



Envergent
TECHNOLOGIES

A Honeywell Company

**RTP™ Rapid Thermal Processing:
An Update from Envergent**

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Envergent Technologies LLC



- **UOP/Ensyn joint venture, a Honeywell company, formed in October 2008**
- **Bringing RTP™ technology to the energy industry**
- **Building on the skills of both companies**



- **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

History and Commercial Experience

- Commercialized in the 1980' s
- Seven units designed and operated in the US and Canada
- Largest is in Renfrew, Ontario, Canada
 - Can process up to 100 BDMTPD of biomass and produce up to 20M liters of renewable fuel per year
- Current modular unit sizes are 150 and 400 BDMTPD

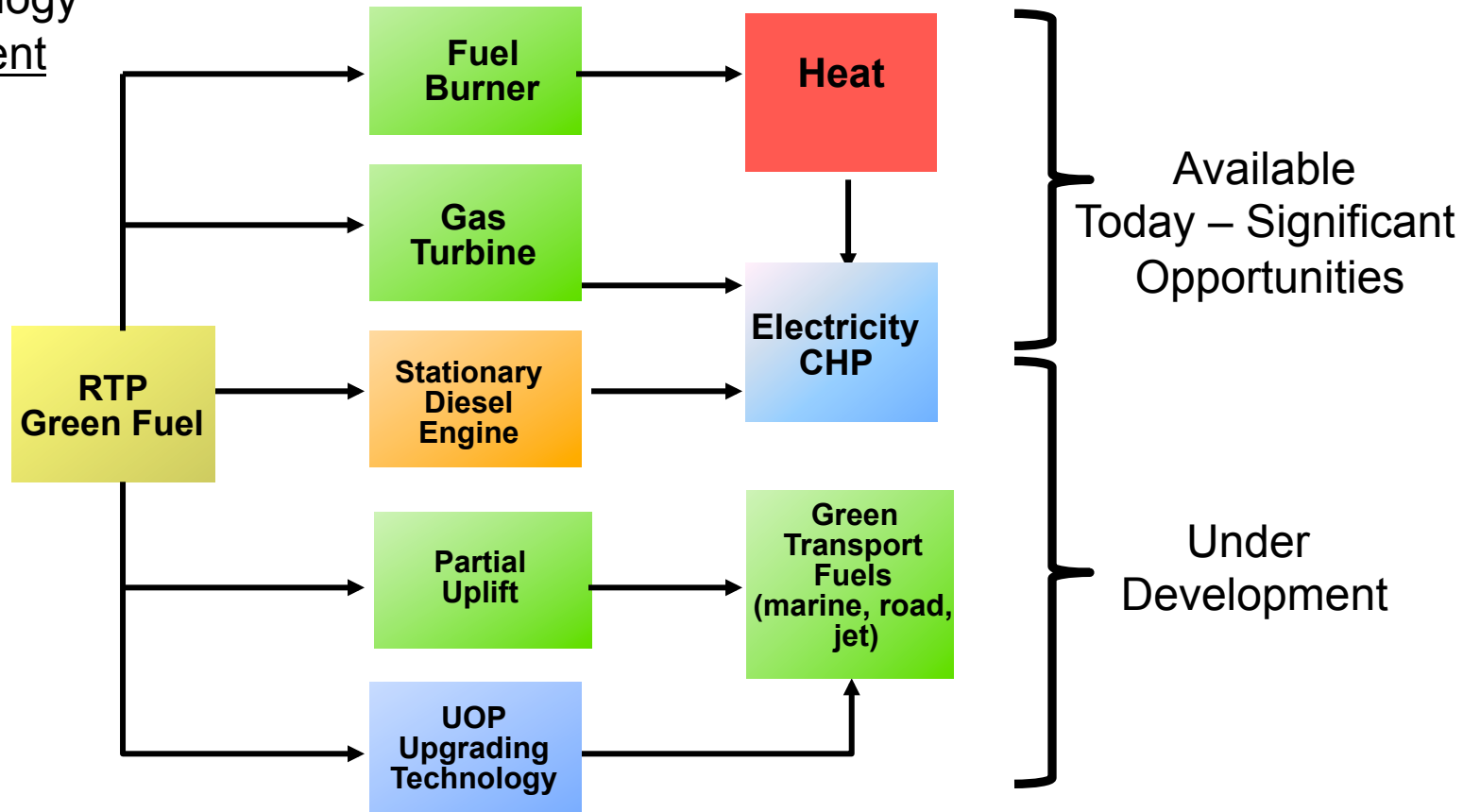


Projects Under Development:

<i>Location</i>	<i>Application</i>	<i>Size (TPD)</i>
Europe	Power Generation	150
Malaysia	Industrial Process Heat	400
Northern Europe	Power Generation	2 x 400
North America	Industrial Process Heat	400
Northern Europe	District Heating	up to 3 x 400

RTP Green Fuel Energy Applications

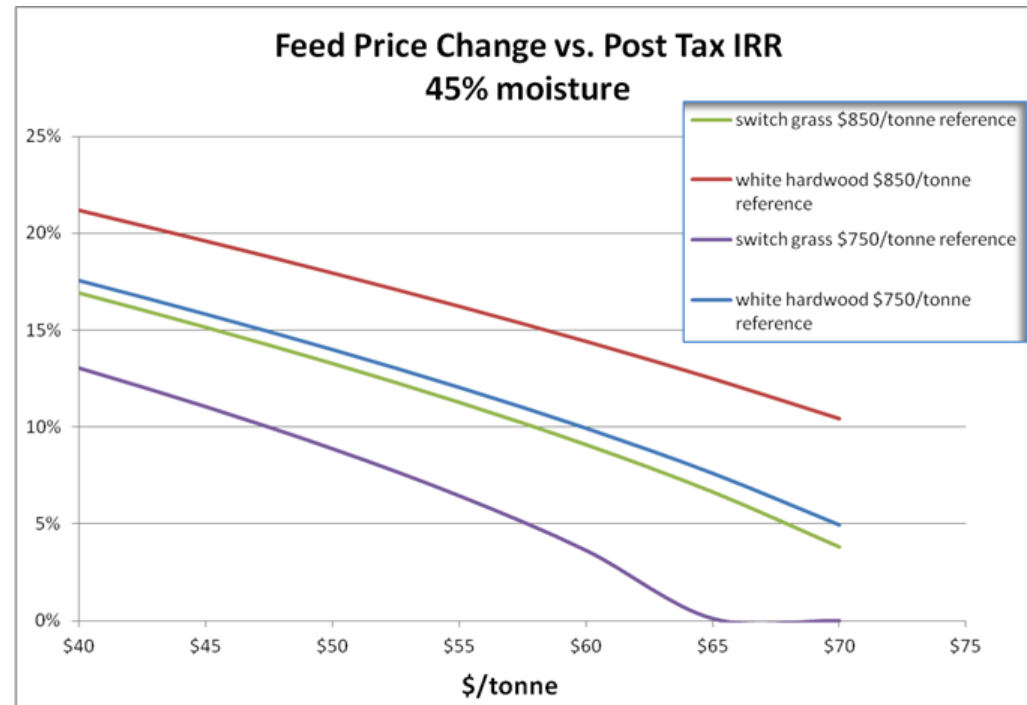
Applications Expand
With Technology
Development



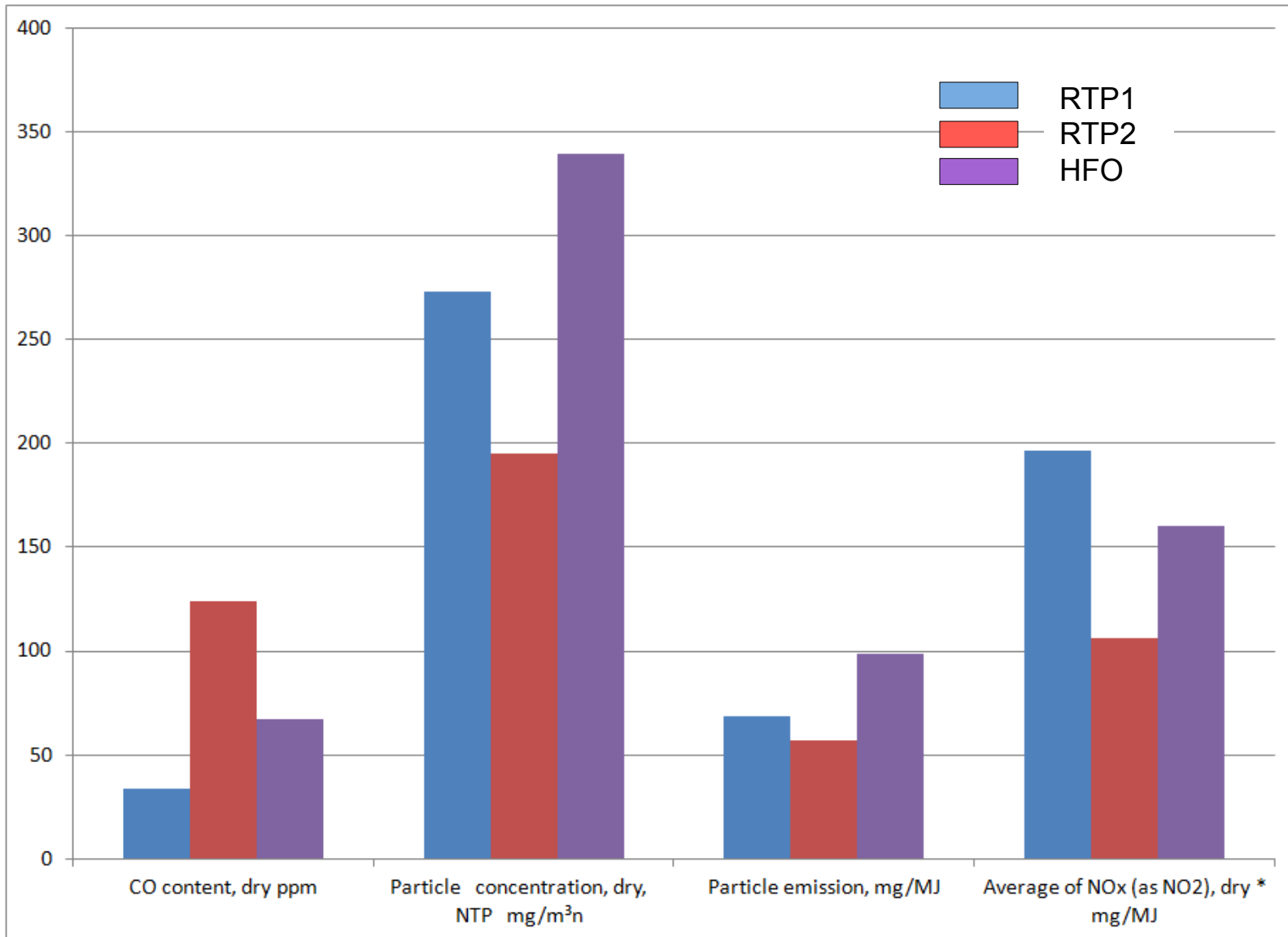
Increasing Applications Broaden Markets and Drive Optionality

RTP Green Fuel - Combustion

- **Over 20 years of industrial experience combusting RTP liquids**
 - Red Arrow, Wisconsin
 - Manitowoc Public Utilities, Wisconsin
 - Over 15 million gallons combusted for heat
- **RTP green fuel can be co-fired or used alone in conventional commercial and industrial boilers with little modification**
- **Combustion emissions compare favorably with heavy fuel oil**
 - SO_x reduction > 99%
 - NO_x emissions depend on biomass nitrogen content

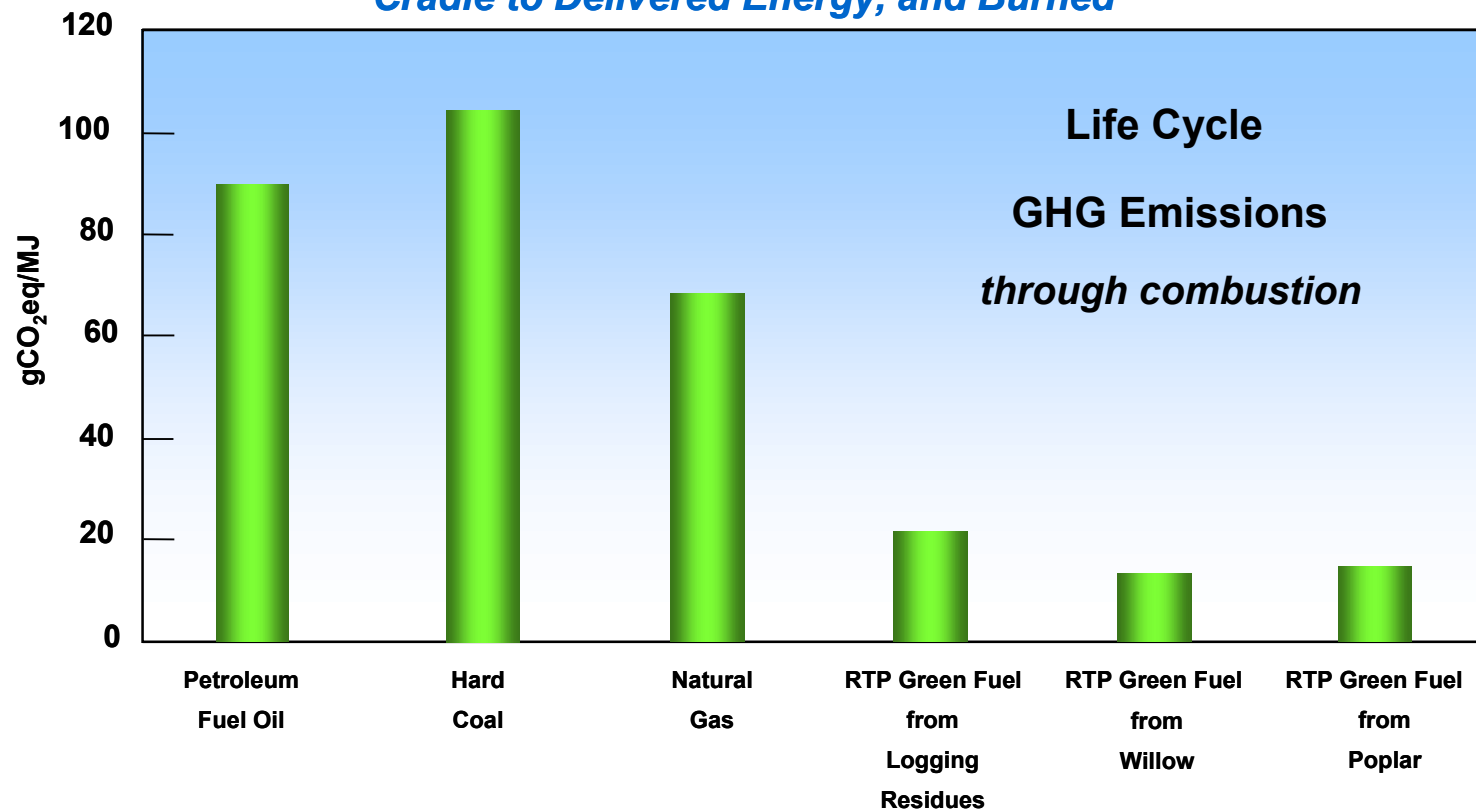


RTP Green Fuel Emissions- Example



RTP Green Fuel vs. Fossil Fuel LCA

Comparison of GHG Emissions Cradle to Delivered Energy, and Burned

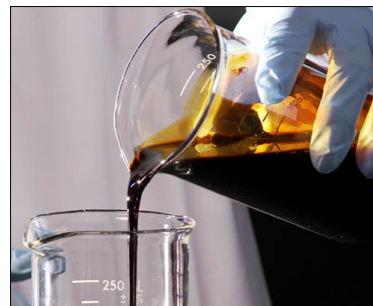
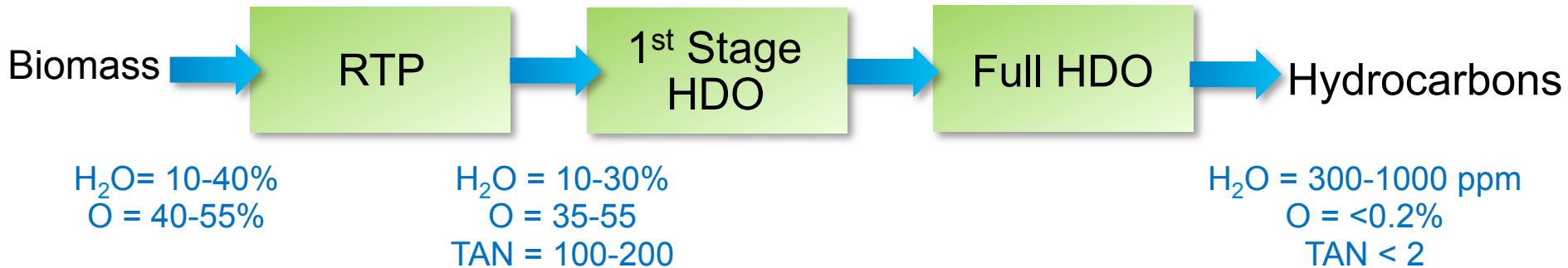


- RTP green fuel **Life Cycle** foot print **Greener** than other alternatives
- Through combustion, 70-88% lower GHG emissions
- SO_x emissions similar to natural gas

Upgrading RTP Green Fuel to Transportation Fuels

- Remove oxygen as water and CO₂ by hydrogen and catalyst
- pH neutral fuel with viscosity equivalent to refined fuels
- Produce high octane gasoline, or diesel/jet precursors

Two Stage Hydrodeoxygenation

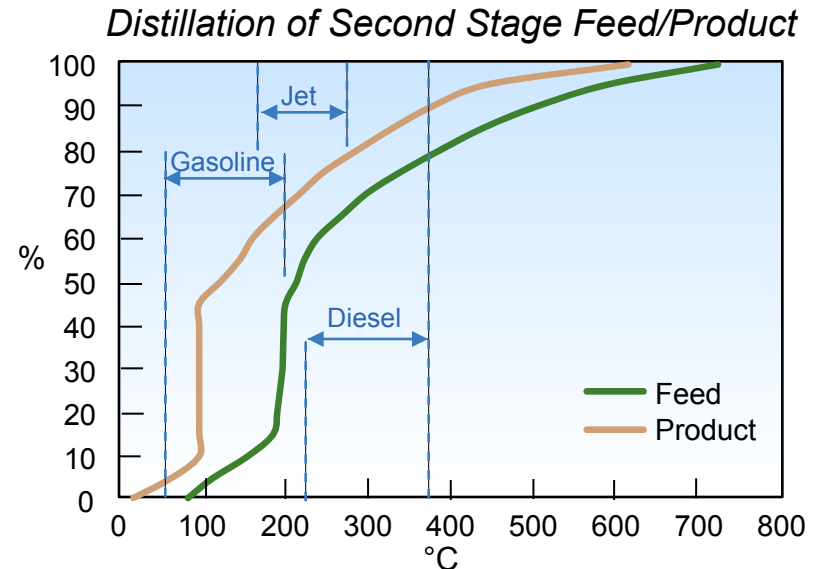


Product Yield and Quality

RTP Green Fuel to Fuels Feed/Product Analysis			
	RTP Green Fuel	Stage 2 Product (Pilot Plant)	Gasoline Requirements
H ₂ O, %	~25	0.03	<0.1
O, %	51	0.25	<2.0
TAN, meq/g	91	<0.1	<0.1

RTP Green Fuel to Liquid Hydrocarbon Yields¹			
	Stage 1	Stage 2	Overall from RTP Green Fuel
Mass Yield %	53	78	41
Volume Yield %	65	93	60

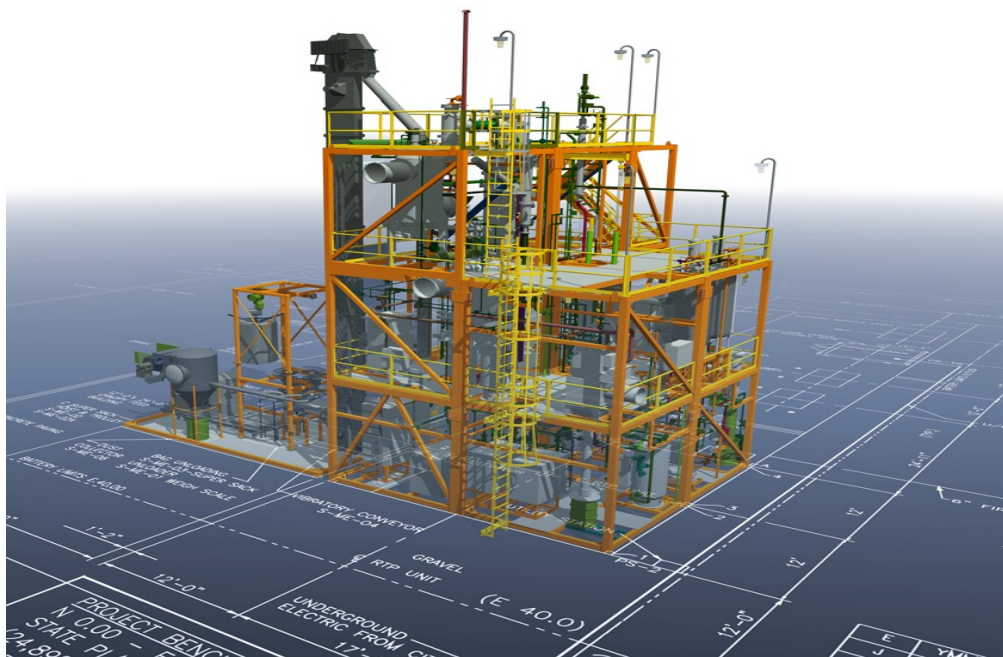
1. Demonstrated yields at multiple equipment scales
 2. Equals **>90 gallons per dry MT** for woody biomass



- **~50-60% of material in gasoline boiling range (IBP-200°C)**
 - RON of gasoline ~ 80-89
 - Passes all tests (color, corrosion, etc) needed as gasoline blend stock
- **~30-40% of material in distillate (jet and diesel) boiling range**
 - Contains paraffins, isoparaffins, naphthenes and aromatics
 - Full Range

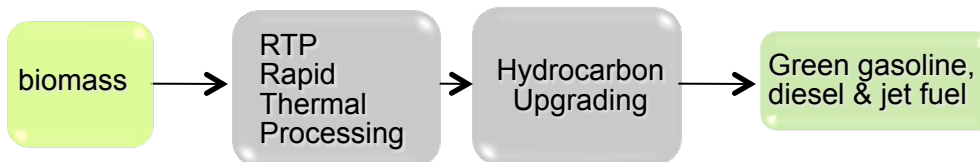
High Yield of Transport Fuels from Biomass

Integrated Biorefinery (IBR) - Biomass to Transportation Fuel Pilot



- Pilot-scale conversion of biomass into liquid transportation fuels
- Located in Hawaii
- Backed by a \$25 million award from the U.S. Department of Energy
- Utilizes a wide range of locally available biomass (switchgrass, algae, forest and agricultural residuals)
- Greater than 60% reduction in greenhouse gas emissions
- Phase 1 start-up in progress
- Fully Operational 4Q 2013

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Making Cellulosic Biofuels a Reality

IBR Site – RTP Unit



IBR Site – Utilities



IBR Site – Control Room/Lab



Summary

- Commercially proven fast pyrolysis process for converting biomass into a renewable liquid fuel
 - Seven units and 20 years of commercial experience
 - High yield of liquid product
- RTP green fuel provides optionality for end-use
 - Heat and power generation applications possible today
 - Significantly improved emissions and carbon footprint relative to combustion of heavy fuel oil
 - Can be upgraded to transportation fuels at high yields in the near future

