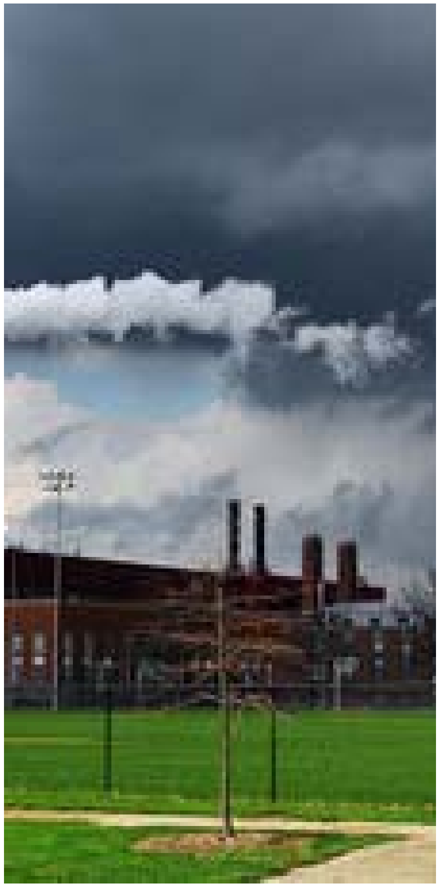


Biomass Economic Feasibility Analysis

UIUC Facilities and Services

+ Introduction to IBC




Student Run • Project Based • Company Focused • University Sponsored

Student Run

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

Project Based

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

Company Focused

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

University Sponsored

- 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

Agenda

Central Question

Economic Feasibility Analysis

What would be the financial impact of UIUC replacing 10% of its coal intake with wood chips?

Methodology

Information was obtained through a combination of primary and secondary research

Primary:

- Contacted over 50 industry professionals and experts
- Went on tours at 2 power plants
- Made contact with over 10 different power plants with co-firing experience

Secondary:

- Researched 5 different relevant biomass associations
- Performed secondary and background research for about 6 weeks

Analysis:

- Identified 4 main operational segments to be affected by the change and detailed relevant costs and savings
- Used data to create a regression analysis regarding Abbott's current decision making process

Issue Tree

Is it financially beneficial for the UIUC power plant to begin supplementing its coal intake by utilizing wood chips to produce 10% of its energy?

Current State

External Factors
- Financial Markets
- Policy
- Funding

Infrastructure
- Facilities
- Transportation of Coal
- Jobs
- Maintenance

Energy Efficiency
- Input Cost vs. Energy Output
- Rates
  - Comparative
  - Historical, Current, and Projected

Desired Future State

External Factors
- Financial Markets
- Policy
- Partnerships
  - Abbot

Infrastructure
- Facilities
  - New
  - Location
- Jobs
- Backup Plan
- Transportation
  - Coal
  - Wood Chips

Energy Efficiency
- Input Cost vs. Energy Output
- Rates
  - Comparative
  - Historical, Current, and projected

Second Half Approach

Decision Making Process

- Obtained an in depth understanding of current purchasing habits that will inform our future projections

Cost of Obtaining Fuels

- Examined all aspects of the transportation of the relevant fuels and calculated the overall impact of the energy switch

Infrastructure Modifications

- Projecting potential costs of modifying or building new infrastructure to support the change

Legal Savings

- Performed extensive research on "Green" tax breaks and grants that would be available to the university, should it decide to proceed

Overall "Green Tax"

- The "Green Tax" is the resultant difference between maintaining the energy status quo and moving forward with the initiative to replace 10% of the university's coal intake with biomass fuel

Cogenerating energy with coal and wood chips will cost the university **$3,475,000** over the next **5** years

Recommendations

Low coal and natural gas prices

- No financial reason to move away from these fuels in the near future

Increased fuel obtainment costs

- Transportation cost increase
- Biomass more expensive than coal on a per BTU basis

Infrastructure creation and modification costs

- Current infrastructure will need modification and storage facilities will need to be built

Tax credits and grants

- Not significant enough to overcome losses in all other facets

At this time, IBC **does not recommend** the undertaking of the biomass initiative on the basis of significant additional expenses

Financial Scenario Analysis

Scenario	2013	2014	2015	2016	2017	Total
Best Case Cost Scenario	($220)	($168)	($168)	($116)	($116)	($790)
Expected Cost Scenario	($757)	($705)	($705)	($653)	($653)	($3,475)
Worst Case Cost Scenario	($780)	($728)	($728)	($676)	($676)	($3,589)

*Numbers are in thousands and indicate the increased cost for biomass above what UIUC would pay to maintain its current energy operations

No matter how well the biomass initiative is implemented, UIUC will lose money; even in the best case and luckiest scenario

Decision Making Process

Regression Analysis Interpretation

- Coal prices increases, consumption decreases
- R-squared=84%, the regression analysis can predict future data points well
- Coal usage in a year=123,627.13 - 767.49 * Coal price
- Future coal consumption and cost can be predicted when prices are projected
- If biomass replaces 10% of coal consumption in volume, approx. $1.5 million coal costs would be saved in the next three years

The regression analysis provides an equation for consumption projections that approx. $1.5 million coal cost is replaced with 10% biomass.

Future Energy Prices

Coal

- Coal prices consistently increased over the last decade
- There has been a decline in domestic demand for coal combined with large inventories of the product available
- Price increase slows down to 1.42% in 2013, and producers export coals to foreign market at record high volume

Natural Gas

- Fracking-the technology drilling natural gas becomes cost effective
- Market is local and winter is mild
- Prices is expected to stay low but will rise if producers decrease supply

Coal and natural gas prices look to remain consistently low into the future and offer no financial justification for altering UIUC's energy plan

Source: http://articles.economictimes.indiatimes.com/2012-06-27/news/32441315_1_coal-prices-thermal-coal-international-coal

Cost of Obtaining Fuels

Cost of Woodchips for EIU

Transportation

+

Woodchips price fixed for EIU

=

Total woodchips cost

Transportation Cost for EIU and Abbott Plant

Unit Price for Fuel in Base Price

- $2.99 per gallon

Gallons Used in the Processing & Delivery of per Green Ton

- 4.88 gallons per green ton

Total Transportation/Processing Cost in the Base Price

- 4.88 X 2.99= $14.59 per green ton

The transportation cost of the woodchips comes out to $14.59 per green ton per EIU's contract

EIU Overview of Prices for Woodchips

Woodchips

$27.49

per green ton

Transportation Cost

$14.59

per green ton

Total Price per green ton

$42.08

per green ton

Taking into consideration the cost of fuel and the cost of transportation, the total cost of obtaining the woodchips is $42.08 for EIU

Cost of Woodchips for Abbot

- According to Levi *et. al* efficiency decreases 4.4% for every 10% moisture increase. So we can calculate the prices for each moisture content as shown:

Moisture Content	Price
10%	$35.01
20%	$33.47
30%	$32.00
40%	$30.59
50%	$29.24

The difference in price at the various moisture levels opens up a potential arbitrage opportunity that will be explored in the infrastructure section

Source: Pirraglia et al. (2012). 'Biomass for direct co-firing' ***BioResources*** 7 (4), 4817-4842.

Potential Supplier: Foster Brothers

- Right now, woodchips cost $53.66 per ton with the delivery

Woodchips

- $32

Transportation Cost

- $15 + $6.66

80 miles difference from Charleston

Total Price

- $53.66

The total estimated cost for UIUC, based on a quote from Foster Brothers, is $53.66

Info from Pann Rogers at the Foster Brothers

Coal Prices & Transportation

- Coal from Knight Hawk Coal
- Transportation costs based on $3.50/gallon #2 Diesel Fuel

Coal
- $43

Transportation Cost
- $21

Total Price
- $64

Disposal Cost
- Ash & gypsum $16

Total Price with Disposal
- **$80**

Coal versus Woodchips, 2012

- Coal is ~2x heat value of wood chips ➔ In order to produce the same amount of energy as coal 2x of wood chip mass is needed
- Ash from woodchips can be given/sold to farmers/EIU if it is burned separately

Fuel Type	Cost per Delivered ton (Dollars)	Net energy Content (Million BTUs per Ton)	Fuel Cost (Dollars per Million BTU)
Coal	$64	15.5	$4.13
Coal with Disposal Cost	$80	15.5	$5.16
Woodchips	$53.66	9.0	$5.89

When the energy content of each fuel is taken into consideration, woodchips prove to be more expensive

Pirraglia et al. (2012). 'Biomass for direct co-firing' ***BioResources*** 7 (4), 4817-4842.

+

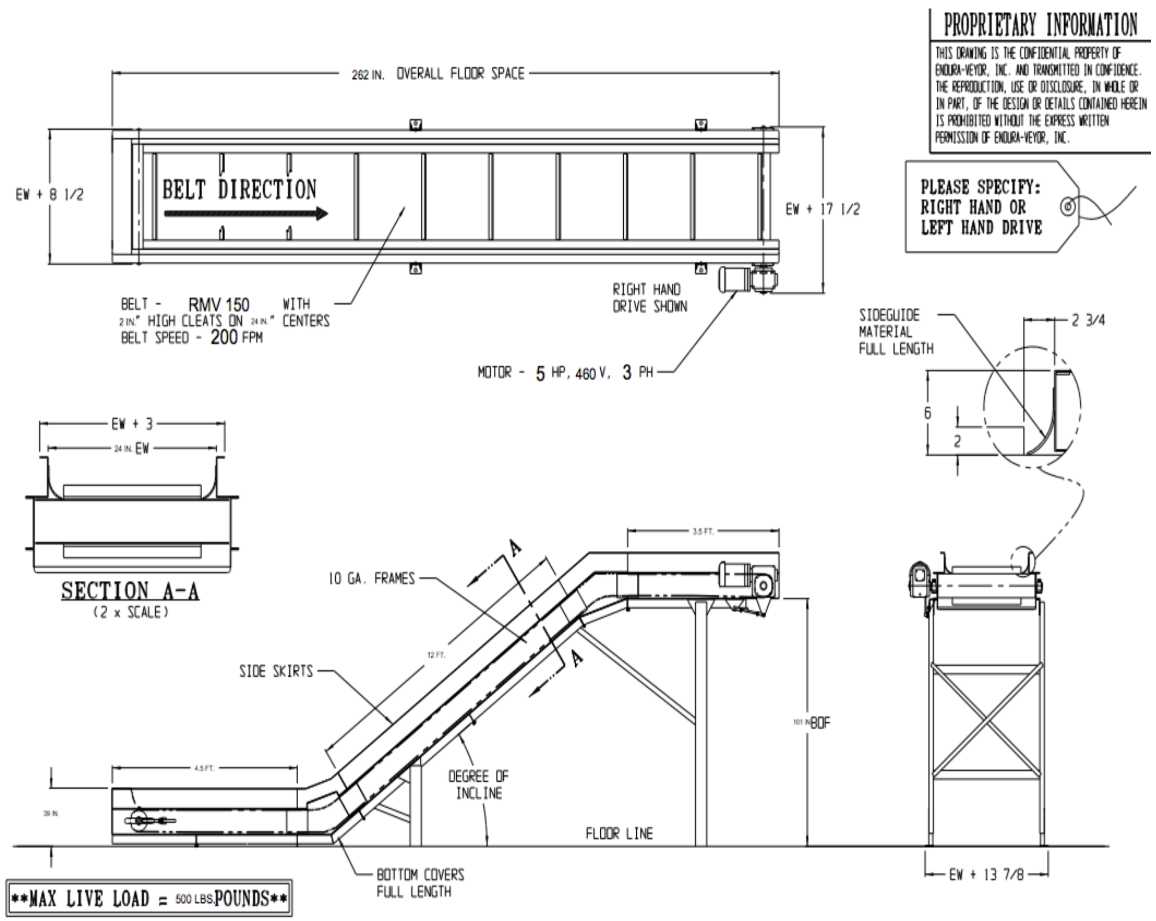
Infrastructure Costs

Facility Modification/Creation

Wear and Tear Cost

Benchmark Analysis

Short-term Solution



Materials:	$25,020.00
Labor:	$17,700.00
Total:	**$42,720.00**

Mass flow steel hopper will cost $42,720

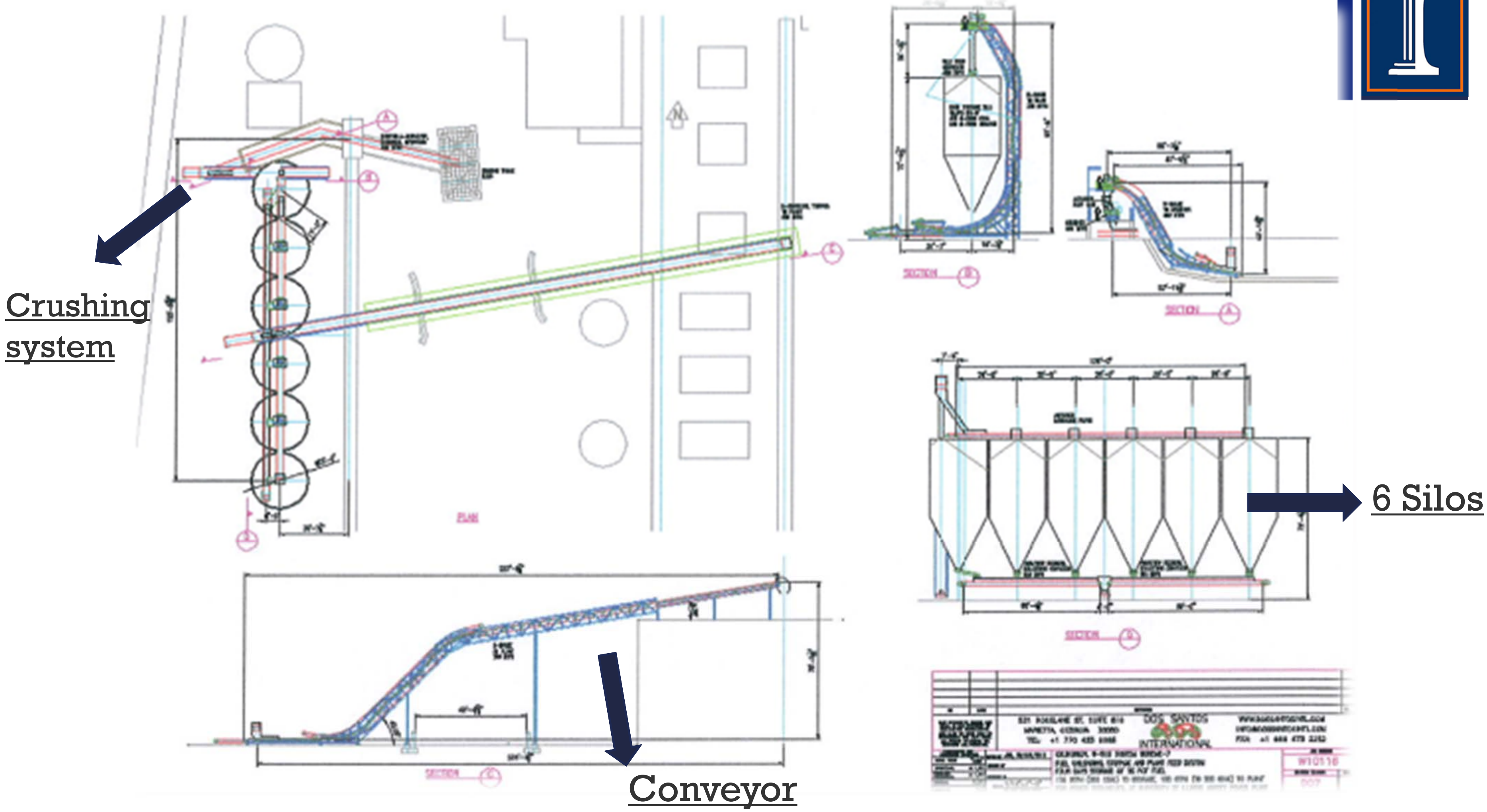
Long-term Solution: Parameters

System will allow for alternative fuels

Covered storage area (i.e.. Silo)

Coal crushing system

Long-term Solution: Preferred



Long-term solution will cost about $8,300,000

+ Why dry woodchips on-site?

10% moisture, $56.67/Ton

30% moisture, $53.66/Ton

Reduce to 10% moisture

Drying woodchips on-site could be cost-saving

+ Woodchip Drying System Cost Analysis

Period	Savings
Period 1-July 1, 2012 to June 30, 2013	$72,240
Period 2-July 1, 2013 to June 30, 2014	$60,220
Period 3- July 1, 2014 to June 30, 2015	$60,200
Period 4- July 1, 2015 to June 30, 2016	$48,160
Period 5- July 1, 2016 to June 30, 2017	$48,160

Savings determined by difference between 10% and 30% moisture

NPV Analysis:

Investment	Value
Bed Dryer	-$772,486.15
Basic Fan*	$147,513.85

The basic fan appears to be a positive value investment, but it would only be a small piece of the $8,300,000 infrastructure investment

*Purchased infrastructure needed

Drying Facility is not feasible

Solar drying would not be effective during winters	Variations in woodchip sizes will reduce efficiencies	Woodchips should not be put into big piles
Additional labor to periodically turnover woodchips	Fuel driers are not found in facilities sized ~10 MMBtu or lower	Turnover rate too high

On-site drying may be not feasible for the Abbott Power Plant

http://www.esru.strath.ac.uk/Documents/MSc_2002/ioannidi.pdf http://www.biomasscenter.org/pdfs/Wood-Chip-Heating-Guide.pdf

Woodchip Drying Financial Summary

Silo/Warehouse Drying

$140,010 (Initial Investment)+ $102,000 (per year)+.306 * # of tons (per year)

Bed Dryer

$1,060,000 (Initial Investment)+ $102,000 (per year)

Both drying options require a significant investments that are too high to justify

Benchmark Analysis

Hibbard Energy Center, Minnesota [Status: Completed]

- **Technical Match**
  - 3 Spreader stoker boiler
  - Primary fuel coal and secondary wood chips
  - Co-firing type – direct
  - Output (Mwe) = 72
  - Wood : Coal = 20%: 80%
- **Upgrades**
  - Facility upgrades
  - Wood handling
  - Boiler control systems
  - Ash and boiler cleaning system for additional 140,000 MWh/year

Total Cost of the Project = $22,000,000

Source: **Minnesota Public Utilities Commission – Staff briefing papers**
https://www.edockets.state.mn.us/EFiling/edockets/searchDocuments.do?method=showPoup&documentId={C4538C8E-54C9-41DE-87C7-130818C38912}&documentTitle=20098-40746-01
http://www.emersonprocessxperts.com/2012/02/more-efficient-wood-based-biomass-energy-production/

Maintenance Issues

Corrosion and Fouling Effects

- **Areas:**
  - Corrosion – Boiler wall/ tube
  - Fouling – Convection section
  - Slagging – Furnace section
- **Causes:**
  - High chlorine and potassium content
- **Effects:**

Flame Location

- **Areas:**
  - Combustion chamber
- **Causes:**
  - High amount of Biomass fuel with lower heating value
- **Effects:**
  - Flame instability – NOx level increases

Corrosion, fouling, and flame location are the main issues encountered when attempting to co-fire in a coal boiler

Source: **Kema Consulting Report, Netherlands** http://www.ieabcc.nl/publications/09-1654%20D4%20Technical%20status%20paper%20biomass%20co-firing.pdf
UMICH Report http://www-personal.umich.edu/~mswool/publications/cofire_prog_official_reprint.pdf

Possible Modifications

Options

- Higher fuel injection level
- Increase Ash removal frequency
- Maintaining control system to handle higher amount of fuel

Cost Estimates

- **$ 1,000,000** per boiler for maintenance

Benchmark Lessons Learned:

- The Ash produced ≈ 1.5 times than the coal only fuel case
- Expected Lifespan after modification = 22 yrs.

Modifications necessary to prevent the increased wear and tear of co-firing will cost $1,000,000 per boiler

Source: **Kema Consulting Report, Netherlands**
http://www.ieabcc.nl/publications/09-1654%20D4%20Technical%20status%20paper%20biomass%20co-firing.pdf
UMICH Report
http://www-personal.umich.edu/~mswool/publications/cofire_prog_official_reprint.pdf

Abbott Implications

Infrastructure Modifications

- **Areas of modifications:**
  - Boiler wall / tubes
  - Convection Section
  - Furnace Section
  - Fuel injectors

Total new facility cost

- **$8,300,000**

Total expected Maintenance Cost for Abbott Power Plant

- **$2,000,000**

Abbott should expect an infrastructure cost of $10,300,000 to take on biomass initiative

+

Legal Savings

Tax Credits

Grants and Subsidies

Renewable Electricity Production Tax Credit (PTC) Overview

- State: Federal
- Incentive Type: Corporate Tax Credit
- Applicable Sectors: Commercial, Industrial
- Carryover provisions: 20 years

PTC is a per-kilowatt-hour tax credit for electricity generated by qualified energy resources and sold by the taxpayer to an unrelated person during the taxable year.

Source:http://dsireusa.org/incentives/incentive.cfm?Incentive_Code=US13F

+ PTC Amount

Resource Type	In-Service Deadline	Credit Amount
Wind	December 31, 2012	2.2¢/kWh
Closed-Loop Biomass	December 31, 2013	2.2¢/kWh
Open-Loop Biomass	December 31, 2013	1.1¢/kWh
Geothermal Energy	December 31, 2013	2.2¢/kWh
Landfill Gas	December 31, 2013	1.1¢/kWh
Municipal Solid Waste	December 31, 2013	1.1¢/kWh
Qualified Hydroelectric	December 31, 2013	1.1¢/kWh
Marine and Hydrokinetic	December 31, 2013	1.1¢/kWh

The tax credit amount varies by resource type that there are two categories for biomass.

Two Types of Biomass Power Plants for Tax Purpose

Closed-loop biomass power plant: the feedstock is grown specifically for the purpose of power generation.

Open-loop biomass power plant: any agricultural or any solid, nonhazardous, cellulosic waste material or any lignin material which is derived from–

- forest-related resources
- solid wood waste materials
- agricultural sources

Abbott would not qualify for the Closed-loop biomass tax credit, but it would fall under the open-loop category and potentially receive 1.1¢/kWh if it meets the rest of the qualifications

+ Co-firing Restriction

A power plant may qualify for the tax credit if it meets the minimum biomass co-firing ratio requirement of 50%

Only the electricity produced by the biomass is eligible to receive a tax credit, but the electricity resulting from the coal is not eligible

Abbott will not qualify for the tax credit due to not meeting the minimum ratio requirement.

Amount of tax credit

- In fiscal year of 2011, campus consumed 5 million MMBTU of energy, with 25.9% coal of 60,479 tons
- coal consumption 379,564,500 kwh

- If 10% of coal were replaced with biomass, the amount of tax credit would be up to $417,521 for fiscal year of 2011

- For projected coal consumption for year 2013 to 2017, total tax credit could be up to $3.3 mill

- Because Abbott power plant uses co-firing method without satisfying minimum coal level requirement, the tax credit cannot be filed

Up to $3.3 million tax credit can be claimed for year 2013 to 2017 if the biomass power plant complies PTC requirements. However, the inefficiencies of co-firing at 50% outweigh the benefit of the tax credit

Applicable Grant Opportunities

Renewable Energy Business Development Program

- Funds projects that support the development of renewable energy
- Proposed projects are eligible for 50 percent of eligible project costs

Biogas And Biomass To Energy Grant Program

- Funds projects that utilize the use of biogas and biomass for on-site energy generation in Illinois.
- Specifically projects that use biogas or biomass to produce electricity with combined heat and power (CHP) through co-firing
- Eligible for funding up to 50 percent of the total project cost

Repowering Assistance Biorefinery Program

- Funds biorefineries which replace fossil fuels with renewable biomass to produce heat or power to operate the biorefineries
- Assistance can be awarded in amounts up to 50 percent of the total project costs

http://www.illinoisbiz.biz/dceo/Bureaus/Energy_Recycling/Energy/Clean+Energy/01b-Renewable+Energy+Business+Development+Program.htm

Total Grant Values

- Renewable Energy Business Development Program
- = $100,000 to $500,000

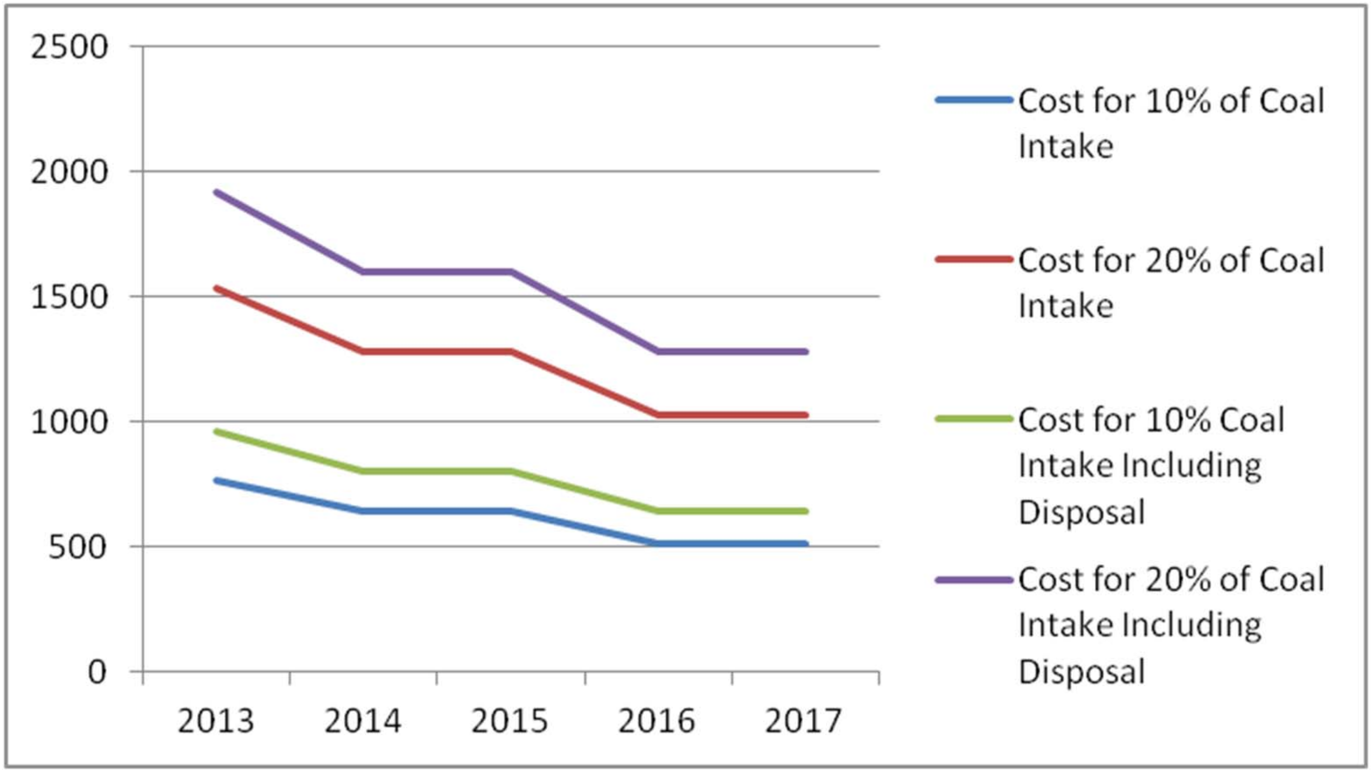
- Biogas And Biomass To Energy Grant Program
- = $0 to $500,000

- Repowering Assistance Biorefinery Program
- = $0 to $500,000

In calculating future expenditures, can use these estimates to illustrate the various funding scenarios that could occur.

+
Financial Analysis and Conclusions

5 Year Coal Intake Projection and Costs



*Numbers in thousands

Determining the cost of the coal that is to be replaced creates a baseline with which to compare the projected biomass costs

Source: Abbott (See appendix)

Scenario 1:Best Case Cost Scenario

- Assumptions:
  - $42,000 infrastructure investment
  - 3 grants totaling $1,500,000
  - Infrastructure life expectancy of 5 years
  - 10% biomass to coal ratio

(in thousands)	2013	2014	2015	2016	2017	Total
Extra investment	($220)	($168)	($168)	($116)	($116)	($790)

Even in lowest possible expense scenario, the woodchip endeavor is projected to cost UIUC $790,000 over the next 5 years

Scenario 2: Expected Case

- Assumptions:
  - $10.3 million infrastructure investment
  - 1 grant total $500,000
  - Infrastructure life expectancy 22 years
  - 10% biomass

(in thousands dollars)	2013	2014	2015	2016	2017	Total
Extra investment	($757)	($705)	($705)	($653)	($653)	($3,475)

When all necessary infrastructure modifications are made and all grants are obtained, the biomass initiative is projected to cost **$3,475,000**

Scenario 3:Worst Case Cost Scenario

- Assumptions:
  - $10.3 million infrastructure investment
  - 0 grants total $0
  - Infrastructure life expectancy 22 years
  - 10% biomass

(in thousands)	2013	2014	2015	2016	2017	Total
Extra investment	($780)	($728)	($728)	($676)	($676)	($3,589)

When all necessary infrastructure modifications are made and no grants are obtained, the biomass initiative is projected to cost $**3,589,000**

Key Findings

Coal and natural gas prices look to remain low into the near future

Woodchips are more expensive than coal based on energy content

The plant's infrastructure will need to be modified and storage facilities must be created

Abbott will not likely receive any tax credits, but may possibly receive between $0 and $1.5 million in grants

Woodchips will be more expensive than coal in almost every important area of UIUC's operation

Final Recommendation

Less than 1% of 3,000 power plants analyzed cogenerate with coal and woodchips

- Due to increased expenses and restrictions placed on tax credits and public funding

It is possible to "go green" via woodchips and biomass in a financially responsible way, but that way is NOT cogeneration

Overall, this endeavor will cost the plant about **$3,475,000** over the next 5 years and is **Not Recommended**

Next Steps

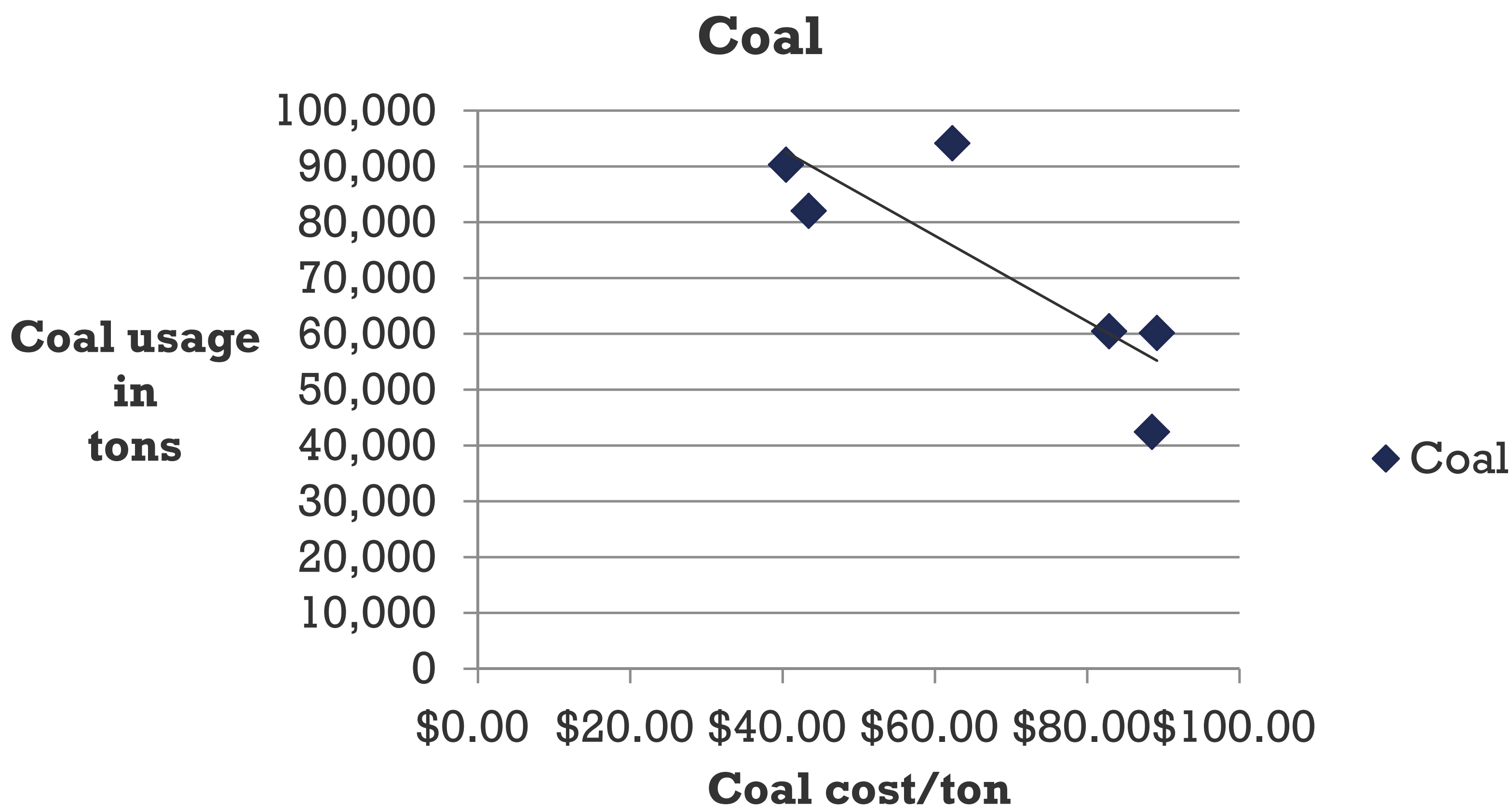
- Undertake an investigative project on the feasibility of a 100% biomass facility
- Explore the viability of other major alternative energy sources that would allow the university to rid its itself of all coal consumption by 2017

Thank You

- Questions?

Appendix

+ Regression analysis on coal prices and Abbott coal usages



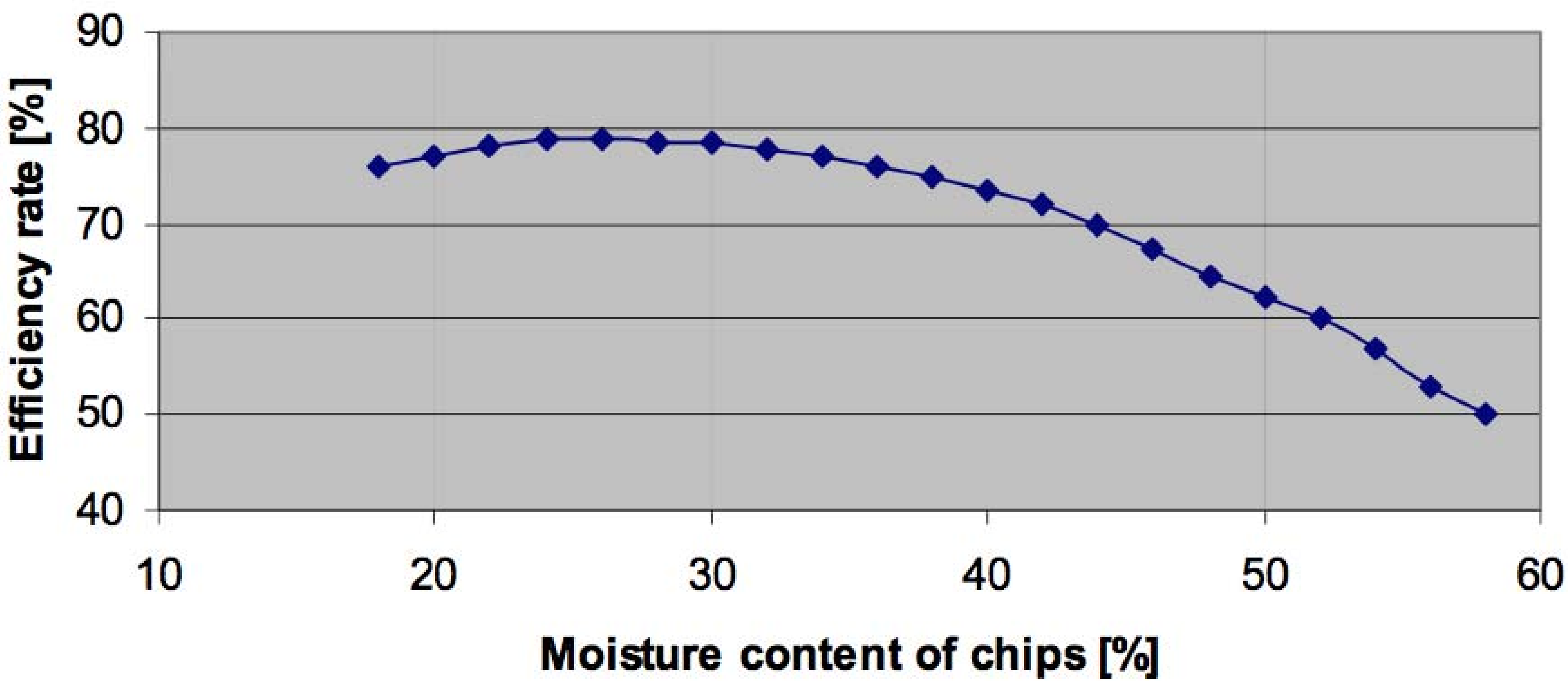
The regression line clearly indicates that Abbott uses more coal when the prices are lower

Estimated Coal Quantities and Contract Periods

- Period 1- July 1, 2012 to June 30, 2013 up to 120,000 tons
- Period 2- July 1, 2013 to June 30, 2014 up to 100,000 tons
- Period 3- July 1, 2014 to June 30, 2015 up to 100,000 tons
- Period 4- July 1, 2015 to June 30, 2016 up to 80,000 tons
- Period 5- July 1, 2016 to June 30, 2017 up to 80,000 tons

→ For each 100,000 tons of coal, the plant will produce up to appr. 14,500 tons of ash cinders, bottom ash as well as appr. 23,000 tons of gypsum

Moisture content vs. boiler efficiency



As moisture content decreases, efficiency rate increases

Techniques

- Open Air: Dried in open air under cover
  - ~20% post-moisture level
- Air Blast: Dried in shed with fan
  - ~15-20% post-moisture level
- Hot Air Blast: Dried in shed with heated fan
  - ~10% post-moisture level

Fixed Cost	
Basic Fan & Labor	$140,010
Variable Cost	
Manual labor	$102,000

A variety of drying methods can be used to reduce moisture

http://www.esru.strath.ac.uk/Documents/MSc_2002/ioannidi.pdf

Drying costs (in wood chips*)

Air Drying	$.237/US Ton
Shed Drying	$.150/US Ton
Predrying	$.306/US Ton
Dehumidification	$.900/US Ton
Conventional	$1.04/US Ton

Additional variable cost of drying is incurred

*Based on Red Oak wood http://www.fpl.fs.fed.us/documnts/fplgtr/fplgtr118.pdf

Credit Eligibility and Credit Period

- Eligibility: If the owner of a qualified open-loop biomass facility is not the producer of the electricity, § 45(d)(3)(B) provides that the person eligible for the credit allowable under ' 45(a) is the lessee or the operator of such facility.
- Period: Generally applies to first 10 years of operation.

The operator or the lessee is the only party who can claim for PTC.