High-Performance School Buildings: 
Wood’s Role as Low Carbon Structure & Renewable Energy Source

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Disclaimer: This presentation was developed by a third party and is not funded by WoodWorks or the Softwood Lumber Board.
Course Description:

Wood is a beautiful, durable and sustainable material for buildings. It can also be an excellent source of renewable energy. This seminar will explore the use of wood as a building material as well as the availability of woody biomass, its harvesting, and its role as a source of renewable energy for projects. Two case studies will illustrate two very different ways wood can be used on campuses – as an enduring building material and a heating source for buildings.
Learning Objectives:

• Review woody biomass, including its harvesting, use, and availability as a renewable energy source.

• Introduce different biomass systems and explain their integration in modern, high-performance buildings.

• Discuss examples of how wood can be implemented in high-performance facilities as structure and finish.

• Explain wood’s role, as both energy source and building material, in achieving sustainable objectives.
AGENDA:

• Woody Biomass and Healthy Forests
  • Operational Review

• Wood: A Beautiful Material for Structure & Finish in High-Performance Buildings
  • Two Case Studies

• Wood: A Renewable Energy Resource
  • Two Different Energy Systems

• Wood and Sustainable Design
  • Lessons Learned
Types of Biomass

- Grains
- Grass
- Straw
- Processing By-Products
- Wood
- Coal
Focus on Woody Biomass
This study estimates the technical biomass resources currently available in the United States by county. It includes the following feedstock categories:

- Agricultural residues (crops and animal manure);
- Wood residues (forest, primary mill, secondary mill, and urban wood);
- Municipal discards (methane emissions from landfills and domestic wastewater treatment);
- Dedicated energy crops (on Conservation Reserve Program and Abandoned Mine Lands).
Biomass Resources of the United States
Secondary Mill Residues

Secondary mill residues include wood scraps and sawdust from woodworking shops - furniture factories, wood container and pallet mills, and wholesale lumberyards. Data on the number of businesses by county was gathered from the U.S. Census Bureau’s 2009 County Business Patterns. For more information on the data development, please refer to http://www.nrel.gov/docs/fy06osti/39181.pdf. Although, the document contains the methodology for the development of an older assessment, the information is applicable to this assessment as well. The difference is only in the data’s time period.

Dry Tonnes/Year
- > 5,000
- 2,500 - 5,000
- 1,000 - 2,500
- 500 - 1,000
- 250 - 500
- < 250
- Not Estimated

June 8, 2012
NREL
National Renewable Energy Laboratory
Biomass Resources of the United States
Urban Wood Residues

Urban wood waste includes wood residues from MSW (wood chips/pallets), utility tree trimming and/or private tree companies, and construction and demolition sites.

Data sources: U.S. Census Bureau - 2010 Population data; BioCycle Journal "State of Garbage in America", 2008; U.S. Census Bureau's 2009 County Business Patterns. For more information on the data development, please refer to http://www.nrel.gov/docs/fy06osti/39181.pdf. Although, the document contains the methodology for the development of an older assessment, the information is applicable to this assessment as well. The difference is only in the data's time period.

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NREL
NATIONAL RENEWABLE ENERGY LABORATORY
Forest Residues

This category includes logging residues and other removable material left after carrying out silviculture operations and site conversions. Logging residue comprises unused portions of trees, cut or killed by logging and left in the woods. Other removable materials are the unused volume of trees cut or killed during logging operations. This map illustrates 65% of logging residues and 50% of other removals which is the portion that could be collected as biomass. The remaining portion is to be left on the field to maintain ecological functions. Source: USDA, Forest Service's Timber Product Output database, 2012.
FOREST MANAGEMENT IMPROVES FOREST HEALTH.

THIS MAY COME AS A SURPRISE.
In 1990–2005, Europe’s 1.5 million square kilometres of forests absorbed about 100 teragrams of carbon more each year than they released, or 10% of the region’s fossil-fuel emissions. Carbon is absorbed by growing trees and is released during decomposition and burning. Wood products act as a temporary carbon sink, and can substitute for fossil fuels.
Forest Growth Provides an Important Carbon Sink
WHERE DOES CARBON GO?
CARBON STORAGE IN A GREAT LAKES FOREST

NET PHOTOSYNTHESIS
2.9 tons of carbon / acre yearly

CO2

LEAVES
1%

TRUNK & BRANCHES
40%

WOODY DEBRIS
1%

SOIL RESPIRATION
2.2 tons of carbon / acre yearly

CO2

CARBON STORED
0.7 tons of carbon / acre yearly

CO2

TREE ROOTS
13%

TOTAL ECOSYSTEM CARBON
80 tons / acre

CO2

SOIL ORGANIC MATTER
45%

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How forests absorb carbon dioxide

Forests can function as carbon sinks, absorbing the climate-changing gas carbon dioxide from the atmosphere and storing it for long periods of time in trees and soil. How the carbon cycle works:

**ABSORPTION**

**Trees**
Carbon is stored in trees and plants as they absorb carbon dioxide from the atmosphere to grow. Trees are very important because they live a long time and therefore store carbon for many years.

**Soil**
Decaying organic matter, such as dead trees, branches, plants and leaves transfer some carbon below ground to be held in the soil, which can hold it for long periods of time. Roots of living trees also transfer carbon to the soil.

**RELEASE**

**Trees**
Some carbon is lost back to the atmosphere through respiration of plants, forest fires and the decomposition of organic matter in the soil.

**Forest products**
Lumber and products made from trees still contain the carbon they absorbed. They hold it for long periods of time, not releasing it until the wood is burned or decays. Carbon is released in logging and manufacturing.

Source: USDA, Northern Research Station
Sustainable Forestry Cycle

New Forest    Thinning    Stand Management Protection    Harvest Planning    New Forest
The Hotchkiss School
Lakeville, CT
Biomass Central Heating Plant

Biomass System: Wood chip
• (2) Messersmith wood-fired boilers
• 14 MMBtu/Hr
• 10,000 lb/hr min steam capacity

Building Square Footage:
• Plant – 16,500 gsf
• Campus – 85 bldgs, 1.2 million gsf

LEED Certified Level: Certified

Berkshire School
Sheffield, MA
Bellas/Dixon Math and Science Center

Biomass System: Wood pellet
• Viessmann High Efficiency KRT-150 Pellet Boiler
• Hot Water – 400 gal storage tank

Building Square Footage:
• 47,000 gsf

LEED Certified Level: Gold
The Hotchkiss School
Biomass Central Heating Plant

Performance of a LEED Certified biomass plant:
• Wood chip fuel displaces more than 150,000 gallons of fuel oil per year
• Plant cuts sulfur dioxide emissions by more than 90 percent
• Reduces the campus carbon footprint by as much as 45 percent
• ESP removes 95 percent of particulate matter
• Includes high-efficiency exterior skin, mechanical systems, and lighting systems
• Abundant daylighting of interior spaces
• Green roof absorbs and filters rainwater into rain gardens and bio-swales
Sustainably Managed Regional Forests
By selectively harvesting only certain trees, forests are able to maintain a healthy forest ecosystem as well as meet their financial needs. The CHF will help to bolster the local economy by providing jobs as well as creating incentives for preserving local forestland rather than developing it.

Biomass Fuel
The CHF will use a “bole” chip, with its origins in sustainably managed forests. The chips come from the bole of the tree - the trunk up to the first series of branches. The remainder of the tree, where 80% of the nutrients reside, is left to decompose and cycle back into the soil.

Resources & Emissions
Emissions are predominantly steam with a 30-50% reduction in overall campus CO2. Emissions are fine particulate matter removal and subsequent increase in protection and improved management of wetlands, water, and other natural resources.

School Farm
Barrels of fly-ash left over from the generation process are used as soil amendments while regenerative land management strategies sequester carbon emissions and build soil, ultimately closing the system’s loop and providing food to the School’s dining hall.

Education
Student learning in ecology, economics, and social systems is enhanced by direct contact with real-world examples of developing more sustainable local and social economic systems.
Landscape Design Strategy

Working in concert with the Green Roof, the landscaping around the Central Heating Plant is designed to slow, channel, filter and absorb excess rainwater from the roof and the site before returning it to the aquifer or nearby wetlands. Additional benefits of this natural approach are that it reduces maintenance and serves as a habitat for wildlife. A combination of strategically located swales, bioswales, and a rain garden receive the runoff from periodic, often intense precipitation, serving as a natural alternative to storm sewers.

Herbaceous Plants
- Blueweed
- Water Smartweed
- Spotted Pennywort

Shrubs
- Sand Rose
- Wild Germander
- Winterberry
- Swamp Rosebay
- High Bush Blueberry

Wetland Herbaceous Plants
- Arrow Grass
- Bluejoint Reedgrass
- Soft Stem Bulrush
- Blue Flag Iris
- Sensitive Fern
- Sawgrass

A rain garden is a planted depression designed by the project's architects. Soil and plants are selected to attract and retain water. The rainwater first seeps through the ground and then passes through vegetation, removing pollutants. The water is then returned to the atmosphere by transpiration or infiltrates the ground.
Local Black Locust - decay resistant tree species
Wood and Sustainable Design

- Wood Chip Boiler
- Glulam Beams
- Laminated Veneer Lumber (LVL)
- Parallel Strand Lumber (PSL)
- Oriented Strand Board (OSB)
- Wheat Board
- Local Forest Lumber
- Forestry Stewardship Council (FSC)
Educational Opportunities
Educational Opportunities
Use of Glulam Beams

- Flexibility in Design
- Fire Rating
- Cost vs Steel
- Aesthetics
The Hotchkiss School
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• However, wood chip system doesn’t meet LEED criteria. Why?
Eligible On-site Systems (p 291)

On-site renewable energy technologies eligible for EA Credit 2 include the following:

- Photovoltaic systems
- Wind energy systems
- Solar thermal systems
- Bio-fuel electrical systems (see list of eligible biofuels, below)
- Geothermal heating systems
- Geothermal electrical systems
- Low-impact hydroelectric power systems
- Wave and tidal power systems

There are some restrictions for . . . Biofuel-based electrical systems. These systems may either produce electric power or provide thermal energy for primary use at the building.
The following biofuels are considered renewable energy under this credit:

- Untreated wood waste, including mill residues
- Agricultural crops or waste
- Animal waste and other organic waste
- Landfill gas,
Energy & Atmosphere (EA)
EAc2 On-Site Renewable Energy

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Energy production based on the following biofuels are not eligible for this credit:
• Combustion of municipal solid waste,
• Forestry biomass waste other than mill residue,
• Wood coated with paints, plastics, or formica,
• Wood treated for preservation with materials containing halogens, chlorine compounds, halide compounds, chromated copper arsenate, or arsenic. If more than 1% of the wood fuel has been treated with these compounds, the energy system is ineligible.
Berkshire School
Bellas/Dixon Math and Science Center

A high-performance building:
• Tight thermal envelope
• High efficiency glazing
• Reduced lighting power density
• Daylight controls
• Air-side energy recovery
• Natural ventilation
• Biomass pellet boiler
• Radiant heating and cooling strategies
Wood and Sustainable Design

- Wood Pellet Boiler
- Salvaged Wood
- Forestry Stewardship Council (FSC)
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LEED v2009 BD+C Reference Guide

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For renewable energy coming from both on-site and off-site sources, the associated environmental attributes must be retained or retired; they cannot be sold. Project teams should understand and value the positive effect of on-site renewables on the surrounding ecosystems. For on-site renewables, energy that exceeds the project building’s demand may be sold at fees equivalent to the market rate of nonrenewable energy, but no premium can be charged for the renewable nature of the energy. Such a premium indicates that these attributes have not been retained, and therefore the project team cannot take credit for that energy as renewable.
LEED v2009 BD+C Reference Guide

Energy & Atmosphere (EA)
EAc2 On-Site Renewable Energy

Documentation:
- Drawings showing the biomass system in the building
- Biomass boiler shop drawings or cut sheets
- Energy model results showing energy consumption by cost
- Statement from Wood Pellet supplier - pellets were manufactured from clean, untreated wood fiber by-products, from other wood manufacturing processes
- Owner’s statement that the system will be used by and for the owner, and will be retained for the life of the building
Final LEED tally for Berkshire’s pellet boiler: Modeling results show that 21.04% of the project’s energy cost is being offset by the high-efficiency pellet boiler. The project achieved 7 points for (EAc2) Energy & Atmosphere Credit 2.
Management of Wood Ash

• Fly Ash
• Bottom Ash
Uses for Wood Ash

- Soil Amendment (Bottom Ash)
- Ingredient for Concrete (Fly Ash)
- Slag in Road Construction (Fly Ash)
- Landfill Alternative Daily Cover (Bottom Ash)
WOOD CASCADE ACCORDING TO CRADLE TO CRADLE

- Defined Pathways
- Defined Use Time
- Defined Materials, Ingredients and Additives According C2C

Solid Wood -> Veneer

Veneer Stripes -> LSL, Scrimber

Chipboard, Fibre Boards

Insulation Boards

Woodchips

Recycling

Energetical Utilization

Return Ashes as Nutrients to Forest

Original EPEA Used with Permission

Ellen MacArthur Foundation
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RECAP

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• Wood: A Beautiful Material for Structure & Finish in High-Performance Buildings

• Wood: A Renewable Energy Resource

• Wood and Sustainable Design
Questions?

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