California Assessment of Wood Business Innovation Opportunities and Markets (CAWBIOM)

Phase II Report: Feasibility Assessment of Potential Business Opportunities

Completed for:

The National Forest Foundation

THE BECK GROUP

With Assistance From:

Carlson Small Power Consultants, Mason, Bruce & Girard, and Fido Management

December 2015

CALIFORNIA ASSESSMENT OF WOOD BUSINESS INNOVATION OPPORTUNITIES AND MARKETS (CAWBIOM)

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This work was funded all or in part by the U.S. Department of Agriculture, Forest Service, State & Private Forestry, Pacific Southwest Region.

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List of Acronyms

AB 32 – California Global Warming Solutions Act
APA – The Engineered Wood Association
BDT – Bone Dry Tons
BDU – -Bone Dry Unit
BECK – The Beck Group
BTU – British Thermal Unit
CARB – California Air Resources Board
CC – Contract Capacity
CDEs – Community Development Entities
CEC – California Energy Commission
CEC – Cavadeas Engineering Corporation
CEMs – Continuous Emission Monitors
CHP – Combined Heat and Power
CNC – Computer Numerical Control
CQ – Contract Quantity
CLT – Cross Laminated Timber
CSPC – Carlson Small Power Consultants
CO – Carbon Monoxide
CO_2 – Carbon Dioxide
CPUC – California Public Utilities Commission
D/C – Demand to Capacity Ratio
EPA – Environmental Protection Agency
EPC – Engineer, Procure, Construct
ERR – Eligible Renewable Resource
ESP – Electrostatic Precipitator
FEA – Forest Economic Advisors
FERC – Federal Energy Regulatory Commission
FIDO – Fido Management
FIT – Bioenergy Feed in Tariff
f.o.b. – Free On Board
GDP – Gross Domestic Product
GSP – Gross State Product
GHG – Green House Gas
GT – Green Ton
GT – Gas Turbine
IC – Internal Combustion
IOU – Investor Owned Utility
ITC – Business Energy Investment Tax Credit
KW – Kilowatt
KWH – Kilowatt Hour
KV – Kilo Volts
KVA – Kilovolt- Amps
LCOE – Levelized Cost of Electricity
LED – Large End Diameter
LVL – Laminated Veneer Lumber
MACRS – Modified Accelerated Cost- Recovery System
MBF – One Thousand Board Feet
MC – Moisture Content
MDF – Medium Density Fiberboard
MDI – liquid polymeric diphenyl methane di-isocyanate
MMBF – One Million Board Feet
MB&G – Mason Bruce & Girard
MMBTU – Million British Thermal Units
MMSF – One Million Square Feet
MRC – Mill Residual Chip
MSA – Metropolitan Statistical Areas
MSF – One Thousand Square Feet
MSR – Machine Stress Rated
MT – Metric Ton
MW – Megawatt
MWH – Megawatt Hour
NFF – National Forest Foundation
NMTC – New Market Tax Credit
NOx – Nitrogen Oxides
O_2 – Oxygen
OSB – Oriented Strand Board
PG&E – Pacific Gas & Electric
PM – Particulate Matter
PM10 – Particulate Matter < than 10 microns in diameter
PM2.5 – Particulate Matter < than 2.5 microns in diameter
PM – Project Manager
PPA – Power Purchase Agreement
PTC – Renewable Electricity Production Tax Credit
QF – Qualifying Facility
REAP – Rural Energy for America Program
ReMAT – Renewable Marketing Adjusting Tariff
RFP – Roseburg Forest Products
RPF – Registered Professional Forester
RPM – Revolutions per Minute
RPS – Renewable Portfolio Standard
RTF – Return to Fiber
RTL – Return to Log
SB 1122 – Senate Bill 1122 (Bioenergy Feed In Tariff)
SCE – Southern California Edison
SDG&E – San Diego Gas & Electric
SED – Small End Diameter
SFM – Sustainable Forest Management
SNCR – Selective Non-Catalytic Reduction
SPI – Sierra Pacific Industries
TG – Turbine Generator
THP – Timber Harvest Plan
USDA – United States Department of Agriculture
USDOE – United States Department of Energy
USFS – United States Forest Service
VOC – Volatile Organic Compound
WLC – Whole Log Chipping

CHAPTER 1 – EXECUTIVE SUMMARY

1.1 INTRODUCTION

Through funding provided by the U.S. Forest Service, State & Private Forestry, California Region, the National Forest Foundation issued a Request for Proposal to assess the status of California's forest products industry and identify forest products business opportunities that will help the U.S. Forest Service increase the pace and scale of forest ecosystem restoration.

The Beck Group, a Portland, Oregon based forest products planning and consulting firm, was selected to complete the project. BECK formed a multi-disciplinary team with expertise in forest inventory and timber supply (MB&G), forest products technology and biomass steam & power technology (BECK, CSPC), and business feasibility and planning (BECK, CSPC, & FIDO). Throughout the project, a multi-agency, public/private Steering Committee provided direction, contacts, references, and insights (see Appendix 3 for list of steering committee members).

The project scope was divided into two phases. In the first phase, BECK assessed the status of California's forest products industry and analyzed nearly 50 technologies for converting wood fiber into products. From that process four technologies were identified that were deemed to have the greatest chance for being developed into viable businesses in California. The Phase I report is available here.

This report documents the Phase II effort and includes more detailed technical, market, organizational, and financial feasibility assessments for the four technologies. It also describes where additional analysis is needed. In addition, policy recommendations are included to enhance these and other business opportunities. The ultimate objective of the feasibility studies and policy recommendations is increasing the pace and scale of forest ecosystem restoration on public and private lands in California.

The following sections summarize key feasibility findings for each technology.

1.1 ORIENTED STRAND BOARD

BECK assessed the feasibility of developing an OSB plant at an industrial site in Anderson, California. OSB is a structural panel used in a variety of building and industrial applications. The main reasons it was chosen for analysis are: strong markets for OSB in California, no nearby competing OSB producers, and the large volume of raw material the plant would consume annually, much of which could be small diameter stems.

The plant considered in the analysis would produce 475 million square feet (3/8" basis) of OSB annually and would have a capital cost of $166.2 million. Financial analysis indicated that such a plant would have an operating margin of nearly $50/MSF, which is roughly 24 percent of the product sales value. This translates into an estimated $23.57 million of operating cash flow annually. This, in turn, translates into a simple payback period of 9.6 years. The preceding set of economics would provide an annual return on capital of 14 percent (assuming 100 percent equity in the project). To aid in further development of this business opportunity, BECK recommends the following:

- *Identification of a Potential Developer* – Given the large capital investment required, the complexity of the manufacturing process, and the sophistication of competing producers, BECK believes the most likely path to a California OSB plant is for an existing OSB manufacturer to pursue development.
- *Raw Material Supply* – Because the markets for sawmill byproducts are limited, sawmills near an OSB plant are likely to invest in equipment to convert sawmill waste (edgings, slabs, trim ends, etc.) into OSB strands. Additional research is needed to validate this concept.
- *Relocating an Idled Plant* – There are a number of idled OSB plants that could be relocated to California. BECK estimates relocating a plant would reduce the capital expense by $18.4 million relative to the estimate of $166.2 million for all new equipment. However, additional analysis is needed to identify a plant that could be dismantled and to more precisely estimate the associated costs and benefits.
- *Environmental and Permitting* – Numerous parties suggested that obtaining an air quality permit in California for an OSB plant would be very difficult. Additional analysis is needed to understand a plant's emission profile relative to California air regulations.

1.2 SMALL SCALE BIOMASS

Senate Bill 1122[1] created a unique opportunity to develop a total of 50 MW of 3 MW and smaller biomass fueled power facilities in California. A requirement of the program is that the plants must be fueled from the products of sustainable forest management. A typical 3 MW plant would consume between 25,000 and 30,000 bone dry tons of fuel annually.

BECK assessed a plant that would use direct combustion technology and have a capital expense of $24 million. BECK calculated that such a plant would have to sell power between $190/MWH and $225/MWH to generate a 12 percent rate of return on equity over 20 years. Such a price is likely to be reached within the BioMAT program. To assist in identifying potential thermal energy users that would help lower the required selling price, BECK completed a high level analysis of seven potential forest products co-located businesses. To aid in further developing small scale biomass projects, BECK recommends the following:

- *Secure Fuel Supply* – It is imperative, for financing purposes, that the facility has contractual access to the required amount of acres/fuel on a long-term basis. Lenders consider a 10 year fuel supply arrangement a minimum. The contracts could be with private landowners or a long-term stewardship contract with a public entity. In either case, BECK recommends that developers engage landowners in discussions.

[1] Initially the term "SB 1122" was used to refer to this program. More recently, however, the term BioMAT has been used as its name. The term ReMAT has also been used to describe the program. Throughout this report the terms SB 1122, ReMAT, and BioMAT are used interchangeably.

- *Fuel Source Verification* – BECK has assumed that the logging slash produced from sustainable forest management activities qualifies as an allowable fuel under BioMAT. BECK recommends that project developers verify this interpretation of the program's rules since a differing interpretation could substantially increase the delivered cost of fuel and, in turn, significantly increase the required power sales price.
- *Project Qualification* – BioMAT allows the price at which a utility will buy power to increase until a developer finds the price acceptable. However, this process only occurs when there are at least three projects in the queue. Therefore, BECK urges prospective project developers to quickly qualify projects for the queue, which is currently forming ahead of a first auction to be held on February 1, 2016. The qualification process and associated costs are described in Chapter 4, Section 4.6.
- *Identify Potential Steam Hosts* – BECK recommends project developers partner with entrepreneurs or existing businesses that utilize thermal energy. Selling thermal energy improves project economics by up to an estimated $25/MWH and could allow a project to begin construction ahead of non-CHP projects and before a BioMAT price review.
- *Technology Selection* – BECK concludes that direct combustion technology will allow developers to meet BioMAT power delivery requirements. In BECK's judgment, gasification technology using forest-derived fuels is not reliable enough at this point. However, gasification technology could provide additional revenue streams. Therefore, BECK recommends that developers monitor advances in gasification technology.

1.3 CROSS LAMINATED TIMBER

CLT is a heavy timber panel product made from laminated layers of lumber. It is used in structural applications including walls, floors, and roofs in multi-story buildings. BECK assessed the feasibility of developing a CLT plant in Northern California. While development of this type of business does not currently directly relate to increased utilization of small diameter trees, it is included because it is has potential for huge market growth and the presence of such a plant(s) in California would help preserve forest products industry infrastructure in the State. The presence of a forest products industry is a prerequisite for cost effective forest restoration.

The plant considered would produce 1.1 million cubic feet of CLT panels annually and would require a raw material supply of 24 million board feet of lumber annually. The capital cost is estimated at $16.7 million. Lumber purchasing, one of the key operating expenses, is assumed to cost $355 per thousand board feet delivered, including a $50/MBF cost for custom drying. The CLT average panel sales price is estimated to be $21 per cubic foot.

With these assumptions, the total cash cost (lumber, glue, manufacturing) is estimated to be $13.17 per cubic foot, resulting in an operating cash flow of $7.84 per cubic foot, or $8.6 million per year. Assuming a 12 month construction period and 100 percent equity investment, the simple payback period is 3.3 years. To aid in further development of CLT manufacturing, BECK recommends the following:

- *Confirm CLT Sales Values* – CLT is a relatively new product in North America. Therefore, published pricing for the material is not available. BECK recommends additional price analysis through a combination of surveys of developers of recently completed North American CLT projects and analysis of pricing for competing materials such as concrete and steel, which would allow a more informed estimation of CLT sales price.

- *Raw Material Supply* – BECK found that an adequate volume of lumber is produced in California to supply a CLT plant. However, additional research and analysis is suggested to verify whether the mix of species, grades, and sizes produced is aligned with what is allowed for use in CLT manufacturing. Additionally, BECK recommends assessing the business case for producing CLT from currently underutilized species such as small diameter ponderosa pine.
- *Validate the Lumber Drying Premium* – BECK assumed that existing sawmills would be able and willing to supply lumber that meets the moisture content specifications of CLT manufacturing. This assumption, however, needs verification through additional research and discussion with existing lumber producers in the region.
- *Assess the Impact of Foreign Currency Exchange Rates on CLT Pricing* – A very recent trend in the lumber industry is that the increase in the strength of the U.S. dollar relative to other currencies such as the Euro allows manufacturers in other countries to supply lumber to the U.S. market at prices that are very competitive against U.S. manufacturers. Research is needed to see if the same is true among CLT manufacturers, especially since most of the existing manufacturers are in European countries.
- *Building Code Adoption* – CLT use has been adopted into U.S. and international building codes, but is facing opposition from other building material suppliers. The rate at which adoption filters down to California's local and regional municipalities is evolving rapidly. BECK recommends that prospective CLT developers monitor this situation closely.

1.4 VENEER MANUFACTURING

There are attractive markets for products made from veneer. In addition, a cluster of existing veneer using manufacturers in Southern Oregon is forced to source veneer from distant locations. Therefore, BECK examined the feasibility of developing a green (i.e., undried) veneer manufacturing plant in Northern California. The plant considered would have a capital cost of $30 million and be capable of producing 170 million square feet of veneer annually from 50 million board feet of logs.

BECK estimates such a plant would generate nearly $204 per thousand square feet in sales with log costs of $125 per thousand square feet and cash manufacturing costs of just over $50 per thousand square feet. This results in an operating cash flow of over $28 per thousand square feet or $4.8 million per year. Assuming a construction period of 18 months, the expected simple payback period is 7.8 years. For further development of this business, BECK recommends the following:

- *Investigation of Fish Tail Veneer Markets* – BECK found that markets for fish tail veneer (a low grade of veneer) in the Northern California Region are likely oversupplied. Research is needed on ways to mitigate this issue.
- *Identification of a Potential Developer* – Given that there are several existing manufacturing operations in the region that are sourcing significant quantities of green

veneer from outside suppliers in distant locations, the logical developer would be an existing veneer, plywood, or LVL manufacturer in the region.

- *Security of Supply* – The most critical aspect of this business is a secure supply of the required log volume. BECK recommends that potential developers engage the U.S. Forest Service in discussions for providing a long term stewardship contract in the North Interior region.
- *Supply Mix* – The raw material supply analysis for this project was completed at a relatively high level. BECK recommends additional analysis to confirm that the size and species mix of the log supply is appropriate for producing veneer used in products such as LVL and for plywood produced in the region.

1.5 CARBON

A number of policy recommendations are provided in Chapter 7. However, a policy issue overarching all of these potential businesses is California's substantial commitment to future reduction of net carbon emissions through the passage of Assembly Bill 32 and several pieces of follow-on legislation.

California's forests have historically played a major role in maintaining the carbon balance by absorbing a substantial percentage of California's total carbon emissions. With the ongoing drought, a changing climate, and increasing forest wildfire, continuation of the forest's traditional role is in doubt. It has been speculated that if current trends continue, California's forests may soon become net carbon emitters, which would be a disaster for California's carbon reduction efforts.

The Governor has recognized this potential and recently issued an Emergency Order regarding the effects of drought on California's forests. The order calls for various State agencies to take actions to reverse this trend. A key goal of this study is to identify businesses that, if initiated, could assist with increasing the pace and scale of forest restoration in California. Forest restoration, done correctly and at scale, could remove drought killed trees and lower stand densities to the current carrying capacity of the land. The goal is to restore health and net growth to the forest, as well as to change and interrupt fire behavior.

Another aspect of developing forest products businesses is that the carbon stored in the wood fiber and then placed into service in products such as OSB, Veneer, and CLT continues to sequester carbon. In addition, biomass material not suitable for forest products can be used for energy production instead of being openly burned in the forest. Utilizing the material in this way displaces carbon emissions from both fossil fuel energy production and from open burning. Assessing the carbon impact (environmental and financial) of these businesses was beyond the scope of this study. However, BECK recommends this topic as an area for potential follow up research. As part of their ongoing efforts to implement AB32, the California Air Resources Board is tasked with developing protocols for various carbon reduction efforts. BECK urges them to include forest product carbon sequestration and open burning reductions in their protocol efforts.

CHAPTER 2 – INTRODUCTION

2.1 FOREST RESTORATION

In the book *1491: New Revelations of the Americas before Columbus*, author Charles Mann argues the indigenous peoples of the Americas controlled and shaped the landscape. Mann's thesis is that at the time of European contact, the region was not a wilderness, but rather an intentionally altered landscape created through the indigenous peoples' use of fire over thousands of years. If true, those practices largely continued until the late 19th century when the U.S. government assumed management of much of the land, especially in the west.

In 1891, the U.S. federal government began setting aside national forest reservations. In 1905, the U.S. Forest Service was formed as the government agency responsible for managing those reservations, which became National Forests. In 1910 a series of catastrophic forest fires burned 3 million acres in a matter of days in Montana, Idaho, and Washington. The national forest managers were convinced those fires could have been prevented and controlled if adequate men and equipment had been available. This led to the development of a forest fire management policy aimed at preventing fires by discouraging the practice of 'light burning' by ranchers, farmers, and timbermen; and quickly suppressing fire once it had started.

Those policies were very effective at removing fire from the landscape. This has led to 100 years of largely unchecked forest growth, which in turn has led to much denser forests today. The increase in forest density is illustrated in the following pair of photographs taken about 10 miles north of Quincy, California (**Figure 2.1**). The photos are from the book *Fire in Sierra Nevada Forests: A Photographic Interpretation of Ecological Change Since 1849* by George E. Gruell. The photos are shot from the same vantage point, but were taken about 100 years apart. The upper photo in **Figure 2.1**, is taken circa 1890, Gruell describes the picture:

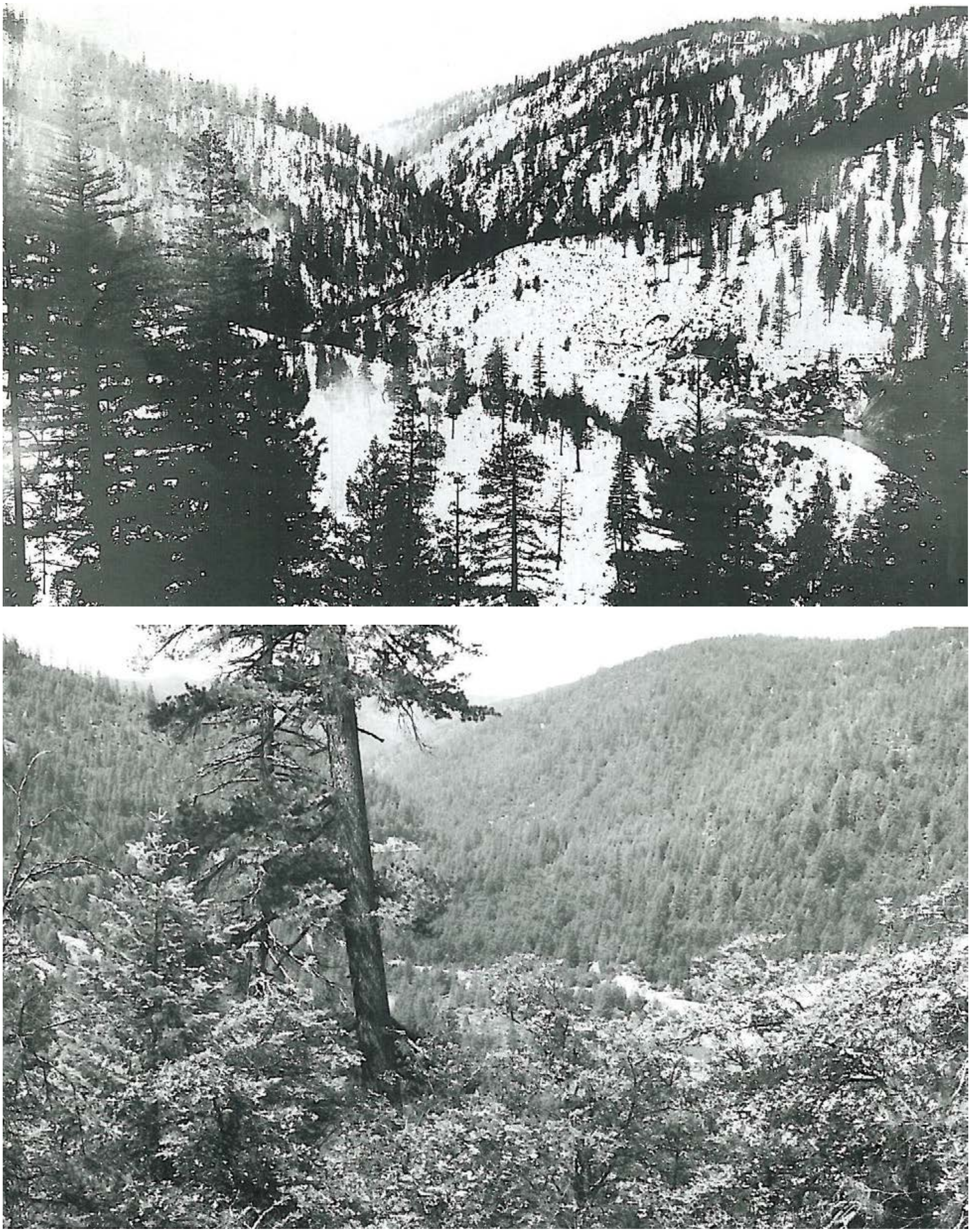
> "The photographer faced southwest and downstream, standing above what later became Paxton, Plumas County. The area had not been logged. Most of the patch tree cover is ponderosa pine. Young conifers grow on the bench at the center; they are also scattered on the far slope. The fire-scarred trees I examined at the site indicated that frequent light surface fires had burned through the area."

The lower photo of figure was taken in 1992. Gruell describes it as follows,

> "…the original photo point was overgrown; I positioned my camera in an opening farther to the right and higher up on the slope. Closed stands of trees, primarily Douglas-fir, ponderosa pine, sugar pine, black oak, and live oak, now dominate the landscape. Fire has not burned here in many decades. Between 1985 and 1986, loggers selectively cut the upper slope to the left above the railroad grade."

Similar stands of dense, overgrown forests are common on public and private lands throughout the Western U.S. Such forests are prone to insect and disease attack and are at high risk for wildfire. One option for mitigating those problems is to restore the forests to less dense conditions by mechanically thinning a portion of the trees. Unfortunately, such stands tend to be dominated by small diameter trees that are costly to remove and have relatively low economic value. Given this situation, a key objective of this study was to identify technologies for converting small diameter trees into products, and to assess the feasibility of businesses that can be developed to utilize the products of forest restoration. The presence of such businesses, would help offset the cost of forest restoration activities.

Figure 2.1 – Time Series Photos Taken near Quincy, California
Circa 1890 (upper) and 1993 (lower)



2.2 REPORT ORGANIZATION

The National Forest Foundation issued a Request for Proposal to assess the current state of California's forest products industry, identify forest products business opportunities that will help the U.S. Forest Service increase the pace and scale of forest ecosystem restoration, identify gaps and weaknesses in policy, and prepare business plans with actionable items for the most promising business opportunities. BECK, a Portland, Oregon based forest products planning and consulting firm, was selected to complete the project. BECK organized a project team with expertise in the disciplines of forest inventory and timber supply, forest products technology, and business feasibility and planning.

The project scope was divided into two phases. In the first phase, nearly fifty technologies for converting wood fiber into products were identified. The technologies judged to provide the most promise for being developed into viable businesses in the context of California's forest products industry were identified. The results of Phase I were summarized in a report that was completed in June of 2015. That report is available on the NFF website. This document provides the results of Phase II, feasibility assessment and business planning for the four technologies – Oriented Strand Board, Small Scale Biomass, Cross Laminated Timber, & Veneer – judged to have the best chance of being developed into businesses in California. Each technology assessed as part of this project has its own chapter in this report. Each of those chapters organized so that it can essentially "stand-alone" as a feasibility study of the given technology. The feasibility of each business opportunity was assessed on the basis of:

1. **Market Feasibility –** assessment of the market for the product(s) produced by the business.
2. **Technical Feasibility** – assessment of technical issues such as suitability of the technology, raw material supply and characteristics, raw material to finished product yields, regulatory constraints.
3. **Economic Feasibility** – assessment and modeling of the business's revenues, operating costs, capital expense, financing options.
4. **Organization Feasibility** – assessment of the skills, knowledge, and experience needed by the management team to successfully operation the business.

Please note that each feasibility study was completed for a "prototypical" or "conceptual" business. In other words, the feasibility studies were not completed for specific entrepreneurs or existing businesses who typically would already have established a number of fundamental aspects of the prospective business, such as location, scale, and management team. Thus, the studies, as completed, represent what BECK believes to be the concept that provides the best opportunity for the given business to be feasible. Entrepreneurs or companies pursuing these businesses may have circumstances that require a different approach.

In addition to the feasibility assessments, this report includes the results of a fiber supply study completed as part of the project (**Appendix 2**). It also includes recommendations about gaps and weaknesses in policy related to developing wood product businesses in California (**Chapter 7**).

CHAPTER 3 – ORIENTED STRAND BOARD

3.1 OSB INTRODUCTION

OSB is a structural panel that is used in a variety of construction applications, including roof and wall sheathing and subflooring. In addition, it is employed in various industrial applications as furniture components and in packaging. A major reason it was selected for assessment in the CAWBIOM study is that the technology can use significant quantities of small diameter trees.

3.2 OSB PLANT CONCEPTUAL PLAN

BECK interviewed several OSB industry contacts regarding development of an OSB plant in California. Based on those interviews, BECK devised the following conceptual plan for the plant modeled in this study.

- **Raw Material Supply** – the plant will be supplied with raw material from three sources:
    1. Whole stems from small diameter trees (i.e., trees too small to yield a sawlog) that are harvested during thinning and wildfire reduction forest management treatments.
    2. The small diameter section of stems remaining after a larger diameter section has been manufactured into a sawlog.
    3. Mill byproducts such as slabs, edgings, and lumber trim ends.
- **Market Region** – California and other nearby states, including Arizona, Nevada, and Oregon, represent a very large market for OSB. However, despite this region's large OSB market, there are no OSB manufacturers within well over 1,000 miles of California. This distance between the market and existing manufacturers creates a transportation cost advantage for a California based OSB producer. Therefore, the plant will focus on serving the market in California and nearby states.
- **Product Mix** – the plant will produce a mix of sheathing and underlayment. However, BECK industry contacts indicated that existing OSB manufacturers first attempt to sell their commodity sheathing and flooring products in markets close to their plants. If those efforts are not successful, the material is often "dumped" into the California market. Therefore, to avoid competing in such markets, a strategy that was not fully evaluated because product values are proprietary would be for the California plant to focus on producing value added products such as moisture resistant and thermal overlays.
- **Plant Equipment** – There are a number of idled OSB plants in North America. For example, in June 2015, Forest Economic Advisors reported that the demand to capacity ratio for OSB in 2015 is about 81 percent. Therefore, it is believed that, given the right circumstances and market opportunities, existing manufacturers would seriously consider dismantling an idled plant and relocating key parts of it to a location in

California. If such used equipment were available, it would keep the capital cost of the prospective plant in California as low as possible.

- **Plant Capacity** – the size of the OSB market in California and surrounding states is very large. Thus, the capacity of the prospective plant is not likely to be constrained by end-product markets. Rather, the capacity of the plant will be dependent on the raw material supply availability and the capacity of the manufacturing equipment.

The balance of this chapter documents BECK's findings with respect to the feasibility of developing an OSB plant in California based on the preceding conceptual design.

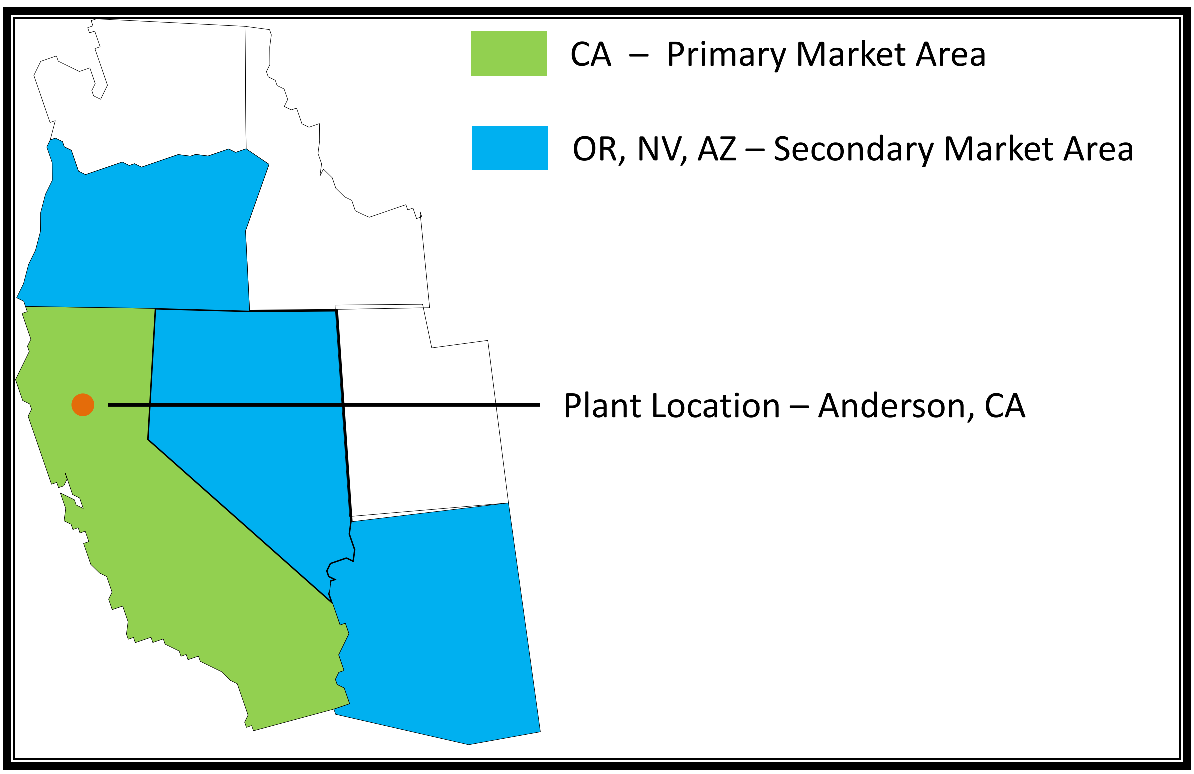
3.3 OSB MARKET FEASIBILITY

The following report sections describe the market for OSB products.

3.3.1 Geographic Market Area

As shown in **Figure 3.1**, the market area for the prospective OSB plant has been organized into two categories that include (1) California – the primary market area, and (2) Oregon, Nevada, & Arizona – the secondary market area. Particular attention is given to California in the following analysis of market drivers.

Figure 3.1 – Geographic Market Areas for Prospective OSB Plant



3.3.2 Market Drivers

New Residential Construction – Roughly 40 percent of all solid wood products produced in the United States are used for new residential construction.[2] **Figure 3.2** provides an illustration of OSB being used as wall sheathing in the construction of a home. Nails are used to fasten the panels to the underlying wall studs. The purpose served by using OSB in this manner is to provide structural support against uplift loads, lateral loads, and wind pressure (i.e., racking shear strength). In addition, the OSB panels provide a basic barrier against the elements of wind and water. OSB is also commonly used as sub-flooring (i.e., installed over floor joists) where it carries the live loads subjected to the floor joists below. OSB subflooring is typically made with a tongue and groove design. Finally, OSB is also frequently used as sheathing for roofs. The panels provide lateral bracing of roof framing members (e.g., trusses, rafters) and carries live and dead loads from above the rafters and trusses.

Figure 3.2 – New Home Construction Using OSB as Wall Sheathing

Since OSB is used in a variety of applications in residential construction, its market is heavily dependent on the construction of new single family, multi-family, and manufactured housing. **Table 3.1** provides a history of housing starts in the primary and secondary market areas. As shown in the table, over the long-term, the average number of new home starts (combined single family, multi-family, and manufactured homes) is about 114 thousand per year for California, which, on average, accounts for about 8 percent of all housing starts in the U.S. As a point of reference, over the same time period only two other U.S. states have accounted for a higher percentage of U.S. housing starts: Texas at 11.5 percent and Florida at 9.2 percent. Since 1995, the highest number of annual starts in California has been 207,000 in 2004, and the

[2] Adair. 2009. Wood Used in New Residential Construction U.S. and Canada. Wood Products Council.

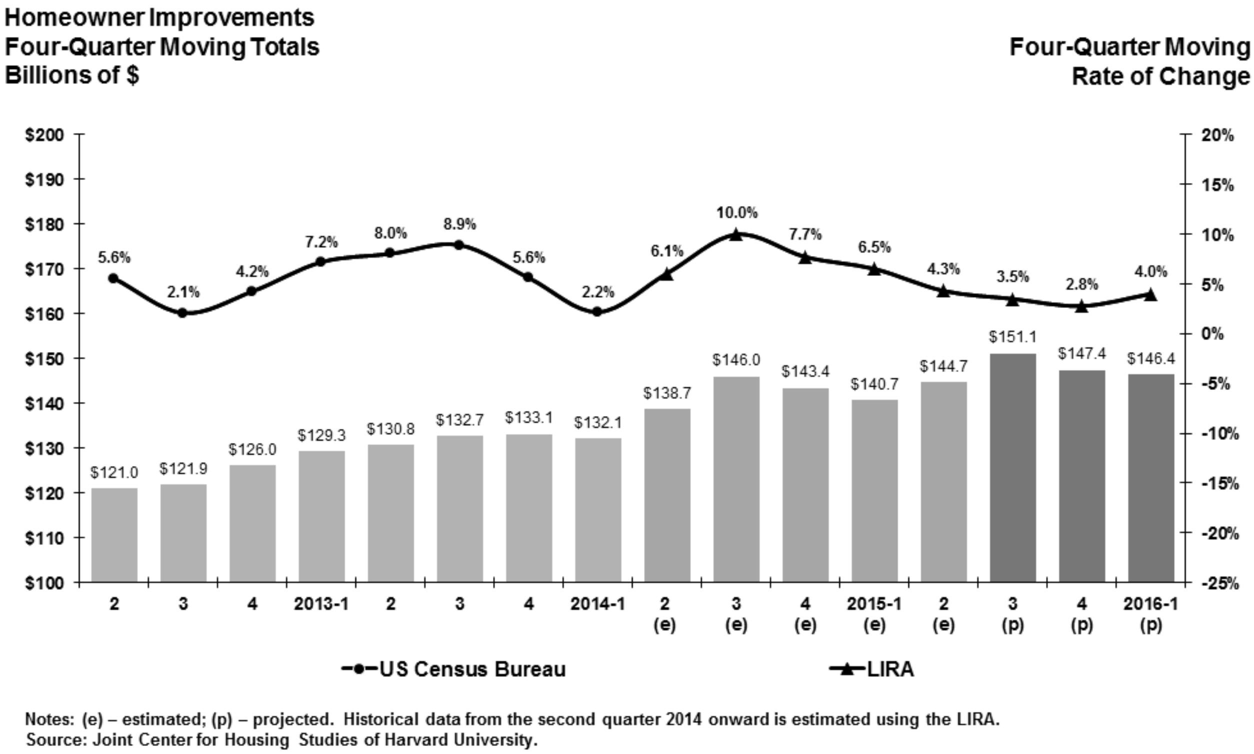
lowest has been 35,000 in 2009. In **Section 3.3.3.1**, the data in **Table 3.1** is utilized to estimate the size of this OSB market segment for each state in the primary and secondary market areas.

Table 3.1 – Historic Level of Housing Starts in Primary and Secondary Market Areas (millions).

		Primary Market Area		Secondary Market Area					
Year	U.S. Total Housing Starts	California Housing Starts	Percent of U.S. Total	Oregon Housing Starts	Percent of U.S. Total	Nevada Housing Starts	Percent of U.S. Total	Arizona Housing Starts	Percent of U.S. Total
1995	1.333	0.084	6.3	0.026	2.0	0.033	2.5	0.053	4.0
1996	1.426	0.092	6.5	0.028	2.0	0.037	2.6	0.054	3.8
1997	1.441	0.110	7.6	0.027	1.9	0.035	2.4	0.058	4.0
1998	1.612	0.124	7.7	0.026	1.6	0.037	2.3	0.064	4.0
1999	1.664	0.138	8.3	0.023	1.4	0.033	2.0	0.065	3.9
2000	1.592	0.146	9.1	0.020	1.2	0.032	2.0	0.061	3.9
2001	1.637	0.147	9.0	0.021	1.3	0.036	2.2	0.062	3.8
2002	1.748	0.160	9.1	0.022	1.3	0.036	2.0	0.066	3.8
2003	1.889	0.192	10.2	0.025	1.3	0.043	2.3	0.075	4.0
2004	2.070	0.207	10.0	0.027	1.3	0.045	2.2	0.091	4.4
2005	2.155	0.205	9.5	0.031	1.4	0.048	2.2	0.091	4.2
2006	1.839	0.161	8.7	0.027	1.4	0.039	2.1	0.065	3.6
2007	1.398	0.110	7.9	0.021	1.5	0.027	1.9	0.050	3.5
2008	0.905	0.063	6.9	0.012	1.3	0.015	1.6	0.026	2.9
2009	0.583	0.035	6.0	0.007	1.2	0.007	1.2	0.014	2.5
2010	0.605	0.044	7.2	0.007	1.1	0.006	1.1	0.012	2.0
2011	0.624	0.045	7.3	0.008	1.2	0.006	1.0	0.013	2.1
2012	0.830	0.059	7.1	0.011	1.3	0.009	1.1	0.022	2.6
2013	0.991	0.081	8.1	0.015	1.5	0.011	1.1	0.025	2.5
2014	1.046	0.084	8.0	0.017	1.6	0.013	1.2	0.027	2.6
Average	**1.369**	**0.114**	**8.0**	**0.020**	**1.4**	**0.027**	**1.9**	**0.050**	**3.4**

Repair and Remodeling – a second key driver of wood products consumption is the repair and remodeling market. The uses of OSB in this market segment are similar to those in new home construction, but are applied to existing homes rather than new homes. **Figure 3.3** shows data from Harvard's Joint Center for Housing Studies Leading Indicator of Remodeling Activity Model from the second quarter of 2015. As the figure illustrates, the recent trend in repair and remodeling spending is upward – from about $121 billion in the second quarter of 2012 to an estimated $145 billion in the second quarter of 2015.

Figure 3.3 – Leading Indicator of Remodeling Activity Q2 2015



The size of the repair and remodeling market is a function of the number of existing households within a given region. **Table 3.2** illustrates the number of housing units in each state in the primary and secondary market areas for the years 2010 through 2014. As the table illustrates, California accounts for about 10.4 percent of the total number of housing units in the United States.

Note that unlike housing starts, where California has trailed Texas and Florida, California is the clear leader in number of housing units. California accounts for about 33 percent more housing units than Texas the state with the next largest number of units at 10.43 million. Texas is followed by Florida, which has 9.14 million units. The total number of housing units in the combined primary and secondary market areas account for nearly 15 percent of all housing units in the United States. The data presented in **Table 3.2** will be used to estimate the size of the repair and remodeling market segment in **Section 3.3.3.2**.

Table 3.2 – Number of Housing Units in Primary and Secondary Market Area (millions)

		Primary Market Area		Secondary Market Area					
Year	U.S. Housing Units	California Housing Units	Percent of U.S. Total	Oregon Housing Units	Percent of U.S. Total	Nevada Housing Units	Percent of U.S. Total	Arizona Housing Units	Percent of U.S. Total
2010	130.04	13.55	10.4	1.65	1.3	1.14	0.9	2.78	2.1
2011	131.03	13.63	10.4	1.67	1.3	1.16	0.9	2.82	2.1
2012	131.64	13.67	10.4	1.67	1.3	1.17	0.9	2.84	2.2
2013	132.83	13.73	10.3	1.68	1.3	1.18	0.9	2.86	2.2
2014	133.96	13.90	10.4	1.70	1.3	1.20	0.9	2.91	2.2
Average	**131.90**	**13.70**	**10.4**	**1.67**	**1.3**	**1.17**	**0.9**	**2.84**	**2.2**

Industrial Uses – a third driver of OSB consumption is usage in industrial applications (e.g., interior framing for upholstered furniture, materials handling, recreational vehicle and trailer components, concrete forming, and signs). **Figure 3.4** illustrates how OSB is used in this market segment, including use as a structural frame for upholstered furniture and as a box for special purpose packaging.

Figure 3.4 – OSB Usage in Industrial Applications

Unfortunately, unlike housing starts and the level of repair and remodeling expenditures for existing homes, there is not a single statistic that is directly correlated to industrial consumption of OSB panels. Therefore, BECK developed a metric that can be used to predict the usage of OSB in industrial applications at the state level. As shown in **Table 3.3**, BECK calculated each state's 2015 GSP in the primary and secondary market areas as a proportion of the United States 2015 GDP. As will be shown in **Section 3.3.3.3**, this metric is used to estimate OSB panel usage by state.

Table 3.3 – Allocation of Industrial OSB Panel Usage to States in Primary and Secondary Market Area

	Primary Market Area	Secondary Market Area		
	California	**Oregon**	**Nevada**	**Arizona**
US GDP ($ in trillions)	18.124	18.124	18.124	18.124
State GSP ($ in trillions)	2.287	0.229	0.137	0.289
State GSP as % of U.S. GDP	12.62	1.26	0.76	1.59

Non-Residential Construction – a fourth OSB market driver is the use of OSB in non-residential construction (e.g., structures for lodging, office, commercial, educational, health care, and other purposes). Again, the types of applications for which OSB is used in non-residential construction are similar to the usage applications in residential construction (e.g., roof, wall, and floor sheathing).

For the primary and secondary market areas, **Table 3.4** shows each state's proportion of total U.S. private non-residential construction value put-in-place for the period 2003 through 2014. The data is from the U.S. Census Bureau. As shown in the table, California, on average, accounts for nearly 8 percent of all private non-residential construction value put-in-place. Arizona, Nevada, and Oregon account for 2.8, 2.1, and 1.5 percent respectively. **Section 3.3.3.4** uses the information presented in **Table 3.4** to estimate OSB market size for the non-residential construction segment for each state.

Table 3.4 – Proportion of Total U.S. Private Non-Residential Construction Value by State and Year (percent)

	Primary Market Area	Secondary Market Area		
Year	California	Oregon	Nevada	Arizona
2003	10.1	1.0	1.8	2.4
2004	9.6	1.0	2.9	2.9
2005	9.6	1.4	2.6	2.9
2006	9.2	1.3	2.9	3.9
2007	8.6	1.2	3.9	3.3
2008	7.3	1.0	3.9	3.1
2009	6.7	0.8	3.3	2.4
2010	6.9	0.8	1.0	2.6
2011	6.2	2.5	0.4	2.9
2012	6.4	2.3	0.6	3.5
2013	6.4	3.0	0.7	1.7
2014	6.9	2.0	0.9	1.4
Average	**7.8**	**1.5**	**2.1**	**2.8**

3.3.3 Market Size Estimate – Primary Market Area

The following sections provide an estimate of OSB panel usage categorized by the four market drivers identified in **Section 3.3.2**, as well as by the primary and secondary market areas. The data used in the analysis is APA's 2015 Structural Panel & Engineered Wood Yearbook. That report provides estimates of total annual U.S. OSB usage (2007 through 2014) categorized by residential, repair and remodeling, industrial, and non-residential segments (i.e., the four market drivers identified in the preceding section).

Table 3.5 provides a summary of the APA data categorized by these four market segments. Note that the data shown is the average usage for the time period 2007 through 2014. This time period includes historically low levels of housing activity. Thus, the market size estimates are likely to be conservative relative to longer-term averages. It was used, however, to avoid extrapolating OSB usage beyond the time period for which data was readily available.

Table 3.5 - APA Structural Panel Data: United States OSB Usage Market Segment Summary (millions of square feet consumed per year 3/8" basis)

Market Segment	Average Annual Usage (square feet, millions, 3/8" basis)	Proportion of Total (%)
Residential	8,044	51
Remodeling	3,505	22
Industrial	2,502	16
Non-Residential	1,713	11
Total	**15,764**	**100**

3.3.3.1 New Residential Construction Market Segment Size Estimate

Using APA data and historic U.S. Census housing start data, BECK calculated that an average of 8,621 square feet (3/8" basis) of OSB was consumed per housing start. The number of housing starts used in the calculations included single-family, multi-family, and manufactured homes.

Table 3.6 shows the estimated historic usage of OSB for residential construction in the primary and secondary market areas between 2007 and 2014 (the same years for which the APA data was available). As shown in the table, the estimated average size of the market for new residential construction in California is 601 million square feet (3/8" basis). The combined average size of the secondary market area is about 440 million square feet (3/8" basis). It should be noted that the period used to estimate that average includes a historically low level of housing starts. For example, if the APA's data about OSB usage per housing start is extrapolated to the period before 2007, there is a period beginning in 1997 and ending in 2007 in which the annual consumption in California average 1.486 billion square feet (3/8" basis). Thus, the estimate of the new residential construction segment market size shown **Table 3.6** is judged to be conservative.

Table 3.6 – Estimated Historic Size of Primary and Secondary Market Areas; New Residential Construction Segment (millions of square feet, 3/8" basis)

	Primary Market Area	Secondary Market Area		
Year	**California**	**Arizona**	**Nevada**	**Oregon**
2007	1,014	457	251	194
2008	589	245	140	110
2009	328	135	63	66
2010	408	115	60	64
2011	424	121	58	72
2012	538	200	83	98
2013	738	231	102	136
2014	765	247	119	152
Average	**601**	**219**	**110**	**111**

Table 3.7 shows the projected size of the new residential construction market in the primary and secondary market areas. The projection is based on forecasted new housing starts from 2016 through 2025 as reported by FEA. Note that FEA only provides a regional breakout of forecasted housing starts. In other words, state level housing start forecasts are not provided. Thus, in order to project housing starts at a state level, BECK applied the historic proportion of housing starts for a given state to the U.S. West home start projection from FEA.

Note from the table that the projected demand is significantly higher in California than the historic demand. As described earlier, the increase in demand is a function of using the 2007 through 2014 time period as the basis of historic demand. That time period included historically low housing start levels. Thus, it likely underestimates demand. The projected levels of over 1.1 billion square feet for California is well within the range of estimated OSB usage in the state during periods of higher levels of home construction (e.g., 1998 to 2005).

Note also that the projected level of OSB usage in Arizona is lower than the historic levels. Again, this is due to limitations in the time period for which data was available for calculating OSB usage per home and per state.

Table 3.7 – Projected Size of Primary and Secondary Market Areas; New Residential Construction Segment (millions of square feet, 3/8" basis)

Year	Primary Market Area	Secondary Market Area		
	California	Arizona	Nevada	Oregon
2016	957	130	146	174
2017	1,168	159	178	212
2018	1,168	159	178	212
2019	1,121	153	171	203
2020	945	129	144	172
2021	1,070	146	163	194
2022	1,159	158	177	211
2023	1,232	168	188	224
2024	1,300	177	198	236
2025	1,364	186	208	248
Average	**1,148**	**156**	**175**	**209**

3.3.3.2 Repair and Remodeling Market Segment Size Estimate

From the APA data on OSB usage in the repair and remodeling segment and from U.S. Census Bureau data about the number of households in the U.S., BECK estimated the size of the OSB market in the primary and secondary market areas for repair and remodeling. This was accomplished by allocating the total repair and remodeling OSB usage as reported by APA by the proportion of all U.S. households in each state in the primary and secondary market areas. The key assumption underlying this methodology is that the level of repair and remodeling is equally distributed across the U.S.

The results shown in **Table 3.8** estimate that 364 million square feet (3/8" basis) of OSB is consumed annually for repair and remodeling in California. In the secondary market area, that includes Arizona, Nevada, and Oregon, an estimated 151 million square feet (3/8" basis) is consumed annually. Note that for this estimate, the U.S. Census Bureau household data was readily available for the years 2010 through 2014. Thus, the estimates are based on the average number of households in each state relative to the U.S. total during those years.

Table 3.8 – Estimated Historic Repair and Remodeling Market Size for OSB in the Primary and Secondary Market Areas (millions of square feet, 3/8" basis)

	Primary Market Area	Secondary Market Area		
Year	California	Arizona	Nevada	Oregon
2010	365	75	31	45
2011	365	75	31	45
2012	364	76	31	45
2013	362	76	31	44
2014	364	76	31	44
Average	**364**	**76**	**31**	**45**

Table 3.9 shows the projected usage of OSB in the repair and remodeling segment in the primary and secondary market areas. The projection is based on the estimated number of housing units in each state in the primary and secondary market area and the average amount of OSB used for repair and remodeling purposes per household from 2007 through 2014.

Table 3.9 – Projected Repair and Remodeling Market Size for OSB in the Primary and Secondary Market Areas (millions of square feet, 3/8" basis)

	Primary Market Area	Secondary Market Area		
Year	California	Arizona	Nevada	Oregon
2016	393	92	41	49
2017	398	95	42	49
2018	403	98	44	50
2019	408	101	45	51
2020	413	103	47	51
2021	419	107	50	52
2022	425	111	52	53
2023	430	115	54	54
2024	436	119	57	55
2025	442	123	59	55
Average	**417**	**106**	**49**	**52**

3.3.3.3 Industrial Market Segment Size Estimate

BECK utilized APA's data on OSB usage in the Industrial Market segment for all of the U.S. and allocated it to the states in the primary and secondary market areas. This was accomplished by using the data shown in **Table 3.3**, which displays each state's GSP as a proportion of U.S. GDP. The assumption underlying this methodology is that U.S. Industrial activity is correlated to GSP and GDP, which are measures of economic output. As shown in **Table 3.10**, the estimated industrial OSB demand is 316 million square feet annually in California and a combined 91 million square feet in the secondary market area states of Arizona, Nevada, and Oregon.

Table 3.10 – Estimated <u>Historic</u> Industrial Market Size for OSB in the Primary and Secondary Market Areas (millions of square feet, 3/8" basis)

Primary Market Area	Secondary Market Area		
California	**Arizona**	**Nevada**	**Oregon**
316	40	19	32

Table 3.11 shows the projected usage of OSB in the Industrial market segment. The estimated industrial usage in California is projected to increase to an average of 442 million square feet (3/8" basis) compared to the historic average of 316 million square feet. The estimate was calculated by using the historic GDP growth rate of 2.88 percent (between 2008 and 2015) to project GSP and GDP levels between 2016 and 2025. Future U.S. wide OSB usage per year was also projected based on historic levels between 2007 and 2015. During that time, industrial OSB usage increased by an average of 3.6 percent per year.

Table 3.11 – <u>Projected</u> Industrial Market Size for OSB in the Primary and Secondary Market Areas (millions of square feet, 3/8" basis)

	Primary Market Area	Secondary Market Area		
Year	**California**	**Arizona**	**Nevada**	**Oregon**
2016	395	49	23	40
2017	406	50	23	42
2018	416	51	24	43
2019	427	52	24	45
2020	437	53	24	46
2021	448	54	24	48
2022	458	54	24	49
2023	469	55	24	51
2024	479	56	24	52
2025	490	57	25	54
Average	**442**	**53**	**24**	**47**

3.3.3.4 Non-Residential Construction Market Segment Size Estimate

BECK estimated the historic size of the non-residential market segment using the APA data and the U.S. Census Bureau data that tracks the dollar value by state of new construction put in place. The proportion of the value in each state was employed to allocate from the U.S. wide level to the state level the amount of OSB used in this segment. **Table 3.12** shows that according to the APA data, between 2007 and 2014, the average annual volume of OSB consumed in California in the non-residential market segment was an estimated 121 million square feet (3/8" basis). The combined total for this market segment in the secondary area was 109 million square feet (3/8" basis).

Table 3.12 – Estimated Historic Non-Residential Market Size for OSB in the Primary and Secondary Market Areas (millions of square feet, 3/8" basis)

Year	Primary Market Area	Secondary Market Area		
	California	Arizona	Nevada	Oregon
2007	181	69	81	26
2008	144	61	77	20
2009	112	40	56	14
2010	106	40	16	12
2011	99	46	6	40
2012	113	62	11	41
2013	100	27	11	46
2014	110	22	14	31
Average	**121**	**46**	**34**	**29**

Table 3.13 shows the projected usage of OSB in the non-residential construction market. The table shows an estimated average of 151 millions square feet (3/8" basis) will be consumed in California's non-residential construction market, with an additional 46, 34, and 29 million square feet (3/8" basis) being consumed annually in Arizona, Nevada, and Oregon respectively. The estimate is based on the following assumptions: First, the annual growth rate in the use of OSB for non-residential applications observed between 2007 and 2014 will continue at the same rate between 2016 and 2025. Second, the proportion of private non-residential construction spending among states, which was used to allocate total U.S. non-residential OSB usage to the state level, observed between 2007 and 2014 will continue unchanged between 2016 and 2025.

Table 3.13 – Projected Non-Residential Market Size for OSB in the Primary and Secondary Market Areas (millions of square feet, 3/8" basis)

	Primary Market Area	Secondary Market Area		
Year	**California**	**Arizona**	**Nevada**	**Oregon**
2016	132	48	36	25
2017	137	49	37	26
2018	141	51	38	27
2019	145	52	39	28
2020	149	53	40	29
2021	153	55	41	29
2022	157	56	42	30
2023	161	58	43	31
2024	165	59	45	32
2025	169	61	46	33
Average	**151**	**54**	**41**	**29**

3.3.4 OSB Market Size Summary

Table 3.14 displays a summary of the historic and projected OSB market size by primary and secondary market area and by market segment. Historically, the size of the market in California was an estimated 1.402 billion square feet (3/8" basis). That is a significant volume, representing roughly 10 percent of the entire U.S. market for OSB over the period from 2007 through 2014. Adding the volumes estimated to be consumed in the secondary market area increases the total estimated market size for OSB consumption in the primary and secondary market areas to 2.914 billion square feet (3/8" basis) or roughly 14 percent of the average size of the OSB market during the period 2007 through 2014.

The table further forecasts that the market size estimates for the future will be considerably larger than the historic market size estimates – 2.158 billion square feet projected for California versus historic usage estimates of 1.402 billion square feet. This is driven primarily by a substantial increase in usage expected in association with significantly higher levels of new home construction, particularly in California, which accounts for about 50 percent of the increase in usage relative to the historic usage estimates. Another 20 percent of the increase is accounted for from increased levels of new home construction in the secondary market area states. The balance of the increase is due to incremental increases in usage among the other market segments.

While the projected usage levels are significantly higher than the historic levels, it is again worth noting that the projected levels are well within the range of usage observed during earlier market periods when the level of housing starts and other economic activity were higher than the historic market period used in this analysis (i.e., the period for which data was available). Thus, BECK concludes the projected market size is reasonable.

Table 3.14 – Summary of Historic and Projected OSB Market Size by Primary and Secondary Market Area and by Market Segment (millions of square feet, 3/8" basis)

	Primary Market Area	Secondary Market Area			Market Segment Total
Market Segment	**California**	**Arizona**	**Nevada**	**Oregon**	
Historic - Residential	601	219	110	111	1,041
Historic - Repair & Remodeling	364	76	31	45	516
Historic - Industrial	316	40	19	32	407
Historic – Non-Residential	121	46	34	29	230
Historic Sub Total	**1,402**	**381**	**194**	**217**	**2,194**
Projected - Residential	1,148	156	175	209	1,688
Projected - Repair & Remodeling	417	106	49	52	624
Projected - Industrial	442	53	24	47	566
Projected - Non-Residential	151	54	41	29	275
Projected - Sub Total	**2,158**	**369**	**289**	**337**	**3,153**

In addition to understanding the amount of OSB consumed by market segment, it is also important to understand the volume of OSB consumed by end-use application (e.g., floor underlayment, roof and wall sheathing, siding, etc.) **Table 3.15** displays APA data from 2014 showing a categorization of OSB production (and implied demand) by end-use application. The table shows that the North American OSB Industry produced 19.885 billion square feet of OSB (3/8" basis) in 2014, with sheathing accounting for 68 percent of the production, followed by floor underlayment at about 21 percent, siding at 3 percent, and other end use application products at 8 percent.

Table 3.15 – 2014 OSB Demand by End-Use Application (millions of square feet, 3/8" basis)

End-Use	Production/ Demand	Percent of Total
Floor Underlayment	4,185	21
Sheathing	13,427	68
Siding	695	3
Other	1,578	8
Total	19,885	100

The data in **Table 3.15** was applied to the market size data in **Table 3.14** to estimate the volume of OSB consumed in the primary and secondary market regions by end use application. The results are shown in **Table 3.16**. Note that the percentage of OSB used as underlayment and wall and roof sheathing was only applied to structural market segments (residential, repair and remodeling, and non-residential). In other words, the amount of material estimated to be used in the industrial segment was excluded. This methodology requires any volume "left over" to be put into the "Other" category. Thus, the volume in that category is higher than what would be expected given the percentages displayed in **Table 3.15**. Nevertheless, the data indicates that by far the biggest end-use application in the primary and secondary market areas is for OSB sheathing products (i.e., material that is typically about ½ inch thick) that are engineered for the strength requirements and other performance characteristics needed for sheathing applications.

Table 3.16 – Estimated OSB Usage in Primary and Secondary Market Area by End Use Application (millions of square feet, 3/8" basis)

OSB Application Type	Primary Market Area	Secondary Market Area			OSB Application Type Total
	California	Arizona	Nevada	Oregon	
Historic - Underlayment	229	72	37	39	**376**
Historic - Sheathing	733	230	118	125	**1,207**
Historic - Siding	36	11	6	6	**59**
Historic - Other	404	68	33	47	**553**
Historic Total	**1,402**	**381**	**194**	**217**	**2,194**
Projected - Underlayment	361	67	56	61	**544**
Projected - Sheathing	1159	213	179	196	**1,747**
Projected - Siding	61	9	8	10	**88**
Projected - Other	577	80	46	70	**773**
Projected Sub Totals	**2,158**	**369**	**289**	**337**	**3,153**

3.3.5 OSB Pricing

It is also important to understand the market value of OSB. Therefore, the following section provides data on the historic price levels for various types and thicknesses of OSB. The historic prices shown are taken from *Random Lengths*, a weekly forest products industry trade publication that reports market pricing for a variety of lumber and panel products in North America. All prices shown in the following section are reported on a delivered to Sacramento, CA basis.

Figure 3.5 shows the historic quarterly value of OSB sheathing for 3/8", 7/16", and 15/32" for the period covering Q1 2001 through Q2 2015. The prices are for material delivered to Sacramento. Without adjusting for inflation, the average sales price over the time period for 3/8", 7/16", and 15/32" was $244, $255, and $271 per MSF, respectively. As the data illustrates, pricing for OSB tends to be highly volatile, being driven largely by demand from new home construction and repair and remodeling relative to supply.

Also note that pricing for the differing thicknesses, while highly correlated, are not necessarily always completely moving in concert. For example, before January 2010, the premium for 15/32" thickness averaged about $18/MSF. However, since January 2010, the premium for 15/32" has only averaged $11/MSF.

Figure 3.5 – Historic Pricing for OSB Sheathing ($/MSF, delivered to Sacramento)

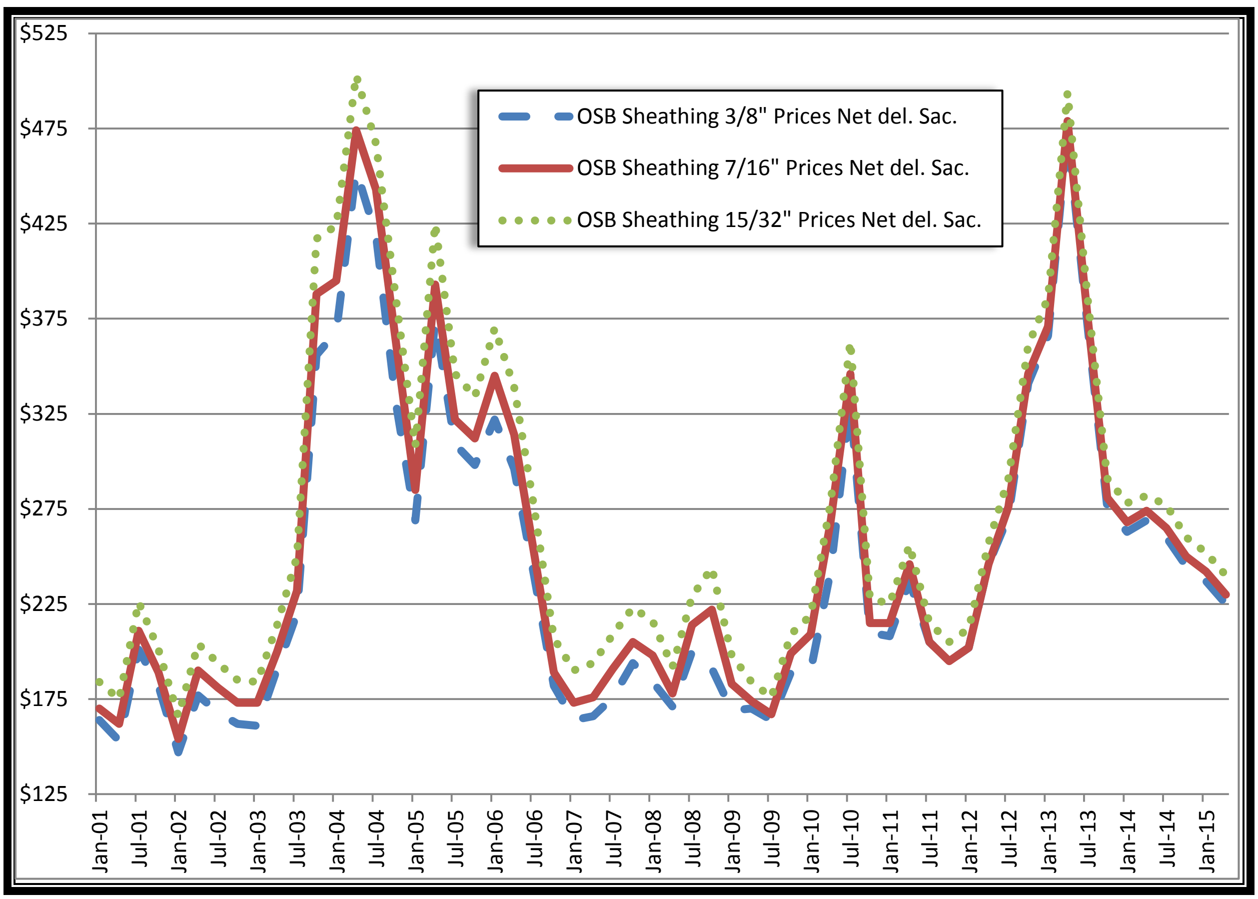
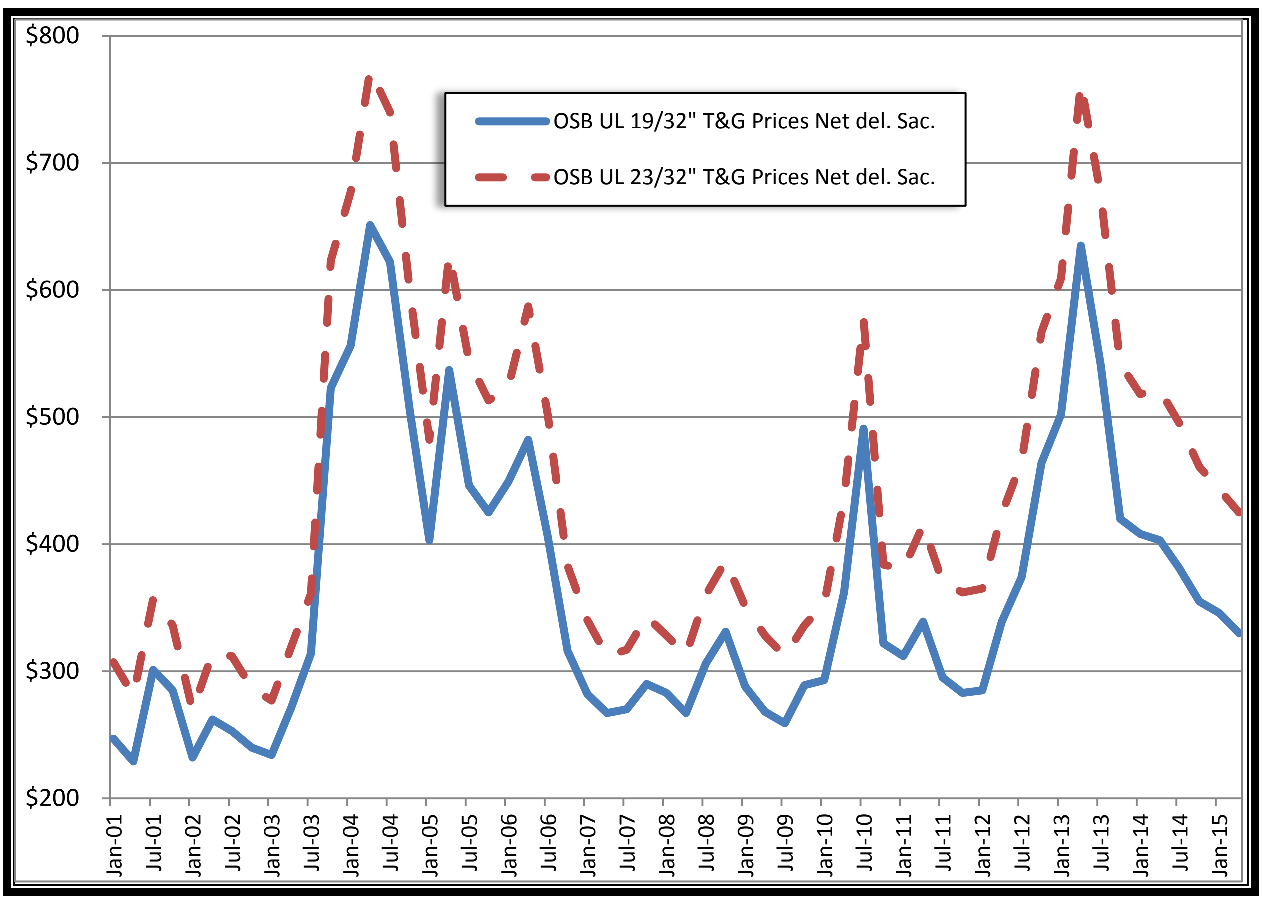


Figure 3.6 also shows the historic quarterly value of OSB. This figure, however, only displays the market price of OSB used as flooring underlayment covering the period Q1 2001 through Q2 2015. The prices shown are for panels delivered to Sacramento. Without adjusting for inflation, the average sales price over the time period for 19/32" and 23/32" is $363 and $441 per MSF, respectively.

Note that the underlayment prices for each thickness are highly correlated, and they are strongly correlated to the prices reported for sheathing. Again, market prices are strongly linked to the level of demand from housing starts, repair and remodeling and, to a lesser extent, industrial and non-residential construction applications. Spikes and subsequent drops are functions of rising demand followed by the OSB industry responding with increased production to increase supply.

Production capacity increases are typically the result of restarting idled plants or developing a new facility. Less common is increasing the number of operating hours of an existing facility since OSB plants typically operate on a 24/7 basis (with some scheduled downtime for repair and maintenance). This situation creates "large chunks" of supply coming online during a relatively short time period, which contributes to price volatility.

Figure 3.6 - Historic Pricing for OSB Sheathing ($/MSF, delivered to Sacramento)



As part of the feasibility analysis, an average sales price on a $/MSF 3/8" basis must be identified. **Table 3.17** illustrates how BECK accomplished that task. It shows the average price for a variety of thicknesses (average calculated for 2001 and 2015 time period for material delivered to Sacramento). It also shows the proportion of production by thickness for the "average" OSB plant in BECK's most recent benchmarking study. The last two columns on the right hand side of the table show the proportion that each thickness contributes to the weighted average price. The second column from the right shows the values placed on the actual thickness of the panels produced. The column on the far right shows the proportion contributed by a given thickness after the price has been converted to a 3/8" basis. As shown the weighted average sales realization on a 3/8" basis is nearly $224/MSF.

Table 3.17 – OSB Plant Average Sales Realization (3/8" basis)

Thickness	Product Type	Average Price 2001-2015 (actual thickness basis)	Proportion of Production (percent)	Proportion of Average Price ($, Actual Thickness Basis)	Proportion of Average Price ($, 3/8" Thickness Basis)
3/8"	sheathing	244	7.6	18.49	18.48
7/16"	sheathing	255	49.5	126.24	108.25
15/32"	sheathing	271	10.6	28.62	22.88
19/32"	underlayment	363	9.0	32.87	20.77
23/32"	underlayment	441	23.3	102.76	53.60
Total			**100.0**	**308.98**	**223.98**

3.3.6 Estimated Transportation Cost Advantage

A key competitive advantage for a California based OSB plant is a lower transportation cost for finished products. **Figure 3.7** and the accompanying **Table 3.18** show the locations and names of existing OSB plants in the U.S. and Canada. As illustrated, there is no existing OSB manufacturing capacity near California. The closest facility is Norbord's plant located at 100 Mile House, BC, which is about 960 miles from Anderson. The next closest are a group of four plants in east Texas that are all within 2,000 to 2,100 miles of Anderson.

Note that the plants in **Table 3.17** that are shaded green are currently idled, but could be restarted. The plants highlighted in orange in the table are permanently closed. As the table shows, the total current production capacity of the OSB industry is estimated to be nearly 24 billion square feet (3/8" basis). If the currently idled plants that could restart are added, the production capacity of the industry is estimated to be about 26.5 billion square feet (3/8" basis). These capacity figures compare to FEA's projected 2015 North American OSB demand of 20.3 billion square feet (3/8" basis), suggesting that demand will lag well below industry capacity. Nevertheless, a plant in California will have a transportation cost advantage over other producers serving that market and would, therefore, be less affected by ebbs and flows in panel demand.

Figure 3.7 – Location of Existing U.S. and Canadian OSB Plants

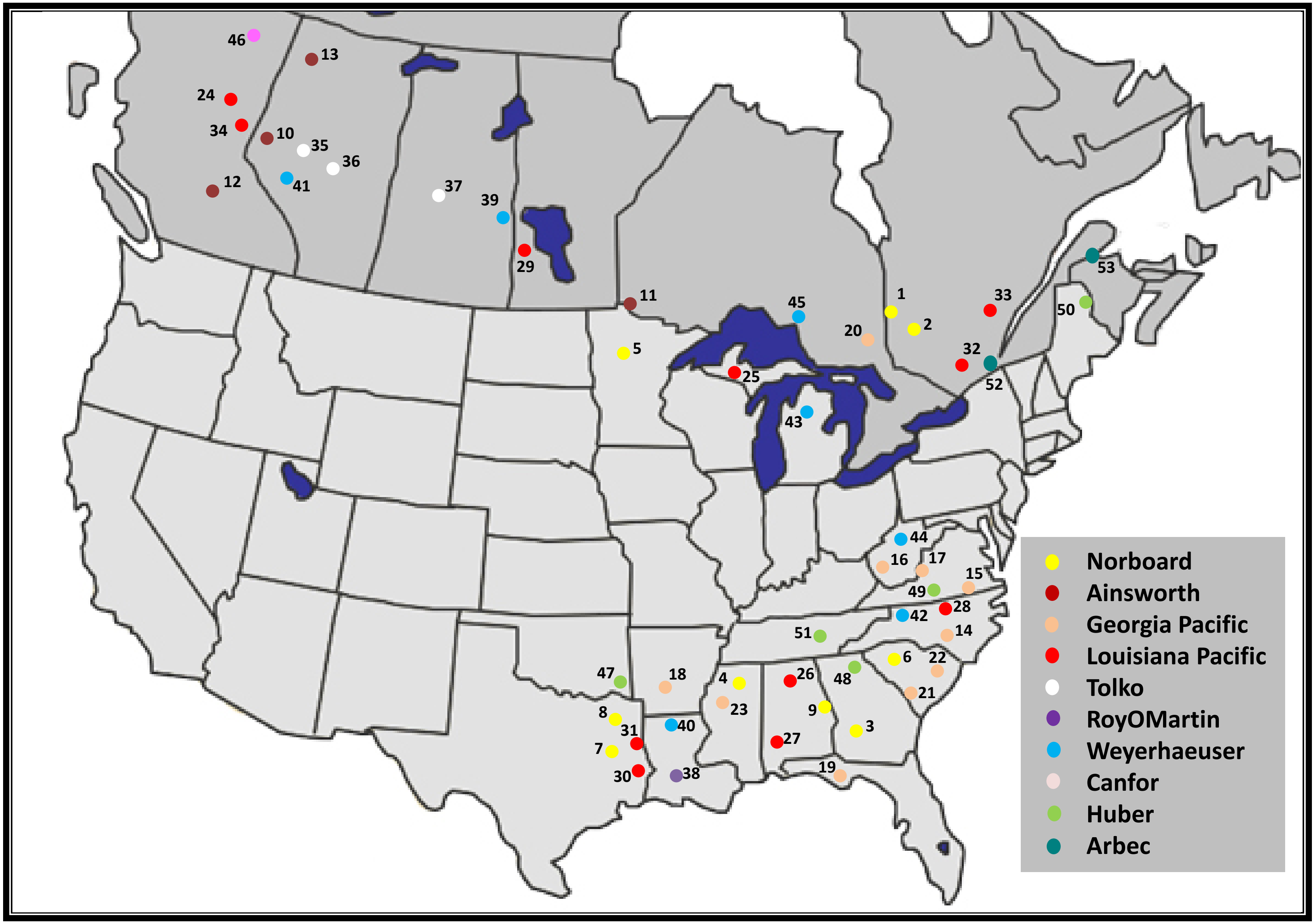


Table 3.18 – Names and Locations of OSB plants in Figure 3.7

Map ID Number	City	State/Province	Company	Capacity
1	LaSarre	Quebec	Norbord	375
2	Val d'Or	Quebec	Norbord	340
3	Cordele	Georgia	Norbord	990
4	Guntown	Mississippi	Norbord	450
5	Bemidji	Minnesota	Norbord	440
6	Kinards	South Carolina	Norbord	500
7	Nacogdoches	Texas	Norbord	380
8	Jefferson	Texas	Norbord	415
9	Huguley	Alabama	Norbord	500
10	Grande Prairie	Alberta	Norbord/Ainsworth	1,300
11	Barwick	Ontario	Norbord/Ainsworth	510
12	100 mile House	British Columbia	Norbord/Ainsworth	440
13	High Level	Alberta	Norbord/Ainsworth	860
14	Dudley	North Carolina	Georgia Pacific	170
15	Skippers	Virginia	Georgia Pacific	365
16	Mount Hope	West Virginia	Georgia Pacific	375
17	Brookneal	Virginia	Georgia Pacific	400
18	Fordyce	Arkansas	Georgia Pacific	500
19	Hosford	Florida	Georgia Pacific	500
20	Englehart	Ontario	Georgia Pacific	760
21	Fairfax	South Carolina	Georgia Pacific	800
22	Clarendon	South Carolina	Georgia Pacific	800
23	Grenada	Mississippi	Georgia Pacific	375
24	Dawson Creek	British Columbia	Louisiana Pacific	380
25	Sagola	Michigan	Louisiana Pacific	410
26	Hanceville	Alabama	Louisiana Pacific	410
27	Thomasville	Alabama	Louisiana Pacific	750
28	Roxboro	North Carolina	Louisiana Pacific	500
29	Swan Valley	Manitoba	Louisiana Pacific	410
30	Jasper	Texas	Louisiana Pacific	475
31	Carthage	Texas	Louisiana Pacific	500
32	Maniwaki	Quebec	Louisiana Pacific	650
33	Chambord	Quebec	Louisiana Pacific	470
34	Peace Valley	British Columbia	Louisiana Pacific	820
35	High Prairie	Alberta	Tolko	642
36	Slave Lake	Alberta	Tolko	825
37	Meadow Lake	Saskatchewan	Tolko	600
38	Oakdale	Louisiana	RoyOMartin	850
39	Hudson Bay	Saskatchewan	Weyerhaeuser	550
40	Arcadia	Louisiana	Weyerhaeuser	425
41	Edson	Alberta	Weyerhaeuser	440
42	Elkin	North Carolina	Weyerhaeuser	425
43	Grayling	Michigan	Weyerhaeuser	535
44	Sutton	West Virginia	Weyerhaeuser	640
45	Wawa	Ontario	Weyerhaeuser	470
46	Fort Nelson	British Columbia	Canfor	625
47	Broken Bow	Oklahoma	Huber	600
48	Commerce	Georgia	Huber	400
49	Crystal Hill	Virginia	Huber	480
50	Easton	Maine	Huber	270
51	Spring City	Tennessee	Huber	350
52	St. Georges de Champlain	Quebec	Arbec	285
53	Miramichi	New Brunswick	Arbec	510
Total Capacity of Currently Operating and Idled Plants				**26,505**
Total Capacity of Currently Operating Plants				**23,910**

Table 3.19 illustrates the estimated freight advantage on a $/MSF 3/8" basis that an OSB plant, located in Anderson, California, would have over the two closest plants in East Texas and Southern British Columbia. The table shows that the prospective California OSB plant would enjoy a freight advantage in the California market regions ranging between $32 and $58 per MSF (3/8" basis) over both the East Texas and Southern British Columbia OSB plants. The prospective California plant also would enjoy a significant freight advantage over the East Texas producers in the Nevada and Oregon market areas. The advantage would be much lower in the Arizona Market. Relative to the Southern British Columbia plant, the California plant would have a freight advantage ranging between $10 and $31 per MSF when serving the Arizona, Nevada, and Oregon market areas.

The methodology used to determine the freight advantage included identifying the U.S. Census Bureau MSA's in the California, Arizona, Nevada, and Oregon market areas and calculating travel times between each MSA and Anderson; 100 Mile House, British Columbia; and Carthage, Texas. The travel times were then used to calculate transportation cost assuming a trucking fee of $85 per hour and a payload of 39,000 square feet per truckload (3/8" basis).

Note that rail transportation rates were not readily available. However, a rail boxcar can carry four times the payload of a semi-truck. Therefore, the total cost of moving an OSB filled rail car between destinations can be four times higher than the cost of moving an OSB filled truck between the same destinations and still have an equivalent shipping cost on a per unit basis. One additional consideration is that it is likely that OSB shipped by rail to California would have to be warehoused and reloaded before reaching its final destination. Those extra logistics increase cost. Therefore, BECK believes that the "truck-only" transportation cost analysis is indicative of the transportation cost advantage a California plant would have regardless of the freight transportation mode.

Table 3.19 – Estimated Freight Advantage of a California Based OSB plant ($/MSF 3/8" basis)

		Average Trucking Cost From Anderson, CA	Average Trucking Cost From TX	Average Freight Advantage Over TX	Average Trucking Cost From BC	Average Freight Advantag e Over BC
Primary Market Area	Central California	10	61	**51**	45	**35**
	Northern California	5	63	**58**	40	**34**
	Southern California	20	52	**32**	54	**34**
Secondary Market Area	Arizona	31	40	**9**	62	**31**
	Nevada	14	55	**41**	45	**30**
	Southern Oregon	8	72	**64**	32	**24**
	Northern Oregon	15	75	**60**	25	**10**

3.3.7 OSB Market Trends

BECK reviewed several years of OSB related market commentary in *Random Lengths*, a weekly forest industry trade publication. The key OSB market trends and other commentary reported in that publication are summarized in the following section.

3.3.7.1 2012 Recap

In early 2012, OSB drew attention with a market run featuring elevated prices not seen since 2006. Scaled-back production levels caused by the housing crash led to the higher prices as increases in housing construction boosted the demand for OSB. With this increase in demand, OSB production in the first quarter of 2012 grew modestly to 6.7 billion square feet (3/8" basis) – up 1.8 percent from 2011. By the end of June 2012, prices of some key OSB items were more than $100/MSF above where they were at the same time the year before.

The sustained run in structural panels (plywood, OSB) during the first half of 2012 allowed producers to operate profitably after years of operating at a loss during the recession. Many industry observers believed OSB producers were going to add more shifts or reopen idled mills, but it did not happen. U.S. housing starts at that time were at a rate of 760,000 units per year, which was an increase of 23.6 percent from June 2011. However, many producers still viewed the economy as too precarious to justify increasing production capacity.

During the second half of 2012, with OSB prices drawing comparisons to the market of 2003 - 2005 and sitting in the range of $325-$360/MSF after being below $200/MSF (3/8" basis) for most of the preceding five years, many producers again contemplated opening idle mills and increasing production (see **Figures 3.5 & 3.6**). North American structural panel production (OSB and plywood) was up 4.7 percent in late 2012 – compared to the first three quarters in 2011 – to a level of 20.9 billion square feet (3/8" basis). This situation continued to the end of 2012, which saw producers announce plans to start idled mills. Many producers at the time indicated the strong run in 2012 and anticipation of stronger housing starts in 2013 as justification for increasing capacity.

3.3.7.2 2013 Recap

Unfortunately, the increased OSB production levels and housing start forecasts that were overly optimistic at the end of 2012 led to a volatile OSB market in 2013. Average selling prices dropped by $71/MSF (3/8" basis) in April of 2013 after gaining more than $100/MSF between the second half of 2012 and the first quarter of 2013. In April 2013, however, the increase in supply caught up with the demand as OSB production increased 10.1 percent over the first quarter of 2012. The trend of increasing production of OSB continued through the first half of 2013 as production gains through the first six months of 2013 totaled 5.9 billion square feet, up 8.9 percent from the same time period the preceding year.

During the second quarter of 2013, OSB prices collapsed. The peak occurred in February of 2013 at $495/MSF, which ended a run that saw a gain of $178/MSF over a 20 week period that began in mid-October of 2012. The reason underlying the drop was a combination of increased production from the industry and housing start levels that failed to meet expectations. For example, in the south, OSB mills reopened in Clarendon, SC and Hanceville, AL. Similarly, restarts occurred in Western Canada at High Level, AB and Slave Lake, AB.

Despite the steep drop in prices, production continued at higher levels than the preceding year. OSB production during the third quarter increased 11.6 percent compared to the same period in 2012. 2013 finished out with OSB prices still low as supply was outweighing demand. In the Southeast, mills relied on the furniture market to sustain demand, with some mills in the south were selling 10 percent of their OSB to furniture manufacturers.

3.3.7.3 2014 Recap

The beginning of 2014 was a continuation of low OSB prices, with the composite price reaching $272/MSF (3/8" basis) the first week of January 2014, a price level 40 percent below the price at the same time a year before. Similar to the prior year, the low OSB price in 2014 was caused by a U.S. housing market that failed to live up to expectations. Most analysts estimated that housing starts would hit 1.1 million units in 2014. Through March of 2014, the seasonally adjusted annual rate averaged only 923,000 housing starts.

Through the second quarter of 2014, OSB production rose 8.4 percent compared to the same period the year before, continuing the trend of higher production levels. The trend of weak demand and relatively high production continued into 2015, with the OSB composite price in February 2015 dropping to within $2/MSF of its lowest level since late 2011. OSB production reached 19.9 billion square feet in 2014, up 6 percent from 2013 and up 18.5 percent from 2012. OSB production has increased over the past two years in the U.S. and Canada, while U.S. housing starts have failed to reach expectations. Total housing starts topped 1 million units in 2014, but have failed to meet analysts predicted totals. For 2015, total U.S. housing starts are estimated to be approximately 1.1 – 1.2 million.

3.3.7.4 Southeastern U.S. Production

Another trend worth noting from *Random Lengths* is that the Southeastern United States region is a major manufacturer of OSB. Halfway through 2012, when OSB prices were high, OSB produced in the Southeast was shipped to markets thousands of miles away. According to *Random Lengths*, the reason for this is that mill production costs are lower in that region than anywhere else in North America. The Southeast has newer, efficient mills that are able to produce OSB for relatively low cost and ship it out of the region. In addition, the region has lower raw material costs on a dollars per ton basis, but since the tree species in the south tend to be more dense than the common species in the west, the raw material cost advantage relative to a potential California producer is somewhat offset.

3.4 OSB TECHNICAL FEASIBILITY

The following sections address the technical feasibility of an OSB plant including a description of the manufacturing process, site considerations, labor, environmental and regulatory concerns, raw material supply.

3.4.1 OSB Technology

The typical manufacturing process[3] entails the logs initially being delivered to the log yard where they are unloaded from trucks and placed into storage in log decks. From the log decks, logs are fed into the mill's conditioning vats (i.e., heated water for submerging the logs), which heat and moisten the logs to improve the yield of strands. Upon exiting the vats, the logs are cut (i.e., bucked) to shorter, more manageable lengths. Then the logs are fed into a debarker, which removes the bark from the logs, but leaves the wood fiber intact.

Next, the now debarked and bucked logs are fed into a stranding machine, which converts them into thin, rectangular shaped wood strands that are typically about one inch wide, 4 to 6 inches long and approximately 1/32" thick. Importantly, the knives on the stranding machine are oriented parallel to the long axis of the logs (i.e., parallel to the wood grain in the logs) to produce stronger strands. The resulting strands are then dried, typically in a large rotary drum dryer.

During the next part of the process, the strands are blended with: a fully waterproof adhesive resin, wax to increase water repellency, and – in some cases – anti-decay chemicals. This resulting blend of strands coated with resin, wax, and preservatives is then formed into a mat with the strands systematically oriented in a pattern designed to achieve the desired panel strength properties. A typical pattern is to create a panel with the strands organized into three distinct layers. In the panel's two face layers, the strands are oriented parallel to each other and to the long axis of the mat conveyor. The strands in the middle layer are oriented parallel to each other, but perpendicular to the strands in the adjacent face layers.

After blending and forming, the mat is compressed under heat and pressure using presses that have multiple openings (i.e., the presses create 8 to 16 panels during each press cycle). Most OSB panels are sold in a dimension of 4' in width x 8' in length. Most presses are double these dimensions in width and length so that multiple 4' x 8' panels are created during each pressing cycle. The final steps involve trimming the resulting panel to size and treating the panel edges with a sealant to help prevent moisture penetration during shipment and on the job site. **Appendix 1** provides an illustrated depiction of the manufacturing process.

The technology for manufacturing OSB was commercialized in 1981. However, prior to that time, OSB's predecessor technology (known as waferboard) had been commercially available since 1962. The key difference between OSB and waferboard is that the wood strands comprising the waferboard panel were not oriented in a specific pattern. In contrast, OSB panels have the long axis of the wood strands systematically oriented at right angles to one another. This breakthrough created much stronger panels and has led to OSB having an ever increasing share of the structural panel market. In recent years, the trend has been away from production of commodity sheathing and flooring products toward value added products that commonly include various overlays. The quality of OSB panels is assured by conformance with standards recognized by national and international building codes in the United States and Canada.

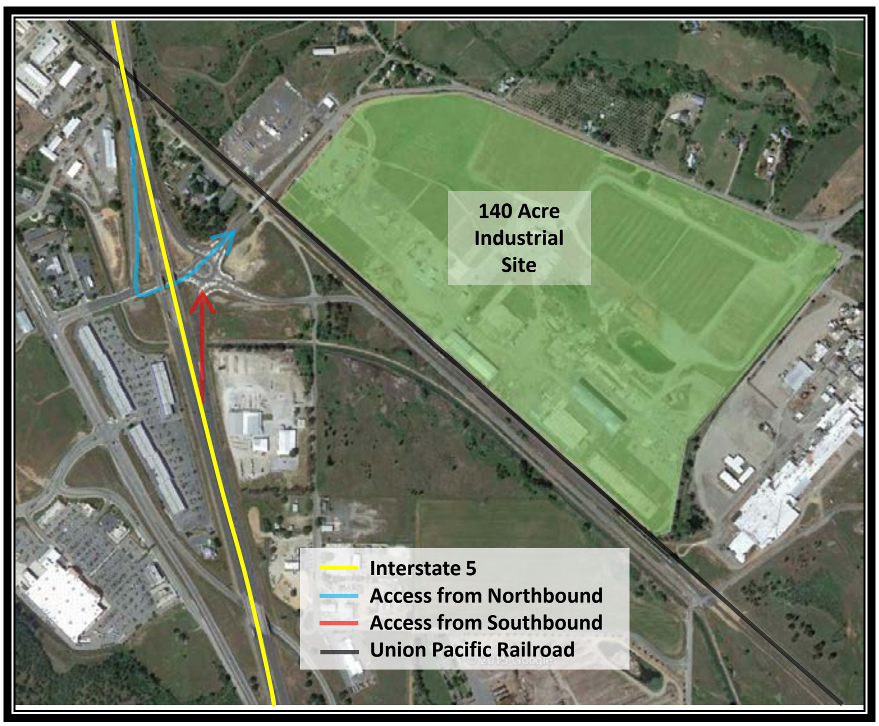
[3] The order of the initial steps for log bucking, debarking, and conditioning may vary from plant to plant.

3.4.2 Site Considerations

BECK identified a former Roseburg Forest Products sawmill site in Shasta County in Anderson, California as a location for the prospective OSB plant (see **Figure 3.8).** The site is approximately 140 acres in size and is located at 5197 Deschutes Road, Anderson, California. In 2015, the land value was $647,500 and improvements were $2,500 for a total assessed value of $650,000. The site is listed by the US Environmental Protection Agency as a regulated facility, but has had no compliance violations reported within the last three years. The site is currently occupied by a diesel truck and trailer, motor home, RV, and bus repair shop. Adjacent to the southeastern boundary of the property is another former mill site for what was once a pulp and paper mill owned by Kimberly Clark Corporation and later by Simpson Paper and known as the Shasta Mill.

As shown in the figure, the site has several remaining buildings, a large area for log storage, and an open pond water storage area. Along the southwestern border of the property is a Class I railroad operated by the Union Pacific Railroad Company, with a rail siding off the Union Pacific track that enters the site. Electric and natural gas service is provided to the site by PG&E.

Figure 3.8 – Aerial View of Potential Site for Anderson, CA OSB Plant



3.4.3 Raw Material Supply and Cost

The following sections provide an assessment of the OSB plant's raw material supply and raw material cost. With regard to cost, a guiding principle used in the analysis is derived from a 2012 BECK benchmarking study of the OSB industry, where the average delivered cost of raw material across all regions was $30 per green ton. To be slightly conservative in this analysis, BECK has assumed that the average delivered raw material cost for the prospective California plant will be $35 per green ton.

3.4.3.1 OSB Plant Raw Material Supply Sources

Per BECK Group benchmarking data, an OSB plant produces an average of 0.63 thousand square feet (3/8" basis) of OSB for every ton of wood fiber consumed. However, the density of the tree species has a significant impact on the yield. For example, plants in the Great Lakes region and Canada, that mainly use aspen, typically recover 0.71 MSF per ton of wood fiber. In contrast, plants in the U.S. South that use southern yellow pine, a denser species, typically yield only about 0.58 MSF per ton of wood fiber.

BECK estimates that the species mix for an OSB plant in California would have an average specific gravity similar to aspen's specific gravity of 0.39. This is based on true firs having an average specific gravity of about 0.36, pines having an average specific gravity of about 0.37, redwood having a specific gravity of about 0.36, and Douglas fir having a specific gravity of about 0.45. When weighted by California's historical harvest volumes by species, the average is very close to 0.39. Therefore, BECK estimates that an OSB plant in California will yield 0.71 MSF per green ton. This means that the plant being considered for this study will need an estimated 669,000 green tons of raw material per year to produce 475,000 MSF (3/8" basis) of OSB annually. BECK has identified three potential sources for the raw material (see **Figure 3.9**):

1. **Topwood** – the tops of trees harvested to produce sawlogs. The current process of harvesting sawlogs typically involves felling the tree and then yarding the whole tree to a centralized landing area. At the landing, a delimber removes limbs along the length of the stem and cuts the stem into saw log lengths. Because tree diameter tapers from the butt to the top the stem becomes too small for use as a sawlog, typically when the diameter reaches 6". The remaining portion of the stem is called the top and it can be utilized as raw material for the OSB plant.

2. **Pulpwood** – includes trees too small to be categorized as sawlogs. They are typically harvested during thinning, forest restoration, and wildfire hazard reduction treatments. In other regions of the U.S., pulpwood harvest and utilization is a common practice. However, in California there currently are very limited markets for pulpwood size material, so the practice is not common. Pulpwood size trees are typically no larger than about 10 to 12 inches in diameter at breast height. They are usually manufactured into a random length stem (i.e., random length to a 3" diameter top size).

3. **Sawmill byproducts** – slabs, edgings, lumber trim ends, etc. that would normally be manufactured into chips, but which would instead be converted into OSB strands. Roughly half of the cubic volume of logs entering a sawmill is recovered as lumber. The balance of log volume becomes mill byproducts in the form of bark, sawdust, planer shavings, or chips. Of this byproduct volume, roughly half is chips. Chip sales are typically a significant source of revenue for sawmills. California, with no remaining paper mills, has limited markets for chips. Therefore, sawmills in California should be interested in the possibility of manufacturing OSB strands.

Figure 3.9 – Illustration of Various Sources of OSB Plant Feedstock

3.4.3.1.1 Topwood Volume Estimate and Delivered Cost Estimate

Topwood is currently a largely unutilized resource in Northern California. Only an estimated 10 to 20 percent is sold by landowners to biomass power plants. The balance is burned in piles after logging or redistributed across the logging site. Both of those activities have cost or risk for the landowner. Therefore, landowners should be interested and motivated in utilizing topwood. For the purposes of this study, BECK modeled the volume of topwood available under two scenarios: 1) paying $7.00 per green ton to the landowner, and 2) paying $0 per green ton to the landowner. In all cases, a $7.50 per green ton payment to the logger is included to cover their additional cost for delimbing, processing, and loading the material. The balance of the delivered cost of topwood is a function of haul distance/time.

The haul costs were calculated on the basis of roundtrip travel time (including time for loading and unloading) and a truck operating cost of $85 per hour. These assumptions were based on interviews with landowners and logging contractors in California and on data of topwood utilization and costs in other regions of the U.S. West. **Figure 3.10** is a travel time map showing the areas from which this material can be delivered within a given amount of travel time. Each color on the map is a different shell of travel time. The times shown in the legend are one way.

Figure 3.10 – Travel Time Map for Topwood

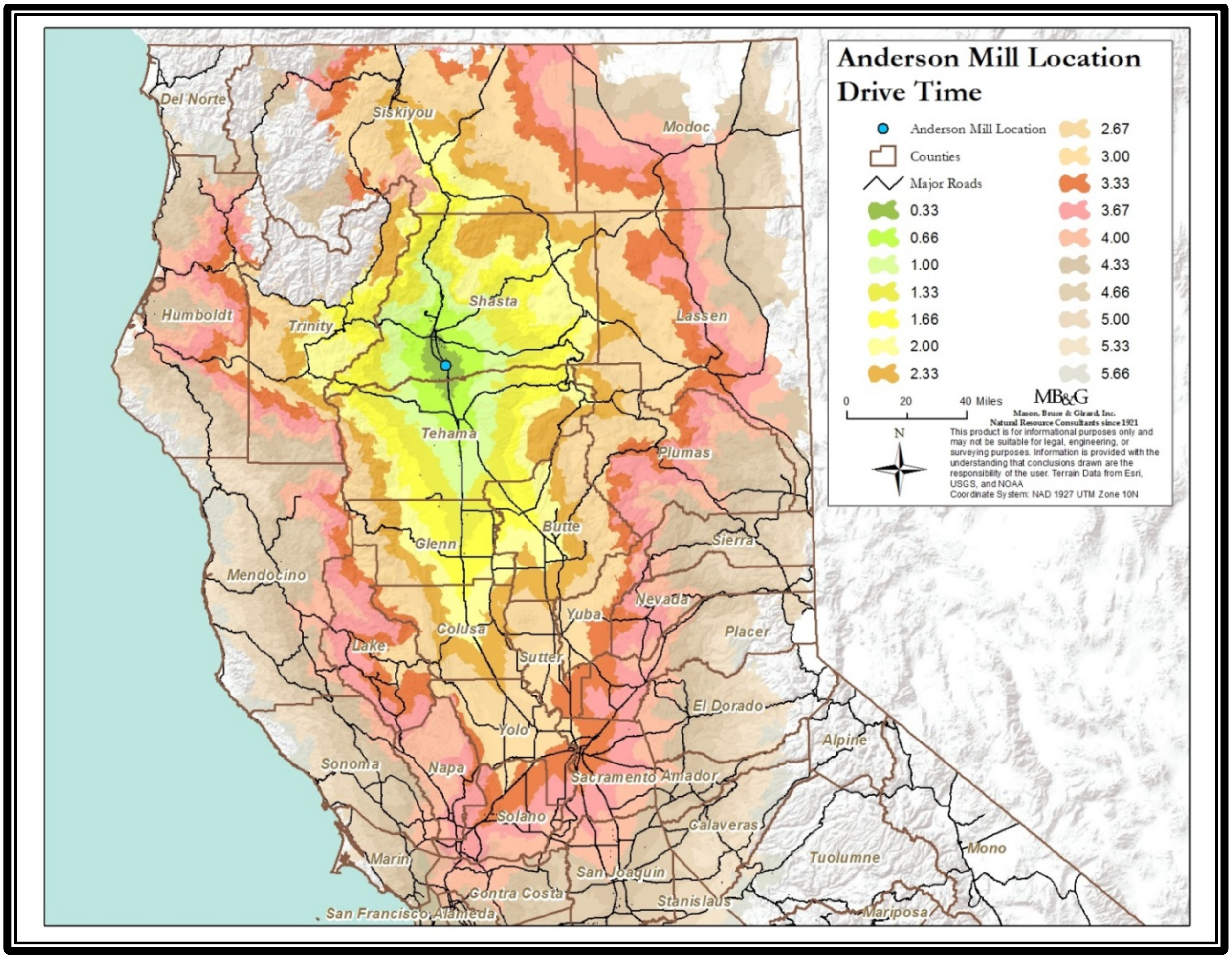


Figure 3.11 shows the estimated volume of topwood from public and private timber harvests that can be delivered to an OSB plant in Anderson, CA for an average delivered cost of $35 per green ton. As shown in **Figure 3.11**, when a $7.00 per ton payment to the landowner is included, approximately 75,000 green tons from public lands is available and approximately 350,000 green tons from private lands is estimated to be available for an average delivered cost of $35/green ton. When no payment to the landowner is included a total of about 700,000 green tons is estimated to be available. See **Appendix 2** for a description of the methodology and assumptions associated with these estimates.

One key assumption in the methodology is that sawlogs are utilized to a 6” small end diameter. However, the presence of an OSB plant may cause sawmills to utilize sawlogs to an 8” diameter since processing larger logs translates into increased productivity at sawmills. If this occurs, it would significantly increase the volume of topwood available.

Figure 3.11 – Volume of Strandable Wood Available at Various Average Costs per Green Ton

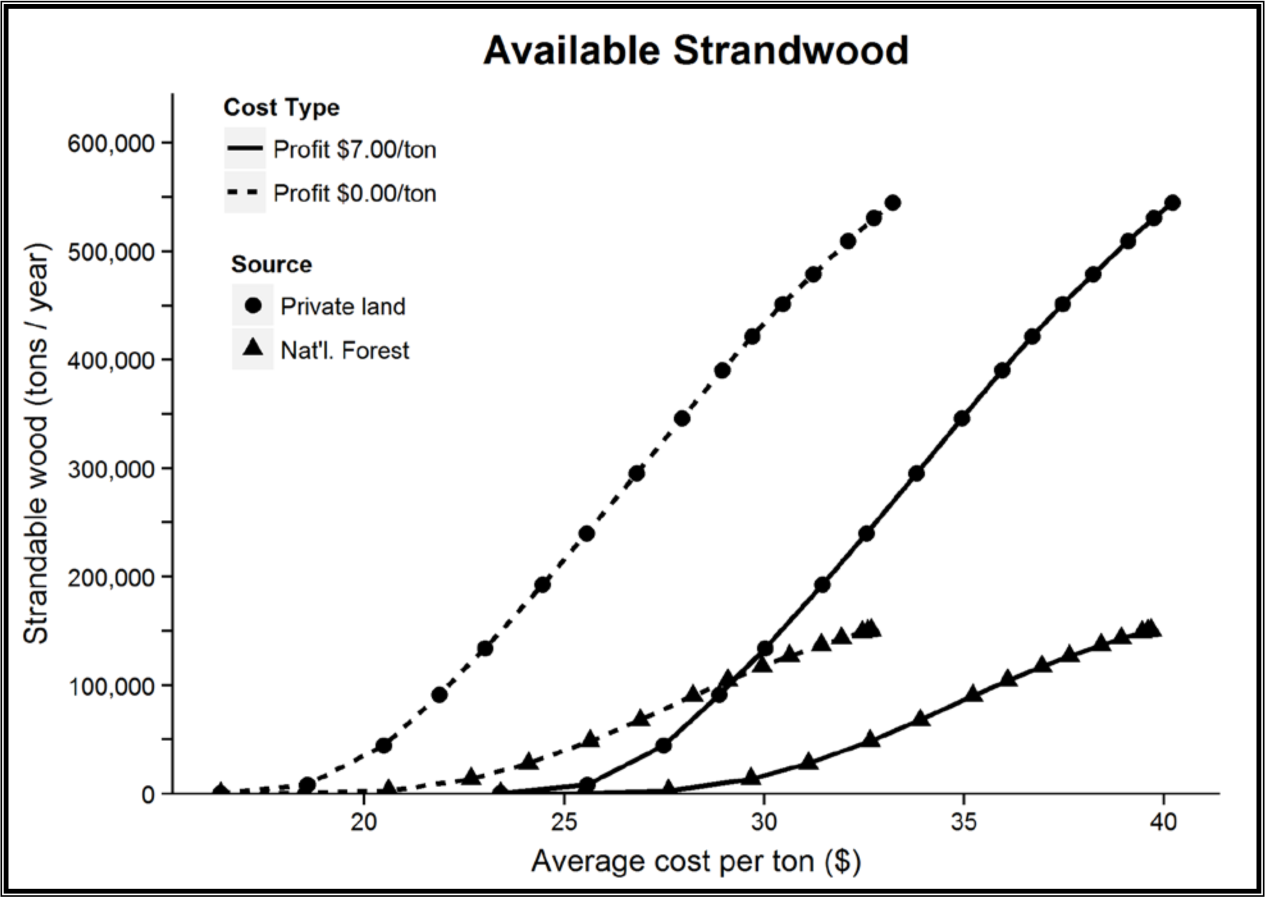
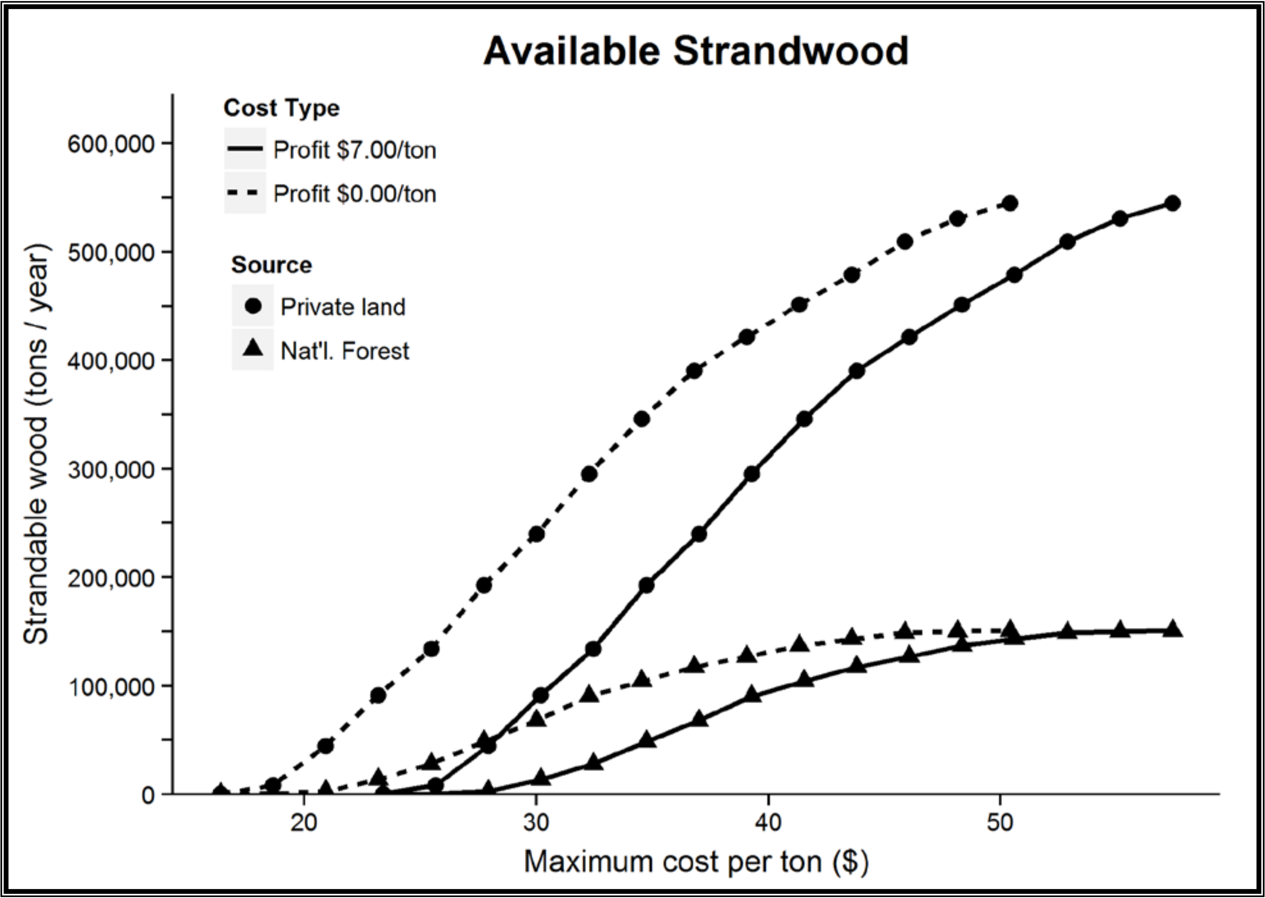


Figure 3.12 also shows an estimate of the volume of strandable topwood as a function of delivered cost. However, this figure shows the increment of supply available at a given price point. For example, consider the scenario where there is no profit to the landowner and private lands. If the price moves from $40 per green ton to $50 per green ton, it would provide about 150,000 additional tons of supply (550,000 @ $50/GT minus 400,000 @ $40/GT).

Figure 3.12 – Supply Curve of Strandable Topwood at Maximum Delivered Cost per Green Ton



3.4.3.1.2 Pulpwood Volume Estimate

The volume of pulpwood available is largely a function of the area of forest treated annually. In turn, the area treated annually is a function of planning and budgets (for public land). Therefore, BECK has approached the pulpwood volume estimate in terms of acres treated and average volumes per acre. According to U.S. Forest Service contacts, forest restoration treatments typically yield between 15 and 30 green tons of pulpwood size material per acre. Given that information, **Table 3.20** provides an estimate of tons of pulpwood as a function of acres treated per year.

Table 3.20 – Estimated Volume of Pulpwood as a Function of Acres Treated Per Year

Acres/Year	Low Range (Green Tons)	High Range (Green Tons)
500	7,500	15,000
1,000	15,000	30,000
2,500	37,5000	75,000
5,000	75,000	150,000
10,000	150,000	300,000

3.4.3.1.3 Pulpwood Delivered Cost Estimate

Pulpwood is by far the highest cost raw material for the prospective OSB facility. The reason for this is that with topwood the cost of harvesting and collecting that material at a centralized location (i.e., log landing) is born by the harvest of sawlogs. In other words, the topwood accumulates at the landing for free. The same is true of mill byproducts, the material has been collected at the sawmill because of the process of producing lumber. Also, unique to California, the mill byproducts have a limited market value because users such as composite panel manufacturers, pulp mills, pellet mills, etc. largely do not exist in the state. In contrast, for pulpwood the entire cost of harvesting, yarding, processing, and transporting the material must be included in the delivered cost of the material.

BECK interviewed logging contractors in other regions of the Western U.S. to estimate the cost of producing pulpwood. Those interviews revealed that a typical “whole tree” logging operation will consist of a mechanized piece of equipment for felling trees, a ground based skidder, a delimber, and a loader. It typically costs (including an allowance for profit) a total of about $4,000 per day to own, operate, and maintain all of that equipment. Such a logging operation typically produces about 7 to 8 truckloads of logs per day at 25 tons per truckload when operating in sawlog size timber. Thus, the cost of production is about $20 to $23 per ton.

However, when operating in small size timber, many more pieces must be handled to achieve the same volume of production. The result is that the machines cannot operate fast enough to achieve the same production rate. The cost, however, remains unchanged at $4,000 per day. For example, a logging operation typically will produce only about 4 truckloads per day when operating in small diameter timber. This translates into a cost of $40 per ton for pulpwood.

Importantly, the preceding analysis only includes the costs for loading material onto a truck. Still to be accounted for is the cost of transporting the material from the woods to the OSB facility. Thus, without even including the cost of transportation, the cost of pulpwood harvesting is higher than the target average delivered cost to the OSB plant.

3.4.3.2 Sawmill Byproducts Volume Estimate

Utilizing sawmill byproducts for OSB manufacturing would require a fundamental change in current sawmill operating practices. The current practice is for slabs, edgings, and lumber trim ends to be manufactured into chips. The sawmills near the site of the prospective plant (**Figure 3.13**) would have to purchase an OSB stranding machine and reconfigure their mills to convey the slabs, edgings, etc. to the stranding machine rather than to a chipper. The concept is untested in California, but it has been used successfully at Martco’s OSB plant in Le Moyen, Louisiana, which is co-located with a sawmill.

Figure 3.13 – Large, Softwood Sawmills Near Anderson, CA

The estimated volume of mill byproducts potentially available to an OSB plant as OSB strands is 232,000 green tons, as shown in **Table 3.21.** Note that the safety factor shown in the table is meant to introduce an element of conservatism into the analysis since it is not known whether the sawmills will make the capital investment in stranding equipment. If all the sawmills opt for stranding, a much higher proportion of the mill byproducts could be utilized as OSB strands. For example, if all sawmill byproducts that are normally manufactured into chips at the six sawmills were converted to strands, the estimated volume is about 673,000 green tons, assuming that 20 percent of the volume would be lost as fines.

Table 3.21 – Estimated Supply of OSB Strands from Mill Byproducts (Green Tons)

Company	Location	Distance to Anderson, CA (miles)	Estimated Chips/Year (BDT)	Safety Factor	Estimated Available OSB Strand Volume (BDT)	Estimated Available OSB Strand Volume (GT)
SPI	Anderson	0	84,000	0.50	42,000	84,000
SPI	Shasta Lake	21	54,000	0.33	17,820	36,000
TRL	Weaverville	58	69,000	0.25	17,250	35,000
Shasta Green	Burney	59	30,000	0.25	7,500	15,000
SPI	Burney	59	86,000	0.25	21,500	43,000
Collins	Chester	90	98,000	0.10	9,800	20,000
Total			**421,000**		**115,870**	**232,000**

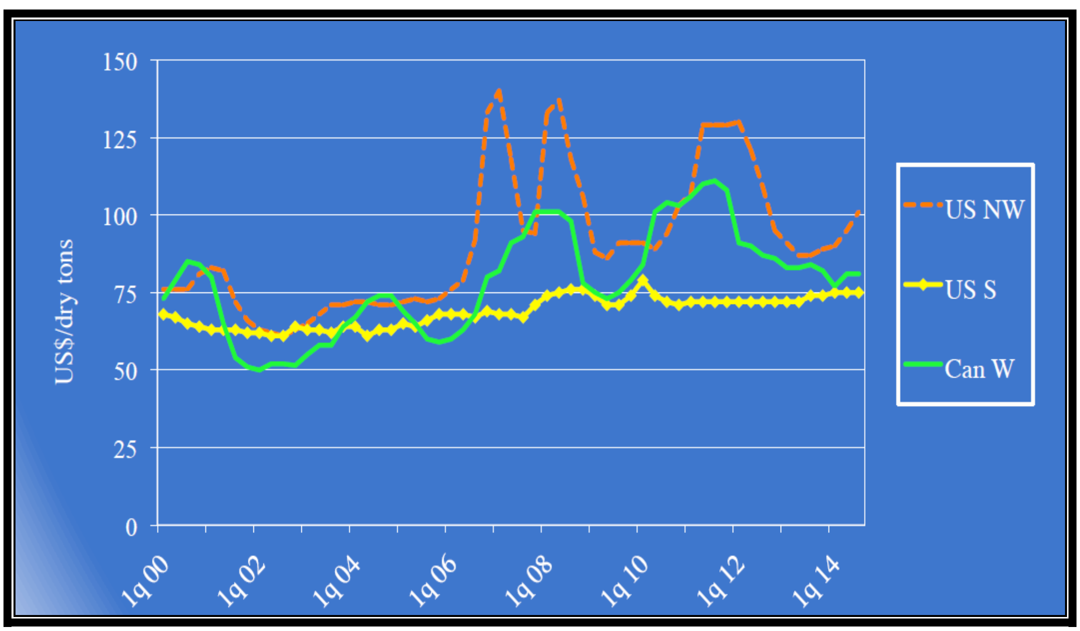
In the preceding table, a factor of 0.41 Bone Dry Units (BDU, 2,400 pounds) of chips was assumed per thousand board feet of lumber production. That factor is an estimated average based on a combination of BECK benchmarking studies and information from other sources. The safety factor column then shows the proportion of what would normally be chip volume that has been estimated to be recoverable as OSB strands.

Note that another unknown in the stranding of sawmill byproducts is the proportion of fines created. Industry sources indicated to BECK that converting mill byproducts to OSB strands can result in relatively high volumes of fines (up to 20 percent). When sawmills produce chips, the proportion of fines is generally in the 5 to 10 percent range. The percentage of fines depends on the average size of the mill residue pieces being utilized. The percentage of fines increases as the average incoming mill residue piece size decreases.

3.4.3.3 Sawmill Byproducts Delivered Cost Estimate

Figure 3.14 illustrates the historic price of mill byproducts delivered to pulp and paper mills in various regions of North America from 2000 through the third quarter of 2014, as reported by the North American Wood Fiber Review, a publication of Wood Resources International. Relative to the U.S. South (the yellow line), prices in the U.S. Northwest (orange line) have been volatile for the last 10 years. This volatility is largely caused by the economic downturn, which greatly affected the production of mill byproduct chips. Another factor is that significant volumes of chips are exported from the U.S. West Coast to various destinations in Asian countries. Sawmills in California are generally located too far from pulp and paper mills in Oregon and Washington to routinely supply chips, or, if chips are supplied to those markets from California, any value they might return to the sawmill is largely consumed by the cost of transporting them to market. Data was not available for current f.o.b. sawmill chip values in California.

Figure 3.14 – Historic Value of Pulp Chips in North America ($/Bone Dry Ton)



As described earlier, BECK assumed an average delivered price of $35/green ton, which is the equivalent of $70 per bone dry ton, for the OSB plant. **Table 3.22** shows the estimated value that delivered price will return to the six sawmills (f.o.b. their plant). The analysis assumes a volumetric expansion factor of 4 when going from solid wood to OSB strands, which is roughly the equivalent expansion factor for planer shavings. Also assumed was an average of 50 percent moisture content, a trucking cost of $85 per hour, an average speed of 45 miles per hour, and half an hour for loading and unloading. The highest values the OSB plant could pay each sawmill are shown in the table. They range from a low of $39 per bone dry ton ($19.50 per green ton) for the most distant mill to a high of $67 per bone dry ton ($33.50 per green ton) for the nearest sawmill. BECK does not have current f.o.b. sawmill bin price data for mill byproducts. However, BECK believes the values shown in the table will be attractive to the sawmills.

Table 3.22 – Estimated f.o.b. Sawmill Bin Value of Mill Byproducts ($/BDT)

Company	Location	Distance (miles)	Estimated Transport Cost ($/BDT)	Estimated f.o.b. Sawmill Bin Value ($/BDT)
SPI	Anderson	0	3	67
SPI	Shasta Lake	21	10	60
TRL	Weaverville	58	21	49
Shasta Green	Burney	59	21	49
SPI	Burney	59	21	49
Collins	Chester	90	31	39

3.4.3.4 OSB Plant Raw Material Volume and Cost Summary

Conservative Scenario - Table 3.23 summarizes all of the preceding information about raw material that is conservatively estimated to be available at an average delivered cost of $35 per green ton. BECK judges this to be a conservative estimate because safety screens have been applied to the total volume of mill byproducts, the utilization standard for sawlogs was assumed to be a 6” small end diameter rather than 8”, and no volume was assumed to be supplied from pulpwood size material since the cost of getting that material to a landing is already higher than the assumed average delivered price. As shown in the table, the amount estimated to be available under the preceding assumptions is almost exactly equivalent to the annual requirement of the OSB Plant.

Table 3.23 – Conservative Scenario - Summary of Raw Material Estimated to be Available at Average Delivered Cost of $35 per Green Ton

Raw Material Type	Estimated Volume (GT)	Estimated Delivered Cost ($/GT)
Topwood - Private	350,000	35
Topwood - Public	100,000	35
Mill Byproducts	233,000	35
Pulpwood	0	n/a
Total	688,000	35

Optimistic Scenario - Table 3.24 summarizes the raw material supply and cost information from an optimistic perspective. In other words, all potentially available mill byproducts are included, the utilization standard for sawlogs was assumed to be 8", and zero payment was assumed for landowners. As shown in the table, under optimistic assumptions and at an average delivered cost of $35 per green ton, there appears to be roughly 2 times the amount of fiber available than would be required annually.

Table 3.24 – Optimistic Scenario – Summary of Raw Material Estimated to be Available at Average Delivered Cost of $35 per Green Ton

Raw Material Type	Estimated Volume (GT)	Estimated Delivered Cost ($/GT)
Topwood - Private	550,000	35
Topwood – Public	150,000	35
Mill Byproducts	673,000	35
Pulpwood	0	n/a
Total	1,373,000	35

3.4.4 Environmental and Permitting

The prospective OSB plant has the potential to emit pollutants, so obtaining the required permits will be a key factor in determining the feasibility of an OSB plant in California. One of the most critical permits is an Air Quality Permit. The Anderson site selected for this study is located in Shasta County, which sits at the northern end of the Sacramento Valley Air Basin. The region is bordered by the Klamath and Coastal Mountains to the northwest and the Cascade Mountains to the northeast and east. That geography, combined with relatively calm winds and stable atmospheric conditions, contributes to the potential for air pollution in the basin. According to the Shasta County Air Quality Resource Management report, the region experiences moderate to very poor capability to disperse pollutants nearly 80 percent of the time. Inversions, stable atmospheric conditions that act as barriers to pollutants, are common in valley locations under 1,000 feet elevation.

According to the report, Shasta County is designated as a Moderate Non-Attainment area with respect to State standards for Ozone and PM10. Shasta County does meet Federal standards for these pollutants. As will be described in the Capital Cost section of this report (Section 3.5), the analysis has included a variety of equipment for mitigating air pollutants, including bag houses, wet electrostatic precipitators, and regenerative thermal oxidizers.

In addition to Air Quality, the resins used to adhere the OSB strands together can be toxic. Phenolic resins are commonly used and are available in either liquid or powder form. They are thermosetting and once cured are highly resistant to water. Phenolic resins are made by reacting phenol with formaldehyde. Once cured, OSB panels have very low levels of residual phenol and formaldehyde. However, strict environmental rules in California may prevent the use of phenolic resins. Another adhesive commonly used in OSB plants is Isocyanate, also known as MDI or liquid polymeric diphenyl methane di-isocyanate. MDI adhesive reacts with molecules containing active hydrogen (i.e., hydroxyl groups found in wood). Once cured, the finished product is virtually free of unreacted MDI. In either case, systems within the plant are needed to control exposure to workers and the environment.

Completing detailed analysis of emission levels and technologies for mitigating those pollutants is beyond the scope of this study. However, if further analysis and planning is pursued for this business opportunity, BECK recommends those efforts include identification of the types of pollutants likely to be emitted, their expected levels, and the technology that will be employed to mitigate their impact on air and water quality.

3.5 <u>OSB ECONOMIC FEASIBILITY</u>

3.5.1 Capital Cost

BECK estimated two capital cost scenarios for developing an OSB plant in California: 1) using all new equipment; and 2) using used equipment from a currently idled facility. Mr. Tony Cavadeas of Cavadeas Engineering Corporation (CEC) assisted BECK in estimating the OSB capital costs. CEC has been involved in the engineering of numerous OSB plants in North and South America. BECK supplied CEC with information about the planned capacity of the plant and its location.

CEC then used information from their database of OSB plant capital costs to develop the capital cost estimates shown in **Table 3.25**

For the Used Major Equipment scenario, CEC contacted a firm that specializes in deconstructing and transporting equipment from various manufacturing facilities to obtain an estimate for the cost of deconstruction. The estimate is based on deconstructing a facility of the size being considered for California that is currently idled in Quebec, Canada. BECK assumed that the used major equipment could be acquired at 50 percent of the value of new equipment.

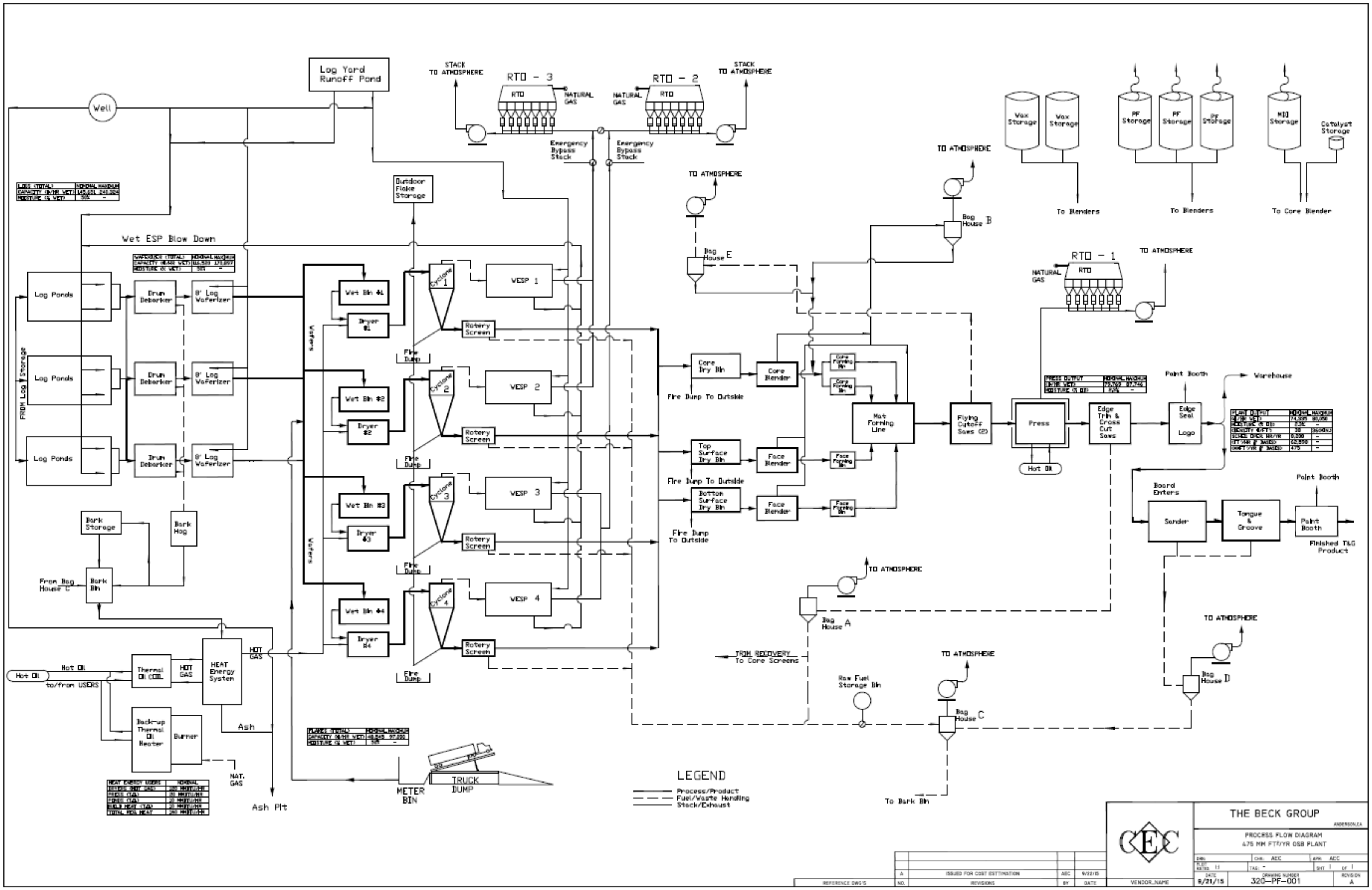
Although not shown in the table, CEC also estimated the cost of including a biomass boiler for generating process energy for fiber drying. The estimated cost for such a boiler, including installation, is $15.0 million. BECK did not model the biomass boiler in the financial analysis, but it is an option that can be considered in any further analysis.

Table 3.25 – Estimated Capital Expense of a 475 MMSF/Year OSB Plant

	All New		Used Major Equipment	
Cost Category	Estimated Cost ($ millions)	% of Total	Estimated Cost ($ millions)	% of Total
Buildings, Structures, & Site	39.2	22.0	39.2	26.3
Major Equipment	42.8	27.8	21.4	14.4
Minor Equipment	23.9	15.5	23.9	16.1
Pollution Control Equipment	26.3	15.9	26.3	17.7
Installation/Misc. Materials	24.9	13.1	2498	16.7
Engineering/Construction Mgmt.	9.1	5.8	9.1	6.1
Equipment Deconst. & Freight	n/a	n/a	4.0	2.7
Total	**166.2**	**100**	**148.8**	**100.0**

Figure 3.15 is a process flow drawing and preliminary layout for the 475 MMSF/year facility. Items to note about the drawing are that: log ponds for conditioning and cleaning the logs are included and three drum debarkers would be used, which, in turn, lead to 3 log waferizers (a.k.a. stranding machines). The balance of the plant would include blenders, formers, a press (8’ wide x 24’ long and 14 openings), and various trim saws and panel finishing equipment. Importantly, to control emission of pollutants to the atmosphere and water run-off from the site, the equipment contained in the capital cost estimate and layout drawing includes numerous baghouses, wet electrostatic precipitators, and regenerative thermal oxidizers.

Figure 3.15 – Process Flow and Preliminary Layout Drawing of a 475 MMSF/Year OSB Plant



3.5.2 Operating Costs

The operating cost of the OSB plant modeled in this study is based on the results of BECK's OSB industry benchmarking study completed in 2013. **Table 3.26** shows operating costs by natural expense classification from the benchmarking study and what BECK's estimated California based OSB plant's operation costs.

Table 3.26 – Estimated OSB Plant Operating Costs

Natural Expense Cost Category	Benchmark Costs ($/MSF, 3/8" Basis)	Estimated California Plant Costs ($/MSF, 3/8" Basis)
Labor (Operating & Maint., & Plant Supervisor Salaries)	24.28	25.15
Administrative and Management Salaries	5.70	4.77
Raw Materials (Total)	86.86	88.19
Sub-component Wood	*47.97*	*49.30*
Sub-component Resin	*31.46*	*31.46*
Sub-component Wax	*7.43*	*7.43*
Operating & Maintenance Supplies	15.48	15.48
Utilities	9.28	14.60
Contracted Services	4.88	4.88
Other Costs	7.31	7.31
Total	**153.79**	**160.38**
Depreciation	**14.09**	***17.50**

*Based on Capital Expense of $166.2 million, 20 year straight-line depreciation schedule, and 475 MMSF/year production

3.5.3 Assumptions Underlying Operating Cost Estimates

Labor – The labor estimate includes hourly labor costs for operating staff, maintenance staff, and the salaries of plant supervisors directly involved in plant operations. In the U.S. South (the region for which BECK had data for comparison), the average hourly wage rate for OSB plant labor was 21 percent higher than the average hourly wage rate of sawmill workers. Therefore, BECK adjusted the average hourly wage rate among Northern California sawmills upward by 21 percent to arrive at an hourly wage rate of $24.59 per hour. Employee benefits were included in the costs at a rate of 39.5 percent of the hourly wage rate. Each employee was assumed to work an average of 17 percent overtime. All of the preceding assumptions translate into an hourly labor expense of $25.15/MSF 3/8" basis.

Salaries – The BECK benchmarking data indicates that the typical plant in the size range considered in this study has about 35 salaried staff for management and administrative positions. At a per unit cost of $5.70/MSF 3/8" basis, this translates into an average fully loaded salary of about $76,500 per year. However, there are several plants that operate with considerably fewer administrative personnel. Therefore, BECK elected to model the plant with a total of 25 management and administrative staff. The average fully loaded salary of those 25 staff was increased to $90,000 per year to reflect the more competitive labor market in California than in other regions. This results in an estimated cost for salaried and administrative staff of $4.77/MSF 3/8” basis.

Raw Materials – The plant modeled in this study was assumed to produce 475 MMSF/year and require 0.71 green tons of raw material per MSF produced. Therefore, the plant requires about 669,000 green tons of fiber per year. The average delivered raw material cost on a dollars per green ton basis in the benchmark studies was $30/green ton. Given higher logging costs and longer raw material transport distances in the region surrounding the plant, BECK estimates that the average delivered raw material cost for the prospective plant will be $35 per green ton, a 16.67 percent increase over the benchmark values. However, since the species in the region surrounding the plant are of lower density than the species used by many of the plants in the benchmark data, the higher delivered cost on a dollars per green ton basis is offset by the material’s lower density. Thus, on a dollars per MSF basis, the plant is estimated to have a delivered wood fiber cost of $49.29/MSF 3/8” basis, which is only about 3 percent higher than the benchmark data. Costs for resin and wax were assumed to be equal to the benchmark data.

Operating Maintenance & Supplies – These costs for the prospective plant were assumed to be the same as the benchmark data.

Utilities – The total benchmark utility costs of $9.28/MSF 3/8” basis are comprised of 77 percent electrical power cost and 23 percent natural gas cost. The average cost of electrical power among the benchmark participants was $60 per MWH. For the purposes of this study, BECK assumed the cost of power at the OSB plant would be $90 per MWH. This translates into an estimated cost for electrical power of $10.77/MSF at the prospective plant. With regard to natural gas, the average cost per MMBTU among the benchmark companies was $3.16. In 2012, the average industrial cost for natural gas in California was $5.77, which is 1.8 times more expensive than the average benchmark natural gas cost. Therefore, the cost of natural gas at the prospective plant was adjusted upward by a factor of 1.8, which results in a cost of $3.83/MSF. Thus, the total cost of utilities assumed for the prospective plant was estimated to be $14.60/MSF 3/8” basis ($10.77/MSF for electrical power and $3.83/MSF for natural gas).

Contracted Services – These costs for the prospective plant were assumed to be the same as the benchmark data.

Other Costs – This category includes otherwise uncategorized costs such as lease expenses, sales expenses, professional fees, association dues, and miscellaneous. These costs for the prospective plant were assumed to be the same as the benchmark data.

3.5.4 F.O.B. Mill Sales Realization

As shown in **Table 3.17**, the average price of OSB between 2001 and 2015 (after accounting for a typical product mix and converting to a 3/8” basis) is $224 per MSF for material delivered to Sacramento. While averaging prices across that long a timeframe is not a normal practice, BECK believes it is appropriate in this situation because OSB pricing is volatile and the longer timeframe covers several market pricing cycles. As shown in Section 3.3 (OSB Market

Feasibility), the market in California is projected to be 4 times larger than the capacity of the plant being considered, and the California plant will enjoy finished product transportation cost advantages ranging between $30 and nearly $60 per MSF 3/8" basis in California markets. BECK believes that the plant will be able to sell much of its output to nearby customers, which will allow it to fully capitalize on the transportation cost advantage. For these reasons, BECK has elected to use an average sales realization of $210 per MSF 3/8" basis f.o.b. plant for the financial analysis.

3.5.5 Financial Analysis Results

Table 3.25 shows a base case *pro forma* income statement (first full year of operation) for the prospective OSB plant given the preceding assumptions about capital expense, operating costs, and sales realization. As shown in **Table 3.27**, the OSB plant is projected to generate an annual operating income of $23.57 million per year. It has been assumed that construction of the plant will require 27 months and that the capital expense will be distributed equally across that time period. This means that the plant has a simple payback period of 9.6 years, and would provide an annual return on capital of 14 percent assuming 100 percent equity in the project.

The analysis does not take into account taxation, depreciation, or financing options, since those will vary significantly depending on the characteristics of a given developer. However, those factors will all affect the financial performance of the plant. The financial analysis was completed in this way so that the financial value of the various businesses could be easily compared on an operating income basis without the complications of comparing a variety of financing and taxation options.

Table 3.27 – Base Case Pro Forma Income Statement

Revenue/Expense Category	$/MSF 3/8" Basis	$
Revenue – Panel Sales	**210.00**	**99,750,000**
Expense - Labor (Operating & Maint., & Plant Supervisor Salaries)	25.15	11,944,902
Expense - Administrative and Management Salaries	4.77	2,268,000
Expense - Raw Materials (Total)	88.19	41,888,243
Sub-component Wood	*49.30*	*23,415,493*
Sub-component Resin	*31.46*	*14,943,500*
Sub-component Wax	*7.43*	*3,529,250*
Expense - Operating & Maintenance Supplies	15.48	7,353,000
Expense - Utilities	14.60	6,935,000
Expense - Contracted Services	4.88	2,318,000
Expense - Other Costs	7.31	3,472,250
Expense - Subtotal Expenses	**160.38**	**76,179,395**
Operating Income (Loss)	**49.62**	**23,570,605**

3.5.6 Sensitivity Analysis

The following section analyzes the sensitivity of the OSB plant's annual operating income to a 10 percent plus or minus change in key variables such as the sales realization, raw material costs, manufacturing costs, and capital expense. **Table 3.28** shows that the business is most heavily impacted by changes in the average sales realization. However, even in that case, the business is relatively stable to the changes. Note, however, that the sensitivity analysis was performed by changing only a single variable at a time while leaving all other variables constant. This means that, for example, in a situation where raw material costs and manufacturing costs increase simultaneously, the impact on the business would be more profound than what is shown in the sensitivity analysis.

Table 3.28 – OSB Plant Sensitivity Analysis

Sensitivity Scenario	Annual Operating Income	Simple Payback
Base Case	23,570,605	9.6
Sales +10%	33,545,605	7.5
Sales - 10%	13,595,605	14.8
Raw Material (Wood and Resin) + 10%	19,734,706	11.0
Raw Material (Wood and Resin) - 10%	27,406,505	8.6
Manufacturing Cost (Excluding Raw Materials) -10%	21,106,080	10.4
Manufacturing Cost (Excluding Raw Materials) +10%	26,035,130	8.9
Cap Ex +10%	23,570,605	10.3
Cap Ex - 10%	23,570,605	8.9

3.5.7 Overlay Case

The OSB business is most heavily impacted by changes in sales realization. Therefore, BECK believes that a strategy of having the plant manufacture specialized panels having either a moisture or thermal resistant overlay applied would improve the financial performance of the plant. OSB manufacturers such as Huber and LP are moving in the direction of producing more specialized panels such as overlays and siding. BECK industry contacts suggested that a fast-cycle press using fast setting adhesives installed offline from the main OSB manufacturing process could be a way for the California plant to participate in the specialized overlay market with a portion of its production, while keeping the capital expense for the additional required equipment to a minimum. BECK's industry contacts estimated that such a press would have a capital expense of approximately $5 million.

Unfortunately, BECK was not able to obtain information about the increased manufacturing cost for producing overlays or for the uplift in sales value since there are no published prices for those proprietary products. BECK recommends further investigation into this strategy in any subsequent analysis of OSB manufacturing in California.

3.6 OSB ORGANIZATIONAL AND MANAGERIAL FEASIBILITY

Typically, a feasibility study would identify the prospective business's management team members and describe their skills, knowledge, and experience relevant to the business. In this case, however, a specific entrepreneur or company has not been identified as the developer of an OSB plant. Thus, it is not possible to assess the developer's management team relative to the skills, experience, and knowledge needed. As an alternate analysis, **Table 3.29** illustrates the typical staffing breakdown for an OSB plant's management team. The data used to develop the table is from The Beck Group's most recent OSB industry benchmarking study that contains data from January 1, 2012 to June 30, 2012.

Table 3.29 – Typical OSB Plant Management Team for a 475 MMSF (3/8" basis) per Year Plant

Position	Number of Staff
General Management	2
Accounting	3
Data Processing	1
Human Relations	1
Quality Control	1
Sales	2
Purchasing	1
General Office	1
Production Supervisor	5
Engineering & Maintenance	3
Project and Process Engineers	1
Procurement	1
Other	3
Total	**25**

As the table shows, a 475 MMSF per year plant (3/8" basis) would require a total of about 25 management and administrative staff. This typically would include 2 staff members that have overall management responsibility for the operation. The balance of the management team would have more specific areas of focus and expertise, including accounting, data processing, human relations, quality control, engineering and maintenance, fiber procurement. Note also that each plant typically has a number of production supervisors who are involved in the day-to-day operation of the plant. However, rather than being paid on an hourly basis like the production workers, the production supervisors would be salaried.

Many firms that operate in the OSB sector have multiple manufacturing facilities. Those firms typically centralize some functions, such as accounting, sales, data processing, engineering, etc., in order to realize a cost savings.

Finally, an OSB facility is a large, complex venture whose efficient operation requires considerable knowledge and experience. Therefore, the only realistic avenue for OSB plant development in California is for a firm that is already in the OSB business to take an interest in developing a plant there. In the alternative, a well-established and well capitalized company could perhaps successfully develop and operate a California OSB facility, provided that company is already in the forest products industry, but perhaps not operating in the structural panel sector.

3.7 OSB SUMMARY

3.7.1 Raw Material Supply and Cost

Given the average delivered cost of fiber in California and for other currently operating OSB plants, BECK assumed that the average delivered cost of material to the plant would be $35 per green ton. Given that parameter, BECK found that an estimated 233,000 green tons of sawmill byproducts and 425,000 tons of topwood from existing sawlog harvests would be available. Combined, these two sources would provide an estimated 658,000 of the 670,000 green tons of raw material needed annually. No raw material from forest thinning operations was judged to be available for less than or equal to $35 per green ton. However, some thinning material could be used so long as its higher costs were offset by topwood or mill residue material that can be delivered for less than the average price of $35 per green ton.

Under a more optimistic assumption where there is no stumpage payment to landowners for topwood, utilization of sawlogs to an 8” top instead of the current practice of 6” top utilization and there is full adoption among sawmills to converting to stranding of byproducts, an estimated 1.373 million green tons of raw material is estimated to be available annually. Given these findings, BECK concludes that adequate raw material would be available to supply the facility.

3.7.2 OSB Markets

To assess historic OSB markets, BECK used OSB market data from APA – The Engineered Wood Association that covered 2007 to 2014. That analysis indicated that an average of 1.4 billion square feet (3/8” basis) of OSB was consumed annually in California. However, the time period for which the data was available included historically low levels of OSB demand because of the downturn in the economy. Therefore, BECK used forecast housing starts, levels of repair and remodeling, and industrial demand to estimate the size of the California OSB market during more robust economic conditions. That analysis indicated an OSB market in California of an estimated 2.158 billion square feet per year (3/8” basis). In both cases, the size of the market is significantly larger than the 475 million square foot annual output of the plant. In addition, the plant would enjoy a finished product transportation cost advantage of $30 to nearly $60 per MSF. Thus, BECK concludes the plant’s location and the size of the nearby market would provide it with significant competitive advantages.

3.7.3 OSB Economic Feasibility

BECK assessed the economic feasibility of the OSB plant using the following key parameters. The delivered cost of raw material was $35 per green ton. The all-in capital expense for the plant would be $166.2 million. The f.o.b. plant sales price for OSB would be $210/MSF 3/8" basis. The manufacturing cost, including raw material, would be about $160/MSF 3/8" basis. This leaves an operating margin of nearly $50/MSF 3/8" basis, which translates into an annual operating margin of an estimated $23.57 million. This, in turn, translates into a simple payback period of 9.6 years and would provide an annual return on capital of 14 percent.

3.7.4 Conclusions and Recommendations

Based on the raw material supply and cost, the OSB markets in California, the lack of nearby OSB producers, and the economic feasibility analysis, BECK concludes that an OSB plant in California can be feasible. However, BECK recommends additional analysis on the feasibility of OSB manufacturing in California. The key items for further development of this concept include:

- *Identification of a Potential Developer* – Given the large capital investment required by this business, the complexity of the manufacturing process, and the sophistication of competing producers, BECK believes that the most likely path for an OSB plant to be developed in California is for one of the existing OSB manufacturers to pursue development. Alternately, there may be forest products companies that are not currently manufacturing OSB, but have the required level of sophistication, resources, and familiarity with the industry to take on the task of development.

- *Possibility of Relocating an Idled Plant* – BECK modeled the plant being constructed using all new equipment, but a possible alternative would be relocating a currently idled plant to California. BECK estimates that pursuing this strategy would reduce the capital expense by $18.4 million. Additional analysis is needed to identify a plant that could be dismantled and more precisely estimate the associated costs.

- *Issues with Obtaining Environmental Permits* – BECK received feedback from numerous parties during the course of the feasibility study that obtaining an air quality permit in California for a plant of this scale would be very difficult at best. The site in Anderson, California considered in this study is in a non-attainment area for PM10 and Ozone per State of California standards, but is compliant with Federal standards. The capital expense estimates used in the analysis include $26.3 million in costs for pollution control equipment, including baghouses, wet electrostatic precipitators, and regenerative thermal oxidizers. Additional analysis of these development requirements is needed if a potential developer secures a site and definitively determines the scale of the plant. BECK recommends additional analysis that models the emissions of existing plants relative to California air quality standards.

- *Issues Concerning Raw Material Supply* – Given very limited markets for sawmill byproducts in California, BECK believes that sawmills near an OSB plant would invest in equipment to convert sawmill waste (edgings, slabs, trim ends, etc.) into OSB strands as opposed to the current practice of converting those materials to pulp chips. This practice has been proven in other regions of North America. However, additional research is needed to more definitively determine the cost of the required equipment. A current, very rough order of magnitude estimate is $2 million per sawmill.

- *Changes to Sawlog Utilization Standards* - further supply analysis is needed to determine if the presence of an OSB plant would result in changes to sawlog utilization standards among sawmills. The current practice is to utilize sawlogs to a 6” small end diameter. However, that practice could change to an 8” small end diameter if an OSB plant were present. BECK believes there is a reasonable chance this could occur since using larger logs increases the processing efficiency of the sawmills. A change to an 8” sawlog utilization standard would significantly increase the volume of fiber available to an OSB plant. Note however, an 8” utilization standard would also require slightly higher sawlog harvest levels to achieve the same level of sawmill supply as when sawlogs are utilized to a 6” top.

CHAPTER 4 – SMALL SCALE BIOMASS HEAT AND/OR POWER

4.1 SMALL SCALE BIOMASS INTRODUCTION

Various technologies exist for converting woody biomass into heat, power, or both. Typically, the process involves combusting or gasifying biomass. The energy created from combustion or gasification is then harnessed to produce electrical power. In addition, combustion or gasification produces thermal energy that can be used to heat (or cool) a building, or supply energy to an industrial process.

In this report the term biomass heat and/or power refers to the process of using biomass fuel to simultaneously generate thermal energy and electrical power. The scale of such projects is frequently measured in megawatts (MW). Biomass fueled heat and power projects can range in size from less than 1 MW to well over 50 MW. For the purposes of this report, small scale refers to projects with 3 MW or less of capacity.

Businesses can be developed from these technologies by selling the power produced to an electrical utility, or much less commonly – generating the power for self-consumption. In addition, the thermal energy can be sold to a nearby thermal customer. Another aspect of this technology is that using woody biomass as a fuel causes the power production process to be viewed as renewable. Therefore, there may be additional revenues available from the sale of renewable energy certificates, carbon credits, and other more complicated tax driven arrangements that enhance the value of renewable power.

Offsetting those revenue streams are the costs of gathering, preparing, and transporting woody biomass to the plant site; the costs of operating and maintaining the plant (labor, supplies, repair, utilities, general and administrative costs); and the cost of amortizing the debt used to develop the project.

The following report chapter provides a feasibility assessment for developing a small scale biomass project in California. In addition, as a means of enhancing the feasibility of such projects, the impact of selling thermal energy to co-located businesses is included in the analysis.

4.2 SMALL SCALE BIOMASS CONCEPTUAL PLAN

Small scale biomass heat and power projects are not generally feasible under current renewable power market conditions. However, the California legislature passed Senate Bill 1122 (also known as SB 1122 or BioMAT). It calls for Investor Owned Utilities (IOUs) in the state to purchase up to 50 MW of power from small scale biomass projects over the next 5 years. The power price adjusting provisions of SB 1122 create a mechanism by which the utility will most likely purchase the power from the small scale plants at higher than market prices. The concept is based on California needing additional markets for the byproducts of sustainable forest management activities, particularly thinnings. Those provisions allow for selected small scale biomass projects utilizing that fuel source to enter the realm of feasibility.

Given the existence of SB 1122, BECK has elected to assess the feasibility small scale biomass as part of the CAWBIOM study. Without the existence of SB 1122, small scale biomass projects would not be feasible under current renewable power market conditions.

The following describes at a conceptual level the prototypical plant that BECK judges to have the highest probability of being feasible:

- **Power Market** – the plant will sell its 3 MW of electrical output to an Investor Owned Utility in accordance with the provisions of the SB 1122 program.
- **Technology** – a direct combustion, biomass fired steam boiler will be coupled with an extraction/condensing steam turbine generator.
- **Scale** – the prototype plant will be designed so that it will generate a net output of 3 MW, after accounting for the plant's own auxiliary load).
- **Biomass Fuel Sources** – the plant will combust forest derived biomass that is the result of sustainable forest management practices.
- **Co-Located Businesses** – the development of a 3 MW power plant will coincide with the development of co-located businesses. Since the specifics of the thermal energy needs of the co-located business can vary significantly by location and business type, BECK has elected to model the financial impact of those businesses on the economics of the power plant by conducting sensitivity analysis on the amount of thermal energy required by the co-located business.
- **Incentives** – a number of incentives are available to enhance renewable power projects. The appropriate incentives will be applied in the assessment of small scale biomass for this project.

The balance of this chapter documents BECK's findings with respect to the feasibility of Small Scale Biomass in California based on the preceding conceptual design.

4.3 SMALL SCALE BIOMASS MARKET FEASIBILITY

As described in **Section 4.2**, the feasibility of a small scale biomass heat and/or power business is wholly contingent on the existence of the SB 1122. Therefore, the following sections explain the program in detail.

4.3.1 SB 1122 Program Description

Through the provisions of SB 1122, Investor Owned Utilities (IOUs) are required to purchase modest amounts of electricity from various small (3 MW or less) biomass facilities. Included in that mandate was the requirement to purchase 50 MW of electricity from the byproducts of sustainable forest management. SB 1122 is a Bioenergy Feed-In-Tariff (FIT) program. A FIT typically makes use of long-term agreements and pricing tied to cost of production for renewable energy producers. SB 1122 will create a scenario that allows small scale biomass generation to be viable when such small facilities are not competitive in the larger wholesale electric marketplace.

4.3.2 Levelized Cost of Electricity from SB 1122 Projects

The SB 1122 legislation is being implemented by the California Public Utilities Commission. The CPUC projected the Levelized Cost of Electricity[4] from 3 MW forest biomass projects[5]. As shown in **Table 4.1,** the costs are estimated to range between $148/MWH and $281/MWH depending on assumptions about the project's capital costs ($/kilowatt of capacity), non-fuel operating costs ($/KW/year), and fuel costs ($/bone dry ton).

Table 4.1 – Small Scale Forest Biomass Projects Levelized Cost of Electricity

	Low Estimate	Medium Estimate	High Estimate
Capital Cost ($/KW)	5,000	6,000	7,500
Non-fuel Operating Cost ($/KW/year)	347	553	590
Size (MW)	3	3	3
Feedstock Cost ($/dry ton)	30	45	60
LCOE ($/MWH)	**148**	**219**	**281**

The financial assumptions used in the Black and Veatch model were that the facility would be owned by a private taxpaying entity and that no tax advantages, credits, or low cost financing would be available. Select metrics in the Black and Veatch model were debt/equity ratio of 60/40, 2 percent annual inflation and equity cost of 12 percent. Other assumptions are listed in their report.

It is likely that some of the assumptions used in the Black and Veatch study will not apply to all projects. For example, some of the projects that are being contemplated utilizing the SB 1122 program are located in economically distressed rural communities, which would make them eligible for NMTC's. Others would typically have some government agency financial involvement. Those two factors are mechanisms for lowering debt costs and equity requirements, which were not accounted for in the Black and Veatch study. In addition, some proposed technologies would produce byproducts with value, and some would have thermal customers – neither of which was included in the Black & Veatch study. Therefore, BECK estimates that a 3 MW rural CHP project could accept a power contract at a price at or lower than the medium estimate shown in **Table 4.1** for a 15 to 20 year agreement.

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[4] LCOE – is the net present value of the unit-cost of electricity over the lifetime of a generating asset. It is often expressed as the average price that the generating asset must receive in a market to break even over tis lifetime.

[5] Small-Scale Bioenergy: Resource Potential, Costs, and Feed-in Tariff Implementation Assessment. Black and Veatch. October 2013. Accessed at: http://is.gd/bxKhQJ.

4.3.3 SB 1122 Allowable Fuel Types

Four types of fuel are acceptable in the SB 1122 program; all of the fuel must be from among the four categories, and at least 80 percent of the fuel for a given project must be sourced from a single one of these categories. In addition, recordkeeping/reporting must be completed annually to provide verification of fuel sources. The four categories are:

1. *Fire Threat Reduction*– Biomass feedstock which originates from fuel reduction activities identified in a fire plan approved by Cal Fire or other appropriate state, local or federal agency. On federal lands this includes fuel reduction activities approved under 36 CFR 220.6(e)(6)ii and (12) –(14).
2. *Fire Safe Clearance Activities* – Biomass feedstock originating from fuel reduction activities conducted to comply with PRC Sections 4290 and 4291. This would include biomass feedstocks from timber operations conducted in conformance with 14 CCR 1038(c) (150' Fuel Reduction Exemption) as well as projects that fall under 14 CCR 1052.4 (Emergency for Fuel Hazard Reduction), 14 CCR 1051.3-1051.7 (Modified THP for Fuel Hazard Reduction), and 14 CCR 1038(i) (Forest Fire Prevention Exemption), and categorical exclusions on federal lands approved under 36 CFR 220.6(e)(6) ii and (12)–(14).
3. *Infrastructure Clearance Projects* – Biomass feedstock derived from fuel reduction activities undertaken by or on behalf of a utility or local, state or federal agency for the purposes of protecting infrastructure, including but not limited to: power lines, poles, towers, substations, switch yards, material storage areas, construction camps, roads, railways, etc. This includes timber operations conducted pursuant to 14 CCR 1104.1(b),(c),(d),(e),(f) &(g).
4. *Other Sustainable Forest Management* – Biomass feedstock derived from sustainable forest management activities that accomplish one or more of the following: 1) forest management applications that maintain biodiversity, productivity, and regeneration capacity of forests in support of ecological, economic and social needs; 2) contributes to forest restoration and ecosystem sustainability; 3) reduces fire threat through removal of surface and ladder fuels to reduce the likelihood of active crown fire and/or surface fire intensity that would result in excessive levels of mortality and loss of forest cover; or 4) contributes to restoration of unique habitats within forested landscapes.

4.3.4 SB 1122 Implementation

The CPUC codified the process by which projects enter the SB 1122 program. The drafting and reviewing of rules and regulations occupied nearly two years at the CPUC, and a final order was approved by CPUC Commissioners on December 18, 2014. It is very complex, but several key points are that the project must be in the service territory of one of the Investor Owned Utilities (Southern California Edison – SCE, Pacific Gas & Electric – PG&E, or San Diego Gas & Electric – SDG&E) who are required to comply with the legislation. Since PG&E's service territory is the most heavily forested, that utility is responsible for 47 MW of the 50 MW requirement.

The initial levelized price offered to project developers will be $127.72 per MWH. If there are at least 3 projects in the queue and none of the three can accept a PPA at the price, then the price begins to increase bimonthly by a predetermined amount and schedule. The price will continue increasing until it reaches a level acceptable to one of the projects. This price adjustment process is called ReMAT (Renewable Market Adjusting Tariff), and the entire program is now referred to as BioMAT. If the offered price reaches $197/MWH without any takers, it may trigger a price cap investigation by the CPUC.

On December 18, 2014, the CPUC decision (D-14) codified much of the previous information and laid out the following program for implementing the 50 MW sustainable forest management portion of SB 1122. Key provisions include:

- Program to begin immediately, with IOUs given 45 days to submit details for approval (now scheduled to accept applications beginning 12/1/2015 and first auction of 2/1/2016)
- 50 MW total requirement (47 MW of which is PG&E's responsibility)
- $127.72/MWH project levelized starting price, with statewide price pool
- Use of Renewable Marketing Adjusting Tariff (ReMAT) mechanism to adjust prices
- Minimum of 3 projects in initial queue to allow price change modification to begin
- Once first 1 MW accepts a contract price, the minimum number of projects in the queue for the price change modification to again go into effect increases to 5 projects
- Use of existing ReMAT PPAs for contracting
- Program terminates 60 months after first offering
- PG&E, SCE to offer 6 MW in each auction, SDG&E to offer 3 MW
- Project must be in service territory of one of the IOUs
- Transmission upgrades must not exceed $300,000 per project unless bought down to that level by developer
- Must be connected to IOU distribution system
- 3 MW maximum "nameplate" rating
- Must qualify at California Energy Commission (CEC) for California Renewable Portfolio Standard (RPS)
- Must be a Federal Energy Regulatory Commission (FERC) Qualifying Facility (QF)
- CPUC staff to review maximum price if it rises to $197/MWH

The general ReMAT program has been in place for several years to satisfy other renewable requirements and is used by the IOUs to purchase small (3 MW or less) renewable power of all types. In PG&E's case there are a set of preconditions that must be satisfied before a project will be allowed to be placed into the ReMAT queue. Those preconditions, which also apply to BioMAT, include:

- Must be physically located in IOU territory
- Must be an Eligible Renewable Resource (ERR)
- Must be a federal Qualifying Facility
- Contract Capacity cannot exceed 3 MW
- Interconnection study, in some form, must be in an advanced stage to indicate interconnection is feasible
- Must have 100 percent site control
- At least one member of development team must have experience with same technology/size project
- This must be the only project being developed at the site
- Cannot have accepted incentives from California Solar Initiative
- Cannot be doing Net Energy Metering at site

Once the initial queue is established, the IOU will hold the first bimonthly subscription of 6 MW of PPAs. Queue position is determined by date of acceptance or by random drawing if on same date. The initial price will be $127.72/MWH fixed for the PPA duration. The IOU will offer PPAs to the first 6 MW of projects in the queue. If no takers, they will go through the queue with the offering. Assuming there are no takers among the 3 or more projects in the queue, the following bimonthly sequence will occur:

- First Bimonthly Adjustment: Original price + $4/MWH
- Second Bimonthly Adjustment: Revised price + $8/MWH
- Third Bimonthly Adjustment: Revised price + $12/MWH
- Fourth and Subsequent Bimonthly Adjustment: Revised price + $12/MWH

The price can also go down according to the same schedule if the 6 MW is fully subscribed. One unique feature in BioMAT will be that once 1 MW is subscribed, the queue must expand to 5 projects before the price can begin to move again. BECK estimates it is likely BioMAT will be in effect for about 14 months before the price reaches levels that are acceptable. Note, however, a 14 month ReMAT period would escalate the price to the level of the trigger price ($197/MWH) at which the CPUC would investigate a price cap.

Once an acceptable price is reached, the project will have 10 days to accept/reject the award. Once accepted, the project will be offered the standard ReMAT PPA. Key provisions of this PPA are:

- Term of 10, 15 or 20 years
- Price fixed for term of PPA
- All sales net of station service
- Contract can be buy all/sell all or excess sales only

- Contract Capacity (CC) cannot exceed 3,000 KW
- Time of day pricing is applicable
- Can deliver up to 110 percent of CC in an hour
- Can deliver up to 120 percent of Contract Quantity (CQ) annually
- All Green Attribute & Resource Adequacy benefits to power purchaser
- 2 year energy guarantee of 180 percent of CQ
- Subject to California ISO forecasting, scheduling, penalties
- Project to post $20/KW collateral for life of contract
- Project on line within 24 months of PPA signing
- Typical definition of Green Attributes, so that any fuel emission related GHG benefits, for instance, would remain with project and not power purchaser

4.4 SMALL SCALE BIOMASS TECHNICAL FEASIBILITY

The following sections provide an analysis of the technical feasibility of small scale biomass heat and/or power in terms of: available technologies, site considerations, fuel supply and cost, and environmental and permitting issues, and co-located businesses.

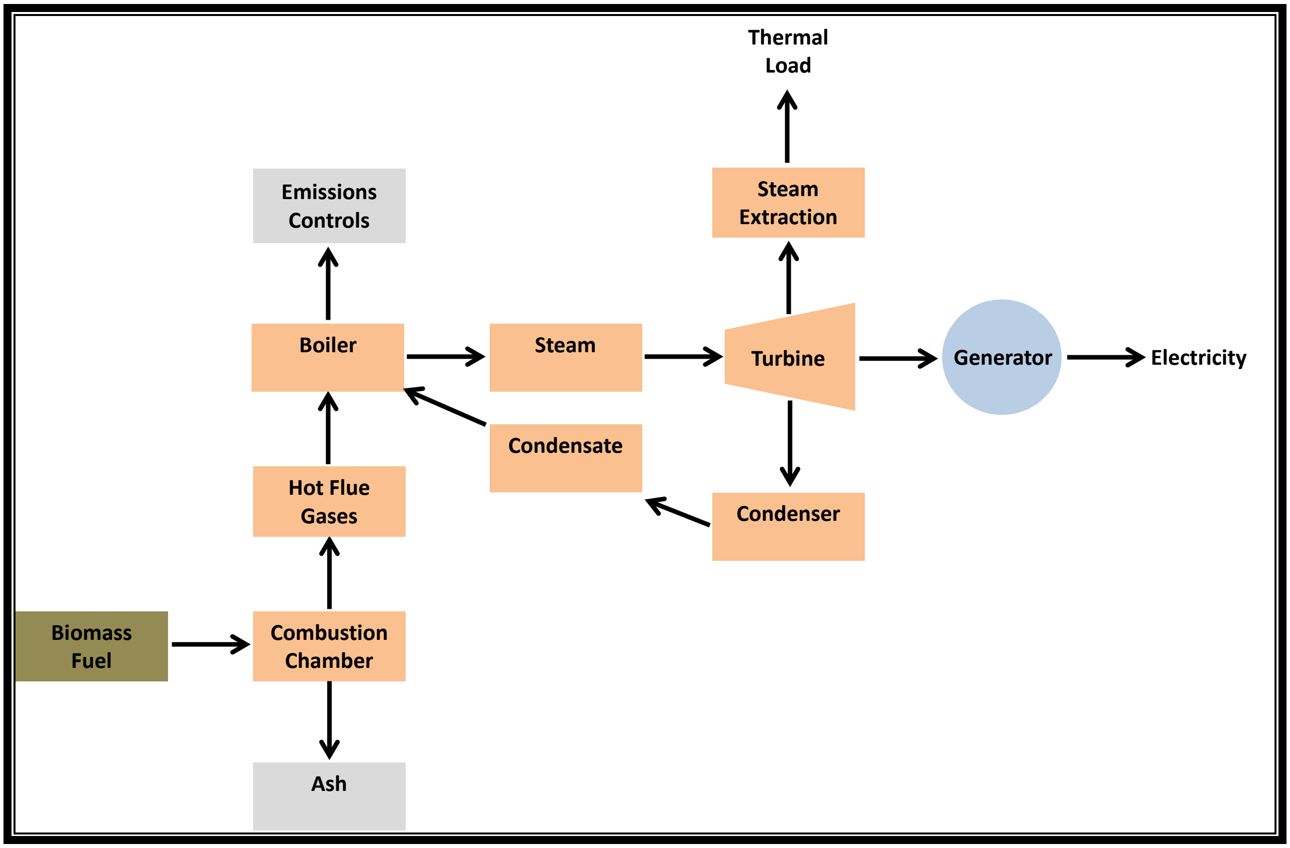
4.4.1 Small Scale Biomass Technology Options

In BECK's judgment, there are two technology options mature enough to be considered for small scale biomass heat and/or power. They are: 1) direct combustion boiler coupled with an extraction/condensing steam turbine generator; and 2) gasification unit coupled with an internal combustion engine-generator. These two technologies are described in the following sections.

4.4.1.1 Direct Combustion and Gasification Technology Overview

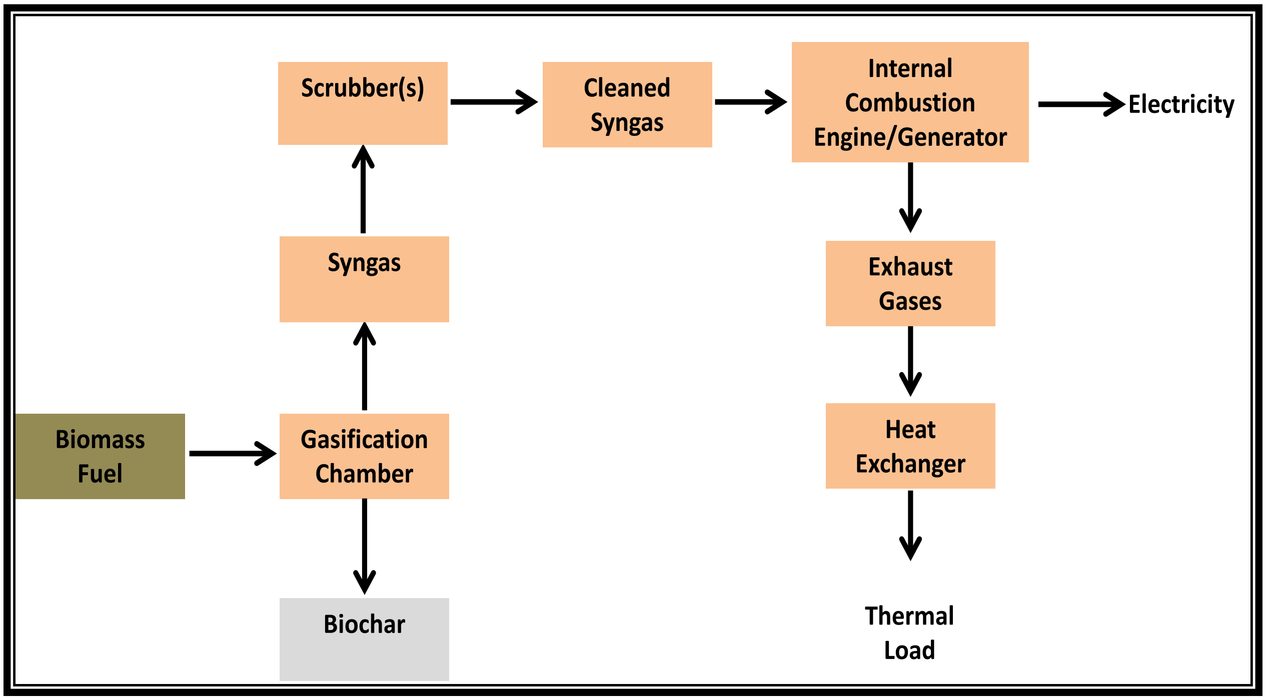
Direct combustion is the process of burning biomass in an enclosed vessel with heat recovery. Combustion occurs in a chamber where volatile hydrocarbons are released and burned, which creates heat energy in the form of hot flue gases. Typically, those flue gases are directed into a boiler to create steam. That steam, in turn, can be used for heating (e.g., a building or manufacturing process), generating electricity, or both. The general concept is illustrated in **Figure 4.1**, which shows steam exiting the boiler and being fed into a turbine–generator to produce electricity. The figure also shows steam being extracted from the turbine at the appropriate temperature/pressure to supply a thermal load.

Figure 4.1 – Simplified Diagram of Direct Combustion Technology for Combined Heat and Power



In contrast to direct combustion, gasification is the process of breaking down biomass fuel through incomplete combustion (i.e., heating the material in an oxygen starved environment). The result is the production of combustible gases, which are called syngas or producer gas. Producer gas contains combustible carbon monoxide, hydrogen, and methane, as well as incombustibles. The syngas is typically collected, cleaned (tars and other impurities removed) and then combusted in an internal combustion engine-generator system. Another result of the process is the production of charcoal, which is often called biochar when it is used as a soil amendment.

Figure 4.2 – Simplified Diagram of Gasification Technology for Combined Heat and Power



4.4.1.2 Small Scale Biomass Technology Comparison

The following sections provide a comparison of gasification and direct combustion technology in terms of: capital expense, compatibility with thermal load, fuel efficiency, environmental performance, staffing, revenue sources, degree of commercialization, and capacity and reliability.

Capital Expense – the gasification/IC engine combination is expected (from the CPUC Black & Veatch Study[6]) to have a capital cost of $5,000 to $7,000/KW, or $15 to $21 million for a 3 MW installation in 2013 dollars. This is lower than some recently announced smaller gasification installations, which cluster more in the $8,000 to $10,000/KW range. With regard to direct combustion, BECK estimates the capital cost for a complete boiler/steam turbine combination (minus process heat costs) of $22-23 million or $7,500/KW net.[7] Please note that both of the capital costs just provided are at a high-level and, given the overlap between the estimates, BECK considers both technologies to be roughly equal in terms of capital expense.

Compatibility With Thermal Load – with regard to gasification, a gasification unit would be continually producing sufficient syngas so that after cleaning it would be capable of producing 3 MW in one or, more likely, two internal combustion engines. The waste heat that must be captured off such a system is essentially a fixed amount at all times. BECK estimates the waste

[6] Small-Scale Bioenergy: Resource Potential, Costs, and Feed-In Tariff Implementation Assessment. Accessed at: http://www.cpuc.ca.gov

[7] Based on a budgetary quote from Wellons Inc., a biomass boiler manufacturer based in Vancouver, WA.

heat represents 60 to 70 percent of the incoming energy (BTUs) in the fuel. To produce 3 MW net for sale, biomass fuel containing an estimated 35-40 million BTUs per hour must be introduced to the gasifier. This means that up to 28 million BTUs (70 percent of 40 million BTUs) per hour appear as waste heat that must either be captured or disposed.

If the thermal load is equivalent to the 28 million BTUs of waste heat produced per hour, the system can be designed with minimal heat rejection equipment (e.g., radiator and cooling tower) and thus be highly efficient. However, if the thermal load is lower than the amount of waste heat produced, heat rejection equipment would be required. A direct combustion boiler/steam turbine arrangement utilizes an extraction/condensing steam turbine-generator (TG) to tailor the amount of process heat to the demand at the time. Thus, the amount of fuel combusted will vary somewhat with the amount of thermal load. Heat rejection equipment is required at the low pressure end of the turbine.

Fuel Efficiency – there are few woody biomass fueled gasifier/IC engine projects in operation. Therefore, well documented fuel efficiency data is difficult to obtain. Nevertheless, in a power generation only mode (producing 3 MW of power), the expected efficiencies appear to fall in the 25 to 31 percent range, with perhaps 27 percent being a reasonable assumption for the average. This is a heat rate of 12,640 BTUs of fuel input per KWH produced. For a direct combustion boiler/steam turbine-generator combination, fueled by the type of forest derived biomass fuel expected at a plant in northern California, a 24 percent overall conversion efficiency would be expected, or a heat rate of 14,220 BTU/KWH. When converted to annual tons of fuel, the gasification unit theoretically would use about 2,000 BDT less fuel per year.

Environmental Performance – gas leaving a gasification unit would be expected to have less NOx, more CO and the same particulate matter relative to gas leaving a direct combustion boiler. However, gas leaving the gasifier is cleaned of tars and some particulates by cooling/condensation.

Larger gasification units are typically equipped with an electrostatic precipitator (ESP) for particulate control. Similarly, biomass direct combustion boilers also have ESP’s. Smaller direct combustion units of 3 MW capacity, however, typically do not have supplemental controls for CO or NOx beyond those incorporated for efficiency reasons unless they are located in an area with extraordinary pollution issues.

Given all of the variables associated with the scale of the equipment and where it would operate, it is difficult to compare environmental performance. Nevertheless, BECK concludes that a gasification/IC engine facility and a boiler/steam turbine facility of 3 MW size to have basically the same pollution control package.

Staffing – in terms of staffing and staff qualifications, the expectation would be that both facilities would be staffed on a 24x7 basis by at least one person per shift. Somewhat surprisingly, California has no licensing requirement for power unit operators. It would be expected that the staffing levels for the two technologies would be similar and that qualified staff would be available given California's long history of biomass power generation.

Revenue Sources – it is expected that a gasification facility could produce significant quantities of biochar as a byproduct, if markets warrant. Biochar is a form of charcoal, but potentially has a market value as a low volume soil amendment. However, BECK recommends caution in overvaluing the biochar as it appears the specialty soil amendment market could be easily saturated by several large plants coming on line.

In the longer term, the role for biochar is likely to be as a form of carbon sequestration when introduced into the soil. As carbon markets become more robust in California and a protocol is approved for sequestration via biochar, biochar can likely produce another stable revenue stream for a gasification project.

However, it is important to note that the production of a high carbon biochar does not occur for free as the BTUs in the carbon of the biochar are not recovered as heat and/or electricity. Work by BECK on other projects has shown that when biochar is produced from forest waste, carbon prices must be above $40/ton of CO_2e before the carbon as biochar becomes a positive income contributor. Currently, carbon markets in California are in the $12 to $13 per ton CO_2e range, and they have consistently been at that level since California's Global Warming Solutions Act (AB 32) was implemented.

An oversized gasifier with a 3 MW IC engine could, for instance, allow for some syngas, post treatment, to be diverted to the production of transportation fuels without dropping the 3 MW production. This may have great potential in a low carbon world, but the timing, technology, and economics all remain unknowns. Absent more definitive information, inclusion of excess capacity in a 2015 project is simply raising initial capital cost with an unknown, if any, return.

A direct combustion system, in contrast, is limited to revenue from the sale of heat, the sale of electricity, and potential carbon credits based on the alternative fates of the fuel combusted.

Degree of Commercialization – the natural conclusion from the preceding discussion is that, all things being equal, the potential slightly higher overall efficiency of gasification/IC engine technology and the potential byproduct markets would push a decision in favor of gasification. However, all things are not equal. The boiler/steam turbine combination burning forest and mill biomass has been demonstrated in hundreds of installations over decades at scales both larger and smaller than 3 MW. Multiple vendors will provide firm prices and will provide bonded guarantees of completion, performance, and environmental compliance. The fuel specification for the unit will be broad, accepting various moisture contents, species, piece sizes and heating contents.

With regard to gasification/IC engine technology, the outcome is far more uncertain. There is much literature regarding the sensitivity of gasifiers, particularly fixed bed gasifiers, to both particle size and moisture content. The literature indicates that the fuel should be dried to provide a consistent moisture content to the gasifier. There is virtually no experience with gasification of mixed forest waste direct from the field (i.e., varied piece geometry and varied moisture content). It is not known whether the constant variation in content between bark, needles, twigs and the tree bole can be consistently gasified in bulk. In addition, the impact of wide variations in seasonal moisture content will affect the operation of the equipment to an unknown degree.

In addition, the gas cleanup equipment ahead of the IC engine is also suspect. Failures in this part of the gasification process have defeated all attempts, over many decades, to successfully operate a gas turbine off clean syngas. IC engine technology is clearly more forgiving and has become the industry standard. Still, there is very limited information concerning long term operation of IC engines on cleaned syngas.

Capacity and Reliability – a BioMAT contract specifies that baseload technologies must produce 180 percent of their annual contract quantity every two years, or be subject to a penalty for the shortfall. This is basically a requirement that the biomass plant annually produce 90 percent of the expected amount of power. This requirement can be softened by not pledging to operate at a high capacity factor. However, that strategy is flawed because then the facility is trapped at that lower amount (i.e., PG&E will not accept more than 120 percent of the contract quantity annually). In a contract capped at 3 MW, the facility's revenue potential is inherently limited and, therefore, the facility must produce as much power as possible at all times. Direct combustion units can meet this standard, but this remains an unknown for gasification units.

4.4.1.3 Technology Selection Conclusion

There are four key points that lead BECK to conclude that selection of direct combustion/extraction-condensing steam turbine technology is appropriate for SB 1122 projects. They are:

1. No substantial gasification experience with mixed forest waste
2. Rejection of ability to utilize perceived value of coproducts in lender financial evaluation
3. Lack of standard commercial warranties from creditworthy vendors
4. Potential failure to meet performance requirements of BioMAT power purchase agreements

The above list is heavily influenced by the fact that small scale biomass is only being evaluated because of the opportunities presented by the SB 1122 program. Without that program small scale biomass would have scored much lower in the initial evaluation and would not have been analyzed further. But the SB 1122 program comes with a unique set of fuel requirements and contract performance requirements that make it very difficult to conclude that gasification technology should be the project choice. An evaluation made for different fuel types, with contract structures or at another point in time might well reach a different conclusion.

4.4.2 Fuel Supply and Cost

The following sections provide information about the allowable biomass fuels under the SB 1122 program, an estimate of supply, and an estimate of delivered cost.

4.4.2.1 SB 1122 Allowable Biomass Fuels

As described in **Section 4.3.3**, the SB 1122 program specifies the use of only certain biomass fuel types, including material arising from: fire threat reduction activities, fire safe clearance activities, infrastructure clearance projects, and other sustainable forest management. In BECK's opinion, the definition of material derived from Sustainable Forest Management activities is open to some interpretation. This is because the SB 1122 language states that material derived from sustainable forest management can include, "…*forest management activities that accomplish one or more of the following: 1) forest management applications that maintain biodiversity, productivity, and regeneration capacity of forests in support of ecological, economic and social needs.*"

According the Cal Fire website, in 1973, California enacted the Forest Practices Act to ensure that logging on privately owned lands is done in a manner that will preserve and protect fish, wildlife, forests and streams. Additional forestry rules have since been enacted by the State Board of Forestry and Fire Protection. The 2015 version of "California Forest Practice Rules" is a 397 page document intended to provide forest management field personnel with working rules for their use. A key component of the Forest Practices Act is that a landowner must file a Timber Harvesting Plan (THP) with Cal Fire and have the plan approved prior to any commercial timber harvesting activities. The THP is an environmental review document describing the timber to be harvested, how it will be harvested, and the steps that will be taken to prevent damage to the environment.

Given the existence of California's Forest Practices Act and the requirement for filing an approved THP prior to logging, in BECK's judgment any timber harvesting operations carried out in California that follow those protocols could reasonably be judged as "Other Sustainable Forest Management". Therefore, biomass fuel such as logging slash derived from Cal Fire approved timber harvesting can reasonably be interpreted to be allowable under the SB 1122. This interpretation needs to be verified by Cal Fire and the California Public Utilities Commission. However, for the purposes of this study, BECK has assumed that logging slash is an allowable SB 1122 biomass fuel.

4.4.2.2 Estimated Biomass Supply

In the biomass industry, facilities use large volumes of relatively low value material. Therefore, the industry has adopted weight measurement as the most cost effective means of measuring material usage. A complicating factor with weight measurement to determine biomass usage is that all biomass also contains water. The amount of water in biomass can vary significantly depending on the type of biomass, and the climatic conditions it has been subjected to since harvesting, and the resulting amount of drying that has taken place.

Therefore, the industry uses a measurement unit called a Bone Dry Ton (BDT) to more precisely measure biomass weight. It is a calculated measurement that expresses biomass weight after accounting for the weight of water. The concept is perhaps best illustrated with an example: most freshly harvested biomass starts out at about 50 percent moisture content. Thus, 1 ton of freshly harvested biomass would contain 1,000 pounds of wood and 1,000 pounds of water and would be equal to 0.5 bone dry tons. If, however, the material is allowed to dry before being utilized as fuel, it may drop to 30 percent moisture content. In this scenario, 1 ton of biomass would contain, 1,400 pounds of wood and 600 pounds of water and would be equal to 0.7 bone dry tons.

In practice, each incoming truckload of fuel is weighed when the truck is full of fuel and when it is empty. This is a measurement of the green weight of the biomass fuel in the truckload. A small sample of biomass is taken from each incoming truckload of fuel. The sample is weighed as received. It is then dried in an oven until all moisture is removed. Finally, it is reweighed. The difference between the original weight and the dry weight of the sample allows for the calculation of the sample's moisture content. The moisture content of the sample is then applied to the truckload's green weight to estimate the bone dry weight of the fuel in the truckload. A general rule of thumb for biomass heat and power is that each megawatt of capacity requires about 8,000 bone dry tons of biomass fuel annually. Thus, a 3 MW plant would require approximately 24,000 bone dry tons of fuel annually. Note that the amount may be higher, if at a given plant, there is a thermal load to be served in addition to the production of electricity.

Table 4.2 shows the average sawlog harvest in every county in California that had a measurable timber harvest during the period 2010 to 2014. As shown in the table, a total of 1.373 billion board feet of saw timber was harvested each year between 2010 and 2014. The five county Northern Interior Region accounts for almost 38 percent of the total, followed closely by the North Coast Region and Sacramento Regions which account for 26 and 25 percent of the total respectively.

The SB 1122 program requires that 47 of the 50 MW mandate is the responsibility of Pacific Gas & Electric. Their service territory is aligned with virtually all of the regions shown in **Table 4.2**. The exceptions are roughly Trinity, Siskiyou, Modoc, and Lassen Counties in the Northern Interior Region, which have areas the extend beyond the PG&E service territory and small portions of counties in the Sacramento and San Joaquin Regions that are east of the Sierra Nevada divide, which also extend beyond the PG&E service territory. Therefore, BECK has elected to include Shasta County and all other regions shown in **Table 4.2** as potential supply areas for a small scale biomass power plant.

Table 4.2 – Average Annual Timber Harvest in California by County (2010 to 2014 time period, MBF Scribner Short Log Scale)

County/Region	Average Timber Harvest (MBF)	County/Region	Average Timber Harvest (MBF)
Northern Interior Region		**San Joaquin Region**	
Shasta County	204,137	Tuolumne County	62,790
Siskiyou County	175,288	Calaveras County	27,401
Lassen County	58,026	Fresno County	15,950
Modoc County	45,428	Amador County	9,181
Trinity County	34,429	Madera County	5,082
Northern Interior Subtotal	*517,308*	Mariposa County	4,439
North Coast Region		Kern County	2,689
Humboldt County	232,212	Tulare County	2,212
Mendocino County	106,628	Mono County	565
Del Norte County	10,173	Alpine County	438
Sonoma County	9,359	*San Joaquin Region Subtotal*	*130,745*
Napa County	25	**Central Coast Region**	
North Coast Subtotal	*358,397*	San Mateo County	5,733
Sacramento Region		Santa Cruz County	9,305
Plumas County	94,993	Santa Clara County	568
Tehama County	63,792	*Central Coast Region Subtotal*	*15,606*
El Dorado County	46,687		
Placer County	45,118		
Butte County	40,091	**Grand Total All Regions**	**1,373,477**
Sierra County	24,323		
Yuba County	18,070		
Nevada County	15,273		
Glenn County	1,188		
Lake County	1,331		
Colusa County	556		
Sacramento Region Subtotal	*351,421*		

A general rule of thumb that applies to the interior forests of Northern California is that every thousand board feet of saw timber (Scribner Short Log Scale) harvested produces a total of 0.9 bone dry tons of sustainable forest management byproducts (e.g., tops and otherwise unmerchantable portions of a tree). That factor can be used to estimate the volume of sustainable forest management byproducts produced as a result of saw timber harvests, as shown in **Table 4.3**. Note that the table has two columns of volume estimates. This is because not all of the total volume can be cost effectively utilized due to factors such as the type of logging system used (e.g., only with whole tree harvesting do limbs and tree tops accumulate at landings) and road systems that do not accommodate chip vans. Thus, the practically available volume is significantly less than the total volume produced. In some cases the practically recoverable volume can be as much as 60 to 70 percent of the total volume. However, in this case, the recoverable volume was conservatively estimated at 50 percent. As shown in the table, a total of 618,000 bone dry tons of utilizable sustainable forest management byproducts has been estimated to be produced annually in California.

The 618,000 bone dry tons annually, by itself, with no contributions from any of the other acceptable fuel categories, would be capable of supplying 1.5 times the fuel needed to produce the 50MW that could be developed under the auspices of the BioMAT program.

Table 4.3 – Estimated Volume of Sustainable Forest Management Byproducts (BDT)

Northern Interior Region	**Sawtimber Harvest (MBF)**	**Total Byproducts (BDT)**	**Utilizable Byproducts (BDT)**
Shasta County	204,137	183,700	91,850
Siskiyou County	175,288	157,800	78,900
Lassen County	58,026	52,200	26,100
Modoc County	45,428	40,900	20,450
Trinity County	34,429	31,000	15,500
Northern Interior Subtotal	*517,308*	*465,600*	*232,800*
North Coast Region			
Humboldt County	232,212	209,000	104,500
Mendocino County	106,628	96,000	48,000
Del Norte County	10,173	9,200	4,600
Sonoma County	9,359	8,400	4,200
Napa County	25	0	0
North Coast Subtotal	*358,397*	*322,600*	*161,300*
Sacramento Region			
Plumas County	94,993	85,500	42,750
Tehama County	63,792	57,400	28,700
El Dorado County	46,687	42,000	21,000
Placer County	45,118	40,600	20,300
Butte County	40,091	36,100	18,050
Sierra County	24,323	21,900	10,950
Yuba County	18,070	16,300	8,150
Nevada County	15,273	13,700	6,850
Glenn County	1,188	1,100	550
Lake County	1,331	1,200	600
Colusa County	556	500	250
Sacramento Region Subtotal	*351,421*	*316,300*	*158,150*
San Joaquin Region			
Tuolumne County	62,790	56,500	28,250
Calaveras County	27,401	24,700	12,350
Fresno County	15,950	14,400	7,200
Amador County	9,181	8,300	4,150
Madera County	5,082	4,600	2,300
Mariposa County	4,439	4,000	2,000
Kern County	2,689	2,400	1,200
Tulare County	2,212	2,000	1,000
Mono County	565	500	250
Alpine County	438	400	200
San Joaquin Region Subtotal	*130,745*	*117,700*	*58,850*
Central Coast Region			
San Mateo County	5,733	5,200	2,600
Santa Cruz County	9,305	8,400	4,200
Santa Clara County	568	500	250
Central Coast Region Subtotal	15,606	14,000	7,000
Grand Total	**1,373,477**	**1,236,200**	**618,100**

4.4.2.3 Estimated Biomass Fuel Cost

The cost of fuel procured from the byproducts of sustainable forest management is a function of the cost of gathering, processing, and transporting the material. **Table 4.4** shows the estimated delivered cost of sustainable forest management byproducts at various hauling distance increments.

Table 4.4 – Estimated Biomass Fuel Delivered Costs

Haul Distance (Miles)	Landowner Allowance ($/BDT)	Grinding/Loading Cost ($/BDT)	Hauling Cost ($/BDT)	Total Delivered Cost ($/BDT)
10	0	33	7	40
20	0	33	10	43
30	0	33	12	45
40	0	33	14	47
50	0	33	17	50
60	0	33	19	52
70	0	33	21	54

The key assumptions associated with the preceding analysis are as follows:

- The daily operating cost for a biomass grinding operation is estimated to be nearly $5,400. This includes fuel ($3.08 per gallon for off highway diesel) for a horizontal grinder and loader, wages for 2 machine operators, salaries for an owner/operator and clerical support, depreciation based on a $1.25 million capital expense, supplies, repair and maintenance.
- The operation will work 250 days per year and produce an average of 182 bone dry tons per day.
- Transportation cost is based on a truck rate of $85 per hour, and the truck will have an average round trip speed of 45 miles per hour and will require an average of one hour for loading/unloading.
- The fuel will be allowed to dry before grinding and transportation and, therefore, will average 35 percent moisture (wet basis), with each truckload averaging 16.6 bone dry tons.
- A 10 percent profit allowance for the grinding contractor was included in the analysis.
- No allowance for a payment to the landowner was included. In BECK's opinion this is justified since utilizing sustainable forest management byproducts allows the landowner to avoid the cost and risk associated with open burning of the material, or the cost of redistributing it across the harvested area.

For the purposes of BECK's financial analysis, the preceding information was assumed to translate into an average delivered cost of $45 per bone dry ton.

As described in the OSB chapter, small diameter trees harvested expressly for the purpose of utilization as fuel could also supply the plant. However, in that case the cost of bring the material to the landing must be allocated to the cost of the fuel rather than to the cost of sawlogs. As described in the OSB chapter, the cost of delivering small diameter trees to a landing is an estimated $40 per green ton (or $80 per bone dry ton). The cost of chipping/grinding and transport would have to be added to the $80 cost. Thus, the use of small diameter trees harvested solely for biomass fuel is cost prohibitive unless steeply subsidized by the landowner.

4.4.3 Environmental and Permitting

The development of any biomass heat and power facility requires a variety of permits from various governmental agencies. Generally, issuance of such permits is under the jurisdiction of various state and local agencies. Among the required permits, the air quality permit is typically the most important and requires the most effort on the part of the project developer.

There are 11 categories of air pollutants for which federal, state, or local guidelines have been established. These include: Carbon Monoxide; Lead; Nitrogen Dioxide; Ozone; Respirable particulate matter less than 10 microns in diameter (PM10); Respirable particulate matter less than 2.5 microns in diameter (PM2.5); Sulfur Dioxide; Sulfates; Hydrogen Sulfide; Visibility Reducing Particles; Vinyl chloride (chloroethene).

Among the preceding list of pollutants, carbon monoxide, nitrogen dioxide, particulate matter and sulfur dioxide are of particular concern for biomass plants. The other pollutants on the list are generally not produced from the combustion of woody biomass.

BECK has estimated the air quality pollutant levels that will be produced by a prospective small scale biomass facility based on the assumption that the biomass boiler being considered will have a heat input of about 50 million BTUs per hour as a stand-alone plant and 60 million BTUs per hour as a cogeneration plant, and it will operate 8,200 hours per year. The boiler would be equipped with the following features for controlling emissions:

- A multiclone mechanical collector for large particulate matter (PM) removal
- A 3 field electrostatic precipitator for fine PM control
- Multiple levels of overfire air for carbon monoxide (CO) and volatile organic compound (VOC) control
- An air heater to heat incoming combustion air, which lowers CO and VOC emissions
- A Selective Non-Catalytic Reduction (SNCR) system (including urea injection) to control NOx
- A complete set of continuous emissions monitors for NOx, CO, CO2, and O2

Given the expected operating conditions of the plant and the pollutant emission level commercial guarantees offered by boiler equipment vendors, **Table 4.5** shows the estimated annual emissions (tons per year) for the pollutants typically of concern at a biomass facility and the typical commercial guarantees on emission limits from equipment manufacturers for each pollutant.

Table 4.5 – Estimated Annual Emissions from the Prospective MR Biomass Facility

Pollutant	Commercial Guarantee (pounds per MMBTU)	Stand-Alone Estimated Annual Emissions 50 MMBTU/Hour (tons per year)	Cogeneration Estimated Annual Emissions 60 MMBTU (tons per year)
PM2.5	0.015	3.0	3.6
Carbon Monoxide	0.22	45.1	54.1
Nitrogen Oxides	0.15	30.8	37.0
Volatile Organic Compounds	0.005	1.0	1.2
Sulfur Dioxide	0.01	2.0	2.4

Another environmental issue commonly associated with biomass plants is water usage and water disposal. A direct combustion boiler that uses a mechanical draft wet cooling tower for condensing steam will typically require about 50 gallons of water per minute for plants in the 3 MW range. The water used replaces water evaporated during the condensation process. Since California is experiencing an extended period of drought, water usage at this level may be problematic. Air cooled condensers are available to reduce water use by 95 percent or more, but they require additional capital expense and make the entire process slightly less energy efficient. They are proven and available, however, if required by permit.

Another water related issue is that a biomass plant will produce about 10 gallons per minute of waste water. The waste water does not contain serious contaminants, but may have slightly elevated concentrations of minerals. This water must be disposed of. Options for disposal include discharge to a municipal sewer system (if available), onsite storage in an evaporation pond, or possible use in a manufacturing process (e.g., in a sawmill for saw cooling, log sprinkling, dust control in a log yard, etc.)

Finally, ash disposal is another environmental issue that must be addressed at biomass plants. Typically, about 3 percent of the dry weight of the biomass combusted will be left over as ash. Thus, a 3 MW plant consuming roughly 25,000 BDT of fuel annually will produce about 750 tons of ash per year.

There are two types of ash – fly ash and bottom ash. The bottom ash is the material that collects under boiler grates. Fly ash is the material that is collected in pollution control equipment downstream of the combustion chamber. The split in volume between the two types is typically about 50/50 on a weight basis. Bottom ash is comprised of sand and gravel that was embedded in the wood fiber. It is clean material and is commonly used as aggregate for road base, pipeline bedding, or as part of the mixture for asphalt or concrete. Fly ash is a much finer size material, which contains a certain percentage of unburned carbon. It generally has a high pH and is often utilized by agricultural operations as a soil amendment because of the material's excellent moisture retention qualities. In the event that the fly ash or bottom ash cannot be disposed of by these other uses it can also be landfilled.

4.4.4 Site Considerations

The physical footprint of a 3 MW biomass plant is small, requiring perhaps only 1 to 2 acres of space. However, the plant will also require space for fuel storage and for the incoming trucks loaded with fuel to maneuver during loading and unloading. Thus, in total, a 3 MW plant might require a space of approximately 5 acres.

Other considerations about the site include access to the required amounts of water and the ability to discharge waste water as discussed in section 4.4.4. SB 1122 is also unique in that it requires the plant to interconnect at distribution voltage (less than 60KV). This requirement actually enhances the ability to site the plant as it eliminates the need to site near higher voltage lines. The chosen circuit must have the capacity to accept 3 MW, however. If a utility substation is not readily available for interconnection, one must be developed onsite. The cost of such a substation is included in BECK's capital cost model.

Another site consideration is the route available to incoming fuel trucks. A plant using 25,000 BDT of biomass fuel per year will require 1,500 to 2,000 truckloads of fuel per year (depending on the average moisture content of the fuel). If fuel delivery hours are limited to weekdays, this translates into an average of 6 to 8 truckloads per day entering the site.

Finally, larger biomass plants are typically equipped with truck dumps for unloading trucks. In such systems, a loaded truck backs onto a ramp that is then raised until the fuel falls out the back end. Such systems are effective for quickly emptying trucks, but are too costly for smaller scale plants. Thus, small scale plants tend to have the fuel delivered in trailers that have "walking floors". In other words, the floors of the trailer are equipped so as to be able to self-unload the fuel into a receiving hopper.

4.4.5 Incentives

Aside from the BioMAT program there are several additional incentives available to biomass heat and power projects, including grants, tax credits, and project financing assistance. The following paragraphs describe selected incentives within each area. Prospective developers should bear in mind that these incentives change over time as federal and state budget priorities change, so this is only the current list as of late 2015.

With regard to grants, the USDA Forest Service offers what is currently known as the *Wood Innovation Funding Request for Proposals*. The cycle of this annual grant program is that submission of proposals is typically due early in the year and awards are announced in the spring. This program offers grants of up to $250,000 to assist projects that are aimed at expansion of wood energy markets or wood products markets. A minimum of a 35:65 funding match is required, with the developer bearing the smaller fraction. Projects considered under this program must use commercially proven technology[8]. The funds cannot be used to purchase equipment or pay for construction. For 2016, the program has a total of $5 million available.

Another grant program is the Rural Energy for America Program (REAP). It provides assistance in the form of grants and loan guarantees to agricultural producers and small business in rural America to purchase, install, and construct renewable energy systems, including biomass. Grants are available in amounts up to $500,000, but are limited to 25 percent of a project's cost. A loan guarantee, also available under this program, cannot exceed $25 million. In 2015, a total of $63 million was awarded in grants and loans under this program.

A financing incentive program is the New Market Tax Credit (NMTC). The NMTC program allows a lender servicing low income communities to take a sizeable tax credit. The program is designed to spur investment in new and operating businesses in low-income communities. The availability of the program depends on the U.S. Census Tract where the project is located (i.e., it must be in what is designated as a low-income or economically depressed census tract).

The mechanics are that the NMTC provides tax credits to Community Development Entities (CDEs) that lend money to projects in the low income communities. The advantages to the loan recipient is that the loan is made at a below market rate and the lender supplies equity to the project that does not have to be repaid by the loan recipient.

Another tax credit program available to biomass projects is the Business Energy Investment Tax Credit (ITC). For combined heat and power projects the tax credit is equal to 10 percent of expenditures, with no maximum limit stated. Normally projects are only eligible if they exceed 60 percent energy efficiency, but this requirement is modified for projects that use biomass for at least 90 percent of the system's energy source.

The Renewable Electricity Production Tax Credit (PTC) allows biomass renewable energy producers to receive an escalating $0.011/kilowatt hour federal tax credit. The program lasts 10 years from the date a facility is first placed into service and credits can be carried forward up to 20 years. This tax credit has been in place sporadically since the 1990s, but is not currently available.

The Modified Accelerated Cost-Recovery System (MACRS) allows businesses to recover investments in certain property through depreciation deductions. Depending on the type of property, assets may be depreciated over schedules as short as 3 years or as long as 50 years. Bonus Depreciation is also available that would allow 50 percent of the total project cost, in addition to normal first year depreciation, to be depreciated for tax purposes in the first full year of operation.

[8] A system that has a proven operating history specific to the proposed application. Such a system is based on established design, and installation procedures and practices. Professional service providers, trades, large construction equipment providers, and labor are familiar with installation procedures and practices. Proprietary and balance of system equipment and spare parts are readily available. Service is readily available to properly maintain and operate the system. An established warranty exists for parts, labor, and performance.

Finally, the U.S. Department of Energy offers a loan guarantee program titled the *Section 1704 Program*. Under this program the USDOE is authorized to issue loan guarantees for projects with high technology risks that “avoid, reduce or sequester air pollutants, or anthropogenic emissions of greenhouse gases”.

For the economic feasibility assessment, BECK has assumed that a project being developed under the SB 1122 program will be able to secure a total of $1 million in project support from some combination of the grants, tax credits and loan guarantees described here. In addition, BECK has assumed that the project would obtain financing under typical NMTC conditions. If an actual project is being contemplated, BECK would advise assembling a then current list of incentives.

4.4.6 Co-Located Businesses

The feasibility of a small scale biomass business can be significantly enhanced by the presence of a co-located business that requires heat for its operation. The advantage of a co-located forest products business occurs in two distinct ways. First, and most directly, is the sale of thermal energy to the co-located business so that the business can dry its raw material or finished products. This represents a second revenue stream for the biomass CHP facility since the thermal energy can be produced very efficiently from an extraction-condensing steam turbine generator.

The second, and subtler impact, is that the co-located business will utilize a more valuable portion of the tree that is harvested under one of the four types of activity mentioned earlier as qualifying for SB 1122 treatment. The co-located business will be able to pay a higher price than the "fuel value" of the log. Since the cost to harvest, process and transport the thinning products to the co-location site is essentially fixed, the higher value assigned to the raw material for the co-located business raw material means that the remaining fuel portion can be assigned a lower value than it would otherwise have had. In addition, the co-located business will typically have residual materials remaining (bark, fines, etc.) that still retain value as fuel for the biomass CHP facility.

The most common example of co-location is a sawmill that kiln dries its lumber. Sawmills are one of the best types of co-located businesses because they produce byproducts that can be used as fuel for the biomass plant and because lumber drying is a process that typically operates 24 hours a day, 7 days a week, nearly 365 days per year. In other words, the heat load provided by the kilns is large, and the demand is constant (though the amount can vary with seasonal changes in climate).

Other forest products based businesses also can be candidates for co-location. The following sections provide a description of a number of potential co-located businesses and an analysis of the economics associated with each business. The economic impact on the biomass power facility can be substantial, with the chosen example in this study showing a $25/MWH improvement in the power selling price from just thermal sales, without assuming any benefit from lower overall fuel prices as described above.

Additional information about prospective co-located businesses, including technology overviews, raw material specifications, market characteristics, production characteristics and location requirements, are included in **Appendix 4.**

RTL and RTF Analysis – developing pro forma income statements for all of the potential co-located businesses is beyond the scope of this study. However, BECK has completed a high-level Return to Log (RTL) or Return to Fiber (RTF) analysis of each business. RTL and RTF are forest industry terms used to describe the value the products produced from a conversion facility will yield after accounting for the cost of converting the material from its original form into a finished product. RTL refers to processes where the incoming feedstock is logs (or roundwood). RTF refers to processes where the incoming feedstock is wood fiber in the form of chips, sawdust, shavings, etc. Thus, while the analysis does not provide what would typically be seen in a pro forma income statement, it does still give a high-level indication of the economics of each co-located business.

To illustrate, an RTL example for sawmills is calculated by:

1. Estimating the total revenue that can be generated from sawing a log (i.e., the combined value of the lumber, chips, sawdust, shavings and bark all expressed on a $/MBF basis).
2. Subtracting the total cost of converting the log into lumber and byproducts from the total revenue (again expressed on a $/MBF basis).
3. The result is referred to as the RTL Value, the Maximum Allowable Delivered Log Cost, or the "break-even log cost".

In other words, the result of RTL and RTF calculations is the value generated by the log/fiber after accounting for the cost of converting it into a product.

BECK has completed RTL/RTF analyses for seven co-located business technologies. Since the various technologies use different units of measure for the raw materials and finished products, *<u>BECK has converted all units to a dollar per bone dry ton basis</u>*. This allows for a direct comparison of the economics underlying each technology and the identification of the co-located technologies capable of generating the greatest value from the wood raw material.

The analysis has been conducted at a relatively high level using a combination of data from BECK's work on prior projects and data generated as part of this study. As a result, a number of assumptions have been made about the scale (and operating costs) of the various technologies. Therefore, the results should not be viewed as precise cost and revenue estimates. Rather, the focus should be on the relative difference between the values generated by each conversion technology.

Table 4.6 shows the estimated RTF/RTL values and key metrics associated with each technology. A list of the key assumptions associated with each technology is included in the sections following the table. Note that the capital cost estimate for each technology is a rough order of magnitude estimate and is considered an "all inclusive" cost estimate (i.e., includes equipment, installation, engineering, project management, etc.)

As shown, lumber manufacturing is by far the technology that creates the highest value (light green). Then shavings, and post and pole manufacturing are in a second tier group that provides similar RTL/RTF values (light orange). There is a third tier group of technologies that includes briquettes, pellets, and firewood that all create roughly equal value (light blue). However, unlike the other technologies just mentioned, using small diameter roundwood as a feedstock for these businesses is marginal at best when costly small diameter trees are the sole supply source. Finally, fuel chips were by far the conversion technology providing the lowest return (light red).

The table also shows the amount of material each conversion facility was assumed to consume annually and an order of magnitude capital cost estimate for developing such a facility. For all technologies it was assumed that the owner/developer requires a 15 percent return (calculated on the entire capital expense, not just on the owner's equity). That cost was added to the conversion cost estimate. A more detailed description of the assumptions used in the analysis is provided following the table.

Table 4.6 – Estimated Return to Fiber/Log Values for Seven Technologies

	Lumber	Shavings	Post and Pole	Briquettes	Pellets	Firewood	Fuel Chips
Sales Value f.o.b. plant, ($/BDT)	206	178	195	167	160	95	25
Conversion Cost Inc. dep. and owner return @ 15% ($/BDT)	109	126	144	126	122	60	19
RTL/RTF Value ($/BDT)	**97**	**52**	**51**	**41**	**38**	**35**	**6**
Volume/Year (BDT)	137,000	10,200	5,000	9,900	47,000	9,400	84,000
Cap EX ($ millions)	40	2.5	1.5	2.0	10	0.5	2.0
Volume to be dried (BDT)	68,500	9,200	n/a	9,900	47,00	7,050	n/a
Avg. Incoming MC (%)	50	50	n/a	50	50	50	n/a
Volume to be dried (GT)	137,000	18,400	n/a	19,800	94,000	14,100	n/a
Tons of Water Removed	54,470	8,178	n/a	8,800	41,778	5,288	n/a
BTU needed/pound of water removed	2,300	2,300	n/a	2,300	2,300	2,300	n/a
BTU needed/year (trillions)	250	38	n/a	40	192	24	n/a
Operating Hours per year	8,400	4,000	n/a	6,000	8,400	6,300	n/a
BTU/hour (millions)	29.8	9.4	n/a	6.7	22.8	3.9	n/a

Lumber – the sawmill modeled in the analysis is based on prior BECK work and would produce 70 million board feet of lumber annually from logs measuring a minimum of 4.5” in diameter on the small end up to no larger than 12” in diameter on the large end. An all-inclusive capital cost for such an operation is estimated to range between $35 and $45 million, depending on the amount of new versus used equipment installed (an “all-in” capital expense of $40 million was assumed for the analysis). On a log scale basis, the mill would consume about 37.8 million board feet Scribner Eastside log scale per year. The assumed log-to-lumber recovered was 1.85. On a volumetric basis, the assumed lumber recovery was 42 percent of the cubic log volume recovered as lumber, with the balance being a combination of sawdust, chips, shavings, and bark. This translates into an estimated annual raw material consumption of 275,000 green tons (~137,000 bone dry tons). The average sales realization for the mill was assumed to be $404 per MBF of lumber and includes the value of mill byproduct sales. This value is comparable to what mills in the Inland West region have experienced in the first quarter of 2015. The conversion cost, including direct manufacturing costs, general and administrative expenses, and owner's return, was estimated to be $213 per MBF (lumber scale).

Shavings – the operation modeled in this study would consume a little over 10,000 bone dry tons of roundwood raw material per year. The business would use "whole log shaving machines" to convert the roundwood into shavings, which would then be bagged and sold as animal bedding. The plant was assumed to have the capacity to produce about 700,000 bags per year, with each bag holding 3 cubic feet of compressed shavings. The average sales value per bag was assumed to be $2.50 (f.o.b. the plant). The conversion cost, including direct manufacturing costs, general and administrative expenses, and owner's return, was estimated to be $1.79 per bag. It was assumed that the volumetric recovery in going from roundwood to shavings was about 85 percent. The operation was assumed to run on a one shift basis. An all-inclusive order of magnitude capital cost for such an operation was estimated to be $2.5 million.

Post and Pole – the operation modeled in this study would consume approximately 5,000 bone dry tons per year and have an all-inclusive capital cost of $1.5 million. The operation would work on a one shift basis for 250 days per year and produce about 1,300 eight foot long posts per day, ranging in small end diameter size from 3 to 6 inches. The average sales value of the posts was assumed to be $2.81 per post f.o.b. the plant. It was also assumed that all plant byproducts would be sold at a value of $20 per green ton f.o.b. the plant (i.e., $0.18 per post). The conversion cost, including direct manufacturing costs, general and administrative expenses, and owner's return was estimated to be $2.20 per pole.

Briquettes – the operation modeled in this study would consume nearly 9,900 bone dry tons of raw material per year and produce about 10,800 tons of briquettes per year (at 10 percent moisture content). Briquettes were assumed to sell for $150 per ton f.o.b. the plant. The operation was assumed to run on a 3 shift basis, 5 days per week or 6,000 hours per year. The production capacity of the briquetting machine was assumed to be 2.0 tons per hour, and the plant was assumed to operate at 90 percent uptime. The conversion cost, including direct manufacturing costs, general and administrative expenses, and owner's return, was estimated to be $110 per ton of finished briquettes sold (i.e., briquettes at 10 percent moisture content).

Pellets – the pellet plant modeled in the study would produce about 50,000 tons of pellets per year and would consume a little over 55,000 bone dry tons of raw material annually. The plant was assumed to run 24 hours per day, 7 days per week and the uptime would average over 90 percent, which translates into about 8,400 hours of uptime per year. This further translates into an average production rate of nearly 6 tons of finished pellets per hour. The plant was assumed to sell pellets at $150 per ton (7 percent moisture content) f.o.b. the plant. The conversion cost, including direct manufacturing costs, general and administrative expenses, and owner's return, was estimated to be $113 per ton of finished pellets sold (i.e., pellets at 7 percent moisture content).

Firewood – the firewood operation modeled in the study was assumed to produce 9,000 cords of firewood per year, which translates into about 9,500 bone dry tons of raw material required annually. Each cord was assumed to contain 80 cubic feet of solid wood. The sales value was assumed to be $100 per cord f.o.b. the plant. The conversion cost, including direct manufacturing costs, general and administrative expenses, and owner's return, was estimated to be $63 per cord.

Fuel Chips – The value of the fuel produced from the operation was assumed to be $25 per bone dry ton.

4.5 SMALL SCALE BIOMASS ECONOMIC FEASIBILITY

The following sections provide an analysis of the economic feasibility of a prototypical SB 1122 small scale biomass project in terms of the required equipment and its cost, operating costs, projected revenues and the associated economic performance of a small scale biomass business.

4.5.1 Small Scale Biomass Equipment Description

As stated previously in this report chapter, there are substantial economic and public acceptance benefits to constructing a Combined Heat & Power (CHP) biomass facility as opposed to a stand-alone, power only facility. Therefore, BECK has chosen to model a CHP project producing 3MW net of power continually as well as selling 10 million BTU per hour of net thermal energy. As shown in **Table 4.6**, this level of thermal sales is sufficient to provide drying for a shavings operation, briquetting operation or dry firewood sales, but is insufficient for either a pellet operation or medium sized sawmill. The following sections describe the specific equipment and operating circumstances associated with the small scale biomass business modeled in the study.

4.5.1.1 Boiler System

The boiler chosen for this application is sized at 40,000 pounds per hour of steam, with outlet steam conditions of 600 psig pressure and 750°F temperature. These are standard steam conditions for small facilities, and several boiler vendors could supply this unit. At full capacity, the boiler will have a fuel input requirement of about 60 million BTU per hour.

This will be a watertube boiler with a single refractory lined firebox. Fuel will be provided to the firebox from multiple metering bins and air assisted spreader stokers. The grate system is moveable in order to be self-cleaning. The boiler will be balanced draft with fans for forced draft, induced draft, overfire air and stoker air. The boiler will be equipped with a tubular air preheater and an economizer to maximize fuel efficiency.

The boiler system will include a deaerator operating at 5 psig. The output of the deaerator will provide 225°F water to the boiler economizer. The water will be supplied through either full sized motor driven or steam turbine driven boiler feed pumps. An automatic ash removal system will take bottom ash and fly ash to separate storage containers.

4.5.1.2 Pollution Control Equipment

The boiler will be equipped with a multiclone mechanical dust collector for the removal of large particulate matter. This will be followed by a three field electrostatic precipitator (ESP) for the removal of fine particulate matter. A stack will be mounted on the discharge end of the ESP and will contain a testing platform and ports.

Control of carbon monoxide will be obtained through the provision of multiple levels of heated overfire air. Nitrogen oxide will be controlled by injection of urea from a Selective Non-catalytic NOx Removal System (SNCR). No controls for sulfur oxides are necessary as wood is inherently very low in sulfur. Emission data will be provided via Continuous Emission Monitors (CEMs) for O2, NOx, CO and CO2, as well as an opacity monitor.

4.5.1.3 Water Treatment Equipment

The incoming makeup water will first be treated by charcoal and sand filters to remove suspended solids. The boiler makeup water will then be treated in a Reverse Osmosis unit for the removal of minerals and stored in a feedwater storage tank. Incoming water is assumed to be of sufficient quality to go directly to the cooling tower after the charcoal/sand filters.

4.5.1.4 Fuel Processing Equipment

Fuel is assumed to be delivered in self-unloading trailers such that a truck tipping facility is not required. Trucks will unload into a hopper equipped with screw conveyers. Metered fuel will be carried by belt conveyer to an elevated disc screen, magnet and hammermill. At that point in the process oversized pieces will be separated and reduced in size and metal contaminants removed. The properly sized and screened fuel will then be moved by belt conveyer to a lowering chute onto the fuel storage pile.

A rubber-tired loader will manage fuel on the storage pile in a first in/first out rotation. The loader will move fuel to an underground fuel reclaim system consisting of chains discharging to a belt conveyer. The fuel reclaim system will have a fuel inventory capability of no less than 12 hours at full load.

4.5.1.5 Turbine-Generator System

The extraction/condensing steam turbine-generator will have a nameplate rating of 3,000 KW at 0.80 power factor, meaning the generator windings have a capability to produce 3,750 KW at unity power factor. The system is thus designed to supply 3MW to the utility while supplying power to its own auxiliary systems.

The turbine will be a multistage rotor spinning at approximately 8,000 RPM. A gearbox between the turbine and generator will allow the generator to turn at 1,800 RPM. Three phase power will be produced at 4,160 volts, which is a standard generator voltage in this size range. The turbine will be equipped with an integral lube oil system and an electronic governor system.

The turbine will have a dual automatic steam extraction system, with one extraction at 50 psig for outside thermal loads and one extraction at 5 psig for deaerator steam supply. Both extractions are designed to supply saturated steam for process loads.

4.5.1.6 Cooling Water System

Steam exiting the turbine and not needed for process loads will be condensed at 2 inch Hg absolute in a two pass tube and shell condenser alongside the turbine discharge. Condensed steam will be collected in a hotwell and pumped to the deaerator by one of two full capacity condensate pumps. Non-condensable gases will be removed from the condenser with steam jet air ejectors operating off extraction steam.

The heated cooling water will be circulated through the cooling tower by one of two full capacity circulating water pumps. The cooling tower will be a single cell mechanical draft tower with wooden structure, plastic fill and a variable speed fan motor. The tower will be designed to provide about 20°F of cooling to the circulating water. The tower will be equipped with high efficiency drift eliminators to minimize fogging.

4.5.1.7 Electrical Power Equipment

The 4,160 volt output of the generator will be stepped up to 12KV in a 3,500 KVA main transformer located in a small on-site substation. The substation will also contain an oil circuit breaker, air switch, metering equipment and a full relay panel to provide plant and system protection.

Between the generator and main transformer a spur will serve a 500 KVA 4160/480V step down transformer to allow the generator to service its own auxiliary loads during operation, and to allow the utility to serve those loads during outages and startups.

4.5.1.8 Other Plant Equipment

All major equipment will be housed within the metal sided main boiler/turbine building or within a separate water treatment building. There will be a small control room and office within the main building. Plant controls will consist of a PC driven system with proprietary software and a series of programmable controllers.

4.5.1.9 Plant Efficiency & Performance

A heat and material balance was prepared for the unit described above. The key parameters of the output are as follows: Boiler Steam Output – 37,500 pounds per hour; Process Load – 10,000 pounds per hour @ 50psig; Deaerator Load – 5,244 pounds per hour @ 5 psig; Turbine Gross Output – 3,332 KW; Boiler Efficiency – 74 percent; Turbine Efficiency – 82 percent; Makeup Water Requirement – 42 gallons per minute; Wastewater Discharge – 9 gallons per minute; Annual Fuel Requirement – 28,532 BDT per year; Boiler Heat Input – 59.85 MMBTU per hour; and Annual Hours of Operation – 8,200 hours.

The 3,332 KW gross turbine output above allows for 11 percent of the output to be used internally before delivering 3,000 KW to the utility.

The boiler efficiency of 74 percent assumes an annual fuel moisture average of 40 percent, which is typical for woods fuel air dried on the landing before processing. The annual fuel requirement of 28,532 BDT per year is approximately 4,000 BDT per year higher than if there were no thermal customer. The boiler average output of 37,500 pounds per hour leaves an additional 2,500 pound per hour capacity to handle variations in process needs by the thermal customer.

4.5.2 Economic Feasibility Assumptions

For the specific capital equipment and plant performance described above, Beck has developed a capital and operating budget and a complete 20 year financial model. The highlights of the project economics are as follows.

4.5.2.1 Capital Cost

The value of the EPC contract for a complete plant is estimated to be $20,650,000. This amount includes the cost to engineer and construct the facility on a prepared site from the truck receiving area through to the main transformer connecting to the utility.

There are other added capital costs not in the EPC contract shown in **Table 4.7**. Inclusion of the other costs brings the total project cost, including all hard and soft costs, to $24,060,000.

Table 4.7 – Estimated Capital Cost of Other Items Aside from EPC Contract

Cost Item	Estimated Cost ($)
Project management and startup	400,000
Site prep & fencing	250.000
Utility interconnection	500,000
Working capital	500,000
Interest during construction	245,000
Debt issuance cost	425,000
Contingency (5 percent)	1,090,000
Total of Other Costs	**3,410,000**

4.5.2.2 Key Operating Costs

The largest single operating cost will be fuel, which is estimated to be $1,284,000 in the first year. This amount is the product of 28,532 bone dry tons required annually at a cost of $45/BDT delivered.

The next largest expense item is labor, with the total cost for labor and benefits for the staff of 8 being about $900,000 annually.

Property tax is estimated to be $288,000 annually. Maintenance expenses are estimated to be $260,000 annually, with $210,000 being for routine maintenance and $50,000 as reserves towards major maintenance items such as turbine-generator overhauls.

Insurance costs will be $90,000 annually, and the costs for chemicals and supplies for both plant operation and environmental compliance will total $130,000 annually. Utilities (water, sewer, backup electric) are expected total $45,000 annually. Both bottom ash and fly ash are expected to be used in construction or agriculture, so ash disposal costs are less than $20,000 annually.

Total operating cost for the project (including fuel) in the first year of operation is expected to be just over $3,000,000.

4.5.2.3 Project Revenues

The project has been modeled with only two revenue streams – the sale of electricity and thermal energy. No income from carbon credits was assumed.

Electricity is sold under the SB 1122 program to the utility to which the facility is interconnected, eliminating wheeling charges. It is assumed that the project will sell a net of 3 MW to the utility for 8,200 hours annually, equaling a total sale of 24,600 MWH annually. If, for instance, the contract price is $190/MWH, the annual electric revenue would be $4,674,000. Because of SB 1122 rules, it is assumed that the electric price is flat for the duration of the contract.

The project is assumed to sell 10,000 pounds per hour of 50 psig saturated steam for the same 8,200 hours annually. This is sufficient steam to supply drying for a co-located shavings or briquetting operation or perhaps a small sawmill. The revenue from the steam sales is $877,000 in the first year. The steam sales price is assumed to escalate at 2.5 percent annually, which is in line with long term inflation.

The steam sales price in the first year is calculated to be $10.70 per 1,000 pounds of steam sold. That amount was calculated to be equivalent to the cost of natural gas fueled steam generation with a retail gas cost of $8.33/million BTU and an 80 percent gas boiler efficiency, with a small allowance for chemicals and water cost.

4.5.2.4 Financial Analysis

A 20 year financial model was prepared for the project. The model solved for an electric power sales rate that would generate a 12 percent after tax return on all project equity. The key assumptions, beyond those described above, are as follows: All project expenses escalate at 2.5 percent annually; Electric sales price has no inflation for 20 years; The project qualifies for New Market Tax Credit financing, resulting in an interest only, no repayment loan of $3,850,000; Debt/equity ratio of 60/40; Long term debt rate of 3.5 percent for 20 years due to USDA loan guarantee; Total grants from federal and state sources of $1,000,000; MACRS depreciation; 35 percent federal income tax rate; 9 percent state income tax rate.

The above results provided inputs to the financial models developed by FIDO Management. The results indicate that a $190/MWH electric sales rate is required to obtain the targeted 12 percent equity return. The model was also run at higher debt rates up to 7 percent annually, creating a range of required power sales prices of $190-$200/MWH.

As a point of comparison, a similar heat balance and financial model were prepared for a stand-alone small biomass facility with no thermal customer. The changes were that a smaller boiler (35,000 pounds per hour) could be employed, lowering capital cost by some $1.3 million. The stand-alone facility had a fuel requirement of 4,000 BDT per year less than the CHP plant and lower annual costs for property tax, insurance, maintenance and ash disposal. The removal of the second revenue stream from thermal sales meant that the required power selling price was $215/MWH in order to obtain the same equity return, $25/MWH above the price for the plant with thermal sales. With higher debt costs (7 percent), the price would have to rise to $225/MWH. Thus, depending on whether the project is CHP and the assumptions used about debt, BECK estimates a project would require a sales price ranging between $190/MWH and $225/MWH to achieve 12 percent after tax return on all project equity.

4.5.3 Sensitivity Analysis

The following section analyzes the sensitivity of the prototypical Small Scale Biomass plant's annual operating income to a 10 percent plus or minus change in key variables such as the sales realization, raw material costs, and a 20 percent change in the value of thermal sales. **Table 4.8** shows that the business is most heavily impacted by changes in the power sales price. The sensitivity analysis was completed using the FIDO financial model.

Table 4.8 – Small Scale Biomass Plant Sensitivity Analysis

	Stand-Alone	CHP
Sensitivity Scenario	Simple Payback (Years)	Simple Payback (Years)
Base Case	12.1	9.8
Power Sales +10%	9.8	8.5
Power Sales - 10%	15.8	11.8
Fuel Cost + 10%	12.8	10.3
Fuel Cost - 10%	11.4	9.4
Thermal Sales +20%	n/a	9.4
Thermal Sales – 20%	n/a	10.4

4.5.4 Discussion

The SB 1122 program has a starting electric power sales price of $127.72/MWH. If there are no takers at the offered price, the price will escalate within 14 months (4/1/17) to the price identified in the financial analysis ($190/MWH) that would support the project modeled above across the entire interest rate spectrum. If the other projects use the stand-alone model, another 2-4 months of price increases will be necessary.

This result is over $20/MWH lower than that projected by the CPUC's contractor, Black & Veatch, for their medium price 3 MW biomass scenario. This is largely due to the positive impact of the steam sales. In round terms, for an increase in capital cost of $2 million and an annual operating cost increase of less than $200,000, a revenue increase of $877,000 is obtained.

The implementation plan has a mandatory CPUC staff review if/when the price reaches $197/MWH (actually $199.72 on the final schedule). It cannot be speculated what action staff may take or how long it may take to analyze the situation once this price level is reached. It would appear, however, that a well-designed small biomass CHP project can accept a price before or at the time such CPUC review would be triggered.

The CPUC's hired engineering firm calculated that a mid-range price for such projects was $219/MWH in 2013, a level which BECK has been able to verify through work on this project. If the program is allowed to run for 2-3 bimonthly cycles beyond the mandatory review price, it is likely that all projects in the queue will have obtained contracts. BECK is concerned whether there will be the requisite 5 other projects in the queue to keep the price moving upward once a single highly integrated project accepts a contract price.

4.6 SMALL SCALE BIOMASS ORGANIZATIONAL FEASIBILITY

The developer of a small scale biomass project will need to assemble a project team early in the process to assure entry into the SB 1122 process and later project development within the timelines established by the PPA.

The developer should appoint a Project Manager (PM) from within the organization to be the coordinator with all outside entities. This PM will also be responsible for pursuing grant opportunities to cover early development expenses, which are estimated to be between $150,000 and $200,000).

The PM will first select a full-service, experienced biomass consultant to assist with the development process. The consultant should have knowledge of the SB 1122 process, interconnection processes, permitting requirements, fuel requirements, available grants/credits, and the ability to conduct feasibility analyses, etc.

The consultant will first conduct a feasibility study for the PM to determine if it is likely that a successful project can be developed in the chosen location under SB 1122. Given a positive finding, the consultant and PM will make a priority list of long lead time items that will allow access to the SB 1122 queue. This list will contain at least the following:

1. File for an interconnection with the utility
2. File for an air quality permit
3. File for a conditional use permit

4. Assess potential sites and obtain site control of chosen site
5. Identify entity that can assist PM in obtaining project financing
6. Initiate a fuel availability and price survey with a qualified consultant

Completing items on the above list will require the services of specialists in such areas as air quality, environmental assessment and electrical engineering. The consultant can assist the PM in obtaining these services.

Once the project has completed adequate tasks to establish an SB 1122 queue position within the utility, it will be time to turn to contracting for plant installation. BECK advises that since these will be relatively small installations that the Engineer, Procure, Construct (EPC) method of contracting be strongly considered. The EPC method keeps all responsibility for engineering, procurement and actual construction within a single entity, and all project guarantees for completion, environmental compliance and performance are with the same entity. In order to obtain an acceptable EPC contract, it will be necessary for the PM to contract with an engineering firm that will prepare a specification for the potential EPC contractors to bid on.

The PM will also need to obtain the services of a commercial attorney to assist with contracts such as the EPC contract, PPA and fuel contracts.

As the plant nears completion under the EPC contract, the PM will advertise for plant staff that would join the operation in time to assist with plant checkout and startup. As envisioned by BECK, based on their experience, the plant staff would consist of:

- Plant Manager (1) – Experienced in biomass plant operation and responsible for day-to-day operation and maintenance, environmental compliance and fuel procurement.
- Shift Operators (4) – Experienced in power industry and responsible for plant operation on individual shifts. Other plant-wide responsibilities for such items as training, safety, environmental reporting and outage planning would be split among the four operators.
- Fuel Operators (2) – Experienced in heavy equipment operation and responsible for fuel receiving, processing, storage and reclaiming. These two will provide 12 hour per day coverage of fuel deliveries, and fuel reclaim design will include no less than 12 hours of automatic live storage.
- Maintenance Mechanic (1) – An experienced mechanic with both mechanical and electrical skills. Hiring emphasis will be on experience with PC systems and programmable controllers.

The above staffing assumes that the development entity has headquarters staff that can provide banking, payroll, purchasing, accounts receivable, human resources and tax services to the project. If not, a full time controller position should be added to the above staffing.

4.7 SMALL SCALE BIOMASS SUMMARY

4.7.1 Fuel Availability and Cost

For a 3 MW facility, between 25,000 and 30,000 bone dry tons of forest fuel will be required annually, with the range being determined by whether the facility has a thermal customer and the size of that customer. The fuel must come from one of four categories of sustainable forest management activities specified by the California Public Utilities Commission (CPUC) in their implementation of SB 1122. Consequently, fueling a single 3 MW project for a year will require access to the biomass material derived from an estimated 2,000 to 3,000 acres of sustainable forest activity (i.e., thinning). If a co-located business can be developed that would use the small stems from thinning projects instead of treating them as fuel, that annual acreage requirement could rise to 4,000 to 6,000 acres.

The types of forest fuels required by SB 1122 are all expensive to gather, process, and haul. All work must be done with diesel powered equipment at the forest site. BECK has made the assumption that fuel for the projects would be obtained from active thinning/logging operations, so the cost of gathering trees to a central landing can be assigned to the party utilizing the tree stems. With this assumption, BECK estimates an average delivered fuel cost of $45 per bone dry ton, which includes an average haul distance of 30 miles.

The fuels will be mixed forest waste containing tops, limbs, needles and bark. Average moisture content is expected to be 40 percent with a range of 25 – 55 percent. Fuel heating value will average 8,600 BTU per dry pound.

4.7.2 Choice of Technology

BECK analyzed two technology options for application to an SB 1122 project: 1) gasification/internal combustion engine; and 2) direct combustion/steam turbine technology. Despite advantages of gasification in producing other potential high value byproducts, BECK recommends and has modeled the direct combustion/steam turbine technology for this study.

Most of the reasons for this choice revolve around the specific requirements of the SB 1122 program. By necessity, the fuel will be mixed forest waste, which is characterized by wide variations in piece size, moisture content, ash content, species, and heating value. All of these variations can occur within a single truckload of fuel. It has not been demonstrated commercially that gasification technology can produce a consistent gas quality and quantity from fuel with such variations.

The SB 1122 program Power Purchase Agreement (PPA) requires that a biomass project produce 180 percent of its annual contractual commitment every two-year period. Again, there is insufficient evidence that gasification technologies using mixed forest waste can meet such a standard.

Another technology issue involves the inability to obtain "full-wrap" warranties for completion, performance and environmental compliance from a creditworthy entity for emerging gasification technologies. Availability of these warranties is essential in obtaining commercial financing for any SB 1122 project. Conversely, hundreds of biomass projects using direct combustion technology have been constructed and operated using forest waste as a fuel source. They have demonstrated high annual capacity factors over long periods, and several vendors can offer the “full-wrap” types of warranties required.

Note this same evaluation performed 3-5 years in the future may reach a different conclusion about the preferred technology. By that time, perhaps a publicly funded project will have demonstrated the ability to comply with SB 1122 requirements, and California's carbon markets may be placing consistently high values on other biomass byproducts. However, that is not the case in late 2015.

4.7.3 Stand-alone Versus Cogeneration Operation

A 3 MW project can be configured to produce electricity only or a combination of electricity and thermal energy to a co-located business or institution. BECK modeled in detail a CHP project and then contrasted that with the stand-alone project. The key reasons for this choice involve CHP projects having higher overall thermal efficiency, a second revenue stream, enhanced public acceptance, and potentially lower fuel cost.

An extraction/condensing steam turbine generator can discharge exactly the amount and pressure of thermal energy required by the customer at all times while maintaining a consistent 3 MW of electrical sales. Most thermal users use hot water or low pressure steam such that much of the energy in the high pressure boiler steam is converted to electricity prior to being sent to the thermal customer, thus boosting overall efficiency.

Sales of thermal energy typically occur at price levels based on the equivalent energy produced from natural gas. At these levels, the small increase in capital and fuel costs associated with serving a thermal customer are returned several-fold in thermal sales.

It is BECK’s experience that a CHP project is inherently easier to permit than a stand-alone project, which could be a significant advantage in California. The public intuitively embraces the concepts of higher thermal efficiency and displacement of fossil fuel with renewables. The thermal customer also "anchors" the CHP facility in the chosen location by answering the "great idea but why don't you build it elsewhere?" question.

If the thermal customer is a co-located forest products business, lower overall fuel costs are the likely result. Since the two businesses are using the same forest activity, any extra value added to the tree stem by the co-located business means the fuel fraction must carry a lower overall percentage of the cost of forest operations.

4.7.4 Co-Located Businesses

Because of the potential value to the SB 1122 project and since it would ultimately result in more forest acres being treated, BECK completed a high level analysis of seven potential forest products co-located businesses. The businesses were: Small log sawmill; Bagged shavings operation; Post and pole production; Fuel briquette manufacturing; Pellet production; Firewood production; Fuel chip production.

These seven businesses were analyzed on a Return to Log or Return to Fiber basis, whichever was appropriate for the business. The results were that the small log sawmill had the highest return potential, nearly twice that of other businesses. A second tier was occupied by shavings and post and pole operations, with a reasonable return of over $50/BDT. A third tier, with returns in the $35 – $40 per BDT, were briquettes, pellets and firewood. Fuel chips had virtually no return. Most of these technologies could be supported thermally for their drying needs by the prototype plant except for the small log sawmill, which would require a substantially larger boiler. The pellet plant would require hot flue gas from the boiler as well.

4.7.5 Prototype Plant

The prototype plant sells a net of 3 MW to the utility while supplying a co-located thermal customer with 10 million BTU per hour of low pressure process steam. The boiler is a single combustion chamber with a moveable grate and a rating of 40,000 pounds per hour of steam at 600 psig/750 degrees Fahrenheit. Pollution control is provided by: a multi-cone collector and 3 field electrostatic precipitator for particulate control, as well as multiple levels of staged heat overfire air for CO and VOC control, and a Selective Non-Catalytic Removal (SNCR) system for NO_x control.

The turbine-generator has double automatic extractions and is rated at 3,000 KW @ 0.8 power factor, meaning that the generator can produce 3,750 KW at unity power factor. The generator is driven at 1,800 RPM through a gear reduction unit with the turbine rotating at 8,000 RPM. Steam not needed for process is condensed in a two pass surface condenser with cooling water supplied from a single cell wet mechanical draft cooling tower. The 42 gallons per minute of makeup water is treated with sand and charcoal filters and the boiler makeup is further treated in a reverse osmosis unit.

The unit is connected to the utility grid through a 3,500 KVA 4160/12KV step up transformer and a circuit breaker controlled by a bank of utility required relays. All major boiler and turbine equipment is housed in a metal sided building.

The total capital cost of the above plant, including all hard and soft costs, using the EPC method of contracting is $24.06 million. A slightly smaller version (35,000 pound per hour steam) could be constructed for $22.8 million for a 3 MW stand-alone operation.

4.7.6 Financial Analysis

The prototype plant was analyzed to determine a fixed power selling price that would result in a 12 percent after tax equity return over 20 years. As described in earlier report sections, the key assumptions in the analysis were: 60/40 debt to equity ratio; New Market Tax Credit financing resulting in $3,850,000 in lender equity; A total of $1,000,000 in state and federal grant funds; Debt interest rate range of 3.5 – 7 percent annually; 10,000 pound per hour of steam sales at $10.70 per thousand pounds; staff of 8 full time employees; first year fuel cost of $45/BDT; escalation of expenses and steam sales of 2.5 percent annually; escalation of power price of 0 percent annually; 3 MW of power sales for 8,200 hours annually.

The above analysis produced a required power sales price range of $190 – $200/MWH for the range of debt interest rates. A companion stand-alone project with lower capital, fuel and operating costs, but with no thermal energy sales was also analyzed. The result was a required power selling price of $215 – $225/MWH over the same interest rate range.

4.7.7 Conclusions and Recommendations

Based on the preceding results BECK concludes that the full implementation of SB 1122 through the development of small scale biomass heat and power projects is likely the only near term opportunity to feasibly develop small scale biomass projects and, in the process, expand biomass utilization from forest derived fuels in California.

This finding comes at a time when, ironically, low wholesale electric prices and contract expirations are causing the shuttering of numerous larger biomass power facilities, several in forested areas that are at the end of their existing PPA's. However, with only a 50 MW limit, the new facilities will not come close to replacing those being lost in terms of forest biomass processing capability. In other words, California will end up with less markets for the products of forest restoration, despite the success of the SB 1122 program, unless policies are changed to assure the future of the fleet of existing larger biomass power facilities (see policy recommendation in Section 7).

These small projects could not hope to compete economically in the California wholesale power market without a program such as SB 1122. These will be, essentially, community scale projects designed to support local efforts to lower fire risk and restore the local forests to health and vitality. They will be small enough that they will not require guaranteed access to large swaths of federal forests over extended periods, something very difficult for federal land managers to provide.

Although sponsoring groups may have hoped to base their projects on the production of newer biofuels or biochar, it will be the standard production of electricity from biomass that allows a long term assured revenue stream so that financing can be obtained. If California "doubles down" on a long term commitment to greenhouse gas reduction, the facilities can later transition to other uses, but will likely begin life as electric power producers with perhaps small quantities of other byproducts or an onsite thermal user.

The bottom line is that SB 1122 is without a doubt the only contracting vehicle that would lead to a viable small scale biomass heat and/or power project in the foreseeable future. The accepted ReMAT contract price will likely be at least 3 times current wholesale renewable power prices. Even with this price multiplier, it does not appear to BECK that there will be a large number of projects proposed.

Given the preceding analysis and results, BECK concludes that a small scale biomass project developed in accordance with the SB 1122 program specifications would be feasible. BECK suggests that prospective developers carefully consider the following recommendations.

- *Secure Fuel Supply* – it is imperative, for financing purposes, that the facility have contractual access to the required amount of acres on a long-term basis. Lenders consider a 10-year fuel supply arrangement a minimum. This can take the form of an access to logging slash from a private landowner to a long-term stewardship contract with a public entity. Therefore, BECK recommends that potential developers engage the USFS in their region to begin discussions for developing long-term, stewardship type supply contracts. Additionally, BECK recommends that developers engage large, industrial private timberland landowners in similar discussions if such entities are in the supply area of a prospective plant.

- *Fuel Source Verification* – BECK has assumed in this study that the logging slash produced from sustainable forest management activities qualifies as an allowable fuel under the SB 1122 program. BECK recommends that potential SB 1122 project developers verify this interpretation of the program's rules since a different interpretation that would not allow this type of fuel could substantially increase the delivered cost of fuel and, therefore, significantly hamper the feasibility of projects aimed at selling power in the $190 to $220/MWH range.
- *Project Qualification* – Implementation of SB 1122, beginning early in 2016, should provide a solid opportunity for small biomass projects such as the prototype 3 MW project analyzed for this study. Provided there are 3 projects in the utility queue on February 1, 2016, the offered price will begin to ratchet upward. Therefore, BECK urges prospective project developers to quickly qualify projects for the utility queue. The qualification process and cost are described in detail in Section 4.6.
- *Identify Potential Steam Hosts* – when developing a project to compete for a SB 1122 ReMAT contract, the benefits of finding a legitimate steam host so that a CHP project can be proposed are quite substantial – as much as $25/MWH when a suitable steam host is identified. This means that a project with a steam host can accept a price earlier in the ReMAT schedule than would have otherwise been possible and thus start construction ahead of a "power only" project and ahead of an uncertain CPUC price cap review. Therefore, BECK recommends potential project developers seek to partner with entrepreneurs or existing businesses that can provide a CHP aspect to the project.
- *Technology Selection* – BECK concludes that direct combustion technology will allow developers to meet BioMAT power delivery requirements. In BECK's judgment gasification technology when using forest-derived fuels is not reliable enough at this point in time. However, gasification technology could provide additional revenue streams. Therefore, BECK recommends that developers monitor advances in gasification technology.

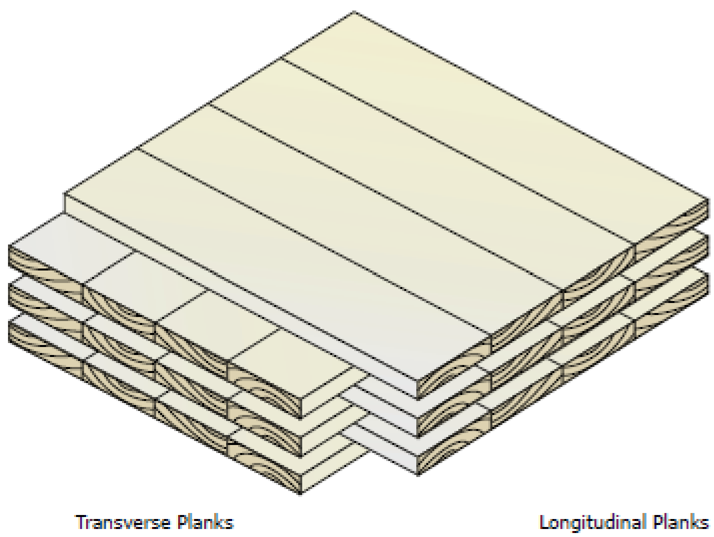
CHAPTER 5 – CROSS LAMINATED TIMBER

5.1 CLT INTRODUCTION

Cross Laminated Timber (CLT) is a structural engineered wood product realizing growing popularity as a construction material substitute for concrete, masonry, and steel. CLT is used in all major structural building parts (floors, interior and exterior walls, and roofs). It has been adopted into the 2015 International Building Code and is currently in the process of being adopted by various local, regional, and state jurisdictions. Once fully adopted, it is anticipated that CLT will be used widely in building construction applications. Another use that has been developed for CLT is as rig and access matting for the oil, gas, forestry, and mining industries.

CLT is made of multiple layers of lumber, with each layer having the wood grain oriented perpendicular to the adjacent layer (**Figure 5.1**). The layers are pressed together with a specialized, non-toxic adhesive. CLT panels used for building construction are commonly 8' to 12' in width, 20' to 60' in length, and 3.5" to 9" in thickness.

Figure 5.1 – CLT Panel Design



Source: FP Innovations

CLT was first commercialized in Europe in the 1990s, and its production in North America is relatively new, with a small number of facilities (the first of which opened in 2011). As of late 2015, only four CLT manufacturers operate in North America, with those being located in British Columbia, Quebec, Montana, and Oregon.

The primary reasons that CLT was selected for assessment in this study is that it is an emerging technology with a large market potential – both locally in California and in the broader region. Because the primary raw material used in CLT production is lumber, its impact on the use of logs (small diameter or otherwise) is indirect. However, it does contribute to maintaining forest products industry infrastructure. An intact forest products industry is a prerequisite to cost effective forest restoration.

5.2 CLT PLANT CONCEPTUAL PLAN

The prospective CLT manufacturing facility is based around a single manufacturing line operating two shifts or 80 hours per week. From this starting point, the plant characteristics will be as follows:

- **Raw Material Supply** – The plant will utilize dimension lumber as its primary raw material. The lumber will most likely be sourced from sawmills located in Northern California. The plant will consume approximately 24 million board feet of dimension lumber annually.
- **Market Region** – Because the North American market for CLT is still in its infancy and there are few existing manufacturers, a plant located in Northern California could potentially serve markets all across the U.S. Relative to existing manufacturers, this plant would have transportation cost advantages to all of California and much of the U.S. Southwest.
- **Plant Equipment** – The potential CLT plant will utilize new, state of the art equipment from reputable manufacturers. Key components, such as the press, are specific to CLT manufacturing and offered by only a few vendors, while other elements, such as the finger jointer and planer and CNC router, are commonly used in other wood products manufacturing facilities and will be more widely available.
- **Plant Capacity** – At two shifts or 80 hours of operation per week, the plant will be capable of producing approximately 1.1 million cubic feet of CLT panels annually.

The balance of this chapter documents BECK's findings with respect to the feasibility of developing a CLT plant in California based on the preceding conceptual design.

5.3 CLT MARKET FEASIBILITY

CLT has been in use for construction applications in Europe since the 1990s, but its use in North America is much more recent – there was no commercial CLT production here until 2011. Therefore, the current North American market for CLT is relatively small but growing and changing rapidly, with several new CLT building projects being announced every month.

5.3.1 CLT Applications in Construction

CLT is most often cost-competitive with other building materials (concrete and steel) used in the structural shell for multi-story applications such as office, multistory residential, and mixed-use buildings. It is not typically cost-competitive with light lumber frame construction applications such as single family homes. While it is sometimes used in single family residential construction and other applications that typically utilize light frame construction, the major uses for CLT likely will be in larger structures.

In some cases, CLT is used for all of the major structural members in a building (floor/ceiling panels, interior and exterior walls, etc.) However, in most North American applications, CLT is used in conjunction with other building materials as part of an integrated building solution. For example, a building might utilize CLT for floor panels and interior walls, but steel framing for exterior walls. Other large buildings may utilize a concrete “core” (stairwells, elevator shafts, etc.), with CLT members in wall and/or floor panels. CLT is often used in conjunction with glue laminated beams. Many different combinations are possible and are being applied in the marketplace.

5.3.2 Typical CLT Products

When used in building construction, CLT panels often fall within the following size parameters:

- Height/width: 8’ to 12’
- Length: 20’ to 40’ or longer (press size and transportation limitations are determining factors)
- Thickness: 3 to 7 layers or 2.25” to 9” (with floor/ceiling panels typically being 5 layers or more in order to provide bending stiffness over long spans)

5.3.3 CLT Advantages

In addition to cost competitiveness in multistory building construction, CLT has unique properties that offer benefits over other building products – especially concrete and steel. Such advantages include:

- **Reduced construction times:** Because CLT panels are prefabricated, on-site construction times can be significantly faster than for traditional building materials. This can lead to cost savings and is advantageous with in-fill construction where there is a desire to minimize disturbance to existing neighborhoods.
- **Excellent strength-to-weight ratio:** Structures made from CLT are much lighter than those made of concrete and steel. This means that an equivalent sized CLT building will require less foundation materials and construction, often leading to significant cost savings. It also means that in areas with soft soil, using CLT can allow for a larger structure than would normally be possible, which can lead to better land utilization and better return on investment for the developer/owner.
- **Good seismic performance:** Because it is much lighter than concrete, buildings made from CLT are much lower in mass and therefore less likely to topple during earthquakes. This will be of significant interest to developers in California.
- **Reduced jobsite labor requirements:** Because CLT panels are prefabricated, on site labor crews are much smaller than when using traditional building materials, which can lead to significant labor cost savings. This is also an important advantage in areas where there are shortages of skilled construction labor or in areas where adverse weather can impact construction.

- **Superior environmental performance:** Because CLT is made of wood it is a renewable resource and sequesters carbon, unlike concrete or steel. Life cycle assessments[9] comparing CLT with concrete and steel construction show that the innovative material outperforms traditional materials in measures of embodied energy, air pollution, and water pollution.
- **Good thermal performance and energy efficiency:** Because of solid wood's high insulation value and the ability to make very tight inter-panel connections, buildings made from CLT are less expensive to heat and cool. A study from the Canadian Wood Council indicates that CLT structures may require just 1/3 of the heating and cooling energy compared to buildings made with traditional building materials and methods.[10]

5.3.4 Building Code Adoption Progress

One key to the continued expansion of CLT markets in North America is the need to have CLT adopted into building codes. Until recently, CLT was not specified in any North American building codes, so any use of CLT in a construction project required the designers and engineers to pursue permitting through "alternative material, design, or method" protocols at the local level. This meant that every building using CLT required the designer to convince permitting agencies that the building system they were proposing was a viable alternative to traditional systems. This typically requires a significant investment of time and expense, with an uncertain outcome. In spite of this, many CLT projects across North America have been approved and constructed.

Once CLT is included in state, provincial, and local building codes, its use is likely to become much more widespread in a variety of applications – especially in multistory buildings. Key milestones in the adoption of CLT into building codes include:

- 2015 – International Building Code (IBC) allows use of CLT in buildings up to 85 feet in height (no more than 6 stories, or 5 stories for a residential building). Note that this is expected to lead to local, state, and regional jurisdictions accepting the use of CLT panels over the next 2-3 years.
- 2015 – The State of Oregon and City of Seattle (WA) have already adopted the 2015 IBC updates, including relevant CLT provisions, into their building codes.
- 2016 – The State of California is in the process of including the 2015 IBC updates into state building codes, with adoption likely in late 2016.

One key consideration is that in order to qualify for use under these building codes, the CLT panels need to be manufactured according to internationally recognized standards, such as the APA standards outlined in Section 5.4.5 of this report.

[9] Life cycle assessment studies evaluate the total environmental impact from raw material extraction all the way through construction and the end of presumed useful life

[10] http://www.woodworks.org/wp-content/uploads/CLT-Solid-Advantages.pdf: pg.4

Future possibilities for code adoption include the use of CLT in even taller buildings. Provisions are being proposed for CLT to be allowed in buildings taller than 85'/six stories for the 2018 IBC updates. These provisions have been challenged on the basis of fire safety questions, with opposition efforts being led by concrete industry groups. CLT has performed well in fire safety tests completed so far, but additional testing will be required, and CLT's performance will need to be communicated effectively to building code officials and the general public in order to overcome this opposition.

5.3.5 CLT Market Size Estimates

Because CLT is a relatively new product in the marketplace with no North American trade associations, data on CLT-specific markets (historical, current, or forecasted) is very limited. BECK interviewed several of the individuals who are most knowledgeable about CLT utilization in North America (including staff from FP Innovations, WoodWorks, and Oregon State University), and none could provide estimates of current or historical volumes used or dollars spent on CLT.

FP Innovations did develop overall estimates of total potential U.S. markets for CLT as part of the CLT Handbook. Their methodology is outlined below, but complete details can be found in Chapter 1 of the Handbook[11].

FP Innovations Market Potential Estimate Methodology

- Evaluated cost competitiveness of CLT construction with traditional building products for a variety of different building types (excluding single family residential).
- Based on actual U.S. construction activity for each building type, estimated total CLT demand assuming CLT was used in every instance where it was considered cost-competitive (volume quantified in terms of thousands of board feet of lumber feedstock utilized). This provided the total potential market, though 100 percent market penetration is unlikely.
- Estimated total CLT demand based on 5 percent and 15 percent market penetration.
- Note that building codes were essentially not considered in estimating market potential. See details related to progress on building code adoption for CLT in Section 5.3.4 of this report.

[11] http://www.rethinkwood.com/masstimber/products/cross-laminated-timber-clt/handbook

Table 5.1 illustrates the total potential CLT consumption for U.S. construction markets and the total demand volume assuming market penetration of 5 percent and 15 percent.

Table 5.1 – CLT Market Potential

	Volumes (thousand board feet)								
	Total Volume			5 percent Scenario			15 percent Scenario		
# Floors:	1-4	5-10	Total	1-4	5-10	Total	1-4	5-10	Total
Apartments	2,075,353	807,351	2,882,704	103,768	40,368	144,136	311,303	121,103	432,406
Commercial	7,130,609	235,318	7,365,927	356,530	11,766	368,296	1,069,591	35,298	1,104,889
Industrial	1,205,566	987	1,206,553	60,278	49	60,327	180,835	148	180,983
Institutional	5,762,991	126,732	5,889,723	288,150	6,337	294,487	864,449	19,010	883,459
Miscellaneous	821,803	248	822,051	41,090	12	41,102	123,270	37	123,307
Total	**16,996,321**	**1,170,636**	**18,166,957**	**849,816**	**58,532**	**908,348**	**2,549,448**	**175,596**	**2,725,044**

Source: FP Innovations CLT Handbook, Chapter 1

As **Table 5.1** illustrates, the market potential for CLT amounts to 0.9 billion and 2.7 billion board feet for the 5 percent and 15 percent market penetration scenarios, respectively. Note that Canadian markets are not included in the above estimates and would likely add another 1-2 billion to the Total Volume (equivalent to approximately 5-10 percent of U.S. market).

At 24 million board feet of lumber consumption, the planned prospective facility will represent only 2.6 percent of the market potential for the 5 percent scenario and less than 1 percent of the market potential for the 15 percent scenario.

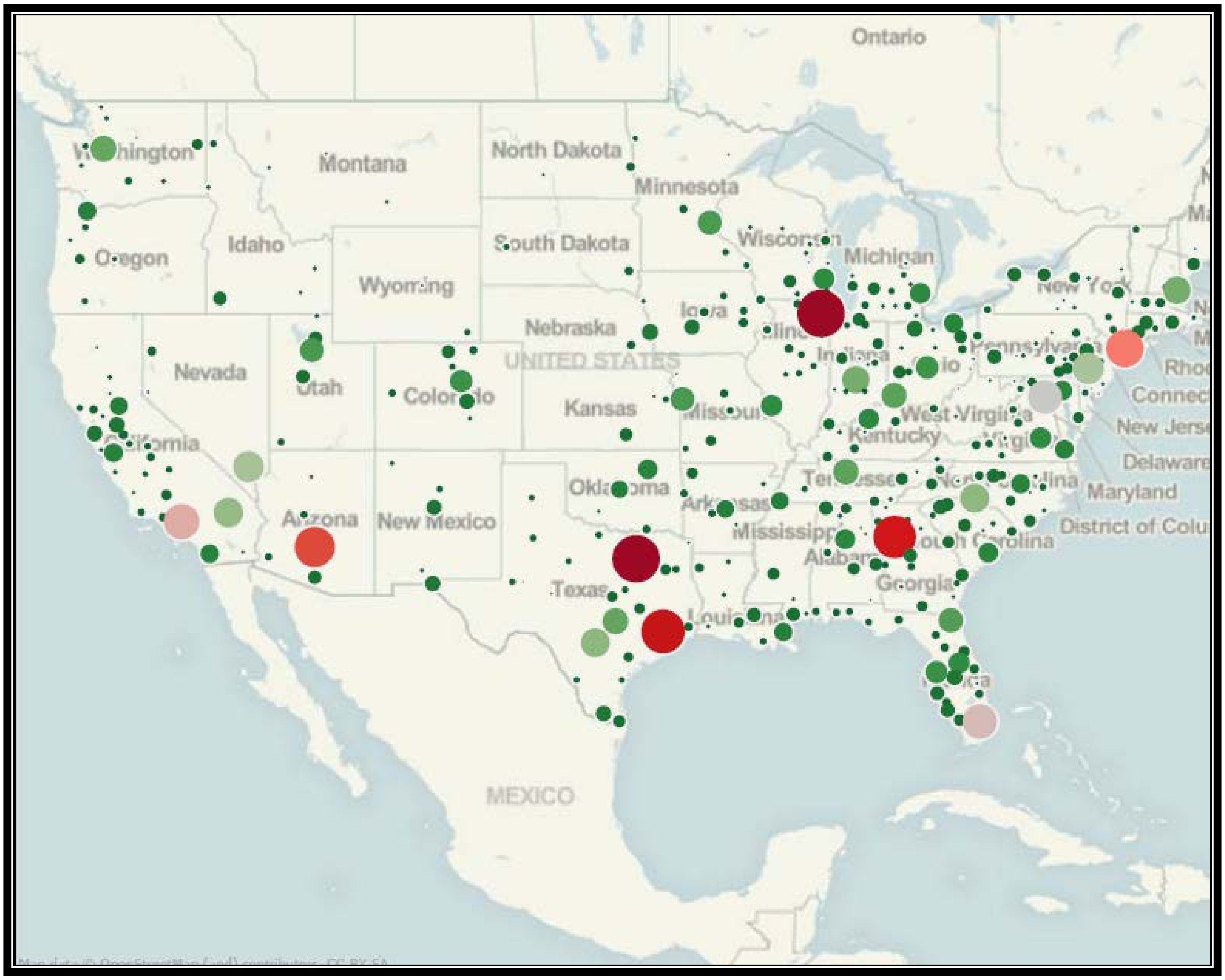
Although it is unclear how long it will take to reach even 5 percent penetration of the total potential market, it appears likely that North American construction markets will eventually be able to support numerous plants similar in scale to the prospective facility.

For reference, historical North American softwood lumber production capacity has been approximately 60 billion board feet. Therefore, even at the higher levels of market penetration for CLT, the increased demand for lumber would be a relatively small part of total lumber production capacity.

5.3.6 Location of Key Markets

The following map (**Figure 5.2)** shows the location of key markets for construction rated CLT products. Because CLT construction is most likely to displace other building materials in multistory building applications, much of the potential market is in urban areas.

Figure 5.2 – Key U.S. Construction Markets for CLT



Source: FP Innovations – circle size corresponds to estimated market size

A CLT plant located in Northern California would have a transportation cost advantage relative to other existing North American CLT manufacturers when shipping panels to numerous key market areas in Central and Southern California, and other Southwestern states.

5.3.7 CLT as Part of a Building System

Because CLT is a new product to many architects and engineers, CLT manufacturers need to be proactive in educating potential customers about the benefits, uses, and potential applications of CLT. Manufacturers are able to draw upon the work of organizations (such as WoodWorks) that have developed educational materials for architects, engineers and designers. In contrast to producers of other building products such as lumber or steel studs, CLT producers do not produce commodity products that flow into a supply chain involving wholesalers and retailers. Instead, CLT producers work directly with customers to develop custom fit solutions for individual building projects. Therefore, CLT manufacturers need to have design and engineering staff available to work with customers. These staff will need to:

- Understand large scale construction projects so that they will be able to work with architects and engineers to resolve design problems, identify potential cost savings that could result from CLT use, and look for ways to make CLT use more attractive in a variety of applications.
- Have a strong understanding of the design properties (especially strength properties) of different configurations of CLT panels in order to identify the best solution for a particular application.
- Know how CLT will work in combination with other building materials, including glue-laminated timber, heavy timber frame, steel, and concrete.

In addition to the CLT panels and design services, CLT manufacturers supply accessories, such as fasteners and connection systems, to its customers. They may also choose to act as a supplier for complementary building products such as glue laminated beams, creating a “one stop shop” for CLT-based building systems.

5.3.8 Market Related Risks

There are two primary risks related to the developing markets for construction-rated CLT in North America. The first risk is that markets will not expand quickly enough to support expanding CLT manufacturing capacity. The second risk is that CLT manufacturers from Europe will continue exporting to North America, suppressing market prices for CLT.

5.3.8.1 Over-production Risk

While North American CLT demand is expanding rapidly, with new CLT building project announcements appearing in the news nearly every week, capacity is expanding as well. As previously stated, the prospective California facility would add approximately 1.1 million cubic feet of capacity. This compares to the existing construction panel capacity of approximately 6 to 7 million cubic feet of North American capacity. Other CLT plants may be in the planning stages as well.

5.3.8.2 Import Risk

One recent trend witnessed in North American lumber markets is the expansion of European lumber being imported to the Atlantic coast region. A strong U.S. dollar relative to the Euro and relatively low shipping costs have made U.S. markets increasingly attractive to the Europeans. Related to this, BECK has heard that KLH, one of the largest CLT manufacturers in Europe, has been beating North American CLT producers with lower cost bids to provide CLT for North American building projects. While European producers will have the greatest advantage along the Atlantic coast (due to land-based transportation costs), the entire CLT market is impacted to some degree. As long as the U.S. dollar remains strong and ocean freight rates remain low, North American CLT producers will likely face competition from overseas CLT producers.

5.3.9 CLT Pricing

There is no publicly available data for market pricing of CLT products. BECK's assumptions on panel pricing are based on a 2011 cost plus margin analysis developed by FP Innovations. The FP Innovations analysis is available in Chapter 1 of the CLT Handbook.[12] For the purposes of this report BECK assumed an f.o.b. mill price of $21 per cubic foot (except where noted).

5.4 CLT TECHNICAL FEASIBILITY

The following section provides an assessment of the technical feasibility of the planned CLT plant in terms of the manufacturing process, equipment, plant site requirements, product specifications, and raw material requirements.

5.4.1 History of CLT Production

CLT is a relatively new engineered wood product first introduced to European builders in the early 1990s. It has gradually gained acceptance and momentum as an innovative building product in both residential and non-residential applications and has been gaining popularity in North American markets in recent years. Global production of CLT has grown from zero in 1990 to approximately 35 million cubic feet in 2015. For reference, the prospective California facility would produce approximately 1.1 million cubic feet of CLT per year at full capacity and would be considered a medium sized facility relative to other CLT plants.

5.4.2 CLT Manufacturing Process

Although CLT is an innovative product, the major steps in the manufacturing process utilize well-established technologies borrowed from other segments of the wood products manufacturing industry. The basic processing steps include: inspecting lumber feedstock, cutting out major defects, and finger-jointing; lumber surfacing; panel lay-up, gluing, and pressing; edge trimming and cutout of desired openings, such as windows; surface machining; and packaging.

5.4.3 Processing Equipment

The following is a listing of the key equipment items required for producing CLT panels.

- **Moisture meter –** Tests the moisture content of each piece of lumber, ensuring that any lumber not meeting the target range (12 percent +/- 3 percent) is rejected.
- **Crosscut saw #1 –** Cuts out short sections of incoming lumber that contain unacceptable levels of defect (rot, splits, wane, etc.)
- **Finger-Jointer –** Cuts finger joints in the ends of each piece of lumber, applies glue to each joint, and presses the pieces together making one continuous piece of lumber.

[12] http://www.rethinkwood.com/masstimber/products/cross-laminated-timber-clt/handbook

- **Crosscut saw #2 –** Cuts the finger-jointed lumber to lengths appropriate to the final product size of the CLT panel (e.g., 8’ to 12’ long for the cross layers and 30’ to 60’ long for the adjoining layers).
- **Planer –** Removes a thin layer of wood from the surface of the lumber in order to “activate” it for reaction with the polyurethane glue and to ensure all pieces are uniform thickness. This step must be completed less than 48 hours prior to applying the glue.
- **Layup machine –** Arranges pieces of lumber into layers according to the target CLT panel design. Glue is also applied to each layer at this machine.
- **Press –** Uses hydraulic pressure on face and sides to hold panel in place as glue cures. Press time varies based on glue formulation and panel layup time.
- **Computer Numerically Controlled (CNC) machine –** Uses saws and router heads to very precisely trim the edges of each panel and cut openings in the panel as desired (for doors, windows, service channels, etc.)
- **Sanding machine –** Puts a smooth finish on the surface of the panel.

All of the machines listed are either borrowed directly from other segments of the wood products manufacturing industry (finger-jointer, planer, crosscut saw) or are variations on existing machine types that have been modified for the specific requirements of CLT production (press, layup machine, CNC machine). Therefore, the technologies employed should be considered well-established and do not pose a significant risk in terms of technical feasibility.

5.4.4 CLT Manufacturing Site Considerations

No specific site has been identified for the prospective CLT plant. BECK assumed that it will be located somewhere in Northern California. If the CLT plant were located adjacent to an existing large scale sawmill, the operation would enjoy certain advantages such as the elimination of lumber transportation costs. However, a plant located separately is certainly feasible. Logical locations include on or near key transportation corridors such as I-5 and Class I railroads.

- **Land Requirements** – the prospective CLT manufacturing plant (capacity of 1.1 million cubic feet per year on a two shift basis) will require a site of approximately 10 to 15 acres depending on the site layout.
- **Building Requirements** – the CLT plant will require approximately 50,000 to 60,000 square feet of enclosed building space (industrial or warehouse-style) for the manufacturing line and a limited amount of storage for in-process inventory. BECK has assumed that incoming lumber and finished CLT panels will be packaged sufficiently to protect against the elements and will be stored outside.
- **Transportation** – as the majority of CLT panels are likely to be shipped by truck, access to major highways will be important. While rail access is not essential, having the ability to ship via rail could prove to be an advantage relative to other CLT producers, especially once the market is more completely developed and CLT manufacturing is more widely distributed across North America.

- **Utilities** – the CLT manufacturing plant will require an industrial (three phase) power supply. The process requires only minimal water (i.e., for cleanup tasks and employee hygiene). Natural gas supply may be desirable for heating employee workspace or offices, but is not essential.
- **CLT Panel Standards** – APA[13] has created a set of technical standards for the materials and methods used in the manufacture of CLT panels (known as ANSI/APA PRG-320). Because architects and engineers rely on the design values (i.e., strength properties, etc.) associated with the ANSI/APA PRG-320 standards, any company producing CLT for use in North American building construction will need to be certified by APA or a similar organization and participate in ongoing testing and quality control programs.

5.4.5 Lumber Specifications

According to ANSI/APA PRG-320 specifications, lumber used in the production of CLT needs to meet the following basic criteria:

- Minimum thickness of 5/8 inch and maximum thickness of 2 inches.
- Minimum width of 3.5 times its thickness in the panel's minor strength direction, and 1.75 times its thickness in the major strength direction.
- Must be derived from a softwood lumber species recognized by the American Lumber Standards Committee (or its Canadian equivalent), with a minimum specific gravity of 0.35.
- If visually graded lumber is used, the minimum lumber grade in the parallel direction is #2. In the perpendicular direction, the minimum grade is #3. Machine Stress Rated (MSR) lumber with a minimum strength rating of 1200f can also be used.
- Moisture content at the time of manufacturing must be 12 percent +/- 3 percent.
- Face bonding surfaces must be free of defects (such as torn grain, skip, thickness variation, etc.) that interfere with glue bonds.

The most likely feedstock for a Northern Californian CLT plant would be #2 and #3 grade 2”x6” and 2”x8” lumber made of Douglas Fir-Larch and White Fir species (white fir, grand fir, hemlock, etc.), meeting or exceeding all of the above size, grade, and species requirements. Inline moisture meters will ensure that moisture content of all lumber feedstock is in the appropriate range. All incoming lumber will be visually inspected for defects and face bonding surface variations. In summary, the plant's planned lumber feedstock will meet all ANSI/APA PRG-320 standards for construction rated CLT.

[13] Formerly The American Plywood Association, this non-profit trade association maintained its commonly known acronym (APA), but has now been rebranded as The Engineered Wood Association in acknowledgement of the broadening array of engineered wood products it represents.

As there is an abundant supply of Ponderosa pine timber in Northern California but only limited markets for the logs, there may be a case for processing pine logs specifically for lumber to be used in CLT. At present, most Ponderosa pine lumber produced in the region is graded for appearance properties, not structural properties, and therefore would not qualify under PRG-320 standards. Therefore, a CLT producer would have to work with supplier sawmills to have special production runs of Ponderosa pine specifically targeted for the CLT plant. This appears to be technically feasible but it is unclear whether it would be practically and economically viable.

5.4.6 Adhesives

BECK assumed that the prospective plant will use *Purbond* brand polyurethane glue for lamination – the same type of glue used by other North American (and European) CLT manufacturers. This glue does meet ANSI/APA PRG-320 adhesive specifications for CLT. It is the same adhesive type utilized by producers of glue laminated beams, so it has been in use for many years and its properties are well known and understood.

One advantage of polyurethane glue is that it is free of formaldehyde and solvents.

5.4.7 Panel Dimensions

In order to meet ANSI/APA PRG-320 standards, finished CLT panels must meet the following criteria:

- Panel thickness shall not exceed 20 inches.
- Panel dimensions shall not vary by more than the following:
    - ♦ +/- 1/16” in thickness (or 2 percent, whichever is greater)
    - ♦ +/- 1/8” in width
    - ♦ +/- 1/4” in length
- Straightness of the panel shall not deviate more than 1/16” inch, and squareness shall not vary by more than 1/8” measured across the diagonal.

5.4.8 Panel Testing

ANSI/APA PRG-320 standards also require strength testing of sample panels for each type/grade of construction rated panel that will be produced. Sample panels will be tested by the certifying agency for shear strength, bending stiffness, bending moment, and interlaminar shear capacity.

5.4.9 Raw Material Supply and Cost

At full capacity, the prospective CLT facility will consume approximately 24 million board feet of dimension lumber annually. Polyurethane glue will be used for panel layup and in finger joints.

5.4.9.1 Lumber Supply

5.4.9.1.1 Lumber Specifications

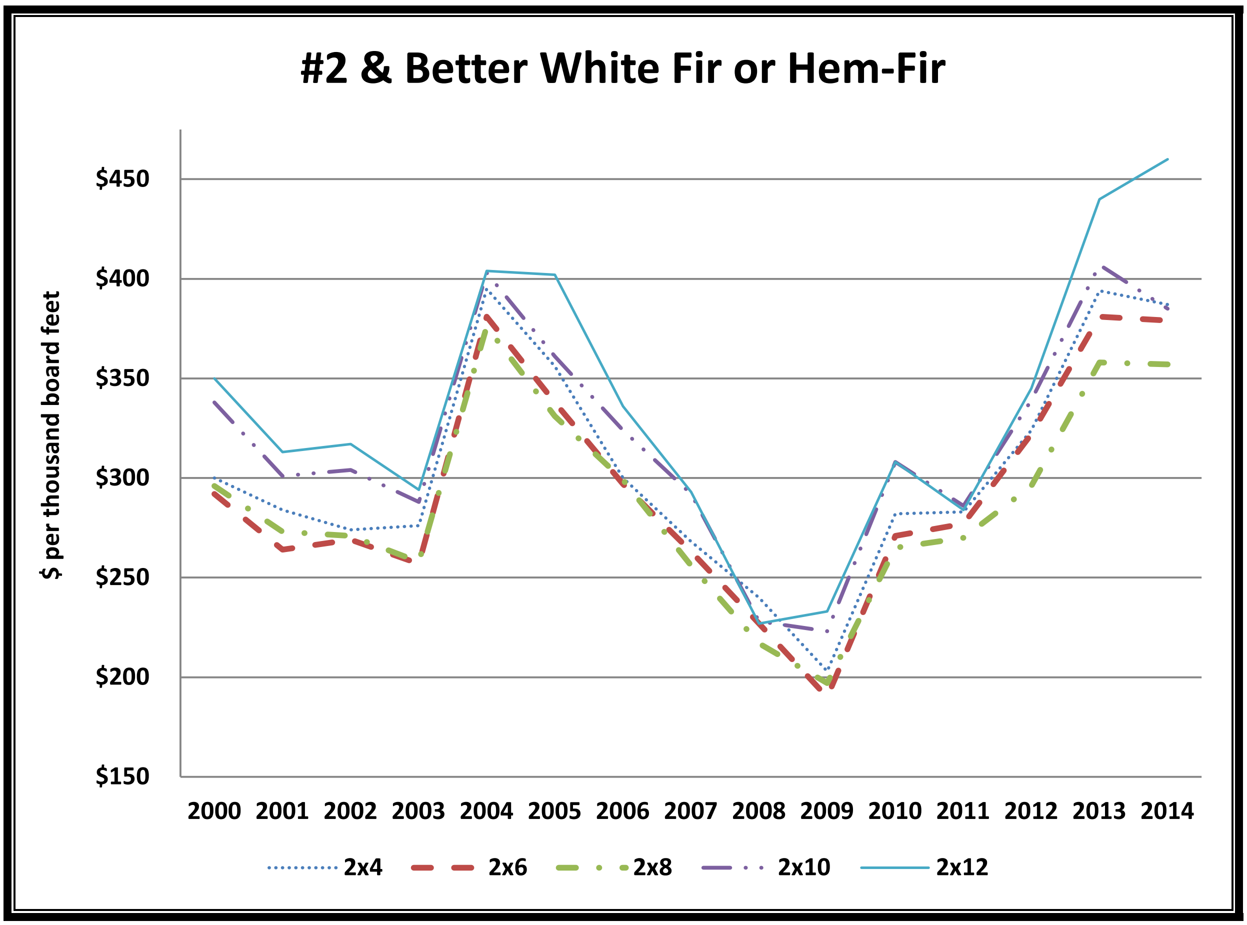
ANSI/APA PRG-320 standards for construction rated CLT would allow the use of:

- 2”x6”, 2”x8”, 2”x10”, or 2”x12” lumber (2”x4” for some parts of each panel). 1” thick lumber is also allowable if graded for structural use.
- #2 grade dimension (or better) in the parallel direction, and #3 grade dimension (or better) in the perpendicular direction.
- A variety of softwood species. The most abundantly available species graded for structural use in Northern California include Douglas Fir-Larch, White Fir, and Hem-Fir.

5.4.9.1.2 Lumber Pricing

Figure 5.3 illustrates the price of White Fir dimension lumber in the Northern California region from 2000 to 2014.

Figure 5.3 – Northern California Lumber Prices



As the chart illustrates, 2"x8" is typically the least expensive size of lumber and therefore will be the most desirable feedstock. 2"x6" is the next-lowest cost during most periods and is more abundantly available, so will also be an attractive choice for the CLT plant. 2"x4" is more expensive than 2"x6" or 2"x8" and is not allowed in some parts of CLT panels (unless the pieces are edge-glued – requiring an additional manufacturing step and additional costs). The small piece size of 2"x4" could also lead to lower productivity and higher unit manufacturing costs. 2"x10" and 2x12" are both more expensive and less abundantly available, so are therefore less likely to be suitable feedstocks for the prospective CLT plant

As **Figure 5.3** illustrates, lumber prices are quite volatile and can change dramatically over the course of a market cycle. The CLT plant will need to change panel pricing to account for changes in its raw material supply or price panels at a level that provides adequate financial returns even in high lumber markets.

Table 5.2 illustrates long term average lumber prices for key Northern Californian lumber products.

Table 5.2 – Dimension Lumber Prices - #2&Better, 2000-2014 Average
($ per thousand board feet)

	2x4	2x6	2x8	2x10	2x12
N. California Inland White Fir	$304	**$294**	**$288**	$319	$334
Inland Douglas Fir & Larch	$338	**$341**	**$329**	$367	$387

While White Fir lumber prices are substantially lower than those for Douglas Fir, CLT customers will likely show a preference for Douglas Fir because of its superior strength characteristics. For purposes of this feasibility study, **BECK has assumed that the average delivered price of lumber will be $330 per thousand board feet, plus a drying premium of $25 per thousand board feet.**

5.4.9.1.3 Moisture Content

One important specification for lumber to be used as feedstock for producing CLT is the moisture content. ANSI/APA PRG-320 standards for construction CLT products require a moisture content (MC) of 12 percent (+/- 3 percent) at the time of manufacturing. This specification also matches the requirements of the polyurethane glue used in the manufacturing process. Because dimension lumber is typically dried to a target MC of 19 percent, the plant will either need to have kiln drying capabilities or purchase lumber already dried to 12 percent MC by the supplying sawmill. The company should be able to purchase #2 lumber dried to 12 percent MC for a premium over standard pricing (BECK has estimated the premium at $25 per thousand board feet). This would be a favorable alternative because drying lumber on site will require more labor and equipment costs, substantial capital investment, additional site acreage, and air emissions permits.

5.4.9.1.4 Regional Lumber Supplies

BECK has assumed the CLT plant will be located in Northern California. The region is a significant producer of softwood lumber products and is home to numerous sawmills. **Table 5.3** Table lists major producers of softwood dimension lumber located in Northern California. In addition to those listed, there are numerous other sawmills in the region that produce lesser volumes of dimension lumber. As previously discussed, the company will likely focus on 2”x6” and 2”x8” sized lumber graded #2 and #3. Starting with total production, BECK has estimated the amount of these lumber products available annually from the mills listed.

Table 5.3 – Major Dimension Lumber Producers in Northern California

Company	City	Annual Volume*
Sierra Pacific Industries	Sonora (Standard)	
Collins Pine	Chester	
Sierra Forest Products	Terra Bella	
Sierra Pacific Industries	Anderson	
Sierra Pacific Industries	Burney	
Sierra Pacific Industries	Lincoln	
Sierra Pacific Industries	Quincy	
Sierra Pacific Industries	Shasta Lake	
Trinity River Lumber	Weaverville	
Total		**1,487,000**
% that is #2 grade		40%
% that is #3 grade		5%
% that is 2x6		30%
% that is 2x8		10%
Total #2 - 2x6 and 2x8		237,920
Total #3 - 2x6 and 2x8		29,740

* Thousands of board feet

As **Table 5.3** illustrates, the total annual production among regional sawmills is nearly 1.5 billion board feet. Key lumber feedstock items needed to produce CLT make up well over 250 million board feet of annual production or more than 10 times the requirements of the planned facility. As discussed above, this table lists only the largest producers of dimension lumber. If other regional producers were included, the total regional supply would be even higher and expanding candidate feedstock to include other appropriate sizes, species, or grades would result in even more available lumber. **In BECK’s opinion, the local supply of lumber appropriate for use at a Northern Californian CLT production facility is more than adequate.**

5.4.9.2 Glue Supply

BECK has assumed that the prospective plant will source polyurethane glue from Henkel – a large multinational company that produces a wide variety of products ranging from soaps and detergents to adhesives. Purbond is the brand of polyurethane glue used by all the current North American CLT producers (and many of those in Europe). There seems to be little risk associated with being able to source the required glue.

5.4.10 Environmental Issues and Permitting

If the prospective CLT plant sources lumber dried to 12 percent moisture content (as assumed throughout this report), it will not need a boiler or lumber drying kilns so there will be no requirement for an Air Quality Permit. The rest of the manufacturing process should not produce significant emissions requiring any special environmental permits.

5.5 CLT ECONOMIC FEASIBILITY

5.5.1 Capital Cost Estimate

BECK reviewed installed capital costs for existing CLT manufacturers and detailed equipment cost estimates for key CLT process machinery. A budgetary capital cost estimate was developed for the prospective CLT plant with the following assumptions:

- A single manufacturing line capable of producing 1.1 million cubic feet of CLT panels on a two shift basis and consisting of the following basic steps:
    - Lumber inspection and defect removal
    - Lumber finger jointing and cut-to-length
    - Lumber planing (surfacing)
    - Layup, gluing, and pressing
    - Sizing and surfacing
- A building of approximately 50,000 to 60,000 square feet to house the manufacturing line and in-process inventory storage.
- A manufacturing site of approximately 12 acres.
- No boiler or lumber drying kilns.

Based on these assumptions, the total estimated capital cost is **$16.7 million,** including $14 million for buildings, installed equipment, and rolling stock, $1.2 million for land, and $1.5 million for “soft” costs such as engineering, permitting, and project management.

5.5.2 Raw Material Costs

5.5.2.1 Lumber Costs

BECK estimated the average delivered lumber price (for material dried to 12 percent MC) at $355 per thousand board feet. After accounting for surfacing and process losses, this translates to approximately $7.85 per cubic foot of finished CLT panel. Additional discussion of lumber prices can be found in Section 5.4.6.1.2.

5.5.2.2 Glue Costs

Based on information from other CLT producers, BECK has estimated the cost of Purbond glue at $1.60 per cubic foot of CLT. This includes the glue required for finger-jointing as well as that applied to each layer of lumber in the CLT panel.

5.5.3 Operating Costs

The following section discusses the manufacturing cost assumptions used in BECK's assessment of financial feasibility for the prospective plant.

5.5.3.1 Labor

As described in Section 4.2, the prospective plant will employ approximately 41 employees.

Table 5.4 – CLT "IN-PLANT" STAFFING

Position	Number of Employees
Management and Supervision	2
Product Design and Engineering	2
Machine Operators	13
General Labor	5
Maintenance	6
Total	**28**

The average wage rate for production and maintenance employees (supervision and designers excluded) is $18 per hour plus 52 percent fringe loading and 5 percent overtime.

5.5.3.2 Electricity

Electrical costs are based on an analysis of the estimated connected horsepower (with assumed utilization rates) at the plant and local power costs. The total electricity cost is estimated at $0.40 per cubic foot of CLT production.

5.5.3.3 Other Variable Costs

BECK estimated other variable operating costs for the operation:

- Operating supplies - $120 per hour
- Repair and maintenance - $85 per hour

5.5.3.4 Salaries for Management and Administration

Salaries for Management and Administration the prospective plant are estimated at $800,000 per year and include:

- 1- Plant manager
- 2 – Production supervisors
- 1 – Design lead
- 1 – Designer
- 1 – Sales representative
- 1 – Accountant
- 1 - Clerk

5.5.3.5 Sales, General, and Administrative

Administrative and overhead costs considered include:

- Miscellaneous office expenses
- Business insurance
- Professional fees
- Marketing, travel, and meals
- Subscriptions, dues, and fees
- Panel certification and testing
- Staff training

5.5.4 CLT Financial Analysis Results

Table 5.5 illustrates the financial performance of the prospective CLT plant using the “Base Case” assumptions described in the preceding sections of the report. The financial performance of the plant is expected to be very attractive, yielding a cash flow of more than 35 percent of sales.

Table 5.5 – Pro Forma Income Statement for Prospective CLT Plant

	$(000)	Volume (FT3)	$/FT3
Panel Sales	23,100	1,100,000	21.00
Raw Materials			
Wood	8,588	1,100,000	7.81
Glue	1,760	1,100,000	1.60
Subtotal	**10,390**	**1,100,000**	**9.41**
Manufacturing Costs			
Hourly labor	1,412	1,100,000	1.28
Operating supplies	724	1,100,000	0.66
Repair & Maintenance	357	1,100,000	0.32
Utilities	440	1,100,000	0.40
Salaries for M&A	800	1,100,000	0.73
Sales, General & Admin	400	1,100,000	0.36
Subtotal	**4,133**	**1,100,000**	**3.76**
Operating Cash Flow	**8,619**	**1,100,000**	**7.84**

It is important to note that only operating cash flow has been evaluated, meaning that depreciation, interest expense, and corporate income taxes have not been considered. Assuming a construction duration of one year, the expected payback period is 3.3 years.

5.5.5 Sensitivity Analysis

The following section explores the prospective CLT plant's operating cash flow when various changes in key assumptions, such as CLT sales value, lumber price, and operating performance, are introduced. **Table 5.6** shows that the business is most heavily impacted by the total volume produced, but that sales value and lumber costs also have significant impacts on the operation's cash flow. A brief description of the assumptions used in each scenario follows the summary table.

Table 5.6 – CLT Plant Sensitivity Analysis Summary

Scenario	Annual Sales		Annual Costs $ (000)		Annual Cash Flow $ (000)	Payback Period (year)
	Volume (million ft3)	$ (000)	Lumber	Glue & Manufacturing		
Base Case	1.1	23,100	8,588	5,893	8,619	3.3
Higher CLT Price	1.1	25,300	8,588	5,893	10,819	2.7
Lower CLT Price	1.1	20,900	8,588	5,893	6,419	3.9
Peak Lumber Price	1.1	23,100	11,249	5,893	5,958	4.1
Single Shift	0.6	11,550	4,294	3,664	3,592	5.9
+10% Productivity	1.2	25,410	9,447	6,135	9,828	3.0
-10% Productivity	1.0	21,000	7,807	5,673	7,520	3.5

5.5.5.1 Sensitivity Analysis Scenario Descriptions

Base Case – This is the same scenario detailed in the Pro Forma Income Statement shown in **Table 5.6**, with assumptions described in the preceding paragraphs.

Higher CLT Price – This scenario assumes that CLT panels can be sold for $23 per cubic foot rather than $21 per cubic foot. (A change of approximately 10 percent)

Lower CLT Price - This scenario assumes that CLT panels can be sold for only $19 per cubic foot rather than $21 per cubic foot. (A change of approximately 10 percent)

Peak Lumber Price – This scenario assumes that the lumber used as raw materials for the CLT panels is priced similar to 2004, the historical peak of the market. At a delivered price of $440 per thousand board feet, the lumber price is more than 30 percent higher than the long term average value of $330 per thousand board feet considered in the base case. In both the base case and Peak Lumber Price scenarios, the same $25 per thousand board foot specialty drying charge was held constant.

Single Shift – This scenario assumes that the prospective CLT plant would operate only a single shift per week with hourly staffing of 14 workers (compared with 24 hourly staff in the Base Case). This would be a reasonable alternative if CLT markets have not expanded quickly enough to accommodate the plant's full capacity at the time of plant startup. While this scenario is less attractive than the base case, it still provides significant positive cash flow.

+10 percent Productivity – This scenario assumes that the plant produces 10 percent more CLT per hour than assumed in the Base Case, leading to increased product sales with some increase in variable costs.

-10 percent Productivity – This scenario assumes that the plant produces 10 percent less CLT per hour than assumed in the Base Case, leading to reduced product sales but also somewhat lower variable costs.

5.6 CLT ORGANIZATIONAL AND MANAGERIAL FEASIBILITY

Because no specific entrepreneur or investor has been identified for the prospective CLT plant it is not possible to evaluate a planned management team. Instead, BECK has developed a list of needed skillsets and staffing requirements for the prospective plant.

Management staff – The plant will require a plant manager capable of overseeing production and quality control with an hourly staff of approximately 24 people.

Maintenance staff – BECK has estimated that a maintenance staff of six will be required for ongoing maintenance and repairs at the prospective CLT plant, including both millwrights and electricians. Assuming the plant uses state of the art machinery, the maintenance staff will need to be skilled in the repair and maintenance of sophisticated equipment, including automated processes requiring knowledge of process logic control (PLC) systems. Based on BECK's experience with other wood products businesses, attracting qualified personnel for these positions may prove to be a challenge.

Design and engineering staff – As discussed in Section 5.3.7, CLT manufacturing is not a commodity production business. As part of its offerings, the company will need to work with customers to clarify their needs and develop practical and cost effective building solutions for their specific applications.

Table 5.7 illustrates the estimated staffing requirements of the prospective CLT plant.

Table 5.7 – CLT "In-Plant" Staffing

Position	Number of Employees
Management and Supervision	2
Product Design and Engineering	2
Machine Operators	13
General Labor	5
Maintenance	6
Total	**28**

5.7 CLT SUMMARY

BECK assessed the feasibility of developing a cross laminated timber (CLT) plant in Northern California. The plant considered would be capable of producing 1.1 million cubic feet of CLT panels annually assuming a single manufacturing line operating two shifts (80 hours) per week. The following sections describe the key findings associated with BECK's feasibility assessment.

5.7.1 Raw Material Supply and Cost

The primary raw material for CLT is structural (dimension) lumber, and a plant will consume 24 million board feet annually (when operated at capacity). While other sizes and species could potentially be used, the primary lumber supply will be Douglas Fir and White Fir, 2"x6" and 2"x8" material.

BECK identified several sawmills in Northern California that produce primarily dimension lumber, with a total annual production of nearly 1.5 billion board feet. Of that amount, more than 260 million board feet is estimated to be the appropriate size, grade, and species, so the prospective CLT plant would require less than 10% of the regional supply.

Based on long term historical lumber prices, BECK has assumed that the average delivered price of lumber will be $330 per thousand board feet. Most dimension lumber is kiln-dried to a moisture content of 19%. CLT requires lumber dried to 12% moisture, so BECK assumed that the prospective plant would pay lumber suppliers a premium of $25 per thousand board feet to provide lumber dried to this lower moisture level.

5.7.2 CLT Markets

CLT is an innovative building material that has been in commercial production in Europe since the 1990s and in North America for less than five years. It is therefore in its infancy in terms of market development.

North American markets are relatively small but expanding rapidly, with the greatest potential in large multistory buildings where it replaces concrete and steel building systems. Key advantages for CLT relative to concrete and steel construction include:

- Reduced construction time
- Excellent strength-to-weight ratio
- Good seismic performance
- Reduced jobsite labor requirements
- Good thermal performance and energy efficiency
- Superior environmental performance

Because CLT is a relatively new product, adoption into building codes is a work in progress. The 2015 International Building Code allows use of CLT in buildings up to 85 feet in height. State and local authorities are expected to incorporate this standard over the next 2-3 years. Future possibilities for code adoption include CLT use in even taller buildings.

Determining the total historical or current market for CLT is difficult because there are not yet any North American trade associations to track its production and sale. FP Innovations developed estimates of future U.S. market potential, projecting the equivalent of between 0.9 billion and 2.7 billion board feet for 5% and 15% market penetration respectively for large multistory buildings, including apartments, commercial, industrial, and institutional categories. While the prospective CLT plant would supply only a tiny fraction of this volume, it is unclear how long it will take for this market to reach its potential. With four existing North American CLT suppliers (in Quebec, British Columbia, Montana, and Oregon) and more likely in the planning stages, it is possible that the market could become oversupplied in the short term.

Unlike many wood products, CLT panels are not generally sold as commodity products, but custom designed products for specific applications. Specifiers and users of CLT are looking for a complete building system solution, so CLT producers need to have design and engineering staff, and complementary building products available. There is no publicly available pricing information for CLT products. Based on a cost-plus-margin analysis performed by FP Innovations, BECK has assumed an average market price of $21 per cubic foot.

5.7.3 CLT Economic Feasibility

BECK assessed the economic feasibility of the CLT plant with the following key assumptions:

- Capital cost: $16.7 million
- Annual production: 1.1 million cubic feet
- Annual lumber consumption: 24 million board feet
- Delivered lumber price (including custom drying): $355 per thousand board feet
- CLT average panel sales price: $21 per cubic foot

With these assumptions, the total estimated cash cost (lumber, glue, manufacturing) is $13.17 per cubic foot, resulting in an operating cash flow of $7.84 per cubic foot, or $8.6 million per year. Assuming a 12-month construction period and 100 percent equity investment, the simple payback period is 3.3 years.

Evaluating this business on the basis of payback period or operating margin as a percentage of sales, CLT is by far the most attractive technology analyzed by BECK.

5.7.4 Conclusions and Recommendations

Based on these results, CLT appears to be the most attractive of the four major businesses evaluated as part of the CAWBIOM project. Recommended next steps for planning and continued analysis include:

- *Confirm CLT Market Sales Values* – in any business the sales price of the finished product is a critical aspect of feasibility. In this case, it is difficult to precisely estimate the price since there are no existing U.S. CLT manufacturers. However, the sales price can be calculated by learning the price of CLT delivered to recently completed projects in North America. The sales price at the prospective California plant could then be calculated by subtracting the cost of delivery. BECK recommends additional analysis of finished product pricing through a combination of surveys of developers of recently completed CLT projects and analysis of typical concrete and steel project construction costs, which would allow estimation of CLT sales price when it is priced relative to the cost of competing materials rather than relative to competing CLT manufacturer's pricing. .

- *Raw Material Supply* – BECK has completed a high level analysis suggesting that ample supply of lumber is available among Northern California dimension lumber producers to support the fiber needs of the prototypical CLT plant considered in this study. Additional research and analysis is suggested to: 1) verify the availability of supply; and 2) discuss whether the lumber producers have existing supply commitments that would constrain the ability of those firms to supply lumber to CLT manufacturers.
- *Validate the Lumber Drying Premium* – BECK has assumed that existing sawmills would be able and willing to supply lumber that meets the moisture content specifications of CLT manufacturing. The assumption is largely based on BECK's experience and knowledge of lumber manufacturing and drying costs and the judgment that lumber producers are always looking for new lumber markets. These assumption, however, need verification through additional research and discussion with existing lumber producers in the region.
- *Assess the Impact of Foreign Currency Exchange Rates on CLT Pricing* – a very recent trend among lumber manufacturers is that the increase in the strength of the dollar relative to other currencies such as the Euro allows manufacturers in other countries to supply lumber to the U.S. market at prices that are very difficult for U.S. manufacturers to compete. Research is needed to see if the same is true among CLT manufacturers, especially since most of the existing manufacturers are in Euro Zone countries such as Austria and Germany.
- *Building Code Adoption* – the adoption of CLT into building codes in California (including state and major municipalities) and other Southwestern states is evolving rapidly. BECK recommends that prospective CLT developers monitor this situation closely.

CHAPTER 6 – VENEER

6.1 VENEER INTRODUCTION

Veneer consists of thin (usually 1/10” to 1/6”) sheets of wood fiber that are peeled from logs and used in a variety of composite wood products. In the U.S. West, most veneer is peeled from softwood logs using a rotary lathe system and is used to produce plywood panels or laminated veneer lumber (LVL).

Veneer production is well established across the U.S. West and in California, which is home to two softwood veneer production facilities. A major reason it was selected for assessment in the CAWBIOM study is that it is a product with a proven track record and strong demand outlook.

6.2 VENEER FACILITY CONCEPTUAL PLAN

Initially BECK considered assessment of a business that would not only produce green (i.e., undried) veneer, but would also include veneer drying and the ability to produce a finished product such as plywood or LVL. However, after interviewing industry contacts, a decision was made to eliminate the “dry end” of the process and produce only green veneer. The advantages of this approach include:

- There is significant demand for green veneer in regional markets.
- Green veneer production results in much fewer air emissions, leading to less permitting and air quality issues (and associated costs).
- By eliminating the drying, layup, and pressing processes, capital investment requirements are much lower (thereby reducing investment risk).

One of the existing veneer peeling facilities in California is a “green end only” plant, while the other has drying and grading on site, but no layup for plywood or LVL. Product from these facilities is shipped to Southern Oregon.

The prospective plant will consist of a log debarking and bucking system, steam vats (for conditioning veneer blocks before peeling), a rotary lathe system, a veneer clipping system, and a green veneer sorting line. Annual capacity when operating two shifts (80 hours per week) will be approximately 170 million square feet (3/8” basis). At this scale, the operation will consume approximately 50 million board feet of logs.

The balance of this chapter documents BECK’s findings with respect to the feasibility of Veneer Manufacturing in California based on the preceding conceptual design.

6.3 VENEER MARKET FEASIBILITY

The following report sections examine markets available to a prospective green veneer producer located in Northern California. Because there are no major users of softwood veneer in California, BECK examined markets in Southern Oregon – the closest major veneer market.

6.3.1 Softwood Veneer Uses

The primary uses for softwood veneer in the Western U.S. are plywood and LVL production. LVL is an engineered structural product that has specific strength specifications. Therefore, only veneer meeting certain specifications is accepted as raw material for LVL production.

In order to determine whether veneer is acceptable for use in LVL production, it must first be dried, then passed through a non-destructive testing machine. On average, only about 20-30 percent of veneer produced meets the specifications for LVL production – the rest is used in plywood production. Douglas Fir typically yields greater percentages of LVL quality veneer than other species, so green (un-dried and un-tested) Douglas Fir veneer commands a higher market price than White Wood veneer (as illustrated in Section 6.3.5).

6.3.2 Veneer Demand in Southern Oregon

Southern Oregon is home to several major users of softwood veneer, including both plywood and LVL producers. **Table 6.1** shows the major facilities with their product type, location, and annual estimated production volume expressed in millions of square feet.

Table 6.1 – Southern Oregon Veneer Users

Type	Company	Location	MMSF*
Plywood	Boise Cascade	Medford	450
	Murphy	Rogue River	120
	Roseburg	Riddle	400
	Roseburg	Coquille	325
	Roseburg	Dillard	100
	Roseburg #2	Dillard	250
	Swanson	Glendale	180
	Pacific Wood Laminates	Brookings	145
	Columbia Forest Products	Klamath Falls	120
	Timber Products	Medford	130
	Timber Products	Grants Pass	80
LVL	Boise Cascade	White City	258
	Roseburg	Riddle	258
	Murphy	Sutherlin	221
Total			**3,036**

* MMSF = million square feet, 3/8" basis. LVL figures based on conversion of 36.9 square feet per cubic foot

As **Table 6.1** illustrates, the total production of veneer based products amounts to approximately 3 billion square feet (3/8” basis) per year.

The mid-term outlook for both plywood and LVL demand is good, with LVL demand poised to grow substantially. Several of the facilities listed in **Table 6.1** have unutilized production capacity, so it is likely that Southern Oregon veneer demand will be even higher over the course of the next market cycle.

6.3.3 Veneer Supply in Southern Oregon

The region is also home to major veneer producers. While significant volumes of veneer are produced and used at the same facility (e.g., Roseburg at Riddle, Boise Cascade at White City), there also are some facilities that are user-only or producer-only (e.g., Nordic Veneer). As **Table 6.2** illustrates, the estimated annual softwood veneer production in Southern Oregon is approximately 2 billion square feet (3/8” basis).

Table 6.2 – Southern Oregon Veneer Producers

Company	Location	MMSF*
Boise Cascade	White City	450
Murphy Plywood	White City	250
Roseburg Forest Products	Riddle	400
	Coquille	250
Nordic Veneer	Roseburg	280
Swanson	Glendale	200
Pacific Wood Laminates	Brookings	145
Columbia Forest Products	Klamath Falls	60
Subtotal		**2,035**

* MMSF = million square feet, 3/8" basis.

6.3.4 Southern Oregon Veneer Market Balance

With estimated annual veneer demand of 3 billion square feet (3/8” basis) and production of approximately 2 billion square feet, there appears to be an overall deficit of approximately 1 billion square feet. This deficit must be supplied from outside of Southern Oregon.

6.3.4.1 California Veneer Production

There are two veneer production facilities in Northern California. Between the Roseburg Forest Products facility in Weed and the Timber Products facility in Yreka, total annual veneer production in California is approximately 500 million square feet (3/8” basis).

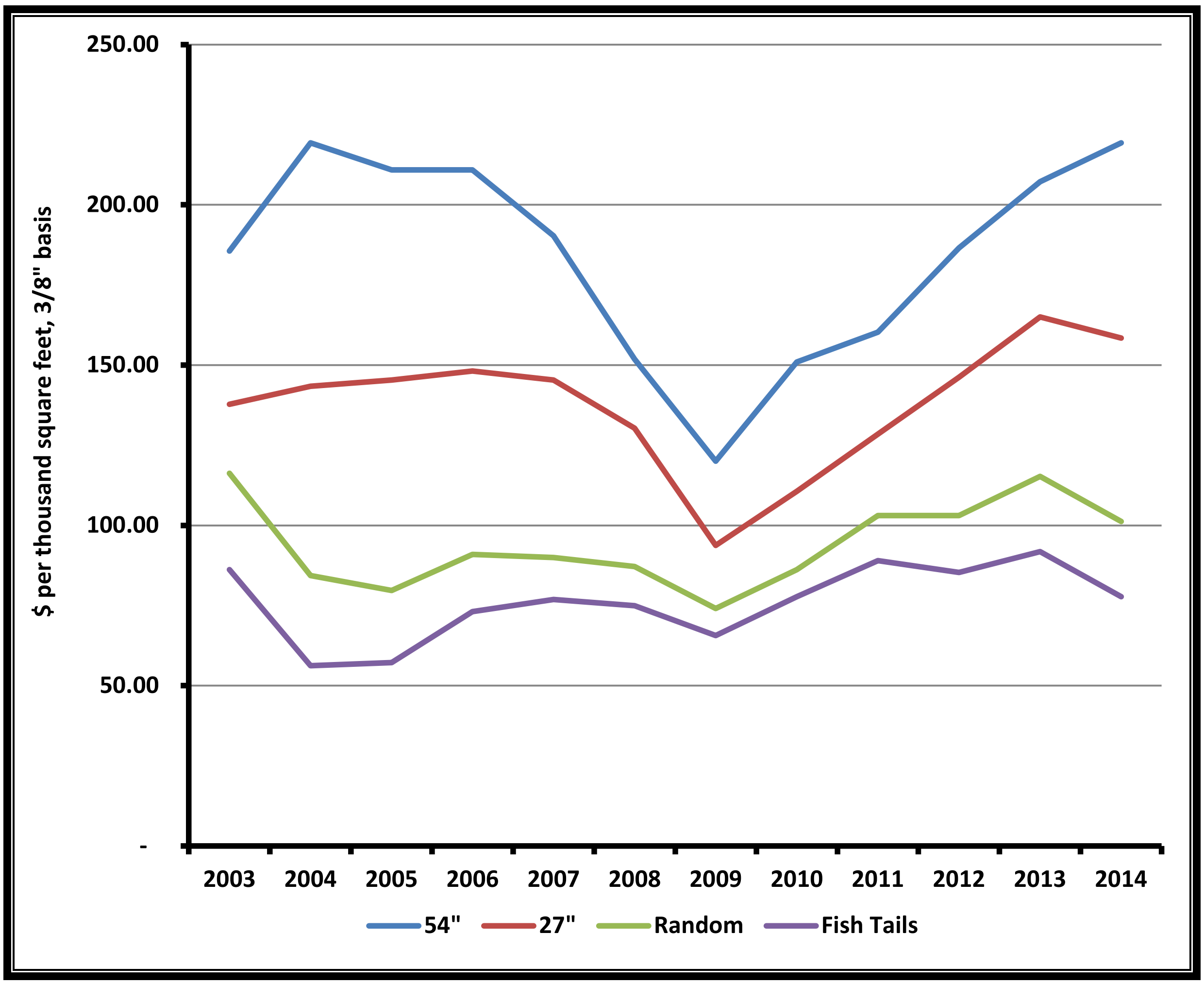
6.3.4.2 Other Veneer "Imports" to Southern Oregon

With a 1 billion square foot deficit and approximately 500 million square feet coming from California, another 500 million square feet of softwood veneer must be brought in from other regions. With veneer supply and demand roughly in balance in the northern half of Oregon, the majority of the additional volume is brought from more distant locations in Washington State and British Columbia.

6.3.5 Veneer Prices

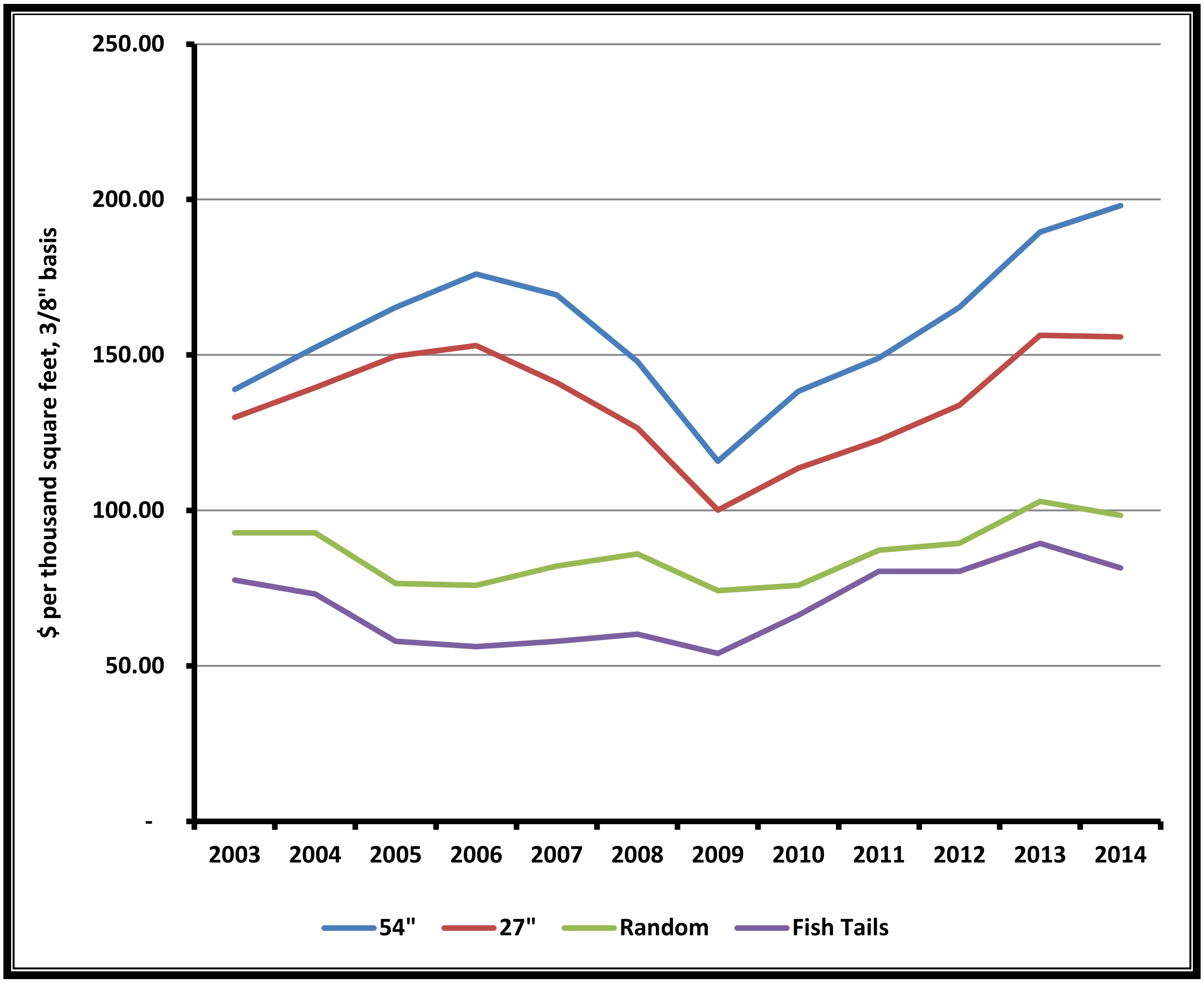
Figure 6.1 and **Figure 6.2** illustrate market prices over time for common Douglas Fir and White Wood veneer products in the West. White Woods include Hemlock, White Fir, and similar species.

Figure 6.1 -- Veneer Prices - Green Douglas fir 1/10"



Source: Random Lengths

Figure 6.2 -- Veneer Prices - White Woods 1/6"



Source: Random Lengths

As the figures illustrate, veneer prices can be volatile, with wider products showing greater volatility.

The mix of 54", 27", Random and Fish Tails produced at each mill varies – primarily depending on log size (diameter) and quality. For purposes of this report, BECK assumed the proportions of 75 percent for 54", 10 percent for 27", 10 percent for Random, and 5 percent for Fish Tails, except where otherwise noted.

6.3.6 Veneer Market Summary

A new veneer producer located in Northern California would have transportation cost advantages relative to producers from Washington and British Columbia and should be able to out-compete distant producers when servicing veneer buyers in Southern Oregon. With a total current estimated "import" level of 500 million square feet (3/8" basis) annually, the available market is more than adequate to absorb the prospective facility's annual production of 170 million square feet. With a positive outlook for both plywood and LVL, the veneer deficit in the region is likely to climb even higher.

While some of the veneer currently being imported from Washington and British Columbia is sold in dried and graded form, interviews with veneer industry representatives indicate that there is adequate veneer drying capacity in Southern Oregon to absorb substantially more than 170 million square feet, so displacing some of the dry veneer imports with green veneer from a new facility should not be a problem.

For purposes of this report, BECK has assumed average veneer sales values of $185 per thousand square feet (3/8” basis) for Douglas Fir and $170 per thousand square feet (3/8” basis) for White Woods.

Industry contacts have noted that the current markets for Fish Tails (the lowest value veneer product) are on the verge of being over-supplied, and the addition of a new veneer peeling plant would make the problem worse. Further investigation into this market, and possible alternative uses for Fish Tails is recommended to anyone considering development of a new veneer plant.

6.4 VENEER TECHNICAL FEASBILITY

The following sections address the technical feasibility of a green veneer plant, including a description of the manufacturing process, site considerations, concerns, raw material supply, etc.

6.4.1 Veneer Manufacturing Process

Wood veneer manufacturing is a well-established industry, with history in the U.S. dating back to the mid-20th century. While technological advancements have brought improvements allowing for higher productivity, improved volumetric recovery, and utilization of a wider variety of log types (especially smaller diameter logs), the basic manufacturing process is largely the same as it was fifty years ago. The prospective veneer plant described below is typical of existing facilities across the West; the technology is well proven.

- **Log yard –** At the log receiving and storage yard, logs will be delivered by trucks in lengths of 8 foot multiples and unloaded using wheel loaders. The most common length delivered to veneer operations is 33 feet (allowing for four blocks, each eight feet in length, plus an allowance for “trim” on each block). Log volume is measured (“scaled”) by rolling the logs out on the ground and recording length and diameter. After scaling, logs are placed into storage. Because of California’s short logging season (typically consisting of only 6 months of “full” logging production with intermittent operations during the rest of the year, the facility will need to have adequate storage space for several months’ worth of logs.
- **Log processing –** Long logs are cut to length or “bucked” into 8 foot long “blocks”, bark is removed using a ring debarker, and the blocks are placed into steam vats for several

hours. Steam conditioning the debarked blocks softens the wood fibers, leading to improved veneer quality, reduced splitting, etc. when the blocks are peeled.

- **Peeling –** After steam conditioning, blocks are peeled using a rotary lathe. Modern lathes include computer optimized scanning and positioning systems that help orient the block in three dimensions in order to maximize the volume recovery of veneer. Because blocks are not perfect cylinders, the outer layer of each log produces uneven strips of veneer known as "fish tails" which have some value but are not worth nearly as much as full length pieces of veneer. Each block is peeled down to a predetermined diameter – typically 3" to 4", leaving a "peeler core". Peeler cores also have some market value and are often sold to pressure treaters and used as fence posts or in landscaping applications.
- **Clipping –** As the logs are turned at the lathe, a continuous ribbon of veneer is presented to the clipper. Modern veneer clippers use computer optimized scanning systems to identify defects (large knots, splits, etc.) and clip those sections out. Based on the amount of defect-free veneer the clipper optimizer detects, the clipper makes the following veneer products:
  - ♦ **54's –** Full width sheets of veneer are 54 inches in width, enough to make a four foot wide plywood panel with trim allowance at the edges.
  - ♦ **27's –** Half width sheets of veneer are 27 inches in width.
  - ♦ **Strip –** When defect-free sections are not large enough to make 54's or 27's, the clipper makes a piece as large as possible while removing defects as necessary. Because these strips have varying widths, they are also referred to as "randoms".
- **Sorting –** Following the optimized clipper, veneer is sorted and stacked according to size. In modern sorting operations, 54's and 27's are typically stacked using an automated machine, while strip and fish tails are stacked by hand.
- **Shipping –** Stacked veneer is loaded for transport – typically onto flatbed semi-trucks.

6.4.2 Veneer Plant Site Considerations

No specific plant site has been identified. The prospective green veneer operation will require the following:

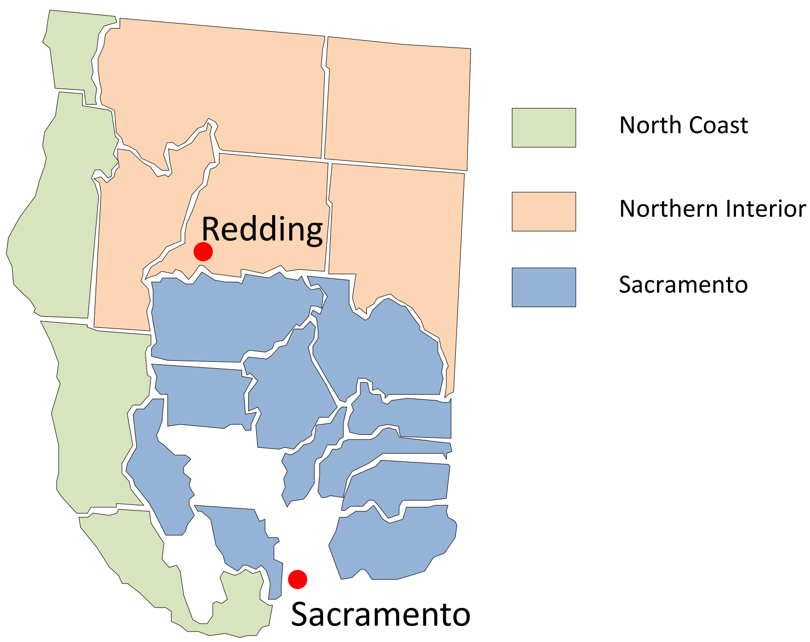
- At least 20 acres of industrial land for manufacturing and log storage.
- Good access for log and veneer trucks, and connection to major highways. A rail spur for loading and unloading rail cars is not essential, but would likely be of benefit. If the plant is located in the Coastal region, access to rail services is unlikely.
- Industrial (3 phase) power supply.
- Water supply sufficient for providing steam to block conditioning vats.
- If a natural gas boiler is used to generate steam for block conditioning, natural gas supply will be required. A natural gas boiler will be lower capital cost and will be easier

to permit for air emissions than a wood fired boiler, but will likely mean higher operating costs.

6.4.3 Raw Material Supply

In the process of analyzing potential log supply for a veneer manufacturing operation, MB&G evaluated the supply and demand balance of timber grown in three major regions of Northern California: The North Coast, North Interior, and Sacramento. These regions are illustrated in **Figure 6.3**

Figure 6.3 – Timber Supply Regions Examined



As shown in **Table 6.3**, MB&G's timber supply analysis of each region reveals significant surplus growth on National Forest land in all three of the regions examined. On private lands, the North Interior and Sacramento regions show only modest surplus growth, while the North Coast region shows a significant surplus.

Table 6.3 – Regional Timber Harvest vs. Growth

	Harvest (MMBF/YR)			Net Growth (MMBF/YR)			Surplus (MMBF/YR)		
	Nat'l Forest	Private	Sum	Nat'l Forest	Private	Sum	Nat'l Forest	Private	Sum
North Interior	60	459	520	1,008	523	1,531	948	64	1,012
North Coast	2	319	321	263	649	912	261	329	590
Sacramento	69	287	356	997	355	1,352	928	68	996
Sum	**131**	**1,065**	**1,196**	**2,268**	**1,527**	**3,795**	**2,137**	**461**	**2,598**

Although there is significant surplus growth on National Forest lands in all three regions, U.S. Forest Service timber harvest levels are not necessarily tied to timber demand and market conditions. Therefore, no additional harvest of merchantable timber is assumed from National Forest lands for purposes of this study.

While total annual log demand for the prospective veneer plant is approximately 50 MMBF per year and the North Interior and Sacramento regions show surplus growth of 64 and 68 MMBF respectively, BECK does not consider supply in either of these regions adequate for supplying a new veneer plant for two primary reasons. First, it is not generally advisable to assume that 100 percent of the surplus growth would be consistently available for harvest. Second, MB&G have advised that only about half of the timber in each of these regions falls into the species groups targeted for veneer manufacturing (Douglas Fir and/or White Woods). Significant proportions of the timber in these regions is Ponderosa Pine, Sugar Pine, and other species. It is possible to peel some of these species for veneer, but markets will be more limited, and yields of high grade LVL veneer would be very limited, meaning that sales value for the veneer would be lower.

This leaves the North Coast region as the area most likely to be suitable for veneer production. Even after considering that this region also has a high proportion of timber species not ideal for veneer production (more than 40 percent of all timber on private lands is Redwood), Douglas Fir is the most abundant species in the area. It appears feasible to procure 50 million board feet of Douglas Fir and White Wood logs for the prospective veneer plant from this region.

The Base Case economic feasibility analysis outlined in this report assumes that logs will be sourced from the North Coast region, with approximately 75 percent of the supply being Douglas Fir and 25 percent being White Wood species.

From the perspective of the U.S. Forest Service and National Forest Foundation, the down side of locating a veneer manufacturing facility in the North Coast region is that this is a relatively low fire danger region and a much lower priority area in terms of forest ecosystem restoration measures for National Forest lands. Therefore, BECK also examined the feasibility of locating a veneer plant in the North Interior region, assuming that a proportion of the timber supply for the plant would be in the form of small diameter timber from National Forest land forest health projects. That scenario would potentially help to increase the “pace and scale” of National Forest restoration initiatives and is examined in Section 6.5.6.3.

For a more complete review of the timber supply and demand analysis completed by MB&G, see **Appendix 2**.

6.4.4 Raw Material Cost

Table 6.4 illustrates timber prices in the North Coast region. Note that the prices listed are for stumpage values (i.e., as standing in the forest) based on California State Board of Equalization values for each time period. Logging and hauling costs are added at the bottom of the table to arrive at the price of logs delivered to the veneer plant.

Table 6.4 – California North Coast Log Prices - $/MBF

Species	Douglas Fir	Hem/Fir[14]
Size Class	**3**	**N/A**
January-June 2012	240	220
July-December 2012	220	180
January-June 2013	220	140
July-December 2013	250	180
January-June 2014	280	220
July-December 2014	350	240
January-June 2015	320	200
Period Average	**269**	**197**
Log and Haul	175	175
Total Delivered	**444**	**372**

For the Base Case scenario analyzed in Section 6.5.4, a mix of 75 percent Douglas Fir and 25 percent White Woods (Hem/Fir) is assumed, resulting in an average delivered log cost of $425 per thousand board feet.

Table 6.5 illustrates timber prices in the North Interior region of California. These log prices are used in the alternative scenario described in Section 6.5.6. Note that the prices listed are for stumpage values (i.e., value of trees standing on the stump) based on California State Board of Equalization values for each time period. Logging and hauling costs are added at the bottom of the table to arrive at the price of logs delivered to the veneer plant.

[14] The Hem/Fir species group is defined by California State Board of Equalization as including western hemlock, mountain hemlock, white fir, red fir, grand fir, spruce, and Shasta red fir

Table 6.5 – California North Interior Log Prices - $/MBF

Species **Size Class**	**Douglas Fir** **3**	**Hem/Fir[15]** **N/A**
January-June 2012	240	170
July-December 2012	250	170
January-June 2013	250	130
July-December 2013	300	170
January-June 2014	310	180
July-December 2014	350	200
January-June 2015	330	190
Period Average	**290**	**173**
Log and Haul	175	175
Total Delivered	**465**	**348**

For the North Interior scenario analyzed in Section 6.5.6, delivered prices of $465 per MBF for Douglas Fir and $348 per MBF for White Woods (Hem/Fir) are assumed for “average” logs. For small logs from National Forest restoration projects, lower delivered prices were assumed.

6.4.5 North Coast Logistical Challenges

As previously described, the North Coast is the region most feasible for locating the prospective green veneer plant from a raw material perspective. This area does pose some logistical challenges related to shipping veneer to buyers in Southern Oregon.

The area does not have a major rail line operating, meaning shipping veneer via rail car will not be possible. Additionally, trucking routes to key customers are limited. Most of the major veneer buyers in Southern Oregon are located near the Interstate 5 corridor, meaning that trucks will most likely cross from the coastal area to Interstate 5 via Highway 199.

Also, because much of the coastal area is relatively low in population density and existing truck traffic is limited, it may be difficult to find adequate an adequate supply of trucking contractors. One way to mitigate this problem would be for the veneer plant operation to own and operate some of its own trucks.

6.5 <u>VENEER ECONOMIC FEASIBILITY</u>

6.5.1 Capital Cost

The estimated capital cost for the prospective green veneer manufacturing plant is $30 million. This total includes approximately $25 million for equipment and buildings, $2 million for a 20 acre site, and $3 million for “soft costs” such as planning, engineering, permitting, and project management.

6.5.2 Operating Costs

The following section discusses the manufacturing cost assumptions used in BECK's assessment of financial feasibility for the prospective green veneer plant.

6.5.2.1 Labor

The prospective plant will employ approximately 14 salaried workers and 48 hourly employees. **Table 6.6** illustrates the staffing levels anticipated in each operating department.

Table 6.6 – Green Veneer Plant Staffing

Department	Staffing Level
Log Yard	4
Log Processing	4
Green End	26
Boiler	4
Shipping	2
Maintenance	8
Hourly Subtotal	**48**
Management/ Supervision	4
Sales	2
Administrative	8
Management Subtotal	**14**
Grand Total	**62**

BECK has assumed an average hourly wage of $19 per hour plus 50 percent fringe loading. The annual loaded labor cost for 14 salaried workers is estimated at $1.19 million.

6.5.2.2 Variable Manufacturing Costs

BECK has assumed the following operating costs:

- Operating supplies: $8.11 per thousand square feet
- Utilities (electricity, water): $6.02 per thousand square feet
- Maintenance: $4.33 per thousand square feet

6.5.2.3 Fixed Manufacturing Costs

BECK has assumed the following fixed overhead costs:

- General and Administrative (excluding salaries): $900,000 per year
- Sales (excluding salaries): $100,000 per year
- Other fixed costs: $300,000 per year

6.5.3 Product Sales

6.5.3.1 Veneer Sales

Assuming a mix of 75 percent 54”, 10 percent 27”, 10 percent Random, and 5 percent Fish Tails, BECK has estimated the average selling value of Douglas Fir veneer to be $185 per thousand square feet (3/8” basis) and $170 per thousand square feet for White Wood veneer.

6.5.3.2 Byproduct Sales

BECK has assumed a total of $22.57 per thousand square feet (3/8” basis) for byproduct revenues, including:

- Peeler cores – $10.00 per thousand square feet
- Veneer chips – $10.56 per thousand square feet
- Bark/hog fuel – $2.01 per thousand square feet

6.5.4 Financial Analysis Results

Table 6.7 illustrates the financial performance of the prospective green veneer plant using the “Base Case” assumptions described in the preceding sections. The financial returns are expected to be modestly attractive, generating approximately $4.8 million in cash flow per year.

Table 6.7 – Green Veneer Plant Pro Forma Income Statement

	Unit	Volume	$(000)	$/Unit
Sales				
Douglas Fir Veneer	MSF 3/8”	127,500	23,588	185.00
Whitewood Veneer	MSF 3/8”	42,500	7,225	170.00
Peeler Cores	MSF 3/8”	170,000	1,700	10.00
Chips	MSF 3/8”	170,000	1,795	10.56
Bark	MSF 3/8”	170,000	341	2.01
Total Sales	**MSF 3/8”**	**170,000**	**34,649**	**203.82**
Green Veneer Recovery (M3/8 per board foot of logs)				**3.4**
Log Costs				
Douglas Fir Logs	MBF	37,500	16,613	443.00
Whitewood Logs	MBF	12,500	4,638	371.00
Total Logs – Log basis	**MBF**	**50,000**	**21,250**	**425.00**
Total Logs – Veneer basis	**MSF 3/8”**	**170,000**	**21,250**	**125.00**
Manufacturing Costs				
Salaries	MSF 3/8”	170,000	1,190	7.00
Hourly labor	MSF 3/8”	170,000	2,941	17.30
Supplies	MSF 3/8”	170,000	1,378	8.11
Maintenance	MSF 3/8”	170,000	735	4.33
Utilities	MSF 3/8”	170,000	1,024	6.02
Sales	MSF 3/8”	170,000	100	0.59
G&A	MSF 3/8”	170,000	900	5.29
Other fixed	MSF 3/8”	170,000	300	1.77
Total Manufacturing	**MSF 3/8”**	**170,000**	**8,569**	**50.41**
Operating Cash Flow	**MSF 3/8”**	**170,000**	**4,830**	**28.41**

It is important to note that only operating cash flow has been evaluated, meaning that depreciation, interest expense, and corporate income taxes have not been considered. Assuming a construction period of 18 months, the expected simple payback period is 7.8 years.

6.5.5 Sensitivity Analysis

The following section explores the prospective veneer plant's operating cash flow when various changes in key assumptions, such as veneer sales value, log price, or operating performance, are introduced. **Table 6.8** illustrates financial performance for a variety of different scenarios. A brief description of the assumptions used in each scenario follows the summary table.

Table 6.8 – Green Veneer Plant Sensitivity Analysis Summary

	Annual Sales		Annual Costs $ (000)			
Scenario	Volume (MMSF)	$ (000)	Logs	Manufacturing	Annual Cash Flow $ (000)	Payback Period (years)
Base Case	170.0	34,649	21,250	8,569	4,830	7.8
Higher Veneer Price	170.0	37,737	21,250	8,569	7,911	5.3
Lower Veneer Price	170.0	31,848	21,250	8,569	2,029	16.3
Higher Log Price	170.0	34,649	23,375	8,569	2,705	12.7
Lower Log Price	170.0	34,649	19,318	8,569	6,761	6.0
Higher Recovery	187.0	37,730	21,250	8,884	7,597	5.5
Lower Recovery	154.5	31,848	21,250	8,284	2,314	14.5
Higher Productivity	187.0	38,114	23,375	8,884	5,856	6.7
Lower Productivity	154.5	31,499	19,318	8,284	3,897	9.3
Single Shift	85.0	17,325	10,625	5,728	972	32.4

As **Table 6.8** shows, operating the plant on a single shift basis would result in cash flow positive operating results, but the return on investment would be very poor.

6.5.5.1 Sensitivity Analysis Scenario Descriptions

Base Case – This is the same scenario detailed in the Pro Forma Income Statement shown in **Table 6.7**, with assumptions described in the preceding paragraphs.

Higher Veneer Price – This scenario assumes that veneer sales prices are 10 percent higher than the Base Case, or about $204 per thousand square feet for Douglas Fir and $187 per thousand square feet for White Woods.

Lower Veneer Price – This scenario assumes that veneer sales prices are 10 percent lower than the Base Case, or about $168 per thousand square feet for Douglas Fir and $155 per thousand square feet for White Woods.

Higher Log Price – This scenario assumes that log prices are 10 percent higher than the Base Case, or about $468 per thousand board feet on average.

Lower Log Price – This scenario assumes that log prices are 10 percent lower than the Base Case, or about $386 per thousand board feet on average.

Higher Recovery – This scenario assumes a green veneer recovery of 3.74, which is 10 percent higher than the Base Case. It is assumed that the increased recovery also increases total annual production and sales (while log consumption remains static). Byproduct yields were decreased slightly to account for higher recovery.

Lower Recovery – This scenario assumes a green veneer recovery of 3.09, which is 10 percent lower than the Base Case. It is assumed that the decreased recovery also decreases total annual production and sales (while log consumption remains static). Byproduct yields were increased slightly to account for lower veneer recovery.

Higher Productivity – This scenario assumes that the plant produces 10 percent more volume per hour (using 10 percent more logs).

Lower Productivity – This scenario assumes that the plant produces 10 percent less volume per hour (using 10 percent fewer logs).

Single Shift – This scenario assumes that the prospective plant runs only one shift, or 40 hours per week. Staffing levels were changed to accommodate this change: Salaried staffing reduced by 2, hourly staffing reduced by 18.

6.5.6 North Interior - Small Diameter Timber Case

As discussed in the preceding pages, the North Coast region is the most likely location in California to supply adequate timber for a new green veneer manufacturing plant. However, this region is not a high fire risk area and is not a high priority area for increasing the “pace and scale” of forest restoration projects on National Forest land. Therefore, BECK also analyzed the feasibility of locating a green veneer facility in the North Interior region. It is worth noting that both of the existing veneer production facilities are located in this region (in the towns of Yreka and Weed).

6.5.6.1 Timber Supply and Requirements

MB&G’s timber supply analysis indicated an annual surplus of approximately 64 million board feet on private lands. In the North Interior region, approximately 50 percent of the total timber consists of species that are typically peeled for veneer (Douglas Fir and White Woods such as White Fir). The balance of the timber supply is Ponderosa and other pine species.

Assuming that a new veneer plant could source 25 million board feet of logs from private lands in the region (only about half of the plant’s typical requirement), it might be possible to secure additional volumes of timber from National Forest lands through use of a Stewardship Contract or similar long term agreement.

When considering this possibility, it is important to note that most veneer peeling operations utilize a relatively large average log. The productivity and veneer recovery rates utilized in the Base Case scenario assume a typical average block diameter of 10” to 12”. Based on BECK’s and

MB&G's experience with National Forest restoration projects in other areas, the logs coming from these projects are typically much smaller, producing an average block diameter of about 7". This diameter differential is important when one considers its impact on cubic volume per log.

For example, the cubic volume of a 10" cylinder eight feet long is approximately 17.4 cubic feet, while the cubic volume of an equivalent 7" diameter cylinder is about 8.6 cubic feet. The 7" cylinder is about one-half of the cubic volume of the 10" cylinder and a 7" diameter veneer block contains about one-half the volume of a 10" diameter veneer block. Further, when one considers that each block contains a core that is unusable for veneer and that for an equivalent size core, the usable volume from the 7" block is even less than one-half of that found in a 10" block. Therefore, the impact on green veneer recovery per cubic foot of logs is dramatic. Veneer plants peeling small logs will experience inferior veneer recovery and also typically lower productivity than those peeling more typical veneer logs.

Because these logs contain much less usable volume per block, productivity at the lathe line is slower. To account for this, BECK has assumed that the plant will utilize only 45 million board feet per year (versus 50 million in the base case). With 25 million board feet coming from private timberlands, an additional 20 million board feet will need to come from National Forests.

A log supply of roughly 50 percent "typical" veneer logs and 50 percent small diameter logs from thinning/restoration projects would not be feasible for the veneer mill, so BECK has assumed that about half of the supplemental logs coming from National Forest lands would be typical veneer log size and half would be small diameter trees from restoration projects, meaning that roughly 25 percent of the veneer plant's total log diet would be small diameter logs. BECK has also assumed that a significant proportion of the small diameter logs would be Ponderosa or other pine species, considering that these species are such a large proportion of the timber in this region and that there would be limited other markets for these small pine logs coming from forest restoration projects.

BECK made the following assumptions about timber supply for the North Interior scenario:

- 21 MMBF of larger Douglas Fir logs (15 million from private lands and 6 million from National Forests) at a (market) delivered price of $465 per thousand board feet.
- 14 MMBF of larger Hemlock and True Fir (White Wood) logs (10 million from private lands and 4 million from National Forests) at a (market) delivered price of $348 per thousand board feet.
- 3 MMBF of small Douglas Fir, 5 million feet of Pine, and 2 million feet of White Wood logs from National Forests, all at a delivered price of $200 per thousand board feet.

The discounted price assumed for small diameter logs recognizes the lower value of these small logs. While $200 per thousand board feet is higher than the typical ground based logging and hauling costs in the region, it is likely lower than the logging and hauling costs for thinning/restoration projects which yield lower volume per acre than typical commercial harvests. BECK has assumed that the stumpage for larger logs would offset some of the thinning costs from small diameter trees – this is not unusual for Stewardship Contract arrangements where some of the logs removed are considered “merchantable” and other material is not.

6.5.6.2 Veneer Recovery and Sales

In order to reflect the lower usable volume in small logs, BECK assumed that the smaller logs would yield only 2.6 square feet of veneer per board foot of logs as compared to 3.4 square feet from the larger logs.

Similarly, the distribution of 54’s, 27’s, Strip, and Fish Tails is different for small logs than for larger logs. To account for this, BECK changed the product distribution as follows:

- 54’s – 70 percent overall (vs. 75 percent in the Base Case)
- 27’s – 12 percent overall (vs. 10 percent in the Base Case)
- Strip – 12 percent overall (vs. 10 percent in the Base Case)
- Fish Tails – 6 percent overall (vs. 5 percent in the Base Case)

This change in size distribution impacts the sales value of the veneer. After considering these changes BECK estimates that the average sales value for Douglas Fir veneer would drop from $185 per thousand square feet to $180 per thousand square feet, and that the average sales value for White Wood veneer would drop from $170 per thousand square feet to $165 per thousand square feet.

Uses for Pine veneer are more limited and little or no LVL quality veneer is likely to be recovered from these species of timber, so this veneer was assumed to sell at a discount of 20 percent compared to White Wood veneer prices.

6.5.6.3 North Interior Scenario Financial Analysis Results

Table 6.9 shows the expected financial performance of the prospective veneer plant with the North Interior scenario assumptions described in the preceding sections. Under this scenario, the plant would generate approximately $2 million less annual cash flow compared with the Base Case scenario. But, it would consume approximately 10 million board feet of small diameter timber annually, creating a significant opportunity to increase the pace and scale of forest restoration on National Forest lands.

Table 6.9 – North Interior Scenario Pro Forma Income Statement

	Unit	Volume	$(000)	$/Unit
Sales				
Douglas Fir Veneer	MSF 3/8”	79,200	14,256	180.00
Whitewood Veneer	MSF 3/8”	52,800	8,712	165.00
Pine Veneer	MSF 3/8”	13,000	1,716	132.00
Peeler Cores	MSF 3/8”	145,000	1,450	10.00
Chips	MSF 3/8”	145,000	1,531	10.56
Bark	MSF 3/8”	145,000	307	2.12
Total Sales	**MSF 3/8”**	**145,000**	**27,972**	**192.91**
Green Veneer Recovery (M3/8 per board foot of logs)				
Standard Logs	3.4			
Small Logs	2.6			
Log Costs				
Douglas Fir Logs	MBF	21,000	9,765	465.00
White Wood Logs	MBF	14,000	4,872	348.00
Small DF Logs	MBF	3,000	600	200.00
Small WW Logs	MBF	2,000	400	200.00
Small Pine Logs	MBF	5,000	1,000	200.00
Total Logs - Log basis	**MBF**	**45,000**	**16,637**	**369.71**
Total Logs - Veneer basis	**MSF 3/8”**	**145,000**	**16,637**	**114.74**
Manufacturing Costs				
Salaries	MSF 3/8”	145,000	1,190	8.21
Hourly labor	MSF 3/8”	145,000	2,941	20.28
Supplies	MSF 3/8”	145,000	1,378	9.50
Maintenance	MSF 3/8”	145,000	735	5.07
Utilities	MSF 3/8”	145,000	1,024	7.06
Other fixed	MSF 3/8”	145,000	300	2.07
Sales	MSF 3/8”	145,000	100	0.69
G&A	MSF 3/8”	145,000	900	6.20
Total Manufacturing	**MSF 3/8”**	**145,000**	**8,569**	**59.08**
Operating Cash Flow	**MSF 3/8”**	**145,000**	**2,766**	**19.08**

6.6 VENEER ORGANIZATIONAL AND MANAGERIAL FEASIBILITY

Because no specific entrepreneur or investor has been identified for the prospective green veneer plant it is not possible to evaluate a planned management team. Instead, BECK has developed a list of needed skillsets and staffing requirements for the prospective plant.

Management staff – The plant will require a plant manager capable of overseeing production and quality control with an hourly staff of approximately 48 people.

Maintenance staff – BECK has estimated that a maintenance staff of eight will be required for ongoing maintenance and repairs at the prospective veneer plant, including both millwrights and electricians. The maintenance staff will need to be skilled in the repair and maintenance of sophisticated equipment, including automated processes requiring knowledge of process logic control (PLC) systems. Based on BECK's experience with other wood products businesses, attracting qualified personnel for these positions may prove to be a challenge.

Table 6.10 illustrates the anticipated hourly staffing requirements, by department.

Table 6.10 – Green Veneer Plant Hourly Staffing

Department	Staffing Level
Log Yard	4
Log Processing	4
Green End	26
Boiler	4
Shipping	2
Maintenance	8
Hourly Staff Total	**48**

6.7 VENEER SUMMARY

BECK examined the feasibility of developing a "green" (i.e., undried) veneer manufacturing plant in Northern California. The prospective plant would be capable of producing 170 million square feet of veneer from 50 million board feet of logs. After initially considering the additional processing steps, such as drying, grading, and layup, to manufacture composite wood products, green veneer was selected as the preferred business because of adequate green veneer markets, lower capital costs, and less restrictive environmental permitting requirements.

6.7.1 Raw Material Supply and Cost

MB&G examined three major timber resource regions in Northern California and found that the North Coast region is the area most likely to be able to supply an additional 50 million board feet of logs to supply the prospective plant. Although a significant portion of the surplus growth in this region is likely to be redwood (which is not suitable for sales into the prospective plant's target markets in Southern Oregon), there appears to be sufficient surplus growth of Douglas Fir and White Wood species on privately owned timberland to supply the prospective operation.

The average delivered cost of Douglas Fir logs from the North Coast region was assumed to be $444 per thousand board feet (Scribner short log scale), while the cost of White Wood logs was assumed to be $373 per thousand board feet.

6.7.2 Veneer Markets

The target market for the prospective green veneer plant would be plywood and laminated veneer lumber (LVL) producers located in Southern Oregon. At present, the region produces about 2 billion square feet (3/8" basis) of veneer while using 3 billion square feet – a deficit of 1 billion square feet. Two existing Northern Californian veneer plants supply approximately 500 million square feet or one half of the deficit, but the balance is brought in from Washington State and British Columbia. The prospective plant should have a transportation cost advantage relative to these distant veneer suppliers.

Based on historical pricing and an average mix of 75% 54", 10% 27", 10% Strip, and 5% Fish Tails, BECK assumed average veneer sales values of $185 per thousand square feet (3/8" basis) for Douglas Fir and $170 per thousand square feet for White Woods.

One market related risk factor is that additional supply of Fish Tails (the lowest value veneer product) would likely be too much for regional markets to absorb.

6.7.3 Green Veneer Economic Feasibility

BECK evaluated the economic feasibility of the prospective green veneer plant with the following key assumptions:

- Capital cost of $30 million

- Annual production of 170 million square feet (3/8” basis) using 50 million board feet of logs
- Hourly staffing of 48, total staffing of 62
- Veneer sales of $185 per thousand square feet for Douglas Fir and $170 per thousand square feet for White Woods
- Byproduct sales of $22.57 per thousand square feet (for peeler cores, veneer chips, and bark/hog fuel)

With these basic assumptions, the plant would generate $203.82 per thousand square feet in sales with log costs of $125 per thousand square feet and cash manufacturing costs of $50.41 per thousand square feet, resulting in an operating cash flow of $28.41 per thousand square feet or $4.8 million per year. Assuming a construction period of 18 months, the expected simple payback period is 7.8 years.

6.7.4 North Interior Scenario

Because the North Coast region is a relatively low risk area in terms of forest fire, and is not a high priority for increasing the pace and scale of National Forest ecosystem restoration activities, BECK also analyzed the feasibility of locating the prospective veneer facility in the North Interior region. Because private lands are unlikely to provide adequate supplies of logs, and in the interest of increasing the pace and scale of forest ecosystem restoration activities, BECK assumed that 20 million board feet of logs would be provided from National Forest lands, including approximately 10 million board feet of small diameter logs.

Because small diameter logs negatively impact veneer recovery and peeling productivity, the North Interior scenario would generate approximately $2 million per year less cash flow than the Base Case scenario, but the plant would utilize 10 million board feet of small diameter logs.

6.7.5 Conclusions and Recommendations

Given the finding of an adequate supply of raw material, the presence of nearby markets for green veneer, a strong market forecast for the products produced from green veneer, and the financial analysis completed for this study BECK concludes that development of a veneer plant in Northern California is feasible. BECK recommends the potential developers complete the following actions for further development of this concept:

- *Investigation of Fish Tail Veneer Markets* – BECK found that markets for fish tail veneer in the Northern California Region are likely oversupplied and the development of an additional veneer manufacturing facility would only exacerbate this situation. Thus, research is needed on ways to mitigate this issues such as the cost/benefit of shipping the material to markets in other regions or identifying alternate uses for the material.
- *Identification of a Potential Developer* – given that there are several existing manufacturing operations in the region that are sourcing significant quantities of green veneer from distant locations, the logical developer would be one of those companies.

An entrepreneur or financier interested in this project may want to approach those manufacturers to gauge their interest in the concept.

- *Security of Supply* – in BECK's judgment the most critical aspect of this business is secure supplying of the required log volume. Further, that supply would most likely come from Federal forests, depending on the location of the plant. Therefore, BECK recommends that potential developers engage the U.S. Forest Service in discussions for providing a long term stewardship contract in the North Interior region.
- *Supply Mix* – the raw material supply analysis for this project was completed at a relatively high level. BECK recommends additional analysis to confirm that the size and species mix of the log supply identified for this study is appropriate for producing veneer used on products such as LVL and plywood produced in the region.

CHAPTER 7 – POLICY RECOMMENDATIONS

Identifying gaps and weaknesses in policy, environmental, and social concerns was a secondary objective of this study. Accordingly, the following report sections identify and describe those types of issues discovered by BECK during the course of the study. In addition, where appropriate, BECK has made specific recommendations about actions that can be taken to address the gaps and weaknesses.

7.1 DEVELOPERS MUST OBTAIN LONG-TERM SUPPLY CONTRACTS TO BE SUCCESSFUL

Any lender financing the initial capital investment of a forest products business will require the business owner to demonstrate that an adequate supply of raw material is available and that the supply is in the developer's control. The specific requirements will vary from lender to lender, but, based on BECK's experience, the owner typically needs to have an independent third party complete a supply study showing that a minimum of 1.5 times the plant's annual raw material requirement is available and that the business owner has a substantial portion of the plant's annual raw material supply requirement contractually secured for the duration of the loan.

In much of the Western U.S. as much as 70 to 80 percent of the forest land is publicly owned. This means that business owners holding traditional timber sale contracts (that might have a maximum duration of 3 years) have difficulty showing a contractually secure supply to lenders. Fortunately, with regard to federal lands, long-term stewardship contracting is a tool that has been increasingly used over the last 10 to 15 years. The length of stewardship contracting terms could allow business developers to secure longer term supply.

One example of the long-term approach is the 4 Forest Restoration Initiative (4FRI) currently underway in Arizona. The project spans four national forests (Kaibab, Coconino, Apache-Sitgreaves, and Tonto) and aims to use a 10 year contract to carry out forest restoration efforts on more than 300,000 acres of forestland. Contracts with that type of long-term duration and large-scale volume are preferred by lenders. While the contractors awarded the 4FRI contract have experienced difficulty carrying out the prescribed treatments, BECK believes the long-term, landscape-wide model could be employed in California. Unlike Arizona, there is sufficient forest products industry remaining in California to successfully process the material harvested during restoration treatments. Development of one or more businesses analyzed in this report would even further enhance the viability of carrying out restoration treatments.

BECK recommends that any entrepreneur pursuing development of a business based on the technologies considered in this report work closely with the U.S. Forest Service to explore opportunities for developing long-term, landscape-scale stewardship contracts.

7.2 CPUC AND CARB SHOULD EXPLORE PROTOCOLS FOR LARGE BIOMASS POWER FACILITIES

Small biomass combined heat and power facilities were identified and analyzed as having one of the highest potentials for additions to California's forest products infrastructure. This ranking is wholly dependent on the existence of BioMAT, which provides for contracts for 50 MW of 3 MW and smaller projects.

At the same time as BioMAT is in development at the CPUC and the IOUs, older larger biomass projects, with similar technology, are closing across California as their Power Purchase Agreement amendments expire and are not renewed by the IOUs. The closures dwarf the size of the BioMAT program, with several hundred additional MW likely to close over the next 24 months.

Given the dire need to utilize the products of accelerated forest thinning and restoration and California's program to dramatically reduce statewide greenhouse gas emissions, the closure of larger biomass power facilities is a perverse outcome that should not be allowed to happen.

California’s Governor, who recently proclaimed a State of Emergency due to drought conditions, recognized the need to extend contracts for existing bioenergy facilities so they remain a tool for dealing with drought killed trees and overstressed forests. As a result, the governor directed the CPUC to utilize its authority for such purpose. This study recommends that the CPUC move aggressively to assist the IOUs and biomass power industry in crafting replacement contract amendments that will allow existing plants to cost effectively run at a high annual capacity factor and allow recently closed plants to restart. Such amendments should extend to the end of the existing PPAs or 2020, whichever is later.

Longer term, the value of the biomass power facilities, both existing and new, in greenhouse gas reduction efforts in California should be analyzed and reported by the California Air Resources Board (CARB) so that a Biomass Power Protocol can be developed and facilities can be allowed to produce carbon credits for sale. The quantity of credits awarded would be based on the demonstrated greenhouse gas reductions versus the alternative fates of the biomass fuels. Displacement of fossil carbon emissions would continue to be captured in the Environmental Attributes that are the property of the purchasing utility. Development of a new revenue stream for biomass power facilities can remove some of the pressure from electric ratepayers who, in the short term, will shoulder the burden of keeping plants open through above market power purchases.

Alternatively, the CPUC's expected redraft of procurement policy for the Renewable Portfolio Standard (RPS) program could mandate levels of biomass power participation in the program and assign carbon credits earned from the Biomass Power Protocol application to the purchasing utility to offset fossil carbon emissions.

7.3 CPUC SHOULD EXPLORE CHANGING BIOMAT PRICE ADJUSTING PROTOCOL

Currently, the bidding protocol for the SB 1122 program requires 3 pre-approved parties in the bidding queue before programmed price changes can begin. It is widely expected that prices must increase substantially from the $127.72/MWH starting price before parties can accept the price. Once a producer of 1MW of capacity or more accepts the price, the queue requirement for further price changes expands to 5 parties in the queue. Beck's analysis of existing development efforts found that it may not be possible to have 5 parties simultaneously seeking contracts, so the queue size requirement should stay at 3 parties.

7.4 CARB SHOULD QUANTIFY BENEFITS OF CONTROLLED FOREST WASTE BURNING

California's strict air quality regulations, when aggressively applied, can greatly increase a forest products conversion facility's capital and operating cost and threaten the economic viability of small biomass power or combined heat and power facilities. However, if such facilities were to be installed, regional air quality might actually be improved as it could lead to less open burning of forest wastes and a lower chance of forest wild fires, which have staggering emission levels of pollutants. For example, controlled combustion of forest wastes in a boiler versus open burning typically results in a 95 percent or more reduction in the criteria pollutants of concern in California (PM, CO, VOC's, NO_x).

BECK recommends that the California Air Resources Board (CARB) recognize the air quality benefits of forest waste combustion under controlled conditions versus open burning of the same materials. CARB should petition EPA to allow consideration of regional air quality benefits and avoided open burning cost in the permitting process for biomass power and CHP facilities. Once approved, CARB should distribute such authority to local permitting agencies in California.

The goal is protection of air quality in the vicinity of the project without overburdening the plant with Lowest Achievable Emission Rate (LAER) technology or operating protocols that would cause the project to be abandoned with the attendant loss of potential regional air quality improvements.

7.5 CARB SHOULD EXPAND FOREST AND BIOMASS PROTOCOLS FOR FOREST RESTORATION

Under AB 32 implementation, the California Air Resources Board is tasked with developing Protocols under which various GHG reduction efforts can be evaluated and offset credits assigned. The work of CARB in this arena should be expanded to include Protocols for forest activities and infrastructure expansions designed to address the need for large scale forest restoration in California, including the need to develop uses for small timber, dead and burned trees, and the byproducts of forest thinning.

The need to limit future wildfires, restore forest health and function, and prevent open burning or decay of forest byproducts have quantifiable GHG reduction benefits that can be analyzed by CARB. The recovery and use of traditional non-merchantable material is very expensive, however, and so the long term sequestration of the carbon in products or the use of the material to offset fossil fuel use should be encouraged by Protocol through the granting of scientifically determined saleable offset credits.

7.6 U.S. FOREST SERVICE SHOULD CONTINUE SUPPORT FOR CLT MARKET DEVELOPMENT

During the summer of 2015 the International Code Council considered a request from the American Wood Council for the development of an International Code Council Tall Wood Ad-Hoc Committee. The purpose of the committee will be to identify appropriate opportunities to expand the current building standards to recognize use of mass timber construction in taller buildings and craft the accompanying requirements. BECK recommends that the USDA continue their ongoing efforts to support this and other initiatives aimed at conducting the required research toward advancing the appropriate use of wood products such as CLT.

7.7 STATE SHOULD STUDY OPPORTUNITIES FOR ENHANCING WOOD PELLET FEASIBILITY

Global demand for wood pellets is expected to rise to over 50 million metric tons by 2025. The forecasted growth is primarily driven by global carbon policies that encourage the substitution of pellets for a portion of the coal currently burned to generate electricity. The vast majority of the growth in pellet demand is expected to come from Europe, Japan, and Korea.

California could potentially capitalize on the expected growth in the pellet market in Asia as there are many sawmills in the state that currently have limited markets for their sawmill byproducts. If a pellet industry were present in the region it would provide markets for those sawmill byproducts. According to the Western Wood Products Association, softwood sawmills in California produced just over 1.9 billion board feet of lumber in 2014. BECK estimates that level of lumber manufacturing translates into the production of about 1.3 million bone dry tons of “clean” mill byproducts (i.e., 900,000 BDTs of chips, 220,000 BDTs of sawdust, 180,000 BDTs of shavings).

There are no pulp mills operating in California to purchase the chips, and there is only one particleboard plant operating in the state to purchase sawdust and shavings. Thus, the clean fiber (non-bark) portion of the mill byproduct production would appear to represent a stable, relatively low cost fiber resource that could be utilized for manufacturing wood pellets.

BECK estimates that nearly 70 percent of the total cost of the delivered pellet can be attributed to the cost of fiber and transportation and logistics. As described previously, California appears to have a supply of low cost fiber. However, California does not currently have port infrastructure to efficiently and cost effectively handle bulk pellet exports. This fact precluded pellets from being considered for detailed financial analysis.

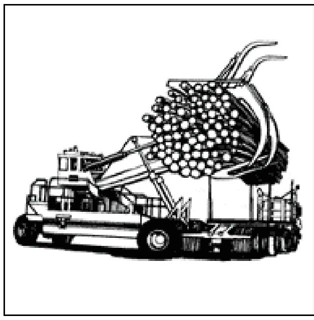
BECK has identified only two ports along the entire North American West Coast with infrastructure specifically designed for efficient and cost effect pellet handling; both are in British Columbia and both ship pellets primarily to Europe through the Panama Canal with much smaller amounts being shipped to Asia. These ports have the following features that are required for pellet handling: rail/truck access, covered receiving area, automated discharge from trucks/rail, receiving systems designed to limit breakage and dust, fire protection, covered/enclosed storage, storage areas with dust control, aeration systems, fire detection and fire control, special loading and unloading equipment designed to minimize breakage, and specially designed loaders to minimize ship repositioning.

In addition, pellet exports are happening on increasingly larger ships, which typically have a loaded draft of about 39 feet. The water depth at the port facility must be capable of handling such ships. According to information published about the two ports equipped for pellets in British Columbia, investments in infrastructure range between $25 million and $50 million per port. The State of California should investigate use of public funds to bring a port in the state up to the standards described above. BECK recommends follow-up analysis to:

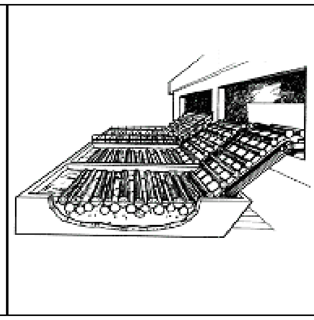
1. Survey sawmill firms in the state to gather data about the market values of their mill residues and gauge their interest in either supplying a pellet manufacturing operation or possibly developing a pellet manufacturing operation
2. Identify a port that is best suited for pellet export infrastructure development

APPENDICES

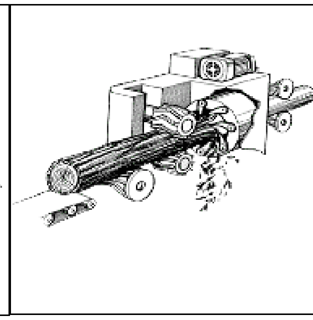
APPENDIX 1 – OSB MANUFACTURING PROCESS ILLUSTRATION



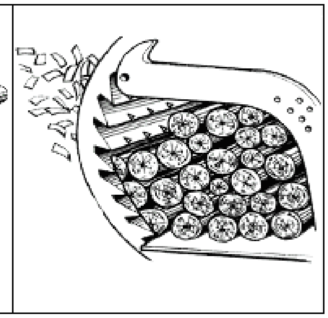
Log Sorting – after harvest, whole logs are hauled to the mill's wood yard.



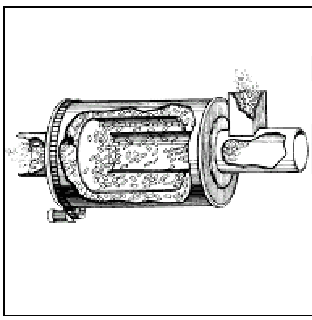
Log Conditioning – logs are soaked, to remove ice and dirt and to prepare wood for stranding.



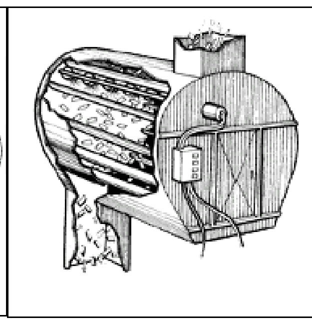
Log Debarking – logs are run through the debarker to remove bark.



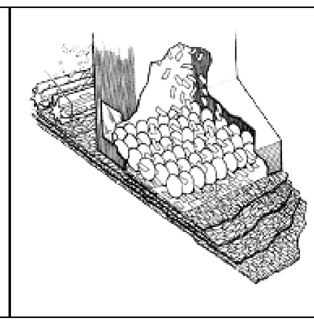
Stranding – the OSB strands are cut from whole logs into precise dimensions.



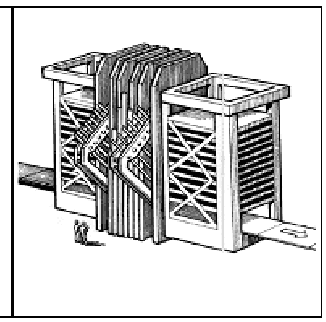
Drying – strands are dried to the appropriate moisture content.



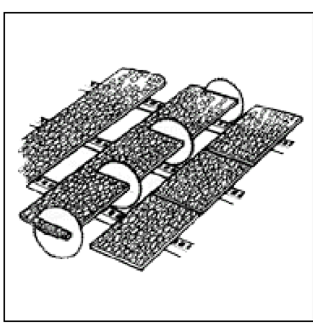
Blending – strands are blended with resin, wax, and preservative chemicals.



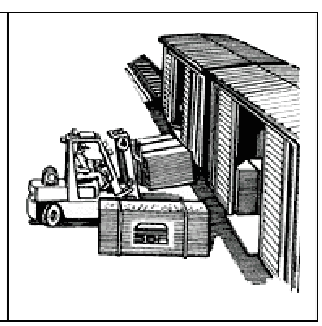
Forming – strands go through the forming line where cross-directional layers are formed into a mat.



Pressing – the mat is pressed under intense heat and pressure to form the panel.



Finishing – panels are cooled, cut to size, grade stamped, stacked in bundles and edge coated.



Shipping – finished panels are loaded onto trucks, rail cars, or containers for destinations around the world.

Illustrations and text listed above are from OSBGuide a website maintained by TECO at: www.osbguide.tecotested.com

APPENDIX 2 – SUPPLY STUDY RESULTS AND METHODOLOGY

Timber Supply Assessment for Northern California

Protocol

Prepared by:

Mason, Bruce & Girard, Inc.
10/28/2015

Prepared for:

The Beck Group
10/28/2015

Executive Summary

This document explains procedures used to estimate strandable wood mass potentially available for use in an oriented strand board (OSB) mill located in Anderson, CA. In addition, we estimate surplus sawtimber growth in the region.

> **Objective 1.** Estimate the amount of strandwood available for a price of $35.00 per ton in an area centered on Anderson, CA.

The maximum amount of strandwood available within 340 minutes of Anderson, CA, is 964,767 green tons per year, assuming zero stumpage price and diversion of 1/3 of the current chip market. This mass can be acquired for an average price of $33.75/ton from private land and $33.81/ton from public land.

Conservatively, it may be the case that the current chip market will not relinquish its existing supply, and that stumpage may cost $7.00 per ton. **Under this set of assumptions, approximately 490,500 green tons per year of strandwood are available from existing harvests for $35.00/ton.**

> **Objective 2.** Determine whether an additional 55 MMbf of sawtimber could be sustainably harvested in the northern CA region.

At 1990's growth rates, the surplus sawtimber growth in the North Interior, North Coast, and Sacramento regions combined is **3,267 MMbf/year**.

With a 15% growth penalty to reflect ongoing severe drought conditions, surplus sawtimber in the three regions is **2,598 MMbf/year**.

Northern California forests have sufficient sawtimber growth surplus to support harvest of 55 MMbf annually. **Total annual surplus from private land is 64 MMbf in the North Interior, 329 MMbf in the North Coast, and 68 MMbf in the Sacramento region.** Note that this does not distinguish between forest industry land and other private land. We estimate that forest industry land constitutes 71% of all private timberland. **Annual surplus from forest industry land is approximately 45 MMbf in the North Interior, 233 MMbf in the North Coast, and 48 MMbf in the Sacramento region.**

DATA SOURCES

Multiple data sources were required to quantify the potential supply of strandable wood mass (strandwood) within the study region. We assembled data from several publicly available sources, as well as certain GIS data already in our possession:

- USFS Forest Inventory and Analysis (FIA) database, 2005 – 2014
- CA State Board of Equalization (CA SBoE) annual harvest reports, 2012 – 2014
- CA Department of Forestry and Fire Protection (CALFIRE) timber harvest plans, 2012 – 2014
- CA State GIS layers, MB&G GIS layers
- USFS CUTS203F National Forest, cumulative quarterly reports of all sales, 2010 – 2014

Forest inventory data from FIA—classified by county, owner type, and forest type—were summarized at the aggregate level and exported at the tree level. For private land, tree-level data were reprocessed through the forest inventory program MBG Tools, and calibrated to annual harvest levels by management regime as reported in CALFIRE and CA SBoE data. For public land, USFS CUTS203F data calibrated to CA SBoE annual average harvests. Sawtimber and strandwood harvests for public and private land were summed across travel time zones in 20 minute intervals spanning distances corresponding to 40 minutes through 340 minutes.

1. INVENTORY AND MERCHANDIZING

Inventory data were extracted from the USFS FIA Pacific Northwest database (PNW FIADB 2005 – 2014). We summarized total volume (million cubic feet) by county, forest type, and ownership (**Table 2**), and exported tree-level data by county and forest type. The lowest level of analysis was forest type within owner type by county. Each of these unique combinations was treated as a stand, using the appropriate expansion factors for tree volume from the FIA database.

In MBG Tools, we calculated at the stand level (county-owner-forest type) total cubic feet, total merchantable Mbf, gross and net cubic feet, and total, gross, and net green tons. Net volume (both cf and bf) consisted of the sum of gross and defect volume subtracted from total volume. For our estimate of merchantable sawtimber, we used net Mbf. For our estimate of strandwood, we used the difference between gross and total green ton mass, plus 50% of the defect green ton mass. We add a fraction of defect to strandwood because the OSB processing facility can accept log fragments that are not sawtimber length or quality.

FIA data were exported according to three different harvest management scenarios. For clearcut and selection harvests, we included data from FIA plots with index age 45 years to 150 years, reasoning that younger stands are unlikely to be clearcut, and that older stands may be managed using an uneven aged regime. We included FIA plots aged 50 to 225 years for uneven aged management, and aged 40 to 75 years for thinning.

Table 2. Comparison of reported FIA gross volume (million cubic feet) to the same parameter recalculated in MBG Tools. Minimal differences in the outcome of this support the volume calculation methods implemented in MBG tools, producing conservative estimate averaging 3.3% lower for National Forest and 2.7% lower for private land.

County	Nat'l Forest (MMcf)			Private Land (MMcf)		
	FIA	MB&G	%Δ M	FIA	MB&G	%Δ M
Alpine	356.1	347.7	-2.4%	18.1	17.8	-2.0%
Amador	158.1	150.7	-4.9%	138.1	136.6	-1.2%
Butte	839.6	818.3	-2.6%	407.2	395.5	-3.0%
Colusa	3.9	3.8	-1.2%	22.6	23.1	2.0%
Del Norte	338.2	324.4	-4.2%	362.9	347.8	-4.3%
El Dorado	2,602.1	2,522.5	-3.2%	464.3	450.8	-3.0%
Glenn	324.3	314.6	-3.1%	0.0	0.0	0.0%
Humboldt	881.6	848.2	-3.9%	3,113.3	3,009.5	-3.4%
Lake	298.8	278.0	-7.5%	82.3	75.3	-9.4%
Lassen	1,254.5	1,246.7	-0.6%	672.5	677.0	0.7%
Mendocino	356.6	330.3	-7.9%	2,967.4	2,867.7	-3.5%
Modoc	815.5	815.5	0.0%	311.0	312.1	0.3%
Nevada	634.3	614.4	-3.2%	519.4	500.1	-3.8%
Placer	1,310.8	1,293.1	-1.4%	356.2	343.5	-3.7%
Plumas	4,174.2	4,101.1	-1.8%	991.8	962.6	-3.0%
Shasta	1,707.8	1,644.9	-3.8%	1,556.3	1,511.1	-3.0%
Sierra	1,675.5	1,641.0	-2.1%	315.4	312.6	-0.9%
Siskiyou	6,162.0	5,997.9	-2.7%	1,471.9	1,446.4	-1.8%
Tehama	1,182.9	1,156.3	-2.3%	569.5	549.5	-3.6%
Trinity	3,593.1	3,392.5	-5.9%	774.3	739.1	-4.8%
Tuolumne	1,728.1	1,654.2	-4.5%	284.2	271.2	-4.8%
Yuba	414.1	397.2	-4.3%	178.0	172.3	-3.3%

Using MBG Tools, we calculated clearcut harvest volume from all trees, with sawtimber merchandized to 6” inside bark small end diameter (SED), and strandwood from tops of sawtimber trees and from small trees, with minimum SED 2”. For selection harvest regimes, we assumed 25% volume of clearcut. Sawtimber and strandwood volume from thinning treatments were calculated in the MBG Tools harvest simulator, using a thinning from below to 80 ft^2 residual basal area. Uneven aged management was simulated as a selection thinning removing 40% of the existing basal area.

2. TRAVEL TIME ZONES

A transport analysis was conducted for all areas in northern CA falling within a 340 minute distance travel time from Anderson. Travel time was determined by road class, with 20 mph limits on gravel, 35 mph on secondary, 45 mph on primary, and 55 mph on highways. Areas within each travel time zone were classified by county, owner type (National Forest, other public lands, private), and forest type, with forest types grouped into commercial softwoods and all others.

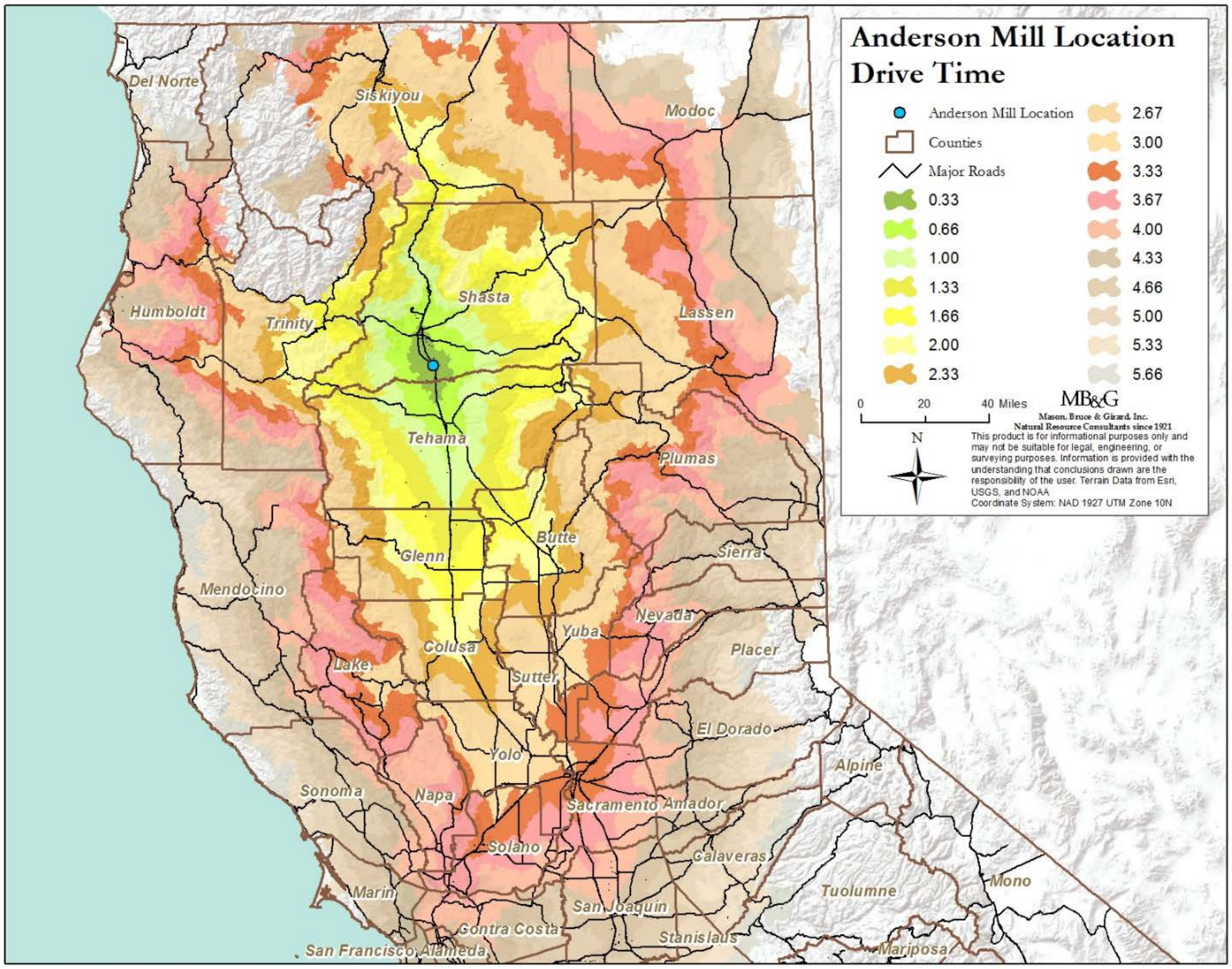


Figure 2. Travel time zones centered on Anderson, CA. Protected wilderness areas (e.g. north Trinity County, southwest Siskiyou County, west Lassen County) were excluded from the area calculation. Here, we present total area encompassed by the time zone. Potential acreage for timber harvest was calculated based on only forested area, and further more on forested area with commercial softwood species types (Appendix A).

3. HARVEST AREA AND VOLUME

We combined remerchandised FIA data, time zone data, and harvest data to produce estimates of sawtimber and strandwood availability within each travel time zone. Total timber harvests by count were calculated from CA SBoE data using the average from 2012, 2013, and 2014 as a likely expectation for future harvest levels. These data are separated by public versus private land, but not any further within these owner types.

3.1. Private land

We used CALFIRE timber harvest plan (THP) and non-commercial timber management plan (NTMP) GIS data and metadata to identify the number of acres harvested by clearcut, selection, thinning, and uneven aged management on an annual basis on private land. Absolute area was converted to a percentage area using forest type and owner type data from the 1990's USFS FIA data. The current 2005 – 2014 FIA data do not track ownership to the level of forest industry versus other private owner types. We multiplied the percent area dedicated to each harvest regime by the timberland area within each travel time zone, and then multiplied by harvest volume (Mbf/ac or green tons/ac) for that regime (see §1), yielding an estimate of Mbf or green tons, implied on an annual basis.

Due to discrepancies between the 1990's FIA classifications of timberland versus the current reality, we calibrated total sawtimber Mbf to reflect average harvest levels from CA SBoE data between 2012 and 2014 for the fractional county areas represented in each travel time zone. For example, by time zone 340 minutes, several counties were completely encompassed, but , and we devised a multiplication factor to adjust sawtimber harvest to equal the CA SBoE value. Assuming a consistent proportionality between sawtimber and strandwood, we also multiplied strandwood mass by the same factor.

3.2. Public land

We used USFS CUTS203F data to calculate annual sawtimber and strandwood harvest on National Forest land. We used the subset of sawtimber from softwoods, excluding mixed conifer-hardwood; strandwood comprised non-saw and green convertible biomass. We calculated a ratio of strandwood to sawtimber for each NF, then calculated the area within each county occupied by the NF. These data were available only for a subset of National Forests, so for those NF's without harvest data, we applied an acreage-weighted average of harvest volume from the other NF's in the county.

The CUTS203F data do not indicate sale acreage. Harvest levels were calibrated to CA SBoE information at the county level. We calculated harvests from public lands (Mbf) using the percentage of volume from public land harvests, then calculated the proportion of the county area within each time zone. We multiplied CA SBoE harvest volume by the acreage proportion to yield the total sawtimber harvest for the time zone. Strandwood harvest in the time zones was calculated as the product of sawtimber and the strandwood ratio from CUTS203F.

3.3. Harvested volume versus available volume

Personal communication with representatives from the State of California and from private timber industry suggested that the vast majority of logging in this area is conducted by whole tree yarding. In this system, all of the strandwood will be available at the landing. Perhaps 1% of the sawtimber harvest is conducted with cut to length systems in which topwood is left in the forest, and therefore inaccessible at the landing. We multiplied harvest volume by 0.99 to reflect the predominance of whole tree harvest systems.

Once at the landing, strandwood is either disposed of or sent to chip markets. Our sources indicated that approximately 30% of the available strandwood is shipped to chipping facilities. Of this volume, 1/3 (or 10% of the total) is shipped at cost. Approximately 30% of the total strandable material is burned and 40% is redistributed on skid trails. In sum, 20% of the potential strandwood is already marketed at some nonzero profit, leaving 80% available for OSB. We remove 5% for processing loss, and allow 75% of the whole tree yarded strand volume to transport (Table 3).

Table 3. Harvested versus available strandwood volume for private and public land within 340 minutes travel distance from Anderson.

Travel time (min)	Private land			Public Land		
	Harvest volume		Available volume	Harvest volume		Available volume
	Mbf	Strand grn ton	Strand grn ton	Mbf	Strand grn ton	Strand grn ton
40	704	706	524	16	79	59
60	15,586	15,618	11,596	168	845	627
80	81,112	80,815	60,005	1,284	6,322	4,694
100	168,513	165,218	122,674	4,950	23,185	17,215
120	248,538	242,122	179,776	11,131	47,999	35,639
140	358,939	348,610	258,843	19,438	76,456	56,768
160	439,036	436,085	323,793	29,161	102,212	75,892
180	525,692	535,775	397,813	42,214	134,224	99,661
200	610,375	627,999	466,290	53,495	161,540	119,943
220	687,317	707,487	525,309	65,271	184,708	137,146
240	763,963	766,132	568,853	76,114	205,728	152,753
260	847,255	827,080	614,107	88,188	224,312	166,552
280	932,510	890,079	660,883	101,242	244,023	181,187
300	1,030,239	960,337	713,050	111,996	253,811	188,455
320	1,098,456	1,008,164	748,562	123,024	259,452	192,643
340	1,138,626	1,036,409	769,534	128,208	262,941	195,233

4. SUPPLY

The supply of strandwood within the 340 minute maximum travel zone is presented as a function of transport cost for private and public land, and for scenarios in which the landowner is compensated for stumpage valued at $7.00 per green ton or at zero stumpage price.

4.1. Transport costs

Costs assigned to elements of loading and transportation were reported from foresters operating in Northern CA (Pers. Comm. S. Zeigler). We use a cost of $85.00 per hour of travel, which includes the profit margin for the hauling company. An hour of travel time implies an additional hour for returning, so a one-hour haul incurs two hours of haulage charges. Each log load includes 30 minutes for loading or unloading at each end of the trip. Processor and loader fees are $125/hour; a 13% profit is allowed to the processor, translating to a final cost of $141.25/hour. Loading requires 30 minutes and processing one hour; unloading is not an incurred cost for the loader, as it is assumed to be the responsibility of the log yard. Unloading does require 30 minutes of truck cost. Fixed costs include one truck hour for loading and unloading, 1.5 processor/loader hours, and any stumpage fees—we show one scenario with stumpage at $7.00/ton, and another at $0.00/ton. Fixed costs range from $296.88 to $471.88, depending on the stumpage. Including transport costs, the shortest haul distance of 40 minutes would cost $410.21 per load, with stumpage set to $0.00 per ton. The most expensive transport cost would be $1,435.21, corresponding to a travel time of 340 minutes with stumpage of $7.00/ton.

Table 4. Haulage and processing costs consist of fixed costs associated with processing, loading, and idling; variable costs are a function of per-hour trucking cost. Each travel hour requires a second hour for the return trip.

Travel zone	Cost (stumpage $0.00/ton)		Cost (stumpage $7.00/ton)	
(min)	Total trip	Per ton	Total trip	Per ton
40	$410.21	$16.41	$585.21	$23.41
60	$466.88	$18.68	$641.88	$25.68
80	$523.54	$20.94	$698.54	$27.94
100	$580.21	$23.21	$755.21	$30.21
120	$636.88	$25.48	$811.88	$32.48
140	$693.54	$27.74	$868.54	$34.74
160	$750.21	$30.01	$925.21	$37.01
180	$806.88	$32.28	$981.88	$39.28
200	$863.54	$34.54	$1,038.54	$41.54
220	$920.21	$36.81	$1,095.21	$43.81
240	$976.88	$39.08	$1,151.88	$46.08
260	$1,033.54	$41.34	$1,208.54	$48.34
280	$1,090.21	$43.61	$1,265.21	$50.61
300	$1,146.88	$45.88	$1,321.88	$52.88
320	$1,203.54	$48.14	$1,378.54	$55.14
340	$1,260.21	$50.41	$1,435.21	$57.41

4.2. Supply curves

The amount of strandwood available from private land is 769,534 green tons, and from public land is 195,233 green tons (Table 3). Combined, a total mass of 964,767 green tons are available from existing harvests. The maximum price per ton required to secure this supply is $50.41 if stumpage costs $0.00/ton, or $57.41 with a stumpage price of $7.00/ton. Strandwood from private land becomes accessible at shorter travel distances than strandwood from public land (**Figure 3**). Private timberland begins relatively close to Anderson, CA, but the closest National Forest is nearly twice as far away as the closest private land. While volume from private land continues to accumulate at higher transport costs, volume from public land reaches a plateau above $45/ton (at $0.00 stumpage), corresponding to a travel distance of around 300 minutes. At this point, areas to the south of the study region supply very little volume, while most areas West, North, and East are protected wilderness or not timberland.

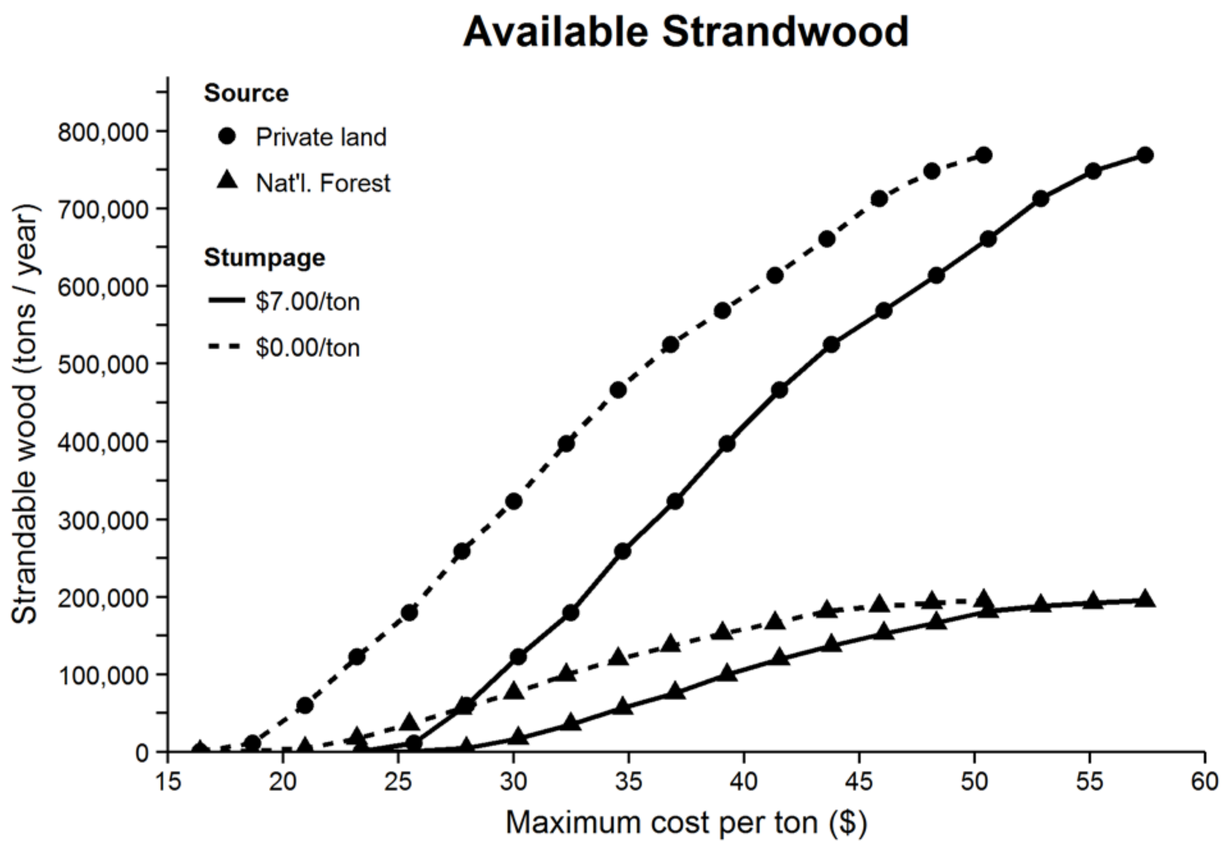


Figure 3. Strandwood supply as a function of the maximum transport cost required. Zero stumpage price (dashed line) results in a maximum cost just over $50/ton. Strandwood from existing harvests on National Forest land (triangles) is approximately 20% of the total available supply.

At a stumpage price of $0.00/ton, the average cost per ton to secure 964,767 green tons of strandwood is $33.75 from private land and $33.81 from public land (dashed line, **Figure 4**). When stumpage price is set to $7.00/ton, each of those prices increases accordingly (solid line, **Figure 4**). Consequently, for $35.00 per ton and zero stumpage price, the sum total of strandwood could exceed 964,767 green tons. With a $7.00/ton stumpage price, 466,289 green tons of strandwood would be available from private land for $34.95 per ton (corresponds to a travel distance of 200 minutes). Again with a $7.00/ton stumpage price, 99,661 green tons of strandwood would be available from public land for $34.92 per ton (180 minutes). With this stumpage price, the total available mass for $35/ton would be 565,960 green tons.

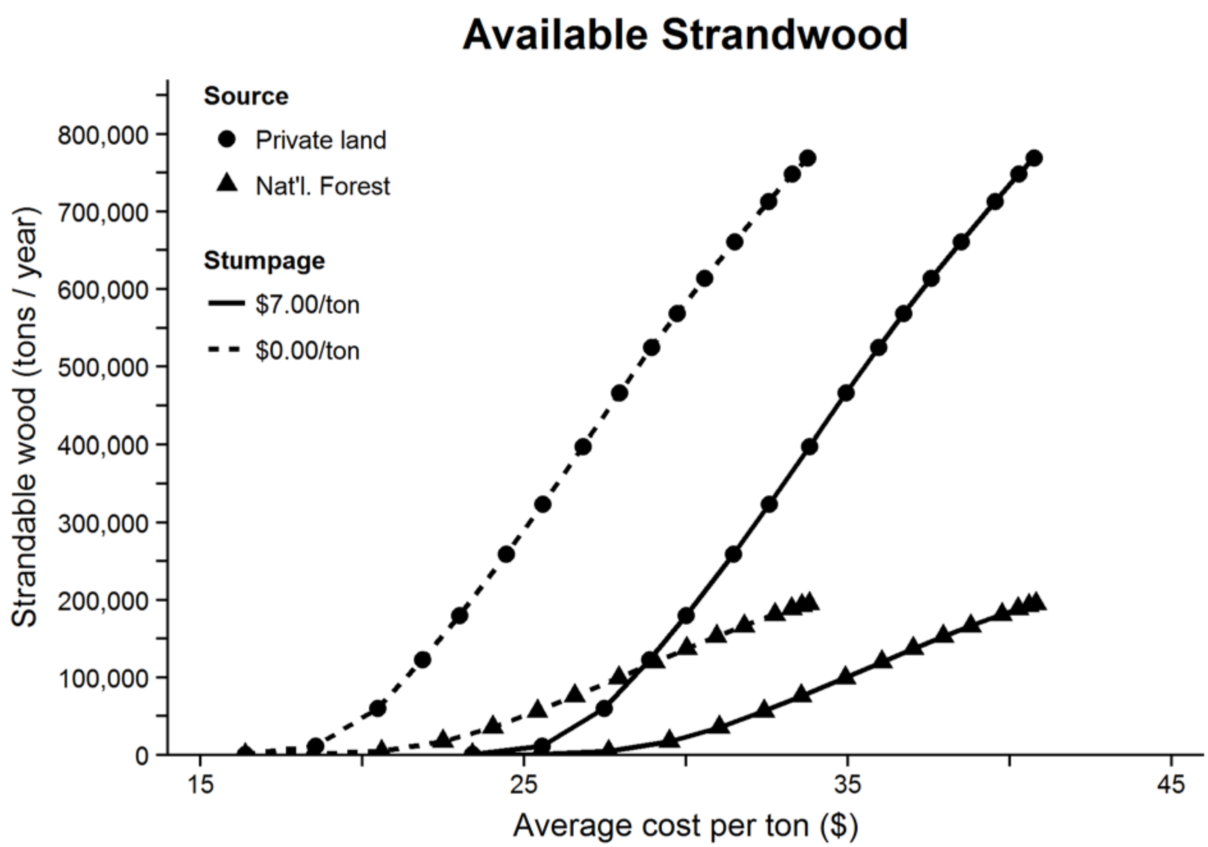


Figure 4. Strandwood from public and private land within 340 minutes travel time of Anderson CA, plotted as a function of average price per ton. At $0.00 stumpage, the total supply could be secured for less than $35/ton. Including a stumpage price of $7.00 and stipulating an average cost of $35.00/ton, the total available supply would be 565,960 green tons, or 58% of the supply without a stumpage cost.

4.4. **Sensitivity analysis**

Thus far, we assume that the 10% of strandwood currently shipped to chipping facilities at cost would be diverted the OSB facility. If the current chip market responds to the construction of an OSB plant to secure their existing supply, only 65% of the available strandwood could be utilized by the OSB facility. At zero stumpage, the total available strandwood mass would decrease under this scenario to 836,131 green tons. If stumpage is $7.00, available strandwood decreases even further to only 490,490 green tons (corresponding a 200 minutes travel time for strandwood from private sources, and 180 minutes for strandwood from National Forest land.

Our analysis suggests that the maximum amount of strandwood available within 340 minutes of Anderson, CA, is 964,767 green tons. This level of availability assumes stumpage at $0.00/ton and diversion of 1/3 of the current chip market to the OSB facility. At the other extreme, with a stumpage price of $7.00 and no diversion of material from the current chip market, approximately 490,500 green tons of strandwood are available from existing harvests.

5. SAWTIMBER SURPLUS ASSESSMENT

Our second objective was to determine whether 55 MMbf additional sawtimber can be sustainably produced from the Northern CA region. In this analysis, we used USFS FIA data (1994) from the North Interior, North Coast, and Sacramento regions to estimate inventory and growth. We compared harvest (CA SBoE data) to net annual growth to determine availability of surplus sawtimber. We also compiled current inventory from the USFS FIA 2005 – 2014 dataset, but these data do not include an assessment of growth, and we hesitate to use them for any purpose beyond confirming that the inventory is of a similar magnitude (**Appendix B**).

Sustainability of additional sawtimber harvest depends on the difference between annual growth and annual harvest, and is not directly a function of standing inventory. We conducted our analysis under a set of assumptions:

i. Average of harvests from 2012 – 2014 represents a likely harvest rate in the future.

ii. Harvest volume consists of principally softwoods, so we consider only growth and inventory of commercial softwood forest types.

iii. Growth rates in the present are comparable to those from 1990's FIA data.

We have no reason to question assumption (i), nor method to predict future harvests. We acknowledge that (ii) includes hardwood harvests, but these are nominal volumes, and by subtracting them from the annual growth we provide a conservative estimate of surplus. It is quite likely that assumption (iii) is inaccurate, especially during the last three years of extreme drought across California. We conduct a rudimentary sensitivity analysis in which growth rate is reduced by 15% to account for drought-related impairment.

In these three regions, we find from 1994 USFS FIA data that annual net growth constitutes between 1.74% and 3.51% of the current standing inventory (**Table 5**). These growth rates are within the range of typical stands in the area, suggesting that surplus calculations based on these values should be reliable. CA SBoE reports an average annual harvest of 1,196 MMbf, and FIA 1994 reports a net growth of 4,464 MMbf (**Table 6**). The difference between annual net growth and annual harvest is 3,267 MMbf (**Table 6**). Our objective was to determine whether 55 MMbf of additional sawtimber could be produced in the region. The difference between net growth and harvest is 59 times greater than the MMbf, so there is abundant surplus from which this extra sawtimber could be harvested. It is likely that forest growth across CA has been impacted by prolonged drought. Applying a penalty of 15% to annual net growth, we find that the annual sawtimber surplus decreases to 2,598 MMbf—still greater than the 55 MMbf target (**Table 6**) by a factor of 47 times. Under both scenarios, adequate surplus exists to support the 55 MMbf annual feedstock requirement of e.g. a veneer mill.

Table 5. Growth and inventory from USFS FIA 1994 data, with percent growth.

Growth (FIA 1994) vs. Inventory (FIA 1994)								
Region	Net Growth (MMbf / yr)			Inventory (MMbf)			Growth rate (%)	
	Nat'l Forest	Private	Sum	Nat'l Forest	Private	Sum	Nat'l Forest	Private
North Interior	1,186	615	1,800	53,870	18,275	72,145	2.20%	3.36%
North Coast	309	763	1,072	17,793	21,765	39,558	1.74%	3.51%
Sacramento	1,173	418	1,591	41,274	17,349	58,623	2.84%	2.41%
Sum:	**2,668**	**1,796**	**4,464**	**112,937**	**57,389**	**170,326**	**2.39%**	**3.13%**

Table 6. Surplus sawtimber calculated as the difference between CA SBoE annual average harvest and annual net growth in the North Interior, North Coast, and Sacramento regions.

Regional timber harvest (CA SBoE average 2012 - 2014) vs. Growth (FIA 1994)									
Region	Harvest (MMbf / yr)			Net Growth (MMbf / yr)			Surplus (MMbf / yr)		
	Nat'l Forest	Private	Sum	Nat'l Forest	Private	Sum	Nat'l Forest	Private	Sum
North Interior	60.4	459.1	520	1,186	615	1,800	1,125	156	1,281
North Coast	1.7	319.4	321	309	763	1,072	307	444	751
Sacramento	68.8	286.9	356	1,173	418	1,591	1,104	131	1,235
Sum:	**131**	**1,065**	**1,196**	**2,668**	**1,796**	**4,464**	**2,537**	**731**	**3,267**

Drought penalty: Regional timber harvest (CA SBoE average 2012 - 2014) vs. Growth (FIA 1994)									
Region	Harvest (MMbf / yr)			Net Growth (MMbf / yr)			Surplus (MMbf / yr)		
	Nat'l Forest	Private	Sum	Nat'l Forest	Private	Sum	Nat'l Forest	Private	Sum
North Interior	60.4	459.1	520	1,008	523	1,530	947	64	1,011
North Coast	1.7	319.4	321	263	649	911	261	329	590
Sacramento	68.8	286.9	356	997	355	1,352	928	68	997
Sum:	**131**	**1,065**	**1,196**	**2,267**	**1,527**	**3,794**	**2,137**	**461**	**2,598**

6. REFERENCES

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3. Waddell, K.L., Bassett, P.M. Timber Resource Statistics for the North Interior Resource Area of California. 1997. PNW-RB-222.
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7. APPENDIX

7.1. **Appendix A**

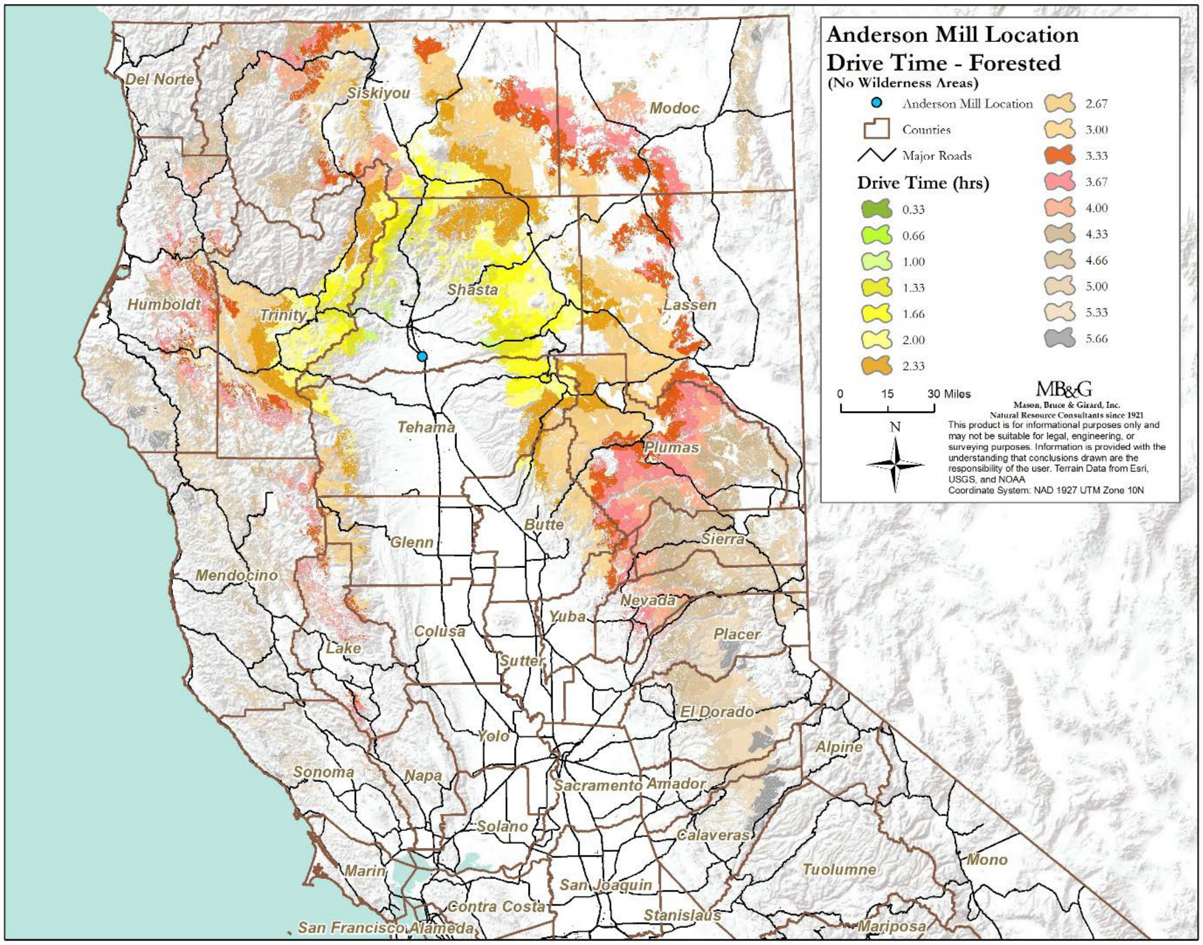


Figure 5. Travel time zones, forest land only.

7.2. Appendix B

Table 7. Inventory of growing stock and sawtimber from FIA 2014 and FIA 1994; growth from 1994.

Inventory (FIA 2014): softwood growing stock on timberland

Region	MMcf				MMbf			
	Nat'l Forest	Public, oth.	Private	Sum	Nat'l Forest	Public, oth.	Private	Sum
North Interior	13,533	370	4,786	18,688	67,807	1,767	20,334	89,909
North Coast	1,576	211	7,571	9,358	8,199	1,190	36,242	45,631
Sacramento	13,460	116	3,992	17,568	68,826	526	18,717	88,069
Sum:	**28,569**	**696**	**16,348**	**45,614**	**144,832**	**3,484**	**75,294**	**223,609**

Region	Mcf / ac				Mbf / ac			
	Nat'l Forest	Public, oth.	Private	Avg.	Nat'l Forest	Public, oth.	Private	Avg.
North Interior	4.73	4.66	2.62	4.01	23.68	22.27	11.14	19.43
North Coast	6.33	11.60	6.32	6.64	32.91	65.52	30.25	33.24
Sacramento	4.14	3.23	2.99	3.75	21.19	14.70	14.04	18.74
Wt. Average:	**4.65**	**7.77**	**3.73**	**4.36**	**23.57**	**41.96**	**17.12**	**21.48**

Inventory (FIA 1994): softwood sawtimber on timberland

Region	MMcf				MMbf			
	Nat'l Forest	Public, oth.	Σ Private	Sum	Nat'l Forest†	Public, oth.	Σ Private	Sum
North Interior	11,217	86	4,417	15,720	53,870	404	18,275	72,549
North Coast	3,057	718	4,432	8,207	17,793	3,664	21,765	43,222
Sacramento	7,937	240	3,765	11,942	41,274	1,138	17,349	59,761
Sum:	**22,211**	**1,044**	**12,614**	**35,869**	**112,937**	**5,206**	**57,389**	**175,532**

Region	Mcf / ac				Mbf / ac			
	Nat'l Forest	Public, oth.	Σ Private	Avg.	Nat'l Forest†	Public, oth.	Σ Private	Avg.
North Interior	3.40	1.51	2.58	3.10	16.31	7.09	10.67	14.30
North Coast	5.82	7.04	4.25	4.92	33.89	35.92	20.89	25.90
Sacramento	3.61	5.11	3.39	3.56	18.75	24.21	15.64	17.80
Wt. Average:	**3.68**	**5.07**	**3.26**	**3.55**	**18.73**	**25.27**	**14.85**	**17.38**

† Inferred from average Public, other; Forest industry; and Private, other Mbf / Mcf ratios in Waddell and Bassett, Timber Resource Statistics for (REGION) Area of California

Net Growth (FIA 1994): softwood on timberland

Region	Growing stock (Mcf / year)				Sawtimber (MMbf / year)			
	Nat'l Forest	Public, oth.	Σ Private	Sum	Nat'l Forest†	Public, oth.	Σ Private	Sum
North Interior	229,855	1,802	121,987	353,644	1,186	10	615	1,811
North Coast	54,439	16,787	137,105	208,331	309	104	763	1,176
Sacramento	198,833	4,327	67,997	271,157	1,173	14	418	1,605
Sum:	**483,127**	**22,916**	**327,089**	**833,132**	**2,668**	**128**	**1,796**	**4,592**

Region (FIA)	Growing stock (cf / ac / year)				Sawtimber (bf / ac / year)			
	Nat'l Forest	Public, oth.	Σ Private	Avg.	Nat'l Forest†	Public, oth.	Σ Private	Avg.
North Interior	69.6	31.6	71.2	69.71	358.9	183.8	359.0	356.97
North Coast	103.7	164.6	131.6	124.82	588.8	1,019.0	732.5	704.77
Sacramento	90.3	92.1	61.3	80.77	532.9	295.6	376.9	478.06
Wt. Average:	**80.13**	**111.24**	**84.65**	**82.50**	**442.46**	**622.84**	**464.83**	**454.70**

† Inferred from average Public, other; Forest industry; and Private, other Mbf / Mcf ratios in Waddell and Bassett, Timber Resource Statistics for (REGION) Area of California

APPENDIX 3 – CAWBIOM STEERING COMMITTEE

BECK would like to acknowledge and thank the following CAWBIOM Steering Committee members who provided their time and thoughtful feedback during the course of the study.

Jerry Bird	Regional Forester's Liaison for Ecologic Restoration, U.S. Forest Service Region 5
Steve Brink	Vice President Public Resources, California Forestry Association
Kim Carr	Assistant Deputy Director for Climate and Energy, California Department of Forestry and Fire Protection
Sherry Hazelhurst	Director of State and Private Forestry, U.S. Forest Service Region 5
Vance Russell	Director, California Program, National Forest Foundation
Larry Swan	Wood Utilization & Biomass Specialist, U.S. Forest Service Region 5
Peter Tittman	Geographer, Center for Forestry, UC Berkeley
Hao Tran	Assistant Director, U.S. Forest Service Northern Research Station
Chris Zimny	Forestry and Fire Protection Administrator, California Department of Forestry and Fire Protection

APPENDIX 4 – CO-LOCATED BUSINESSES

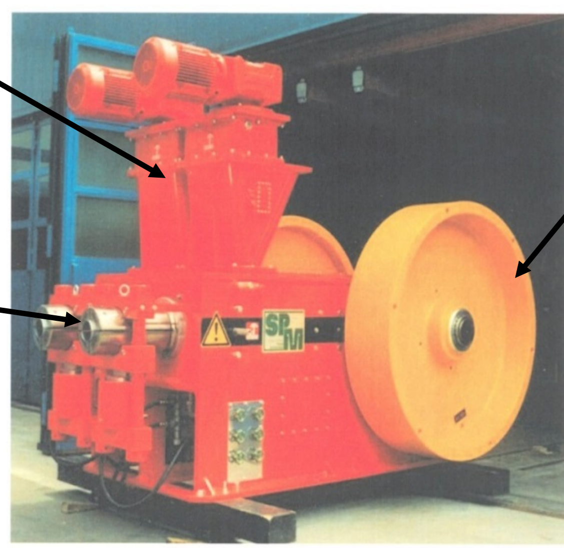
1. BRIQUETTES

1.1 Technology Overview

Wood briquette (also fire logs or fuel bricks) manufacturing is a technology for densifying wood fiber and then combusting it for thermal heating (most common use). Similar to the process used for making wood pellets, small wood particles are compressed under high pressure to form the wood briquettes. However, the dimensions of the briquettes are much larger than pellets – generally about the size of a mortar brick.

Figure 4.3 illustrates how the briquetting technology works. Appropriately sized and dried material is feed by gravity into two chutes from the top of the machine. Two large drive wheels power a piston which presses the raw material through a conical nozzle that provides counter pressure to the action of the piston. The counter pressure compacts and heats the wood as the pressure increases. As the wood heats, the lignin portion of the fiber "plasticizes" and helps the material flow through the nozzle. As the material exits the nozzle it takes the shape of the cone and it is cooled to "set" the briquette in its final form. No added adhesives are used in the manufacturing process. Finished briquettes are dense and durable, which means they can be economically transported long distances with little degradation. Finished briquettes typically contain less than 10 percent moisture (by weight). Briquettes are similar in density to pellets (about 40 pounds per cubic foot), but no grading standards exist for briquette quality. The shape and size of briquettes vary, but most are between about 2 inches in height and width and about 5 inches in length.

Appendix 4: Figure 1 – Wood Briquetter



Source: Pawert – SPM AG, Basel Switzerland

1.2 Raw Material Specifications

Briquetting requires raw material (wood fiber) to be dried to approximately 10 to 12 percent moisture content (MC). It also must be milled to a uniform size (< ¾") and then compressed with either a hydraulic or mechanical press. Bark can also be used for a portion of the feedstock for briquette manufacturing. However, using bark increases the ash content of the material, which makes it less desirable for the end user.

A significant disadvantage of making briquettes (or pellets) from roundwood is that the entire high cost of harvesting and transporting small diameter material must be borne by the economics of the manufacturing process. In contrast, when sawmill byproducts are used as the feedstock, most of the cost of collecting, sizing, and sometimes drying that material has already been absorbed by the lumber manufacturer. Therefore, the only costs associated with those materials are the cost of transportation and their market value. In addition, cost savings are realized at the conversion facility when mill residues are used because they are frequently already reduced to a size appropriate for briquetting and they may already be dry enough for briquetting.

1.3 Market Characteristics

In the Pacific Northwest, briquettes sell for nearly $400 per ton at retail when sold in 30 pound bundles with each bundle containing 6 five pound briquettes. The $400 per ton cost translates into about $6 per bundle. Typically, however, wood briquette users purchase briquettes in large quantity when they are used for home heating. Quantity buying allows users to obtain the material at a lower cost per ton, with prices ranging between $225 to $300 per ton, depending on manufacturer and region.

Briquette manufacturers typically sell their material for about $150 per ton (f.o.b. their plant). Thus, the difference between the retail value and the manufacturers selling price is about $75 to $100 dollars. Within that price differential the cost of transporting the pellets to market and the retailers markup must be accounted for. Retailers typically aim to capture at least a $50 per ton markup. Thus, the amount of margin left for transportation varies between $25 and $50 per ton. Pallets of finished briquettes weigh approximately 1 ton per pallet, with flatbed trucks being able to haul about 22 tons of pellets per trip. Therefore, if the available margin for transportation is $25 per ton, the total cost for the truck cannot exceed $625. If the available margin for transportation is $50 per ton, the total cost for the truck cannot exceed $1,250.

A key market advantage of briquettes over wood pellets is that briquettes can be burned in a homeowners existing wood stove or fireplace. This creates a fairly broad potential market for briquettes. Users of wood pellets, in contrast, must purchase a stove specifically designed to burn wood pellets. Such stoves can cost several thousand dollars, and this expense represents a hurdle to wider adoption of wood pellets as a heating fuel.

Another key market factor in the use of wood briquettes and wood pellets is the price of alternate heating fuels, especially natural gas. Most areas have a natural gas distribution system such that homeowners are supplied with the gas via a connection between their home and the distribution system. When natural gas prices are low (as they currently are), it is difficult for wood pellets to be a cost competitive heating fuel, as shown in **Table 4.6**. However, when the alternative is fuel oil or propane, switching to firewood/briquettes is often cheaper. As a general rule, the availability of natural gas is limited in rural areas. Therefore, the opportunities for briquette markets for home heating should be relatively high in many rural parts of Northern California. It should be noted, however, that a hurdle to briquette use in such regions is that many homeowners prefer to cut their own firewood at the cost of their own time and the relatively minor expense of owning and operating a chainsaw and pickup truck.

Appendix 4: Table 1 – Comparison of Cost among Various Heating Fuels

Fuel Type	Fuel Unit	Fuel Price Per Unit (dollars)	Fuel Heat Content Per Unit (BTU)	Fuel Price Per Million BTU (dollars)	Heating Appliance Type	Approx. Efficiency (%)	Fuel Cost Per Million BTU (dollars)
Coal	Ton	200.00	25,000,000	8.00	Furnace	75	**10.67**
Natural Gas	Therm	1.00	100,000	10.02	Furnace	82	**12.22**
Firewood	Cord	200.00	17,000,000	11.76	Stove	63	**18.67**
Briquettes	Ton	250.00	17,000,000	14.71	Stove	78	**18.85**
Electricity	Kilowatt Hour	0.12	3,412	35.13	Baseboard	100	**35.13**
#2 Fuel Oil	Gallon	4.02	138,690	28.99	Furnace	78	**37.17**
Propane	Gallon	2.93	91,333	32.11	Furnace	78	**41.17**

1.4 Production Characteristics

The scale of briquetting operations tends to be much smaller than pellet manufacturing. This is primarily driven by the capacity of the briquetting machines, which are typically designed with capacities ranging between 0.25 to 2.0 tons of finished product per hour. The plants are highly automated and can essentially operate 24 hours per day, 7 days per week, 365 days per year. Typically, however, scheduled downtime of several weeks per year is taken for maintenance.

Given those operating rates, plants commonly operate about 8,400 hours per year. This means that a plant with a production capacity of 2.0 tons per hour can produce nearly 17,000 tons of briquettes per year. Assuming the briquettes are about 8 percent moisture content when finished, this translates into about 15,600 bone dry tons of feedstock annually. If the feedstock is clean wood fiber, this, in turn, translates into nearly 35,000 green tons of raw material required per year (assuming 50 percent average moisture and bark being 10 percent by weight).

The equipment required for making briquettes is relatively straightforward and includes a truck scale for weighing incoming material, a wheeled loader for unloading stems from the trucks and feeding the stems into the manufacturing process. The manufacturing process includes a debark machine and the appropriate transfers and conveyors for removing the bark from the stems. Hammermills and screens are needed for sizing the feedstock to the appropriate size prior to briquetting. A dryer is also necessary to reduce the moisture content of the incoming feedstock to the appropriate levels for briquetting (with heat supplied by the adjacent biomass power facility). A briquetting machine (as previously described) is required for converting the feedstock into briquettes. At the back end of the plant, packaging equipment is needed for packing the briquettes into a form suitable for transport. An order of magnitude capital cost estimate for this equipment, land/building, and installation is $2.5 to $3.0 million.

As shown on Table 4.12 later in this section, a commercial briquetting operation would require about 6.7 million BTU/hour for material drying, about two thirds the level shown in the modeled small biomass CHP facility

1.5 Location Requirements

The location requirements for briquette manufacturing are not restrictive. Key requirements include space and buildings, with a 100’ x 100’ building on a 5 acre site being adequate. Briquette manufacturing requires a fairly robust, 3 phase electrical service. Thus, the electrical service must be industrial in nature.

2. FIREWOOD

2.1 Technology Overview

The production of firewood is perhaps the lowest tech and lowest capital cost option of any considered in this report. However, it can be a profitable source of extra income for people already involved in forestry and forest products (e.g., loggers, truckers, arborists, foresters, etc.) There are also firms that are full-time firewood production operations.

The process consists of converting tree stems into firewood blocks and then splitting and drying the material before it is burned to produce heat. While this process can be accomplished entirely with hand tools and by letting the material air dry, mechanized equipment exists for cutting stems to firewood lengths and splitting. There are also conveyors that are used to carry material away from the conversion equipment to an area where it can be stacked, sorted, or prepared for drying.

While some commercially made firewood dry kilns exist, “homemade” type drying systems appear to be more commonly used. They typically involve converting an old shipping container into a firewood dry kiln. A shipping container equipped with fans for circulating air, and vents for ejecting moisture laden air and would be supplied with thermal energy from the adjacent biomass CHP facility.

Homeowners who heat their homes with firewood tend to purchase in relatively large quantities (e.g., 1 to 2 cords per delivery). Note that a cord of Douglas fir firewood at 15 percent moisture content is estimated to weigh 1.2 bone dry tons. A cord of pine firewood is estimated to weigh 1.0 bone dry ton. There is also a market for “ambiance” firewood (i.e., occasional use of firewood in a home fireplace, backyard fire pit, or during camping trips). These users are typically found in urban settings and do not necessarily have access to their own firewood or the space to store a large volume of firewood. Therefore, they are willing to pay a relatively high price for several small bundles of firewood to be used occasionally.

2.2 Raw Material Specifications

The raw material requirements for firewood are not restrictive. However, homeowners who use firewood for home heating generally prefer to have pieces from larger trees because larger piece size translates into slower burning rates and less need for the home owner to re-stoke the fire. There also are some differences in the heating value by species. **Table 4.7** displays the higher heating value for several species commonly found in the Western U.S.

Appendix 4: Table 2 – Higher Heating Values of Common Western U.S. Tree Species

Species	Higher Heating Value (BTU per Pound)
Douglas fir	8,900
Lodgepole pin	8,600
Ponderosa pine	9,100
True firs	8,300
Western hemlock	8,400
Western Red Cedar	9,700

2.3 Market Characteristics

In 2011, California was estimated to have a total of 11.5 million housing units, with almost 2 percent using wood (207,052 units) as the primary heating fuel. This information is displayed in **Table 4.8**. Assuming the typical home in California uses 3 cords of firewood per winter, the size of the market is estimated to be over 600,000 cords per year.

Appendix 4: Table 3 – Primary Heating Fuels Used in California Housing Units

Heat Type	All California Number of Housing Units	Percent of Total (%)
Utility Gas	8,132,529	70.7
LP Gas	437,109	3.8
Electricity	2,507,626	21.8
Fuel Oil	34,509	0.3
Coal	0	0.0
Wood	207,052	1.8
Other Fuel	23,006	0.2
No Fuel Used	161,040	1.4
Total	**11,502,859**	**100.0**

The value of firewood depends on factors such as whether it is green or dry, the species, whether it has been split, and whether it is customer pick-up or delivered. Prices in metropolitan areas, average about $225 to $250 per cord for delivered Douglas fir firewood or about $175 to $200 per cord if 2 cords are purchased at once. Seasoned pine firewood, on the other hand, typically sells for about $125 to $150 per delivered cord. Some large firewood producers may offer even deeper per cord discounts for customers purchasing even larger quantities.

2.4 Production Characteristics

As previously described, the production process for making firewood can be very simple, involving only the use of hand tools. However, for the purposes of this analysis it is assumed that the firewood operation will be of a larger scale and involve mechanized equipment. Some of the highest production mobile firewood processors can generate about 10 cords per hour. Thus, a single firewood processor of that scale that operated 2,000 hours per year at 85 percent uptime and at an average uptime production rate of 7.5 cords per hour would produce nearly 13,000 cords per year or a little over 14,000 bone dry tons per year.

Such systems typically require a log loader to place stems onto a log deck having transfer chains. The transfers move the firewood perpendicular to the long axis of the stem until it drops into a trough, which begins to move the stem in a direction parallel to the long axis of the log. The log is moved forward until it encounters a cut-off saw, which can either be a chainsaw type or a circular blade. That saw cuts the pieces to 16” lengths, which is a standard in the industry, although some customers prefer shorter or longer lengths. Once a firewood block has been cut from the stem, gravity is used to drop the piece into a trough, which has a splitting wedge at one end and a hydraulic ram at the other. The ram engages and drives the piece against the splitting wedge. A conveyor system is typically mounted behind the splitting wedge so that finished pieces can be carried away for sorting and/or stacking or prepared for drying. Some systems also utilize a trommel screen right after the conveyor to remove some of the small bark and wood splinters that develop during the splitting process (fuel for the adjacent biomass CHP).

Two laborers can run the equipment: one to load and unload material and one to operate the firewood processor. If the business offers firewood delivery services, an additional full or part time person may be required as well. An order of magnitude estimate for the required equipment is $300,000 to $500,000, which would include a mobile, high production firewood processor; log transfers; conveyors; and trommel screen. It would also include a front-end loader for moving logs and finished product, a delivery truck, and a shipping container refurbished as a wood-fired firewood dry kiln.

Table 4.12 later in this section shows the firewood drying requirements for a commercial scale firewood operation to be about 3.9 million Btu/hr, or about 40 percent of that shown in the modeled biomass CHP facility.

2.5 Location Requirements

The location requirements for a firewood operation are not restrictive. Since the operation can be mobile, a key consideration is to locate it close to the raw material, so as to reduce log transportation costs, or locate it closer to the markets to reduce the transportation cost of the finished product. Since the finished product is dried, it is likely more effective (from a transportation cost reduction perspective) to locate the operation closer to the raw material, but at a fixed location.

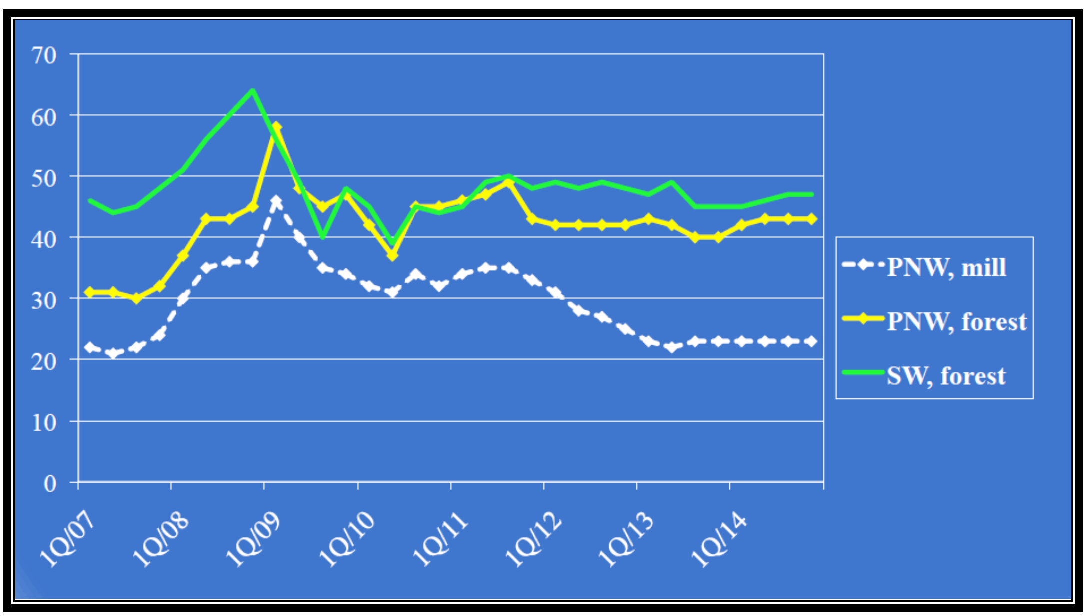
3. FUEL CHIPS FOR BIOMASS HEAT AND POWER

3.1 Technology Overview

Wood-fired boilers can burn a wide range of wood species and types of wood fiber, including bark, sawdust, chips, planer shavings, and ground logging slash. Given the ability of boilers to utilize a variety of fuels, businesses have been developed to facilitate the use of forest derived materials (i.e., chipping and grinding small diameter trees and logging slash) that supply the boilers.

It is important to note, however, that forest derived fuels tend to be more costly than mill residues (**Figure 4.4**), as reported by *North American Wood Fiber Review*. As shown in the figure, since 2010, Pacific Northwest mill residues (sawdust and bark) have had average delivered values of about $10 to $20 per bone dry ton less than Pacific Northwest forest residues. As described in the biomass heat and power technology section, this is because the cost of collecting and processing mill residues is “subsidized” by the process of producing lumber. In contrast, the full cost of collecting, processing, and transporting forest derived fuel must be reflected in its delivered value.

Appendix 4: Figure 2 – Delivered Values of Mill Residue Fuel versus Forest Derived Fuel ($/BDT)



3.2 Raw Material Specifications

The raw material requirements for fuel chips are not restrictive. Virtually any type of woody biomass can be ground and chipped for use as fuel. However, as described earlier in the small biomass discussion, piece size and moisture content are important raw material requirements.

3.3 Market Characteristics

The market for biomass fuel chips is wood fired boilers, especially large industrial scale boilers as might be found at sawmills or pulp and paper mills. Smaller scale wood fired boilers are used in many places, but it is fairly common for those applications to specify wood pellets as a heating fuel as opposed to fuel chips from forest materials. This is because smaller systems tend to operate more efficiently when the fuel is very consistently sized and has little variation in moisture content (i.e., wood pellets). Pellet systems can also be automated to the point that they do not need to be manned on a full time basis. The drawback to that approach is that pellets typically cost about $200 or more per ton versus a cost of roughly $40 to $50 per bone dry ton for fuel chips.

3.4 Production Characteristics

Chipping operations can be either mobile (using diesel powered engines) or stationary (using electric motors). For the purposes of this analysis, mobile chipping operations have been assumed. The primary reasons for this decision are that the reduced capital cost and the ability to move the chipper closer to markets (if required) are viewed as options for lowering risk given the volatility of the chip market. A drawback is to mobile operations, however, is that diesel is a more expensive fuel than electrical power.

In mobile operations, a wheeled log loader (front end load) feeds from a log deck to a loader on or at the chipper. The loader at the chipper feeds the stems into the chipper. Bark and fines drop out the bottom of the chipper and are cleared away by a front-end loader. The chips that make it through the screens (i.e., the finished product) are dumped into a pile on the ground to await loading into chip vans. Some operations may feed the logs from the chipper directly into waiting chip vans.

3.5 Location Requirements

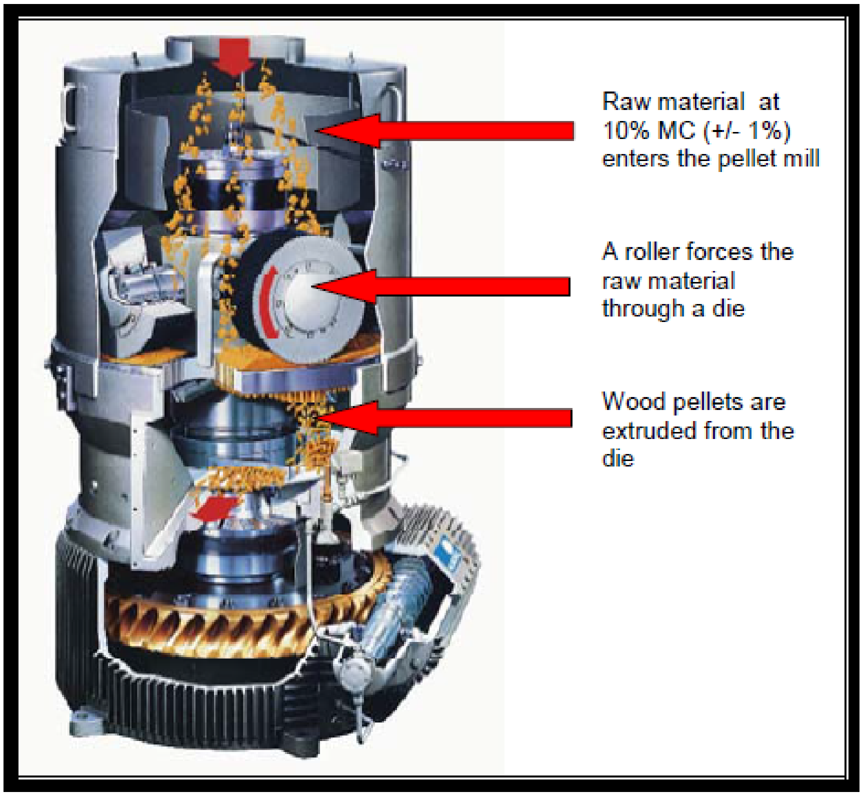
Given that the operation considered here is mobile, the site requirements are largely limited to having enough available space to deck logs, to allowing enough space for the equipment, and to allowing trucks to bring logs in and take pulp chips away.

4. PELLETS

4.1 Technology Overview

Wood pellets are a biomass fuel that is burned to heat buildings or co-fired with coal to generate electricity. The manufacturing process involves drying wood fiber to approximately 10 percent moisture content and then milling them to a uniform size (+/- 1/8"). This material is then compressed with a die and roller to a density of about 40 pounds per cubic foot (See **Figure 4.5**).

Appendix 4: Figure 3 – Pellet Mill Cut-Away Diagram



4.2 Raw Material Specifications

In the Western U.S., wood pellets are generally manufactured from sawmill byproducts such as sawdust and planer shavings. The advantages of those feedstocks are that: they are sometimes already dry (i.e., shavings); they are already in a size and form that requires little additional processing prior to pelletizing; and in some regions of the west, sawdust and, to a lesser extent shavings, have limited market value for other users.

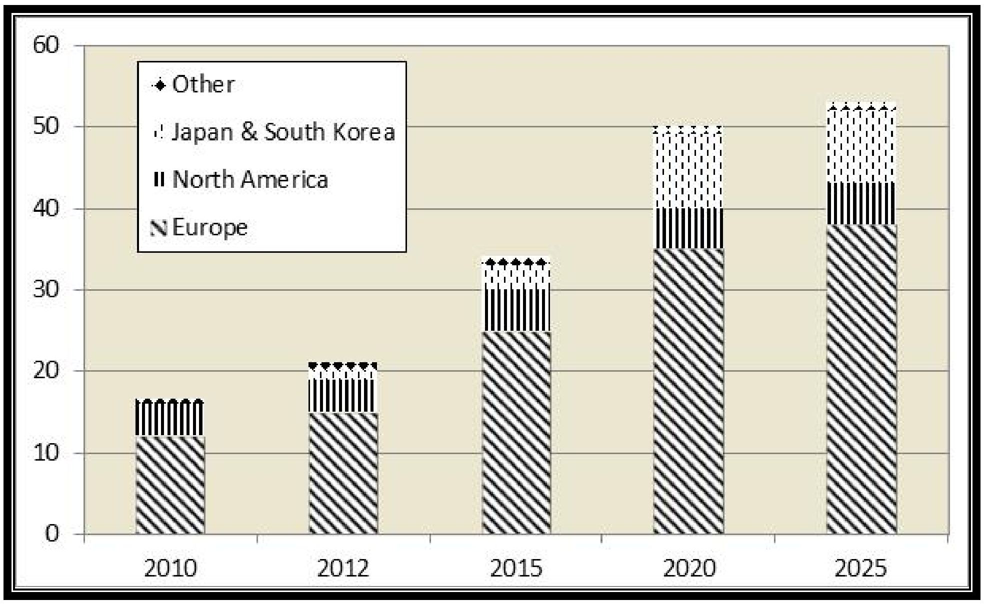
In contrast, roundwood, as a feedstock, requires extra costs for chipping/grinding and hammer milling the incoming stems into a form suitable for pelletizing. In addition, roundwood is usually purchased on a weight basis. About 10 to 15 percent of the weight of roundwood is bark, which is typically not used in the manufacture of pellets. Thus, the cost of the actual wood fiber is increased by the proportion of bark included. Finally, unless it comes from standing dead trees, roundwood has to be dried because its moisture content is too high for pelletizing.

Pellet plants range in size from plants as small as 5,000 to 10,000 tons per year to plants producing more than 500,000 tons of pellets per year. There can be virtually no yield loss in going from the incoming feedstock to finished pellets. Thus, the output of a plant can mirror relatively closely the incoming raw material requirement. However, it is a fairly common practice to screen fines from the finished product and use those fines as fuel for a dryer, which dries the pellet feedstock to the appropriate moisture content. The fines can also be supplied to the co-located biomass CHP for fuel.

4.3 Market Characteristics

Wood pellets have two main uses. The first is for space heating, including residential, commercial, and industrial buildings. The second is for co-firing with coal in the production of electrical power. The global market for wood pellets has grown rapidly. In 2013, the global market for wood pellets was estimated to be 23.6 million metric tons. Since 2001, the size of the market has grown by an average of 21 percent annually. Of the consumption in 2013, 4.0 million metric tons was burned in North America, primarily for space heating. 1.0 million was utilized in Asia. Europe used 10.0 million for space heating and 9 million for co-firing. The market is forecast to grow to over 50 million metric tons by 2025 (see **Figure 4.6**).

Appendix 4: Figure 4 – Forecasted Global Pellet Demand (Millions of Metric Tons)



Source: Poyry & Wood Pellet Association of Canada

As shown in the figure, the North American market is forecast to be relatively stable due to its market being primarily for space heating. This fact offers a potential advantage to a pellet producer in Northern California manufacturing pellets (as a replacement fuel for homeowners replacing more costly propane and heating oil) for domestic space heating in the region.

Also illustrated in **Figure 4.6** is data showing that the Asian market is forecasted to be a significant part of the growth, with the main use being for co-firing. Up to this point, much of the demand from Asia has been satisfied from pellet manufacturers in Vietnam and from a relatively small amount of pellets that are exported from Canada and the Western U.S.

Many believe that further development of an Asian market will be an opportunity for wood pellet manufacturers on the U.S. and Canadian West Coast. However, several obstacles exist. First, there are a number of existing pellet manufacturers in British Columbia that have access to low cost feedstocks (i.e., mill residues that have limited market value aside from use as pellet feedstock) and well established logistics, including networks for transporting pellets from the mill via rail and truck to port facilities, storage and handling infrastructure at the port, and ports with sufficient depth to accommodate large bulk carriers. Such world class pellet handling logistics in the Pacific Northwest and CA are not well established.

Second, while there may be an ample supply of feedstock available from pulpwood, the economics of manufacturing pellets using pulpwood feedstock are less cost-effective than using mill byproducts. This is because the full cost of harvesting and hauling the pulpwood must be borne by the pelleting operation. When mill residues are used, the cost of harvesting and hauling the material to a centralized location is "subsidized" by the sawmill.

Additional information about pellet markets can be inferred from the Wood Briquette section since both products can be used for home heating. Remember, however, that use of wood pellets require homeowners to purchase a special pellet stove. Wood briquettes can be utilized in an existing fireplace or wood stove.

4.4 Production Characteristics

Assuming that the incoming feedstock is clean (no bark) chips produced from small diameter roundwood, the process of pellet manufacturing includes the following steps:

4. Fiber Preparation – incoming raw material must be screened to remove tramp material such as metal, stones, dirt, glass, etc.
5. Drying – the incoming chips must be dried to the moisture content appropriate for pelletizing (i.e., about 10 percent moisture – wet basis). This is accomplished with either a rotary drum dryer or a belt dryer. The chosen drying system can supplied with boiler flue gas from the co-located biomass CHP if a rotary drum dryer is chosen, or process steam if a belt dryer is chosen
6. Grinding – the raw material must be ground to a size of approximately plus or minus 1/8" prior to being pelletized. The grinding process is completed using a series of hammermills, with each successive mill providing a more finely ground product.
7. Conditioning – just prior to entering the pellet mill, the feedstock is *conditioned*. This stage is commonly accomplished by injecting steam into the finished raw material. This contact of the hot steam with the wood fiber raises the temperature of the material and creates a very fine film of moisture on the surface of the feedstock. Conditioning also lowers the amount of mechanical energy needed to force the material through the pellet dies.
8. Pelleting – as shown in **Figure 4.5**, the raw material enters the pellet mill die cavity, and the roller then forces the material to exit the die cavity. A cut-off knife on the underside of the dies cuts the pellets off at the desired length – most pellets are about one quarter to five sixteenths inch in diameter and three quarters to one and one half inches long. Incoming feedstock generally weighs about 10 pounds per cubic foot compared to finished pellets weighing about 40 pounds per cubic foot.
9. Cooling – as the material is forced through the dies, the pressure increases, which, in turn, causes the temperature of the pellets coming out the dies to increase to about 200

degrees Fahrenheit. Pellets exiting the dies need to be cooled so that they are more durable and become “set” in their final form.

10. Screening – after the pellets are cooled they are screened to remove any fines that may have been generated during the process.
11. Bagging and Palletizing – for pellet plants making pellets for the home heating market, the final step in the process is bagging the pellets into 40 pound plastic bags. This is accomplished by feeding the pellets into a bagging bin. A fixed amount of pellets is fed from the bin into a plastic bag. The bags are then placed on pallets – usually 50 bags per pallet, with each bag weighing 40 pounds. Thus, a single pallet contains a ton of pellets. The pallet is then shrink wrapped and a slip cover is placed over it to protect the pellets from moisture.

Thus, the main pieces of equipment for the pelletizing process include various conveyors and transfers, hammermills, a dryer, a feedstock conditioner (steam), pellet mills, pellet cooler, screening system, and a bagger/palletizer. An order of magnitude factor for estimating capital costs for relatively large pellet plants (e.g., > 100,000 tons per year) is $175 to $225 per ton of pellet manufacturing capacity per year. For example, a 100,000 ton per year plant would have an estimated capital cost of $17.5 to $22.5 million. BECK is not aware of a rule of thumb factor for the capital cost at smaller plants, (e.g., < 50,000 tons per year). However, it is likely to be greater than $225 per ton of capacity since soft costs, such as permitting, engineering, etc., are likely to be a higher percentage of the total cost.

Table 4.12 later in this section shows a thermal load for raw material drying of 22.8 million BTU/hour for a commercial pellet operation. This is about twice the thermal load modeled for the biomass CHP and can be supplied through a combination of hot boiler flue gas and process steam.

4.5 Location Requirements

Pellet manufacturing is a power intensive process. Therefore, a robust electrical service is required. A general rule of the thumb is that every ton per hour of manufacturing capacity requires 100 horsepower of electrical motors to operate the pellet mill. For example, a pellet mill with a capacity of 5 tons per hour requires a 500 horsepower motor. A number of additional motors are required for conveyors, hammermills, etc. As an example, a 50,000 ton per year mill requires about 2,500 connected horsepower of electrical motors.

Another consideration for pellet manufacturing is that during certain times, bagged Douglas fir pellets can be in high demand in the U.S. Northeast. Existing pellet manufacturers in the Pacific Northwest have shipped pellets by rail all the way to the U.S. Northeast. Therefore, locating at a site with a rail siding potentially could be an important consideration.

5. POST AND POLE

5.1 Technology Overview

This technology involves the processing of manufacturing tree stems into finished products (posts and poles) that still have a round cross section and range in length from 8 to 20 or more feet and in diameter from 2 inches to as much as 10 inches.

The main piece of equipment for producing such products is either a post peeler or a doweller. A peeler is a machine that removes the bark and a thin layer of wood fiber from the outer surface of a log while maintaining the natural taper of the log. The post and pole doweller is a machine that feeds the long axis of a log through a rotating set of knives to produce a post or pole that has a fixed diameter along its entire length. Dowelling machines are much more productive than peeling machines, but have a higher capital cost. Some customers prefer that the post and poles have the natural taper, while others prefer dowels that have a uniform diameter along the entire length of the log. Therefore, it is fairly common that post and pole manufacturing plants have both peelers and dowellers on site.

5.2 Raw Material Specifications

Relative to some of the other technologies considered in this report, post and poles have more stringent raw material specifications. For example, the following is a description of the incoming log specifications at a post and pole plant operating in Eastern Oregon. The operation buys three species of logs: lodgepole pine, ponderosa pine, and white fir. Regardless of species, logs are received in lengths of 16, 18, 24, and 32 feet, with a 6 inch over length allowance on all logs. Also, regardless of species, logs can be no larger than 10” in diameter at the large end. Finally, logs can be no less than 4” on the small end.

Regarding the pricing of delivered raw material, there are differences by species. The following prices were current as of 2012: $36 to $38 per green ton for lodgepole pine, $30 to $32 per green ton for ponderosa pine, and $28 to $30 per green ton for white fir. All prices are for logs delivered to the post and pole yard.

The typical post and pole plant in the U.S. West consumes about 10,000 bone dry tons of raw material annually.

5.3 Market Characteristics

The post and pole market is a consumer of small diameter roundwood. According to a study conducted by the U.S. Forest Service, the post and pole industry in 12 western U.S. states produced an estimated 60,000,000 linear feet of treated and untreated posts and poles of varying diameter in 2001 (the most recent data available). Of that amount, about one-third was produced in Montana and one-quarter in Oregon, the first and second leading post and pole producing states, respectively. A significant market for posts and poles is the vineyard industry in California and, to a lesser extent, Oregon.

Although a number of species are commonly used in the western U.S. for the manufacture of posts and poles, Lodgepole pine is a preferred species because the bark is thin, which makes for relatively easy processing. The trees tend to grow in densely stocked stands, have smaller branches (small knots), and occur in nearly pure stands. This means that the stems tend to be very straight, with little taper and defects, which results in posts and poles with desirable characteristics. In addition, Lodgepole pine trees tend to have a large sapwood area. This means that the chemical preservative is readily absorbed by this species.

Post and Pole manufacturers in the Western U.S. produced an estimated 60 million linear feet of treated and untreated material in 2001. The production falls into four general post and pole size classes. **Table 4.9** shows the relative amount of production in each size category produced in 2001 (the most recent data available).

Appendix 4: Table 4 – Size Distribution of Post and Pole Production in the Western U.S.

Size Class	Percent of Production (lineal foot basis)
2.0 to 2.9 inches	13
3.0 to 4.9 inches	56
5.0 to 6.9 inches	26
7.0 inches and larger	5
Total	**100**

Table 4.10 shows the prices obtained per linear foot (f.o.b. the plant) for both treated and untreated material. As shown in the table, treating provides manufacturers with an average increase in value of 12 percent (unweighted by volume in each size class) and by 16.5 percent (weighted by volume in each size class).

Appendix 4: Table 5 - Post and Pole Average Sales Value by Diameter Class and Treated Versus Untreated

Size Class	Treated ($/lineal foot)	Untreated ($/lineal foot)
2.0 to 2.9 inches	0.36	0.33
3.0 to 4.9 inches	0.6	0.49
5.0 to 6.9 inches	1.12	1.02
7.0 inches and larger	1.84	1.75

5.4 Production Characteristics

Post and pole operations in the Western U.S. use several methods for preparing the posts and poles for “peeling” or dowelling. For example, a fairly common procedure is to use tracked loaders equipped with forest harvesting processing heads in the log yard to cut whole length stems to the desired lengths (e.g., 6’ to 16’). Then the bucked lengths are sorted into mobile bins by diameter, and the bins are transported to the peeler or doweller for further manufacturing. This “pre-sorting” process allows the plant to run efficiently since all of the material being processed at a given time is uniform in size.

Another common practice is for logs from the log yard to be placed on log transfer decks. The logs are then advanced to chop saws, which buck the whole length stems into post and pole standard lengths. This process is less costly than bucking and sorting logs to size in the log yard. However, it also means the post and pole plant must process material of varying sizes simultaneously, which can lead to lower efficiency. The posts and poles under this scenario are sorted to size classes after they are peeled or dowelled.

As previously described, posts and poles are produced by either a peeling or dowelling machine. It is common for post and pole plants to have additional pieces of equipment for producing posts and poles with pointed ends or for boring into the posts for producing a mortise/tenon type joint for making wooden fences.

Finished posts and poles are sorted into bins and then wrapped with metal banding for shipment to customers. For posts and poles that are to be treated, they are typically stored in a yard for air drying prior to application of the chemical treatment. Chemical preservatives are applied using standard pressure treating equipment.

The equipment required for post and pole manufacturing includes a front-end loader for unloading log trucks and loading finished product onto trucks; a tracked loader equipped with a processing head for bucking and sorting tree length stems; and a post and pole peeler and/or dowelling machine, including log deck, transfers, outfeed conveyors, outfeed sort transfers, waste conveyers and a dust/chip blower. An order of magnitude capital cost estimate for all of this equipment, including land and building, is $2.0 to $2.5 million.

Depending on the scale of the plant and the degree of automation designed into the process, post and pole plants require 5 to 15 employees.

5.5 Location Requirements

Similar to the other technologies considered in this report, the site requirements include access to a highway that has been designed to allow long and heavy trucks to easily enter and exit the site from the highway (e.g., turn lanes and road width adequate to accommodate trucks with a wide turning radius). In terms of space, a post and pole facility can be located on a site of about 10 acres in size. The site will also need a truck scale for weighing incoming and exiting log trucks since the raw material is purchased on a dollars per ton basis.

6. SAWN LUMBER FROM SMALL DIAMETER LOGS

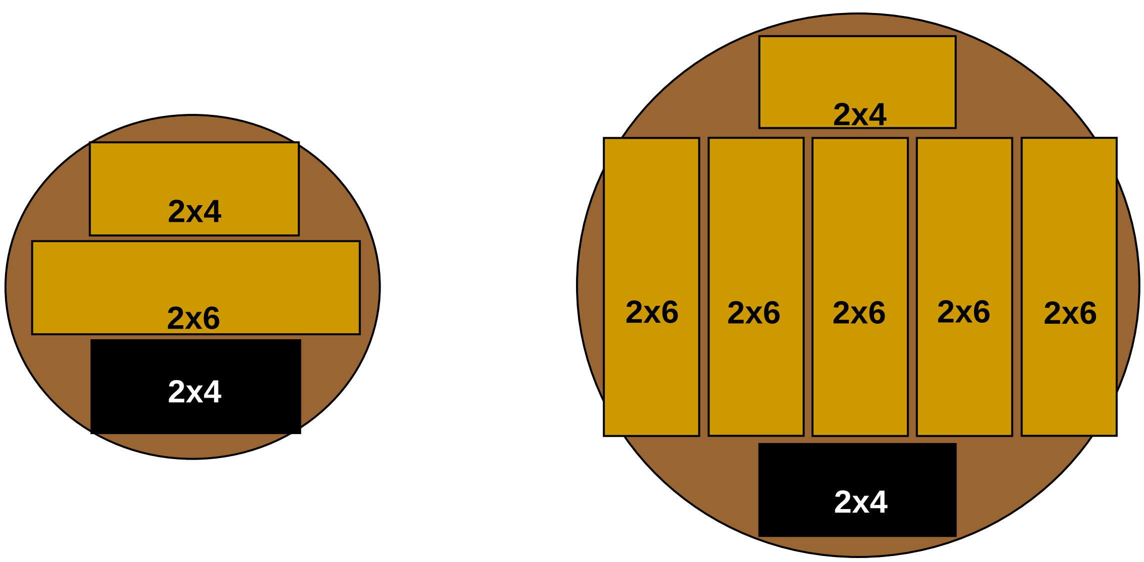
6.1 Technology Overview

The technology of sawmilling is mature and well proven. However, with respect to a small log sawmill, there continue to be incremental changes aimed at improving: 1) efficiency (log to lumber recovery); 2) productivity (increasing log processing speed); and 3) automation (upgrading/improving). Each of the following paragraphs describe these factors.

Recovery refers to the efficiency with which the cubic volume of the log is converted into lumber. Recovery at sawmills has improved perhaps most significantly because of the development of systems for scanning logs prior to sawing so that the sawing solution that will yield the highest combination of lumber volume and value can be produced. Complementing the scanning systems are log positioning systems that are capable of orienting the log relative to the saw in the position the scanning system has identified for achieving the optimal log to lumber breakdown.

To illustrate the importance of recovery consider the following. In small logs an error in recovery results in a much higher loss in lumber output volume relative to a similar error on a larger log. In **Figure 4.8**, assume the log on the left has a small end diameter of 6.5 inches, is 12 feet long, and will yield a sawing solution of two 2x4s and one 2x6 (28 board feet) if sawn optimally. However, if the log is not positioned relative to the saws correctly and one of the 2x4s cannot be recovered, then the log will only yield 20 board feet of lumber, and the sawing mistake causes a 29 percent volume reduction. In contrast, the log on the right has a small end diameter of 10” and is 12’ long and will yield 76 board feet of lumber if sawn optimally. If one of the 2x4 pieces of lumber cannot be recovered, the yield drops to 68 board feet –only an 11 percent reduction on lumber volume recovery.

Appendix 4: Figure 5 – Importance of Sawing Accuracy in Small Logs



The scanning and log positioning systems just described are able to operate at very high speeds. Achieving high throughput rates is critically important for small log processing because many pieces must be handled to achieve a desired level of output. For example, consider two sawmills with each producing 60 million board feet per year when operating 8 hours per day (one shift). Mill A saws logs that average 10” small end diameter and are 12’ long. Mill B saws logs that average 6.5” small end diameter and are 12’ long. Mill A will yield about 76 board feet of dimension lumber per log and will have to cut about 6.6 logs every minute. Mill B will yield about 28 board feet of lumber per block and will have to cut about 17.8 blocks per minute. Thus, in order for both mills to achieve the same annual production over 2,000 hours, Mill B needs to run nearly three times as fast.

Automation is the third critical factor in small log sawmilling. Many of the historically labor intensive processes in a sawmill have been automated. For example, sorting lumber by grade/length on a green chain using labor has been replaced by automated bin sorters that recognize special markings on individual boards to drop the piece out at the appropriate bin. Another example is that lumber grading has been highly automated.

6.2 Raw Material Specifications

To develop a small log sawmill that would be able to produce softwood lumber cost competitively (i.e., be of sufficient scale to operate at relatively low per unit manufacturing cost), a mill would require 30 to 40 million board feet of logs per year when operating on a one shift basis and sawing only logs less than 12 inches in diameter (i.e., a 4.5” minimum small end diameter and a 12” maximum large end diameter) and a minimum length of 16 feet.

6.3 Market Characteristics

In general, lumber markets rise and fall with new home construction and repair/remodeling activity. This is especially true of structural lumber products, but it also applies to many types of specialty products. **Table 4.12** provides a summary of how softwood lumber production/demand has risen and fallen in North America over the last 10 year economic cycle.

Appendix 4: Table 6 – Western Wood Products Association Softwood Lumber Industry Production and Consumption 2006 to 2014 (MMBF)

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
U.S. Lumber Production										
West	19,333	17,983	16,315	12,994	10,710	11,137	11,617	12,593	13,488	14,067
South	18,986	18,696	16,985	14,641	11,789	12,354	13,474	14,295	15,071	16,111
Other	2,138	2,047	1,858	1,542	1,255	1,311	1,414	949	1,392	1,471
Total U.S. Lumber Production	*40,457*	*38,726*	*35,158*	*29,177*	*23,754*	*24,802*	*26,505*	*27,837*	*29,951*	*31,649*
Imports to U.S. from Canada										
From British Columbia	12,231	11,859	9,814	6,781	5,075	5,252	4,797	5,336	5,916	6,199
From East of Rockies	9,274	8,290	6,858	4,840	3,228	3,781	4,051	4,192	4,999	5,939
Total imports from Canada	*21,505*	*20,149*	*16,672*	*11,621*	*8,303*	*9,033*	*8,848*	*9,528*	*10,915*	*12,138*
Imports to U.S. from Other Regions										
From Latin America	-	785	620	426	285	231	202	161	193	329
From Europe	-	1,603	880	487	177	105	147	87	146	142
Total Non-Canadian	-	*2,657*	*1,712*	*1,060*	*551*	*435*	*441*	*336*	*442*	*569*
Total Lumber Imports into U.S.	*21,505*	*22,806*	*18,384*	*12,681*	*8,854*	*9,468*	*9,289*	*9,864*	*11,357*	*12,707*
U.S. Exports of Lumber										
to Canada	248	250	254	295	268	395	350	377	383	371
to China	-	-	-	-	-	154	422	245	396	344
to Japan	51	51	67	101	115	161	175	164	181	129
to Mexico	224	209	196	207	182	197	235	282	288	296
to All Others	375	420	476	421	417	440	485	514	545	600
Total U.S. Lumber Exports	*898*	*930*	*993*	*1,024*	*982*	*1,347*	*1,667*	*1,582*	*1,793*	*1,740*
U.S. Softwood Lumber Consumption										
Shipments from U.S. Producers	40,553	38,596	34,712	29,153	24,001	24,700	26,503	27,734	29,940	31,619
Plus Imports	24,678	22,806	18,385	12,681	8,855	9,468	9,289	9,864	11,357	12,707
Minus Exports	(897)	(930)	(993)	(1,024)	(983)	(1,347)	(1,667)	(1,582)	(1,793)	(1,740)
Apparent Consumption	***64,334***	***60,472***	***52,104***	***40,810***	***31,873***	***32,821***	***34,125***	***36,016***	***39,504***	***42,586***

6.4 Production Characteristics

Sawmilling is a relatively complicated process. Incoming logs are typically purchased on a weight basis (for small diameter logs). The logs are then debarked and bucked to lumber lengths (e.g., 8 to 20 or more feet in two foot increments). The bucked log lengths then enter the sawmill where (for small log operations) they typically are processed from log into lumber and byproducts in a "single pass". In other words, at a larger log sawmill, a single log will reciprocate numerous times through the single saw. Small log mills, in contrast, generally have multiple saws and chipping heads at the primary breakdown so that the log is converted into a combination of lumber, chips, and sawdust in a single pass.

Beyond the primary breakdown, a small log sawmill will be very similar to mills that process larger logs. In other words, there will be conveyors for moving the lumber through the process, bins for sorting lumber into like widths, lengths, grades, etc. Stackers for stacking lumber into units prior to drying in dry kilns. And a planer mill for finishing lumber to its final dimension.

An order of magnitude capital cost for developing a "greenfield" small log sawmill is $35 to $45 million dollars, and it would include bucking and debarking equipment, a sawmill, lumber dry kilns, and a planer.

Cost competitive dimension and stud mills in the Western U.S. will have per unit manufacturing costs of roughly $120 to $140 per thousand board feet of lumber produced. This includes all costs for handling, debarking and bucking logs in the log yard, sawmilling, drying, planing, and general and administrative expenses, including depreciation. In other words, all of the costs for manufacturing lumber except for the cost of purchasing the logs.

Another key production characteristic of small log sawmilling is that it produces significantly more mill residues than sawmills processing larger diameter logs. For example, using the sawmills from the previous comparison (Mill A processing logs that average 10" in small end diameter and Mill B processing logs that average 6.5" in small end diameter), if each sawmill produces 100 million board feet of lumber per year, the small log mill will produce an estimated 63,000 bone dry tons of chips compared to an estimated 29,000 bone dry tons of chips at the mill processing larger logs. This is because larger logs allow for a higher proportion of the log's cubic volume to be recovered as lumber.

The small log sawmill described above would supply a substantial fraction of the fuel required by the co-located small biomass CHP. Table 4.12 later in this section shows that such a mill would have a thermal demand of 29.8 million BTU per hour of low pressure steam, about 3 times the amount included in the small biomass CHP model.

6.5 Location Requirements

Small log sawmilling would require significantly more space than most of the other technologies considered in this report – perhaps a total of 20 to 40 acres, depending on the scale of the operation. In addition, like some of the other technologies considered, a sawmill is fairly power intensive, so the electrical service to the site must be robust. Also, small logs are typically purchased on a weight basis, so the site needs a truck scale. Small log sawmilling will involve lumber drying. Therefore, the site will need a boiler or co-located biomass CHP that will likely be fired, at least partially, by sawmill residues. Finally, lumber is often shipped long distances to end users. Therefore, a site with a rail siding would almost certainly be a requirement for this technology

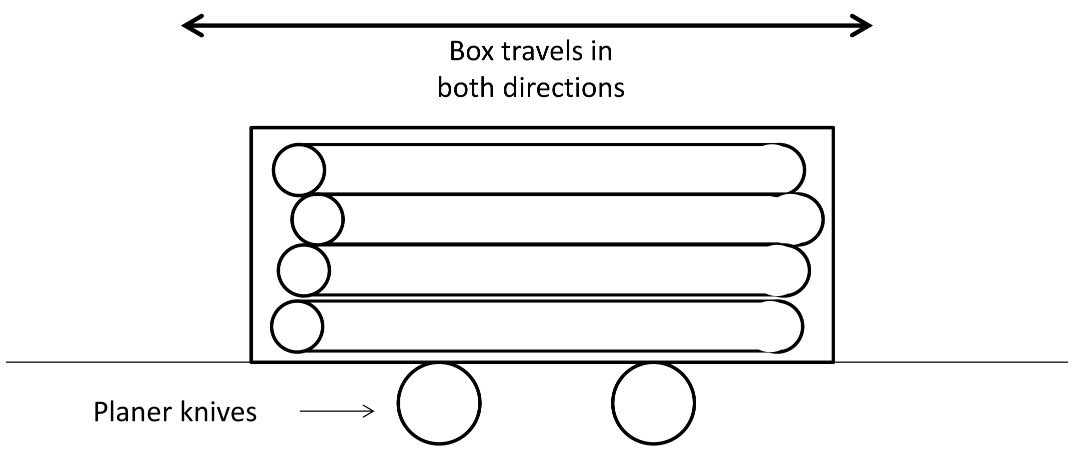
7. SHAVINGS (ANIMAL BEDDING)

7.1 Technology Overview

Shavings made from wood fiber are commonly used as bedding for animals, including horses, chickens, and small pets kept in cages. Historically, the shavings used for this purpose came from the byproducts of sawmilling (i.e., when lumber is planed to its final dimension). The Great Recession, when sawmills were operating at historically low levels and producing limited amounts of shavings, spurred wider adoption of a technology for converting small diameter roundwood into shavings.

Small diameter logs are placed into bins that move back and forth over planer knives. As the logs move across the rotating knives, gravity presses the logs against the knives and shavings are produced. **Figure 4.9** illustrates the concept from a side view.

Appendix 4: Figure 6 – Small Diameter Roundwood Shavings Planer (side view)



7.2 Raw Material Specifications

The raw material requirements for making wood shavings are not restrictive (i.e., a wide range of material sizes and species can be used). Common specifications for the feedstock are a minimum small end log diameter of 3 inches, a maximum diameter of 20 inches, and a minimum length of 8 feet. These specifications are very similar to “pulpwood” specifications at a whole tree chipping operation.

A shavings machine operating on a one-shift basis will consume about 25,000 green tons (12,500 BDT) of small diameter trees annually. This translates into the production of about 700,000 bags of shavings per year (3 cubic feet of compressed shavings per bag). Shavings operations typically pay about $25 to $35 per green ton for raw material delivered to the facility in roundwood form.

7.3 Market Characteristics

In the Western U.S. the largest market for wood shavings is bedding for horses. This type of bedding is sold in bags. A convention in the industry is to start with 9 cubic feet of shavings and compress it into a plastic bag with a volume of 3 cubic feet. When the end user of the shavings opens the bag, the shavings again expand to a volume of 9 cubic feet.

BECK is not aware of any published information about the size of the market for animal bedding from wood shavings. However, the population of horses can provide us with an indication of market size. **Table 4.13** shows the Western U.S. horse population by state in 2012. Assuming that 15 percent of those horses are bedded in a stable and that each of those horses uses one bag of shavings every other day, it translates into an annual usage of over 23.1 million bags of shavings per year. Assuming an expansion factor of 2.5 when going from solid wood to shavings, a total of 1.2 cubic feet of solid wood is contained in each bag. This, in turn, translates to about 33 pounds of wood per bag. Assuming a weight of 33 pounds per bag (at 10 percent moisture content), the estimated size of the bagged shavings in tons is about 380,000 tons per year.

Bagged shavings (3 compressed cubic feet/bag) sell for about $5 to $6 per bag at the retail level. At the shavings plant, bags typically sell for about $2.50 to $3.00 per bag depending on the operation and the distance to market.

Appendix 4: Table 7 – Western U.S. Horse Population (2012)

State	Horse Population
AZ	92,394
CA	142,555
CO	110,360
ID	61,439
NM	50,723
NV	22,464
MT	97,921
OR	70,427
UT	58,979
WA	64,616
WY	72,461
Total	**844,339**

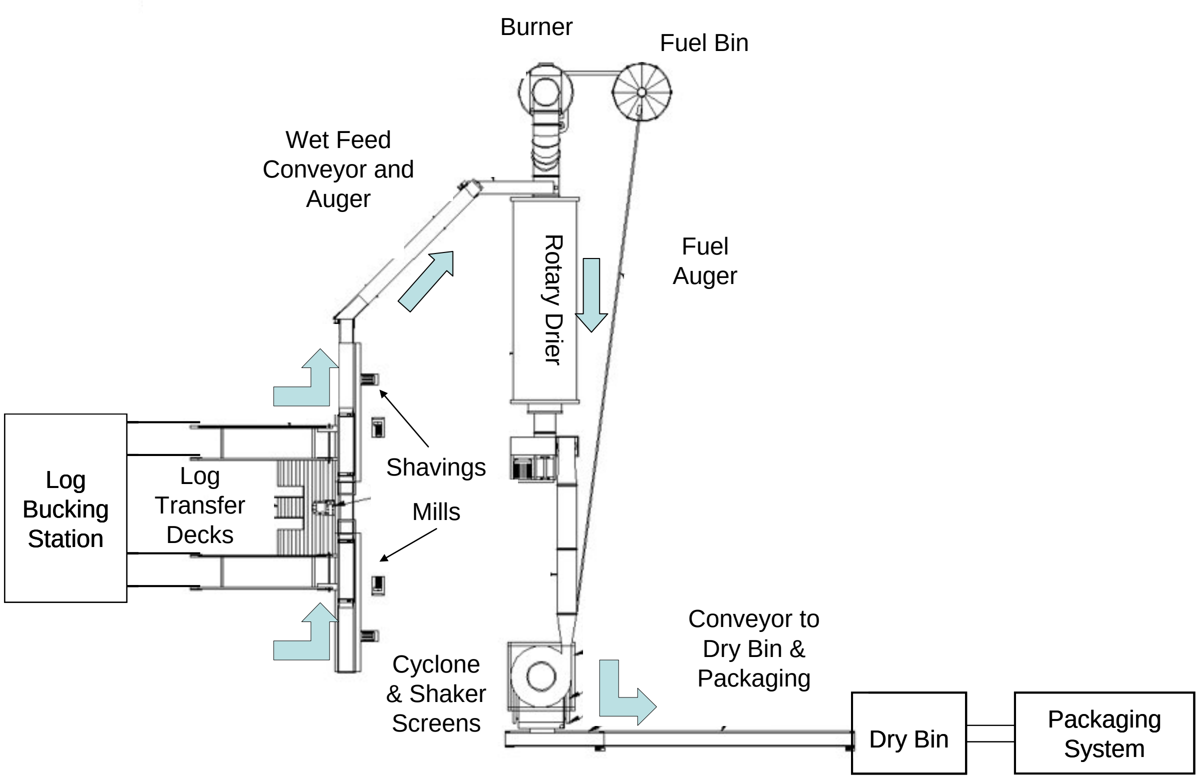
7.4 Production Characteristics

Manufacturing wood shavings from roundwood is a relatively simply process. The diagram shown in **Figure 4.10** is a typical shavings operation layout. The blue arrows show the flow of material. Starting at the left side of the diagram, a log bucking station cuts the logs to length (either 4’ lengths or 8’ lengths, depending on the type of shaving machine). If a biomass burner is used for drying the material, logs do not need to be debarked prior to conversion to shavings because much of the bark becomes the fines that are burned in the dryer. In this example, the burner would be replaced by a co-located biomass CHP facility and the dryer supplied by some combination of hot boiler flue gases and process steam, and the bark fines supplied to the biomass CHP as fuel.

The bucked logs are placed on log transfer decks, which move the logs to the shaving machine(s) **Figure 4.9** shows a simplified drawing of the two machines. Planer knives in the shavings machine convert the roundwood into shavings, which then fall out of the bottom of the machine and onto a conveyor and auger system that delivers the shavings to the dryer. The shavings pass through the dryer and exit at about 12 percent moisture content (by weight).

Next, a cyclone system transfers the dried shavings to one or more screens which sort the smaller and larger shavings pieces. The small pieces from the screener are sent back to the fuel bin to await being burned to provide heat for the dryer or biomass CHP. Typically, about 12 to 15 percent (dry volume basis) of the original material ends up as burner fuel (most of which is bark). The larger portions exit the screener and are conveyed to a large dry bin. From the dry bin, the shavings are sent to a packaging machine where they are compressed and bagged. Filled bags are placed on pallets and then shrink-wrapped prior to shipment.

Appendix 4: Figure 7 – Wood Shavings Manufacturing Process Layout Diagram



The following is a list of the capital equipment required for the operation of a stand-alone wood shavings plant:

- **Truck Scale –** raw material (logs) for the plant is purchased on a weight basis. Therefore, a truck scale is required to measure the volume of logs received on each truckload.
- **Forklift –** the forklift will perform multiple functions at the operation (e.g., feeding logs from the log storage area into the manufacturing process, unloading logs from trucks [in the case of trucks that do not have self-loaders], moving pallets of finished product into storage, loading outbound trucks with pallets of finished product). Special attachments for the forklift (log tongs and forks) are required to complete all of these functions.
- **Knuckleboom Loader/Cut-Off Saw –** this is a stationary piece of equipment that processes longer length logs into pieces of the appropriate length for the shavings mill.
- **Log Transfer Decks –** these are chain conveyors that are used to transport cut-to-length logs to the shavings mill.
- **Shavings Mill –** this is the equipment used to convert the logs into shavings.
- **Burner/Fuel Bin/Rotary Drum Dryer/Cyclone –** this set of equipment is used to dry the shavings to a low enough level of moisture so that the shavings can be packaged in bags without developing mold, mildew, fungus, etc. A number of different fuels can be used to heat the dryer, but we have assumed the dryer will burn the small material (fines) produced by the shavings process since this is the most cost efficient fuel. Alternatively, the heat for the dryer would be supplied by the co-located biomass CHP.
- **Dry Bin –** this is simply a large bin for storing dried shavings prior to bagging.
- **Bagger –** this piece of equipment is an automated bagging system for compressing the wood shavings into a sealed bag that can more efficiently be stored and shipped than uncompressed bulk shavings.
- **Miscellaneous Conveyers** – many of the previously described pieces of equipment are connected with belt conveyors for transporting the material from station to station as it flows through the manufacturing process.

An order of magnitude capital cost estimate for the preceding list of equipment and a 100’ x 100’ building is $3.0 to $3.5 million.

A shavings operation such as the plant described here requires staffing of four hourly employees. One person is needed to operate the log bucking station. A second is needed to offload the bucked logs into the shavings machine(s). A third person is needed on the back end of the plant for operating the bagging machine and stacking finished bags onto pallets. A fourth person is needed to operate a loader for feeding logs to the operation and taking finished pallets of shavings away from the back end of the operation. Table 4.12 later in this section describes a thermal requirement for drying of 9.4 million Btu/hr for a commercial shavings operation. This is virtually the modeled amount of thermal energy from the small biomass CHP.

7.5 Location Requirements

The site for a shavings plant must be readily accessible by semi-tractor trailer typed trucks (i.e., wide entry/exit roads at the site and roads into and out of the site that are capable of supporting trucks weighing as much as 80,000 pounds. A shavings plant of the scale described here will use electrical power requiring service to the site of approximately 500 to 1,000 kilowatts. The raw material procured for the plant would be purchased on a weight basis, which means the site would require a truck scale. In terms of size, a facility of the scale described here could be sited on a space of 5 to 10 acres.