STATE OF CROSS-LAMINATED TIMBER

DENIZ ARAC
Portland State University

For most of the 20th century, much of Oregon economy was dominated by the lumber industry one way or another. Because of the Pacific Northwest's abundance of forests, and in particular, Portland's access to the Willamette River, Portland became a major timber city and port. In recent years, Oregon's economy has become less dependent on timber and has become dependent on a different forest—the Silicon Forest, and the tech companies associated with it. A construction material that is rapidly gaining attention in the United States for structural applications may be a beacon of hope to sustain and enhance Oregon's economy by building on its past. That product is cross laminated timber (CLT). In this paper we will briefly discuss what CLT is, benefits and obstacles of CLT, the current market for CLT production and demand, market and the economic implications of CLT domestically.

Deniz Arac is a candidate for the Masters in Real Estate Development degree and currently works as a development manager for the Trammell Crow Company. Any errors of omissions are the author's responsibility. Any opinions are those of the author solely and do not represent the opinions of any other person of entity.

CLT INTRODUCTION AND HISTORY

Cross Laminated Timber is a wood paneling system made up of lumber boards glued side-by-side then layered, between three and nine layers, stacked perpendicular to the layer below and above, then adhered to become one unit. The structure is similar to glued-together Jenga blocks, as shown in Figure 1.

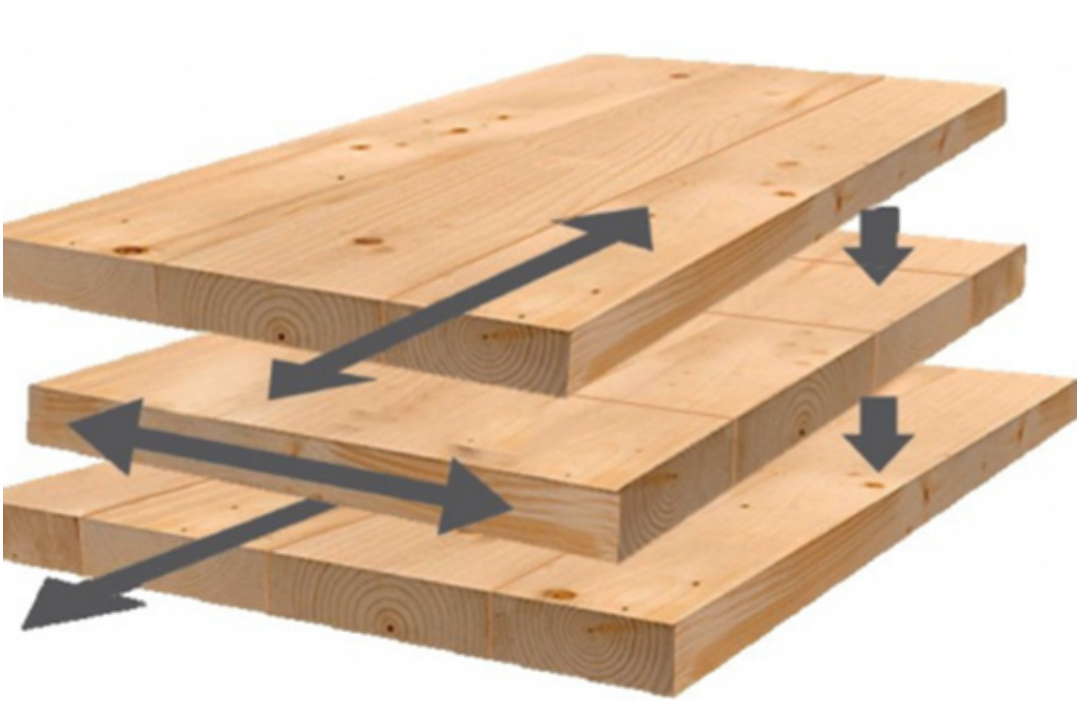

Figure 1 - CLT Conceptual Diagram

The panels come prefabricated from a manufacturer and are typically lifted straight off of the delivery truck and into place, where connections, that can be concealed, lock the CLT in place. CLT can be used in structural or aesthetic applications as floor or roof decking, beams, walls and columns. CLT was developed in Austria and Germany in the 1990s, and has been incorporated into hundreds of buildings in England, Japan, France, Canada, Norway, Italy, Australia and a few other countries. Needless to say, the United States has been a slow adopter. CLT can be a replacement for, or used in conjunction with, steel and concrete construction. CLT, and the orthogonal orientation of the lumber boards, carries loads in both directions, which mimics the load transfer of a two-way structural concrete slab or wall. Thus, CLT can be used to replace concrete or steel shear walls and building diaphragms.

CLT BENEFITS

There are numerous benefits to CLT in terms of aesthetics and its structural performance, but first we will look at the environmental impacts. One of the buzz phrases most associated with CLT is carbon sequestration. Carbon sequestration is “the process by which atmospheric carbon dioxide is taken up by trees, grasses and other plants through photosynthesis and stored as carbon in biomass and soils.” Thus, wood that is sourced from sustainably-managed forests are considered carbon neutral4. A life-cycle analysis study of two five-story office buildings, one of CLT and the other of concrete, concluded that over the life of building the CLT building consumed 15 percent less energy than the concrete building. In addition, the CLT building had a 10 percent lower operation energy demand than the concrete building, mainly due to the insulating benefits of the wood compared to concrete.4 Studies in the UK have shown that taking into account the carbon

CLT BENEFITS

sequestration, CLT buildings actually turn out to be carbon-negative, essentially creating a "carbon-sink." An issue with normal wood products are defects in trees and only certain trees being able to be used for structural purposes. Since CLT is an engineered wood product, CLT can use low-quality timber and smaller diameter wood.

While the environmental benefits effect the overall community, developers need to buy-in to make CLT a mainstream choice as a building material. Developers will be mainly interested in the time and cost implications, and CLT has a response for both. Panels and walls are prefabricated in the shop and detailed using a computer numerical control machine. Prefabrication is typically synonymous with quicker installation on-site in construction. The Murray Grove project in London, UK is an eight story CLT building over one story of concrete podium. The eight stories of CLT were built in 27 days, which is about half the time or even less than a comparable concrete building. Sophisticated manufacturing and logistic companies will ship the prefabricated panels in the order they are to be installed, which allows the crane to only pick them up once, and put them in place. A typical crew is four or five workers for this operation, which is much less than required to place concrete. CLT is also up to 75 percent lighter than concrete, allowing for less intensive foundations and smaller cranes on the sites for even more construction efficiencies.

The performance of CLT buildings, in terms of structural, seismic, fire and thermal have been studied significantly. As discussed previously, the orthogonal orientation of the layers, allow panels to carry in both directions, very similar to a concrete slab. The strength-to-weight relationship also allows for greater usage of CLT structures for mid and high-rise applications. CLT is also able to span up to 25 feet by increasing the amount of layers in a panel, which is ideal for having unimpeded floors below. All of this is comparable with standard concrete and steel buildings. Seismically, the CLT buildings have performed well, and studies have shown that only limited damage and no permanent damage would be expected from an earthquake. The fire performance of the CLT buildings have also been exceptional as the outer wood starts to char and provides a protective layer to protect the non-charred wood, which prevents the structure from an abrupt collapse. The thermal performance of CLT buildings are increased due to less air leakage from precise connections and also the thermal properties and energy conservation from the wood itself. These combined allow reduced wall thickness when used at the exterior.

CLT OBSTACLES

While the many benefits of CLT can prove to be a viable option for many different types of buildings, there are still obstacles and disadvantages. First we will look at the cost implications.

A recent study compared costs for the structure for 10-story residential buildings in the Pacific Northwest. The CLT building utilizes CLT walls (including the shear walls) and floors, while the concrete building is all cast-in-place reinforced concrete. The results concluded that the CLT structure is between $48 to $56 per gross square foot, compared to the concrete which was $42 to $46 per gross square foot. This study suggested that there is between a 16-29 percent premium on the structure for CLT buildings. However, this only take into account the costs for the actual structure. Efficiencies in the costs for CLT buildings come in the form of reduced construction time (reduces contractor time on-site and labor hours) and lower shipping costs (lighter than steel and concrete). Another study, summarized in Figure 2, shows the cost differences are minimal and actually save money in projects over 12 stories in Western Canada.12

CLT OBSTACLES

	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

Figure 2 – Cost Comparison of Concrete and CLT Structures in Western Canada

Another economic impact that has not been realized yet is efficiencies of mass production of CLT. Currently, CLT is still considered a new building method in the U.S., and has not been produced at the same scale as concrete and steel.

The most glaring obstacle with CLT right now is the regulation surrounding it. Whenever there is uncertainty around an aspect of project, it can be a major red-flag for a developer. In the case of CLT the uncertainty on permitting is that red-flag. As it stands now, mass timber high rises cannot go through the same permitting process as a concrete and steel building. In 2015 for the first time, the International Code Council, included CLT as a material, although there wasn't much additional information on what to design the CLT structural elements. In Oregon, projects have to go through the State of Oregon's Statewide Alternate Method, No. 15-01 Cross-Laminated Timber provisions. This means that each project is looked at on a case-by-case basis through the state and not the local government, as a concrete or steel structure would. This adds time and uncertainty of costs to a project. While there are current revisions to the U.S. building code regarding CLT, the lack of predictability will hamper the adoption of CLT for the time being.

A current under-construction CLT project, The George W. Peavy Forest Science Center at the Oregon State University Campus, recently had to halt the construction of the CLT panels because a section of the CLT floor panel had failed and fell. An investigation was performed, and the fault was in the manufacturing process and using preheated wood during assembly which adversely affected the adhesive. The panels have since been fixed and this process corrected. While Oregon State is still a believer in CLT as a structural product, for-profit developers may see this as another uncertainty that they cannot afford on their projects. As new CLT manufacturers come online and current manufacturers try to expand, quality control and the manufacturing process will be under scrutiny every time there is an issue.

CURRENT MARKET AND DEMAND

As detailed in the sections above, there are many beneficial attributes to a CLT building, and is especially attractive in the Pacific Northwest, despite its challenges. The map in Figure 3 shows the high-rise CLT buildings in the U.S. and Canada currently. The Framework project in Portland still under construction, and many more projects at various stages of permitting.

Figure 3 - Map of High-rise CLT Buildings

It should be noted that there are CLT buildings under the high-rise designation built or in the pipeline as well. A recent study estimated that between 2016 and 2035, the demand for CLT panels in the Pacific Northwest alone to be 56 million cubic-feet, with slow-growth of 1.3 million cubic-feet per year by 2020 to 6.6 million cubic-feet per year by 2035. Figure 4 shows the projected growth of CLT buildings over the next 20 years by the number of stories.

CURRENT MARKET AND DEMAND

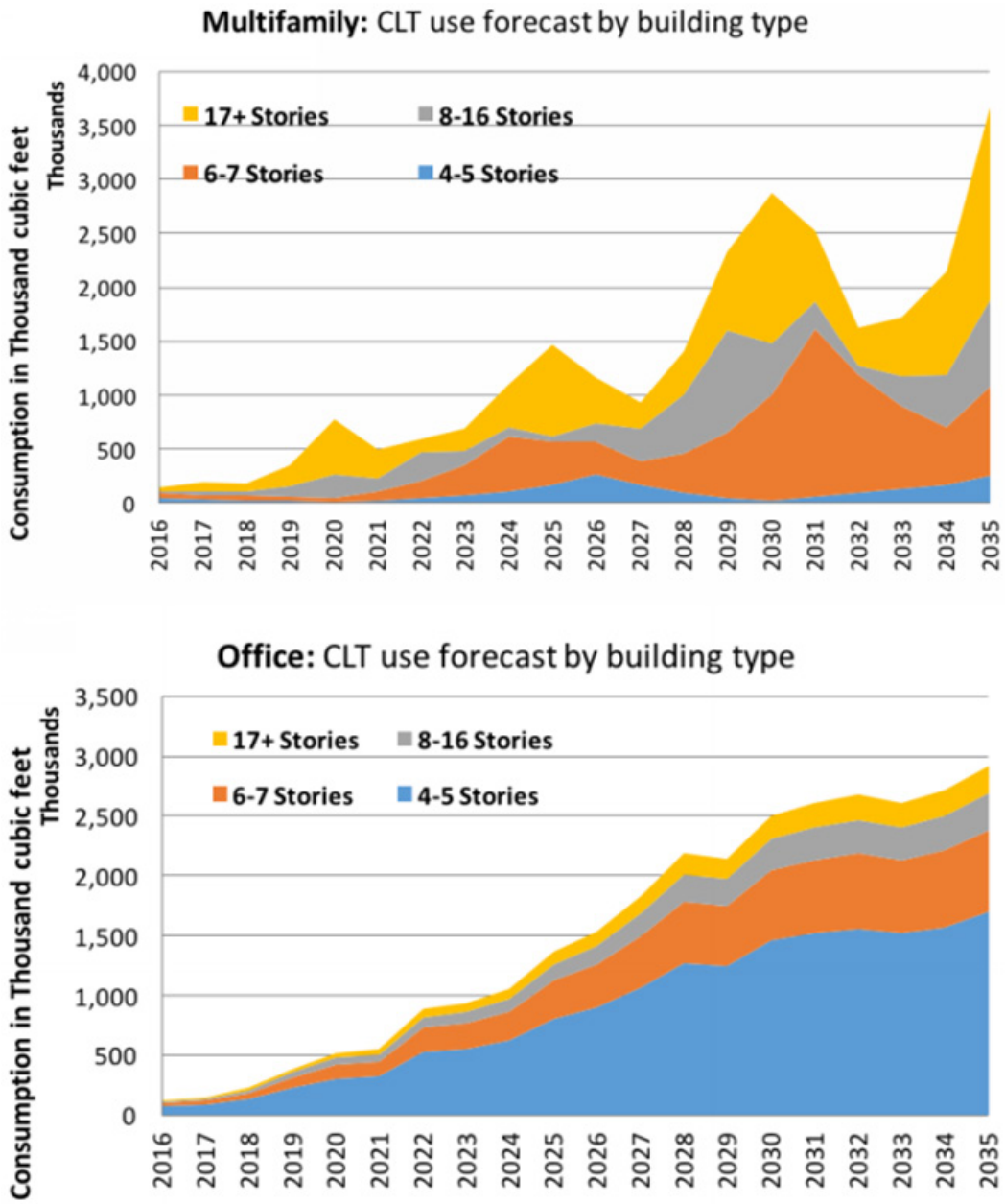

Figure 4 - CLT Forecast by Building Type14

Figure 5 shows the demand for CLT buildings in the PNW over the next 20 years, as well as demand in the "best case scenario" which eliminates all of the obstacles listed in previous section. These studies also do not include CLT buildings being introduced to other markets such as K-12, healthcare and industrial, which would further increase demand.

CURRENT MARKET AND DEMAND

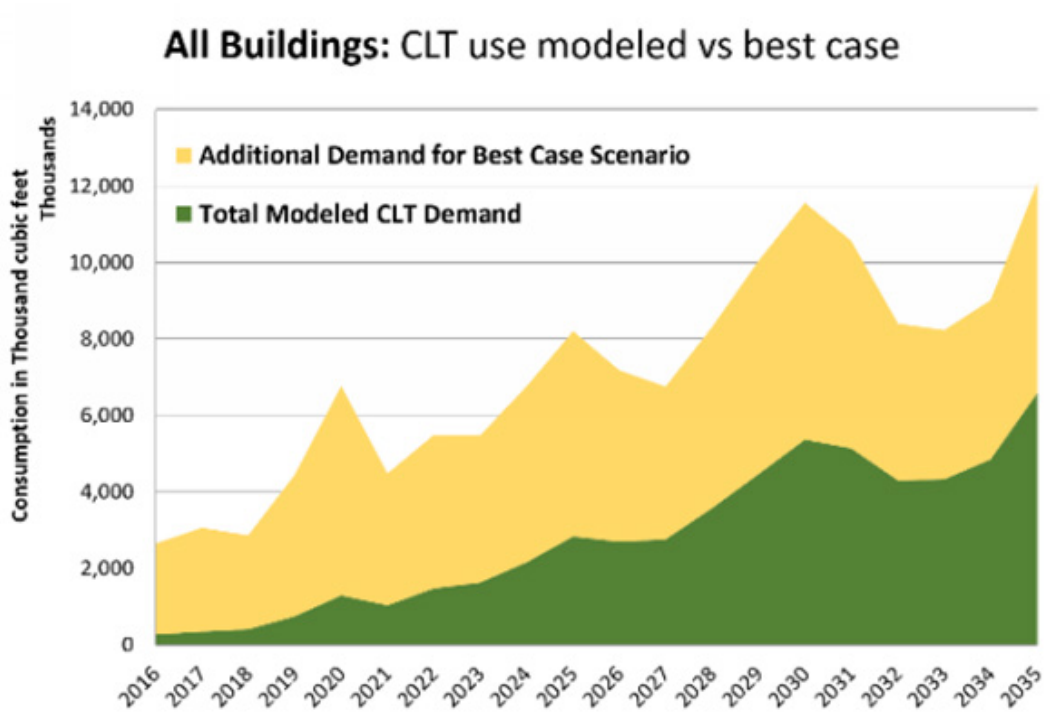

Figure 5 - CLT Total Demand14

PRODUCTION AND ECONOMIC IMPLICATIONS

The next question is can the Pacific Northwest support this increased demand in terms of harvesting and manufacturing. According to the same study, even the anticipated increased demand of 6.6 million cubic-feet, accounts for less than 5 percent of the annual wood volume exported out of the Western United States. This would imply that the region would not run into an issue of lumber shortage, but would enhance the current state of the lumber industry. In the US, there is more wood available for harvest in its forests then there was 100 years ago because of the sustainable management practices of our forests. For Oregon, this means that there is ample potential to improve our lumber industry.

While the forests in the U.S. seem to be able to support an anticipated increase in demand, the CLT manufacturers will need to keep up. Currently there is one manufacturer of CLT in the U.S., D.R. Johnson in Riddle, Oregon. The majority of CLT is produced in Canada by SmartLAM and Structurlam, or oversees in Europe by, Zublin Timber, KLH and Stora Enso. There are two potential manufacturers in the region that are exploring options to expand into CLT manufacturing, Columbia Vista and American Laminators. Figure 6 shows the annual capacity of each of the CLT producers.

PRODUCTION AND ECONOMIC IMPLICATIONS

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

Figure 6 - Annual Capacity for CLT Production12

From the numbers we can see that the bottleneck in producing CLT buildings, besides the obstacles in a previous section is, that manufacturing. While the current demand may be satiated by the current and potential production, if we look back at Figure 5, we can see that we will need an expansion in CLT production to meet demand. D.R. Johnson is adding a second shift and expanding their production capabilities, but there is still opportunity for other players in this market.

Based off of a study of the percent of market share that Oregon could achieve in the mass timber market, Figure 7, shows the potential for new jobs correlated with market share. Figure 8 shows the income tax generated by the increase in market share.

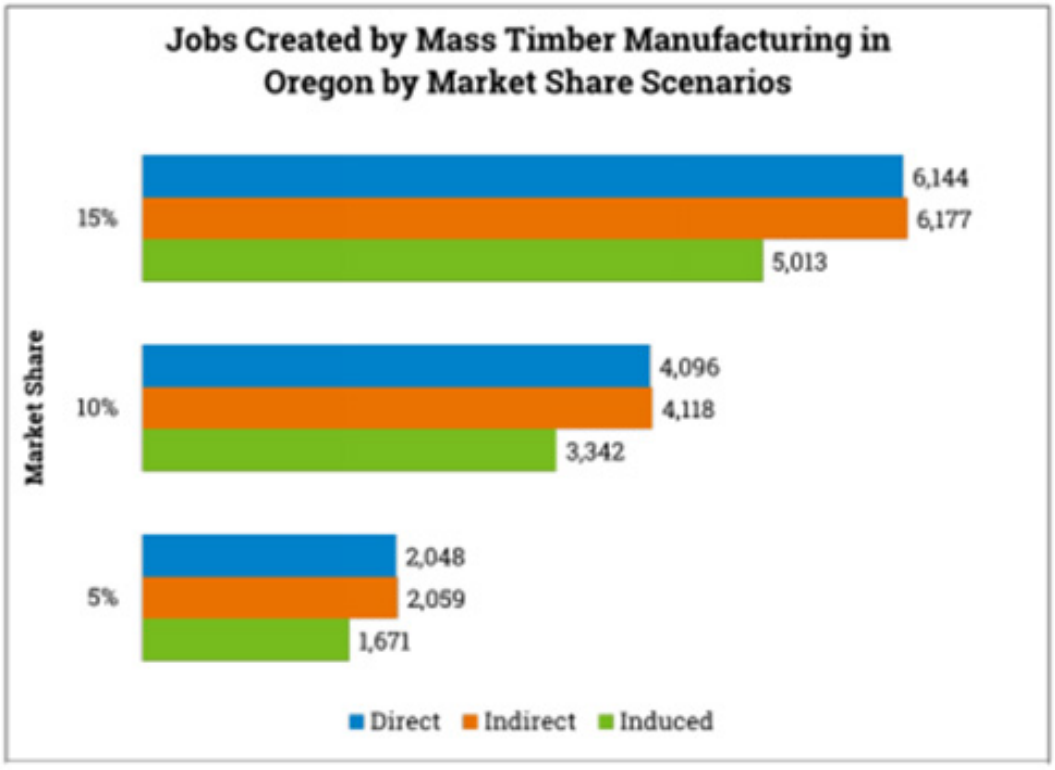

Figure 7 - Jobs by Market Share12

PRODUCTION AND ECONOMIC IMPLICATIONS

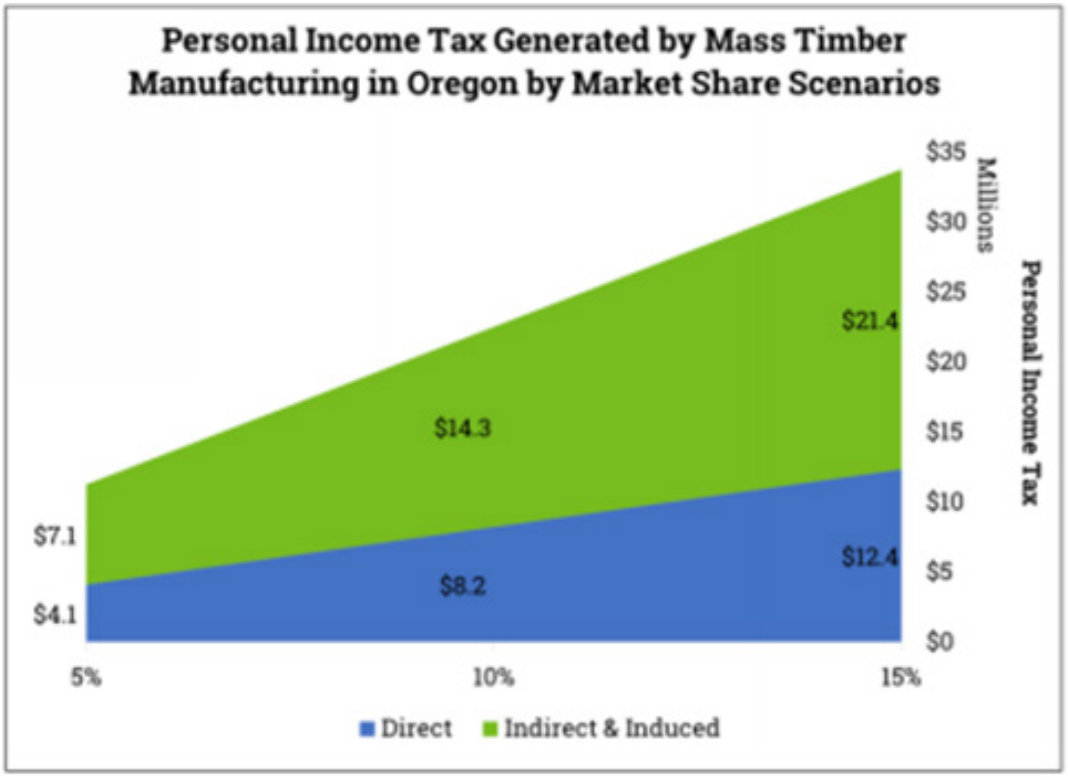

Figure 8 - Income Tax Generated12

In summary, there is great potential for CLT and the other mass timber products to have a profound impact on the economy of Oregon and the PNW region.

CONCLUSION

There is no denying that CLT in the U.S. is going to be gaining steam over the next 20 years and will challenge the rest of world for most complex and impressive CLT buildings. While the U.S. has been slow to adopt CLT, there are many innovative companies, organizations and designers looking to push the regulations and building code to foster CLT as a mainstream building product. The benefits are equal to or better than its concrete and steel counterparts, but the obstacles are still prevalent and will take time to sort through.

As manufacturers try to scale up to meet the upcoming demand, there will be more issues like the one at Peavy Hall at OSU. It will be the responsibility of the manufacturers to ensure that quality is not being compromised for quantity, as doing the latter will have an inverse effect on the propensity to choose CLT as a structural system.

While the U.S., and Oregon in particular, have sustainably-managed trees and forests, other areas of the world do not. It will be important for our upcoming projects to demand that the CLT and wood products be from these forests, and not supporting the use of trees that have been clear cut from regions with less regulation. CLT could very well be a great hedge against potential steel tariffs. It remains to be seen the extent to which CLT will be adopted into mainstream construction, or if it will simply be an amenity in select projects.

END NOTES

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