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Case Report

A Case Study on the Impact of Transportation of Mass Timber Products on the Cradle-to-Gate LCA Results for an Institutional Building

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Abstract

Mass timber products (MTPs) are being adopted in new building constructions and remodels in the last three decades, credited to their renewable and low carbon footprint characteristics. However, there are no mass timber manufacturers currently existing in Atlantic Canada. Extended distances of transporting MTPs to this region from other Canadian provinces may sacrifice the environmental benefits of using MTPs. This study was aimed to understand, via conducting a cradle-to-gate life cycle assessment (LCA), the environmental impacts of a mid-rise institutional building, which is located in the Province of New Brunswick Canada. By comparing the current steel frame design of this building with an alternative mass timber building design with the same height range and function including the transportations of major building materials. It was found that the mass timber building design could still have environmental advantages over the steel structure, as much as 19.5% lower global warming impact and 16.8% lower ozone depletion impact, even with MTPs delivered from the furthest location considered in this study. However, the disadvantages in other impact categories, such as 31.9% higher smog impact, 13.6% higher acidification impact, and 248.2% higher eutrophication impact were found when using the TRACI impact assessment in this whole building LCA study.

Keywords

Life cycle assessment; mass timber products; institutional building; transportation; environmental impact

1. Introduction

Mass timber product (MTP) is a term used to describe a family of engineered wood products with large section that offers the construction industry a viable alternative to traditional products like structural steel and reinforced concrete [1]. These products include large-scale, thick-panel products, such as cross-laminated timber (CLT) and structural composite lumber, as well as adhesively or mechanically laminated linear elements like glue-laminated timber (GLT), nail-laminated timber, and dowel-laminated timber [2]. Using MTPs such as CLT for construction has multiple advantages over traditional building materials, including faster on-site construction, better thermal performance, lighter structure, and a lower carbon footprint when sourcing from sustainably managed forests for wood materials [3]. Wood also has carbon sink capability as trees absorb carbon dioxide through photosynthesis during their growing process and store it in products during their service life [4]. Moreover, a mass timber building can serve as a carbon sink over the lifespan of the building. This may help with the mitigation of climate change as storing carbon in buildings will trap the carbon in these buildings until the end of service periods of the buildings [5], which are assumed to be 50~60 years [6, 7]. This length of service period is currently based on traditional concrete buildings but would be anticipated to be much longer for mass timber buildings.

To quantify the environmental impact already caused by or to be caused by the construction of a building, it is necessary to use a standardized and well-recognized method. Which is to conduct a Life Cycle Assessment (LCA) on the whole building with either a cradle-to-gate or cradle-to-grave system boundary. LCA is a technique that is used to address environmental aspects and potential environmental impacts throughout the life cycle of a product from raw material acquisition through production, transportation, use, end-of-life treatment including recycle and final disposal (i.e., from cradle to grave) [8]. The system boundary for an LCA must be defined in relation to the goals of the study as it will identify which stages/aspects of a product or building life cycle to be included in the study. The tools used for LCA studies can be separated into three types. The first type is used for generic product LCA. This level of LCA software includes GaBi, SimaPro, and OpenLCA. The second type is a streamlined tool to assess the whole building LCA. This includes Eco-Quantum, Athena Impact Estimator, Tally, OneClick LCA and eTool. The third type is a framework for whole building assessment, such as BREEAM [9] and LEED [10, 11].

LCA studies have revealed that buildings built with MTPs usually have lower global warming impacts than traditional buildings but may have slightly worse performance in one or two other environmental impact categories in different cases [12-16]. These other impact categories include acidification potential (AP), eutrophication potential (EP), ozone depletion potential (ODP), and

Smog formation potential (SFP). Currently, there are very few mass timber structures in the Atlantic provinces (New Brunswick, Newfoundland and Labrador, Nova Scotia, and Prince Edward Island) of Canada when compared to other provinces, such as Quebec and Ontario, Canada [17]. Also, there are no mass-timber manufacturers currently located in Atlantic Canada, which would impose additional transportation costs and environmental burden when using MTPs for building materials in these provinces.

There are few studies examining the role of transportation in the overall GWP of MTPs or mass timber buildings. Hemmati and others [18] conducted LCA on the transportation stage of CLT panels from three different origin points (Graz, Styria in Austria; Seattle, WA and Conway, AR in the USA) to a construction site located at Fayetteville, AR in the USA. Two software programs with different databases (SimaPro with Ecoinvent database, and Tally with Gabi database) were used in order to study the difference in the outputs of these programs. The results from this study indicated that the combination of transportation distance and methods had a major impact on the GWP of MTPs and using different software and database combinations could produce different results. Chen and others [19] studied the impact of species mix and transportation on LCA results of CLT panels manufactured in the western Washington state area, USA, and found that a 14% decrease in overall GWP for CLT panels could be achieved by sourcing lumber locally (reducing the CLT panels transportation distance to the construction site from 322 km to 104 km and lumber transportation to the CLT mill distance from 440 km to 21 km) and using low-density species (from Douglas-fir to Sitka spruce) at the same time. To learn if building with MTPs would still have environmental benefits in New Brunswick and quantify such benefits, similar research focused on transportation impacts was carried out in this study for the capital city of New Brunswick--Fredericton.

This study was aimed at examining and determining the degree of the impact of extended transportation of MTPs that are proposed to be used in the institutional buildings located in the province of New Brunswick, Canada. The New Brunswick Climate Change Action Plan released by the Government of New Brunswick [20] encouraged increasing usage of wood products in construction and major renovations (based on a favorable lifecycle evaluation) for publicly funded buildings. The findings from this study could help with implementing the plan with science-based information provided to stakeholders such as government officials, contractors, and clients who will build new buildings or renovate old buildings.

2. Materials and Methods

To compare the environmental impact of buildings built with MTPs and traditional building materials in the products manufacturing and transportation stages, a building LCA was conducted following ISO 21930:2017 [21] and EN 15978 [22] standards using a tool for generic LCA (SimaPro software).

2.1 Scope of LCA

2.1.1 Research Building

The research building used in this study was the IUC New Forestry Building (Figure 1) on the University of New Brunswick (UNB) campus in Fredericton, New Brunswick, Canada. This building is a steel frame structure falling in the category of institutional building, constructed in 1975 and opened for use in 1976. The structural components of this building include a reinforced concrete foundation, steel framing, and reinforced concrete floor. Interior walls were built with Concrete Masonry Units (CMUs), while exterior walls were constructed with the same material plus a layer of insulation and bricks. The functional space of this building contains 20 individual offices for faculty members and four shared offices that are being occupied by graduate students. Two classrooms, several small laboratories, and computer laboratories are included in the building as well. The unique features of this building include two greenhouses on the rooftop and one cold storage unit in the basement, which were excluded from the study as these were not common features for mid-rise institutional buildings.

Figure 1 IUC Forestry Building, a three-story steel-frame institutional building.

The Mass Timber design in this study was a schematic (concept) design with mass timber replacing concrete and steel in the IUC Forestry Building, where the steel frame structure was replaced with GLT columns, beams, and a CLT floor system. The interior walls were replaced with steel stud walls to reduce the deadweight load from the interior walls. The column and beam spacing used for this building was referenced to the mass timber atrium to be constructed for the Faculty of Engineering on the UNB campus. Due to the limitation of the material data provided by the old blueprints of the IUC building, only its structural parts (e.g., foundation, floors, roof, columns, and beams) and walls (i.e., exterior walls and interior partitions) were included in this study as the structural components are major components of the building, while the wall designs were impacted by the usage of different structural materials. Windows and doors were excluded from the study. The functional unit of this LCA study is defined as 1 m^2 of floor space.

2.1.2 System Boundary

The system boundary for this building LCA study includes the Products Stage of A1-A3 and the transportation of building materials to the construction site, Stage A4, as defined by building LCA standard EN 15978 shown in Table 1 [22]. The carbon sink capability of CLT panels, GLT columns, and GLT beams used in the mass timber building design is quantified in the study but listed separately as these benefits should not be included in the A1-A4 stage of the life cycle. The carbon in mass timber products will be stored for the lifetime (50-60 years) of the building before being released back into nature or staying in the materials that will be recycled to the next product life, hence delaying the greenhouse gas (GHG) emissions from these building materials.

Table 1 Life cycle stages adapted from EN 15978:2011 [22].

Building Assessment Information	Building Lifecycle Information	Product Stage	A1	Raw material supply
			A2	Transport
			A3	Manufacturing
		Construction Process stage	A4	Transport
			A5	Construction-installation process
		Use stage	B1	Use
			B2	Maintenance
			B3	Repair
			B4	Replacement
			B5	Refurbishment
			B6	Operational energy use
			B7	Operational water use
		End-of-life stage	C1	De-construction demolition
			C2	Transport
			C3	Waste processing
			C4	Disposal
	Supplement information beyond the building life cycle		D	Benefits and loads beyond the system boundary

2.2 Life Cycle Inventory (LCI)

To conduct LCA, one of the important steps is to collect material and energy data necessary to meet the defined goals of the study. These collected primary data are used to construct the Life Cycle Inventory (LCI) of a product or service, according to the ISO standard [8]. The building LCA started with collecting the bill of materials (BOM) from a building design, then assigning each product with the LCI dataset from a building material database.

On-Screen take-off software [23] was used to collect building materials and quantity information from the architectural and structural designs of the IUC Forestry Building. The same software was used to collect material use information for the alternative mass timber design of the IUC Forestry Building as shown in Figure 2.

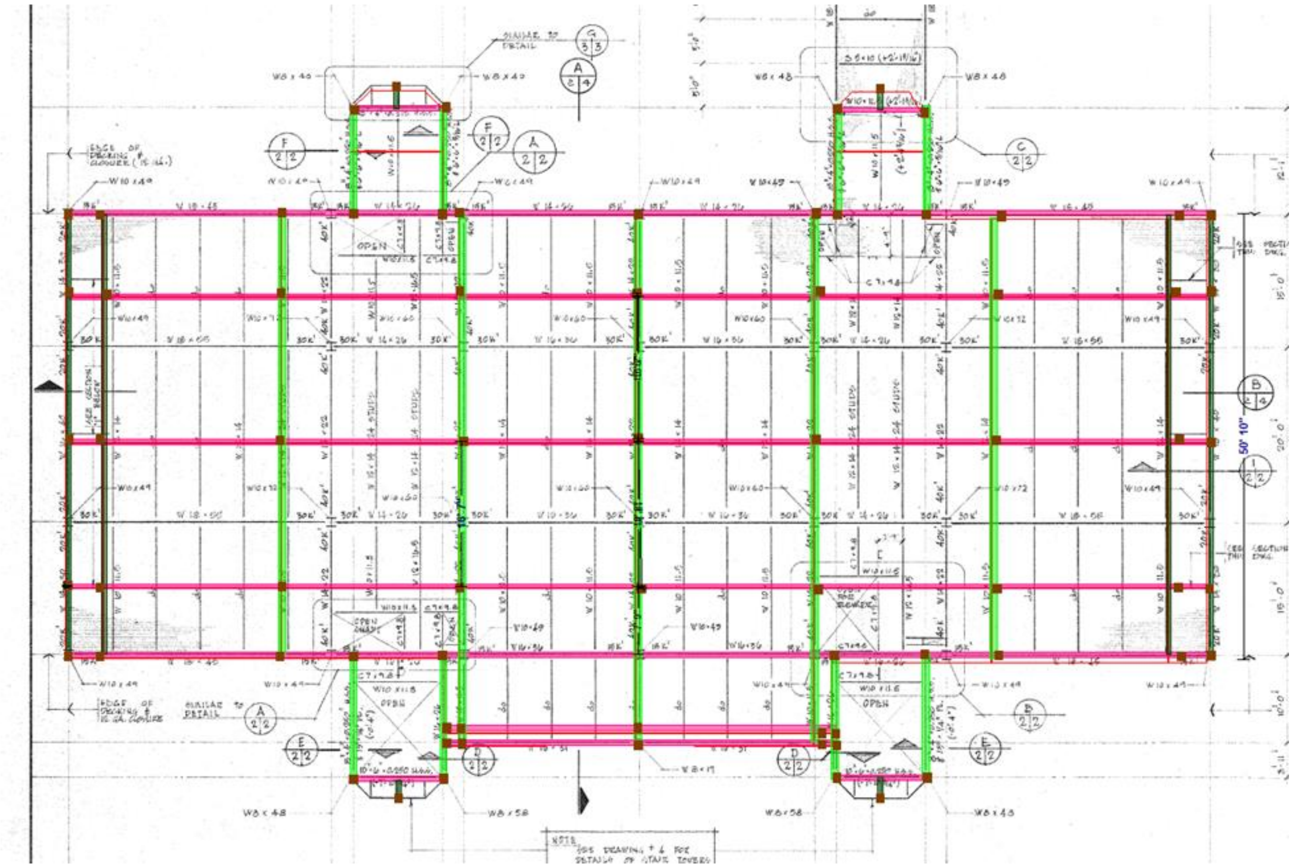

Figure 2 Design of GLT frame structure for IUC Forestry Building with the spacing distance of column and beams being lowered compared to the original steel frame design.

SimaPro [24] was used to conduct the whole building LCA with the 2021 DATASMART LCI Package [25] to provide information on individual materials' manufacturing and transportation impacts. The DATASMART Package database uses modified data based on the Ecoinvent 2.2 database [26] to provide regional data specific to the United States market. This LCI database was chosen to be used as there is no LCI database specifically made for the Canadian market. Environmental Product Declarations (EPDs) of CLT and GLT made by Nordic Structures [27, 28] were used to collect environmental impact information of the MTPs in this study, as the LCI dataset for CLT panels was not included in the current DATASMART Package. Data from the US LCI database [29] was used to simulate the transportation of the materials.

2.3 Life Cycle Impact Assessment

The Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts (TRACI) developed by the U.S. Environmental Protection Agency (EPA) [30] was used to assess several environmental impacts from the building materials in the whole building design. TRACI reports the environmental impacts in the categories of ozone depletion potential (ODP), global warming potential (GWP), smog formation potential (SFP), acidification potential (AP), eutrophication potential (EP), human health cancer, human health noncancer, eco-toxicity, fossil fuel depletion, land use, and water use. This study only focused on ODP, GWP, SFP, AP, and EP of the building and building design as these indicators are commonly used in EPDs.

2.4 Assumptions

Due to the limitations in data collection, a few assumptions were made for this study:

(1) Transportation distance for non-MTP building materials was assumed to be 177 km, which is the travel distance from Fredericton, NB, to another major city, Moncton in NB as most of the suppliers can be found in Moncton, NB, or within the 177 km range. The transportation method for this distance is diesel-powered, combination truck in a short-haul manner defined by the USLCI database [29].

(2) In order to study the effect of transportation of MTPs, multiple origin points of MTP were selected. These origin points were Moncton (New Brunswick), Halifax (Nova Scotia), Montreal (Quebec), Chibougamau (Quebec), and St. Thomas (Ontario) in Canada. Mass timber factories can be found in the latter three locations, while the first two locations are suitable for accommodating a mass timber factory in the future in these Regions of Atlantic Canada. Assumed transportation distances from these origin points were 177 km, 430 km, 813 km, 1099 km, and 1543 km. The transportation method for MTPs is diesel-powered, combination truck in a long-haul manner, except that the short haul when the origin point is Moncton, defined by the USLCI database [29].

(3) the design of the MTP version of the IUC Forestry Building applied the same column spacing from the head hall atrium design that is approved for structural integrity.

(4) Foundation and roof design were assumed to be the same for both MTP and steel frame buildings.

(5) Fasteners required for the connection of steel frames and mass timber structure were not included in this study.

2.5 LCA Model

The bills of materials were estimated and are given in Table 2, Table 3, and Table 4, which were used for this comparative LCA analysis of the whole building.

Table 2 Bill of material for roof and foundation of both versions of IUC Forestry Building.

Assemblies	Material name	Amount	Unit	Material name in LCI database
Roof	6 mil Polyethylene	6.77	kg	Packaging film, LDPE, at plant/US - US-EI U
	6" Normal Weight Concrete Block	13346.86	kg	Concrete block, at plant/US** US-EI U
	8" Normal Weight Concrete Block	75930.77	kg	Concrete block, at plant/US** US-EI U
	Concrete Benchmark CAN 30 MPa	70.34	m^3	Concrete, sole plate and foundation, at plant/US* US-EI U
	Expanded Polystyrene	1033.91	kg	EPS insulation board, at plant/kg/RNA
	Galvanized Decking	5392.43	kg	Galvanized steel sheet, at plant/RNA
	Metal Roof Cladding	1531.28	kg	Galvanized steel sheet, at plant/RNA
	Metal Wall Cladding	93957.26	kg	Brick, at plant/US - US-EI U
	Ontario (Standard) Brick	2910	kg	Reinforcing steel, at plant/US - US-EI U
	Rebar, Rod, Light Sections	7.11	m^3	Sawn lumber, softwood, planed, kiln dried, at planer, NE-NC/m^3/RNA
	Softwood Plywood	375.00	kg	Plywood, at plywood plant, US SE/kg/US
Foundation	4" Normal Weight Concrete Block	20919.69	kg	Concrete block, at plant/US** US-EI U
	Bolts, Fasteners, Clips	0.13	Tonnes	Steel, electric, chromium steel 18/8, at plant/US - US-EI U
	Concrete Benchmark CAN 30 MPa	447.14	m^3	Concrete, sole plate and foundation, at plant/US* US-EI U
	Expanded Polystyrene	135.4	kg	EPS insulation board, at plant/kg/RNA
	Ontario (Standard) Brick	5960.96	kg	Reinforcing steel, at plant/US - US-EI U
	Rebar, Rod, Light Sections	13.74	Tonnes	Brick, at plant/US - US-EI U
	Welded Wire Mesh/Ladder Wire	1.37	Tonnes	Steel, electric, chromium steel 18/8, at plant/US - US-EI U
	Wire Rod	0.38	Tonnes	Reinforcing steel, at plant/US - US-EI U

Table 3 Bill of materials for column, beams, floor and wall of steel frame IUC Forestry Building.

Assemblies	Material name	Amount	Unit	Material name in LCI database
Column and Beams	4" Normal Weight Concrete Block	9660.34	kg	Concrete block, at plant/US** US-EI U
	6" Normal Weight Concrete Block	6057.24	kg	Concrete block, at plant/US** US-EI U
	8" Normal Weight Concrete Block	24714.83	kg	Concrete block, at plant/US** US-EI U
	Expanded Polystyrene	378.87	kg	EPS insulation board, at plant/kg/RNA
	Hollow Structural Steel	4.62	Tonnes	Steel, low-alloyed, at plant/US - US-EI U
	Ontario (Standard) Brick	82484.46	kg	Brick, at plant/US - US-EI U
	Rebar, Rod, Light Sections	3.52	Tonnes	Reinforcing steel, at plant/US - US-EI U
	Small Dimension Softwood Lumber, kiln-dried	4.88	m^3	Sawn lumber, softwood, planed, kiln dried, at planer, NE-NC/m^3/RNA
	Steel Plate	0.02	Tonnes	Cold rolled sheet, steel, at plant NREL/RNA U
	Wide Flange Sections	133.26	Tonnes	Steel, low-alloyed, at plant/US - US-EI U
Floor	Concrete Benchmark CAN 30 MPa	140.98	m^3	Concrete, sole plate and foundation, at plant/US* US-EI U
	Galvanized Decking	17.38	Tonnes	Galvanized steel sheet, at plant/RNA
Wall	12" Normal Weight Concrete Block	11885.25	kg	Concrete block, at plant/US** US-EI U
	4" Normal Weight Concrete Block	53842.65	kg	Concrete block, at plant/US** US-EI U
	6" Normal Weight Concrete Block	455791.88	kg	Concrete block, at plant/US** US-EI U
	8" Normal Weight Concrete Block	204173.62	kg	Concrete block, at plant/US** US-EI U
	Expanded Polystyrene	1136.85	kg	EPS insulation board, at plant/kg/RNA
	Ontario (Standard) Brick	263963.05	kg	Brick, at plant/US - US-EI U
	Small Dimension Softwood Lumber, kiln-dried	6.78	m^3	Sawn lumber, softwood, planed, kiln-dried, at planer, NE-NC/m^3/RNA

Table 4 Bill of material for column, beams, floor, and wall of mass timber IUC Forestry Building.

Assemblies	Material name	Amount	Unit	Material name in LCI database
Columns and beams	Glulam Sections	196.15	m^3	Nordic GLT beam/Column
	Hollow Structural Steel	12543.30	kg	Steel, low-alloyed, at plant/US - US-EI U
	Wide Flange Sections	19402.10	kg	Steel, low-alloyed, at plant/US - US-EI U
Floor	Concrete Benchmark CAN 30 MPa	111.00	m^3	Concrete, sole plate and foundation, at plant/US* US-EI U
	Cross Laminated Timber	363.80	m^3	Nordic CLT panel
	Expanded Polystyrene insulation	771.85	kg	EPS insulation board, at plant/kg/RNA
	Galvanized Decking	5293.41	kg	Galvanized steel sheet, at plant/RNA
Wall	12" Normal Weight Concrete Block	11329.92	kg	Concrete block, at plant/US** US-EI U
	4" Normal Weight Concrete Block	41956.43	kg	Concrete block, at plant/US** US-EI U
	8" Normal Weight Concrete Block	152108.04	kg	Concrete block, at plant/US** US-EI U
	Expanded Polystyrene	1136.85	kg	EPS insulation board, at plant/kg/RNA
	Ontario (Standard) Brick	263963.05	kg	Brick, at plant/US - US-EI U
	Small Dimension Softwood Lumber, kiln-dried	6.78	m^3	Sawn lumber, hardwood, planed, kiln dried, at planer mill, SE/m^3/RNA
	Stainless steel Stud	9800.71	kg	Steel, electric, chromium steel 18/8, at plant/US - US-EI U
	Gypsum board	9449.34	m^2	Gypsum wallboard product, type X, 0.625 inch (15.875 mm)/m^2/RNA
	Glass wool sound insulation	5433.37	kg	Glass wool mat, at plant/US* US-EI U

3. Results

The building environmental impacts from stages A1-A4 of both building designs are presented in this section.

3.1 Manufacturing Materials on Environmental Impacts from Stages A1 to A3

The LCA results from the SimaPro model in this comparison showed that in the Products stage (A1-A3), the steel frame version of the IUC Forestry Building has a higher GWP than the MTP version of the IUC Forestry Building (Figure 3). Using the steel framed IUC Forestry Building as the baseline (282.43 kg CO_2 eq/m^2 of floor space), without considering transportation stage A4, the MTP version of the same building has 24.3% lower GWP at 213.67 kg CO_2 eq/m^2. Other impact categories show mixed advantages and disadvantages of the two buildings/designs. Near identical AP (1.0% higher for the mass timber building) for both buildings; much higher EP for the MTP version of the IUC Forestry Building, and lower ODP (16.8% lower), higher SFP (25.6% higher) for the MTP designed building when compared to the steel version structure.

Figure 3 TRACI method reported life cycle environmental impacts from the materials used in the two functional equivalent buildings from stages A1~A3.

3.2 Transportation of Building Materials on Environmental Impacts

Although most of the building materials can be acquired locally (within the 177 km range) except MTPs, the increase in transportation for MTPs could still cause a significant increase in the environmental impact of the MTP version of IUC Forestry Building.

With the inclusion of the transportation stage (A4), the result of environmental impact comparison of both buildings changed (Figure 4). The inclusion of transportation has little or even no impact on OD, but only small impact on GWP. However, the increase in AP, SP, and EP are more significant. The increase in EP is illustrated in Figure 5 with an aim to facilitate understanding Figure 4.

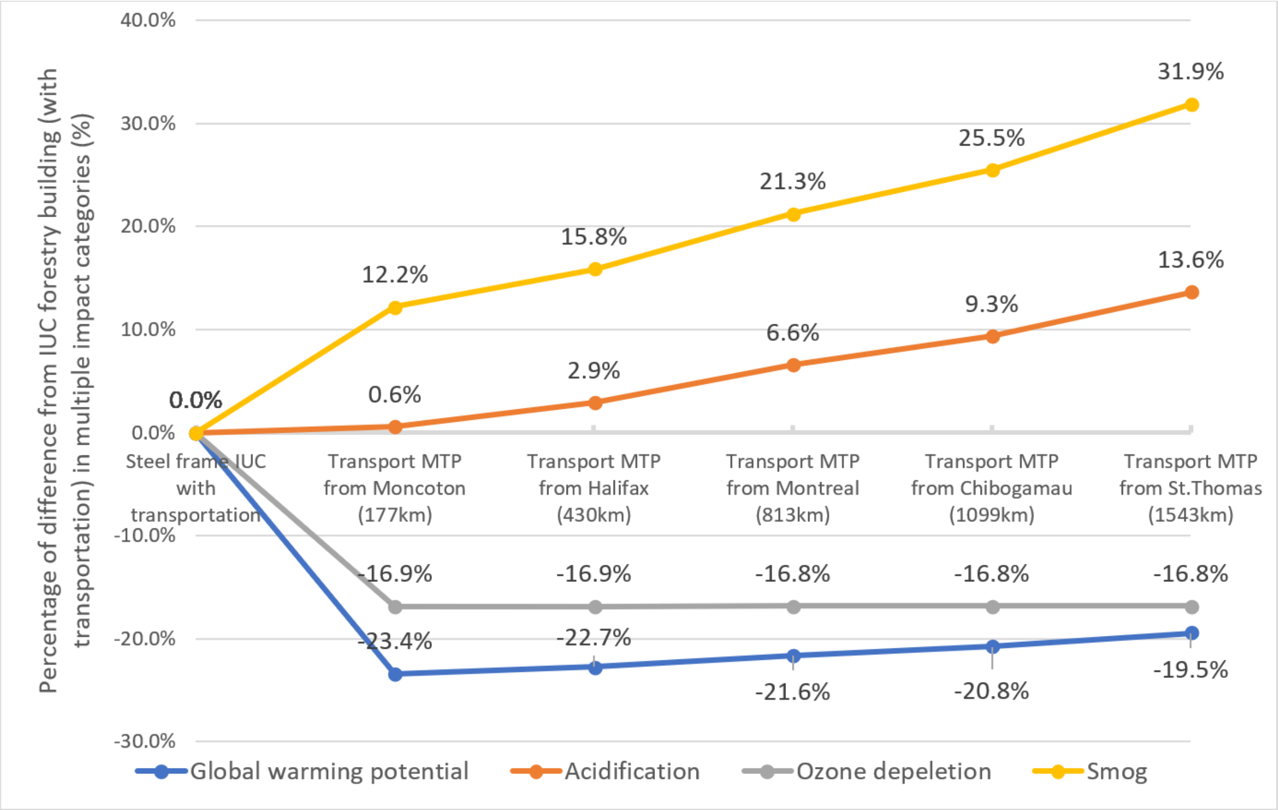

Figure 4 Comparing four environmental impact categories of IUC Forestry Building with transportation A4 stage to its mass timber counterpart by different transportation origins.

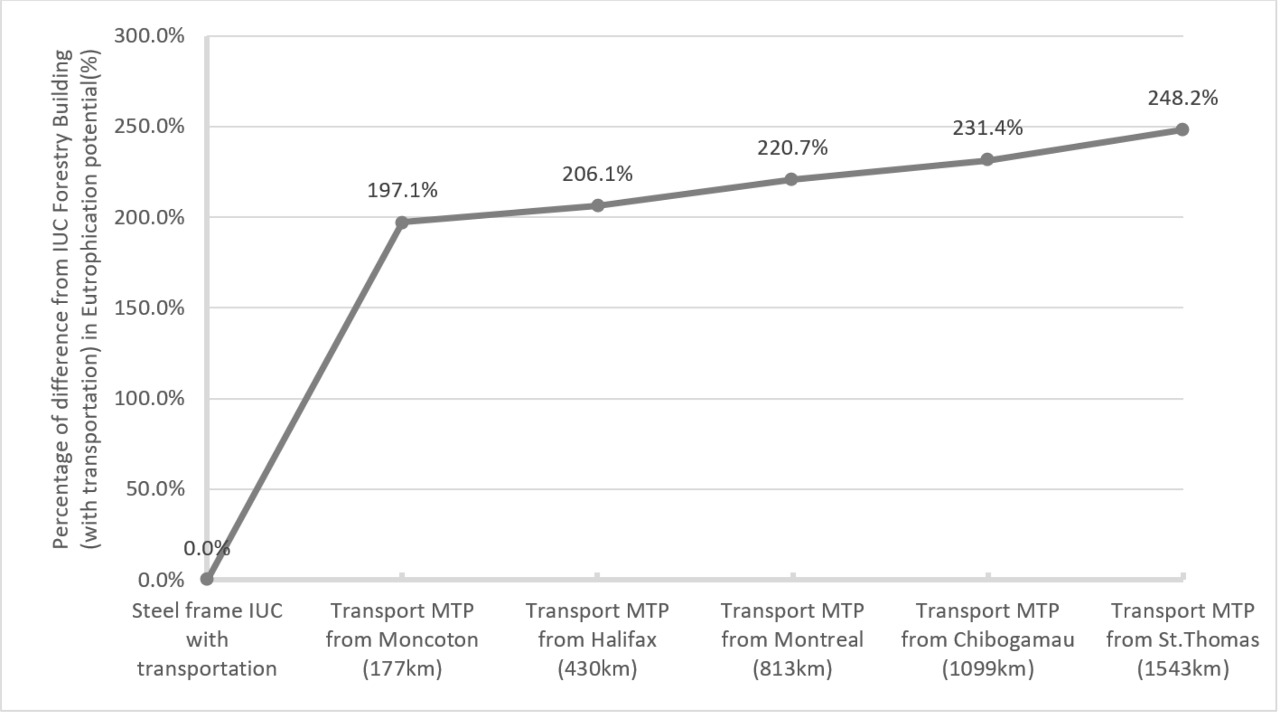

Figure 5 Transportation of MTPs influencing the eutrophication potential of IUC Forestry Building.

4. Discussion

4.1 The LCA Environmental Impacts of the Two Building Structures without Transportation Impact

Comparing the environmental impacts of two building structure types from the LCA results, it showed (Figure 3) that the mass timber version of IUC Forestry Building has lower impact in GWP and ODP but similar impact in AP. While the disadvantage can be found in higher SP and far higher EP for mass timber version of IUC structure. These results, exclude differences in EP, are aligned with the results of previous studies [14-16].

Huge difference in EP between the two structures is caused by the steel design of IUC Forestry Building using significant amount of steel products, which has very low EP in its product LCA result. The “galvanized steel sheet” LCI dataset was chosen from the database [29] that is used in the building LCA, and it has negative EP to the environment in the product LCA result. Such negative EP from galvanized steel sheet could be due to the recycled steel materials assumed in the production process of the galvanized steel sheet.

4.2 Carbon Sink Capability of Mass Timber Products

According to the data provided by EPD of MTPs [27, 28], application of 78911.47 kg of GLT beams and 149492.7 kg of CLT panels in the IUC Forestry Building to replace concrete and steel would store 4.15×10^5 kg of CO_2 in the building for 50-60 years. If combined with the LCA reported GWP, the total GWP result for the MTP version of the IUC Forestry Building will be further reduced to 170.91 kg CO_2 eq/m^2 (75.7% lower than the steel framed IUC Forestry Building even with MTPs transported from St. Thomas, i.e., 1543 km away). The service life span of institutional buildings was assumed to be 50~60 years [6, 7, 31]. Without the end-of-life scenarios for MTPs in New Brunswick, the destination of carbon stored in MTPs remain unknown. Although in the worst-case scenario the stored carbon in MTPs could be released back into the atmosphere through the biodegradation of wood, a study conducted by Campbell [32] examining knowledge gaps with MTPs showed different possibilities. Campbell [32] studied the end-of-life scenarios for MTPs and indicated that it is unlikely for MTPs to be disposed of in a landfill due to environmental legislation and demand for wood fiber. This gives hope that part of the carbon sinking benefit of MTPs can be preserved after the service life of the building by recycling MTPs for wood fiber.

4.3 Impact of Transportation for MTPs on Overall LCA Result

Although the transportation distance for the MTPs used in the IUC Forestry Building is relatively farther than that for the original IUC Forestry Building materials, the transportation of MTPs did not have a significant impact on the overall GWP and ODP of the mass timber version of the IUC Forestry Building. Adding transportation impact in the LCA results reduced the advantage of the mass timber IUC Forestry Building in GWP from 24.3% lower than steel framed building to 19.5% in the worst-case transportation scenario. The GWP benefit is considered a significant advantage for the IUC building structure design with MTPs. The results of this study are consistent with previous comparative whole building LCA studies where mass timber buildings were found to have about 20% lower GWP compared to traditional buildings over the span of the cradle-to-gate stages [13, 15, 16]. However, the transportation of MTPs has shown a greater influence on other environmental impact categories. With AP of mass timber building was increased to 13.6% from 1.0% and SFP increased to 31.9% from 25.6% as compared to the steel frame building, assuming the MTPs were sourced from St. Thomas. The degree of these two disadvantages could be lowered to 0.6% AP and 12.2% SFP if sourcing MTPs from Moncton. This lowering in disadvantage can be explained by the reduced weight of the building caused by using MTPs. The inclusion of transportation also reduced the difference in EP between the IUC Forestry Building and the mass timber design of the same building as transportation increased the EP of the IUC Forestry Building greatly.

From this study, it was shown that even with extended transportation distances, applying MTPs in construction still provides environmental benefits than the steel frame buildings in New Brunswick. These advantages include lower GWP and ODP. The disadvantages that came with mass timber building (higher EP, SFP, and slightly higher AP) could be reduced (measured by the difference in these impacts from the steel frame building) if MTPs were sourced locally and worsened when they were sourced from somewhere further. It is expected the findings from this LCA study will help the policy or decision-makers to determine building a future mass timber structure in New Brunswick and sourcing the MTPs domestically. It's worth mentioning that the establishment of a mass timber factory in New Brunswick could further reduce the environmental impacts of the transportation of the MTPs, yet it is unknown if this option is economically viable. This subject is beyond the scope of this study but should be investigated and determined by future research.

5. Conclusions

In this study, the environmental impacts from the whole building LCA study of the steel structured IUC Forestry Building located on the UNB Fredericton campus were compared to the mass timber design version of the IUC Forestry Building. This study showed that building a mass timber building in New Brunswick could result in lower GWP and ODP than constructing a traditional steel frame building using locally sourced materials. The increase in transportation distance for the MTPs didn't result in a significant increase in the overall GWP. Yet the disadvantage of using MTPs in buildings, for example, higher impacts in EP, SP, and AP, could be worsened by the long-distance transportation of MTPs. Having a mass timber factory in New Brunswick or other Atlantic provinces will reduce the degree of these disadvantages, but it is still necessary to study the economic viability of building such a factory.

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Author Contributions

Chang Gu—Conceptualization, data collection, data analysis, and manuscript preparation. Hongmei Gu—Technical advice, data analysis, supervision, and manuscript review. Meng Gong—Conceptualization, funding acquisition, supervision, and manuscript review. Janet Blackadar—Supervision and manuscript review.

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Competing Interests

The authors have declared that no competing interests exist.

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