Woody Biomass in Humboldt County

Select Alternative Uses

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ENGR 492 Capstone
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Humboldt State University

Proposed Alternatives

Compost Additive

Wood Pellets

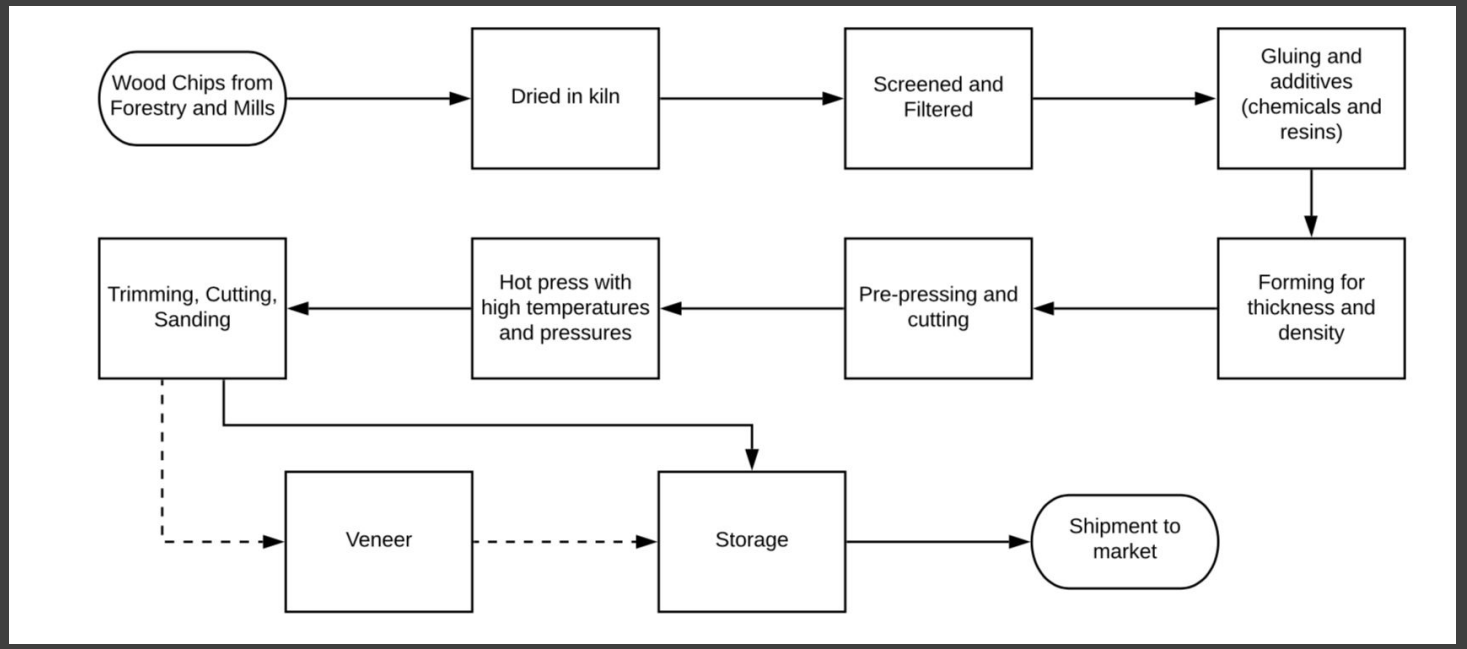
Energy Creation via Gasification

Particleboard

Particleboard Production

- Made from wood chips and sawdust
- Uses resins and chemical adhesives
- Generates emissions like CO, HC, PM, NOx, VOC
- Sold for building and furniture projects (non-structural)
- Uses 100% of available biomass
- 12 year payback period
  - $287.6 million capital cost
- Negative net carbon emissions
  - -525,000 mton CO_2e per year
- Estimated 289 jobs created
- 50 pollutants other than GHGs

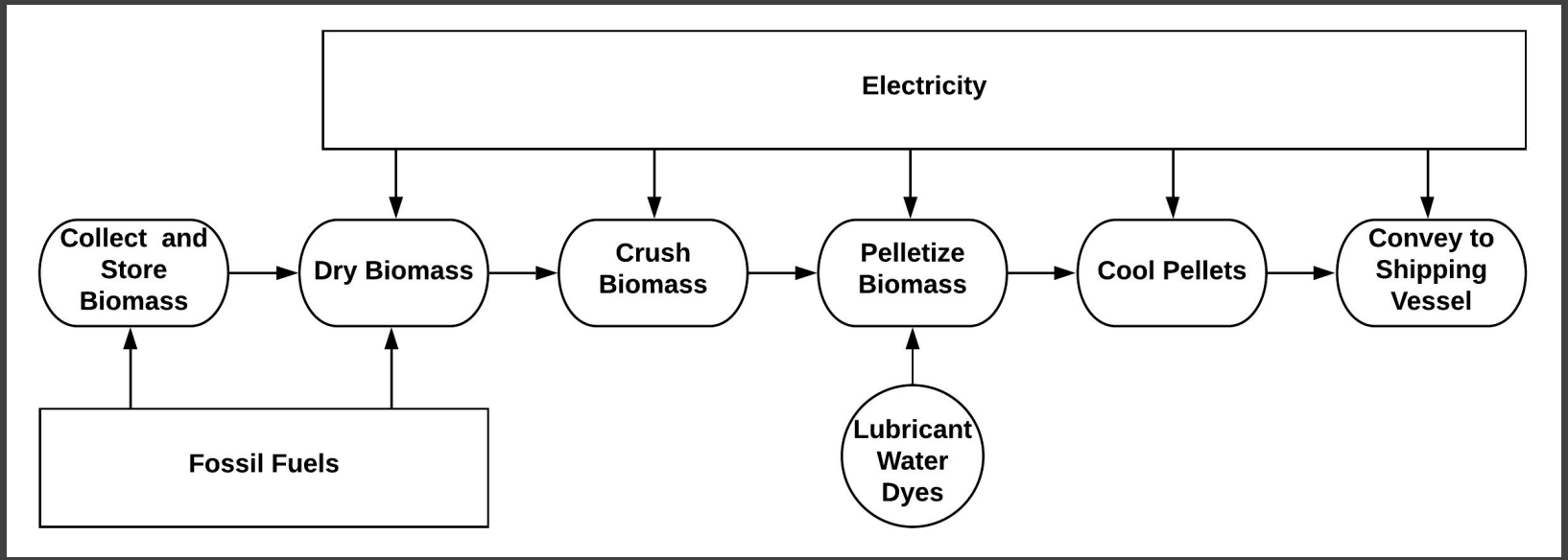
https://www.timberindustrynews.com/siempelkamp-deliver-particleboard-plant-green-river-panels-thailand/



Wood Pellets

- Domestic heating/fuel to create energy
- 100% of biomass use
- 70 ton/hr; 7,000 hr/yr
  - Large, parallel system
- 2.4 year payback period
  - $54.8 million capital cost

https://www.draxbiomass.com/



Gasification

- Process converts raw woody biomass into Substitute Natural Gas (SNG)
- Consumes 58% of available biomass stream
- Produces 30M therms/year supplying local natural gas grid, replacing fossil fuels
- Estimated $320M capital cost, 18 year payback period
- Scale up of Swedish GoBiGas demonstration plant
- Represents first commercial implementation of technology

https://bioenergyinternational.com/research-development/time-start-gobigas-1

https://www.semanticscholar.org/paper/An-Evaluation-of-the-Performance-of-the-GoBiGas-Karlbrink/

Composting Alternative

- Mix of biomass and nitrogen-rich waste streams
  - Manure, Food Waste, Biosolids
- 40 year payback period
  - $3 million capital cost
- Negative net carbon emissions
  - -2.96E6 kg CO2e per year
  - Diversion of cow manure from typical waste stream
- Estimated 17 jobs created

CalRecycle 2020

Constraints

1. All federal, state, and local water and air pollutant standards must be met.
2. A demand for imported biomass or non-waste source of biomass must not be created.

Criteria

Category	Criteria	Description	Quantifiable Indicator	Weight
Economic	Payback Period	The time required to recoup the funds expended in investment in alternative	Years until break-even point	10
Environmental	Environmental Impact	Net GHG emissions	CO2e emissions (kg/year)	7
	Diversion of Wood Waste	How much biomass is utilized and therefore diverted from waste to product	% of wood waste diverted	6
Technical	System Robustness	System technical reliability, reliance on outside sources, ability to use woody biomass and fuel flexibility	% downtime	6
	Operator Skill Required	Ease of use to operate and maintain system	% skilled employees	5
	Maturity and Availability	Commonality of industry use and ease of procurement	Years of reliable industry use and testing	5
Social	Public Health Impact	Quantity and type of pollutants produced which are detrimental to human health	# pollutants other than GHGs	5
	Public Benefit	Added benefit to public and community	Number of jobs created	3

Scoring

- Ranges used to score alternatives
- 10 is the best; 1 is the worst
- Assigned scores were weighted based on client and group weights

		Score				
		1-2	3-4	5-6	7-8	9-10
Criteria	**Unit**	**Poor**	**Less than Average**	**Average**	**Greater than Average**	**Excellent**
Payback Period	Years	>50 yr	25-50	10-25	5-10	<5
Environmental Impact	kg/yr	> 750,000,000	250,000,000 - 750,000,000	0 to -250,000	-250,000 to -1,000,000	< -1,000,000
Diversion of Wood Waste	% of wood waste diverted	0-25%	26-45%	46-65%	66-85%	86-100%
System Robustness	% downtime	>40%	39-21%	20-11%	10-5%	<5%
Operator Skill Required	% skilled employees	>80%	60-79%	40-59%	20-39%	<20%
Maturity and Availability	Years	<5 yr	5-15 yr	16-30 yr	31-50 yr	>50 yr
Public Health Impact	# pollutants other than GHGs	20 +	10-19	5-9	1-4	No extra pollutants
Public Benefit	# Jobs	0-10	10-20	20-50	50-100	100+

Alternative Performances

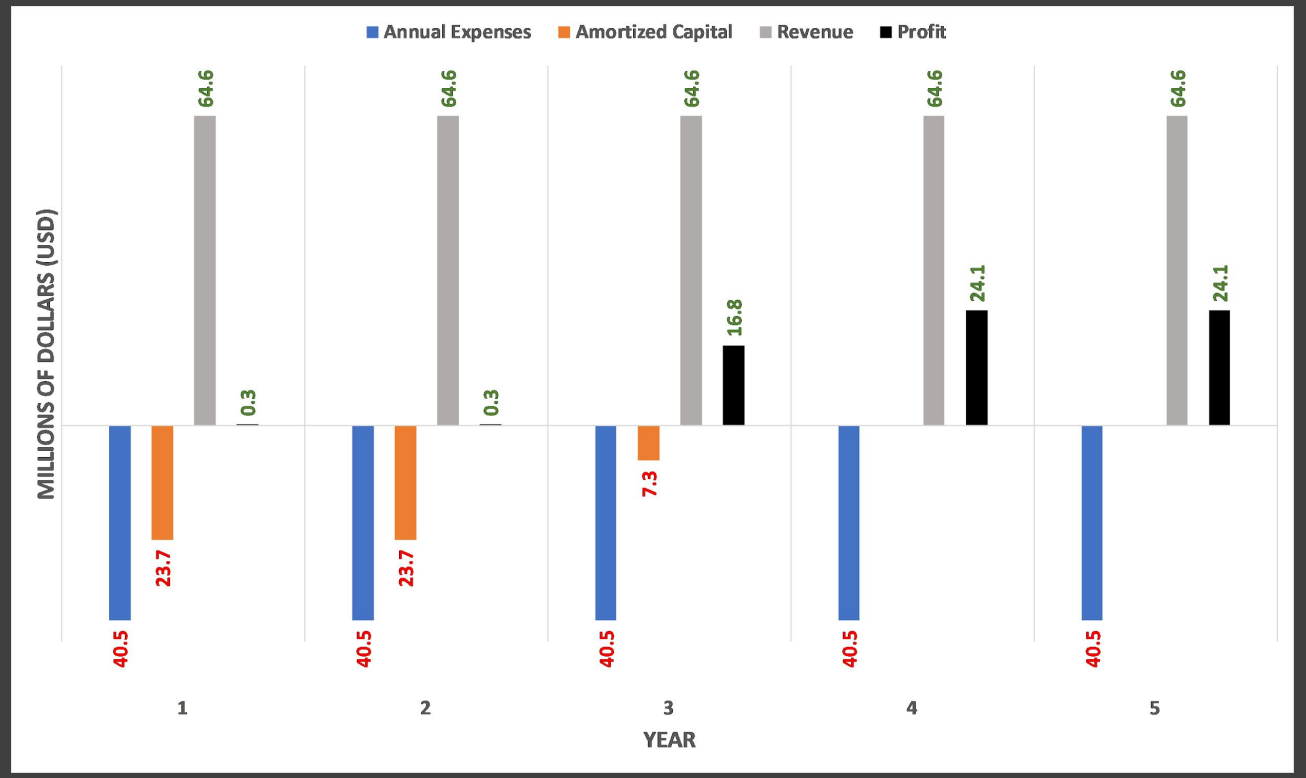
Criteria	Unit	Compost	Particle Board	Pellets	Gasification
Payback Period	Years	40	12	2.4	18
Environmental Impact	kg/yr	-2.96E+06	-5.25E+08	5.56 E+08	0
Diversion of Wood Waste	% of wood waste diverted	3.5	100	100	58
System Robustness	% downtime	10-20	10-20	1.4-4.1	5
Operator Skill Required	% skilled employees	20-30	40	22	1
Maturity and Availability	Years	>100	73	35	3
Public Health Impact	# extra pollutants	2	50	8	0
Public Benefit	# Jobs	17	289	37	15

Decision Matrix

Criteria	Weight	Particleboard Grade	Weighted PB Score	Pellet Grade	Weighted Pellet Score	Compost Grade	Weighted Compost Score	Gasification Grade	Weighted Gasification Grade
Payback Period	10	6	60	**10**	**100**	3	30	7	70
Environmental Impact	7	**10**	**70**	3	21	9	63	5	35
Diversion of Wood Waste	6	**10**	**60**	**10**	**60**	1	6	6	36
System Robustness	6	6	36	**9**	**54**	6	36	5	30
Operator Skill Required	5	5	25	**8**	**40**	**8**	**40**	1	5
Maturity and Availability	5	9	45	8	40	**10**	**50**	3	15
Public Health Impact	5	1	5	5	25	**9**	**45**	**9**	**45**
Public Benefit	3	**10**	**30**	5	15	4	12	4	12
Total Weighted Scores			**331**		**355**		**282**		**248**

Preferred Alternative - Wood Pellets

- 2.4 year payback period
  - $54.8 million capital
- 37 direct full time employees
  - 482 indirect employees
- Cleaner, more efficient vs. firewood
  - Less combustion/emissions
- Non-point source
  - Spread out combustion impacts
- Temporal/seasonal combustion



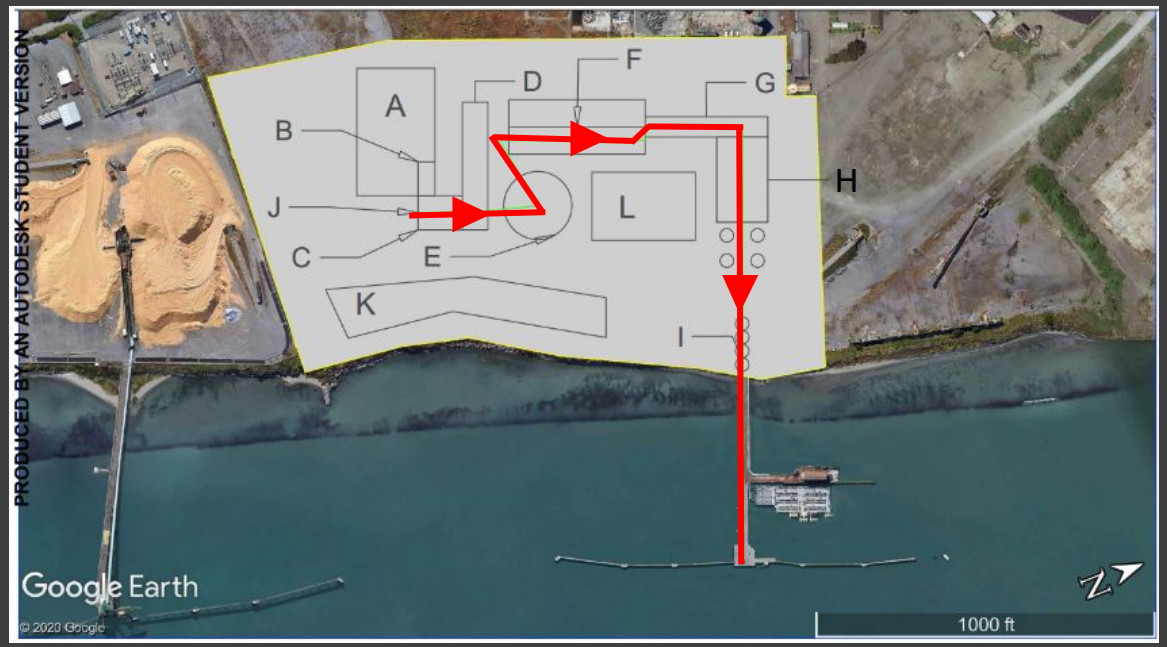
	Criteria Pollutant & GHG Emissions (tons/yr)					
	CO	NO_x	SO_x	PM_{10}	$PM_{2.5}$	CO_2
DG Fairhaven	1,341	158	28	31	29	200,466
Humboldt Sawmill Company	876	175	35	37	33	218,130
Pellet Facility (Manufacturing)	-	176	19	<1	<1	76,954
Combustion of Pellets	7,683	2,691	78	1,896	741	666,130

Preferred Alternative - Prospective Site

- 3 parcels needed to secure coastal shipping
  - 191.8 acres
- Facility uses 42 acres
- Samoa Peninsula
  - Northeast of DG Fairhaven

Preferred Alternative - Facility Design

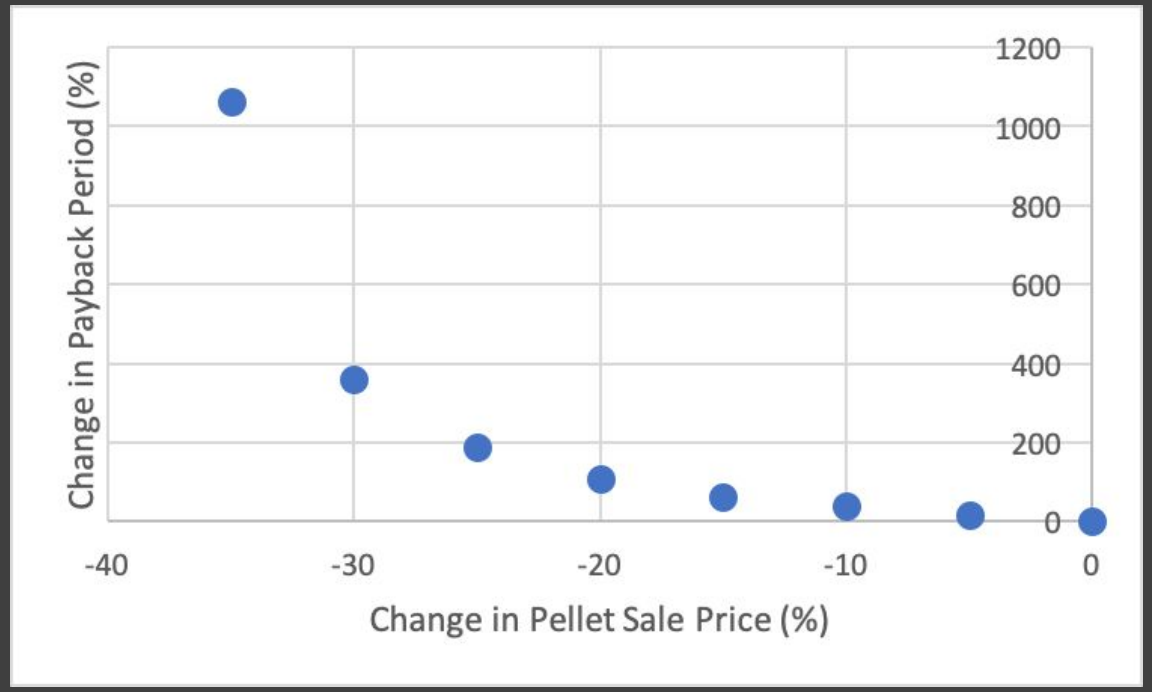
- Recommended facility production line and general layout



Label	Item	Label	Item
A	Truck Staging Bay	**G**	Hammer and Pellet Mills
B	Truck Tipper	**H**	Pellet Coolers and Sifters
C	Biomass Hopper	**I**	Storage Silos
D	Shredder	**J**	Conveyor Runs
E	Stacker-Reclaimer	**K**	Stormwater Basin
F	Dryer	**L**	Extra Shredded Material Storage

Sensitivity Analysis

- Economic inputs analyzed
- Payback period sensitivity
  - Capital cost and pellet sale price
- Doubling capital cost
  - Doubled payback period
- Pellet sale price
  - 35% decrease = 1000% increase in payback period
  - 40% decrease or more = negative yearly revenue



Recommendations and Conclusions


https://images.app.goo.gl/j8beKiL4vNLgjofh7

- Lowest payback period
- Uses all biomass
- Further site inspection/feasibility study
- Pellet sale price/market study
- Inquiries with proposed manufacturers

Thank You!!

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References

- Anyang Gemco Energy Machinery. (2020). "Pellet Mill Report: A Complete Guide for Pellets Industry Beginners and Pellet Mill Buyers." <http://www.biofuelmachines.com/pellet-mill-report-for-pellet-business-starters-and-equipment-buyers.html> (Apr. 4, 2020).
- Ciolkosz, D. (2009). "Manufacturing Fuel Pellets from Biomass." *Penn State Extension*, <https://extension.psu.edu/manufacturing-fuel-pellets-from-biomass> (Mar. 13, 2020).
- Katers, J. F., Snippen, A. J., and Puettmann, M. E. (2012). "Life-Cycle Inventory of Wood Pellet Manufacturing and Utilization in Wisconsin." *Forest Products Journal*, Forest Products Society, 62(4), 289–295.
- Hoefnagels, R., Junginger, M., and Faaij, A. (2014). "The economic potential of wood pellet production from alternative, low-value wood sources in the southeast of the U.S." *Biomass and Bioenergy*, 71, 443–454.
- Homer Pro. (2020). "Capital Recovery Factor." <https://www.homerenergy.com/products/pro/docs/latest/capital_recovery_factor.html> (Apr. 5, 2020).
- Homer Pro. (2020). "Real Discount Rate." <https://www.homerenergy.com/products/pro/docs/latest/real_discount_rate.html> (Apr. 5, 2020).
- Hunsberger, R., and Mosey, G. (2014). "Pre-Feasibility Analysis of Pellet Manufacturing on the Former Loring Air Force Base Site." *Renewable Energy*, 58
- Index Journal. (2020). "Maryland-based company buying Colombo plant." <https://www.indexjournal.com/community/maryland-based-company-buying-colombo-plant/article_2c31c0e7-6bb0-5643-a25f-e91471a8c2b8.html> (Apr. 5, 2020).
- Mobini, M., Sowlati, T., and Shahab, S. (2013). "A simulation model for the design and analysis of wood pellet supply chains." *Science Direct*, 111, 1239–1249.
- S. Mani, S. Sokhansanj, X. Bi, and A. Turhollow. (2006). "ECONOMICS OF PRODUCING FUEL PELLETS FROM BIOMASS." *Applied Engineering in Agriculture*, 22(3), 421–426.
- Reed, D., Bergman, R., Kim, J.-W., Taylor, A., Harper, D., Jones, D., Knowles, C., and Puettmann, M. E. (2012). "Cradle-to-Gate Life-Cycle Inventory and Impact Assessment of Wood Fuel Pellet Manufacturing from Hardwood Flooring Residues in the Southeastern United States*." *Forest Products Journal; Madison*, Forest Products Society, Madison, United States, Madison, 62(4), 280–288.
- Shah, A., Baral, N. R., and Manandhar, A. (2016). "Chapter Four - Technoeconomic Analysis and Life Cycle Assessment of Bioenergy Systems." *Advances in Bioenergy*, Y. Li and X. Ge, eds., Elsevier, 189–247.
- Spelter, H., and Toth, D. (2009). *North America's wood pellet sector*. U.S. Department of Agriculture, Forest Service, Forest Products Laboratory, Madison, WI, FPL-RP-656
- U.S. Energy Information Administration. (2020). "U.S. Energy Information Administration - EIA - Independent Statistics and Analysis." <https://www.eia.gov/biofuels/biomass/#table_data> (Mar. 13, 2020).
- Visser, L., Hoefnagels, R., and Junginger, M. (2020). "Wood pellet supply chain costs – A review and cost optimization analysis." *Renewable and Sustainable Energy Reviews*, 118, 109506.
- Wei, W., Zhang, W., Hu, D., Ou, L., Tong, Y., Shen, G., Shen, H., and Wang, X. (2012). "Emissions of carbon monoxide and carbon dioxide from uncompressed and pelletized biomass fuel burning in typical household stoves in China." *Atmospheric Environment*, 56, 136–142.