



A New Vision for Value-Added Forestry

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Presentation Overview

- The need
- The technology
- Product markets and uses
- The vision for forestry
- The current situation

The Need—Value Added Markets

- Small diameter and other low quality wood
- Healthy Forest Initiatives
- National Fire Plan
- Pulpwood oversupply

**Healthy Forest Initiative Present Situation —
Mechanical Removal
at a cost up to \$1,000/acre**



No Cost Effective Way to Recover Value

A Solution — ROI's Patent Pending Fast Pyrolysis Technology

- Allows decoupling of end-use from BioOil production
- Avoids hauling low density Biomass long distances

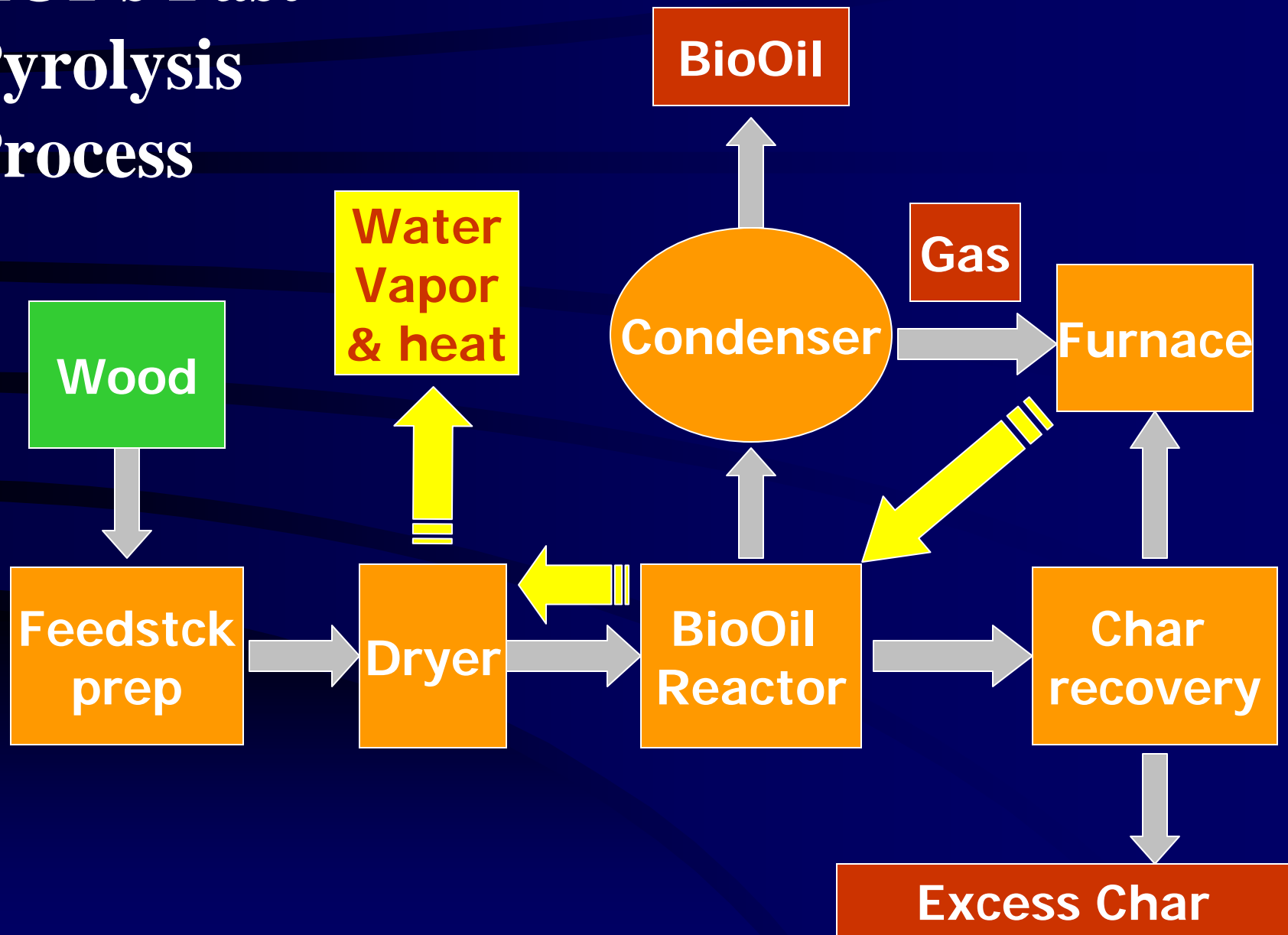
Characteristics of Fast Processes

- Rapid heating of the biomass at 1000 F per second
- Rapid condensation of the vapors within 2 seconds
- Liquid yields on the order of 60 to 75%
- Liquid has relatively low viscosity
- Liquid energy value from wood roughly 80,000 Btu/gal

Advantages of ROI's Fast Pyrolysis Technology

- Plants have relatively small footprint
- Plants can be transportable
- Process can handle dirt, twigs, leaves, small stones mixed with the feedstock
- Process at atmospheric pressure
- Relatively low capital and O&M costs

ROI's Fast Pyrolysis Process



Product Yields

- 60% wt BioOil
- 25% wt char with ash
- 15% wt syngas

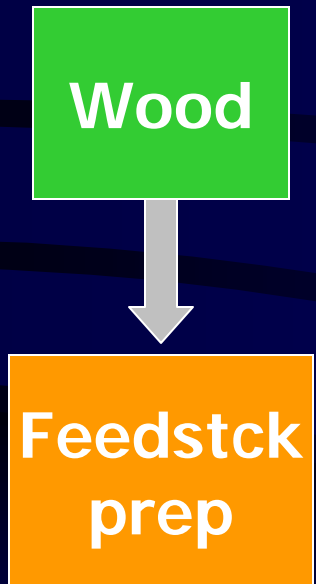
Other Fast Pyrolysis Systems

- Use sand-filled beds in reactor
- Beds and biomass heated with hot gas
- Relatively energy intensive process resulting in high parasitic loads
- Relatively complicated processes

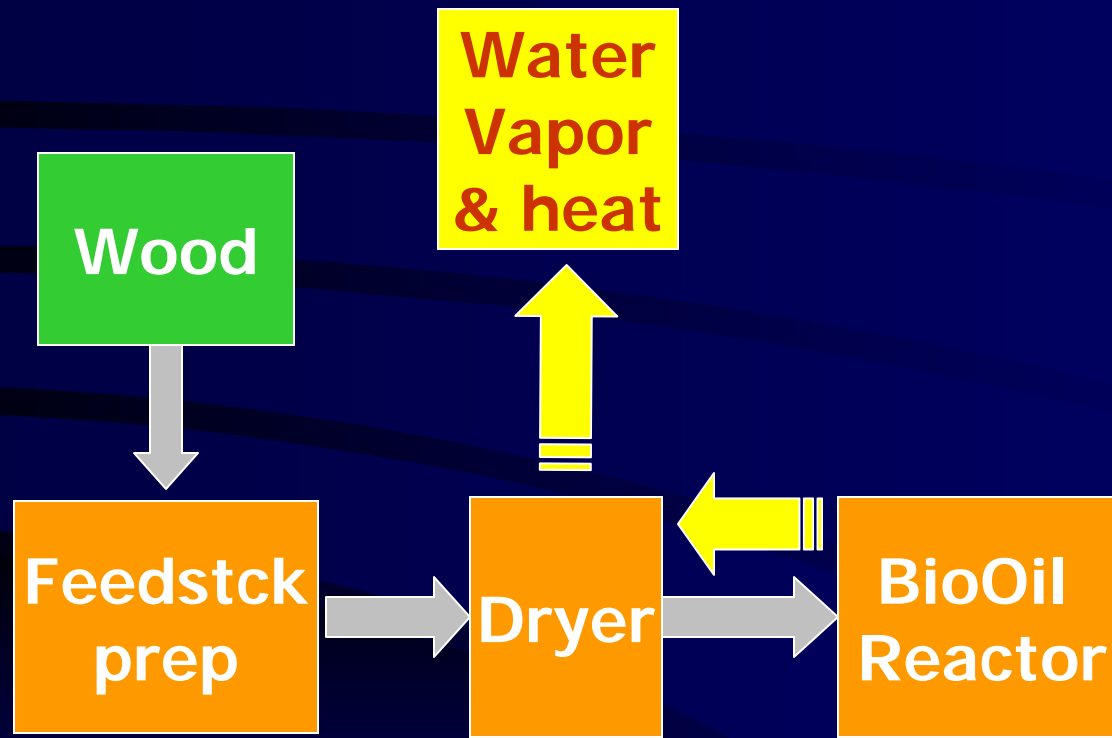
ROI Fast Pyrolysis Technology

- Mechanically mixes biomass and a solid heat carrier
- Relatively simple to construct and operate
- Relatively low energy requirements, can be energy self-sufficient
- Allows for small scale, modular plants that can be factory fabricated and transportable
- Relatively inexpensive to construct and operate

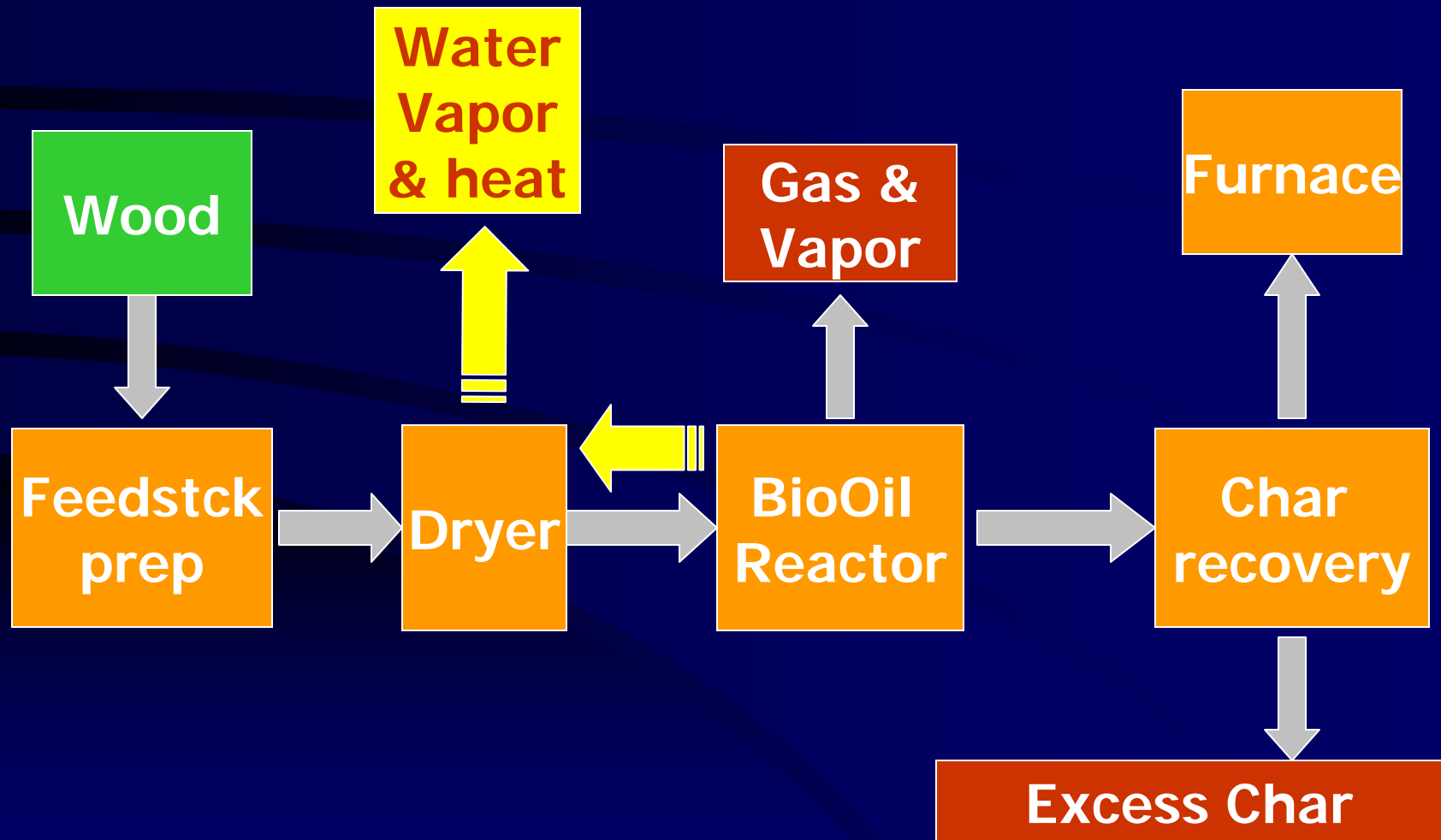
ROI's Fast Pyrolysis Process



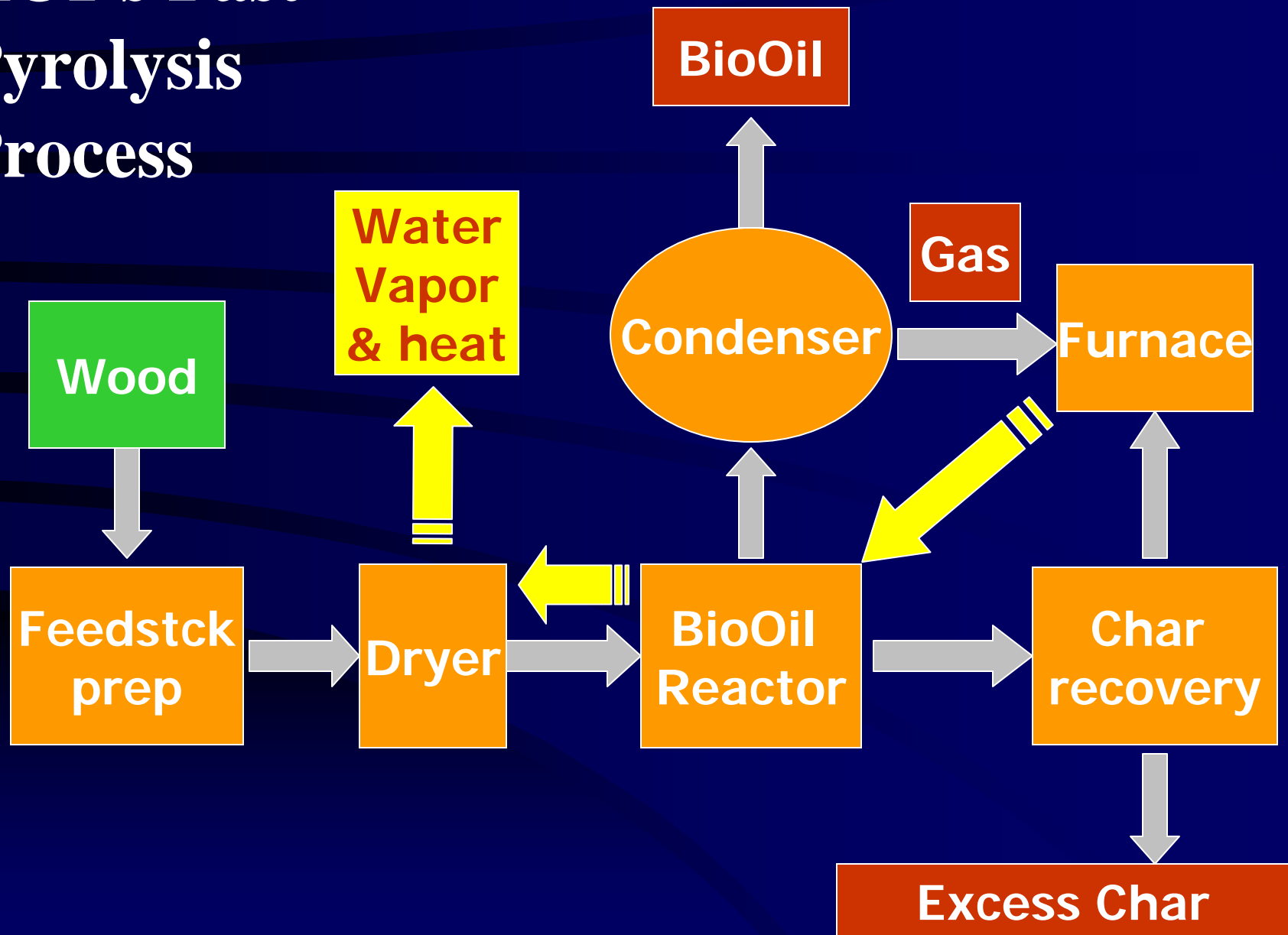
ROI's Fast Pyrolysis Process



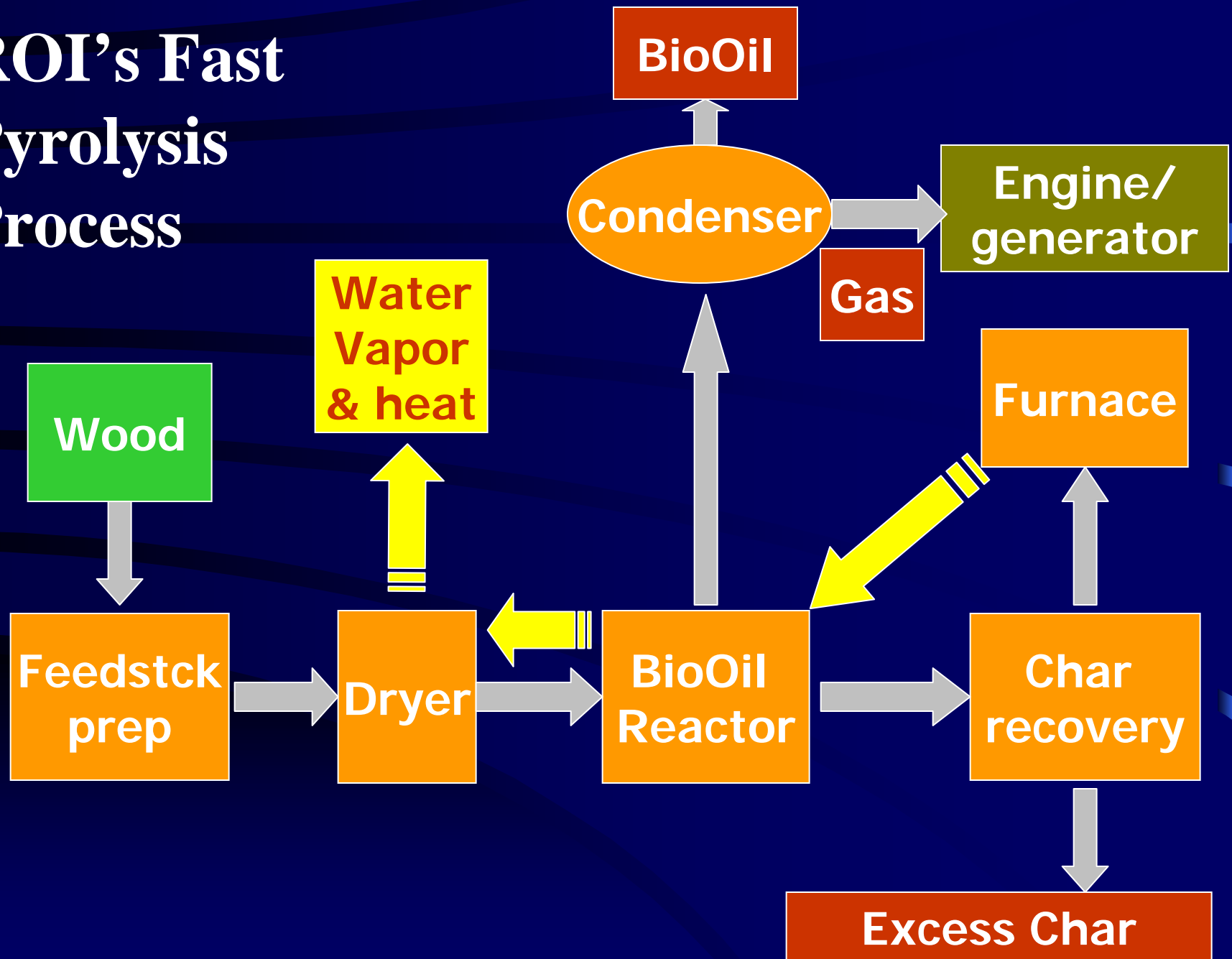
ROI's Fast Pyrolysis Process



ROI's Fast Pyrolysis Process



ROI's Fast Pyrolysis Process



Char, 25% wt



Char Markets

- Charcoal briquettes
- Activated carbon and other absorbent applications
- As a fuel, including mixing with BioOil to create a biofuel with a higher energy content
- Other markets and uses

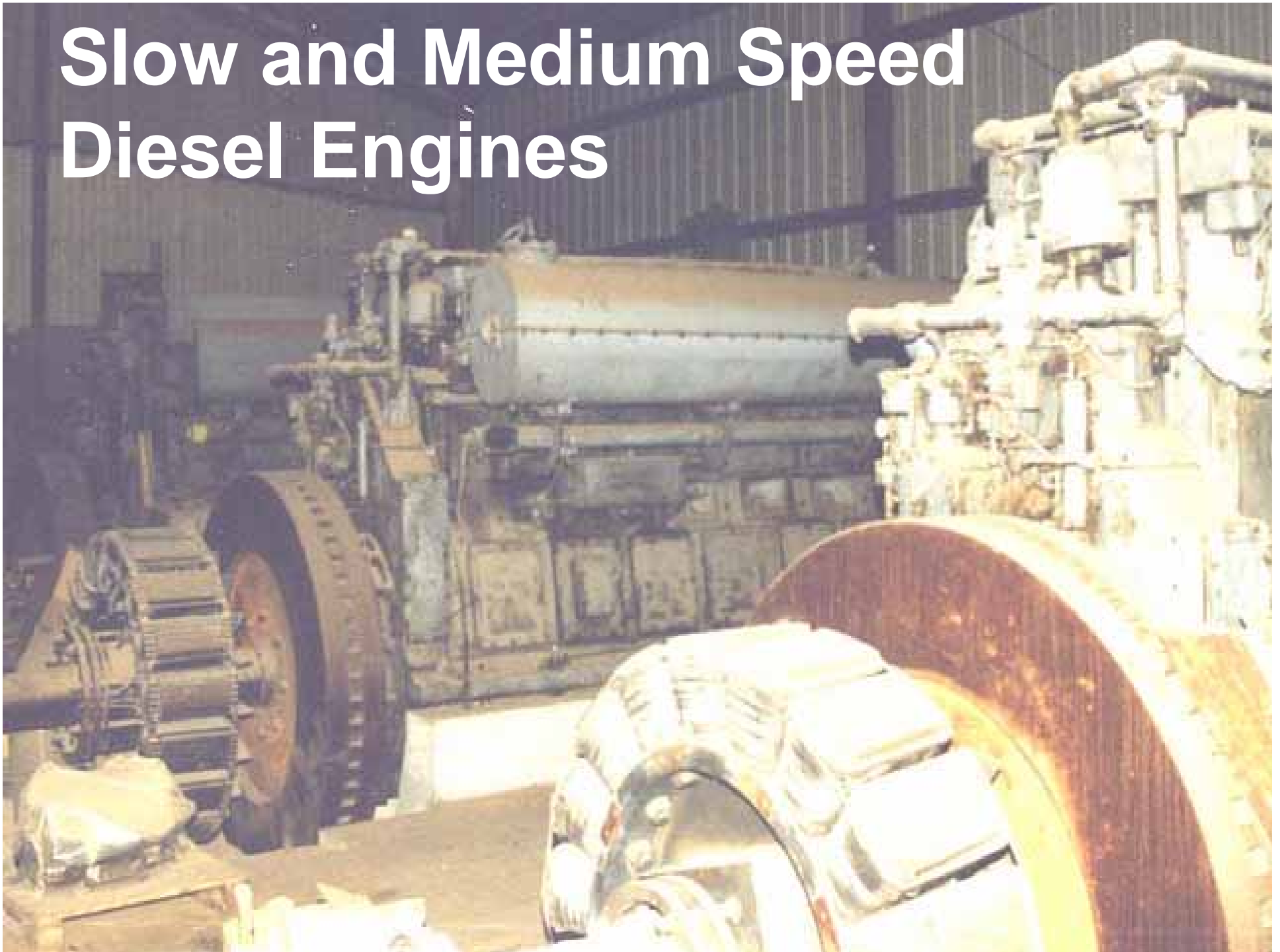
BioOil Markets & Uses

- Chemical feedstock
- Energy applications
 - Process heat
 - Space heating and cooling
 - Electricity generation
- Other applications

Orenda 2.6 MW Combustion Turbine



Slow and Medium Speed Diesel Engines



Fuel Applications

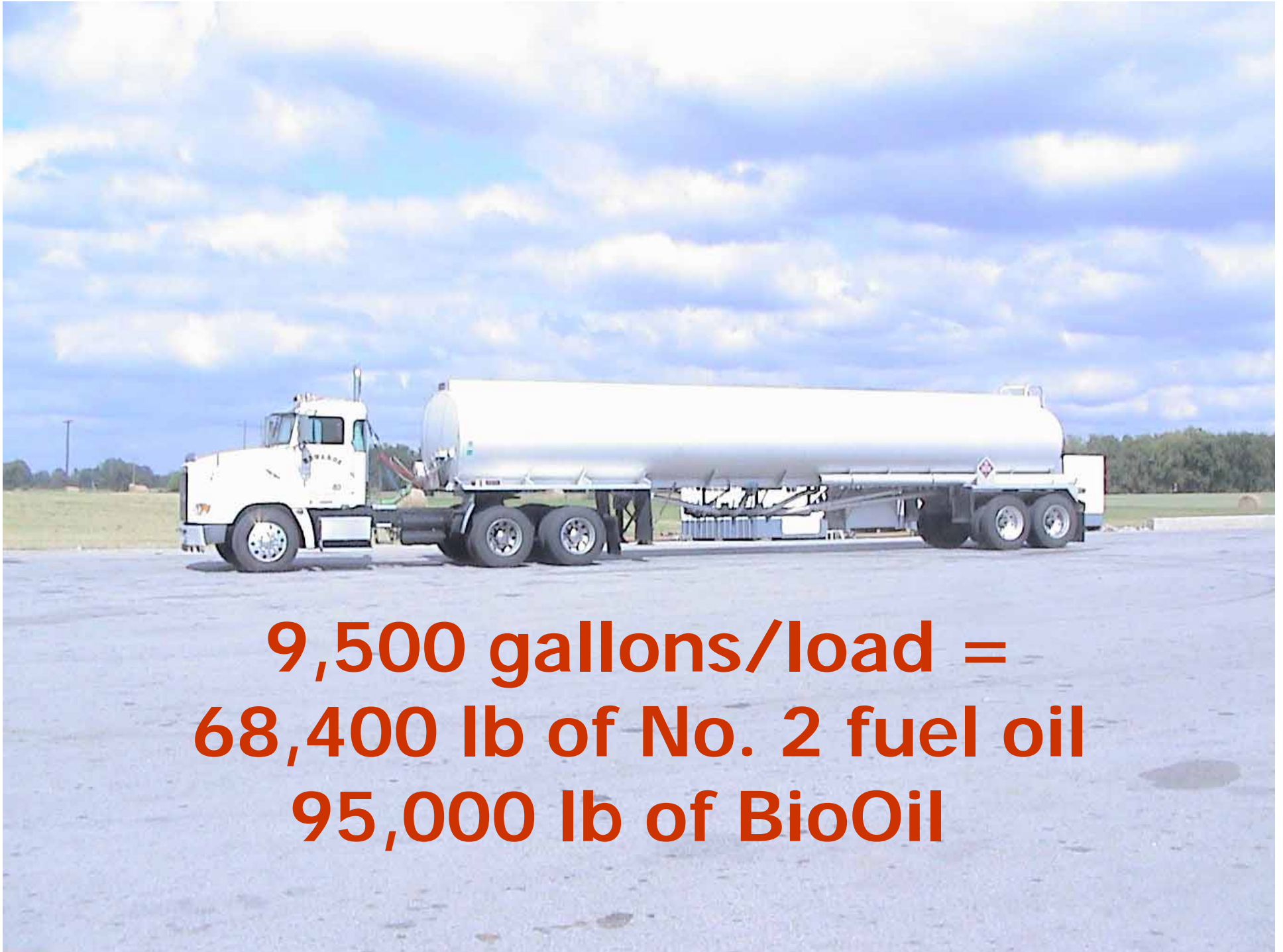
- Can be used as a diesel fuel substitute
- Does not naturally mix with fossil fuels
- BioOil-to-diesel fuel microemulsion technology
 - Up to 50% BioOil
 - Stability and physical properties similar to fossil diesel

BioOil Handling Benefits

- Liquids are easier to transport and handle
- Energy density of green whole tree chips ~100,000 Btu/lb
- Energy density of BioOil ~600,000 Btu/lb



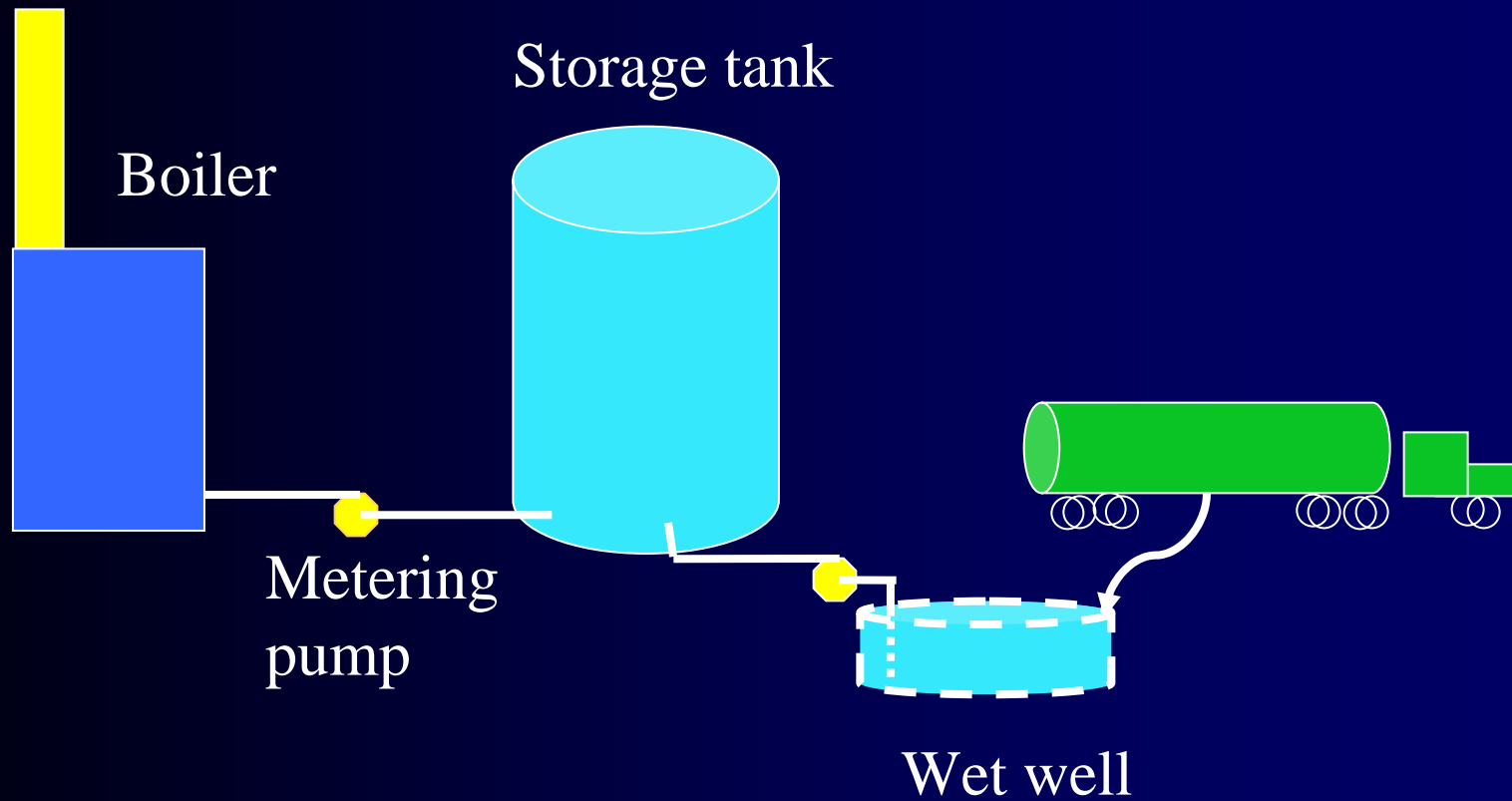
**56,000 lb/net load typical
for green wood chips**



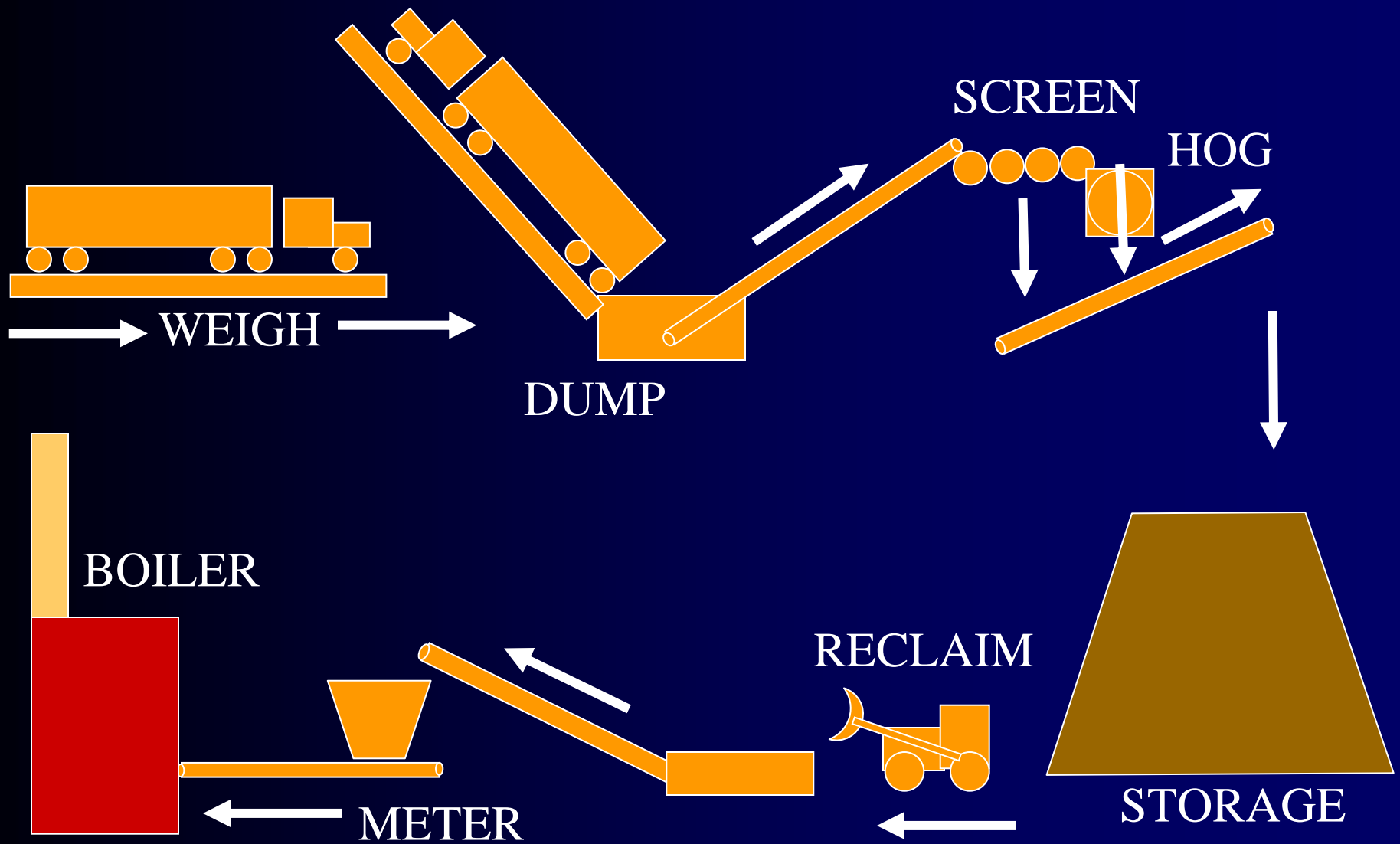
**9,500 gallons/load =
68,400 lb of No. 2 fuel oil
95,000 lb of BioOil**



**2X Btu per load
with BioOil**



BioOil Handling System

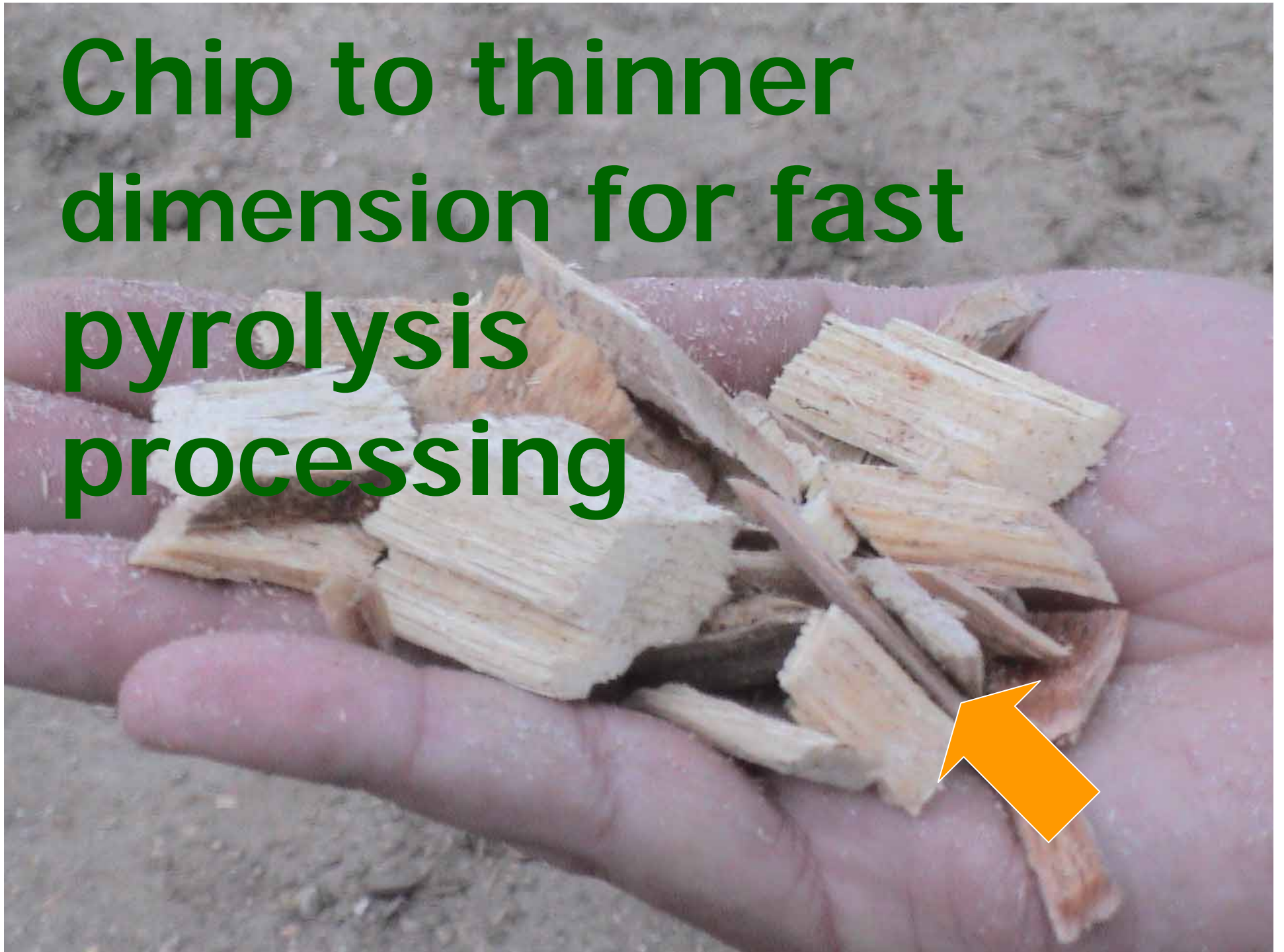


Solid Wood Fuel Handling System

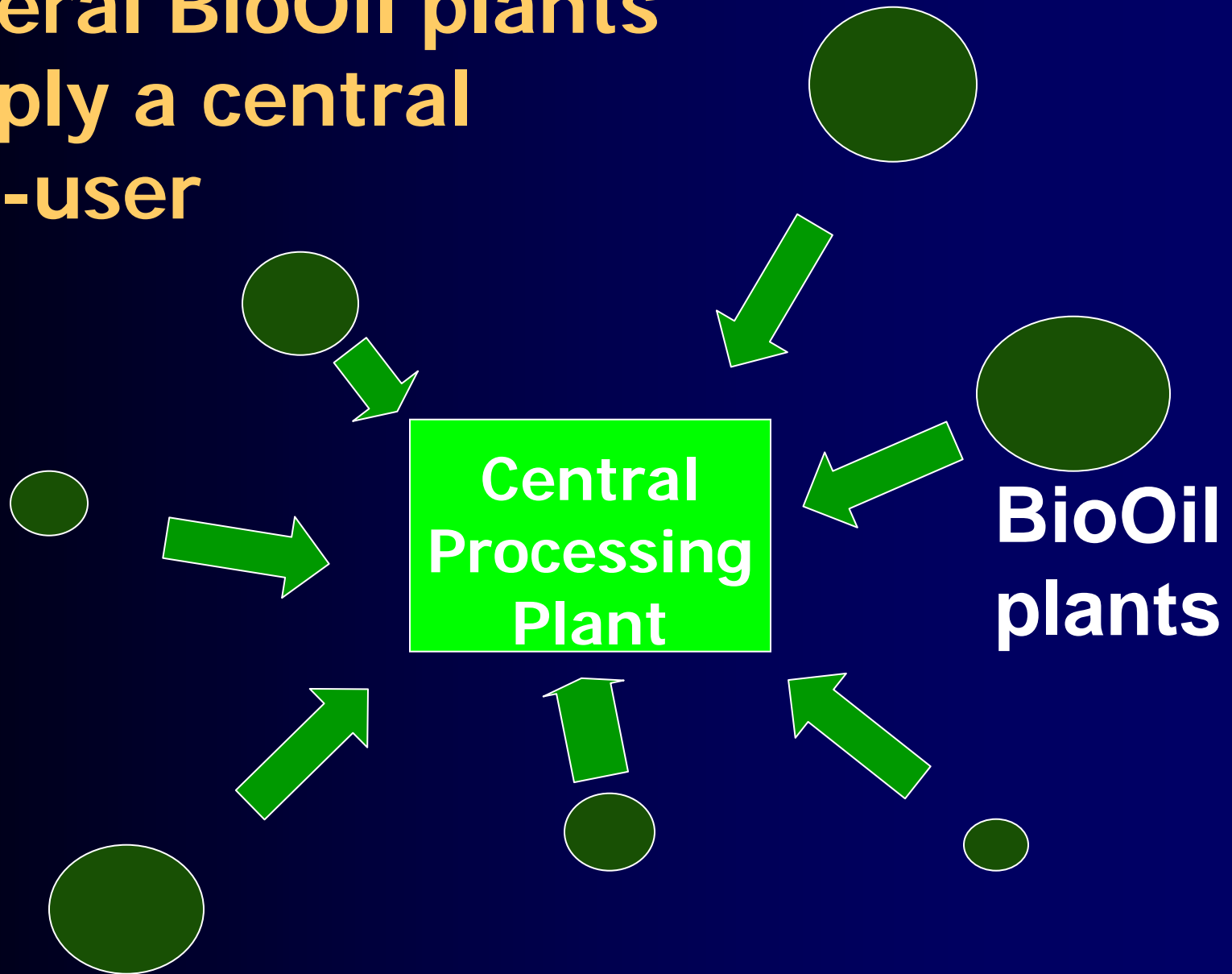
The Vision—Harvest Using Standard Harvesting Equipment and Techniques



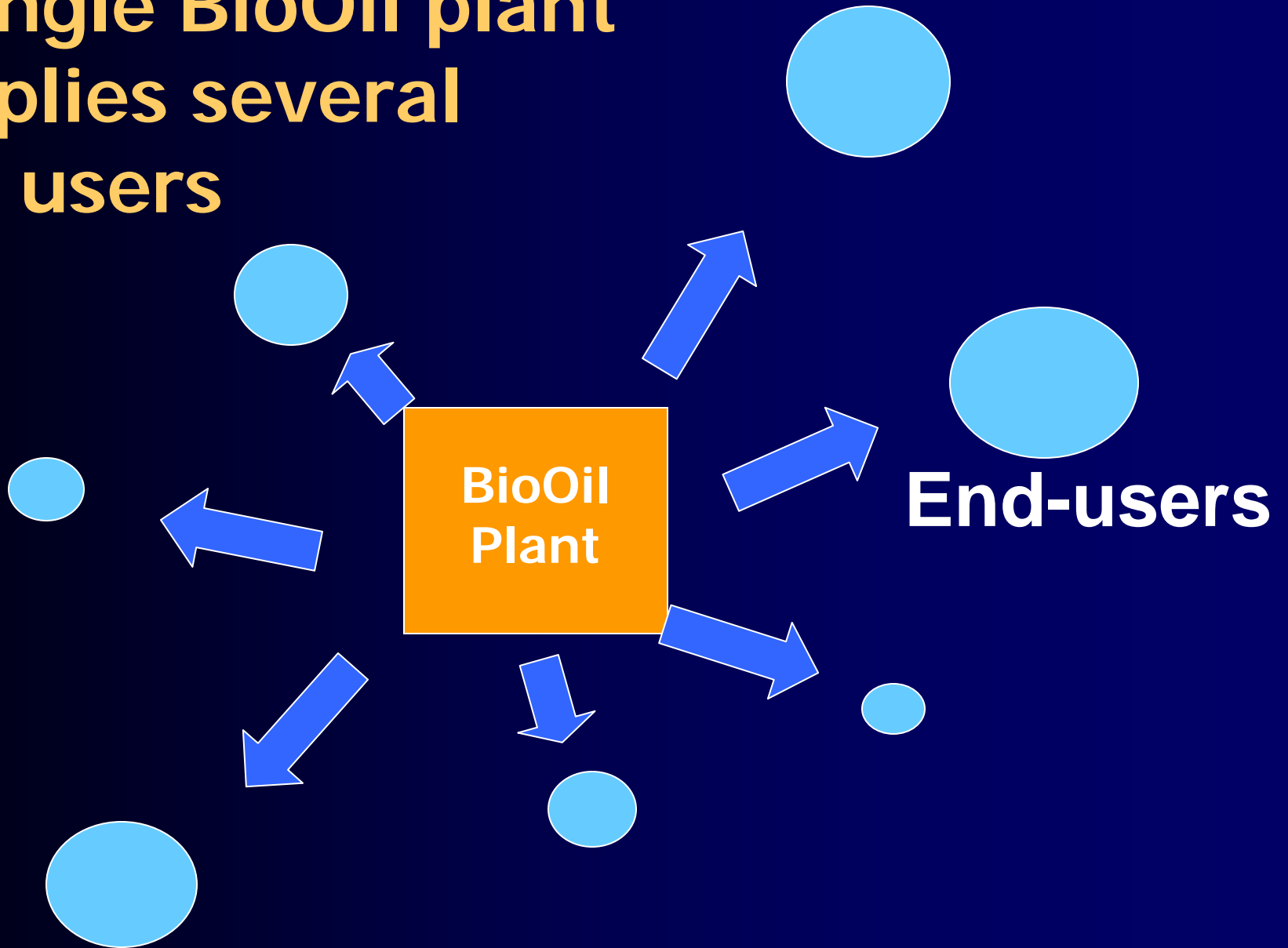
**Chip to thinner
dimension for fast
pyrolysis
processing**



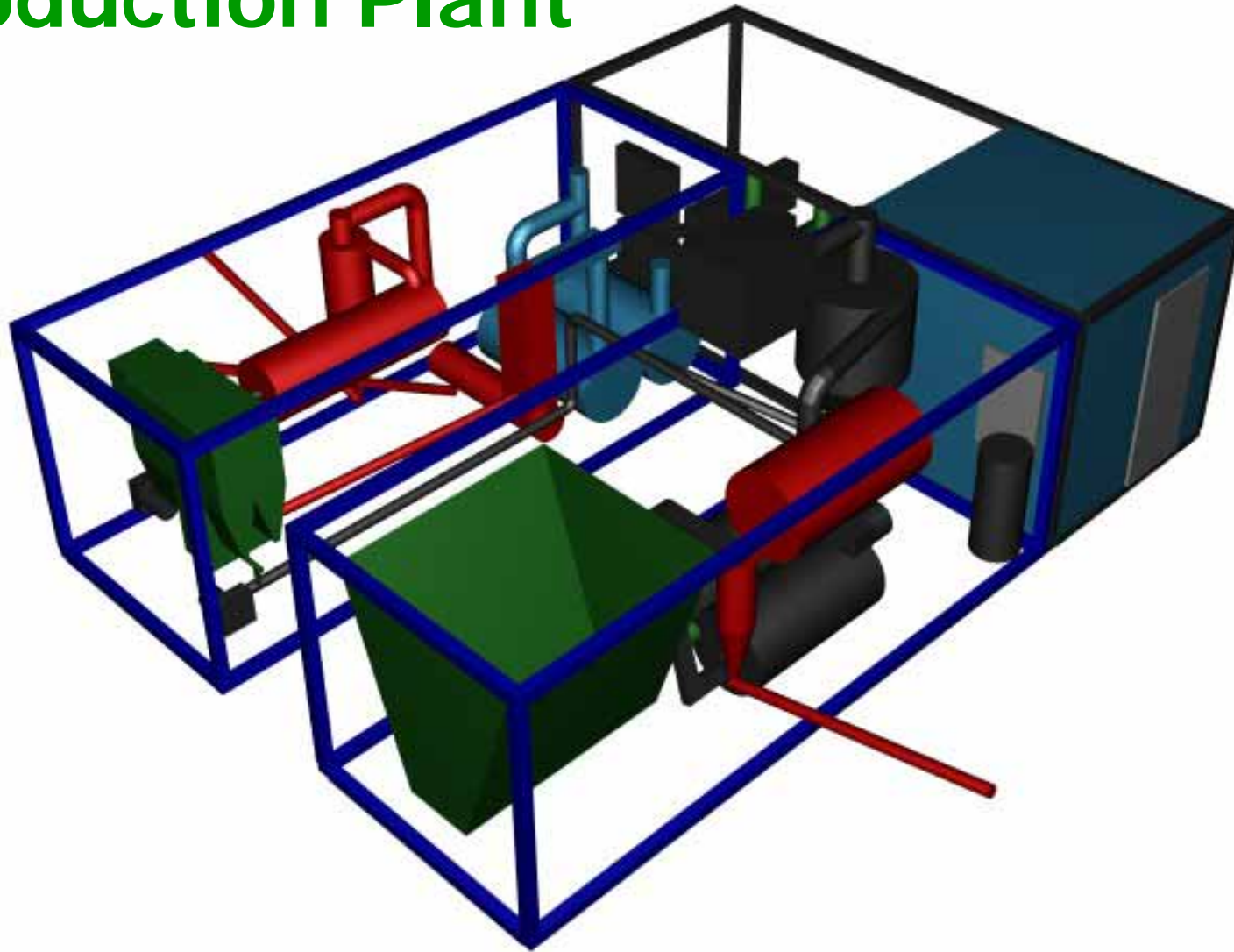
Several BioOil plants
supply a central
end-user



**A single BioOil plant
supplies several
end users**



15-dtpd ROI Modular BioOil Production Plant

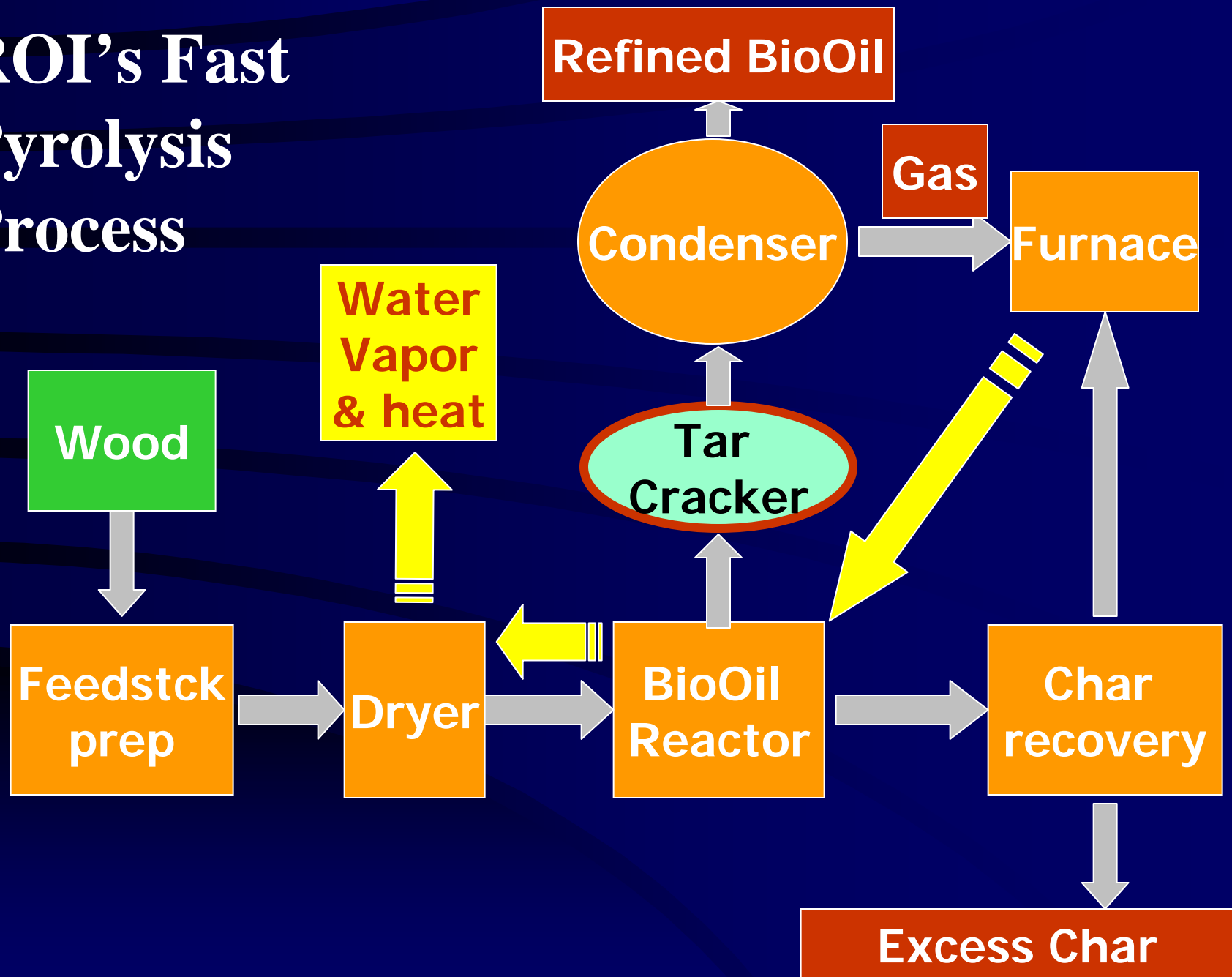




Feed/Dryer Module, 15-dtpd Plant



ROI's Fast Pyrolysis Process



Tar Cracker

- Increases liquid yields
- Increases liquid quality to produce a diesel fuel substitute
- Cost effective at small scale

Diesel Fuel

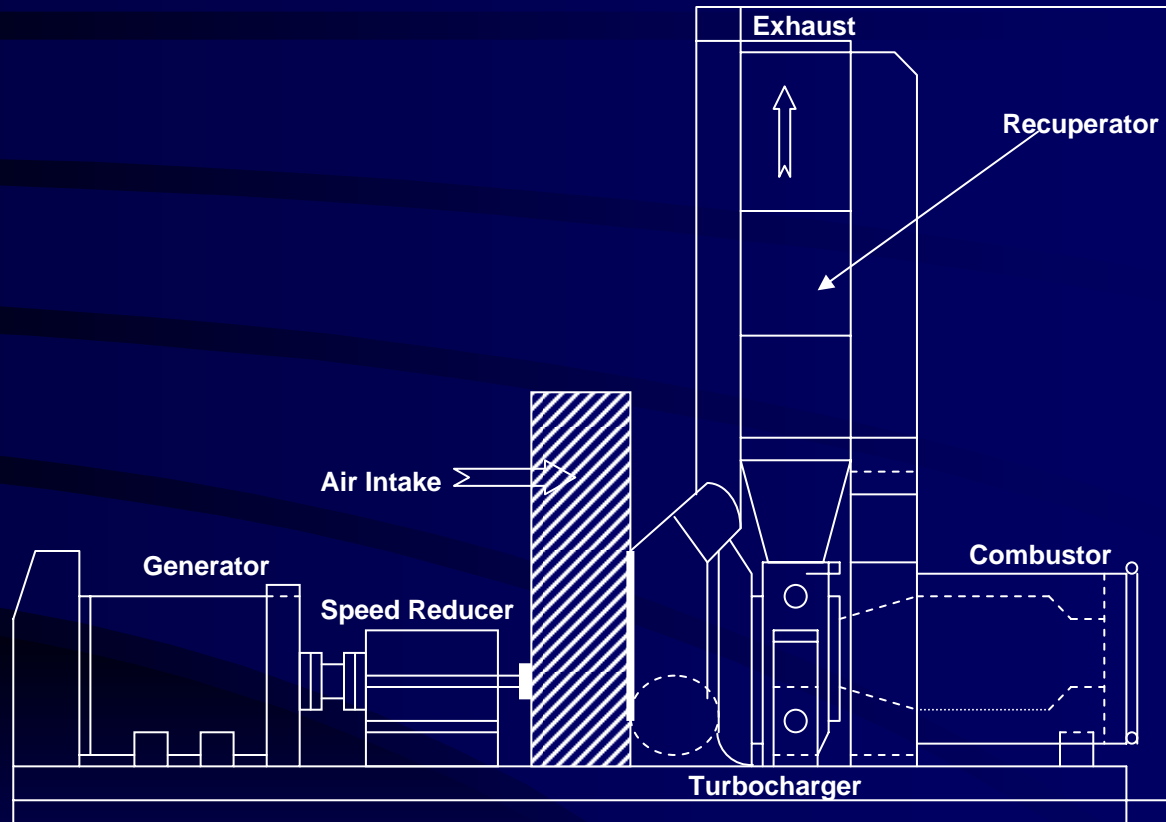
- US diesel consumption = 56 billion gal/yr
- 20% of US transportation fuel
- 95% of power to move US freight
- 95% of US buses and heavy machinery use diesel
- **Current Biodiesel production = 353 million gal/yr (0.6% of current US diesel use)**
- **Biodiesel production under construction = 31 million gal/yr**

DOE/USDA

1 Billion Ton Biomass Study

- 1.3 billion tons biomass/yr available
- Only 76 million tons/yr from grains = 6% of total
- Thus limited potential for starch/sugar ethanol and Biodiesel
- The real potential is from cellulose!

Turbocharger Gas Turbine Generator



Cost Effectiveness

- Cost of wood feedstocks
- Cost of processing into BioOil
- Value of competing products

Cost Effectiveness

- Processing cost

< \$2/MMBtu of BioOil

- Feedstock cost —

Every \$10/dry ton of wood add
\$1/MMBtu of BioOil

ROI

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