Life Cycle Emissions Considerations for Mass Timber Construction

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SPDC
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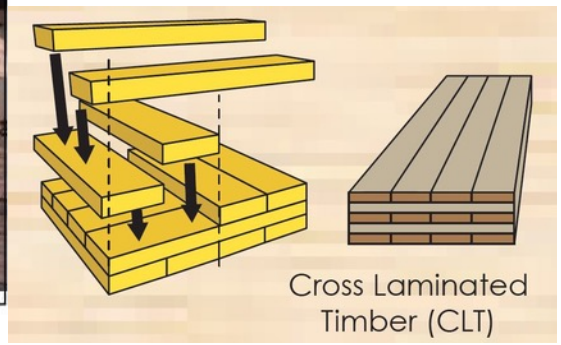
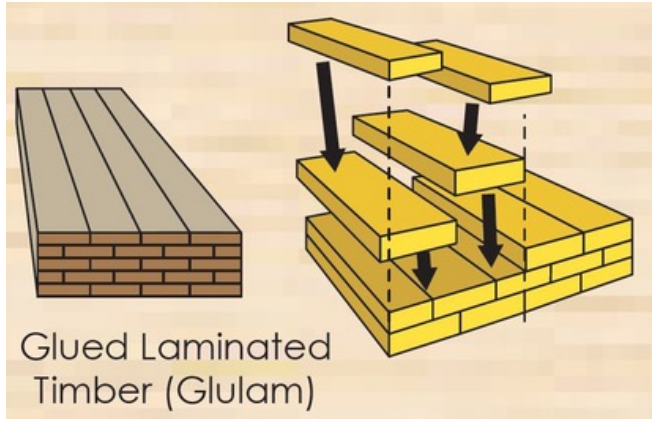
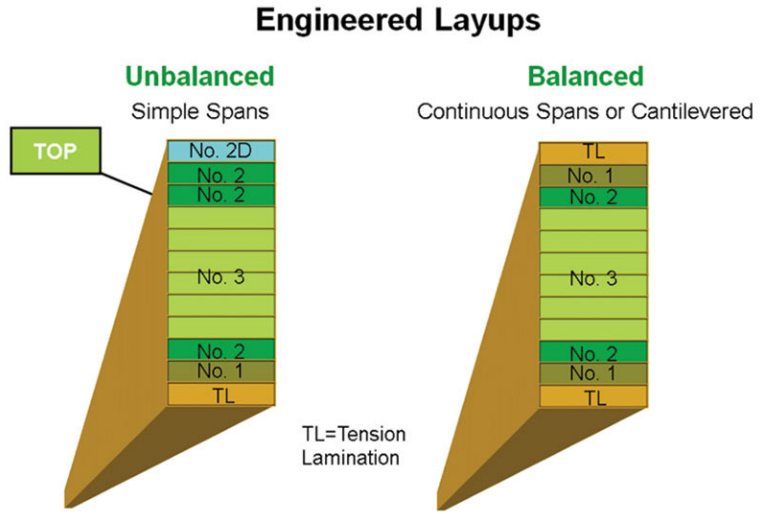
Image Source: https://c1.staticflickr.com/1/895/39309537140_07240b9d5c_b.jpg

What is Mass Timber Construction?





A structural panel consisting of three, five, or seven layers of dimensional lumber that are able to bear loads in and out of plane, which can be used as floor or wall system.



What is Mass Timber Construction?

https://c1.staticflickr.com/5/4735/38622803985_639d700a04_b.jpg

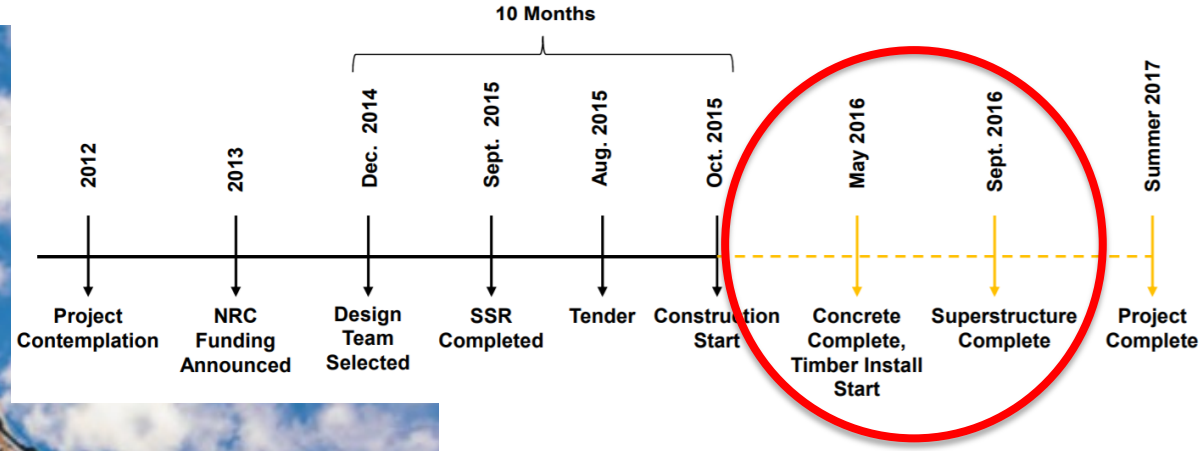
Source: http://www.woodworks.org/wp-content/uploads/2016-Tall-Timber-Workshop-Brock-Commons_Jackson.pdf

What is Mass Timber Construction?

Source: http://www.woodworks.org/wp-content/uploads/4-Story-CLT-Hotel-WoodWorks-Case-Study-Redstone-Arsenal-01-05-16.pdf

Mass Timber Construction – Time and Cost Benefits

Brock Commons – UBC, Vancouver, BC



TIMBER
192 $/ft²

Source: http://www.woodworks.org/wp-content/uploads/2016-Tall-Timber-Workshop-Brock-Commons_Jackson.pdf

Candlewood Suites – Redstone Arsenal. AL

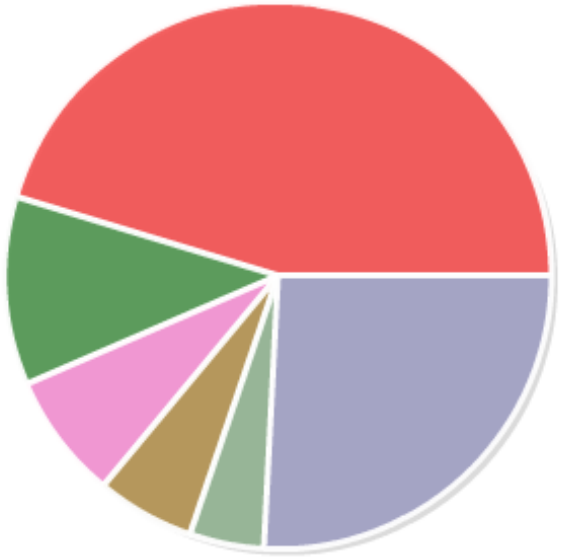
PAL Portfolio	Typical New PAL Hotel (Actual*)	Redstone Arsenal (Actual)	Difference
Gross square feet (sf)	54,891	62,688	+14%
Average # of employees	18 (peak 26)	10 (peak 11)	-43%
Structural duration (days)	123	78	-37%
Structural person hours	14,735	8,203	-44%
Structural production rate/day	460 sf	803 sf	+75%
Overall schedule	15 months	12 months	-20%

Source: http://www.woodworks.org/wp-content/uploads/4-Story-CLT-Hotel-WoodWorks-Case-Study-Redstone-Arsenal-01-05-16.pdf

Domestic Construction Sector LCA

Metric Tons of CO2 Equivalent (MTCO2E) used in : Commercial Structures, Including Farm Structures

Per **1 million dollars** of US commercial building construction activity:



2332A0 Commercial Structures, Including Farm Structures	187.8
221100 Electricity	46.1
327310 Cement	31.0
484000 Truck Transport	24.0
331110 Primary Iron, Steel, And Ferroalloy Products	18.2
All Other Sectors(486 remaining sectors)	106.9

Later On

Later On

Next Slides

Next Slides

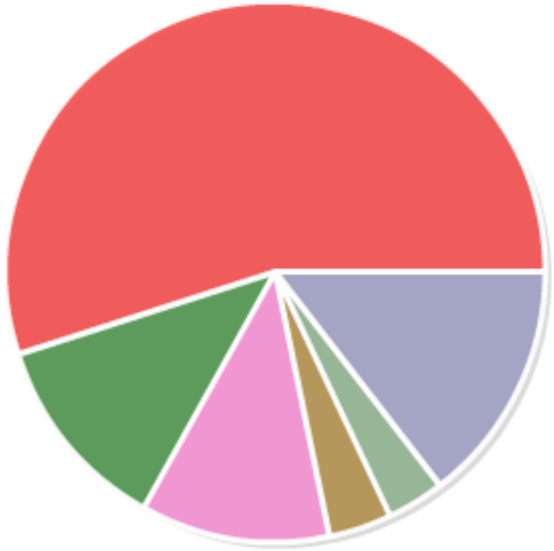
414 MT CO2 equivalent

Carnegie Mellon University Green Design Institute. (2019) Economic Input-Output Life Cycle Assessment (EIO-LCA) US 2007 (388 sectors) Producer model [Internet], Available from: <http://www.eiolca.net/> [Accessed 6 Feb, 2019]

Domestic Construction Sector LCA

Metric Tons of CO2 Equivalent (MTCO2E) used in : Primary Iron, Steel, And Ferroalloy Products

Per **1 million dollars** of US iron, steel, and ferroalloy manufacturing:



331110 Primary Iron, Steel, And Ferroalloy Products	758.2
221100 Electricity	165.4
212100 Coal	156.3
221200 Natural Gas	51.7
484000 Truck Transport	47.7
All Other Sectors(486 remaining sectors)	200.7

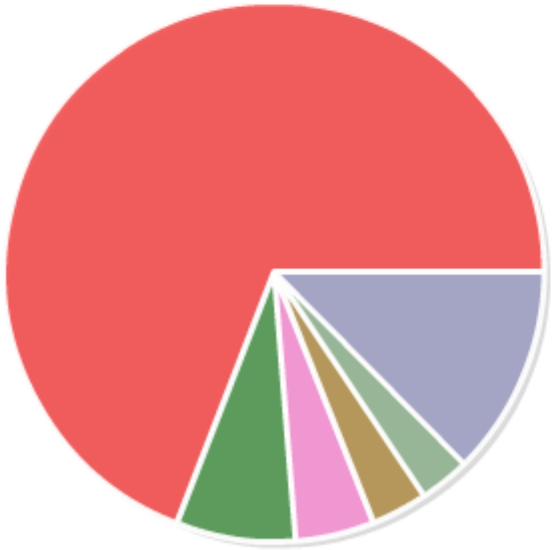
1,380 MT CO2 equivalent

Carnegie Mellon University Green Design Institute. (2019) Economic Input-Output Life Cycle Assessment (EIO-LCA) US 2007 (388 sectors) Producer model [Internet], Available from: <http://www.eiolca.net/> [Accessed 6 Feb, 2019]

Domestic Construction Sector LCA

Metric Tons of CO2 Equivalent (MTCO2E) used in : Ready-Mix Concrete

Per **1 million dollars** of US ready-mix concrete manufacturing:



327310 Cement	1.5K
221100 Electricity	160.2
327320 Ready-Mix Concrete	106.7
2123A0 Sand, Gravel, Clay, Phosphate, Other Nonmetallic Minerals	75.3
484000 Truck Transport	67.9
All Other Sectors(486 remaining sectors)	281.8

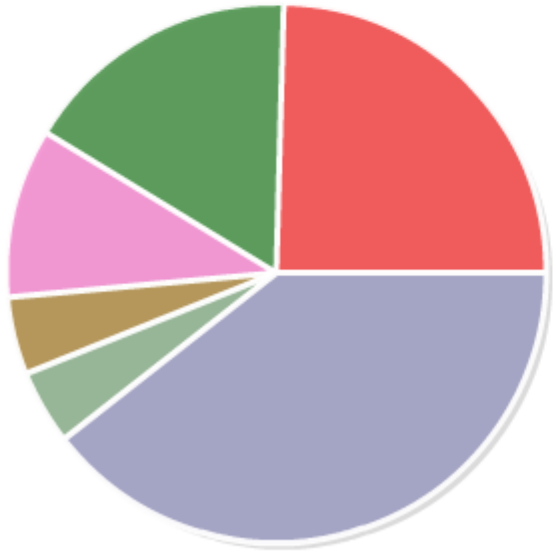
2,240 MT CO2 equivalent

Carnegie Mellon University Green Design Institute. (2019) Economic Input-Output Life Cycle Assessment (EIO-LCA) US 2007 (388 sectors) Producer model [Internet], Available from: <http://www.eiolca.net/> [Accessed 6 Feb, 2019]

Domestic Construction Sector LCA

Metric Tons of CO2 Equivalent (MTCO2E) used in : Veneer, Plywood, And Engineered Wood

Per **1 million dollars** of US veneer, plywood, and engineered wood manufacturing:



221100 Electricity	108.5
3219A0 Veneer, Plywood, And Engineered Wood	74.0
484000 Truck Transport	44.8
221200 Natural Gas	20.7
331110 Primary Iron, Steel, And Ferroalloy Products	19.8
All Other Sectors(486 remaining sectors)	174.2

442 MT CO2 equivalent

Carnegie Mellon University Green Design Institute. (2019) Economic Input-Output Life Cycle Assessment (EIO-LCA) US 2007 (388 sectors) Producer model [Internet], Available from: <http://www.eiolca.net/> [Accessed 6 Feb, 2019]

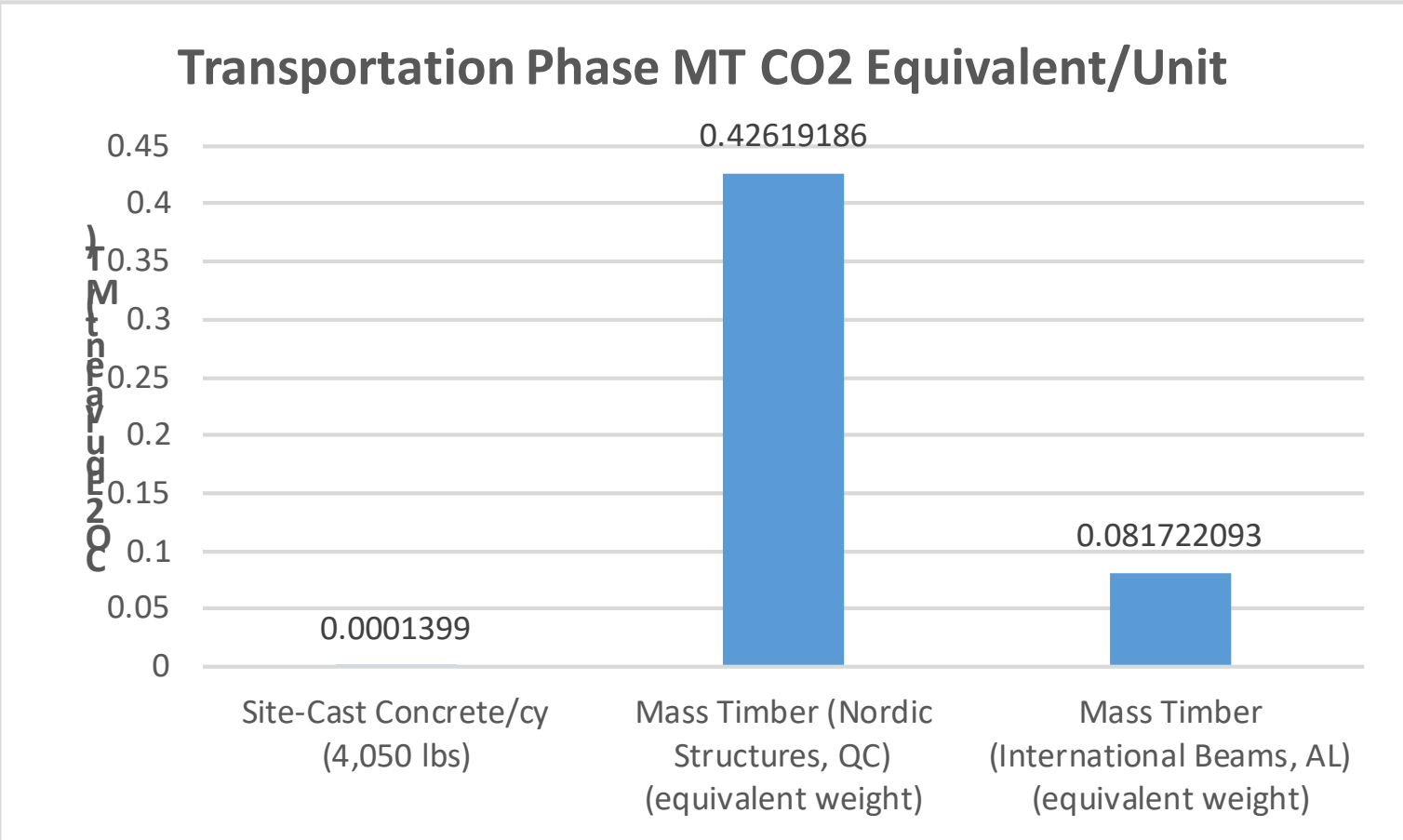
Environmental Impacts – Vehicle Usage

Redstone Arsenal Example:

- 45 fewer days (37% reduction) for structure
- 8 fewer workers onsite (43% reduction)
- 2006 Tier 3 emission standards capped engines >135 kW at 3.5 grams of CO/kWh

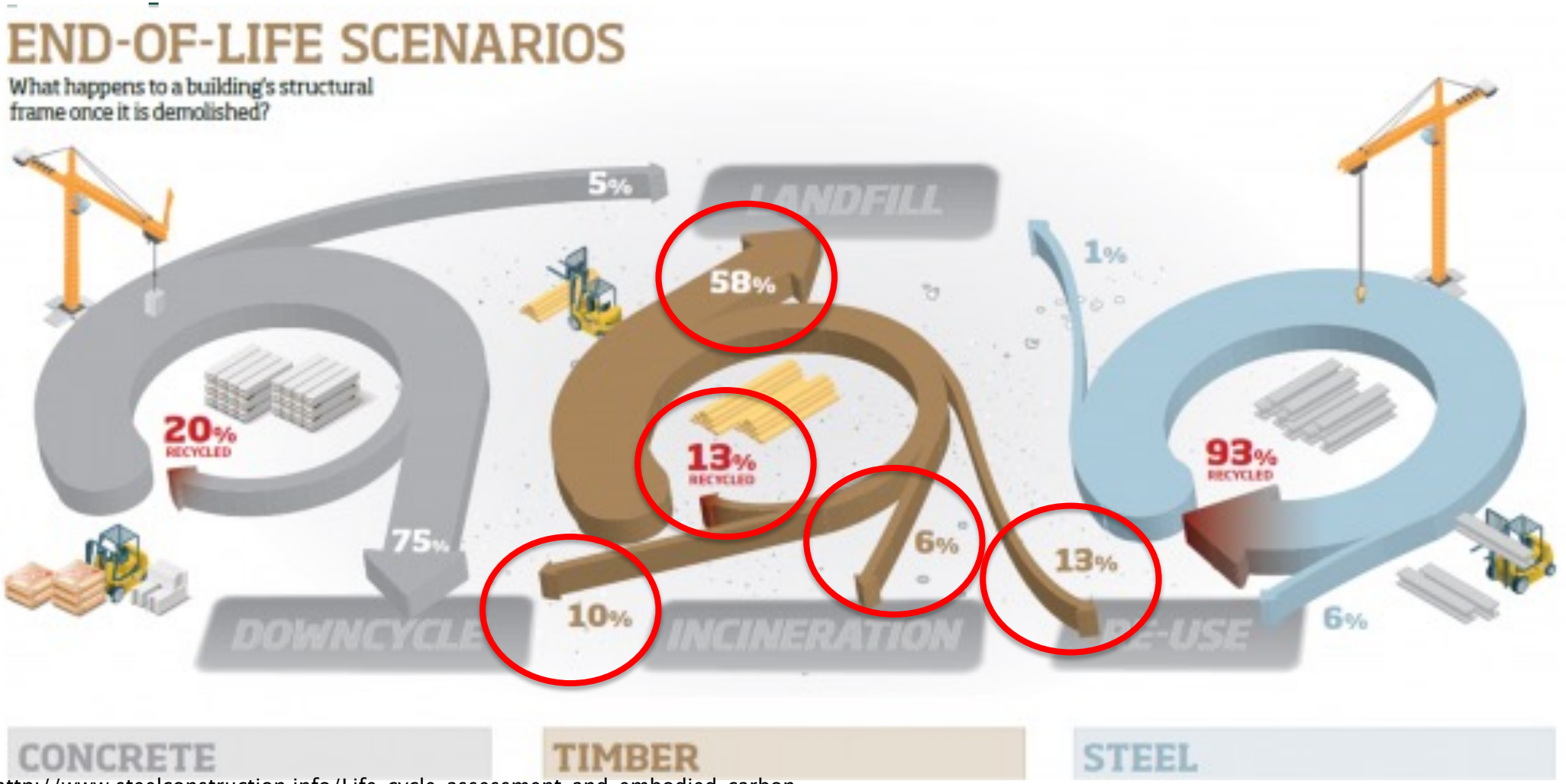
- This could mean, minimally:
    - 0.00126 MT CO reduced from cranes (without downsizing)
    - 0.00084 MT CO reduced from fewer crew vehicles over 3 month shorter duration

Environmental Impacts – Transportation

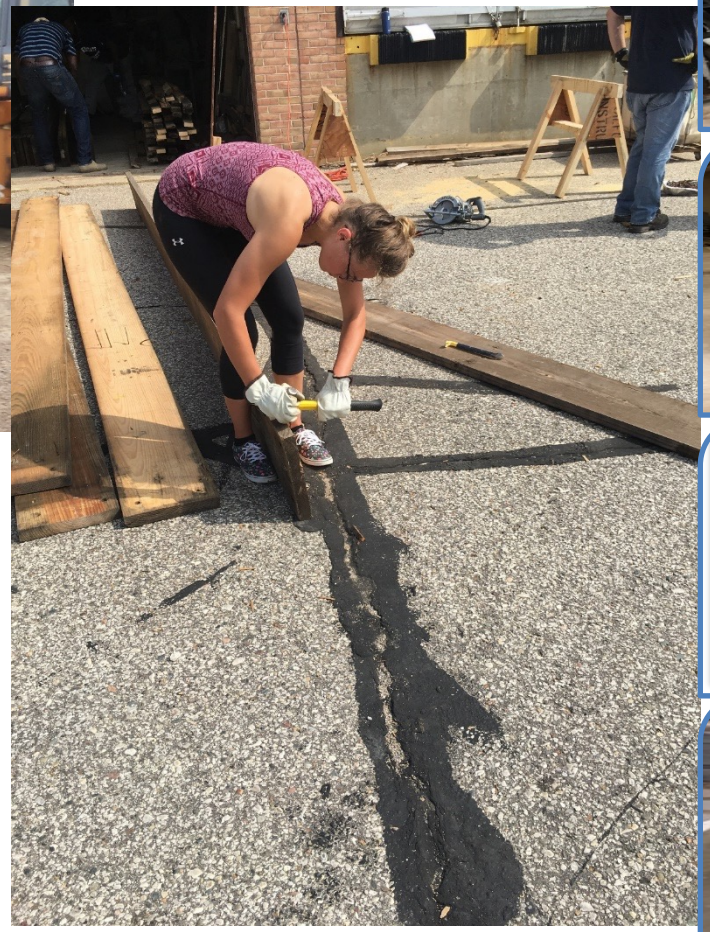


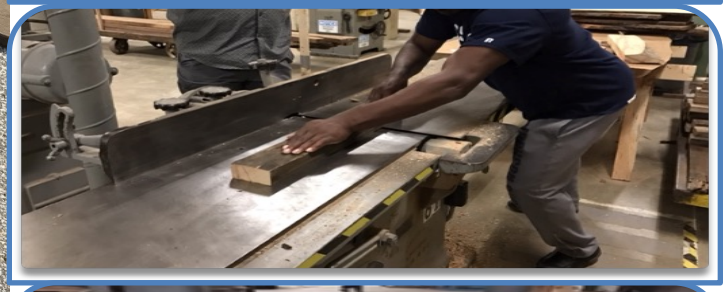
Mass Timber Construction – Benefits of Salvaged Lumber

Mass Timber Construction – Benefits of Salvaged

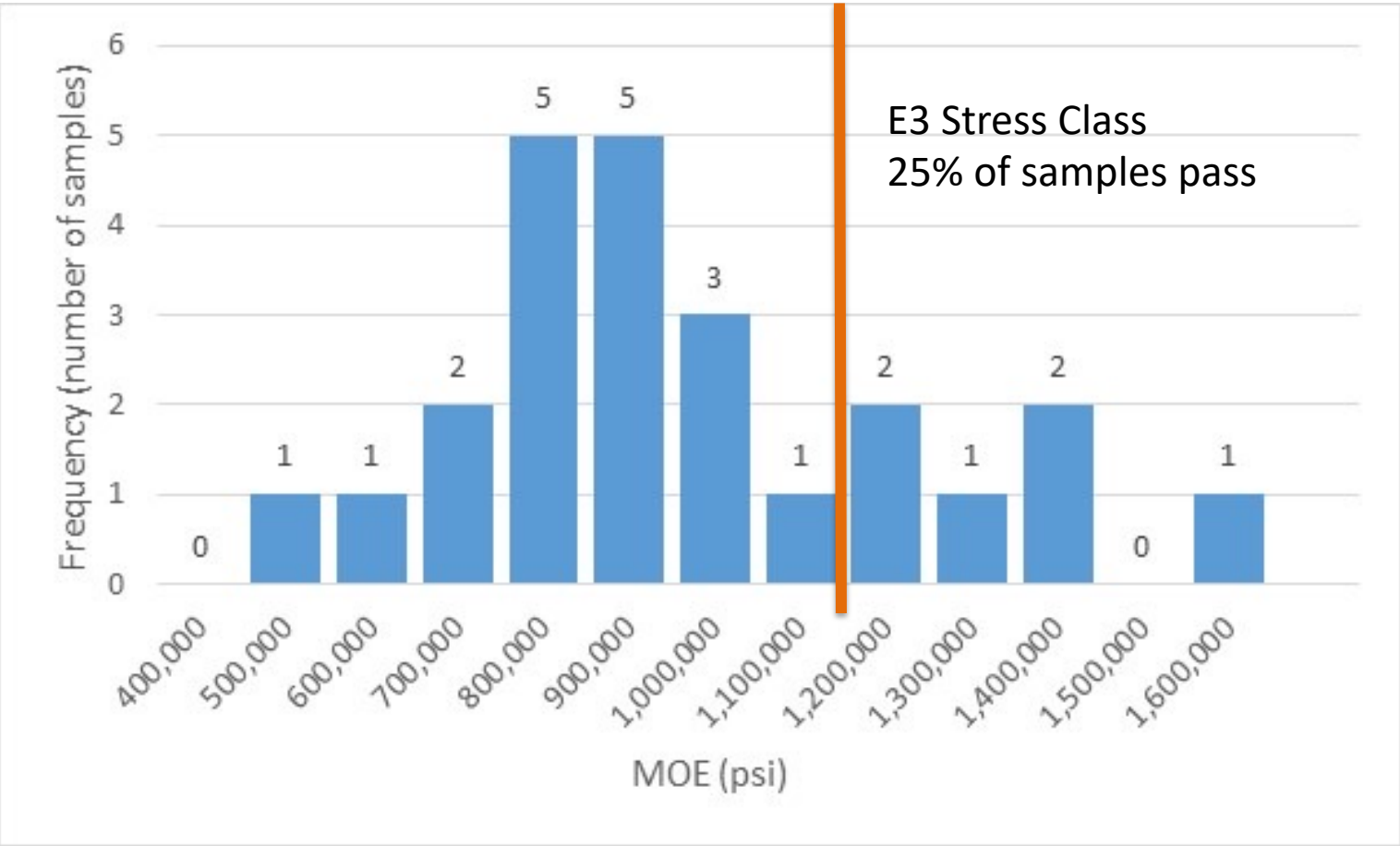


Source: http://www.steelconstruction.info/Life_cycle_assessment_and_embodied_carbon

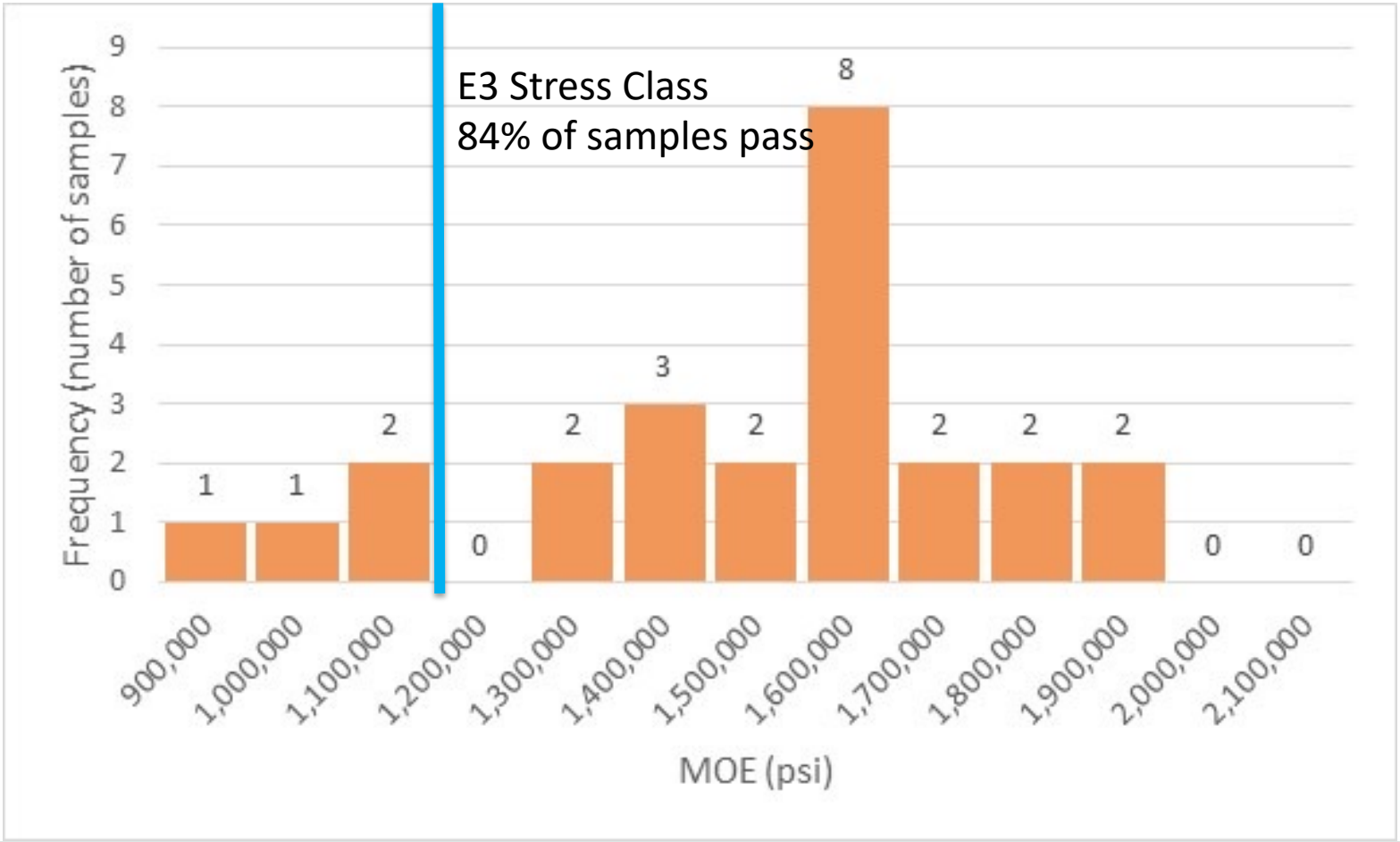




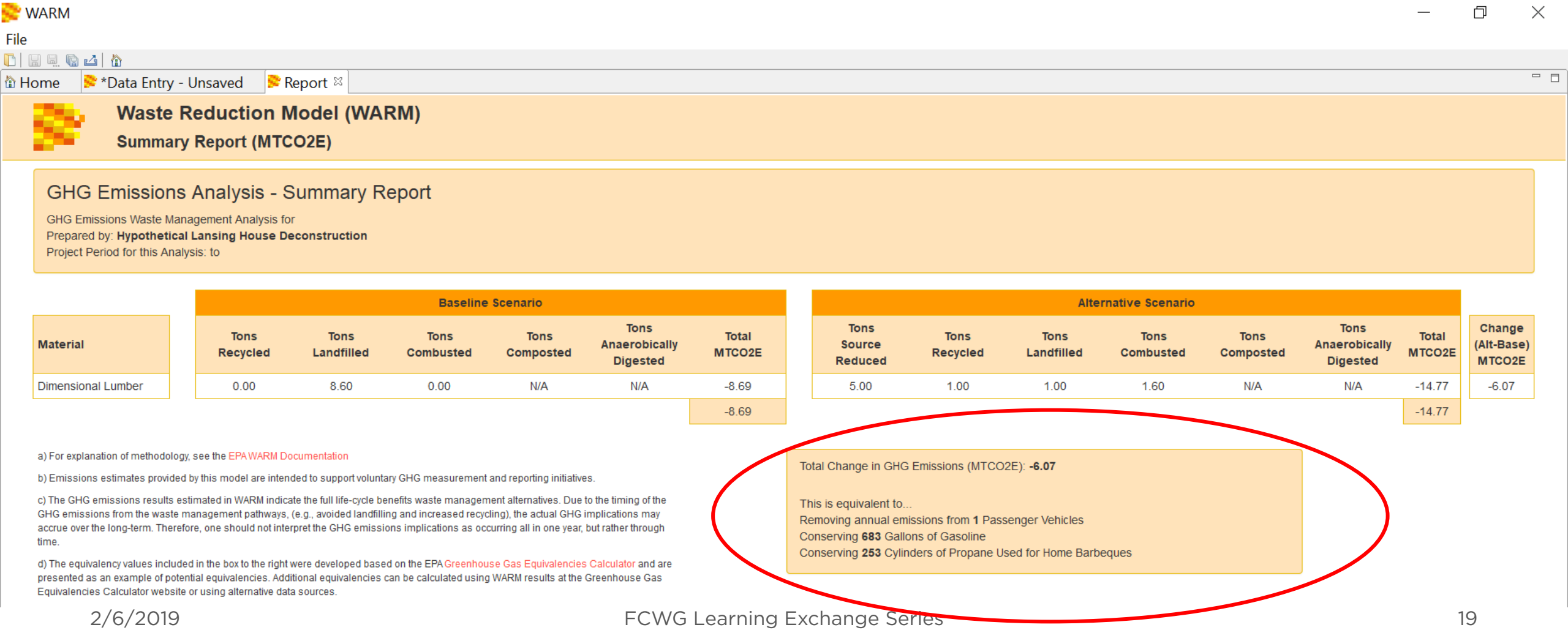
1902 Home – Larch Spp.



~1954 Home – Spruce and Pine Spp.



Mass Timber Construction – Benefits of Salvaged



WARM

File

Home | *Data Entry - Unsaved | Report

Waste Reduction Model (WARM)

Summary Report (MTCO2E)

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for
Prepared by: **Hypothetical Lansing House Deconstruction**
Project Period for this Analysis: to

	Baseline Scenario						Alternative Scenario							
Material	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E	Tons Source Reduced	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E	Change (Alt-Base) MTCO2E
Dimensional Lumber	0.00	8.60	0.00	N/A	N/A	-8.69	5.00	1.00	1.00	1.60	N/A	N/A	-14.77	-6.07
						-8.69							-14.77	

a) For explanation of methodology, see the EPA WARM Documentation

b) Emissions estimates provided by this model are intended to support voluntary GHG measurement and reporting initiatives.

c) The GHG emissions results estimated in WARM indicate the full life-cycle benefits waste management alternatives. Due to the timing of the GHG emissions from the waste management pathways, (e.g., avoided landfilling and increased recycling), the actual GHG implications may accrue over the long-term. Therefore, one should not interpret the GHG emissions implications as occurring all in one year, but rather through time.

d) The equivalency values included in the box to the right were developed based on the EPA Greenhouse Gas Equivalencies Calculator and are presented as an example of potential equivalencies. Additional equivalencies can be calculated using WARM results at the Greenhouse Gas Equivalencies Calculator website or using alternative data sources.

Total Change in GHG Emissions (MTCO2E): **-6.07**

This is equivalent to...
Removing annual emissions from **1** Passenger Vehicles
Conserving **683** Gallons of Gasoline
Conserving **253** Cylinders of Propane Used for Home Barbeques

Innovation in Materials Reuse

That's about:
- 181 million end tables
- 9 million dining tables
- 4.5 million picnic tables
- 531 Brock Commons projects!

- MSU's work focuses on increasing the yield of high-volume, low-value materials

Location	Number of Abandoned Homes	Approximate Volume of Salvageable Lumber	Equivalent # of Trees
Michigan	225,946	903,784,000 BF	1,246,598
Midwestern US	1,379,720	5,518,880,000 BF	7,612,248
United States	5,813,286	23,253,144,000 BF	32,073,302

Data Sources and Notes:
- MSU Center for Community and Economic Development (2016). Muskegon, Michigan Deconstruction Economic Cluster Feasibility Study.
- US Census Bureau (2016). American Community Survey, Vacant Housing Units.
- BF=board foot = a piece of lumber 12"x12"x1"
- Tree equivalent is a tree of 24" diameter producing 4 16' logs

Mass Timber Construction – Use Phase Energy Benefits

- Hypothetical 1,000sf building module located in upper Midwest
- Design options are glulam/CLT and concrete and steel and concrete
- Modeled using eQuest with the DOE2 simulation engine
- CLT/Concrete
  - Total annual BTUs: 108,568,458
- Steel/Concrete
  - Total annual BTUs: 116,376,573
- Total Difference
  - Mass Timber consumes 7,808,115 BTUs less per year
  - 6.7% savings

Future Research

- Predictive time and cost tool development (currently USFS funded)
- Full LCA model development for mass timber building prototypes
- Crane usage model

Thank You!

Questions?

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