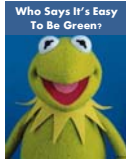


Introduction

- Green Building is Everywhere!
 - But what is it?
 - Are we green?
 - Why be green?



Green Building Principles

- Environmental Factors
 - Amount of resources used
 - Amount of pollution created
- Economic Factors
 - Cost of products
 - Cost of operation
- Social/Human Health Factors
 - Social Equity
 - Buildings do not adversely affect human health

“Slow Green Simmer”

- Green products and buildings are expected to grow tremendously even in the current economic climate
- Avoid greenwashing!
- Positioning and repositioning of products and buildings to take advantage of green

Post-Frame Buildings Have, Been, Will Be Green!

- White paper series by T&R Committee
- More to Come!
- Giving Ourselves Credit



http://www.nfba.org/files/public/Putting_the_Green_Into_Post_Frame_Final.pdf

Moving Forward

**To Avoid Greenwashing
And Demonstrate Value, We
Must Demonstrate the
Green Value of Post-Frame
Buildings**

Quantitative Measures of Green

- Quantitative = Distinct, Measurable
- Measures Are Lacking
- Examination of 'Life Cycle' of a Structure
 - Manufacturing (Including Extraction)
 - Construction
 - Operations and Maintenance
 - End-of-Life (Deconstruction, Demolition)

Life Cycle Terms

- Life Cycle Analysis – Cataloging all the inputs and outputs involved in building a structure
- Life Cycle Costing – Describing all the phases of a building in terms of costs

Life Cycle Analysis

- Study and interpretation of the environmental inputs and outputs of a building
- Consider all stages of building life cycle
- Life cycle inventory (LCI) of products used as the database
- Addition/Compilation of LCI data to account for building performance
- Output = Environmental Indicators

Life Cycle Analysis – Environmental Indicators

Indicator Name	Units
Global Warming Potential	Tons CO ₂ Equivalent
Stratospheric Ozone Depletion	Tons Halon Equivalent
Ground Level Ozone	Tons Projected Ozone
Acidification	Tons SO ₂ Equivalent
Eutrophication	Tons Phosphate Equivalent
Aquatic Toxicity	Tons Toxic Equivalent
Human Health	Tons Toxic Equivalent
Fossil Fuel Depletion	Tons Oil Equivalent
Mineral Depletion	Tons Mineral Equivalent (by Mineral)
Water Depletion	Volume of Water Equivalent (Surface and Groundwater)
Land Use	Equivalent Area of Endangered Species and Non-Endangered Species Habitat

**Life Cycle Analysis –
Interpretation of Results**

- Use of environmental indicators is not dictated by many LCA programs
- Weighting is left up to LCA users
- Considerations for weighting
 - Geographical
 - Landscape
 - Type of Structure
 - Concerns of Owner

LCA – What Is It Good For?

- Marketing of Products
- Supplier Decisions
- Design Choices or Product Use
- Benchmarking Within A Company (Multiple Facilities)
- Year to Year Tracking of Energy and Material Use
- Management and Policy (Importance of Environmental Indicators)
- Green Building Certification Systems
- Technical Data for Architects and Engineers

Life Cycle Costing

- Determine cost of structure over lifetime
- Purely an economic assessment
- Main Use is Purchasing Decisions (US Government, Corporations)
- Account for more than initial price of building

Life Cycle Costing – Basic Formula

LCC = Initial Cost + Replacement Cost – Resale Cost
+ Life(Operations, Maintenance, Repair Costs)

- LCC decisions based upon:
 - Real Estate prices
 - Cost of energy
 - Inflation
 - Depreciation Rate
- See Any Difficulties With LCC's?

LCA and LCC Computer Programs

- A variety of free and commercial software programs are available
- LCA software uses an LCI database (public or private)
- LCC software focuses on energy modeling to determine the operations costs

Post-Frame Market Initiative (PFMI)

- Help post-frame construction identify green attributes
- Position post-frame buildings for success in market
- Help post-frame professionals with tools and techniques to demonstrate their role in green buildings

Project Goal: Develop LCA and LCC Tools To Account for Sustainable Attributes of Post-Frame Construction

Objectives:

- 1) Develop LCA Tools for Post-Frame
- 2) Explore LCC Tools for Post-Frame
- 3) Develop Example LCAs for Post-Frame

Objective 1 : LCA Tools

- All LCA software requires a type of building construction
 - Where to locate building components
 - Compiling features
- No LCA software includes post-frame construction!
- Decision to use a conventional construction design and modify to create a post-frame structure

Objective 1: LCA Program Choice

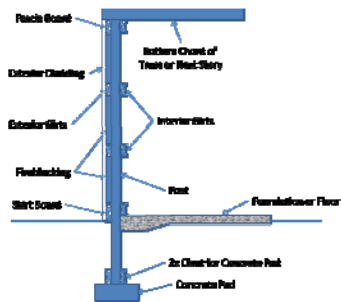
- *Impact Estimator for Buildings* by ATHENA Institute and Morrison-Hershfield was chosen
- Choice based on graphical outputs, ease of use, ability to compare different designs
- <http://athenasmi.org/tools/impactEstimator/order.html>
- Disclaimer: PFMI, NFBA, and Hindman are NOT endorsing this LCA program. Similar procedures discussed can be adapted for other LCA programs.

Objective 1 : LCA Tool

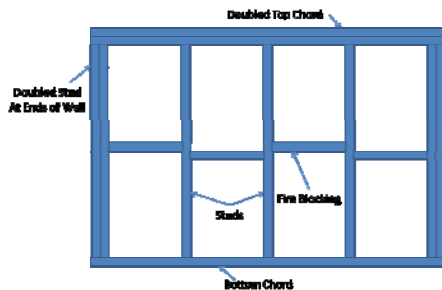
- The tool created is a spreadsheet to create an equivalent conventional construction structure based on a post-frame structure
- Uses 'Extra Basic Materials' feature
 - Addition or subtraction of extra materials

Post-Frame Structure = Conventional Structure
+/- Extra Basic Materials

Objective 1 : Post-Frame Structure



Objective 1 : Conventional Wall Structure



Objective 1: Roof Modifications

- Automatic assumptions made in the *Impact Estimator for Buildings* must be removed
- Roof modifications (as needed) included:
 - Spacing of trusses different than 2 feet on center
 - Removal of OSB

'Roof' Spreadsheet

Roof -		
L	Longest Truss	26ft
J	Longest roof section (perpendicular to truss)	26ft
F	Type of Roof (G: Gypsum, W: Wood, M: Metal)	M
T	Truss spacing	2ft
SE	OSB thickness	0.75
Additional Wood Calculator		
W	width of joist	6ft
H	depth of joist	6ft
L	length of joist	0.875
W	additional wood material	0 M/bf
T	volume of truss	-0.60762 M/bf
W	volume of purlins	0.1785 M/bf
Extra Materials for Roof 1 in Impact Calculator for Buildings		
Wood	Additional Lumber, Small Dimension, 1/2" thick	0.43911 M/bf
Steel	Other Lumber/Steel	-0.97231 M/bf

Inputs of Roof System

Calculation Cells

Inputs for "Extra Basic Materials"

Objective 1 : LCA Tool

- Spreadsheet capabilities
 - 8 wall types
 - 4 roof types
- Available on NFBA website after conference
- Accompanying report contains all equations for calculations made
- Spreadsheet calculation cells are protected

Objective 2 : Explore LCC Programs

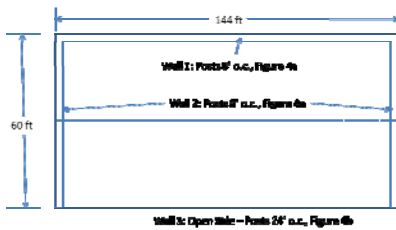
- LCC is much more complicated than LCA
- *eQUEST* was chosen for graphical outputs and ease of use
- Disclaimer: PFMI, NFBA and Hindman do not endorse the LCC program
- Tools for LCC could not be produced because of energy modeling used
- LCC is provided for information only

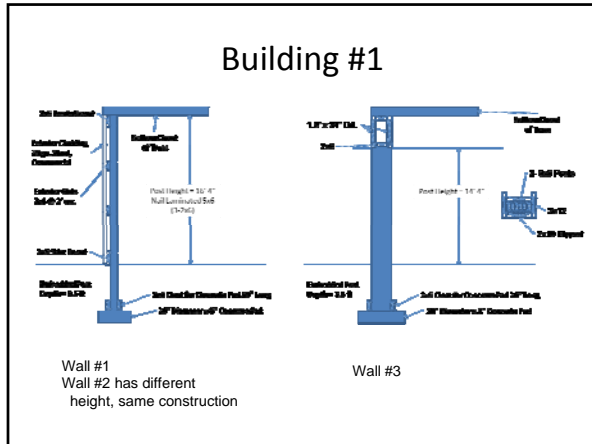
Objective 3 : LCA Examples

- Three different post-frame buildings are discussed
- Goal is to demonstrate how to perform a post-frame LCA
- Individuals can compare post-frame buildings with other types of buildings using LCA programs and LCA tools – not the objective of this study

Building #1

- 8,640 sq. ft. open sided machine shed





- ### Building #1
- 3 walls, 1 roof
 - Only components of the building are post-frame walls
 - Wall #1 : Sidewall with 2x6 Equivalent Wall
 - Wall #2 : Combined length 2 Endwalls with 2x6 Equivalent Wall
 - Wall #3 : Sidewall without 2x6 Equivalent Wall

Walls Input Sheet

Items	Wall # 1	Wall #2 - Both Endwalls	Wall #3 - Open Wall
Length of Wall	144 ft	120 ft (2 60 foot walls)	144 ft
Height of Wall	16.333 ft	21.333 ft	14.333 ft
Spacing of Posts	8 ft	8 ft	24 ft
Width of Post	4.5 in	4.5 in	8.5 in
Depth of Post	5.5 in	5.5 in	12 in
Embedment Depth of Post	3.5 ft	3.5 ft	3.5 ft
Type of Post	Nail Laminated (3-2x6)	Nail Laminated (3-2x6)	Nail Laminated (3-2x6 surrounding 2x10 and 2x12)
Nail Density Per Foot	5 nails/ft	5 nails/ft	5 nails/ft
Depth of Shearboard	7.25 in	7.25 in	N/A
Depth of Fascia	5.5 in	5.5 in	N/A
Girts Exterior or Double Sided ?	Exterior	Exterior	N/A
Depth of Girt	3.5 in	3.5 in	N/A
Depth of Girts	5.5 in	5.5 in	N/A
Spacing of Girts	2 ft	2 ft	N/A
Depth of Finblocking	N/A	N/A	N/A
Depth of Embedment Clear	5.5 in	5.5 in	5.5 in
Length of Cleat	20 in	20 in	20 in
Diameter of Concrete Pad	20 in	20 in	20 in
Height of Concrete Pad	8 in	8 in	8 in

Walls Calculations and Extra Basic Materials Sheets

Items	Wall # 1	Wall #2 - Both Endwalls	Wall #3 - Open Wall
Volume of Posts	0.777206 Mbf	0.819489 Mbf	1.061064 Mbf
Volume of Slatboard	0.1305 Mbf	0.10875 Mbf	0 Mbf
Volume of Fencing	0.099 Mbf	0.0825 Mbf	0 Mbf
Volume Girts	0.441 Mbf	0.4725 Mbf	0 Mbf
Volume Cleat Embedded	0.043542 Mbf	0.036667 Mbf	0.016042 Mbf
Volume of freeloading Stud Wall	0 Mbf	0 Mbf	0 Mbf
Volume of Additional Wood Material	0 Mbf	0 Mbf	1.135 Mbf
Volume of Equivalent Stud Wall	1.604428 Mbf	1.662182 Mbf	N/A ¹
Items	Wall # 1	Wall #2 - Both Endwalls	Wall #3 - Open Wall
Softwood Lumber, Small Dimension, kiln dried	-0.11318 Mbf	-0.142276 Mbf	2.2122545 Mbf
Glulam Beams	0 ft ³	0 ft ³	0 ft ³
Softwood Lumber, Large Dimension, green	0 Mbf	0 Mbf	0 Mbf
3000 psi Concrete, Average flyash	0.96963 yd ³	0.80802 yd ³	0.323209 yd ³
Nails	0.044999 tons	0.048979 tons	0.024863 tons

Roof Input/Output Sheet for Building #1

Roof Inputs	
Truss Span	60 ft
Length of Building	144 ft
Truss Spacing	8 feet on center
Purlin Spacing	2 feet on center
Roof Outputs - Extra Materials Section	
Softwood Lumber, Small Dimension, Kiln Dried	-6.880652 Mbf
Oriented Strand Board	-11.5049 msf (3/8" basis)

Combined 'Extra Basic Materials' for Building #1

Material	Quantity
Softwood Lumber, Small Dimension, kiln dried	-4.92356 Mbf
Oriented Strand Board	-11.5049 msf, 38" basis
Glulam Beams	0 ft ³
Softwood Lumber, Large Dimension, green	0 Mbf
3000 psi Concrete, Average flyash	2.100859 yd ³
Nails	0.11842 tons

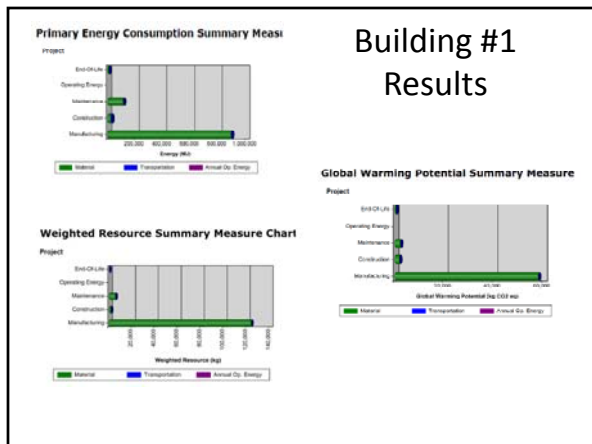
Building #1 Results :Bill of Materials

- Generated by *Impact Estimator for Buildings*
- Helpful to make sure all components included

Material	Quantity	Unit
#15 Organic Felt	417.9815	100sf
Concrete 20 MPa (Type II)	2,2059	yd ³
Galvanized Sheet	4,7111	Tons
Nails	9,2660	Tons
Oriented Strand Board	0.0000	sm ² (100 Sides)
Residential 30 gal Steel Cladding	16226.1193	sf
Screws Nuts & Bolts	0.0220	Tons
Small Dimension Softwood Lumber, Green	0.7430	Mcfm
Small Dimension Softwood Lumber, kiln-dried	11.7770	Mcfm
Solvent Based Alkyd Paint	185.7190	US Gallon
Water Based Latex Paint	155.4320	US Gallon

Building #1 Results: Environmental Indicators

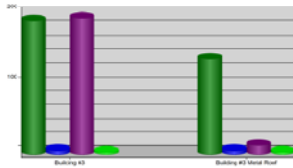
- A number of environmental indicators (listed in the LCA discussion section) can be found in the *Impact Estimator for Buildings*
- Indicators can be viewed in terms of life cycle stage of structure
- Note for examples: No operating energy was included for any of the designs



Comparison of Building #3 – Roof Types

- Comparison between asphalt shingles and metal roofing

Comparison Of Global Warming Potential By Life Cycle

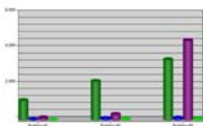


Comparison of All Buildings

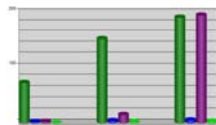
Indicator	Building #1	Building #2	Building #3
Primary Energy Consumption, MJ	1.05x10 ⁶	9.38x10 ⁵	9.73x10 ⁵
Weighted Resource Use, kg	1.31x10 ⁵	2.23x10 ⁵	1.11x10 ⁵
Global Warming Potential, kg CO ₂ Eq.	6.29x10 ⁵	6.12x10 ⁵	4.76x10 ⁵
Acidification Potential, moles H ⁺ Eq.	2.32x10 ⁵	3.18x10 ⁵	2.565x10 ⁵
Human Health Respiratory Effects Potential, kg PM2.5 Eq.	1.32x10 ⁵	2.48x10 ⁵	1.66x10 ⁵
Eutrophication Potential, kg N Eq.	2.15x10 ³	2.54x10 ³	1.38x10 ³
Ozone Depletion Potential, kg CFC-11 Eq.	1.80x10 ⁻⁴	1.26x10 ⁻⁴	3.54x10 ⁻⁴
Smog Potential, kg NO _x Eq.	2.50x10 ²	3.24x10 ²	2.51x10 ²

Comparison of All 3 Buildings

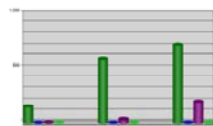
Comparison Of Primary Energy Consumption By Life



Comparison Of Global Warming Potential By Life Cycle



Comparison Of Weighted Resource By Life Cycle Stages



Conclusions

- LCA can help quantify the performance of buildings
- Spreadsheet tool can be used to perform LCA analysis of post-frame buildings
- LCC programs need to be explored further, but are not currently used to evaluate green buildings
- Spreadsheet, example files and report will be available on the NFBA website after the conference

For More Information

- ATHENA Institute *Impact Estimator for Buildings*
<http://athenasmi.org/tools/impactEstimator/order.html>
- eQUEST <http://doe2.com/equest/>
- "LCA for Mere Mortals"
<http://iere.org/store/products/88-life-cycle-assessment-for-mere-mortals.aspx>
