# Refueling Wisconsin with Wood Energy Series

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Wisconsin Statewide Wood Energy Team

# Wood Energy Systems in Commercial and Industrial Settings

Tom Wilson, Wilson Engineering Services, PC

Lew McCreery, US Forest Service

WES Energy · Environment · Enterprise

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WERC Wood Education and Resource Center

# USFS Strategic Energy Framework Role

- Proactively further the transformation of the Nation's energy supply and use of renewable energy and other alternative fuels for addressing national energy security needs while maintaining and enhancing the productivity and health of the Nation's forest and grassland resources;
- Advance the Agency's energy policy and energy-related activities to alleviate the impact of high energy costs, to develop long-term sustainable energy solutions, and to mitigate climate change; and
- Carry out its commitment to the Nation's quest for energy security, energy education initiatives, energy conservation, and climate change solutions through renewable energy activities and technologies.

# WERC Wood Energy Technical Assistance Team

- Help Facility Owners Evaluate and Implement Wood Energy Projects
- Technology and Vendor Neutral

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# Technical Assistance Team Partners

- USDA Forest Service Wood Education and Resource Center
- Wilson Engineering Services, PC

# Initial Owner Discussions

- Establish realistic goals with the owner and narrow down the list of options
  - Example: "I would like to generate all my electricity from biomass."
- Potential Budget = Savings * Acceptable Payback
  - How much is spent now on heating?
  - How much can be saved?
  - What cash flow is needed?

# Basic System Data

- Annual Fuel Use and Cost
- Electricity Costs
- Heat Generation, Distribution, and Use
- Thermal Load Modeling

# Fossil Fuel Use and Costs Drive Most Projects

- Establish facility's baseline fossil fuel usage from records or projections (modeling)
- Consider past impacts to records such as weather data and future changes such as efficiency projects, facility expansion, etc.
- Establish baseline fossil fuel cost from historical data and future projections
- Baseline usage and cost drives project economics – vet with the owner

# How is the Heat Used? – Generation, Distribution, and Quality

## Steam

- Temperature
- Pressure
- Uses (heating, humidification, etc.)
- Building or process operating schedule
- Allowable variance

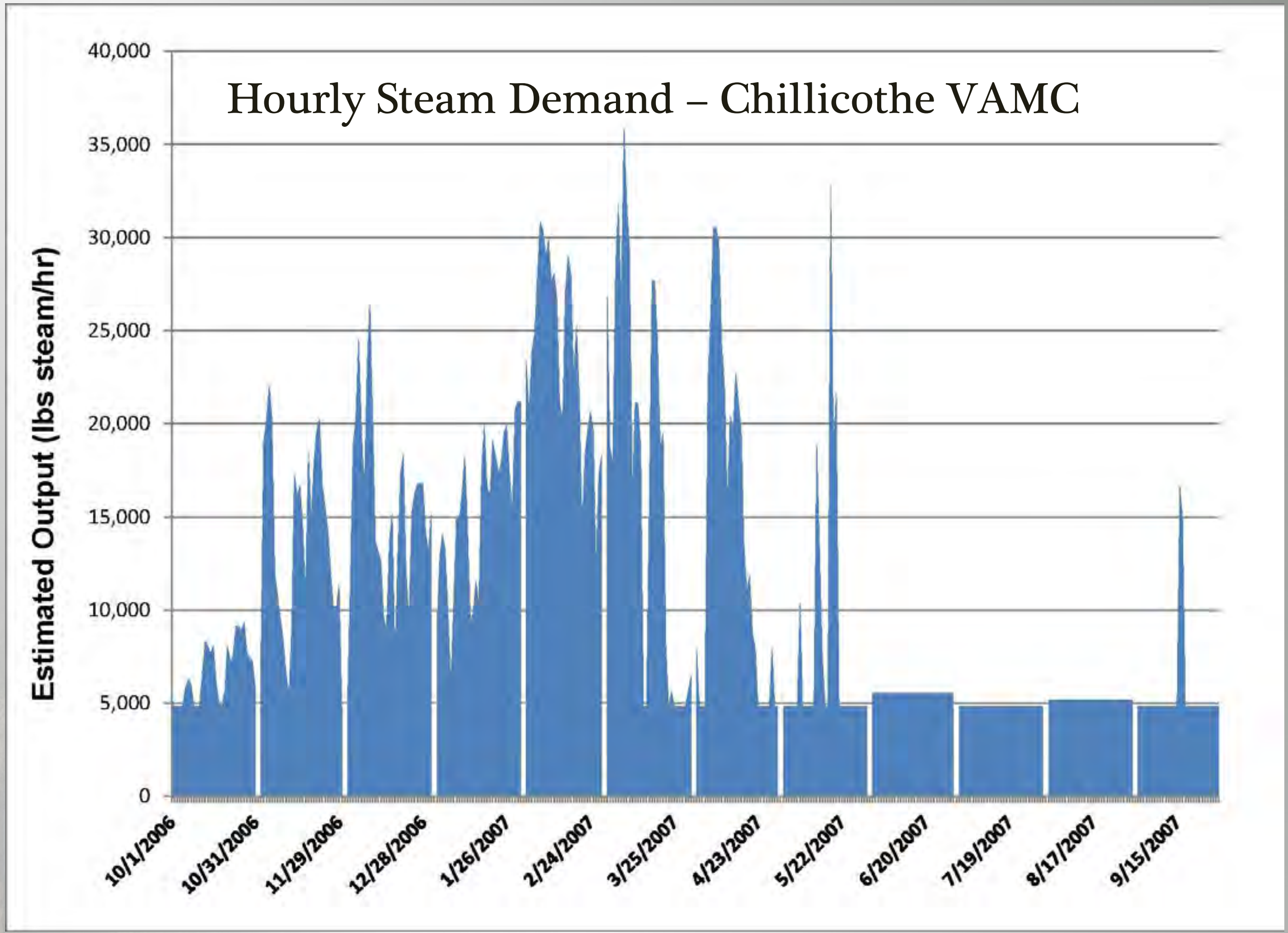
## Hot Water

- Required temperature
- Uses (pool, DHW, heating, laundry, drying, etc.)
- Building or process operating schedule
- Allowable variance

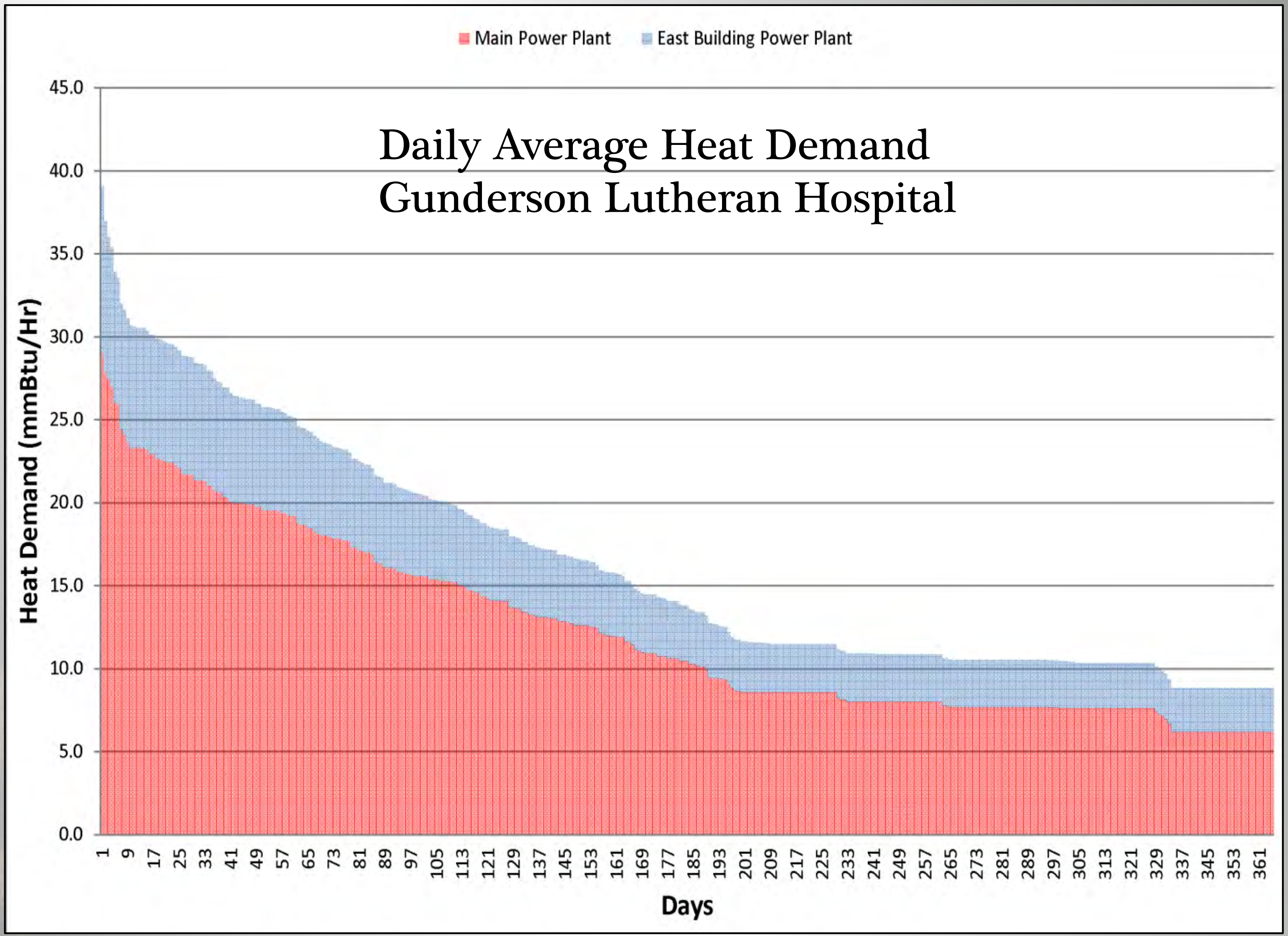
## Forced Air

- Required temperature
- Required air flow
- Uses (heating, drying, etc.)
- Building or process operating schedule
- Allowable variance

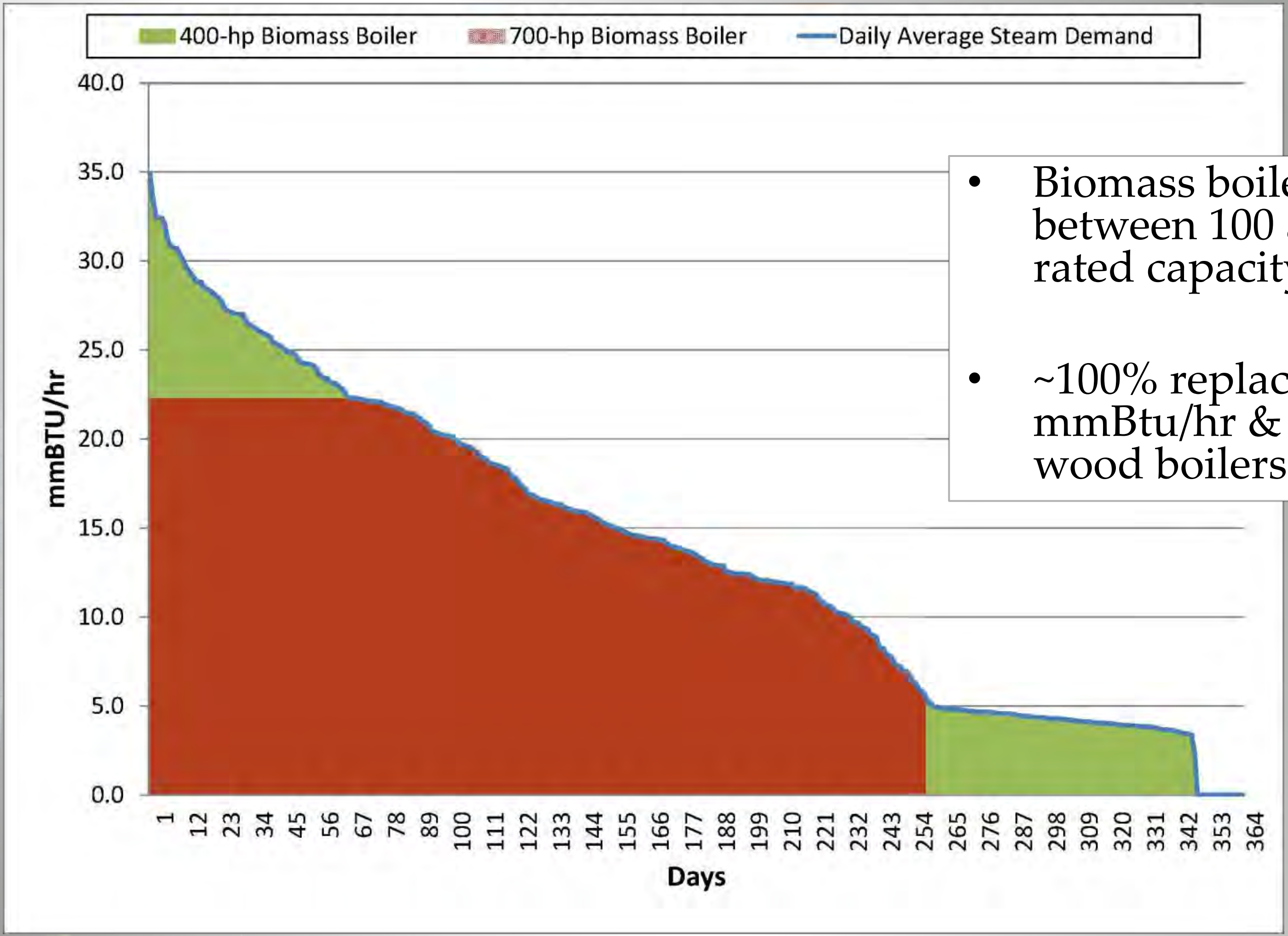
# Use Data to Model Loads



# Develop Load Duration Curve



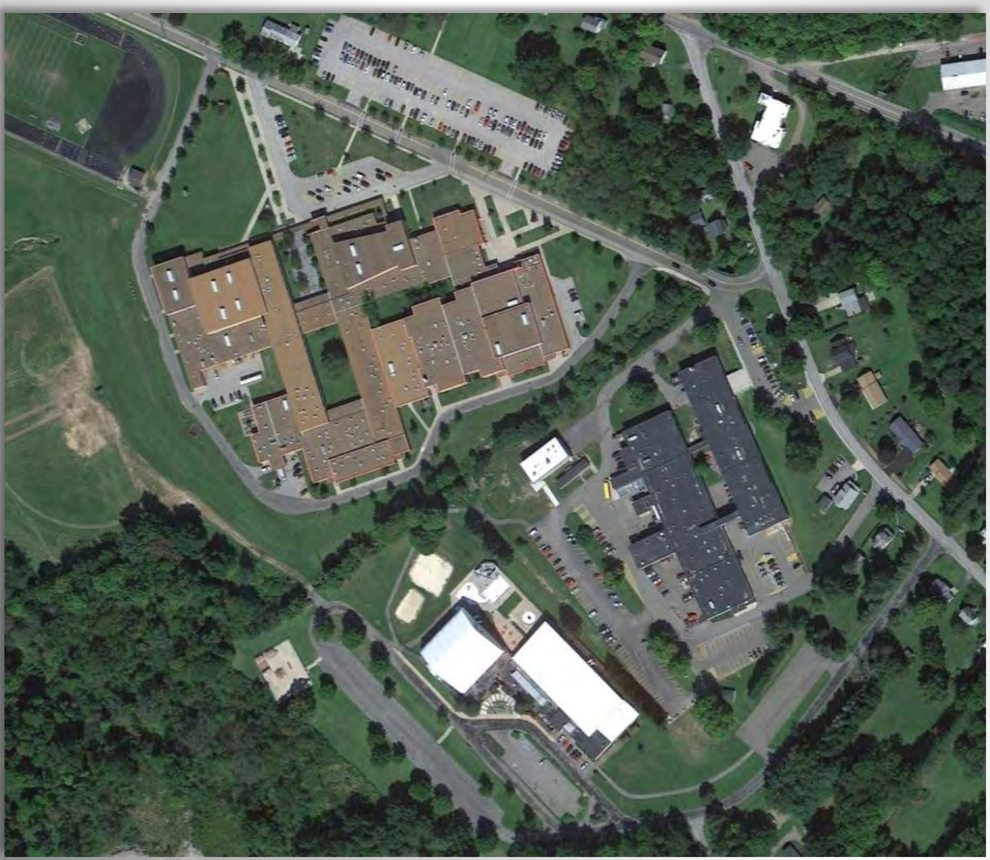
# Boiler Sizing Example – Two boilers to Cover Nearly 100% of Load




- Biomass boilers operate between 100 and 25% of rated capacity
- ~100% replacement with 23 mmBtu/hr & 13 mmBtu/hr wood boilers

# IS There Potential To Add Loads?

## Can adjacent buildings be cost effectively connected

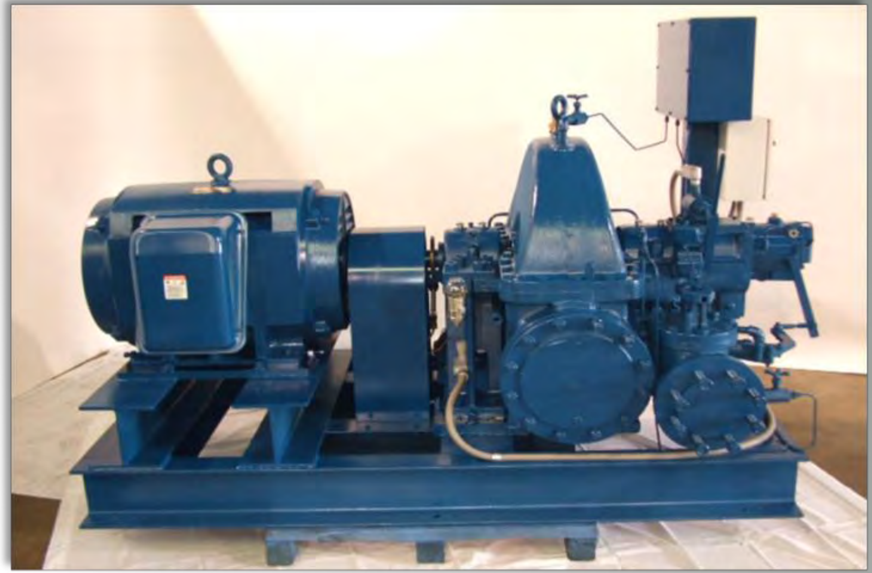


- Increased fuel savings
- Varied load profile for extended seasonal coverage
- Potential to operate closer to rated boiler capacity
- incremental increase in heating capacity generally lowers investment per unit of capacity
- Shared (lower) operating costs per unit of heat delivered

# Is There Potential To Add Loads?

## Thermally Led CHP

- May improve year round load profile
- May be helpful to overall project Economics

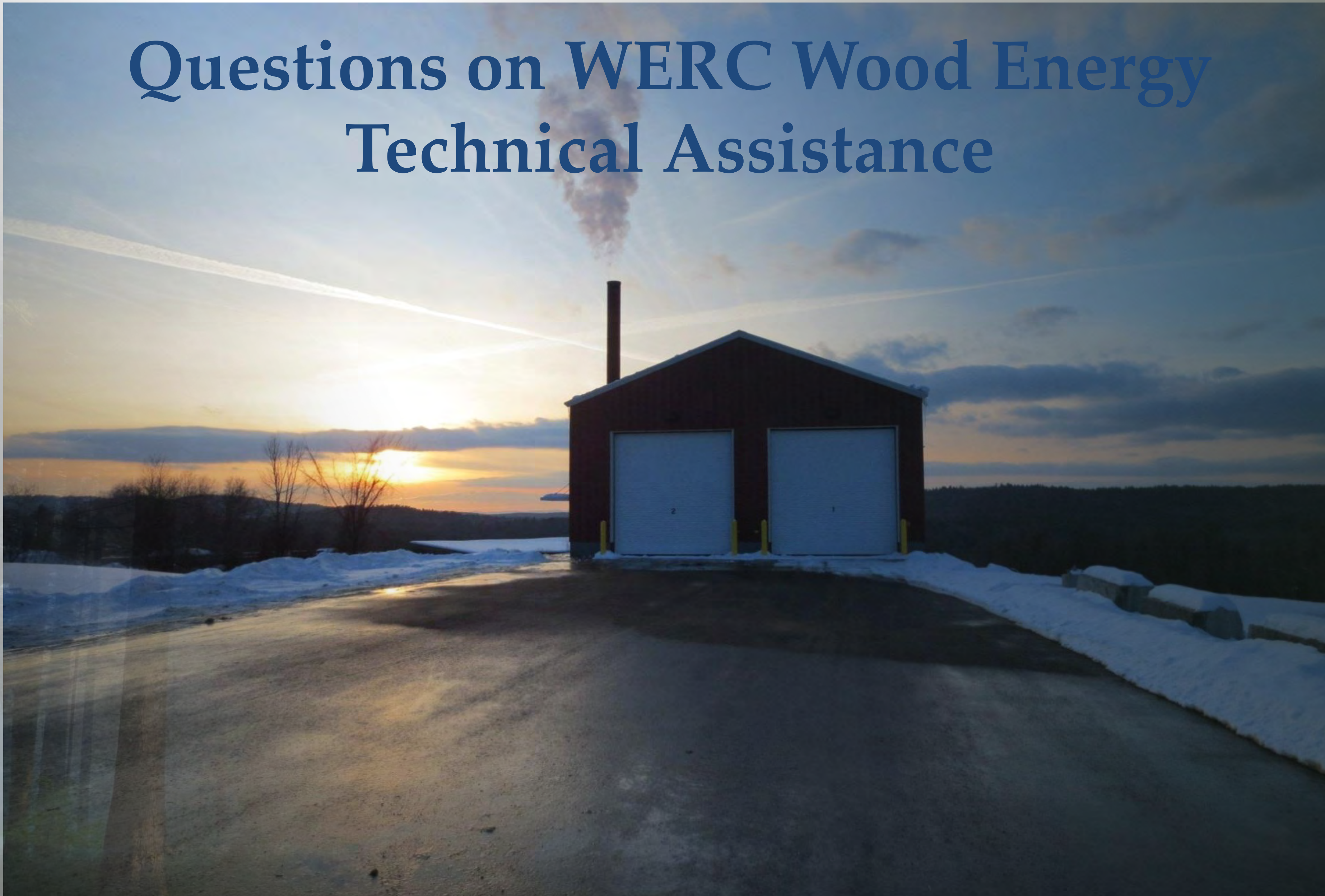


# IS There Potential To Add Loads?

## Air Conditioning/Chilling

- May allow year round operation of boiler to offset summer heating loads?
- Substantial savings for reduced electric demand charges?

# Questions on WERC Wood Energy Technical Assistance



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# Wood Energy System Design and Operation Considerations


- Fuel – now and in the future
- Boiler Room Equipment
- The Facility/Buildings Served
- Staffing

# Modern Wood Energy Systems

- Efficient
- Clean Burning
- Automated

# Systems Based on Fuel Type

- Pellet
- Cord Wood
- Wood Chip

# Wood Energy Projects

## Driven by Savings

- Cord Wood
  - Lower fuel costs than pellets
  - Low capital costs
  - More labor intensive
- Wood Chips
  - Highest capital cost
  - Lowest fuel costs
- Pellets
  - Highest fuel cost
  - Lowest potential capital cost

## Type of Setting

- Cord wood
  - Small industrial or commercial
  - Least automated
  - Fuel management is job #1
- Pellets
  - Smaller commercial or institutional
  - Can be completely automated with minimal maintenance
  - Minimal fuel storage space
- Wood Chip
  - Larger institutional, industrial or commercial
  - Larger footprint

# Cord Wood



# Cord Wood Fuel Storage and Delivery

Pallets

Trailer

# Containerized Pellet System

- Minimal site work
  - Concrete pad
  - Piped utilities
- Grain bin fuel storage
- Auger pellet delivery to boiler

# Pellet Fuel Storage and Delivery

3 to 6 ton Bags

30 ton Grain Bins

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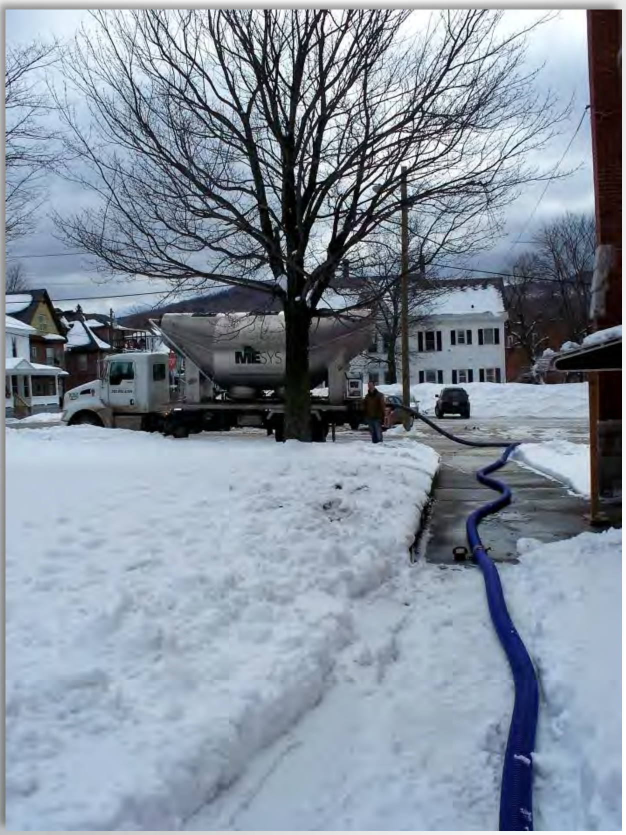
# Pneumatic Pellet Delivery



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# Wood Chip Boilers

# Key Design Points

## Maximize Cash Flow (balance savings and investment)

- Type of system
  - Fuel availability and price
  - Level of automation
  - Savings opportunity
- Practical loads to connect
- CHP? Absorption Chiller?
- Sizing the boiler
- Thermal storage
- Fuel flexibility
- Emission Controls

# Components of a Chip System

- Fuel Storage
- Fuel Delivery to Boiler
  - Sort oversized pieces
  - Surge bin
- Combustion Unit
  - Stoker
  - Pneumatic
  - Moving grate
  - Automatic Ash handling
  - Daily raking
- Thermal Storage (Hydronic)
- Heat Delivery
  - Hot air
  - Hot Water
  - Steam

# Components of Wood Chip Fuel System

- Storage
  - Expensive
  - 3-5 days maximum
  - Full truck loads minimum
- Reclaim from Storage
  - Traveling augers
  - Hydraulic rakes
  - Spring and auger
- Screen Oversized Fuel
  - Shaker table
  - Pinch point
  - Rotary drum
- Delivery to Boiler
  - Belts
  - Augers
  - Shaker table
  - Drag chain

Fuel Bunker

Wedge Floor System

Vibrating Screen Removes Oversized Materials

# Whole Tree Chips




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# Bole Chips



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# Hog Fuel

# Wood Chip Fuel Storage and Delivery

# Creative Spaces

# Leveling Screws to Move Pile

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# Church Communities School
# Esopus, NY

# Storage in Old Coal Bunker

# Crotched Mountain Rehab Center


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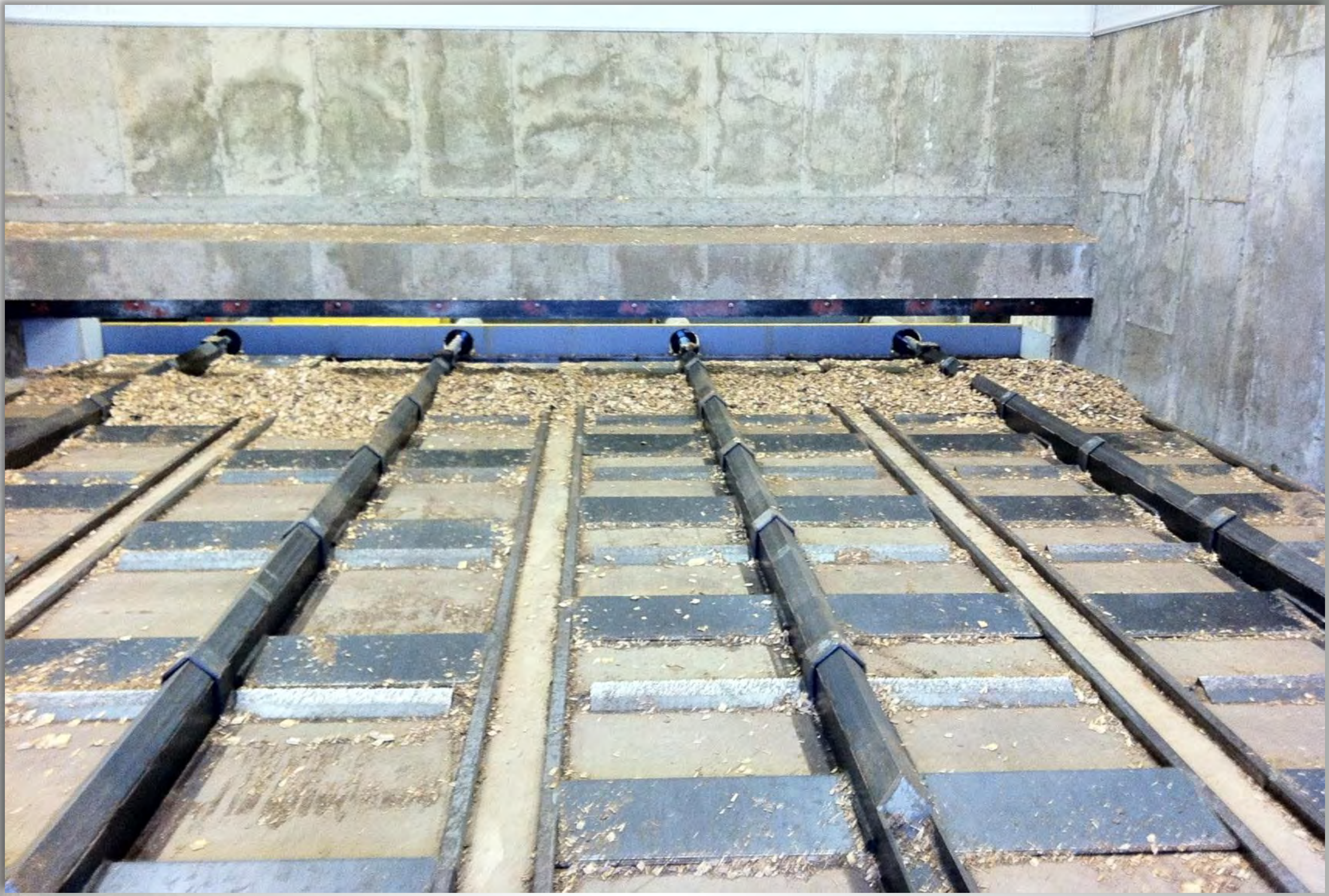



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# Spring Agitator/Auger

# Semi-automated Fuel Handling Systems




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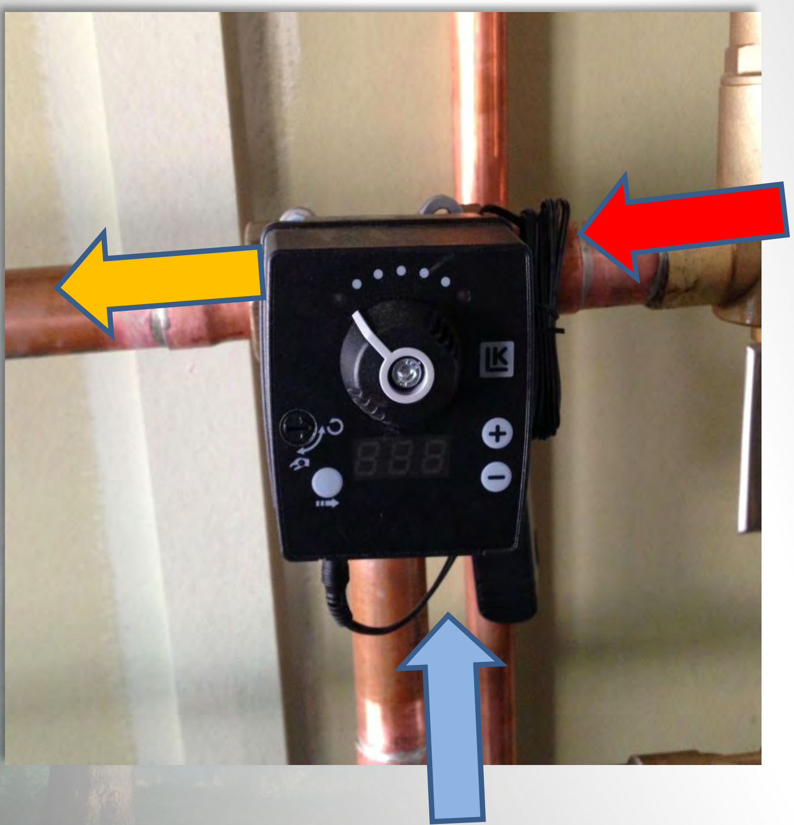
# In-line Screening Systems

# Thermal Storage Systems

- Energy fly wheel
- Improves combustion
- Reduced boiler size
- Extends boiler life
- Connection to other energy systems-solar thermal

# Thermal Storage

Three Way Mixing Valve




Tank Temperature Higher than Distribution Temperature



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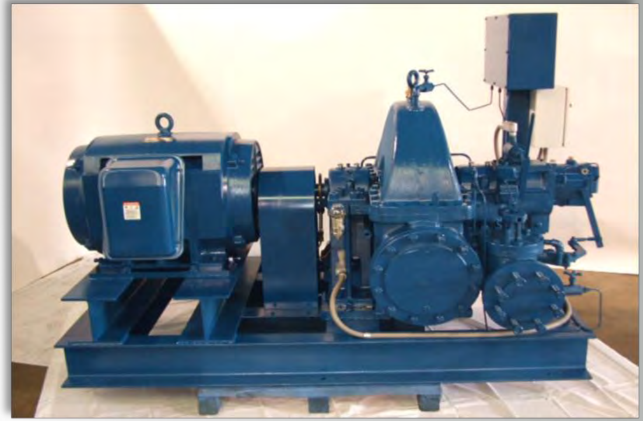
# Thermally-Led CHP
## <$0.02/kWh Energy Cost

## Commercially Available Closed Cycle Biomass Power Generation Options

- Backpressure Steam (~5-10% electrical efficiency)
- Organic Rankine Cycle (~15-20%)



**Tips:**

- Use onsite to maximize value of electricity generated
- Year-round load helpful to economics
- Lower quality heat needed onsite = better CHP potential

# Absorption Chillers

- Consider When
  - Low Cost Heat
  - High Electric Prices
  - High Demand Charges

- Single Stage COP = 0.7
- Double Stage COP = 1.3
- Electric water cooled COP = 6
- Electric air cooled COP = 4

- Biomass Absorption Cooling for $0.04 - $0.07/ton-h cooling
  ($30/ton wood chips)

# Emission Control

- Electrostatic Precipitators
- Multi-cyclones
- Fabric Filters
  - Bag house
  - Traveling belt

# Design Questions



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# Projects

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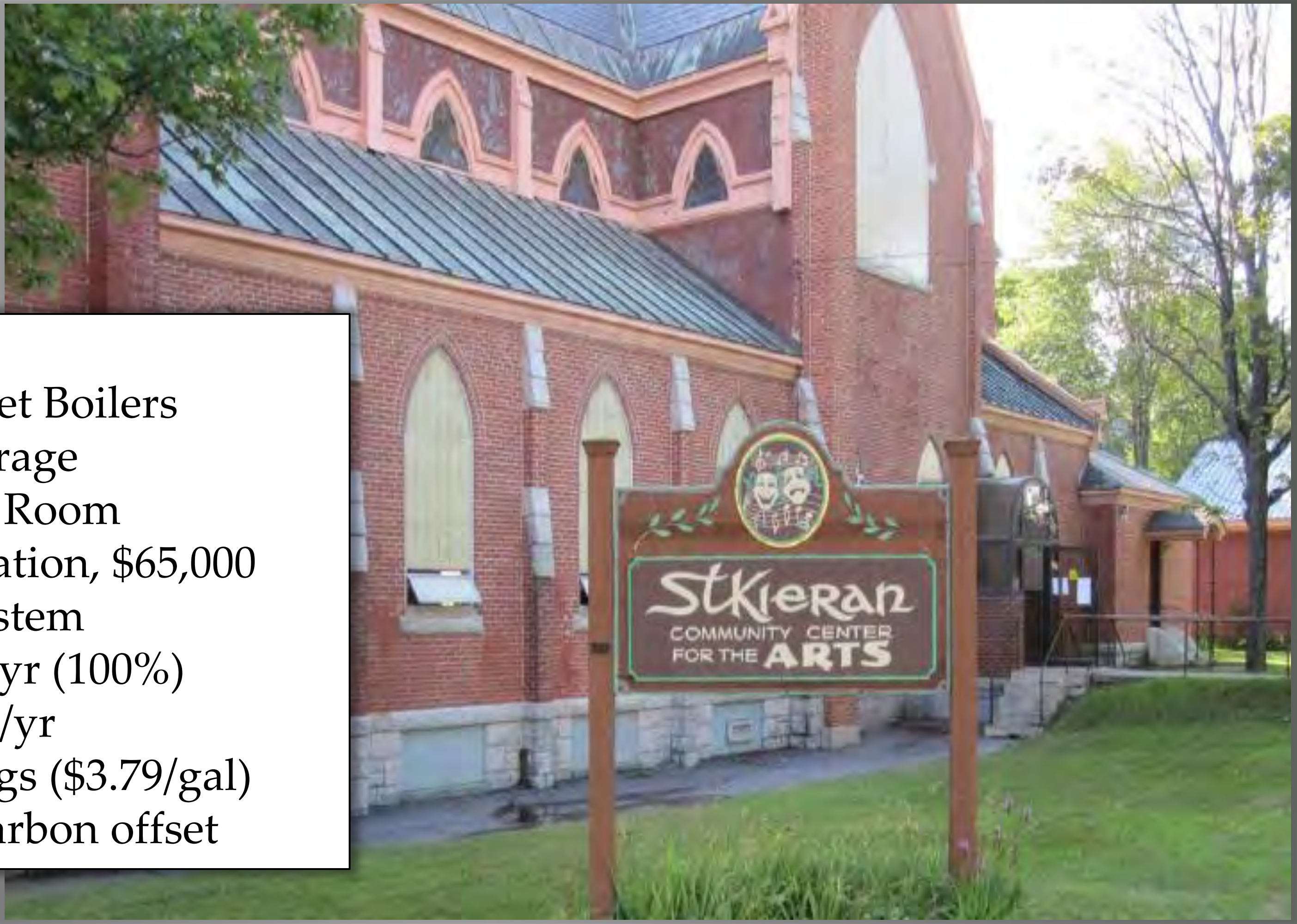
# Commercial Facility Pellet Project
# Oil-fired Steam to Pellet-fired Hot Water




- 8,353 sf
- 2- 0.2 mmBtu/hr Pellet Boilers
- 300 gal. Thermal Storage
- 12 ton Pellet Storage Room
- $90,000 pellet installation, $65,000 upgrade to HVAC system
- Replace 4,800 gal #2/yr (100%)
- 34 tons Wood Pellets/yr
- $9,930 Annual Savings ($3.79/gal)
- 25.9 mtCO2/yr net carbon offset

# Basement Installation

Basement Installation


6 ton Bagged Storage



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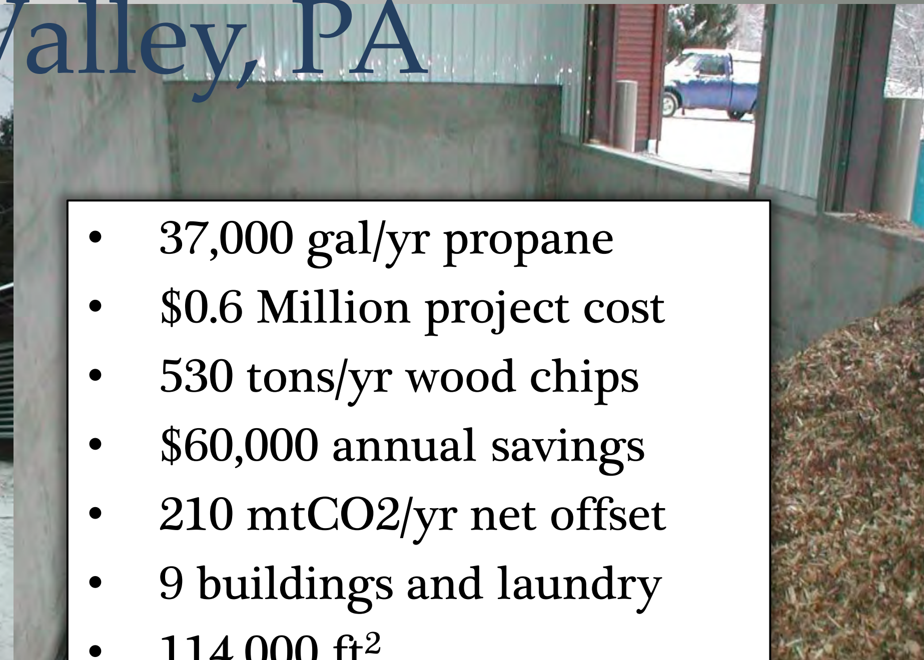
# Harvard Forest Cordwood System


- 3- 170,000 btu/hr boilers
- 2,500 gal. thermal store
- Serves about 50,000 ft2

# Spring Valley, PA



- 37,000 gal/yr propane
- $0.6 Million project cost
- 530 tons/yr wood chips
- $60,000 annual savings
- 210 mtCO2/yr net offset
- 9 buildings and laundry
- 114,000 $ft^2$

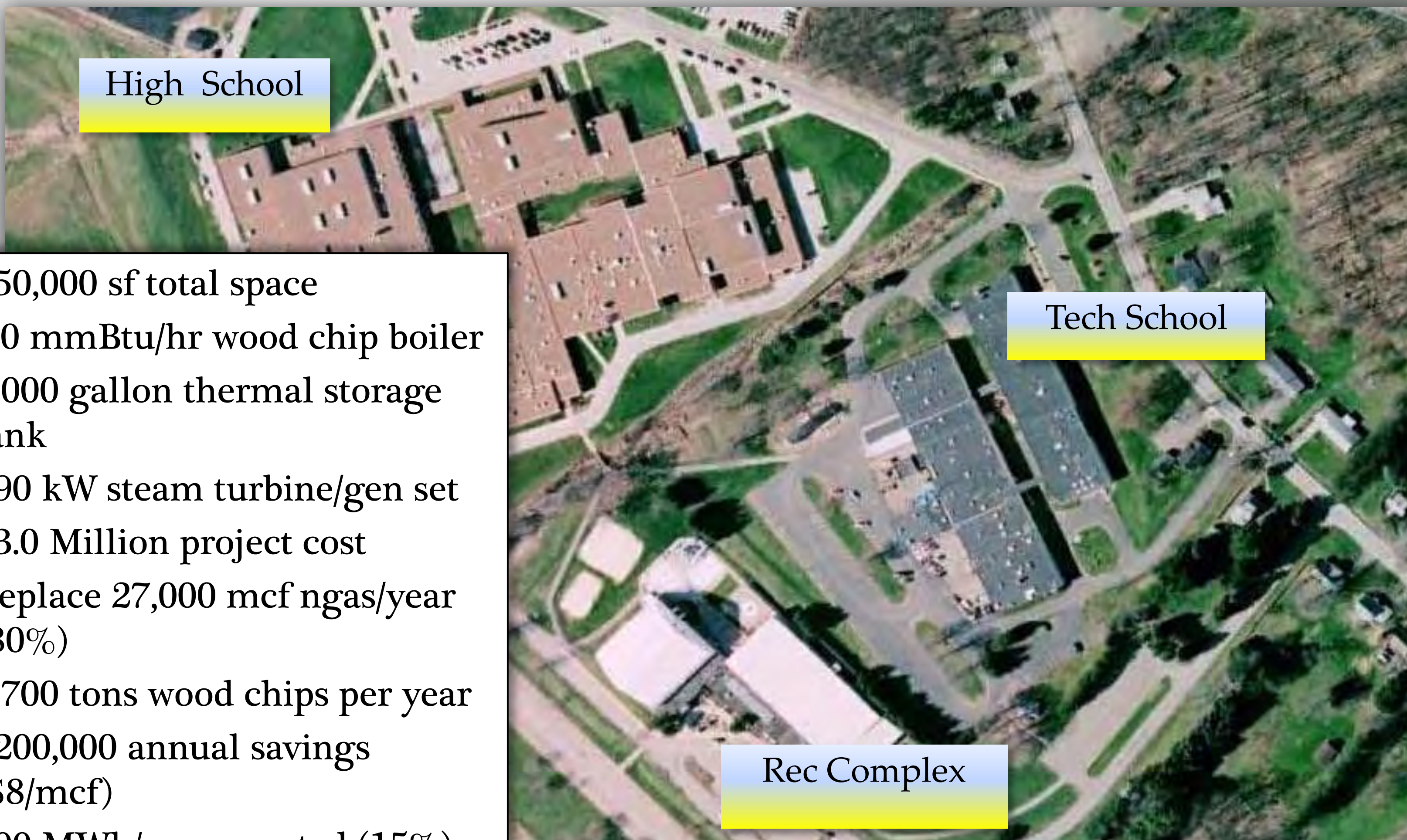

# Biomass Thermal

## (Converted Steam to Hot Water)
## Mt. Saint Alphonsus Seminary, New York

- 165,000 sf Facility
- 4.2 mmBtu/hr & 1.8 mm Btu/hr Wood Chip Hot Water Boilers
- Two 2,500 gal Thermal Storage Tanks
- $2.22 Million Project Cost
- Replace 84,500 gal Fuel Oil/year (100%)
- 1,600 tons Wood Chips/year
- $271,300 Annual Energy Savings
- 850 mtCO2/yr net carbon offset

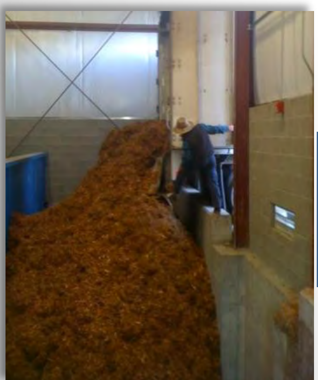
# Crawford County Complex

# Crawford County Biomass CHP & District Heating (Hot Water)




- 550,000 sf total space
- 8.0 mmBtu/hr wood chip boiler
- 6,000 gallon thermal storage tank
- 190 kW steam turbine/gen set
- $3.0 Million project cost
- Replace 27,000 mcf ngas/year (80%)
- 2,700 tons wood chips per year
- $200,000 annual savings ($8/mcf)
- 500 MWh/yr generated (15%)

# Key Project Components



300 cy Storage

chips

8 mmBtu/hr Boiler

175# steam

200 kW Turbine/Generator

10# steam

Steam to Hot Water Heat Exchanger

210°F H2O

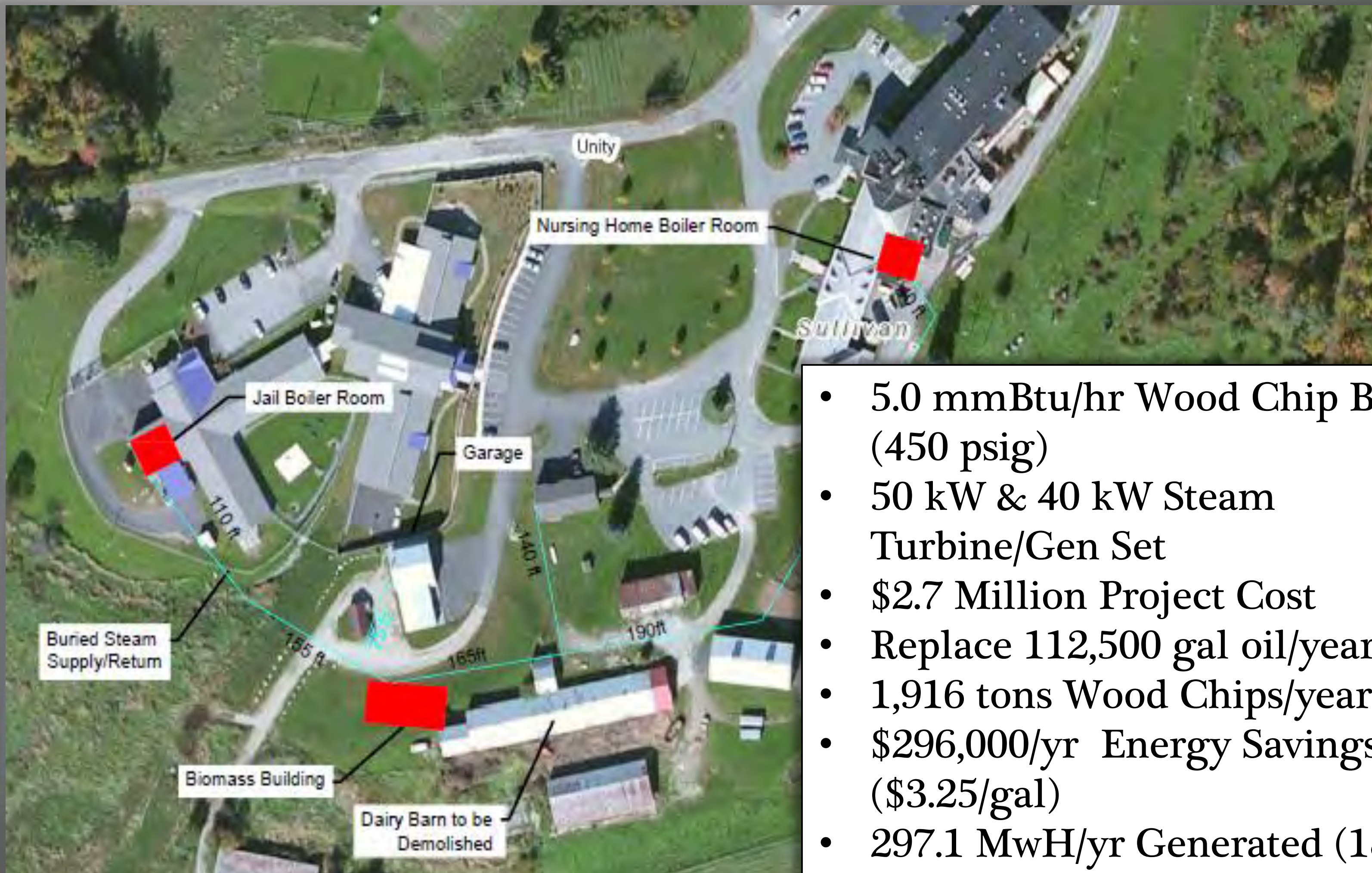
6,000 gallons Thermal Storage

200°F H2O

HX and Distribution Pumps to Three Facilities

# Sullivan County, NH

# District Heating and CHP (Steam)
## Sullivan County, NH




- 5.0 mmBtu/hr Wood Chip Boiler (450 psig)
- 50 kW & 40 kW Steam Turbine/Gen Set
- $2.7 Million Project Cost
- Replace 112,500 gal oil/year (90%)
- 1,916 tons Wood Chips/year
- $296,000/yr  Energy Savings ($3.25/gal)
- 297.1 MwH/yr Generated (18%)

# VA Hospital
## Chillicothe, OH

- CHP Unit Heating and Cooling
- over 1 million ft2

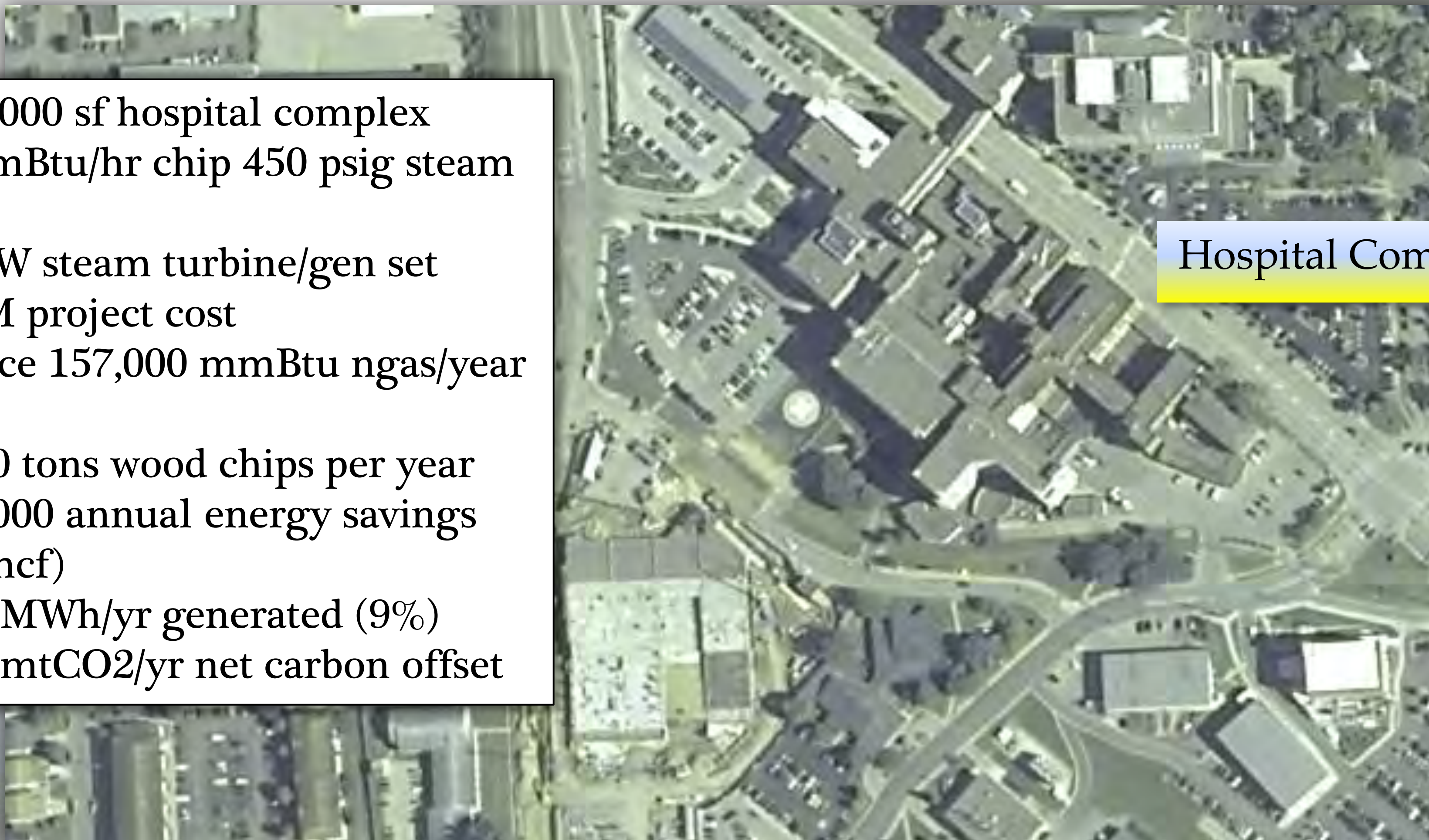
# Biomass CHP District Heating/Cooling VAMC Chillicothe, OH

- 1,000,000+ ft2 - 300 bed hospital
- 20 mmBtu/hr biomass steam boiler, 450 psig
- 350 kW turbine
- 200 ton absorption chiller
- 15,000 tons biomass annually
- Replace 140,000 mmBtu/yr natural gas (90%)
- 1,600 MWh/yr renewable electricity
- $400,000 annual operating cost savings
- 9,250 mtCO2/yr net carbon offset

Image Sources: Wellons, FEI & IDEA 2011 – Woolpert Presentation

# Gunderson Lutheran CHP District Heating (steam)

- 1,100,000 sf hospital complex
- 28 mmBtu/hr chip 450 psig steam boiler
- 350 kW steam turbine/gen set
- $6.5 M project cost
- Replace 157,000 mmBtu ngas/year (90%)
- 18,000 tons wood chips per year
- $470,000 annual energy savings ($6.5/mcf)
- 1,600 MWh/yr generated (9%)
- 9,500 mtCO2/yr net carbon offset

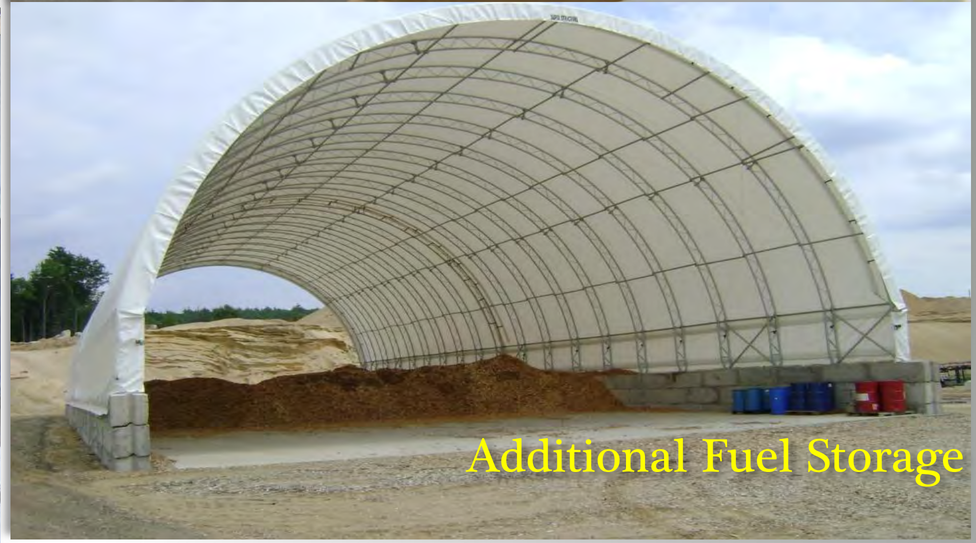


# Pleasant View Gardens

- 250,000 gal. of #2 fuel oil/yr
- 400 HP Hurst boiler
- 100,000 gal. thermal storage
- 4.5 acres of greenhouse space

# Pleasant View Gardens Wood Energy System



# Biogas to IC Engine CHP Systems

- Limited commercial availability in US
- Available units are small, Borealis and All Power Labs (45kWe and 18kWe)
- Units are downdraft gasifiers using fabric filters to clean gas
- Approximately efficiency based on HHV 25%e, 45%thermal

# Biogas to IC Engine CHP Systems

- Lots of companies have built pilot projects and beta testing e.g. (Vulcan, Community Power, Pheonix Energy)
- Larger commercial unit sold in Europe by Babcock and Wilcox Volund (up to 6MWe), not available in the US (liquid gas cleaning)
- Major engineering issue to overcome is economically removing tars from the gas for reliable IC engine operation.

# Summary

## Project Design

- Remember the goal
- Choose the right system
- Properly size the system
- Thermal storage is a key component in hydronic systems
- Match system with resources

## Wood Energy

- Clean
- Efficient
- Automated

# What will I learn?

- **Webinar Schedule** (All webinars will run from 1:00 PM to 2:15 PM CST)

Presentation slides and videos of presentation will be available at
**wisconsinwoodenergy.org/learning.html**

- **Feb 18** The Wisconsin Energy Picture
- **Feb 25** Types of Wood Fuels & Appliances
- **March 4** Pre-Feasibility Assessment Tools & Grant Funding
- **March 11** Residential/Commercial Project Examples & Economics
- **March 18** Overview of Industrial Wood Heating & Power Systems
- **March 25** Case Study of Large Scale Wood Energy Projects
- **April 1** Wood Fuel Supply and Distribution Business
- **April 8** Wood Energy Cluster Development /District Heating

# Questions

This presentation was develop by:

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