



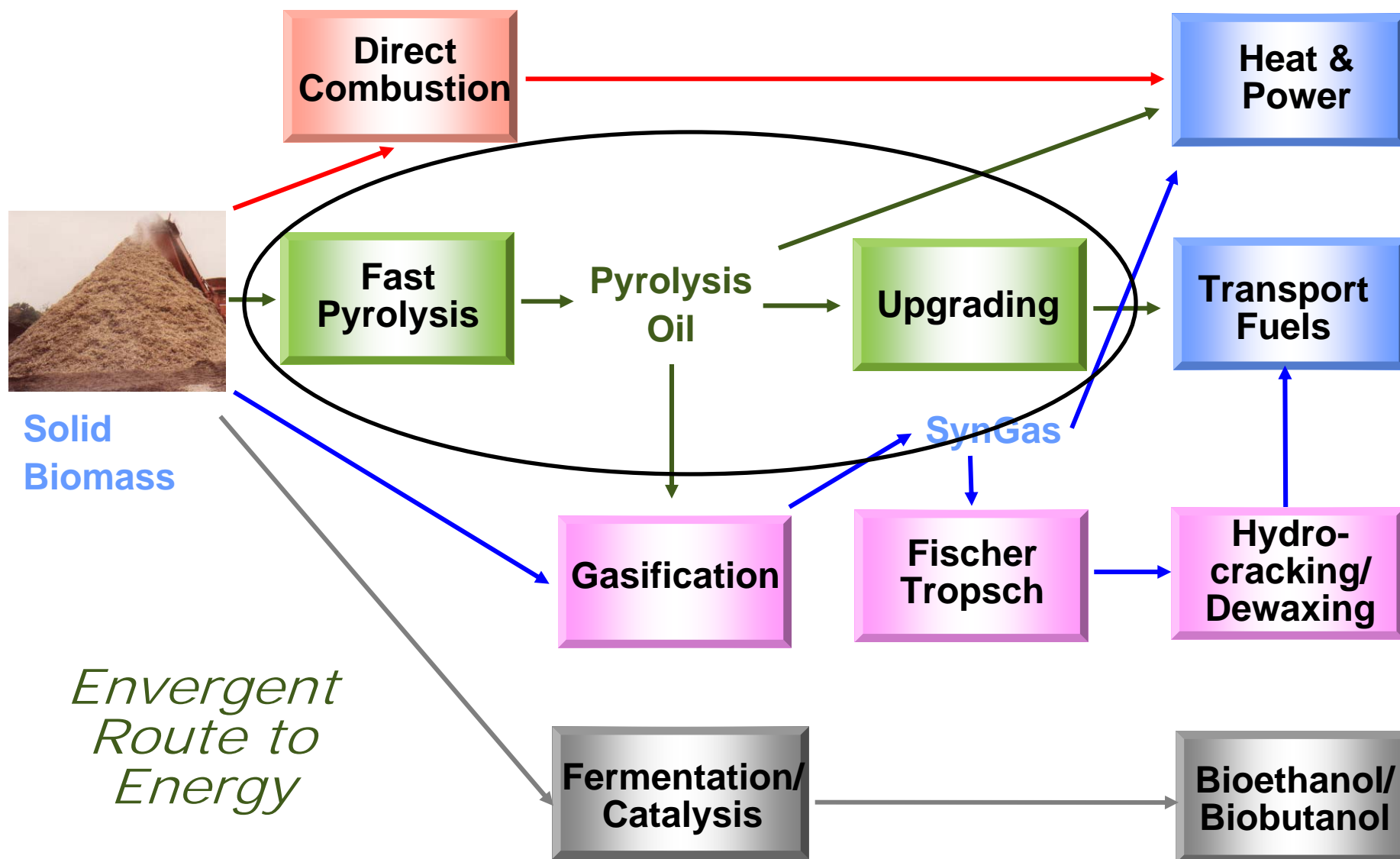
Fast Pyrolysis: Pathway to Unlocking Value from Forest Product Residuals

Randal Goodfellow
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Agenda

- **Introduction**
- **Rapid Thermal Processing (RTP™) Technology**
- **Applications**
- **Project Development**
- **Summary**

Lignocellulosic Biomass Processing Options



Envergent Technologies LLC – UOP / Ensyn Joint Venture



- **Formed in October 2008**
- **Provides pyrolysis oil technology for fuel oil substitution and electricity generation**
- **Development of technology for upgrading pyrolysis oil to transportation fuels**



- **Leading process technology licensor~\$2 billion in sales, 3000 employees**
- **Nearly 100 years of refining technology development, scale-up and design**
- **Modular process unit supplier**
- **Global reach via Honeywell & UOP sales channels**



- **Over twenty years of commercial fast pyrolysis operating experience**
- **Developers of innovative RTP™ fast pyrolysis process**
- **Seven commercial RTP units designed and operated**

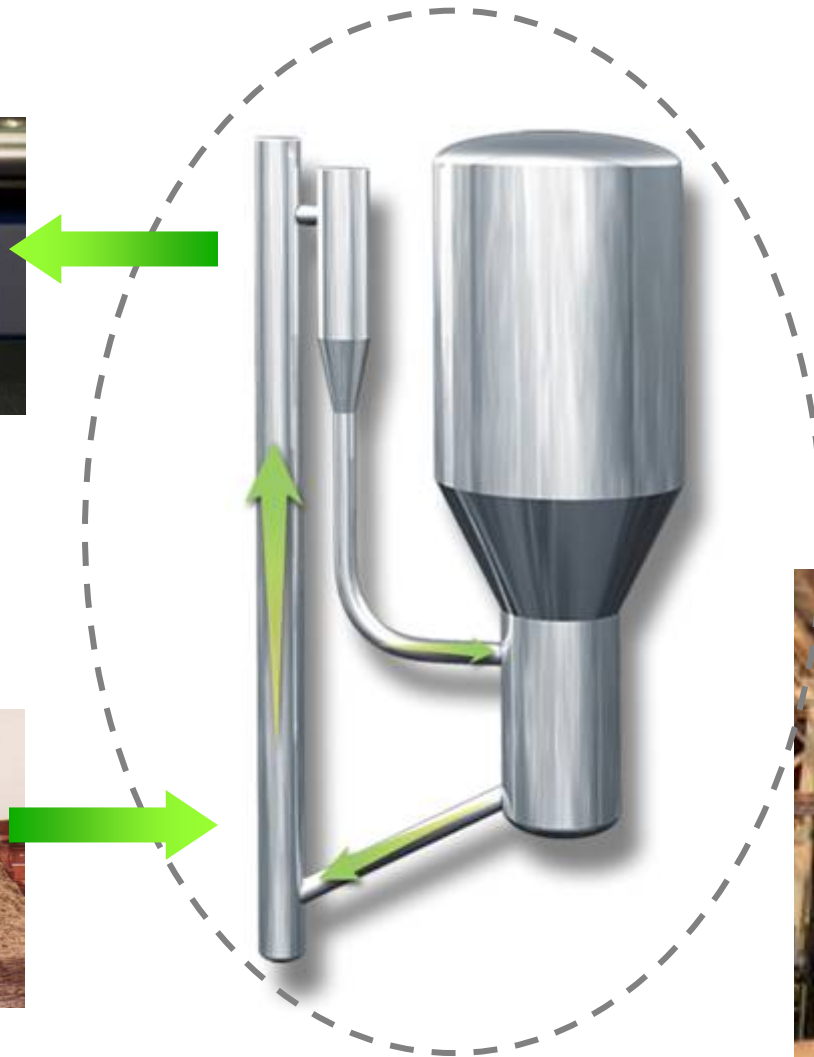
*Second Generation Renewable Energy Company –
Global Reach*

Rapid Thermal Processing (RTP™) Technology

Pyrolysis Oil



Solid Biomass

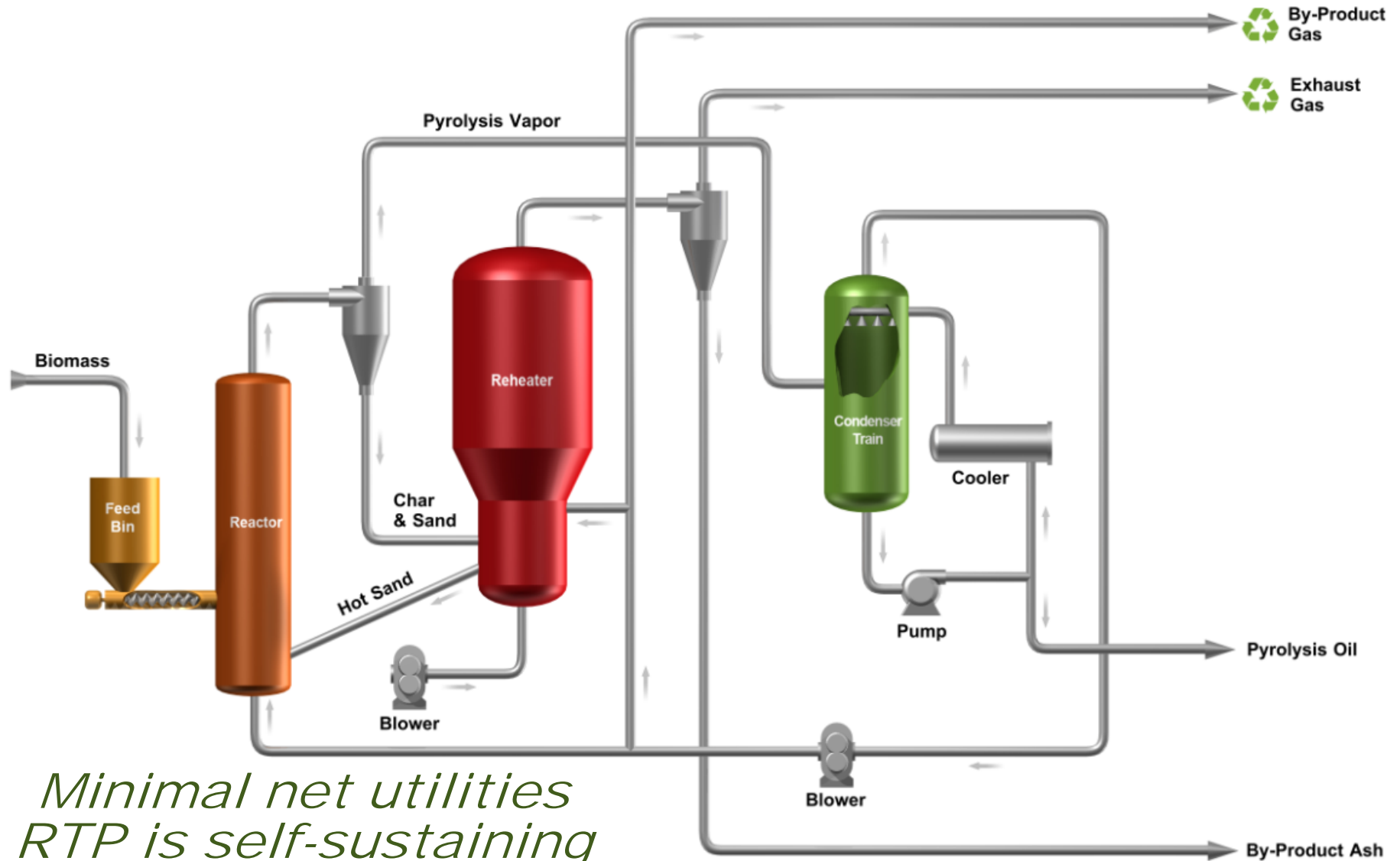


- 510°C, <2 seconds
- Biomass converted to liquid pyrolysis oil
- Fast fluidized bed, sand as heat carrier
- High yields; >70 wt% liquid on woody biomass



Commercially Proven Patented Technology

RTP™ Flow Diagram



Feedstock Sources

- **Forestry and Pulp and Paper**

- Wood chips, sawdust, bark
- Forestry residues

- **Agricultural**

- Residues – corn stover, expended fruit bunches from palm (EFB), bagasse
- Purpose-grown energy crops – miscanthus, elephant grass

- **Post-consumer**

- Construction and Demolition Waste, Categories 1&2
- Municipal solid waste (future)



RTP™ Product Yields

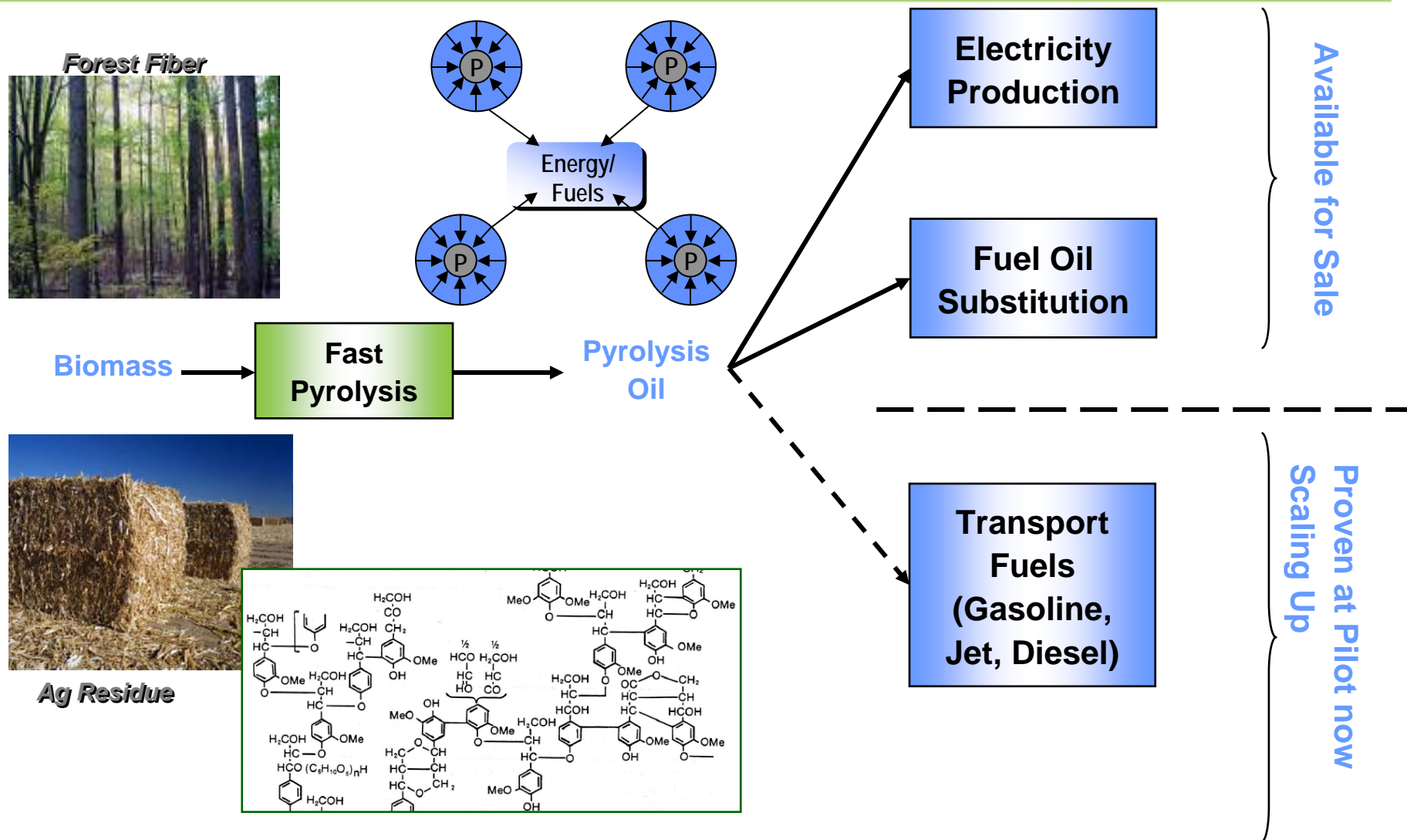
400 BDMTPD of Hardwood Whitewood

Feed, wt%	
Hardwood Whitewood	100
Typical Product Yields, wt% Dry Feed	
Pyrolysis Oil	70
By-Product Vapor	15
Char	15

Yields For Various Feeds

Biomass Feedstock Type	Typical Pyrolysis Oil Yield, wt% of Dry Feedstock
Hardwood	70 – 75
Softwood	70 – 80
Hardwood Bark	60 – 65
Softwood Bark	55 – 65
Corn Fiber	65 – 75
Bagasse	70 – 75
Waste Paper	60 – 80

Pyrolysis Oil to Energy & Fuels Vision

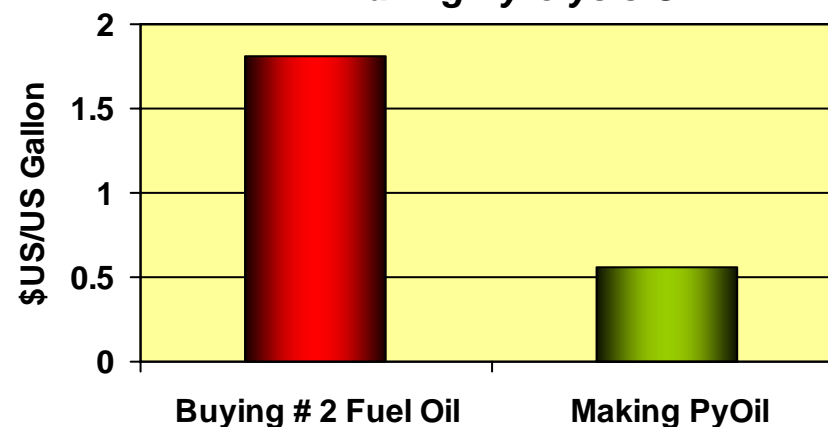


Pyrolysis Oil: Replacement of Fossil Fuels to Generate Heat

- **Low emissions (NO_x, SO_x)**
- **Significant GHG emission reduction of 70-90% compared with**
- **Cost competitive on a BTU basis with fossil heating oil (comparison made when fossil crude was \$ 60 / barrel)**



Comparison of Cost of Buying #2 Fuel Oil vs. Making Pyrolysis Oil



Pyrolysis Oil: Production of Green Electricity

- **Specialized gas turbines**
- **Medium Speed Diesel Engine application – soon to be announced**



Pyrolysis Oil: Upgrading to Green Transportation Fuels

- **Objectives**

- Remove oxygen molecules
- Reduce acidity and viscosity
- Break up molecules to make gasoline and diesel/jet precursors

- **Solution**

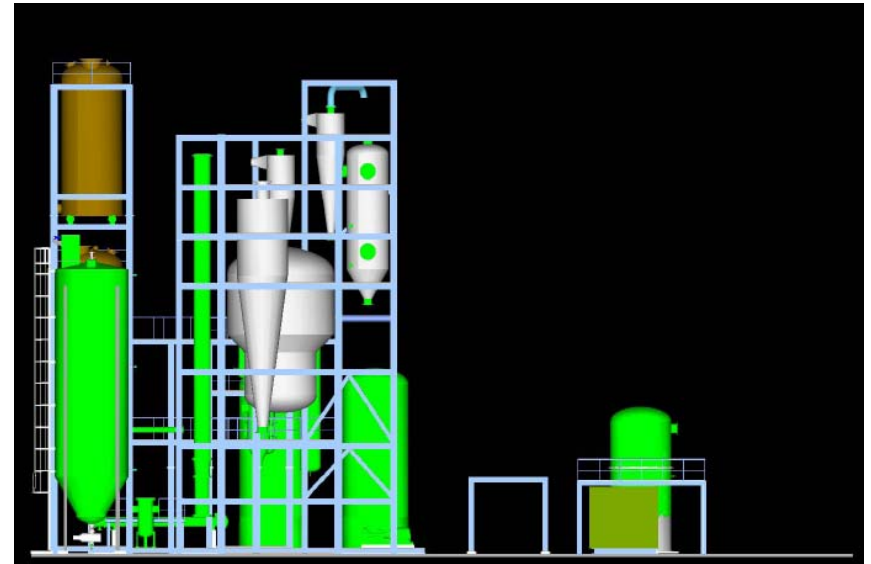
- Thermo-chemical upgrading; leverage UOP's extensive hydro-processing experience
- Continuous, reliable guaranteed process, per current refinery standards



Achieved in Lab, Working on Scale-up

Delivery & Scope of Supply

- **Standard sized modular units offered**
 - 200, 400 and 1000 Bone Dry Metric Tonnes per Day (BDMTPD)
- **Broad modular experience in refining, petrochemical and oil & gas industries**



Modular Delivery Provides Faster Execution and Higher Reliability