OREGON CROSS-LAMINATED TIMBER; AN ECONOMIC SOLUTION TO INCORPORATING TIMBER INTO CAP AND TRADE

by

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As the state of Oregon begins to introduce a new cap and trade program to reduce the effects of its greenhouse gas emissions, the state has opted not to incorporate its largest greenhouse gas emitter; the timber industry. The decline of the timber industry after the 1980's had lasting effects on disadvantaged communities, and state politicians have battled the cap and trade bill in fear of further deterioration of the timber industry. In this paper I aim to take an in depth look at the potential that CLT has in Oregon, how it can be promoted by the government, and what the environmental effects of it are. I found that, with the rise of mass timber construction and promotion of green building, the state has the opportunity to use revenues from its cap and trade program to economically incentivize CLT construction that can provide relief to economically stressed rural logging communities, all whole bolstering its efforts to better the environmental impact of an ever expanding construction industry.

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Introduction

Timber and the Environment

Oregon's current economic climate has the ability to become a national hub for the mass timber industry. Establishing Cross-Laminated Timber (CLT) manufacturing can have positive economic impacts throughout the state. Depending on the market share that Oregon will be able attain with the promotion of CLT manufacturing and construction, the production of CLT could create an estimated 5,800 to 17,300 jobs through CLT manufacturing and construction. The economic impact could increase total labor income to $1 billion a year and generate up to $33.8 million annually from state personal income tax. The economic impacts associated with CLT manufacturing and construction stem from Oregon accessing a 15% market share scenario within the U.S.[1] The economic effects would have significant impacts to Oregon's rural communities, as well as benefit Oregon's urban communities.

Economically incentivizing CLT production and construction in Oregon has the potential to incorporate the Oregon timber industry into a market that can have beneficial economic and environmental impacts across the state. The current economic incentives that are associated with CLT production can be bolstered by utilizing state cap and trade funds to promote the construction of CLT buildings, as well as establishing a strong CLT manufacturing foothold in the Northwest.

In establishing a strong mass timber movement through CLT promotion, the timber industry has the potential to revive the rural communities that have been

[1] Economic Development Administration, United States, and Oregon BEST. "Advanced Wood Product Manufacturing Study for Cross-Laminated Timber Acceleration in Oregon & SW Washington ." *Business Oregon and State Agency*, 2017

impacted by the decline of the timber industry, while reducing the carbon impact of construction throughout the state.

Climate Change Policy

Climate Change Overview

Oregon is currently in a position to pass one of the most ambitious cap and trade bills in the nation. With the federal government's lack of progressive climate change policy, many states have taken the initiative to institute their own climate change policies in order to reduce total state emissions. The Intergovernmental Panel on Climate Change (IPCC) has given civilization less than 12 years to reduce greenhouse gas emissions by a minimum of 45% below 2010 emission levels in order to prevent global temperatures of rising above 1.5 degrees Celsius[2]. If temperatures rise above 1.5 degrees Celsius it could have disastrous consequences for the earth; decimating the fish population, exposing millions to climate related poverty[3]. Due to suggestions by the IPCC as well as global protocols that have been agreed upon by nearly every country besides the United States, Oregon has taken it upon themselves to establish a climate change policy that can aid in reducing the states emissions.

Why Cap and Trade?

Much of the discussion centered around Oregon has been regarding which climate policy the state should choose, and how progressive this policy should be. Though many republican politicians do not believe that there should be any sweeping environmental regulations, Oregon has chosen to establish a statewide cap and trade program. The cap and trade program was chosen instead of other potential

[2] Talberth, John. "Oregon Climate Bill Leaves out Big Timber - the State's Largest Polluter - and Instead Rewards It with Two More Subsidies." *Center for Sustainable Economy*, 19 June 2019
[3] Inter-Governmental Panel on Climate Change. "Summary for Policymakers." *Global Warming of 1.5 ºC*, 2020

environmental policies such as command and control policies, or instead of solely introducing economic incentives to reduce these emissions. Command and control regulations consist of the direct regulation of a specific industry or activity by legislation where the state permits what is legal and what is illegal. This is enforced through direct regulation of a specific act where a lack of compliance to this regulation is met with punishment in the form of legal action or fines. This means that when these regulations or laws are broken, they must then be strictly enforced. Many critics of the command and control method believe that this form of legislation is more effective in terms of specific regulations on a smaller scale. This sort of policy is not a sweeping reform and would not be neither as ambitious nor as technical as the current cap and trade legislation aims to be. Command and control is a punitive measure which has been criticized as being a regulatory measure that lacks efficiency within the economy. It is costly for the government regulators to be consistently monitoring the actions of companies and the punishments for noncompliance are costly. Many people cite that the given the approach of command and control it lacks compatibility with the complexity that is global climate change[4].

Command and Control regulation differs from economic incentive, which establishes benefits for specific acts by offering tax breaks, as well as government subsidies. These benefits are offered for the compliance of laws and regulations. Economic incentives have been found to be effective in terms of environmental regulation. Any sort of subsidy or tax breaks puts money in the pocket of the person who is abiding by the regulation and automatically creates higher revenue for the good

[4]United States EPA. "Economic Incentives." *EPA*, Environmental Protection Agency, 1 Feb. 2018

actors[5]. Though this is perceived to be a more efficient way to encourage the good actor, it does not punish the bad actor. This can also give competitive advantages to those who choose not to participate in these incentives. Often these economic incentives are used to supplement policies such as command and control regulation and cap and trade.

Though both command and control as well as economic incentives, have individual positives and negatives, there is a reason that many countries are using market-based instruments instead of these policies. Market based instruments are policy instruments that aim to incorporate the market failure of the negative externalities into the market by placing an external cost on the production or consumption of these negative externalities. This essentially sets up a proxy market of these negative externalities where they can be traded like commodities. This is being used throughout the world, most commonly as cap and trade emissions regulation.

One of the most beneficial factors of cap and trade is the benefits of appropriating added tax money for spending on additional environmental policies. These revenues stem from the sale of additional carbon credits that are bought at auction by firms who pay for the pollution that they emit. These funds are typically used by the state to further environmental concerns and support impoverished communities throughout the state. Cap and trade is a flexible policy that has the ability to fund supplemental policies throughout the state, while simultaneously reducing statewide emissions. Additional policies that can supplement cap and trade can be in the form of economic incentives or adapted command and control methods.

[5] United States EPA. "Economic Incentives." *EPA*, Environmental Protection Agency, 1 Feb. 2018,

Climate Change Policy in Oregon

Currently within the United States there are twelve states that have adopted carbon cap and trade systems to reduce the effects of global climate change. A cap and trade program is a market-based system that aims to reduce greenhouse gas (GHG) emissions by setting a cap on the amount of GHG emissions that are emitted. In this system GHG emissions are reported directly to the state; then a cap is set based on how much the state wishes to reduce emissions. The state then offers a number of permits that allow polluting companies to emit a certain amount of GHG emission. Companies can then sell these permits if they emit less GHG emissions than they were allotted. This produces an incentive for companies to emit less GHG emissions each year in order to profit off of selling these emission permits. For companies that produce more emissions than they were allotted they can purchase extra permits on the open market, or they will be penalized if they produce more emissions than their cap allows. The companies that go over there permit allowances are taxed and these taxes go back to the state to fund other climate change reduction initiatives throughout the state[6].

Oregon is currently in a place where they have the potential to promote state legislated environmental policy actions by enacting effective climate change legislation. Oregon has the ability to learn from the failures of cap and trade programs in other states. Oregon's cap and trade legislation has been influenced by the successes and failures of California's current cap and trade program. Currently California has a cap and trade program which has not met several of the initial goals established in 2013. This is mainly because in 2013, California set the cap on emissions far too high when

[6] United States EPA. "Economic Incentives." *EPA*, Environmental Protection Agency, 1 Feb. 2018,

they began the program oversaturating the market with emission permits. This means that California companies did not have a reason to reduce their emissions because these emissions allowance permits were either very cheap or the companies that were large GHG emitters were already in a satisfactory position to be at or below its allotted allowance. Learning from California's climate change policy allows Oregon to be able to correct California's mistakes with a better cap and trade program of their own.[7] Though California has had struggles with the initial cap and trade policy they have been able to combat their initial mistake by using complementary measures to reduce GHG emissions. According to the California Air Resources Board (CARB), 62% of emissions reductions projected through 2030 will come from complementary measures that have been associated with the cap and trade program[8]. Though these complementary policies have been effective, a more effective approach would be to set an initial cap that could steadily reduce GHG emissions over time.

For the past decade there has been consistent debate within the Oregon legislative meetings regarding what Oregon should do in order to combat climate change. The solution to introducing a climate change policy came in the form of House Bill 2020 which passed within the house by a very narrow margin. This is aimed to reduce Oregon's emissions to 45% below the 1990 levels by the year 2035 and 80% by the year 2050.

[7] Carbon Policy Office. Oregon's Cap-and-Trade Program (HB2020): An Economic Assessment. Berkley Economic Advising and Research, 2018, pp. 1–72, Oregon's Cap-and-Trade Program (HB2020): An Economic Assessment.
[8] Talberth, John, et al. "Beyond Cap and Trade: Towards a Green New Deal for Oregon." *Sustainable-Economy.org*, Feb. 2019

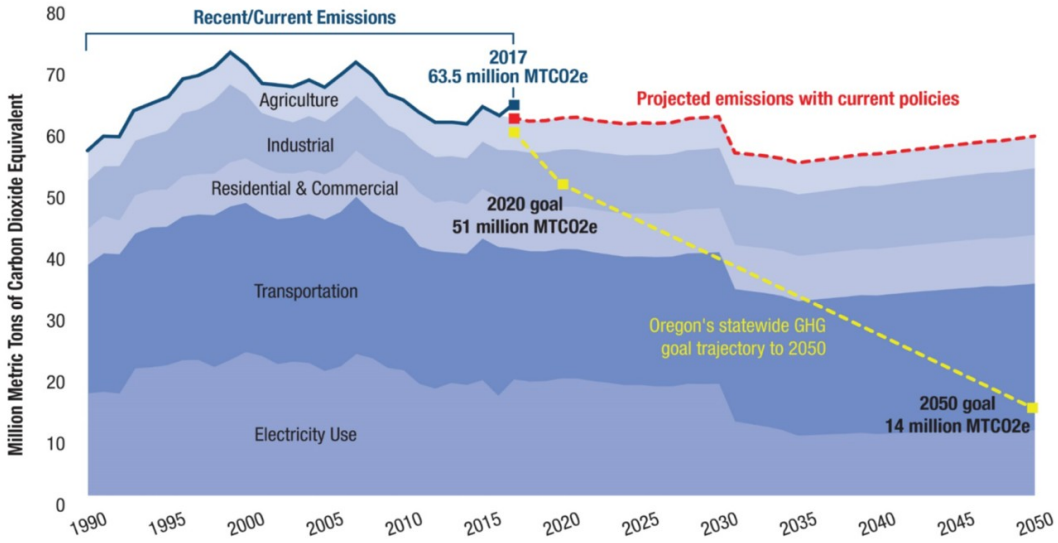


Figure 1: Oregon Cap and Trade Emission Targets[9]

This bill then went to the senate in the form of Senate Bill 1530 and has continued to create much controversy regarding the most efficient way to introduce climate change policy into Oregon. With the end of the 2020 legislative session the senate chamber was only able to pass 3 of the 258 bills that were introduced due to a massive walkout by republican senators. This also came at the expense of again another failed climate change bill. Though the proposed climate change legislation would likely help in reducing carbon emissions across the state, Oregon's leading polluter the timber industry is exempt from SB1530[10]. This was done in the hope that excluding the timber industry from the state cap and trade program would build support for this bill, such that a bipartisan agreement could be made. Unfortunately, this did not work for fear of the effects the cap and trade program would have on rural communities and the associated timber industry. Governor Kate Brown has since issued an executive order stating that

[9] Carbon Policy Office. Oregon's Cap-and-Trade Program (HB2020): An Economic Assessment. Berkley Economic Advising and Research, 2018, pp. 1–72, Oregon's Cap-and-Trade Program (HB2020): An Economic Assessment

[10] Law et al., "Land Use Strategies to Mitigate Climate Change in Carbon Dense Temperate Forests."

this climate change bill has no choice but to be passed. This executive order has issued 19 state agencies and commissions to work together with state bureaucracy to jumpstart this cap and trade program. Though Governor Brown has issued an executive order it does not mean that this fight is over, there is still debate on whether or not the governor has the power to issue this executive order. Currently the government is acknowledging that the executive order is valid until it is challenged in court, thus finally instituting a statewide cap and trade program[11].

Timber in Cap and Trade

One of the most pressing topics that was met with criticism from the democratic side was the exclusion of the timber industry. An amendment passed on the cap and trade bill "ensures 'wood products manufacturing facilities' do not suffer any 'permanent or temporary' reductions in the 'supply of wood fiber' in the carbon offsets protocols of HB 2020"[12]. This amendment was passed as well as another amendment that offers a rebate for low income log truck drivers that may be affected by increases in gas prices due to the effects of the cap and trade program. The argument behind excluding the timber industry is that if the timber industry is negatively impacted due to an increase logging prices because of additional transportation costs stemming from the cap and trade bill, the reduction in timber production would then be supplied from other states where they are not met with the competitive disadvantage of increased costs because of environmental regulation. This ultimately excludes the timber industry from having to be incorporated in the cap and trade bill in fear of a "leakage". Leakage means

[11] VanderHart, Dirk. "Oregon Gov. Kate Brown Orders State Action On Climate Change." *Oregon Public Broadcasting*, OPB, 11 Mar. 2020,
[12] Talberth, John. "Oregon Climate Bill Leaves out Big Timber - the State's Largest Polluter - and Instead Rewards It with Two More Subsidies." *Center for Sustainable Economy*, 19 June 2019

it will not create a reduction in logging emissions because the emissions from logging will increase in another market where there is less regulation. This leakage has been common in California, and though it seems that there is a reduction in GHG emissions, these emissions are being increased in somewhere other than California[13]. Though the timber industry is vital to the economy of Oregon, they are also the leading GHG emitter in the state. Therefore, there is a complex dynamic where if the state regulates the timber industry, it will likely result in leakage, as seen in California. However, not regulating the timber industry in Oregon makes; them free to emit without being incorporated into the cap and trade program. Due to the lobbying power of the big timber industry as well as the current layout of the cap and trade program, incorporating the timber industry into the bill would be politically infeasible[14]. This is why instead of incorporating timber industry directly into the cap and trade there, there should be talks on how to incentivize the timber industry to add to the reduction of Oregon GHG emissions through the natural carbon reduction properties of Oregon's forests through carbon sequestration.

Carbon Sequestration

Carbon sequestration is the long-term storage of carbon that exists in wood. As timber grows within the forests through the natural forces of photosynthesis, the wood is able to store the carbon dioxide within the wood fibers. After a tree is harvested, half of the timber product is carbon and the wood does not lose this carbon until it starts to decompose or burns, and releases the embodied carbon into the air. The sequestering of

[13] Fowlie, M., Reguant, M., and Ryan, S. 2016. “Measuring Leakage Risk”. Prepared for The California Air Resources Board (CARB). May 2016.
[14] Davis, Rob. “Here's Who Put $120,000 behind Oregon's Climate Walkout and Protests.” *Oregonlive*, 20 July 2019

large amounts of carbon is referred to as a carbon sink; this is where the amount of carbon that is stored reduces the total GHG emissions within the region. Carbon sinks can work to offset emissions within Oregon due to the renewability of timber. Currently within the United States approximately 10 to 20 percent of the GHG emissions are being offset by the forest carbon sinks that exists across the nation[15]. Within Oregon, according to a study by Oregon State University researchers, the Oregon forests currently sequester 32 million tons of carbon each year, offsetting half of Oregon's 64 million tons of carbon emissions each year.[16] Oregon's timber is one of the state's key resources and the environmental opportunity of utilizing this timber can create carbon sinks not only within Oregon's forests, but also within our cities as well. The way in which Oregon is able to create carbon sinks within cities is by utilizing wood-based construction material to sequester carbon within mass timber buildings, mainly cross-laminated timber.

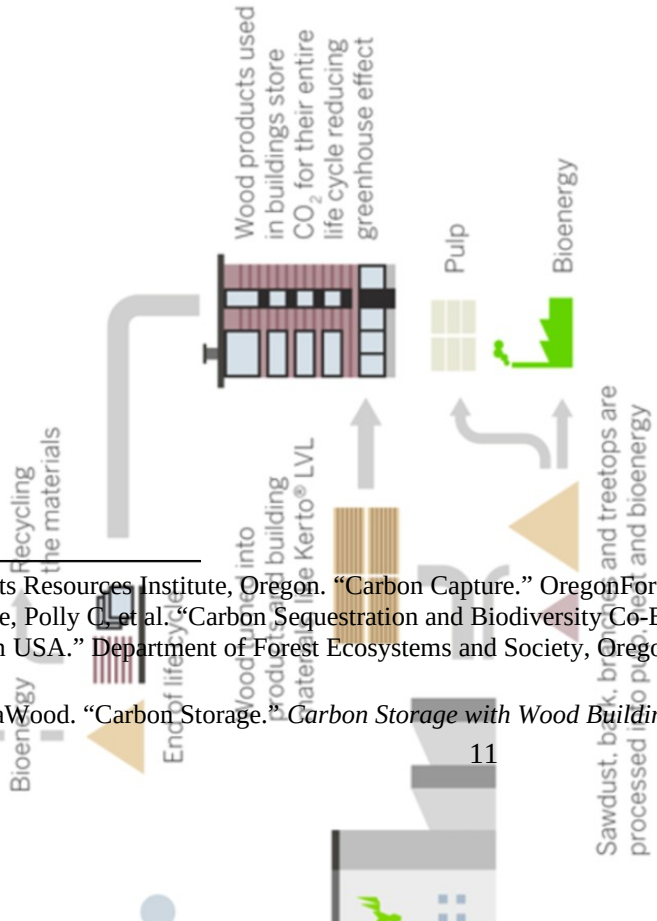
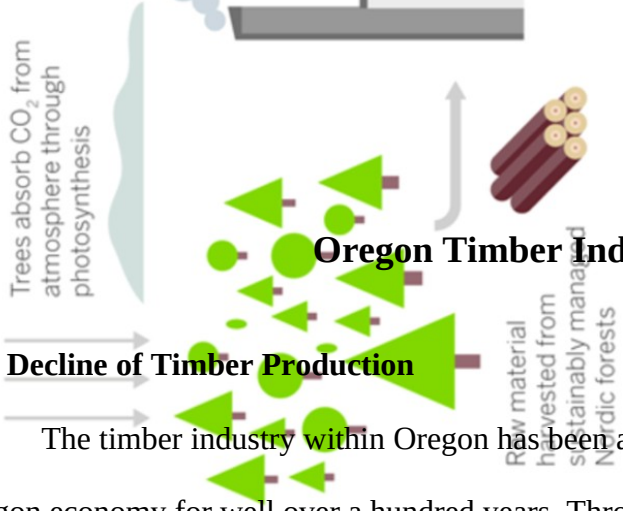


Figure 2: How Carbon is Stored within Mass Timber Buildings (Metsawood)[17]

[15] Forests Resources Institute, Oregon. "Carbon Capture." OregonForests, 2019
[16] Buotte, Polly C, et al. "Carbon Sequestration and Biodiversity Co-Benefits of Preserving Forests in the Western USA." Department of Forest Ecosystems and Society, Oregon State University, 2019,
[17] MetsaWood. "Carbon Storage." *Carbon Storage with Wood Buildings*, 2020



Oregon Timber Industry

The Decline of Timber Production

The timber industry within Oregon has been a consistent economic driver in the Oregon economy for well over a hundred years. Throughout Oregon's history the timber industry was able to sustain rural economies throughout the state, as well as provide much needed tax revenue to these rural communities. However, in the 1980's, due to new environmental policies, the economy took a steep downturn. The timber industry, as well as these rural communities, have still struggled to recover from what it once was. From the 1980's to today, the job market for the timber industry has declined by nearly 50,000 workers, and the average salary has decreased by 40% of the statewide average[18].

[18] Economic Development Administration, United States, and Oregon BEST. "Advanced Wood Product Manufacturing Study for Cross-Laminated Timber Acceleration in Oregon & SW Washington ." *Business Oregon and State Agency*, 2017

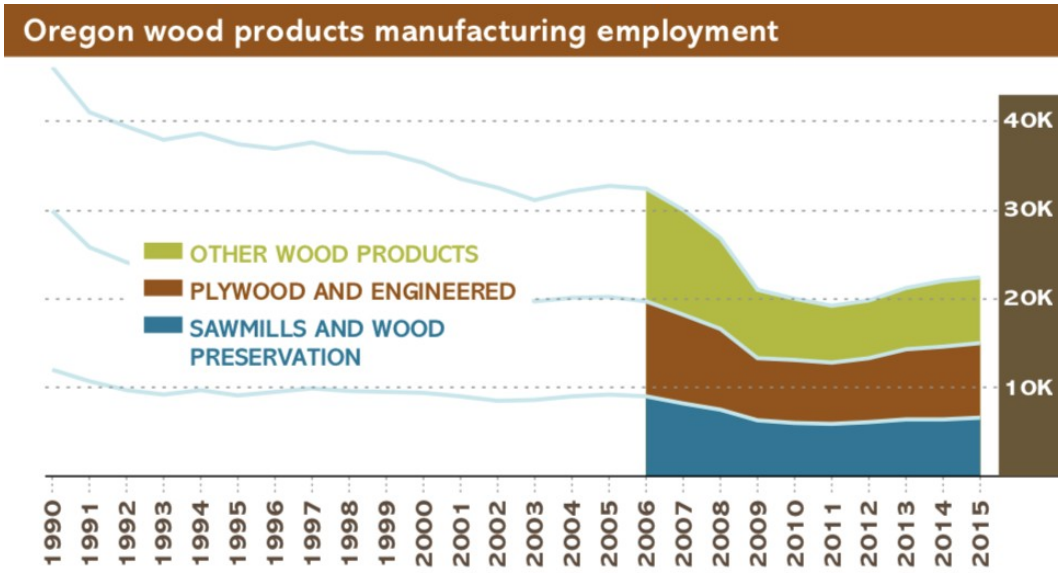


Figure 3: Timber Associated Employment

Oregon Timber FAQ[19]

This negative economic impact has been deeply felt within these rural communities and any new industry has yet to take its place 40 years later. With this loss of production of lumber, it is clear that Oregon has a much higher capacity of producing lumber than they are currently producing[20]. Some of these job losses can be accounted for by technological changes, but the majority is due to the economic downturn of timber production. Timber industry growth not only has the potential to revitalize these rural communities, but the potential to boost the Oregon economy. This can be done by promoting the carbon sequestration efforts across the state to create a large carbon sink. The efforts to grow Oregon's carbon sink could complement the currently proposed cap and trade program. Mass timber construction and production has the ability to sequester

[19] Cloughesy, Mike. "Oregon Forest Facts." US Department of Forestry, 2015.
[20] Economic Development Administration, United States, and Oregon BEST. "Advanced Wood Product Manufacturing Study for Cross-Laminated Timber Acceleration in Oregon & SW Washington ." Business Oregon and State Agency, 2017

millions of tons of carbon, while simultaneously addressing an ever-growing market that is currently lacking sufficient supply.

Supporting the timber market through the use of cap and trade funds can be done in order to address the concerns that are associated with the belief that the cap and trade will negatively impact the timber industry. Revenue that stems from the cap and trade can be used to make Oregon's timber industry a more environmentally beneficial industry. The supply of raw materials for the manufacturing of CLT will be needed to increase the carbon sink, and Oregon forests could be the answer.

Timber Production

After the timber industry downturn in the 1980's, Oregon has not been able to operate at the production capacity needed to economically restore the timber industry. The state of Oregon is comprised of 47% forestland and 80% of this forestland land classified as timberland. Timberland means that it has the ability to grow commercial grade timber and excludes protected forest area where logging is restricted. Oregon is currently the nation's leading producer in softwood lumber producing over 5 billion board feet in timber each year.

Softwood lumber production Top 10 states and U.S. total production (in millions of board feet)[10]

	2010	2011	2012	2013	2014	2015	% of U.S. total for 2015
Oregon	**3,994**	**4,134**	**4,659**	**5,119**	**5,448**	**5,222**	**17%**
Washington	3,637	3,685	3,763	3,942	4,035	3,745	12%
Georgia	1,856	1,995	2,111	2,190	2,363	2,454	8%
Alabama	1,455	1,613	1,808	1,950	2,034	2,155	7%
California	1,435	1,623	1,838	1,937	1,938	1,957	6%
Arkansas	1,638	1,737	1,808	1,859	1,944	1,937	6%
Mississippi	1,523	1,604	1,622	1,715	1,824	1,821	6%
Idaho	1,258	1,353	1,494	1,647	1,667	1,717	5%
North Carolina	1,248	1,331	1,521	1,564	1,664	1,678	5%
Texas	1,055	1,101	1,191	1,260	1,296	1,332	4%
TOTAL U.S.	24,803	26,508	28,257	29,951	31,496	31,644	

Figure 4: Top Softwood Producer in the Country

Oregon Forestry FAQ[21]

[21] Cloughesy, Mike. "Oregon Forest Facts." *US Department of Forestry*, 2015.

Introduction to Cross-Laminated Timber

Mass timber is defined as "building construction where the primary load bearing members in the structure are made up of wood, including engineered wood products and/or large dimension solid sawn wood"[22]. Mass timber is an overarching term that includes wood products such as: structural composite lumber, Glue laminated Timber (Glulam), dowel laminated timber, nail laminated timber, and lastly cross laminated timber. The most popular of the mass timber is cross-laminated timber, otherwise known as CLT. This CLT technology was engineered and developed in the early 1990's, most predominantly in Germany and Austria, as a cost competitive, environmentally friendly building material that has the potential to replace concrete, steel, and masonry. CLT has been widely used throughout all of Europe for the best of twenty years. The use of CLT in Europe is often attributed to the fact that European engineers have been working with wood building for most of their history. However, within the United States there has been a certain reluctance to adopt this technology due to lack of technological advances in construction material, as well as a widespread fear of the flammability of timber. Fears associated with timber as a construction material can be seen with the late adoption of building codes, being nearly 20 years behind Europe[23]. With the continued urbanization of the world, the market for technological advances in building material is much overdue.

[22] The Beck Group. "California Assessment of Wood Business Innovation Opportunities and Markets (CAWBIOM)." Initial Screening of Potential Business Opportunities, 2015, nationalforestfs.org.
[23] Clt Handbook: Cross-laminated Timber. Québec: FPInnovations, 2013

Importance of CLT

CLT is made up of timber that is approximately 1-2 inches thick; these pieces of wood are arranged side to side, glued and pressed together, then another layer is added at 90 degrees to the previous layer thus forming the cross-lamination of timber. These CLT panels typically consist anywhere between three to nine layers thick of timber boards and have been engineered for a variety of high-performance applications. These panels are often prefabricated within the production facilities, then shipped to be put together with precision so that there is minimal waste during the construction process. Due to the general fears that surround the flammability, stability, and overall application of large-scale wooden buildings, CLT has had to pass rigorous safety tests within the U.S. CLT has been able to pass these tests and the structural stability associated with it has led to governmental interest by sectors, including the Department of Defense. This came with the increased government blast testing for government building applications[24]. Part of the unique application of CLT is the wide array of different timber types that are able to be used in the construction of CLT panels. CLT manufacturers and promoters hope that with increase in CLT adoption they will one day be able to create a high-rise skyline of wood buildings.

[24] WoodWorks. "Tall Wood Buildings in the 2021 IBC." *Woodworks.org*, 2019

Structural Benefits of CLT

Fire Resistance

A key advantage of CLT is its fire resistance. CLT has been engineered to be fire resistant, holding its structural integrity within a fire for 60 minutes. As the CLT panels burn, the surface of the panels will begin to char, while the structural integrity of the wood stays intact. During fire testing, the steel brackets that support the CLT panels give way before the wood panels. Though these results have exhibited these strong char resistances there are still added tests that are being conducted in order to ease the fears of architects and investors that wood is a more flammable material than a building made from steel, concrete, or brick[25].

Seismic Resistance

Another structural benefit of CLT is that it has extremely high seismic resistance. Compared to concrete and steel, where during an earthquake they are likely to either fracture or disintegrate under strong seismic activity, the CLT panels and its connectors are able to flex. The flexibility in CLT is able to dampen and absorb the seismic vibrations under extreme stress. An Italian study to test the seismic ability of CLT has shown that a seven story CLT structure is able to withstand a 7.0 size earthquake. This is comparable to the 1995 Great Hanshin earthquake in Japan that completely destroyed 1 in 5 buildings and rendered them unusable. Keeping in mind that the Pacific Northwest is located on a fault as well as the potential for the Cascadia Quake to strike Oregon within the near future any preparation for seismic activity and

[25] CLT Handbook: Cross-laminated Timber. Québec: FPInnovations, 2013

safety can have the potential to reduce the economic devastation that Oregon will face in the foreseeable future. The seismic benefits of the reliability of CLT with continued promotion and education provide a unique opportunity for the application of CLT structures throughout the pacific rim. These benefits are what has continued to fuel the Japanese CLT market[26].

Energy Efficiency

CLT has benefits in terms of thermal performance and energy efficiency as well. Due to the density of the wood panels it is able to provide insulative benefits that reduce heat loss within the buildings. This benefit provides additional cost saving and on average reduces cost of temperature control within buildings. These savings are estimated to reduce the use of energy for temperature control by ⅔ when compared to traditional steel and concrete buildings[27].

[26] Albee, Raquel R. Global Overview of the Cross-Laminated Timber Industry. : Oregon State University.
[27] Lupien, Sandra. "Removing Barriers to Cross-Laminated Timber Manufacture & Adoption in California." Sage Hen.ucnrs.org, 2018

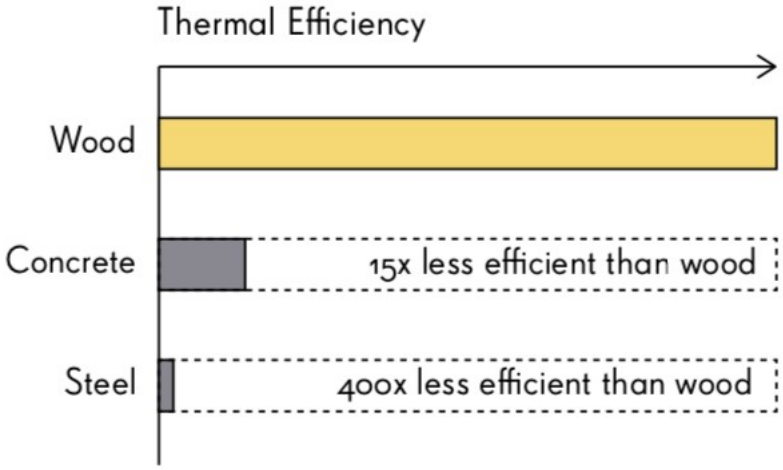


Figure 5: Thermal Efficiency of CLT compared to Concrete and Steel (CLT Handbook)[28]

Oregon Timber Industry and CLT

In Oregon the majority of the lumber that is produced is exported across the world, and the associated shipping and transportation costs for this product cause the bulk of the emissions. Keeping the use of this timber local will ultimately decrease the associated transportations costs as well as emissions that are associated with the timber industry. An additional benefit that is associated with CLT is that in the manufacturing process, CLT is able to utilize small diameter trees that are not normally harvested by the timber industry. Incorporating these small diameter trees into the production of CLT will allow new opportunities for forestry management that can have additional environmental impacts[29]. In creating better opportunities for forestry management, this can help in reducing the susceptibility of Oregon forest fires which cost Oregon a record

[28] Clt Handbook: Cross-laminated Timber. Québec: FPInnovations, 2013
[29] Minnesota Duluth, University, and Bureau of Business and Economic Research. "Economic Feasibility of Mass Timber Manufacturing in Minnesota." *University of Minnesota Duluth*, 2018

high $514 million in 2018 and a projected $10 billion in associated health costs[30]. The smaller diameter trees are typically left because there is no manufacturing application; these conduct fires both vertically as well as horizontally creating more destructive wildfires. CLT has the potential to create a market for these smaller diameter trees that typically go untouched.

The drive for finding a better solution to help combat the industries of concrete production, masonry, and steel is what has influenced CLT to become a material with the greatest potential. The benefits associated with CLT are not purely environmental. Though the environmental impact of this material has been a significant driving force by political figureheads it is also a cost competitive material. The way in which CLT is constructed allows for much faster construction which significantly decreases construction costs. This is because when the architects and designers of the buildings are planning the construction, they are able to digitize the modeling of their construction projects. This allows for the construction of these CLT panels to be constructed with extreme precision down to the millimeter. These panels act as sorts of building blocks so that they are much easier to assemble. Most steel and concrete buildings are built from scratch, while on-site CLT allows for quick assembly and minimal debris waste.

[30] Limaye, Vijay, and Juanita Constible. “Up In Smoke: Oregon Wildfires Cost Billions In Health Harms.” *NRDC*, 3 Feb. 2020

Environmental Impact

Construction Carbon Footprint

In the age of the Anthropocene, with a constantly increasing population the world is growing denser, and there exists a consistent trend of urbanization. With this continued urbanization, cities will need to adapt to this growth. This means an increase in the materials that will be used for this construction. According to the Organization for Economic Cooperation and Development (OECD), there will be an increase in the demand for steel from 1.537 billion tons to 2 billion tons of steel by the year 2030. The OECD also projects an increase in concrete demand from 1 billion tones in 1990 to 5 billion tons of concrete by 2030[31]. The carbon footprint associated with these materials tends to be very high. The world's current largest GHG emitter, China, is also host to the world's largest construction and manufacturing markets. This is no coincidence; steel represents 33% of China's total emissions and cement represents 26% of total emissions. Both of these materials have very high carbon footprints and it is not exclusive to China. In the United States construction contributes to 40% of total carbon dioxide emissions and this number will continue to grow[32].

One of the most beneficial characteristics of CLT is its environmental impact. In our current society the value of a green product is rapidly rising. More people are becoming environmentally conscious of their actions in their daily lives, and that translates into the demand for green products. With the current negative trajectory of environmental impact of construction, in conjunction with ever-growing urbanization,

[31] Organschi, Alan, et al. "Growing an Urban Carbon Sink with Glue, Screws, and Cellulose Fiber." *World Conference on Timber Engineering*, 2016,

[32] Houtman, Nick. "Use of Structural Wood in Commercial Buildings Reduces Greenhouse Gas Emissions." *Life at OSU*, 12 May 2018

more people are demanding alternative technologies. With the establishment of Oregon's cap and trade program, this will be at the forefront of every political conversation.

According to Portland State University's Population Research Center Oregon, has been consistently growing in population. Within the last ten years, Oregon has added more than 400,000 residents due to migration as well as general population growth and major cities in Oregon within the last year have increased by about 1.2%. With the continued population growth in Oregon, most of this is occurring in larger cities. These larger cities will need to be met with an increase in additional jobs as well as the expansion of the urban areas. Since 1998, 27,000 acres have been added to the urban growth boundary in the Portland metro area with the expected housing permits expected to grow to 67,000[33].

The reduction in energy consumption and that are associated with CLT tend to be one of the benefits for the use of this material. Within the U.S., more timber is grown each year than is harvested, due to strict laws within the timber industry. In 2018, the construction of a First Tech Federal Credit Union in Hillsboro, OR became the largest CLT project to be constructed within the U.S. This building is 156,000 square feet, and within Oregon alone, the amount of wood that was used for the building was regrown in 46 minutes. The construction of this building was able to store 4,192 metric tons of carbon, avoiding 1,622 metric tons of greenhouse gas; this is the equivalent of removing 1,229 cars for a year[34]. As long as the structures are standing and in use, the wood will

[33] Portland State University. “PSU’s Population Research Center Releases Preliminary Oregon Population Estimates.” *Portland State University | News*, 2019,
[34] Silva, William, director. A Case Study of the Hillsboro First Tech Federal Credit Union. Mass Timber Conference, 2018

be able to sequester the carbon. The amount of carbon sequestered in the wood is also referred to as the amount of embodied carbon within the wood. The amount of carbon that is embodied within the wood is different based on the amount of CLT that is used to construct the buildings; however, the net carbon emissions that are associated with producing CLT have the ability to create carbon sinks that can offset emissions that have been associated with years of carbon emissions[35].

[35] Locke, T. (2018, December 21). A big win for tall wood. Retrieved December 26, 2018

CLT Market Construction

Current Market Demand

Though benefits of CLT have been proven to be environmentally friendly as well as cost competitive in comparison to other building structures, there has been a delay in incorporating CLT as a normal building material. Much of this delay has stemmed from overall fear of the structural integrity combined with a general lack of knowledge. According to a presentation by Jeff Marrow at the 2018 Mass Timber Conference the construction industry is one of the most inefficient industries in the nation. This is because the conservative nature of the construction industry prioritizes the use of proven industry techniques for construction projects due to its established safety. Over last-30 years, there has been a 0% increase in productivity within the construction industry, and construction has the lowest adoption of new technologies. Some of this lack of adoption of new technology can be attributed to the construction industries low level of spending on new construction technology. The construction industry allocates only 1% of their spending to technology[36].

Due to the conservative nature of the industry, there is typically pushback and mixed receptions for new technology. Though this has been the case for the last 30 years, with the current advancement in robotic technology within the past few years, the construction industry is beginning to look forward to incorporating new technology. New robotic manufacturing techniques and the digitizing of construction design has been well received by the construction industry, which are now beginning to adapt to

[36] Marrow, Jeff, director. *Mass Timber: The Gateway to Revolutionize Project Conception, Design and Delivery*. *Mass Timber Conference*, 2018

the use of these new technologies. Within the CLT industry, this has given the material an advantage because of the prefabrication design of CLT buildings. This can be seen with the new incorporation and revision of building codes that will make it much easier to approve the construction of CLT buildings.

Within the United States in 2018, 439 CLT buildings were constructed or are being constructed. The following demand increases were calculated using CLT construction data from WoodWorks[37]. This year (2020) there are now 782 CLT buildings that have been completed or are being built. That is an increase in CLT construction by 43.9% over the course of two years. The West Coast, including Oregon, Washington and California, has seen an increase in CLT construction by approximately 21%. Though momentum for CLT adoption has increased throughout the nation, the west coast's early adoption of CLT has begun to slightly taper off; only increasing CLT production from 2018 to 2020 by approximately 17.7%, which is under the national average. Within the west coast, Washington was able to grow their CLT construction market the most, by 55%, while California grew by 45%, and Oregon fell slightly behind at a 28% increase in CLT construction. CLT demand continues to rise, not only in Oregon, but across the nation.

[37] WoodWorks. "Building Trends: Mass Timber." *WoodWorks*

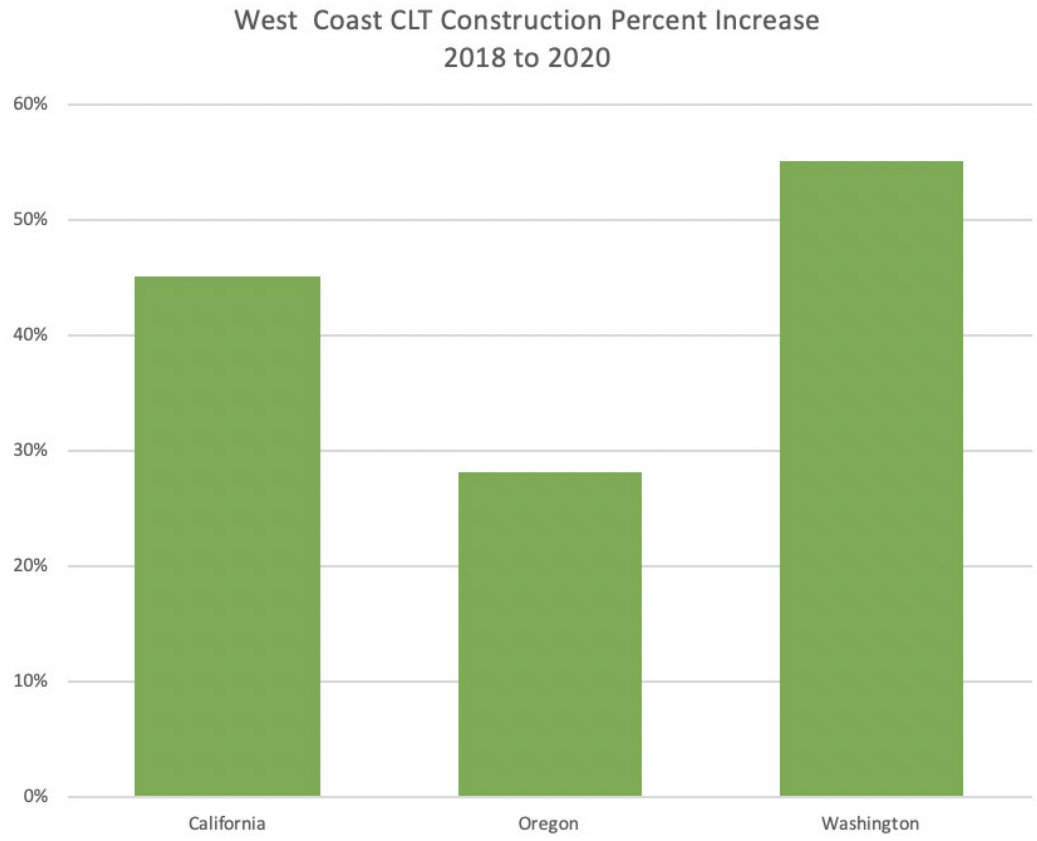


Figure 6: West Coast CLT Construction Increase

Data Processed using informatio from (WoodWorks Building Trends 2018 and 2020)[38]

[38] WoodWorks. “Building Trends: Mass Timber.” *WoodWorks*

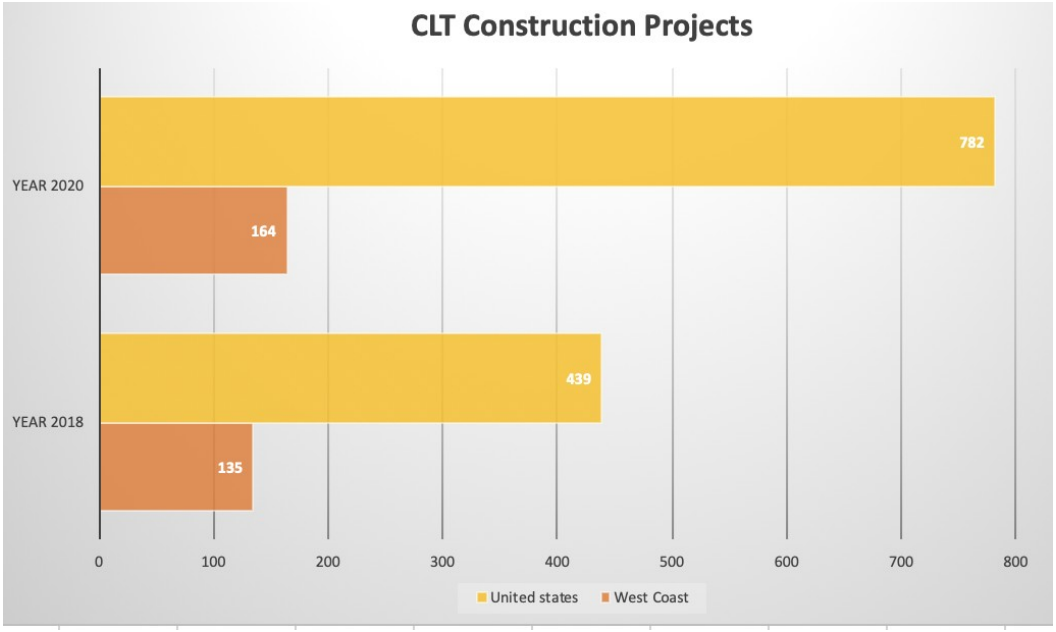


Figure 7: US and West Coast CLT Construction Projects

Data collected from (WoodWorks Building Trends 2018 and 2020)[39]

The revision to the 2021 International Building Code (IBC) was approved by the International Code Council in 2019 and will allow for the construction of tall wood buildings. The IBC will now allow for the construction of mass timber buildings to be approved up to 18 stories. These revisions came after the fire safety and structural integrity of mass timber, mainly CLT, was thoroughly studied. The incorporation of Mass Timber into the IBCC building codes will open up new opportunities for CLT construction in the future, and is projected to significantly increase the demand for CLT structures.

CLT is Cost Competitive

The estimated material costs of CLT throughout the market vary, and are largely dependent on the contextual factors that surround the construction projects. While some

[39] WoodWorks. "Building Trends: Mass Timber." *WoodWorks*.

studies indicate that the material cost savings can be as great as 22%, compared to steel and concrete, other studies have indicated it can be 18% to 25% more costly[40]. Contextual factors that provide pricing variation includes the labor availability, transportation costs, building type, and the approval process. With incentives for expedited permitting process, as well as locally sourced timber with minimal transportation costs, CLT can be a more cost-effective option as compared to steel and concrete options. Due to the maturity of the concrete and steel markets, they have been able to establish cost competitiveness which has driven down costs. The CLT industry has yet to reach economies of scale which will eventually drive down costs of the material. However, with the current price of the CLT being generally high, the cost efficiency savings of the construction method alone can provide a cheaper alternative.

An analysis conducted comparing CLT cost effectiveness to concrete and steel options with minimal transportation costs as well as optimal approval processes tested multiple CLT options compared to the traditional concrete and steel options[41]. Option 1 and 2 represent different scenarios in which the CLT is purchased at a high cost (option 1), and a low cost (option 2).

[40] Central City Association of Los Angeles. "Mass Timber: White Paper." *Ccala.org*, 2019
[41] Laguarda-Mallo, Maria & Espinoza, Omar. (2016). Cross-Laminated Timber vs. Concrete/Steel: Cost Comparison Using a Case.

Table 1: Side by Side Structural Cost Comparison Using a Napa California Case Study

CLT Extras: Additional CLT connectors, and labor costs

Elements	Concrete/ Steel option	CLT Options			
		Basic CLT option 1	Basic CLT option 2	Green option 1	Green option 2
	(Concrete Walls/roof. Steel beams light steel frame)	(CLT walls/roof, steel beams, light steel frame)		(CLT walls/roof, Glulam beams, wood frame)	
Structural Walls	$ 1,071,680	$ 624,417	$ 414,901	$ 624,417	$ 414,901
Concrete Slab	$ 256,416	$ 256,416	$ 256,416	$ 256,416	$ 256,416
Roof System	$ 600,975	$ 427,809	$ 289,339	$ 427,809	$ 289,339
Interior walls	$ 155,304	$ 155,304	$ 155,304	$ 297,666	$ 297,666
Steel beams	$ 506,575	$ 506,575	$ 506,575	$ -	$ -
Glulam Beams	$ -	$ -	$ -	$ 29,022	$ 29,022
Extra CLT walls	$ -	$ -	$ -	$ 115,407	$ 84,977
Extras for CLT	$ -	$ 595,241	$ 595,241	$ 654,768	$ 654,768
Total	$ 2,590,950	$ 2,565,762	$ 2,217,776	$ 2,405,505	$ 2,027,089
SQFT	$ 40,065	$ 40,065	$ 40,065	$ 40,065	$ 40,065
Cost per SQFT	$ 64.67	$ 64.04	$ 55.35	$ 60.04	$ 50.60
Cost Savings	$ -	$ 25,188	$ 373,174	$ 185,445	$ 563,861
Percent Cost Savings	0%	1%	14%	7%	22%

A basic CLT structure would provide an overall 1% cost savings, due to the reduced costs of the structural walls and roofing systems. CLT option 2 provides further cost savings of 14% overall further cost reduction in the structural walls and roof system. These cost reductions are associated with the speed and efficiency of construction with the CLT material. The weight ratio and prefabrication provide a more efficient, construction with fewer workers, and less construction equipment. Other green options 1 and 2 use Glulam beams to form a mass timber that is glue laminated, similar to cross laminated timber, but is used instead of steel beams to frame the building. These buildings can offer further cost saving by replacing steel beams and using the cheaper glulam beams requires additional CLT walls. Green scenario 1 with glulam beams reduces the overall cost by 7%. Green scenario 2 reduces overall costs by 22%. This scenario assumes cost competitive CLT and glulam prices, as well as tests two different CLT and Green options with different costs associated to construction efficiency[42].

Another study by the Los Angeles California City Association used a cost comparison, according to California structural costs of CLT projects conducted from 2010 to 2019 for both 3 to 5 level buildings as well 10 to 20 level buildings.

[42] Laguarda-Mallo, Maria & Espinoza, Omar. (2016). Cross-Laminated Timber vs. Concrete/Steel: Cost Comparison Using a Case.

Side by Side Structural Cost Comparison:
Figures for 3 to 5 Level Buildings in California 2010 to 2019

Uniformat Description	Steel Bldgs	Concrete Bldgs	CLT Bldgs
	$/SF Range	$/SF Range	$/SF Range
A10 – Foundations	$4.50 - $10.00	$7.00 - $14.00	$3.75 - $8.00
B10 – Superstructure	$40.00 - $60.00	$50.00 - $65.00	$40.00 - $100.00+

Side by Side Structural Cost Comparison:
Figures for 10 to 20 Level Buildings in California 2010 to 2019

Uniformat Description	Steel Bldgs	Concrete Bldgs	CLT Bldgs
	$/SF Range	$/SF Range	$/SF Range
A10 – Foundations	$4.00 - 8.00	$4.50 - $8.50	$3.75 - $8.00
B10 – Superstructure	$45.00 - $50.00	$47.00 - $55.00	$40.00 - $60.00

Figure 8: Los Angeles California City Association Study

(LA CCA)[43]

Though the associated costs greatly vary, the lower end cost of CLT has the potential to significantly reduce construction costs. Taking into consideration that this study was conducted in California, Oregon has a better mass timber infrastructure, as well as expedited mass timber permit processing that would likely drive CLT associated costs down.

[43] Central City Association of Los Angeles. “Mass Timber: White Paper.” *Ccala.org*, 2019

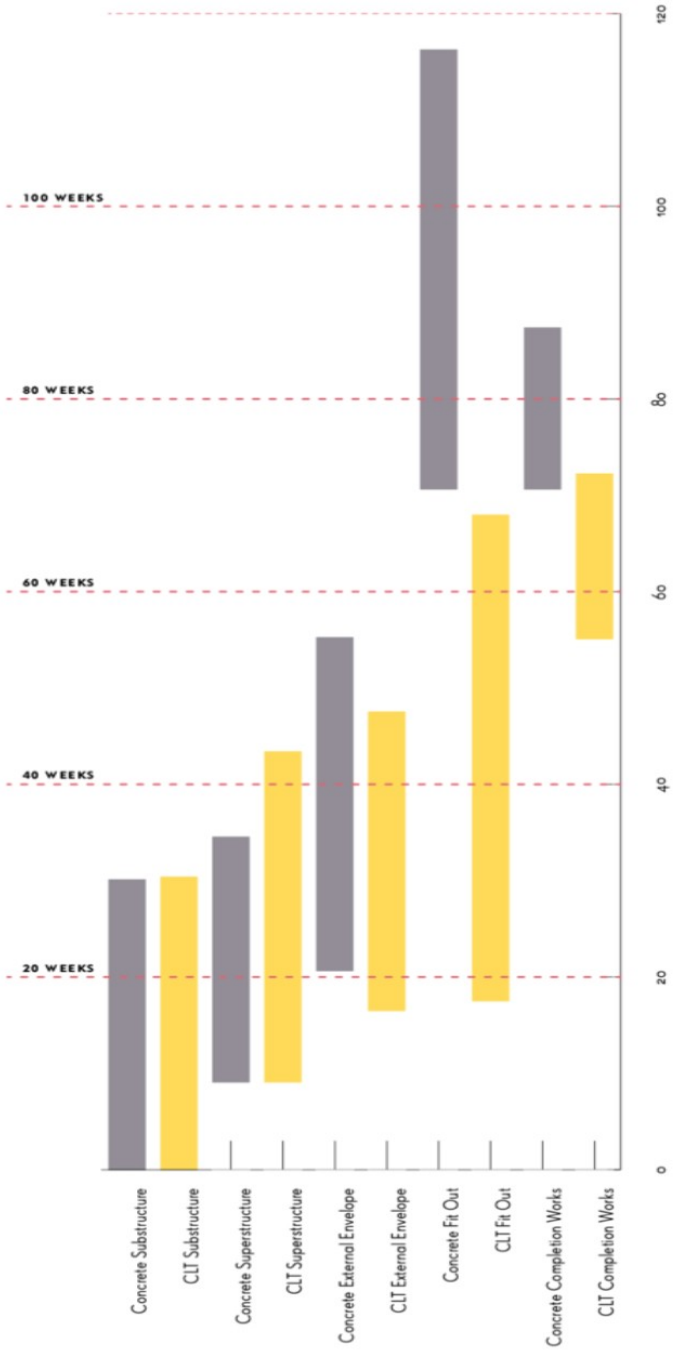


Figure 9: Timeline Comparison of Concrete and CLT construction

(CLT Handbook)

This Gantt chart shows the average timeline in construction compared to a traditional concrete and steel structure.

Green Economic Incentive Programs

Introduction

As the societal drive to adopt CLT and more environmentally friendly construction continues, there has also been economic support in the form of governmental incentives. These governmental incentives have been shown to contribute to the growth of the CLT market in other countries such as Canada, France, and Japan. Canada has currently pledged over $5.6 billion to the construction of Mass Timber buildings, leading to some of the largest CLT structures in the world[44]. With massive economic incentives to help boost CLT, it has grown exponentially in these countries. Oregon's current demand is only able to fulfill one fifth of the market demand for CLT within the state. Clackamas County has estimated that Oregon will need 8 to 10 additional manufacturing facilities in order to fulfill market demand in Oregon alone[45].

Establishing these economic incentives within the U.S., and particularly Oregon can help propel the CLT industry to increase market demand for this product. There are currently multiple incentives that exist within the U.S. for furthering the use of green buildings, as well as economic incentives for the construction of CLT buildings. These incentives are aimed at sequestering more carbon by furthering the construction of CLT and continuing to grow the CLT industry.

Effective incentive approach

> This suggests that local and state governments view money as the major issue for encouraging developers to "go green," based likely on the

[44] Albee, Raquel R. Global Overview of the Cross-Laminated Timber Industry. : Oregon State University.
[45] Clackamas County. "Clackamas County Mass Timber." *Integrated Mass Timber Market Strategy*, 2019

> perception that green buildings cost more and need to be incentivized with funds to lower costs. One government official put it this way, "When it comes down to it, it is about money. Would we not build ALL green IF we had the money for it?"

(NAIOP Green Incentive Research Report)

The NAIOP conducted a survey, asking industry specialist about what the most impactful incentives are to increase green construction. The top incentive are financial incentives that can offer tax breaks as well as incentives in the form of development approval processes. According to the study, respondents believed these were the most beneficial incentive programs to improve green building.[46]

- Expedited permit processing – 13%
- Tax reductions – 13%
- Density bonuses – 12%
- Expedited plan review – 10%

Several of these incentives are currently being used by Oregon to incentivize green construction and to provide monetary incentives for companies. However, what is equally or more important, is the expedited permit processing, as well as expedited plan reviews. Within Oregon there has been a joint effort by the federal government, state, county and local jurisdictions to integrate mass timber into rural communities. This has come in the form of individual county, state and federal resources. Oregon is already beginning to see dividends pay off; in 2021, Sauter timber will be opening a CLT manufacturing city in Estacada, and beginning at the end of 2020, a 146,000 square foot

[46] Yudelson Associates. Green Building Incentives That Work: A Look at How Local Governments Are Incentivizing Green Development. Commercial Real Estate Development Association, 2007, pp. 1–35

CLT office building will begin construction[47]. Both of these new CLT production facilities as well as the CLT office building are taking advantage of incentives that have been incorporated into Oregon.

Relevant Economic Incentives

With the combined efforts of local, county and state agencies there has been extensive financing support for manufacturing facilities within disadvantaged communities as well as environmentally beneficial manufacturing facilities. This includes tax incentives, state and federally sponsored grants, as well as technical incentives. All of these incentives have been touted by Clackamas County as a way in which they are making initiatives that are "Leading the development of the world's next major mass timber market"[48]. All data on specific economic incentive program was collected from The Oregon Business Development Department website[49].

Tax Incentives

Strategic Investment Zones Program

The strategic investment zone program (SIP) offers a 15-year property tax exemption on capital investments. This program was created in the 1990's to grow large, capital-intensive facilities to benefit Oregon's rural communities. This program currently exists to serve the "traded sector" industry, which is defined by Oregon law as "member firms sell their goods or services into markets for which national or

[47] Sisson, Patrick. "Will This Billion-Dollar Startup Unlock the Future of Sustainable Buildings?" *Curbed*, Curbed, 24 Sept. 2019
[48] Clackamas County. "Clackamas County Mass Timber." *Integrated Mass Timber Market Strategy*, 2019
[49] Oregon's Official State Economic Development Agency. "Oregon Economic Incentive Programs." *Oregon's Official State Economic Development Agency*, 2020

international competition exists."[50]. There are three qualifying investment costs that have correlating taxable portion amounts:

- A total investment costs under $500 million has an initial taxable portion amount of $25,000,000
- A total investment cost between $500 million and a $1 billion has am initial taxable amount of $50,000,000
- A total investment greater than $1 billion has an initial taxable portion amount of $100,000,000

The SIP program stipulates that projects that are located within rural communities must have an initial project cost of $25 million. Companies can also access these tax benefits if they are not located in rural communities, however the initial investment must be over $100 million dollars. When researching the current companies that have taken advantage of the SIP program since 2016, the lowest investment value was $108 million dollars with all other companies investing more than this. This means that every business investment in this program would not have to be located in a rural area.

The average CLT manufacturing plant costs between $8 million and $25 million dollars, which would result in most CLT manufacturing plants being ineligible for this program. Due to the 3% increase in the SIP taxable portion a larger CLT investment of $25 million dollars would result in companies paying more in taxes by approximately $3 million dollars (refer to Appendix Table 1). Though this program cannot support the average company, it could support potential CLT manufacturing

[50] Oregon's Official State Economic Development Agency. “Oregon Economic Incentive Programs.” *Oregon's Official State Economic Development Agency*, 2020

plants similar to the newly established Katerra manufacturing facility. This facility is the largest mass timber production plant in the U.S. and invested $150 million[51]. An investment comparable to the Katerra plant was used to assess the potential tax incentives for the SIP.

In this scenario, we are assuming a total investment cost of $150,000,000 for both new plant and equipment by a newly purchased and approved business that has not previously been exempt from taxes under SIP or an enterprise zone. The assessed taxable value is the total property, both including land, property plant, and equipment (PPE) investment. Total spending on land is 25% of the investment and the equipment makes up 75% of the investment equating to the total taxable value of the investment. In order to take into account, the real market value of investment we assume that the land appreciates at 4% a year and the equipment has a depreciation rate of 3.6% per year calculated using the average commercial equipment lifespan of 27.5 years. The property tax rate is 1.65%[52].

[51] Sisson, Patrick. “Will This Billion-Dollar Startup Unlock the Future of Sustainable Buildings?” *Curbed*, Curbed, 24 Sept. 2019,
[52] Oregon's Official State Economic Development Agency. “Oregon Economic Incentive Programs.” *Oregon's Official State Economic Development Agency*, 2020

Years	Total AV	Land Value	PPE	Base Property Tax	SIP Taxable Portion	AV of SIP Project	Reduced Property Tax	Property Tax Savings	Community Service Fee	Total Value Benefit
1	$ 150,000,000	$ 37,500,000	$ 112,500,000	$ 2,475,000	$ 25,000,000	$ 22,525,000	$ 371,663	$ 2,103,338	$ 525,834	$ 1,577,503
2	$ 147,450,000	$ 39,000,000	$ 108,450,000	$ 2,432,925	$ 25,750,000	$ 23,317,075	$ 384,732	$ 2,048,193	$ 512,048	$ 1,536,145
3	$ 145,105,800	$ 40,560,000	$ 104,545,800	$ 2,394,246	$ 26,522,500	$ 24,128,254	$ 398,116	$ 1,996,130	$ 499,032	$ 1,497,097
4	$ 142,964,551	$ 42,182,400	$ 100,782,151	$ 2,358,915	$ 27,318,175	$ 24,959,260	$ 411,828	$ 1,947,087	$ 486,772	$ 1,460,315
5	$ 141,023,690	$ 43,869,696	$ 97,153,994	$ 2,326,891	$ 28,137,720	$ 25,810,829	$ 425,879	$ 1,901,012	$ 475,253	$ 1,425,759
6	$ 139,280,934	$ 45,624,484	$ 93,656,450	$ 2,298,135	$ 28,981,852	$ 26,683,716	$ 440,281	$ 1,857,854	$ 464,464	$ 1,393,391
7	$ 137,734,281	$ 47,449,463	$ 90,284,818	$ 2,272,616	$ 29,851,307	$ 27,578,692	$ 455,048	$ 1,817,567	$ 454,392	$ 1,363,175
8	$ 136,382,006	$ 49,347,442	$ 87,034,564	$ 2,250,303	$ 30,746,847	$ 28,496,544	$ 470,193	$ 1,780,110	$ 445,028	$ 1,335,083
9	$ 135,222,659	$ 51,321,339	$ 83,901,320	$ 2,231,174	$ 31,669,252	$ 29,438,078	$ 485,728	$ 1,745,446	$ 436,361	$ 1,309,084
10	$ 134,255,065	$ 53,374,193	$ 80,880,873	$ 2,215,209	$ 32,619,330	$ 30,404,121	$ 501,668	$ 1,713,541	$ 428,385	$ 1,285,155
11	$ 133,478,322	$ 55,509,161	$ 77,969,161	$ 2,202,392	$ 33,597,909	$ 31,395,517	$ 518,026	$ 1,684,366	$ 421,092	$ 1,263,275
12	$ 132,891,798	$ 57,729,527	$ 75,162,271	$ 2,192,715	$ 34,605,847	$ 32,413,132	$ 534,817	$ 1,657,898	$ 414,474	$ 1,243,423
13	$ 132,495,138	$ 60,038,708	$ 72,456,430	$ 2,186,170	$ 35,644,022	$ 33,457,852	$ 552,055	$ 1,634,115	$ 408,529	$ 1,225,586
14	$ 132,288,255	$ 62,440,257	$ 69,847,998	$ 2,182,756	$ 36,713,343	$ 34,530,587	$ 569,755	$ 1,613,002	$ 403,250	$ 1,209,751
15	$ 132,271,337	$ 64,937,867	$ 67,333,470	$ 2,182,477	$ 37,814,743	$ 35,632,266	$ 587,932	$ 1,594,545	$ 398,636	$ 1,195,909
Total				$ 34,201,923			$ 7,107,720	$ 27,094,203	$ 6,773,551	$ 20,320,652
	Depreciation calculated using average commercial life span of 27.5 years									
	$ 4,090,909	to --> Depreciation Rate	0.036							

Table 2: Oregon SIP Tax Accounting example of an initial investment of $150 Million

Large CLT manufacturing tax incentive SIP Program

The total assessed tax value was calculated assuming the sum of the 25% investment of land purchases as the initial investment would appreciate at 4% a year, and the 75% of the plant and equipment depreciates at a rate of 3.6% a year. The base case property tax is 1.65% a year of the entire assessed tax value. The SIP taxable portion because the company invested less than $500,000,000 equates to $25,000,000 increasing every year by 3% (ORS 307.123(2)(b)). The assessed tax value of the SIP is the difference of base property tax and the SIP taxable portion. The reduction in the property tax equates to the base case property tax times the assessed value of the SIP. The savings in the property tax is then the difference in the base property tax and the reduced property tax. Then the community service fee is 25% of the property tax savings. Finally the total value benefit is the difference in the property tax saving and the community service fee.

With an investment of $150,000,000 to construct a large CLT manufacturing facility the overall tax benefits would equate to $10,518,314.03 The community service fee revenue of $3,506,104.68 is then distributed throughout the county that the investment is located in. Much of the distribution goes to fund government expenditures, fire protection, libraries, as well as other county agencies.

Strategic investment zone opportunity can provide millions in tax breaks only if the initial investment of the project is substantial in nature. Though the SIP investment program stipulates that rural communities can be provided these tax breaks for investments above $25,000,000, any investment that is below $62,000,000 will begin to pay more in tax in year 15. This is because the SIP taxable becomes more costly than the base property tax that the company would be paying due to the depreciation value of

the plant's assets. Though there is extra cost in year 15 of the SIP program at an investment level of $62,000,000 the overall tax benefit would still be positive.

Any investment below $41,700,000 would be more costly overall the producer would receive tax benefits through year seven. This tax benefit can help bring large CLT manufacturers to Oregon, just as Washington has done by working with Katerra Manufacturing to bring a CLT production facility that can produce 13 million board feet of timber per year. This is the equivalent of sequestering 30,677 tons of CO2 per year. For reference, that is the equivalent of taking 6,628 passenger vehicles driver for a year or 3,540 homes energy use for one year[53].

Enterprise Zone Incentives

This incentive provides a five-year tax exemption for the company. Eligible companies must be expanding employment by 10% in the first year with a total minimum investment of $50,000. Qualifying companies must pay an average of one and half times the average wage in these enterprise zones. This incentive can be a more small-scale investment compared to the strategic investment program, and can incentivize smaller scale CLT producers. The caveat is that employer must pay its employers above the average wage and continue to increase employment, which could be costly; however, with consistent increases in demand, it could be an accomplishable task[54]

[53] Environmental Protection Agency "Greenhouse Gas Equivalencies Calculator." *EPA*, Environmental Protection Agency, 15 Oct. 2018.
[54] Oregon Business Development Department. "Enterprise Zones." *Enterprise Zones - Strategic Economic Development Corporation*, 2020

Oregon New Market Tax Credits

This incentive aims to help finance investment create jobs in low-income communities. This program allows for below market rate investment options over the course of seven years. The program's maximum tax credit is $3,120,000, and is allocated on a first come first serve basis to projects, not to exceed an investment amount of $8,000,000. $16,000,000 in tax credits are allotted to programs each year, in which 15% of the funds or $2,400,000 are allocated towards clean energy projects such as CLT manufacturing. This could incentivize smaller scale CLT manufacturers but due to the investment cap larger scale manufacturers would not be eligible.

Grant Incentives

Mass Timber University Grant Program

This is the only specific grant program to focus on the construction of CLT buildings on college campuses across the nation. Its main goal was to support the construction of Mass Timber construction on college campuses. The program received 16 proposals, and 10 were selected for $100,000 grants per college (USDA 2019). Oregon State University received one of these grants for their new $80 million Arts and Education center on campus. Though this program might have helped influence other smaller projects across the nation, the incentive is very minimal compared to the entire cost of the construction project.

Community Development Block Grants

This program offers a broad range of projects that may be assisted with these grants. This grant is aimed at developing urban communities for people of low and

moderate incomes by expanding housing and suitable living environments. This program is an incentive for developers aiming to incorporate low income housing projects. The total grants allotted in 2019 were $8,371,147 for 16 projects in three counties and 13 city projects.

Federal EDA Incentives

These incentives are sponsored by the U.S. Economic Development Administration and offer specialty grants for economic opportunities. These incentive programs change year to year based on the necessary economic needs of the region. Currently this incentive program is primarily for businesses affected by COVID-19[55].

Financing Incentives

The Rural Economic Development Loan Program

This incentive program is a federally sponsored program that provides zero interest loans in rural areas that will support the local economy. The maximum loan amount that can be requested is $1,000,000.

Industrial Development Bonds

These bonds are tax-exempt bonds issued by the state in order to increase manufacturing growth. This provides long term financing for job creation, land development, for projects in the range of $1,000,000 to $5,000,0000. This lowers overall capital expenses associated with financing. These loans can also be used for business expansion after the manufacturer has been in operation.

[55] United States EPA. “Economic Incentives.” EPA, Environmental Protection Agency, 1 Feb. 2018

Oregon Business Development Fund

This is a state loan fund that provides financing for land, buildings, and equipment, with the eligibility status being dependent on growing rural and distressed areas. These loans are for the improvement of rural and distressed areas. The maximum loan amount for this fund is $1,000,000.

Technical Incentives

Workforce Development Assistance

This program provides technical incentives to Oregonians. This includes job placement and training, employment related services for veterans, migrant farm workers and other Oregonians in need of a job. This is aimed for businesses that are seeking people to fulfill their labor needs.

Potential Tax Incentives

Currently there are no tax incentives that are tailored toward incentivizing CLT production. The existing tax incentives that are offered are for large scale investments of $100,000,000 or for small scale investments under $5,000,000 investments. However, CLT manufacturing facilities typically cost in the range of $10,000,000 and $25,000,000 for PPE purchases[56]. Creating a tax incentives program that is tailored towards CLT manufacturing could potentially interest CLT manufacturing companies to invest in Oregon CLT. In the following scenario, the following tax incentive was created similar to the Strategic Investment Program, however it has been tailored to fit the typical CLT manufacturing investments. Assumptions were made that 75% of the

[56] Chouinard, Patrick. "The Evolution of CLT Manufacturing in North America." *Wood Design & Building*, About the Author / Dovetail, 5 Oct. 2017

investment is in PPE which is on the larger scale of CLT manufacturing at $24,500,000. An additional 25% of the investment is on land value of $8,250,000. The SIP taxable portion is about a ¼ of the initial investment (similar ratio used in the original SIP) equating to a SIP taxable portion of $8,250,000 increasing 3% a year. Community service fee is 25% of the property tax savings. The depreciation rate of 3.6% was calculated using the average commercial life span of 27.5 years and depreciated annually. We assume that land appreciates at 4% a year.

Table 3: CLT SIP Program Scenario

Average CLT manufacturing tax incentive adopted from SIP Program

Years	Total AV	Land Value	PPE	Base Property Tax	SIP Taxable Portion	AV of SIP Project	Reduced Property Tax	Property Tax Savings	Community Service Fee	Total Value Benefit
1	$ 33,000,000	$ 8,250,000	$ 24,750,000	$ 544,500	$ 8,250,000	$ 7,705,500	$ 127,141	$ 417,359	$ 104,340	$ 313,019
2	$ 32,439,000	$ 8,580,000	$ 23,859,000	$ 535,244	$ 8,497,500	$ 7,962,257	$ 131,377	$ 403,866	$ 100,967	$ 302,900
3	$ 31,923,276	$ 8,923,200	$ 23,000,076	$ 526,734	$ 8,752,425	$ 8,225,691	$ 135,724	$ 391,010	$ 97,753	$ 293,258
4	$ 31,452,201	$ 9,280,128	$ 22,172,073	$ 518,961	$ 9,014,998	$ 8,496,036	$ 140,185	$ 378,777	$ 94,694	$ 284,083
5	$ 31,025,212	$ 9,651,333	$ 21,373,879	$ 511,916	$ 9,285,448	$ 8,773,532	$ 144,763	$ 367,153	$ 91,788	$ 275,365
6	$ 30,641,805	$ 10,037,386	$ 20,604,419	$ 505,590	$ 9,564,011	$ 9,058,421	$ 149,464	$ 356,126	$ 89,031	$ 267,094
7	$ 30,301,542	$ 10,438,882	$ 19,862,660	$ 499,975	$ 9,850,931	$ 9,350,956	$ 154,291	$ 345,685	$ 86,421	$ 259,263
8	$ 30,004,041	$ 10,856,437	$ 19,147,604	$ 495,067	$ 10,146,459	$ 9,651,393	$ 159,248	$ 335,819	$ 83,955	$ 251,864
9	$ 29,748,985	$ 11,290,695	$ 18,458,290	$ 490,858	$ 10,450,853	$ 9,959,995	$ 164,340	$ 326,518	$ 81,630	$ 244,889
10	$ 29,536,114	$ 11,742,322	$ 17,793,792	$ 487,346	$ 10,764,379	$ 10,277,033	$ 169,571	$ 317,775	$ 79,444	$ 238,331
11	$ 29,365,231	$ 12,212,015	$ 17,153,215	$ 484,526	$ 11,087,310	$ 10,602,784	$ 174,946	$ 309,580	$ 77,395	$ 232,185
12	$ 29,236,196	$ 12,700,496	$ 16,535,700	$ 482,397	$ 11,419,929	$ 10,937,532	$ 180,469	$ 301,928	$ 75,482	$ 226,446
13	$ 29,148,930	$ 13,208,516	$ 15,940,414	$ 480,957	$ 11,762,527	$ 11,281,570	$ 186,146	$ 294,811	$ 73,703	$ 221,109
14	$ 29,103,416	$ 13,736,856	$ 15,366,560	$ 480,206	$ 12,115,403	$ 11,635,197	$ 191,981	$ 288,226	$ 72,056	$ 216,169
15	$ 29,099,694	$ 14,286,331	$ 14,813,363	$ 480,145	$ 12,478,865	$ 11,998,720	$ 197,979	$ 282,166	$ 70,542	$ 211,625
Total				$ 7,524,423			$ 2,407,624	$ 5,116,799	$ 1,279,200	$ 3,837,599
	Depreciation calculated using average commercial life span of 27.5 years									
	$ 900,000	to --> Depreciation Rate	0.036							

Observations

This hypothetical CLT manufacturing incentive offers a more realistic approach to draw CLT businesses to Oregon. This incentive program would offer beneficial tax savings for CLT manufacturers and could provide jobs in rural communities. The total value benefit of this program is $3,837,599 which would be money going back to the producer that is likely located in a rural community. This program would also be eligible for the original SIP however it would begin paying more for taxes in year three, than it would paying with the base tax. The overall additional costs would be $2,174,123 (See Appendix Table 2).

CLT Economic Conclusion

All of these incentives have been advertised by Clackamas County as a way to incorporate CLT manufacturing and construction into the community. Many of these economic incentives are tied to increasing rural and distressed areas throughout Oregon which is often associated with former regions that have been affected by the decline of the timber industry. There is no specific state incentives for CLT or Mass Timber production. Economically incentivizing CLT manufacturing with Oregon's already existing timber production infrastructure has the ability to improve rural communities. Specific financing incentives for CLT production, as well as construction using newly generated cap and trade revenue, can help distressed rural timber communities while having positive environmental effects. This does not have to come at the expense of the timber industry, but instead can support and improve the timber industry, all the while having positive environmental benefits as the cap and trade program is intended to do. Large scale production facilities similar to Katerra manufacturing in Washington can

meet the demand needs of the growing CLT industry. Other economic incentive programs similar to the Strategic Investment Program that are specifically designated to grow the timber industry can also benefit the Oregon economy.

Allocating Cap and Trade Revenue

As quoted above the main issue concerning CLT promotion is capital incentives. With the new Oregon cap and trade program Oregon has the potential to bring in millions of dollars a year in revenue stemming from the auction sale of carbon credits. California cap and trade program beginning in 2013 has since raise a cumulative $9.3 Billion in auction revenue that has been distributed throughout the state[57].

[57] Economic Development Administration, United States, and Oregon BEST. "Advanced Wood Product Manufacturing Study for Cross-Laminated Timber Acceleration in Oregon & SW Washington ." *Business Oregon and State Agency*, 2017

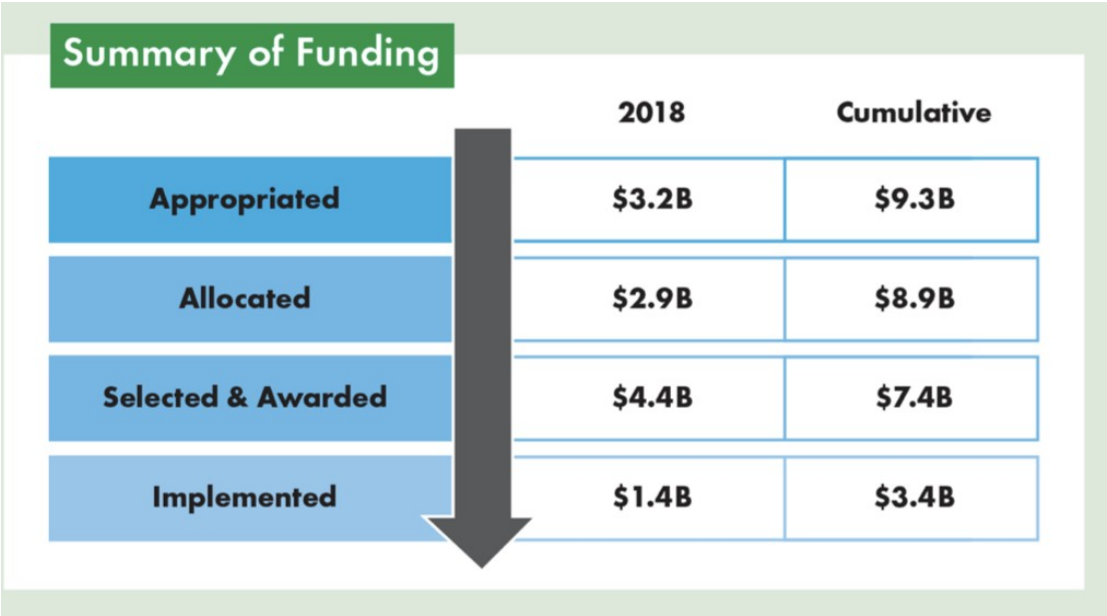


Figure 10: California State Cap and Trade Revenue

California Air Resource Board Data[58]

Though California sustains a much larger economy than Oregon, any amount of funding towards CLT specific economic incentives could benefit the CLT industry as well as rural timber production-based communities. California has been using much of its funding to benefit disadvantaged communities. According to the California Air Resources Board (CARB), California Assembly Bill 1550 requires that 39% of funds be allocated to and benefit disadvantaged communities, 16% allocated to benefiting low income communities and households, and 5% to be allocated to benefiting low-income communities and households within a half a mile of disadvantaged communities. Cap and trade can offer previously nonexistent capital to increase timber production in rural communities. Promoting CLT would also provide associated environmental benefits.

[58] California Air Resources Board. "California Air Resources Board." *Report: Cap-and-Trade Spending Doubles to $1.4 Billion in 2018*, 2019.

Issue in the CLT Market

Barriers to Market

The actively changing market for CLT has shown signs of promise but there still exist several key barriers to market including a general lack of knowledge of CLT by both the design and construction industries. With the updated IBCC building codes to incorporate CLT, the industry has been able to jump one of the biggest barriers within the U.S., but due to the lack of technological innovation in the construction industry there is still a lack of knowledge regarding CLT technology throughout the country. If the CLT market wishes to pursue widespread adoption throughout the country, there needs to be further education in support of this material[59]. Another key factor is the lack of supply of CLT. According to a 2015 survey of industrial professionals the lack of availability is the largest potential barrier for CLT. To keep pace with continued demand of this product there needs to be continued education on the success of the early adopters of CLT manufacturing. Until CLT supply catches up with the demand, there will still be skepticism surrounding the use of this product. Due to this lack of supply, CLT also faces high transportation costs for CLT construction projects that are not near production facilities. Transportation costs tend to be minimal due to the regional timber production strengths on the west coast; however, this can be a deciding barrier for projects that are not located within the region.

With the modern-day importance of high environmental impact construction projects, CLT can be susceptible to greenwashing by developers. Greenwashing is the

[59] Economic Development Administration, United States, and Oregon BEST. "Advanced Wood Product Manufacturing Study for Cross-Laminated Timber Acceleration in Oregon & SW Washington ." *Business Oregon and State Agency*, 2017

emphasis that the product or project that a company or organization is using is more environmentally friendly than it is. CLT use in construction could be easily manipulated to seem more environmentally friendly than the project is. The environmental impact of CLT is dependent on how much CLT is used in the project in replacement of more harmful material. Due to the wood aesthetic of CLT, is very noticeable and if used solely for the interior of a project or purely for its looks it can be perceived as being more environmentally friendly than it is.

Conclusion

The current trajectory of the CLT market, in combination with additional state revenue due to cap and trade funds has the potential to aid CLT production and construction across Oregon. The benefits associated with CLT would be able to better the states rural disadvantaged timber communities, while simultaneously offering environmental benefits. The associated environmental benefits, stemming from carbon sequestration, can create a net carbon sink throughout cities in Oregon. The answer to a potential bi-partisan agreement on Oregon cap and trade could lie with the expansion of the CLT market. Combining the strengths of Oregon's timber manufacturing with additional incentives might be a politically feasible way of solving a political issue that has captivated the state for years. In order to do so further economic incentives, need to be created that are tailored to support the growing industry.

Appendix 1

Years	Total AV	Land Value	PPE	Base Property Tax	SIP Taxable Portion	AV of SIP Project	Reduced Property Tax	Property Tax Savings	Community Service Fee	Total Value Benefit
1	$ 25,000,000.00	$ 6,250,000.00	$ 18,750,000.00	$ 412,500.00	$ 25,000,000.00	$ 24,587,500.00	$ 405,693.7500	$ 6,806.2500	$ 1,701.5625	$ 5,104.6875
2	$ 21,500,000.00	$ 6,500,000.00	$ 15,000,000.00	$ 354,750.00	$ 25,750,000.00	$ 25,395,250.00	$ 419,021.6250	$ (64,271.6250)	$ (16,067.9063)	$ (48,203.7188)
3	$ 18,760,000.00	$ 6,760,000.00	$ 12,000,000.00	$ 309,540.00	$ 26,522,500.00	$ 26,212,960.00	$ 432,513.8400	$ (122,973.8400)	$ (30,743.4600)	$ (92,230.3800)
4	$ 16,630,400.00	$ 7,030,400.00	$ 9,600,000.00	$ 274,401.60	$ 27,318,175.00	$ 27,043,773.40	$ 446,222.2611	$ (171,820.6611)	$ (42,955.1653)	$ (128,865.4958)
5	$ 14,991,616.00	$ 7,311,616.00	$ 7,680,000.00	$ 247,361.66	$ 28,137,720.25	$ 27,890,358.59	$ 460,190.9167	$ (212,829.2527)	$ (53,207.3132)	$ (159,621.9395)
6	$ 13,748,080.64	$ 7,604,080.64	$ 6,144,000.00	$ 226,843.33	$ 28,981,851.86	$ 28,755,008.53	$ 474,457.6407	$ (247,614.3101)	$ (61,903.5775)	$ (185,710.7326)
7	$ 12,823,443.87	$ 7,908,243.87	$ 4,915,200.00	$ 211,586.82	$ 29,851,307.41	$ 29,639,720.59	$ 489,055.3897	$ (277,468.5659)	$ (69,367.1415)	$ (208,101.4245)
8	$ 12,156,733.62	$ 8,224,573.62	$ 3,932,160.00	$ 200,586.10	$ 30,746,846.64	$ 30,546,260.53	$ 504,013.2988	$ (303,427.1940)	$ (75,856.7985)	$ (227,570.3955)
9	$ 11,699,284.57	$ 8,553,556.57	$ 3,145,728.00	$ 193,038.20	$ 31,669,252.03	$ 31,476,213.84	$ 519,357.5283	$ (326,319.3330)	$ (81,579.8333)	$ (244,739.4998)
10	$ 11,412,281.23	$ 8,895,698.83	$ 2,516,582.40	$ 188,302.64	$ 32,619,329.60	$ 32,431,026.96	$ 535,111.9448	$ (346,809.3045)	$ (86,702.3261)	$ (260,106.9784)
11	$ 11,264,792.70	$ 9,251,526.78	$ 2,013,265.92	$ 185,869.08	$ 33,597,909.48	$ 33,412,040.40	$ 551,298.6667	$ (365,429.5871)	$ (91,357.3968)	$ (274,072.1903)
12	$ 11,232,200.59	$ 9,621,587.85	$ 1,610,612.74	$ 185,331.31	$ 34,605,846.77	$ 34,420,515.46	$ 567,938.5051	$ (382,607.1954)	$ (95,651.7988)	$ (286,955.3965)
13	$ 11,294,941.55	$ 10,006,451.37	$ 1,288,490.19	$ 186,366.54	$ 35,644,022.17	$ 35,457,655.64	$ 585,051.3180	$ (398,684.7823)	$ (99,671.1956)	$ (299,013.5867)
14	$ 11,437,501.57	$ 10,406,709.42	$ 1,030,792.15	$ 188,718.78	$ 36,713,342.84	$ 36,524,624.06	$ 602,656.2970	$ (413,937.5211)	$ (103,484.3803)	$ (310,453.1408)
15	$ 11,647,611.52	$ 10,822,977.80	$ 824,633.72	$ 192,185.59	$ 37,814,743.12	$ 37,622,557.53	$ 620,772.1993	$ (428,586.6092)	$ (107,146.6523)	$ (321,439.9569)
Total				$ 3,557,381.65			$ 7,613,355.1810	$ (4,055,973.5315)	$ (1,013,993.3829)	$ (3,041,980.1486)

Appendix 2

Total AV	Land Value	PPE	Base Property Tax	SIP Taxable Portion	AV of SIP Project	Reduced Property Tax	Property Tax Savings	Community Service Fee	Total Value Benefit
$ 33,000,000.00	$ 8,250,000.00	$ 24,750,000.00	$ 544,500.00	$ 25,000,000.00	$ 24,455,500.00	$ 403,515.7500	$ 140,984.2500	$ 35,246.0625	$ 105,738.1875
$ 28,380,000.00	$ 8,580,000.00	$ 19,800,000.00	$ 468,270.00	$ 25,750,000.00	$ 25,281,730.00	$ 417,148.5450	$ 51,121.4550	$ 12,780.3638	$ 38,341.0913
$ 24,763,200.00	$ 8,923,200.00	$ 15,840,000.00	$ 408,592.80	$ 26,522,500.00	$ 26,113,907.20	$ 430,879.4688	$ (22,286.6688)	$ (5,571.6672)	$ (16,715.0016)
$ 21,952,128.00	$ 9,280,128.00	$ 12,672,000.00	$ 362,210.11	$ 27,318,175.00	$ 26,955,964.89	$ 444,773.4207	$ (82,563.3087)	$ (20,640.8272)	$ (61,922.4815)
$ 19,788,933.12	$ 9,651,333.12	$ 10,137,600.00	$ 326,517.40	$ 28,137,720.25	$ 27,811,202.85	$ 458,884.8471	$ (132,367.4506)	$ (33,091.8627)	$ (99,275.5880)
$ 18,147,466.44	$ 10,037,386.44	$ 8,110,080.00	$ 299,433.20	$ 28,981,851.86	$ 28,682,418.66	$ 473,259.9079	$ (173,826.7116)	$ (43,456.6779)	$ (130,370.0337)
$ 16,926,945.90	$ 10,438,881.90	$ 6,488,064.00	$ 279,294.61	$ 29,851,307.41	$ 29,572,012.81	$ 487,938.2113	$ (208,643.6039)	$ (52,160.9010)	$ (156,482.7029)
$ 16,046,888.38	$ 10,856,437.18	$ 5,190,451.20	$ 264,773.66	$ 30,746,846.64	$ 30,482,072.98	$ 502,954.2041	$ (238,180.5459)	$ (59,545.1365)	$ (178,635.4094)
$ 15,443,055.63	$ 11,290,694.67	$ 4,152,360.96	$ 254,810.42	$ 31,669,252.03	$ 31,414,441.62	$ 518,338.2867	$ (263,527.8689)	$ (65,881.9672)	$ (197,645.9016)
$ 15,064,211.22	$ 11,742,322.45	$ 3,321,888.77	$ 248,559.49	$ 32,619,329.60	$ 32,370,770.11	$ 534,117.7068	$ (285,558.2217)	$ (71,389.5554)	$ (214,168.6663)
$ 14,869,526.36	$ 12,212,015.35	$ 2,657,511.01	$ 245,347.19	$ 33,597,909.48	$ 33,352,562.30	$ 550,317.2779	$ (304,970.0929)	$ (76,242.5232)	$ (228,727.5697)
$ 14,826,504.78	$ 12,700,495.96	$ 2,126,008.81	$ 244,637.33	$ 34,605,846.77	$ 34,361,209.44	$ 566,959.9557	$ (322,322.6269)	$ (80,580.6567)	$ (241,741.9702)
$ 14,909,322.85	$ 13,208,515.80	$ 1,700,807.05	$ 246,003.83	$ 35,644,022.17	$ 35,398,018.34	$ 584,067.3027	$ (338,063.4756)	$ (84,515.8689)	$ (253,547.6067)
$ 15,097,502.07	$ 13,736,856.44	$ 1,360,645.64	$ 249,108.78	$ 36,713,342.84	$ 36,464,234.05	$ 601,659.8619	$ (352,551.0776)	$ (88,137.7694)	$ (264,413.3082)
$ 15,374,847.20	$ 14,286,330.69	$ 1,088,516.51	$ 253,684.98	$ 37,814,743.12	$ 37,561,058.14	$ 619,757.4594	$ (366,072.4805)	$ (91,518.1201)	$ (274,554.3604)
			$ 4,695,743.78			$ 7,594,572.2059	$ (2,898,828.4285)	$ (724,707.1071)	$ (2,174,121.3214)

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