs/WA%20Clean%20Energy%20Roadmap%202012.pdf

[29] The WSU Energy Program compiled a thermal energy baseline of all boilers in the state permitted by the regional clean air agencies and the Department of Ecology Industrial Section.

Looking Ahead

This densified biomass study by the WSU Energy Program focuses on a sustainable way to meet rural Washington's energy needs. By differentiating between the state's two energy economies – those with and those without pipeline natural gas – this study also examines how to move the wood pellet industry forward.

The current pellet mill industry has an opportunity to increase demand for its products and to mature and grow as an industry. Like other emerging bioenergy industries, it needs on-going technical/ programmatic support to make this happen. Much of the policy work has been done. Helping to develop market demand is a key next step. Considerable work still needs to be done to build on the assessment and recommendations given here. The WSU Energy Program looks forward to continuing this effort.

Looking ahead, it could be useful to note the following insights gleaned by the WSU Energy Program team about preparing useful feasibility studies for the wood pellet industry and lessons learned.

Feasibility Studies

In recent years, a number of biomass/bioenergy feasibility studies and business plans have been developed in the Northwest and around the U.S. They have been of varying quality. Strong due diligence is essential to proceed with this type of project. Any useful feasibility study of developing biomass facilities in Washington state must address these points:

- **Is the biomass available?** An investment-grade feedstock supply study is crucial. Not all densified biomass plants are co-located with a forest products mill that is producing available wood waste.
- **How much will it cost to deliver the feedstock?** Mature analysis is needed of the cost to deliver the feedstock supply, which is a key price driver.
- **What is the emerging potential to compete for the feedstock?**
- **Could the bid specification create a monopoly seller of the necessary equipment?**
- **Does the team possess quality engineering expertise with specific experience in project development of densified biomass facilities?** General engineering expertise is insufficient.
- **If supply and demand costs shift, how viable is the project?** Economic supply and demand sensitivity analysis is key.[30]

[30] For a free download of a very strong financial analysis tool, see http://www.northwestcleanenergy.org/ResourcesSoftwareLinks/Software.aspx.The pro forma financial statements provided are the Income Statement, Cash Flow Statement, Balance Sheet, and Sources/Uses of Funds Statement for each project year in the 20-year analysis period. Flexible user inputs include capital costs for construction, funding (equity, grants, and loans), operating costs (purchased fuels, labor, materials/expendables, etc.), taxes and fees (depreciation, tax credits, franchise costs, tax rates, etc.), cost escalation factors, income from energy, power and co-product sales, and income from sales of carbon offsets, renewable energy credits and renewable energy production incentives. Use of financial ratios and other financial performance indicators enable the RELCOST user to evaluate project financial outcomes under various model scenarios.

- **Has a biorefinery approach been considered with multiple revenue streams coming from one facility?**

An outline of a strong feasibility study is included as Appendix B.

Lessons Learned

There are a number of hard lessons to be learned in developing a densified biomass/pellet mill industry in Washington. Many of them have been scattered through this document. They are summarized here as follows:

1. **It is not productive to think: "Build it and they will come"** – A far better approach is to build demand first with larger anchor tenants that can offset their use of fuel oil or residual oil/waste oil. As that demand builds a base is then available for sizing the pellet mill. The Sealaska approach to build demand first and then add the supply is highlighted.
2. **Export costs are not all equal** – While Washington is significantly closer to the Asian market than the southeastern U.S., entering this market will be a challenge. Significant upfront capital investment would be needed.
3. **Competing with existing and future uses of biomass** – It is very important to trace current uses of feedstock supply within the wood shed territory including availability by volume, price and who else is buying the feedstock. Full due diligence is required and, if possible, long term contracts will help. U.S. Forest Service stewardship contracts take time to develop, but can be very helpful to undergird pellet mill projects.
4. **Wood pellet supply competition** – Current prices for wood pellets can shift as new wood pellet supply come to market. This occurred in Fairbanks, AK when Superior Pellet Fuels first came to market. Citywide wood pellet prices fell about $100/ton.
5. **Debt is dangerous** – It almost goes without saying, under-capitalized and highly leveraged facility financing is perilous due to financial shifts that can occur. Lower debt requirements translate directly into lower operating cost and improved profit margins.
6. **Proper engineering expertise** – It is essential to have an engineer/engineering firm with expertise in designing/building a pellet mill system to be directly involved in project design and development.
7. **Biorefineries: Maximize revenue by maximizing products** – Pellet mills can be adjuncts to other forest products mills/pulp and paper mills. Both Manke lumber in Tacoma and Ochoco Lumber in John Day, OR have this business model. They are using their own feedstock supply (clean sawdust). From a larger picture, biorefineries are beginning to emerge in the Northwest. For example, a biorefinery is co-locating with Stoltze Lumber in Columbia Falls, Montana.
8. **State policies** – Having a good understanding of the history and development of bioenergy, biomass, forest sustainability, and economic development policies in the state can be very helpful as a project moves forward. How supportive is state policy toward densified biomass and the wood pellet industry?

9. **Environmental concerns** – Last on this list, but crucially important is a solid understanding the potential environment al concerns that can arise. This report deliberately spends a considerable number of pages on the environmental aspects of the report. There are multiple perspectives from multiple environmental directions regarding forest biomass and their uses. Do not overlook this aspect of project development.

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Meetings and Events

ANSI Biofuels Standards Panel: http://publicaa.ansi.org/sites/apdl/Documents/Forms/AllItems.aspx?RootFolder=%2fsites%2fapdl%2fDocuments%2fMeetings%20and%20Events%2fANSI%20Biofuels%20Standards%20Panel&View={21C60355-AB17-4CD7-A090-BABEEC5D7C60}.

Appendix A – U.S. and European Pellet Standards

U.S. Pellet Standards Developed by the Pellet Fuels Institute

	Residential/Commercial Densified Fuel Standards See Notes 1 - 3		
Fuel Property	PFI Premium	PFI Standard	PFI Utility
Normative Information - Mandatory			
Bulk Density, lb./cubic foot	40.0 - 46.0	38.0 - 46.0	38.0 - 46.0
Diameter, inches	0.230 - 0.285	0.230 - 0.285	0.230 - 0.285
Diameter, mm	5.84 - 7.25	5.84 - 7.25	5.84 - 7.25
Pellet Durability Index	≥ 96.5	≥ 95.0	≥ 95.0
Fines, % (at the mill gate)	≤ 0.50	≤ 1.0	≤ 1.0
Inorganic Ash, %	≤ 1.0	≤ 2.0	≤ 6.0
Length, % greater than 1.50 inches	≤ 1.0	≤ 1.0	≤ 1.0
Moisture, %	≤ 8.0	≤ 10.0	≤ 10.0
Chloride, ppm	≤ 300	≤ 300	≤ 300
Heating Value	NA	NA	NA
Informative Only - Not Mandatory			
Ash Fusion	NA	NA	NA

European Pellet Standards

Annex 2: Specification of Wood Pellets for Non-Industrial Use According to EN 14961-2

Property class /Analysis method	Unit	A1	A2	B
Origin and source EN 14961-1		1.1.3 Stemwood 1.2.1 Chemically untreated wood residues	1.1.1 Whole trees without roots 1.1.3 Stemwood 1.1.4 Logging residues 1.1.6 Bark 1.2.1 Chemically untreated wood residues	1.1 Forest, plantation and other virgin wood 1.2 By-products and residues from wood processing industry 1.3 Used wood
Diameter, D [a] and Length L [b], prEN16127	mm	D06, 6 ± 1; 3,15 ≤ L ≤ 40 D08, 8 ± 1 3,15 ≤ L ≤ 40	D06, 6 ± 1; 3,15 ≤ L ≤ 40 D08, 8 ± 1; 3,15 ≤ L ≤ 40	D06 6 ± 1; 3,15 ≤ L ≤ 40 D08 8 ± 1; 3,15 ≤ L ≤ 40
Moisture, M, EN 14774-1, EN 14774-2	as received, w-% wet basis	M10 ≤ 10	M10 ≤ 10	M10 ≤ 10
Ash, A, EN14775	w-% dry	A0.7 ≤ 0,7	A1.5 ≤ 1,5	A3.0 ≤ 3,0
Mechanical durability, DU, EN 15210-1	as received, w-%	DU97.5 ≥ 97,5	DU97.5 ≥ 97,5	DU96.5 ≥ 96,5
Fines at factory gate in bulk transport (at the time of loading) and in small (up to 20 kg) and large sacks (at time of packing or when delivering to end-user), F, prEN 15210-1	w-% as received	F1.0 ≤ 1,0	F1.0 ≤ 1,0	F1.0 ≤ 1,0
Additives [c]	w-% dry	≤ 2 w-% Type and amount to be stated	≤ 2 w-% Type and amount to be stated	≤ 2 w-% Type and amount to be stated
Net calorific value, Q, EN 14918	as received, MJ/kg or kWh/kg	Q16.5, 16,5≤Q≤19 or Q4.6, 4,6≤Q≤5,3	Q16.3, 16,3≤Q≤19 or Q4.5, 4,5≤Q≤5,3	Q16.0, 16,0≤Q≤19 or Q4.4, 4,4≤Q≤5,3
Bulk density, BD, EN 15103	kg/m^3	BD600 ≥ 600	BD600 ≥ 600	BD600 ≥ 600
Nitrogen, N, prEN 15104	w-% dry	N0.3 ≤ 0,3	N0.5 ≤ 0,5	N1.0 ≤ 1,0
Sulphur , S, prEN 15289	w-% dry	S0.03 ≤ 0,03	S0.03 ≤ 0,03	S0.04 ≤ 0,04
Chlorine, Cl, prEN 15289	w-% dry	Cl0.02 ≤ 0,02	Cl0.02 ≤ 0,02	Cl0.03 ≤ 0,03
Arsenic, As, prEN 15297	mg/kg dry	≤ 1	≤ 1	≤ 1
Cadmium, Cd, prEN 15297	mg/kg dry	≤ 0,5	≤ 0,5	≤ 0,5
Chromium, Cr, prEN 15297	mg/kg dry	≤ 10	≤ 10	≤ 10
Copper, Cu, prEN 15297	mg/kg dry	≤ 10	≤ 10	≤ 10
Lead, Pb, prEN 15297	mg/kg dry	≤ 10	≤ 10	≤ 10
Mercury, Hg, prEN 15297	mg/kg dry	≤ 0,1	≤ 0,1	≤ 0,1
Nickel, Ni, prEN 15297	mg/kg dry	≤ 10	≤ 10	≤ 10
Zinc, Zn, prEN 15297	mg/kg dry	≤ 100	≤ 100	≤ 100
Informative: Ash melting behavior [d], prEN15370	°C	Should be stated	Should be stated	Should be stated

[a] Actual diameter class (D06, D08) of pellets to be stated.

[b] Amount of pellets longer than 40 mm can be 1 w-%. Maximum length shall be < 45 mm.

[c] Type of additives to aid production, delivery or combustion (e.g., pressing aids, slagging inhibitors or any other additives like starch, corn flour, potato flour, vegetable oil,...). Also additives which are used after production, before unloading to end-user storages, shall be stated similarly (type and amount).

[d] All characteristic temperatures (shrinkage starting temperature (SST), deformation temperature (DT), hemisphere temperature (HT) and flow temperature (FT) in oxidizing conditions should be stated.

ENPlus is a quality label for the European whole pellet supply chain that creates three levels of pellets for different end-user markets. Pellets can only be sold as ENplus when every actor in the supply chain (pellet producer, traders, and retailers) is individually certified. Additionally, ENplus covers not only quality issues but also criteria for sustainability and supply security – which are crucial for the future development of the pellet market.[31]

[31] Pellet Process website

Comparison of U.S and European Pellet Standards

United States Pellet Fuels Institute Standard	European prEN 14961-2
-	Origin and Source
Diameter mm & Length mm	Diameter mm & Length mm
Moisture %*	Moisture %
Mechanical Durability	Mechanical Durability *
Fines % (Mill Gate) *	Fines % (Factory Gate) bulk
-	Additives
-	Net Calorific Value, Q
Inorganic Ash	Ash*
Bulk Density	Bulk Density
-	Nitrogen
-	Sulpher
-	Chlorine
-	Arsenic
-	Cadmium
-	Chromium
-	Copper
-	Lead
-	Mercury
-	Nickle
	Zinc
Ash Fusion	Ash Melting Behavior

The European pellet standards address energy content and heavy metals; the U.S. standards do not.

Appendix B – Feasibility Studies

A quality feasibility study must start with asking the right questions and analyzing the right problems. Listed below are suggested contents for feasibility studies.

Introduction

- What is a densified biomass system?
- Investment-grade feedstock supply and price
- Site location and site qualification (land, water, rail, power, etc.)

Overview: Details and Assumptions

- Detailed facility/mill description
- Plant energy requirements
- Equipment selection, sizing and rationale

Labor-Related Matters and Costs

Facility Inputs and Outputs

- Projected revenue streams
- Densified biomass system costs
- Engineering requirements for project development

Technical Analysis and Feasibility

- Market and economic analysis and feasibility study
- Emissions analysis and permitting requirements
- Management capabilities

Summary and Conclusions

Appendix C – Factsheet:
Ground-Source Variable Refrigerant Flow Heat Pumps

[Will be attached as a PDF.]