Phillip C. Badger, Renewable Oil International® LLC

BioOil—The World's Growing Energy Resource

SAUBR Conference
Tuscaloosa, Alabama
October 25-26, 2004

Presentation Overview

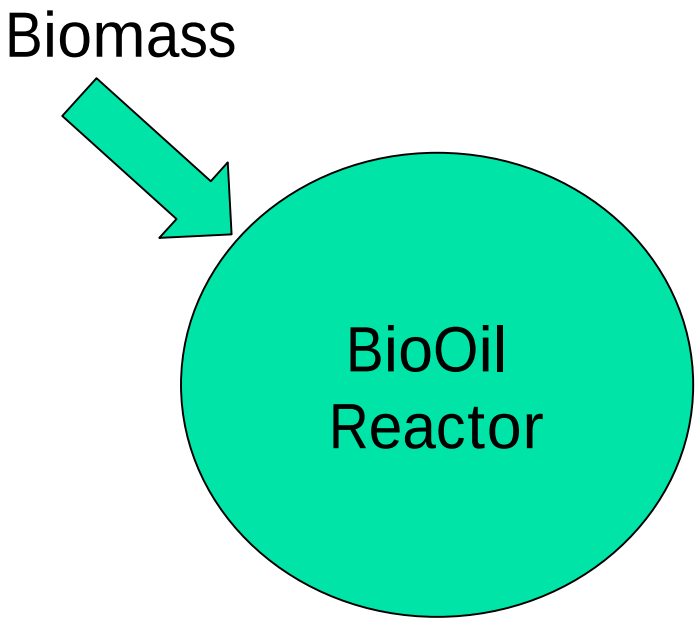
- BioOil production processes
- Products, markets, and uses
- Technology advantages
- Technology economics
- The vision
- Renewable Oil International® LLC (ROI)
- The future


NICK ANDERSON © 10-16-02 COURIER-JOURNAL
NANDERSON@COURIER-JOURNAL.COM
MIDEAST
GAS-N-GO
I FEEL SO VULNERABLE OUT HERE...
...BUT I HAVE TO HAVE GAS!

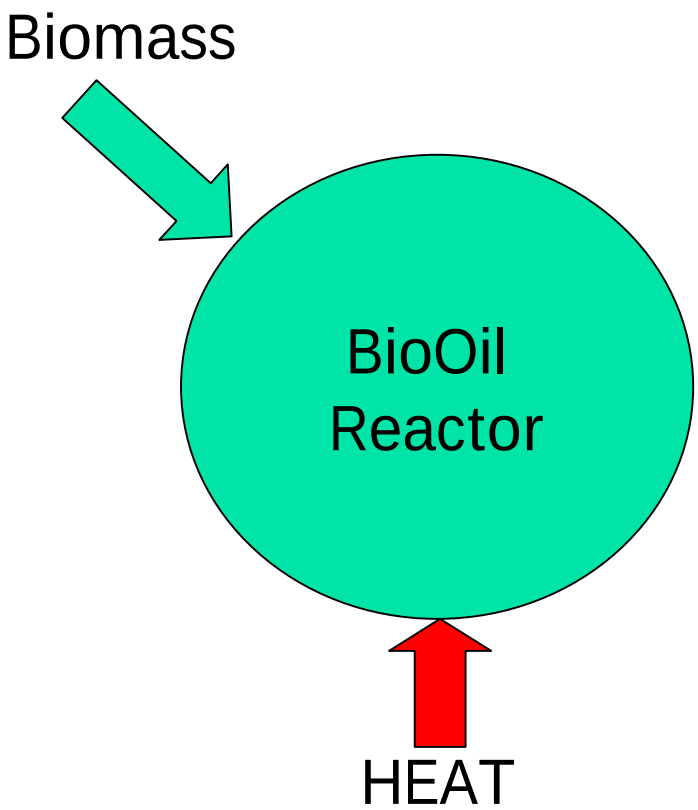
BIOMASS

The only renewable source of liquid fuels

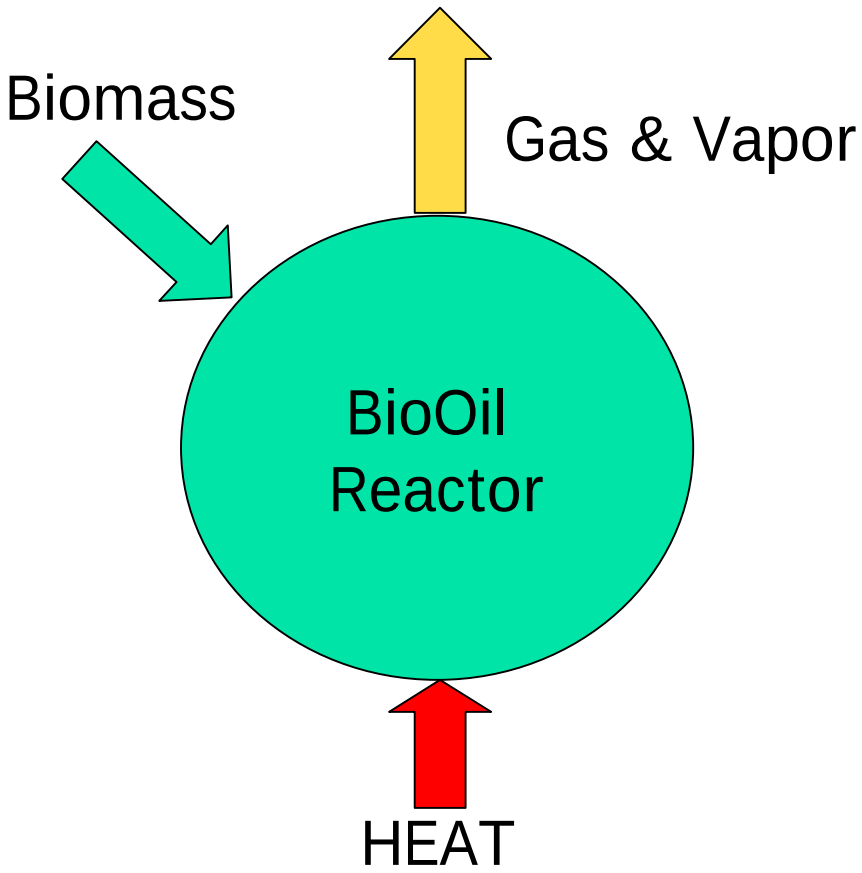
Liquid fuels are prized for their high energy density and convenience (handling, storage)



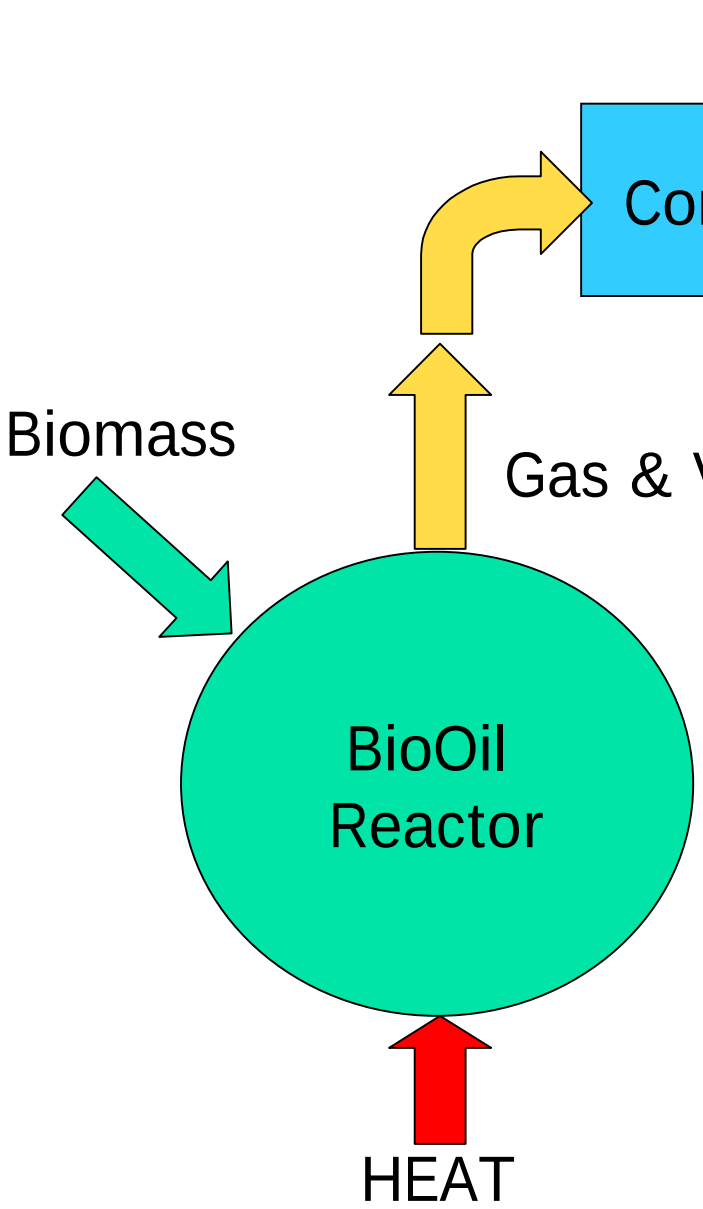
The Pyrolysis Process



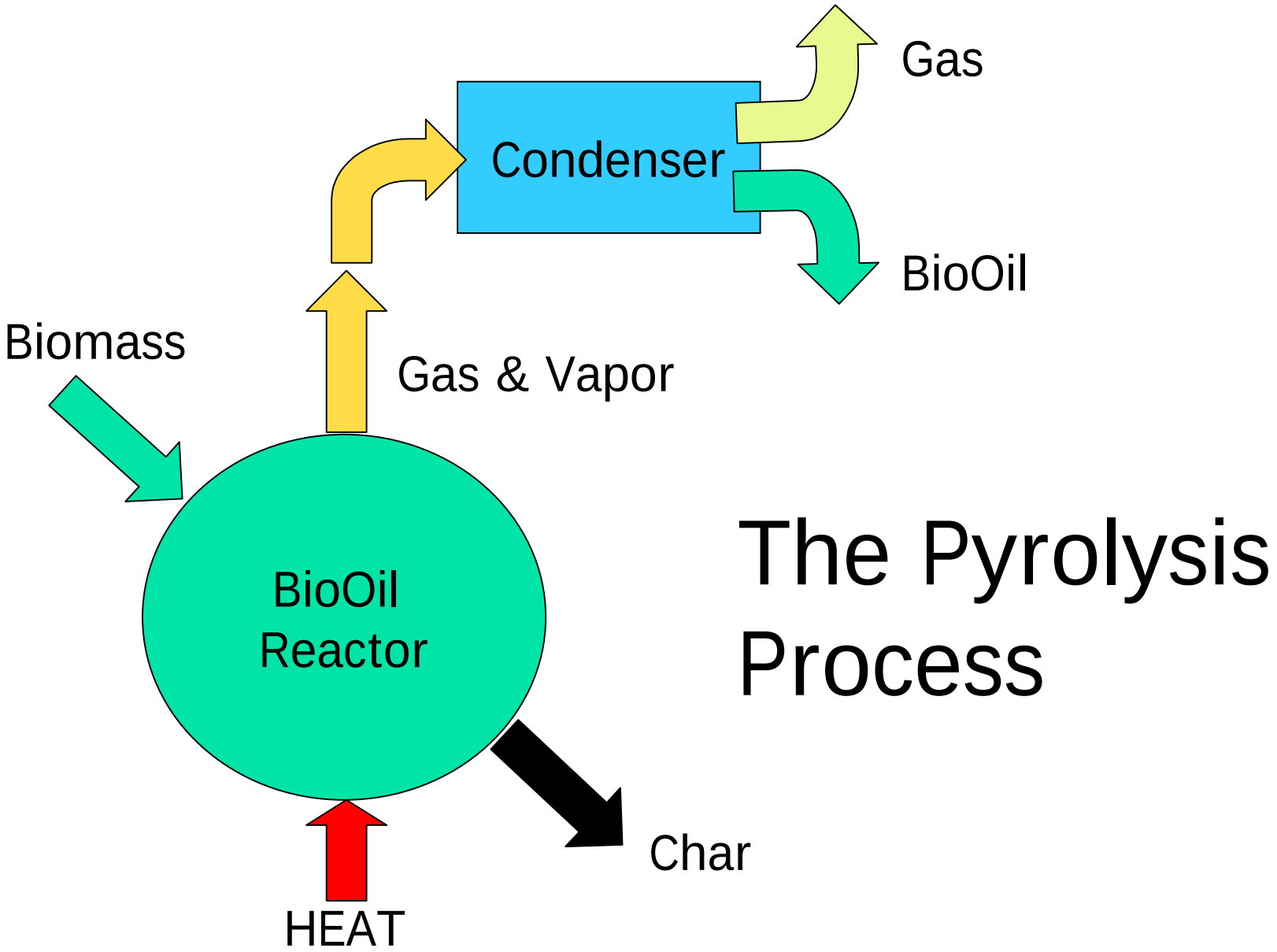
The Pyrolysis Process



The Pyrolysis Process



The Pyrolysis Process



The Pyrolysis Process


Char


ASH

The ROI Process

Continuous fast pyrolysis process under atmospheric pressure conditions = BioOil

Characteristics of Fast Pyrolysis Processes

- High heating and heat transfer rates
- Reaction temperature of around 500^0C in the vapor phase
- Short vapor residence times of typically less than 2 seconds
- High quality BioOil product

High Quality BioOils

- Process parameters to make high quality BioOils lie within a very narrow range
- Only recently has the technology to produce high quality BioOils been available
- Only very recently has the technology to produce high quality BioOils cost effectively been available

BioOil Properties

- Viscosity similar to No. 2 fuel oil
- ~80,000 Btu/gal (similar to ethanol)
- 20% water
- 30% oxygen

Potential BioOil Markets

- Chemicals
- Process heat
- Building heating and cooling
- Mechanical power
- Electricity generation

Potential BioOil Uses

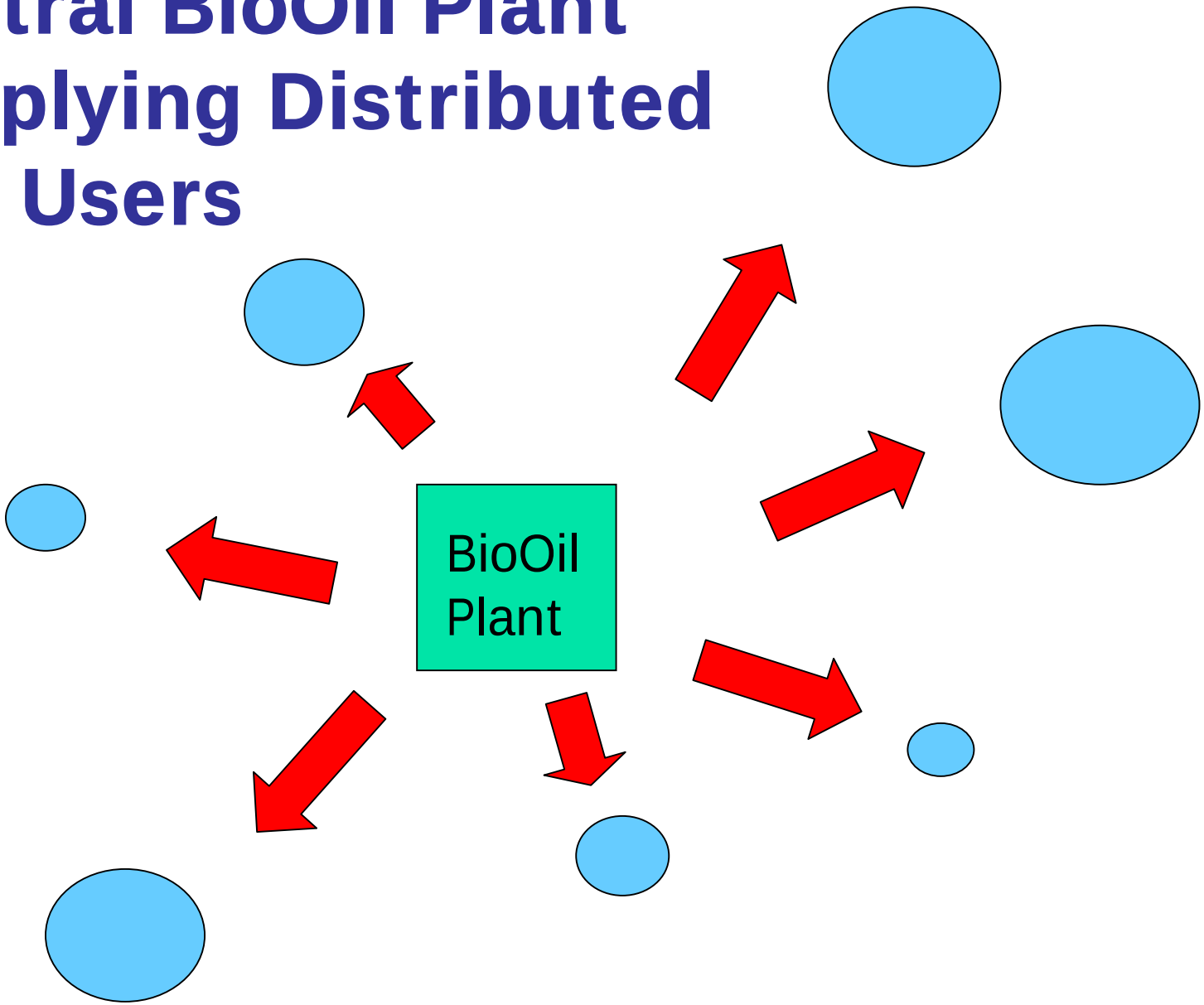
Electricity generation

- Baseload applications
  - Straight boiler fuel
  - Cofiring
- Peaking applications
  - IC engines
  - Combustion turbines

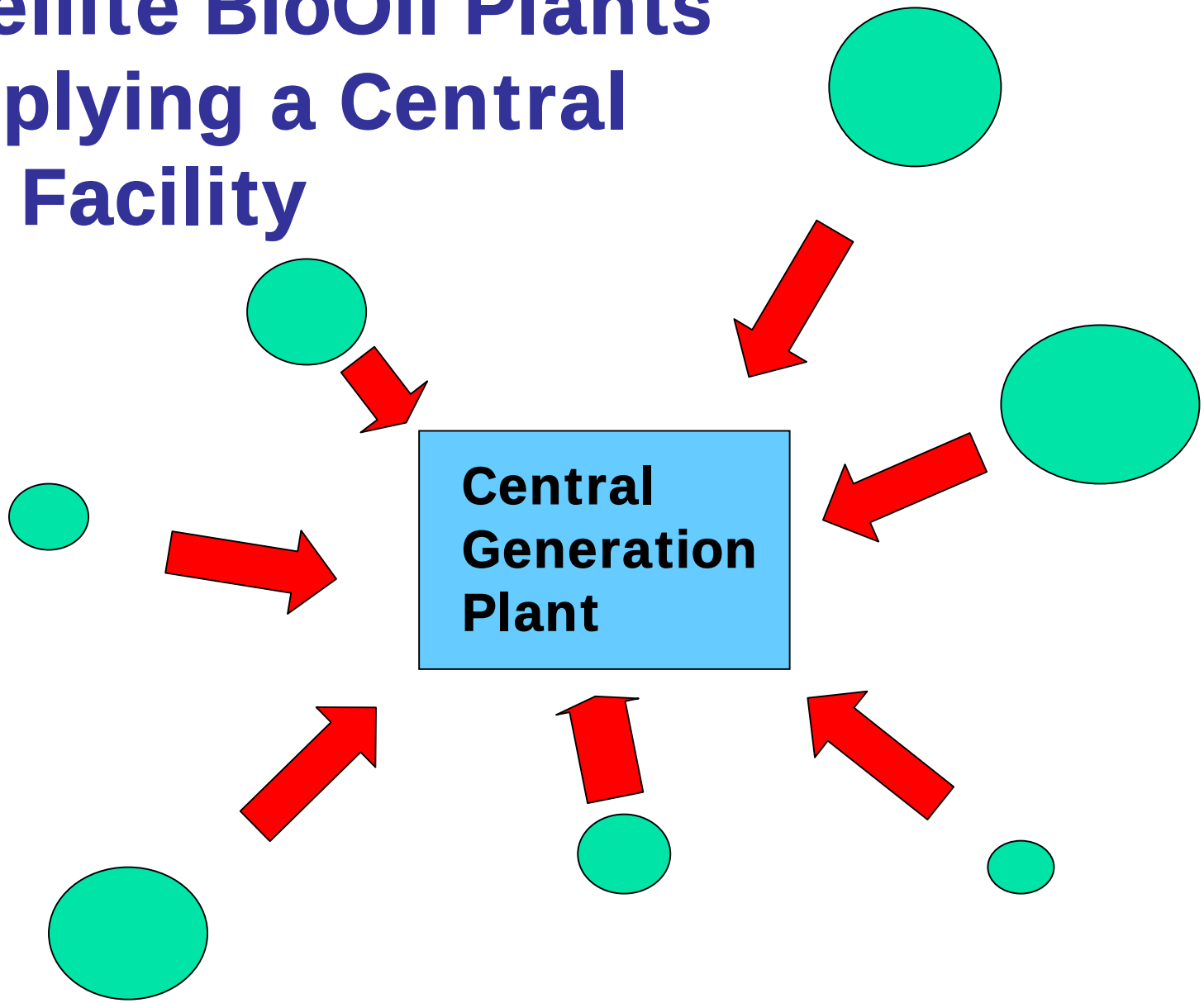
Advantages—Technology

- Relatively simple in nature
- Modular plants
  - Allows for factory fabrication
  - Allows for fast field installation
  - Keeps costs low

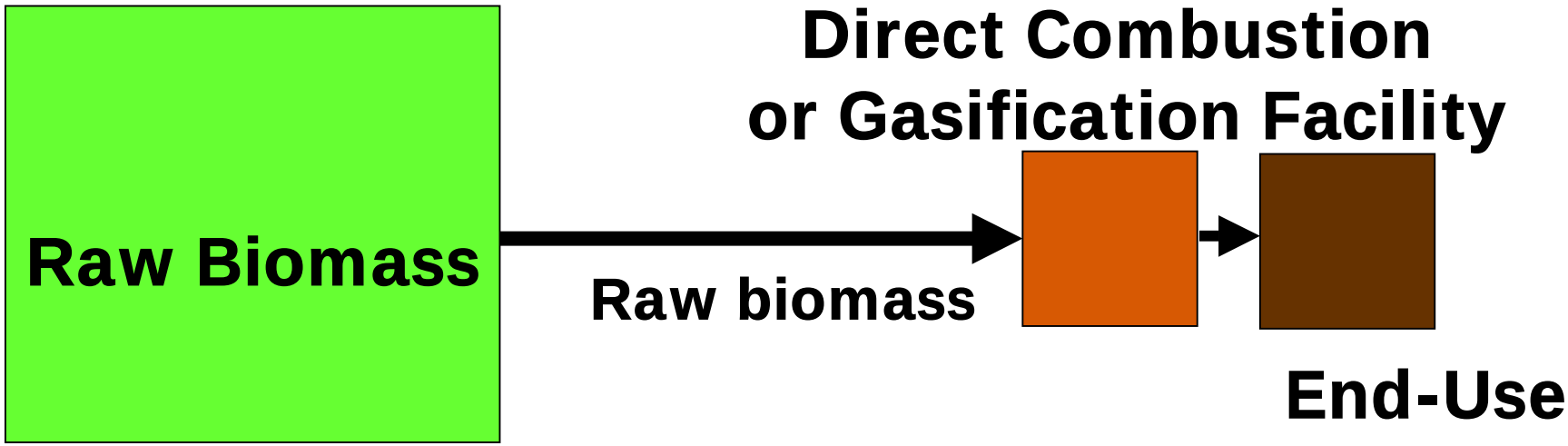
Central BioOil Plant Supplying Distributed End Users



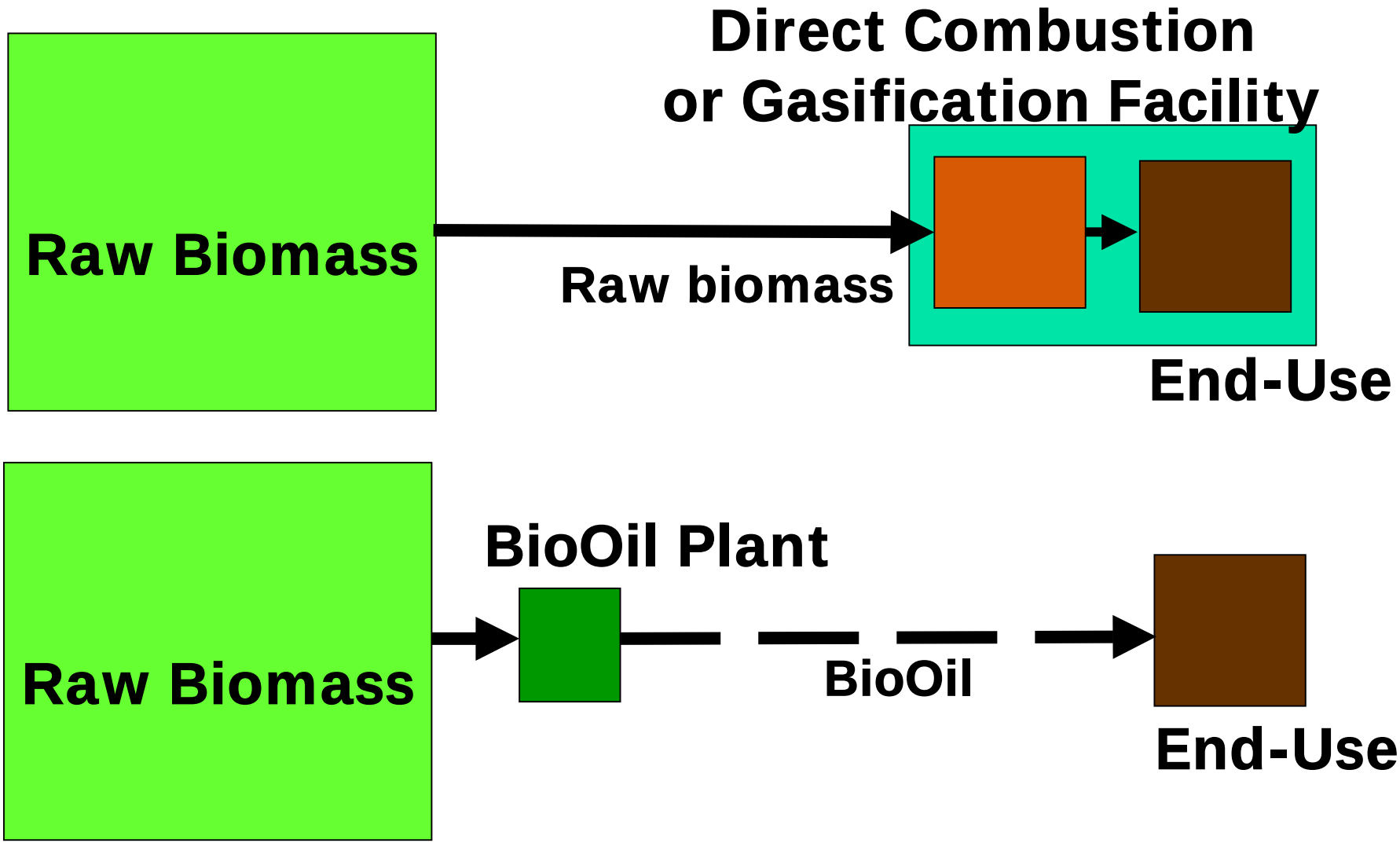
Satellite BioOil Plants Supplying a Central Use Facility



Handling Comparisons



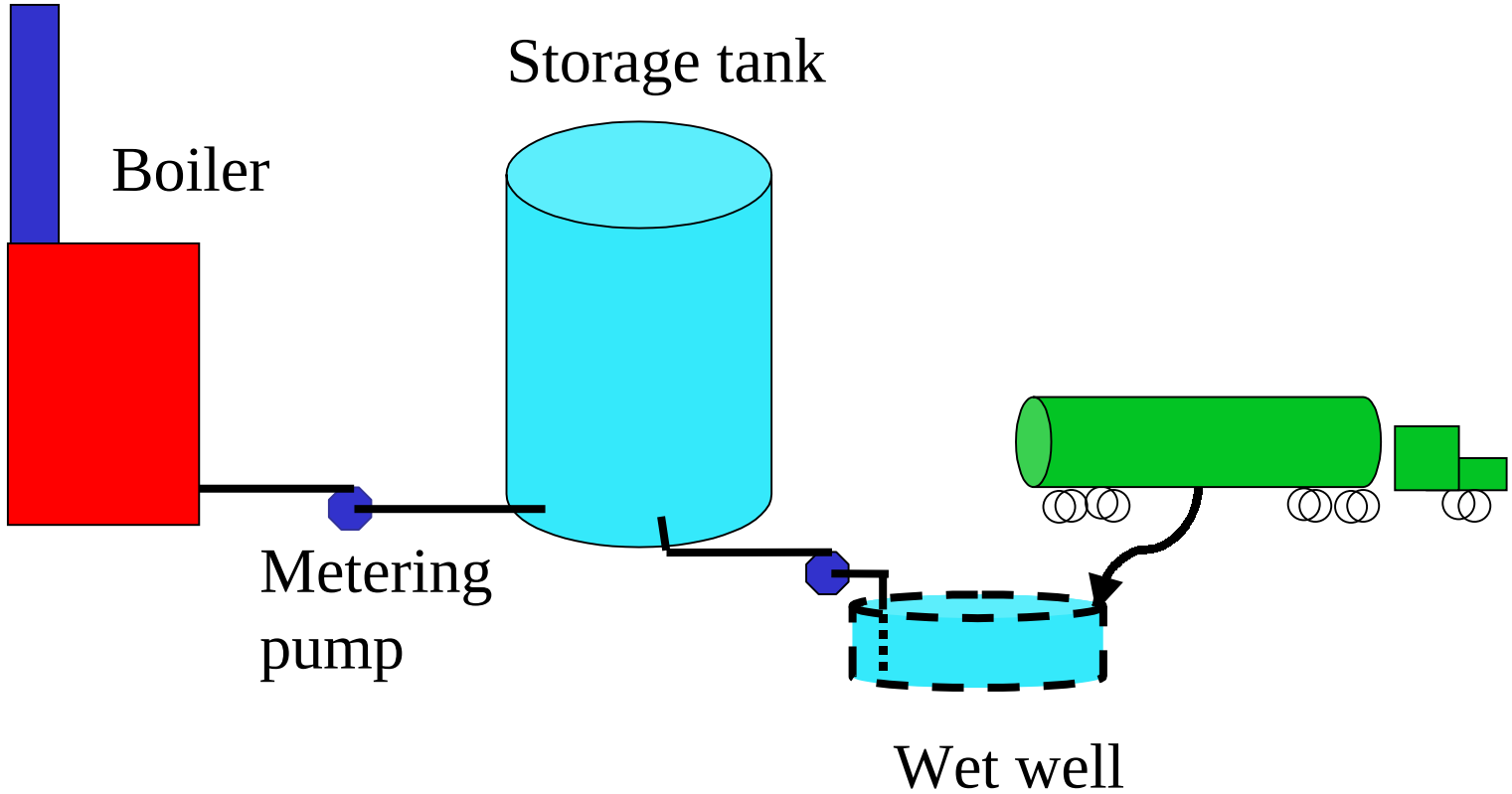
Handling Comparisons



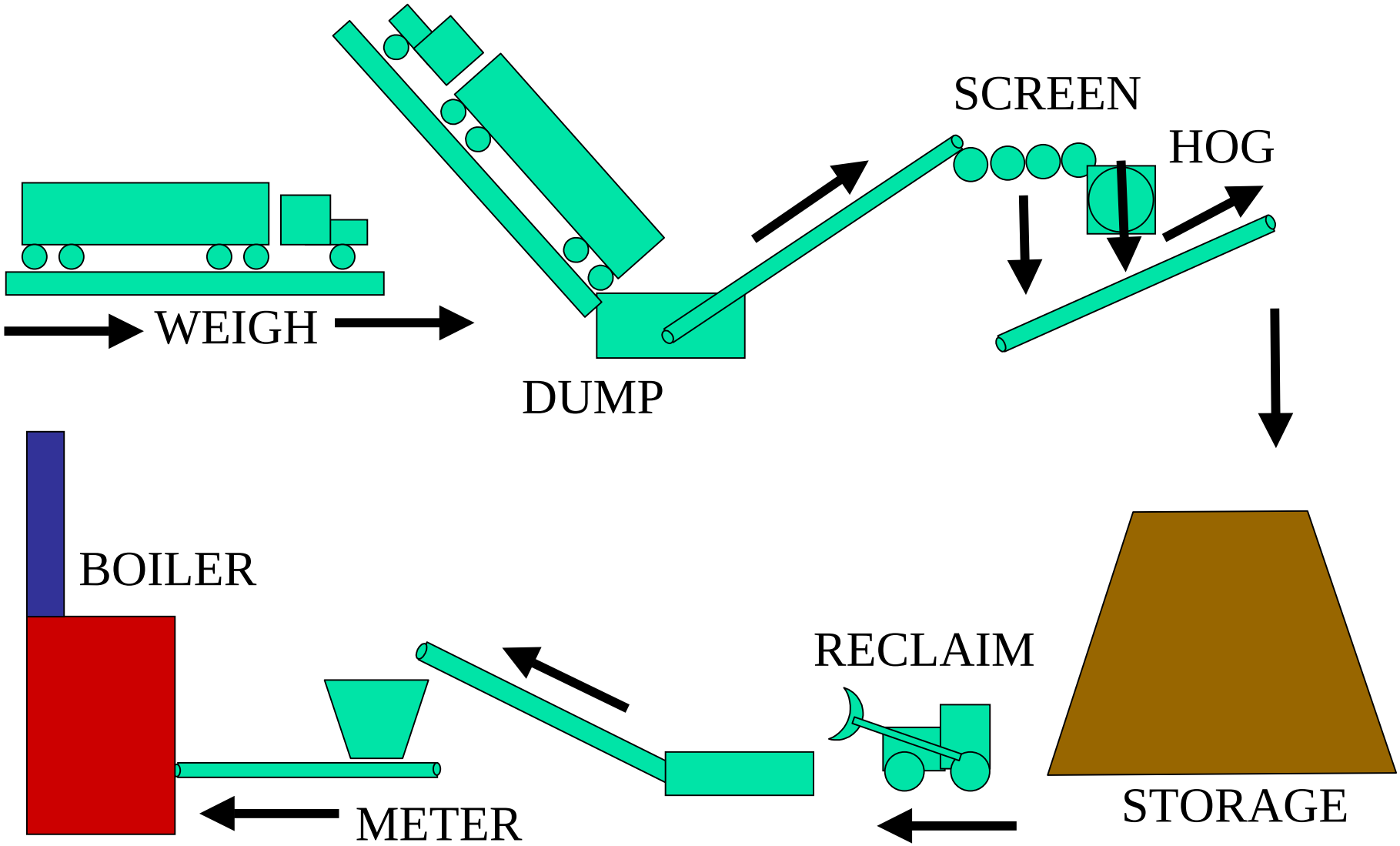
Energy Density Comparisons

	Density	MC	Energy Density		Energy density ratio
	lb/ft3	% wb	Btu/lb	Btu/cf	
Loose straw or hay	6	20	6,666	40,000	1/15
Baled grasses	12	20	6,666	80,000	1/7
Green whole tree chips	22	56	3,667	80,000	1/7
Green whole tree chips	22	45	4,583	100,000	1/6
Solid wood, L density	25	12	7,333	185,000	1/3
Cubes (e.g., grasses)	28	8	7,666	215,000	1/3
Pellets	40	10	7,500	300,000	1/2
Solid wood, H density	54	12	7,333	400,000	2/3
BioOil	75		8,000	600,000	1

2X Btu per load with BioOil



BioOil Handling System



Solid Wood Fuel Handling System

BioOil vs. Solid Wood Handling Systems

- Capital costs comparable—excluding land
- Land requirements half for BioOil
- BioOil system significantly less complex
- O&M significantly less for BioOil

The Vision: Forestry

- Modular BioOil plants can be taken into the forest to directly convert forestry materials into BioOil
- Feedstock preparation: Green whole tree chips as harvested and processed with current equipment

© ROI 2003

wood chips

The Vision: Forestry

Addresses:

- National Fire Plan
- National Healthy Forests Initiative
- Markets for CRP thinnings
- Markets for other low value materials

© ROI 2003

The Vision: Agricultural Crops & Residues

- Modular BioOil plants can be taken to the field edge to directly convert raw agricultural materials into BioOil
- Feedstock preparation: Hay crops cut, field dried, raked, chopped with forage harvester—all conventional equipment

© ROI 2003

The Vision: Agricultural Crops & Residues

Addresses markets for:

- non-commodity crops
  (e.g., switchgrass)
- harvesting residues
  (e.g., corn and cotton stalks)
- Processing residues
  (e.g., cotton gin trash, peanut hulls)

© ROI 2003

Poultry litter is a major resource in the South

The Vision- Nutrient Management

- Energy process pays for separation and concentration of nutrients
- High temperatures kill pathogens
- Large reduction in material volume
- Nutrients recovered in ash, ash co-product worth $40-50/ton
- Decreases nutrient transportation costs

Fuel Cost Comparisons

Fuel	$/unit	$/MMBtu
Natural gas*	$8.76/Mcf	$ 8.76
Propane	$1.00/gal	$ 11.76
Propane	$1.25/gal	$ 14.71
***Average US Industrial Price, March 2004 (Source: US DOE)**		

Cost Effectiveness

- Conversion to BioOil w/o feedstock costs =$1.50/MM Btu
- Wood feedstock costs add

  ~ $1.00/MM Btu per $10/dry ton wood
- Example: Wood to BioOil at $20 dry ton of wood = $3.50/MM Btu BioOil cost

© ROI 2003

Economics $$$$

- 100 dry ton per day wood input
- BioOil production: ~12,000 gal/day or

  ~ 4.3 million gal/yr (wood)
- Total capital cost <$2.5 million
- Can support ~2.5 MW of power production w/ 450 ºC waste heat

© ROI 2003

Advantages—Financial Security

- Relatively low cost to construct and operate
- Cost effective at relatively small scale (100 dry tons per day)
- Products have multiple markets
- Can compete in today's energy markets

Advantages—Financial Security

- Can handle multiple feedstocks
  - Forestry crops & residues
  - Agriculture crops & residues
  - Agricultural & forestry processing residues
  - Hog & dairy manure solids
  - Waste plastics, sludges, MSW
  - Other

Advantages—Financial Security

- If feedstocks disappear or become too expensive, plant can be moved with minimal loss

Renewable Oil International® LLC

- Over US$800,000 from Natural Resources Canada
- Technology vetted by Fluor-Daniel (Ranked in top two on ENR's "The Top Design-Build Firms" list)
- Received pilot plant funding from Farm Pilot Project Coordination thru nationwide competitive solicitation
- Invited to give Congressional Briefing in US Capitol on May 20th, 2003
- Invited to give presentation to International Energy Agency (IEA) Task 31 Team, October 2003
- Received funding for 15-dtpd plant from MA Technology Collaborative under nationwide solicitation

Business Strategy

- Scale-up
  - 5 dry tons per day (pilot plant)
  - 25 dry tons per day (pre-commercial plant)
  - 125 dry tons per day (commercial scale)

ROI Commercialization Status

- Incorporated in December 2001
- 5-dry ton per day (input) pilot plant on poultry farm in North Alabama funded by Farm Pilot Project Coordination (FPPC)


ROI 5 dry ton per day plant
in NW Alabama
© ROI 2003

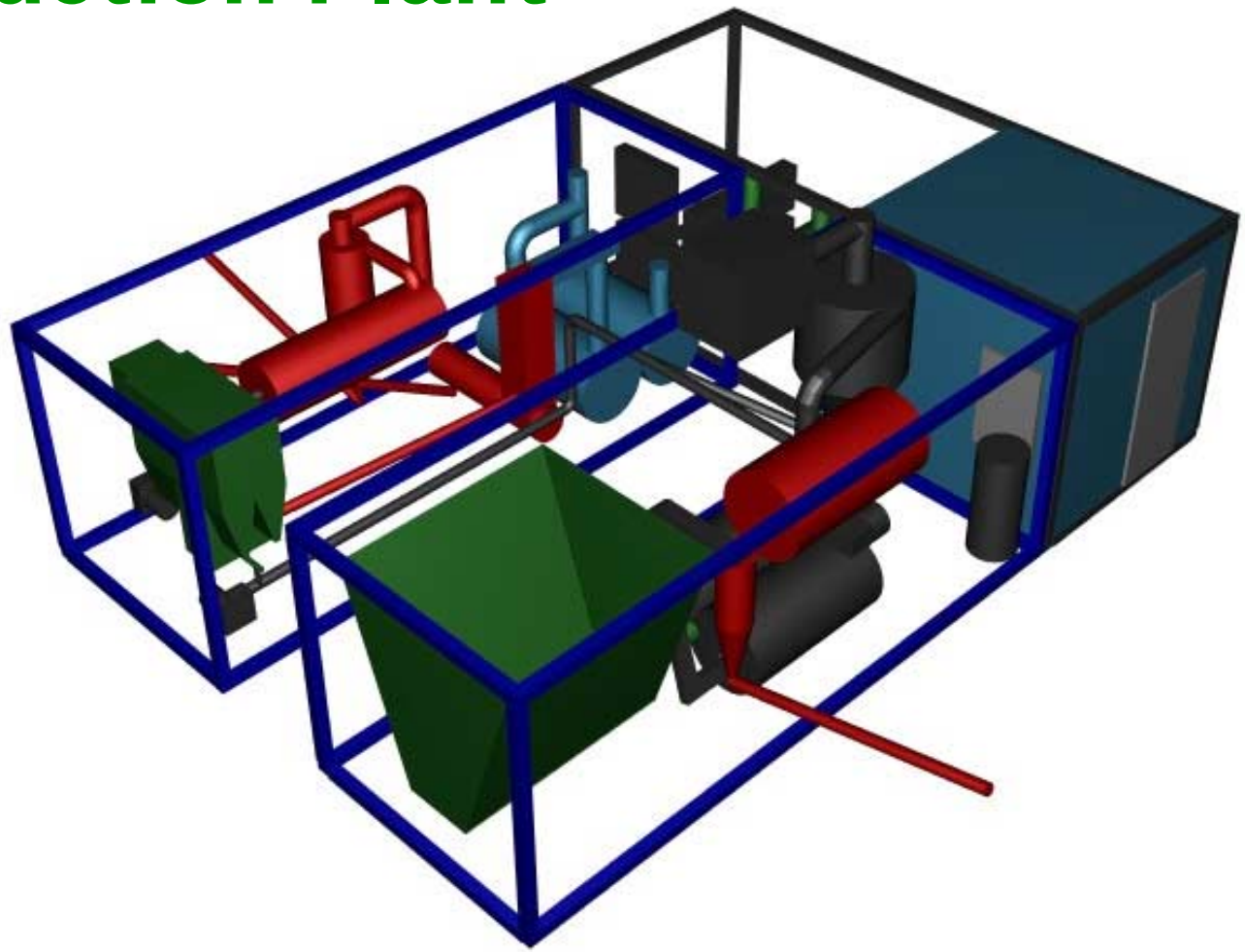
Pilot Plant Results

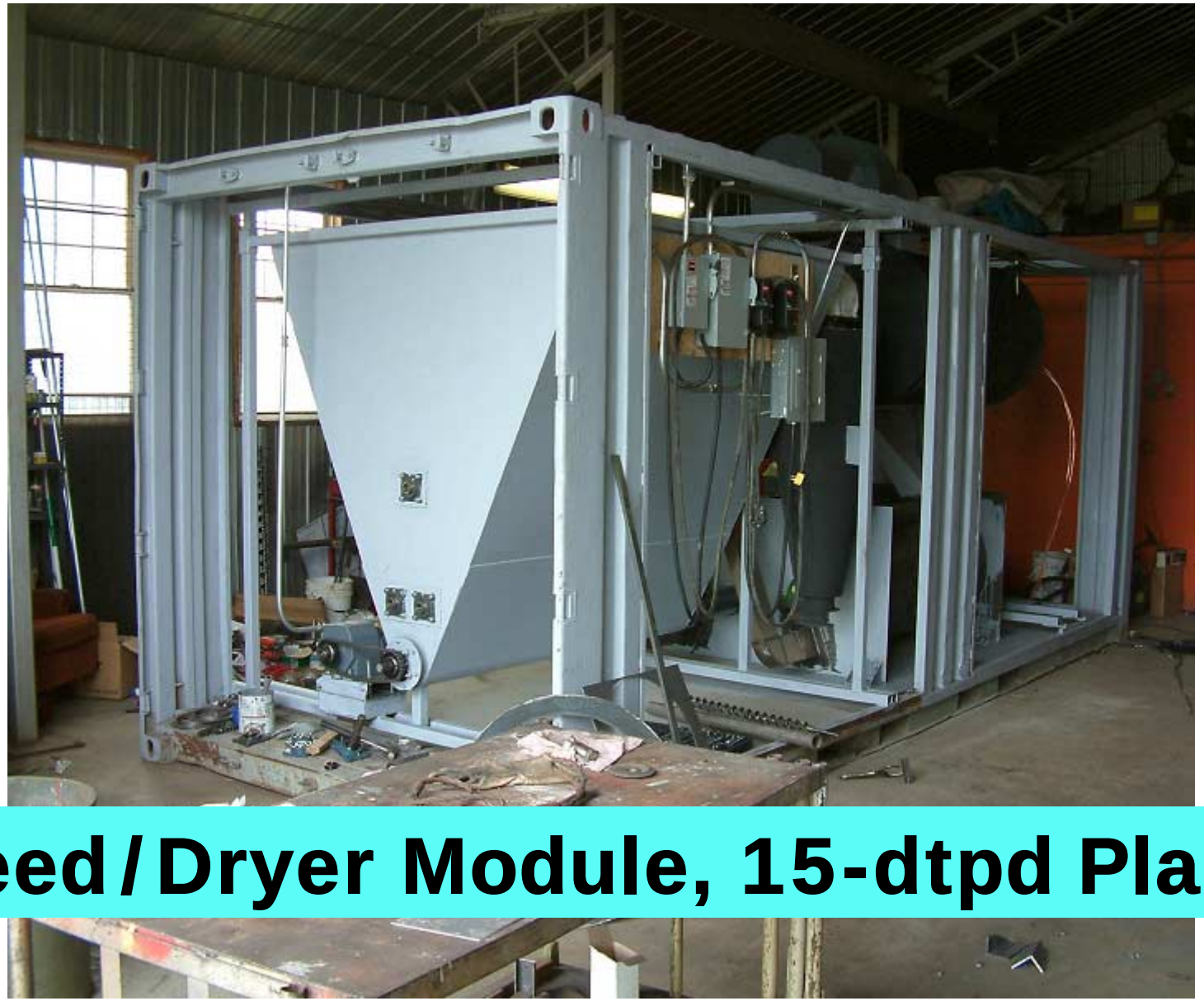
- Concept works
- PL makes a 2-phase BioOil
- PL BioOil has an energy content of up to 12,000 Btu/lb vs the 8,000 Btu/lb typical of BioOil from other feedstocks

ROI Commercialization Status

- Constructing 15-dtpd plant that will operate on wood waste
- Will be installed in the largest sawmill in Massachusetts
- Will generate power in a CHP system that will also heat dry kilns

15-dtpd ROI Modular BioOil Production Plant





Feed/Dryer Module, 15-dtpd Plant

BioOil-Fueled Heaters for Poultry Houses

- Funded by AL Dept of Economic & Community Development
- Project cooperative with Auburn University
- To be installed in one poultry house at host farm in NW Alabama


Poultry House Heating System
© ROI 2003

Business Strategy

- Scale up
  - 5-dry tons per day
  - 15 dry tons per day
  - 50 dry tons per day
  - ???

ROI Summary

- Relatively simple technology
- Multiple feedstock capability
- Multiple products with multiple markets
- Modular, transportable system
- Financial security for investors
- Can address many national needs
- Cost effective at a small scale

Contact Information

- Phillip C. Badger
- Renewable Oil International® LLC
- 3115 Northington Court
- P.O. Box 26
- Florence, AL 35630
- Phone: (256) 740-5634
- Fax (256) 740-5635
- Email: pbadger@renewableoil.com