Oakridge Community and Commercial Firewood Program Feasibility Study

Prepared for:
Inbound, LLC
Oregon Department of Forestry
Lane Regional Air Protection Agency

Prepared by:
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1. Acknowledgements

Good Company would especially like to thank Inbound, LLC, Oregon Department of Forestry, Lane Regional Air Protection Agency (LRAPA) and Lane County for their commitment and financial support of this study. Additionally, the City of Oakridge, Southern Willamette Forest Collaborative (SWFC) and the United States Forest Service (USFS) were instrumental in collaborating and assisting in accessing primary data necessary for the feasibility analysis. We would also like to acknowledge all of the organizations and businesses that offered their expertise and they are identified in the section *Review of Existing Firewood Programs*.

This report was researched and written by the consultant team of Good Company, a sustainability consulting firm located in Eugene, Oregon. The primary authors of this report include:

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2. Executive Summary

This study analyzes the market, supply and operational components of a firewood operation that would serve a community firewood program and a larger scale commercial firewood business. Details of each of these three study areas are located in the main sections of the report but given the substantive amount of information and data this executive summary serves to touch on the principal results and lessons learned. *Note: This is an abbreviated version of the original feasibility study. Due to some of the confidential information certain sections of the study were removed to keep this sensitive information private.*

Summary Findings

- **Community firewood program is feasible:** If support is continued by multiple companies and organizations, namely the City of Oakridge, Seneca and Inbound, the community firewood program could continue to sell 50-200 cords of firewood at roughly a break-even point.
- **Commercial firewood program is feasible:** If Inbound were to invest in the necessary equipment to operate a scaled-up firewood business and could connect to essential markets, namely the firewood bundled market sold at retail stores, a larger operation would be viable. Unfortunately, if Inbound were to just sell local and regional cords of wood at the going market price of ~$200 per cord, they would likely lose money without some significant amount of grant funding or subsidy.

Project Challenges and Opportunities

This section provides a high-level assessment of market, supply and operational challenges.

Market challenges

- **Feasibility reliant upon higher margin market firewood bundles sold at retail stores:** For a larger commercial firewood operation, it is essential to sell a segment into the firewood bundled market, which has greater profit margins, and helps to reduce financial risk and buoy the overall viability of the business.
- **Existing competition in regional market:** Wood resource is in great abundance in the region and there is competition from individuals that will continue to operate side businesses as well as larger operations, such as Lane Forest Products, that can leverage their access to multiple supply streams.

- **Demand of wood likely to decrease over time:** With an installation of efficient ductless heat pumps, and the greater prevalence of warmer winters due to climate change, the demand for wood heat will most likely continue to decrease.

Market opportunities

- **Oregon Woodland Cooperative interest:** OWC, based in the Portland area, is a statewide sales collaborative and is interested in Inbound becoming a member and producer. Wallowa Resources may also be able to access market opportunities and should be contacted.
- **Kiln brings out-of-state market opportunities:** If Inbound were to pursue a larger-scale business, contingent on firewood bundles, a kiln would be warranted which would give Inbound the opportunity to sell firewood bundles into the neighboring states of California and Washington.

Supply-side challenges

- **Consistent and diverse supply of wood:** To ensure that there is enough feedstock each year, it is important to have a reliable source of wood supply. It is one of the primary downfalls for a commercial firewood business to not have enough supplier diversity to maintain operations.
- **Moisture content**: One of the main variables and assumptions of this study is the moisture content of the wood coming in from the forest. The moisture content of wood is highly variable and is contingent upon season, timing of felling, tree species, location, weather among others. Based on the best information available, three and half green tons of wood is equivalent to one dry cord of wood.
- **Timber prices are currently very high in Oregon**: Higher prices are leading to greater competition for sales and higher prices that will pressure the economics and supply access of a commercial firewood program. While better prices could mean more wood resource for firewood, there is an opportunity cost for partners, operators and subcontractors that are focused on the highest value activities.
- **Road deposits tax:** On public lands, road deposits can be a significant cost to be incorporated into the feedstock cost. Commercial firewood programs, C-2.11 agreements or nearby sourced wood are options for keeping these costs lower.

Supply-side opportunities

- **U.S. Forest Service is interested in finding opportunities for supply:** The Middle Fork District Office has been instrumental in sharing and identifying multiple pathways to accessing firewood supply.
- **Forest Collaborative partnership is fundamental to success of program:** Southern Willamette Forest Collaborative (SWFC) and its director Sarah Altemus-Pope, are vital contributors and partners to the success of a community firewood program and a commercial firewood business.

- **Resource supply is close:** Oakridge is surrounded by public and privately-held forest, therefore, it is a matter for finding the contracting mechanisms to access firewood supply. A reasonable distance from the processing facility, such as within 25 or 35 miles, is important to establish as it contributes significantly to operating costs.
- **Private timber companies will continue to donate wood:** Seneca will continue to donate wood to the community firewood program. Roseburg is also willing to donate when they cut in the area in the next few years. Donated wood is the primary vehicle for making the community firewood program sustainable on its own.

Production facility challenges

- **Equipment investment similar despite production thresholds:** If Inbound purchases a base package of equipment to operate a commercial firewood facility, the facility is largely capable of producing at varying levels and scales more with the amount of labor and select pieces of equipment that may be pinch points in the production flow (e.g., kiln).
- **High hauling and handling costs:** Each time firewood is handled at the processing facility, costs are incurred and is a key variable for profitability. The best way to manage this challenge is to streamline the process layout and utilize equipment to minimize unnecessary handling.
- **Storage costs:** A firewood business will incur the cost of wood sitting for long stretches of time depending on site size and facility cost constraints. Storing for multiple seasons, in the right storage conditions (roof and sufficient airflow) is helpful to curing and seasoning the wood. Longer storage time opens up risk of theft or damaged wood supply. A kiln can reduce these costs of wood exposure to the elements and potential theft.
- **Waste product:** A firewood operation at scale will produce a substantial amount of wood waste. This could be an issue depending on the scale that would either warrant the purchase of a wood hog (essentially a grinder) or an opportunity to partner with other organizations that could utilize this waste resource (e.g., Wood Recovery, City of Oakridge, Rexius).

Production facility opportunities

- **City is supportive of assisting firewood program:** The City serves as one of the most important partners for the community firewood program. The City continues to support the program with facility and transportation assistance.
- **Industrial park space available:** The City of Oakridge currently has plenty of property available that could serve a commercial firewood business well.

Financial Results

A more careful and robust comparison of the variables and assumptions of the financial analysis are included in Financial Analysis and Results.

1. **A community firewood program is feasible albeit with donated feedstock and continued assistance from partners such as the City of Oakridge.**
2. **A commercial firewood business is feasible but will only be profitable with sales to retail stores and in the region.**

Phase I Only			
	Base Assumption	CFP and Local Only	CFP - Donated Feedstock
Net Present Value	$2,714,352	($444,225)	($178,349)
Discount Rate	5%	-	-
Capital Investment	$466,050	$45,000	$45,000
Payback Period	5 years	> 12 years	9 years
Sales Revenue - Year 5	$812,500	$73,000	$73,000
Operating Expenses - Year 5	$533,607	$76,017	$61,382
Net Income - Year 5	$278,893	($3,017)	$11,618

Base Feasibility Scenarios	
	Base Assumption
Net Present Value	$2,714,352
Discount Rate	5%
Capital Investment	$466,050
Payback Period	5 years
Sales Revenue - Year 5	$812,500
Operating Expenses - Year 5	$533,607
Net Revenue	$278,893

Different Market Approaches			
	Base Assumption	No Bundled Firewood	Lower Bundled Price $400
Net Present Value	$2,714,352	($1,926,265)	$407,678
Discount Rate	5%	-	-
Capital Investment	$466,050	$414,250	$466,050
Payback Period	5 years	> 12 years	6 years
Sales Revenue - Year 5	$812,500	$448,000	$660,500
Operating Expenses - Year 5	$533,607	$496,092	$533,607
Net Income - Year 5	$278,893	($48,092)	$126,893

Recommendations for Next Steps

- **Continue community firewood program:** Carry out Phase I to ensure community firewood program objectives are met. Continued assistance from partners should ensure that the program at least breaks even financially. Formalize agreements with City of Oakridge and land owners (e.g., Seneca) that are donating or sell wood.
- **Bid on commercial firewood sale:** Plan to bid on one of the upcoming firewood sales to ensure supply for 2019 season.
- **Ensure market access:** Coordinate and confirm market connections with Oregon Woodland Cooperative for bundled firewood. Reach out to additional market channels including Wallowa Resources.
- **Develop both short and long-term supply:** Continue conversation with Forest Service on road deposit costs and road maintenance program to see if progress can be made that assists in shorter term supplies of firewood. Ensure long-term firewood supply prior to significant investments in equipment and facility. Continue to work with the Forest Service to develop potential contracts and partnerships for firewood supply.
- **Identify opportunities to reduce financial risk:** Access funding assistance for equipment, facility and firewood supply for Phase II operations, particularly the Wood Innovation funds. If a Phase II is pursued, study the benefit-cost ratio of different kiln options and work with LRAPA and ODF staff to determine the best path ahead. Determine whether it is possible to place a particulate filter on firewood processor to ensure that the air quality benefits are not undone by the kiln emissions.

3. Introduction

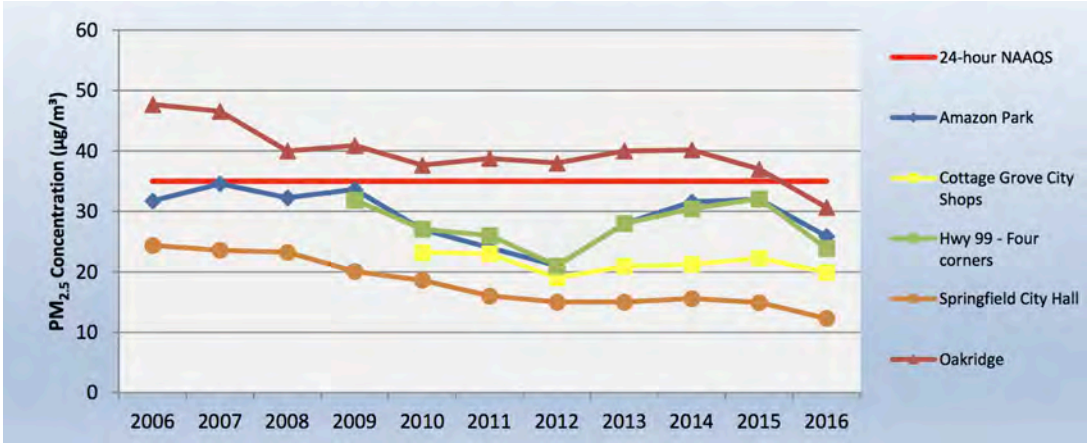
Community Firewood Program Goals

The primary goal of the Oakridge Community Firewood Program (CFP) is to help mitigate air pollution from improper firewood burning in order to help the City of Oakridge meet its air attainment goals while employing more local residents over the winter months. Over the past few years in particular, Oakridge has made progress on reducing levels of particulate matter (PM2.5) (see Figure 1 below) in the air by weatherizing residences, installing certified woodstoves and ductless heat pumps. After the technology conversions, the most significant long-term action is to ensure the use of dry, seasoned wood to reduce the use of green or wet wood. When wet firewood is burned, the fine particulate emissions cannot be properly abated, regardless of using a certified wood stove.

A community firewood program is a necessary strategy to safeguard the health of the community as well as contributing to local economic development, job creation/retention, and the best utilization of wood resources. A higher proportion of particulate matter contributes to respiratory and cardiac challenges and disease while increasing the likelihood of cancer risk. Specific objectives of the program include:

- Short to long-term reduction and maintenance of air quality standards
- Provide affordable, seasoned firewood to every resident that needs it
- Provide local jobs for Oakridge residents in the off/shoulder season
- Support the reinstatement of a forest service commercial firewood sale program
- Educate the community about clean burning practices
- Assist low-income, senior and disabled residents

Figure 1: Three Year Average of PM2.5 24-Hour Concentrations



Source: LRAPA, 2017

Intent of Study to Develop Sustained CFP and Expanded Business Model

The City of Oakridge, the Southern Willamette Forest Collaborative, LRAPA, Inbound LLC and other partners have been involved in reducing woodsmoke in the Oakridge airshed. Inbound managed two seasons of a small-scale CFP to provide seasoned firewood at affordable rates to the community. The sustainability and viability of this program relies on ensuring financial viability of the program before investments and funding is directed to equipment purchases and facility development or retrofits. The purpose of this study is to determine if there is a legitimate approach to making this CFP an ongoing strategy to reduce woodsmoke impact. Additionally, this study evaluates the potential for a larger scale operation and market for commercial firewood that could access the necessary supply and market to sustain a larger business model.

Overview of this Feasibility Study

Market Potential and Pricing

- Potential markets and products
- Scaling the need for firewood
- Pricing options by market type
- Competition

Supply Assessment

- Overview of supply source options
- Opportunities and challenges
- Contracting supply details and comparative analysis
- Potential partners
- Analysis and recommendations

Site Assessment and Permitting

- Overview of site needs and operational footprints
- Public-private partnership
- Site location and process layout
- Permitting and regulations

Financial Analysis and Results

- Overview of scenarios and assumptions
- Capital costs
- Funding and support opportunities
- Operating expenses
- Anticipated production and revenue
- Pro forma and high-level results
- Project outcomes

4. Market Potential and Pricing

Potential Markets and Products

Primary Products Evaluated

The primary products that a community firewood program and commercial firewood business could produce and sell include:

- Subsidized firewood for community firewood program, sold by cord
- Local and regional sales, sold by cord
- Regional and adjacent state sales, sold by bundle

Other Markets and Products to Study

Due to the limited scope of this project, an extensive analysis of markets other than firewood was not expected or conducted. However, for the purposes of further study and analysis, the following is a set of potential markets that could be incorporated into an integrated biomass facility.

- Firewood bricks, pellets or compressed logs
- Biochar and compost
- Post and pole
- Small diameter sawmill
- Biomass and wood to energy

Scaling the Need for Firewood

Overview of Demand for Production Modeled in Analysis

This set of different markets begins locally with the community firewood program to regionally for commercial firewood business.

- **Past community firewood program sales in Oakridge:** 54 cord average in two seasons of operation.
- **Proposed Community Firewood Program annual demand:** 200 cords (estimate based on woodsmoke program data).
- **Oakridge/Westfir general firewood sale:** additional 200 cords (analysis based on USFS and LRAPA data).
- **Subregional sale (Lowell, Jasper, Springfield, Eugene):** additional 1,000 cords (analysis based on USFS and LRAPA data).
- **Number of Cords/Year (firewood bundles):** 1,000 cords (low end estimate based on interviews). As a point of reference Heritage Resources planned a 10,000 annual cord production with the majority of that volume directed to firewood bundles, part of which would be transported via rail.

Current Demand for Firewood in Oakridge/Westfir

- **Firewood demand less personal firewood permits:** Based on the wood use data (demand) and the personal use permits (supply) in the sections below, Oakridge has a demand of 600 to 1,300 cords per year that are purchased from other sources.
- **Current Households in Oakridge/Westfir:** 1,691 households
- **Number of wood users:** Oakridge residents that mainly burn wood for heat: 425 households based on LRAPA survey (431 households) and U.S. Census data (444 households).
- **Average use per household:** Three cords for main source of wood heat (e.g., woodstove) and approximately one and a half cords per household for fireplaces without an insert.
- **Total demand in Oakridge for firewood**: Range between 1,400 and 2,000 cords per year.

Based on information from the U.S. Census Bureau's 2012-2016 American Community Survey, we are able to estimate the number of residences in Oakridge and the number of wood users (which is roughly the percentage of residences that identified wood heat in SWFC's heating survey).[1] Based upon the average number of cords used per household and the number of firewood permits provided in the Oakridge/Westfir area, we estimate the current demand for firewood in the immediate area is approximately three cords per year per household based on a wood use survey (see Table 1). This level of demand for wood heat is subject to decreasing given continued installation of ductless heat pumps and weatherization. According to U.S. Also it is likely that some number of residents will switch from gathering their own wood to purchasing given that there is a local source of seasoned, dry wood.

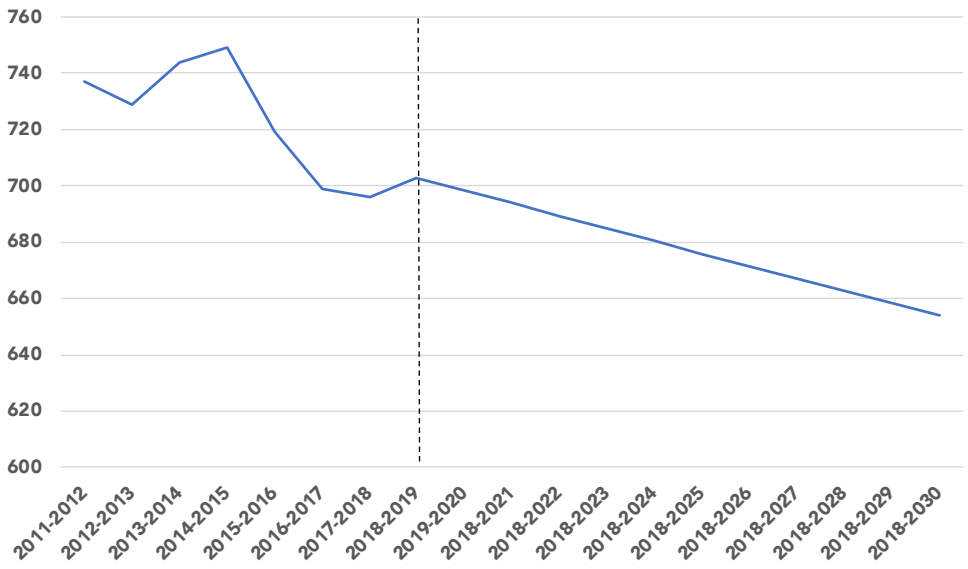
[1] Southern Willamette Forest Collaborative. Heating Survey. https://docs.wixstatic.com/ugd/cb6d32_dea93c4a5af4439e9ea8d4ec1699063b.pdf

Table 1: Oakridge Wood Use Survey Results

Woodburning Device	Base Year Wood Fuel Use Survey (Households)	Base Year Wood Fuel Use (tons/HH)	Base Year Wood Fuel Use (tons/year)
Oakridge NAA			
21-04-008-100 Fireplace without Insert	123	1.6	195.6
21-04-008-320 Certified Non-Cat Wood-Stove	256	3.0	770.6
21-04-008-330 Certified Cat Wood-Stove	64	3.0	192.6
21-04-008-310 Conv Wood Stove	111	3.0	334.1
21-04-008-230 Fireplace Insert Cert Catalyst	28	3.0	84.3
21-04-008-220 Fireplace Insert Cert Non-Cat	112	3.0	337.1
21-04-008-210 Fireplace Insert Conv.	96	3.0	289.0
21-04-008-400 Exempt Pellet Stove	228	1.2	264.5
21-04-008-510 Central Furnace	0	0.0	0.0
Total	1,018		2,468

Source: https://www.oregon.gov/deq/EQCdocs/0117ItemEAttachC.pdf

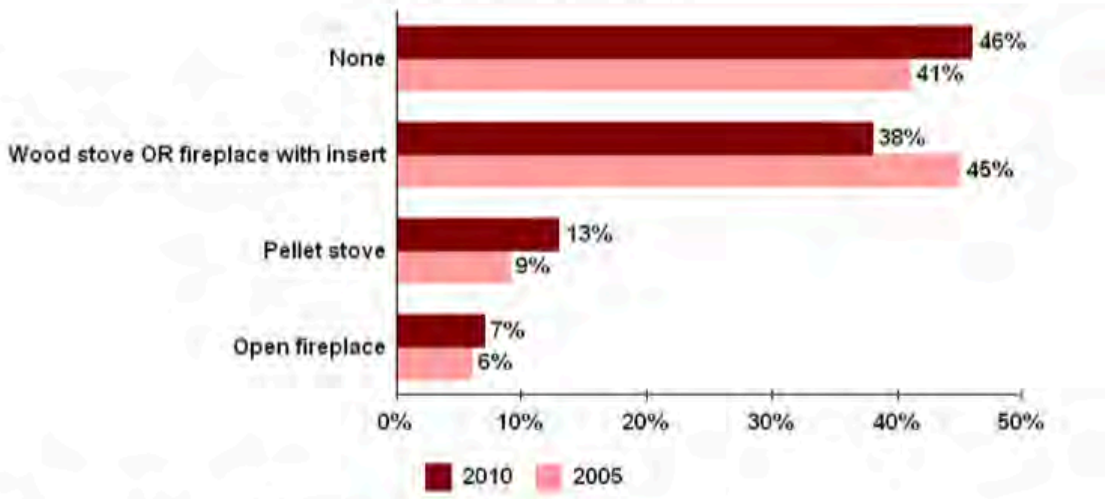
Figure 2: Western U.S. Number of Households Using Wood as Primary Space Heating Fuel (thousands)



Source: US EIA data, 2018

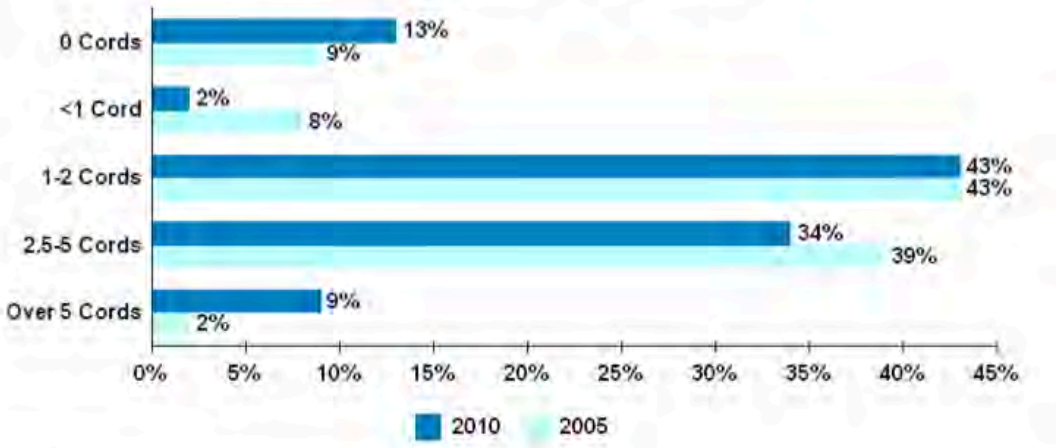
The following figure shows the approximate breakdown of wood burning devices used in the Oakridge. The number of wood burning devices went down 5% from 2005 to 2010 and the number of residences with a woodstove or fireplace with insert also went down 7%.

Figure 3: Breakdown of Wood-Burning Devices in Oakridge



Source: LRAPA http://www.lrapa.org/DocumentCenter/View/1135/Appendix_D_-_Oakridge_Emission_Inventory_with_Attachments?bidId

Figure 4: Consumption of Wood for Wood Stoves and Fireplaces with Insert



Source: LRAPA
http://www.lrapa.org/DocumentCenter/View/1135/Appendix_D_-_Oakridge_Emission_Inventory_with_Attachments?bidId

- **Number of firewood permits issued by USFS:** The number of personal use firewood cord permits requested out of the USFS Middle Fork District office has ranged between 900-1200 cords per year over the last six years (see

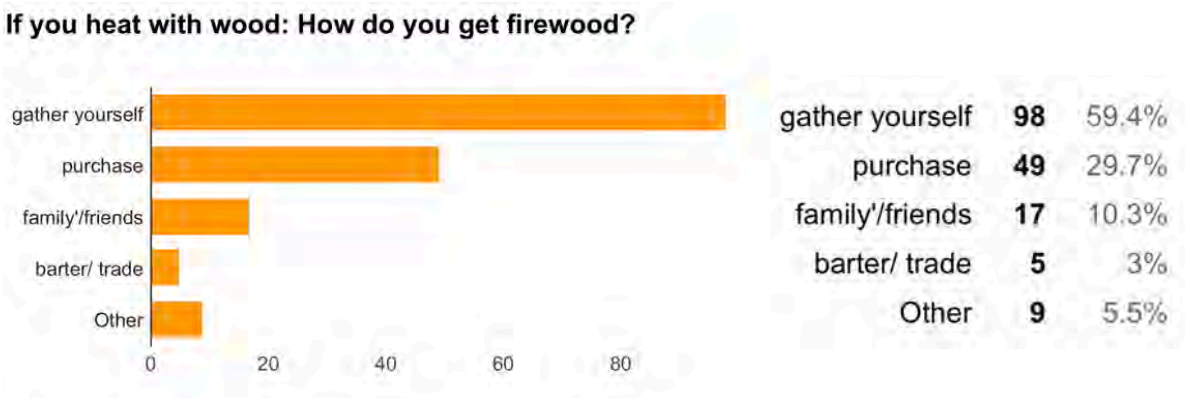
-
- Table 2). Note that permits have been decreasing in recent years and this may be due to a variety of factors: transition to ductless heat pumps, warmer winters, and the challenge some residents have described finding good wood on USFS permits. A permit holder can cut two cords per permit. Forest Service permits for personal use are $10/cord with a two cord minimum but up to six cords. The Middle Fork District Office provided a breakdown of permits by location and ~48% were requested by Oakridge residents for a total purchase of 3,063 cords over 5 years yielding an average annual purchase of 612 cords. The Oakridge heating survey found that ~60% of Oakridge resident respondents gather wood themselves and if that proportion was allocated to the total demand of firewood in Oakridge, it would equate to a total demand of ~1,000 cords annually with two-thirds of that supply coming from personal use wood. This leaves approximately 400 cords of wood of demand locally.

Table 2: Personal Use Firewood Cords Harvested via USFS Permit

Year	Cords
2012	1,196
2013	1,493
2014	1,579
2015	1,187
2016	1,070
2017	924

Source: USFS Middle Fork District Office

Figure 5: How Oakridge Residents Access Firewood

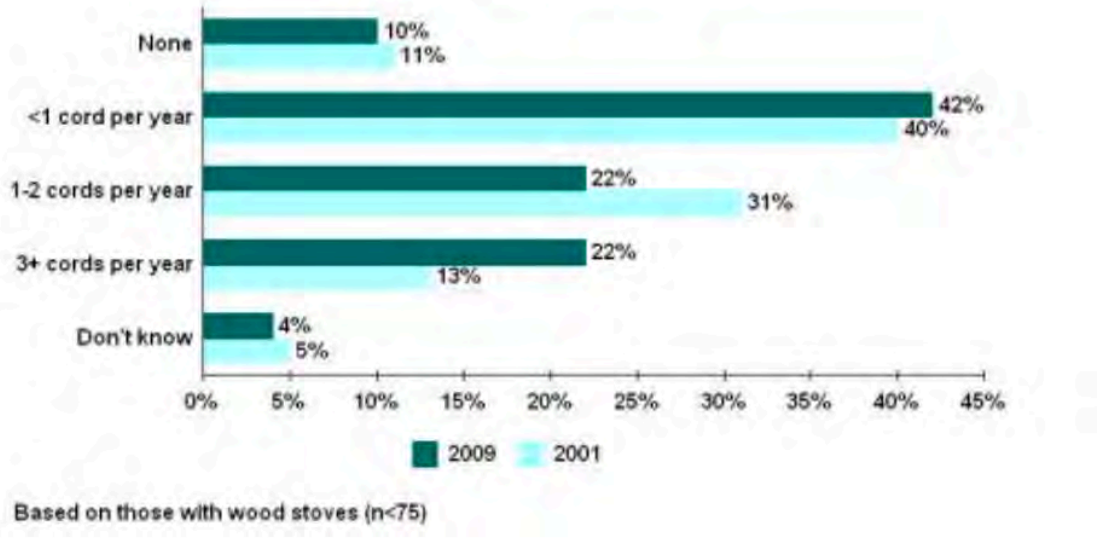


Source: SWFC Heating Survey
https://docs.wixstatic.com/ugd/cb6d32_dea93c4a5af4439e9ea8d4ec1699063b.pdf

Demand in the Region

The Eugene/Springfield wood usage can similarly be modeled based on heating survey information. Based on a 2010 LRAPA heating survey ~4% of the population has a wood stove as its primary heat source and ~16% of population have a wood stove as a secondary heat source. Given 66,401 households in Eugene and 23,665 households in Springfield, coupled with the LRAPA heating survey information, provides the following estimates of 3,600 households use heat as a primary source and 14,410 households use heat as a secondary source which equates to approximately 5,000 cords as primary source fuel.[2]

Figure 6: Amount of Wood Burned in Eugene-Springfield



Source: Fuel Use Survey, October 2009.

The Eugene-Springfield PM10 Limited Maintenance Plan was adopted by the LRAPA Board in September 2011.

Pricing Options by Market Type

- **Subsidized firewood program price:** Historically, the CFP program has sold firewood at a subsidized price to residents that are on the non-exempt list with the City or meet certain criteria (e.g., low-income, disabled, and elderly criteria). However, access to donated wood and City assistance (facility space, transportation) made this subsidized price possible. Inbound currently anticipates selling a cord of wood for $150 per cord without delivery.

[2] U.S. Census https://www.census.gov/quickfacts/fact/table/eugenecityoregon/PST045217

- **General Oakridge/Westfir firewood price:** For other Oakridge residents, a sales price of $185 per cord of softwood (Doug Fir) is recommended to stay just below the average retail price. A higher price of $200 or above would be relevant for hardwood species.
- **Sliding scale fee:** Another approach could be a sliding scale based on Lane County income averages calculated by Housing and Urban Development (HUD). The HUD figures are based on federal poverty guidelines and are also used by the Eugene/Springfield home heating exemption program. This approach needs to be evaluated further to determine whether this approach would restrict participation. http://www.huduser.org/portal/datasets/il/il2015/2015summary.odn
- **Delivery charge:** Based upon costs of labor (time and hourly wages) and transportation (per mile costs), local and regional delivery price points of $30 and $50 are likely to cover those operational expenses. However, the current pricing structure of delivery is not anticipated to be an area of profit margin for Inbound. $30 serves as a comparable local delivery price based on other firewood providers. Most firewood operators prefer that customers pick up their own cord of wood, however, this cannot be expected. $50 covers the cost for regional delivery, but might be too low, depending on the time allocated per trip in unloading. Lane Forest Products charges between $50-75 per load depending on the type of firewood product purchased. The firewood delivery charge may need to be increased based on true costs of time and labor in the field. Inbound may choose to partner with organizations like Moose Lodge, the Boy Scouts or others to help deliver firewood locally for the community firewood portion of the operation.

- **Subregional and additional markets:**
  - *Retail firewood bundles:* $300 to $640 per cord is the approximate wholesale price when bundled together for firewood and sold to retail outlets such as grocery and hardware stores. Selling into this market is limited to higher quality firewood, additional packaging/processing of the firewood bundles, and the distance to market. Oregon Woodland Cooperative sells bundled firewood to several grocery outlets in the Portland area including New Seasons Market, Whole Foods Market, Green Zebra, Market of Choice, and Ace Hardware. OWC sells bundled softwood firewood (Doug Fir), bundled premium hardwood firewood (maple, alder, hemlock), and kindling bundles.[3] The OWC firewood bundle sells for $6.99 at New Seasons for 0.75 cubic feet and OWC, earns $4 per bundle wholesale which is double the normal $2 per bundle wholesale price. Tule Creek sold primarily to a broker for a large grocery store chain with operations in Northern California and gained access via Wallowa Resources. With a similar partnership, Inbound could gain market access beyond the immediate regional market and would be marketing under the broker label. Scott at Heritage Resources mentioned that vendors were incredibly interested in kiln-dried supply. The benefits of kiln dried firewood included reduced moisture content and the product can be transportation across state lines, whereas other firewood products are not because they can potentially transmit harmful pests (see permitting section for more detail).

[3] Oregon Woodland Cooperative https://www.oregonwoodlandcooperative.com/bundled-firewood.html

Scott mentioned that in order to avoid the limitations of the viability of a regional market.

- *Campgrounds:* Firewood sales to campgrounds or campground vendors and concessionaries (e.g., Hoodoo) in the Oakridge area is another potential market. Retail pricing for a bundle is generally $5-7 per bundle which approximates the pricing for grocery stores and other retail outlets.

Table 3: Benchmarking to other community firewood programs/woodbanks

Program	Location	Price per cord	Quantity/Limit (if any)	Website
Heart of Oregon	Bend, OR	Retail price, fees support youth training	Not listed	http://heartoforegon.org/get-involved/purchase-firewood.html
Oregon Youth Authority – Camp Tillamook	Tillamook, OR	Donated	Not listed	https://www.oregon.gov/oya/pages/facilities/youth_made_products.aspx
Senior Firewood Program	Nevada County, CA	$300	1.5 cords	http://www.goldcountryservices.org/senior-firewood-program/
Sheriff's Work Alternative Program (SWAP) Firewood Program – sold to 55+ with low to moderate income	Humboldt County, CA	Vouchers are priced on a sliding scale costing between $100-150 (tax included in the fee)	1 cord (additional cords sold later in the year)	https://humsenior.wordpress.com/services-offered/

Competition

- **Direct, local competition:** No commercial firewood vendors are located in Oakridge/Westfir. Most residents gather firewood from the nearby Willamette National Forest or purchase firewood from out of town vendors. There are some woodcutters that sell cords of firewood, but these operations are ad hoc and do not supply adequate firewood to meet the demand. Often, firewood that is gathered locally or purchased from vendors is not properly seasoned before being burned, this contributing to the woodsmoke problem during the winter.
- **Regional competition:** There are regional businesses and sources of firewood such as Lane Forest Products. Those vendors are identified in
- Table *4*. One resource for identifying potential competitors for firewood is the Oregon Forest Industry Directory hosted by OSU.[4]
- **Other timber products:** Timber prices in the Pacific Northwest, including Doug Fir, are currently high and are therefore affecting the end use markets and where timber companies and contractors place their focus.[5] These higher prices make it more challenging for products such as firewood and wood chips to compete with higher value wood products and markets.

Table 4: Firewood vendors with online presence

Westfir	Doug Fir	$180-225/cord	https://eugene.craigslist.org/for/d/premium-old-growth-doug-fir/6641086128.html https://bend.craigslist.org/for/d/premium-old-growth-doug-fir/6641087234.html
Westfir	Campfire wood	$10/wheelbarrow	https://eugene.craigslist.org/for/d/camp-firewood/6598383952.html
Pleasant Hill	Doug Fir	$210/cord	https://eugene.craigslist.org/grd/d/seasoned-firewood/6652335069.html
Jasper	Nat's Firewood	unknown	http://www.jasper-wood-products.com
Eugene	Fir	$185/cord	https://eugene.craigslist.org/for/d/firewood-fir/6611575988.html
Eugene	1. Doug Fir - Uniform	1. $175/cord 2. $175/cord 3. $125/58 cu ft 4. $175/cord	http://laneforest.com/firewood-and-fuel/

[4] Oregon Forest Industry Directory http://www.orforestdirectory.com

[5] Douglas Fir Log Prices Reach Record Highs in Pacific Northwest. https://blog.forest2market.com/douglas-fir-log-prices-reach-record-highs-in-pacific-northwest

	2. Doug For - Random split 3. Peelercore 4. Tie ends 5. Mill ends 6. Pole ends	5. $128/cord 6. $175/cord *all unseasoned **$50-75 for delivery	
Eugene	Softwood for residential / campground	Not listed	www.coyotecreekfirewood.com
Eugene	Oak, Maple & Madrone	$230/cord	https://eugene.craigslist.org/for/d/hardwood-firewood-oak-maple/6611563879.html
Eugene	Doug Fir (kiln dried)	$295/cord	https://eugene.craigslist.org/for/d/firewood-kiln-dried-douglas/6642903819.html
Eugene	Maple & Oak (delivered)	$325/cord	https://eugene.craigslist.org/for/d/firewood-for-sale-seasoned/6642904451.html
Bend	Doug Fir (brought over from valley)	Not listed Delivery fee	https://www.centraloregonfirewood.com

Next Steps

In the near term we recommend that Inbound do the following:

- **Visit and become a member of Oregon Woodland Cooperative:** We met with OWC leadership and they demonstrated interest in expanding their markets to the southern end of the Willamette Valley with the help of Inbound.
- **Contact and develop business relationship with Wallowa Resources:** Nick with the Watershed Center recommended contacting Wallowa Resources for potential market connection if the decision is made to operate a bundled firewood operation.

5. Supply Assessment

Overview of Supply Source Options

To make a firewood program viable there must be access to:

(1) Consistent and adequate supply of firewood resource
(2) Reasonable distance the firewood processing facility
(3) Reasonable price of feedstock or the means to conduct/contract timber work to access that supply

The two high-level options for supply in the Oakridge area are private timber holdings and public holdings managed by the U.S. Forest Service. Private and public each offer several options and pathways including:

Private land options

- Donated wood
- Purchased wood from timber companies (C-2.11 agreements are addressed under public land options below)

Public land options

- Commercial firewood program
- C-2.11 agreement (included above, partner with private timber company)
- Stewardship
    - Integrated Resource Timber Contracts
    - Integrated Resource Service Contracts
    - Stand-alone Service Contracts
    - Stewardship Agreements
- Good Neighbor Authority

Opportunities and Challenges

Consistent and adequate supply of firewood

There is more than an adequate amount of wood near to Oakridge that could supply a commercial firewood business; however, ensuring *access* to the raw wood is the greatest challenge to the business. As Tule Creek experienced, purchasing all of the wood either on the open market via timber companies or individual sales can be an insurmountable challenge. Third parties are reliant on mill prices which fluctuate and affect the demand. Tule Creek developed contracts with landowners and private

timber companies. When the market shifted and prices increased, timber operators focused solely on sawlogs, and did not meet the agreements they had set forth prior on small or hazard trees. As the private side supply agreements were not followed through on, Tule Creek appealed to the Forest Service to release sales but there was not sufficient time to get those supply opportunities open.

Reasonable distance from firewood processing facility

Generally, biomass studies evaluate biomass within a 50 mile radius[6]; however much shorter distances (<25 miles) are preferable and highly recommended due to the significant cost of transportation and labor involved. Our team evaluated the costs of transportation from different distances and the relationship to the effect on total cost per cord. Interviews indicated that a commercial firewood program should target a maximum cost of $120 per cord to the processing facility gate – covering feedstock and transportation costs. The distance of the firewood source to the processing facility is a critical factor. The further the distance the more in haul costs (e.g., driver time, fuel, and maintenance) associated with the operation. Ideally, Inbound will source from within 35 miles but will strive to make those distances even shorter (10-25 mile trips) to ensure profitability.

The analysis below compares not only the importance of distance and its relationship to overall cost, but also whether a log truck should be rented or purchased. We compared the capital and operating costs of either renting a truck or purchasing a vehicle. For truck ownership, we allocated the capital cost over five years of trips delivering on the base assumption of cords delivered in the production model. Not only does the purchase of a self-loader reduce transportation costs, but also owning and controlling this aspect of the operation ensures that the business is not challenged by scheduling or outright disinterest by transportation contractors. Waiting for a logloader at the landing can be a scheduling challenge which can be avoided with truck ownership. Truck rental and truck ownership are roughly equal in cost at 15 mile distances but truck rental becomes more expensive than ownership as the distance increases. It is best to own a truck if Inbound is doing trips beyond 15 miles and is producing at the level outlined in the production model.

[6] Valley County, Idaho. 2017. Woody Biomass Utilization Assessment https://www.mccallstarnews.com/images/images_downloads/BioMass%20Study.pdf

Table 5: Transportation Distance Costs

Transportation Distance Costs						
Truck Rental						
Number of miles from processing site	15	25	35	50	75	100
Total incoming haul cost	$206	$343	$480	$686	$720	$914
Per cord cost incoming haul cost	$26	$43	$60	$86	$90	$114
Total cost per cord	**$26**	**$43**	**$60**	**$86**	**$90**	**$114**
Truck Ownership						
Number of miles from processing site	15	25	35	50	75	100
Fuel cost	$2	$3	$5	$7	$10	$14
Maintenance costs	$0.5	$0.8	$1.1	$1.5	$2	$3
Driver cost	$6	$7	$10	$14	$21	$29
Equipment allocation (based on 5 years of use)	$121	$121	$121	$121	$121	$121
Equipment allocation (per cord)	$17	$17	$17	$17	$17	$17
Transportation cost	$25	$28	$33	$40	$51	$62
Total cost per cord	**$25**	**$28**	**$33**	**$40**	**$51**	**$62**

Road deposits

Road deposits are charged by USFS for transporting logs via public roads to cover maintenance of those roads. Road deposits can play a significant role in the overall feedstock cost. Based on the comparison below, road deposits beyond 35 miles would make projects infeasible because they add too much cost to the per cord production cost to be recaptured. For example, distances of 50 to 100 miles contribute $40 to $80 per cord in cost. If Inbound access supply from public sources they should strive to minimize the distance to the processing facility or see if road deposit negotiations can be made.

Table 6: Road Deposits by Distance

Road Deposits - Rented Truck						
Number of miles from processing site	15	25	35	50	75	100
Transportation	$26	$43	$60	$86	$90	$114
Road deposits	$13	$22	$30	$43	$65	$86
Total cost per cord	**$39**	**$64**	**$90**	**$129**	**$155**	**$200**
Road Deposits - Owned Truck						
Number of miles from processing site	15	25	35	50	75	100
Transportation	$25	$28	$33	$40	$51	$62
Road deposits	$13	$22	$30	$43	$65	$86
Total cost per cord	**$38**	**$50**	**$63**	**$83**	**$115**	**$148**

Moisture content of wood

The moisture content (MC) of wood plays a significant role in the viability and underlying assumptions of the business model. MC can vary greatly based on season and the state and location of the wood (e.g., green wood, standing dead, recently cut, decked wood). Seasoned wood has a maximum moisture content of 20% but green wood can be as high as 120% (containing more water than the weight of the dry wood). While the MC will vary based on the source and location of the wood, the base assumption of 3.5 tons of wet wood to each cord of dry wood was used for this study. It is important to note that the summary analysis assumed a $35 per ton feedstock cost or $120 per cord cost taking into account the 3.5 green tons per dry cord of wood. In interviews, both private and public stakeholders hesitated to provide more specific ratios given the wide range of what is found in the field given the variability of moisture contents.

Hardwoods and non-merch softwood

The predominant species to be purchased and sold in a firewood program is likely to be Douglas Fir. However, there are possibilities of purchasing other sources, some of them hardwood (maple, alder, hemlock) and dead or dying wood that may have higher value in the market as well as lower transportation cost.

Adding another business operation and market channels

To address the challenges of inadequate supply, Inbound could control supply to its firewood operations by purchasing timber sales or participating in stewardship contracts. Nick Goulette at the Watershed Center recommended taking this approach as it eliminates one of the critical challenges to a viable firewood business. Additionally, by controlling the purchase of timber, it allows Inbound and partners to market sawlogs that can help make the overall bottom line function. While it does *reduce* risk on one side of the business, it does *add* risk (or cost) by creating additional management and facilitation requirements.

Contracting and purchasing pathways

As mentioned in the overview of supply options, there are several ways that Inbound could access the firewood needed to develop a commercial firewood business. The following table outlines the opportunities and challenges associated with each of these supply options.

Table 7: Opportunities and Challenges on Private and Public Lands

Privately Sourced	Opportunities	Challenges
Donated wood	• Inexpensive source of firewood supply reduces overall costs • Timber companies are interested in supporting local communities with a resource that does not have significant monetary value	• Inconsistent supply volume and quality • Distance / transportation costs and road deposits • Need to demonstrate that have liability insurance to access lands
Purchased wood	• One of the easiest transactions available • Opportunity to build a relationship with timber companies to maintain sales on an annual or consistent basis to ensure supply	• Competition with other biomass markets • Current high price of timber makes it difficult for firewood supply to compete • Requires time spent to build relationships and reach out to potential timber company partners • Private company may not comply with selling wood even if a contract exists if markets shift considerably to prioritize other outlets
Publicly Sourced	**Opportunities**	**Challenges**
Commercial firewood program	• Wood is already cut down and in piles/decks	• Open to competitive bid • Inconsistent supply and location • Road deposits: $0.86 per mile per CCF of asphalt road
Stewardship	• Provides different agreement approaches based on need and desired outcome on the landscape • Potential for a multi-year pathway to guaranteed supply of wood • Offers the opportunity to achieve multiple benefits	• Considerable effort and partnership needed to bring a stewardship project to bear in comparison to other supply options

	in the community and on the landscape	
Road maintenance	• Creative mechanism that could be developed under stewardship or commercial firewood program • Benefits to USFS include providing maintenance on roads that don't receive maintenance and developing firebreak/reduction in hazardous fuels • Benefits to Inbound include access to supply of good hardwood and softwood (within a reasonable distance <35 miles), ability to build the guaranteed supply into multi-year agreement	• Likely requires a third-party contractor to conduct the clearing and associated tasks (e.g., chipping, burning) needed to fulfill the contract • Need to account for costs of logging/maintenance costs.
C-2.11 agreement	• Wood is already cut down and often in piles • Relatively inexpensive source of wood (e.g., penny per ton)	• Unlikely due to lack of interest by timber companies, contracting issues, price point to cover costs. • Road deposits can be significant depending on distance • Challenge of access to timber company property i.e. legal/insurance liability • Subject to level of interest and perceived value of private timber company • Inconsistent supply unless formal agreement is developed and adhered to • Requires time spent to build relationships and reach out to potential timber company partners

		• Smaller logs than a chip sort (up to 3 inch top; anything less than the timber market)
Good Neighbor Authority	• ODF capacity to execute timber sales • Can use local workforce • Evolving part of the supply picture — collaborative, forest and state working together • Build relationship to broker/purchaser • Seneca could be putting up sales	• Newer program • Agency partnerships could be fruitful in terms of scale but will require time to establish and carry out

Contracting Supply Details and Comparative Analysis

Donated and Purchased Wood

To date, private timber companies have been the source of donated firewood for the community firewood program. Seneca has been a supporter of Oakridge's community firewood program for two years and is willing to make similar arrangements for wood donation in coming years. Seneca can offer donated wood from two main sources: (1) private land holdings and (2) thinning programs from federal lands. Roseburg is also interested in supporting the program, however, they do not own very much land (~250 acres) within close proximity to Oakridge and they do not plan on cutting for the next couple of years.

- **Supply of wood:** Seneca estimates that it has approximately 100 tons of wood that could be salvaged annually (15 dump trucks at 7 tons each).
- **Location of private wood supply:** The distance of the wood ranges from 15-30 miles away from Oakridge (up Hills Creek). Note that private timber lands are not subject to road fees.
- **Best timing for hauling:** Seneca runs its logging operations fall, winter, and spring for private timber lands and does not operate in the summer due to fire season. Collecting firewood in the summer is not ideal for Seneca, nor would it be for Inbound given their focus on wildland firefighting. The spring is the best time to collect and deliver wood to the processing facility to allow for passive drying and seasoning.
- **Willingness to participate:** Seneca is willing to donate any wood on the private logging side that is going to be left on the ground.

- **Road user fees a challenge on public lands:** With federal lands, road user fees could be too big a financial burden for a community firewood program. It is possible that the Forest Service could waive these road user fees, but the USFS has not confirmed or established that as an option.
- **Contract details:** Seneca would prefer to develop an annual renewal contract with Inbound that establishes the necessary requirements of insurance and that Inbound will conduct basic logging duties that comply with OSHA and safety laws. This agreement is in development and will be signed by both parties. Seneca estimates that Inbound has insurance that goes above and beyond the needed insurance requirements due to the nature of their primary work.

Table 8: Private Timber Options

Timber Company	Amount of Wood	Contact	Other Notes
Seneca	100 tons per year (private lands) *Additional tons are located on public lands	Kevin Tuers	Open to an annual renewable contract for donated wood.
Roseburg	Roseburg has a limited number of acres in the Oakridge area	David Cramsey, Aaron Ason	Roseburg plans on cutting timber in 3-5 years in the Oakridge area. They are interested in donating again when they have top wood available.

Source: Stakeholder Interviews

Commercial Firewood Program

- **Description:** The commercial firewood provides the sale of firewood sold at a lump sum rate via competitive bid decked wood (down and piled together). The purchase does not require the firewood to be weighed but requires loading, hauling and unloading.
- **Location:** USFS is putting out the following sales: (1) Deception commercial firewood sale in Fall 2018 TBD with base rates of ~$5/cord (2) Rosboro recently won the Burnt stewardship sale and commercial firewood will be part of that contract (3) Jones Hazard Sale with a cost of ~$3/ton or $8/CCF.
- Considerations:
    - *Competition:* Competition with other firewood or wood related companies (e.g., post and pole, chipping)

- *Challenge:* Commercial firewood programs divert USFS funds and staff time from regular timber sales which are mandated work. Administratively, the USFS needs a target that is linked to outcomes.

Table 9: Commercial Firewood Program Options

Location	Amount and price	Type of Sale/Timing
Deception	• 30-40 cords • $5 per cord for the sale plus the labor to get the work done, chipping all waste (brush disposal - BD) highly variable; need to bid it right	• Most likely to be an oral auction • Going to sale in fall 2019
Burnt (via a stewardship sale with Rosboro)	• Not yet quantified the scale of the commercial firewood	• The contract requires top wood centralization for a later commercial firewood sale.
Jones Hazard	$3/ton or $8/CCF	

Source: Stakeholder Interviews

C-2.11 Agreement

- **Description:** Initially, this agreement is between a private timber company and USFS to log portions of public land. The C-2.11 agreement (timber subject to agreement) allows for timber companies to sell portions of the resource from that logged area to third parties as sawtimber or non-sawtimber. The USFS Middle Fork District Office has between 30-40 C-2.11 agreement sales on the books at a time. Inbound could source wood from existing C-2.11 agreements so it could approach existing timber companies that have contracts with USFS in the Oakridge area.
- **Locations:** Multiple but the Wildland-Urban Interface (WUI) thin is located near Oakridge. WUI thins assist in reducing fire risk.[7] Given the increasing danger of wildfire, this is likely to be available in many communities.
- **Considerations:**
  - *Disinterest from private timber companies:* Unlikely pathway due to lack of interest by timber companies given the challenges of seasons, contracting, challenge of access to timber company property (legal/insurance liability) and price point to cover costs. This contracting pathway is subject to the level of interest and perceived value by the private timber company. Don Hardwick

[7] USFS Oakridge/Westfir Thinning and Fuels Reduction Project
https://www.fs.usda.gov/detail/willamette/fire/?cid=fseprd576662

at Roseburg mentioned that they have tried this approach before with other entities that did not have the insurance or legitimacy to be trusted. Given Inbound's level of risk insurance held as a wildland firefighting outfit and reputation, Don shared the contact information for Franklin Clarkson Investments which now owns and operates the private lands for Roseburg.

- *Inconsistent supply unless formal agreement is developed:* Tule Creek had the experience of developing agreements with private timber and landowners but many of those agreements were not followed through on because the pricing went up and made it more worthwhile for landowners to sell into other markets and products.
- *Requires relationship building*: Requires time spent to build relationships and reach out to potential timber company partners
- Low price option for purchaser (e.g., penny a ton) but need to make it profitable to transport to timber companies.
- *Significant supply of wood:* biomass volumes.

- *Table 10: C-2.11 Biomass Volumes in the Oakridge Area* below outlines the number of green tons USFS estimates via C2.11 agreement biomass volumes.

Table 10: C-2.11 Biomass Volumes in the Oakridge Area

			Total Volume				Total Biomass (Green Tons)		
Sale Name	Acres	Species	Gross BF	Gross CF	Net BF	Net CF	Tip (6"-0")	Branches	Foliage
Chalk Thin	428	DF, GF, WH	9,242,338	1,731,409	9,136,396	1,710,660	5,573.7	2,761.7	3,763.2
Armet Thin	472	DF, WH	13,227,238	2,392,494	13,025,036	2,355,883	4,684.7	6,686.3	5,119.0
Ash Thin	341	DF, WH	10,955,095	2,001,567	10,455,330	1,911,787	5,383.3	4,267.2	4,383.7
Black SBA	186	DF, RC, WH	4,630,901	848,056	4,380,590	803,992	2,862.2	1,242.5	1,857.1
Crale	232	DF, WH	5,939,549	1,105,811	5,858,798	1,091,299	3,517.3	1,858.8	2,433.8
Dell	271	DF	4,884,638	919,237	4,637,089	873,430	3,325.5	1,144.2	2,021.0
Duval	232	DF, WH	4,359,323	811,691	4,311,330	803,195	2,888.7	1,057.5	1,793.1
Lone SBA	408	DF, WH	9,929,316	1,842,206	9,435,385	1,754,480	6,277.3	2,706.8	4,134.8
Kreuger	318	DF, RC, WH	5,773,983	1,104,233	5,696,990	1,089,591	4,544.4	1,010.3	2,452.5

Source: USFS Middle Fork District Office

Stewardship

- **Description:** Stewardship work is directed to assist in contributing additional benefits on the landscape for public lands. For example, other benefits include the removal of tight young stands that would improve habitat and removal of certain types and stands of trees would reduce hazardous fuels and wildfire risk. Additional target benefits include parcels that are overstocked and could be candidates for tree removal. Wallowa Resources has been successful in NE Oregon in coordinating with the Wallowa-Whitman Forest Collaborative on stewardship and other timber

sales. A similar partnership with Southern Willamette Forest Collaborative is essential to success.

- **Types of stewardship contracts:**
    - *Integrated Resource Timber Contracts (IRTCs):* IRTCs are used when the value of timber exceeds the cost of the services. There are two types of IRTC, one for timber measured after harvest, and the second for timber measured before removal. https://www.fs.fed.us/restoration/Stewardship_Contracting/guidance.shtml
    - *Integrated Resource Service Contracts (IRSCs):* IRSCs are used when the cost of the services exceeds the value of the timber. https://www.fs.fed.us/restoration/Stewardship_Contracting/guidance.shtml
    - *Stand-alone Service Contracts:* These contracts would not apply to firewood because they do not include product removal.
    - *Stewardship Agreements:* Stewardship agreements are used to achieve mutual benefit by allowing both parties to contribute resources and agreements may include product removal. While stewardship agreements have mostly been used in the Eastern U.S., Lomakatsi in Southern Oregon has been successful in developing stewardship agreements that include an educational component but also assist in accessing supply of wood for their business. Based on the last Farm Bill, stewardship agreements can be made for up to 20 years.
- **Locations:** Current work is setting the stage for the Rigdon area for a stewardship sale. See Figure 21 in the Appendix for map of Rigdon planning units that are in pre-commercial thinning stage (overplanting) for pine plantations that want to thin out for restoration (grass feeding areas for elk). Lowell is the next location that may be incorporated into the planning phase for stewardship sales but might be too far from Oakridge to be economically viable.
- **Considerations:**
    - *Real coordination time needed:* Multiple USFS staff from different departments are required to develop a project (e.g., silviculture, contract management, etc.) which is challenging when individual departments are focused on their own outcomes (e.g., board feet, habitat).
    - *Evolving metrics aligning with stewardship:* Historically USFS has been focused on the number of board feet logged and sold, but a new timber metric is being established – acres of fuels reduction (still to be defined and implemented). Generally, small timber sales are viewed as diverting USFS funds and staff time from regular timber sales which is mandated work. Administratively, this provides USFS a target that is linked to appropriated work. A commercial firewood program is not going to amount to much in the

way of board feet, reduction of hazardous fuels is a more likely fit and way to demonstrate shared value with USFS metrics. In addition to this new metric, the timber goal for the Middle Fork District Office is going to increase from 40 million board feet to 50 million board feet by 2020.

- *Timing:* Stewardship sales take time to organize and implement which means this type of pathway is a better longer-term strategy (beyond 2019).
- *Scale:* Stewardship contracts can usually be scaled from 5 to 500 acres
- *NEPA:* It is preferable to focus on locations that would *not require additional NEPA* studies because that adds more complexity and decreases the possibility of completing the project. Due to NEPA, felling versus logging would be treated differently.
- *Reliability:* The Middle Fork USFS office is making a significant effort to identify opportunities to find solutions to a community firewood program. A few interviewees in other USFS districts mentioned that the USFS can be unreliable in long-term contracts due to shifts in leadership and management. Changes at the federal level in policy approach can ripple through the local USFS district office and make it difficult to follow through on previous partnership approaches.
- *Equipment:* Either Inbound would need to do the logging or it would subcontract or purchase this service from a timber or logging firm. Given the significant capital investment in logging equipment such as a yarder and log truck, it is preferable that Inbound contract out these services for the foreseeable future. Inbound does not intend to become a logging company and the sheer cost of owning this equipment and not keeping it as close to full or optimal utilization would result in higher costs of ownership and negatively affect the viability of the project as a whole.

Table 11: Stewardship Options

Location	Amount	Additional notes
Valley Thin	• 1,886 CCF biomass[8] • 60%/40% sawlog to biomass	• $90,000 for hauling costs for biomass portion; extreme example of expensive road fees • See Appendix for pictures of Valley Thin

[8] David Haupt. 2016. Valley Thin Biomass and Sawlog Project Economics.

Burnt	• 1.8 million in retained receipts for further restoration	• Rosboro made the purchase in 2018; portion will go to commercial firewood sale

Source: USFS Middle Fork District Office; Sarah Altemus-Pope, SWFC

Good Neighbor Authority (GNA)

- **Description:** GNA is a different pathway to supply wood similar to timber sales, commercial firewood, and stewardship contracts. The GNA program is new to the state and is mandated by a master agreement between the State of Oregon and USFS to carry out "authorized forest, rangeland, and watershed restoration services' on National Forest System lands." The program, managed by Oregon Department of Forestry (ODF) has three current GNA Foresters working in Oregon (Klamath Falls, Grants Pass, Springfield) covering nearby forests (e.g. Willamette National Forest). A Supplemental Project Agreement (SPA) is an ODF administered timber sale on federal forest land and the revenue from the sale is used to cover costs and accomplish additional restoration. Example projects include: thinning (commercial and non-commercial) for hazardous fuels reduction or forest health or NEPA support work (e.g., botany survey, stand exam, analysis, drafting).
- **Location:** Willamette National Forest. ODF is currently working on two sales, one on the Middle Fork and another on the McKenzie. The following mapping resources highlight the locations of public lands in Eastern Lane County and the Oakridge area.
    - https://gisapps.odf.oregon.gov/maps/pdm/SouthCascade_ELaneWest_2012.pdf
    - https://gisapps.odf.oregon.gov/ProtectionMapDownload/

Road Maintenance – *An alternative approach*

- **Description:** This creative mechanism could be pathway developed in multiple ways from a stewardship sale to commercial firewood sale or an agency service project (IQ – pre-approved contractors). This road maintenance pathway would offer Inbound the option of clearing overstory trees parallel to the road within 30 feet from the road. Daylighting the road would provide Inbound with soft and hardwood trees in the diameter of 4-20" – the ideal diameter for commercial firewood processors. Road maintenance would be helpful to the USFS because encroaching trees increase road repair and maintenance costs. A daylighted road can dry out faster and snow melts faster, which both lead to longer road longevity. Inbound or a contractor would cut roadside sources and also be responsible for chipping all waste (brush disposal - BD) or piling and burning.

- **Locations:** Strategically identified fire break roads close to Highway 58, within 5 to 10 miles from Oakridge may be suitable for the project. Additional locations that may function for this project include Road 19, Pine Grass stand and Pioneer Gulch.
- **Considerations:**
    - *Volume and feasibility:* This pathway of roadside linear harvesting might not add up to a sufficient amount of volume to meet financial feasibility given that much of the roadside material is small diameter wood. Interviewees of firewood businesses indicated that this approach is inefficient in comparison to standard commercial logging as most of the roadside material falls below the economic margin. Tule Creek ran numbers on this idea and also on bidding on small sales and found a minimum threshold of 150 acres within 5 road miles and that the area must be within 15 miles of the processing facility. Tule Creek determined that to run a 8 person operation and produced 200 finished outgoing loads on a truck it would require approximately 300 acres with a net cost of $35 per ton delivered.
    - *Higher costs associated with logging and maintenance*: This approach would also require the removal of brush patches and pile slash (e.g., limbs) that has limited value or increased costs.
    - *Inbound capable of this work*: Inbound does have the equipment and skilled crew to complete this work. Making it financially feasible is another matter.
    - *Potential to access hardwoods:* Roadside wood would include softwoods but also offer access to maple, alder and hemlock. Additionally, saw timber from this work could go to the mill to help offset costs.
    - *Potential to incorporate into contracts or access grant dollars:* The use of stewardship or retained receipts could pay for this work and be packaged into small timber sales and IRTC contracts to fund the roadside projects in the same landscape or to tap into hazardous fuels dollars given that it provides fuel breaks via the road system. Another possibility for Inbound and the resource development work being directed toward woodsmoke mitigation, would be to request grant funding for firewood supply that is reducing hazardous fuels, improving road infrastructure and meeting the air quality efforts of the community firewood program.
    - *Road deposits*: Paved roadway maintenance locations could accumulate significant amount of road deposits given the long stretch of asphalt road. The approximate cost would be $0.86 per mile per cord when traveling on an asphalt road. This analysis or per distance road deposits is included in a preceding section.

Potential Partners

The following table outlines different types of partners that could either assist in gaining access to supply or markets. In some instances, these organizations could serve as competition.

Table 12: Potential Partners and Collaborators

Organization	Partner Type	Benefit	Contact
Burnt Forest Products	Complementary	Co-location; partner to access supply more easily	TBD – may not be sited in Oakridge
Giustina Resources (GR)	Private timber sales	sort yard in Dexter 37755 Hwy 58	Dexter; Contact: 541-345-2301
High Mountain Resources	Logging subcontractor	http://highmountainlogging.com/about-us/	Ken Groat, 541-954-2089
Houser Logging	Logging subcontractor	http://www.orforestdirectory.com/company/houser-logging	Tom Houser, 541-954-5108
Jones Logging	Logging subcontractor	Contractor on small sales (commercial firewood, stewardship)	Trent Jones, 541-954-7248
Oakridge Sand & Gravel (Fisher Land Co)	Rental equipment, road deposit weight scale	http://www.oakridgesand.com/productsservices/#/equipmentrentals/	Lindsay Skordahl, 541-782-2201
O'Malley Bros.	Logging subcontractor	https://www.omalleybros.com	(503) 407-3055
Oregon Woodland Cooperative	Complementary or competitor	Market access https://www.oregonwoodlandcooperative.com	Neil Schroeder, OWC
Pride LLC	Logging subcontractor	Contractor on small sales (commercial firewood, stewardship)	Chris Schipp, 541-521-4692
Scott Timber / Campbell Global	Private timber sales	Supply of firewood; WUI thin just outside of Oakridge	Mark Oergel, Northwest Regional Manager
Seneca	Private timber sales	Supply of firewood	Kevin Tuers, 541-913-2143
T2 Incorporated	Logging subcontractor	Could perform logging operations in Oakridge area	Jeremy Totman, 541-367-5180
Triple T Logging	Logging subcontractor	Contractor on small sales (commercial firewood, stewardship)	Tom Asher or Cody Wilson; 541-937-3129
Wood Recovery	Complementary or competitor	Co-location; partner to access supply more easily	Russ Van Wyck, 541-735-1086

Analysis and Recommendations

Supply is one of the greatest challenges to the feasibility of a commercial firewood program. Reliance upon one source of wood, either private or public could endanger the long-term viability of a business given peer experiences. Longer-term public side contracts are most likely to provide Inbound and potential partners the most secure source of supply. Being strategic about developing public and private relationships and agreements, while staying ahead of the upcoming year's demand for wood, may require storing wood for longer time periods to ensure that it is available for the firewood season. Small timber sales, stewardship agreements and commercial firewood sales are most likely the best contracting pathways for the long term. It may be possible to partner with a timber company or logger on certain contracts that are mutually beneficial where saw timber would be coupled with firewood supply.

- **Phase I Approach (2018-ongoing): Donations, commercial firewood program and private purchase:** Supply in the near term is contingent on finding relatively swift transactions that can access a smaller supply of wood at a reasonable price. The best near-term potential for accessing firewood supply for the community firewood program is to:
  (1) Partner with private timber companies to receive donated wood
  (2) Win a commercial firewood auction via the Forest Service
  (3) Purchase wood from private timber companies

- **Phase II Approach (2020-2030) Collaboration and small sales:** A larger firewood operation will require a more significant and consistent supply of wood. Stewardship collaboration is most likely the best opportunity for a reliable source of firewood while maximizing the number of benefits for multiple stakeholders (e.g., forest health, wildfire suppression, community health, economic development).
  - *Small sales:* Potential to go after small sales similar to what USFS has put out recently. Cowhorn (1 million board feet) and Slick (1.5 million board feet). However, these sales will have a lot of competition and will require partners to leverage the diversity of wood types/markets as the sales ~$85 per ton.
  - *Collaborative and building the case within USFS:* Categorical Exclusions (CE) for fuel reduction are prioritized by the District Ranger annually. CFP could be part of that exclusion but requires political capital and priority.
  - *Finding a solution for road deposits:* If the wood is sold by tons it requires road deposits (paid based on the approximated value of sold timber diameter/volume) but if sold by cords it would not require road deposits.

- *USFS multi-delivery approach:* Tule Creek mentioned the possibility of replicating the USFS approach for small areas which has been done in certain areas (e.g., southern California's San Bernardino and Los Padres National Forests) which pre-dated the type of IRSC contracts (e.g., Malheur National Forest selling prior to the 10-year with Iron Triangle) for a single sole source, 10- year stewardship contract. This approach "separates the logger from the log" and removes the motive of the logger to cut first and high grade because income is not tied to the wood. Instead delivery is made on the amount of wood to certain endpoints with a subset of that wood going to commercial firewood programs.
- *Maintain donated wood partnerships:* Inbound should reach out to Seneca and Roseburg every six months to determine the short to medium term planning of timber cutting and what sources could be accessed for donation.

6. Site Assessment and Permitting

Overview of Site Needs and Operational Footprints

The range of site, equipment and permitting requirements range widely from a simple, small-scale commercial firewood operation to an integrated biomass facility that is processing and producing multiple end-use products or outputs (e.g., energy). For the purposes of this feasibility study, we have determined that a phased approach from a community firewood program (Phase I) could be built into a more substantial commercial firewood business in a few years (Phase 2) with the appropriate investment in site and equipment.

- Phase I: 2018-ongoing – small scale community firewood program (50-500 cords)
- Phase II: 2020-2030 – develop larger site, facility and equipment to increase the production and supply of seasoned firewood (1,000 to 4,000 cords)

Overview of Phase I: 2018-2020

- **Site and facility:** Facility space at the former Oakridge Public Works building, adjacent lot and outbuilding to process and store wood for the program. The Public Works building is located at 47899 Highway 58. The site consists of 1.89 acres of which the main building is 5,200 ft^2 and the shed is ~2,000ft^2.[9]

[9] Rick Zylstra, City of Oakridge

Figure 7: Public Works Building for Phase I Use

Source: City of Oakridge, Google Earth image

Overview of Phase II: 2020-2030

- **Site and facility:** The City will consider providing Inbound with a lot or lot portion at the Oakridge Industrial Park suitable for an enhanced operation with additional space allocations to process and store firewood.
- **Site improvements:** Inbound will make improvements to the site to ensure the function and security of a firewood operation. Next year the City and Inbound will work to establish an understanding of Inbound's contribution to facility improvements in the event of another tenant's interest in the site (e.g., right of first refusal, financial compensation).

Site size required in Phase II

- **Processing and drying space:** For Phase II, the site would require a roofed processing facility but it would ideally be sided. Also required is a yard for storage and processing of no less than 21,000 ft^2 to dry wood, whether that was done by spreading the wood thinly out on the asphalt, stacked, piled, caged or palleted.
- **Storage space:** A cord occupies 32 square feet of floor space and 128 cubic feet of volume (4 feet wide by 4 feet high by 8 feet long). Table 13 provides the amount of square footage needed for Phases I and II based on annual production and whether the cords are stacked in bins one-high, two-high, or three high? Depending on

stacks, Phase I would require between 3,200-12,800 ft^2 and Phase II would require 20,800-83,200 ft^2.

- **Other examples:** Washington Woodland Cooperative is currently occupying a 15,000 ft^2 warehouse space in Skagit County and has temporarily built hoop structures in Whatcom County for its operations there.

Table 13: Storage Space Required for Firewood Cords

Space required	**Phase I**	**Phase II**
Number of cords	400	2,600
Single stack (sq. ft.)	12,800	83,200
Double stack (sq. ft.)	6,400	41,600
Triple stack (sq. ft.)	3,200	20,800

Figure 8: Example of Stacked Cords in Cages

Source: http://mlarge.com/offers/

Public-Private Partnership

The City of Oakridge is a key partner in sustaining the community firewood program. The City has been instrumental in past community firewood program years, donating space for processing and storage as well as assisting Inbound in the transportation and access to firewood. Without the City, the program would not have been possible and it is key to have the City participate in sustaining the community firewood program in a way that is works for the City and ensures a stable foundation for the residents in need.

MOU Agreement

As a part of this work, we worked with the City of Oakridge, Inbound and SWFC to draft an MOU agreement. The MOU agreement outlines the public-private partnership between the City and Inbound and highlights the assistance of the City to ensure the longevity of the community firewood program. With the assistance of the City, Inbound intends to operate the community firewood program at the Public Works building for two years before moving to the Oakridge Industrial Park to develop a more substantial operation. The MOU was vetted in October 2018 by Oakridge City Council and the City will support the community firewood program for another year to be evaluated next year with respect to facility location and plans.

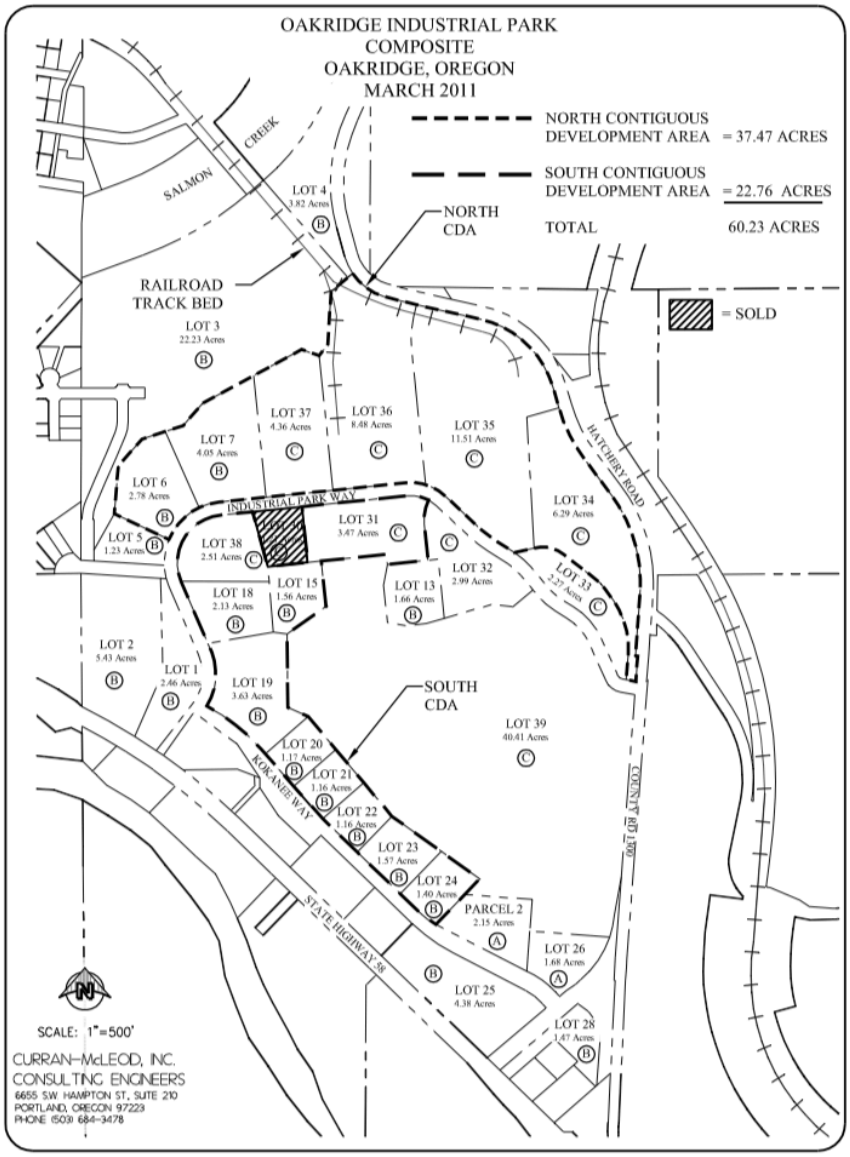
- **Equipment and personnel:** For both phases, Inbound will provide all necessary machinery, personal protective equipment, security and insurance needed to complete the work. Inbound will also be responsible for hiring workers and managing the jobsite.
- **Transportation and delivery:** In Phase I, the City will provide access to transportation and delivery of donated wood from local timber companies when the distance for dump trucks and City staff is within a reasonable distance (<35 miles) *when City staff are available*. In Phase II, Inbound will continue to rent or purchase equipment to carry out the transportation of wood supply to the processing and storage facility.

Site Location and Process Layout

Sites available

The City of Oakridge is a critical partner, not only in Phase I but also in Phase II. The Figure below outlines the lots and site boundaries at the Oakridge Industrial Park (OIP) which might be the most likely locations for a Phase II siting. Currently, Inbound is utilizing a small portion of a lot in the OIP. In Phase II, this lot may be the one appropriated for the firewood program with additional space to account for increased operations and storage. Per the MOU agreement, the site location for Phase II is left vague on purpose as site opportunities is likely to shift over the next two years.

Figure 9: Oakridge Industrial Park Layout and Lot Lines



Source: City of Oakridge

Process layout and design flow

Given that every time firewood is touched, it adds labor costs, it is vital that site layout and process minimize the amount of labor and facilitate each of the primary steps and flow of an operation. This particular cost center is one that can jeopardize profitability, therefore, a more detailed process layout and engineering design should be completed if a large-scale biomass facility were to be developed. Wood innovation grants could be helpful in paying for part of the site design.

Interviewees did share some of the following recommendations for site process layout and flow:

- **Production flow:** The operation's equipment will dictate how the movement and flow of firewood production goes. Tule Creek, for example, used a process that went from a self-loader to the firewood processor into a tumbler (to rotate out fines) to a bin which was moved by a skid-steer to the kiln, which was then batched and then bundled into firewood bundles.
- **Consideration of waste:** Waste will be created throughout the process due to breakage and wood fines. OSU Biomass Model anticipates that 10% of the wood is fit for the wood hog.

Figure 10: Wood Fines

Source: http://www.marks-miller.com/woodchips?lightbox=image1be3

Figure 11: Use of Wood Waste as Fuel to Power Kiln

Source: TimberLine, January 2016, Volume 22, Number 01

- **Process direction:** Its essential to set up the flow of the site so that wood flows through the equipment and can be sorted into different quality piles and storage. Washington Woodland Cooperative has a system flow that runs through the log splitters into two piles based on quality, then is set to stack and bin. Heritage Resources had a more sophisticated set up, using a telehandler and the function of gravity. Heritage relied upon an engineering study developed by grant funds from a wood innovation grant. A number of firewood operations rely upon placing firewood cords in bins or cages and move them around with a forklift.

Figure 12: Drying Firewood Post-Processing

Source: https://forestproud.org/2018/04/03/living-with-fire/

- **Drying requirements:** There are a combination of different approaches that commercial firewood operators choose to dry wood. The choice of how to dry wood is a function of the timing and scale of the wood supply, site facility and its ability, equipment, personnel and availability of time. Based on interviews, the following are the two most likely approaches for drying although they come with the need for site specific modifications:
    - *Open air:* Exposing wood to air and particularly using the sun in the summer months to help dry wood is one approach. Some spread wood a couple of feet thick out on a hard surface, such as asphalt, to allow the sun to penetrate the wood. Some operators stack wood (post-processing) and position the stacks in such a way that prevailing breezes or wind can go through the stacks of wood and further the drying process. Stacking provides more air flow so the wood can season and dries off any moisture that would help fungus and rot. The primary challenge with stacking is the labor involved. Tule Creek tried the spreading of wood on asphalt, however, found that it resulted in a fairly dirty product. Some operations use fans to help

season wood and prevent mold and a few of the Oregon Woodland Cooperative members use dehydrators in an insulated building to treat the wood but this most likely functional for smaller batches of wood (i.e. may not be scalable based on cost constraints). Some complete the drying process

after processing the wood but others dry the wood first during the summer months and process afterward. Drier, seasoned wood is more difficult to cut with equipment but it does provide the benefit of pre-drying which Tule Creek considers more important than additional saw maintenance. He also mentioned dry logs do not reabsorb moisture very easily.

- *Kiln:* Larger commercial firewood operators, particularly those that sell firewood bundles that cross state lines, generally use a kiln system to dry wood, in part due to the significant amount of space and human labor required to process firewood at scale. Additionally, a larger scale firewood operation will also accumulate a significant amount of wood waste in its process and a kiln can be one place to utilize the waste wood as a fuel. Natural gas and electric powered kiln options are available as well and referenced in the financial feasibility section. For Tule Creek, they noted that there was waste at almost every stage of the process due to breaks and lack of uniformity in incoming pieces. When a wood-fired kiln is up to temperature, it runs smoothly and cleanly, but generally emits visible smoke when it is getting up to temperature. The challenge with a kiln outside of the permitting requirements and the potential to undo the air quality benefits of the dry firewood (see section on permitting); is the necessary oversight it requires to cycle it in and out of the rest of the operation. Some level of "feel" is necessary to stage the labor and someone is needed to watch the kiln (overnight and on weekends) even though the kiln system has the electronics to manage temperature and fire suppression. A moisture meter is not an internal feature of the kiln although this could probably be added by modified by the user. Tule Creek took out a sample from the kiln to measure moisture content. For Tule Creek, drying became the pinch point in the process and they eventually needed two kilns to run at full production. Tule Creek mentioned that the timing of feeding through the kiln and being ready to ship can be a challenge. Ideally firewood is kiln dried and wrapped not too long before it is shipped because the firewood bundles covered in plastic can absorb moisture and start to mold.
- *Insulated building with dehumidifiers:* For smaller operations, such as OWC, some of their members use small, well insulated buildings (e.g., R36 building insulation) with 3-4 dehumidifiers at 120 degrees to dry the wood.
- *Methods to avoid:* Many of the interviewees recommended to avoid tarps which prevent air flow. Piling wood was advised against since the lack of air flow grows fungus and promotes rot and decay.

Technical personnel

For larger systems, particularly in Phase II, interviewees recommended strongly to hire a process engineer to design the layout that could maximize efficiency of the site. Evergreen Engineering might be a point of initial contact. ODF may also have connections to the firm that completed the technical and engineering for the USFS Wood Innovation grant given to Heritage Resources.

The following page has an aerial image of a medium-sized commercial firewood business operation. This is helpful in identifying the different piles of material (different log sorts, cut firewood, and broken/waste material. In the center of the photo is the firewood processor with conveyors to a tumbler and then another conveyor to a truck. This operation has multiple trucks, skidsteer, log loader and wood hog. Overall the site arrangement is fairly compact reducing time and labor but there perhaps could be more of a linear process from initial feedstock to final product.

Figure 13: Aerial View of Site Layout of Burnwood Industries

Source: http://extension.umd.edu/sites/extension.umd.edu/files/_docs/programs/woodland-steward/U%203%20Stories%20from%20a%20Firewood%20Business%20Owner-Chirico.pdf

This series of photos shows the series of steps that the Watershed Center's Tule Creek operation.

https://forestproud.org/2018/04/03/living-with-fire/

https://forestproud.org/2018/04/03/living-with-fire/

Permitting and Regulations

This section provides a summary of federal, state, and local permits and regulatory considerations that will need to be completed to construct the commercial firewood facility, as well as any potential regulatory and permitting issues that may hinder the development of the facility.

City of Oakridge

Local permits required for a commercial firewood program would include:

Industrial permit designation:

- Light Industrial District (I-1) or Heavy Industrial District designation (I-2) which includes businesses for "retail sale of wood for fuel or the sale of other wood products" and would likely be dependent on the City of Oakridge's Planning Commission's classification.[10]
- Both light and heavy industrial district require a 10,000 square foot facility minimum size, although an applicant could request a conditional use permit from the City's planning commission.
- The maximum height of the building would be three stories or 35 feet, whichever is less.

Conditional use permit:

- Article 24 covers Conditional Use Permits and provides an overview of the application requirements[11]:
    - Site and building plans and elevations.
    - Existing conditions on the site and within 300 feet of the site.
    - Utility and access data.
    - Operational data.
    - All other information requested by the Planning Commission.
- In September 2018, Inbound, with the assistance of Good Company, submitted a conditional use permit for the Public Works building use. The submission provided details on the goals of the community firewood program, local and parcel maps,

[10] City of Oakridge. Section 2.01 Building Permits and Inspection. https://www.ci.oakridge.or.us/documents

[11] City of Oakridge. https://www.ci.oakridge.or.us/sites/default/files/fileattachments/general/page/15001/ord874_land_uses_and_development.pdf

neighbor contact information, and additional information required in Section 24.06 and 24.03 of the zoning ordinance, specifically:

- Front 25 feet of building depth allocated for sales of the community firewood program COZO 8.02(2)(g)
- Screening on the fence or out of site storage COZO 8.02(2)(i)
- Noise and hours of operation COZO 24.07(1-11)

Lane Regional Air Protection Agency (LRAPA)

LRAPA has been an important partner for improving woodsmoke in Oakridge and should be included in conversations regarding equipment options. Per LRAPA staff, if the commercial firewood program would be operating a wood-powered kiln, the project would require the air contaminant discharge permit under either A.9 or B.62.[12]

- "A9. Sawmills and/or planing mills and/or millwork and/or wood furniture and fixtures manufacturing and/or plywood manufacturing and/or veneer drying of more than 5,000 but less than 25,000 board feet/maximum 8 hour finished product."
- "B. 62 Sawmills and/or planing mills and/or millwork and/or wood furniture and fixtures manufacturing and/or plywood manufacturing and/or veneer drying of more than 5,000 but less than 25,000 board feet/maximum 8 hour finished product."

Seneca and Other Private Timber Companies

During the course of this feasibility study, Good Company coordinated with Seneca for the donation of 40 cords of wood to be donated in 2018 to the community firewood program. Seneca and Inbound are entering into an annual, renewable contract which grants Inbound access to Seneca's private lands to access the donated firewood resource. Inbound is complying with the required insurance needed to ensure that they hold the liability necessary.

[12] Lane Regional Air Protection Agency. 2018. Table 1 - Section 37-8010 Activities and Sources. http://or-lanerapa.civicplus.com/DocumentCenter/View/264/Title-37---Table-1-PDF?bidId=

Oregon Occupational Safety and Health Division (OSHA)

If Inbound is cutting, collecting or transporting wood from private and public lands, they will need to comply with OSHA's Division 7 Forest Activities document which outlines forest activities rules and standards.[13] Inbound is already bound to wildland fire suppression regulations which are likely to exceed the Forest Activities requirements. Depending on Inbound's approach and involvement in certain operations, Inbound should guarantee that they are complying with OSHA's requirements for:

- Log hauling
- Timber cutting and thinning operations
- Clearing and slash disposal

Oregon Department of Agriculture

There are no explicit conditions for commercial firewood for in-state sale; however there are limitations imposed on out of state export sales to avoid the transport of invasive species. The best practice is to limit the movement of firewood within the immediate region or use a kiln to dry the wood which also eliminates pests.

- Oregon Department of Agriculture – Division 52 PEST AND DISEASE CONTROL: 603-052-1080 Firewood Restrictions To Prevent Transport Of Invasive Species https://secure.sos.state.or.us/oard/viewSingleRule.action?ruleVrsnRsn=158399
- U.S. Department of Agriculture (USDA) – Risk Assessment of the Movement of Firewood within the United States https://www.aphis.usda.gov/import_export/plants/plant_imports/firewood/firewood_pathway_assessment.pdf

[13] Oregon Occupational Safety and Health Division. 2018. https://osha.oregon.gov/OSHARules/div7/div7.pdf

7. Financial Analysis and Results

Note: The financial analysis shared in this section was developed in a series of Excel worksheet tabs (feasibility scenarios, cash flow, production and revenue, and capital and operating expenses). This spreadsheet will also be provided as a deliverable to Inbound to assist in the decision-making process and forecast potential supply, market, and production facility considerations as project details shift and change.

Overview of Scenarios

This section begins with an overview of the components of the two phases of the commercial firewood program including location, equipment, product mix and feedstock.

Phase I

Facility location and improvements: Old Oakridge Public Works building; nominal upgrades to security and fencing to comply with the conditional use permit.
Equipment: Small scale equipment set up – skidsteer or front-end loader (used) and kinetic splitter (new).
Labor: For Phase I, just under 3 FTEs are assumed over a three month window of time.
Product mix: Cords for community firewood program and local cords
Feedstock: Donated and purchase from public and private sources

Phase II

Facility location and improvements: Oakridge Industrial Park; either retrofitting existing industrial park facility or erecting a Clearspan building to accommodate processing and storage.
Equipment: Large scale equipment set up – firewood processor (used), small log loader (used), firewood bundler (new), dump truck (used), kiln (used/new) and production table (new).
Labor: For Phase II 7 FTEs are assumed over a six-month window annually.
Product mix: Cords and firewood bundle options
Value add: Kiln dried option
Feedstock: Multiple source options (donated, private, public)

Capital Costs

This section provides the cost estimates associated with the start-up capital costs that would be necessary to implement a commercial firewood facility. These costs are distributed between two major costs areas – facility improvements and equipment.

Facility Improvements

Inbound will operate initially at the city owned facility or site before likely moving to the Oakridge industrial park. If Inbound uses one of the City lots in the Oakridge Industrial Park in Phase II, Inbound will most likely need to either contribute to facility improvements (e.g., constructing walls on current facilities with only rooftops) or build Clearspan buildings for processing and storage. The exact location of operation will determine the level of investment required to either retrofit the building or to stage Clearspan buildings with Ecoblock foundations. Given that most of the Industrial Park is paved open space, it is likely that a clear site would be the easiest for the City to provide. The baseline assumption for the building and facility is a Clearspan structure and was compared against higher and lower facility investment options in the financial analysis. Inbound could either pursue grant funding, purchase or request a loan to complete these building or site improvements.

- **Retrofitting the industrial park facility:** City staff has indicated that the facility that might be available is one that already has an existing roof structure but has no walls and therefore would require putting insulated walls and necessary (bathroom, office space) would cost up to $500,000 according to City staff.
- **Clearspan:** Clearspan offers a variety of building options. We received estimates from Clearspan on building sizes of 165x150 Kwanza hut design and 100x200. Brad Williams shared that the scale of costs is not linear to the building size. Clearspan buildings that are no wider than 100 feet on one side are more reasonable in price and do not require additional engineering. The exception to this is the hoophouse/Kwanza hut that Clearspan sells. The following are the project costs and specifications for two buildings that would work for Phase II. For a model with just one end wall, a partial end wall would cost between $5,000-10,000. Insulating the building can be quite expensive due largely to the labor cost. For instance, $180,000 would be the estimated cost of insulating a 20,000 square foot building the Arch building model. Additional components and costs can include ventilation system (big box fans) which are only a few thousand dollars. Security is a recommended consideration and there are specific options available.
    - *Hoophouse/Kwanza:* 165 x 150ft^2, total cost of $132,500; $90,000 for the structure (one open end, close end), $30,000 in labor costs, and $12,500 in ecoblocks for a six foot foundation/retaining wall of six feet (requiring 250 at

a $50 per block cost. A ready mix concrete company such as UltraBlock (Vancouver, WA) is a potential provider. This model offers 30 feet of clearance in the middle of the structure and nine feet on the edges.

- *Arch Building:* 100 x 200ft^2, total cost of $285,000, this design comes with end walls with engineering $220,000; $65,000 in installation costs; This model would be 40 feet in height in the middle and 12 feet eave height at the edges.

Table 14: Facility Improvement Costs

Facility improvements	Phase I	Phase II	Source
Building/Land	-	$5,000	City of Oakridge
Facility improvements	$500	-	Inbound
Retrofit exising building*	-	$500,000	City of Oakridge
Clearspan building (165x150)	-	$132,500	Clearspan
Clearspan building (100x200)	-	$285,000	Clearspan
Electrical and water connection	-	$15,000	City of Oakridge
Log decks area	-	$5,000	OSU Biomass Model

* insulated building sides, breakrooms and bathrooms

Note: The base assumption for facility improvements used Clearspan building costs of $132,500.

Equipment

This section provides an overview of the necessary and additional equipment options for both a Phase I and II operation. The base scenario for costs includes used equipment to keep the initial capital investment lower; however, research identified new or upgraded equipment and that information is contained in the table below.

Table 15: Equipment Costs

Equipment Costs	Phase I	Phase II	New or Upgrade	Source
Skidsteer / front-end loaders	$42,000		$140,000	Multiple, local regional providers
Trailer	$12,000		$25,000	Trailers Plus
Firewood splitter (kinetic)	$3,000			OWC / Super Splitter
Self-loading log truck		$100,000	$175,000	Multiple - see table in study
Firewood processor		$50,000	$100,000	Multiple - see table in study
Small log loader		$50,000	$150,000	Multiple - see table in study
Firewood bundler		$2,300	$15,000	Twister Industries / OWC
Kiln		$49,500	$150,000	Kiln Direct / Nyle
Dump truck		$100,000	$300,000	Multiple - see table in study
Wood hog (1000 #/h)		$40,000		OSU
Production table		$5,000		
Cages		$1,750	$35	

Phase I: Smaller firewood operations choose a different array and combination of equipment so there is no prescribed set of equipment; however, a skid-steer and a combination of kinetic and hydraulic splitter seem to be the best practice.

- **Skid-steer loader with grapple or front-end loader:** This piece of equipment is essential in moving firewood on-site at the processing facility and should be readily found used.
- **Kinetic splitter and hydraulic splitter:** Inbound already owns a hydraulic splitter. By adding a kinetic splitter, it opens up the opportunity to cut pieces of wood that are more difficult given its design as well as the benefit of operating the machinery on electricity, meaning fewer air emissions. Oregon Woodland Cooperative and Washington Woodland Cooperative members utilize this type of log splitter and sell it at a subsidized price to members.

Phase II: The second phase of the firewood business requires a much more significant investment of capital. The combination of equipment provided here is fairly standard across operations; however, the specific models and outputs are generally scaled to the types of businesses and anticipates the scale of markets and demand they are targeting. We have adjusted the equipment list and modeled each to be appropriate to the scale of opportunity identified in this study. The following section outlines the recommended equipment and details about peer businesses or equipment manufacturers and is followed by tables of potential vendors and locations for equipment purchases.

- **Firewood processor:** There are a wide variety of manufacturers and models of firewood processors that are available for sale, both new and used. For the purposes of this study we assumed a $50,000 cost for a used firewood processor based on comparable costs and models on the market capable of processing two cords per hour or 16 cords per day. Depending the configuration, firewood processors may include conveyors but if not, these can cost an additional $5,000 to $10,000. Other firewood processors operated the following equipment:
    - Tule Creek used a CordKing 100 HP processor which can cut between 4-10 cords per hour. Tule Creek had a hard time keeping up with the capacity of the CordKing.
    - Heritage Resource purchased a Multitek 2040 which can produce 4-6 cords per hour.
    - One OWC member uses a Timberwolf 50hp which is capable of producing 3-4 cords an hour and costs $75,000.
    - Tetreault & Son Forest Management use two Multitek 2040 firewood processors, a 2009 Multitek 2040 XP2 and a 2002 Multitek 2040 XP in their firewood operation in Massachusetts.

Prior to purchasing a processor, it is important to ensure that the model would be appropriate for Inbound's production including providing the right splitting head and appropriately scaled for the typical size of the wood Inbound is receiving (i.e. difficult to put small logs through big log processors).
    - Current used options for sale as of October 2018:
        - Heritage Resource is selling their Multitek 2040 for ~$49,000
        - 2007 Timberwolf Pro-MX Firewood Processing Machine Roseburg Oregon 97443 for $28,000 https://www.ebay.com/itm/Firewood-Processor-/173337859251
        - 2012 Desjardins Firewood Processor for $25,000 https://cordking.ca/product/2012-desjardins-firewood-processor/
- **Log loader:** If Inbound is managing a larger scale operation, it may be useful to purchase a log loader to facilitate the movement and process flow. A used log loader is approximately $50,000 depending on the age and model. Used log loaders are commonly available in the region.
- **Dump truck or trailer:** One OWC member uses a trailer that can fit three to four cords of cut wood. The investment in this piece of equipment is between $8,000 and $15,000. Inbound may choose to purchase lower cost equipment for the first few years of operation to reduce risk and upfront costs. Used dump trucks are available in the region.
- **Self-loading log truck:** As described previously, a self-loading log truck is not essential, but it would significantly facilitate the loading and transport of firewood material. Inbound could delay the purchase of this piece of equipment for a couple of years until it was needed based on the volume and frequency of loading trips. A mule train would be a viable alternative although to have the self-loader potential on the truck would be preferable.
- **Kiln:** A kiln will be an essential piece of equipment if Inbound decides to scale up to a 1,000 plus cords of annual production, particularly if Inbound is going after firewood bundle markets. A kiln allows entry into out-of-state markets (eliminates pests that are not allowed to travel across state lines), reduces drying time, and ensures moisture content of less than 20%. Interviews indicated that the kiln will often be the pinch point in a firewood operation so some operations either purchase multiple kilns or size these large enough to accommodate the production flow. Multiple types of kilns exist and the majority are fueled by wood, natural gas or propane. Due to air quality issues in Oakridge, and the inability to access natural gas in pipeline, we researched the possibility of an alternatively powered kilns. Solar kilns are not functional at commercial scale which leaves electric-powered kilns. According to kiln retailers, no firewood operation in the U.S. operates an electric-

powered kiln due to the sheer cost of electricity to bring the kiln up to needed temperature. Below is a list of manufacturers of kilns and what peer businesses use.

- *Wood-fired kiln*
  - Kiln Direct is a well-known provider of wood-fired kilns. http://www.kiln-direct.com
  - Tule Creek operated a Kiln-Direct 6 which is currently for sale or could be leased https://eugene.craigslist.org/hvo/d/6-cord-firewood-kiln/6714801647.html
- *Dehumidification kilns (DH):* the challenge to these kilns are the longer amount of time required for drying compared to wood-fired kilns.
  - Nyle https://www.nyle.com/lumber-drying-systems/lumber-kiln-drying/chamber-packages/
  - Kiln Direct also provides a propane-fueled kiln.
- Custom made kiln
  - Heritage Resources engineered a kiln and used chips to feed a gasifier that went to burner tips in the kiln.

Table 16: Comparison of Kiln Costs per Cord

Kiln Comparison	Vendor	Capacity	Normalize to per cord	Energy Use	Units
Wood-fired kiln	KilnDirect	12 cords	$11	3.6	cords/batch
Propane-fueled kiln	Nyle	15 cords	$75	30	gallons/cord
Electric-powered kiln	Nyle	15 cords	$92	17,280	kwH/batch

Source: Good Company Analysis with Kiln Direct and Nyle inputs

We developed a basic comparison of different kiln systems costs based off the technical specifications provided by vendors. See Table 16 for the analysis table comparing kiln types and *Table 17* from Sawmill & Woodlot that compares costs between wood heat and gas.

Kiln Direct's wood-fired kiln with a 12-cord capacity uses approximately a trailer and a half of woody material every one and a half weeks. KilnDirect approximated that this volume would be 36 cords of material for the 10-11 days of operation and split in a three day turn in the kiln equates to 3.6 cords worth of wood needed. At a $35 per cord cost of material (Kiln Direct uses $7 per cord of wood waste cost), to $11 in per cord costs for drying if that material was needing to be purchased. Inbound could certainly utilize some level of wood waste in powering the kiln. OSU estimates in their Biomass Model that a firewood operation can anticipate 10% of total throughput in waste from breakage and fines. Kiln Direct mentioned that its clients approach wood

heating supply differently depending on the nature of their operations and ability to access low-cost feedstock. The moisture content and species (hardwood vs. softwood) will play a role in how much feedstock material is needed. A wood fired kiln will operate best with dry material while wet, softwood wood waste will make the system operate less efficiently and require more feedstock.

A propane-fueled kiln by Nyle is expected to use approximately 30 gallons of propane per cord of wood dried which equates to $75 per cord. And an electric-powered kiln requires a 240 kW heating system for a 72-hour rotation (longer in colder months) with a electricity cost of $0.08/kWh results in a $92 per cost per cord, although this number would probably drop as the system can go down to 5% of operating energy need by maximizing fans and airflow rather than relying purely on heat treatment (estimated around 50% of operating rating. Nyle has only modeled electric-powered options for international buyers that have inexpensive power (hydropower in Canada and nuclear power in Saudia Arabia). Nyle would need to specially engineer this system as it does not offer an electric powered system in its current suite of offerings. Woodmizer does sell an electric-powered dehumidification kiln but the intent of that kiln is directed to drying lumber which has different set of conditions for the width and organization of the wood that is being dried. Firewood is much thicker and would be placed randomly in cages rather than stacked neatly, increasing the time and cost of drying.

In terms of air emissions, KilnDirect is currently undertaking an air emissions study on the model of wood-fired kiln that most suits Inbound's scale. Study results will be available in November and December 2018 and will be shared with Inbound once received. Nyle shared details on the air emissions associated with their propane-fueled equipment. The table shows the values of actual emissions readings taken during heater operation. According to Nyle, four heating units would be needed in a model for Inbound's needs (~1,000 annual kiln-dried cords).

Emission Component	Value
CO_2 %	9.0 -10 %
$CO_{(AF)}$ ppm	0 - 20
NO ppm	60 - 70
NO_2 ppm	7 -10
Nox ppm	67 - 80
SS Efficiency %	82.2
AFUE	80

In summary, a wood fired kiln could add $11,000 of operating costs annually for producing 1,000 cords of kiln-dried firewood. This factor could balloon to $92 per cord or $92,000 for the same level of production. *Note: further information from the kiln producers is being provided and was not available prior to the final submission of this report. A subsequent analysis will be shared with Inbound.*

Table 17: Comparison of Costs for Kiln Drying Firewood

ENERGY COST FOR DRYING 1 CORD OF FIREWOOD	THEORETICAL LAB CONDITIONS	FIREWOOD KILN CONDITIONS
Estimated weight of green firewood: (oak=4,900 lbs., maple, soft=3,960 lbs., ash=4,240 lbs., hackberry=4,040lbs., alder=3,600 lbs.) = average 4,150 lbs./cord	4,150 lbs./cord	
Estimated weight of dry firewood: (oak=3,425 lbs., maple, soft=2,640 lbs., ash=3,181lbs., hackberry=2,940 lbs., alder=2,220 lbs.) = average 2,880 lbs./cord	2,880 lbs./cord	
Amount of water extracted per cord of firewood to be dried.	1,270 lbs./cord	1,270 lbs./cord
How much energy will it take to evaporate 1 lb. of water? Starting temperature is 60° F. Raising 1 lb. of water from 60° F to 212° F = 152 Btu (1Btu = 1° F per lb.). Evaporating 1 lb. of water at 212° F = 971 Btu. Theoretical energy needed to evaporate 1 lb. of water from 60° F = 1,123 Btu. If there is a heat waste factor in any kiln, you will need much more heat due to heat energy escaping during venting, or through walls, floors, and other inefficiencies. *The rule of thumb in lumber drying is 35%–60% waste factor, which means it will cost between 1,700 to 2,800 Btu to evaporate 1 lb. of water in a kiln.*		
How much energy does it take to evaporate 1,270 lbs. of water from firewood? Theoretical: 1,270 lbs. of water x 1,123 Btu/lbs. = 1.4 million Btu (not possible). LOW Estimate: 1,270 lbs. of water x 1,700 Btu/lbs. = 2.2 million Btu. HIGH Estimate: 1,270 lbs. of water x 2,800 Btu/lbs = 3.6 million Btu.	1.4 million Btu	between 2.2 million Btu and 3.6 million Btu
How much energy does it take to raise 1 cord of firewood from 60° F to about 212° F? Average weight of firewood dry (with 20% water) = 2,880 lbs. Temperature increase is (212° F - 60° F) = 152° F increase. Approximately 1 Btu/lbs./1° F increase. Total energy needed to raise wood temperature (2,880 lbs. x 152 Btu/lbs.) = 437,760 Btu.	approx. 440,000 Btu	approx. 600,000 Btu
Total energy consumption needed to dry 1 cord of firewood: THEORETICAL: (1,400,000 + 440,000) Btu = 1.8 million Btu LOW estimate: (2,200,000 + 600,000) Btu = 2.8 million Btu HIGH estimate: (3,600,000 + 600,000) Btu = 4.2 million Btu		
Total cost in energy to dry one cord of wood in the MINIQUICK Firewood Kiln	1.8 million Btu	2.8 million Btu to 4.2 million Btu
Estimated cost of energy with wood waste: 1 cord of firewood is normally 15–20 million Btu (cost per cord = $0–$100)	~10% of a cord up to $10	16%–24% of a cord $16–$24
Estimated cost of energy using LP ga:s Each gallon of LP gas = 91,000 Btu /gal. LP gas Current gas costs: $2 per gal. (probably too low) THEORETICAL: 1,800,000 / 91,000 Btu/gal. = about 20 gal. LOW estimate: 2,800,000 / 91,000 Btu/gal. = about 31 gal. HIGH estimate: 4,200,000 / 91,000 Btu/gal. = about 46 gal.	$40	$62–$92
Estimated cost of energy using natural gas: 1 cu. ft. of natural gas = 1,000 Btu (100 cu. ft. = 1 therm) Current average cost for 1 therm of natural gas = $0.80 per therm Theoretical: 1,800,000 / 100,000 Btu/therm – about 18 therm Low estimate: 2,800,000 / 100,000 Btu/therm – about 28 therm High estimate: 4,200,000 / 100,000 Btu/therm – about 42 therm	$14.40	$22–$33

THIS CALCULATION ASSUMES THE FIREWOOD IS DRIED TO 20% AVERAGE MOISTURE CONTENT—MUCH OF THE KILN- DRIED FIREWOOD ON THE MARKET TODAY DOES NOT, IN FACT, MEET THIS STANDARD.

Table 5. Energy and Cost of Drying Firewood.

Source: Sawmill & Woodlot, 2014

For new equipment, Kiln-direct provided proposed costs for two models – LittleQuick (9 cord capacity) and SmallQuick (12 cord capacity). They provided the model information for both wood and gas heat options.

Table 18: LittleQuick Firewood Kiln – Wood Heating (9 cord capacity)

Operating cost for heat treating 1200 cords/year with 9 CORD LittleQuick Firewood Kiln This is calculation includes USDA upgrade, **WOOD WASTE HEATING**, and **single** set of baskets delivered to Oakridge, OR		
One Firewood kilns for 9 cords (It can HT+KD up to 1000-1600 cords/year) SINGLE PHASE POWER ADDS $2650 EXTRA. (Installed separately)	US$	62800.00
Upgrade to USDA requirements, wireless communication for office computer.	US$	2350.00
Wood Waste heating system with firebox and Stainless steel heat exchanger and 30 cubic yard chip/mulch/sawdust bin.	US$	68700.00
Total for Firewood Kiln with 9 cord capacity	**US$**	**133850.00**
Eight 1.2 cord baskets (special price with kiln of $1100.00) These baskets can be shipped with kiln at no freight costs. THIS WILL REQUIRE ROTATOR FORKS WITH 8000 LBS LOADER/FORKLIFT	US$	8800.00
KILN: Freight cost to Oakridge, OR: 3244 miles at $5.90 per mile = US$: 19139.60 BASKET: Freight cost to Oakridge, OR: 3244 miles at $3.50 per mile = US$: 11354.00	US$	30493.60
Total for Firewood Kiln including baskets delivered to Oakridge, OR	**US$**	**173143.60**
Estimated cost to dry 1200 cords a year		
Monthly lease payment based on 60month and 8% interest. Between $2900-3100/month	US$/yr	36000.00
Labor to load, unload and fill chip bin - 2 hour at $45.00 per cycle (1200/12 x 2 x 45)	US$/yr	9000.00
Labor cost for operating kiln (1 hr x $15 for paperwork/operating kiln) (1200/12 x 15)	US$/yr	1500.00
Fuel costs based on customer experience ($5-$12 per cord) - 1200 cord x $7 YOU WILL NEED TO CORRECT THIS FOR YOUR SITUATION.	US$/yr	8400.00
Electrical cost: $0.12/kw - 46hr/load - 7kw/hr - 100 loads/year	US$/yr	3864.00
Maintenance costs estimated at $25 per load. (1200 / 12 x 25)	US$/yr	2500.00
Total annual cost for heat treating and drying 1200 cords of firewood.	**US$/yr**	**61264.00**
Total cost per cord (61264/ 1200) including cost of baskets.	**US$**	**51.05**
Cost per additional cord or after kiln is paid for: 9000+1500+8400+3864+2500 = $25264 / 1200 cord	**US$**	**21.05**

Source: Kiln-direct

Table 19: LittleQuick Firewood Kiln – Gas Heating (9 cord capacity)

Operating cost for heat treating 1440 cords/year with 9 CORD LittleQuick Firewood Kiln This calculation includes USDA upgrade, **GAS HEATING,** and **two** sets of baskets delivered to Oakridge, OR		
One Firewood kilns for 9 cords (It can realistically HT+KD up to 1200-1500 cords/year - theoretically as much as 2300 per year) Heating system: 1200000 btu/hr = 133000 btu/cord/hr Air circulation: 10HP main fan = 1.1 HP/cord SINGLE PHASE POWER ADDS $2650 EXTRA.	US$	62800.00
Upgrade to USDA requirements, wireless communication for office computer.	US$	2350.00
Total for Firewood Kiln with 9 cord capacity	**US$**	**65150.00**
Eight 1.2 cord baskets (special price with kiln of $1100.00) Eight 1.2 cord baskets UNASSEMBLED (special price with kiln of $1000) These baskets can be shipped with kiln at no freight costs. THIS WILL REQUIRE ROTATOR FORKS WITH 8000 LBS LOADER/FORKLIFT	US$	16800.00
Freight cost to Oakridge, OR: 3244 miles at $5.90 per mile = US$: 19139.60	US$	19139.60
Total for Firewood Kiln including baskets delivered to Oakridge, OR	**US$**	**101089.60**
Estimated cost to dry 1440 cords a year		
Monthly lease payment based on 60month and 8% interest. Between $1650-1850/month	US$/yr	21000.00
Labor to load and unload - 1 hour at $45.00 per cycle (1440/9 x 45)	US$/yr	7200.00
Labor cost for operating kiln (1/2 hr x $15 for start/stop/paperwork) (1440/9 x $7.50)	US$/yr	1200.00
Fuel costs based on current customer experience: $30-$50 per cord (1440 x $40) ONLY AN ESTIMATE AND MAY NEED TO BE ADJUSTED FOR YOUR SITUATION	US$/yr	57600.00
Electrical cost: $0.12/kw - 32hr/load - 8kw/hr - 160loads/year	US$/yr	4915.00
Maintenance costs estimated at $7.50 per load. (1440 / 9 x 7.50)	US$/yr	1200.00
Total annual cost for heat treating and drying 1440 cords of firewood.	**US$/yr**	**93115.00**
Total cost per cord (93115 / 1440) including cost of baskets.	**US$**	**64.66**
Cost per additional cord or after kiln is paid for: 7200+1200+57600+4915+1200 = $72115 / 1440 cord	**US$**	**50.08**

Source: Kiln-direct

Table 20: SmallQuick Firewood Kiln – Wood Heating (12 cord capacity)

Operating cost for heat treating 1440 cords/year with SmallQuick Firewood Kiln This is calculation includes USDA upgrade, **WOOD WASTE HEATING**, and **single** set of baskets delivered to Oakridge, OR.		
One Firewood kilns for 12 cords (It can HT+KD up to 1400-2200 cords/year) SINGLE PHASE POWER ADDS $4750 EXTRA. (Installed separately)	US$	80800.00
Upgrade to USDA requirements, wireless communication for office computer.	US$	2350.00
Wood Waste heating system with firebox and Stainless steel heat exchanger and 30 cubic yard chip/mulch/sawdust bin.	US$	68700.00
Total for Firewood Kiln with 12 cord capacity	**US$**	**151850.00**
16 x 3/4 cord baskets (special price with kiln of $800.00). THIS WILL REQUIRE ROTATOR FORKS	US$	12800.00
KILN: Freight cost to Oakridge, OR: 3244 miles at $9.25 per mile = US$: 30007.00	US$	30007.00
BASKET: Freight cost to Oakridge, OR: 3244 miles at $3.50 per mile = US$: 11354.00		11354.00
Total for Firewood Kiln including baskets delivered to Oakridge, OR	**US$**	**206011.00**
Monthly lease payment based on 60month and 8% interest. Between $3500-3700/month	US$/yr	43200.00
Labor to load, unload and fill chip bin - 2 hour at $45.00 per cycle (1440/12 x 2 x 45)	US$/yr	10800.00
Labor cost for operating kiln (1 hr x $15 for paperwork/operating kiln) (1440/12 x 15)	US$/yr	1800.00
Fuel costs based on customer experience ($5-$12 per cord) - 1440 cord x $7 YOU WILL NEED TO CORRECT THIS FOR YOUR SITUATION.	US$/yr	10080.00
Electrical cost: $0.12/kw - 46hr/load - 10kw/hr - 120 loads/year	US$/yr	6624.00
Maintenance costs estimated at $25 per load. (1440 / 12 x 25)	US$/yr	3000.00
Total annual cost for heat treating and drying 1440 cords of firewood.	**US$/yr**	**75504.00**
Total cost per cord (75504 / 1440) including cost of baskets.	**US$**	**52.43**
Cost per additional cord or after kiln is paid for: 10800+1800+10080+6624+3000 = $32304 / 1440 cord	**US$**	**22.43**

Source: Kiln-direct

Table 21: SmallQuick Firewood Kiln – Gas Heating (12 cord capacity)

Operating cost for heat treating 3000 cords/year with SmallQuick 12 cord PERFORMANCE Firewood Kiln This is calculation includes USDA upgrade, **GAS HEATING**, and **two** set of baskets delivered to Oakridge, OR.		
SmallQuick 12 cords BASIC model (It can HT+KD up to 2800-3400 cords/year) SINGLE PHASE POWER ADDS $4750 EXTRA. (Installed separately)	US$	95800.00
Upgrade to USDA requirements, wireless communication for office computer.	US$	2350.00
Total for Firewood Kiln with 12 cord capacity	**US$**	**99150.00**
32 fully assembled 3/4 cord baskets (special price with kiln of $800.00). THIS WILL REQUIRE ROTATOR FORKS	US$	25600.00
KILN: Freight cost to Oakridge, OR: 3244 miles at $9.25 per mile = US$: 30007.00 BASKETS: Freight cost to Oakridge, OR: 3244 miles at $3.50 per mile = US$: 11354.00	US$	41361.00
Total for Firewood Kiln including baskets delivered to Oakridge, OR	**US$**	**166111.00**
Estimated cost to dry 3000 cords a year		
Monthly lease payment based on 60month and 8% interest. Between $2650-2850/month	US$/yr	33000.00
Labor to load, unload and fill chip bin - 1.5 hour at $45.00 per cycle (3000/12 x 1.5 x 45)	US$/yr	16875.00
Labor cost for operating kiln (1/2 hr x $15 for paperwork/operating kiln) (3000/12 x 7.50)	US$/yr	1875.00
Fuel costs based on current customer experience: $30-$50 per cord (3000 x $40) ONLY AN ESTIMATE AND MAY NEED TO BE ADJUSTED FOR YOUR SITUATION	US$/yr	120000.00
Electrical cost: $0.12/kw - 23hr/load - 15kw/hr -250loads/year	US$/yr	10350.00
Maintenance costs estimated at $10.00 per load. (3000 / 12 x 10.00)	US$/yr	2500.00
Total annual cost for heat treating and drying 3000 cords of firewood.	**US$/yr**	184600.00
Total cost per cord (184600 / 3000) including cost of baskets.	**US$**	**61.53**
Cost per additional cord or after kiln is paid for: 16875+1875+120000+10350+2500 = $151600 / 3000 cord	**US$**	**50.53**

Source: Kiln-direct

Figure 14: Kiln Direct Wood-Fired and Propane Kilns

Figure 15: Nyle FHT Heat Treating System

Table 22: New Equipment Retailers

Company	Equipment	Geography	Website
Bell's Machining*	Firewood processors	Canada	http://bellsmachining.com/firewood-processors/
Blockbuster Inc.	Firewood processors	Iowa	http://blockbuster-inc.com
Built-Rite	Firewood processors	Vermont	http://www.built-rite.com
Cord King*	Firewood processors	Canada	https://cordking.ca
Dyna Products*	Firewood processors	Michigan	https://www.dyna-products.com/firewood-processing
Oregon Woodland Cooperative*	Splitter	Oregon	https://www.oregonwoodlandcooperative.com/
Papé*	Skid-steer, loaders	Oregon	https://construction.papemachinery.com
Twister	Firewood bundler	Minnesota	http://www.twister-industries.com/woodwrapper.htm
Wallenstein	Firewood processors	Canada	http://www.wallensteinequipment.com

* recommended retailers

Table 23: Used Equipment Vendors

Company	Equipment type	Geography	Website
Craigslist	2015 Multitek 30/40 processor	Varies (this one is in CA; $28,000)	https://eugene.craigslist.org/hvo/d/2015-multitekfirewood/6672223109.html
Dyna Products*	Firewood processors	Michigan	https://www.dyna-products.com/used-firewood-processor-machines-for-sale
eBay	Firewood processors	Varies	https://www.ebay.com/bhp/firewood-processor
Equipment Trader	Skid-steers and loaders	Varies	https://www.equipmenttrader.com/Construction-Equipment/listing/2003-CATERPILLAR-950G+Series+II-5002210854
Forestry Equipment Sales*	Firewood processors and log trucks	U.S. and Canada	https://forestryequipmentsales.com/29/Firewood-Processors.html https://forestryequipmentsales.com/34/Log-Trucks.html
Lumbermen Online*	Firewood processors and log trucks	Mostly Midwest and East Coast	https://www.lumbermenonline.com/find-for-sale/Firewood?class=Firewood https://www.lumbermenonline.com/find-for-sale/Truck-Log?class=Transportation&category=Truck-Log
Machinery Trader	Forestry equipment	Varies	https://www.machinerytrader.com/listings/construction-equipment/for-sale/list/category/1035/forestry-equipment
Papé	Skid-steers and loaders	Oregon	https://construction.papemachinery.com
Sawmill Exchange	Firewood processor	Varies	https://sawmillexchange.com/view_product/18211/
Tree and Landscape Equipment Trader*	Log Loaders/ Knuckleboom	Varies	https://equipment.treetrader.com/index.php?a=5&c=5&b=215
Truck Paper*	Logging trucks	Varies	https://www.truckpaper.com/listings/trucks/for-sale/list/category/221/heavy-duty-trucks-logging-trucks?page=2
Whit-Log Trucks*	Logging trucks	Oregon	https://www.whitlogtrailers.com

* recommended retailers

Figure 16: Self-loading Log Truck

Source: Log Trucker Magazine

Figure 17: 5-Axle Mule Train

Source: Whit-Log Inc.

- **Timber work equipment:** Timber equipment could be required if Inbound were to take on the role and responsibility of felling timber for firewood sourcing, beyond road-maintenance related work. It is beyond the scope of this study to determine the efficacy of purchasing timber equipment and the return on investment or feasibility of adding this element to the business model. A koller yarder would most likely be $75,000 to $200,000 depending on the specific model and cost. Iron Triangle's equipment includes numerous Komatsu XT430 feller bunchers, several forwarders, log loaders, processors, and Pierce strokers, along with a few dozers and excavators.

Funding and Support Opportunities

This section provides a summary of potential federal, state, and local funding opportunities that may reduce the capital expense of developing this program.

Local Funding

City of Oakridge
The City donated the equipment necessary to transport, process, and store wood the last two years. The City will continue to support this effort, by contributing the process and storage space required as well as transportation of the donated feedstock within 35 miles.

Lane County Economic Development
Lane County is providing Inbound's community firewood program with $30,000 annually for the next three years (2018-2020). An annual contribution of $30,000 is included in the financial analysis for all feasibility scenarios.

Lane Regional Air Protection Agency (LRAPA)
LRAPA has contributed in multiple aspects to the reduction of woodsmoke in Oakridge's airshed. In their annual budget for 2017-2018 LRAPA contributed over $100,000 in air quality monitoring, attainment planning, and implementation which includes participation in the community firewood program.

Seneca and Roseburg
Seneca has been the most consistent donor of firewood historically and is willing to annually donate wood to the community firewood program. Roseburg has less acreage in the Oakridge area but are prepared to assist when they do log their properties.

Union Pacific
A grant from Union Pacific in 2017 provided tarps and moisture meters to the community firewood program.

Boy Scouts
It is our plan to reach out to the Boy Scouts office to see if a woodshed building project might be something that boy scouts or an eagle scout might be interested in. Covering wood with inadequate shelter or tarps can lead to mold and wood that is above 20% in moisture content.

State Funding and Support

Senator Merkley's Office provides the City of Oakridge coordinator grant opportunities at the state and federal level that apply to health and environmental projects. No specific opportunities were identified that are currently open but Good Company, serving as the Woodsmoke Coordinator for Oakridge, will continue to monitor these opportunities. Additionally, there is an effort that Good Company is leading to find state and federal support for this program given its ability to be replicated and help other rural communities in Oregon and beyond.

Federal Funding and Support

Wood Innovation Funds
The USFS has a grant funding program for wood innovation that funds this type of program. The application date is in January. The last offering had $7 million in total funding with a maximum ask of $250,000. Last year's application is included here: https://www.fs.fed.us/sites/default/files/media_wysiwyg/9231_werc_fy18woodinnovrpfinstructions_rev20171107.pdf

Rural Development Business and Industry Guaranteed Loan Program
United States Department of Agriculture

- Loan guarantees for rural businesses that create or save jobs in rural areas. Loan guarantees ranging from 80% on loans of $5 million or less to 60% on loans of more than $10 million up to $25 million.
- Rolling application
- Website: https://www.rd.usda.gov/programs-services/business-industry-loan-guarantees

SBA General Small Business 7a Loans

U.S. Small Business Administration

- Small business loans with an average amount of $371,678 and a maximum amount of $5 million. Loan purposes vary, but include equipment purchase, real estate purchase, building construction or renovation.
- Rolling application
- Website: https://www.sba.gov/funding-programs/loans

Loans and Grants for Rural Economic Development and Job Creation Projects

United States Department of Agriculture

- Competitive grant program designed to support targeted technical assistance, training and other activities leading to the development or expansion of small and emerging private businesses in rural areas which will employ 50 or fewer new employees and has less than $1 million in gross revenue. The maximum amount an individual applicant may receive is $200,000. Grant recipients must provide matching funds equal to 25 percent of the total project costs.
- Website: https://www.rd.usda.gov/programs-services/rural-business-development-grants/or
- Applications due annually in June

Nonprofits and Foundations

As part of Oregon Solutions work in 2017, Good Company identified 70 funding organizations in the state that could fund woodsmoke reduction projects including a community firewood program. That list of organizations will be shared with Inbound as part of the deliverables.

Besides equipment and facility investment assistance, Inbound's community firewood program could request funding for firewood supply that also meets other objectives such as hazardous fuels reduction. This type of program would employ local contractors (economic development), reduce fuels (increase safety and forest health) and ensure the community firewood program had sufficient supply (health and wellbeing).

Operating expenses

The primary operating expenses are employees, feedstock costs, firewood bundling costs, facility expenses and transportation related to the inbound movement of feedstock and outbound delivery of wood locally and regionally.

Labor

For labor, we developed two main scenarios based on other program experiences in the number of staff and job roles needed. We used wages that Inbound currently pays and built in benefits and workers compensation based on Inbound's current experience. In addition, we compared these roles and breakdown's to OSU's Biomass Model. The light blue cells are dropdown lists and can be changed to fit the context of a larger or smaller operation. For Phase I, just under 3 FTEs are expected and 7 are expected for Phase II. As a point of comparison, Tule Creek had 8 FTEs and Heritage was planning on 10 FTEs for larger-scale programs. One important assumption is that the Phase I business would operate over a three month window of time and Phase II would operate over a six month window annually.

Table 24: Labor Costs for Phase I and II

Labor	Hourly Wage	Annual (full-time)	Phase I (season)	Phase I FTEs	Phase II	Phase II FTEs	Source
Total FTE				**2.7**		**7**	
Supervisor and Sales	$20	$41,600	$3,640	0.35	$20,800	1	Inbound / multiple
Operators	$12	$24,960	$12,480	2	$62,400	5	Inbound / multiple
Transportation	$20	$41,600	$2,600	0.25	$10,400	0.5	Inbound / multiple
Office	$20	$41,600	$1,040	0.1	$10,400	0.5	Inbound / multiple
Subtotal			***$19,760***		***$104,000***		
Benefits and Workers Comp			$4,940		$26,000		Inbound
Total			***$24,700***		***$130,000***		

Feedstock Costs

Feedstock costs is one of the most important variables and costs in the entire analysis. For every cord of processed wood, approximately three and half green tons of feedstock are required. There are four primary sources of feedstock we identified and evaluated. The first is donated feedstock and while the material is free, there is cost associated with it being cut down or transported from the site to the processing facility. Currently, Inbound does not have the means to do that work, therefore, it must pay for a couple of operators to either cut the wood into more manageable sections onsite or transport it to the processing facility via rented vehicles. Secondly, purchased feedstock from private operators is another pathway and the going rate for that material is $35 per ton or ~$123 per cord. This value was used by other firewood operations and was validated by Seneca. The third option is purchased feedstock from public lands, such as the commercial firewood program which can sell for $5-7 per cord. The fourth option is to harvest feedstock on public lands either through roadside maintenance, stewardship sales or small timber sales. ***Quantifying the per cord cost of operating and harvesting wood is one of the more challenging components of this study given the context and costs associated with different approaches (e.g., roadside maintenance, etc.).*** For roadside maintenance to operate a five-person crew at $35-40 per person per hour and the cost of a self-loader for $70 per hour (with operator)

would necessitate $270 of cord value being cut in that timeframe. Feedstock cost should ideally not be any higher than $120 per cord including material and initial transportation to the processing facility. Due to the differences in density of trees per acre it has been difficult to reasonably assume the level of production given the other activities of chipping and brushing.

Table 25: Feedstock Costs by Sourcing Type

Feedstock Costs (per cord)	Material Cost	Transport	Road Deposits	Cost per Cord	Source
Donated Feedstock (private)	$48	$33	$0	$81	Seneca / GC
Purchased Feedstock (private)	$123	$33	$0	$155	Seneca / MARS
Purchased Feedstock (public)	$53	$33	$30	$115	USFS
Harvested Feedstock (public)	$50	$33	$30	$113	GC analysis

Transportation costs

Transportation costs were shared in a prior section on truck ownership versus rental. The minimization of transportation distance is essential and plays a role in the cost per cord of firewood.

Table 26: Transportation Distance from Source to Processing Facility

Truck Ownership						
Number of miles from processing site	15	25	35	50	75	100
Fuel cost	$2	$3	$5	$7	$10	$14
Maintenance costs	$0.5	$0.8	$1.1	$1.5	$2	$3
Driver cost	$6	$7	$10	$14	$21	$29
Equipment allocation (based on 5 years of use)	$121	$121	$121	$121	$121	$121
Equipment allocation (per cord)	$17	$17	$17	$17	$17	$17
Feedstock costs	$123	$123	$123	$123	$123	$123
Transportation cost	$25	$28	$33	$40	$51	$62
Total cost per cord	**$148**	**$151**	**$155**	**$162**	**$173**	**$185**

Facility and Additional Operating Expenses

Finally, the remaining expenses are the facility, electricity and fuels, and bundling material costs. The facility costs are subsidized by the City of Oakridge for Phase I operations and it is likely that Inbound would need to pay for a facility lease in Phase II, although the City of Oakridge may ask for a lower than market rate option based on the community impact and benefit. For equipment, the fuels and electricity costs associated with their operation was calculated based on their efficiency and output. Additional costs of operating supplies, maintenance, and general contingency costs were included in the pro forma. Bundling costs was estimated at approximately $0.50 based on the plastic wrap, labels and palettes needed.

Table 27: Facility and Additional Operating Expenses

Facility Expenses	**Phase I**	**Phase II**	
Lease Building/Land	$12	$12,000	
Additional Operating Expenses	**Phase I**	**Phase II**	
Electricity and fuels	$2.54	$3.02	per cord costs
Log splitter	$0.80		6 HP engine 6HP x 746 W = 4476Wh = 4.47 kWh
Firewood processor		$1.49	50 hp diesel engine
Firewood bundler		$0.07	1/2 HP
Skidsteer	$1.70	$1.43	2 gallons/hour; 4-8 hrs operation divided by avg # of annual cor
Dump truck			included in delivery costs
Kiln	$0.04	$0.04	Electric Costs: 225 KWH/1000 BF
Operating supplies	$2,500	$5,000	base assumption
Processor maintenance		$5,000	base assumption

Table 28: Bundling Costs

Bundling Material Costs	**Unit price**	**# of bundles**	**Cost per cord**	**Notes**	**Source**
Plastic wrap and labels	$18	150	$0.12	18" x 2,000'	ULINE
Palettes	$7		$0.42		

Anticipated Production and Revenue

Production

The market analysis for cords to be sold via the community firewood program, locally, regionally and via firewood bundle markets served as the basis for the projections in production. The equipment is scaled reasonably to this operation in terms of output per hour and given the team of operators. Table 29 below provides an overview of production by market and Table 30 shows the number of cords sourced by feedstock source (e.g., donated, private, public or harvested). For the purposes of the base assumption, we modeled a combination of sources and the financial analysis shows the variance in financial outcomes based on the choices of feedstock. Additionally, we chose to ramp up production slowly within Phase II assuming that time would be required to fully understand the production dynamics and market side. The largest jump in production comes in the transition from Phase I to Phase II but the equipment and increased capacity of staff should be more than adequate to satisfy those outputs. Oregon State University's *Measuring Timber Products Harvested from Your Woodland* served as a helpful reference for determining conversions and measurements and can be accessed here: https://catalog.extension.oregonstate.edu/sites/catalog/files/project/pdf/ec1127.pdf

Table 29: Overview of Annual Cord Production for Phase I and II

	Phase I		Phase II									
	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Annual Production Output by Product Type	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12
CFP Cords	**50**	**100**	**150**	**200**	**200**	**200**	**200**	**200**	**200**	**200**	**200**	**200**
Local Cords/Year	**0**	**50**	**100**	**150**	**200**	**200**	**200**	**200**	**200**	**200**	**200**	**200**
Regional Cords/Year	**0**	**0**	**250**	**500**	**750**	**1,000**	**1,050**	**1,103**	**1,158**	**1,216**	**1,276**	**1,340**
Firewood Bundle Retail Cords/Year	**0**	**50**	**250**	**750**	**1,000**	**1,050**	**1,103**	**1,158**	**1,216**	**1,276**	**1,340**	**1,407**
Total	***50***	***200***	***745***	***1,588***	***2,133***	***2,430***	***2,531***	***2,638***	***2,749***	***2,867***	***2,990***	***3,120***

Table 30: Detail of Annual Production by Product Type

		Phase I		Phase II									
		2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Annual Production Output by Product Type		**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**	**Year 11**	**Year 12**
CFP Cords		**50**	**100**	**150**	**200**	**200**	**200**	**200**	**200**	**200**	**200**	**200**	**200**
Donated Feedstock	50%	50	100	75	100	100	100	100	100	100	100	100	100
Purchased Feedstock (private)	50%	0	0	75	100	100	100	100	100	100	100	100	100
Purchased Feedstock (public)	0%	0	0	0	0	0	0	0	0	0	0	0	0
Harvested Feedstock (public)	0%	0	0	0	0	0	0	0	0	0	0	0	0
Local Cords/Year		**0**	**50**	**100**	**150**	**200**	**200**	**200**	**200**	**200**	**200**	**200**	**200**
Purchased Feedstock (private)	50%	0	25	50	75	100	100	100	100	100	100	100	100
Purchased Feedstock (public)	50%	0	25	50	75	100	100	100	100	100	100	100	100
Harvested Feedstock (public)	0%	0	0	0	0	0	0	0	0	0	0	0	0
Regional Cords/Year		**0**	**0**	**250**	**500**	**750**	**1,000**	**1,050**	**1,103**	**1,158**	**1,216**	**1,276**	**1,340**
Purchased Feedstock (private)	33%	0	0	83	165	248	330	347	364	382	401	421	442
Purchased Feedstock (public)	33%	0	0	83	165	248	330	347	364	382	401	421	442
Harvested Feedstock (public)	33%	0	0	83	165	248	330	347	364	382	401	421	442
Firewood Bundle Retail Cords/Year		**0**	**50**	**250**	**750**	**1,000**	**1,050**	**1,103**	**1,158**	**1,216**	**1,276**	**1,340**	**1,407**
Purchased Feedstock (private)	33%	0	17	83	248	330	347	364	382	401	421	442	464
Purchased Feedstock (public)	33%	0	17	83	248	330	347	364	382	401	421	442	464
Harvested Feedstock (public)	33%	0	17	83	248	330	347	364	382	401	421	442	464

Table 31: Feedstock Requirements, Production Capacity and Transportation

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Production Requirements	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12
Feedstock Needs												
Cords per Year	50	200	750	1,600	2,150	2,450	2,553	2,660	2,773	2,892	3,016	3,147
Green tons	175	700	2,625	5,600	7,525	8,575	8,934	9,310	9,706	10,121	10,557	11,015
Production Capacity												
Processing per hour (cords per hour)	0.5	0.5	2	2	2	2	2	2	2	2	2	2
Processing per day (cords per day)	4	4	16	16	16	16	16	16	16	16	16	16
Processing per week (cords per week)	20	20	80	80	80	80	80	80	80	80	80	80
Processing per month (cords per week)	80	80	320	320	320	320	320	320	320	320	320	320
Processing per year (cords per year)	240	240	1,920	1,920	2,560	2,560	2,560	3,200	3,200	3,200	3,200	3,200
Transportation												
Incoming log trucks	7	28	105	224	301	343	357	372	388	405	422	441
Outgoing trucks (CFP)	3	5	8	10	10	10	10	10	10	10	10	10
Outgoing trucks (Local)	0	3	5	8	10	10	10	10	10	10	10	10
Outgoing trucks (Regional)	0	0	13	25	38	50	53	55	58	61	64	67
Outgoing trucks (Bundles)	0	3	13	38	50	53	55	58	61	64	67	70

Revenue

The community firewood program in its current form is limited in its ability to generate income and cover costs. Comparable production to past iterations for the community firewood program of 50-100 cords equates to $7,500 to $15,000 of revenue annually. Phase II significantly increases revenue potential going into the six figures and ranging from ~$250,000 to over $1.1 million based on the scaled volume of sales.

Table 32: Phase I Revenue Generation

			Phase I	
			2018	2019
Production			**Year 1**	**Year 2**
CFP Cords/Year			50	100
Local Cords/Year			0	50
Regional Cords/Year			0	0
Firewood Bundle Retail Cords/Year			0	0
Revenue	**Retail Price**		**Year 1**	**Year 2**
CFP subsidized per cord price	$150		$7,500	$15,000
Local per cord price	$185		$0	$9,250
Local delivery	$30	50%	$750	$2,250
Regional cord price	$200		$0	$0
Regional delivery	$50	100%	$0	$0
Bundled cord price	$552		$0	$0
Total Revenue			**$8,250**	**$26,500**

Table 33: Phase II Revenue Generation

		Phase II									
		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Production		**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**	**Year 11**	**Year 12**
CFP Cords/Year		150	200	200	200	200	200	200	200	200	200
Local Cords/Year		100	150	200	200	200	200	200	200	200	200
Regional Cords/Year		250	500	750	1,000	1,050	1,103	1,158	1,216	1,276	1,340
Firewood Bundle Retail Cords/Year		250	750	1,000	1,050	1,103	1,158	1,216	1,276	1,340	1,407
Revenue	**Retail Pric**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**	**Year 11**	**Year 12**
CFP subsidized per cord price	$150	$22,500	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000
Local per cord price	$185	$18,500	$27,750	$37,000	$37,000	$37,000	$37,000	$37,000	$37,000	$37,000	$37,000
Local delivery	$30	$3,750	$5,250	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000
Regional cord price	$200	$50,000	$100,000	$150,000	$200,000	$210,000	$220,500	$231,525	$243,101	$255,256	$268,019
Regional delivery	$50	$12,500	$25,000	$37,500	$50,000	$52,500	$55,125	$57,881	$60,775	$63,814	$67,005
Bundled cord price	$552	$138,000	$414,000	$552,000	$579,600	$608,580	$639,009	$670,959	$704,507	$739,733	$776,719
Total Revenue		**$245,250**	**$602,000**	**$812,500**	**$902,600**	**$944,080**	**$987,634**	**$1,033,366**	**$1,081,384**	**$1,131,803**	**$1,184,743**

- **Retail pricing:** The model includes base level assumptions on pricing for the subsidized community firewood program, local, regional and firewood bundled pricing. Again, the blue cells are dropdown lists that include the option for different pricing assumptions.
- **Delivery pricing and costs:** Pricing for local delivery of $30 (Oakridge area) and regional delivery of $50 (Eugene/Springfield) are assumed to have a relatively low profit margin. It is assumed that in Oakridge more

deliveries will be individual cords whereas transportation to the valley will be to transport firewood bundles or cord deliveries in greater volume (e.g., three cords). In both instances, multiple cords can be transported and the most efficient approach to routing trucks is expected. It is expected that at least half of sales in Oakridge will pick up the cords rather than request delivery.

Pro Forma and High-Level Results

This section provides a comparison of different scenarios to assist in identifying some of the most critical variables which pose both risks and opportunities. The base assumption is described earlier but it consists of a modest Clearspan facility with the most essential list of equipment, most of it used equipment, sourcing from different feedstocks, and selling into four different markets.

Table 34: Base Assumptions and Outputs

Base Feasibility Scenarios	
	Base Assumption
Net Present Value	$2,714,352
Discount Rate	5%
Capital Investment	$466,050
Payback Period	5 years
Sales Revenue - Year 5	$812,500
Operating Expenses - Year 5	$533,607
Net Revenue	$278,893

The base assumption of a 5% discount rate was compared again 8 and 10% discount rates to identify the variation in net present value (NPV).

Table 35: Discount Rate Comparison

Different Discount Rates			
	5% discount rate	8% discount rate	10% discount rate
Net Present Value	$2,714,352	$2,115,902	$1,798,078
Discount Rate	5%	8%	10%
Capital Investment	$466,050	-	-
Payback Period	5 years	-	-
Sales Revenue - Year 5	$812,500	-	-
Operating Expenses - Year 5	$533,607	-	-
Net Income - Year 5	$278,893	-	-

This comparison simply looks at the financial health of a program that maintained only the community firewood program and local sales. This pathway would not require significant investment and would operate right around break-even.

Table 36: Community Firewood Program Sustained

Phase I Only			
	Base Assumption	CFP and Local Only	CFP - Donated Feedstock
Net Present Value	$2,714,352	($444,225)	($178,349)
Discount Rate	5%	-	-
Capital Investment	$466,050	$45,000	$45,000
Payback Period	5 years	> 12 years	9 years
Sales Revenue - Year 5	$812,500	$73,000	$73,000
Operating Expenses - Year 5	$533,607	$76,017	$61,382
Net Income - Year 5	$278,893	($3,017)	$11,618

The baseline assumption for facility investment is building a Clearspan structure at the Oakridge Industrial Park. The higher investment option spends $500,000 on retrofitting one of the industrial park facilities. And the lower investment assumes that Inbound uses an existing structure and does not need to make any capital investments in the facility.

Table 37: Facility Investment

Higher and Lower Facility Investment			
	Base Assumption	Higher Investment	Lower Investment
Net Present Value	$2,714,352	$2,251,335	$2,881,290
Discount Rate	5%	-	-
Capital Investment	$466,050	$923,550	$423,550
Payback Period	5 years	5 years	~4 years
Sales Revenue - Year 5	$812,500	-	-
Operating Expenses - Year 5	$533,607	-	-
Net Revenue - Year 5	$278,893	-	-

This comparison looks at a higher investment in both upgraded or new equipment. While almost double the amount of capital investment it does not change the overall viability of the program.

Table 38: Equipment Investment

Higher Equipment Investment		
	Base Assumption	Higher Investment
Net Present Value	$2,714,352	$2,490,049
Discount Rate	5%	5%
Capital Investment	$466,050	$1,079,050
Payback Period	5 years	5 years
Sales Revenue - Year 5	$812,500	-
Operating Expenses - Year 5	$533,607	-
Net Income - Year 5	$278,893	-

This comparison adds both the higher facility and equipment costs together to evaluate whether these costs are insurmountable but the analysis shows that they do not significantly alter the viability albeit they do reduce the overall returns of the project.

Table 39: Facility and Equipment Investment

Higher Facility and Equipment Investment		
	Base Assumption	Higher Investment
Net Present Value	$2,714,352	$2,027,032
Discount Rate	5%	5%
Capital Investment	$466,050	$1,486,550
Payback Period	5 years	5 years
Sales Revenue - Year 5	$812,500	-
Operating Expenses - Year 5	$533,607	-
Net Income - Year 5	$278,893	-

This variation compares feedstock costs at different per cord costs to see what the relationship to overall revenue and profitability. A lower per cord cost of wood has a significant impact on return on investment and annual profitability and jeopardizes feasibility when it is too high.

Table 40: Feedstock Costs

Different Feedstock Approaches							
	Base Assumption	$10/cord	$25/cord	$50/cord	$100/cord	$150/cord	$200/cord
Net Present Value	$2,714,352	$5,368,973	$4,771,240	$3,775,019	$1,782,576	($209,866)	($2,202,309)
Discount Rate	5%	-	-	-	-	-	-
Capital Investment	$466,050	-	-	-	-	-	-
Payback Period	5 years	4 years	4 years	4 years	5 years	7 years	> 12 years
Sales Revenue - Year 5	$812,500	-	-	-	-	-	
Operating Expenses - Year 5	$533,607	$378,991	$413,538	$471,115	$586,270	$701,425	$816,580
Net Income - Year 5	$278,893	$433,509	$398,962	$341,385	$226,230	$111,075	($4,080)

The base assumption for market approaches is that it sells into four market types: (1) community firewood program 200 cords/year, (2) local retail 200 cords/year, (3) regional 1,000 cords/year and firewood bundles 1,000 cords/year. The most valuable market is the bundled firewood one as it provides the greatest profit margin. The value of bundled firewood by cord is between $400-$600 and a marginal wholesale fee is included to pay to OWC or other wholesale intermediaries for market connection and sales relationship. The analysis below shows the stark difference in net present value if the operation does not sell to firewood bundle markets.

Table 41: Selling Solely Corded Wood or Lower Bundled Firewood Price

Different Market Approaches			
	Base Assumption	No Bundled Firewood	Lower Bundled Price $400
Net Present Value	$2,714,352	($1,926,265)	$407,678
Discount Rate	5%	-	-
Capital Investment	$466,050	$414,250	$466,050
Payback Period	5 years	> 12 years	6 years
Sales Revenue - Year 5	$812,500	$448,000	$660,500
Operating Expenses - Year 5	$533,607	$496,092	$533,607
Net Income - Year 5	$278,893	($48,092)	$126,893

Project Outcomes

Job creation and retention

- **Assist Inbound in employing residents of Oakridge year-round:** Provide work for 5-7 jobs during the winter months, a difficult timeframe for finding local work.

Biomass utilization

- **Reduce fuel loading on National Forest:** Removing top wood and cull wood will reduce "jackpot" fuels near roads and improve visuals. If road maintenance projects were possible it would also ensure road durability on USFS roads.

Air quality

- **Sustaining good air quality:** The City of Oakridge airshed is moving into attainment and has made considerable progress since 2007 where the 24-hour particulate matter count was 47 micrograms per cubic meter (µg/m3). It is the expressed goal of this project to decrease and sustain that number to below 30 µg/m3.

8. Appendix

Businesses, Programs and Organizations Contacted

- Alliance for Green Heat
http://www.forgreenheat.org
- California Air Resources Board, Kasia Turkiewicz, ARB
- Ecosystem Workforce Program/Institute for a Sustainable Environment, University of Oregon, Autumn Ellison
- Heritage Sustainable Resources, North Powder, Oregon http://heritagesr.com
- Mt. Adams Resource Stewards, Nate Ulrich (former employee) http://www.mtadamsstewards.org/programs/natural-resource-economic-development/
- Oregon Wood Innovation Center, Scott Leavengood
http://owic.oregonstate.edu
- Oregon Woodland Cooperative, Neil Schroeder
https://www.oregonwoodlandcooperative.com
- Southern Willamette Forest Collaborative, Sarah Altemus-Pope https://southwillamette.wixsite.com/swfc/community-firewood-program
- Sustainable Northwest, Dylan Kruse
http://www.sustainablenorthwest.org/what-we-do/programs/sustainable-northwest-wood
- T2 Incorporated, Jeremy Totten, Sweet Home, multi-product biomass *(did not respond)* https://www.t2incorporated.com/home.html
- U.S. Environmental Protection Agency, Kathleen Stewart
- U.S. Forest Service, Robert Mickey, Duane Bishop, Kate MacFarland
- Washington Woodland Cooperative, Terrance Meyer
http://www.washingtonwoodland.coop/about/#home
- Watershed Center / Tule Creek, Nick Goulette https://fireadaptednetwork.org/fantastic-failure-biomass-utilization/
- Wood Recovery, Russ Van Wyck *(did not respond)*

Additional Potential Contacts

- Dean Innovations http://firewoodportland.com/firewood_vendors.php
- Iron Triangle Logging https://treesource.org/news/goods-and-services/wildfires-restoration-economy-oregon/
- JB Firewood Co. https://www.jbfirewood.com

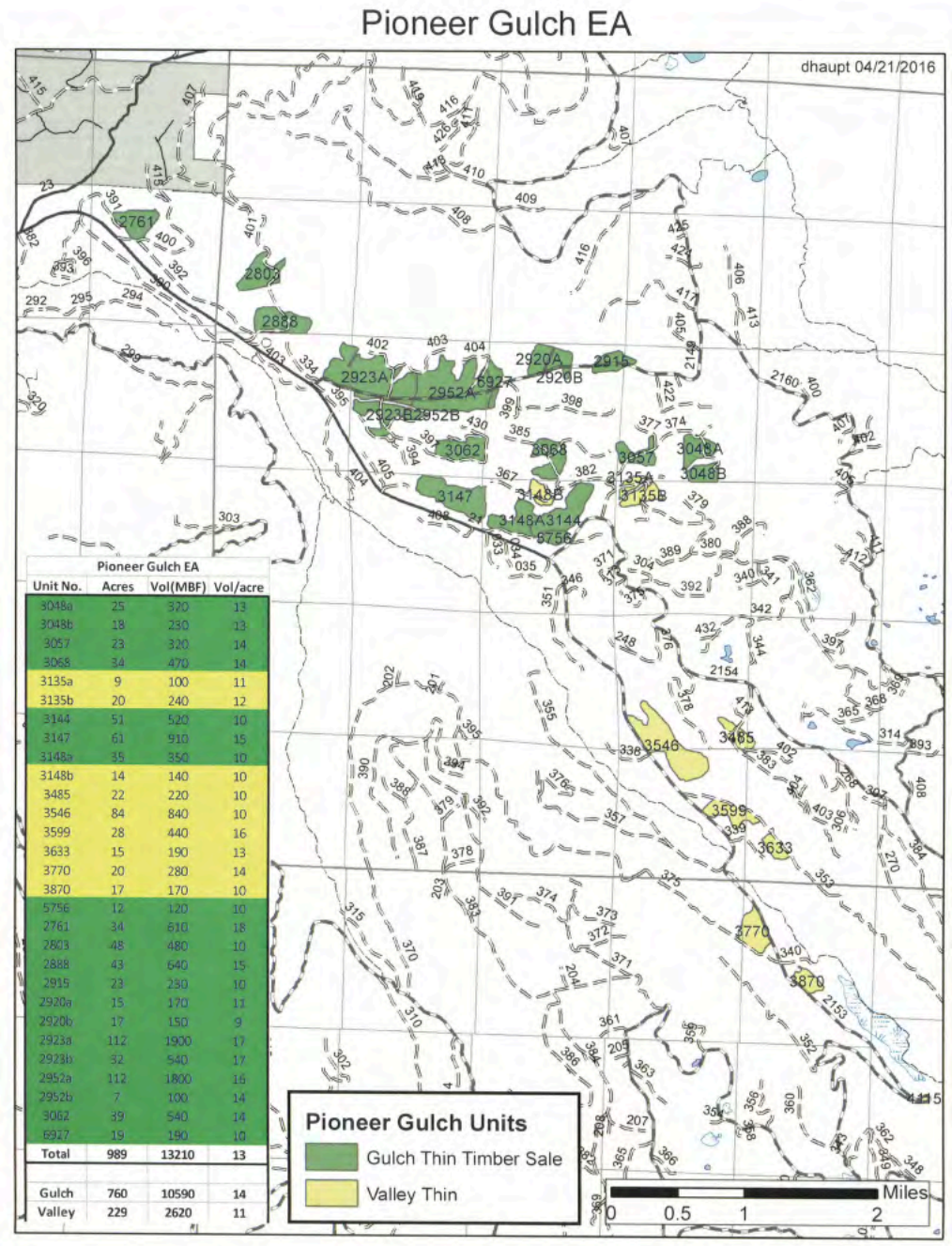
- National Firewood Association http://nationalfirewoodassociation.org
- Noble Enterprises (Philomath/Corvallis)
- O'Malley Brothers https://www.omalleybros.com/forestry
- Oregon Forest Resources Institute
- OSU Renewable Materials, Instructor David Smith
- Sisters Forest Products http://sistersforestproducts.com/firewood/4510410
- Wallowa Resources Integrated Biomass Energy Campus (IBEC)

Resources Evaluated

The following is a list of the documents and resources that we reviewed:

- Analyzing Firewood Business Investments – Sawmill & Woodlot https://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/tennessee/how-to-evaluate-potential-profitability-of-a-firewood-business.pdf
- Certified Firewood Marketing Plan For Certified Wood from Central Minnesota http://www.cura.umn.edu/sites/cura.advantagelabs.com/files/publications/CAP-031.pdf
- A Community Guide to Starting & Running a Wood Bank – University of Maine https://digitalcommons.library.umaine.edu/cgi/viewcontent.cgi?article=1000&context=sfr_studentpub
- Community Assistantship Program: Certified Firewood Marketing Plan http://www.cura.umn.edu/sites/cura.advantagelabs.com/files/publications/CAP-031.pdf
- Equipment for The Production of Firewood – North Carolina https://outreach.cnr.ncsu.edu/woodworkshops/documents/Marcus.MultitekC.pdf
- Firewood Processor and Portable Sawmill Workshop https://www.fs.usda.gov/naspf/news/firewood-processor-and-portable-sawmill-workshop-june-7-2018
- Oakridge Biomass Facility Cost and Feasibility https://docs.wixstatic.com/ugd/cb6d32_441f4d95086349cabbaf9b98d1b5dfda.pdf
- Renewable Wood Heat: Warm Toes & Healthy Forests http://www.biomassthermal.org/wp-content/uploads/2017/12/NSAAJournalArticle_2017_WoodEnergy.pdf
- Valley County Idaho Forest Products Campus Feasibility Study, WR Community Solutions Inc. https://www.mccallstarnews.com/images/images_downloads/BioMass%20Study.pdf
- Watershed Center, formerly assisted in the Tule Creek Forest Products organization which sold bundled firewood in CA and OR
- Wilseyville Woody Biomass Value-Added Product Yard Feasibility Study, TSS Consultants http://ucanr.edu/sites/swet/files/176215.pdf

Figure 18: Valley Thin Timber Sale (Pioneer Gulch)



Pioneer Gulch EA

Unit No.	Acres	Vol(MBF)	Vol/acre
3048a	25	320	13
3048b	18	230	13
3057	23	320	14
3068	34	470	14
3135a	9	100	11
3135b	20	240	12
3144	51	520	10
3147	61	910	15
3148a	35	350	10
3148b	14	140	10
3485	22	220	10
3546	84	840	10
3599	28	440	16
3633	15	190	13
3770	20	280	14
3870	17	170	10
5756	12	120	10
2761	34	610	18
2803	48	480	10
2888	43	640	15
2915	23	230	10
2920a	15	170	11
2920b	17	150	9
2923a	112	1900	17
2923b	32	540	17
2952a	112	1800	16
2952b	7	100	14
3062	39	540	14
6927	19	190	10
Total	989	13210	13
Gulch	760	10590	14
Valley	229	2620	11

Source: USFS Middle Fork District Office

Figure 19: Valley Thin Photos

Source: Sarah Altemus-Pope, SWFC

Figure 20: Firewood BTU Ratings

FIREWOOD BTU OF WESTERN SOFTWOOD SPECIES

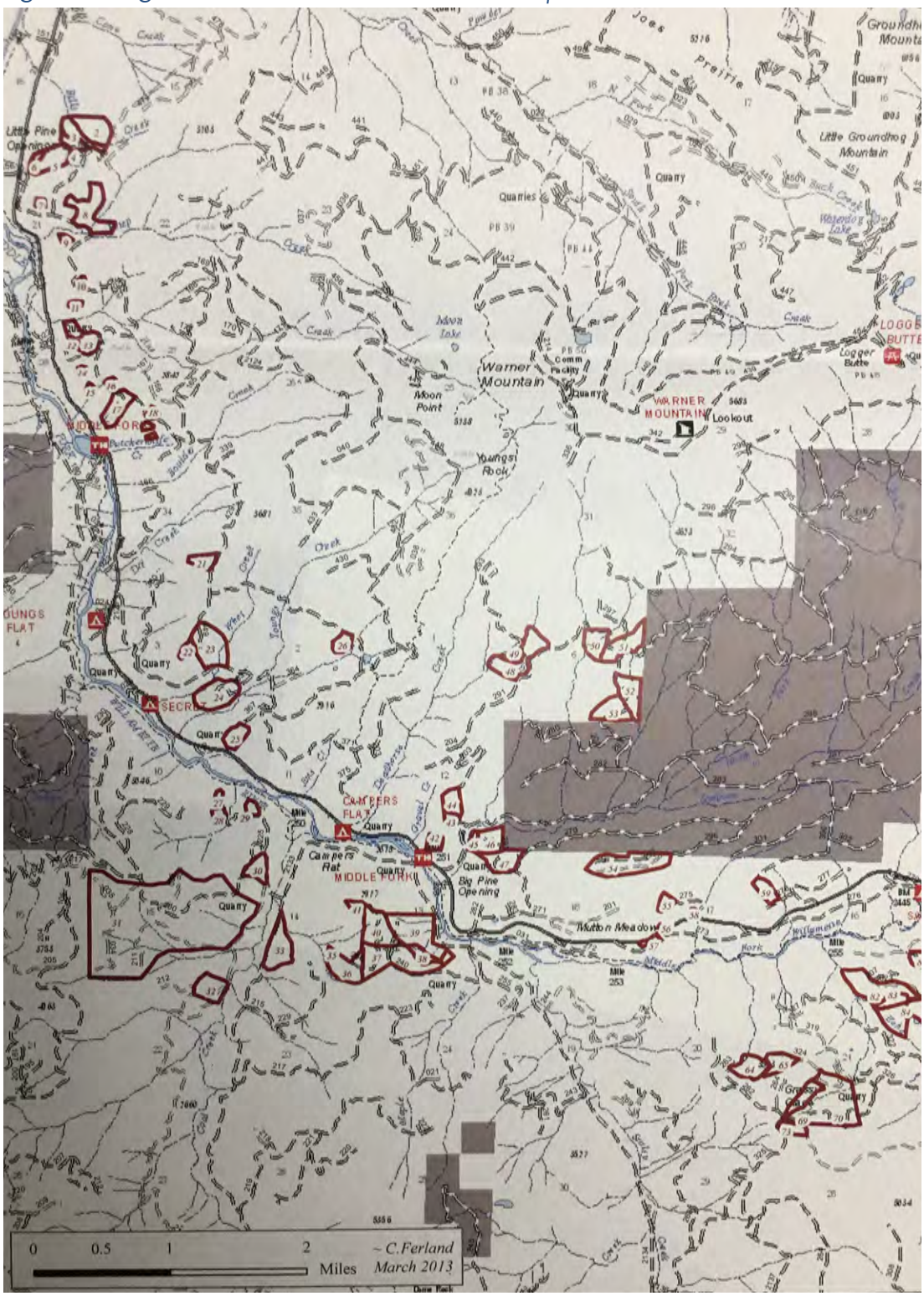
Species	Million BTU's per Cord	Pounds Per Cord Green	Pounds Per Cord Dry
Douglas Fir	26.5	5050	3075
Western Juniper	26.4	5410	3050
Western Hemlock	24.4	5730	2830
Port Orford Cedar	23.4	4370	2700
Lodgepole Pine	22.3	4270	2580
Ponderosa Pine	21.7	4270	2520
Jeffery Pine	21.7	4270	2520
Sitka Spruce	21.7	4100	2520
White Fir	21.1	3190	2400
Red Fir	20.6	4040	2400
Incense Cedar	20.1	3880	2350
Coast Redwood	20.1	4040	2330
Grand Fir	20.1	3880	2330
Sugar Pine	19.6	3820	2270
Western White Pine			
Sequoia Redwood			

FIREWOOD BTU OF WESTERN HARDWOOD SPECIES

Species	Million BTU's per Cord	Pounds Per Cord Green	Pounds Per Cord Dry
Live Oak	36.6	7870	4840
Eucalyptus	34.5	7320	4560
Manzanita	32.0		
Pacific Madrone	30.9	6520	4086
Dogwood	30.4	6520	4025
Oregon White Oak	28.0	6290	3710
Tanoak	27.5	6070	3650
California Black Oak	27.4	5725	3625
Pepperwood (Myrtle)	26.1	5730	3450
Chinquapin	24.7	4720	3450
Bigleaf Maple	22.7	4940	3000
Red Alder	19.5	4100	2600
Quaking Aspen	18.0	3880	2400
Cottonwood	16.8	3475	2225

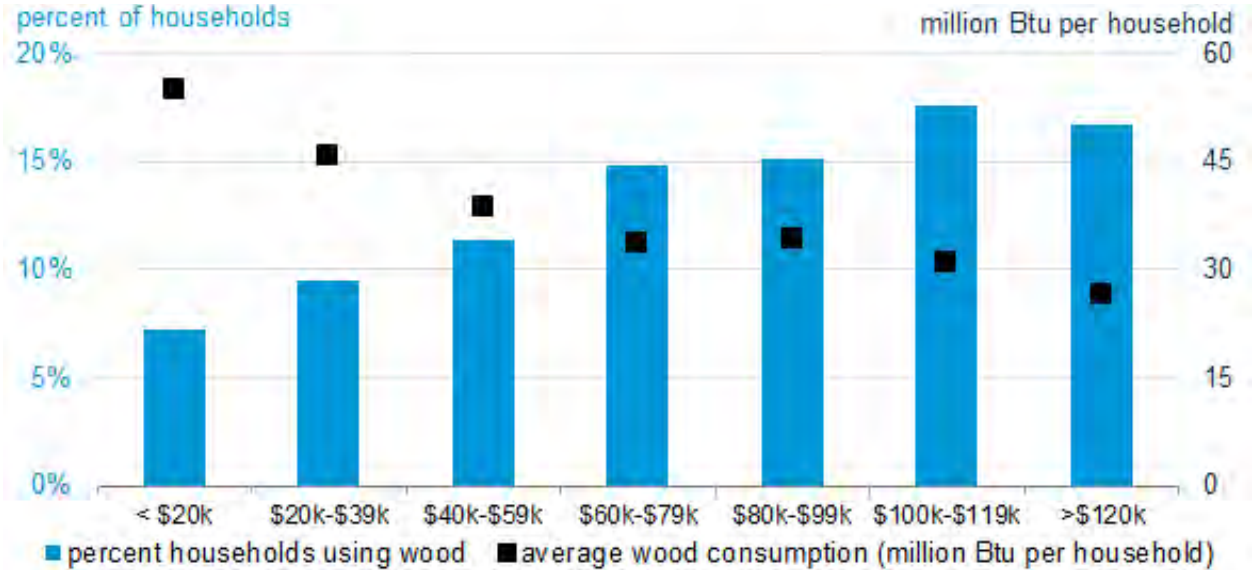
Source: http://worldforestindustries.com/forest-biofuel/firewood/firewood-btu-ratings/

Figure 21: Rigdon NEPA and Potential Stewardship Locations



Source: USFS Middle Fork District Office

Figure 22: Wood Use by Income



Source: EIA https://www.eia.gov/todayinenergy/detail.php?id=15431

Figures 23: Oregon Woodland Cooperative: Equipment


WOOD PROCESSING EQUIPMENT
TIMBER WOLF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