Wood Products Life Cycle Analysis: New research shows the environmental benefits from using wood

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College of Forest Resources, University of Washington

And
President CORRIM
Consortium for Research on Renewable Industrial Materials
A non-profit corporation formed by 15 research institutions to conduct cradle to grave environmental studies of wood products
Roadmap of Presentation

• Objectives and Methodology: LCI/LCA
• Scope of CORRIM Phase I Study
• Environmental Performance through Building Construction (opportunities for improvement)
• Through Building Use, Maintenance & Disposal
• Carbon pools from Forests to Buildings
• Conclusions & Scope of Phase 2 Extensions
Study Objectives

• To develop a public database and models of environmental performance measures over the life cycles of wood products used in residential buildings

• To examine a range of management, product, and process alternatives to identify strategies to improve environmental performance
Life Cycle Assessment of Wood Products & Buildings

- Management & Harvest
- Production
- Construction

Air Emissions

Water & Land Emissions
Life Cycle Inventory Analysis

- MATERIALS
  - Forest Management (Regeneration)
  - Raw Material Acquisition (Harvest)
  - Product Manufacturing
  - Building Construction
  - Use/Maintenance
  - Recycle/Waste Management

- ENERGY

- WATER

- OTHER RELEASES
  - EMISSIONS
  - EFFLUENTS
  - SOLID WASTES
  - OTHER RELEASES

- PRODUCTS
  - Useful life of house

- COPRODUCTS

System Boundary
CORRIM’s Research Protocol

• Created CORRIM, a non-profit research corporation (15 research institutions)
• Developed a comprehensive Research Plan - 22 modules
• CORRIM’s research guidelines follow LCI and LCA international protocol of ISO 14040’s Standards
• Reviewed by International LCI/LCA experts
Output of CORRIM Study

- LCIs of forest, harvesting, and structural wood products.
- LCAs of the constructed building, use, maintenance and demolition.
- Carbon tracking and storage for forest and wood products.
- Sensitivity analysis of LCI and LCA models.
- Basis for benefit cost analyses and identification of opportunities for improvement.
Why are these results important?

- Provide benchmarks of environmental performance for forests, mills, and buildings that can be used to evaluate improved performance alternatives in terms of:
  - Global warming potential
  - Air quality index
  - Water quality index
  - Waste
  - Energy use (renewable and non-renewable)
  - Forest structure/health/biodiversity

  *i.e. (Life Cycle Assessment-LCA)*
Why are these results important?

• Life cycle inventory data and assessment can be used to establish fair and reasonable environmental standards.

• CORRIM data will be used in US LCI Database which is being established for all primary processes.
Environmental Data

- Collected primary data for forest, harvesting, wood products manufacture, and transportation (20 primary surveys)

- Used secondary data for non-wood building materials, electricity, fuels, and transportation through ATHENA™ and SimaPro/Franklin
Input & Output Surveys conducted on 20 product processing and housing life stages

Pacific Northwest Wood Production

Minneapolis House Cold Climate

Atlanta House Warm Climate

Southeast Wood Production
CORRIM’s Phase 1 Research

“Cradle”

Forest Resources & Harvesting
PNW and SE

Processing of Structural Materials
PNW and SE
- Lumber
- Plywood
- Glulam
- LVL
- I-joists
- OSB (SE only)

Product
“Gate-to-Gate”

Construction of Virtual Residential Buildings to Code
- Minneapolis wood and steel designs
- Atlanta wood and concrete designs

Building Use and Maintenance

“Grave”

Disposal or Recycle
Manufacturing Survey’s of Lumber, Plywood, OSB, LVL, glulam, I-joists, Trusses

- Unit process descriptions (saw, dry, plane etc.)
- Mill surveys at unit process level
- Non-wood inputs (energy by source, raw materials)
- Emissions and solid waste outputs
- Yields, flows (co-products) and mass balances
- Calculate unit factor estimates (raw materials, air, water, and solid emissions, energy, carbon)
<table>
<thead>
<tr>
<th><strong>Inputs</strong></th>
<th><strong>Materials</strong></th>
<th><strong>Units</strong></th>
<th><strong>Per MSF 3/8-in. basis</strong></th>
<th><strong>Outputs</strong></th>
<th><strong>Materials</strong></th>
<th><strong>Units</strong></th>
<th><strong>Per MSF 3/8-in. basis</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood/resin</td>
<td>Roundwood (log)</td>
<td>ft.3</td>
<td>6.56E+01</td>
<td>Bark</td>
<td>Bark waste</td>
<td>lb.</td>
<td>1.31E+01</td>
</tr>
<tr>
<td></td>
<td></td>
<td>lb.</td>
<td>1.89E+03</td>
<td>Bark ash</td>
<td>lb.</td>
<td>7.75E+00</td>
<td></td>
</tr>
<tr>
<td>Phenol-formaldehyde</td>
<td>lb.</td>
<td>1.59E+01</td>
<td>Total</td>
<td>lb.</td>
<td>2.09E+01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extender and fillers</td>
<td>lb.</td>
<td>8.90E+00</td>
<td>Products</td>
<td>plywood</td>
<td>lb.</td>
<td>9.91E+02</td>
<td></td>
</tr>
<tr>
<td>Catalyst</td>
<td>lb.</td>
<td>1.11E+00</td>
<td>Co-products</td>
<td>Wood chips</td>
<td>lb.</td>
<td>4.25E+02</td>
<td></td>
</tr>
<tr>
<td>Soda ash</td>
<td>lb.</td>
<td>3.30E-01</td>
<td></td>
<td>Peeler core</td>
<td>lb.</td>
<td>4.62E+01</td>
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<tr>
<td>Bark</td>
<td>lb.</td>
<td>1.98E+02</td>
<td></td>
<td>Green clippings</td>
<td>lb.</td>
<td>3.10E+01</td>
<td></td>
</tr>
<tr>
<td>Dry veneer</td>
<td>lb.</td>
<td>6.81E+00</td>
<td></td>
<td>Veneer downfall</td>
<td>lb.</td>
<td>3.44E+00</td>
<td></td>
</tr>
<tr>
<td>Green veneer</td>
<td>lb.</td>
<td>1.51E+01</td>
<td></td>
<td>Panel trim</td>
<td>lb.</td>
<td>1.07E+02</td>
<td></td>
</tr>
<tr>
<td>Electrical energy</td>
<td>Electricity</td>
<td>kWh</td>
<td>1.39E+02</td>
<td>Air emissions</td>
<td>Acetaldehyde</td>
<td>lb.</td>
<td>1.12E-02</td>
</tr>
<tr>
<td>Fuel for energy</td>
<td>Hog fuel (produced)</td>
<td>lb.</td>
<td>3.83E+02</td>
<td>Acetone</td>
<td>lb.</td>
<td>4.80E-03</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hog fuel (purchased)</td>
<td>lb.</td>
<td>3.40E+01</td>
<td>Acrolein</td>
<td>lb.</td>
<td>4.95E-07</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wood waste</td>
<td>lb.</td>
<td>5.00E-01</td>
<td>Benzene</td>
<td>lb.</td>
<td>4.77E-04</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Liquid propane gas</td>
<td>gal.</td>
<td>3.59E-01</td>
<td>CO</td>
<td>lb.</td>
<td>1.91E+00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Natural gas</td>
<td>ft.3</td>
<td>1.63E+02</td>
<td>CO 2 fossil</td>
<td>lb.</td>
<td>2.78E+02</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Diesel</td>
<td>gal.</td>
<td>3.95E-01</td>
<td>CO 2 non-fossil</td>
<td>lb.</td>
<td>2.78E+02</td>
<td></td>
</tr>
</tbody>
</table>

a These materials were excluded based on the 2% rule.
b Bark and hogged fuel are wet weights whereas all other wood materials are oven-dry weights; bark weight is included in the “hog fuel (produced)” weight.
## Process Fuels from Biomass

<table>
<thead>
<tr>
<th>Wood Product</th>
<th>PNW</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>OSB</td>
<td>N/S</td>
<td>74%</td>
</tr>
<tr>
<td>Glulam</td>
<td>58%</td>
<td>56%</td>
</tr>
<tr>
<td>plywood</td>
<td>61%</td>
<td>62%</td>
</tr>
<tr>
<td>LVL</td>
<td>53%</td>
<td>50%</td>
</tr>
<tr>
<td>Lumber</td>
<td>58%</td>
<td>100%</td>
</tr>
<tr>
<td>Average</td>
<td>58%</td>
<td>69%</td>
</tr>
</tbody>
</table>
Life Cycle Assessment In Terms of Performance Indices

- Embodied Energy
- Global Warming Potential
- Air Emissions
- Water Emissions
- Solid Waste
Houses Designed to Local Code

Minneapolis House
Cold Climate

Wood vs. steel framed house designed to same R code.
Concrete basement, sheetrock, insulation, wood trusses, vinyl windows, vinyl siding and asphalt roofing.

Atlanta House
Warm Climate

Wood framed vs. concrete block exterior walls designed to same R code.
Slab on grade, sheetrock, insulation, wood trusses, vinyl windows, stucco/vinyl siding and asphalt roofing.
Although referred to as a wood framed house, concrete is the dominant mass, with other materials playing lesser roles.
Design Differences: Minneapolis
Steel minus Wood
Extraction (primary materials in kg)
Energy in Products Being Substituted - Minneapolis

Steel Frame
- Other, 595 (78%)
- Insulation, 37 (22%)
- Steel, 117

Total = 164
Subtotal = 43
(7%)

Wood Frame
- Other, 603 (93%)
- Insulation, 13
- Wood, 17

Total = 646
Subtotal = 164
(22%)

+17 %

Total = 759

+281 %
GLOBAL WARMING POTENTIAL INDEX

CO$_2$ EQUIVALENCE EFFECTS; CO$_2$, N$_2$O, CH$_4$
Worst Offending Substance - after dilution to safe EPA standard:
Better Intermediate Risk Measure Than Aggregate Mass
Emissions to Water: Minneapolis
On Equal Health Risk Basis

- Iron
- Sulphide
- Sulphate
- Oil-Gr
- Alum
- Chlor
- Halo-Org
- Nitr-Al
- Phenol
- CN
- Non-Ferr
- PAH
- TDS

Wood
Steel

Emissions to Water: Minneapolis
On Equal Health Risk Basis

- Iron
- Sulphide
- Sulphate
- Oil-Gr
- Alum
- Chlor
- Halo-Org
- Nitr-Al
- Phenol
- CN
- Non-Ferr
- PAH
- TDS

Wood
Steel
Emissions to Water: Atlanta On Equal Health Risk Basis

- Iron
- Sulphide
- Sulphate
- Oil-Gr
- Alum
- Chlor
- Halo-Org
- Nitr-Al
- Phenol
- CN
- Non-Ferr
- PAH
- TDS

[Graph showing emissions levels for various substances with two bars for each, one representing Concrete and the other Wood.]
# Solid Waste (kg) by Stage of Processing

<table>
<thead>
<tr>
<th></th>
<th>Minneapolis</th>
<th></th>
<th>Atlanta</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wood</td>
<td>Steel</td>
<td>Wood</td>
<td>Concrete</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>6,605</td>
<td>7,763</td>
<td>5,317</td>
<td>5,865</td>
</tr>
<tr>
<td>Construction</td>
<td>7,162</td>
<td>5,879</td>
<td>2,127</td>
<td>5,403</td>
</tr>
<tr>
<td>Total</td>
<td>13,767</td>
<td>13,642</td>
<td>-1%</td>
<td>7,444</td>
</tr>
</tbody>
</table>

*Volume may be as good if not a better indicator of the problem.*
Summary Performance Indices
Minneapolis House

Bar chart showing the comparison of steel vs. wood design in various performance indices:

- Embodied Energy: 17%
- Global Warming: 26%
- Air Emissions: 14%
- Water Emissions: 312%
- Solid Waste: -1%
Summary Performance Indices
Atlanta House

Concrete vs Wood Design (%)

- Embodied Energy: 16%
- Global Warming: 31%
- Air Emissions: 23%
- Water Emissions: 0%
- Solid Waste: 51%
## Energy Used in Representative Building Life Cycle Stages

<table>
<thead>
<tr>
<th></th>
<th>Minneapolis House</th>
<th>Atlanta House</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Energy in the Structure (GJ)</strong></td>
<td>Wood</td>
<td>Steel</td>
</tr>
<tr>
<td>Energy from Maintenance (GJ)</td>
<td>646</td>
<td>759</td>
</tr>
<tr>
<td>Energy for Demolition (GJ)</td>
<td>73</td>
<td>73</td>
</tr>
<tr>
<td>Energy Subtotal (GJ)</td>
<td>727</td>
<td>840</td>
</tr>
<tr>
<td><strong>House Cost</strong></td>
<td>$168,000</td>
<td>$168,000</td>
</tr>
<tr>
<td><strong>Construction Cost</strong></td>
<td>$92,000</td>
<td>$92,000</td>
</tr>
<tr>
<td><strong>Energy Use</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heat &amp; Cool (GJ) (75 yrs)</td>
<td>7800</td>
<td>7800</td>
</tr>
<tr>
<td>Cost/yr heat &amp; cool</td>
<td>$692</td>
<td>$692</td>
</tr>
<tr>
<td>Present Value Cost (75 years @ 5%)</td>
<td>$13,490</td>
<td>$13,490</td>
</tr>
<tr>
<td>% of Construction $</td>
<td>14.7</td>
<td>14.7</td>
</tr>
</tbody>
</table>
## Carbon Emissions in Representative Building Life Cycle Stages

<table>
<thead>
<tr>
<th>CO₂</th>
<th>Minneapolis House</th>
<th>Atlanta House</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Metric Tons</strong></td>
<td>Wood</td>
<td>Steel</td>
</tr>
<tr>
<td>Emissions in Mfg</td>
<td>37.1</td>
<td>46.8</td>
</tr>
<tr>
<td>Construction &amp; Demo</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emissions from Biofuel</td>
<td>3.6</td>
<td>2.6</td>
</tr>
<tr>
<td>Emissions from Maintenance</td>
<td>3.4</td>
<td>3.4</td>
</tr>
<tr>
<td>Emissions from Heating &amp; Cooling</td>
<td>390</td>
<td>390</td>
</tr>
<tr>
<td><strong>Subtotal of Sources</strong></td>
<td>434</td>
<td>443</td>
</tr>
<tr>
<td>Forest Sequestration</td>
<td>(467)</td>
<td>(246)</td>
</tr>
<tr>
<td>Wood product Storage</td>
<td>(22.4)</td>
<td>(11.8)</td>
</tr>
<tr>
<td><strong>Subtotal of Sinks and Stores</strong></td>
<td>(489)</td>
<td>(258)</td>
</tr>
<tr>
<td>Net emissions</td>
<td>(55)</td>
<td>185</td>
</tr>
</tbody>
</table>
Carbon Dynamics vs Steady State

- LCI provides a cross sectional profile of all processes -- a steady state analysis

- Tracking carbon pools over time offers a dynamic alternative for a more financial cost/benefit perspective
Silvicultural Pathways are Designed and Simulated using the Landscape Mgt. System (LMS).
Carbon in Forest Pools
80-Year Rotation with Two Thinnings
Carbon in Forest Pools
45 and 80-Year Rotation with Two Thinnings
Forest contributions to carbon storage: (2) the product pools

1. PNW Forests store more carbon than other regions
   - Bigger trees on longer rotations and unmanaged old-forests
     • 29 tonnes/acre average in PNW commercial forest

2. Commercial forests produce long lived products and store carbon in buildings
   • 24.5 tonnes/acre average in 120 years and growing
Carbon in Product Pools
Processing Energy and Displacement
Forest contributions to carbon storage: (3) the substitution for fossil intensive products pool

1. PNW Forests store more carbon than other regions
   - Bigger trees on longer rotations and unmanaged old-forests
     • 29 tonnes/acre average in PNW commercial forest

2. Commercial forests produce long lived products and store carbon in buildings
   • 24.5 tonnes/acre average in 120 years and growing

3. Long lived wood products substitute for fossil fuel intensive products
   • 51.2 tonnes/acre less carbon emissions from less steel/concrete framing in 120 years and growing
Forest, Product and Substitution Pools

Forest, Product, Emissions, Displacement & Substitution Carbon by Component

- Stem
- Root
- Crown
- Litter
- Dead
- Chips
- Lumber
- HarvEmis
- ManufEmis
- Displacement
- Substitution

Year

Metric Tons Per Hectare

Forest with Products

Forest with Substitution
Carbon in Forests, Products and concrete Frame Substitutes

Averages over time intervals

Rotation Length in Years

Metric Tons per Hectare

Forest | Products, Emissions, and Displacement | Substitution
# PNW Carbon Response

<table>
<thead>
<tr>
<th>Scenario</th>
<th>0-45 yrs Tones/acre</th>
<th>0-120 yrs Tones/acre</th>
<th>0-120 yrs Tones PNW Private</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ignore carbon in products (the Kyoto error)</td>
<td>0</td>
<td>-26</td>
<td>-455 million</td>
</tr>
<tr>
<td>Intensive-Mgmt</td>
<td>7</td>
<td>14</td>
<td>245 million</td>
</tr>
<tr>
<td>No-Mgmt vs. Intense (i.e. no-harvest)</td>
<td>-11</td>
<td>-47</td>
<td>-823 million</td>
</tr>
</tbody>
</table>
Environmental Performance Index for Western Washington Forests

- Simulate impact of treatment strategies
- Criteria: Regulatory objectives are seeking
  - increased late-seral (old forest)
  - decreased stem exclusion (overly dense)
# Average Bio-index Shares and Harvest Levels under Management Alternatives

<table>
<thead>
<tr>
<th></th>
<th>Base (%)</th>
<th>Long Rotation (%)</th>
<th>Intensive Mgmt (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Late seral average</td>
<td>32</td>
<td>37</td>
<td>32</td>
</tr>
<tr>
<td>Stand initiation average</td>
<td>32</td>
<td>28</td>
<td>32</td>
</tr>
<tr>
<td>Stem exclusion average</td>
<td>30</td>
<td>28</td>
<td>26</td>
</tr>
<tr>
<td>Reinitialiation average</td>
<td>5</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>Harvest billion bdft/ yr</td>
<td>5.4</td>
<td>5.2(-4)</td>
<td>5.8(+6)</td>
</tr>
</tbody>
</table>
Forest fires release emissions with no savings in fossil fuel and retard regeneration of the forest.
ENVIRONMENTAL IMPROVEMENT OPPORTUNITIES

- Redesign of the house to use less fossil intensive products
- Greater use of low valued wood fiber for biofuel

*But what components, design features and process improvements are most important?*
- Wall components/design
- Floor components/design
MN Wall Subassembly - Resource Use: Steel Minus KD

- Iron Ore: 0 kg per 10 sq. meters
- Wood Fiber: -150 kg per 10 sq. meters
- Metallurgical Coal: -100 kg per 10 sq. meters
- Primary Fuels: -50 kg per 10 sq. meters
MN Wall Subassembly - Total Energy per Component

Arrows show % increase over common energy requirements.

Wall Type
- MN - Green Lumber
- MN - Steel
- MN - KD Lumber

Energy per Component
- Lumber
- Plywood
- Fiberglass
- EPS
- Vinyl Siding
- Gypsum

Energy in MJ per 10 sq. meters:
- 0 to 1000
- 1000 to 2000
- 2000 to 3000
- 3000 to 4000
- 4000 to 5000
- 5000 to 6000
- 6000 to 7000
- 7000 to 8000

121% increase over common energy requirements.
56% increase over common energy requirements.
MN Wall Subassembly - Fossil Fuel Energy per Component

- Lumber
- Fiberglass
- Plywood
- EPS
- Vinyl Siding
- Gypsum

Arrows show % increase over common fossil fuel requirements:
- Steel: 129%
- MN - Steel: 81%

Fossil excludes hydro, biofuel, nuclear
MN Wall with Potential Substitution and Increased Use of Biofuel

MN Wall Subassembly - Fossil Fuel Energy per Component

Arrows show % increase in fossil fuel requirements

Wall Type

- MN - Subs
- MN - Steel
- MN - KD Lumber

MJ per 10 sq. meters

- Wood-based insulation
- 1/2" Plywood
- 1/4" Plywood
- Lumber
- EPS
- Fiberglass
- Plywood
- Vinyl Siding
- Gypsum
- Steel

347%
32%
MN Wall Subassembly - Fossil Fuel Energy per Component

Arrows show % increase in fossil fuel requirements

Wall Type

Wood-based insulation 281%

Lumber 27%

OSB

Fiberglass

EPS

Steel

Vapor

Gypsum

Vinyl Siding

Lumber

OSB

27%

Vinyl Siding

Gypsum

MN - KD subs

MN - Steel

MN - KD Lumber

MJ per 10 sq. meters
MN Wall with Potential Substitution and Increased Use of Biofuel

MN Wall Subassembly - Global Warming Potential per Component

- Arrows show % increase in Global Warming Potential
- Wood-based insulation: 288%
- Lumber: 46%

Lumber-based insulation

kg of CO₂ per 10 sq. meters

Wall Type:
- MN - Subs
- MN - Steel
- MN - KD Lumber
MN Wall with Potential Substitution and Increased Use of Biofuel

WPI per 10 sq. meters

Arrows show % increase in Water Pollution Index

Worst offending substance: Steel=cyanide, Wood=phenol
MN Wall with Potential Substitution and Increased Use of Biofuel

Worst offending substance: sulphur oxide
MN Wall with Potential Substitution and Increased Use of Biofuel

MN Wall Subassembly - Solid Waste per Component

Arrows show % increase in Solid Waste

- Wood-based Insulation (80%)
- Steel
- EPS
- Plywood
- Fiberglass
- Lumber
- Vinyl Siding

kg per 10 sq. meters

1/4" Plywood
1/2" Plywood

MN - Subs
MN - Steel
MN - KD Lumber
ATL Wall Subassembly - Resource Use - Concrete Minus KD

<table>
<thead>
<tr>
<th>Material</th>
<th>kg per 10 sq. meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limestone</td>
<td>-100</td>
</tr>
<tr>
<td>Clay &amp; Shale</td>
<td>-200</td>
</tr>
<tr>
<td>Fine Aggregate</td>
<td>500</td>
</tr>
<tr>
<td>Wood Fiber</td>
<td>0</td>
</tr>
<tr>
<td>Primary Fuels</td>
<td>0</td>
</tr>
</tbody>
</table>
ATL Wall Subassembly - Fossil Fuel Energy per Component

Arrow shows % increase over common fossil fuel requirements

- Plywood
- Vinyl Siding
- Fiberglass
- Gypsum
- Lumber
- Stucco Siding
- Vinyl Siding
- Gypsum

Wall Type

ATL - KD Lumber

236%

ATL - Concrete

MJ per 10 sq. meters
ATL Wall Subassembly - Global Warming Potential per Component

<table>
<thead>
<tr>
<th>Component</th>
<th>CO₂ kg per 10 sq. meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gypsum</td>
<td>412%</td>
</tr>
<tr>
<td>Fiberglass</td>
<td>412%</td>
</tr>
<tr>
<td>Concrete</td>
<td>0</td>
</tr>
<tr>
<td>Lumber</td>
<td>0</td>
</tr>
<tr>
<td>Vinyl Siding</td>
<td>0</td>
</tr>
<tr>
<td>Plywood</td>
<td>0</td>
</tr>
</tbody>
</table>

Arrow shows % increase over common Global Warming Potential.
Floor Subassembly - Fossil Fuel Energy per Component

Arrows show % increase in fossil fuel requirements

MJ per 10 sq. meters

Wood I-Joists
Wood Dimension Joists
Concrete Slab
Steel Joists

Floor Type

Steel
Plywood
Lumber
Concrete Slab
Wood Dimension Joists
Wood I-Joists

47%
202%
504%
Floor Subassembly - Global Warming Potential per Component

Arrows show % increase in Global Warming Potential

- Plywood
- Lumber
- Steel
- Concrete

kg of CO₂ per 10 sq. meters

Floor Type

Wood I-Joists
Wood Dimension Joists
Concrete Slab
Steel Joists

48%
580%
927%
ENVIRONMENTAL IMPROVEMENT OPPORTUNITIES - products

- Wood substitutes for steel, or concrete produce substantially lower burdens

- Also for EPS, fiberglass, gypsum, cladding
  
  If other stages of processing pass muster: siding can be made to last, wood fiber insulation does not sag and along with paneling is fire retardant.
  
- While OSB is more energy intensive than plywood, it is better than steel or concrete, can be better in EWP, and is much less supply constrained i.e. resource efficiency
ENVIRONMENTAL IMPROVEMENT OPPORTUNITIES - design

- Fossil energy embodied in steel floor is 4+ times that used in the wall before insulation - sized for stiffness
- Dimension joists use 170% more fiber than EWP I-joists - sized for stiffness
- Pre-cut designs produce less waste
ENVIRONMENTAL IMPROVEMENT OPPORTUNITIES
- Forest Management -

- More intensive forest management
- More solid wood production
  - But not longer rotations
- Even small carbon incentives for additionality
- Longer rotations produce better biodiversity but less stored carbon and at a high cost
ENVIRONMENTAL IMPROVEMENT OPPORTUNITIES

- What is needed -

- Product development for lower burdens
- System designs for lower burdens
- Get ahead of setting environmental standards for products and design
- Pollution standards set using LCI or CO2 credits
Conclusions

• We can assess the environmental performance of products in buildings. Guessing cannot.

• There are many potential improvements by using less fossil intensive products and more wood products.

• Energy for heat production remains the driving factor in wood processing energy, but most could be bioenergy (if fuel costs or incentives were higher).

• The opportunity exists to steer the trend toward product and design standards to LCA performance measures.

• Short rotations with intensive management store the most carbon across all stages of processing.

• Wood used in long term products provides the greatest reduction in fossil fuel use & emissions.

• Forest fires reduce carbon storage, a lost opportunity to reduce fossil fuel uses.
Support Acknowledgements

• CORRIM- Consortium for Research on Renewable Industrial Materials
  - 15 research institutions and 23 authors
  - DOE & 5 companies funded the Research Plan
  - USFS/FPL, 10 companies & 8 institutions funded Phase I
• USFS, xx companies & 6 institutions currently funding Phase 2
• PNW & SE product manufactures surveyed
<table>
<thead>
<tr>
<th>Phase I</th>
<th>Phase II</th>
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</thead>
<tbody>
<tr>
<td>Forest Resources LCIs – PNW and SE Softwoods</td>
<td>Forest Resources LCIs – Inland West (IW) Softwoods, NE/NC Soft and Hardwoods</td>
</tr>
<tr>
<td>Product LCIs – Lumber, Plywood, Glulam, LVL, and I-joists (NW &amp; SE); OSB SE</td>
<td>Product LCIs – Lumber IW and NE/NC, OSB NE/NC, MDF, Particleboard, Resins</td>
</tr>
<tr>
<td>Residential Construction (typical to code) LCA – Minneapolis (cold), Atlanta (warm)</td>
<td>Building Component LCIs – wall and floor component by component</td>
</tr>
<tr>
<td>• Construction</td>
<td>• Product LCI/LCA for easier use</td>
</tr>
<tr>
<td>• Building use</td>
<td>• Residential Construction (alternatives) LCA</td>
</tr>
<tr>
<td>• Maintenance (and life expectancy)</td>
<td>- West Coast residential</td>
</tr>
<tr>
<td>• Demolition</td>
<td>- Demo building NCSU</td>
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<tr>
<td>Pilot test procedures to develop LCI data from primary surveys of mills and LCA for residential structures using ATHENA EI E</td>
<td>- Townhouse</td>
</tr>
<tr>
<td></td>
<td>- Alternative materials and designs</td>
</tr>
<tr>
<td></td>
<td>• Full geographic coverage for high volume products and more end uses</td>
</tr>
</tbody>
</table>
The details:

Complete Phase 1 report (800 pages), 12 page sum, 4 page fact sheet, and 1 page release available at CORRIM website:  WWW.CORRIM.ORG

Athena:  www.athenaSMI.ca

LMS:  http://LMS.cfr.washington.edu

USLCI database:  www.nrel.gov/lci