Biomass Resource Feedstock Supply

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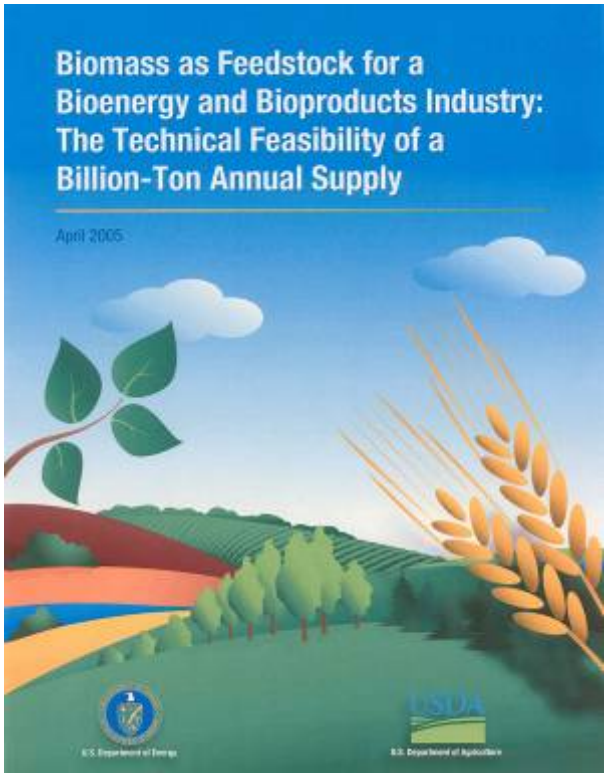
Biorefining Industry Goals

http://feedstockreview.ornl.gov/pdf/billion_ton_vision.pdf

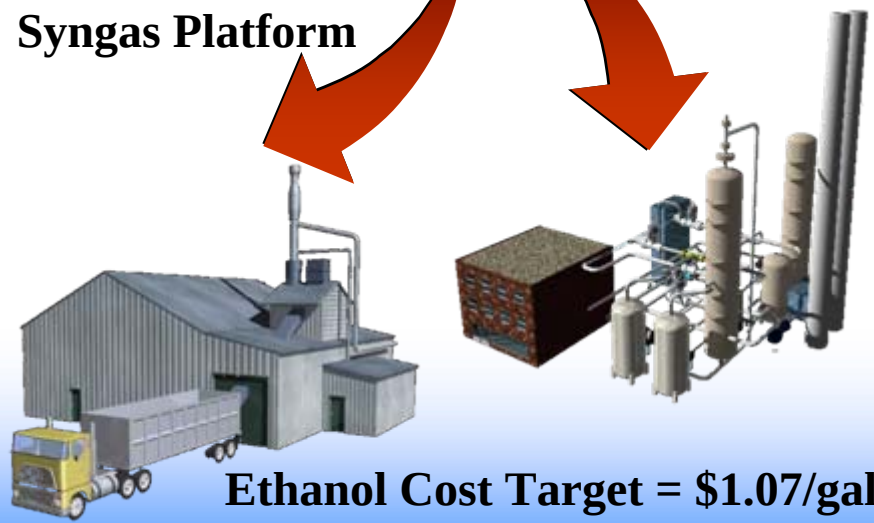


Displace 30% of Gasoline by 2030, or 60 billion gals./year

1.3 B tons/yr Biomass Potential in the U.S.

Sugar Platform

Syngas Platform



Ethanol Cost Target = $1.07/gal.

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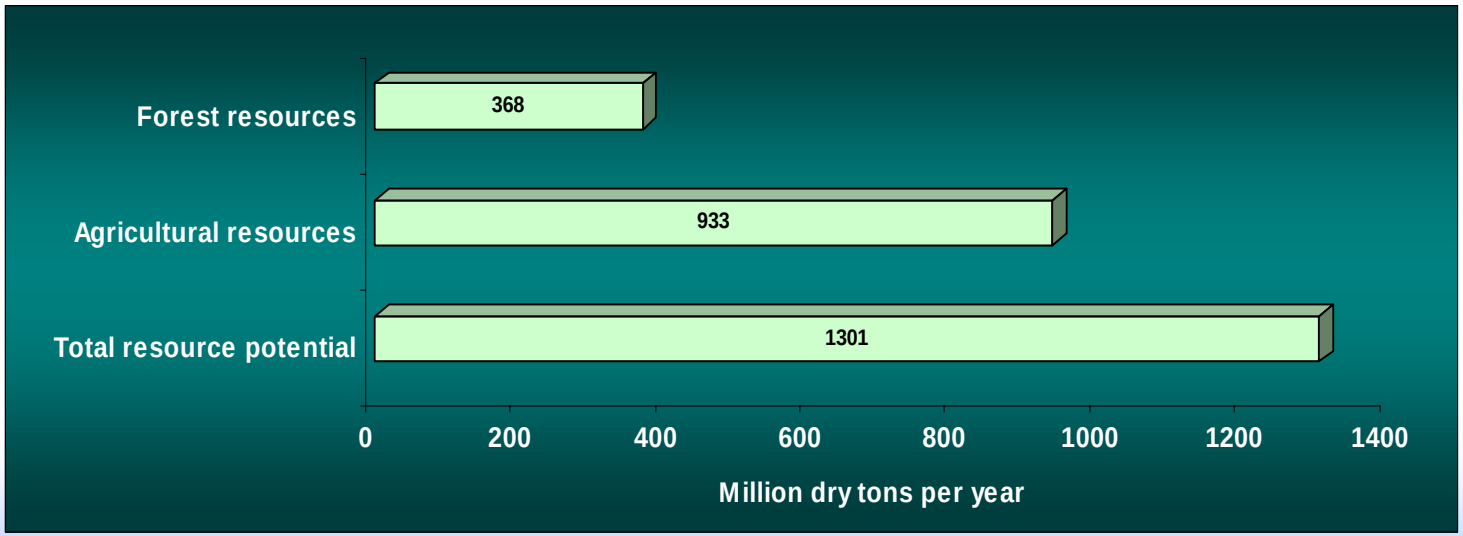
Enough Biomass for the US ?

Are there sufficient resources to meet 30% of the

Country's petroleum requirements ?

- Land resources of the U.S. could sustainably supply more than 1.3 billion dry tons/yr and still continue to meet food, feed, and export demands – based on the scenarios
- Realizing this potential will require R&D, policy change, stakeholder involvement
- Required changes seem reasonable given current trends



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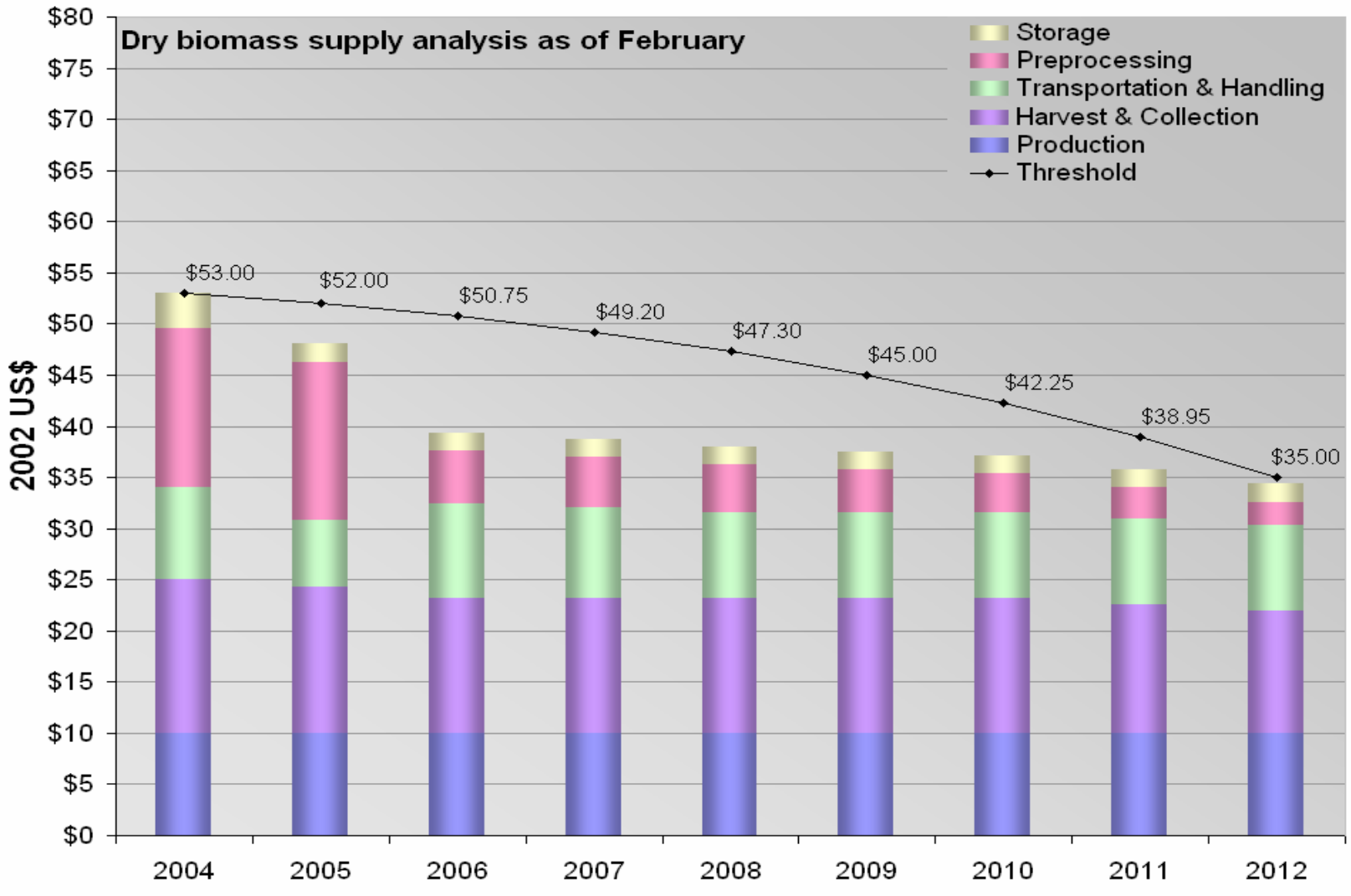
Lignocellulosic Feedstock Supply Types

- Dry – Agriculture Residues/Crops at less than 15% moisture
- Wet - Agriculture Residues/Crops greater than about 50% moisture
- Energy Crops – Wet and Dry
- Woody – Forest resources

Feedstock Cost Reduction by Cost Elements (Dry)



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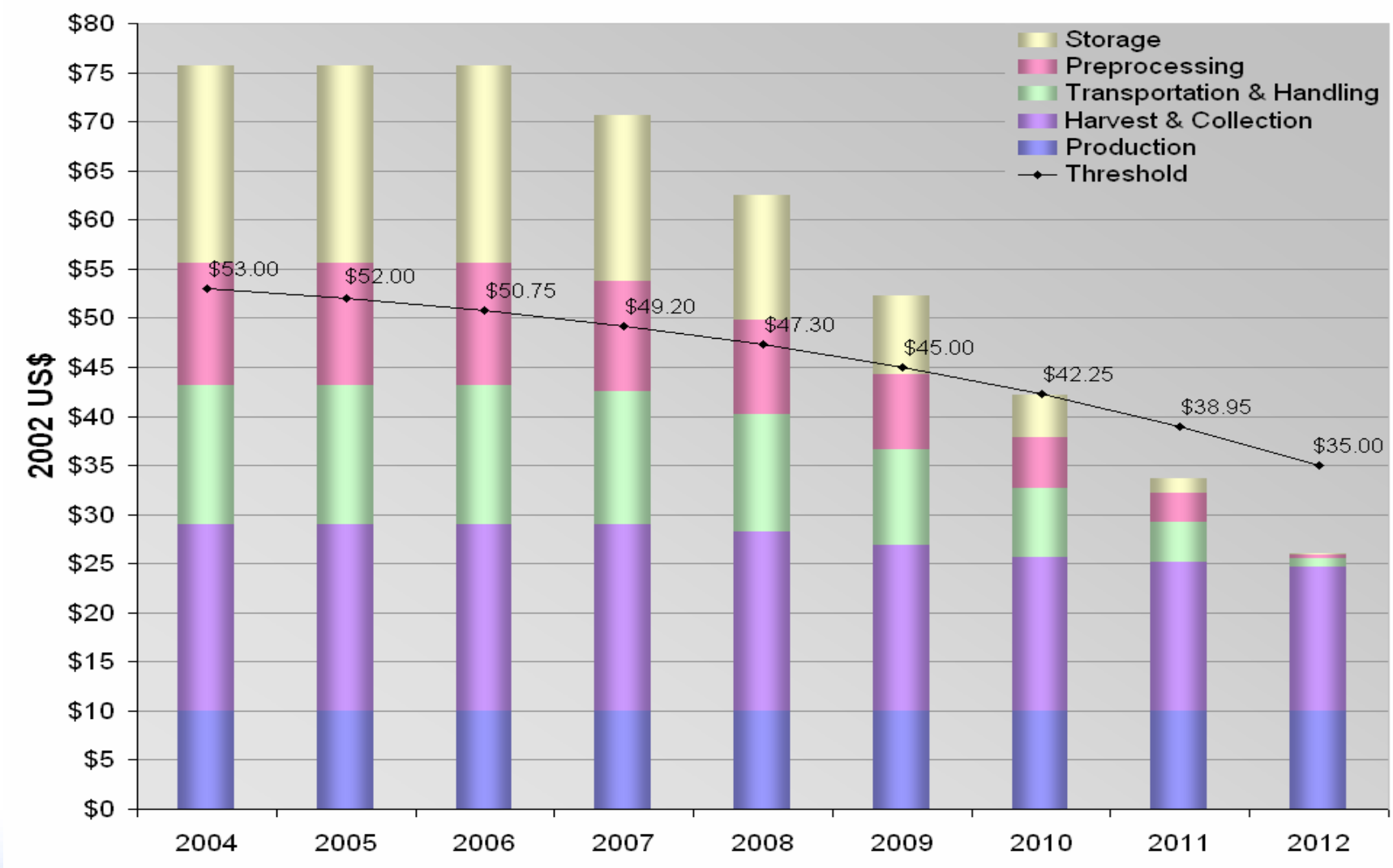
Note: Cost reductions assume efficiency and cost improvements only

Feedstock Cost Reduction by Cost Elements (Wet)



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Note: Cost reductions assume efficiency/cost improvements and feedstock quality improvement credits

Feedstock Cost Target and Interface Point

Biomass Production
- Agricultural Resources:
  - Crop Residues
  - Energy Crops
- Forest Resources:
  - Logging Residues
  - Harvested for Energy

Production Interface:
- Resource characterization / assessment
- Biomass Quality / Composition
- Fractional Removal

Grower payment threshold cost = $10 / dry ton

Harvest and Collection → Storage → Preprocessing → Transportation → Handling and Queuing at the Biorefinery

Feedstock-Conversion Interface:
- Biomass Composition (or functional yield)
- Dockage
- Fractionation and Blending (Depot concept)
- Biomass conversion efficiency characteristics

Feedstock Interface

Conversion Pathway's Reactors:
- Agricultural Residues
- Energy Crops
- Forest Products

Boundary

2012 feedstock threshold cost is $35 / dry ton (includes grower payment) delivered to the starting point of the conversion process

Supply System Models and Business Elements

Distributed On-farm Storage

Bale-Based Feedstock Supply System

Bulk Feedstock Supply System

Bales or other formats

Agriculture

Agri business

Centralized Agri-business Storage

Supply System Case Study: Idaho

- Resource Assessment:
  - Feedstock: Cereal Straw
  - Moisture: 15.0%
- Feedstock Demand: 800,000 ton/yr biorefinery
- Location:
  - No residue removal constraints
  - Road Limits: 115 ft., 105,500 GVW

➢ Bottom Line Delivered Feedstock Cost: $45.22/dry ton (2006 $) , includes $10.00 payment to grower

Supply System Design: Bulk System

Bulk Operations Field Equipment

- Deere 3280 Tractor
- Hesston 4910 Bailer
- Stinger Stacker 6500
- Caterpillar TH220B Telehandler
- Daimond Z 1460B Grinder
- Kenworth T800 Series Tractor
- Trinity Eagle 42’ Trailers
- Various ½, ¾ and 1 ton trucks

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Baling

Installed Capital Costs	Capital Costs per Year	Operating Costs per Year	Labor Costs per Year	Total Costs per Year	Feedstock Costs ($/dry ton)
$28,495,508	$3,679,047	$3,321,665	$555,944	$7,556,656	$11.11*

Notable Parameters:

- 4’x4’x8’ bales
- Six string
- 1000 lbs per bale
- 7.8 lbs/ft^3
- No bale accumulator
- 1.88 tons/acre
- Windrow from 30 ft swath

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*Cost per ton estimates can vary based on yield, feedstock type and operational size assumptions.

Field side Stacking (Roadsiding)

Installed Capital Costs	Capital Costs per Year	Operating Costs per Year	Labor Costs per Year	Total Costs per Year	Feedstock Costs ($/dry ton)
$7,413,024	$565,560	$585,703	$237,339	$1,388,603	$2.04*

Notable Parameters:

- Stinger collects from field and stacks field-side
- Stack 1-wide, 4-high
- 1 stack for each quarter-section
- Stack size: 300 tons

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*Cost per ton estimates can vary based on yield, feedstock type and operational size assumptions.

Storage

Installed Capital Costs	Capital Costs per Year	Operating Costs per Year	Labor Costs per Year	Total Costs per Year	Feedstock Costs ($/dry ton)
$0	$0	$1,449,760	$0	$1,449,760	$2.13*

Notable Parameters:

- No payroll labor costs
- Operating costs include 5.0% shrinkage for arid climate
- Cost includes insurance and land rent

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*Cost per ton estimates can vary based on yield, feedstock type and operational size assumptions.

Preprocessing (Field-side Grinding)

Installed Capital Costs	Capital Costs per Year	Operating Costs per Year	Labor Costs per Year	Total Costs per Year	Feedstock Costs ($/dry ton)
$6,848,009	$996,468	$2,778,419	$1,338,388	$5,113,276	$7.52*

Notable Parameters:

- Twine ground with bales
- Bulk density = 11.50 lbs/ft^3
- Capacity = 26 tons/hr

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*Cost per ton estimates can vary based on yield, feedstock type and operational size assumptions.

Bulk Biomass Transportation

Installed Capital Costs	Capital Costs per Year	Operating Costs per Year	Labor Costs per Year	Total Costs per Year	Feedstock Costs ($/dry ton)
$11,965,758	$1,288,639	$3,054,188	$2,368,213	$6,711,040	$9.87*

Notable Parameters:

- Double 42’ trailers with 4’ side extensions
- Truck volume = 5,022 ft^3
- Truck net wt. = 57,753 lbs
- Loads always tarped

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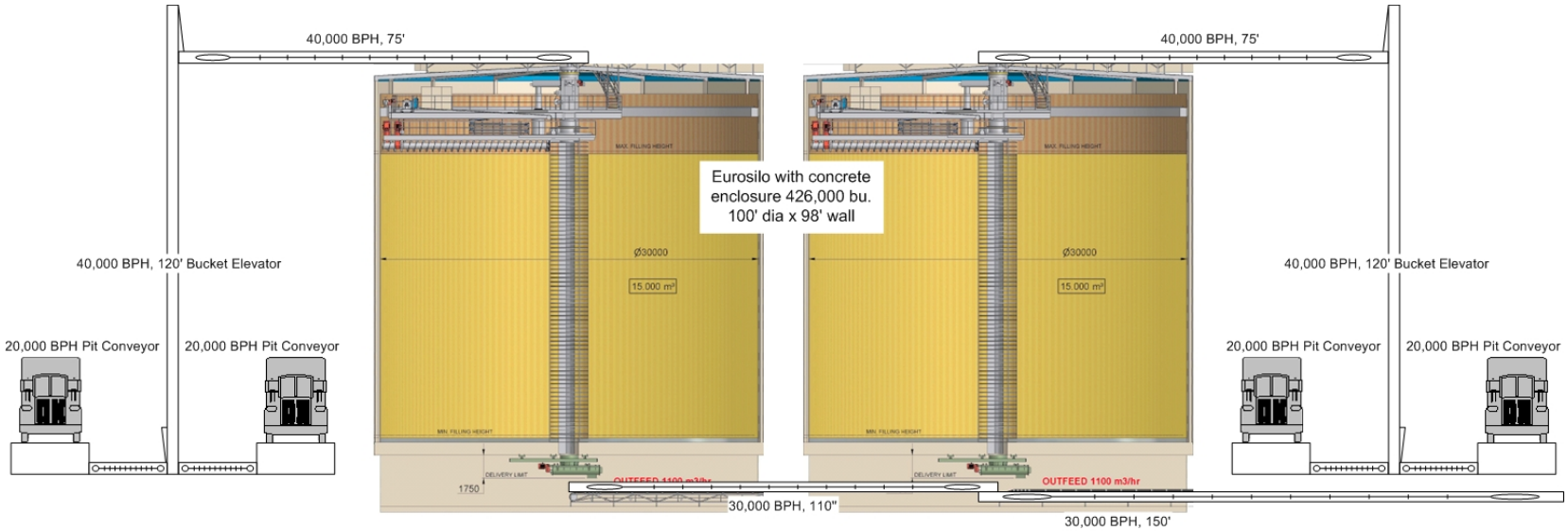
*Cost per ton estimates can vary based on feedstock type and operational size assumptions.

Bulk Receiving and Handling

Installed Capital Costs	Capital Costs per Year	Operating Costs per Year	Labor Costs per Year	Total Costs per Year	Feedstock Costs ($/dry ton)
$11,201,472	$836,808	$247,488	$247,555	$1,726,313	$2.54*



Notable Assumptions:

- 72-hr. inventory - 973,000 ft^3
- Conveyor density 5.2 lb/ft^3, bin density 14.1 lb/ft^3
- Simultaneous fill and discharge during receiving hours

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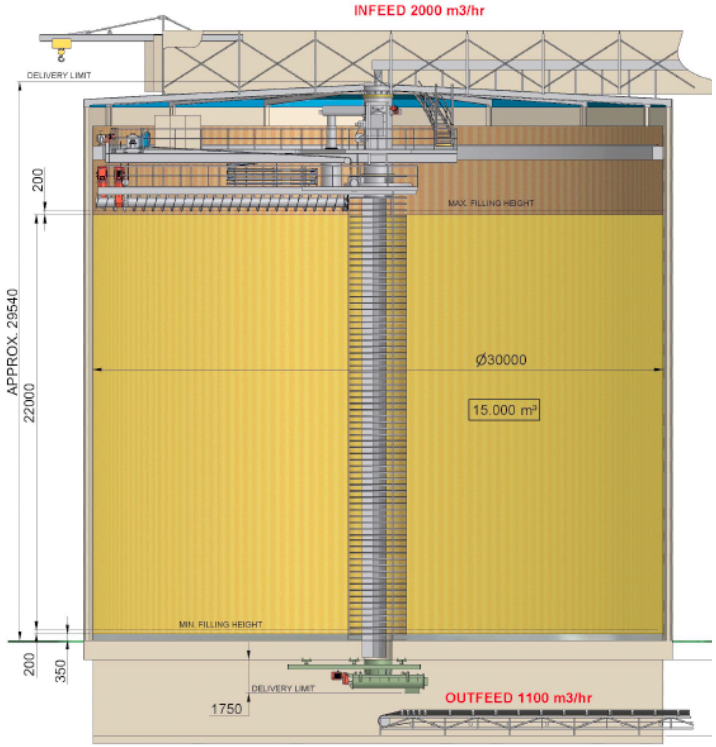
*Cost per ton estimates can vary based on yield, feedstock type and operational size assumptions.

Bulk Biomass Queuing



- Storage in commercial bins will not work due to arching, ratholing, consolidation
- Alternatives:
  - Queing pile
  - Eurosilo

<u>Eurosilo Advantages</u>

- Fully enclosed (dust, moisture)
- Material flowabilty not an issue
- Fully automated
- Simultaneous fill/discharge
- Blending capability

Management Structure (Overhead)

Start up Capital Costs	Start up Equipment Costs	Total First Year non-Labor Costs	First Year Labor Costs	Total First Year Costs	First Year Feedstock Costs ($/dry ton)
$1,080,200	$457,940	$1,538,140	$1,560,726	$3,098,866	$3.87*

Overhead Capital:
- Office Buildings
- Laboratory Building
- Shop
- Vehicles

Overhead Equipment:
- Office
- Laboratory Analysis
- Tools

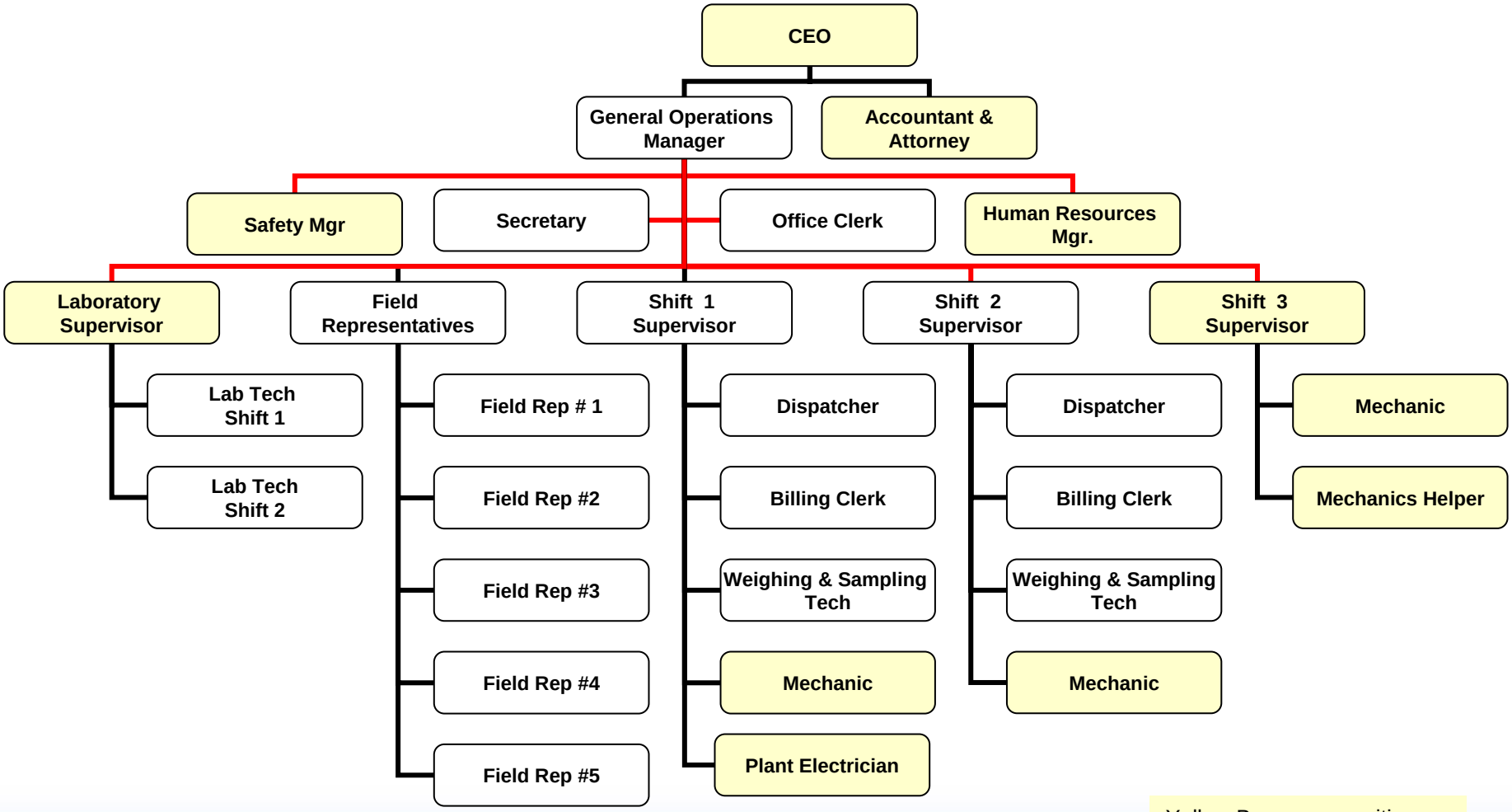
Overhead Personnel (Labor):
- Chief Executive
- General Operations Manager
- Field Rep's – Biomass Buyers
- Secretary
- Office Clerk
- HR Person
- Safety Engineer
- Accountant (1/2 Time)
- Attorney (1/4 Time)
- Billing Clerks (1/shift)
- Dispatchers (1/shift)
- Shift Supervisors (1/shift)
- Weighing & Sampling Techs (1/shift)
- Mechanics (1/shift)
- Electrician
- Mechanic's Helper (3rd Shift Only)
- Laboratory Manager
- Laboratory Technicians (1/shift)

Cost Data Presented Does Not Include Profit Estimates nor Profit/Equity Sharing Assumptions

*Estimated out year overhead = $2.45 / dry ton

*Cost per ton estimates can vary based on operational size assumptions.

Management and Overhead Organization



Yellow Boxes are positions that could be shared with the Ethanol Plant operations

QA/QC Analysis (Overhead)

Purpose
- Prioritize and Schedule Grinding Operations
- Feedstock blending throughout the year

Sample Rate
- Field Samples – 5 individual (1 Composite) per 200 ton stack
- Receiving Samples – 1 per truck

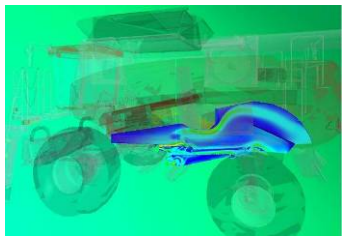
Facilities, Equipment and Staffing
- Facilities: $198K - 20' X 30' @ $400/sqft + Office and Storage 20' X 30' @ $150/sqft
- Equipment: $310K (startup) NIR Spectrometers, Balances, Vacuum Rifle Splitter, Grinding Mill, Drying Oven, Ro-Tap Shaker, Coring Tools
- Staffing: 1 Lab Manager and 2 Lab Technicians

Analysis
- Moisture Content
- Buffering Titrations
- Near Infrared Spectroscopy for Complete Compositional Determination

Feedstock Fractions Quality

Wet Storage

Dry Storage



Selective Harvest

Preprocessing

Feedstock value for $1.07/gal cost target:

- **Wet storage conditions affecting composition changes created a $28* range in feedstock value**
- **Dry storage conditions affecting composition changes created a $22* range in feedstock value**
- **Selective harvest composition changes created a $10* range in feedstock value**
- **Mechanical Preprocessing and fractionation composition changes created a $12* range in feedstock value**

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*Value estimations based on NREL Aspen model analysis

Biorefining Depends on Feedstock