

Alternative Uses of Biomass: Thermally Treated Biomass in Building Materials

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Overview

Background: Role of Bio-based Building Materials in Potential Emerging Markets

Current Status of Bio-based Building Materials: Role of Wood and Grass Type Materials

Potential Alternative Building Materials: Focus on Thermally Treated Biomass using SRWC and Perennial Grasses

Background: Positioning of Biomass Feedstock

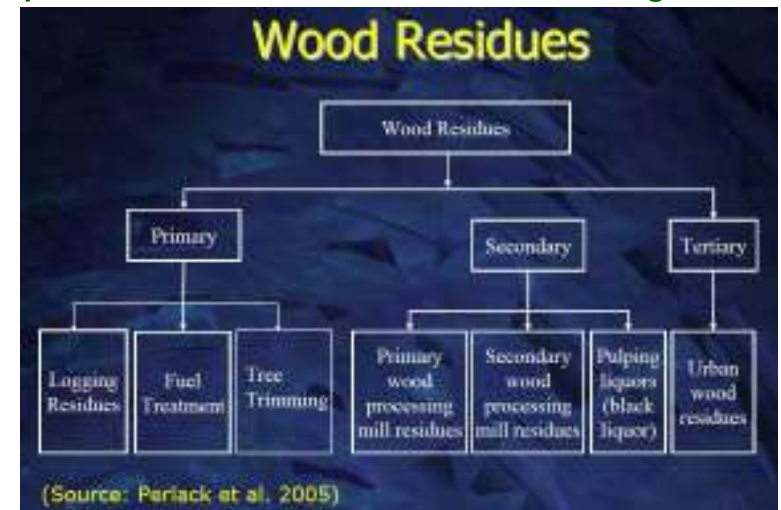
A variety of wood forms are used as feedstock for materials



Ref: USDA Wood Handbook Figure 11-2. Basic wood elements, from largest to smallest (adapted from Kretschmann et al. 2007)

Background: Traditional Competition

Short rotation woody crops (SRWC) and perennial grasses compete with wood residues for use in building materials



(Source: Periack et al. 2005)

Background: Green Building: Potential Emerging Market

- Potential opportunity to reduce environmental impacts as the building sector uses 1/3 of the global energy



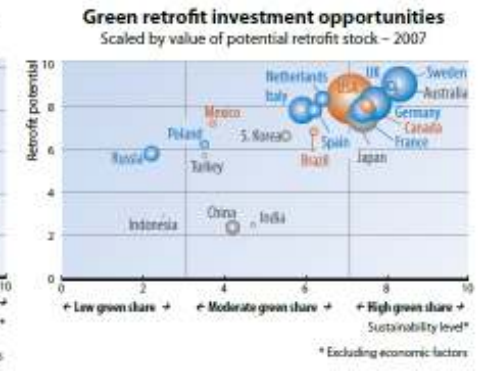
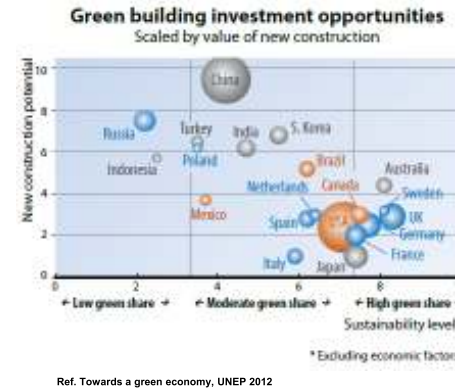
- Construction is second leading green employment sector in the US



- Green building market expected to increase in value in the US

Background: Potential Emerging Build Markets

- Potential opportunity in both new construction and remodeling of existing structures



Ref. Towards a green economy, UNEP 2012

Green Building in the USA: Voluntary Standards

- LEED® (Leadership in Energy and Environmental Design)
 - Developed and admin. by U.S. Green Building Council
 - Certification for both single-family and commercial
 - Gold, Silver, and Platinum levels
- NAHB National Green Building Program™
 - 1st ANSI approved green building standard in the U.S.
 - Requires builders to include features in 7 categories
 - Four certification levels (Bronze, Silver, Gold, & Emerald)
- Others
 - Green Globes™, Energy Star (US-EPA), Collaborative for High Performance Schools, Green Communities Initiative, CALGreen, Wisconsin Green Built Home™

Green Building in the USA: Mandatory Standards

- 2012 International Green Construction Code
 - Developed by the International Code Council (ICC)
 - Collaboration with:
 - USGBC
 - AIA
 - ASTM International
 - IES



Background: How Building Materials Get Points

- Different standards in the U.S. view the “points” for forest and bio-based products differently
- LEED® (Leadership in Energy and Environmental Design)
 - Points for locally sourced, recycled, FSC certified, low VOC emissions
- NAHB National Green Building Program™
 - Points for bio-based, certified, use of fewer materials, local, manufactured at ISO 14001 certified facility, used of structural panel certified to PS1 or PS2, no added urea or in accordance to CARB



New Markets for Bioenergy Crops



Background: How Building Materials Get Points

- Some mandatory items affect bio-based products differently
- IgCC
 - Mandatory 55% of materials of recycled, recyclable, bio-based or local (can have multiple attributes)
 - 80% construction waste diversion minimum
 - Required recycling areas for use in buildings
 - Moisture control
 - Material emission limits
 - Acoustics



New Markets for Bioenergy Crops



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Role Of Bio-based Materials in Building

Why do we care about Bio-based Materials in Construction?

Residential Construction

- Employs 8.9 million people in US
- Uses 24.2 billion board feet (bf) of softwood and engineered wood lumber/year
- 1 billion bf hardwood lumber/year
- 21.2 billion ft² of wood structural panels/year
- Wood: 43% total cost of building materials
- Wood: 98% of framing materials



<http://www.claytonhomes.com/i-house.cfm>



<http://www.ainsworthengineered.com>



New Markets for Bioenergy Crops



New Markets for Bioenergy Crops



Opportunities for Alternative Bio-based Materials in Building

With emerging use and acceptance of green building programs there is an opportunity for short rotation woody crops (and maybe perennial grasses) in composites with:

- Modified for improved characteristics (ex. thermal modification)
 - Improved thermal performance
 - Added-value to locally sourced wood and biomass
 - Reduced carbon footprint and construction time



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Opportunities for Alternative Bio-based Materials in Building

President Obama announced a “Promoting a Bioeconomy” initiative on Feb. 21, 2012 that directs the federal government to, over the next 2 years, dramatically increase bio-based product purchasing



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Opportunities for Alternative Bio-based Materials in Building

- Round 2
 - Adhesive and Plastic Removers
 - Composite Panels - Acoustical
 - Engineered products designed for use as structural and sound deadening material suitable for office partitions and doors.
 - 37% - Minimum Biobased Content
 - Composite Panels - Interior Panels
 - Engineered products designed specifically for interior applications and providing a surface that is impact-, scratch-, and wear-resistant and that does not absorb or retain moisture.
 - 55% - Minimum Biobased Content
 - Composite Panels - Plastic Lumber
 - Engineered products suitable for non-structural outdoor needs such as exterior signs, trash can holders, and dimensional letters.
 - 23% - Minimum Biobased Content
 - Composite Panels - Structural Interior Panels
 - Engineered products designed for use in structural construction applications, including cabinetry, casework, paneling, and decorative panels.
 - 89% - Minimum Biobased Content
 - Composite Panels - Structural Wall Panels
 - Engineered products designed for use in structural walls, curtain walls, floors and flat roofs in commercial buildings.
 - 94% - Minimum Biobased Content
- Disposable Containers
- Fertilizers
- Plastic Film Transformers - Synthetic Paper/Paper

Minimum bio-based standard



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Current Major Types of Bio-based Building Composites

- ### Composite Panels
- Plywood
 - Oriented Strandboard
 - Particleboard
 - Fiberboard
 - Specialty Composites

- ### Structural Composite Lumber
- Laminated Veneer Lumber
 - Parallel Strand Lumber
 - Laminated and Oriented Strand Lumber

- ### Biomaterial/Non-Bio Composite
- Inorganic Bonded Composites
 - Wood Thermoplastic Composites

- ### Some Other Bio-based Composites
- Wood I-Joists
 - Glue Laminated Timbers (Glulam)
 - Structural Insulated Panels



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Commercial Building Products From Non-Wood Biomass

Past attempts at using straw and other grass materials to make structural and panel type building products had minimal success

- Isoboard: Elie, Manitoba, 215,000-square-foot facility in 1998, then Dow (closed in 2005)
- Phenix Biocomposites (1998), then Environ (2005), now Agristrand



Commercial Building Products From Non-Wood Biomass

Newer strawboard ventures seem to be focusing heavily on the environmental aspects and LEED Credits (in US)



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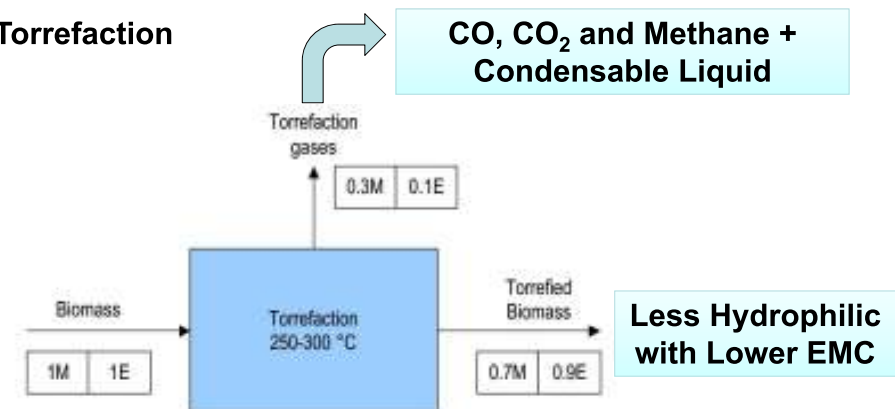
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Potential Alternative Building Products: Thermal Treatment

The application of thermal pre-treatment of SRWC and perennial grass raw material has the potential to increase the performance of current building materials

Torrefaction



(P.C.A. Bergman, 2005)

Potential Alternative Building Products: Thermal Treatment

Biochar produced from pyrolysis may have beneficial properties

- Biomass pyrolysis is thermal decomposition of biomass in the absence of atmospheric oxygen.
- The pyrolysis process produce a solid residue (char), liquid condensate, and gas products



Potential Alternative Building Products: Thermal Treatment

Biochar produced from pyrolysis may have beneficial properties

- Slow pyrolysis
 - Used for carbonization when the resulting principal product is solid charcoal or char (biochar)

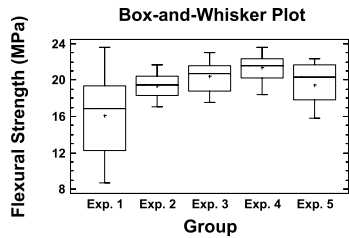
- Biochar Applications
 - For combustion
 - As an absorbent
 - Soil amendment
 - Catalyst development
 - Composite Materials?



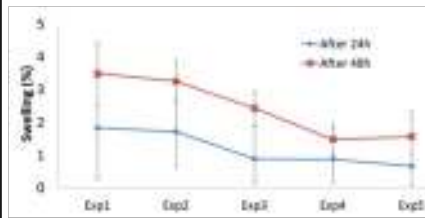
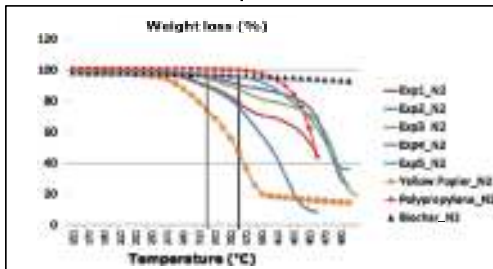
Biochar

Thermal Improvement: Wood/Biochar/Plastic Composites

Use of biochar as a replacement for wood flour has shown improved mechanical properties and thermal performance



DeVallance et al. 2012, Forest Products Society

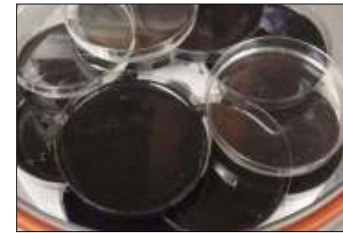


Thermal Improvement: Films and Building Wraps

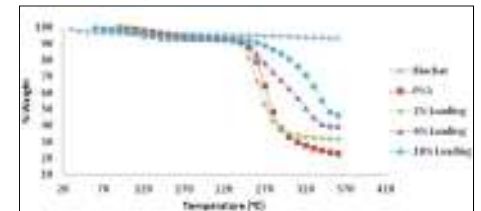
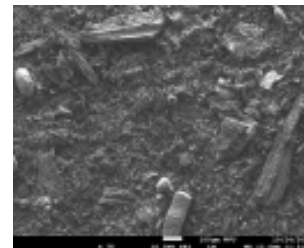
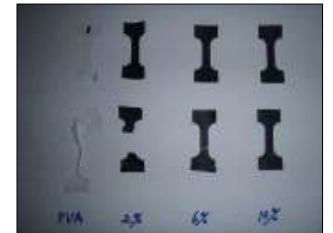
Biofilm material with biochar particles are being investigated for higher thermal and mechanical properties at WVU



Jacobson et al. 2010



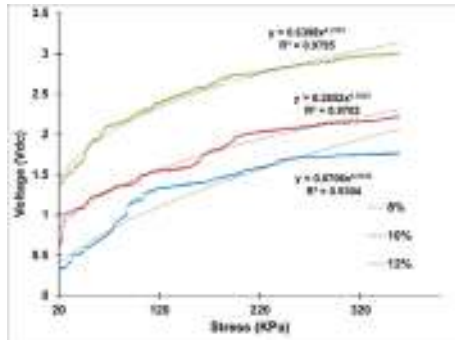
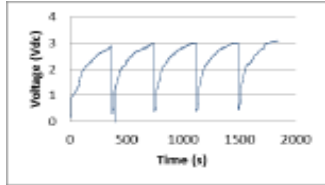
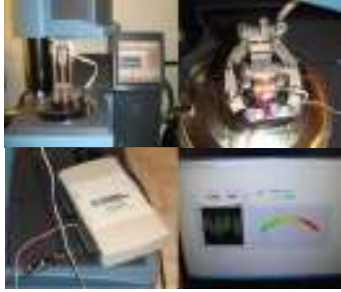
DeVallance and Nan. 2012 – Wood Utilization Research Program



DeVallance and Nan 2014

Sensing Applications

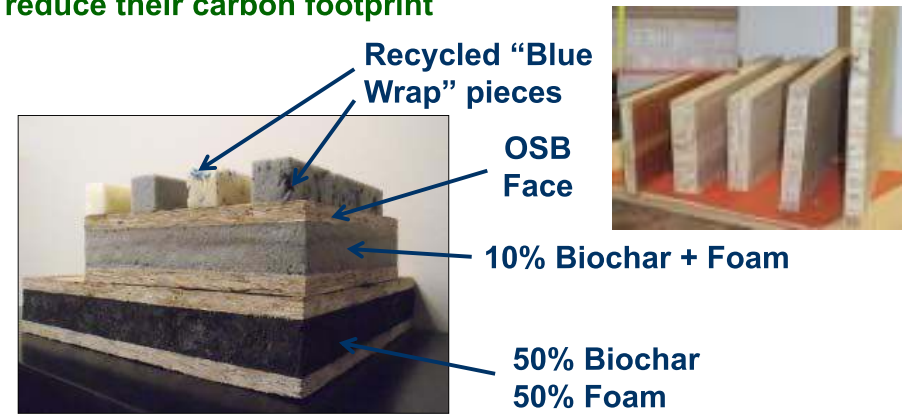
Biofilms biochar nanoparticles are being investigated for piezoresistive touch sensors at WVU



- Voltage output increases as % biochar and stress are increased
- Sensors are repeatable

Insulating Materials

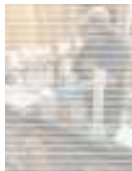
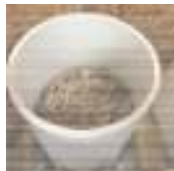
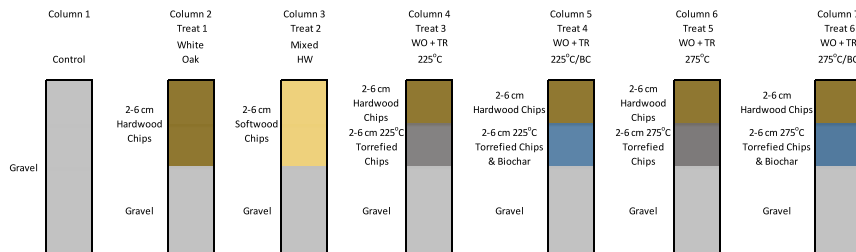
Biochar and recycled materials may help improve the insulating values of structural insulated panels (SIPs) and reduce their carbon footprint



Building Material for Livestock Living Areas?

Work is underway at WVU to investigate a layered biomass chip filter for a livestock heavy use loafing area

Laboratory Column Studies: 3 rain events & 48 hr. hold



Building Material for Livestock Living Areas?

Work is underway at WVU to investigate a layered biomass chip filter for a livestock heavy use loafing area

Field Studies: 3 pads and 3 "Sample Boxes"



Summary

SRWC and perennial grasses:

- use in “traditional” building materials is somewhat limited but may be able to gain new footholds in a green economy
- have potential as materials to be thermally pre-treated and used in advanced and innovative building material design
- use should focus on high-value applications that improve the thermal performance, reduce the carbon footprint, and improve the properties of existing building materials
- are more likely to be used in niche markets until harvesting, transportation, and storage logistics makes them competitive against currently available wood residues



New Markets for Bioenergy Crops



Questions

Biomaterials and Wood Utilization Research Center
(<http://www.wdscapps.caf.wvu.edu/BioMatWURCtr>)
http://forestry.wvu.edu/faculty_staff/david_devallance



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