

*Pyrolysis Oil: Heat,
Electricity, Green
Transportation Fuel,
and Chemicals Too*



September 13th, 2010



Agenda

- Ensyn and Fast Pyrolysis
- Pathways of Biomass to Stationary and Transportation Fuels
- The Joint Venture
- Applications of Pyrolysis Oil

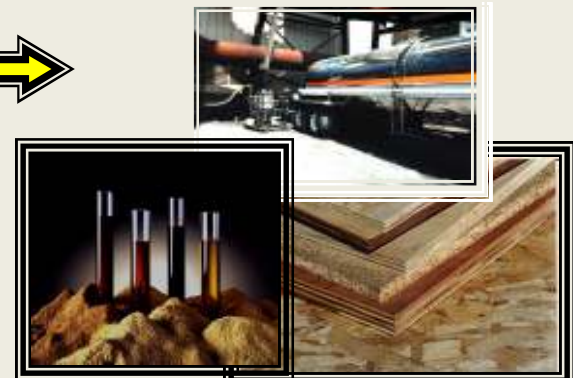
Core Competency

Ensyn's Core Competency is the rapid cost effective conversion of solid biomass into a liquid.

Liquid Biomass ("Pyrolysis Oil")

Refined Products

*Wood/Agricultural
Biomass Residues*

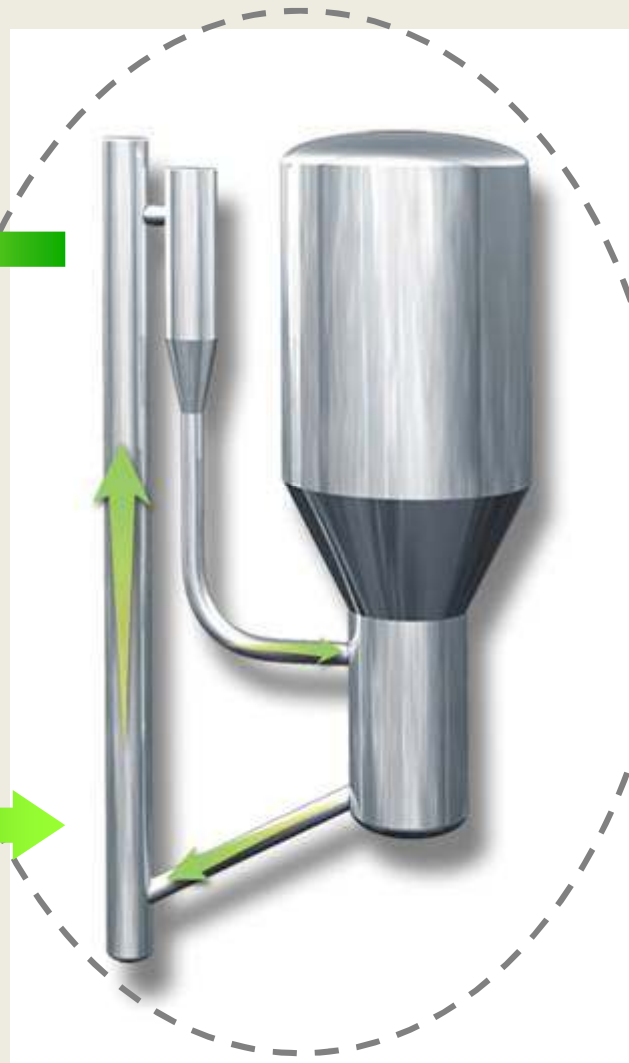


Rapid Thermal Processing (RTP™) Technology

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

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

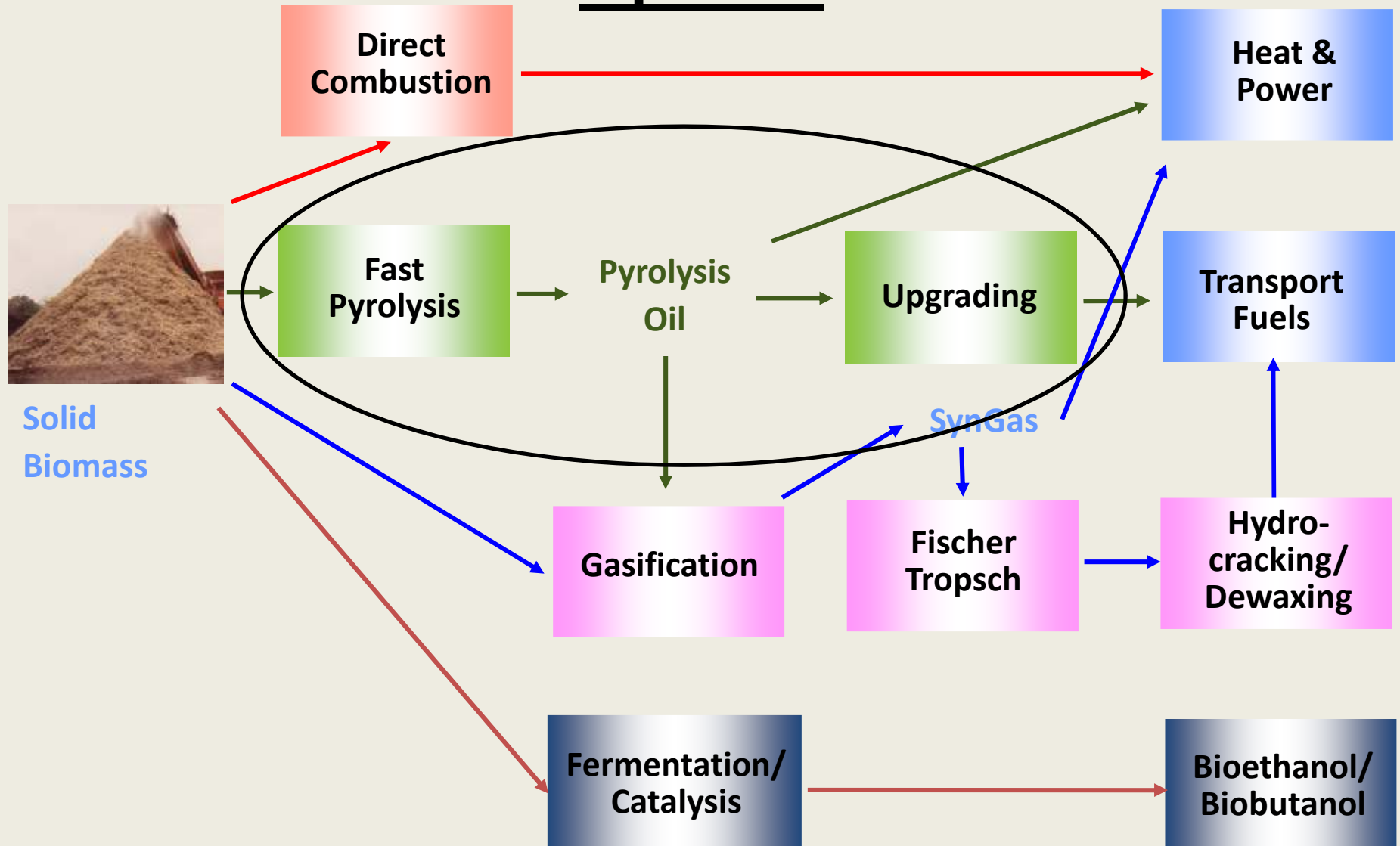
Municipal solid waste (future)

- **DoE study 2005 - > 1 billion ton per year available in United States alone**



Cellulosic Feedstocks Widely Available

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
- Channel for UOP R&D program to upgrade pyrolysis oil to transportation fuels

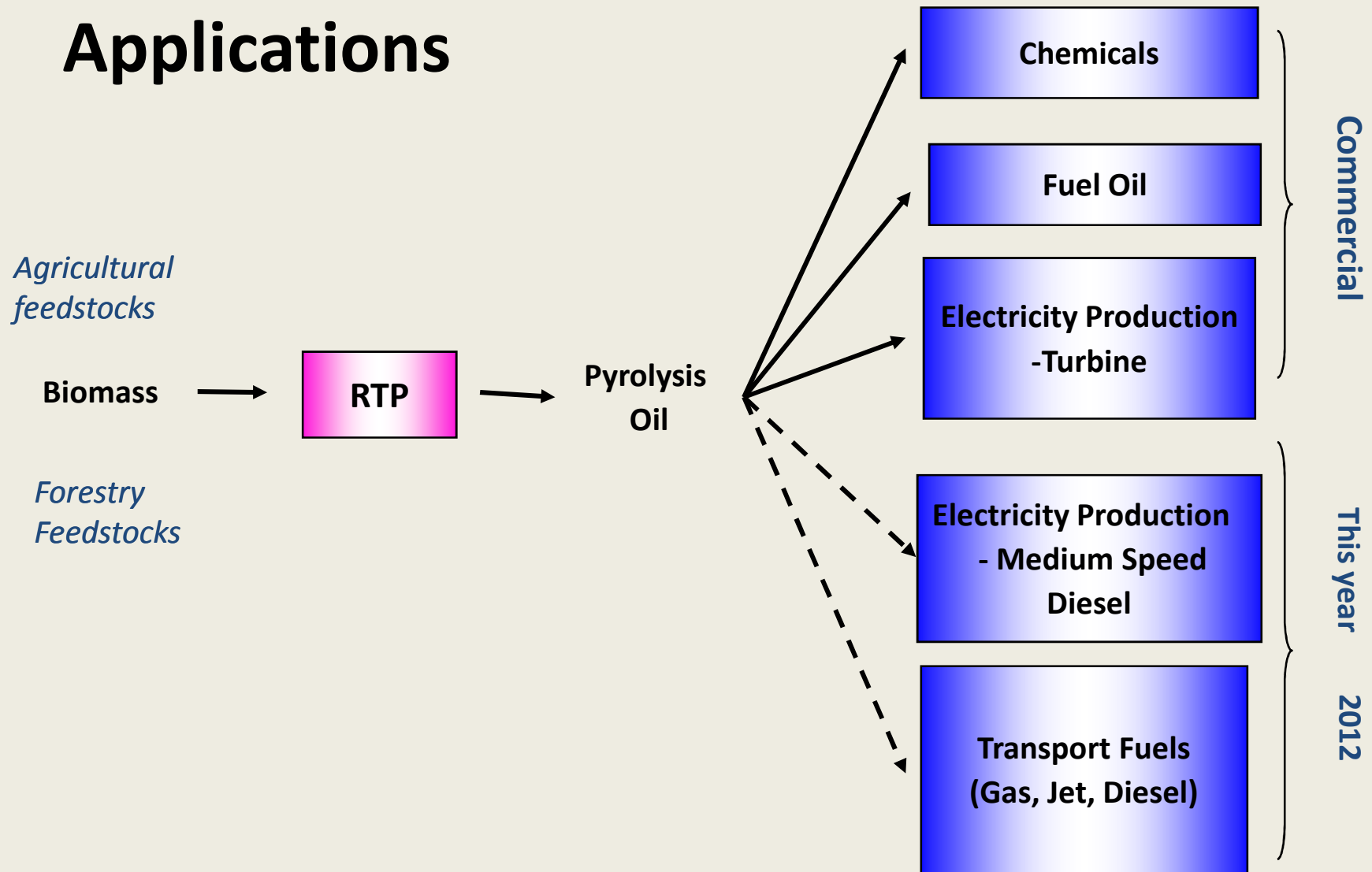


- **Leading process technology licensor~\$2 billion in sales, 3000 employees**
- **Co-inventor of FCC technology**
- **Modular process unit supplier**
- **Global reach via Honeywell & UOP sales channels**



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

Current and Near Term Applications

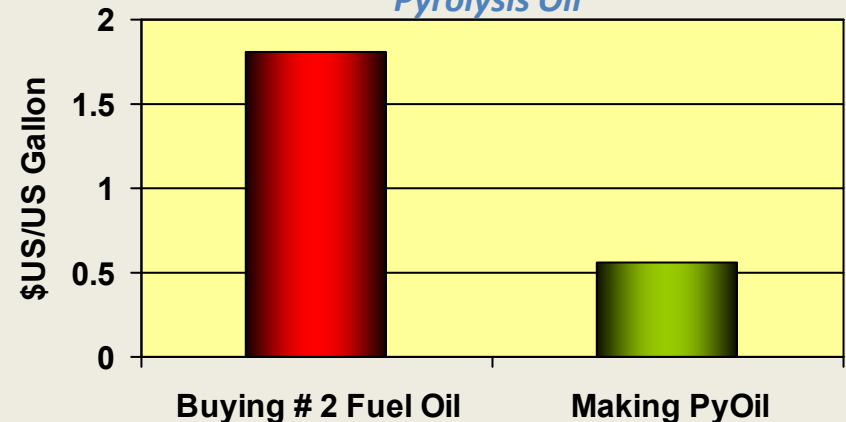


Pyrolysis Oil: Replacement of Fossil Fuels to Generate Heat

- Specialized burner tips improve flame/burning
- Low emissions (NO_x, SO_x)
- Fuel consistency - *ASTM D7544*
- Flexibility to decouple pyrolysis oil production from energy generation (location and time)
- GHG emission reduction of 70-90%
- Low cost liquid biofuel
 - ~40% cheaper to make and use pyrolysis oil than to purchase #2 fuel oil on an equivalent energy basis
 - 400 BDMTPD RTP Unit
 - Assumes 60 \$US/bbl crude
 - Includes RTP operating cost and 15-yr straight line depreciation of CAPEX
 - 330 Days per Year



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



~ 8 \$US Million per Year Savings

Pyrolysis Oil: Production of Green Electricity

- Compatible with specialized turbines
- Green electricity production cost is 0.10 \$US/kW-h
 - Includes RTP operating cost and 15-yr straightline depreciation of CAPEX (including gas turbine)
- Experience in stationary diesel engine as blend with fossil fuel
 - Operation with 100% pyrolysis oil under development



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
 - Commercialization expected in 2012
- Solution
 - Thermochemical upgrading; leverage UOP's extensive hydroprocessing experience
 - Continuous, reliable guaranteed process, per current refinery standards



Achieved in Lab, Working on Scale-up