

# ADVANCED WOOD PRODUCT MANUFACTURING STUDY FOR CROSS-LAMINATED TIMBER ACCELERATION IN OREGON & SW WASHINGTON, 2017

A Catalytic Project of the Pacific Northwest Manufacturing Partnership

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# SUMMARY

Oregon and southwest Washington are poised as a manufacturing hub for the emerging Cross Laminated Timber (CLT) market in the United States. The region is bountiful with luscious forestland, a large percentage of which is designated as working forests. Thirty million acres of forest span across Oregon alone. As a value add product that has environmental and social co-benefits, CLT is economically competitive as a structural framing product for multi-story, even high-rise building construction: a market previously dominated by concrete and steel.

CLT was first developed in the 1990s, in Europe. Global CLT production has been steadily increasing, with nearly 80% of it produced in central Europe. Demand for the product has slowly grown, but there is very little commercial production of CLT in the US. A task force of partners recognized the potential for the Pacific Northwest to effectively compete with European and Canadian manufacturers with effective strategic activities and partnerships.

The research and outreach activities performed as part of this 2015-2017 study have played a vital role in continuing the advancement of the CLT market in Oregon & SW Washington. Eager regional stakeholders see CLT and other mass timber panel products as forest products capable of providing economic benefit to communities within our region that had grown around forest product industries.

Oregon BEST partnered with eight regional stakeholders to evaluate the potential of and accelerate the developing market for CLT (mass timber panels) in Oregon and Southwest Washington. With funding from the Economic Development Administration (EDA), Oregon BEST and its partners have conducted research to provide a realistic assessment of CLT's market potential in this region.

The study aimed to answer key questions about the developing panel market in Oregon and southwest Washington. In a basic sense, these questions were:

- Is the mass timber panel market a feasible and sustainable market in Oregon?
- How much of the domestic US market could CLT and other mass timber products penetrate?
- Based on that demand, can regional forest & lumber producers supply enough raw material?
- Which companies could the region look at to come online as a producer?
- How would the estimated demand impact Oregon & SW Washington?
- What are the barriers to accelerating the CLT market?
- What support and/or resources do Oregon partners need to continue moving forward?

To estimate the potential market and economic impact in the region, this analysis ultimately turned to the expertise of FPIInnovations. FPI and regional industry experts incrementally estimated the potential market for mass timber in the U.S. (based on 2015 new construction data) to be up to 6.1 billion board feet in new and existing markets (Fell, 2017). With this level of potential market demand for material domestically, the need for raw material processing, lumber drying, innovation, manufacturing, education of design & construction staff, and multi-organizational collaboration is vital to the success of this transformative market. An initial approach was taken by the team, led by Oregon State University, to quantify the economic impact based on construction data and forecasting for the Pacific Northwest; however, this method severely underestimated the market potential for PNW manufacturers. Results of that 2015-16 market sizing assessment can be found in the Appendix: NW Council Data.

The manufacture of CLT panels in Oregon, especially if the raw materials (lumber or logs) are sourced within Oregon, will have **positive economic impacts on the region**. Economic analysis by Business Oregon determined that cross-laminated timber (CLT) and related mass timber manufacturing has the potential to create 2,000 to 6,100 direct jobs in Oregon, depending on Oregon's market share of demand for mass timber in the U.S. Including jobs created by indirect and induced impacts, approximately 5,800 to 17,300 jobs could be created in Oregon from mass timber manufacturing. For every job created in mass timber manufacturing in Oregon, an additional 1.8 jobs would be created.

Labor income generated from direct jobs in mass timber manufacturing would range from \$124 to \$371 million a year. Labor income from total impacts would be between \$338 million and \$1 billion annually. State personal income taxes generated from direct labor income would range from \$4.1 to \$12.4 million a year. State personal income taxes generated from total impacts would be between \$11.3 and \$33.8 million annually.

An increased demand for this engineered wood product is sure to increase the **demand for natural resources**. The question has been raised as to whether increased demand for wood challenges the sustainability of forests? The expertise of Oregon Department of Forestry and Clackamas County Forest Management staff were brought in to address this concern. While it is expected that an increased market share for mass timber products (particularly CLT) would raise the regional consumption levels for wood, evaluation of growth and yield as well as additional investigation underlines that there is no concern regarding the ability of PNW forests to support increasing demands while remaining sustainable in terms of production capacity and forest health. Beyond forest and harvest capability, there is an expected constriction where kiln capacity is concerned. Economic incentive parallel to increased demand should be sufficient for developing additional capacity and is not a limiting factor long term. Additionally, there is also recognition that CLT production methods continue to evolve and as additional species and materials are considered the volume of material available for inclusion in production grows as well. Overall, with current analysis, it is clear that Oregon and the broader PNW forests are more than capable of accommodating both near term and long term demand for CLT and other mass timber products; however, access to the raw material is uncertain and a heavily debated topic.

The recent increased demand for wood structural panels has instigated the onset of multiple additional CLT producers. Columbia Vista, American Laminators, and Vaagan Brothers are expected to join the only two other U.S. manufacturers, DR Johnson (Riddle, Oregon) and SmartLam (Columbia Falls, Montana), by 2019. Freres Bros (Lyons, Oregon) will also be coming on the market soon with mass plywood panels. Prior to these rapidly changing developments being publically announced, Oregon Manufacturing Extension Partnership (OMEP) lent their expertise in analyzing the **characteristics and capabilities of potential producers of CLT in the region**. Partners from this study interacted with dozens of companies in the forest products industry and profiled 10 companies who were determined by partners to have strong potential as a "next producer of CLT". As of late 2016, only 3 of the 10 companies surveyed were considering an investment in CLT manufacturing. The survey revealed a few common themes:

- All the respondents found CLT is interesting, but many felt the market is not quite mature enough
- Many respondents were concerned about the lumber availability and pricing.
- As CLT has not been used in many jurisdictions, concern was expressed that the demand would be blunted until CLT use was permitted for additional structures.



In this early adoption market, incentivizing potential producers would support investment by companies needed to enter the CLT manufacturing and supply chain market. As with any investment, an appropriate risk adjusted return is required to induce action. Any systematic action that can be done to increase perceived (or actual demand) or reduce cost (or risk) should have an effect on investment. Such actions could include:

1. Grants or subsidies for equipment (or assistance into federal programs, including R&D tax credit)
2. Loan guarantees for equipment
3. Working to increase prescriptive codes for CLT beyond 5 stories in Oregon and elsewhere
4. Providing streamlined permitting for buildings using Oregon CLT
5. Marketing to engineering/design firms about Oregon CLT or CLT in general
6. Creating a protected purchasing program (or guaranteed cost savings subsidy) for government buildings built with Oregon CLT.
7. Facilitating discussions with potential partners (investors, building contractors, etc.)

The average return in the wood products industry is 10%<sup>1</sup> for publically held firms; however privately held or family run business likely has a higher threshold, likely 20% or higher<sup>2</sup>. While CLT holds promise of higher margins than commodity lumber, it still requires a \$10-15 million investment<sup>3</sup> and a sizable market. To provide a 5-year payback after taxes will require sales on the order of 500 thousand ft<sup>3</sup> per year.<sup>4</sup> Set-asides and incentives for local CLT manufacturers could dramatically reduce that risk.

As adoption of CLT increases in the domestic market, as will the demand for the raw materials needed in manufacturing: particularly the kiln-dried lumber feedstock. Current analysis of the market does not demonstrate a strain in production or volume availability; however, if market adoption increases as expected by industry experts, regionally processed lumber meeting the specifications needed for CLT could be a pinch point. The lumber market is fluid across state borders meaning feedstock could be imported from other regional areas. If the Oregon and SW Washington area wants to continue to be a manufacturing hub of CLT, it would be the interest of local economic development stakeholders to pursue investments not only in additional CLT manufacturing, but in the facilities and materials needed to support manufacturing.

As the US CLT market is in the early adoption stage there are still **barriers to getting product to market** needing to be addressed. Of particular focus for addressing barriers are strategic activities related to expanding code/prescriptive language, design & adoption education, workforce training, and marketing. For CLT panels to become an industry norm in the US, they must continue to be integrated into local building codes. A multi-tiered strategy is required to officially adopt CLT into US building codes. This strategy includes the development of a product standard as well as a material design standard and the subsequent adoption of these standards into local codes and regulations. Additionally, because CLT

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<sup>1</sup> <http://www.investopedia.com/ask/answers/011415/what-average-annual-return-does-forest-products-sector-generate.asp>

<sup>2</sup> from survey data

<sup>3</sup> Based on a facility already producing similar advanced wood products such a glulam beams. New facilities with no similar production line may require \$30 million+.

<sup>4</sup> \$15 million capital expense. 7% interest. 20% taxes. \$8/ft<sup>3</sup> margin.

interest has taken off so quickly in the United States, outdated misinformation is being disseminated and we need to target education amongst all fields in a consistent, accurate, and conjoined effort.

Oregon partners are continuing to lead the domestic market in accelerating the mass timber panel market. As the activities of this study came to a conclusion, new projects and next steps developed among some of the same partners as well as new regional partners. Several related projects are seeking funds and will soon be in motion. Multiple working groups are meeting regularly and are attended by partners who worked on this study as well while pulling in the growing interest of new regional partners. An overview of known projects in the region has been outlined in the content of this study along with the lead partners of the effort.

Opportunities for innovation and entrepreneurship are prevalent in this new (to the US) market. Some of those opportunities are as follows:

- Utilization of Lower Grade Timber
- Utilization of Small Diameter Timber
- Access to Federal Timber Supply
- Additional Production Facilities
- Potential for Foreign Partnership
- Efficiency in the Production Facility
- Adhesives
- Connections & Fasteners
- Composite Products

While CLT manufacturing is not likely to be the silver bullet for revitalizing the forestry sector to what it once was, it does provide a transformative, value add product that dramatically reduces the carbon footprint of the built environment while creating what is expected to be a strong, sustainable demand for lumber from regional forests. Now that engineered wood products can compete more fluently in the big and tall building construction market, typically dominated by concrete and steel, we should see this positively impact the forestry sector by delivering a value-add product into the market stream of wood products coming out of the Northwest. The entire global construction market is currently valued at \$8.5 trillion USD and is expected to grow to \$10.0 trillion by 2020 (Timetric Construction Intelligence, 2015). Accessing additional construction segments are expected to have significant

CLT manufacturing technologies combine Oregon and Southwest Washington's traditional competitive advantage in softwood timber supply with advanced manufacturing processes. This pairing holds the promise to bring a major new sustainable and renewable manufacturing industry to the Pacific Northwest. It has the potential to provide substantial benefit to both rural and urban communities and strengthen the nexus between them.

Oregon has the potential to be a national competitor in CLT and other mass timber production markets. With continued collaborative efforts of multiple partners and continued early support from state and federal stakeholders that market will only be accelerated.

The information gleaned from this collaborative effort is expected to:

**Accelerate Global Competitiveness:** The international market for engineered wood products is increasing. The activities of this study aimed to provide needed market research while simultaneously convening stakeholders outside the study to maintain the momentum of CLT adoption in the United States; especially in the Oregon and SW Washington region.

**Support environmentally sustainable development:** Timber as a construction material is renewable and when harvested, continues to sequester and store carbon not only in the buildings in which wood products are used, but also in the forests used to regenerate new production. Buildings that use wood

products create multiple environmental benefits over materials that are made from fossil-fuel intensive processes that use steel and concrete.

**Provide relief and support to economically distressed and underserved communities:** The rapid and significant downsizing of the wood products industry and associated mill closures in Oregon and Southwest Washington have had a lasting impact. This feasibility study focuses on distressed rural areas and communities affected by the transition of the wood products economy the region.



# FOREWORD



To the reader,

As part of Oregon BEST's charter to accelerate the development of clean technologies in Oregon and to help grow our state's innovation economy, we jumped at the opportunity to convene state universities, business development, city, county, state, and federal partners in Oregon and Washington.

Natural resources have long been at the center of this region's economy and cross laminated timber represents an opportunity to bring innovation to both the construction industry globally and our region's forest products industry sector.

As one of the founding participants in creating the Pacific Northwest Manufacturing Partnership, a nationally-recognized "Investing in Manufacturing Communities Partnership" region, we were happy to use this cross laminated timber feasibility study as a catalytic project to bring the various partners together to work on an initiative that will bring new manufacturing jobs to Oregon and SW Washington.

This region was the logical place for this project to happen and for cross laminated timber to establish itself as a job creator. Long a leader in adopting new green building technologies and techniques, home to leading institutions in forestry and wood science, and the birthplace of other engineered wood products in the 20th century, mass timber construction and cross laminated timber represent a terrific economic opportunity. Unlike some earlier advances in green building practices, the use of CLT and other mass timbers in mid- to high-rise construction creates a strong link between the region's rural communities and the development and construction leaders in urban centers. Adoption of mass timber construction practices will create jobs in our region throughout the supply chain, including in lumber mills and CLT manufacturing plants, especially as these construction practices are adopted in more cities and states outside of Oregon and Washington.

As readers will discover in this report, the work completed in this study addresses important questions about resource capacity and market demand that will help key players in the supply chain make investment decisions and that will help to accelerate the production of CLT. Further, the identification and discussion of real and perceived barriers to the use of CLT will enable additional steps to break down those barriers and provide awareness to overcome misperceptions that exist, accelerating the adoption of this new (to the United States) product.

Best regards,

A handwritten signature in black ink, appearing to read "David Kenney", is positioned above the printed name.

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# INTRODUCTION

While the technologies and demands in the wood products industry are evolving, the inherent strengths of Oregon and SW Washington have placed the region in a strong position to take advantage of emerging mass timber markets.

Oregon BEST along with members of the Pacific Northwest Manufacturing Partnership (PNMP) shared a vision to advance a catalytic project to assess the opportunity for the manufacture of cross laminated timber and its potential to modernize the wood products industry throughout the supply chain in the region.

Through PNMP, the collaboration between communities, government, industry, academic and research institutions across 17 counties in Oregon and SW Washington resulted in the commitment to this project. It underscores the institutional strength of the partnership and exemplifies its core focus to support manufacturing industries that use innovative materials and engineering to transform products or manufacturing processes that strengthen their competitive advantages.

This project is a featured element of the competitive application that led to PNMP's federal designation as 1 of 24 manufacturing communities in the U.S. under the Investing in Manufacturing Communities Partnership (IMCP) program. The designation gives the PNMP heightened access to federal agency personnel, technical assistance and grant funding.

Funding for the project was provided by the U.S. Department of Commerce/Economic Development Administration (EDA) and generous in-kind contributions from organizations in the PNMP including: Oregon BEST, Oregon State University, the City of Eugene, Clackamas County, the Corvallis-Benton County Economic Development and the State of Oregon through its agencies, the Oregon Business Development Department (Business Oregon) and the Oregon Department of Forestry.

The project was led by Oregon BEST under a Partnership Agreement with Oregon State University, Oregon Manufacturing Extension Partnership, and Washington State University.

A complete list of authors and contributors can be found in the appendix.

The remainder of this report is organized into multiple sections:

- **Industry Background** provides the economic context for the wood products industry in the Pacific Northwest and a description of how CLT is produced and the existing market.
- **Natural Resource Capacity** discusses harvest volume of soft-wood timber in Oregon and the estimated portion that could be directed into an advanced wood product, such as CLT.
- **Capable Producers** profiles 10 existing lumber production facilities that have the physical and economic capacity to shift production to CLT, but also explores the capabilities future CLT producers should be aware of.
- **Economic Impact** estimates the impact that CLT production could have on jobs, income, and tax revenue.
- **Barriers to Market** provides an overview of existing barriers to market and outlines a pathway of education and outreach activities needed to address these barriers.
- **The Path Forward** outlines opportunities for innovation and support services as well as “next step” projects in the region.

- **Glossary** provides definitions of the technical terms and acronyms used throughout the report.
- **Appendix** elements provide a deeper-dive into the research summarized in each section along with an effort to appreciate the work of the individuals who make up our project team.

As a result of this study, the research and outreach activities have played a vital role in continuing the momentum of advancing this to drive the commercial development of CLT and bring back economic opportunities to communities within our region that had grown around forest product industries

## Industry Background

### Regional Economic Conditions

The Pacific Northwest has a long history in the wood products industry dating back to when the region was known as the Oregon Territory. This natural resource has been transformed by workers into value-added dimensional lumber, glued laminated timber, plywood, particleboard, medium-density fiberboard and oriented strand board. The manufacture of these products sustained rural and urban economies in Oregon and Southwest Washington for many years, providing jobs with good wages and sizeable tax revenue for local and state governments. As a result of economic and policy shifts since the early 1980s, the number of jobs in the wood products industries has dramatically declined. In addition to the diminished economic opportunity for residents of timber-dependent communities, the federal government shifted policies that affected its payments in lieu of taxes to counties with large tracts of federal land, greatly reducing resources available to local governments in those regions.

Total employment in Oregon and southwest Washington's wood products industry has greatly declined since the late 1970s. Economic, technology, and policy shifts have caused employment in Oregon's logging and wood products industries to decline from approximately 80,000 in 1980 to about 30,000 in 2014. The average wage in this industry has declined as well. In real terms, the industries' average wage decline from about \$50,000 per year in 1980 to about \$40,000 in 2010. The 1980 wage was about 140% of the statewide average; the 2010 wage was just below the statewide average (State of Oregon, 2013).

The negative economic impact has been especially pronounced in the rural parts of the region. The wood products industry employed thousands of workers in different counties. For example, in 2012 southern Oregon and the southern coast counties accounted for 12% of Oregon's population, 10% of Oregon's employment, but 31% of Oregon's wood products and logging employment. As those jobs that had above-average wage jobs disappeared, no industry has come to rural areas with comparable wages (State of Oregon, 2013).

The lack of employment opportunities has led to increased levels of poverty. In those Oregon counties where the timber industry was most concentrated in the late 1970s--Lane, Douglas, and Coos--now have some of the highest concentrations of poverty in Oregon: one in five people live in poverty (The Oregonian, 2014; State of Oregon, 2012).

Across non-metropolitan Oregon, employment levels have not recovered the losses experienced in the economic recession that began in 2008 (State of Oregon, 2015). There are fewer jobs in rural Oregon in 2017 than in 2007.

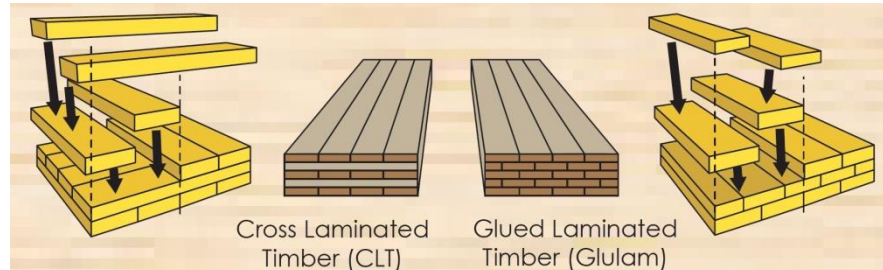
Although many lumber mills across the region have closed, forest-land owners export a substantial volume of raw logs to non-domestic markets. The export of the region's raw material is a lost opportunity for Oregonians and Washingtonians to find employment in the wood products industry (Oregon Forest Resources Institute, 2012).

This loss could be offset by building up capacity in the region's advanced wood products manufacturing. By developing new markets for value-added forest products, our region can expand employment opportunities in areas that have been most negatively affected by the decline of the region's timber industry. By revitalizing manufacturing and marketing locally processed wood products, we can provide a more resilient path forward for Oregon and Southwest Washington's traditionally timber-oriented rural communities.

The wood products industry is still a significant component of the region's culture, employment and overall economy. As with most industries, the processes to produce these products have evolved, become increasingly optimized and more efficient over time, thereby reducing the overall potential and real economic impact of the industry on this region. Oregon's forest sector alone accounts for 6.8% of Oregon's economic base, remaining one of the state's largest traded sector industries (OFRI, 2012).

In this context, members of the Pacific Northwest Manufacturing Partnership observed an immediate opportunity to focus on the advanced wood products market and in particular, building out the commercial production of cross laminated timber (CLT), to revitalize the region's traditional competitive advantage in softwood timber supply while capitalizing on recent advancements in engineering and material sciences.

The CLT commercialization effort also received a financial boost when in February 2016 it received a U.S. Commerce Department's Economic Development Administration grant of \$447,231. The EDA's Regional Innovation Strategies grant was awarded to Oregon State University to support the Oregon State Engineered Wood Building Products Commercialization Project.



**FIGURE 1: CROSS LAMINATED TIMBER VERSUS GLUE LAMINATED TIMBER.**  
*PHOTO CREDIT: BUILDING & CONSTRUCTION AUTHORITY*

## Cross Laminated Timber

Cross-laminated timber, or CLT, is a massive structural composite panel product usually consisting of 3 to 9 layers of dimensional lumber arranged perpendicular to each other, much like layers of veneer in plywood, and can be used as prefabricated wall, floor and roofing elements in residential, public, and commercial structures. This is not merely a new engineered composite product but an entirely new building technology revolutionizing the use of timber in construction.

CLT competes with steel and concrete as a structurally sound building material, but is made from timber, a renewable resource. The strength characteristics of CLT are such that low-grade, small-



diameter timber can be used in its manufacture. CLT structures are been shown to have less than half the amount of embodied carbon than concrete or steel structures.

### ***Advantages of Cross Laminated Timber***

As demonstrated in Europe, Canada and increasingly elsewhere in the world, there is a growing global demand for new engineered wood products such as CLT. CLT has many advantages over traditional building methods that rely on concrete and steel, including environmental impacts, building performance, and construction costs.

CLT building systems can successfully compete with steel and concrete. Prefabricated load carrying CLT wall, floor and ceiling panel assemblies show the capacity of substantially reducing the waste of materials and time in the construction of multi-story commercial buildings. This savings of materials and time translates into significant cost savings, playing a major part of the rising popularity of this material.

CLT combats current social environmental issues by storing carbon over time, turning buildings into carbon sinks. In addition, when the growth of timber and manufacturing of CLT panels is considered as a life-cycle, considerable carbon footprint advantages are gained. CLT structures have been shown to have less than half the amount of embodied CO<sub>2</sub> than concrete or steel structures, and save up to 18% of non-renewable energy when compared to concrete. Other estimates show that the embodied carbon footprint of a high-rise timber structure could be 60%-75% less than that of a concrete structure (Skidmore, et al., 2013). CLT panel manufacturing also creates a demand for small diameter trees that were overlooked by the construction industry. In this way, CLT is a product that utilizes the natural environment more efficiently (Watts and Helm, 2015). Overall, CLT is energy efficient in its manufacturing, building, and forest management operations over time.

In a survey of CLT industry professionals and occupants of CLT panel buildings conducted by Forestry Innovation Investment, respondents emphasized the quality of CLT building performance. These advantages included the airtightness of these buildings, due to the precise cut of the CLT panels, and the thermal comfort of the buildings despite seasonal shifts (Forestry Innovation Investment, 2014). CLT also performs well when tested for fire and seismic hazards. This is shown in greater detail in the chapter on *Barriers to Entry*.

The cost of wood as a building material and as the raw material for CLT is expected to stay stable in the near future, while concrete and steel prices are forecast to raise with their relative energy prices and carbon costs (Green, 2012). Many times, when transportation costs are reasonable, purchasing CLT panels costs the same as purchasing steel or concrete products. However, CLT cost savings are realized because construction time is reduced, because of the ease of assembly of CLT structures (Watts and Helm, 2015). A comparative study by WoodWorks for large retail structures shows that using CLT reduced construction costs by \$989,000, when compared to steel. Almost half (43%) of these savings are found within reduced structural material costs, 41% in reduced roof insulation costs, and 16% in reduced contractor fees (WoodWorks, 2015).

CLT Panels can be reused and reduce construction time, which also decreases the overall environmental footprint of these buildings. Due to the nature of these interlocking panels, they are delivered to construction sites ready to assemble, which makes the CLT construction process much more rapid but requires greater preparation during the design phase (Cook, 2015). Construction with CLT takes up to four days per floor, seventeen fewer days than concrete. The use of CLT in Canada has been known to save up to 10 weeks of potential construction time. Much of this has to do with CLT being a lightweight

material, especially when compared to concrete or steel (Green, 2012). This reduction in construction time also reduces construction labor costs.

Table 1 shows a direct cost comparison between building projects in western Canada that used concrete and those that used CLT panels. The study compares buildings that are 12 stories high and 20 stories high. The analysis shows that, on average, CLT is the lower cost option. In the 12-story buildings, CLT saved an average of \$262,000 per design, a 1.4% cost difference. For 20-story buildings, CLT saves an average of \$184,000, a 0.6% cost difference (Green, 2012).

**TABLE 1: COST COMPARISON OF CONCRETE AND CLT PANEL STRUCTURES IN WESTERN CANADA (GREEN, 2012).**

	Concrete Structure Cost Estimates	CLT Panel Structure Cost Estimates	Concrete Structure	CLT Panel Structure
Region of Western Canada	Cost Estimates: 12 stories		Cost Estimates: 20 Stories	
Vancouver	\$17,550,800	\$17,518,000	\$30,097,900	\$30,297,100
Northern BC	\$19,832,404	\$19,269,800	\$34,010,627	\$33,326,810
Interior BC	\$18,779,356	\$18,393,900	\$32,204,753	\$31,811,955
Fraser	\$17,550,800	\$17,518,000	\$30,097,900	\$30,297,100
Vancouver Island	\$18,691,602	\$18,393,900	\$32,054,264	\$31,811,955
Average Cost Estimate	\$18,480,992	\$18,218,720	\$31,693,089	\$31,508,984
Average CLT Cost Savings	For 12 Stories:	\$262,272	For 20 Stories:	\$184,105

The Forestry Innovation Investment surveyed building managers and owners about operating costs. The majority of respondents reported no difference in insurance plans or insurance premium costs when working on wood building projects (Forestry Innovation Investment, 2014).

The construction process itself is relatively simple like concrete construction. CLT is unlike a traditional wooden material because CLT structures are composed of a few large materials needed for the building design (Fernanda Laguarda Mallo and Espinoza, 2015). The locality of this product to the Northwest and the cleaner/quieter construction process also produces savings for urban areas of this region, especially sites with less room for construction (Petrie, 2015). This body of positive characteristics needs to be

disseminated through education before CLT is widely accepted and is a viable product in the marketplace.

Proven seismic performance of CLT technology (recent testing reference) makes it an attractive option for new design and construction projects as well as for alternative solutions for retrofits in a region seeking robust remedies to the imminent threat of seismic activity.

The strength characteristics of CLT are such that lower grade timber can be utilized for high-strength application – reducing pressure on older forest stands to provide valuable materials, and putting foresters back to work, as well as increasing long-term forest sustainability.

The Pacific Northwest, and particularly Oregon, is uniquely positioned to become the hub for the domestic CLT industry and development of domestic building technologies based on cross-laminated timber (CLT) panels. The factors that favor Oregon include rich and diverse timber lands ranking among the most productive on the globe, traditional profile of the state industry, in-state community of progressive architects and engineers, as well as the proximity to a large domestic market (populous and seismic California), and a relatively easy link to huge markets overseas (populous and seismic Pacific Rim nations). Among these factors, the seismic threat is of particular importance to the entire Pacific Coast region.

Europe, Canada and Japan have already heavily invested in the development of CLT technology and keep gaining traction in world markets. If Oregon and SW Washington, a region with forest products in its collective DNA, do not continue to act with agility and haste to position communities and companies here on the path towards global (if not dominant) position in that industry/market, a substantial opportunity to restore and elevate the Region’s wood products manufacturing heritage will be missed.

By utilizing the convening capability of Oregon BEST and the resources of the PNMP, this study builds on the State of Oregon’s Business Development Department and Department of Forestry to implement the Oregon’s Executive Order 12-16 which calls for a strategy to accelerate the research and commercialization of innovative wood products and applications. The intended beneficiaries include Pacific Northwest communities and manufacturers, by providing reliable information on the capital cost necessary to invest in this new technology, potential revenue, investment, jobs and economic and ecological prosperity, as well as on potential barriers.

This study aimed to answer key questions about the feasibility of developing a market for CLT production in Oregon and southwest Washington. Oregon BEST partnered with nine regional stakeholders to identify and evaluate the feasibility of developing a market for CLT in Oregon and southwest Washington. With funding from the Economic Development Administration (EDA), Oregon BEST and its partners have conducted research on key activities, which provide a realistic assessment of CLT’s market potential.







**TITLE:** Working forest landscape in Tillamook County

**LOCATION:** Oregon

**PHOTO:** Oregon Forest Resources Institute



# DEMAND AND RAW MATERIAL

## Introduction

Based on the incremental market demand estimation, cross laminated timber may be viewed as competing for market share where concrete, steel, or masonry have historically dominated. Two of the multiple drivers for CLT adoption include renewability and sustainability as a major benefit of this building material. However, there are people unfamiliar with the forest potential who have raised the question as to whether increased demand for wood challenges the sustainability of forests? While it is true that with increased market share for mass timber products (particularly CLT), this could in effect raise the regional consumption levels for wood, evaluation of growth and yield as well as additional investigation underlines that there is no concern regarding the ability of PNW forests to support increasing demands while remaining sustainable in terms of production capacity and forest health.



### NATURAL RESOURCE CAPACITY

**Identify  
forest capacity  
within the region  
to supply CLT  
sustainably  
in the US.**

## Sustainability and the North American Forests' Ability to Accommodate Demand

In considering forest supply and production capacity in terms of renewability, it is helpful to consider forests at a broad geographical scale. In this regard, there are more standing forests and available wood in the U.S. today than there were 100 years ago (Oswalt & Smith, 2014). Outside of the US, there is some deforestation occurring, particularly in regions that are still developing and forest is being converted to alternate uses or is relied upon for cooking or heat. Regardless, there is overall a greater volume of forest and wood available today in the world than previously, underlining the renewability and sustainability of wood from well managed forests.

### Forest Ownership, Management, and Renewability in the United States

In terms of management and utilization of forests in the US, approximately 11 million individual U.S. landowners supply 92% of the fiber needs of the U.S. forest products industry. Of these forestland owners, a survey by the National Association of State Foresters in 2015 found that 91% of these private

landowners utilize internationally recognized certification standards and/or employ best management practices (BMPs), which are a part of sustainable forest management (American Forest & Paper Association, 2016). In other words majority of the fiber produced domestically is managed according to standards which maintain and/or expand standing forests.

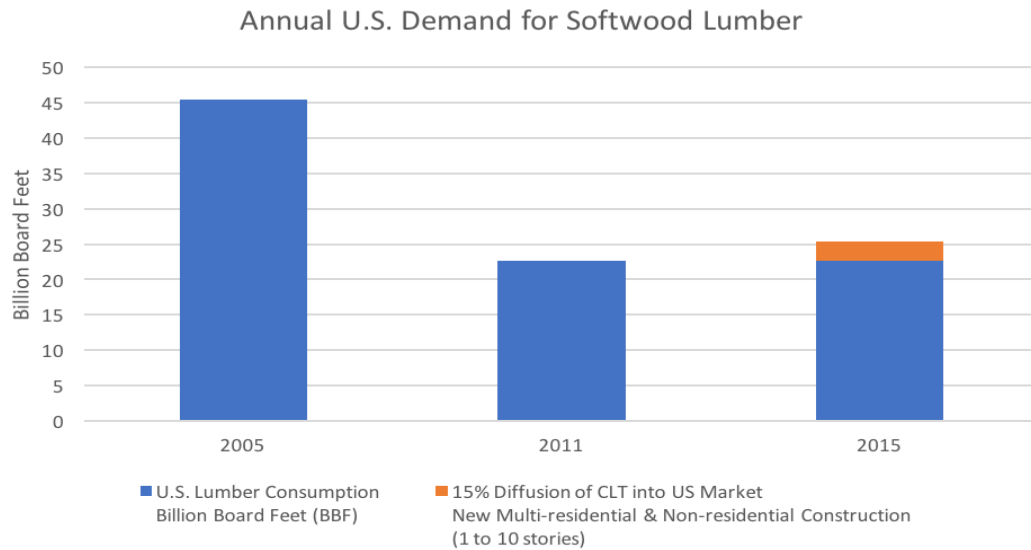
Presently wood utilization in the commercial and multifamily arena is limited; however, as adoption of mass timber grows, the question of how North American forests accommodate increased demand has been raised. FPIInnovations, an independent Vancouver B.C. based nonprofit research and consulting organization, considered this question in the publication CLT Handbook for Canadian and U.S. markets (Karacabeyli & Douglas, 2013). Beyond production performance and design considerations, the CLT handbook includes a comparison of “theoretical CLT consumption in the context of current construction wood usage” and provides a meaningful perspective on consumption and the potential impact of increased CLT adoption:

“An assessment of the market opportunity for CLT was completed whereby the estimated 2015 volume of new construction was overlaid by market segment with the scenarios of CLT capturing both 5% and 15% of that new construction market. If CLT was used for 15% of new multi-residential and non-residential construction projects (1 to 10 stories) built in 2015, there would be a 12% increase in the overall board footage demand over 2011 levels. To put this in perspective, in 2011 the estimated U.S. lumber consumption was 22.6 billion board feet (BBF) (RISI), while in 2005, when the United States was at its peak for lumber demand, it is estimated that 45.5 BBF (RISI) was consumed—[a difference of 101%]. For the lumber market to see 2005 levels of demand based on the construction expectations for 2015, CLT would have to comprise over 100% of the multi-residential and non-residential market.

There are many end uses for forest resources, all of which may compete for a finite supply of raw materials depending on market economics. Should U.S. housing starts ever return to 2005 peak levels and thereby once again create a large demand for framing lumber, restricted supply of raw resources and the resulting effect on market prices may affect the availability of raw resources for CLT production. The current example is not meant to suggest that enough CLT would necessarily be available for building 100% of all multi-residential and non-residential buildings.”

Using this analysis, Figure 2 reflects the modeling of lumber consumption and potential for CLT diffusion at 15 percent.

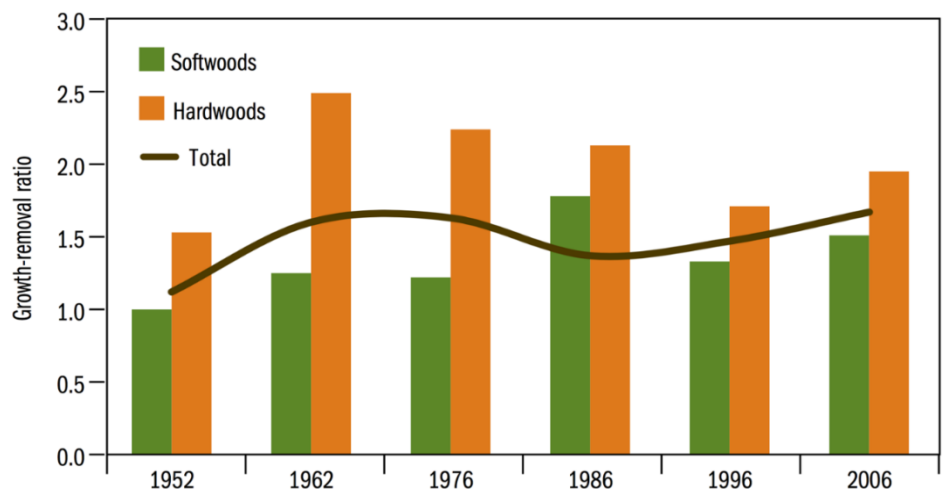




**FIGURE 2: ANNUAL US DEMAND FOR SOFTWOOD LUMBER (ORIGINAL VISUAL; SOURCE DATA: KARACABEYLI & DOUGLAS, 2013)**

## Forest Growth and Removal

Beyond forestland area, historical growth-removal ratios are another metric for evaluating the ability to forests to support fiber consumption. Growth-removal ratios (G:R) provide an estimate of the sustainability of timber harvest volume and are calculated by dividing net growth by growing-stock removals. In the PNW, G:R for Douglas Fir (a feature component of CLT production in the PNW) is observed at 1.99% (roughly twice as much wood growth as is removed). This exceeds the nation-wide average softwood G:R ratio of 1.88%. Considering mortality—due to insects, disease, and fire—an updated report shared that nationwide standing inventory of softwood increased by 3% from 2007 to 2012 (Oswalt,



**FIGURE 3: GROWTH-REMOVAL RATIOS BY SOFTWOODS AND HARDWOODS, 1952-2006 (SOURCE: SMITH, MILES, PERRY, & PUGH, 2009)**

Smith, Miles, & Pugh, 2014). Historical growth-removal ratios grouped by softwood and hardwoods can be seen in Figure 3.

## Oregon's Forest Resource

Closer inspection of regional resource potential suggests Oregon has tremendous production potential. In terms of area, the state of Oregon is approximately 60 million acres, of this nearly half (47%) is identified as forestland (see Figure 4). Of the Nearly 30 million acres of forestland in Oregon, approximately 80 percent of is further classified as “timberland” or “land capable of productively growing commercial grade timber” (Pacific Northwest Research Station, 2013). The timberland designation does not include forestland with lower forest productivity or regions where production is restricted (wilderness areas, national parks, or other reserved areas) (US Forest Service, 2005). Subsequently the timberland underlines the significant potential for commercial forest production and activity.

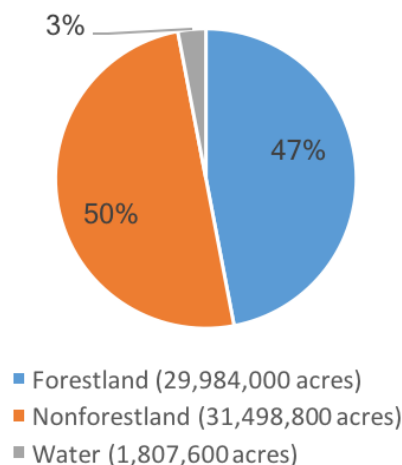


FIGURE 4: OREGON LAND BASE, OFRI

In terms of forest growth, the United States Forest Service (USFS) Federal Inventory Analysis (FIA) program regularly assesses the change in forest growth relative to harvest and or mortality throughout the country. The program seeks to monitor the growth and/or loss of forests through natural or removal processes. A recently completed survey of Oregon’s forests by FIA indicates that overall there is significantly more growth relative to removal or mortality. This perspective underlines the differential between what is grown and what is lost. A positive balance indicates more growth than removal while a negative balance represents diminishing forests. The Oregon analysis underlines that more timber is grown relative to removals (US Forest Service, 2008). The positive differential could be interpreted as additional resource opportunity that is unrealized (see Table 2).

The US Forest Service has recognized ample opportunity for forest products in general, but specifically for CLT because its ability to incorporate lower grade lumber within its core, lays in the federal forest growth mortality reflected in Figure 3.

TABLE 2: OREGON SOFTWOOD FOREST GROWTH, MORTALITY AND HARVEST 2011-2015

	OREGON SOFTWOOD FOREST GROWTH, MORTALITY AND HARVEST 2011-2015 (THOUSAND CUBIC FEET)			
	Harvest	Mortality	Net Change	Total Growth
<b>Federal</b>	119,340	384,540	822,120	1,326,000
<b>State</b>	96,860	30,060	40,080	167,000
<b>Private</b>	875,250	128,370	163,380	1,167,000
<b>Total</b>	1,091,450	542,970	1,025,580	2,660,000

Source: Oregon Forest Resources Institute. (2017). Oregon Forest Facts 2017-18 Edition. Oregon Forest Resources Institute.

Nearly three times more wood dies in the federal forests than what is harvested (384,540 cuft mortality versus 119,340 cuft harvested). Harvest economics, logistics, and environmentalist opposition often stunt the harvest capabilities needed to remove decaying fiber from the forests. The USFS Wood

Innovation grants are the ideal funding opportunity for programs or projects focused at targeting this need.

## Harvest Volume and Consumption

The volume of Oregon's forest harvest has varied over time reflecting economic and policy events relevant to harvest considerations. In other words, annual harvest fluctuations correlate directly with wood demands: both domestic and export. When demand increases, harvests reflect demand pricing and in periods of declining demand harvest declines. In terms of harvest consumption, the primary consumers of Oregon's harvest are domestic value-added production, domestic Oregon consumption, export, and other domestic consumption (Outside Oregon). An estimate for domestic Oregon consumption of harvest based on recent harvesting years ranges at approximately 26% of total harvest (Oregon's Forest Products Industry and Timber Harvest 2013 with trends through 2014. Simmons E., Scudder M., Morgan T., Berg E., and Christensen G. USDA). Accordingly there is a significant portion of Oregon's harvest that is exported out of the state (75% <sup>+/</sup>). As this material is feeding a broader market demand there is significant volume and capacity for this production to remain regional to supply value added production such as CLT. The transition to feeding a new demand could create some pricing changes long term however near term new production demands would likely have limited impact on broader market pricing.

## Kilns and Capacity

While there is abundant dimensional material to support additional production enterprises regionally, a primary requirement for CLT construction is kiln dried lumber (KD). Kiln dry softwood lumber is standard lumber that has been dried (typically 15% moisture content) in kilns. CLT production requires KD lumber and manufacturers require an even lower average moisture content, 12% ± 3% for production purposes. Depending on a customer base, it is realistic that not every sawmill in the

**TABLE 3: SAWMILLS WITHIN OREGON AND SW WASHINGTON INCLUDED IN MODEL: KD LUMBER PRODUCERS THAT SHARED PRODUCTION FIGURES**

SAWMILLS WITHIN OREGON AND SW WASHINGTON INCLUDED IN MODEL			
Producers No.2 and No.3 grades of kiln-dry (KD) lumber that shared production figures			
Sawmill	County	City	State
High Cascades	Baker	Carson	OR
Interfor, Molalla Division	Clackamas	Molalla	OR
Hampton Lumber Mills, Inc.	Clatsop	Warrenton	OR
Southport Lumber Company, LLC	Coos	North Bend	OR
South Coast Lumber Co.	Curry	Brookings	OR
Roseburg Forest Products Co.	Douglas	Dillard	OR
Swanson Group Inc., Glendale Sawmill	Douglas	Glendale	OR
Swanson Group Inc., Roseburg Stud Mill	Douglas	Roseburg	OR
Collins Pine Co	Lake	Lakeview	OR
Rosboro LLC	Lane	Springfield	OR
Frank Lumber Co., Inc.	Linn	Mill City	OR
Hampton Lumber Mills, Inc.	Tillamook	Tillamook	OR
Stimson Lumber Co., Tillamook Mill	Tillamook	Tillamook	OR
Stimson Lumber Co., Forest Grove	Washington	Forest Grove	OR
Hampton Lumber Mills, Inc. Willamina Division	Yamhill	Willamina	OR
Columbia Vista Corporation	Clark	Vancouver	WA
SDS Lumber	Klickitat	Bingen	WA
Sierra Pacific Industries Centralia Division	Lewis	Centralia	WA
Weyerhaeuser, Raymond, Washington	Pacific	Raymond	WA
count			19

region that produces KD lumber would be willing or able to give up kiln capacity to dry lumber to 12%. For example, some sawmills are focused on volume based consumer outlets (e.g. Home Depot) while others offer specialty products to serve niche markets.

There are currently 69 sawmills in the evaluated region of Oregon and SW Washington of these 21 produce kiln dry lumber (Table 3) and while the number of KD capable mills is limited regionally, creating additional capacity for KD production is limited only by addition. As CLT utilization increases and production grows, it is anticipated that markets will incent development of kiln infrastructure commensurate with demand and KD lumber availability is not expected to challenge increasing CLT production requirements.

Furthermore, the region houses companies with kiln drying capacity not related directly to sawmills. For example, Patrick Lumber offers drying services. Additional needs could potentially divert through these type of companies if need be.

## Conclusion

The positive initial response to utilizing CLT and mass timber in commercial and multifamily construction has driven optimistic projections of broader adoption moving forward. Accelerated adoption is attributed to multiple economic and environmental advantages associated with mass timber use including but not limited to cost and time savings, structure passivity and performance, renewability and reduced carbon footprint, architectural design freedom, and realization of inherent biophilia proclivities. As these attributes drive demand there will be a commensurate increase in the consumption of the wood necessary for production. In light of this, there is question as to the capacity of PNW forests to meet the near and long term additional demand.

## Near Term Projection

Near term, there is more than a sufficient volume of both dimensional lumber and kiln facilities to meet emerging demand associated with additional CLT production facilities. As noted above majority (~75%) of the material processed in Oregon is directed and consumed outside the region. Subsequently there is no near term supply challenge associated with redirecting this material to new regionally based value added mass timber producers. Moreover, the economic additionality of demand and production could incent additional harvest and processing from lands that not as actively managed. Additional kiln capacity may be necessary as the drying time is greater than the present norm; however developing additional capacity is limited only by investment. Additionally, there is also recognition that CLT production methods continue to evolve and as additional species and materials are considered the volume of material available for inclusion in production grows as well. Ongoing projects are examining using low grade lumber from logs harvested in national forest restoration programs. This management includes treatments like thinning which reduces the risk of wildfire (Oregon Department of Forestry, 2015). Pending results, this work may translate to improved and less costly forest restoration and improved resiliency as well as improved carbon sequestration.

## Long Term Projection

Long term there is no question that PNW forests are more than capable of supporting additional demand for wood commensurate with increased adoption of CLT. Moreover as existing processing facilities largely operate below capacity infrastructure is more than capable of providing for additional value-added production demand. This outlook is underlined by Table 3 which reflects forest productivity and capability. More specifically, Table 2 demonstrates the exceptional productivity of regional forests and ability of growing stock to meet the long term needs of additional demand estimated by the FPIInnovations working group. Beyond forest and harvest capability, there is an expected constriction where kiln capacity is concerned; however, economic incentive parallel to increased demand should be sufficient for developing additional capacity and is not a limiting factor long term.

The caveat to this projection is the nature of forest land ownership in Oregon and forest accessibility. Of the nearly 30 million acres of forest land in Oregon (see Figure 4) nearly 60% is federally owned and as such would be an important provider based on long term projected demand. Of late, there has been significantly less harvest on federally owned forest lands relative to previous decades. Today, the volume of harvest on these lands has been and continues to be a subject of intense dispute and whether additional harvest will be permitted to accommodate CLT and mass timber demand is subject to debate. Based on the information provided there is little question as to the capability of these lands to provide more than adequate supply, but access is uncertain. Based on recent history there is limited expectation that additional harvest on these lands will occur, but there is optimism that the profound environmental benefits attributed to innovative CLT construction relative to older traditional uses of steel and concrete will be an important driver in reframing the present paradigm associated with the utility of public lands.

Questions surrounding forest capacity and capability are worthwhile and important in directing for economic and environmental investment. However, it is clear that Oregon and the broader PNW forests are more than capable of accommodating both near term and long term demand for CLT and other mass timber products. In terms of evaluation and measure of long term capability, growth and mortality and cubic feet are reliable indicators of outcome; however, an alternative perspective underlining the conclusions noted above are provided by the Oregon Forest Resources Institute in evaluating the productivity of Oregon forests: Carbon 12, an eight story CLT building located in Portland Oregon, used 24,411 cubic feet of wood in construction which Oregon's forests grow every 6.1 minutes (OFRI, 2017). Alternatively each day Oregon's forests grow a sufficient volume of wood to create 236 Carbon 12's a level of productivity more than sufficient to meet emerging market needs today and well into the future.





PROCESS: D.R. Johnson, CLT layup

LOCATION: Riddle, Oregon

PHOTO: Business Oregon



# CAPABLE PRODUCERS

## Introduction

Cross-laminated timber manufacturing requires a new and different combination of skills, capabilities, and equipment than existing wood product manufacturing activities. With any new product or service there are numerous key elements for the existing companies in a region to be successful. It is important to understand the latent capabilities of the region to be able to exploit this new market.

This research activity categorizes and identifies key gaps in capabilities or skills and provides a scorecard of which areas may need regional assistance. A survey sought to achieve the following:

- Determine physical capabilities of potential producers
- Determine knowledge of market & technology
- Inquire about interest in producing CLT / interest in partnership opportunities

Though not fully explored in this study, it is anticipated that the market will support different types of producers (e.g. large panels, custom panels, panel cutting).

Included within this work are the profile assessments of ten (10) companies located in Oregon and Southwest Washington capable of supplying CLT commercially. The profiles include details about the number and quality of jobs created by an individual production line, as well as market feasibly served by location.

## Approach

To initially define the necessary capabilities of a potential manufacturer, a matrix was drafted using input from Imarc, Beck, and guidance from Lech Muszynski of Oregon State University (Imarc, 2016; Beck, 2015)<sup>5</sup>. The array identifies both the type of wood products firms most relevant to the study as well as the key capabilities necessary to be successful in producing and successfully selling CLT. The hypothetical profiles were generated using public information regarding the known capabilities of firms

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<sup>5</sup> See Appendix 1: Expected Capabilities Matrix



**Profile  
manufacturers in  
Oregon and SW  
Washington  
capable of  
supplying CLT  
commercially.**

in those categories. From the sources above and additional secondary materials from DR Johnson and foreign CLT producers, a comprehensive survey of relevant indicators and criteria for the potential for success in the nascent regional CLT market was further developed (see Survey). An initial 'super set' of manufacturers was generated using NAICS codes from existing database sources. Companies were identified and invited via email and other social media outbound marketing; however very few firms self-selected using these passive means. The only successful method for interaction was to contact a sample of recommended potential producers directly to discuss their capabilities.<sup>6</sup> These results are categorized in a results matrix. This matrix provides the basis for the discussion below and identified key missing capabilities for these firms to be successful, both individually and collectively. As a result of this research, the profiles of these companies have been cataloged and made into the final deliverable of this report.

## Elements of a Capable Producer

The initial phase of this section was to develop a standard matrix to identify the key elements that would be necessary to be successful in CLT manufacture (see appendix). These elements can be broken into four (4) objective areas and one (1) cultural need.

- 1) Sales experience: familiarity with selling custom products to engineers/architects
- 2) Raw Materials: familiarity with handling structural lumber
- 3) Process: familiarity with gluing, particularly if you can handle structural lumber
- 4) Physical: available space and related processing equipment.

But perhaps most importantly:

- 1) Institutional will: The company must have an entrepreneurial outlook to assume the capital investment risk in this new market.

To elicit the above information a survey was drafted and administered to ten (10) companies (see Survey).

The survey generated a few common themes.

- All the respondents found CLT is interesting, but many felt the market is not quite mature enough
- Many respondents were concerned about the lumber availability and pricing.
- As CLT has not been used in many jurisdictions, concern was expressed that the demand would be blunted until CLT use was permitted for additional structures.

A) The cautious.

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<sup>6</sup> Interviews with industry professionals provided insight into a subset of potential manufacturers.

These inherently market-based, external barriers to investing in a new product have placed the cautious members of this group into a wait and see position. Oregon wood product producers have worked hard to generate a stable niche for their companies during extremely challenging regulatory environment. So regardless of their capabilities, this group as a whole was not ready to invest heavily in CLT. Though many of these companies have sufficient infrastructure to accommodate customized sales requests, their products are sufficiently well understood to not require after the sale support in their use. With the consolidation of lumber industry in Oregon and SW Washington, one fortunate result is a wide range of skills at each firm. Each of the firms has personnel generally familiar with nearly the full range of processes present in the wood products industry. The one critical element missing or untested from these firms is some form of engineering support. First mover firms like DR Johnson will have an advantage in this key area. Without this key member on staff, the firms are also missing an internal, trusted source of market data that could champion the process forward.

#### B) The willing

American Laminators and Columbia Vista and perhaps Murphy Plywood<sup>7</sup> have expressed considerable interest in moving forward and could have lines in place in the next 2 years. These firms have a keener understanding of the engineering driven construction market and therefore have better insight to the value of CLT and the ability to exploits its unique qualities.

#### C) Outside investment

Though outside the geographic scope of this report, KLH and Vaagen have expressed interest in establishing partnerships in the region. KLH, the world leader in CLT production already has a local sales office here in Portland, Oregon and StructureLam has a sales support office here as well. The actions suggested below for inducing investment could be targeted towards outside firms coming into Oregon to partner with local firms. These subject matter experts would augment the existing capability set outlined below. Any action to create a local market or set-asides for local CLT firms would seem to be particularly enticing. However, before implementing plans to entice outside investment, it will be important to confirm if the other key issues regarding geography (availability of lumber, suitable humidity, proximity to projects) truly favor this region.

(NOTE: those knowledgeable with Boise Cascade and Weyerhaeuser suggested that their corporate interests do not include investing in CLT. )

Below is the description of the results along with a ranking of the general readiness of the region.

(Qualitatively a 1 represents significant actions must be taken to increase the chance of success, while a 10 represents a factor that is well under control and does not pose a significant capability barrier.)

#### 1) Specialty vs. commodity mindset and selling to architects/engineers

##### Regional Readiness Level - 5

The cultural question of selling to engineers or architects is key. As the market matures it may be possible for a commodity CLT manufacturer to emerge, however in the near future it is imperative that a new firm have a culture to support a custom product mindset and

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<sup>7</sup> Not interviewed

production capability. This includes the front line sales staff to discuss specific needs, support for any specific engineering related questions, and the back office systems to accommodate unique designs and change orders. Interestingly, there were positive, unexpected results from firms in Oregon in this regard. Several firms, while selling standard products, had coupled their offerings with sophisticated customization or adaptability to serve the specific needs of their clients. This included Columbia Forest Products and C&D Lumber who commonly pick very specific pallets of items to ship to their customers.  
Readiness Accelerant: Training, travel, subsidized consultants, pooled resources

#### **1a) Design/Build support**

##### **Regional Readiness Level - 1**

A key element in selling CLT as a construction material will be providing onsite or on-demand support during the build process. This will be particularly important in the early stages of the process as few builders have sufficient familiarity with the material to solve complications as they arise. This element is understandably missing from capable producers as they are not yet manufacturing CLT. It is possible that this role could be served through 3<sup>rd</sup> parties such as WoodWorks. Though first adopters driven to use new materials will be accommodating, a CLT manufacturer wishing to break into the next level developers will need seamless construction support.

Readiness Accelerant: Training, travel, subsidized consultants, pooled resources

#### **2) Familiarity with structural lumber**

##### **Regional Readiness Level - 9**

Structural lumber is the key raw material for building CLT, so the ability to procure and handle this material is the first key manufacturing capability. With the exception of the plywood only firms, all parties were familiar with structural lumber. Handling pallets of 2x6s is well within the capabilities of the likely producers of CLT in the region. In one form or another, this is an end product for the mill.

Readiness Accelerant: none

#### **3) Familiarity with standards, certification, QA**

##### **Regional Readiness Level - 10**

As an engineered product, companies must be willing and able to comply with a fairly rigorous set of standards and quality control. Each of the companies surveyed is currently operating under a series of standards or is generally familiar with operating under ASTM or other guidelines. There is an overwhelming use of technology and understanding of how standards bodies and certification programs operate.

Readiness Accelerant: Maintain library of relevant standards, develop best in class implementation.

#### **4) Hardware for handling heavy material (cranes, etc)**

##### **Regional Readiness Level - 3**

CLT panels range from 10'x40' to 12'x80'. With 3-9 layers, they can weigh as much as 50lbs/ft<sup>2</sup> or 40,000 lbs for a 10'x80' panel. Moving these off the assembly line into storage or shipping vehicles is a new need at nearly all lumber facilities. While most firms are aware of some of needs in this area, only one firm, Freres, has the necessary heavy lifting machines

to accommodate large structural panels. All the firms have some form of material handling equipment.

Readiness Accelerant: financing,

**5) Familiarity with adhesive bonding**

**Regional Readiness Level - 4**

Adhering the panels together is straightforward, but also takes attention to detail and a quality control mindset. Being sensitive to dust and other contaminant control as well as any related issues surrounding the storage and administration of adhesive, is helpful. As expected, plywood and glulam firms are familiar with the needs of space. That being said, many of the other firms had latent understanding or previous experience in adhesives and felt up to the task.

Readiness Accelerant: Training,

**6) Finger joining**

**Regional Readiness Level - 3**

CLT can use finger-joined lams to allow for more complete use of feedstock. In addition as these members are glued and can be up to 80' long, the logistics of preparing, moving, storing and then placing the lams can be awkward and challenging. Finger joining is only performed within the glulam firms. Though the process of making a long finger-joined lam is not overly complex, the workflow issues surrounding their creation may present issues. This was not commonly done in the survey group. Though a low score, the technical aspects of this capability could be acquired. Without a firm design plan it is not possible to know if a company has appropriate space to accommodate the flow of work in progress inventory.

Readiness Accelerant: financing, pooled resources

**7) Familiarity with structural connections, fittings etc.**

**Regional Readiness Level - 1**

As noted in the design build support, having an understanding of the ways CLT can be (and should not be) attached is helpful in the sales and post sales process. If a designer is eager to use CLT as a building material, they will tend to choose an professional familiar with the major issues of construction. Clearly a firm just getting started will have a significant issue in this capability. Partnerships or starting with more straightforward projects will likely be the pathway to success.

Readiness Accelerant: Training, virtual trade shows,

**8) Sizeable and flexible manufacturing facility to support massive timber panel production**

**Regional Readiness Level – 4**

As noted in the source materials, a significant amount of space is necessary for raw material storage, prepared lam storage, panel prep, the press, and finished panel inventory. Though the group was evenly split on availability of space, the consensus was this would not be a problem to implement if the market warranted it. As the northwest wood products industry has shrunk, many sites have excess capacity and suitable locations abound.

Readiness Accelerant: Accelerated permitting, pre designed structures, financing

**9) Area Press**

**Regional Readiness Level – 2**

CLT requires a large press. Though it is possible to press with vacuum, vacuum pressing requires extra preparation to ensure the lams are especially smooth and flat. As expected this is a missing capability; however the providers of this equipment seem capable of bringing a willing firm up to speed quickly. It is important to note that this (along with related material handling equipment) is customer-designed machinery costing \$2-2.5 million (Imarc, 2016). Note that Freres recently acquired a large press for their mass-plywood panel product. This new product and its related material handling are substantially similar to the equipment necessary for manufacturing CLT.

Readiness Accelerant: Financing, reviews of equipment manufacturers

#### **10) Familiarity with CNC machining.**

##### **Regional Readiness Level - 1**

The CNC milling of panels to accommodate doors, windows, or other openings is another major purchase and capability not generally present. As CLT evolves, CNC as a service may also become available, however in the early stages, this capability must be brought in house. This is a fairly skilled job and an expensive piece of machinery. Though not being used for their end product, several firms use them for making parts for their processing equipment. Like the press, purveyors of CNC machines have training available; however a deep understanding of appropriate tools and sequencing is vital for maximizing efficiency through this key step. Like the press, this tool and related material handling equipment costs \$2.-2.5 million (Imarc, 2016).

Readiness Accelerant: Training courses, reviews of equipment manufacturers, OMEP support.

## **Job Creation**

Only three of the 10 companies surveyed for this report are strongly considering an investment in CLT at this time and do not have hard numbers regarding job creation. The incremental number of jobs necessary to initiate a single shift plant is relatively modest, having been estimated at 10-12 manufacturing related jobs for a plant generating 500,000 ft<sup>3</sup> per shift/yr (The Beck Group, 2015). It is also assumed that an additional 2-4 engineering/design and management jobs would materialize. The total number of new jobs would depend on what skills were currently in-house. It is assumed that current personnel would absorb most of the administrative work. Most of the manufacturing jobs are medium skilled work and eminently trainable. Note, as the plant moves from manual assembly to automated, the manufacturing labor will rise as shifts are added, but then plateau or perhaps drop as automation is implemented. One key-missing element from many of these firms is a key relationship manager with knowledge of CLT construction and an ability to communicate with engineers. This individual may serve as the front line sales person, but perhaps more importantly be available to help with on-site construction issues as they arise. Training for this role will be challenging and will require someone initially familiar with construction and who will then learn the issues surrounding the details of CLT installation.



## Summary

### What will it take to get more producer of Oregon CLT on market?

As noted, the ability to pursue CLT as a new product is well within the latent capability of existing firms in the area. However the industry remains reserved in their enthusiasm. The reasons for the cautious approach taken by regional firms stems from a combination of:

1. inability to address the market with the right personnel,
2. uncertainty on the size of the market, and
3. the investment necessary to enter the market.

These factors are somewhat interlinked. If the personnel were on staff to examine the market, it is possible that this internal study would provide institutional comfort to the size of the market and therefore warrant the investment. Continuous outreach and education of capable producers will help overcome the first two issues.

An interesting risk mitigation method is being employed by the Columbia Vista joint venture. This group will be vertically integrated and can generate its own pull to sufficiently use the CLT investment to pay off its costs in less than 5 years. Though the internal financing of this arrangement is unknown, it would appear that the construction firm is paying more for prefabricated parts in exchange for lower contract labor costs on site.

The decision to jump into the market is also impacted by the local availability of appropriate lumber. Douglas Fir is the predominant species, but because of limited harvesting, the price of this lumber may be cost prohibitive. In addition, lumber harvested west of the cascades may be more expensive to dry, as the environmental conditions are relatively humid. As a result, a local CLT producer may need to import logs, which is the strategy DR Johnson has reportedly taken. An import strategy has its own risks as the price of lumber can fluctuate (and may be impacted by a dramatic shift to CLT).

### Efforts to Induce Investment

As with any investment, an appropriate risk adjusted return is required to induce action. Any systematic action that can be done to increase perceived (or actual demand) or reduce cost (or risk) should have an effect on investment. Such actions could include:

1. Grants or subsidies for equipment (or assistance into federal programs, including R&D tax credit)
2. Loan guarantees for equipment
3. Actively addressing building code barriers in Oregon
4. Providing streamlined permitting for buildings using Oregon CLT
5. Marketing to engineering/design firms about Oregon CLT or CLT in general
6. Creating a protected purchasing program (or guaranteed cost savings subsidy) for government buildings built with Oregon CLT.
7. Facilitating discussions with potential partners (investors, building contractors, etc)

The average return in the wood products industry is 10%<sup>8</sup> for publically held firms; however privately held or family run business likely has a higher threshold, likely 20% or higher<sup>9</sup>. While CLT holds promise of higher margins than commodity lumber, it still requires a \$10-15 million investment and a sizable market. To provide a 5-year payback after taxes will require sales on the order of 500 thousand ft<sup>3</sup> per year.<sup>10</sup> Set-asides for local CLT manufacturers could dramatically reduce that risk.

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<sup>8</sup> <http://www.investopedia.com/ask/answers/011415/what-average-annual-return-does-forest-products-sector-generate.asp>

<sup>9</sup> from survey data

<sup>10</sup> \$15 million capital expense. 7% interest. 20% taxes. \$8/ft<sup>3</sup> margin.



**TITLE:** The Oregon Engineered Wood Products Economic Ecosystem

**GRAPHIC:** Clackamas County

# ECONOMIC IMPACT

## Introduction

The limited presence of CLT industry in the United States does not give a full representation of the diversity of potential business models, levels of vertical integration and market strategies as they may emerge in the region.

Oregon State University- College of Business and Business Oregon convened to assess the potential for job creation and related economic benefits along the CLT supply chain.

The OSU Forest Products research team investigated the elements of the CLT supply chain along with the manufacturing process, including inputs, outputs, current volumes, and revenues (see “Appendix: Supply Chain Analysis”). The details include analysis of the supply chains of the existing CLT plants in North America including lines that do not currently produce structural CLT products. From this mapping, the current elements of the supply chain existing in the region (Oregon and Southwest Washington) were highlighted: revealing the intricate details along the CLT supply chain.

This chapter investigates elements along the CLT supply chain, determines the current and potential economic inputs to CLT production, then analyzes the potential economic benefit to the immediate region based on FPIInnovation’s incremental opportunities in the domestic new construction market.

Economic analysis by Business Oregon determined that cross laminated timber (CLT) and related mass timber manufacturing has the potential to create 2,000 to 6,100 direct jobs in Oregon, depending on Oregon’s market share of demand for mass timber in the U.S. Including jobs created by indirect and induced impacts, approximately 5,800 to 17,300 jobs could be created in Oregon from mass timber manufacturing. For every job created in mass timber manufacturing in Oregon, an additional 1.8 jobs would be created.

Labor income generated from direct jobs in mass timber manufacturing would range from \$124 to \$371 million a year. Labor income from total impacts would be between \$338 million and \$1 billion annually. State personal income taxes generated from direct labor income would range from \$4.1 to \$12.4 million a year. State personal income taxes generated from total impacts would be between \$11.3 and \$33.8 million annually.



**Regional jobs  
potential  
& overall  
economic  
benefits to the  
region.**

As an added note, an initial analysis (2015-2016) by Oregon State University attempted to quantify the economic impact based on construction data and forecasting for the Pacific Northwest to include: Washington, Oregon, Idaho, and Montana. However, during consultation with the working group's Steering Committee it was determined that this method of sizing the potential market severely underestimated the market potential for PNW manufacturers of mass timber panels. The research, data, forecasting and analysis were extremely detailed and useful for assessing the potential market for mass timber in the PNW; it only failed to explore the economic impacts of Oregon panel manufacturing based on penetration of a national market. Results of that 2015-16 market sizing assessment can be found in the appendix: NW Council Data.

## CLT and Mass Timber Demand Modeling

The potential demand for CLT and mass timber products used in this analysis comes from FPIInnovations (Fell, 2017). FPIInnovations is a Canadian non-profit organization engaged in research and technology transfer for forestry and wood products in Canada. Their research into potential U.S. demand for CLT and mass timber products is the most cited and comprehensive market size analysis available. The potential market demand used in this analysis from FPIInnovations is not limited to CLT, rather it includes all mass timber products. The rationale for including market demand for all mass timber products in this analysis rather than only CLT is that the market for mass timber is ever evolving in the U.S. and throughout the world. CLT, glue-laminated timber, nail-laminated timber and other mass timber products share similar applications, supply chains, and manufacturing processes and are, in many cases, substitutable for each other. Consumer demands for one product over the other may change over time and are difficult to predict. In addition, innovation and regulatory changes could impact some products more than others, altering demand for certain mass timber products. Overall, the economic impacts are similar, regardless of the specific product.

FPIInnovations and industry experts estimates the market potential for mass timber construction in the U.S. to be up to 6.1 billion board feet in new and existing markets. This estimate includes potential market share of mass timber by building type and height, and considerations for other factors affecting the adoption and use of mass timber construction in the market.

## Oregon Market Share Scenarios

The share of U.S. market demand for mass timber that Oregon will capture is unknown, however, scenarios can be created based on Oregon's market share of other softwood products. When calculating market share, it's important to note the difference between production and consumption. For example, in terms of production, Oregon represented 16.5 percent of total softwood lumber production in the U.S. in 2015 (OFRI, 2017). Most softwood lumber produced in the U.S. is consumed domestically, but a small percentage is exported (under 10 percent in Oregon in 2015). In terms of consumption, the U.S. market for softwood lumber is much larger than the volume of lumber produced in the U.S. As a result, the U.S. imports softwood from other countries to meet demand; the vast majority of those softwood imports come from Canada (about 95% of all imported). Canadian softwood represents about one-third of total U.S. consumption of softwood (Chase, 2016). So, while Oregon softwood may make up 16.5 percent of U.S. softwood production, it certainly makes up less than 16.5 percent of U.S. softwood consumption, due to imports of Canadian softwood.

Market share scenarios of 5, 10, and 15 percent were used in this analysis to represent potential Oregon market share of the mass timber market in the U.S. Each scenario was applied to potential market demand, and the resulting mass timber volume was converted to cubic feet for pricing. D.R. Johnson provided a market price of \$27 per cubic foot for CLT<sup>11</sup>, which was applied to the mass timber volumes for each scenario to get sales for mass timber manufacturing.

## Economic Impact Modeling

This economic impact analysis was conducted with IMPLAN, an input-output model. The study area for this analysis is the state of Oregon. Data used in the model is from 2015. Although this analysis is based on 2015 data, IMPLAN uses deflators to express impacts in current dollars.

This analysis considers the economic impact of jobs created by the manufacture of CLT and other mass timber products in Oregon on total employment, labor income, output, value added, and tax revenue in Oregon. The total impact is the sum of the following items:

- **Direct Impacts:** The initial economic change in the economy. In this case, the employment, labor income, and value added by the manufacture of CLT and other mass timber products in Oregon.
- **Indirect Impacts:** The economic changes that occur due to spending for inputs (goods and services) by the industry or industries directly impacted. In this case, that includes impacts generated by companies that supply mass timber manufacturers.
- **Induced Impacts:** The economic changes that occur due to spending by employees in the industry or industries directly or indirectly impacted. In this case, that includes impacts from mass timber manufacturing employees and others spending their labor income in the community.

An analysis-by-parts approach was used in the economic impact analysis to account for unique production inputs for mass timber manufacturing that are not reflected in existing IMPLAN industry sectors. Regional purchasing

**TABLE 4: INDUSTRY SPENDING PATTERN FOR CLT MANUFACTURING IN OREGON**

Industry Spending Pattern for CLT Manufacturing in Oregon			
Sector	Industry Title	Value	Local Direct Purchase
3134	Dimension lumber and boards	23.1%	80.0%
3166	Plastics materials and resins	8.9%	1.3%
3461	Management of companies and enterprises	6.7%	100.0%
3156	Refined petroleum products	5.1%	0.3%
3118	Coated fabric coating	3.7%	0.1%
3049	Electricity transmission and distribution	3.3%	100.0%
3395	Wholesale trade distribution services	2.9%	81.1%
3236	Saw blades and handtools	2.2%	64.6%
3411	Truck transportation services	1.5%	100.0%
3050	Natural gas distribution	1.3%	76.8%
3178	Adhesives	1.1%	8.9%
3177	Paints and coatings	0.9%	23.4%

Source: Oregon Business Development Department with data from 1) IMPLAN (2014), Oregon, and 2) Brent Lawrence interviews with D.R. Johnson.

<sup>11</sup> Price varies drastically by manufacturer and by product size. Estimation based on 2015 manufacturing capability, growth will likely occur shortly after publication of this report.

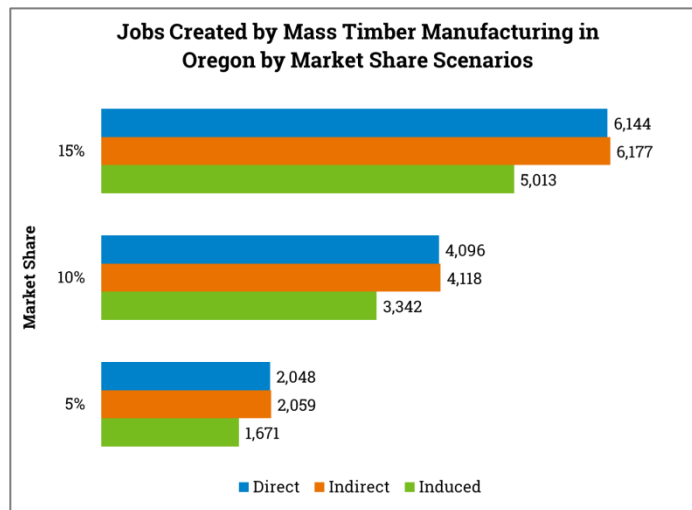
coefficients (RPC) for key inputs were determined with data provided by D.R. Johnson, with RPCs for remaining inputs based on IMPLAN's industry spending pattern for reconstituted wood products and engineered wood members and trusses. Table 4 details the top inputs into the CLT manufacturing industry spending pattern. Sales estimates from each market share scenario were applied to the CLT industry spending pattern, minus a percentage of revenue for labor costs and value added.

Labor demand for CLT manufacturing was modeled on information obtained from D.R. Johnson on production workers needed to produce CLT. The 2014 industry staffing pattern for wood product manufacturing in Oregon from the Oregon Employment Department was used to estimate job demand for management, administration, and maintenance occupations to fill out the rest of the CLT manufacturing staffing pattern. Wage information was not provided by D.R. Johnson. The average wage for jobs created in CLT manufacturing was based on the average wage of the engineered wood member and truss manufacturing sector in IMPLAN for Oregon. This analysis assumes that workers filling all jobs created reside in Oregon.

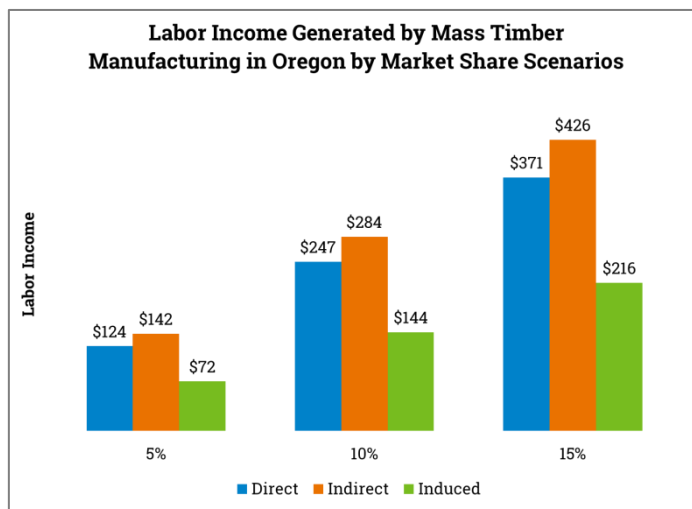
Tax impacts created by direct, indirect, and induced effects were produced in the IMPLAN model. IMPLAN state personal income tax estimates are usually very close to manually calculated estimates using effective tax rates and, if anything, tend to be slightly lower, thus representing a conservative estimate of state income tax revenue.

## Economic Impact Analysis

Economic impacts from the manufacture of CLT and mass timber in Oregon depend on the amount of market share mass timber can gain in markets for residential and non-residential buildings currently constructed with steel, concrete, and masonry. For that, this analysis relies on potential market demand data from FPInnovations. The share of that market demand that Oregon can capture also has a large effect on economic impacts in the



**FIGURE 5: JOBS CREATED BY MASS TIMBER MANUFACTURING**



**FIGURE 6: LABOR INCOME GENERATED BY MASS TIMBER MANUFACTURING**

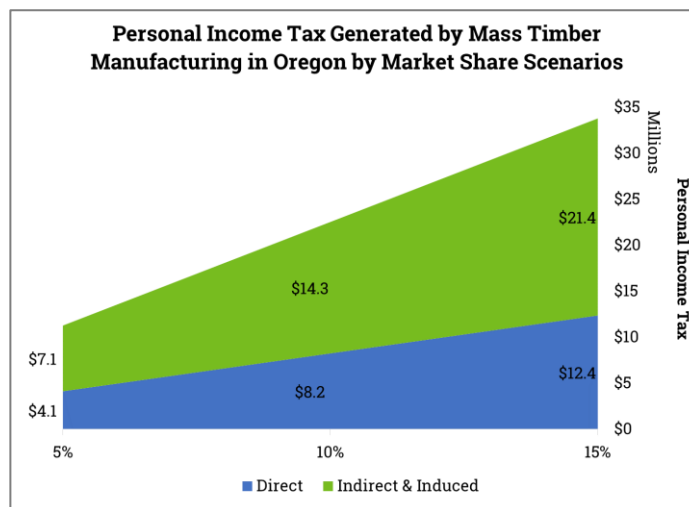


state. This analysis models economic impacts in Oregon from the manufacture of CLT and mass timber products at market shares of 5, 10, and 15 percent.

Under the 15 percent market share scenario, mass timber manufacturing in Oregon would create 6,144 direct jobs in mass timber manufacturing. Indirect impacts from these jobs would create an additional 6,177 jobs through supply chain effects in Oregon. Induced impacts would create 5,013 jobs from employee spending, for a total of 17,334 jobs created in Oregon from 15 percent market share of mass timber demand in the U.S. The 6,144 direct jobs in mass timber manufacturing would generate about \$371 million a year in labor income and \$12.4 million a year in state personal income taxes. Including indirect and induced impacts, total impacts from mass timber manufacturing would generate over \$1 billion in labor income and \$33.8 million in state personal income taxes in Oregon annually under the 15 percent market share scenario.

Under the 10 percent market share scenario, mass timber manufacturing in Oregon would create 4,096 direct jobs in mass timber manufacturing. Indirect impacts from these jobs would create an additional 4,118 jobs through supply chain effects in Oregon. Induced impacts would create 3,342 jobs from employee spending, for a total of 11,556 jobs created in Oregon from 10 percent market share of mass timber demand in the U.S. The 4,096 direct jobs in mass timber manufacturing would generate over \$247 million a year in labor income and \$8.2 million a year in personal state income taxes. Including indirect and induced impacts, total impacts from mass timber manufacturing would generate \$675 million in labor income and \$22.5 million in state personal income taxes in Oregon annually under the 10 percent market share scenario.

Under the 5 percent market share scenario, mass timber manufacturing in Oregon would create 2,048 direct jobs in mass timber manufacturing. Indirect impacts from these jobs would create an additional 2,059 jobs through supply chain effects in Oregon. Induced impacts would create 1,671 jobs from employee spending, for a total of 5,778 jobs created in Oregon from 5 percent market share of mass timber demand in the U.S. The 2,048 direct jobs in mass timber manufacturing would generate about \$124 million a year in labor income and \$4.1 million a year in personal state income taxes. Including indirect and induced impacts, total impacts from mass timber manufacturing would generate nearly \$338 million in labor income and \$11.3 million in state personal income taxes in Oregon annually under the 5 percent market share scenario.



**FIGURE 7: PERSONAL INCOME TAX GENERATED BY MASS TIMBER MANUFACTURING**

The employment multiplier for CLT and mass timber manufacturing in Oregon is 2.8, meaning that for every job created in mass timber manufacturing, 1.8 additional jobs are created throughout Oregon from indirect and induced effects. This employment multiplier is similar to other wood product manufacturing industries in Oregon and higher than average for most manufacturing industries in

Oregon. Perhaps not surprisingly, the industry group that indirectly benefits the most from CLT and mass timber manufacturing growth in Oregon is forestry and wood products. Sawmills and logging are the two industries that would create the most jobs from indirect impacts, as additional logs would need to be harvested to supply sawmills that provide lumber to CLT and mass timber manufacturers.

## Impact Summary

The scope of this analysis did not include an analysis of the ability of in-state suppliers to meet increased demand from CLT and mass timber manufacturing. This is primarily a concern in regards to the main input into CLT manufacturing: lumber. The majority of lumber produced in Oregon comes from logs harvested in Oregon. The growth of CLT and other mass timber manufacturing in Oregon could have significant impacts on the supply of timber in the state, and more broadly, in the Pacific Northwest. The model used in this analysis assumes that 80 percent of lumber used in CLT manufacturing in Oregon comes from in-state suppliers. Not all of that lumber would come from Oregon forests, but a significant amount would likely need to. Under the 15 percent market share scenario, 915 million board feet (MMBF) of lumber would be required to meet demand for mass timber manufacturing in Oregon. Under the 10 and 5 percent scenarios, 610 MMBF and 305 MMBF would be required.

CLT and mass timber manufacturing in Oregon has the potential to create over 17,000 jobs and revitalize wood product manufacturing in Oregon. As with other wood product manufacturing in Oregon, the supply chain for CLT manufacturing includes many commodities that are able to be supplied from within the state, primary among them, lumber. As a result, the multiplier effects from increased employment in CLT and mass timber manufacturing creates proportionately large numbers of jobs in Oregon from indirect and induced impacts. While it is difficult to accurately predict how large the market for CLT will be in the U.S. and how much of that market Oregon manufacturers will penetrate, it is not difficult to see the comparatively large economic impacts this industry could create in Oregon should the potential demand for CLT and mass timber come to fruition.

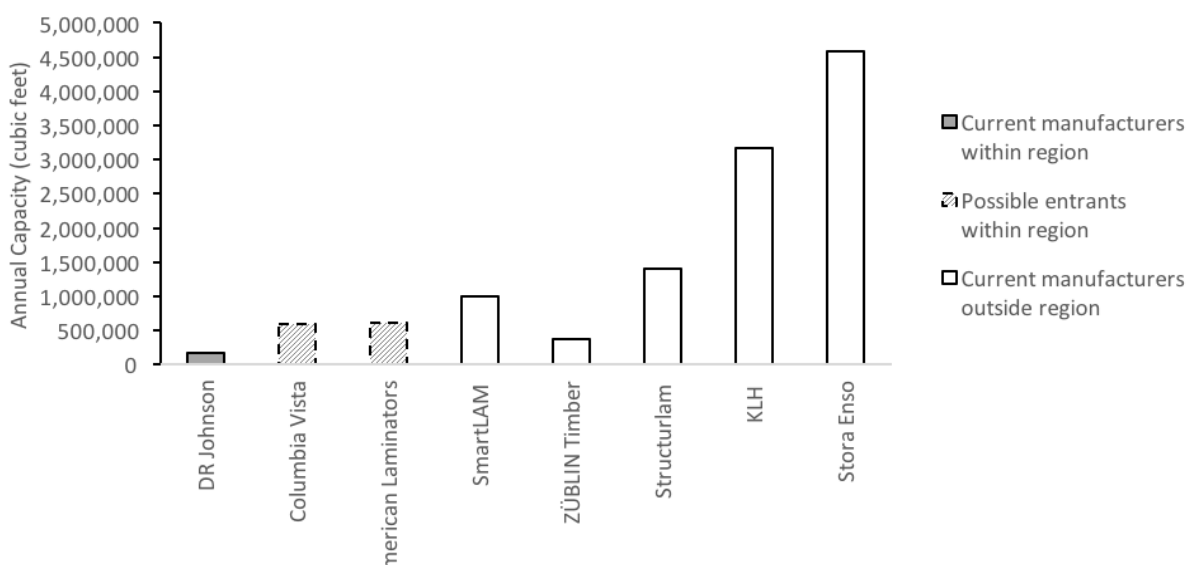
## Triggering Additional Investments in the Supply Chain

Not only would the increased demand for CLT create more jobs throughout the supply chain, but also it would also trigger additional investments in existing manufacturers upgrading their equipment, or new entrants' initial investments.

As of September 2015, DR Johnson (Riddle, Oregon) was the first manufacturer in the United States to receive APA-certification for its CLT panels; thereby allowing the panels to be used in structural applications (Bell, 2015). Located in Montana, SmartLAM recently received the same certification in August 2016 (APA, 2016). At the time of this report's publication, these are the only two domestic producers. SmartLAM is outside the region for this study and therefore this analysis is focused on DR Johnson and potential market entrants including Columbia Vista and American Laminators.

For almost every CLT manufacturer, the CLT pressing is typically the bottleneck constant pressure must be maintained while adhesives set up. The adhesives used for CLT panels typically require two to three hours to sufficiently harden before they can be moved; therefore, current presses used in Europe and North America typically allow for three to four pressing cycles per shift.

DR Johnson's annual capacity as of 2015<sup>12</sup> was approximately 173,250 ft<sup>3</sup> of CLT (this assumes one shift and one press). To compare DR Johnson's current capacity to the global production of cross laminated timber, global production of CLT in was reported to be 22,071,667m<sup>3</sup> in 2014 and was forecasted to increase to around 25 million m<sup>3</sup> in 2015 (FAO, 2015). Figure 8 shows DR Johnson's annual capacity compared to established CLT manufacturers in Canada and Europe.



**FIGURE 8: ANNUAL CAPACITY (CUBIC FEET) OF SELECTED CURRENT AND POTENTIAL MANUFACTURERS. BASED ON 2015 MANUFACTURING CAPABILITIES.**

Due to increasing demand throughout the US marketplace, DR Johnson is adding a second shift per working day and is said to be adding another press in 2017.

It is unlikely DR Johnson will be the only supplier to the mass timber construction market in the Pacific NW. Because shipping only accounts for a small percentage of the total package costs, it is not uncommon to have Canadian or European manufacturers to submit bids for buildings constructed in the Pacific Northwest. In fact, KLH—a European firm with manufacturing operations in Austria—has shown that even accounting for shipping costs, they can still offer successfully competitive bids to the North American market. Seeing signals of the growing potential of the West Coast market, KLH has recently expanded and opened a sales office in Portland, Oregon.

<sup>12</sup> Based on DR Johnson's production line in 2015: facility details and capability are expected to increase in 2017.

Having additional suppliers of CLT has the potential to expand the market. As an industry moves from the introduction stage into the growth stage in its lifecycle, incumbent firms will tend to focus on process innovation. This drives down manufacturing costs, enabling each to remain more competitive in the market. Each supplier can then either offer lower prices to their customers while retaining the same level of profit, or by keeping the same price they can increase the entire industry's profitability (Rothaermel 2015).

Product innovation is also apparent in the market. Not reflected in the capacity numbers (due to timing of interviews) is Freres Brothers who expect to produce mass plywood panels (MPP) in the coming years. This product is expected to directly compete with CLT products. Additionally, dowel laminated timber is entering the market; also an alternative product line.

From a practical perspective, each supplier is likely to have its own sales personnel. These individuals are responsible for identifying potential customers and help adequately educate them to allow the customer to determine if CLT is the right fit for their specific project or firm. This educational component is cumulative across the entire industry; thus the more suppliers, the more salespersons—or educators—in the market contributing for a larger opportunity for CLT. While each CLT supplier can view each other as competition to some degree, this industry is still growing; for that reason, a sense of allied camaraderie should be felt as they are all trying to raise awareness for the value that CLT offers ultimately increasing not only their firm's profitability but that of the entire industry.

## Interpretation

As cubic feet of cross laminated timber is perhaps a figure difficult to grapple with or visualize, these volumes have been converted into notable recent projects utilizing CLT. In addition to serving as a tangible visualization, this also serves as a figure to “back-calculate” to the original forecasted construction. The four referenced projects are Albina Yard, Brock Commons, Dalston Lane, and Framework.

Albina Yard is a four-story office building in Portland, Oregon finished in summer 2016. Albina Yard was designed by LEVER Architecture and KPFF Consulting Engineers completed the structural engineering. This building used glulam beams for the frame and CLT for the floors and roof (LEVER Architecture & reworks, 2016). At 16,000 square feet, the primary intent of the building “was to utilize domestic CLT in a market-rate office building that would pave the way for broader market adoption of renewable mass timber construction technologies in Portland and the US (LEVER Architecture, 2015).”

Brock Commons is an 18-story structure on the University of British Columbia scheduled for completion in August 2017 (naturally:wood, 2016). The structure will accommodate housing for 690 students. A 174-foot tall design of this nature would ordinarily not be possible, but “the ability for UBC to permit building construction as an independent jurisdiction made this ambitious venture possible” (Pei, Rammer, Popovski, Williamson, & van de Lindt, 2016).

Dalston Lane is a mixed-use 10-story structure nearing completion in Hackney, London. It will offer 37,000 square feet of commercial space in addition to 121 housing units (Esler, 2015). The design utilized over 135,000 cubic feet of CLT in its walls and flooring system in addition to its CLT core (Foster, Reynolds, & Ramage, 2016; Gonchar, 2015). Dalston Lane was designed by architecture firm Waugh Thistleton, international leaders in the field of mass timber construction. As construction began, this was

the largest CLT structure by volume in the world (Esler, 2015). Besides environmental benefits, choosing CLT rather than concrete or steel allowed for a lighter structure and consequently smaller and cheaper foundation. This was important because of high speed rails passing beneath the building site which limited the structure's weight; choosing CLT allowed the developers to build an additional two stories of housing units, increasing their expected ROI on the project (White, 2015).

**TABLE 5: COMPARISON OF STRUCTURAL SYSTEMS AND WOOD USE PER AREA FOR SELECTED CLT STRUCTURES**

COMPARISON OF SELECTED CLT STRUCTURES							
		STRUCTURAL SYSTEM			WOOD USE PER AREA		
	number of stories	vertical	lateral	flooring	floor area (ft <sup>2</sup> )	CLT used in design (ft <sup>3</sup> )	ratio
<b>Albina Yard</b>	4	column GL	PLY	CLT	16,000	5,500	2.91
<b>Dalston Lane</b>	10	wall CLT, RCGF	core + wall CLT	CLT + Sc55	171,792	136,032	1.26
<b>Brock Commons</b>	18	GL + RC core, RCGF	core RC	CLT	162,700	76,733	2.12
<b>Framework<sup>a</sup></b>	12	core PT CLT, column GL	core PT CLT	beamGL+CLT+Sc?	89,896	43,012 <sup>b</sup>	2.09 <sup>c</sup>
<p>Note: CLT indicates cross-laminated timber; RC# indicates reinforced concrete of thickness # mm; Sc# indicates nonstructural concrete screed of thickness # mm; Sc? indicates nonstructural screed of unknown thickness; GL indicates glue-laminated timber; RCGF indicates ground-floor podium level with concrete transfer slab above; PT indicates posttensioning; PLY indicates plywood sheathed shear walls.</p> <p><sup>a</sup>Unrealized building at the time of writing.</p> <p><sup>b</sup>Estimated by dividing the floor area by the estimated ratio.</p> <p><sup>c</sup>Estimated by averaging ratio of Albina Yard and Dalston Lane.</p> <p>source: (Foster, Reynolds, &amp; Ramage, 2016; Lawrence &amp; McDonnell, 2017; Lawrence &amp; Redfield, 2017; Lawrence &amp; Spiritos, 2017)</p>							

Framework (Portland, OR) has recently been permitted to begin construction. It is a 12-story mixed-use building nearly 90,000 square feet that is expected reach up to 130 feet tall (Heppner & Hallova 2016). The real estate firm—Project^—and Home Forward, a local investor, envision the building to be constructed in the Pearl District in Portland (McKnight 2015). Designed by LEVER Architecture, its development has been aided by funding from the USDA Tall Wood Building Prize Competition. Framework would contain both retail and community space in the double-height ground level, and the upper levels would offer both apartments and office space. Similar to Albina Yard, Framework's design will incorporate CLT as floor slabs. However, Framework will also employ CLT as its core like Dalston Lane. Because Dalston Lane employed CLT in its wall elements rather than Framework's proposed design which utilizes more glulam (Foster, Reynolds, & Ramage, 2016), the ratios of floor area to cubic foot of CLT in Albina Yard and Dalston Lane have been averaged and the resulting value used to estimate the volume of CLT that could potentially be used in Framework.

Table 5 compares the structural systems and wood use per area of these buildings.

## Potential Entrants

As awareness continues to increase for CLT and professionals become more comfortable with designing and constructing buildings with mass timber, our region may see new entrants in the form of sawmills or glulam manufacturers adding CLT to their product lines.

### Columbia Vista: Partnership of sawmill, glulaminator, and contractor

Columbia Vista Corporation and partners in Vancouver, Washington are likely to form an entity to begin manufacturing CLT within the region. In an initial meeting in Spring 2016, President Bob Lewis shared that he, his associate Doug Calvert of Calvert Company, Inc., and Matt Olson of Robertson & Olson Construction, Inc. had been discussing the possibility of forming a partnership for the past two years (B. Lawrence, Lewis, Lawrence, & Muszynski, 2016b).

In operation for over sixty years, Columbia Vista is a sawmill producing kiln-dried lumber for both the international and domestic market. Although the market can fluctuate, at the time of interview Columbia Vista was exporting 30% of their annual production to Japan, Australia, and China, while the remaining 70% remained in the domestic market. Calvert Company, Inc. has been manufacturing glulam for over fifty years, and Robertson & Olson Construction, Inc. operates in the commercial sector and has expertise in tilt-up concrete construction which translates well into prefabricated assemblies like CLT. Robert & Olson also has six engineers regularly designing in CAD, and is currently developing unique mechanical connections to speed up the construction of mass timber buildings. Furthermore, Robert & Olson's frequent work in multi-family construction has allowed the company to form relationships with real estate developers from Seattle to Eugene, and some developers have indicated that they would specify CLT for future building types if this partnership were to materialize. Because of this collaboration across multiple sectors of the supply chain, this vertical integration offers a considerable advantage in continuing to develop the domestic market for mass timber.

These partners have already identified a facility for manufacturing CLT in the Port of Vancouver; a structure and storage yard was idle at the time of this report. Lewis envisions an 18-24 month timeline for installation and progression toward full production capacity, and once this status is reached he anticipates revenues to allow for a two-year payback period.

Finally, it is worth noting that the implied assumption of this section is that market demand is the main driver of any additional investments in the local supply chain. This is referred to as existing demand "pulling" the product from the supply chain upstream.

While it is true that Columbia Vista would not make the investments if demand did not seem to be growing, they have the distinct advantage of being able to leverage Robert & Olson's existing customers to expand the existing market for CLT. This allows the supplier to "push" the product downstream. As reflected in Figure 8, sometimes only a few large buildings are needed to fully utilize the annual capacity of a CLT manufacturer, and it is not uncommon for CLT manufacturers to run below full capacity. Robertson & Olson's existing clientele has strong potential to propel the amount of mass timber construction within the region at a quicker rate than the current trajectory.

A conversation with President Bob Lewis in December 2016 revealed that he and his associates were “90-95% of the way there” to finalizing the financing to form a corporation, order equipment, and expand facilities (Lawrence, B., Lewis, B. 2016). Pro forma financial statements had been created, and Bob and his associates are currently working with Craft3, a nonprofit Community Development Financial Institution.

While detailed figures were not able to be disclosed, approximate investments including contributed capital and loans accounted for \$7 million to bring CLT as a product offering. An existing \$1 million in existing building, infrastructure, and equipment would be allocated for the proposed corporation.

As suggested in initial conversations, Bob anticipates the first projects being four or five midrise CLT buildings as part of the redevelopment of the waterfront in Vancouver. Consistent with other mixed-use buildings commonly seen in new timber construction including Framework, the ground floors will be retail while the upper four or five stories of these structures will be housing units (Berger 2016).

Rough estimates for capacity assume that 18 panels could be produced in an 8-hour shift, and planning has supposed that an additional 12 panels could be produced in a second shift. Assuming 240 working days per year and that these panels are 3-layer with sizes of 10’ x 40’, this would result in an annual capacity of 594,000 ft<sup>3</sup> per one shift or 990,000 ft<sup>3</sup> with the second shift added. These figures are shown in Table 6.

**TABLE 6: CAPACITY ESTIMATES OF COLUMBIA VISTA COMPARED TO NUMBER OF SELECTED CLT STRUCTURES THAT COULD BE PRODUCED ON AN ANNUAL BASIS**

CAPACITY ESTIMATES OF COLUMBIA VISTA COMPARED TO NUMBER OF SELECTED CLT STRUCTURES THAT COULD BE PRODUCED ON AN ANNUAL BASIS			
	Actual or estimate CLT used in design (ft <sup>3</sup> )	How many could be produced annually (capacity 594,000ft <sup>3</sup> )	How many could be produced annually (capacity 990,000ft <sup>3</sup> )
Albina Yard	5,500	108	180
Dalston Lane	136,032	4	7
Brock Commons	76,733	8	13
Framework <sup>a</sup>	43,012 <sup>b</sup>	14	23
<sup>a</sup> Unrealized building at the time of writing. Estimated by averaging the use of CLT per area in Albina Yard and Dalston Lane <sup>b</sup> Estimate; for methodology, see preceding table "Comparison of Structural Systems and Wood Use Per Area for Selected CLT Structures"			
source: (Foster, Reynolds, & Ramage, 2016, 2016; Lawrence & McDonnell, 2017; Lawrence & Redfield, 2017; Lawrence & Spiritos, 2017)			

### American Laminators: Glulaminator’s Product Diversification

The following information was obtained in a direct interview with American Laminators’ top management to determine their interest and potential capabilities for manufacturing cross laminated



timber. This interview was conducted by the co-authors of this section in Spring 2016 (Anderson & Williams 2016).

American Laminators has been manufacturing specialty glue laminated timber, or glulam, for custom projects within the region for over 50 years. As beams are often used to support roofs with wide spans, some of their projects include ranger stations for the US Forest Service, ice arenas, wedding pavilions, water reservoirs, and perhaps most notably University of Oregon's Autzen Stadium.

This company has been involved in internal and collaborative new product development. One example included development of fiber-reinforced glulam technology and pursued certification for its use as building material (Gilham 2007).

American Laminators has been closely monitoring the development of the cross laminated timber technology because in many respects the manufacturing process and the nature of interaction with potential market are remarkably similar to their specialty glulam business.

American Laminators has an idle facility in Swiss Home, Oregon that could be adapted for manufacturing CLT. While figures with greater resolution would be required to pursue financing, estimates in the range of \$7-10 million were considered accurate to utilize this existing facility. This estimate is consistent with other conversations with prior and potential entrants and Chris Claflin, formerly Economic Development Manager for Business Oregon, noted that this range can tend to be a "sweet spot" for industrial development bonds considering their low interest rates.

Though this rough figure is not exhaustive, this range in financing includes the following required elements:

- infrastructure for material movement (also referred to as rolling stock)
- overhead cranes (around \$100,000 each)
- glue-applicator typically designed and installed by the adhesive manufacturer (\$200,000)
- CNC machine and software (around \$1,000,000)
- press for cross laminating layers of lumber into panels
- spray booth for architectural finishes

Some economists and policymakers have asked if the sale of equipment for adding a CLT manufacturing line will be produced by domestic or foreign equipment manufacturers. It is worth noting that both American and European manufacturers of the required elements exist within the competitive landscape, and both US and European equipment are commonly observed in US wood products manufacturing facilities.

Glulam manufacturers typically have a majority of the equipment necessary to begin producing CLT. As such, because the land, facility, and finger-jointing line already exist and are owned, this financial range is lower than cited green field investments for manufacturing CLT by prior research conducted by forest product consultants The Beck Group. In their 2015 study, they estimated total capital cost at "\$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 (Beck 2015)."

Based on their research in the European market, American Laminators was partial to the idea of producing large CLT panels (up to 10 feet wide and up to 60 feet in length). This approach differs from other domestic manufacturers (often producing 40 feet in length or less). Assuming 240 working days, and 3.75 cycles per shift (adhesives could be setting in between shifts), operating one shift would yield

an annual capacity more than 433,000 ft<sup>3</sup> (over 12,000 m<sup>3</sup>). This would require finger-jointing 21,700 bf of lumber per day which is well within the capacity of their current operational efficiency.

One key advantage of American Laminators is their expertise in kiln drying. The PRG320 specifies that lumber must be dried to 12% moisture content +/- 3%, while on average most kiln dried lumber is dried to 15-19% moisture content (American National Standards Institute, 2014). Therefore, lumber for CLT must be specially requested to be dried to a more precise standard, decreasing the number of suppliers in the market and raising the cost of material. Otherwise, the laminators would have to rely on the lumber air drying to the target 12% moisture content in their outdoor storage yards—which would be highly dependent on seasonal fluctuations in local climate conditions—or incorporate kiln drying capacity into their own production line (B. Lawrence, Lawrence, & McDougall, 2016).

American Laminators recognizes the value of vertical integration in developing CLT manufacturing capacity as an addition to their current line of products: whether developing internal expertise to help design or construct mass timber buildings or having close partnerships with other firms maintaining these competencies. The company acknowledged this level of change their business strategy and related investments a substantial challenge.

Another challenge expressed by American Laminators was that should any large domestic or international players in forest products industry choose to join the local CLT market, they would likely do so on a massive scale putting local small players at serious disadvantage.

At the time of the interview, American Laminators rested the potential of joining the CLT market on the future assessment of their own performance and that of the general market perceptions of mass timber.

A summary of annual capacities for current manufacturers within the region, possible entrants within the region, and select manufacturers outside the region can be seen in Table 7.

**TABLE 7: ANNUAL CAPACITY OF CURRENT AND POTENTIAL MANUFACTURERS OF CLT, BOTH WITHIN AND OUTSIDE OF THE REGION**

	ANNUAL CAPACITY FOR PRODUCING CLT		
	Current manufacturers within region (ft <sup>3</sup> )	Possible entrants within region (ft <sup>3</sup> )	Current manufacturers outside region (ft <sup>3</sup> )
<b>DR Johnson</b>	173,250	—	—
<b>Columbia Vista</b>	—	594,000	—
<b>American Laminators</b>	—	608,438	—
<b>SmartLAM</b>	—	—	999,996
<b>ZÜBLIN Timber</b>	—	—	376,737
<b>Structurlam</b>	—	—	1,412,587
<b>KLH</b>	—	—	3,178,320
<b>Stora Enso</b>	—	—	4,590,907



**PROJECT:** Albina Yard

**LOCATION:** Portland, OR

**ARCHITECT:** LEVER Architecture

**OWNER:** Albina Yard, LLC

**CONTRACTOR:** Reworks

**STRUCTURAL ENGINEER:** KPFF Consulting

**CLT SUPPLIER:** D.R. Johnson

**PHOTO:** WoodWorks!

# BARRIERS TO MARKET

## Introduction

The use of cross laminated timber (CLT) in commercial and residential buildings in the US depends on its acceptance under fire, seismic, architectural, and structural codes. Barriers for accepting CLT are tied to the perception of CLT meeting code specifications. Current barriers are identified and mapped for stakeholders, and, where possible, these barriers need to be addressed.

In this section, the research group identifies and proposes a path to address the challenges associated with making this product usable by US builders from a full commercialization perspective.

The team sought to understand the barriers faced by CLT in the domestic market and to address those barriers. Largely, the barriers related to seismic, fire, architectural and structural codes that must be met during design and construction. The research team reviewed previous market surveys so all potential barriers are included in the survey. From those surveys, current attitudes toward CLT use were mapped. Stakeholders with high influence and the most negative attitudes were identified. Then based on this research, the dominant attitudes for groups of stakeholders were summarized. For earlier defined target markets for CLT, the team proposes strategies to decrease the CLT barriers. Codes or sections of the codes that limit CLT usage or are perceived to limit CLT usage are identified and addressed. The team then proposed educational strategies to reduce any negative perceptions of CLT and to boost the marketplace for CLT, along with workforce training needs.

## Assessing the Barriers to Market

A combination of interviews, research, and industry knowledge were used to target the key barriers: current attitudes toward CLT, building codes/permitting process, seismic & fire testing needs, gaps in industry knowledge, product availability, transportation, and labor force limitations still remain barriers to one extent or another for getting CLT to market. In this section, these challenges are further defined followed by a pathway to overcoming those barriers. The research determined that growing the CLT market will require overcoming barriers on the supply side, i.e., manufacturing CLT, and on the demand side, i.e., constructing buildings with CLT. In this section, both supply and demand barriers were examined.



**A path to address  
feasibility  
challenges  
faced by  
stakeholders  
in bringing  
CLT to market.**

## Product Availability

Evidence from Europe and the U.S. shows that the lack of CLT's availability is a barrier to using it as a construction material. In Europe, 39% of surveyed industry experts reported that the low availability of CLT is a major market barrier to its use (Espinoza, et al., 2015). Based on the 2015 survey of US architectural professionals, most U.S. industry experts identified CLT's lack of availability in the market place is the greatest barrier for this product to overcome: 94% of respondents considered this a large or potential barrier. At the time of the survey CLT was not being produced in the US yet. However, with very few CLT-producing firms in the U.S., CLT availability remains a significant barrier (Fernanda Laguarda Mallo and Espinoza, 2015).

Watts and Helm (2015) suggested a dilemma with regard to CLT production and demand that informs the product availability barrier: unless there is supply of CLT there will be only minor demand for it, and unless there is demand for CLT, suppliers might not be willing to take the risk on producing it. The solution to the dilemma is probably increased demand spurring initial production and sustainable production keeping pace with continued demand.

Existing wood-products manufacturers are unlikely to understand how to manufacture CLT to meet the performance standards of American Plywood Association (APA) PRG-320. The construction industry has interest in using CLT, but until their desires align with manufacturers' abilities, the use of CLT will be stunted.

One challenge for the Tall Timber Alliance is to recruit more timber companies to increase the production of CLT panels to meet the demand created by new projects (Cook, 2015). The success of these early adopters will hopefully encourage other timber firms to manufacture CLT.

## Transportation Cost

The transportation costs of moving this product needs assessment project to project. Currently, transportation costs do not appear significant enough to detour out of region, even foreign producers, from competitively bidding on regional building projects. Shipping costs can and have been overcome because of a need to satisfy environmental needs, aesthetics, or both. The CLT buildings in the United Kingdom (UK) used CLT which was produced in Austria and shipped over land and sea to building sites (ex. International House Sydney in Barangaroo, Sydney). Likewise, a CLT building in Melbourne, Australia was constructed of CLT shipped overseas. If no concern is given to the sourcing of the raw material inputs for the panels, foreign producers are proving to have the competitive advantage currently.

With concern to sustainability practices, timber-centered economies in California, Oregon, and Washington have the potential to locally supply raw materials for CLT manufacturing to fulfill the demand for CLT in buildings. The Northwest in particular contains the natural resources and innovative attitudes necessary to be a leading region in sustainable, locally sourced, regionally impactful construction. The combination of regional manufacturing strengths with the demand for sustainable building is important, since transportation costs of moving the product will likely be the deciding barrier.

## General Attitudes Toward CLT in the US

Based on a survey of architectural professionals conducted by the University of Minnesota, opinions are split regarding the perceived likelihood of CLT adoption in the US (Fernanda Laguarda Mallo and Espinoza, 2015). When considering the overall adoption of CLT, and especially in residential buildings, 51% of respondents were uncertain about CLT's adoption while 32% considered adoption likely. When discussing CLT in high rise buildings, responses changed to 28% who were uncertain, 27% who thought it likely, and 25% who thought it unlikely (see Table 8 and Table 9).

The common opinion in the US is that CLT panels are best suited for residential and multi-family buildings (Fernanda Laguarda Mallo and Espinoza, 2015). However, engineers surveyed by Silva Fennica Research, found that CLT has a good strength-to-weight ratio, which would make CLT ideal for the structuring of warehouses and large halls (Roos, et al., 2010). National CLT developments include a North American CLT product standard that has been under development since 2012 and has been approved by the International Code Council for the 2015 international building code. A material design standard still needs to be approved before CLT becomes an official component of the products included in the US building codes (FPInnovations, 2013).

**TABLE 8: PERCEIVED LIKELIHOOD OF CLT ADOPTION IN THE U.S. (FERNANDA LAGUARDA MALLO AND ESPINOZA, 2015).**

Likelihood of CLT Adoption	Count of Respondents	% of Respondents
Very Likely	25	8.7%
Likely	92	32.2%
Uncertain	145	50.7%
Unlikely	15	5.2%
Very Unlikely	4	1.4%
Total	281	
* Doesn't add to 100% because 5 survey participants didn't answer this question.		

**TABLE 9: PERCEIVED LIKELIHOOD OF CLT ADOPTION IN THE U.S-HIGH RISE BUILDINGS. (FERNANDA LAGUARDA MALLO AND ESPINOZA, 2015).**

Likelihood of CLT Adoption	Count of Respondents	% of Respondents
Very Likely	44	15.4%
Likely	76	26.6%
Uncertain	79	27.6%
Unlikely	70	24.5%
Very Unlikely	10	3.5%
Total	279	
*Doesn't add to 100% because 7 survey participants didn't answer this question		



The survey data show that very few architectural professionals think CLT is *unlikely* to become more widespread, but half are uncertain. The high level of uncertainty shows an opportunity for better education to help that industry understand CLT's uses and advantages.

## U.S. Building Codes

For CLT panels to become an industry norm in the US, they must be approved in local building codes. As expected, the permitting of projects arose as a significant barrier to current developers in the region. Using CLT is unique and new process to the United States. A multi-tiered strategy is required to officially adopt CLT into US building codes. This strategy includes the development of a product standard as well as a material design standard and the subsequent adoption of these standards into local codes and regulations. These standards include local building codes, as well as related codes on energy efficiency and green building methods.

The North American Advisory Committee on CLT, along with its Research and Standards sub-committee, was formed specifically to develop a roadmap for code adoption (Mohammad, 2013). An Ad Hoc Committee on tall wooden structures was formed in 2016 composed by the International Code Council for developments to the 2021 International Building Code (International Code Council (2.), 2016). The lower construction costs of CLT buildings may help it to become established within local building codes as there is a strong desire in the industry to reduce costs in a safe and efficient manner (Schmidt and Griffin, 2013).

An additional study conducted by Silva Fennica Research (Roos et al., 2010) provides some valuable insights on how the attitudes of industry officials impact the advancement of CLT. The study found that contractors, developers, and regulatory agencies have the strongest ability to encourage the use of CLT panels. However, attitudes held by individuals in those positions were mostly critical. The regulatory agencies that make decisions regarding building codes shared their opinions on the matter, but these opinions were inconclusive. As there is an opportunity to shape attitudes through education, promoting a positive perception of CLT among these agencies is crucial. Roos, et al. (2010) also showed positive attitudes towards CLT among architects, timber suppliers, and the end users living within these structures. Unfortunately these groups have considerably less influence and regulatory power.

A CLT product standard has existed in the US since 2012, and the development of a material design standard has also begun. The 2015 building code, as determined by the International Code Council, has officially added an agreed upon definition for CLT and a CLT product manufacturing standard (International Code Council (1.), 2016). Two current revisions of the 2018 US building code already include relevant rules for tall wooden structures, such as those designed with CLT panels. The first proposed revision currently being discussed would allow the construction of nine-story wooden buildings. The other revision being debated re-evaluates the fire safety of CLT structures based on the results of recent fire safety testing (Grasser, 2015).

Cross Laminated Timber currently meets building code requirements internationally for residential, commercial, institutional, and industrial facilities (Spickler, 2014). This is because the nature of these international or foreign buildings codes is performance-based, meaning that building codes are based on previous studies and project examples of what has already been done. US building codes are different in that they are prescriptive in nature, meaning that building codes regarding construction materials are based on prescriptive design requirements decided by local code officials. In this way, building designers

have to meet these prescriptive design requirements in order for a new material such as CLT to be approved by code officials (Watts and Helm, 2015). CLT is incorporated in the North American building codes since 2015 as a heavy timber element. For performance-based design to be approved, designers must meet local prescriptive requirements and have reliable information to back up the quality of this material, such as CLT’s success overseas. These prescriptive requirements vary based on the local building codes, but are usually based on height and structural safety as determined by local officials. Firms in Canada are already doing this, and regularly submit CLT structures for approval on a jurisdiction-by-jurisdiction basis (FP Innovations, 2013).

In Canada, there is currently a system in place that determines the ease of presenting tall wooden construction products such as CLT as an alternative construction solution to building code officials. This system is based on the proposed building’s height. Table 10 shows this system.

**TABLE 10: CANADIAN BUILDING CODE SYSTEM FOR DELIBERATING CLT AS AN ALTERNATIVE SOLUTION (GREEN, 2012).**

Building Height in Stories	Ease of Code Acceptance
1-6 stories high	Wood solutions are permitted
7-9 stories high	Alternative wood solutions are readily accepted by code officials.
10-12 stories high	Alternative wood solutions require advanced analysis
13 stories or more	Alternative wood solutions require extensive research

According to the International Building Code as provided by the ICC, CLT is defined as a heavy timber construction material and currently has no seismic design guidelines. The state of Oregon has adopted this definition of CLT and its use as an alternative material, but with some conservative seismic design parameters required in order to receive code approval (Mayo et al., 2016).

## Seismic Safety

Many consumers and construction professionals fear that CLT structures are more vulnerable to seismic hazards. However, CLT structures experience less vibration in their floors since most CLT buildings are designed with a uniformly distributed load between the walls and floors. This feature balances CLT buildings and makes them structurally sound (F.P. Innovations, 2013).

CLT buildings have had satisfactory seismic test results during shake tests; showing that they are able to survive major seismic shifts with little to no damage. For example, a seven-story CLT building survived shake table testing numerous times with only minor repairs needed (Portland State University, 2013).

## Fire Safety

There are also fire safety concerns when considering CLT building projects. Fire safety testing shows that CLT panels are safe and fire resistant because they char on the outside of the panel, which prevents central heat build-up and allows walls to remain structurally sound (Portland State University, 2013). CLT is usually used for floor and loadbearing walls and allows for fire-rated compartmentalization, which reduces the spread of fire beyond its point of origin. This wall design also reduces the chances of the structure collapsing because the structure's weight is evenly distributed. The European Union and Canada have conducted fire safety testing that has shown similar results, and have concluded that CLT cannot be classified as a combustible material (Green, 2012). The thick panels of wood used for CLT are already fire resistant, but fire retardant CLT panels are also being developed to improve fire resistance (F.P. Innovations, 2013). The thickness of CLT panels is important; panel thickness is a key component of fire resistance, equivalent to burning a full sized tree log without any kindling (Fountain, 2012).

Fire safety building codes are considerably more difficult to comply with than other housing codes. This is due to fire safety code specifications that vary depending on the size of the proposed building. For this reason, considerable fire testing of CLT structures will be required in order to pass code inspection (F.P. Innovations, 2013). However, it is encouraging that those who know of CLT are learning rapidly of CLT features that are resistant to fire damage. A 2015 survey of architectural experts showed that 36% of respondents believed that CLT performed well when fire tests were conducted (Fernanda Laguarda Mallo and Espinoza, 2015).

The Framework project in Portland, OR in conjunction with DR Johnson, has independently fire tested the floor/ceiling assembly to exceed the prescriptive code requirements for non-combustible materials.

## Labor Force Limitations

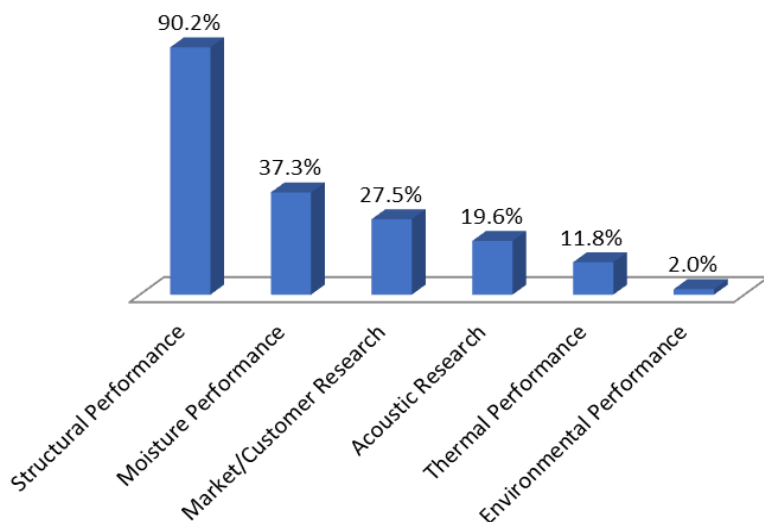
Another barrier related to wider acceptance of CLT construction is the lack of an adequately skilled labor force to support the industry. A skilled labor force that knows CLT design and construction methods is in high demand and quite difficult to acquire as this process is still new to the US (Cook, 2015).

## Raw Material Supply

In nearly every conversation about CLT the topic of timber supply arises.

Forest practices and harvest continues to be a controversial topic. A large majority of timber comes from private landowners and those

## High CLT Research Priorities



**FIGURE 9: EUROPEAN INDUSTRY OPINIONS: FURTHER CLT RESEARCH CONSIDERED A "HIGH PRIORITY" (ESPINOZA ET.AL, 2015)**

landowners are already maximizing their sustainable harvest limits. There is much concern that if the demand for CLT continues to increase, this will put a strain on timber supply.

The prices for logs and lumber are already a primary driver of the cost of CLT. One line of thinking is that the market for CLTs increases, the state's raw log and timber exports will be absorbed into local CLT production. This may also drive up the cost per bf, making it difficult for locally manufactured products to compete in the global market. Others argue that the public needs to realize these benefits and re-open public lands; allowing for working forests to supply the raw materials for engineered wood products such as CLT.

CLT is capable of utilizing small diameter and lower grade timbers; however, the harvest and processing of material as a feedstock is often not economically viable. It is imperative that research and harvest modeling initiatives continue to improve this process.

## Gaps in Knowledge

A survey of Portland experts in this industry illustrate that major barriers to using CLT panels include overcoming the testing of housing systems such as fire resistance and acoustics, the public acceptance of wood's aesthetics, and gaps in public knowledge regarding CLT (Schmidt and Griffin, 2013). Most of these barriers are due to gaps in public knowledge regarding CLT as it is still a new product. All testing of CLT housing systems has yielded satisfactory results, and many designers believe that the aesthetics of wooden buildings are preferred and widely accepted by consumers, particularly when compared to concrete or steel buildings (Naturally: wood, 2011). A 2015 survey of US architectural experts shows that 39% are "not very familiar" with CLT (Fernanda Laguarda Mallo and Espinoza, 2015). Closing this gap in knowledge is a significant opportunity to educate.

The overall level of awareness of CLT in Europe is also low, even though it was created there over 20 years ago. A survey of European industry experts showed that 91% to 98% believe that CLT awareness is still uncommon among contractors, building owners, and construction professionals (Espinoza, et al. 2015). This survey compiled a list of the most valuable future research priorities as suggested by those surveyed. Structural performance topped the list with 90% of respondents, followed by moisture performance (37%), and market/customer research (28%). There were also some concerns regarding the acoustic, thermal, and environmental performance of CLT (Espinoza, et al., 2015). These responses further highlight the need to better publicize the positive aspects of CLT, especially when discussing structural performance (Figure 9).

A survey meant to outline the public perception of strong wooden construction products in Western Canada such as CLT showed that many individuals who do know about CLT have a negative view of the product. Common misconceptions about CLT were the following (Green, 2012):

- CLT structures cost more than concrete structures because wood is more expensive than concrete.
- Constructing CLT buildings takes longer than pouring concrete for buildings.
- The fire-resistance of a CLT structure cannot replicate the performance of concrete.
- A CLT building will not survive a major earthquake.
- The necessary supply of wood needed to manufacture large amounts of CLT panels will have a negative impact on local forests.

There is substantial evidence that CLT panels are lower cost than concrete because of a faster construction process, they are resistant to seismic and fire hazards, and they are entirely sustainable when matched with forest management that is built on sound conservation values. The findings indicate that significant education is needed in order to convince construction and design experts of the value of CLT in various building types. Later in this section is a proposed pathway to addressing education and workforce training needs in the Oregon & SW Washington region.

Like other structural products (including concrete), CLT panels cannot be saturated with water before they are incorporated into a structure. This factor has the potential to increase time spent at the construction site (Portland State University, 2013). However, a survey of CLT industry professionals conducted by Forestry Innovation Investment found that moisture protection is not seen as a major issue by many CLT design teams. This is because all exposed structural elements of the wood are usually protected by the shell of the building, or are covered by an overhang of some sort (Forestry Innovation Investment, 2014). Minimal exposure to the elements can occur as long as the panels have the ability to dry out. Moisture protection is still necessary to ensure long term durability of CLT structures, which is why some projects have used a poured concrete topping or some sort of waterproof membrane on CLT floors to create separation to avoid future water leaks (Skidmore, Owings & Merrill, 2013). Handling instructions are specific to each design, and must be understood by the construction labor force. Construction firms should fully understand the implications of its ability to be exposed to wet weather during the construction process.

## Education and Outreach Plan

The research team determined that key barriers to growing the CLT market in the U.S. are perceptions about CLT. These barriers can be overcome with education.

### Part 1: Target Sectors for Education

Education has a broad reaching scope that covers the entire supply chain including sectors, from forestry/supply to manufacturing to design and construction. Because CLT interest has taken off quickly in the United States, outdated misinformation is being disseminated and we need to target education amongst all fields in a consistent, accurate, and conjoined effort.

In order for these target sectors to be identified, target fields and skillset descriptions need to be developed and defined. The division between supply-side and demand-side seems a logical first step.



## ***Supply-side***

### **Short-term Needs:**

Because of wood's positive impact on reducing our carbon footprint and greenhouse gas emissions, there is a fast desire to use wood to reduce the environmental impact of building structures. As rural communities struggle, CLT offers an opportunity to use local resources and reinvigorate our rural workforce. This surge has produced a gap from a timber industry that has suffered financially over the last several decades and has not been capable of providing the necessary levels of education across the various sectors.

CLT has the opportunity to use low-value lumber and allows smaller diameter trees. This can lead to selective thinning or pre-commercial thinning reducing the impacts of wildfires that we are spending extraordinary amounts of money to combat. On the supply-side, foresters need to understand and be educated on the demands CLT will impose on their forests and forest management practices.

Manufacturing has several components to be addressed. First, manufacturers need to be educated on why and how this product is going to be used so they can understand how to manufacture CLT to meet the design standards of APA PRG-320 and also, the desires of the design community for project specific manufacturing of panels. The American Plywood Association (APA) has been fundamental in developing the PRG-320 standard and future research necessary to further the standard. CLT is currently manufactured as a build-to-order product requiring manufacturers to include and educate their workforce on how to fabricate this product to the designer's needs. The equipment used typically entails coordination with 3-Dimensional (3-D) modeling of the building structure. Thus 3-D manufacturing, or advanced manufacturing, is requiring a higher level of education of the labor force.

Distributing the raw material from the forest, to the mills, to the CLT manufacturing facility is nothing new for established companies. New entities need to examine this supply chain to cost effectively locate forest supply, locate a manufacturing facility, and then a distribution path to jobsites. Transportation costs, handling and re-handling material can be significant factors in delivering the final product to a jobsite.

**Long-term Needs:**

Forestry management is a learning process and as the opportunity to use low-value lumber, small diameter trees, and selective thinning occurs, foresters can learn and educate on whether these approaches are having a positive impact on our forest health. Another issue that could arise is the supply of raw material. Foresters have to negotiate among private lands, tribal lands, state lands, and public lands. As awareness of the benefits of managed forestry occur, public lands need to realize these benefits and re-open public lands, the closure of which has devastated our rural communities. "Because of that collaboration, forestry has built sustainability and science-driven innovation into our daily routine. We're continually researching and implementing smart, science-based, and continuously improving practices."<sup>13</sup>

Manufacturing and efficiencies will be realized as more projects occur and this is just a natural process that has to occur over time. Distribution systems will also learn new efficiencies as more product is distributed.

***Demand-side*****Short-term Needs:**

Permitting projects using CLT has been a unique process. The American Wood Council (AWC) is the primary entity developing the building code language to allow the use of CLT. This is naturally a long process along with state and local jurisdictional review, approval, and adoption which is having trouble keeping pace with the surge demand of designers looking to utilize CLT. The AWC has developed language to allow CLT in the 2015 International Building Code (IBC), which typically is adopted by jurisdictions on a two-year delay. Thus the 2015 IBC will likely be adopted by most jurisdictions in 2017; however, even in 2016 there are many jurisdictions currently mandating the 2006 and 2009 building codes; significantly behind the typical code adoption cycle. As of 2017, Washington, Oregon, and California have adopted the 2015 IBC while other surrounding states remain on older codes.

The AWC will need to continue outreach to building officials to educate the officials on building code changes, completed testing, and future testing proving mass timber's robustness in regards to fire, seismic, and durability. The AWC and WoodWorks have worked hand-in-hand with early adopters to allow the use of CLT prior to the adoption of the 2015 IBC. Adoption of the 2015 IBC should allow a more widespread use of CLT. Jurisdictions on a delayed code cycle adoption could stunt mass market adoption for an entire state. Without assistance from AWC and WoodWorks, there have been several non-uniform interpretations and utilizations of CLT by building officials typically from lack of education or misinformation from a practicing professional which needs to be avoided for successful, long-term viability of CLT.

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<sup>13</sup> Working Forests Action Network, <http://www.workingforestsaction.org>, (2016)

Designing projects using CLT has many aspects that require technical assistance. WoodWorks is the primary educator with the expertise necessary for assisting stakeholders with defining construction types, defining heights and areas, detailing of connections, effective layouts, fire design, vibration design, environmental benefits, sourcing suppliers, sourcing components, and seismic design. WoodWorks has hosted or co-hosted every mass timber conference in the United States and in 2015 provided over 43,000 hours of education on wood construction of which approximately 19,000 were on mass timber and CLT. WoodWorks will continue this work but needs to stay ahead of research as it occurs in order to disseminate this information accurately and effectively.

Construction of CLT projects has varied widely, from small projects constructed by local framers to large projects constructed by well-established, large contractors. CLT is a unique product in that it is wood, which most people associate with small scale projects or residential construction, but it is a product better suited for large scale commercial projects. Thus, sourcing sub-contractors and framers that can scale up has been difficult and large-scale contractors constructing with other materials are ill-suited to retrain their workforce to utilize a new material. This is a void that needs to be filled.

#### **Long-term Needs:**

Anecdotally in 2016, both Washington, Oregon, and Montana architecture, structural, and construction companies have stated “we researched CLT a couple of years ago and it just isn’t viable. We have no manufacturers in North America and it just isn’t going to work”. When told we have four manufacturers, three distributors, and several more manufacturers setting up operations, these same companies are stunned and unaware of recent advances. As with any new market, the market is rapidly changing. This challenge points to a need for a long-term education plan occurring at regular intervals to provide updates on the status of the evolving market. This could include a list of manufacturers and distributors (to date) and then a list of projects proposed (to date) and then completed projects (to date) to show a progression of CLT adoption. On the tall mass timber projects, <http://www.woodskyscrapers.com> has begun a voluntary compilation of tall mass timber projects utilizing CLT and other mass timber products. The Timber Innovation Act in Congress is a long-term opportunity to continue research and development for mass timber buildings.

Permitting projects using prescriptive language in the IBC will develop, rapidly allowing the use of CLT. Even with this, developing prescriptive fire and acoustic assemblies of floor/ceilings, roof/ceilings, and walls will greatly increase the ability of designers to prescriptively permit these projects. However, to exceed the prescriptive heights and areas using a performance-based design will require additional product testing, which is occurring through the USDA Tall Wood Building Competition. This performance-based testing will be publicly available to provide practitioners a template for future projects.

There are many aspects to designing buildings to incorporate CLT. Recently the main issues that have arisen from designers are proving fire resistance, acoustic assemblies, sourcing local materials, and insurance. Several North American fire tests have now been completed both with CLT encapsulated with gypsum sheathing and fully-exposed CLT panels. Blast tests of CLT panels are underway with the first set of tests just completing testing. The results are overwhelmingly positive and as manufacturers are willing to share this information for the greater good and fire officials are educated on these tests and results, more projects utilizing CLT will occur. Acoustic assemblies are typically using European assemblies found in the US CLT Handbook and modifying them using local materials. This will continue to occur until a database of US tested assemblies can be compiled and the information disseminated. Insurance quotes for early adopters has been interesting as some companies see no difference in insuring a mass timber building and several liken mass timber to residential construction, thus increasing quotes. A poll of European and Canadian insurance companies showed they had no change in premiums for the different construction materials. Insurance companies need to be educated on the difference between light-frame construction, mass timber construction, construction safety benefits, and the robustness of mass timber related to fire.

As projects are constructed, lessons learned, skilled tradespeople, and efficiencies of construction will begin. Sharing of this knowledge will help future construction companies and framing contractors.

## Part 2: Education Providers

This section identifies the organizations that can help implement education activities to the different sector. In Table 11 a compilation of organizations that are best suited for providing education to the various sectors. This is by no means a complete list, but a starting point to be built upon as organizations realize they can already fill a niche, adjust to fill a niche, or develop a new business to fill a niche.

### **Forestry**

Education of foresters can occur as early as the high school level, to degreed programs at the university, and through practicing foresters. The Oregon Forest Resources Institute already has a webpage dedicated to providing resources at <http://oregonforests.org/content/education>.



The Oregon Legislature created the Oregon Forest Resources Institute in 1991 to advance public understanding of forests, forest management and forest products and to encourage sound forestry through landowner education. A 13-member board of directors governs OFRI. It is funded by a portion of the forest products harvest tax in Oregon. [www.OregonForests.org](http://www.OregonForests.org)

## Manufacturing

Manufacturing processes are relatively unchanged for the mass timber market. The “National Manufacturing Study” by the Oregon Manufacturing Extension Partnership showcases new trends and the next steps for success in the manufacturing sector. However, the advanced manufacturing will need to evolve as standard mill equipment becomes more specialized and automated (OMEP, 2011). As 3-D building modeling becomes more prevalent and building products like CLT inherently require 3-D fabrication, advanced manufacturing education will need to occur.



## Permitting

As most municipalities adopt the 2015 IBC, constructing buildings using CLT will become more widespread utilizing the prescriptive code requirements. As building officials permit more projects and the AWC broadens their CLT education, fear of permitting these projects will decrease.

## Designing

Even today, designers are cautious of specifying mass timber prior to understanding the permitting agency's stance. As WoodWorks educates practitioners on how to use mass timber within the current codes and coordinates with the AWC on future code development, designers will become more comfortable within the prescriptive code limits and then expand more comfortably into performance based design projects.

## Construction

The ebb and flow of residential construction affects the wood framing crews available for the commercial construction industry. The shift to large format construction requires fewer laborers but does require one primary with a more advanced skillset. Education can come from trade associations or on-the-job training.



# WoodWorks



**Wood  
Products  
Council**



An initiative of the Wood Products Council, WoodWorks provides free project assistance as well as education and resources related to the design of non-residential and multi-family wood buildings. Our technical experts offer support from design through construction on a wide range of building types—including mid-rise/multi-residential, educational, commercial, corporate, institutional and public.

Table 11: Mass Timber Education Providers

Mass Timber Education Providers			
Supply Side		Demand Side	
Forestry	USDA Forest Service, Colleges of Forestry, Oregon Forest Resources Institute, Washington Forest Protection Association, Oregon Forest & Industries Council, Oregon Department of Forestry, National Association of State Foresters, Technical Schools	Designing - Students in degree programs	College/University - University of Oregon, Oregon State University, Washington State University, University of Washington, Portland State University; Oregon Manufacturing Innovation Center
Manufacturing	USDA Forest Product Lab, Technical Colleges, Community Colleges, Oregon Forest & Industries Council, Oregon Manufacturing Extension Partnership, Workforce Southwest Washington, Oregon Manufacturing Innovation Center	Permitting - Building Officials, Code Officials	American Wood Council – prescriptive based design versus performance based design
Advanced Manufacturing - CNC	Technical Colleges, Carpenters International Training Center, Everett Community College	Designing - Practicing Professionals	WoodWorks
Distribution		Designing - Developers, Owners	WoodWorks
		Construction - General Contractors. Sub-contractors, framers, erectors	Northwest College of Construction, Technical Colleges, Carpenters International Training Center, Timber Framers Guild, Workforce Southwest Washington, Pacific Northwest Regional Council of Carpenters

## Part 3: Education Plans

### ***Forestry***

Many colleges of forestry have well-developed curricula for forestry supply-side needs. From a casual demand-side observation, colleges of forestry have focused on forestry and wood as a discrete element. Whereas from a practitioner's perspective, understanding the fundamentals of wood is critical, but much more important for performance-based design is how multiple wood elements interact to form an entire building system. This may be a blurring of lines between forestry departments and engineering departments, but historically engineering departments have been funded by steel and concrete industries and wood engineering has been under-represented, except in the school of forestry. The new Center for Advanced Wood Products at Oregon State University is the first step in making a historical, fundamental shift to provide building system ready data to help practitioners more readily incorporate wood into their buildings. The new Center is a joint effort between Oregon State University's college of engineering and college of forestry in conjunction with the University of Oregon's school of architecture.

### ***Manufacturing***

As delineated earlier, standard manufacturing processes will not change drastically but continuing education will need to occur with modernization of equipment. The advanced manufacturing will not only require education of the operator but also of the facility or manufacturer bringing in the newer CNC equipment. Oregon State University currently has a School of Mechanical, Industrial, & Manufacturing Engineering which will likely incorporate new technology related to CLT manufacturing.

### ***Permitting***

The AWC is continually performing outreach to building officials and hosting events showcasing changes to the wood portions of the prescriptive international building code.

### ***Designing***

WoodWorks continually monitors shifts in the market and targets their education appropriately from multi-family to commercial construction. WoodWorks also listens to practitioners' needs and develops education opportunities based on their input. Through a variety of venues WoodWorks provides education from one-on-one project assistance, lunch and learns at a practitioner's office, two to four-hour lunch series for 50-75 practitioners, to its all-day Wood Solutions Fair reaching approximately 400 practitioners. WoodWorks provides education on all wood products including mass timber products.

### ***Construction***

The difference between contractors that self-perform framing versus ones that sub-contract will determine how much education needs to be provided. The carpenters union in Las Vegas responds to needs voiced by its membership, so unless contractors are reaching out to them requesting skilled framers for mass timber construction, they will not implement an education plan. Similarly, technical colleges and workforce groups rely on input from other organizations to determine education plans. This appears to be a communication gap without a consistent framework for disseminating needs.

## Part 4: Education Plan Summary

“Proper management lets forests be a part of climate solutions. Unfortunately, today's legal gridlock and outdated policies interfere with modern forest management on federal lands and leave forests vulnerable to large, severe wildfires, insect infestations and invasive species—all major factors which directly contribute to global warming. Our forests can and should be an asset instead of a liability” (ReThink Forests, 2016).

Outreach activities related to educating the community on the fact CLT and mass timber can have a beneficial impact on the health of our forests is critical as well as educating foresters on the supply-chain, end product, such that foresters are excited and proud to promote positive products like CLT and mass timber. Likewise, students and practicing professionals need to be better educated on positive forestry practices; demonstrating wood is a renewable, responsible choice in building material selection. Education and outreach organizations need to continue to “Promote Positive Perception” and focus on wood’s strengths and environmental benefits, educating the whole on the positive benefits of forestry through the entire wood supply chain focusing on the positive impacts that the final wood product has in the construction industry, built-environment.

The United States needs to promote prescriptive-based design and more importantly, performance-based design to be a leader of building designs. More and more, innovation is stifled by limiting practitioners to prescriptive limits and makes performance based design so burdensome that developers settle for outdated prescriptive limits.

Sharing of technology needs to happen in the manufacturing sector as well as the design sector. The United States is competitive and sharing of technology occurs but is typically limited to prevent a competitive edge. An objective of both the USDA Tall Wood Competition and the Oregon BEST/TallWood Design Institute’s CLT Design Competition is for the testing and results to become public knowledge in an effort to test and disseminate results so that future practitioners can more readily use wood.

The Oregon Wood Products Working Group by Oregon Forest Resources Institute and the Oregon Department of Forestry is a fine example bringing together related interests from the forestry sector, the manufacturing sector, the education sector, workforce development sector, and the practicing professional sector to share updates and educational needs in each of the related fields. The group meets bi-monthly, focusing on the strengths of each individual sector to create and implement strategies for development of advanced wood products manufacturing in Oregon to support rural economies.

With target sectors, key stakeholders, and skillset descriptions defined, targeted education amongst all fields in a consistent, accurate, and conjoined effort needs to occur.

## Conclusion

Cross Laminated Timber is a product with significant potential in a national construction market in need of a more sustainable building material and construction process. The Northwest has the potential to lead the US in innovation of CLT and enjoys a competitive advantage because of an economy centered on timber, the raw material of CLT. This advantage comes from the high quality wood grown in the region and the resource conservation values that are necessary to create sustainable and efficient forest management.

CLT meets building code requirements internationally, but requires some navigation to reach approval within current US building codes (Spickler, 2014). CLT is not an explicitly approved material, but anyone can request a design review and submit a CLT design for approval as an alternative construction material. The only requirement is that the designer has reliable information to back up the quality of CLT, such as its success overseas. Other major barriers to CLT's entry into the construction market include seismic safety testing, fire safety testing, gaps in public knowledge, CLT product availability, transportation costs until more CLT is produced locally, and the lack of a readily available labor force trained in CLT construction. Progress is being made in building code compliance, as CLT performs very well when compared to fire and seismic safety standards.

Barriers involving the public perception and general knowledge of CLT seem surmountable. However, more informative CLT campaigns, such as programs conducted by Oregon BEST and the Tall Timber Alliance, are crucial in order to overcome these barriers. A detailed educational training plan for CLT design and construction will be necessary in order to gain traction within the construction marketplace. More design contests and events that encourage incorporating CLT panels into a variety of building designs will also be helpful to inspire innovative CLT designs. This will result in construction firms enthusiastically supporting CLT, not simply taking a chance on a new material.

Clear CLT methods for efficient construction must be developed in order to reduce cost uncertainty and any perceived risk felt by the construction firm. More CLT methods will reveal more possibilities in the various target markets with time, and the increased demand will improve economic development in timber-centered economies such as those in the Northwest US. The spread of quality information on CLT's advantages and uses is crucial to the success of this venture. A comprehensive CLT education plan that can be distributed to relevant stakeholders should be developed in the near future.





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business  
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# THE PATH FORWARD

## Introduction

The activities of the feasibility study not only convened the diverse partners on this project but led to many meetings with regional economic development managers, building officials, developers, CLT manufacturers, city officials, elected officials, architects, sawmill staff and other along the supply chain. Barriers and points of contingency were of course a common topic, but those interviewed were also encouraged to share their view of the remaining opportunities in the primary or secondary markets for CLT. These conversations differed between stakeholder's of varying expertise, but often shared several reoccurring themes: innovation opportunities, activities to accelerate the market follow-on projects or key activities, suggestions to induce investment, and recommendations for advancing the market.

True to the nature of a catalytic project, the knowledge gaps and action efforts inspired by this study spurred several of the project partners to form specific follow-on initiatives. Another exciting note is how the buzz from this project and other efforts teased the interest of other organizations that have since emerged as key stakeholders going forward.

The objective for highlighting these opportunities is to catalyze the opportunity for stakeholder collaboration, communicate the importance for financially supporting the opportunities, and to build overall awareness of the efforts and activities being made to advance these efforts. This chapter will focus on the known activities focused on advancing mass timber by Oregon and southwest Washington organizations.

## Opportunities for Innovation

Various opportunities for all the CLT supply chain were discovered throughout the activities of this study.

**Utilization of Lower Grade Timber** – Continued testing to incorporate lower grade timber into the core of the panels will further the opportunity to increase margin and add value to wood materials.

**Utilization of Small Diameter Timber**- Need for improvement to harvest feasibility, processing, and utilization of small diameter timber as a feedstock to CLT and other mass timber products.



**Other  
opportunities &  
recommendations  
revealed from  
research  
activities**

**Utilization of Alternative Species** – Continued testing to elaborate on the possible cross-species utilization that can be incorporated into panels.

**Access to Federal Timber Supply** – Several concerns were raised during the research activities related to the lack of access to federal harvest supply; especially if demand for raw material strains or exceeds the sustainable harvest levels provided by private forest owners.

**Additional Production Facilities** - The current demand, coupled with an expected increase of penetration in new construction market, strongly suggests that the demand for CLT in the domestic market will exceed the capacity of Oregon’s single regional facility, DR Johnson<sup>14</sup>.

**Potential for Foreign Partnership** – Business Oregon’s Global Trade Specialists are working to establish relationships with foreign stakeholders looking to either partner or invest in regional facilities.

**Efficiency in the Production Facility** – Facility owners can work with organizations and consultants to streamline their manufacturing process. Doing so could

**Adhesives** – The adhesives used in mass timber products provide an opportunity for innovation as the industry attempts to diversify the panels with various species of timber and remain low/non-toxic chemicals.

**Connections & Fasteners** – The need for innovative connections and fasteners came up quite often in conversation. As CLT becomes increasingly integrated into structures, there is a design need to connect CLT panels with other materials such as concrete, steel, and definitely other mass timber products.

**Composite Products** – As with composite concrete and steel design, composite design of CLT and concrete serves to expand the capabilities of CLT alone.

## Accelerating the CLT & Mass Timber Market

A growing number of efforts are being made to accelerate the CLT market in the region: both in the domestic and global market. The momentum that has been gained around advancing the CLT has taken a multi-organizational effort to accomplish: from first informing stakeholders about the benefits of CLT, to coordinating to influence and support the first Oregon (and US certified structural producer of CLT) manufacturer of CLT (DR Johnson), to the State’s first CLT buildings, and now onto so much more. Without this type of collaboration, market acceleration is stunted and efforts are usually redundant lacking strategy. Further multi-organizational efforts are vital to the ongoing success of the region’s market.

If there were a crystal ball to see into the future, the region would likely experience several more CLT production facilities, each with differentiation; increased harvest rates (reliable supply) with more than

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<sup>14</sup> Based on DR Johnson’s production line in 2015: facility details and capability are expected to increase in 2017.

adequate sustainable practices; a large percentage of the built environment will be incorporating mass timber elements into structures of all building types; and prescriptive building code language allowing for taller structures.

The stepping stones to this future are being addressed by several forward-thinking organizations in the Pacific Northwest.

## Overview of Oregon & SW Washington Initiatives

Several organizations and individuals have emerged as leaders of this CLT movement in Oregon. They consistently have a “what can we do” attitude and should be consulted throughout collaborative opportunities to excel the market. Most of these organizations show up in the brief overview of projects & activities below. The primary contacts for the project is listed along with the description and those individuals contact information can be found in the appendix with the acknowledgement and authors list.

In no particular order, the known projects focused on accelerating CLT and other mass timbers in the Oregon and southwest Washington region are:

**OFRI’s “Forest to Frame” publication** – Forest to Frame is 20-page educational document showcasing mass timber activities of regional architects, engineers, contractors and developers and is intended to highlight the benefits of utilizing wood from working forests as the most responsible building material on earth. *Contact: Timm Locke (OFRI)*

**Mass Timber Purpose-Drive Harvest Plan** –Clackamas County, Sustainable Northwest, and Business Oregon will design a model, purpose-driven timber sale as part of a proposed federal forestland pilot project seeking to increase the supply and utilization of federal and private timber for cross laminated timber (CLT) processing in Western Oregon and Southwest Washington. *Contact: Rick Gruen (Clackamas County) & Tricia Clemans(Consultant)*

**Regular structural testing updates to Oregon Building Code Officials, Architects, and Engineers** – The TallWood Design Institute, OFRI, and Oregon BEST are working to collaborate with the American Wood Council and Oregon Building Officials Association to conduct regular education workshops for building officials. *Contact: Iain MacDonald (TallWood Design Institute) & Tricia Clemans(Independent)*

**Oregon Mass Timber Summit: A CLT discussion presented by Governor Kate Brown** (March 2017) - Business Oregon and the Governor's office are working on an inbound trade mission that is focused around the Mass Timber Conference that will engage global industry experts from UK, Austria, Japan, Chile and Australia who are leading mass timber manufacturing and design. The US market is poised for growth and we want Oregon/SW Washington well positioned early. *Contact: Amanda Welker and Dana Shannon (Business Oregon)*

**Oregon Wood Products Working Group** – Led by OFRI, these bi-monthly meetings in Portland and Salem to convene stakeholders within the state on accelerating wood products in the region with a pipeline to address research and performance, government/policy relations, marketing/advocacy, manufacturing, and code development. *Contact: Paul Barnum and Timm Locke (OFRI)*

**Library of CLT Research & Testing** – Current efforts are underway by reThink Wood/Softwood Lumber Board and University of Minnesota to develop, house, and maintain a library of publically accessible research and testing related to CLT. Until these platforms are ready for use/access, the TallWood Design

Institute, OFRI, and Oregon BEST are in collaboration for an interim solution to ensure an up to date library of mass timber structural testing is readily accessible for use/review by designers, engineers, and building officials. *Contact: Peter Dusicka (PSU) and Tricia Clemans (Independent)*

**PNMP-Federal Manufacturing Roundtable** – The Pacific Northwest Manufacturing Partnership (PNMP) event, led by City of Springfield & Eugene, is in the early stages of planning. The alliance of manufacturers throughout Oregon & SW Washington will convene to strategically leverage the region's resources and work to attract federal funding to the area with the priority of advancing manufacturing in wood products and the food & beverage industry. *Contact: Donna Greene-Salter (Business Oregon) and Tricia Clemans (Independent)*

**Peer Review Assistance for Municipalities Building with Mass Timber** – With funding from the Economic Development Agency (EDA), the TallWood Design Institute offers a service partnering consultants with the local building department and their building code officials for a peer review of local building permit applications for buildings utilizing mass timber. *Contact: Iain MacDonald (TallWood Design Institute)*

**Mass Timber Certification Program** - The TallWood Design Institute has commenced development of a first-of-its-kind certificate program on mass timber manufacturing. The program will feature a number of course modules that can be taken by industry learners in the wood products manufacturing and construction sectors. Topics will include: drafting and detailing of mass timber components using 3D computer-aided-design (CAD) software; interfacing between CAD and computer-aided-manufacturing equipment; automated manufacturing using computer numerical control (CNC) production machinery; in-house quality assurance and testing methods, and; jobsite installation and erection of mass timber components. Delivery of the program will be through a combination of online instruction, classroom sessions in partnership with various community colleges, and hands-on design-build experiences in the Institute's new A.A. "Red" Emerson Advanced Wood Products Laboratory. Modules will be available beginning in 2018. *Contact: Iain MacDonald (TallWood Design Institute)*

**Testing Support for Oregon Wood Product Manufacturers** - With funding from Economic Development Agency (EDA) the TallWood Design Institute can offer structural testing services to manufacturers seeking to have develop or improve mass timber products.

**CLT & Other Mass Timbers as a Solution to Affordable Housing** – This is a much needed discussion to continue to have; especially in the Portland Metro area. In early March of 2017, The TallWood Design Institute hosted a roundtable on the potential of mass timber for the affordable housing market. This interactive discussion focused on identifying the potential role of different wood and hybrid building systems and how they might be integrated into Oregon's affordable housing programs. New wood products and computerized production techniques aiding pre-fabrication are changing the way wood is incorporated into buildings. This event was meant to catalyze future conversations about the opportunities and challenges for advanced wood products in the affordable housing industry. A summary paper will be made available at [tallwoodinstitute.org](http://tallwoodinstitute.org) by mid-March. *Contact: Iain MacDonald (TallWood Design Institute)*

**Building with Wood Project Assistance** - WoodWorks provides free project assistance as well as education and resources related to the design of non-residential and multi-family wood buildings. Their regional Technical Director, Ethan Martin, is in Portland, Oregon and is dedicated to assisting developers and owners along the West Coast and inland. These technical experts offer support from design through



construction on a wide range of building types—including mid-rise/multi-residential, educational, commercial, corporate, institutional and public.<sup>15</sup> *Contact: Ethan Martin, WoodWorks!*

**Sector Specific Adoption** – Efforts led by Business Oregon and OFRI are aimed at educating specific public sector markets as to the benefits of building with mass timber. *Contact: Amanda Welker (Business Oregon) and Timm Locke (OFRI)*

**Sustainability & CLT** – Sustainable Northwest is working to optimize sustainability outcomes as the CLT market matures, including ensuring sustainably sourced CLT feedstock. They are also exploring and more actively advocating for CLT buildings in large development projects, including for example the Broadway Corridor in Portland.

**Mass Timber & Climate Action Plans** – Nearly every regional municipality has a climate action plan in one phase or another. Partners are aiding in the incorporation of renewable materials sourcing (mass timber utilization) in the language of developed climate action plans.

An exciting point to note is that these initiatives are just the efforts being made in the southwest Washington and Oregon area; it does not include the efforts taking place in other parts of the nation. Also worth noting is that these are just the activities known at the time of publication. This report will no more than be published and more efforts will form. The nature of this quickly growing market and charter of initiatives has already been transformative to the region.

## Suggested Market Studies & Strategies

**Distribution & Export Strategy for Oregon Produced CLT** – As the local manufacture market for CLT grows, as will the need to distribute product out of state and into the domestic and foreign marketplace. Partners need to develop deliberate strategies and to map current distribution methods and identify future opportunities capable of growing with the market. The current market situation appears to demonstrate the feasibility of importing panels into the region with little challenge; however, for Oregon producers to remain globally competitive any barriers that do exist will need to be addressed sooner rather than later. Distribution barriers do exist and a pathway to address these challenges will need to be explored.

**Market Opportunities Along the CLT Waste Stream** – As noted within this study, during the manufacturing process approximately 5% of the lumber weight for panel production is lost to waste. This doesn't include any cuts to the whole panels for windows, doorways, or custom shaping results in sections of panel being removed. Finding feasible, reuse market outlets for this waste could provide additional funding to manufacturing facilities and reduce waste. Furthermore, a life cycle analysis of CLT panel production would likely reveal other opportunities for waste capture.

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<sup>15</sup> WoodWorks.org

**More Outreach by Sector & Municipality** – MUSH (municipalities, universities, schools, and hospitals) sector specific outreach. Of particular focus going forward is adoption within the public school systems. As mentioned previously, Business Oregon and OFRI are conducting initial outreach efforts to educate specific market stakeholders; however additional outreach efforts and partnership is needed. Mature markets who have been utilizing CLT for decades now (e.g. United Kingdom) have proved this is key to growing the market. When sectors embrace a product, material, or behavior, this creates a model for its benefactors and cascades into secondary systems.

## Efforts to Induce Investment

Those interviewed during the study period were asked to share suggested policies to support the adoption of CLT in the market. The various responses returned a fairly common theme: for jurisdictions to adopt a carbon first approach throughout jurisdictions. The specific recommendations included mention of a carbon first approach, carbon neutral building systems, and carbon credit system (cap & trade). Several efforts being made by municipalities are already incorporating language into climate action plans to source local materials, achieve low carbon footprints, and other efforts to lessen environmental impact. The carbon sequestered in engineered wood products such as CLT offer an offset to the embodied carbon in other materials utilized in building structures; especially to that of concrete and steel.

In addition to cities, counties, or states adopting carbon-first type policies, similar approaches are encouraged to be adopted across public and private sectors. For example, as of March 2017 over \$3 billion in construction bonds have passed throughout Oregon to rebuild and/or heavily renovate schools. Ongoing efforts from partners plan to educate superintendents, school boards, and specific construction companies on the benefits of building with mass timber when construction public schools.

### Activities to Induce Investment & Accelerate the Market

- Seek foreign or out of state manufacturing partnerships
- Equipment/facility/capital investment support (grants, loans, manufacturing support)
- Equip additional sawmills with kiln drying capability
- Grants or subsidies for equipment (or assistance into federal programs, including R&D tax credit)
- Loan guarantees for equipment
- Financially support the testing of a suite of mass timber connections and assemblies
- Provide streamlined permitting for buildings using Oregon CLT
- Permitting costs waived or reduced
- Carbon tax credits (cap & trade)
- Creating a protected purchasing program (or guaranteed cost savings subsidy) for government buildings built with Oregon CLT
- Local sourcing policies
- Sector specific targeting for mass timber utilization
- Create a CLT and mass timber designated liaison(s) to strategize, collaborate, and drive on-going initiatives

Additional strategic efforts are needed aimed to explore other building types utilizing CLT and other mass timbers with stakeholders of manufacturing facilities, hospitals, affordable housing developments, public utilities, and of course multi-story office and residential buildings.

Also important to emphasize is a policy for local sourcing and the utilization of local labor. Commenters acknowledge that policies of this sort may already be in place throughout different jurisdictions but hope these policies will continue to be enforced.

And finally, interviewees suggested the state (ex. Business Oregon) designate a position or two specifically for a CLT/mass timber liaison. This person(s) would strategize, collaborate, and drive on-going initiatives around the state; creating a common thread throughout, ideally, all CLT/mass timber related initiatives. The Oregon Wood Products Working Group (hosted by OFRI) is meant to be a place to convene leaders of wood and mass timber related projects and would serve this purpose; however, having a designated person(s) would increase the efficiency and speed of collaborative projects.

In summary, Oregon has formed a strong alliance of partners actively engaged in accelerating the use of engineered wood products in the built environment. The market is without a doubt in a growth spurt with tenacious, action-oriented individuals dedicated to ongoing success.

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# ACRONYMS, ABBREVIATIONS & SYMBOLS

**Approved Agency (U.S.)** – an established and recognized agency regularly engaged in conducting tests or furnishing inspection services, when such agency has been approved by regulatory bodies (see Qualified Inspection Agency and Qualified Testing Agency)

**Cross-Laminated Timber (CLT)** – a prefabricated solid engineered wood panel made of at least three orthogonally bonded layers of solid-sawn lumber or structural composite lumber (SCL) that are laminated by gluing of longitudinal and transverse layers with structural adhesives to form a solid rectangular-shaped, straight, and plane timber intended for roof, floor, or wall applications

**CLT Grade** – a unique designation of a class of CLT panels having the same layup of different panel thicknesses

**Edge Joints** – joints made by gluing of the edges of adjacent laminations within a CLT layer

**End Joints** – joints made by gluing of the finger joints of the same laminations within a CLT layer prior to laminating adjacent layers

**Face** – one of the four longitudinal surfaces of a piece or panel

- Lamination narrow face – the face with the least dimension perpendicular to the lamination length
- Lamination wide face – the face with the largest dimension perpendicular to the lamination length
- Panel face – the face of the CLT length-width plane

**Lamination** – a piece of sawn lumber or structural composite lumber, including stress rated boards, remanufactured lumber, or end-joined lumber, which has been prepared and qualified for laminating

**Layer** – all laminations on one side of a face bondline for panel face or all laminations between two adjacent bondlines for others

- Parallel – the laminations oriented parallel to the major strength direction
- Perpendicular – the laminations oriented perpendicular to the major strength direction

**Layup** – an arrangement of layers in a CLT panel

**Major Strength Direction** – general direction of the grain of the parallel layers of the CLT panel and also referred to as the parallel direction

**Manufacturing Standard** – a document that establishes the minimum requirements for manufacturing practices, staff, facilities, equipment, and specific quality assurance processes, including inspection (in the U.S.) and/or certification (in Canada), by which the product is manufactured

**Mill Specification** – a manufacturing specification based on product evaluation to be used for quality assurance purposes by the manufacturer and the approved agency

**Minor Strength Direction** – perpendicular to the major strength direction of the CLT panel and also referred to as the perpendicular direction

**Pacific Northwest Manufacturing Partnership (PNMP)** - The PNMP is an alliance of urban and rural communities to deepen integration of Willamette Valley, Columbia River Gorge and Portland-Vancouver metropolitan economies. The PNMP was formed in response to a federal initiative: the Investing in Manufacturing Communities Partnership (IMCP), which aims to accelerate the resurgence of manufacturing in the United States and create a competitive climate for job creation and private investment. In 2014, 12 qualified U.S. communities with winning strategies received the designation of "Manufacturing Community" that gives them elevated consideration for \$1.3 billion in federal dollars and assistance from 13 cabinet departments and agencies.

**Qualified Inspection Agency (U.S.)** – an agency meeting the following requirements:

- (a) has trained personnel to verify that the grading, measuring, species, construction, bonding, workmanship, and other characteristics of the products as determined by inspection in compliance with all applicable requirements specified in this standard,
- (b) has procedures to be followed by its personnel in performance of the inspection,
- (c) has no financial interest in, or is not financially dependent upon, any single company manufacturing the product being inspected,
- (d) is not owned, operated, or controlled by any such company, and
- (e) is accredited by a recognized accreditation body under ISO/IEC 17020

**Qualified Testing Agency** – an agency meeting the following requirements:

- (a) has access to the facilities and trained technical personnel to conduct testing on the characteristics of the products by sampling and testing in compliance with all applicable requirements specified in this standard,
- (b) has procedures to be followed by its personnel in performance of the testing,
- (c) has no financial interest in, or is not financially dependent upon, any single company manufacturing the product being tested,
- (d) is not owned, operated, or controlled by any such company, and
- (e) is accredited by a recognized accreditation body under ISO/IEC 17025

**Recognized Accreditation Body** – an organization complying with ISO/IEC 17011 and recognized by the regulatory body having jurisdiction as qualified to evaluate and accredit certification agencies, inspection agencies and/or testing agencies

**Remanufactured Lumber** – lumber that meets the requirements of Section 4.3.4 of ANSI/AITC A190.1 in the U.S. or NLGA SPS 1, 2, 4, or 6 in Canada

**Structural Composite Lumber (SCL)** – an engineered wood product that is intended for structural use and bonded with adhesives, and meeting the definition and requirements of ASTM D5456



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# APPENDICES

## Appendix 1: DR Johnson Capacity Calculation

DR Johnson's production line, as of 2015<sup>16</sup>, can press up to seven layers at a time, and each layer is 1.375 inches thick. One shift can produce 900 square feet of 5-ply or 7-ply panels. Since two 3-ply panels can be stacked during a press cycle, one shift would also be capable of producing 1,800 square feet of 3-ply panels.

To obtain maximum annual production capacity, each shift was calculated as pressing 7-layers, and 240 working days were assumed:

$$900 \text{ ft}^2 * 240 \text{ days} = 216,000 \text{ ft}^2$$

To convert this figure in volumetric units, seven layers equates to panels 9.625 inches thick.

$$216,000 \text{ ft}^2 * \frac{9.625 \text{ inches}}{12 \text{ inches}} = 173,250 \text{ ft}^3$$

This can also be presented in cubic meters:

$$173,250 \text{ ft}^3 * 0.0283168 \frac{\text{m}^3}{\text{ft}^3} = 4905.89 \text{ m}^3$$

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<sup>16</sup> DR Johnson's manufacturing capability to produce CLT is expected to increase in late 2017.



## Appendix 2: CLT Supply Chain Analysis

### Introduction

Oregon State University- College of Business and Business Oregon convened to assess the potential for job creation and related economic benefits along the CLT supply chain.

The OSU Forest Products research team investigated the elements of the CLT supply chain along with the manufacturing process, including inputs, outputs, current volumes, and revenues. The details include analysis of the supply chains of the existing CLT plants in North America including lines that do not currently produce structural CLT products. From this mapping, the current elements of the supply chain existing in the region (Oregon and Southwest Washington) were highlighted: revealing the intricate details along the CLT supply chain.

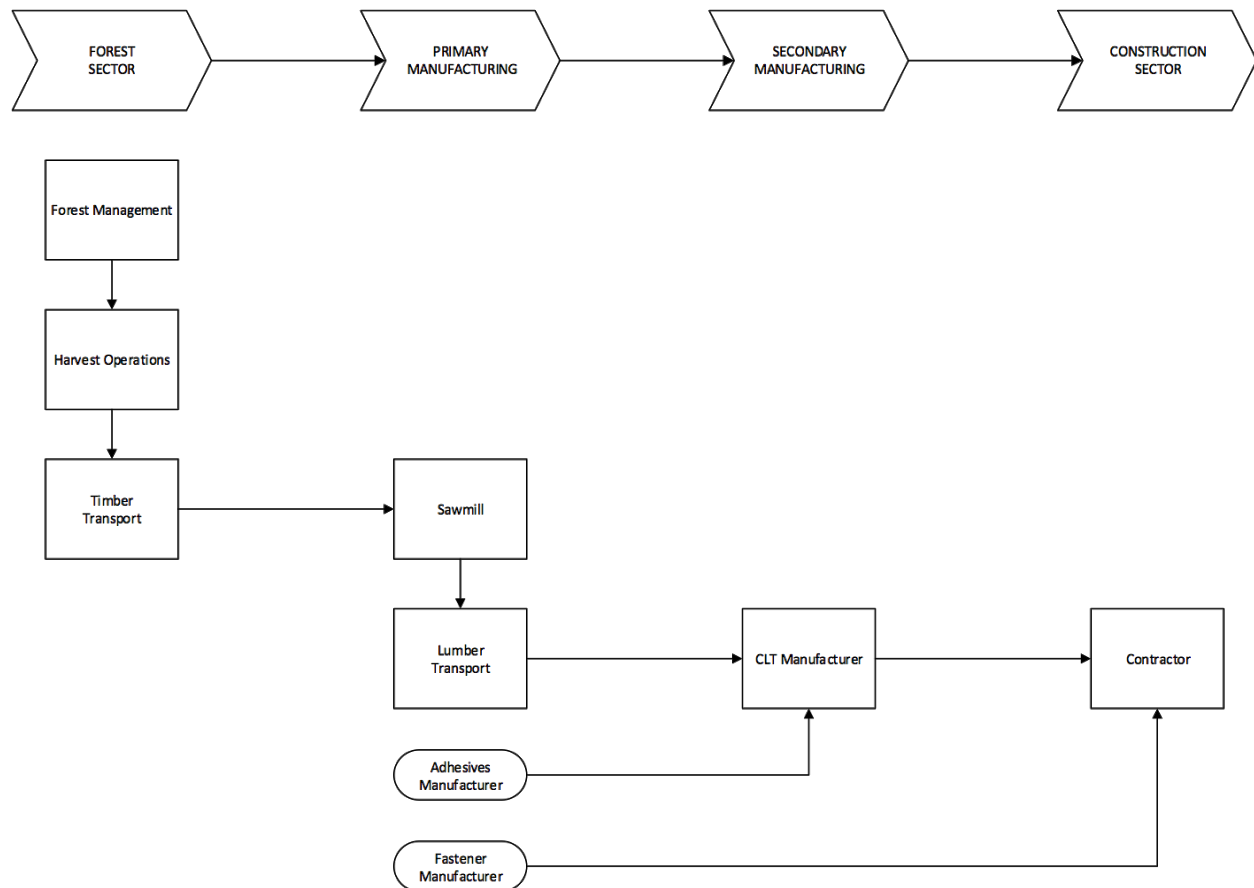
To examine how manufacturing costs could impact sectors supplying raw materials and services to CLT producers within the region, first a comprehensive survey of sawmills in the existing region was conducted by OSU.

Building off this information and the market potential estimated by FPIInnovations, Business Oregon applied a function of predicted percent (%) market capture then utilized IMPLAN, an economic impact analysis modeling software to show the statewide economic impacts of the adoption of cross laminated timber within the region.

The scope of this project covers not only the demand that may be generated within Oregon and Southern Washington, but also the overall effect (strain) of that demand on the supply chain. To understand supply chain effects, it is best to understand the chain as a whole and what happens within it. Much of the process is demonstrated in a flow-chart (Figure 11). Readers should note, differences in process does occur and are noted throughout.

### Harvesting

Technically, CLT production starts with lumber as the raw material input. Arguably, the supply chain could go back as far as timber harvest; however, the harvesting process was not deconstructed within this study because the process is relatively straightforward and there are no discernable differences between how harvesting is done for general lumber/wood products and CLT production. Timber is harvested per a range of prescriptions and then is cut to length at the harvesting site or at the harvest site landing. CLT production is currently looking at using small diameter timber, which is not greatly used currently in the industry, to help reduce costs. While the harvesting of small diameter timber does require somewhat specialized machinery, simply due to the smaller size, it does not change how it is harvested compared to the industry's standard size.



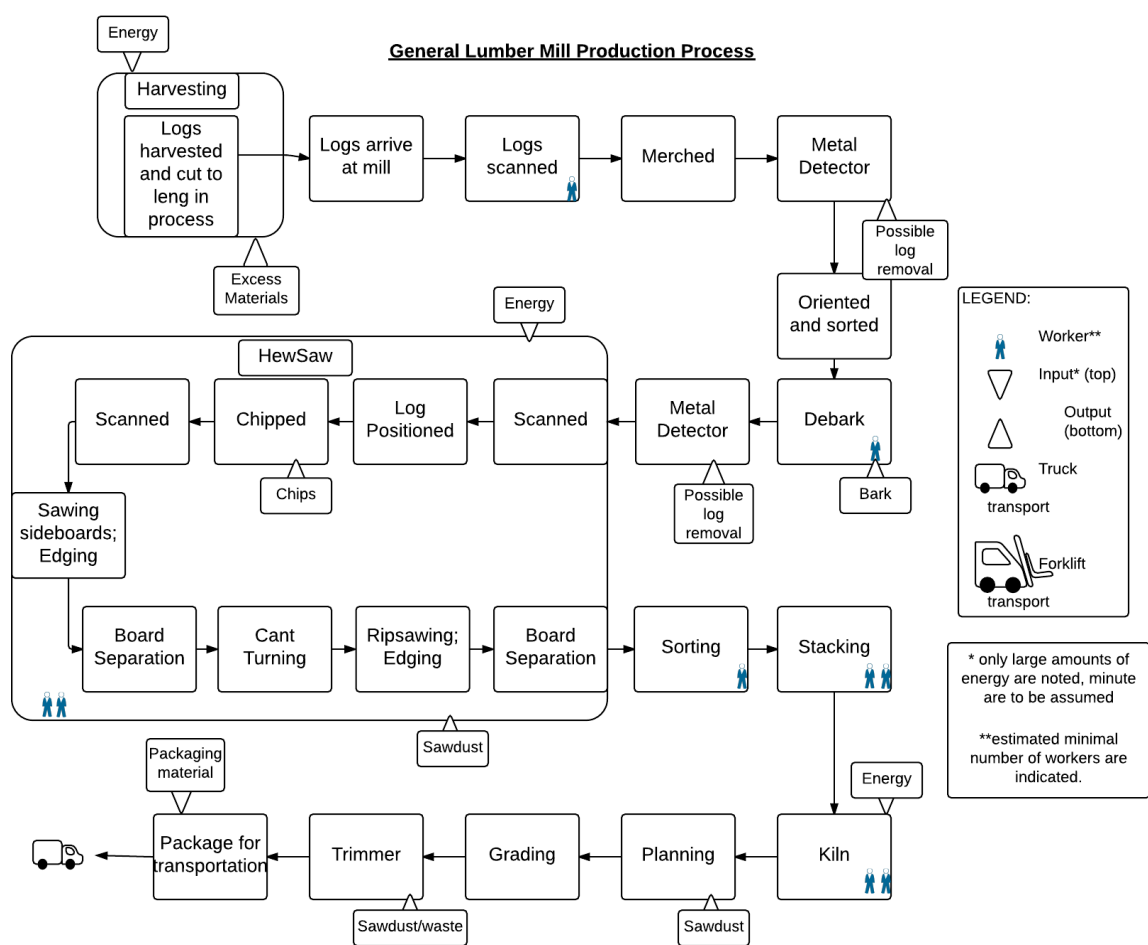
**FIGURE 10: SUPPLY CHAIN FOR PRODUCING CLT**

Additional detail was obtained through an interview with local harvesting company: Baker & Sons (Corbett, OR), Alan Baker and his father Tim Baker, who have been a part of the timber harvesting industry for the last few decades. Like many of the harvesters in the state, they are family owned and are harvesting a moderate amount compared to others in the region.

There are some challenges when it comes to expanding the harvesting practices for the Oregon area. The equipment required to harvest small diameter timber is enormously expensive, where one machine has the potential to cost nearly \$500,000 new or used. Typically the machine is not be purchased brand new, but instead obtained come from east coast sources secondhand. In other words, this would not help local manufacturers of timber harvesting equipment listed in this report. It is also common for companies to buy equipment for certain jobs and then turn around and sell it again. This is also similar to the employment of additional workers; many companies will hire temporarily while the work is available and not hire permanent positions.

## Processing/Breakdown

Figure 12 models the production process at a mill producing dimensional lumber. Figure 12 is somewhat unique when it comes to lumber mills since it has a recently upgraded facility. The extent of the company's upgrade is not what is typically seen within the industry. Many companies' upgrade machinery piece by piece making a montage of differently aged machines or when an upgrade occurs, it may be to a newer machine that is 20 years old. With the addition to the HewSaw at the facility it not only became one of the "newest" mills, but also it could be argued that they became one of the most efficient.



**FIGURE 12: GENERAL MILL PRODUCTION PROCESS**

Typically all structural lumber is sold through distribution companies; including “big box stores” such as Home Depot or Lowes and secondary manufacturing entities. This study looks at all the mills within Oregon and Southern Washington handling the wide range of customers that purchase from the timber industry—meaning that few can be directly modeled on the process flow-chart provided. The main difference between the majority of mills and the model is their equipment is often over a decade old.

Lumber mills do not frequently purchase new equipment even when replacing equipment. New equipment is necessary, used equipment requires substantial financial investment, so mills will seek lower cost solutions to replace or upgrade equipment. Purchases have a greater impact on the local economy: companies will first look at what will benefit them and what is most cost effective for what they need.

The lumber that is required for CLT does require some specific characteristics:

- Grades of No. 2 and No. 3 that are cut with a square edge (this allows for the greatest amount of surface coverage with the resin and are either a 2"x6" or 2"x8"<sup>17</sup>).

The lumber itself is required to be dried to a moisture content of 12% +/- 3. Industry standard is anywhere between 15-19%, which allows for the characteristics of the wood maintain stability for processing. This extra drying takes at least another week in the kiln. The combination of a square-edged cut and the low moisture content it makes nearby sourcing CLT lamina difficult for current manufacturers.

Lumber will typically be purchased from regional producers, but machinery will typically not be and it is difficult to see if there will be any benefit to local manufacturers of machinery when there are better cost efficient alternatives. However, USNR (located in Woodland, WA) is a supplier of equipment and technologies capable of pressing CLT. USNR supplied a press to DR Johnson in Oregon. To maximize economic impact to the region, the ideal purchase would be local, but with limited manufacturers, this may be difficult to achieve.

## Production of Panels

When it comes to the production of panels, each of the facilities in the Northwest region is similar, as shown in Figure 13 below. With minor differences between the types of press used, the movement of panels between production steps, and the drying method the overall production of panels is a somewhat slow and arduous process. What makes the production of the panels so difficult is they involve two directions of laying material requiring the panels to be laid-up by hand or by sophisticated machinery. The main differences between presses are the size and the amount that a company will have. These are very important aspects that determine the volume of CLT the company can produce, which translates to the speed a project could be finished.

Length of panel production is a very important aspect of the market. The length directly impacts whether and how the end-use markets can utilize the material. If a building is designed with a 30'x30' grid, the CLT must be at least 30' long. At this point, building designers working with mass wood panels will need to establish their panel producer early in the design process. Press length capability will influence how the building is designed.

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<sup>17</sup> Based on DR Johnson's production line in 2015: facility details and capability are expected to increase in 2017. Thicknesses vary by manufacturer.

## General CLT Production Process

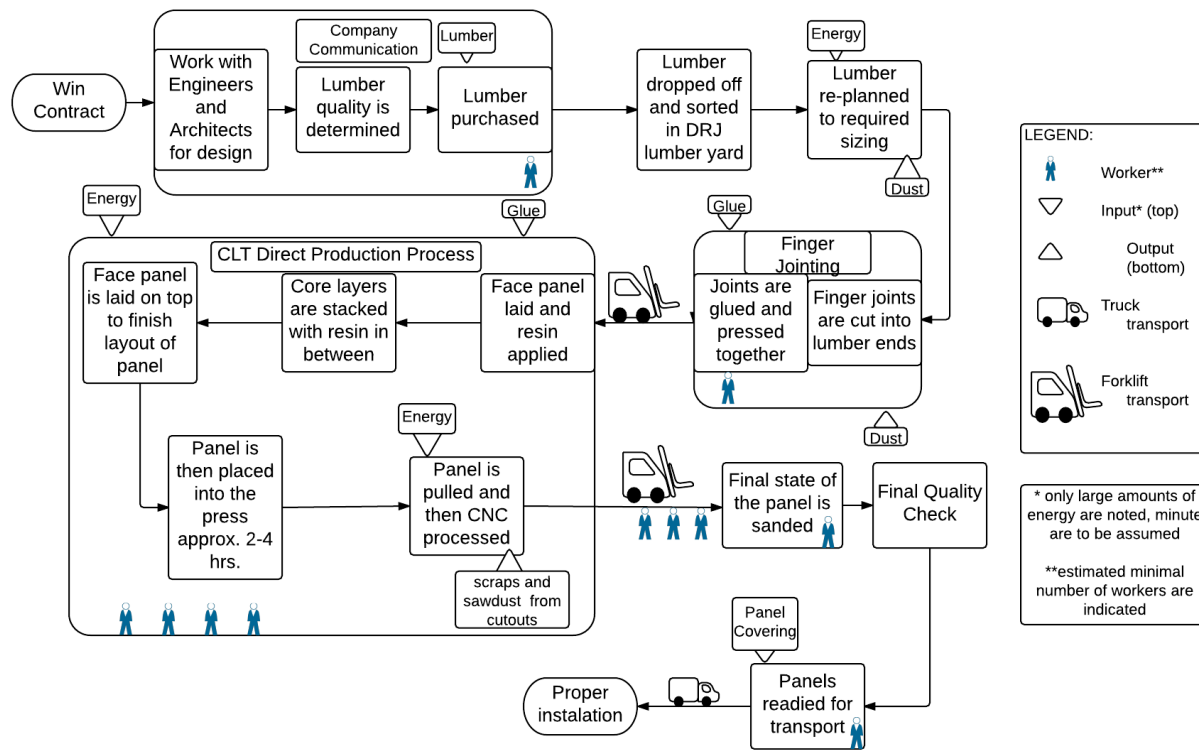


FIGURE 13: GENERAL CLT PRODUCTION PROCESS

Presses also must be somewhat customized for specialty panels, in reference to their size. Each building that is made with CLT is custom built and can require a wide range of different sized panels and cut-outs. Currently, all Northwest CLT manufacturers have Computer Numerical Controlled (CNC) machines for this production step. This allows each panel to be cut to the highly precise dimensions specified by the project. Many of the current production companies are working with multiple engineered wood products, which will make it easier for them to add CLT to their product lines.

## Appendix 3: NW Council Data

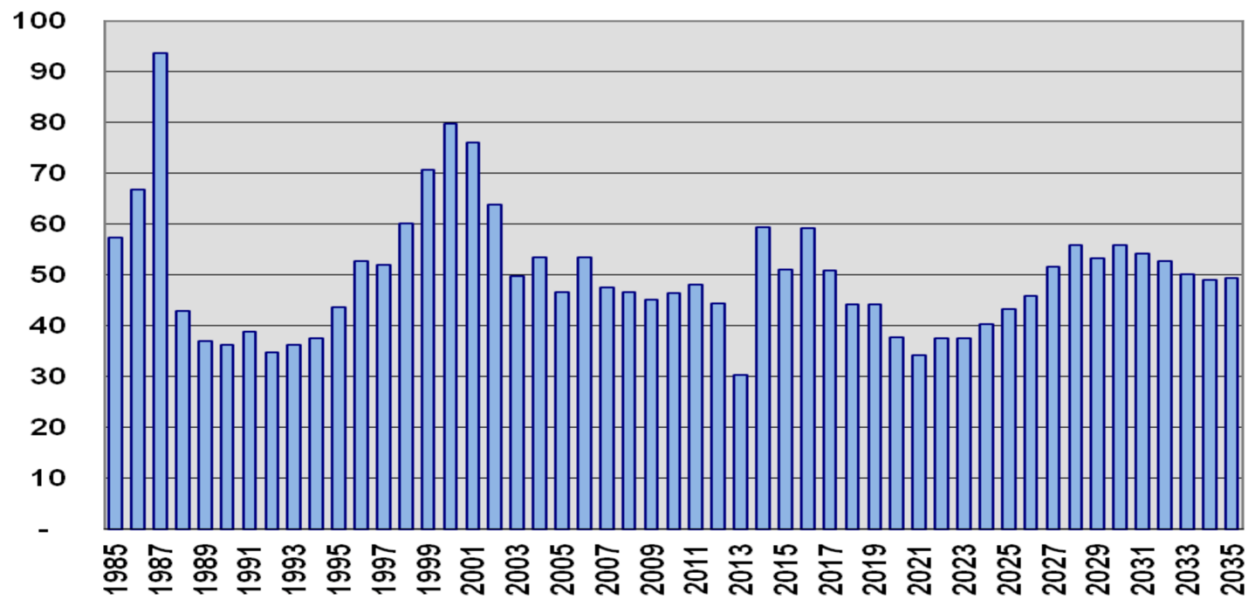
CLT can be used both in commercial and residential sectors (accounting for multifamily homes). The methodology for the commercial sector forecast from the NW Council is as follows (NW Council, 2016a):

The key driver for the commercial sector is the stock square footage required to conduct business activities in designated building types. To calculate this square footage, the Council developed a simple model that uses the number of employees per business activity and median square footage per building type with the following analytic steps:

- 1) The Bureau of Labor Statistics (Quarterly Census of Employment and Wages) provides the number of establishments and employees at the end of 2013 (at 6-digit NAICS code level). This enabled a detailed investigation of the type of business activities and the number of employees for each business type. Each business activity was assigned one of the 17 commercial building types used in load forecasting and conservation assessment.
- 2) The median square footage per main-shift employees (the hours of 8 a.m.-5 p.m.) for various business activities are reported as part of Commercial Building Energy Consumption Surveys (CBECS 2012) from the U.S. Energy Information Administration.
- 3) CBECS micro data (individual site data) for 1992-2003 for more than 21,000 buildings are used to calculate the median square footage per employee and the number of hours of operation for various establishments.
- 4) The Bureau of Labor Statistics provides the percent of “major” occupation categories engaged in a business activity (at 4-digit NAICS). <http://stat.bls.gov/oes/home.htm>
- 5) An estimate of existing floor space stock and the demolition rate by building type from the 2014 Commercial Building Stock Assessment (CBSA).
- 6) Floor space additions for each building type for 2002-2013 from F.W. Dodge are used to augment the 2001 building floor space stock to create an assessment of the existing floor space in 2013. This floor space stock was reduced by calculated demolitions during 2002-2013.
7. An initial estimate of 2014 square footage requirements for each business activity was estimated using the following factors:
- 7) An initial estimate of 2014 square footage requirements for each business activity was estimated using the following factors:
  - a. The assigned building type
  - b. Median square footage per employee
  - c. Number of employees
  - d. Percent of business activity engaged in an occupation
- 8) The estimated 2014 floor space stock for each business activity was adjusted so that the total square footage for that building type is close to the benchmark floor space stock in 2014.
- 9) Future floor space requirements were forecast by applying the annual growth rate in employment in each business activity to Global Insight’s forecast (at state, and 4-digit NAICS code level), and to the 2014 floor space requirements for that business activity.
- 10) For each year, the new floor space requirements across business activities were aggregated by building type, and for each building type, a portion of floor stock is estimated to be demolished.
- 11) For years 2015-2035, the estimated commercial floor space stock is fed into the demand forecasting model.

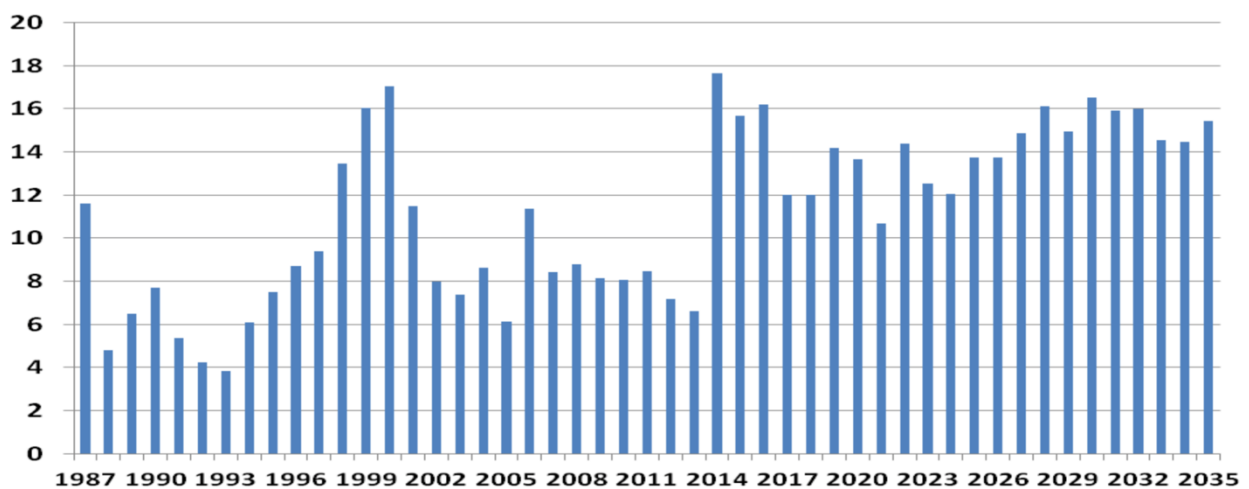
The projection for applicable use of CLT shows a decline from 2016 to 2018 and from 2021 to 2025. Within the residential sector, this is caused by anticipated recovery from pre-recession levels; further explanation is offered toward the end of this section near Figure 19. Within the commercial sector, the NW Council explains that these declines are largely attributed to the cyclical nature of commercial floor space additions (NW Council, 2016a):





**FIGURE 14: TOTAL COMMERCIAL FLOOR SPACE ADDITIONS (MILLIONS OF SQFT) (SOURCE: NW COUNCIL: APPENDIX D)**

The overall pattern of floor space additions for the commercial sector is presented in Figure 14. A quick review of the historic data shows the cyclical nature of commercial floor space additions. The sharp increase in late 1980s is followed by a significant slowdown in the early 1990s. The late 1990s indicate a sharp increase in new construction activities. The 2000-2002 recession slowed construction activities. In 2005, another wave of commercial construction took place. Due to the long construction time for commercial activities, it would typically take a year or two for construction activities to reflect the economy.



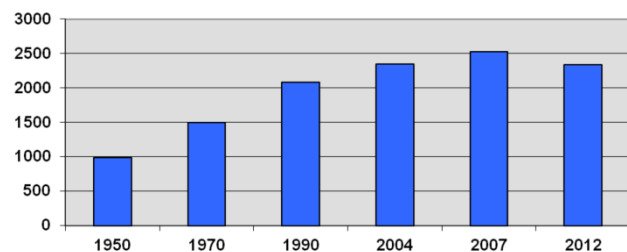
**FIGURE 15: PATTERN OF OFFICE SPACE ADDITIONS (MILLIONS OF SQFT) (SOURCE: NW COUNCIL: APPENDIX D)**

The long-term forecast projects a slowdown in floor space additions, from 60 million square feet per year to about 40 to 50 million square feet. The forecast for future floor space additions do show a wide swing in construction activities in this sector. However, these swings in construction activity are not due to business cycles but rather due to changing demographics and changing in commercial trends.

Office space requirements, shown in Figure 15, suggest a decline in new office space additions for 2012-2014, followed by a stable period from 2015-2019. Starting with 2020, the Council forecasts an escalation of commercial office construction activities.

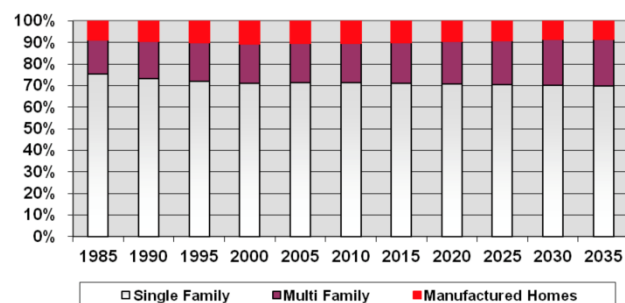
The residential sector projections included single family, multifamily, and manufactured homes and were driven by regional population growth rates, house size, and composition of the population. The region's population in 2010 was 13 million and was projected to grow at a rate of 0.9% to over 16 million by 2035 (NW Council, 2016a). The Economic Forecast discusses decreasing household size as being a notable factor leading to residential floor space:

While the number of occupants per household has declined, the square footage of homes has been increasing. According to the U.S. Bureau of Census's annual survey of new homes, the average single-family house, defined as a detached single-family home or a multi-plex unit of up to 4 units, completed in 2007 had 2,521 square feet, 801 more square feet than homes in 1977. Going back to the 1950s, the average square footage of a new single-family home was about 983 square feet. As can be seen from Figure 16, over the past five decades, the average home size has grown by more than 250 percent. As a result of economic recession starting in 2007, and slow-down in house construction by 2012, we see a drop in the average size of single family units and a shift to multifamily structures. Multifamily homes are defined as housing with greater than four units but less than 4 stories.



**FIGURE 16: GROWING AVERAGE SIZE OF NEW SINGLE FAMILY HOMES (SOURCE: NW COUNCIL: APPENDIX D)**

The Residential Building Stock Assessment showed that this was not the case merely for single-family residences, but also for multifamily homes. Historical data from 1985 to 2014 showed a 7-9% increase in square footages for multifamily residential units in Idaho, Montana, Oregon, and Washington.



**FIGURE 17: HISTORIC AND FUTURE COMPOSITION OF HOUSING STOCK IN THE PACIFIC NORTHWEST (SOURCE: NW COUNCIL: APPENDIX D)**

In absolute terms, the number of housing units has been growing at a faster pace than the overall population. Between 1985 and 2012, the population grew at 1.5 percent per year and the number of single family homes grew at 1.5 percent per year, with multifamily and manufactured homes growing at 2.2 to 2.3 percent per year, respectively. The future outlook for growth in homes coincides with slower projection for growth in population.

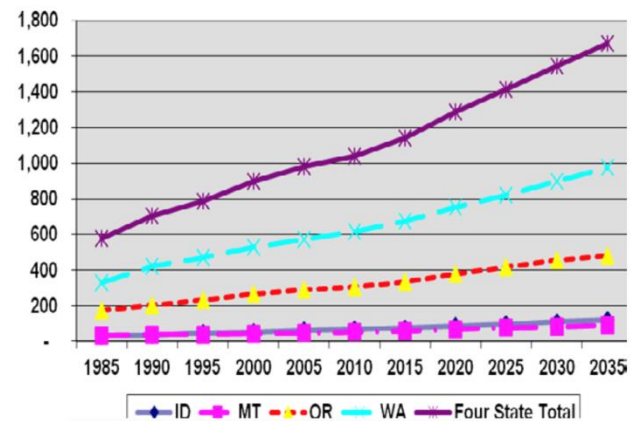
Figure 17 shows the historic and forecast mix of housing types in the total Northwest stock from 1985 through 2035. This figures shows that the share of single family homes declines gradually between 1985 and 1995, then remains fairly constant over the remaining period.

Figure 18 shows the historical and forecast number of multi-family homes added to the stock each year by state and the regional total.

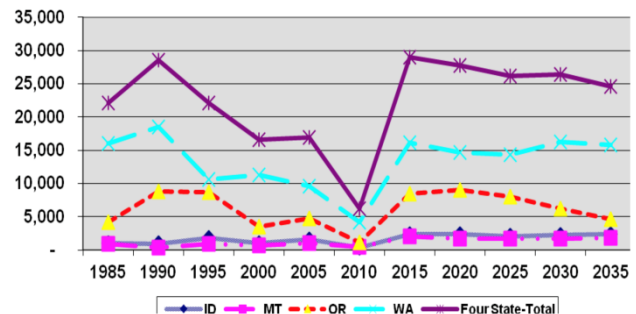
As previously mentioned, the projection in Figure 15 for applicable use of CLT shows a decline from 2016 to 2018 and from 2021 to 2025. This is partially explained by lag and volatility in the commercial sector as well as in Figure 19 which shows the NW Council's Seventh Plan forecasted recovery new multifamily home construction to pre-recession levels by 2015.

Finally, overall composition of housing stock and the increasing market share of multifamily homes is presented:

As can be observed from Table 12, the overall composition of housing stock has recently been changing to favor multifamily homes. Although single-family homes had been increasing in market share in the late twentieth century, recent trends are that they are gradually losing market share. Single-family homes represented 47 percent of homes in the region in 1985. By 2015 they are expected to represent 66 percent of housing stock. However, by 2035, the forecast is for single-family homes to decline to about 64 percent. Multifamily homes represented 34 percent of residential housing stock in 1985, 18 percent by 2000, and are projected to be about 27 percent of the total housing stock by 2035. Within the multifamily building type, high rise structures have been and are projected to continue to represent a larger share. Figure 20 shows that within high-rise buildings, those with four stories and above are projected to constitute about 18 percent of multifamily housing stock by 2035, nearly doubling their market share from 1985-2000.



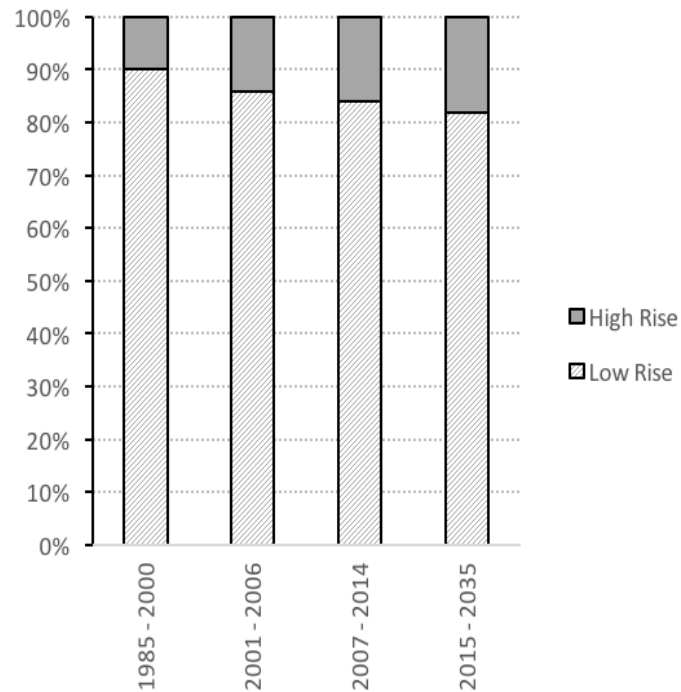
**FIGURE 18: NUMBER OF MULTI-FAMILY HOMES (000) STOCK (SOURCE: NW COUNCIL: APPENDIX D)**



**FIGURE 19: NEW MULTIFAMILY HOMES PER YEAR (SOURCE: NW COUNCIL: APPENDIX D)**

building type	1985	2000	2015	2030	2035
single family	47%	67%	66%	64%	64%
multifamily	36%	21%	32%	34%	33%
– low rise	34%	18%	26%	28%	27%
– high rise	2%	3%	6%	6%	6%
manufactured housing	17%	12%	2%	3%	3%

**TABLE 12: MARKET SHARE BY BUILDING TYPE (SOURCE: NW COUNCIL: APPENDIX D)**



**FIGURE 20: REGIONAL MULTIFAMILY NEW ADDITIONS MARKET SHARE (SOURCE: NW COUNCIL: APPENDIX D)**

## Appendix 4: Economic Impact Analysis Utilizing NW Council Data

This analysis provides three multi-year scenarios of CLT demand in the Northwest. Market penetration of 2.5 percent by 2025 would result in 21 jobs created in Oregon at D.R. Johnson, its suppliers, and other businesses from employee spending. Under this scenario, \$6.8 million in total labor income would be generated between 2015 and 2025. At 5 percent market penetration by 2025, there would be 41 jobs created with \$13.6 million in total labor income generated by 2025. Finally, under a scenario of 10 percent market penetration, 82 jobs would be created in Oregon with \$27.1 million in labor income generated between 2015 and 2025. For every job created in CLT manufacturing in Oregon, an additional 1.9 jobs would be created.

### Modeling Inputs & Assumptions

- Direct job creation at D.R. Johnson for CLT production workers was provided by the company, while the industry staffing pattern for wood product manufacturing in Oregon was used to estimate job creation for management, administration, and maintenance occupations. Information from D.R. Johnson was gathered and provided by Brent Lawrence, graduate research assistant in the Wood Science & Engineering program within the College of Forestry at Oregon State University.
- The average wage for jobs created at D.R. Johnson was not provided by the company. An average wage was calculated by dividing sales of CLT from D.R. Johnson at its current capacity by the full staffing pattern for CLT manufacturing to get sales per employee. Sales of CLT was then divided by sales per employee to calculate the number of employees. The labor income generated from sales was then converted to wages and divided by the number of employees to get an estimated average wage of \$46,392 in 2016 for jobs created at D.R. Johnson.
- The average sale price for CLT used in the model was \$27 per cubic foot in 2016, based on information obtained from Brent Lawrence from D.R. Johnson.
- A custom industry spending pattern, or list of inputs, was developed for CLT manufacturing based on information from D.R. Johnson obtained by Brent Lawrence. The local purchase percentage of key commodities (in this case, from Oregon) was also provided by the company.
- The market size for CLT was based on research from Wolcott, Bender, Beyreuther, and Dolan (2015). Using data and projections from the Northwest Power and Conservation Council on current building stock, types, use, and square footage, Wolcott et al. analyzed projections for new construction in the Northwest most likely to implement CLT into structural elements. Building types most likely to utilize CLT are office buildings (7-16 stories) and multi-family homes (6-16 stories).
- The potential market for CLT in the Northwest devised by Wolcott et al. (2015) included construction forecasts based on a cyclical forecast model, with spot forecasts for each year



between 2016 and 2025. The result is a forecast with sizable fluctuations in the market from year-to-year and one that can become quickly outdated if the business cycle is incorrectly forecasted, which often happens with cyclical forecasts that extend out over several years. Given the relatively small amounts of potential CLT market share gain presented in this analysis in comparison to the overall market size, this analysis uses a ten year forecast based on the average market size over the ten years presented by Wolcott et al. rather than their cyclical forecast to show the secular trend in market adoption.

- Three different scenarios for CLT market penetration are presented in the analysis, 2.5 percent, 5 percent, and 10 percent.
- Economic impacts from capital investments in the D.R. Johnson plant to make CLT (machinery, etc.) were not included in this analysis.
- This analysis assumes that workers filling all jobs created reside in Oregon.
- The company's investment does not displace other investment in Oregon, instead it adds to the total economic capital stock of the state.
- Impacts are presented in 2016 dollars.

## Methodology

This analysis considers the economic impact of jobs created by the manufacture of CLT at the D.R. Johnson facility on total employment, labor income, output, and value added in Oregon. The total impact is the sum of the following items:

- **Direct Impacts:** The initial economic change in the economy. In this case, the employment, labor income, and taxes generated by the manufacture of CLT at the D.R. Johnson facility.
- **Indirect Impacts:** The economic changes that occur due to spending for inputs (goods and services) by the industry or industries directly impacted. In this case, that includes impacts generated by companies that supply D.R. Johnson.
- **Induced Impacts:** The economic changes that occur due to spending by employees in the industry or industries directly or indirectly impacted. In this case, that includes impacts from D.R. Johnson employees and others spending their labor income in the community.

This economic impact analysis was conducted with IMPLAN, an input-output model. The study area for this analysis is the state of Oregon. Data used in the model is from 2014. Although this analysis is based on 2014 data, IMPLAN uses deflators to express impacts in current dollars.

An analysis-by-parts approach was used in the economic impact analysis to account for unique production inputs for CLT manufacturing that are not reflected in existing IMPLAN industry sectors. Regional purchasing coefficients (RPC) for key inputs were provided by D.R. Johnson, with RPCs for remaining inputs based on IMPLAN's industry spending pattern for reconstituted wood products.

## Economic Impact Analysis

Economic impacts from the manufacture of CLT in Oregon depend on the amount of market share CLT can gain from markets for steel and concrete office buildings (7-16 stories) and multi-family homes (6-16 stories). This analysis provides three multi-year scenarios of CLT demand in the Northwest at 2.5 percent, 5 percent, and 10 percent market penetration. Market share gain is diffused linearly in 10 equal increments from 2016 to 2025 in each scenario with market penetration of 2.5 percent, 5 percent, or 10 percent achieved by 2025.

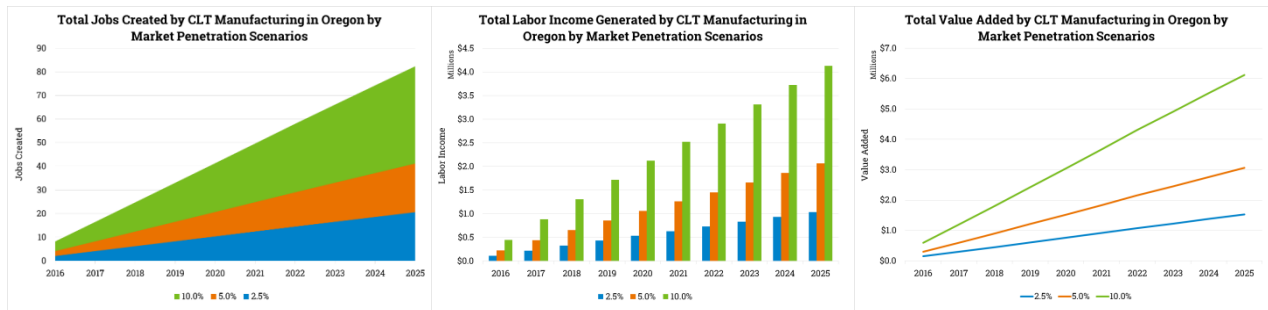
Under the scenario of 2.5 percent market penetration in the Northwest, CLT manufacturing in Oregon will result in the creation of 7 direct jobs in CLT manufacturing. These jobs will create an additional 8 indirect jobs through supply chain effects in Oregon. Spending by employees will create 6 induced jobs, for a total of 21 jobs created in Oregon from 2.5 percent market penetration for CLT manufacturing. The 7 direct jobs in CLT manufacturing will generate \$458,739 a year in labor income. Including indirect and induced impacts, total impacts from CLT manufacturing will generate over \$1.2 million a year in labor income in Oregon. Between 2016 and 2025, total labor income from all impacts will generate \$6.8 million in Oregon.

Under the scenario of 5 percent market penetration in the Northwest, CLT manufacturing in Oregon will result in the creation of 14 direct jobs in CLT manufacturing. These jobs will create an additional 16 indirect jobs through supply chain effects in Oregon. Spending by employees will create 11 induced jobs, for a total of 41 jobs created in Oregon from 5 percent market penetration for CLT manufacturing. The 14 direct jobs in CLT manufacturing will generate \$917,479 a year in labor income. Including indirect and induced impacts, total impacts from CLT manufacturing will generate \$2.5 million a year in labor income in Oregon. Between 2016 and 2025, total labor income from all impacts will generate \$13.6 million in Oregon.

Under the scenario of 10 percent market penetration in the Northwest, CLT manufacturing in Oregon will result in the creation of 28 direct jobs in CLT manufacturing. These jobs will create an additional 32 indirect jobs through supply chain effects in Oregon. Spending by employees will create 22 induced jobs, for a total of 82 jobs created in Oregon from 10 percent market penetration for CLT manufacturing. The 28 direct jobs in CLT manufacturing will generate over \$1.8 million a year in labor income. Including indirect and induced impacts, total impacts from CLT manufacturing will generate \$5 million a year in labor income in Oregon. Between 2016 and 2025, total labor income from all impacts will generate over \$27.1 million in Oregon.

The employment multiplier for CLT manufacturing in Oregon is 2.9, meaning that for every job created in CLT manufacturing, 1.9 additional jobs are created throughout Oregon from indirect and induced effects. This employment multiplier is similar to other wood product manufacturing industries in Oregon and higher than average for most manufacturing industries in Oregon.

## Impact Summary



## Conclusion

The commercialization and manufacture of CLT in Oregon has the potential to create 21 to 82 jobs in Oregon by 2025. As with other wood product manufacturing in Oregon, the supply chain for CLT manufacturing includes many commodities that are able to be supplied from within the state, primary among them, timber. As a result, the multiplier effects from increased employment in CLT manufacturing create proportionately large amounts of indirect and induced jobs in Oregon. While it is difficult to predict how much market share CLT will gain in the Northwest, it is not difficult to see the comparatively large economic impacts this industry could create in Oregon should demand for CLT emerge and grow.

## Appendix 5: Capable Producer Analysis

### Expected Capabilities Matrix

CURRENT BUSINESS						
Aspects of CLT manufacturing	GLULAM	LVL	PLYWOOD	STRUCTURAL LUMBER	GENERAL CONTRACTOR	BUILD FROM SCRATCH
Specialty vs. commodity mindset <sup>1</sup>						
Interfacing with engineering firms <sup>2</sup>			not really, sheathing	supply glulam		
Familiarity with structural lumber <sup>3</sup>	supply		no			
Familiarity with structural products (standards, certification, QA)						
Hardware for handling heavy material (cranes, etc) <sup>4</sup>			pallets	yes (logs)		
Familiarity with adhesive bonding			bonded with thermosetting.			
Finger joining				some may have equip.		
Familiarity with panel products (vs. beams)						
Familiarity with structural connections, fittings etc.						
Sizeable and flexible Manufacturing Facility to support massive timber panel production						
Availability of area press		wrong type/size	wrong type/size			
Familiarity with CNC machining						
						Untested, but in theory will have everything
<b>COLOR LEGEND:</b>			<b>FOOTNOTES:</b>			
Very familiar			<sup>1</sup> Responsiveness and customized order			
Somewhat familiar or unknown			<sup>2</sup> Marketing to Engineers			
Likely not familiar			<sup>3</sup> Familiar with purchasing, moisture content, grading, processing			
			<sup>4</sup> Familiar with moving large pieces of wood			

(McFeeters-Krone and Muszynski)

## Survey

Script:

Thank you for participating in our EDA survey for interested CLT producers.

By now you have a working knowledge of the general promises of CLT, but may be a little unclear about what is required to set up a plant to produce panels. The manufacturing process is relatively straightforward and can be broken into a number of steps.

OMEP's task is to determine your readiness relative to the equipment and skills necessary to begin manufacturing. This process is only to begin discussions with your company to determine your desire to close those gaps. We welcome the chance to bring likeminded individuals together to vertically integrate around these gaps.

General questions

Marketing

- Who are your customers today
- Are you familiar with selling custom projects/product
- Are you familiar with selling to engineers
- Are you familiar with selling to architects

General capabilities

- Are you familiar with purchasing structural lumber
- Do you have material handling equipment for structural lumber
- Do you have material handling equipment for large panels
- Are you familiar with adhesive bonding
- Are you familiar with CNC machining
- Are you familiar with LVL manufacturing

Site selection

- Do you have access to 10 to 15 acres for manufacturing, lumber storage, etc? (Beck)
- Do you have 40<sup>18</sup>-50,000<sup>19</sup> square ft climate controlled enclosed space for manufacturing line and WIP? (Beck)
- Is your site accessible to road or rail for shipment of complete large panels? (Beck)

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<sup>18</sup> Imarc

<sup>19</sup> Beck

The steps for manufacturing are commonly broken into the following segments.

## Manufacturing detail

### 1) Primary lumber selection

- Do you currently handle structural lumber?
- Do you have lumber handling equipment to
  - Receive shipments
  - Grade
  - Store
  - Finger joining
  - Bring to layup
- Grading
  - Do you have a defined visual grading protocol?
  - Do you have electronic grading equipment?
  - ANSI/APA PRG 320
- Moisture: Are you familiar and capable of measuring and maintaining a moisture content of  $12 \pm 3\%$ ? (Note: Near infrared surface readings are not viewed as sufficient) (HB)
  - Do you have lumber drying facilities
  - If not do you have a ready source to purchase dried lumber?

### 1a) Finger Joining

- 1) Do you do finger joining now?
- 2) Do you have access to a Crosscut saw to remove knots

### 2) Lumber grouping

- Do you have access to a Crosscut saw to cut to length parallel or orthogonal lams
- Do you have space to stack and store (60-80' parallel or 10-12' orthogonal) lams (HB)
- Climate controlled 60°F or higher (HB)

### 3) Lumber planing

- Do you have access to a planer able to meet the specifications for CLT?
- thickness across the width of a lamination is limited to  $\pm 0.008$  inch (0.2 mm) or less,
- thickness along the length of a lamination is limited to  $\pm 0.012$  inch (0.3 mm).
- Do you have a work flow that will allow all freshly planed lumber to be used in 48 hours

### 4) Adhesive application



- Are you familiar with 1 or more of the adhesives qualified for CLT?
  - phenolic types such as phenol-resorcinol formaldehyde (PRF)
  - Emulsion polymer isocyanate (EPI)
  - One-component polyurethane (PUR)
  - others
- Are you familiar with other adhesive application
- Are you familiar with the standards for CLT adhesives
  - AITC 405 [16] with the exception that the extreme glue bond durability tests in AITC 405 (either ASTM D3434 [17] or CSA O112.9 [18])
  - Glulam standard, ANSI/AITC A190.1 in the United States and CSA O177 [23] in Canada,
  - others

#### 6) CLT panel lay-up

- Do you have sufficient space to assemble a complete 10'x60' (or bigger) panel?
- Are you capable of meeting the CLT standards for flatness and square panels?
  - laminations must be qualified in accordance with the glulam standard, ANSI/AITC A190.1 in the United States and CSA O177 [23] in Canada,
  - Thickness:  $\pm 1/16$  inch (1.6 mm) or 2% of the CLT thickness, whichever is greater;
  - Width:  $\pm 1/8$  inch (3.2 mm) of the CLT width; and
  - Length:  $\pm 1/4$  inch (6.4 mm) of the CLT length.
  - Other notes
    - ANSI/AP PRG 320 applies for “effective bonding area”

#### 7) Assembly pressing

- Do you have sufficient space for a panel to be pressed after assembly in a climate controlled 60°F (15°C) space?
- Do you have access to a hydraulic or vacuum press?
  - If no, do you have experience with hydraulic or vacuum presses?
- So you have equipment necessary to make shrinkage relief kerfs
- Are you considering RF pressing?
- Do you have cranes capable of moving finished product

#### 8) CLT on-line quality control, machining and cutting

- Do you have access to appropriate equipment or protocols to confirm CLT panel squareness and straightness
  - Square: as the length of the two panel face diagonals measured between panel corners, to be within  $1/8$  inch (3.2 mm) or less.

- Straight: as the deviation of edges from a straight line between adjacent panel corners, is required to not exceed 1/16 inch (1.6 mm).
- Are you familiar with maintaining ASTM quality control standards.
- How else to describe QA/QC needs
  - ASTM D2915
  - ASTM D198
  - ASTM D4761
  - Process change qualification
  - Delamination tests

#### 8a) Finishing

- Do you have sanding equipment capable of +0.004 inch (0.1 mm) accuracy?

#### 9) Product marking, packaging and shipping

- CLT grade qualified in accordance with this standard;
- CLT thickness or identification;
- Mill name or identification number;
- Approved agency name or logo;
- Symbol of “ANSI/APA PRG 320” signifying conformance to this standard;
- Any manufacturer’s designations which shall be separated from the grade-marks or trademarks of the approved agency by not less than 6 inches (152 mm); and
- “Top” stamp on the top face of custom CLT panels used for roof or floor if manufactured with an unbalanced lay-up

Are these a barrier? Is there an implementation issue, or do you just need to be sure you do it?

#### 10) Business model questions:

- Labor issues
- When will the market be right
- Is this something you are thinking of doing?

Details for this survey were taken from the [CLT Handbook Chapter 2 – Manufacturing](#) and California Assessment of Wood Business Innovation Opportunities and Markets (CAWBIOM) by the Beck Group

## Company Summaries:

1. C&D [www.cdlumber.com](http://www.cdlumber.com)
2. RSG [www.rsgfp.com](http://www.rsgfp.com)
3. Murphy (not surveyed) [www.murphyplywood.com](http://www.murphyplywood.com)
4. Freres [www.frereslumber.com](http://www.frereslumber.com)
5. Hampton [www.hamptonlumber.com](http://www.hamptonlumber.com)
6. Columbia Forest Products [www.columbiaforestproducts.com](http://www.columbiaforestproducts.com)
7. Collins [www.collinsco.com](http://www.collinsco.com)
8. SDS [www.sdslumber.com](http://www.sdslumber.com)
9. American Laminators [www.americanlaminators.com](http://www.americanlaminators.com)
10. Columbia Vista [www.columbiavistacorp.com](http://www.columbiavistacorp.com)
11. Roseburg Lumber [www.roseburg.com](http://www.roseburg.com)
12. Zip O Log (not surveyed) [www.zipolog.com](http://www.zipolog.com)

CAPABILITY MATRIX BY COMPANY CHARACTERISTICS & CURRENT PRODUCT AREA										
	HAMPTON	FRERES	C&D	COLUMBIA	COLLINS	SDS	ROSEBURG FP	RSG	AMERICAN LAMINATORS <sup>†</sup>	COLUMBIA VISTA / JV <sup>†</sup>
Aspects of CLT manufacturing	Structural Lumber	Plywood	Timbers	Veneer	Particle Board siding	Structural/plywood	Structural/plywood/LVL	Structural	Glulam	SawMill JV
Specialty vs. commodity mindset <sup>1</sup>	commodity	yes	yes 500K plus SKUs	custom	custom	commodity	custom panels	no	yes, special glulam	mix
Interfacing with engineering firms <sup>2</sup>	formerly	yes	no	no	no	no	yes	supply glulam	yes	yes
Familiarity with structural lumber <sup>3</sup>	yes	no	yes	no	yes	yes	yes	yes	yes	yes
Familiarity with structural products (standards, certification, QA)	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Hardware for handling heavy material (cranes, etc) <sup>4</sup>	yes	yes	yes (logs)	no	large panels 4' x 24'	yes (logs)	yes	yes	yes	glulam yes
Familiarity with adhesive bonding	yes, limited	yes	no	yes	yes	yes	yes	no	yes	yes
Finger joining	formerly, equip still in place	no	no	no	no	no	yes, LVL	no	yes	yes
Familiarity with panel products (vs. beams)	no	yes	no	yes	yes	yes	yes	no	no	no
Familiarity with structural connections, fittings etc.	no	no	no	no	no	no	no	no	through engineering firm	through engineering firm
Sizeable and flexible manufacturing facility to support massive timber panel production	space yes, crane no	yes	no	no	no	yes, no climate	yes, climate	partial	yes	no, will lease
Availability of area press	no	yes	no	no	no	no	yes, lvl	no	no	no
Familiarity with CNC machining	on site metal parts	yes	no	no	yes	on site metal parts	no, sell through	no	no	no
Labor	not issue	Extreme	-	problem	-	-	no issue	-	-	-
Other								shortage of logs		Partners: Calvert glulam Robert / Olsen

<b>NEW COLOR LEGEND:</b>
Very familiar
Unexpectedly familiar <sup>††</sup>
Somewhat familiar or unknown
Likely not familiar

**FOOTNOTES**

<sup>1</sup> Responsiveness and customized order

<sup>2</sup> Marketing to Engineers

<sup>3</sup> Familiar with purchasing, moisture content, grading, processing

<sup>4</sup> Familiar with moving large pieces of wood

†† One of the more compelling discoveries of this survey was many firms had capabilities beyond there assumed category. See report for more details.

<sup>†</sup> from Brent Lawrence (OSU) interview

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