Mass Timber Factory in Southeastern Ontario

Final Report

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Executive Summary

This report presents the findings of a study conducted to explore the integration of mass timber, specifically Cross-Laminated Timber (CLT), in Ontario's residential construction sector. Motivated by the urgent need to address housing affordability and environmental sustainability, this initiative assesses the viability of establishing a new CLT factory in Southeastern Ontario.

The initial phase of the project focused on analysing the current mass timber market, focusing on existing industry data and the local availability of wood resources suitable for CLT production. This involved assessing the environmental impacts of mass timber construction and highlighting its benefits over conventional materials like concrete and steel in terms of CO_2 emissions and energy consumption. This study emphasizes the adaptability of the findings, noting that while the focus was on Maitland, Ontario, the insights are applicable to any similar location within Southeastern Ontario.

After the data gathering, the project shifted focus towards forecasting the demand for mass timber within the Ontario market. This included a detailed examination of market trends, potential growth, and the impact of regulatory changes on mass timber adoption. Additionally, the study analyzed the production capabilities of Element5, the only existing CLT facility in Ontario.

The financial aspects of the project were then analysed to determine the costs associated with constructing and operating a new mass timber facility. This included capital investment requirements, operational costs, and potential revenue streams. The financial analysis also projected the break-even point and return on investment, which are crucial for potential investors. Factors such as land acquisition costs, equipment, labor, and raw materials were all considered to provide a comprehensive overview.

Based on the findings from the study, strategic recommendations are offered, which may be useful for stakeholders considering investment in mass timber production facilities. These recommendations address the need for further research into optimizing production processes, potential partnerships with local governments for subsidies or incentives, and strategies for market penetration and expansion.

In conclusion, the establishment of a new CLT facility in Southeastern Ontario presents a viable solution to the challenges related to environmental sustainability and housing affordability. With careful planning and strategic investment, mass timber may significantly contribute to the future of construction in Ontario.

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1.0 – Introduction and Background

In 2021, approximately 24.4% of private dwellings in Ontario were identified as unaffordable, with unaffordable housing being defined as spending more than 30% of household income on housing services [1]. Since then, house prices have increased by 3.3%, whereas rental prices have surged by 15.8%, intensifying the affordability challenge [2], [3]. In response, the provincial government has mandated the construction of 1.5 million housing units within the next decade [4]. As Ontario addresses the pressing need for constructing new housing units, there is an opportunity to adopt sustainable building materials in this new construction. Mass timber is a sustainable wood product designed for structural use in buildings and emerges as a possible replacement for concrete and steel [5]. Mass timber demonstrates similar strength and stiffness characteristics to concrete and steel, allowing it to be a feasible substitute for residential construction [5]. An inherent benefit of mass timber is its renewable nature, functioning as a building material that not only reduces CO_2 emissions but also actively reduces emissions by sequestering carbon [6]. In 2022, Canada's construction sector released 96 million metric tons of CO_2 into the atmosphere which accounted for 13% of the nation's total greenhouse gas emissions [7]. Mass timber possesses the capability to offset a portion of these emissions through carbon sequestration [5]. However, a critical obstacle remains; there is an absence of a mass timber factory in Southeastern Ontario, which limits the ability for this construction material to be used in this area [6].

Mass timber construction refers to a category of robust engineered wood products designed for structural use in buildings [8]. These engineered wood products are created from dimensional lumber, veneer, or wooden strands that undergo lamination to create structural elements [8]. Cross Laminated Timber (CLT) is a type of mass timber that is commonly used as panels in residential construction [5]. Its durability, dimensional stability and structural integrity make it the ideal material to incorporate as roofing, flooring, or walling in mid-and high-rise residential buildings instead of concrete or steel [9], [10]. Ontario has the local wood resources that enable the province to manufacture CLT for domestic use [6]. However, Ontario has lagged in the adoption of mass timber construction for residential buildings compared to British Columbia [10]. As of 2024, British Columbia has built 48 residential buildings with mass timber, whereas Ontario has only built 16 [10]. This difference may be attributed to the greater number of manufacturing facilities available in British Columbia compared to Ontario [10]. This indicates a potential opportunity for expansion in mass timber use within Ontario's residential construction sector.

From the viewpoint of construction companies, mass timber construction presents cost-saving advantages as it is prefabricated off-site, thereby reducing the installation process, and minimizing on-site labour and machinery requirements [5]. For instance, when building a floor with concrete there is a 28-day curing period required before moving onto the next floor [5]. This delay is significantly minimized with mass timber as floor construction requires only a 3-to-4-day period [5]. The material cost of constructing with mass timber compared to concrete varies by region, with mass timber construction being approximately 2% more expensive than concrete construction [11]. A contributor to the higher cost of mass timber compared to concrete is its underdeveloped supply chain [12]. Addressing the underdeveloped supply chain for mass timber could lead to a 20% reduction in costs compared to traditional materials like concrete and steel [8]. For Ontario to fully leverage the benefits of mass timber for residential development, it requires the distribution of mass timber factories throughout the

province [8]. This widespread availability will contribute to making the material more affordable [8]. Despite its potential, to the best of the authors' knowledge, there are no known publications outlining a business case for a mass timber production factory in Southeastern Ontario.

As Ontario streamlines the construction of more housing units, it is imperative for the province to simultaneously address the negative environmental impacts associated with the construction industry. The extraction and manufacturing processes involved in steel and concrete production result in significant CO_2 emissions [13]. Specifically, it is estimated that for every 1000 kg of steel produced, 1850 kg of CO_2 is emitted and for every 1000 kg of cement produced, 1000 kg of CO_2 is emitted [13]. Both steel and cement are commonly used in the construction of housing units [13], [14]. For instance, constructing a mass timber residential building will emit 193 kg CO_2/m^2 per floor area, whereas concrete buildings emit 237 kg CO_2/m^2 per floor area [14]. However, mass timber buildings also sequester a significant amount of CO2 at 276 kg CO2/m2 per floor area compared to only 4.3 kg CO2/m2 per floor area sequestered by concrete buildings [14]. A diagram showing this can be seen in Figure 1 below. Considering that Canada has set an Emission Reduction Plan aiming to reduce greenhouse gas emissions by 40-45% by 2030, using alternative building materials could help the country achieve this goal [13], [15]. By opting for mass timber over traditional materials like steel and concrete for residential construction, the province can significantly reduce its carbon footprint in the construction industry, contributing to Canada's emission reduction targets [12].

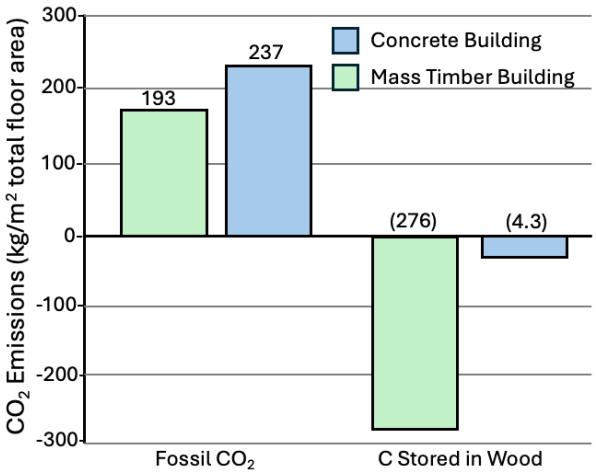


Figure 1: Comparison of CO2 emissions from mass timber and concrete buildings, based on the data from Liang et al. (2020) [14].

Despite the environmental and economic advantages of mass timber construction, it still faces lower popularity in residential construction compared to traditional materials such as concrete and steel [5], [6]. However, awareness is expanding in Ontario due to organizations such as the Mass Timber Institute based at the University of Toronto, which offers resources for mass timber research, education, and development. Moreover, research indicates that incorporating wood and natural materials into living spaces can reduce stress and promote positive mental health for individuals [16], [17]. Given the opportunity for mass timber to be included in upcoming residential construction, the availability of more literature and business cases becomes crucial for the inclusion of this material in the construction industry.

2.0 – Project Justification

This section outlines the justification for a project aimed at assessing the financial viability of establishing a new Cross-Laminated Timber (CLT) mass timber factory in Southeastern Ontario.

2.1 – Problem Statement

Ontario is currently facing an opportunity to innovate within its construction industry amidst an ongoing housing crisis and pressing environmental concerns [1], [15]. Based on this, the focus of this project is to assess the financial viability of establishing a CLT mass timber factory in Southeastern Ontario. Currently, there is only one factory in Ontario that makes CLT, and it is in St. Thomas [6]. Therefore, this project seeks to determine the current and projected market demand for mass timber in Ontario and explore whether this demand justifies the establishment of a new production facility.

2.2 – Project Objectives

To determine the financial viability of establishing a mass timber factory in Southwestern Ontario the specific objectives of this project are to assess the market demand and potential for mass timber in the region, conduct a cost-benefit analysis to determine the economic feasibility of the factory, and finally provide recommendations. These will highlight potential challenges and opportunities associated with establishing the factory. These objectives were addressed by conducting market research to understand the demand for mass timber in Ontario and analyzing the costs associated with the construction and operation of the potential factory.

2.3 – Project Scope

This project investigates the market of the mass timber sector throughout Ontario; however, it places a specific emphasis on the practicality of building a new mass timber manufacturing facility in Southeastern Ontario. For this investigation a potential site in Maitland has been selected as a case study for the calculations. However, it is important to note that these findings are applicable to any similar site in the Southeastern Ontario region.

Additionally, the project specifically focuses on utilizing timber from the Boreal Forest region of Ontario, chosen for CLT production. This decision is due to the forest's expansive territory, abundant softwood forest coverage, and the suitability of its tree species for CLT manufacturing processes [18]. Although it has been acknowledged there is the potential to utilize hardwood for CLT manufacturing, specifically from the Great Lakes St. Lawrence region, it was decided to exclude this option from the scope of this project due to time constraints and lack of information.

To gain a comprehensive understanding of the current state and potential growth of the mass timber market, the project focused on a blend of primary and secondary data collection methods. Firstly, a field visit was completed to the proposed site in Maitland, allowing for an initial assessment of construction feasibility and logistics. This research was complemented by a thorough review of existing industry reports, academic research, and government publications.

To ensure the project goal was manageable, several aspects were excluded from the scope. This includes the regulatory approval processes related to the establishment of a new mass timber factory, detailed architectural and engineering drawings of the proposed facility, export market considerations for mass timber products, and extensive comparisons with alternative construction materials such as steel or concrete. The project also does not cover logistics related to raw material transport, and instead centers its attention on domestic construction applications within Canada.

2.4 – Project Assumptions

Various assumptions were made throughout the planning and completion of this project. Firstly, it was assumed that the primary use of the CLT panels manufactured at the facility would be for constructing residential units within Canada, with a specific focus on Ontario. It was also assumed that the housing utilizing the CLT panels would be mid-rise, specifically between 6 and 12 storeys. This is because mass timber is most cost-effective in multi-storey buildings, and also because there is currently a 12-storey height restriction on mass timber construction [11], [19].

It was also assumed that the research and data collected, both online and from direct engagements with stakeholders, would be up to date. While it was assumed there would be a level of bias in the information gathered, both positive and negative, this was mitigated by carefully considering which to use in the analysis. Additionally, the assumption that there would be cooperation with various internal and external stakeholders was integral to the project, as their engagement throughout provided valuable insights and resources. Finally, despite regulatory concerns being outside of the scope of this project, it was assumed that regulations related to mass timber and factory construction would be relatively stable.

Assumptions specific to the market estimation and financial analysis, including considerations regarding data selection and economic modeling, will be addressed in more detail in 4.0 – Data Collection and Analysis.

2.5 – General Project Constraints

The execution of this project was contingent on several internal and external constraints. Firstly, the project was bound by a time constraint, and needed to be completed before the end of the semester. The deadline for submitting the final business case report was April 14th, 2024. Additionally, cost considerations for this project were minimal because the primary delivery involves the development of a comprehensive business case rather than the physical construction of a mass timber factory. Also, the project's geographical focus on Ontario, and specifically on the establishment of a new facility in Maitland, introduced geographical constraints. These limitations influenced site selection, resource accessibility, and the logistical considerations of transporting materials.

Constraints specific to the market estimation and financial analysis will be addressed in more detail in 4.0 – Data Collection and Analysis. These constraints are critical to the integrity of the analysis.

2.6 – Project Stakeholders

The project has benefited from the involvement of a wide range of stakeholders, each contributing valuable expertise and unique perspectives. The primary stakeholder in this project is Sandra Lawn, who represents the Ontario East Wood Center. She is the driving force behind the project and provided many valuable resources to the team.

Academically, this project has received guidance from the APSC/APSX 401 Course Instructors and Teaching assistant, as well as from multiple professors in the Smith School of Business.

Industry and mass timber experts were also involved in the completion of the project. Notably, Ledinek Engineering is the company that was responsible for constructing the existing Element 5 mass timber facility and provided valuable information regarding construction costs and potential for expansion. Additionally, various employees at the Element 5 facility shared operational data and insights into the considerations for running a mass timber facility. Finally, various individuals at the Daniels Mass Timber Institute also provided valuable resources.

3.0 – Literature Review

The following section will offer a review of the various findings concerning mass timber in literature, used to inform the project's trajectory.

3.1 – The Environmental and Structural Advantages of Mass Timber Construction

Construction using mass timber signifies a transformative shift in modern building practices, offering a substitute for conventional construction materials such as concrete and steel [5]. This change is supported by the environmental and structural benefits of mass timber. Mass timber is a renewable and sustainable building material, with a lighter carbon footprint compared to conventional materials [5]. If mass timber were to replace steel and concrete in the construction of buildings across the country, an estimated 600,000 tonnes of CO_2 could be eliminated annually in Canada by 2030 [20]. With an average mass timber building height of 12 storeys and each capable of sequestering 1169 metric tons of CO_2, approximately 513 mass timber buildings would need to be constructed to store this amount of CO_2 [20]. As a comparison, a reduction of 600,000 tonnes of CO_2 is equivalent to eliminating 125,000 cars from the roads annually, considering that each car emits approximately 4.6 to 5 metric tons of CO_2 per year [21], [22].

Additionally, as trees grow, they absorb CO_2, which they release back into the atmosphere when they die [23]. However, when wood is sustainably harvested for use in mass timber construction the carbon remains sequestered throughout the lifespan of the structure [6], [23]. Mass timber structures have an average lifespan of 60 years, and at the end of their life cycle, mass timber can be reprocessed and repurposed [24], [25]. If in good condition, the mass timber can be reused for primary structural purposes such as beams or columns; if damaged, it can be used for furniture or wood particle products [25].

An example of this is the 18-storey Brock Commons Tallwood House at the University of British Columbia, which exemplifies the carbon sequestration potential of mass timber by effectively removing

1752 metric tonnes of CO_2 from the atmosphere [25]. This structure can be seen in Figure 2: Brock Commons Tallwood House at the University of British Columbia [25].Figure 2 below.

Figure 2: Brock Commons Tallwood House at the University of British Columbia [25].

Ontario has experienced an increase in the interest and implementation of mass timber construction. In 2007, only 6 mass timber projects were recorded, shown in Figure 3 [10].

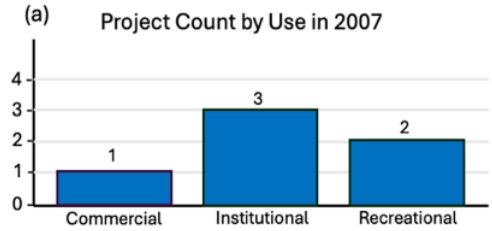


Figure 3: A graph showing the number of mass timber projects in Ontario in 2007[10].

However, this count has increased to a total of 151 projects across various sectors including commercial, residential, institutional, and industrial, shown in Figure 4 [10].

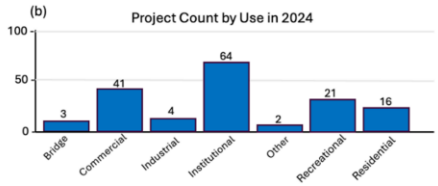


Figure 4: a graph showing the 2024 projections is shown on the right, using data from Naturally Wood's: The State of Mass Timber Map [10].

In recent years, Ontario has undergone significant progress in the regulatory landscape governing mass timber construction, mirroring the advancements seen in British Columbia [26]. Initially, under the Ontario Regulation 451/22 from 2006 to 2015, mass timber structures were limited to 4-storeys in height [26], [27]. Subsequent amendments in 2015 and 2022 extended this limit to six and twelve storeys, respectively [27].

In contrast, British Columbia has been at the forefront of mass timber construction, in 2009 it permitted 6-storey buildings and enacted the Wood First Act [28]. This program has been instrumental in promoting wood as the primary building material by requiring provincially funded projects to use wood [28]. Given Ontario's recent regulatory shifts and growing interest in sustainable construction, there is potential for the province to replicate British Columbia's initiatives and implement a similar program in the future. The establishment of a program like British Columbia's Wood First initiative could accelerate the adoption of mass timber construction and propel Ontario's trajectory towards sustainable and innovative building practices.

3.2 – Types of Mass Timber Products

There are several different types of mass timber products available, distinguished by their specific wood products and binding techniques [6]. This project is focused on cross laminated timber (CLT), which is a fabricated wood product characterized by its composition of multiple layers of dimension lumber, arranged orthogonally in alternating orientations in adjacent layers [29]. CLT elements are composed of three or more layers of boards bonded together with structural adhesives such as resin [30]. In building frameworks, such as walls, floors, and roofs, CLT panels serve as load bearing elements due to their high strength-to-weight ratio and excellent fire resistant and seismic properties [6].

It is also indicated that mass timber exhibits a low charring rate when exposed to fire, the main benefit offered over traditional wood construction [5], [28]. Mass timber will form a protective layer of low-density char that shields the underlying timber from intense heat, preventing immediate combustion and meeting fire safety standards [5], [28]. This protective layer's formation is attributed to the considerable thickness and hermeticity of the mass timber layers, further supported by temperature-insensitive adhesives [5], [29]. CLT can be customized based on a predictable charring rate, ensuring that the required load-carrying capacity remains intact in fire conditions [29].

Moreover, studies have investigated the structural response of CLT buildings during seismic events, revealing their ability to withstand a Maximum Credible Earthquake with a collapse probability of less than 0.1% where Canadian standard is a collapse probability of 2% [31]. To achieve specific structural capacities panels can undertake specific configurations. For example, lumber in the outer layers of CLT panels utilized in walls are generally oriented vertically, parallel to gravity loads; this optimizes the wall's vertical load capacity and is shown in Figure 5 below [29].

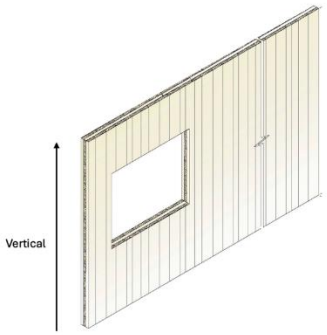


Figure 5: An image of a CLT wall from the Canadian CLT Handbook (2019) [29].

Contrastingly, in floor and roof installations, the timber in the outer layers is aligned such that its fibres run parallel to the span direction, shown in Figure 6 below [29].

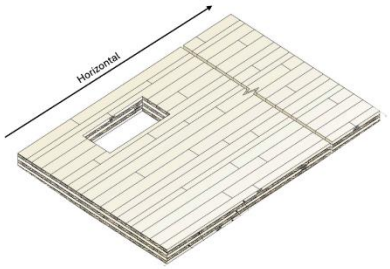


Figure 6: An image of a CLT floor or roof from the Canadian CLT Handbook (2019) [29].

The CLT manufacturing process involves three main stages: lumber preparation, finger jointing, and panel manufacturing. During lumber preparation, the wood undergoes machine stress-rating and kiln drying to optimize moisture content to 12±3%, as specified in the PRG 320 standard for North American, and dimensional stability for panel manufacturing [30], [31], [32]. Finger jointing involves gluing multiple layers of lumber together on their wide faces in alternating directions using structural adhesives [30], [31]. In panel manufacturing, prefabricated CLT panels are produced, and openings are precut using Computer Numerical Controlled (CNC) routers [30], [31]. CLT production must adhere to the ANSI/APA PRG 320 standard, which includes manufacturing, qualification, and quality assurance requirements [29]. Certification is overseen by accredited Certification Bodies and Testing Organizations, as mandated by the Standards Council of Canada [29].

3.3 – Assessing Ontario's Mass Timber Resources

When discussing CLT panels, it should be noted that within Ontario, they are currently only fabricated from softwoods such as spruce, pine, and fir; this information was verified by Chris Latour Vice President of Engineering & Operations at Element5 through email (personal communications, March 15, 2024). There are two main reasons for this; firstly, because the softwoods have material properties that are conducive to producing CLT panels, and secondly, because there is existing technology and machinery that has been optimized for creating CLT panels specifically from softwoods [33]. Furthermore, regulations stipulated by the Canadian Lumber Standards Accreditation Board (CLSAB) under CSA O141 mandate the use of softwood lumber species in CLT manufacturing [33]. Currently, no similar specifications exist for the use of hardwood lumber in CLT production within Canada. Therefore, the structural integrity, widespread availability, and manufacturability of spruce, pine, and fir make them the optimal choices for CLT production. Moreover, these softwoods are capable of enduring significant loads, making them particularly valuable for multi-storey construction projects [34].

Given this context, Ontario's boreal forest stands out as the primary source for the essential softwood species needed for CLT production and is shown in Figure 7. Spanning over 50 million hectares, this vast expanse forms a significant portion of Ontario's forest cover [18]. It consists of trees such as black and white spruce, jack pine, balsam fir, tamarack, and southeastern white cedar, which are favored for their

straight trunks and uniform texture – which are extremely beneficial in the CLT production process [18], [35].

Figure 7: An image outlining the different forest regions in Ontario [18].

It should be noted that the proposed region of Southeastern Ontario, and the chosen site example of Maitland, are close to the Great Lakes-St. Lawrence Forest region. This region contains tree species of white pine, red pine, hemlock and white cedar, all of which are hardwood trees [18]. While there is research to suggest that the production of CLT with hardwood as the base material is fully aligned with ANSI/APA PRG 320, implying that it is entirely feasible to produce CLT with certain hardwood species, due to the lack of data regarding hardwood CLT production, it has not been included in the scope of this project [36]. However, should the regulations change, the findings of this project would likely be applicable to the Great Lakes-St. Lawrence Forest region.

Therefore, despite the boreal forest's greater distance from the proposed facility, the decision has been made to source the wood from this region. The anticipated efficiency of the supply chain to the factory is expected to effectively mitigate the logistical challenges posed by this distance, a topic that will be explored in further detail in 3.4 – Factors Influencing the Facility Site Selection.

3.4 – Factors Influencing the Facility Site Selection

The selection of Maitland, Ontario, as the case study site for the proposed mass timber factory is based on a wide variety of factors. The proposed site can be seen in Figure 8 below.

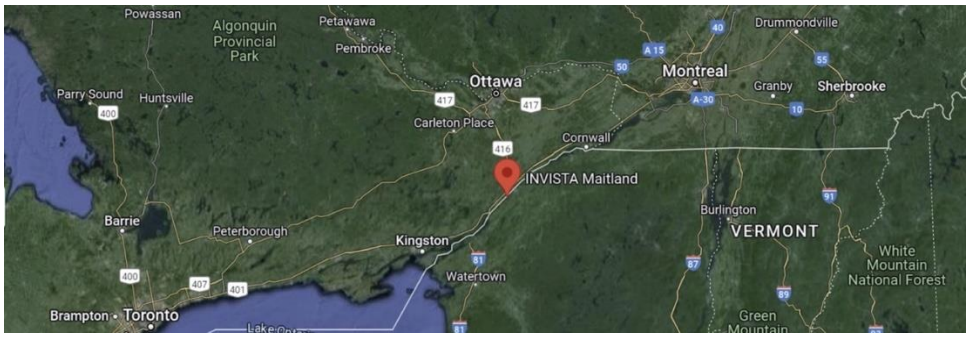


Figure 8: A satellite view from Google Maps showing the potential location in red for a new mass timber factory in Southeastern Ontario [37].

One main factor of consideration is the current availability of a substantial plot, formerly owned by Chemours, which at a purchase price of $1.9 million, offers a cost-effective foundation for the project according to a representative of Chemours (P. McCaslin, personal communications, February 13, 2024). This 69.9-acre site also benefits from pre-existing industrial zoning, which will streamline the setup process (P. McCaslin, personal communications, February 13, 2024). Additionally, the site's proximity to the INVISTA Maitland factory, with its established water and electrical infrastructure, presents an opportunity to reduce the initial costs associated with setting up such foundational utilities (P. McCaslin, personal communications, February 13, 2024).

Another notable benefit of the Maitland location is the integrated railway system that passes directly through the plant area, presenting an efficient and economical transportation option for the import of raw materials and the export of finished CLT products (C P. McCaslin, personal communications, February 13, 2024). In Figure 9 below, the Canadian National Railway tracks can be seen to pass directly through the proposed site.

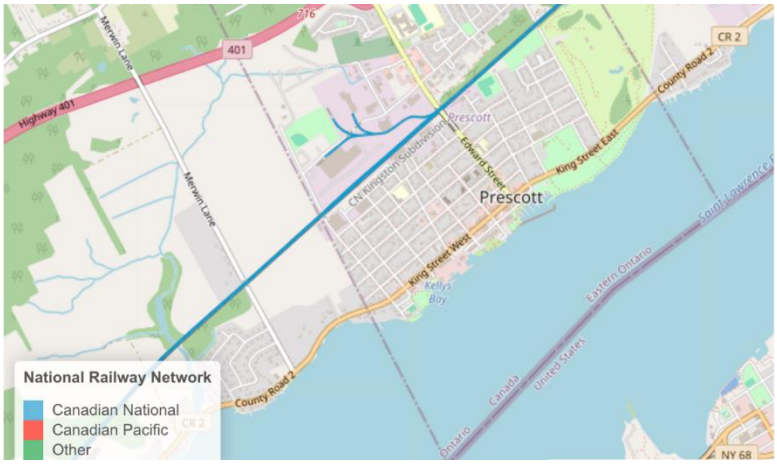


Figure 9: Canadian National Railway tracks passing through the proposed site location, shown in blue [38].

The Canadian rail system, known for its large network that connects domestic production with international markets in the USA and Mexico, has the capacity to transport large volumes over long distances [38]. The extent of the railway system can be seen in Figure 10 below.

Figure 10: The National Railway Network across Canada [38].

This capability is advantageous for the mass timber factory, as it will ensure the supply chain is consistent, and not constrained by the limitations often associated with road transport. Rail transport not only offers a cost-efficient alternative for moving materials, but also aligns with the environmental sustainability objectives of the mass timber industry by emitting lower greenhouse gases compared to road transport [39].

Furthermore, the proximity of the proposed facility to the St. Lawrence River significantly increases the factory's export potential, as it provides a direct maritime route to crucial markets in Europe, the Middle East, and North Africa [40]. The river, and its support for maritime transport, will introduce the ability to move large quantities of goods internationally. This logistical advantage is supported by Canada's trade agreements and the environmental benefits of maritime transport, which has a lower carbon footprint than road freight [41].

3.5 – Existing Mass Timber Facilities within Ontario

Currently in Ontario, Element5 is the only mass timber factory that produces CLT [6]. The factory is in Western Ontario, specifically in St. Thomas and it began operations in 2021 [42]. The factory has the capacity to produce 40, 000 m^3/year and 5,000 m^3/year of another type of mass timber known as glue-laminated timber [42]. The initial investment for the project was $50 million and the engineering of the project and its equipment was conducted by Ledinek, an engineering firm located in Slovenia [42]. The factory contains a fully automated production line for CLT and glue-laminated timber, shown in Figure 11 [43]. Element5 has produced mass timber products for projects throughout Ontario including the building of YWCA Supportive Housing in Kitchner, YWCA Supportive Housing in East Gwillimbury, and SOAHAC - Nshwaasnangong Childcare and Family Centre in London Ontario [42].

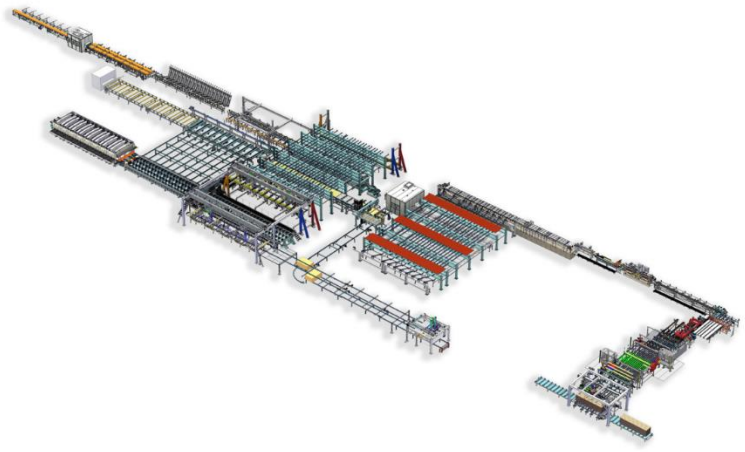


Figure 11: Blueprint of the manufacturing equipment at the Element5 facility [43].

Given that this is the only factory in Ontario that produces CLT, most cost calculations in 6.0 – Feasibility of Constructing a New Mass Timber Factory will be based on pricing for this factory.

4.0 – Data Collection and Analysis

This section will explore the comprehensive data collection and analysis process undertaken to assess the current and projected market for CLT within Ontario. It aims to establish a detailed understanding of both the volume of CLT currently used in construction and the future demand forecasts, allowing for a thorough evaluation of the financial and operational feasibility of a new mass timber production facility.

4.1 – Market Analysis and Projections

The mass timber industry is still in its early stages, and as a result, there are no established industry associations specifically focused on gathering and sharing data about the volume of wood products used in mass timber constructions. This makes it difficult to accurately measure the consumption of solid, CLT and other engineered wood products in these structures. Despite these challenges, the significant media coverage and the growing number of new projects being launched suggest that the industry is undergoing rapid expansion.

4.1.1 Understanding the Global CLT Demand Trends

The mass timber market is experiencing significant growth, as evidenced by the rising number of projects being designed and constructed globally [44]. A variety of non-profit organizations and private market research firms have begun to focus on the use of wood products, such as CLT, in nonresidential and multifamily buildings [44]. These entities provide technical support to architects, engineers, builders, and developers, with a specific emphasis on promoting CLT and other mass timber systems [45]. Data gathered by these organizations has been consolidated to forecast the market growth in Ontario. This analysis will adopt a top-down approach, examining global macroeconomic trends related to CLT growth to project the market's trajectory in Ontario.

The chart depicted in Figure 11below illustrates the projected financial growth for Cross-Laminated Timber (CLT), converted from USD to cubic meters using the global average cost of $600 per m^3 [46]. These projections extend to 2035, demonstrating an exponential growth trend represented by the red curve and the lighter-colored bars in the graph. Studies indicate a global growth rate for CLT at approximately 14% compound annual growth rate (CAGR), with the North American market expected to expand even more rapidly at 17% CAGR [46], [47]. This suggests that the demand for CLT will continue to rise significantly. Additionally, the current projection estimate for North America is at 17% and the calculation shows that the market will comprise about 55% of the global CLT volume by 2035.

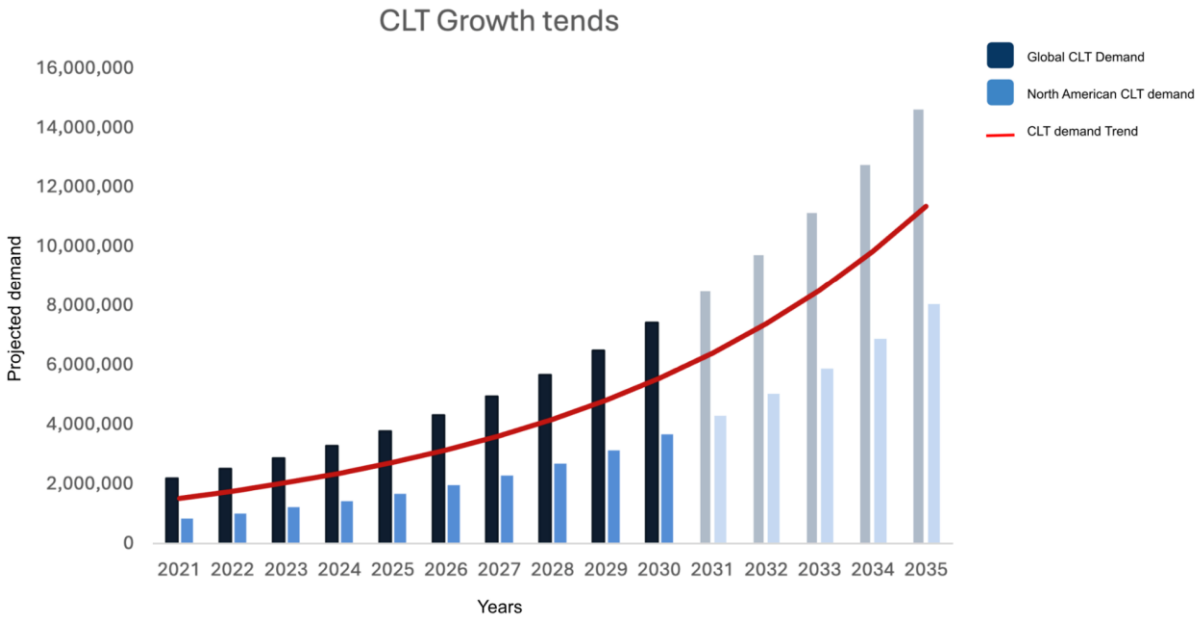


Figure 12: Global and North American growth projection along with the demand trends (red curve) [46], [47].

4.1.2: Translating the Global Demand to Ontario

The estimation of the increase in CLT usage in Ontario involved a complex process. The approach began with the utilization of the WoodWorks Mass-timber project database which records data on mass-timber construction projects across North America, including those utilizing CLT specifically in Ontario [48]. A spreadsheet was then compiled, detailing the name, location, construction year, number of floors, and area per floor in square meters for each structure.

To determine the volume of CLT used, references were used from a specific project that established a CLT usage ratio of approximately 0.3 m^3 per m^2 of floor area [49]. This metric was then used in the estimation of the volume of CLT used per floor for each building. This is shown in Equation 1 below, where A is the total floor area in square meters, N is the total number of floors in the construction unit, and T is the total volume of CLT used in m^3.

$$T = \left(\frac{0.3\ m^3\ of\ CLT}{1\ m^2\ floor\ area}\right) * A * N \quad (1)$$

By multiplying this value by the number of floors in each building, the total CLT consumption for each project was calculated. Summing these amounts and dividing by the number of years covered by the projects, which spanned eight years, provided an average annual estimate of CLT usage. This calculation served as a basis for understanding the rate at which CLT usage is growing in the region, and it is represented in Equation 2, where T is again the total volume of CLT used in m^3.

$$Average\ Annual\ CLT\ Usage = \frac{\sum(T)}{8\ years} \quad (2)$$

The specific projects used for the calculations can be seen in Table 1 below.

Table 1: Summary of all the CLT projects in Ontario over the last 8 years [48].

Name	Location	Number of Floors	Area of Flooring (m^2)	CLT Usage/Floor (m^3)	Total CLT Usage (m^3)	Year Built
Cambrian Heights	Sudbury	2	4315	1295	2589	2025
80 Atlantic	Toronto	5	7432	2230	11148	2020
Limberlost Palace	Toronto	10	16257	4877	48771	2023
Smart VMC BT	Vaughan	1	929	279	279	2019
Railway Parry Sound House	Parry Sound	2	325	98	195	1983
T3 Bayside	Toronto	10	23225	6968	69675	2023
Churchill Meadows Center	Mississauga	2	2332	700	1399	2021
Fire Hall	Port Stanley	1	929	279	279	N/A
Passage House	East Gwillimbury	2	1560	468	936	2022
55 Franklin	Kitchener	6	4645	1394	8361	2023
Oakville Fire Station	Oakville	2	120	36	72	N/A
YWCA Housing Building 2	Kitchener	3	1895	569	1706	2021
St. Thomas Day Care	St. Thomas	1	780	234	234	2020
SOAHAC Childcare	London	1	1012	304	304	2021
Trinity College	Toronto	4	1342	403	1610	N/A
YWCA Supportive Housing	Kitchener	4	2136	641	2563	2022
Ontario Secondary School	Toronto	3	11519	3456	10367	2024
TRCA Building	Toronto	4	7432	2230	8918	2017
Bill Fisch Forestry Stewardship and Education Center	Whitchurch-Stouffville	1	371	111	111	2017
Young Charles Shoppers Drug Smart	Toronto	4	1947	584	2336	2025
Seine River First Nation Cultural center	Mine Center	2	771	231	463	N/A
CNL Site Entrance	Chalk river	2	4273	1282	2564	2021
Harold Industrial Park	Sudbury	2	1474	442	884	N/A

The results of the calculations are summarized in Table 2, and show that the total amount of CLT used in Ontario was approximately 175,746 m³ over an eight-year period from 2017 to projects expected to complete by 2025. Based on this information, the average annual consumption of CLT in Ontario was calculated to be around 21,971 m³. This value represents the typical volume of CLT utilized annually in various construction projects within the region.

Table 2: Summary of the CLT calculations.

Total CLT used (m³)	**175,764**
CLT ratio (m³)	0.3
Number of years	8
Average CLT used/year (m³)	21,971

Considering Ontario's average annual CLT usage, currently at approximately 21,970 m³, alongside the projected global and North American increases in CLT demand—14% and 17% respectively—a forecast was created to estimate the future demand for CLT in Ontario [46], [47]. This forecast, detailed in Table 3 below, utilizes these growth rates to project annual demand from 2025 to 2036 for CLT in Ontario. The projections are split into three columns: one estimating growth based on the global rate, one on the North American rate, and one averaging the two, to provide a comprehensive view of the anticipated market expansion.

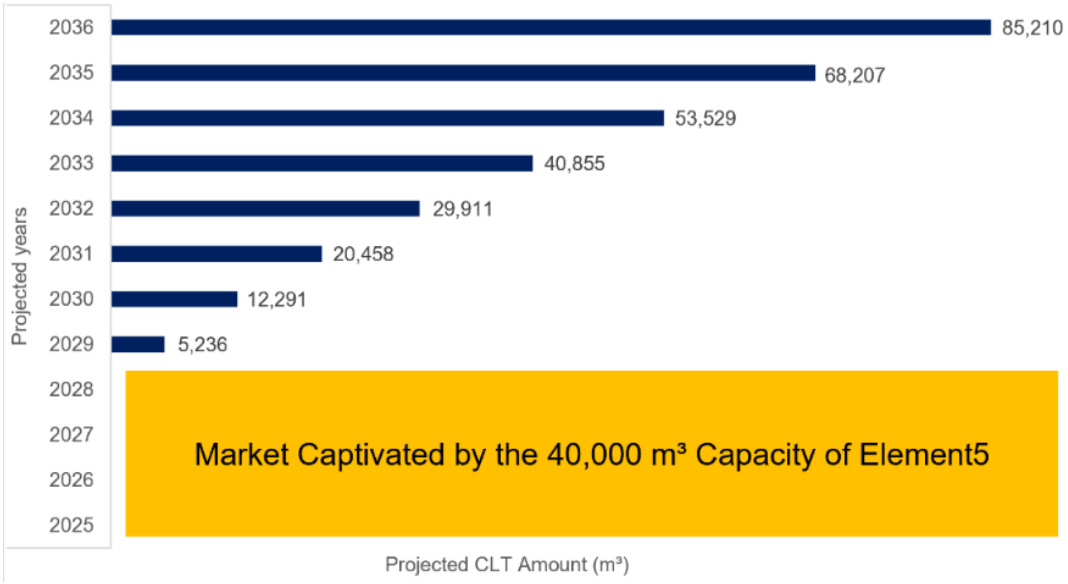
This final column is significant as it highlights the anticipated demand that exceeds the production capacity of Element5, currently the only facility in Ontario manufacturing CLT, which has a maximum annual production capacity of 40,000 m³ (C. Latour, personal communications, March 15, 2024). The values in this column represent the excess demand starting from the year when the forecasted demand exceeds Element5's capacity, indicating the point at which a new facility could potentially enter the market to meet the growing need for CLT.

Table 3: Forecasted CLT Demand in Ontario Based on global and North American CAGR's.

Year	**Global CAGR at 14% (m³)**	**North American CAGR at 17% (m³)**	**Average of CAGR Projection's (m³)**	**Demand Beyond Element5's Capacity (m³)**
2025	25,046	25,706	25,376	N/A
2026	28,553	30,075	29,314	N/A
2027	32,550	35,188	33,869	N/A
2028	37,107	41,170	39,139	N/A
2029	42,302	48,169	45,236	5,236
2030	48,225	56,358	52,291	12,291
2031	54,976	65,939	60,458	20,458
2032	62,673	77,149	69,911	29,911
2033	71,447	90,264	80,855	40,855
2034	81,450	105,609	93,529	53,529
2035	92,853	123,562	108,207	68,207
2036	105,852	144,568	125,210	85,210

The table is displayed as a graph in Figure 13 below. Based on these predictions, Element5, the CLT manufacturing plant located in St. Thomas, Ontario, is expected to reach its annual production capacity of 40,000 m³ by 2028 (C. Latour, personal communications, March 15, 2024). The graph illustrates the potential demand that a new facility could satisfy, beginning in 2029 with an anticipated additional demand of 5,236 m³, and forecasted to rise to 85,210 m³ within a decade. These projections are based on a CAGR of 15.5%, which is an average of the global and North American growth rates.

Figure 13: CLT demand growth projections in Ontario after Element5 reaches capacity.



It's important to note that the estimates provided are conservative. The average growth rate of 15.5% might not fully capture the unique market dynamics in Ontario, since much of North America's reported growth originates from regions like the Pacific Northwest and California [48]. The task of determining an accurate growth rate for Ontario has been particularly challenging due to the scarcity of data, especially as the demand in regions such as Ontario is only beginning to materialize. Despite these obstacles, an effort was made to calculate the CAGR for Ontario, to gain a clearer understanding of the demand trends.

The CAGR for Ontario was calculated using the Equation 3 below [59]. In this equation: EV is the end value is the CLT used in Ontario in 2024 (10367 m³), BV is the beginning value is the CLT in 2017 (9030 m³), and N is the number of years over the period of 7 years.

$$CAGR = \left(\left(\frac{EV}{BV} \right)^{\frac{1}{n}} - 1 \right) * 100 \quad (3)$$

The data used for these calculations came the WoodWorks Mass-timber projects [49] and is summarized in Table 4 below.

Table 4: Summary of CLT/Year usage in Ontario [49].

Year	CLT Used/Year (m^3)
2017	9029
2018	0
2019	279
2020	11382
2021	5973
2022	3499
2023	126807
2024	10367

Based on this data, the CAGR for Ontario was calculated to be 1.99%, however, it is important to note that is based on a limited data set and may be prone to biases. This rate is significantly lower than the earlier estimate of 15.5%, which was derived by averaging North American and global growth rates. According to this CAGR, the demand necessary for a new facility to be viable would not be met until 2056, when the demand for CLT is expected to surpass the 40,000 m^3 threshold (C. Latour, personal communications, March 15, 2024). However, this projection should not be considered a definitive indicator of actual demand. Based on the research completed by the team, it is estimated that the real demand is likely somewhere between the average rates of 15.5% and 2%.

Additionally, as depicted in the global trend graph, the demand for CLT appears to follow an exponential trend curve, which aligns with the calculated CAGR of 1.99%. Therefore, any significant growth drivers could have a considerable impact on enhancing the demand for CLT.

4.1.3 – Understanding the Key Drivers

The use of CLT in Ontario has shown steady but slow growth in recent years. However, considering North American trends alongside the long-term outlook in Ontario, the demand for CLT is on a clear exponential growth trajectory. This growth is primarily driven by the increasing need for housing in Ontario. A report by the Canada Mortgage and Housing Corporation (CMHC) forecasts a significant housing shortage in Ontario, projecting a shortfall of 1.48 million housing units by 2030, potentially escalating to 1.86 million units. This shortage is expected to trigger a surge in housing prices in Ontario, with an anticipated increase of 86% by 2030, a rate significantly higher than that in other provinces, with Quebec projected to have the next highest gap of 860,000 units [51]. A breakdown of the supply-demand gap in the housing market broken down by province can be seen in

. This scenario indicates a market correction where new supply will need to meet the increasing demand.

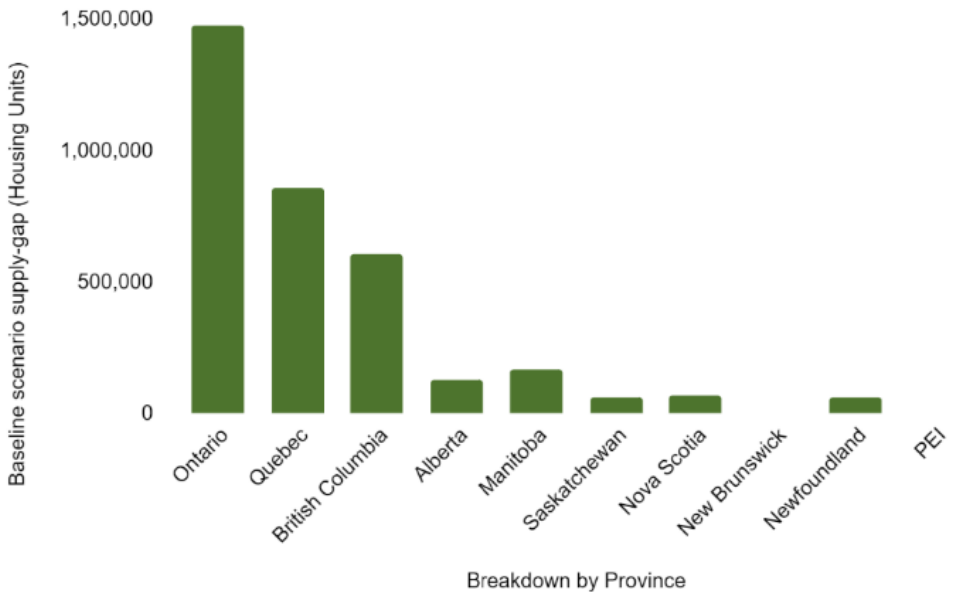


Figure 14 14: CLT demand growth projections in Ontario after Element 5 reaches capacity.

This anticipated housing deficit presents an opportunity for construction projects that utilize CLT for three primary reasons:

1) Increased Usage in Residential Construction: Research by FPInnovations highlights that residential construction tends to use CLT more extensively than general construction, with average usage rates of 0.64 m^3 per m^2 of area, compared to the general construction usage rates of 0.3 to 0.5 m^3 [52].
2) Efficiency in Construction: CLT projects benefit from their design and fabrication being completed in a facility before being assembled on-site. This pre-fabrication process significantly speeds up construction times compared to traditional methods, making it an attractive option for government-subsidized or sponsored mass housing projects [13].
3) Financial Attractiveness for Developers: The overall lower construction costs associated with CLT, in comparison to traditional building methods, can result in higher returns for developers, making CLT projects financially appealing [13].

Furthermore, considering the average size of a housing unit as defined by CMHC (approximately 1700-2000 m^2), and the projected baseline shortage of 1.48 million housing units by 2030, constructing just 64 of these units per year could generate an annual CLT demand exceeding 80,000 m^3 [51]. This volume is sufficient to fully utilize the capacities of both the existing Element5 facility and a new facility. Therefore, the trends in Ontario present a significant opportunity for the CLT market to contribute to addressing the housing shortage while also capitalizing on the increased demand.

4.1.4 – Case Study Supporting the Growth Driver: Adoption in Europe

To further highlight the role of Ontario's housing gap in influencing the adoption of CLT, a comparative analysis was completed regarding the uptake of mass-timber construction in Europe following the 2008 financial crisis. This period was characterized by a similar housing supply gap, due to a massive drop-in construction activity due to the collapse of the housing market [53].

Utilizing a database of mass-timber projects in Europe from the University of Stuttgart [53], and employing an event-study analysis, the impact of the 2008 financial crisis on the adoption of mass-timber construction was assessed, shown in **Error! Reference source not found.**. Before 2008, between 1 and 3 mass-timber projects were initiated in Europe annually. However, after 2008, there was a notable increase, with 9 projects launched in 2009 alone. Since then, mass timber construction has seen an exponential increase, with a record-breaking 50 mass-timber projects completed in Europe in 2019 [53].

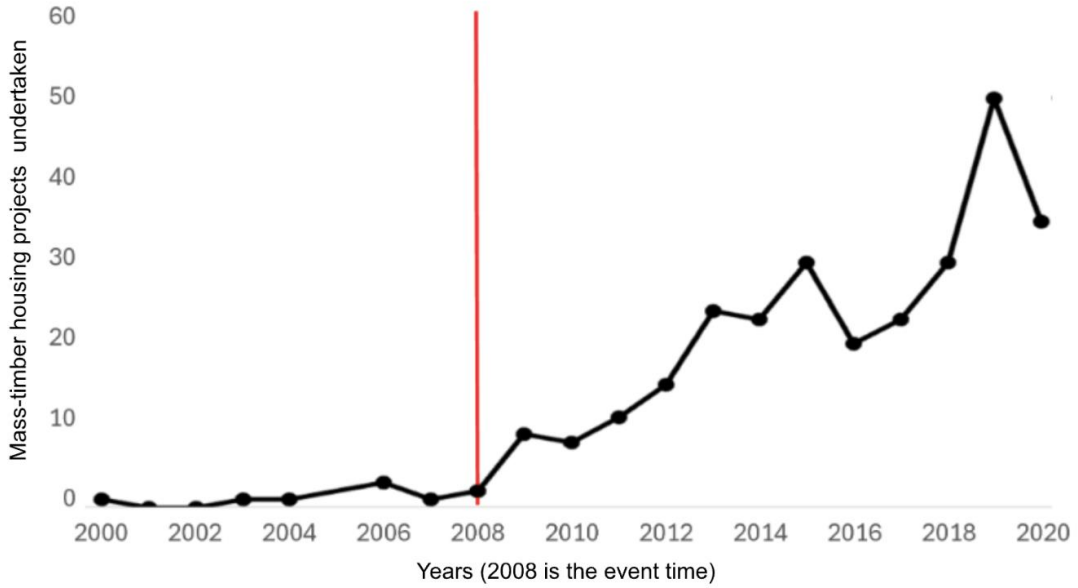


Figure 15: Event-study analysis of mass-timber project construction in Europe post the housing market collapse during the 2008 financial crisis. Data provided by the University of Stuttgart [53].

A 2021 study published by the Journal of Building Engineering examined the escalation in adoption of these construction methods, particularly focusing on mass timber structures in Europe [54]. The findings show several factors influencing the choice of CLT construction techniques, like those in Ontario:

1) Cost Effectiveness: Mass timber construction is found to be more cost-efficient than traditional building methods, offering a solution to regions grappling with affordable housing shortages [54].
2) Construction Speed: Mass timber buildings can be erected significantly faster than traditional structures, leading to reduced labor costs and quicker occupancy times [54].

These factors have led to the widespread acceptance of mass timber construction in Europe. Therefore, a similar pattern is anticipated in Ontario, given the current housing crisis.

Overall, despite the variation in the mean CAGR of 15.5% and the calculated Ontario CAGR of 1.99%, the trends observed both now and, in the past, suggest that the predictions for demand in Ontario are likely like the global and North American mean.

5.0 – Forecast and Expansion for Element5

Currently, the CLT production line at the Element5 factory is operating at approximately 60% of its total capacity, producing 24,000 m^3/year (C. Latour, personal communications, March 15, 2024). The factory plans to update these production lines in the future, and these enhancements will allow for full-scale production of CLT to be 40,000 m^3/year. The expansion of the CLT line is limited to equipment upgrades as expanding the CLT past full scale production will only result in extended production times (J. Bradac, personal communications, February 28, 2024). At the beginning of 2024, Element5 announced plans for factory expansion. However, the expansion will primarily focus on enhancing the glulam line and adding office space. A portion of the investment will be allocated to updating the CLT production lines (C. Latour, personal communications, March 15, 2024).

Market demand projections indicate that the Element5 factory will be capable of meeting all the CLT demands in Ontario during this period. Given the factory's established connections within the industry, it is assumed that it will accommodate all new buyers until it reaches its maximum capacity of 40,000 m^3/year. Given that the Element5 Factory's CLT production line will satisfy the current and upcoming demand for CLT in Ontario, it is not economically viable to begin building a new CLT factory in Southeastern Ontario until 2027, with operations commencing by 2029 to align with projected market demand. Additionally, while it has been stated that the CLT line at the Element5 factory cannot expand beyond 40,000 m^3/year, caution should be exercised regarding the construction of a new facility if these metrics were to change.

6.0 – Feasibility of Constructing a New Mass Timber Factory

In this section, the feasibility of constructing a new mass timber factory in Ontario is explored. To ensure a thorough understanding of our cost analysis, several critical assumptions were made.

6.1 – Assumptions for the Cost Analysis

Initially, it was assumed that the demand for CLT in Ontario was entirely met by Element5. From Section 4.1.3 it was projected that CLT demand would surpass Element5's annual production capacity of 40,000 m^3. Consequently, it was further assumed that there would be a two-year gap between the commencement of plant construction in 2027 and the start of CLT production in 2029. This construction timeframe is that of the Element5 factory [42]. This time frame has been used as a benchmark to gauge the necessary investment for the new facility. These following estimates assume that the prices and quantities of materials required for the construction of the plant and the production of 40,000 m^3 of CLT would remain fixed from 2024 to 2035. Additionally, some cost data obtained from earlier reports were adjusted using inflation rates provided by the Bank of Canada [55]. Other fundamental assumptions included the plant occupying 125,000 ft^2, producing 40,000 m^3/year of CLT with a panel thickness of 3-5 ply using spruce pine fir lumber, and selling the CLT at \$742/m^3 [36].

6.2 – Constraints

The estimates provided in this analysis are influenced by several factors. Although Maitland is considered the plant's location, this could change based on the specific needs for CLT production. Thus, while this analysis helps determine the financial viability of establishing a new plant in Ontario, the estimates are subject to change should the location shift. The assumptions themselves are notable constraints. Holding pricing and quantity constant over an extended period is unrealistic due to potential fluctuations in inflation rates and tax increases, which could significantly impact the cost of investment and CLT production. Additionally, the analysis assumes a plentiful supply of skilled labor, and doesn't consider the costs associated with specialized training. Important construction costs, such as those for the concrete foundation, labor, and the plant's architectural and design work, are not included in the cost analysis.

6.3 – Investments

The acquisition cost of production equipment and capital investments listed below were determined using information from various sources, including wood processing equipment manufacturers like Ledinek Engineering, Chris Latour (VP of Engineering & Operations at Element5), and the Technological and Economic Analysis of Manufacturing Cross-Laminated Timber (CLT) conducted by FPInnovations [52].

6.3.1 – Land and Construction

Land acquisition costs at the Maitland site were determined based on information from Paul McCaslin, who represents Chemours, the property owners. The current asking price for the property is $1.9 million, which covers 69.9 acres of land and the existing buildings (P. McCaslin, personal communications, February 13, 2024).

6.3.2 – Equipment

Equipment and installation costs were provided by Ledinek Engineering, a Slovenian company responsible for the Element5 CLT line construction. The estimated cost for this equipment and installation is approximately $30 million, with an additional recommended markup of $450 thousand to accommodate potential demand increases (J. Bradac, personal communications, February 28, 2024). The equipment covers various production stages such as handling, preparation, end jointing, layering and gluing, finishing, and pressing. Since this equipment qualifies for the Cleantech subsidy program of the Government of Canada, a $10 million deduction is applicable [56].

6.3.3 – Facilities, General Costs and Engineering Costs

Cost estimates for mechanical and electrical facilities were obtained from FPInnovations and adjusted for inflation using the Bank of Canada's inflation rate index. The adjusted construction costs are approximately $1.4 million for the mechanical facility and $1.7 million for the electrical facility [52]. Although facilities operated by Invista already exist at the site, inquiries about the cost-sharing potential were not made, which might affect the final cost estimates. FPInnovations also provided data on general and administrative costs, which were similarly adjusted for inflation and are displayed alongside other investment costs in Table 5 [52].

6.3.4 – Total Investment Costs

Table 5 summarizes the total investment costs associated with building a CLT facility in Maitland, Ontario, with a yearly target production of 40,000 m^3. The estimated overall cost comes to approximately $56 million, which includes production equipment, warehouse and infrastructure, set up, engineering, general and admirative expenses and a 10% contingency reserve.

Table 5: Investment costs for a 40,000 m^3/year CLT plant.

Cost Element	Cost
Land[1]	$1,900,000.00
Production Equipment[2]	$24,500,000.00
Construction Costs[3]	$17,500,000.00
Engineering [52]	$824,221.45
Mechanical Facilities [52]	$1,373,702.42
Electrical Facilities [52]	$1,785,813.15
General and Administrative Expenses [52]	$3,434,256.06
Contingency Reserve [52]	$5,110,799.31
Total	**$56,119,791**

1 Source: P. McCaslin, personal communications, February 13, 2024

2 Source: J. Bradac, personal communications, February 28, 2024

3 Source: Latour, personal communications, March 15, 2024

By summing all the anticipated costs, the total investment is calculated to be $56,119,791.

6.4 – Production Costs

This section of the report provides a detailed cost breakdown focused on the production side of the proposed Cross-Laminated Timber (CLT) plant. The major cost elements considered are divided into variable and fixed costs.

Variable costs include expenditures such as raw materials, energy, gas, waste management, and transportation. These costs are dynamic and fluctuate based on production volume, market rates, and operational efficiency [57]. Contrastingly, fixed costs are primarily associated with maintenance and labor [57]. These costs remain relatively stable and do not typically vary with the level of production, though they are crucial for the ongoing operation of the plant [57].

It is important to note that production costs will vary from one plant to another and would be influenced by factors such as the types of products manufactured, the technology employed, and the optimization of production processes.

The provided estimates for variable and fixed production costs are projected for a yearly production capacity of 40,000 m^3, which is expected to be reached after 4 years of operations based on calculations from Section 4.0.

6.5 – Projected Variable Costs Breakdown

This section will breakdown the specifics of the projected variables costs, such as raw materials, energy inputs, water consumption and waste, and transportation costs.

6.5.1 – Raw Materials

There are three categories of raw materials that will be used in the manufacturing of our CLT panels. These are lumber, adhesives, and plastic wrap. The costs of the raw materials are summarized in Table 6 below.

Table 6: Cost summary for lumber, adhesives and plastic wrap.

Raw Materials	For 1 m^3 CLT	Raw Materials Needed for Maximum Output	Cost/year CND 2024
Spruce fir wood [58]	0.911 Mfbm [60]	36,440 Mfbm	$11,880,000
Polyurethane Reactive Adhesive [52]	4.3kg [60]	172,000 kg	$2,064,000
Isocyanate Adhesive [52]	3.53kg [60]	141,200kg	$423,600
Plastic Lumber Wrap [59]	1.4kg [60]	56,000kg	$1,231,898
Total			**$15,599,498**

1. **Lumber**
   The yearly consumption of lumber, spruce pine fir, is at estimated at 36,440 board feet (Mfbm). Refer to Appendix II for a breakdown of the cost calculation.
2. Adhesives
   Assuming the same number of plies of boards and 2-inch Lumber to develop 5-ply panels that require gluing on four surfaces, the total panel face area that should be glued yearly comes to a yearly cost of 2.4 million dollars. Refer to Appendix II for the breakdown of the calculations.
3. Plastic Wrap
   The specific choice of plastic used by Element5 was unknown, prompting the selection of a heavily reinforced poly-sheeting as a default option capable of withstanding rain, snow, rot, and chemicals [59]. Plastic wrap is applied to cover the finished product before shipping. Refer to Appendix II for the breakdown of the calculations.

6.5.2 – Energy Input

Table 7 outlines the energy inputs required for CLT production based on production from the Element5 factory [60]. Each energy input is broken down into the total energy needed per cubic meter of CLT production. The cost for each energy input is derived from the provincial average. Refer to Appendix II for the breakdown of the calculations.

Table 7: Energy inputs required per cubic meter of CLT.

Cost Element	Resource Needed 1 m^3 CLT	Resources Needed for Maximum Output	Cost
Electricity [61]	122 kWh [60]	488,000kWh	$888,100
Natural Gas [62]	17.6 m^3 [60]	704,000 m^3	$104,614
Propane [63]	0.070L [60]	2,800 L	$2,716
Total			**$998,146**

6.5.3 – Water Consumption and Waste

Table 8 below outlines the water consumption and waste associated with CLT production, based on production from the Element5 factory [60]. It is assumed that the factory will be serviced by a disposal company in Prescott, Ontario for its wood waste [64]. The costs for water and wastewater are based on the current regional prices for Maitland, Ontario [65]. Refer to Appendix II for the breakdown of the calculations.

Table 8: Waster consumption and waste associated with CLT production.

Cost Element	Resource Needed 1 m^3 CLT	Cost
Wood Waste [64]	22.4 kg [60]	$7,509
Wastewater [65]	194.8L [60]	$31,168
Water [65]	194.8L [60]	$23,376
Total		**$62,053**

6.5.4 – Transportation Costs

Table 9 presents the railway delivery costs. Should transportation beyond the railway be required, it will be the customer's responsibility to arrange and cover the associated trucking expenses. Refer to Appendix II for the breakdown of the calculations. The calculations for the railway expenses were determined assuming a 360km radius from the Maitland site.

Table 9: Transportation costs associated with transporting materials by rail.

Delivery Method	Annual Output m^3	Cost
Railway [66]	40,000	$320,332

6.6 – Total Projected Variable Costs

Table 10 below summarizes the total projected variable costs that the plant will incur to produce Cross-Laminated Timber (CLT). This summary was compiled by analyzing information based on the current prices and specifications of a plant in the St. Lawrence region, which benefits from access to the rail facilities located inside the Invista chemical plant.

Table 10: Total projected variable costs for the CLT facility.

Cost Element	Cost for 1 m³ of CLT in $CAD	Annual Cost
Lumber (SPF) [58]	297	$11,880,000
PUR (Polyurethane reactive) adhesive [52]	51.6	$2,064,000
Isocyanate adhesive [52]	10.59	$423,600
Plastic Lumber Wrap [59]	30.80	$1,231,898
Electricity [61]	22.2	$888,100
Natural Gas [62]	2.62	$104,614
Water Waste [65]	0.78	$31,168
Transportation Delivery [66]	7.8	$320,332
Propane [63]	0.068	$2,716
Wood Waste [64]	0.58	$7,509
Water [65]	0.58	$23,376
Total		**$16,977,313**

This table captures the range of variable costs associated with producing CLT, ranging from raw materials like lumber and adhesives to operational expenses such as energy and waste management. Each cost element is calculated per cubic meter of CLT produced and scaled up to the annual expense based on the plant's production capacity.

6.7 – Projected Fixed Costs Breakdown

This section details the fixed costs associated with the operation of the CLT plant, including maintenance and labor costs, and depreciation.

6.7.1 – Maintenance Costs

Maintenance costs are considered a replacement of the investment, essentially serving as the capital investment for maintaining the new build. Typically, maintenance costs range between 2-5% of the Initial Investment Cost (IIC) [52]. For this project, a rate of 3% was selected based on these standards [52]. Given that the cost of building the plant was approximately $56.2 million, the maintenance cost is calculated at about $1.7 million annually, specifically $1,683,570, which represents 3% of the IIC.

6.7.2 – Labour Costs

The labor required to produce 40,000 m³ of CLT per year is summarized in Table below, detailing the positions needed along with their respective salaries and total annual cost.

Table 11: Summary of Annual Labor Costs for CLT Production.

Fixed Costs	Yearly Salary	Yearly Cost

Shift operators (44)	$39,000.00 [67]	$1,716,000.00
Shift Supervisor (1)	$75,000.00 [67]	$75,000.00
Maintenance Technician (2)	$57,041.00 [67]	$114, 082
Plant Manager (1)	$110,000.00 [67]	$110,000.00
Plant Engineer (1)	$191,030.00 [67]	$191,030.00
Maintenance Supervisor (1)	$77,912.00 [67]	$77,912.00
Accountant (1)	$85,000.00 [67]	$85,000.00
Total Cost		**$2,369,024.00**

The labor strategy was influenced by a 2021 study by Zhang and Lan, which analyzed a CLT plant producing 30,000 m³ of CLT annually. From their findings, it was clear that the majority of labor comprised shift operators and maintenance technicians [68]. Given that this plant will produce 133% more CLT annually than the plant in their study, it was determined that one shift operator would be required for every 909 m³ of CLT produced, totaling 44 shift operators. Initially, it was suggested that a yard employee may be needed but to reduce costs, this worker can be replaced by rental services which will be decided by the plant's management team. The salaries were determined based on the average Canadian wages in 2024 [67].

6.7.3 – Depreciation

The depreciation rate applied to the entire initial investment cost is 7% [52]. This results in an annual depreciation expense of $3,741,000, calculated from the total initial investment.

6.8 – Projected Revenue and Net Income

Figure 16 shows the income statement for the plant, which accounts for costs, depreciation, and taxes to provide a detailed cash flow estimate and a forecast of the payback period over 10 years.

Income Statement		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Revenue	$ -	$ 3,885	$ 9,120	$ 15,179	$ 22,194	$ 29,680	$ 29,680	$ 29,680	$ 29,680	$ 29,680	$ 29,680
Variable Costs	$ -	$ 2,222	$ 5,217	$ 8,683	$ 12,695	$ 16,977	$ 16,977	$ 16,977	$ 16,977	$ 16,977	$ 16,977
FPDE Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Raw Material Margin	$ -	$ 1,663	$ 3,903	$ 6,496	$ 9,499	$ 12,703	$ 12,703	$ 12,703	$ 12,703	$ 12,703	$ 12,703
Fixed Cost	$ -	$ 4,052	$ 4,052	$ 4,052	$ 4,052	$ 4,052	$ 4,052	$ 4,052	$ 4,052	$ 4,052	$ 4,052
Project Expense	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Gross Margin	$ -	$ (2,389)	$ (149)	$ 2,444	$ 5,447	$ 8,651	$ 8,651	$ 8,651	$ 8,651	$ 8,651	$ 8,651
SG&A Expenses											
EBITDA	$ -	$ (2,389)	$ (149)	$ 2,444	$ 5,447	$ 8,651	$ 8,651	$ 8,651	$ 8,651	$ 8,651	$ 8,651
Depreciation (book)		$ 3,741	$ 3,741	$ 3,741	$ 3,741	$ 3,741	$ 3,741	$ 3,741	$ 3,741	$ 3,741	$ 3,741
EBIT	$ -	$ (6,130)	$ (3,890)	$ (1,297)	$ 1,706	$ 4,910	$ 4,910	$ 4,910	$ 4,910	$ 4,910	$ 4,910
Taxes	$ -	$ (705)	$ (447)	$ (149)	$ 196	$ 565	$ 565	$ 565	$ 565	$ 565	$ 565
NIAT	**$ -**	**$ (5,425)**	**$ (3,443)**	**$ (1,148)**	**$ 1,510**	**$ 4,345**	**$ 4,345**	**$ 4,345**	**$ 4,345**	**$ 4,345**	**$ 4,345**
Capital Expenditures	(56,119)	-	-	-	-	-	-	-	-	-	-
(+) Depreciation		3,741	3,741	3,741	3,741	3,741	3,741	3,741	3,741	3,741	3,741
(+) Book Taxes		(705)	(447)	(149)	196	565	565	565	565	565	565
(-) Cash Taxes		(1,243)	(1,663)	(871)	(180)	430	600	718	801	859	900
Cash Flow	**$ (56,119)**	**$ (1,146)**	**$ 1,514**	**$ 3,315**	**$ 5,627**	**$ 8,221**	**$ 8,051**	**$ 7,933**	**$ 7,850**	**$ 7,792**	**$ 7,751**
Payback											
Cummulative Cash	(56,119)	(57,265)	(55,751)	(52,436)	(46,809)	(38,589)	(30,538)	(22,605)	(14,755)	(6,963)	788
Payback Period		1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	9.9

Figure 16: Detailed Plant Income Statement.

According to the income statement derived from the projected revenue and costs outlined earlier in the report, the plant is anticipated to achieve a payback period of 10 years. This timeframe indicates that the total cost of the plant will be repaid to investors within a decade. The income statement further estimates an initial return on investment of 0.2% with a net present value of $735 thousand. These financial metrics suggest a positive outlook on the financial viability of the plant.

7.0 – Conclusions and Recommendations

This section summarizes the findings from the project, and offers recommendations based on the analysis.

7.1 – Summary

Before offering recommendations, it is important to summarize the key findings from the investigation. Research into existing facilities in Ontario has identified Element5 as the region's sole provider of mass timber, currently operating at 60% of its capacity. Despite plans for expansion, it is projected that by 2028 there will be a significant gap between supply and the escalating demand for Cross-Laminated Timber (CLT) in Ontario.

Market analysis has demonstrated robust demand for CLT both globally and in North America, with a Compound Annual Growth Rate of 15.5% [48]. This growing demand, alongside the Ontario government's initiative to build new housing, highlights significant growth potential for mass timber within Ontario [4] This positions’ the proposed facility to effectively meet this rising demand.

Financially, the analysis has revealed a positive Net Present Value of $735,000, suggesting that investing in a new factory would not only be profitable but is also expected to start generating income within 3 years of operation.

7.2 – Recommendations

While CLT offers a promising method to reduce carbon footprints, it remains a relatively new product. The current CLT plant, known as Element5, is producing 27,000 m^3 of CLT annually and plans to increase its output in the forthcoming years (C. Latour, personal communications, March 15, 2024). Element5 will adequately meet all the CLT demand until 2029. However, post-2029, the demand will surpass their capacity. It is recommended that investors consider constructing a new CLT plant, anticipated to be operational by 2029. Given that the Internal Rate of Return (IRR) is only 0.2% and the new plant offers a net present value of $735 thousand, it would be a prudent investment for environmentally focused investors.

However, it should be noted that these estimates are predicated on 2024 prices, which introduces a degree of uncertainty, as these prices are likely to fluctuate in the future. Investors are also encouraged to explore different locations for the plant, since costs can vary significantly based on geographic location.

Based on the analysis detailed in this report, investing in a new plant immediately is not recommended, but rather it should be considered in a few years.

7.3 – Next Steps

Future steps for this project could include a series of initiatives to ensure its viability and alignment with market demands. Firstly, a feasibility study should be conducted to explore potential locations for the new CLT plant. This study could consider key factors such as the proximity to raw materials, transportation logistics, and local labor markets.

Additionally, it is important to engage with potential investors and stakeholders to discuss the financial and environmental benefits of the proposed CLT plant, with the hope of securing funds.

Further steps might involve updating the market analysis to reflect any significant changes in the global and North American timber markets, particularly in response to economic shifts or new regulatory policies.

Finally, continuous monitoring of the performance and capacity utilization of Element5 is necessary to better predict the optimal timing for initiating the construction of the new plant.

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Appendix I

Statement of Contributions

Table 12 below displays the contribution to the project by each team member.

Table 12: Breakdown of team member contribution to the project and report.

Team Member	Contributions
Ritvik Awasthi	Market research, Global trend projections, CLT usage equation formulation, Market demand projections, housing supply-gap research, Event-study analysis for the case-study.
Lukas Cote	Financial research, Cost assumptions, Cost Analysis, Recommendations, Editing and formatting
Kailey Fejer	Introduction, Literature Review, Recommendations/Next Steps, Editing and Formatting
Hailey Wolfgram	Introduction, Literature Review, Cost analysis Recommendations/Next Steps, Editing and Formatting, Appendices, references

Appendix II

Specific Calculations

Calculations for the Raw Materials

Lumber

Based on the report from Athena Sustainable Materials Institute [60] a 1 m^3 of CLT requires 0.911 m^3. The current trading price for softwood lumber is $700/ a thousand board feet (mfb) [69]. The conversion for 1 mfb to m^3 is 2.36 [69]. Therefore, $700/ 2.36 is $297 CAD.

Adhesives

Based on the report from Athena Sustainable Materials Institute a 1 m3 of CLT requires 4.3kg of polyurethane reactive adhesive [60]. From the FPInnovation report in 2010, polyurethane reactive adhesive cost $8.80 CAD/kg [52]. Accounting for inflation in the price, in 2024 polyurethane reactive

adhesive cost $12.00 CAD/kg [52]. Thus, when the factory is operating at maximum capacity producing 40,000 m^3 per year, the total cost for PUR is $2,064,000.

Based on the report from Athena Sustainable Materials Institute a 1 $m^3$of CLT requires 3.53kg of isocyanate adhesive [60]. From the FPInnovation report in 2010, polyurethane reactive adhesive cost $2.20 CAD/kg [52]. Accounting for inflation in the price, in 2024 isocyanate adhesive $3.00 CAD/kg [60]. Thus, when the factory is operating at maximum capacity producing 40,000 m^3 per year, the total cost for isocyanate adhesive is $423,600.

Based on the report from Athena Sustainable Materials Institute a 1 m3 of CLT requires 1.4kg of plastic wrap [59]. One roll of Heavy-Duty Reinforced Poly Sheeting weighing 22kg cost $358.00 US [62]. Thus, one roll costs $483.96 CAD and the cost per kg is $22.00 CAD, the exchange rate used was the average conversion from United States dollars to Canadian dollars of the past year. Given this, 1.4kg of plastic wrap for 1 $m^3$of CLT costs $30.8. Thus, when the factory is operating at maximum capacity producing 40,000 m^3 per year, it requires 56,000 kg of plastic wrap for a total cost of $1,231,898 CAD.

Calculations for the Energy

Electricity

The average cost of electricity according to the Ontario Energy Board (OEB) is $0.182/ kWh [61]. The price for peak hour time was selected as it coincides with when the factory conducts most of its operations. Given that 1 m^3 of CLT requires 122kWh, the cost for producing 1 m^3 CLT is $22.20 CAD and when the factory produces 40, 000 m^3 the cost of electricity is $888,100 [62].

Natural Gas

The average cost of natural gas in Ontario is $0.1486/ m^3, this commodity rate includes storage and transportation charges [62]. Given that 1 m^3 of CLT requires 17.6 m^3 of natural gas, the cost for producing 1 m^3 CLT is $2.62 CAD and when the factory produces 40,000 m^3 the cost of natural gas is $104,614 [60].

Propane

The average cost of propane in Ontario is $0.97/L [63]. Given that 1 m^3 of CLT requires 0.070L of propane, the cost for producing 1 m^3 CLT is $0.0679 CAD and when the factory produces 40,000 m^3 the cost of natural gas is $2,716 [60]. Note, the price of delivery of the propane was not accounted for in this calculation.

Wood Waste

The factory can utilize a waste container rental service capable of holding 8153.80 kg of wood waste [64]. At maximum operational capacity, the factory generates a yearly waste output of 896,000 kg, equivalent to a weekly average of 17,230 kg. This would fill approximately 2.1 waste containers per

week [64]. Given this, waste container pickups will be scheduled four times a week to accommodate any additional waste produced by the factory, costing $625.74 per month for this service. Hence, the total annual cost for waste management amounts to $7,509 [64].

The total annual waste pickup cost is $7509 for the factory. This cost covers 8154 kg of waste per pickup, with four pickups per week.

First, we calculate the weekly cost of waste pickup, as seen in Equation 4 below.

$$Weekly\ Cost\ (\$) = \frac{Total\ Annual\ Cost\ (\$)}{Number\ of\ Weeks\ in\ a\ year} = \frac{7509}{52} = \$144.40 \quad (4)$$

Next, we find the cost per kilogram of waste, calculated using Equation 5 below.

$$Cost\ per\ kg = \frac{Weekly\ Cost}{Kg\ per\ week} = \frac{\$144.40}{17230\ kg} = \$0.00838 \quad (5)$$

Finally, we calculate the cost of 22 kg of waste, using Equation 6.

$$Cost\ of\ 22kg = (22kg) * Cost\ per\ kg = (22kg * \$0.00838) = \$0.184. \quad (6)$$

Therefore, the cost of 22 kg of waste disposal is approximately $0.184.

Wastewater

In the St. Lawrence region, water is priced at $4.00 per m^3[65]. With 1 m^3 equivalent to 1000 liters, and 1 m^3 of CLT requiring 194.8L of water (0.1948m^3), the cost per m^3 of water for producing 1 m^3 of CLT is $0.78 [65]. Thus, with the factory producing 40,000 m^3, the total cost of water amounts to $31,168.

Water

In the St. Lawrence region, water is priced at $3.00 per m^3[65]. With 1 m^3 equivalent to 1000 liters, and 1m^3 of CLT requiring 194.8L of water (0.1948 m^3), the cost per m^3 of water for producing 1 m^3 of CLT is $0.58 [65]. Thus, with the factory producing 40,000 m^3, the total cost of water amounts to $23,376.

Calculations for the Transportation Delivery

According to C. Latour, one freight container can accommodate 40 m^3 of CLT product [66]. Thus, to transport 40,000 m^3 of CLT, 1000 freight containers are required. For the railway service utilized by the factory at the Maitland location, Paul McCaslin provided a rental quote of $200 per car. In addition to this base fee, a fuel surcharge applies; the factory's travel radius is 224 miles from the site. The fuel surcharge is calculated at $0.5372 per mile, totaling $120.33 per trip. Consequently, the annual railway costs for transporting 40,000 m^3 of CLT is $320,332.