Facility Heating with Biomass

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Presentation Outline

- Biomass resources
- Drivers
- Technology overview
  - Facility heating
  - Not covering power generation in this talk
- Overview of NREL's new plant
- Barriers and success factors

Biomass Resources and Issues

Wood Residues

- Sawdust
- Wood waste
- Forest thinnings

Agricultural Residues

- Corn stover
- Wheat straw
- Rice hulls
- Sugarcane bagasse
- Animal waste

Energy Crops

- Switchgrass
- Hybrid poplar
- Willow

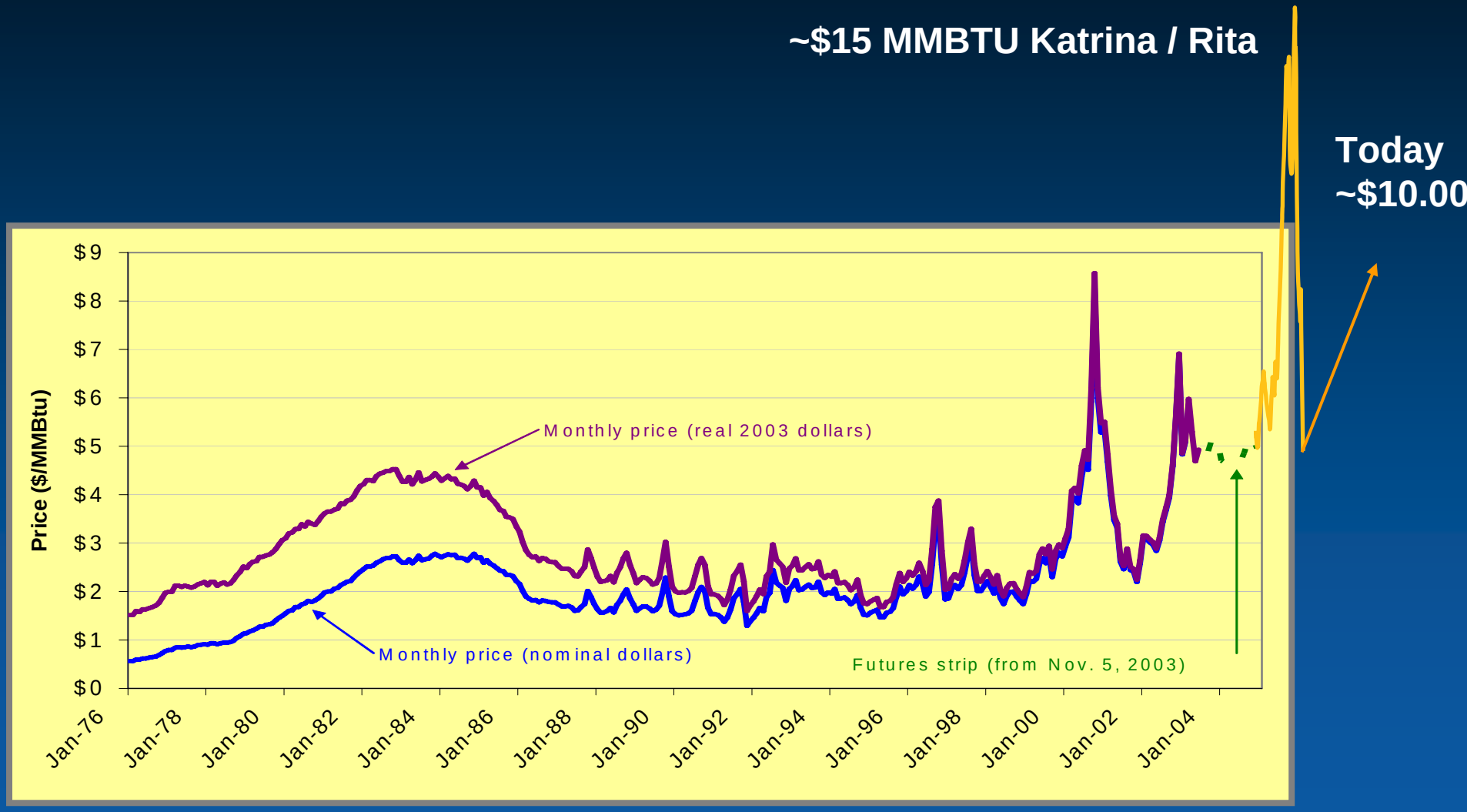
Landfill gas, manure

- ✓Cost
  - ✓Production
  - ✓Collection and Transportation
  - ✓Quantity Available
  - ✓Integrated Supply System
- ✓Sustainability
  - ✓Land, Air and Water Resources
- ✓Quality
  - ✓Composition
- ✓Ease of Conversion

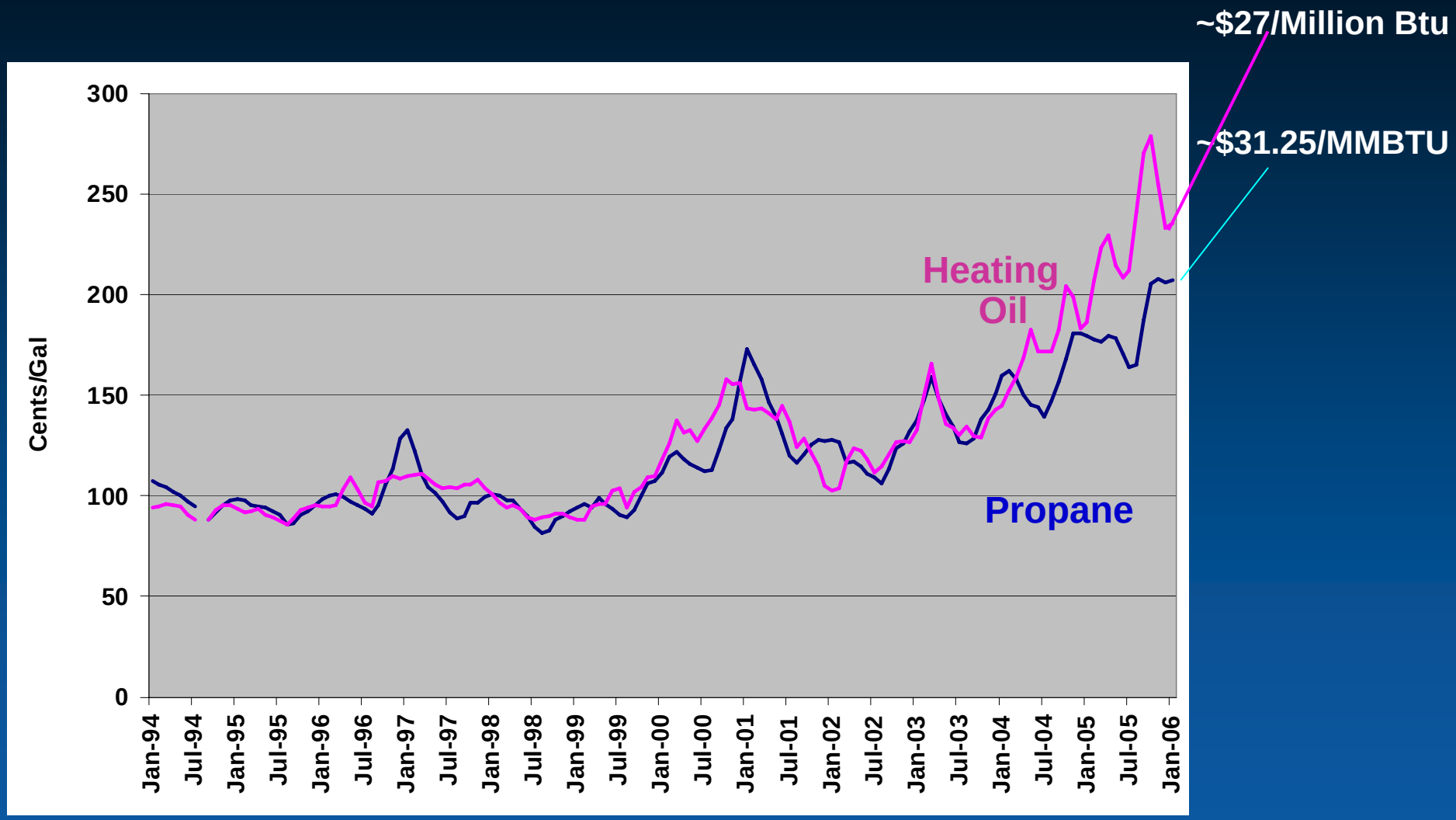
Benefits of Biomass Energy

- Reduced facility energy bills compared to fossil fuels
- High capacity factor (for power generation)
- 24x7 availability
- Historically stable fuel prices
- Rural economic development
  - Jobs and money stay in the community
- Reduced SOx emissions
- CO_2 neutral

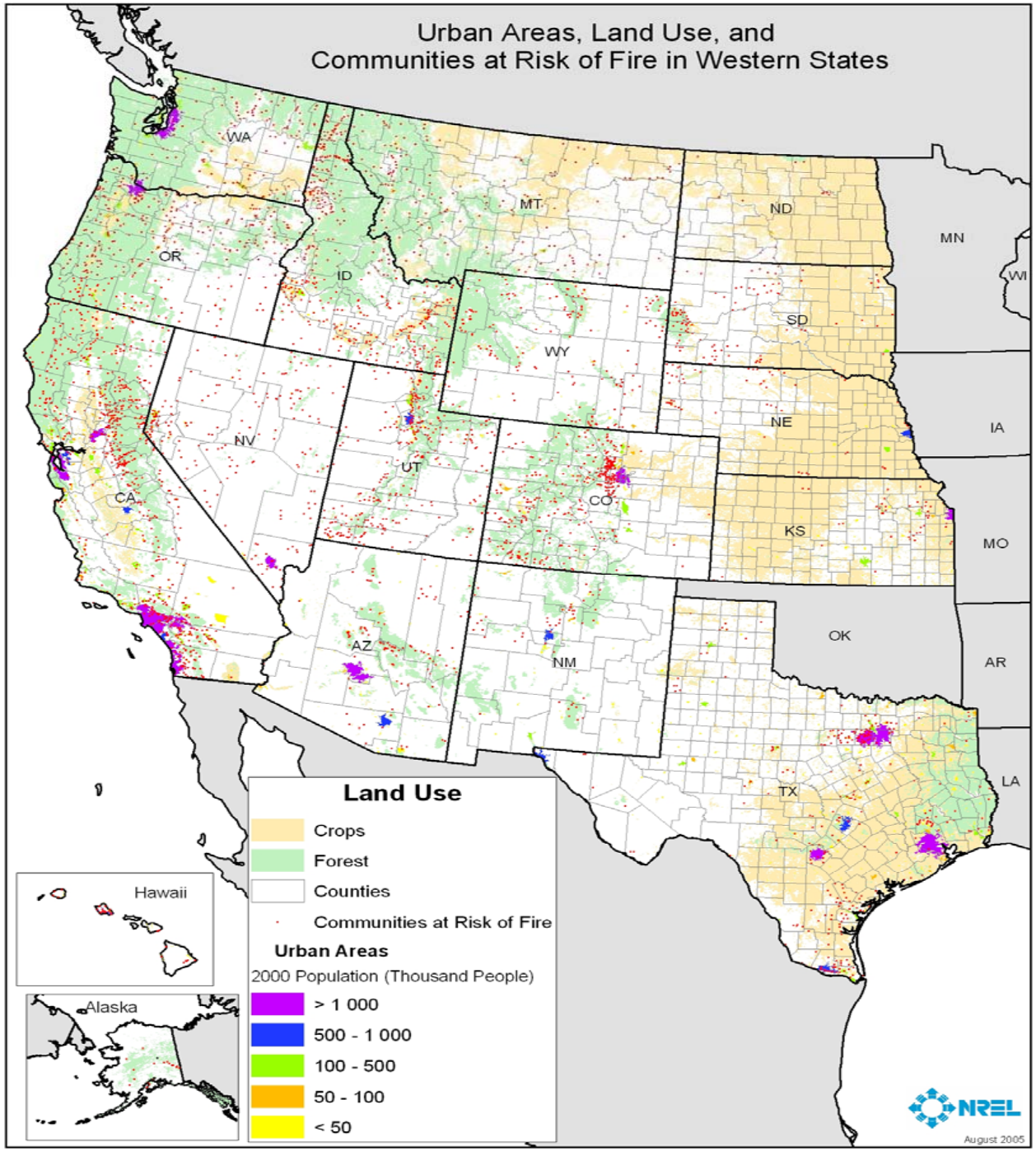
Natural Gas Prices



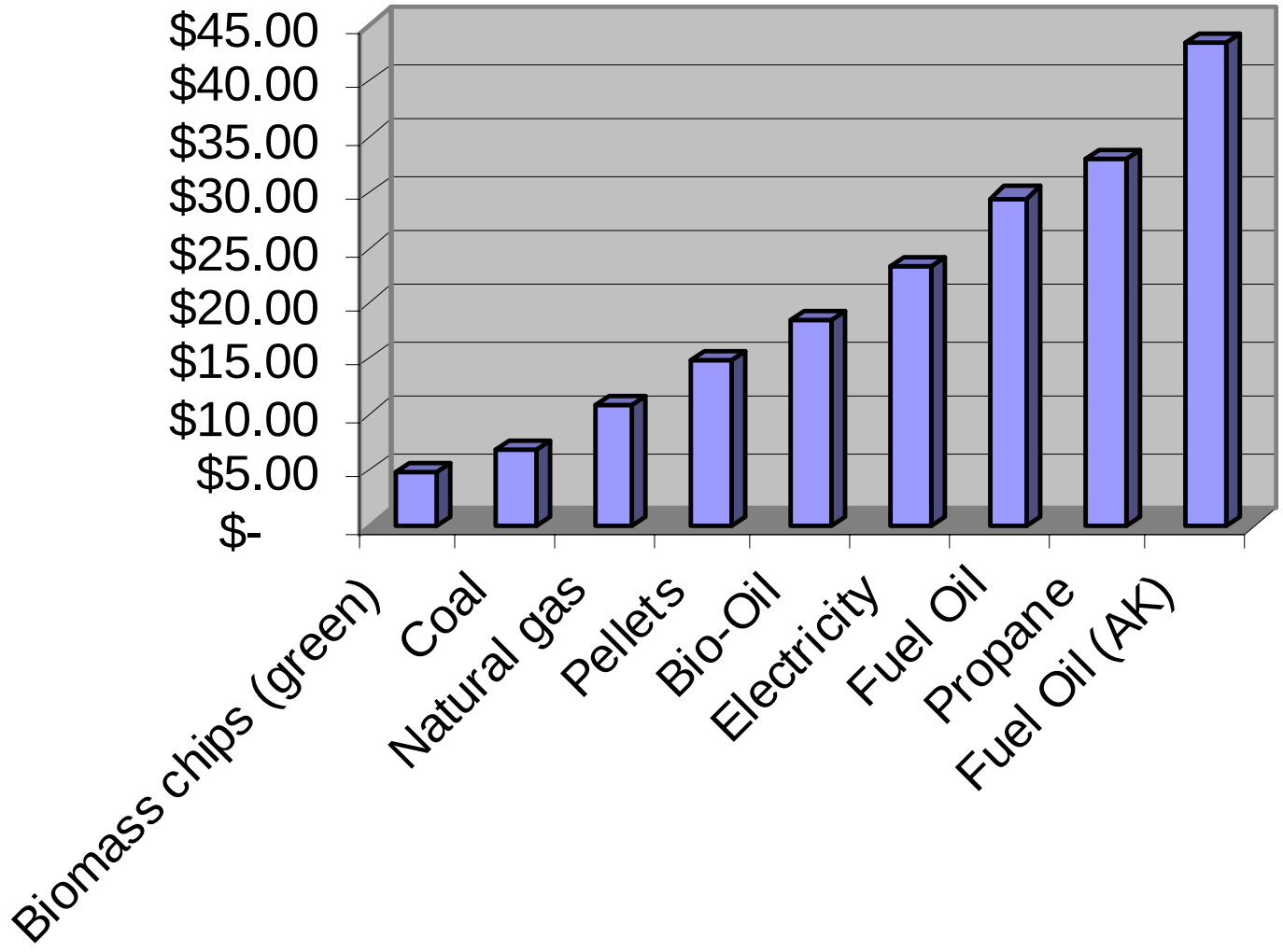
Propane and Fuel Oil



- Drought
- Beetle outbreak
- Fire suppression
- Suburban expansion
- Changing forest conditions
- Build up of fuels
- Loss of forest products industry



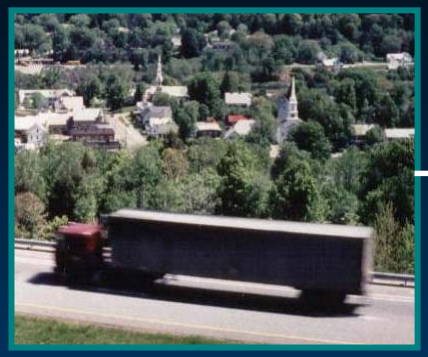
Sample Fuel Cost Comparisons ($/MMBtu Delivered)



Biomass Heating Technologies

- Commercial, proven technologies
  - Hot water or low pressure steam
  - Positive operator experience
  - Automated to hand fed
  - Clean burning
  - Wood chips, cord wood or pellets
  - Moisture up to 50-60%, but 30% is better
- Low to moderate payback periods depending on wood cost and alternate fuel cost

Commercial-Scale Wood Heating



Green wood chips (50% moisture) @ $50/ton
~8.6 MBTU/ton in a
high efficiency wood boiler @ 85% efficiency

~ $7.00/MBTU delivered to building

Existing Systems

Darby, MT

Wood Products

Industry

Court House
Middlebury, VT

Biomass stored below ground

Boulder County, Longmont Campus

Four Main System Types

- Large, automated wood chip
  - Typically buildings over 100,000 square feet
    - Smaller buildings if they have year round need for hot water (prison, hospital
  - Must have large heating bills to justify the investment
- Semi-automated surge bin
  - 10,000 – 100,000 square feet
  - Bucket loader
- Pellet-fired
  - 5,000 square feet and up
  - Systems less expensive, less storage
- Cord wood
  - 5,000 – 50,000 square feet
  - Manual loading of fire wood 1-3 times per day

Automated Chip Systems

- High capital costs,
- Storage needs,
- Fuel must be consistent, no sticks
- Minimal labor

Vermont Army National Guard

MESSERSMITH
MANUFACTURING

Surge-bin system

Smaller,

Simpler,

Cheaper

Source: USFS Fuels for Schools Program

Pellet Systems

- Fuel is more expensive
- Storage smaller, cheaper
- Boiler smaller, cheaper

Source: USFS Fuels for Schools Program

Pellets vs. chips

- Pellets
  - Consistent quality
  - Dry fuel
  - Lower capital costs
  - Higher fuel costs
  - Smaller footprint
  - Storage in silos
  - Need commercial pellet infrastructure for bulk fuel deliveries
  - Lower ash

- Chips
  - Lower fuel costs
  - Potential quality problems
  - Possible moisture issues
  - Larger footprint
  - Larger storage area
  - Higher equipment capital costs
  - Low ash

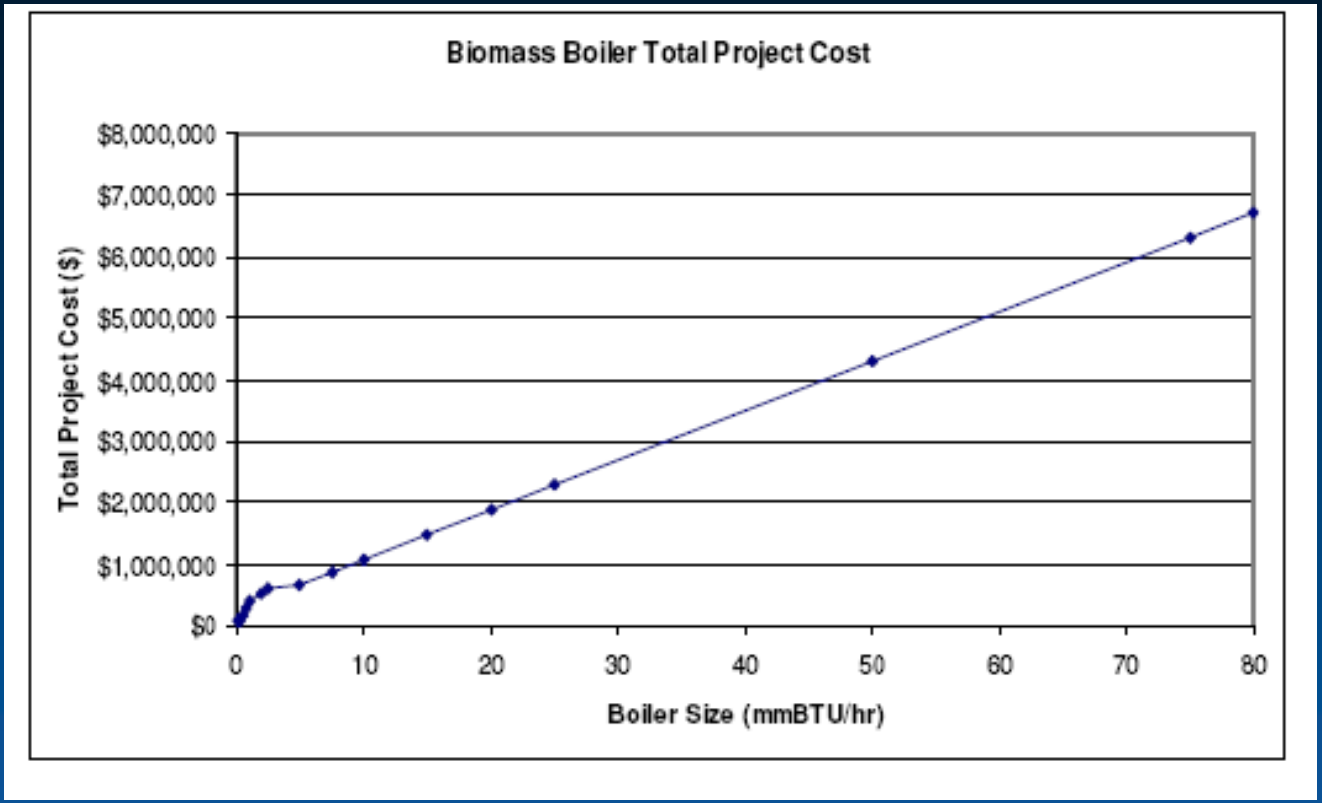
Emerging Options – Ag Residues

- Straw burners
  - Europe, CIS
- Ag pellets (straw and corn stover)
  - Earthtech Energy
  - Show-Me-Energy Coop
  - Prairie Fire Bioenergy Coop
- Corn cobs
  - Poet Energy (ethanol)
- Mobile pelletization
  - Stay tuned

Major Vendors

- US commercial pellet systems vendors
  - Tarm, Harman
- US chip systems
  - Messersmith, Chiptec, Advanced Recycling, Hurst
- European biomass boiler manufacturers (pellets, chips, ag waste)
  - Uniconfort, Köb, Fröeling, Osby Parca, Passat Energi
  - Just making their way to US markets
  - Several going through ASTM certification

Biomass Boiler Project Costs

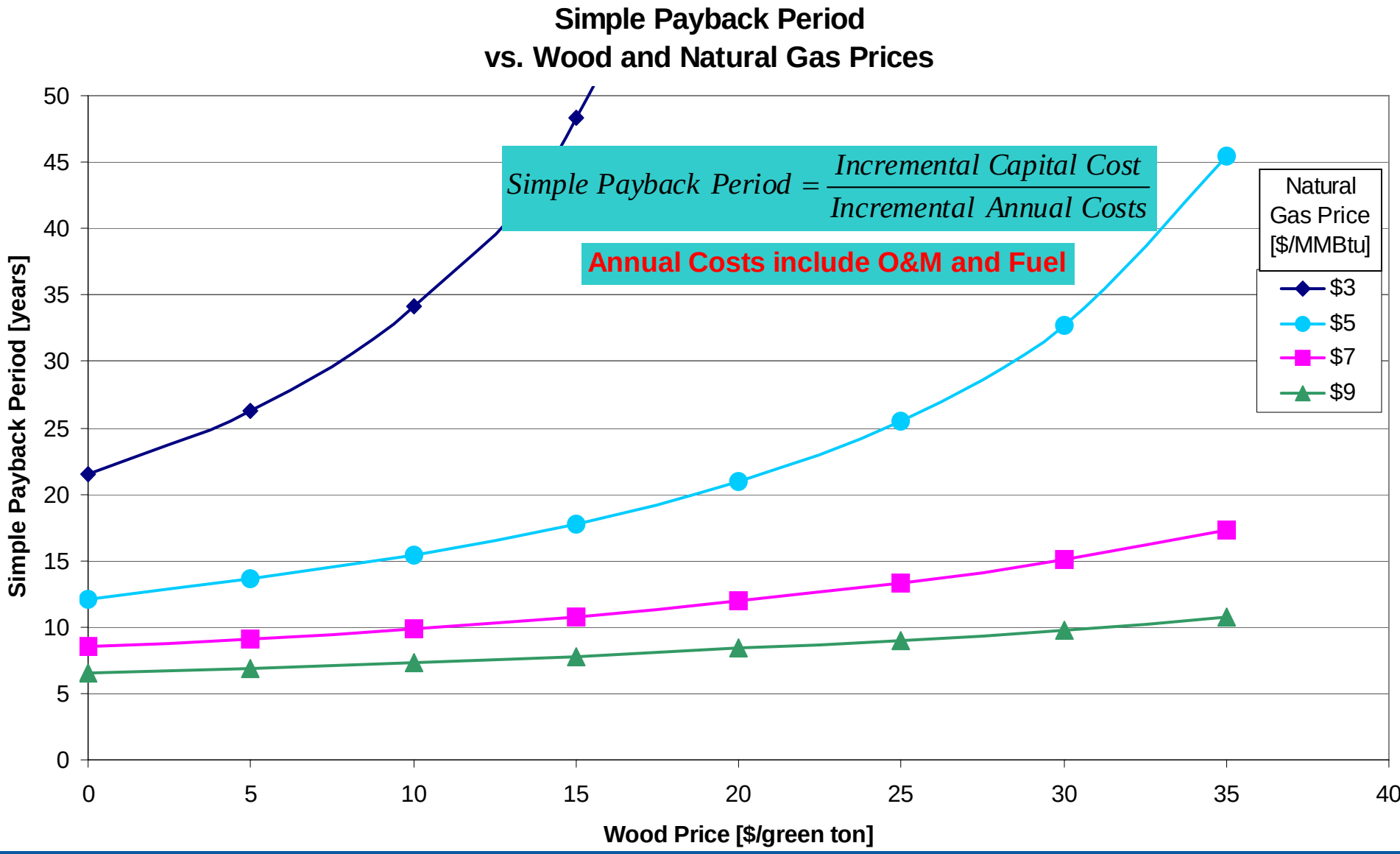


Source: CTA Architects and Engineers, Biomass Boiler Market Assessment, October 2006

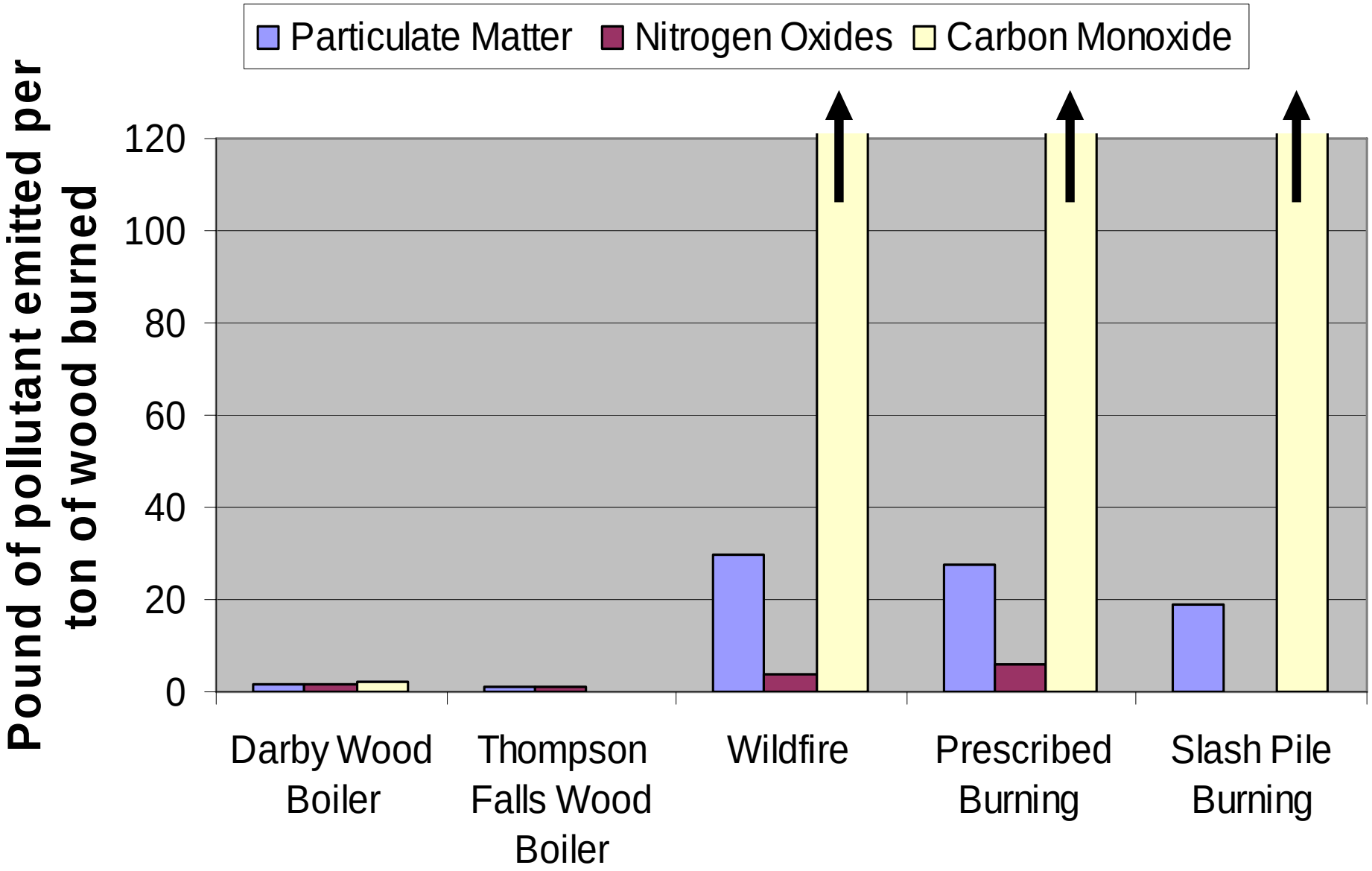
Simplified Economic Analysis

Assume we are replacing 90% of energy with wood

System Cost:	**$ 500,000**		
Biomass System	**Quantity**	**Cost**	Total
Biomass fuel use	656.00	$ 25.00	$ 16,400
Natural gas use	6,716	$ 1.02	$ 6,850
O&M			$ 2,200
Annual Cost			$ 25,450
Natural Gas System			
Natural gas use	67,166	$ 1.02	$ 68,509
O&M			$ 200
Annual cost			$ 68,709
Savings of biomass system			$ 43,259
Simple payback			**11.56**

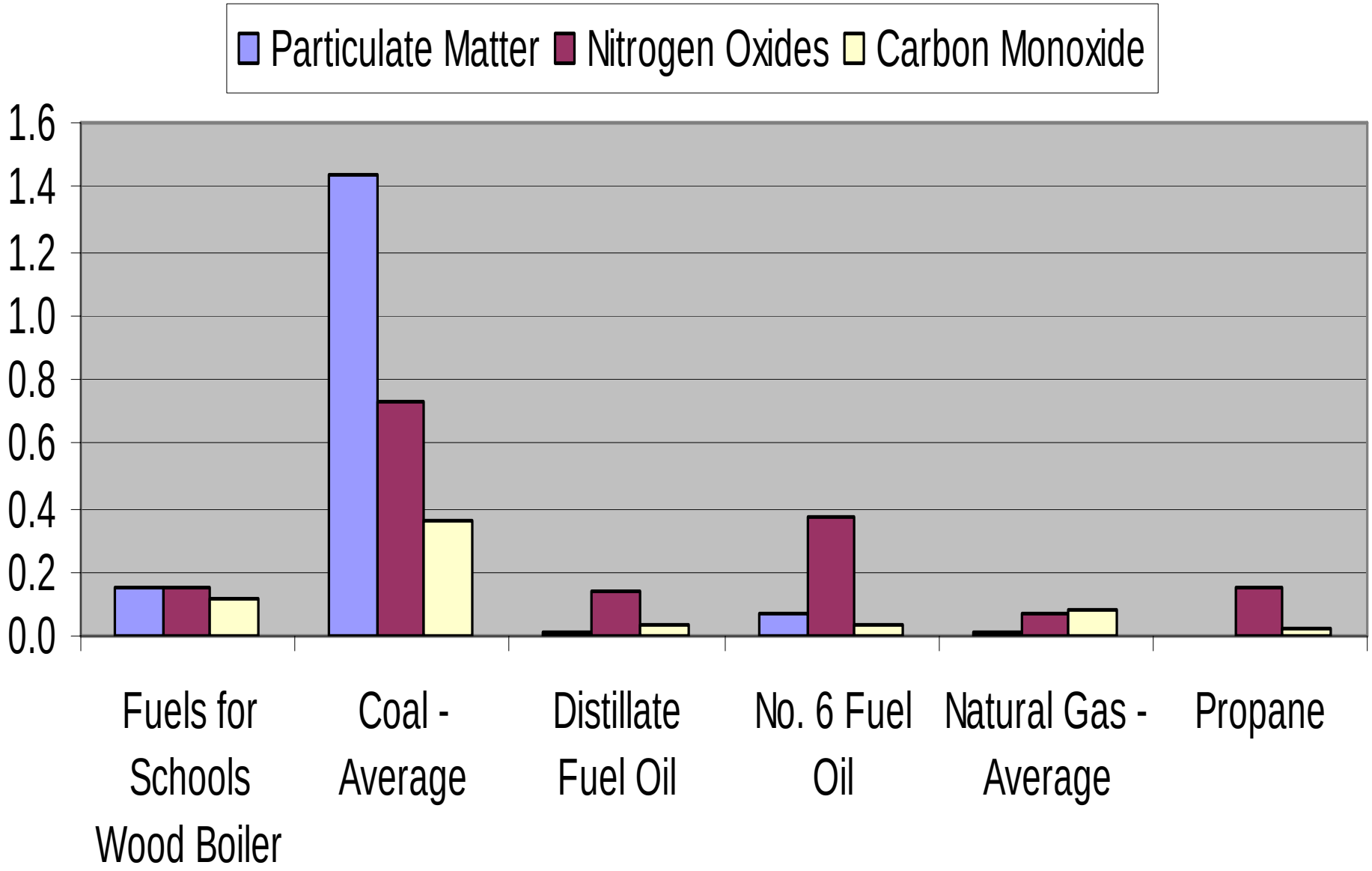

Simple Payback Period
vs. Wood and Natural Gas Prices
Simple Payback Period = Incremental Capital Cost / Incremental Annual Costs
Annual Costs include O&M and Fuel
Natural Gas Price [$/MMBtu]
$3
$5
$7
$9
Simple Payback Period [years]
Wood Price [$/green ton]
0
5
10
15
20
25
30
35
40
45
50

Pollutant Emission Rates for Wood Boilers and Fire Activities



Source: USFS Fuels for Schools (note: no pollution control on boiler systems)

Pollutant Emission Rates by Fuel Type (lb/MMBtu)

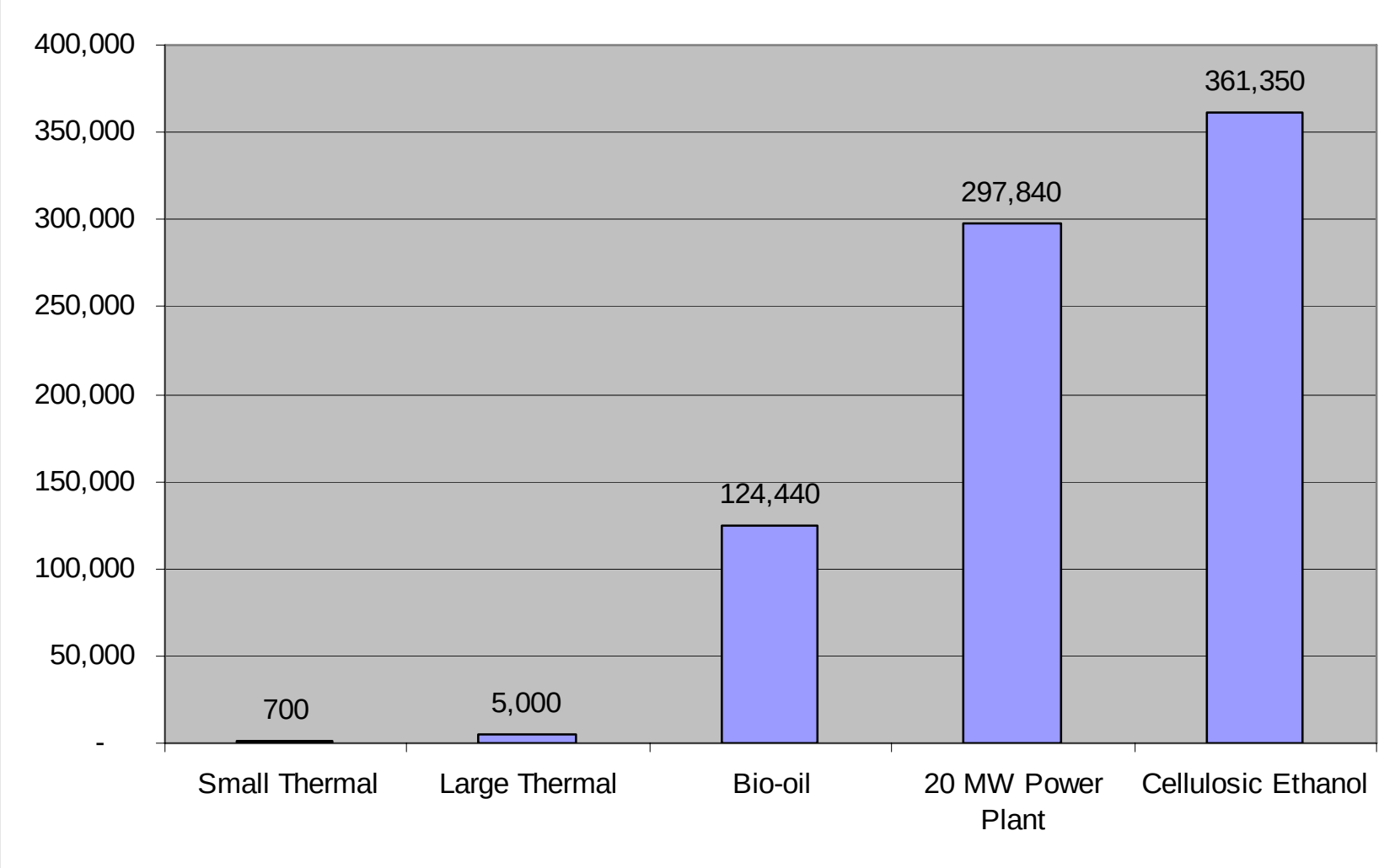


Source: USFS Fuels for Schools

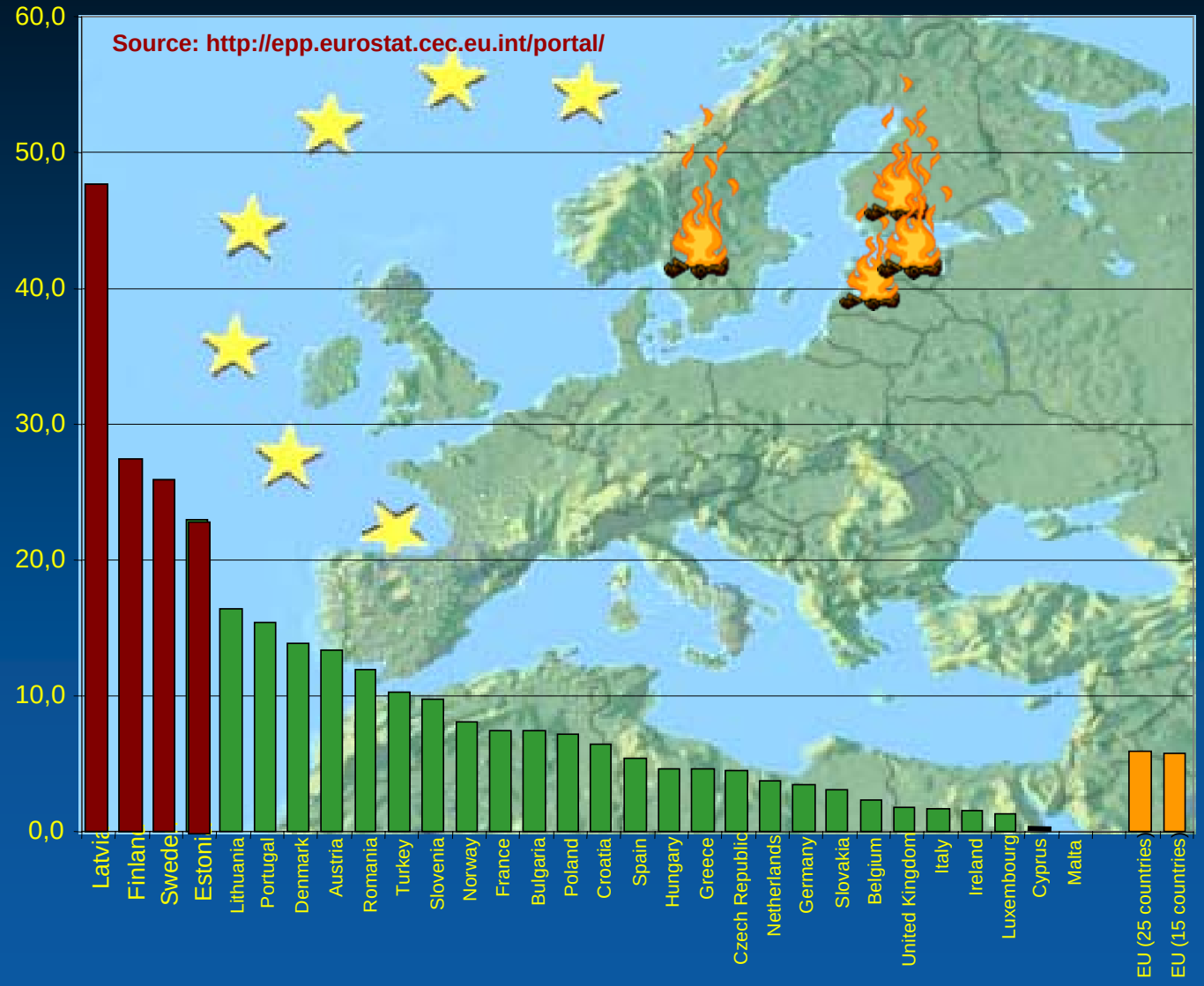
Biomass Supply Issues

- How much do I need?
- Where will it come from?
- How reliable is the source?
- Who will bring it to me?
- What will it cost?
- Quality, moisture, contaminants?
- Sizing, storing?
- Pave your storage site

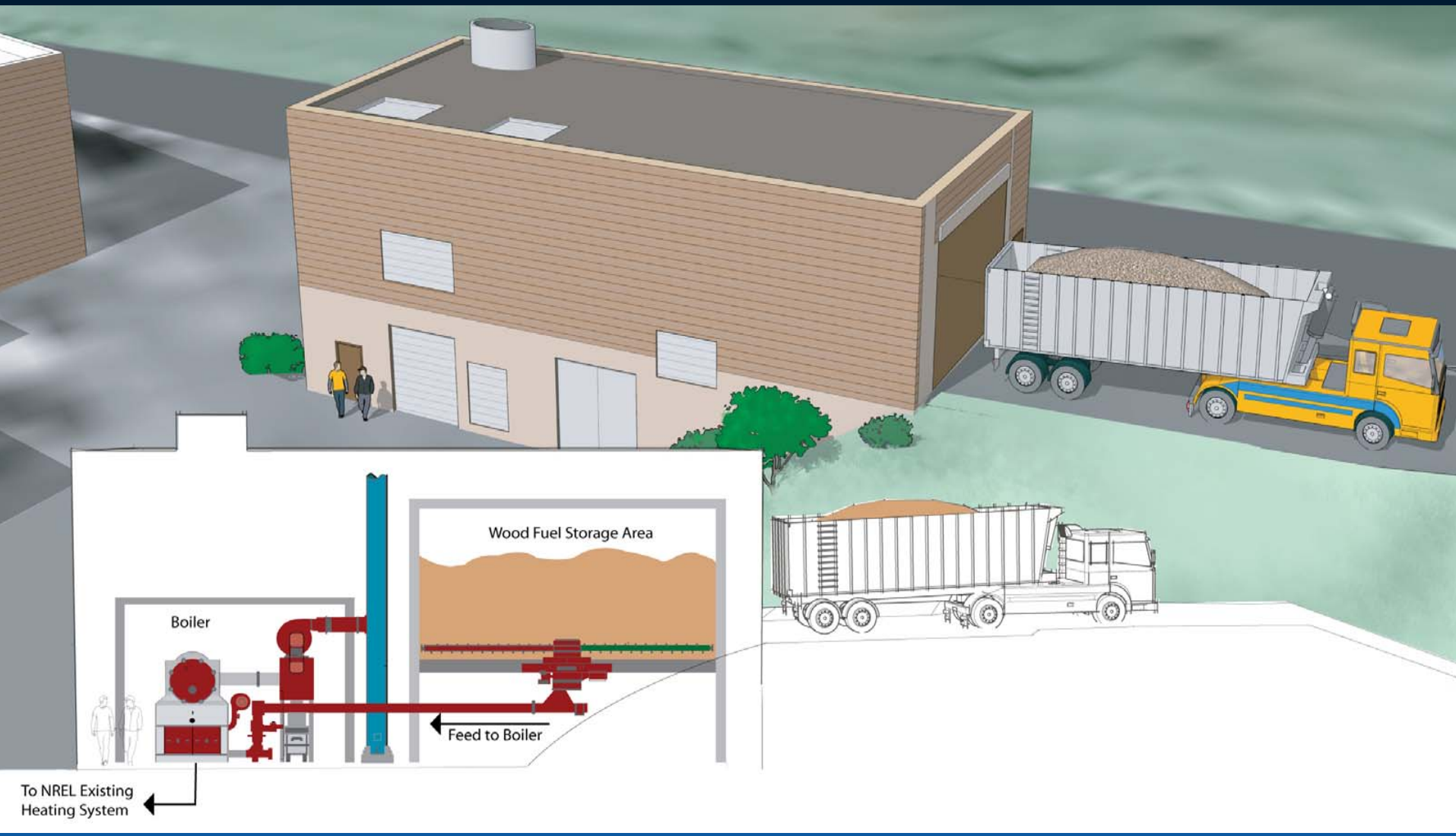
Typical annual biomass fuel requirements (green tons/year)



Share of Bioenergy (Europe 2003 %)



NREL's Renewable Fuel Heating Plant

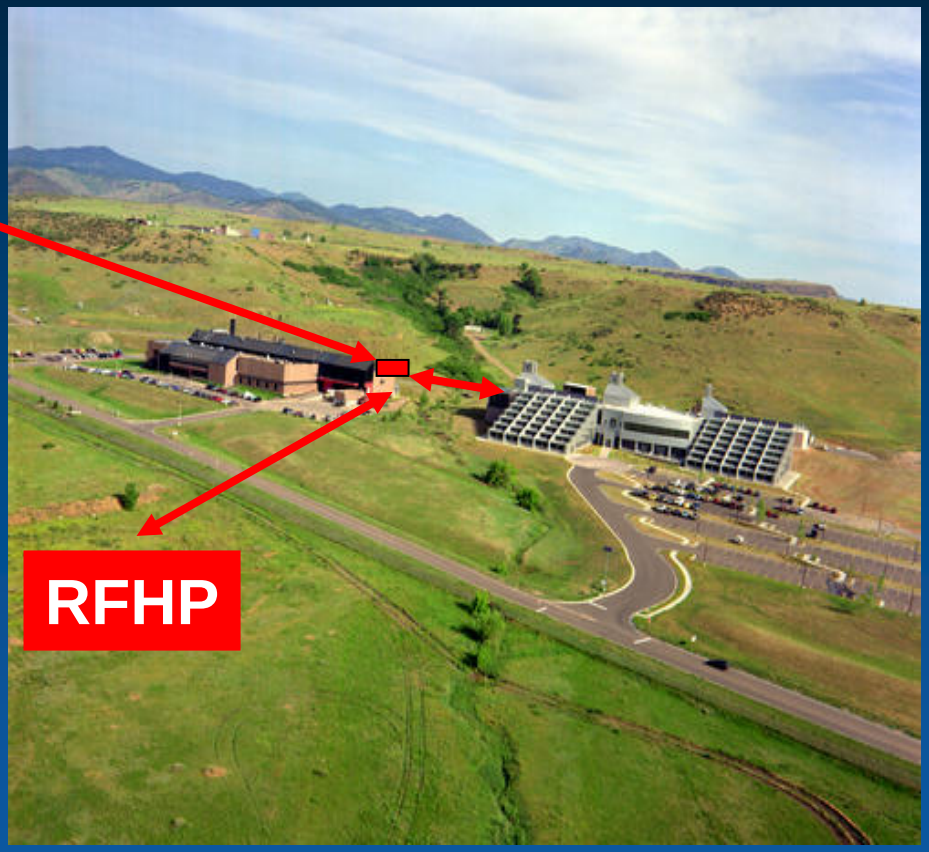


Overview

- Completely automated system
  - Includes combustion system, hot water distribution system, fuel storage and handling system, ash removal
  - Existing NG boilers provide 100% backup
- Performance guarantee through ESPC
  - Continuous metering of RFHP output
  - Payments based on guaranteed cost savings
- ESCO has long term fuel purchase contract

RFHP Will Heat Major Lab Buildings

- ~ 75% of campus heat
- Fuel from Front Range forest thinnings (USFS, private landowners) and urban wood
- Biomass cost is $29/ton ($2.42/MMBtu vs. $10.00/MMBtu gas)
- 2,200 tonnes CO_2 reduction/year
- 8 year simple payback



NREL RFHP - System and Economics

9 MMBtu/hr wood-fired boiler

- ESCO investment: $3,307,200
  - Plus $700k of additional site work not in ESPC
- Annual savings: $ 406,072
- Simple pay-back: 8.3 years
- Delivery order term: 25 years

Barriers

- Fuel supply risk (quantity and quality)
- Higher up-front costs
- Additional maintenance compared to natural gas
- Perceived emissions issue
- Lack of knowledge about the technology by architects, engineers, facility people, key decision-makers

Bioenergy Success Factors

- Supply
  - Cost, quantity, quality, sizing, storage
  - Delivery contract structure (who bears risk?)
  - Delivery infrastructure?
- Cost of competing fuels
- Biomass conversion technology
  - Commercial, reliable, efficient, fuel flexible
- Facility issues
  - Champion
  - Familiarity with technology
  - Site-specific details