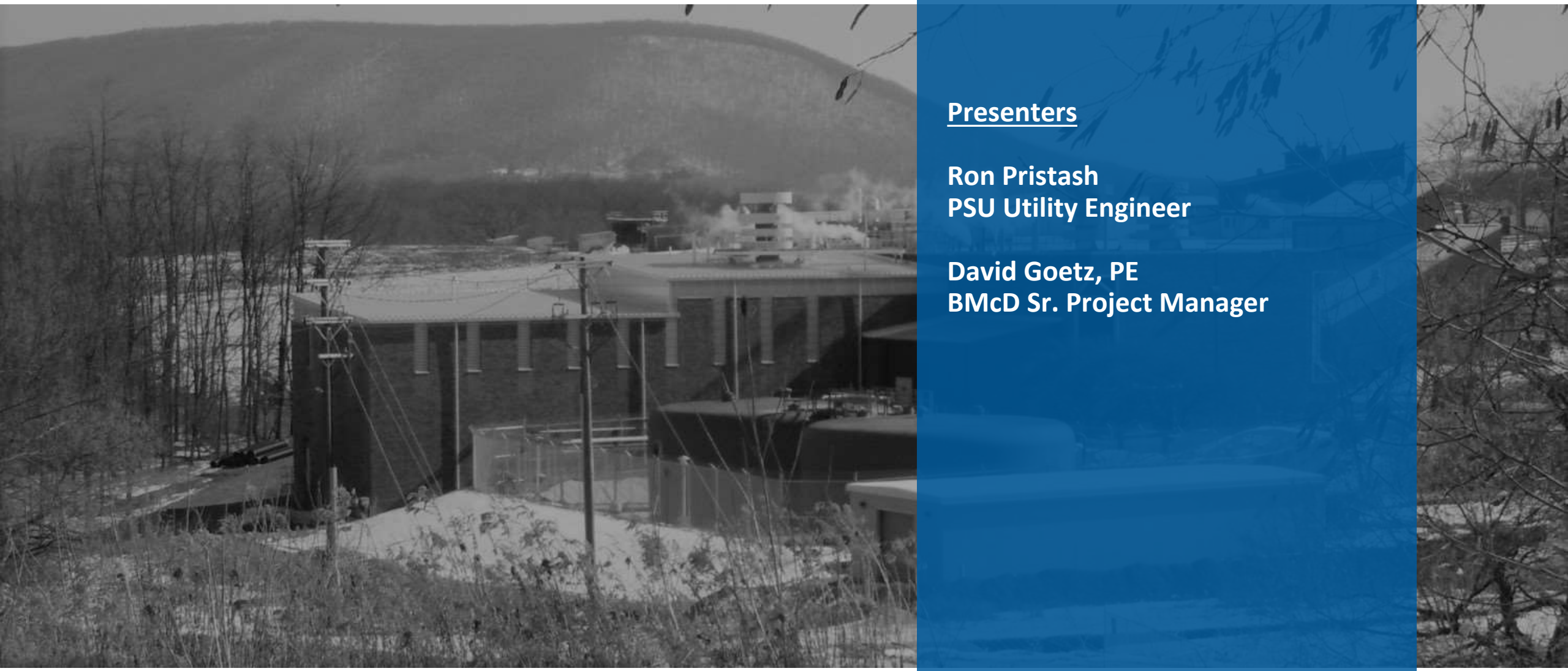
PSU's Road to Sustainability
East Campus Steam Plant Study

October 2, 2018

BURNS & McDONNELL

Introduction



Presenters

Ron Pristash
PSU Utility Engineer

David Goetz, PE
BMcD Sr. Project Manager

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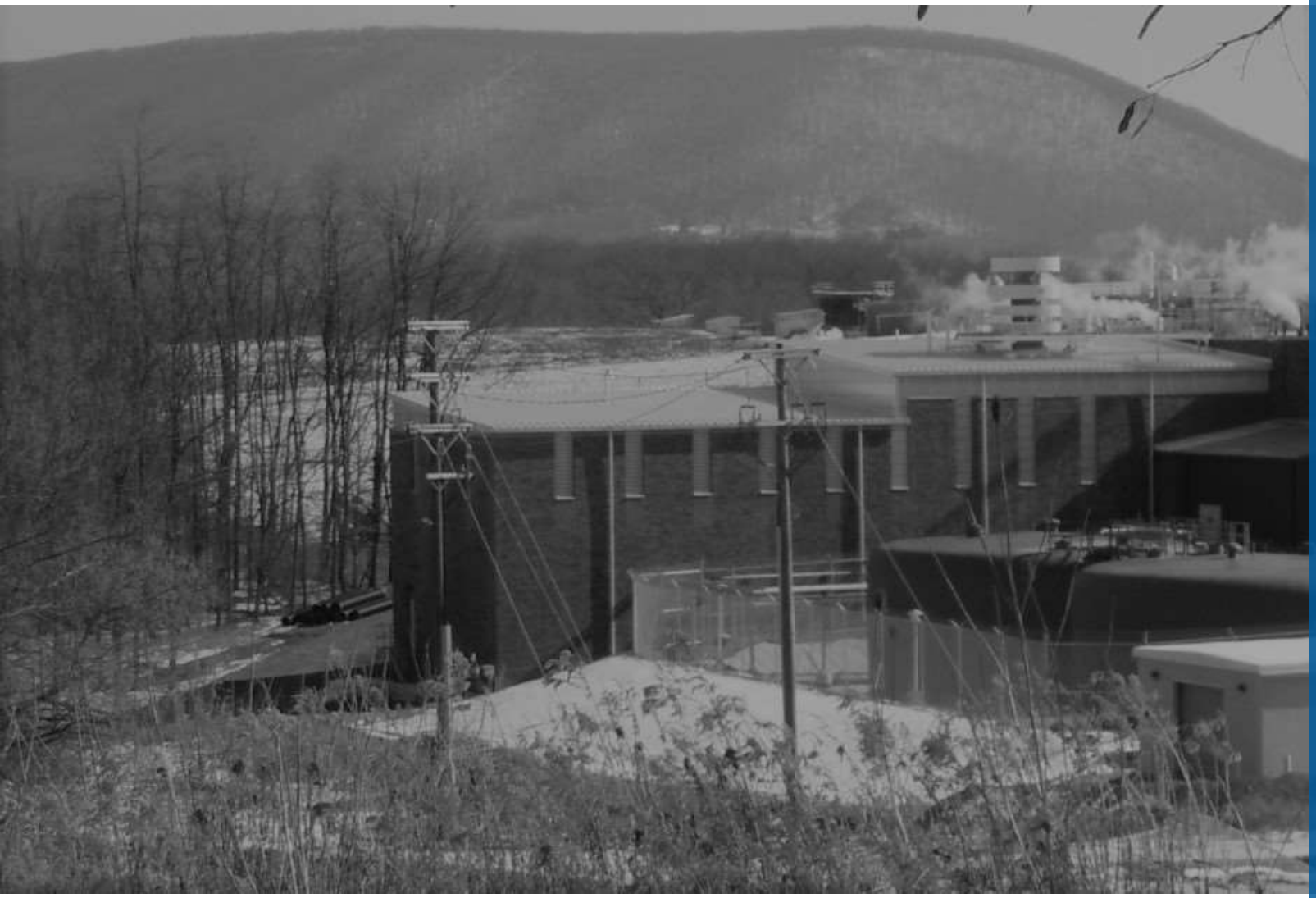
AGENDA



- Introduction
- Fuel Supply Analysis
- Option Definition
- Biomass
- Modeling
- Environmental Impact
- Economics
- Conclusions
- Questions

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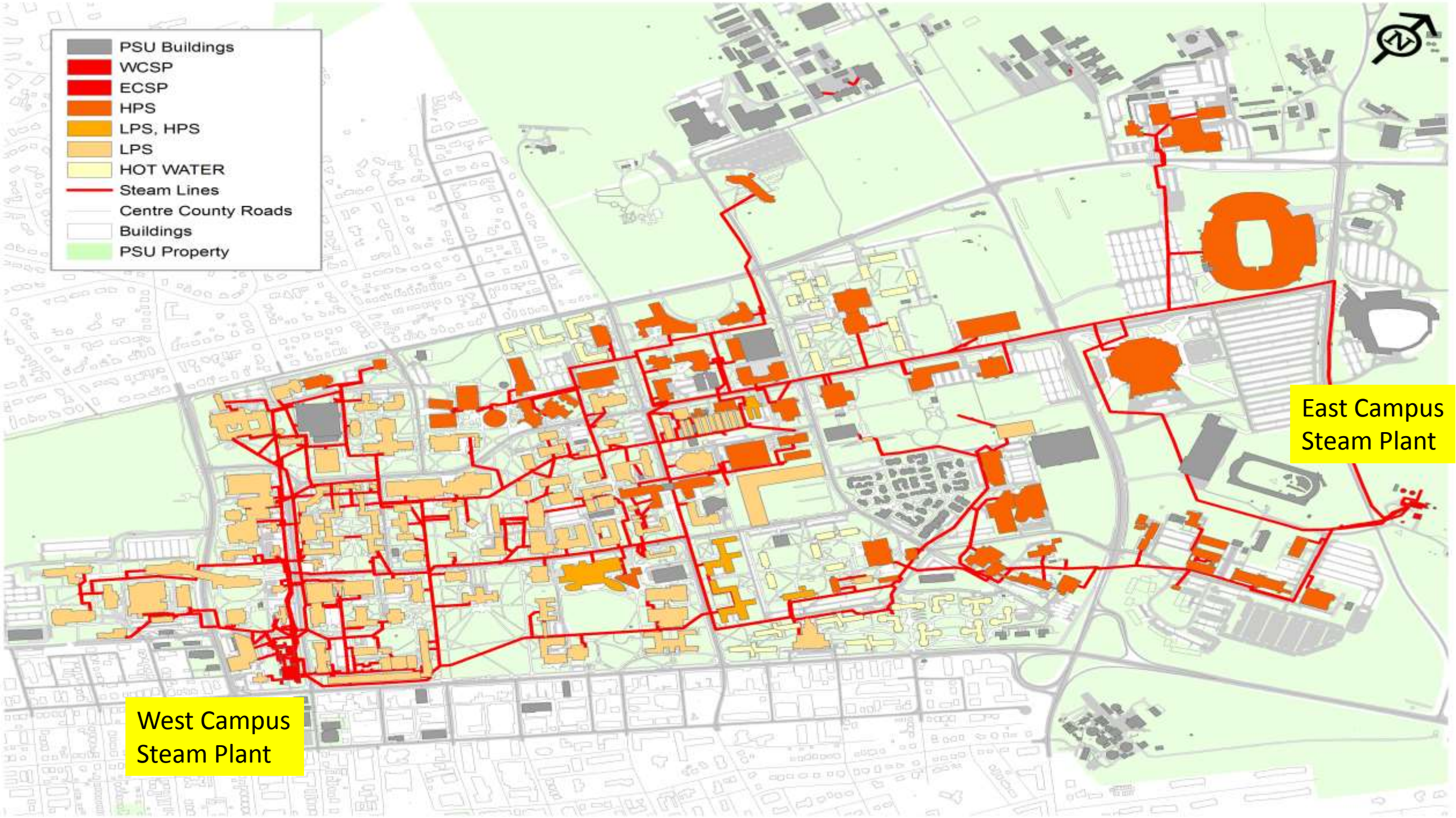

PSU Buildings
WCSP
ECSP
HPS
LPS, HPS
LPS
HOT WATER
Steam Lines
Centre County Roads
Buildings
PSU Property
East Campus Steam Plant
West Campus Steam Plant

W. College Ave.
ONE WAY

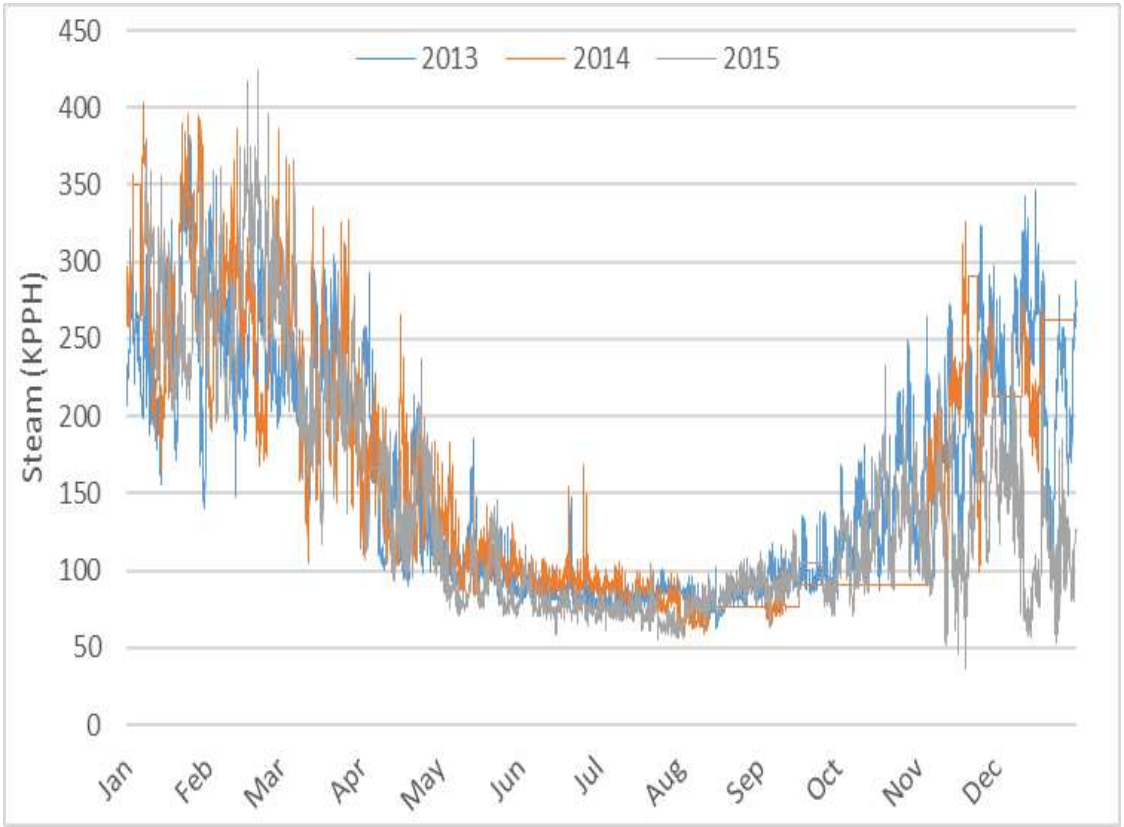
Steam Generating Assets, Existing Plan

Asset (Report Tag)	Capacity (PPH)	Location
WCSP CTG (WT)	93,000	WCSP
ECSP CTG (ET)	117,000	ECSP
Boiler (W1-PKG)	150,000	WCSP
Boiler (W2-PKG)	150,000	WCSP
Boiler (E1-Tube)	100,000	ECSP
Boiler (E2-Tube)	100,000	ECSP
Boiler (W8-SW)	38,000	WCSP

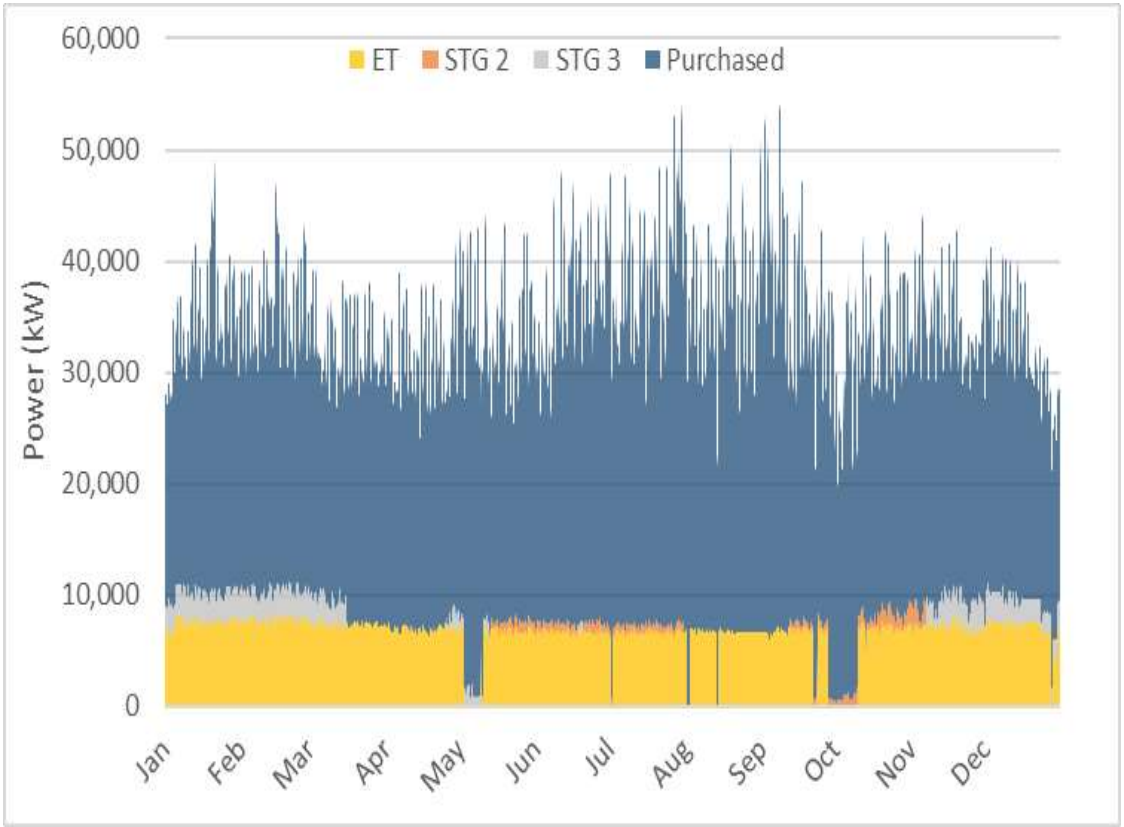
Power Generating Assets, Existing Plan

Asset (Report Tag)	Capacity (kW)	Location
WCSP CTG (WT)	5,700	WCSP
ECSP CTG (ET)	7,500	ECSP
STG (STG-2)	2,200	WCSP
STG (STG-3)	2,800	WCSP
STG (STG-4)	2,500	WCSP

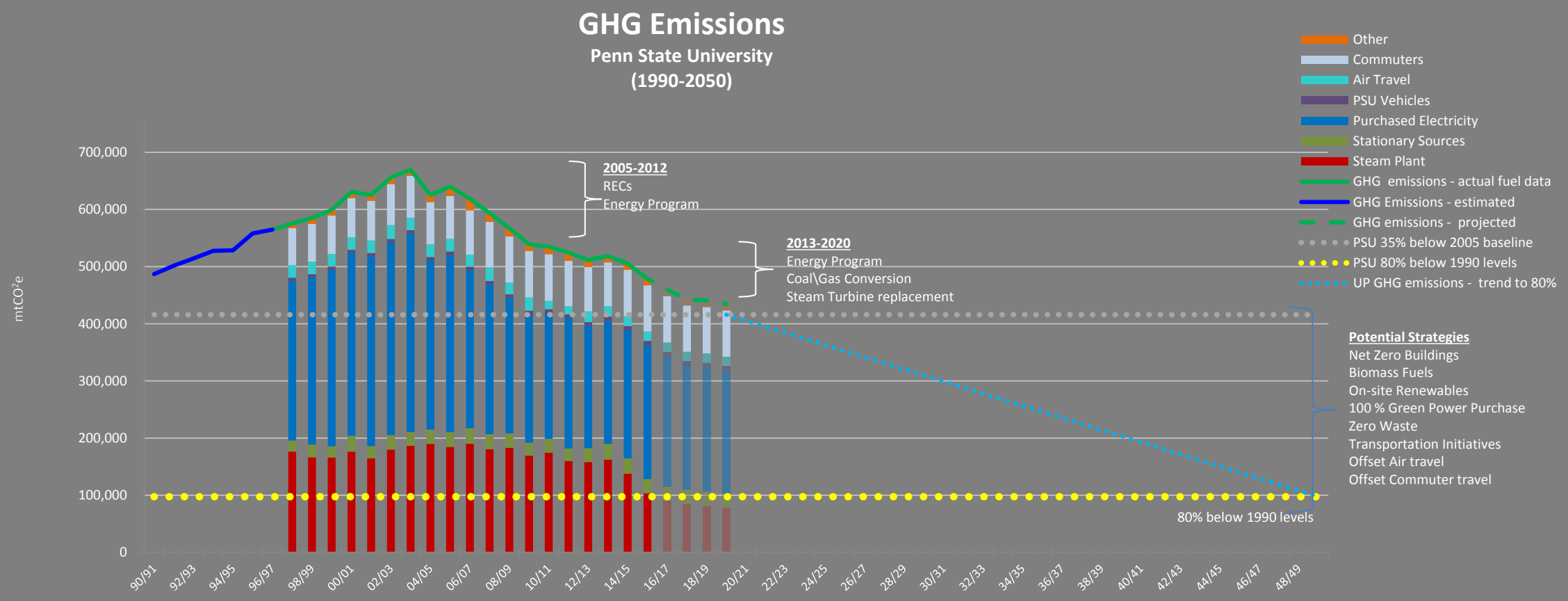
Production Steam Load Profile



Power Load Profile



2050 Greenhouse Goal – 80% Below 1990 Levels



Penn State GHG Emissions include stationary sources, purchased electricity, OPP & Fleet vehicles and estimated commuter miles, air travel, waste, refrigerants and animal management.

Pennsylvania Forest Facts

- **More than half of Pennsylvania land nearly 17 million acres (90% Hardwoods) is forested.**
  - #1 producer of hardwoods in the country.
  - Pennsylvania forests are increasing in size, over 20% growth in the last decade

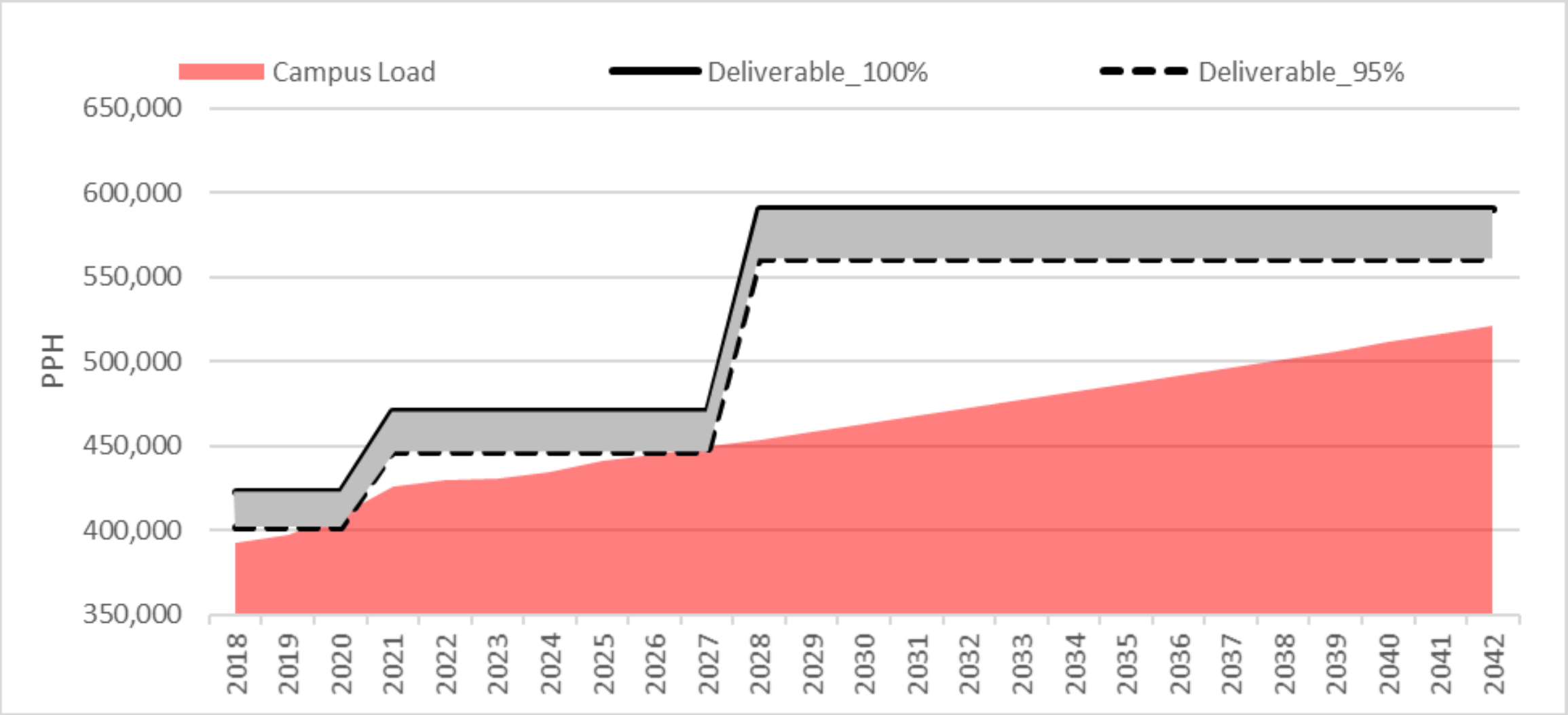
- **Pennsylvania is a national leader in the implementation and promotion of sustainable forestry practices that provide renewable resources to support industry, while ensuring sustainability of our forests for future generations.**
  - Annual volume growth in our forests is still more than twice the volume harvested to support industry. **Forest growth-to-harvest ratio is better than 2:1**.

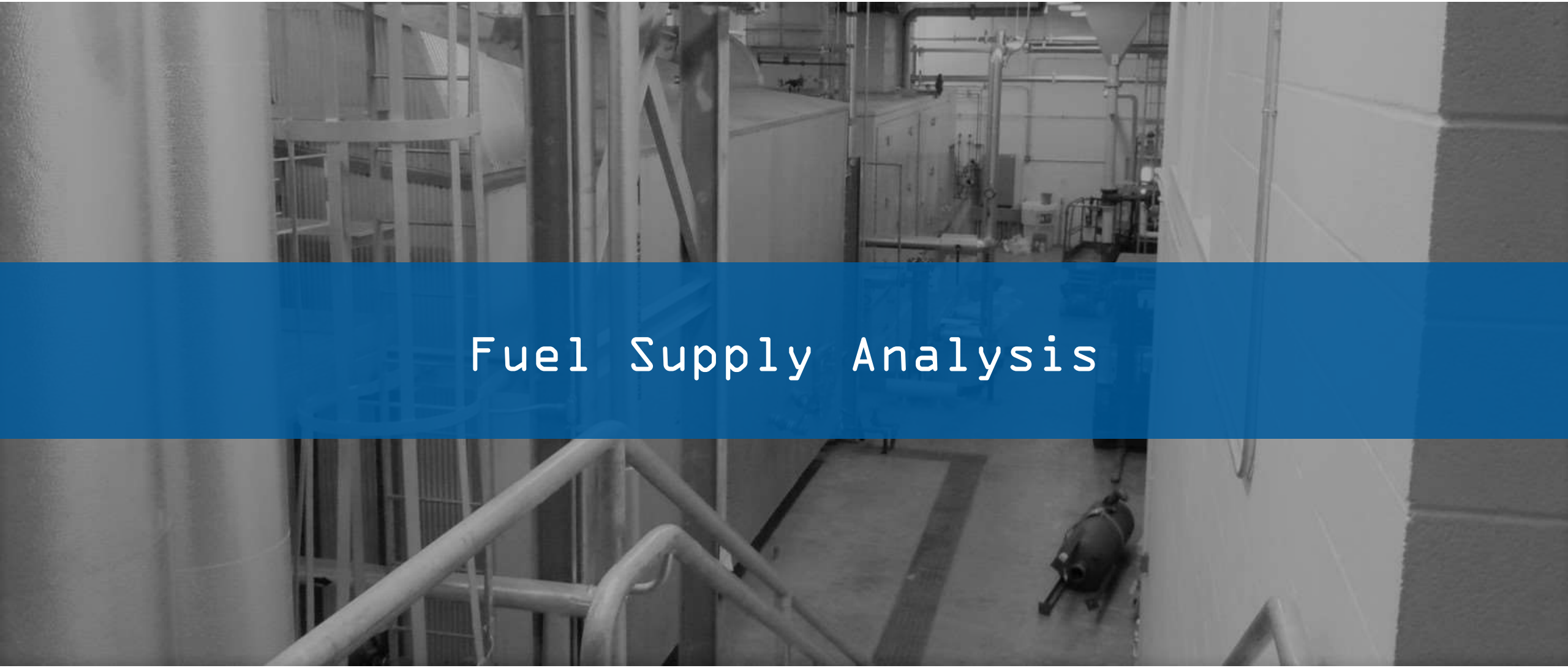
- **Great for Pennsylvania economy**
  - Over 90,000 Pennsylvanians make a living in the industry and over 10% of the state manufacturing workforce is involved in the forest products industry.

PSU Steam Production Capacity Plan: Current Plan

PSU Steam Production Capacity Plan: Adjusted Plan

PSU Deliverable Capacity with New Boilers





Fuel Supply Analysis

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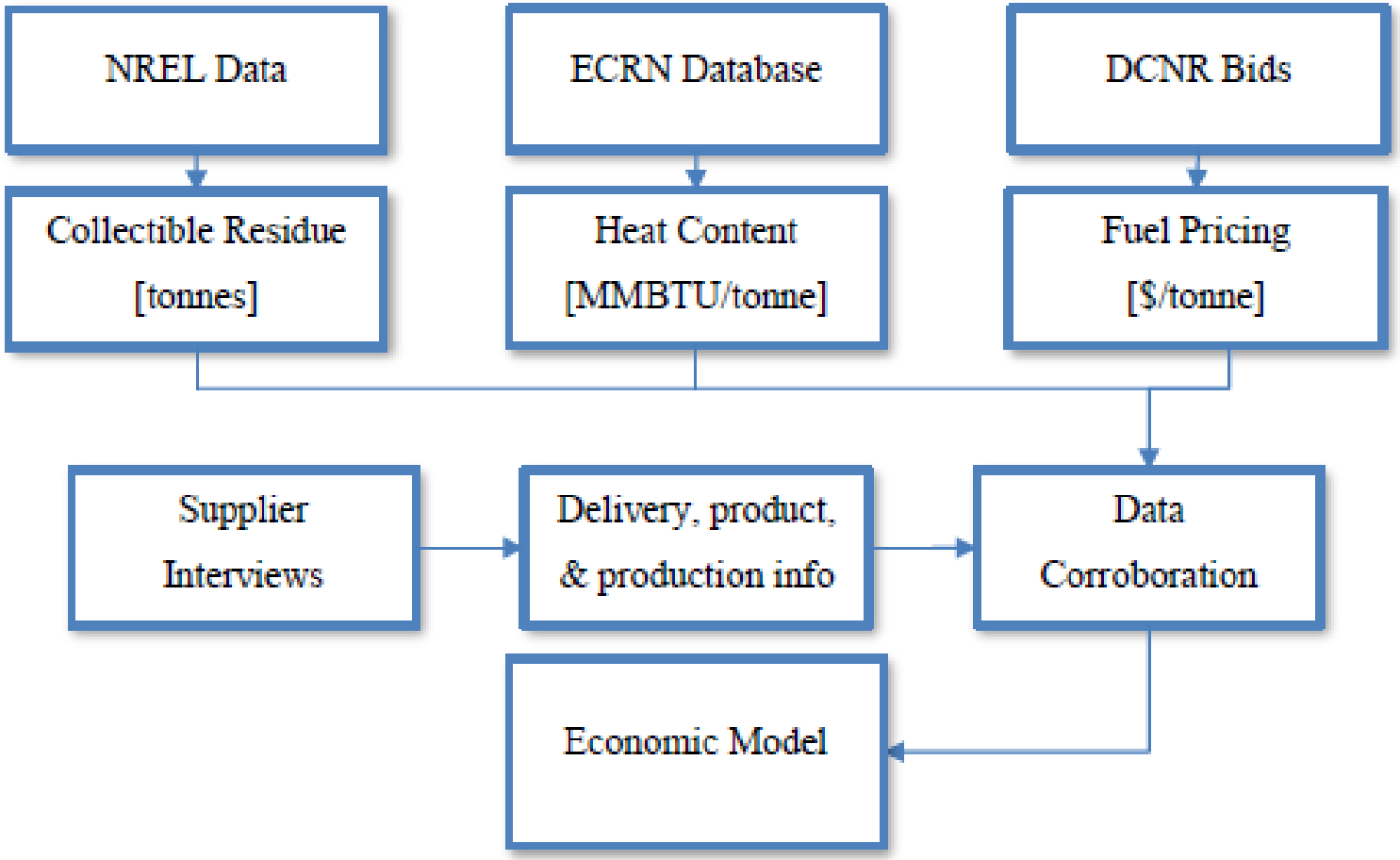
Biomass Data Sources

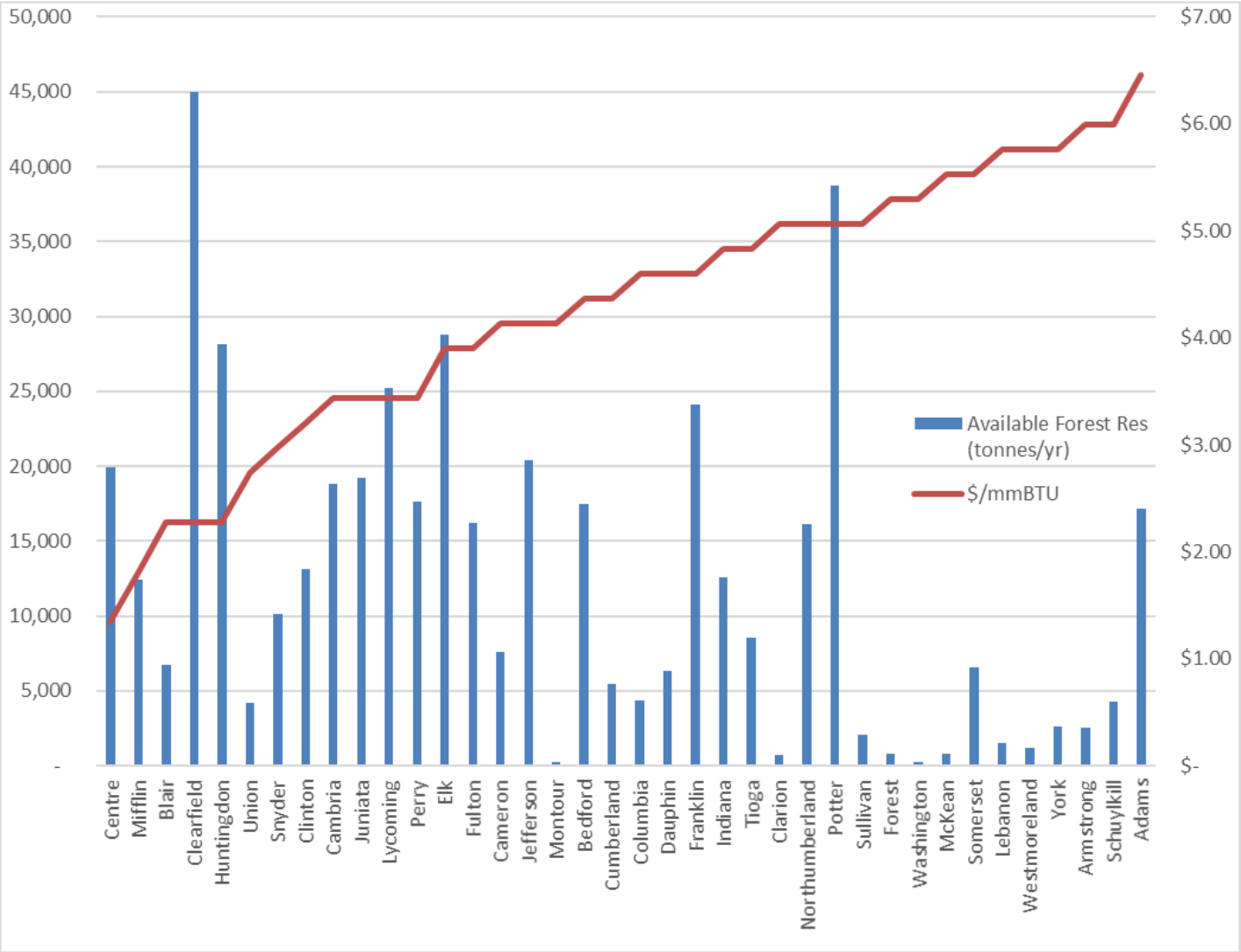
- ✓ National Renewable Energy Laboratory (NREL)
- ✓ Pennsylvania Dept of Conservation and Natural Resources (DCNR)
- ✓ Energy Research Centre of the Netherlands (ECN)
- ✓ Pennsylvania data on awarded timber sales

Developed high level estimates for all counties - Total delivered price of fuel in $/MMBTU

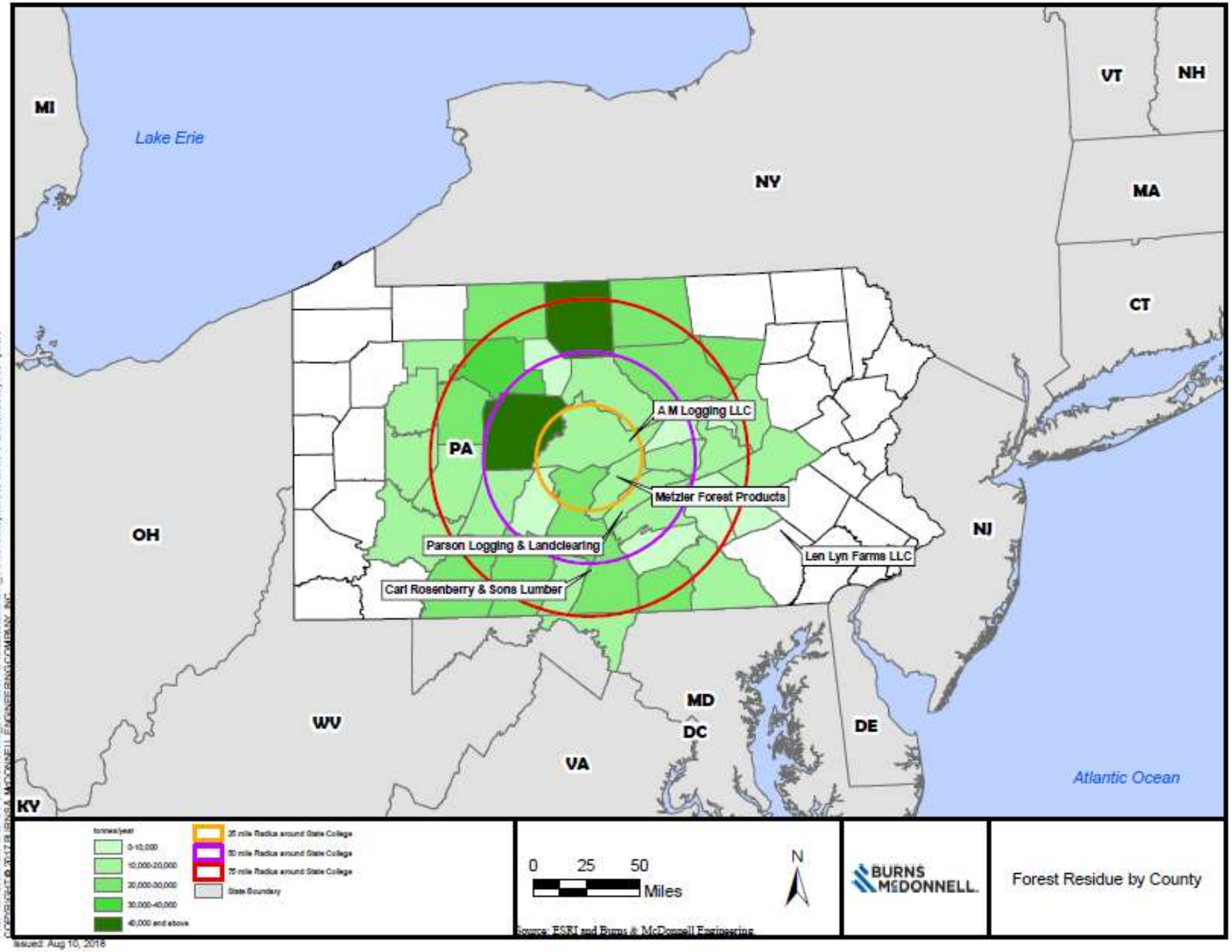
Methodology Flowchart



Fuel Cost by County



Fuel Supply Analysis



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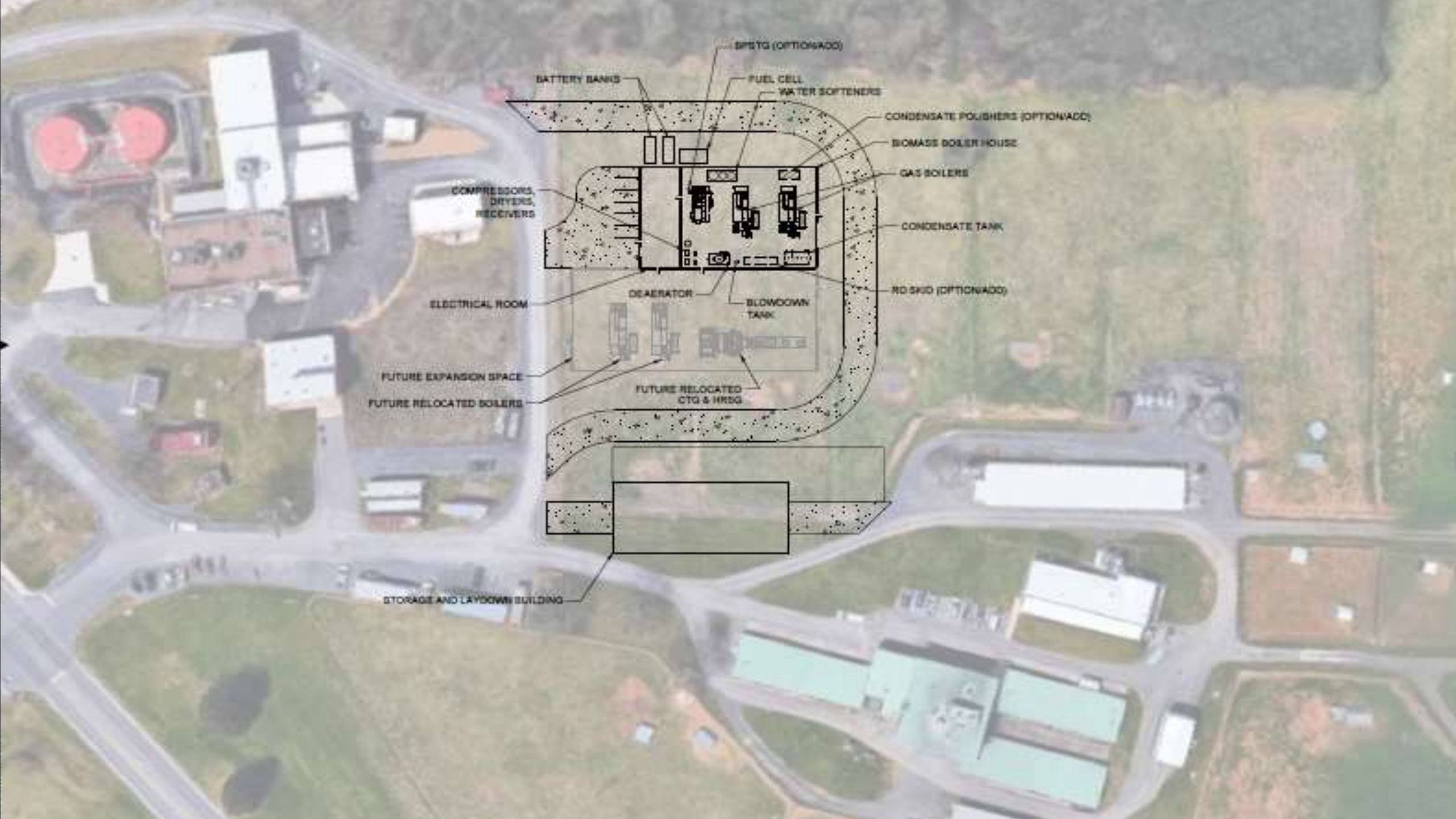
Fuel Summary

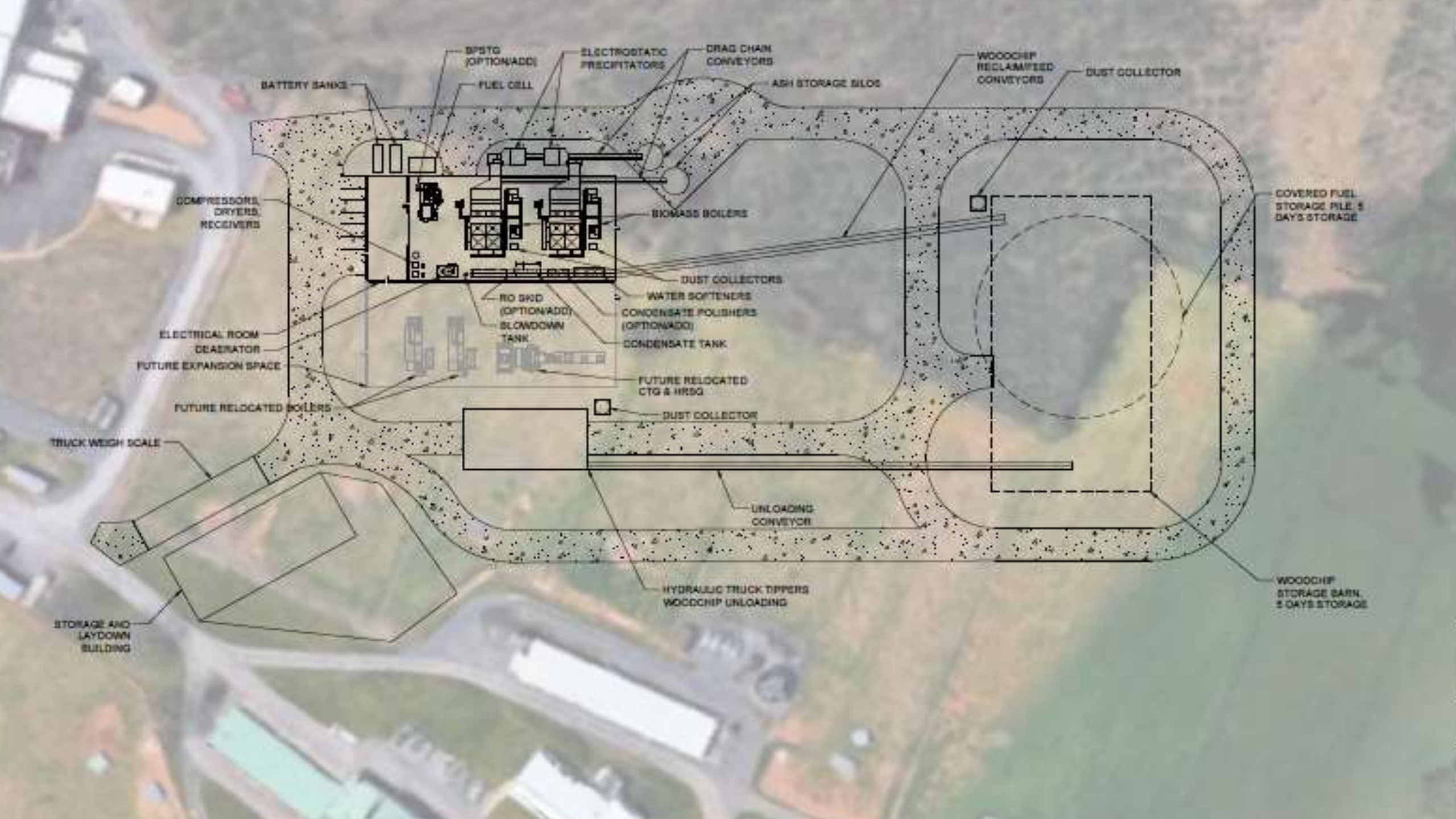
- ✓ Available Fuel is over double potential maximum consumption
- ✓ 2018 Delivered cost of $42/tonne ($4.28/MMBTU)
- ✓ Used $0.47 per loaded tonne-mile for delivery charge

Options Definition

Options Evaluated

- ✓ Gas Boiler
- ✓ Biomass - Stoker Boiler
- ✓ Biomass - BFB Boiler
- ✓ BPSTG Addition
- ✓ Solar PV
- ✓ Fuel Cell and Battery Bank


BPSTG (OPTION/ADD)
BATTERY BANKS
FUEL CELL
WATER SOFTENERS
CONDENSATE POLISHERS (OPTION/ADD)
BIOMASS BOILER HOUSE
GAS BOILERS
COMPRESSORS, DRYERS, RECEIVERS
CONDENSATE TANK
RO SKID (OPTION/ADD)
ELECTRICAL ROOM
DEAERATOR
BLOWDOWN TANK
FUTURE EXPANSION SPACE
FUTURE RELOCATED BOILERS
FUTURE RELOCATED CTG & HRSG
STORAGE AND LAYDOWN BUILDING


BPSTG (OPTION/ADD)
ELECTROSTATIC PRECIPITATORS
DRAG CHAIN CONVEYORS
WOODCHIP RECLAIM/FEED CONVEYORS
DUST COLLECTOR
BATTERY BANKS
FUEL CELL
ASH STORAGE SILOS
COMPRESSORS, DRYERS, RECEIVERS
BIOMASS BOILERS
COVERED FUEL STORAGE PILE, 5 DAYS STORAGE
DUST COLLECTORS
WATER SOFTENERS
RO SKID (OPTION/ADD)
CONDENSATE POLISHERS (OPTION/ADD)
BLOWDOWN TANK
ELECTRICAL ROOM
DEAERATOR
CONDENSATE TANK
FUTURE EXPANSION SPACE
FUTURE RELOCATED CTG & HRSG
FUTURE RELOCATED BOILERS
DUST COLLECTOR
TRUCK WEIGH SCALE
UNLOADING CONVEYOR
HYDRAULIC TRUCK TIPPERS WOODCHIP UNLOADING
WOODCHIP STORAGE BARN, 5 DAYS STORAGE
STORAGE AND LAYDOWN BUILDING

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Biomass

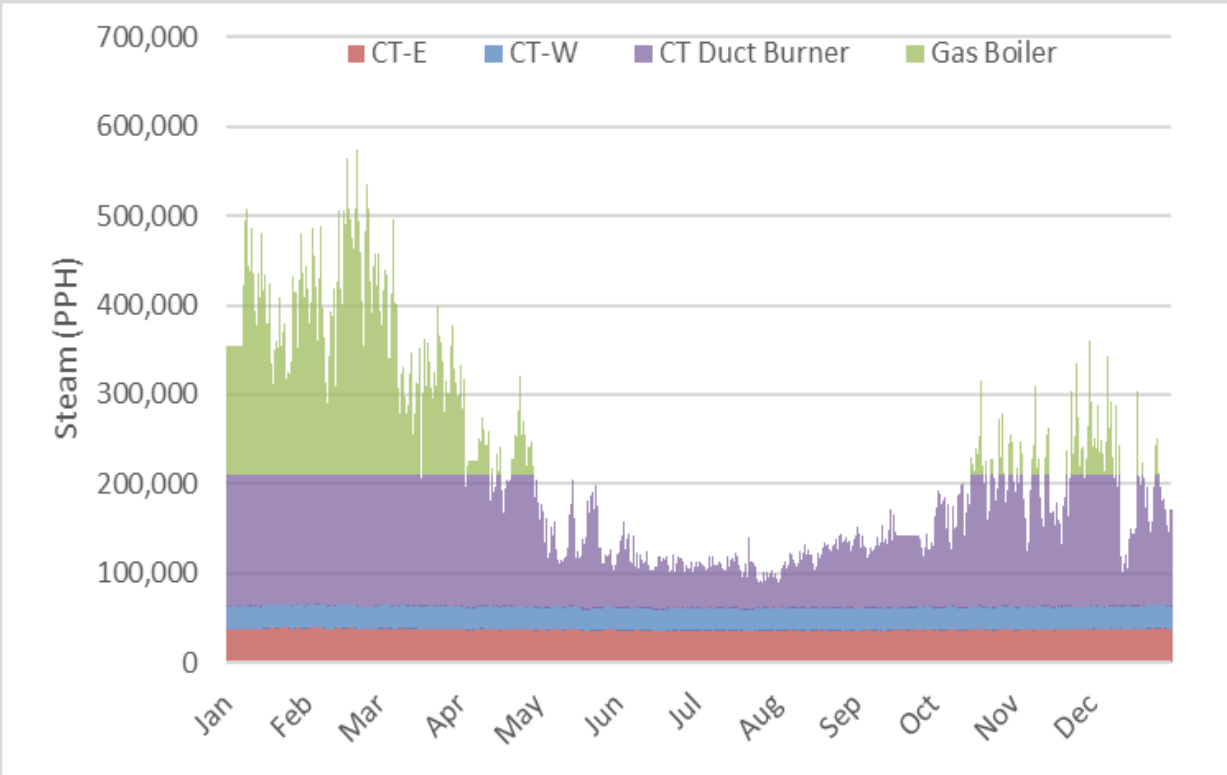
Stoker and Fluidized Bed Comparison

Feature	Boiler Type	
	Stoker	Fluidized Bed
Combustion Mechanism		
Flow of solid fuel	Transported on stoker	Fluidized by combustion air and circulated through the combustion chamber and cyclone
Combustion zone	On the stoker	Entire area of combustion furnace
Mass transfer	Slow	Active vertical movement-mass and heat transfer
Combustion Control		
Responsiveness	Slow response	Quick response
Excess air control	Difficult	Possible
Fuel Issues		
Applicability to various fuels	Fair	High
Fuel pretreatment	Generally not necessary	Lumps must be crushed
Environmental Factors		
Low sulfur dioxide combustion	In-furnace desulfurization not possible	High rate of in-furnace desulfurization
Low NOx combustion	Difficult	Inherently low NOx
Appropriate facility size	Small	Medium to large

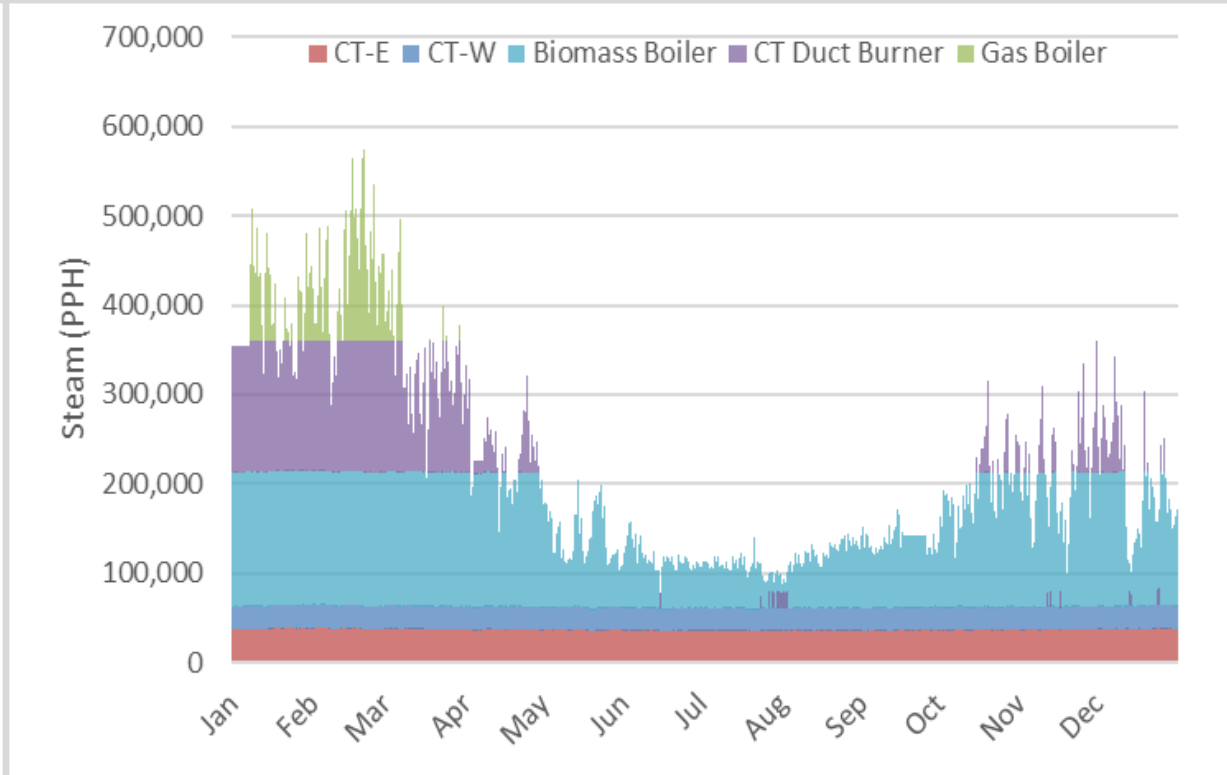
Solids Handling

Modeling

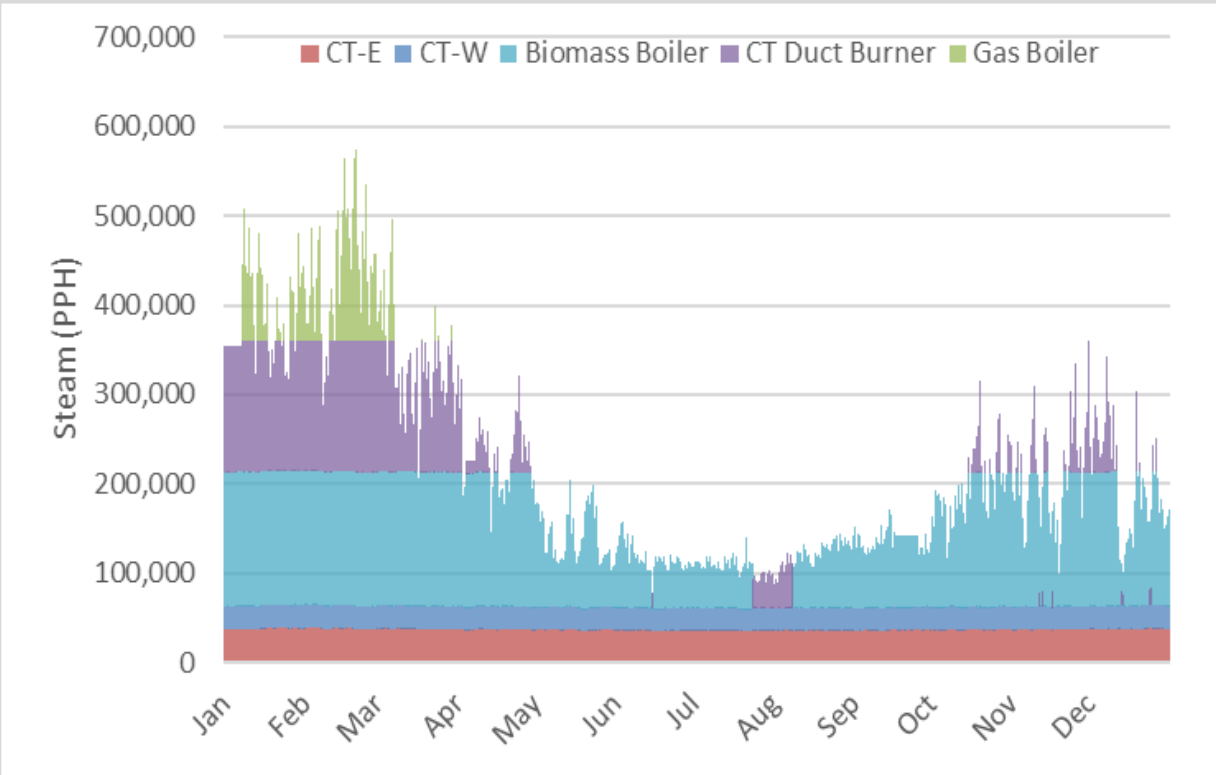
ECSP/WCSP Production (2028) Without Biomass



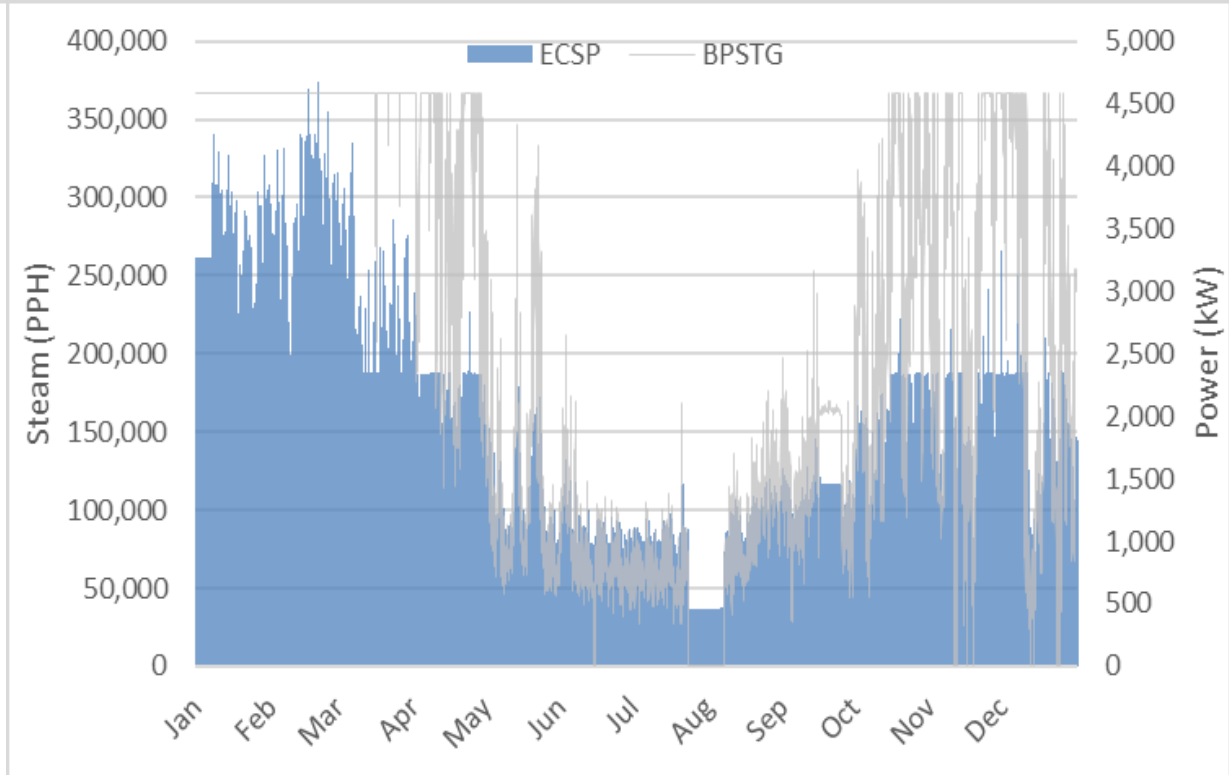
ECSP/WCSP Production (2028) With Biomass



ECSP/WCSP Production (2028) W/ Seasonal Biomass Ops



BPSTG Production (2028) With Seasonal Biomass Operation



2028 Energy Summary

		Option						
		Gas Boilers	Gas Boilers + STG	Stoker	Stoker + STG	BFB	BFB + STG	
Fuel	CT-E/W	1,340,000	1,340,000	1,340,000	1,340,000	1,340,000	1,340,000	MMBTU, HHV
	CT-E/W DB	910,000	690,000	310,000	310,000	310,000	310,000	
	Gas Blr	386,000	691,000	56,000	56,000	56,000	56,000	
	Stoker Blr	N/A	N/A	1,028,000	1,279,000	N/A	N/A	
	BFB Blr	N/A	N/A	N/A	N/A	987,000	1,228,000	
	Solid Fuel	N/A	N/A	104,898	130,510	100,714	125,306	Tonnes
Elec	STG Energy	20,230,000	33,710,000	8,910,000	31,930,000	8,910,000	31,930,000	kWh
	Grid Energy	211,230,000	197,750,000	233,460,000	210,440,000	234,850,000	211,830,000	
	Demand	476,400	462,500	506,400	480,900	508,200	482,600	kW

Environmental Impact

Estimated 2028 Greenhouse Gas Reduction from Gas Boiler Case

	Option						
	Gas Boilers	Gas Boilers + STG	Biomass Stoker	Biomass Stoker + STG	Biomass BFB	Biomass BFB + STG	
CO_2e Gross	N/A	5,090	28,700	38,100	28,600	38,100	Tons/Year
CO_2e Trucking	N/A	0	140	170	130	160	
CO_2e Net	N/A	5,000	28,600	37,900	28,500	37,900	
Capital/Ton CO_2e Reduced	N/A	$6,800	$2,800	$2,300	$3,200	$2,600	

Note: *eGRID2016 RFC West data assumed-19.0 lb NOx/GWh, 108.0 lb VOC/GWh, 1243.4 lb CO2/MWh

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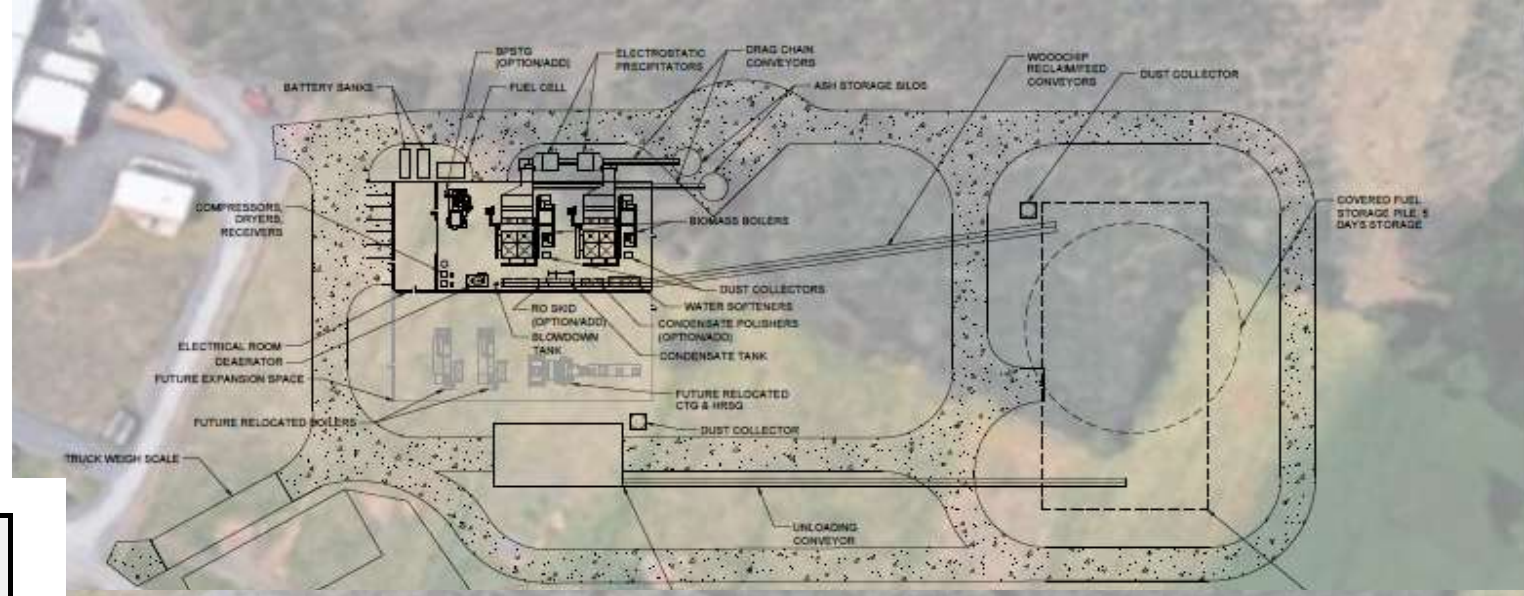
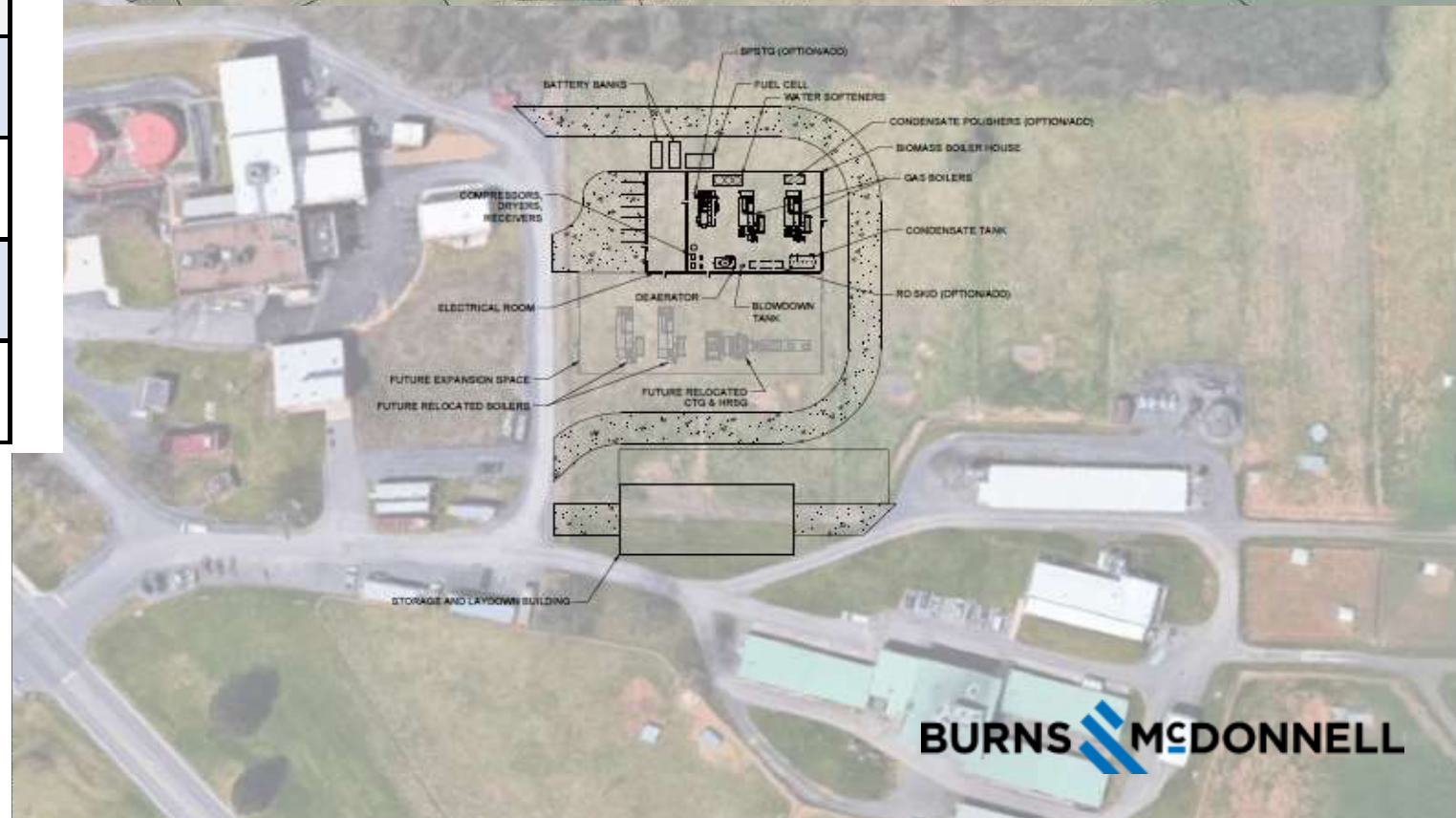
Economics

Capital Cost Summary (2018 $)

Option	Capital Cost
Gas Boiler	$28,000,000
Biomass: Stoker	$80,000,000
Biomass: BFB	$91,000,000
BPSTG ADD	$7,000,000





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Option 2028 O&M Costs with Gas Boiler Option Comparison

	Gas Boilers	Gas Boilers + STG	Biomass Stoker	Biomass Stoker + STG	Biomass BFB	Biomass BFB + STG
Fixed	$675,000	$675,000	$1,325,000	$1,325,000	$1,325,000	$1,325,000
Variable, Non-Fuel	$142,000	$217,000	$101,000	$231,000	$126,000	$256,000
Variable, Energy						
Gas	$14,913,000	$15,395,000	$9,677,000	$9,677,000	$9,677,000	$9,677,000
Biomass	N/A	N/A	$5,646,000	$7,022,000	$5,420,000	$6,741,000
Electric Energy	$18,186,000	$17,112,000	$20,072,000	$18,202,000	$20,188,000	$18,319,000
Electric Demand	$880,000	$855,000	$934,000	$890,000	$937,000	$893,000
Total	$34,797,000	$34,255,000	$37,754,000	$37,347,000	$37,673,000	$37,210,000
Incremental Savings	N/A	$542,000	-$2,958,000	-$2,550,000	-$2,876,000	-$2,414,000
Capital Cost	$27,700,000	$34,700,000	$79,700,000	$86,700,000	$91,000,000	$98,000,000
Ton CO_2e Reduced	N/A	5,000	28,600	37,900	28,500	37,900
O&M/Ton CO_2e Reduced	N/A	-$106	$103	$67	$101	$64
Capital/Ton CO_2e Reduced	N/A	$6,800	$2,800	$2,300	$3,200	$2,600
Breakeven Carbon Credit ($/Ton CO_2e Reduced)	N/A	N/A	$148	$94	$146	$90

Conclusions

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Q&A Discussion

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NAUFRP

National Association of University Forest Resources Programs

Creating Knowledge–Developing Leaders

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University of Florida

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University of Tennessee

Jim Johnson, International
Oregon State University

Terry Sharik, Education

November 6, 2014

Gina McCarthy, EPA Administrator
U.S. Environmental Protection Agency
William Jefferson Clinton Federal Building
1200 Pennsylvania Avenue, N.W.
Mail Code: 1101A
Washington, DC 20460

Dear Administrator McCarthy:

On behalf of the National Association of University Forest Resources Programs representing 80 of the country's universities that have programs devoted to forest resources and who share a common purpose to advance the health, productivity and sustainability of our nation's forests, we are pleased to write you regarding your ongoing efforts on biomass carbon accounting.

As leaders in the science community, we appreciate your consistent emphasis on providing a strong science foundation for agency policy. We also acknowledge and wish to respond to your several requests for current, peer-reviewed science to inform the agency's work.

To that end, we provide the attached summary of science fundamentals, signed by more than 100 university experts in the field, that many in the science community, and the forestry disciplines in particular, strongly believe should underlie the agency's policy considerations for biomass carbon accounting.

Hazardous Air Pollutants Comparison by Fuel Type

CAS#	HAP	Wood (AP42, 1.6) (tpy)	Natural Gas (AP42, 1.4) (tpy)
107028	Acrolein	3.50	0.00
71432	Benzene	3.68	0.00
50000	Formaldehyde	3.85	0.06
110543	Hexane	0.00	1.50
7439965	Manganese	1.40	0.00
7647010	Hydrogen chloride	16.64	0.00
100425	Styrene	1.66	0.00
Other HAPs (<1 tpy each)		3.26	0.01
	Total	34.01	1.58

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