Carbon Footprint Analysis

UIUC Facilities and Services

Organization Overview




Student Run • Project Based • Company Focused • University Sponsored

- 250 to 300 students per-year
- Students are peer-selected
- Rigorous screening and selection process
- The University's top talent

- 45 projects last year
- Over 800 projects since 1996
- 12-14 week semester-long engagements
- 650 – 800 student work hours

- Over 500 clients since 1996 including:
  - ✓ Fortune 500 Multinationals
  - ✓ Government Agencies
  - ✓ Non-Profit Organizations
  - ✓ Start-ups

- Operates under the College of Business
- Access to the research and expertise of U of I
- Professional guidance and oversight
- Client owns all intellectual property & deliverables

Team Introduction

Name	Position	Major
Obi Egekeze	Senior Manager	MBA 2
Stephanie Acker	Project Manager	Accounting & Finance
Mike Lyman	Consultant	Accounting
Ladi Ogunnubi	Consultant	MBA
Tim Veldman	Consultant	MS in Civil Engineering
Maria Jones	Consultant	MBA
Tim Ammendola	Consultant	Technical Systems Management
Nathan Kelleher	Consultant	Bioengineering

Agenda

Project Overview

- Scope
- Methodology
- Recommendation

Life Cycle Analysis

- Different Systems Boundaries
- Efficiencies of Coal & Biomass Co-Firing

Other Considerations

- Future Benchmarks
- Appendix

Scope

Carbon Footprint Analysis

- Can the overall carbon footprint be decreased by using 10% of biomass in place of 10% of coal ?

Will the Carbon Footprint Decrease with a 10% Substitute of Woodchips for Coal?

Current Carbon Footprint

- Current Operations
  - Seasonal Effects
  - Transportation
  - Current Coal Footprint
- Coal Efficiency

Projected Carbon Footprint

- Source (Woodchips)
- Transportation
- Coal + Woodchip Efficiency

Other Plants

- Other Schools
- EIU
  - Total Output
  - Footprint Before/After
- Barriers To Entry
  - Legislation/Permits
  - Storage & Transportation

+
Methodology

Secondary Research

- Analyzed reports provided by experts in the biomass field
- Used Comparable co-firing plants & benchmarks

Primary Research

- Conducted interviews with experts to gain data & knowledge

Analysis

- Utilize Secondary & Primary research to make a final statement on whether the overall footprint will be decreased by substituting woodchips for coal

Initial Recommendation

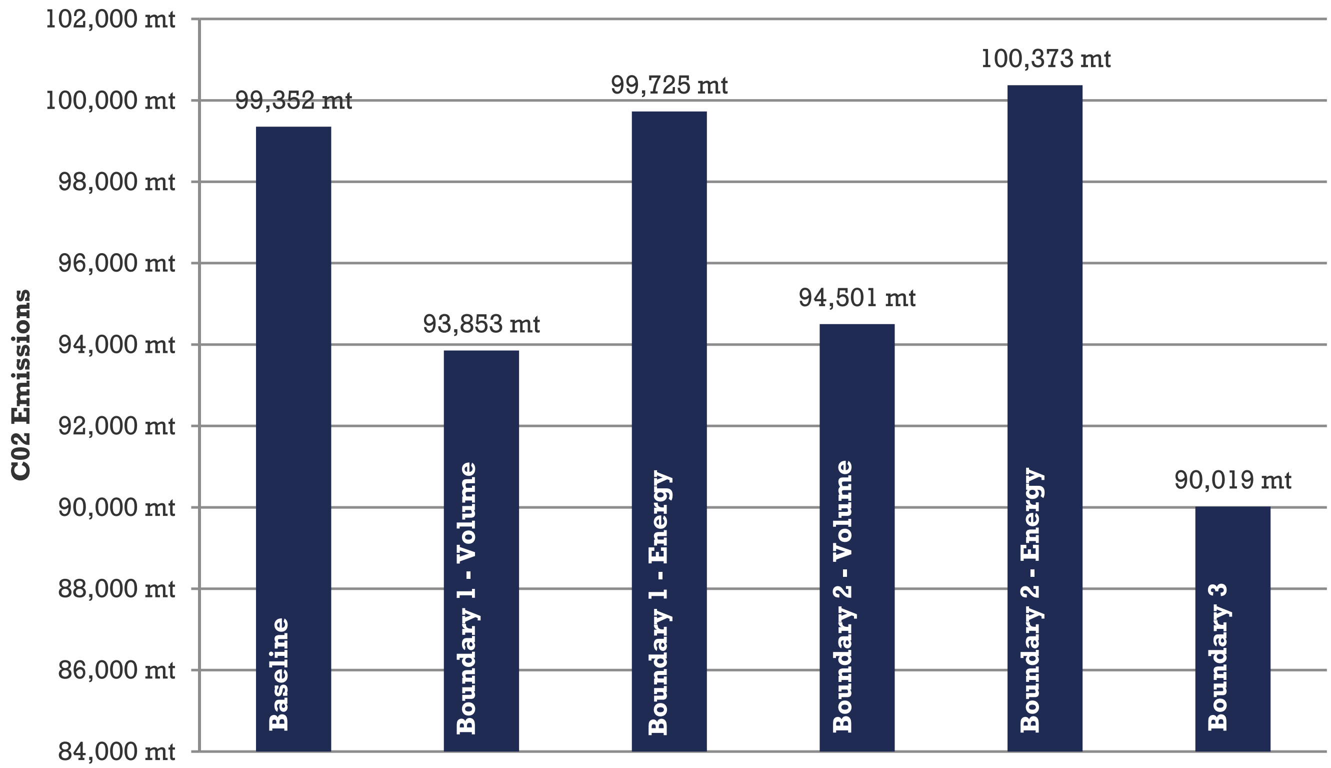
Extent of Carbon Footprint Reduction Relies On:	• Percentage of Biomass Co-fired • Distance Biomass Travels
Increased Transportation and Truck Deliveries From Biomass	• Does not significantly impact carbon footprint reductions from biomass utilization – 2.21% of total carbon footprint
Types of woodchips will affect your efficiencies	• Hard wood woodchips are the ideal source of wood for co-firing

Conclusions

Through the utilization of carbon neutrality, co-firing with hard wood biomass reduces the overall carbon footprint.

If carbon neutrality is not implemented, there will be an increase in CO2 emissions when trying to maintain energy levels

Carbon Neutrality Decreases Overall Carbon Footprint



A larger volume of biomass will be needed to achieve the same energy output as coal when co-firing

Pros & Cons: Co-firing at Abbott

- Pre-existing infrastructure
- Fuel diversity
- Carbon neutral
- Co-firing rate dependent reduction in emissions

- Need for reliable & sustainable source of fuel
- Change in fuel storage, handling & Processing
- Fouling, corrosion, ash deposition
- Loss of efficiency

Loss of efficiency is the greatest deterrent from co-firing

Source: M. Sami, K. A. (1999). Co-firing of coal and biomass fuel blends. *Progress in Energy and Combustion Science*
- National Research Center for Coal and Energy. (2000). *Final report of the Governor's Task Force on Co-firing.* State of West Virginia, National Research Center for Coal and Energy.

Life Cycle Analysis

+
Calculating CO_2 Footprint

- Life Cycle Analysis (LCA) - Cradle to Grave method
- Methodology - ISO 14000 standards

1. Estimate sources of Carbon emission in the cycle
2. Determine boundaries
3. Calculate carbon emissions within the boundary
4. Calculate emissions of alternatives
5. Calculate total emissions and perform cost benefit analysis

Life Cycle Analysis is a proven method to gauge the actual carbon footprint

+ Calculating CO_2 Footprint

This image cannot currently be displayed.

Choosing an appropriate system boundary is critical in creating a LCA

Source: M.K. Mann; P.L. Spath Life Cycle Assessment of Coal- fired Power Production (NREL)

Different Boundaries

Boundaries

Boundary 1
- Combustion

Boundary 2
- Combustion
- Transportation

Boundary 3
- Combustion
- Transportation
- Full life cycle of woody biomass

System boundaries determine the amount of emissions

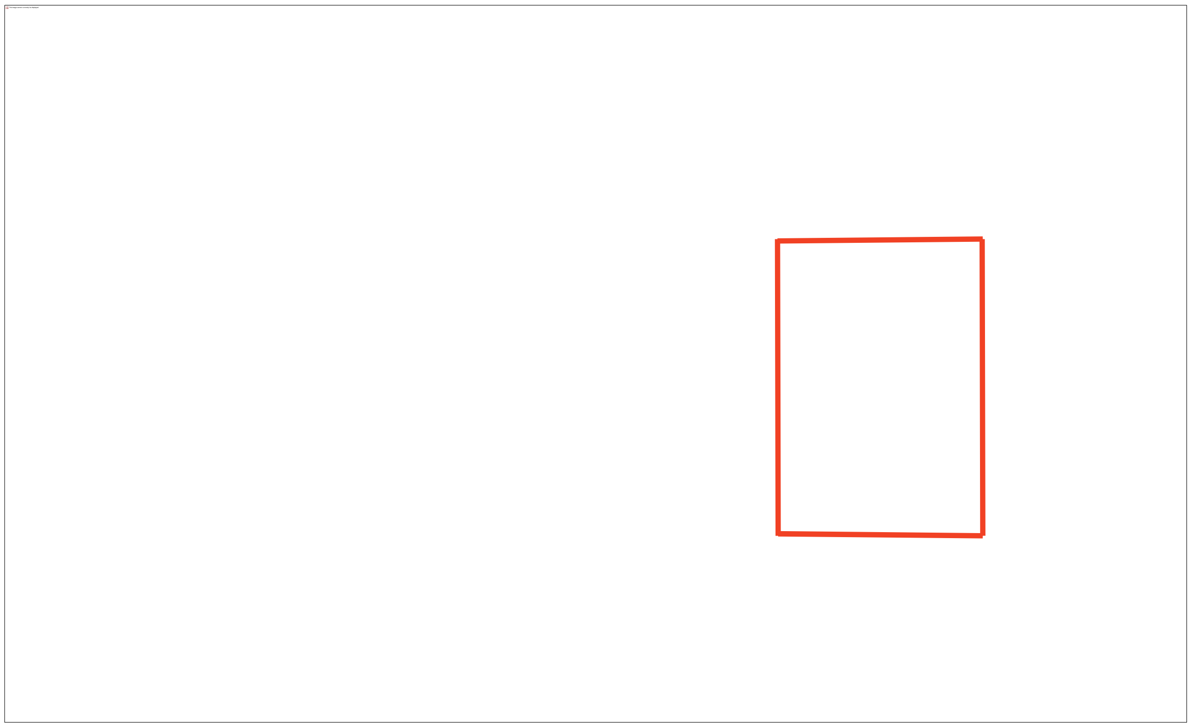
+ Emissions Calculation Procedure

- Inputs
  - Weight of Coal
  - % of Co-firing
  - Woodchip Type
  - Woodchip travel distance
- Methods
  - Volume of coal replaced
  - Equivalent energy output

Fuel Type	Density (kg/m^3)	Density (ton/yd^3)	Energy Density (mmBTU / ton)	CO_2 Emission Factor (kg CO2 / mmBTU)
Coal (Bituminous)	1089.5	0.918	24.93	93.12
English Elm	600	0.506	15.38	96.62
Douglas Fir	530	0.447	15.38	96.62
Pine	760	0.641	15.38	96.62
Oak	560	0.472	15.38	96.62

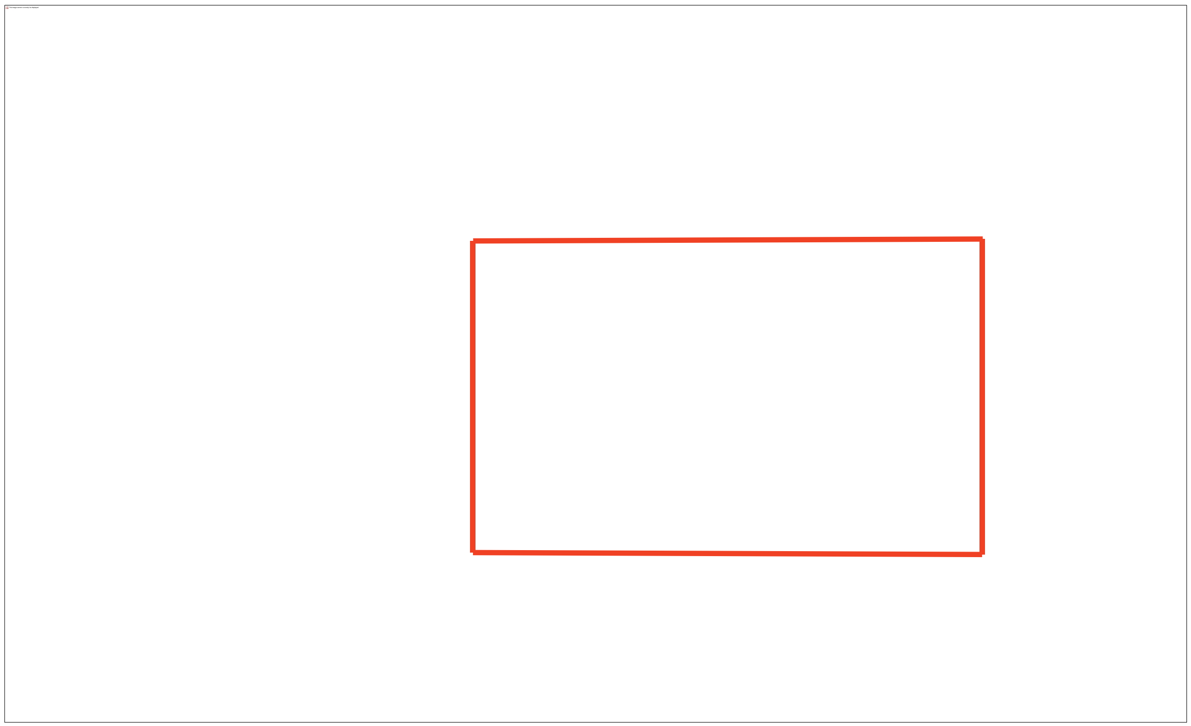
Solving for the equivalent energy output will result in higher calculated emissions

+ Boundary 1



Emissions from coal = 99,352 mt CO2
Emissions using replacement of volume = 93,853 mt C02
Emissions using replacement of energy output = 99,725 mt C02

+ Boundary 2



Emissions from coal = 99,352 mt CO2
Emissions using replacement of volume = 94,501 mt C02
Emissions using replacement of energy output = 100,373 mt C02

+ Carbon Footprint From Coal Transportation

2,247 metric tons of CO_2e per year

The carbon emissions from coal transportation compose only 2.21% of the total carbon footprint caused by coal

Source GHG Emissions Calculation Tool Version 2.3 from The Greenhouse Gas Protocol Initiative

Transportation Carbon Footprint: Round Trip

Percentage of biomass co-firing	50 miles (in mt of CO_2e)	100 miles (in mt of CO_2e)	200 miles (in mt of CO_2e)
10%	32.2	64.5	128.9
15%	48.0	96.2	192.3
20%	63.9	127.9	255.7

As distance and co-firing percentage rise, carbon emissions increase

Source: GHG Emissions Calculation Tool Version 2.3 from The Greenhouse Gas Protocol Initiative

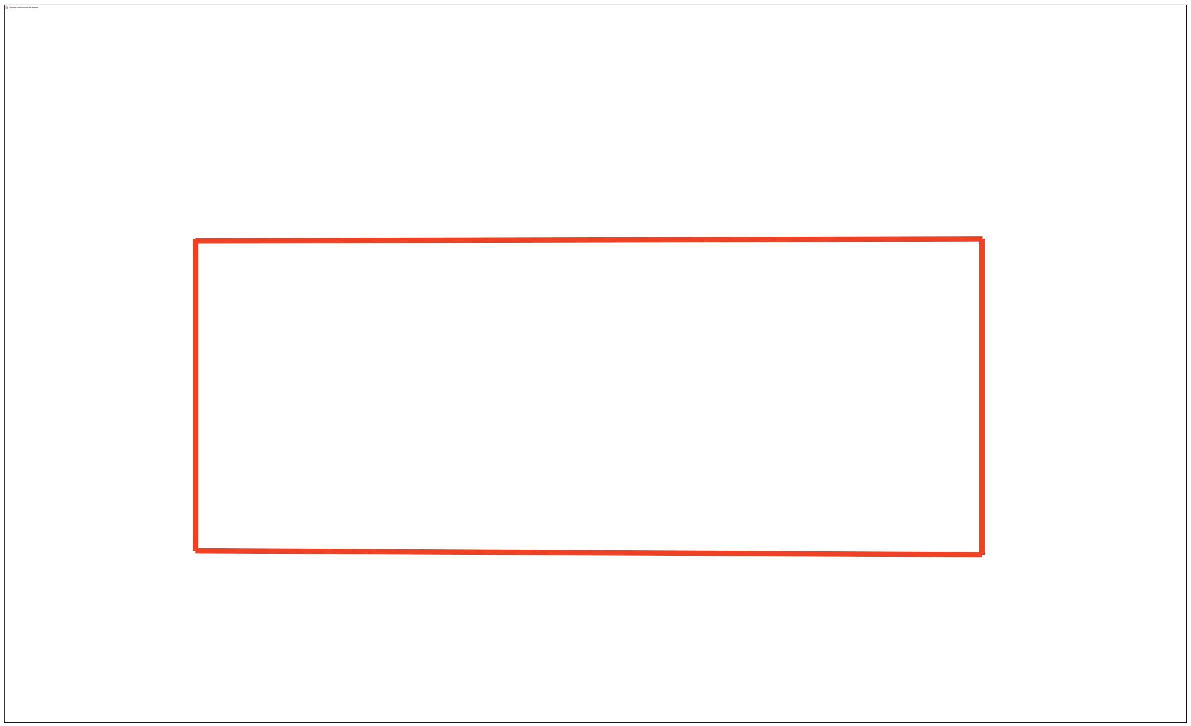
Carbon Footprint: Biomass & Coal Transportation

Percentage of biomass co-firing	50 miles (in mt of CO_2e)	100 miles (in mt of CO_2e)	200 miles (in mt of CO_2e)
0%	2,247	2,247	2,247
10%	1,265.0	1,297.3	1,361.7
15%	1,224.8	1,273.0	1,369.1
20%	1,159.9	1,223.9	1,351.7

Calculated carbon emissions, when transporting materials within 200 miles, will be less than the current carbon footprint from transporting 100% coal

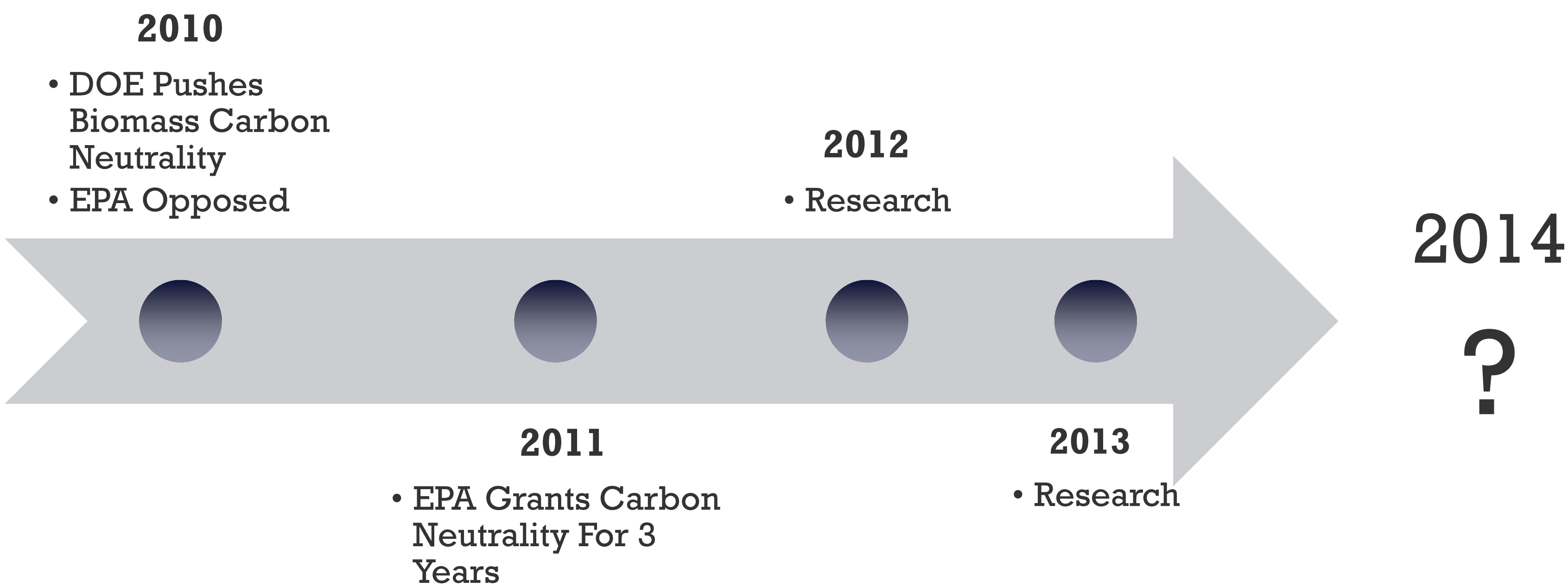
Source: GHG Emissions Calculation Tool Version 2.3 from The Greenhouse Gas Protocol Initiative

Boundary 3



Emissions from coal = 99,352 mt CO2
Incorporates carbon neutrality argument of woodchips
Emissions = 90,019 mt C02

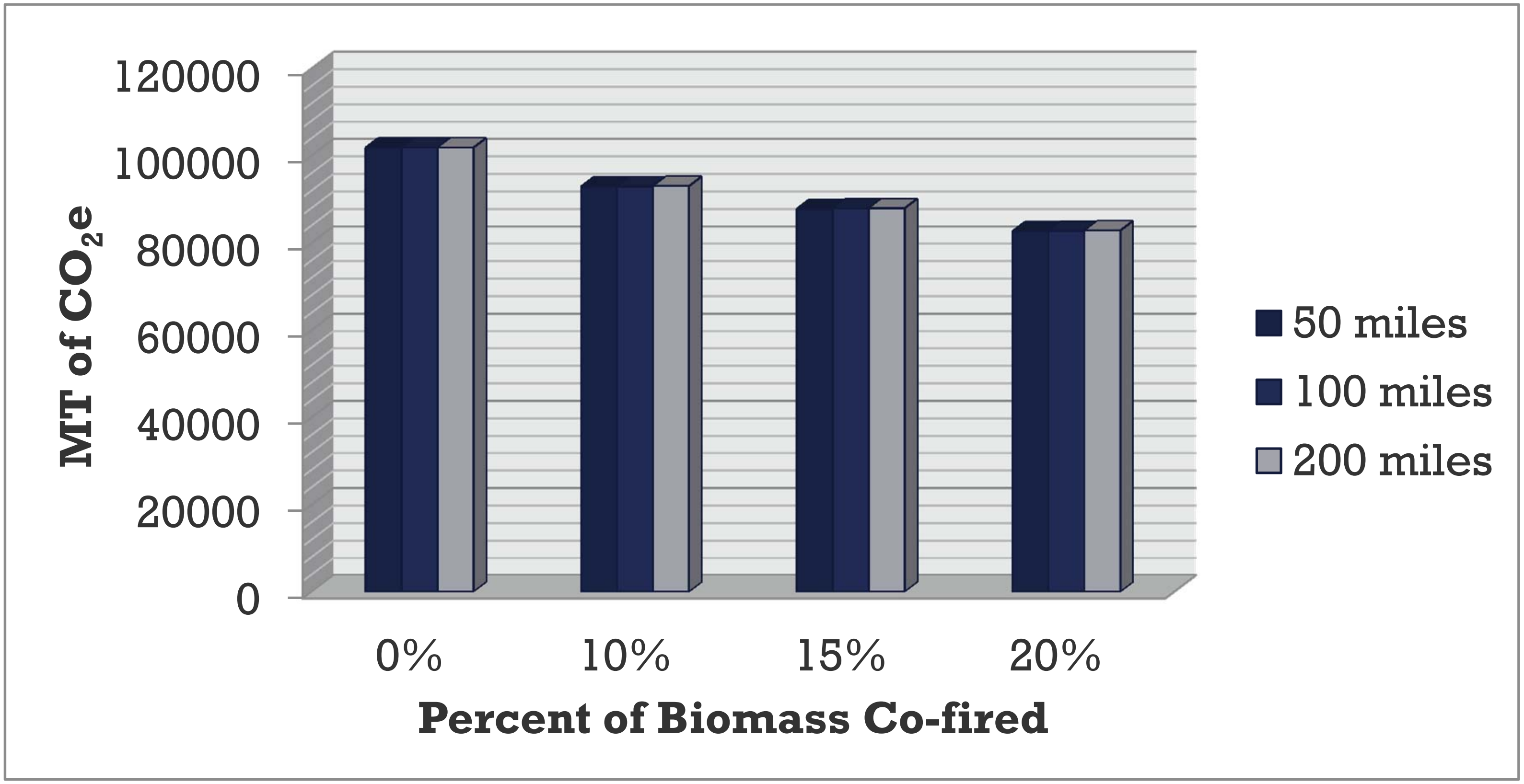
+ Carbon Neutrality Stipulations



Although biomass carbon neutrality is currently an accepted concept, in 2014 it may no longer be an accepted principle by EPA standards

http://www.fas.org/sgp/crs/misc/R41603.pdf

Total Carbon Footprint vs. Transportation Distance



Higher percentages of co-fired biomass and shorter transportation distances reduce the overall carbon footprint

Source: GHG Emissions Calculation Tool Version 2.3 from The Greenhouse Gas Protocol Initiative, 2011 data from Mike Larson and 2006-2010 data from http://www.energymanagement.illinois.edu/pdfs/Carbon%20Footprint%20FY10.pdf

Efficiencies of Coal and Biomass

More volume of woodchips will be needed to maintain energy levels

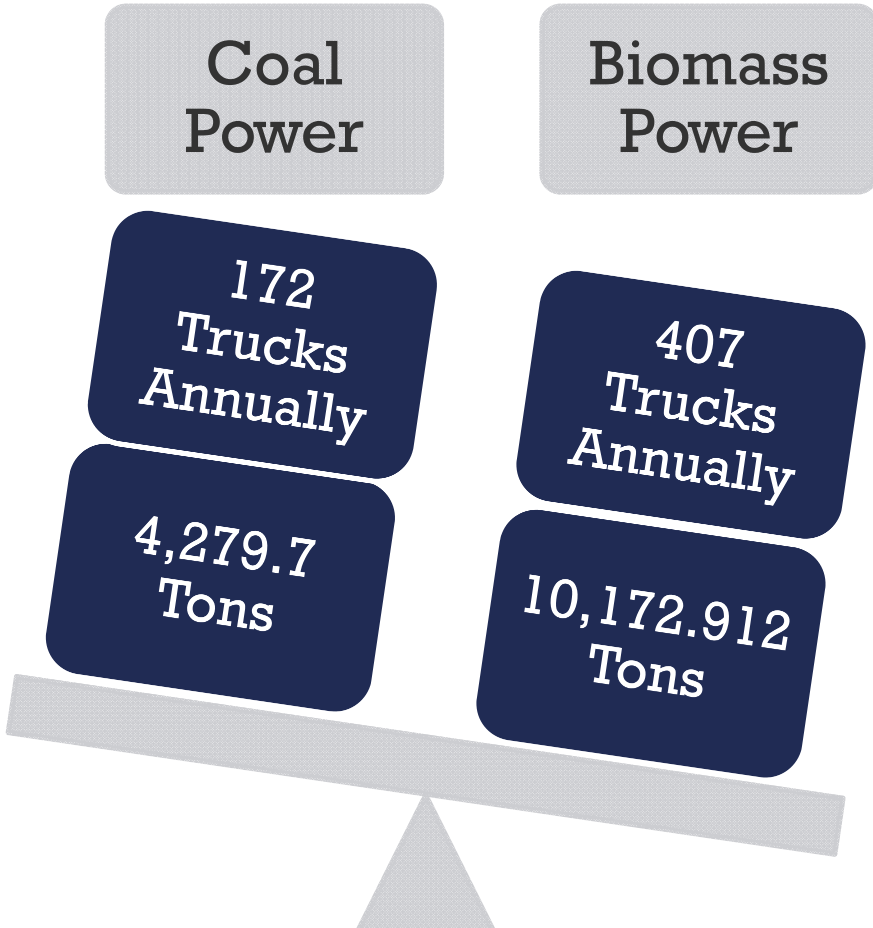
Oak Wood (Moist) Energy Production – 4,938 Btu/lb

Oak Wood (Dry) Energy Production – 8,445 Btu/lb

Bituminous Coal Energy Production – 11,500 Btu/lb

Since more woodchips are needed to maintain energy levels, the number of trucks needed for transportation will increase

10% of Coal Replacement

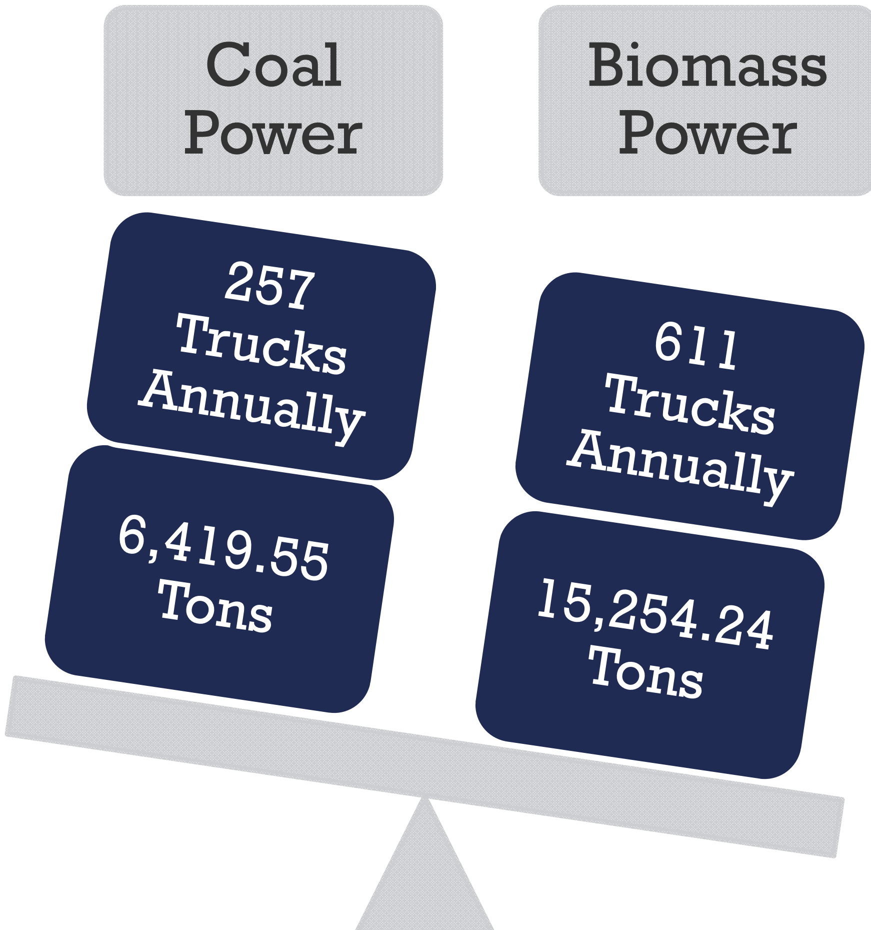


10% of Coal Mass to be replaced with Biomass- 4,279.7 Tons or 8,559,400 lbs

98,433,000,000 BTUs of Energy

10,172.92 Tons of Biomass will be needed to supplement the same amount of energy at 10% co-firing

15% of Coal Replacement

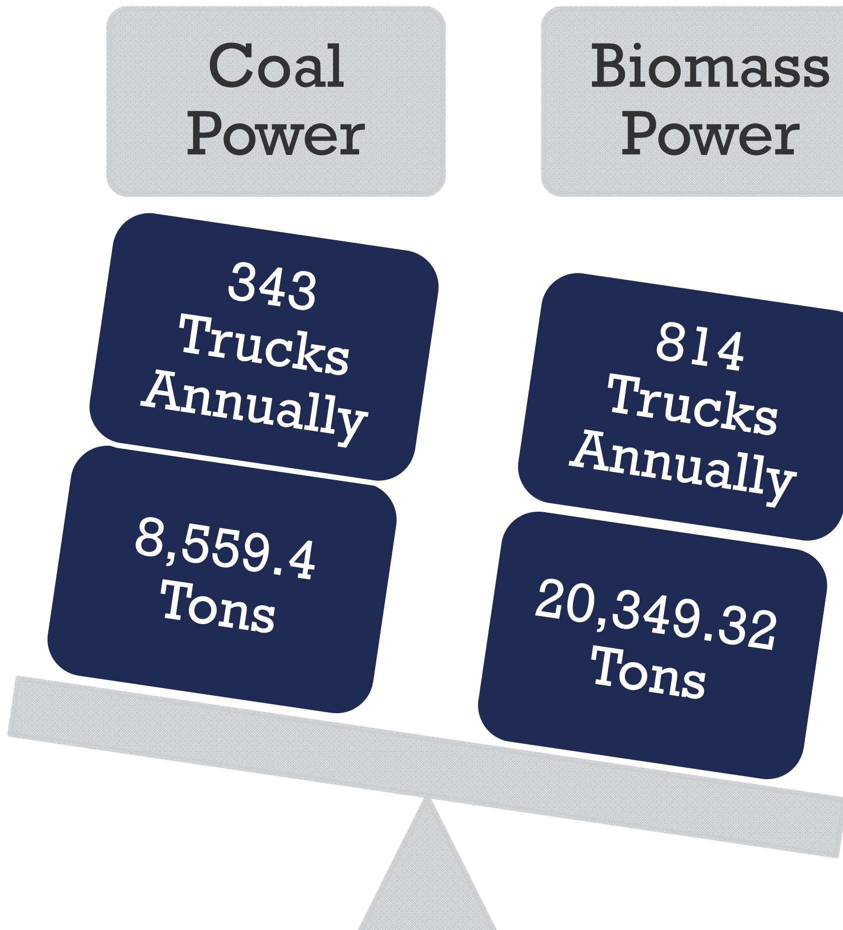


15% of Coal Mass to be replaced with Biomass- 6419.55 Tons or 12,839,100 lbs

147,600,000,000 BTUs of Energy

15,254.24 Tons of Biomass will be needed to supplement the same amount of energy at 15% co-firing

20% of Coal Replacement



20% Coal Mass to be replaced with Biomass- 8559.4 Tons or 17,118,800 lbs.

196,900,000,000 BTUs of Energy

20,349.32 Tons of Biomass will be needed to supplement the same amount of energy at 20% co-firing

Northern Wood Insights

*Taken from an interview with station manager Richard Despins

- Operator training can be a huge challenge
- Wood is sourced from about 55-60 different suppliers
- 300 trucks (each truck with 30 ton load) supplied weekly

"The more consistent the fuel in the system, the better off you're going to be."

Conclusions

Through the utilization of carbon neutrality, co-firing with hard wood biomass reduces the overall carbon footprint.

If carbon neutrality is not implemented, there will be an increase in CO_2 emissions when trying to maintain energy levels

Key Findings & Recommendation

Current infrastructure does not support efficient co-firing of biomass

Based on an analysis of suppliers, Abbott is not in an area with a sustainable supply of wood biomass

There has been a major trend towards increased natural gas usage

Completely firing biomass is a more viable technology

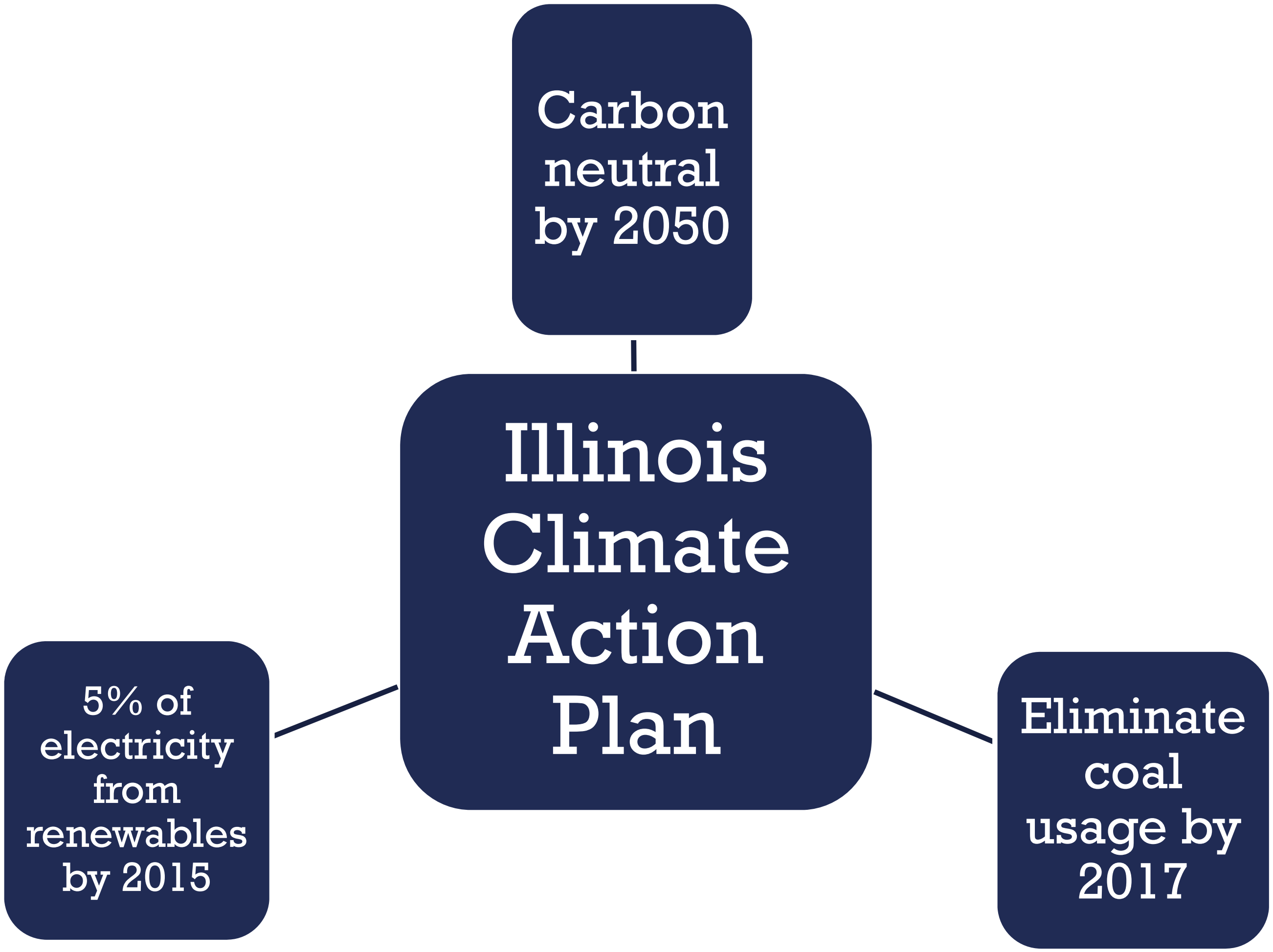
After taking all extenuating factors into account, we recommend not co-firing

Questions?

Appendix

Table of Contents: Appendix

Future Goals



Due to iCAP and price trends, U of I has significantly decreased coal usage each of the past three years

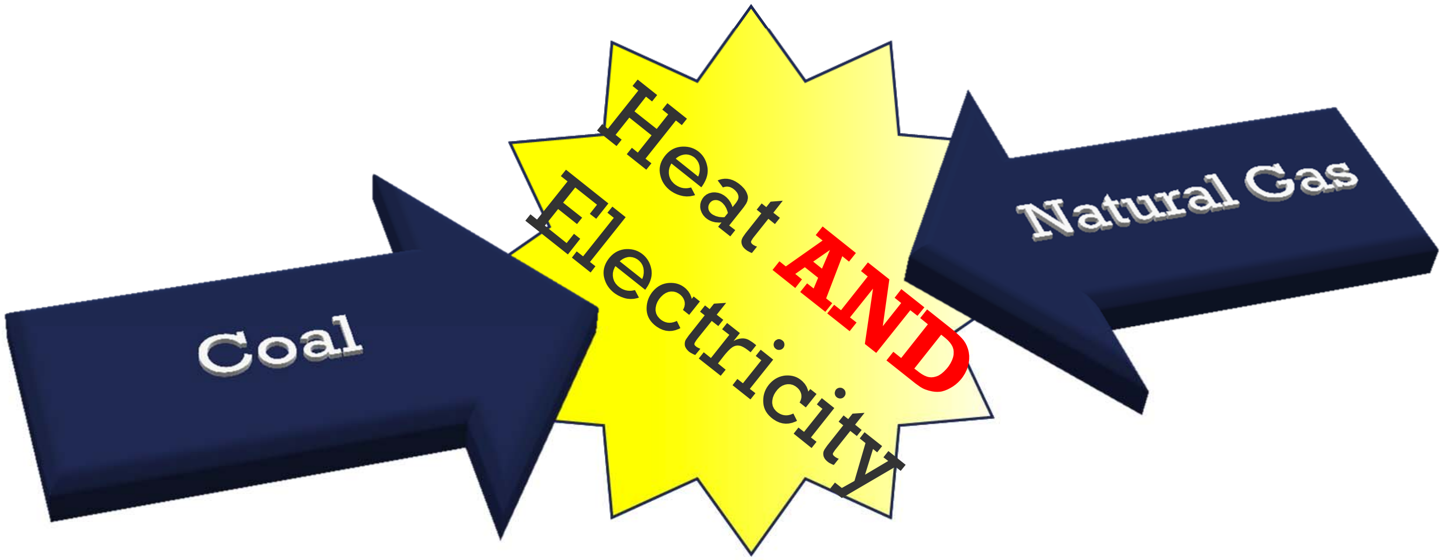
Current Operations

- Abbott Plant can only economically be run as cogeneration plant
  - Steam used to heat buildings
  - Electricity used to power buildings
- Natural gas has been preferred fuel source for previous few years
  - Lower prices
  - Newer, more efficient equipment

The majority of U of I carbon emissions come from purchasing electricity or co-generation at Abbott Plant

Source: http://www.energymanagement.illinois.edu/utilities_energymgmt.cfm

+ Cogeneration



The Abbott Power Plant cogenerates heat (in the form of steam) and electricity (as a byproduct) by utilizing a cost-effective fuel mix of coal and natural gas

Source: Mike Larson during Abbott Power Plant visit on 10/8/12

+ Types of Carbon Emissions

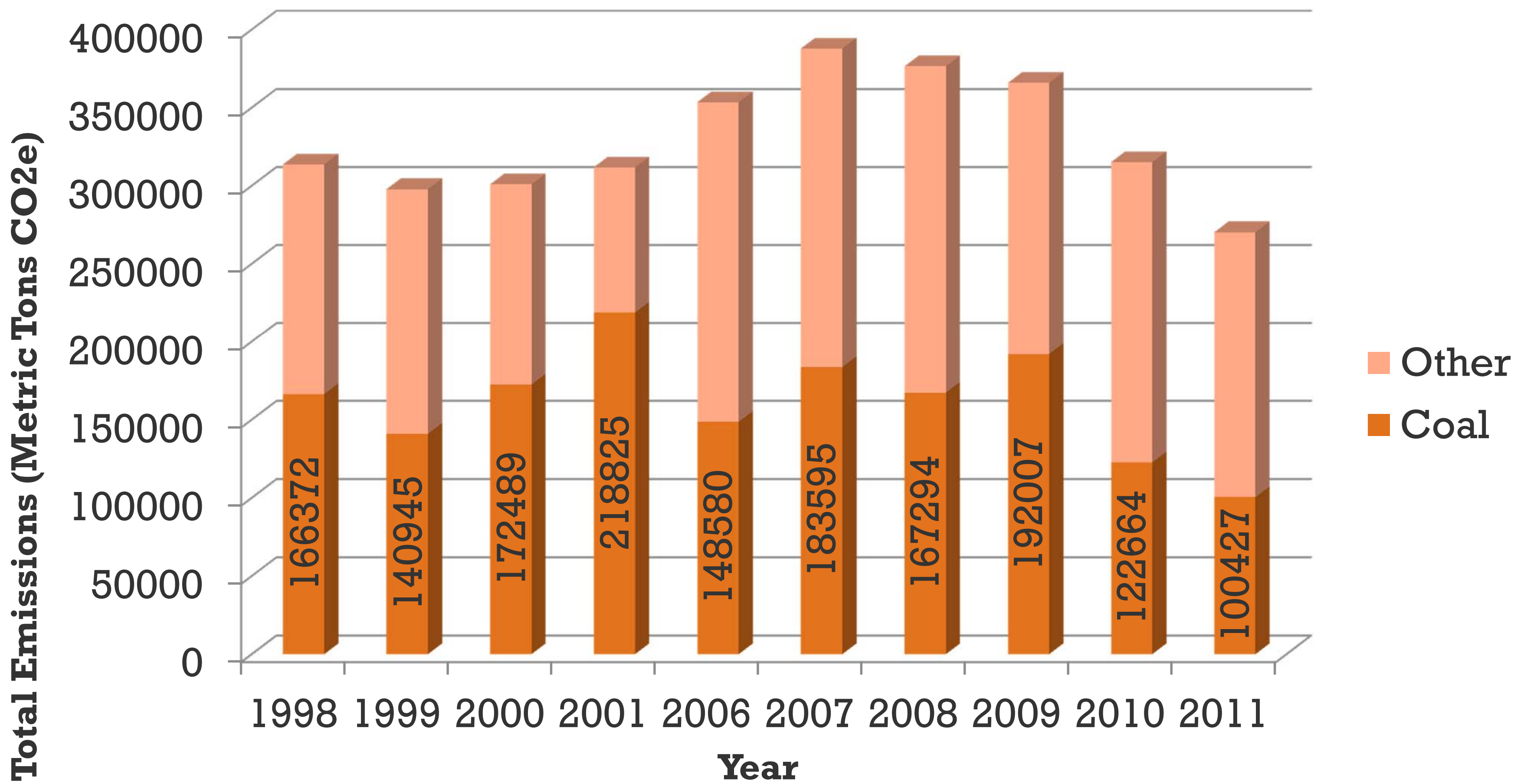
This image cannot currently be displayed.

- Three scopes of carbon emissions
  - Scope 1: Direct emissions
  - Scope 2: Indirect emissions (purchased electricity)
  - Scope 3: Indirect emissions not directly related to the entity's activities

Our focus will be on Scope 1 carbon emissions

Source: http://www.awa.asn.au/uploadedImages/cfootprint_scope.gif

+ U of I Scope 1 Carbon Footprint



In 2011, Coal combustion accounted for 37% of scope 1 emissions at 100,427 metric tons of equivalent CO2

Source: http://www.energymanagement.illinois.edu/pdfs/Carbon%20Footprint%20FY10.pdf

Assumptions Behind Calculations

Coal is transported from approximately 200 miles away[1]

Approximately 3.15 gallons of diesel per ton of coal are consumed by delivery trucks[1]

The Abbott Power Plant utilizes roughly 100,000 tons of coal per year[1]

Trucks can carry up to 25 tons of material[1]

Wood chips are carbon neutral because the CO_2e emissions from combustion are counterbalanced by the amount of carbon dioxide absorbed during photosynthesis[2]

Used oak wood chips as received (4938 btu/lb) from fuel specs for calculating transportation carbon footprint[3]

Did not account for additional reduction in carbon footprint due to decreases in coal mining, handling, and other emissions that are not combustion related

Sources: 1. "Biomass Resource Assessment Final Report *University of Illinois Urbana Champaign*" Antares Group Inc.,
2. http://www.powermag.com/coal/Options-for-reducing-a-coal-fired-plants-carbon-footprint-Part-II_118_p3.html, 3. 2011 fuel specifications from Mike Larson

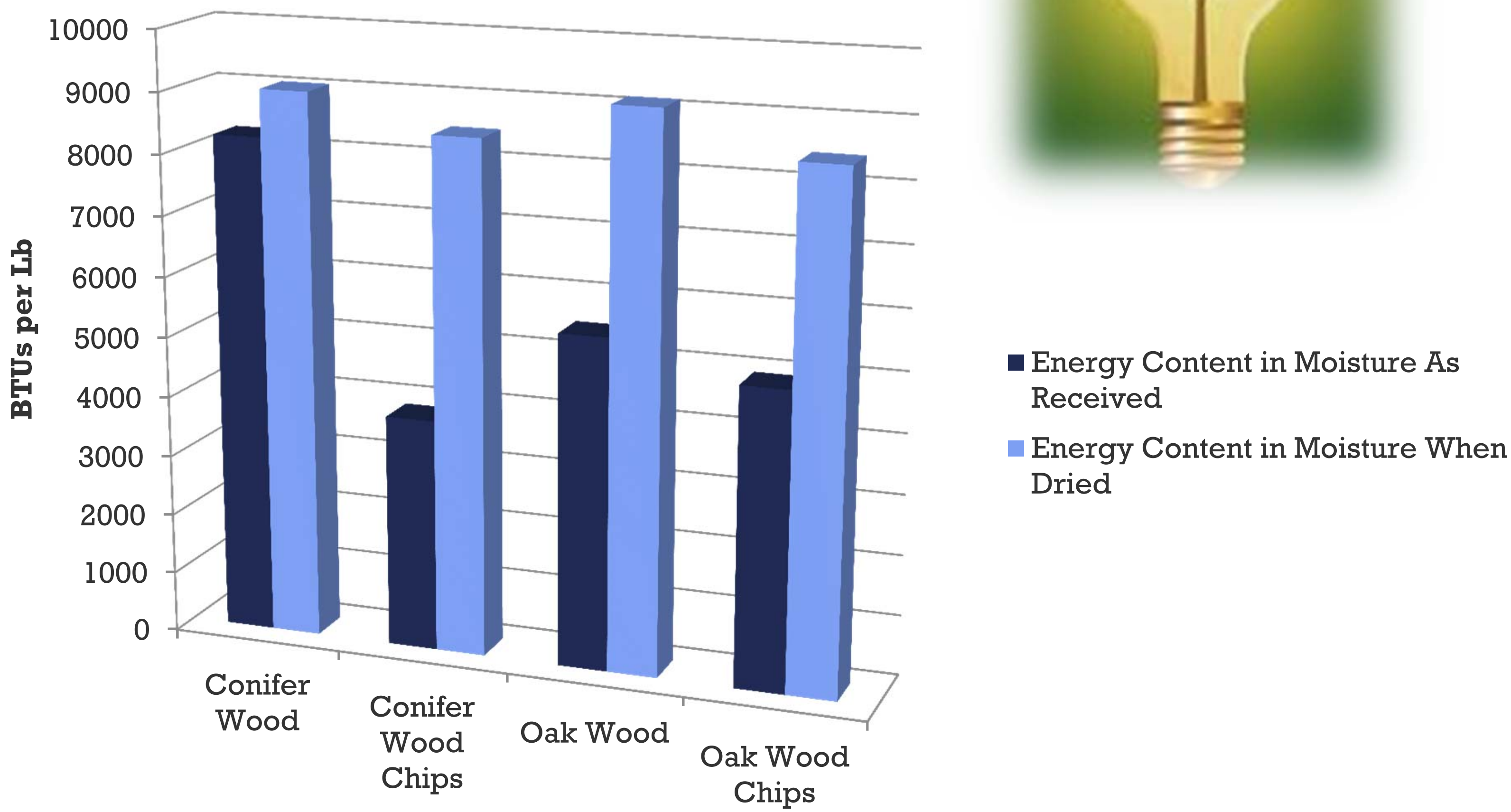
Eastern Not Our Benchmark

Eastern Illinois	UIUC
Gasification Process	Cogeneration Process
Produces 650 kW of power	Produces 80 MW of power
Does not monitor carbon emissions	Required to monitor carbon emissions
Goal: Provide clean energy & avoid volatility of coal market	Goal: Reduce carbon footprint by using 10% biomass

Due to many differences, Eastern Illinois will not be a suitable comparison

Source: Chad Weber Head Mechanical Engineer EIU Biomass Facility

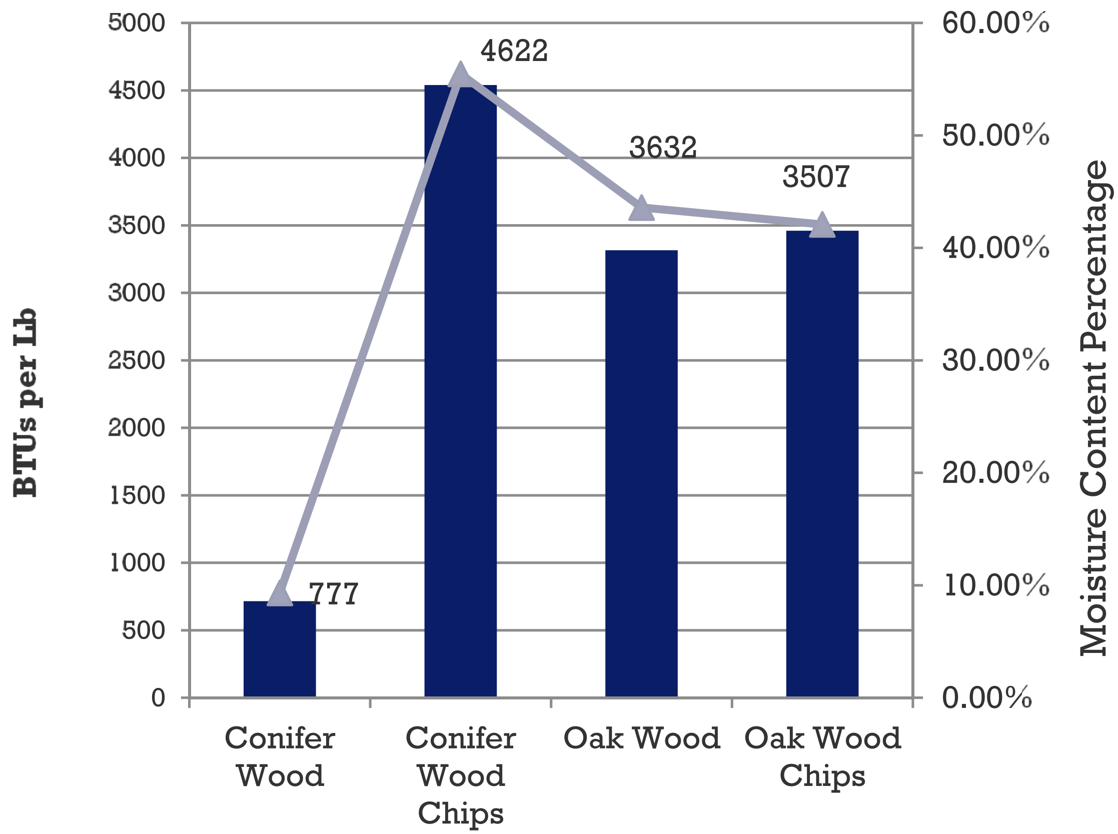
Energy Content



After drying, there is more energy (BTUs) per pound realized in the woodchips biomass fuel

Source: Data from the Abbott Power Plant Fuel Specification Document

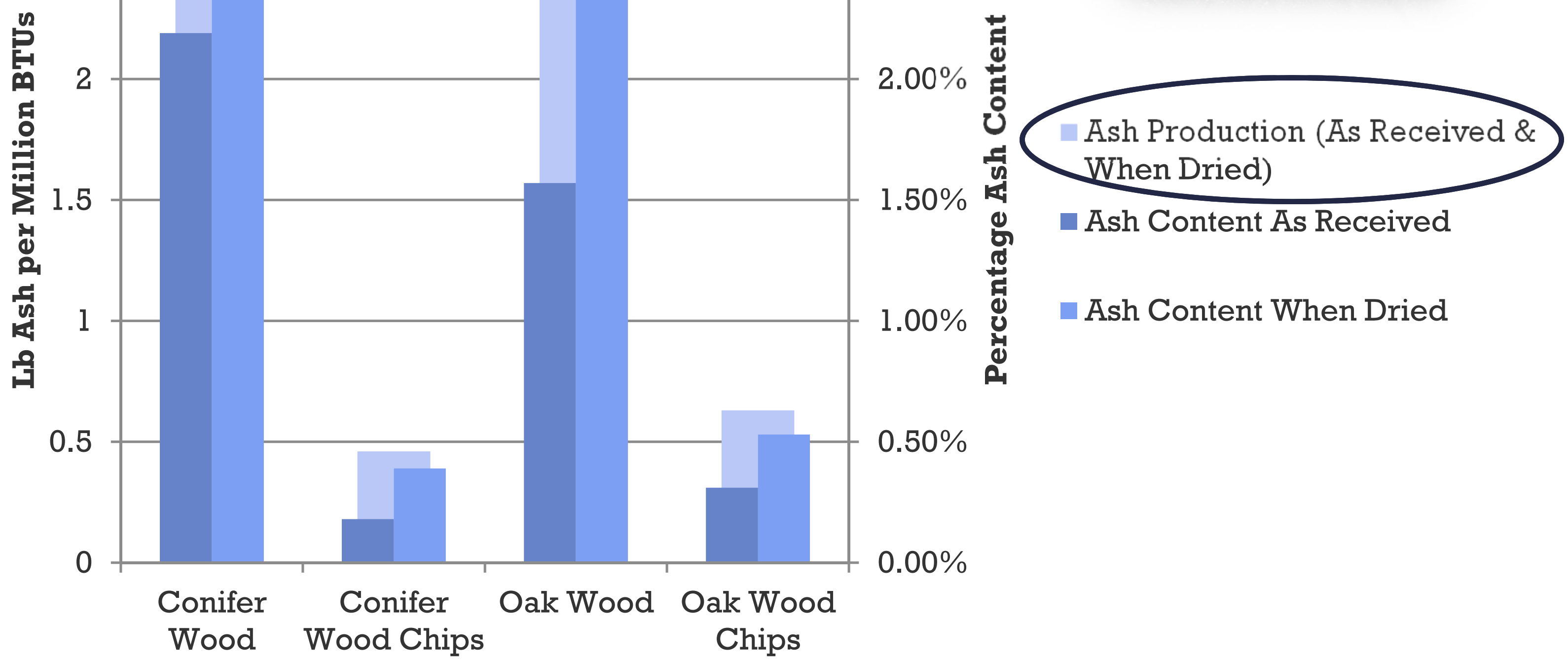
Moisture Content and Energy



Moisture content in the woodchips correlates directly with the heat energy value of the biomass

Source: Data from the Abbott Power Plant Fuel Specification Document

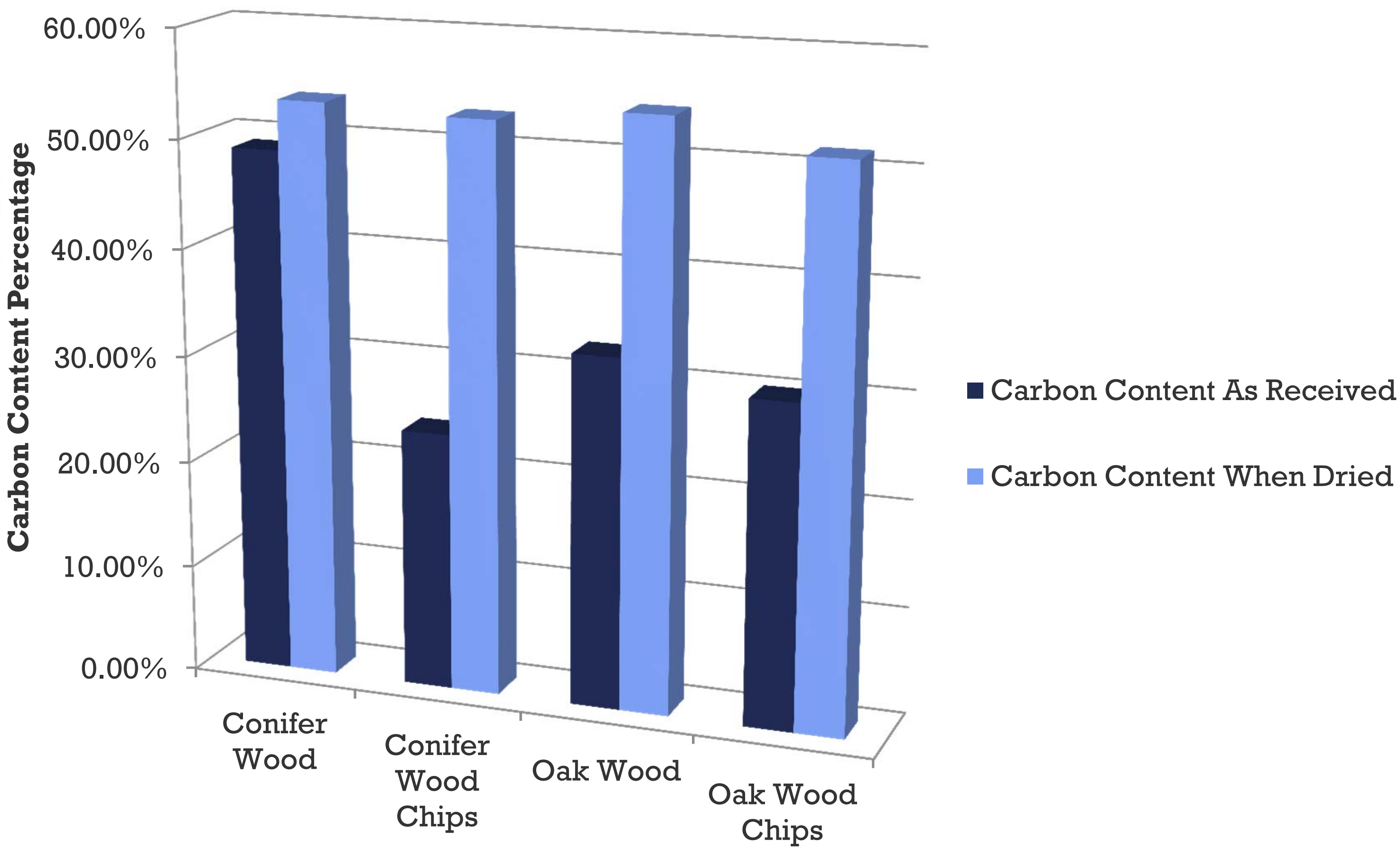
Ash Content and Production



Ash from woodchips is produced at same rate for both natural and dried states, thus, the recommendation is to dry the woodchips before use in order to get more energy per pound

Source: Data from the Abbott Power Plant Fuel Specification Document

Carbon Content



After drying the woodchips, there is an increase in carbon content of the woodchips fuel

Source: Data from the Abbott Power Plant Fuel Specification Document

+ Suppliers

Supplier	Within 50 Miles	Within 100 Miles	Wood Types	Moisture Content	Contaminants	Quote (per ton)
Ecostrat	✓	✓	Green Virgin, Post Industrial Virgin, Composite	47%, 30%, 25%	None	$58
Foster Brothers		✓	General Hardwood Mixture	N/A	None	$42
Beeman & Sons		✓	95% hardwoods, Some Softwoods	22-25%	None	$50

Ecostrat is the closest location followed by Beeman & Sons and then Foster Brothers. Ecostrat also offers the greatest variety but at the highest price

Source: Prices - http://www.procure.stateuniv.state.il.us/dsp_notice.cfm?Uni=EIU&PN=BK109881 , http://www.ecostrat.com/biomass-fuel.php, & Phone Calls

Beeman & Sons

Beeman & Sons has 1 location approximately 80 miles from Champaign.

"Woodchips are produced on site and have a moisture content of approximately 25%."

-Beeman Employee

Foster Brothers

Champaign

Peoria, IL
(90 miles)

Auxvasse, MO
(241 Miles)

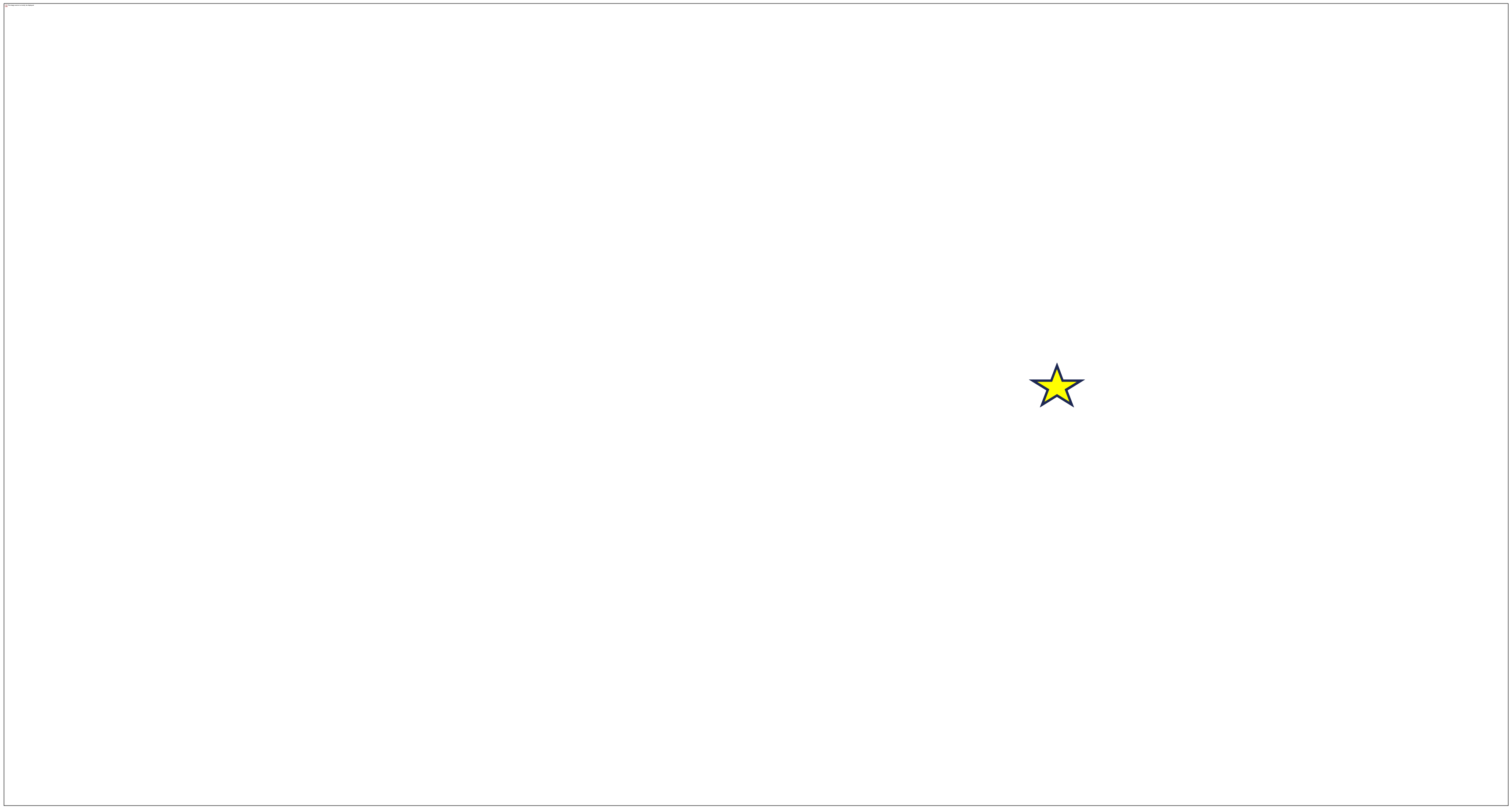
Mehiville, MO
(195 Miles)

Ramsey, IL
(105 Miles)

Ramsey, IL is the closest location; Ramsey produces woodchips on site, which reduces the CO_2e produced by trips to various distribution centers

Source: http://www.fosterbros.com/services.php

Ecostrat



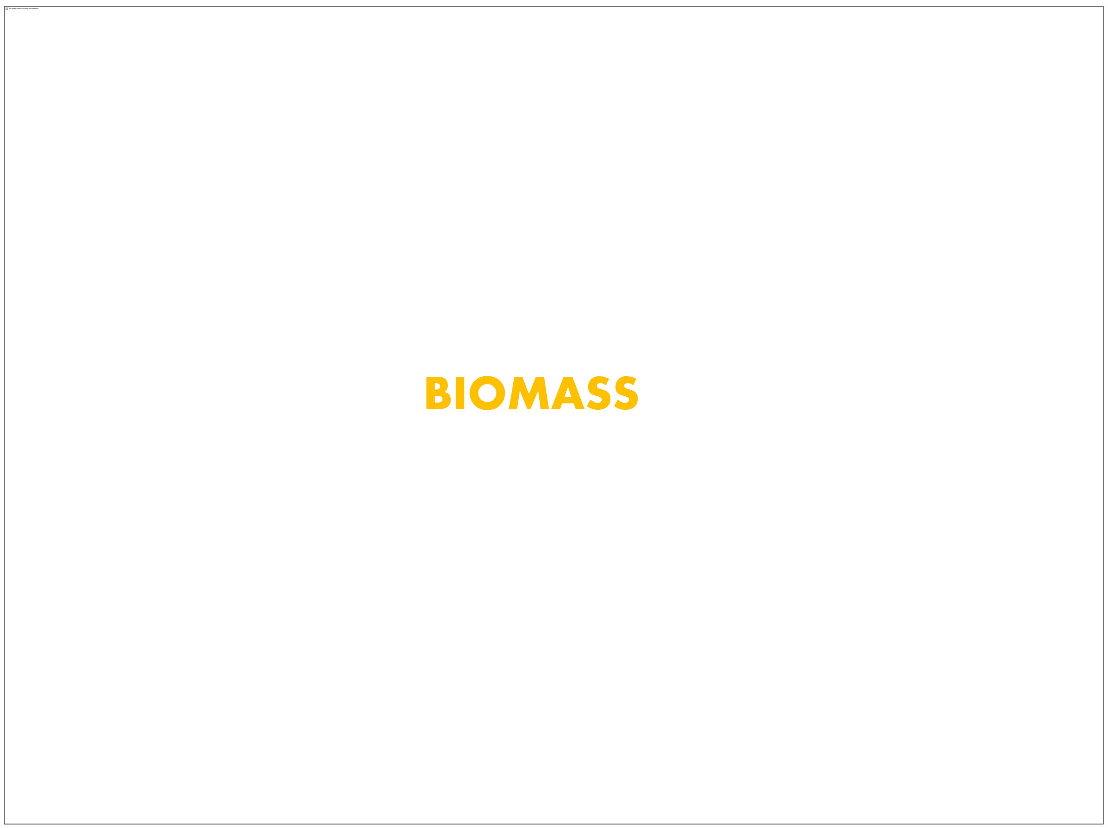
Ecostrat's 200,000 locations minimize transportation costs and risks related to woodchip availability

Source: http://www.ecostrat.com/wood-chip-supplier.php

Carbon Neutrality

Biomass

Carbon Cycle



Fossil Fuels

One way process

Biomass is carbon neutral over time

Different Operations with Woodchips

Process of Burning

Co-Firing

↓

Truck Deliveries

Increase in Truck Deliveries

↓

Labor Hours

Increase

↓

Boiler Operations

Boilers need to run into the night

Due to the new co-firing process, Abbott will need to increase the amount of truck deliveries, mass burned, labor hours, and boiler operating times

+ Potential Benchmark

- Richard Despins, Power Plant Station Manager
- Located in New Hampshire
- Operational since 2006
- Dedicated biomass boiler
- Capacity is 50 MW
- New Hampshire is very favorable for biomass

"The more consistent the fuel in the system, the better out you're going to be."

Factors for Success in Co-firing

Biomass

- Availability and price of biofuel within 50–100 miles of the plant
- Year round steady supply

Coal

- Usage of coal is high
- Prices of coal are high
- Required reduction in emissions

Facility

- Storage facility available onsite
- Bag house or cyclone separator is available
- Minimum modifications are required

Success in co-firing is **site-specific** and depends upon the Economic value of Environmental benefits

Source: Federal Technology Alert. (May 2004). *Biomass Co-firing in Coal-Fired Boilers.* US Department of Energy: Energy Efficiency and Renewable Energy