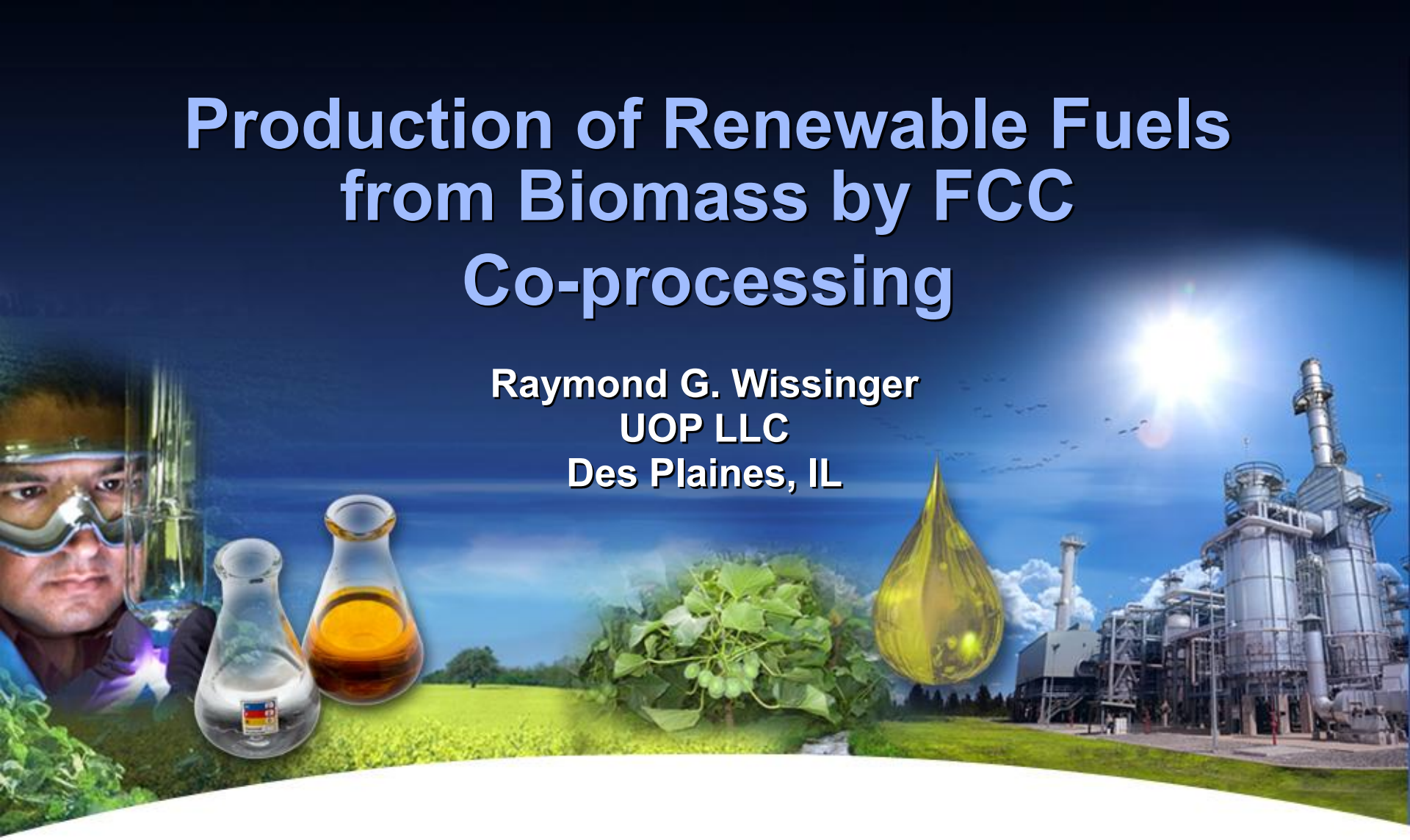
Production of Renewable Fuels from Biomass by FCC Co-processing



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UOP
A Honeywell Company

Presentation Outline

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- Background on UOP
- Overview of FCC Co-processing
- Implementation and Future Plans
- Q&A

Who is UOP?

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Honeywell UOP creates knowledge via invention and innovation and applies it to the energy industry

- 1,570 scientists and engineers
- 3,000 employees worldwide
- 2,600 active patents
- Expertise
- Experience

- Process technology
- Catalysts
- Adsorbents
- Equipment
- Services

Petroleum

Petrochemicals

Natural Gas

Renewables

More than 60% of the World's Gasoline & 85% of Biodegradable detergents are made using UOP Technology

UOP Renewables Vision

- Building on UOP technology and expertise
- Produce real "drop-in" fuels instead of fuel additives/blends
- Leverage existing refining, transportation, energy, biomass handling infrastructure to lower capital costs, minimize value chain disruptions, and reduce investment risk
- Focus on path toward second generation feedstocks & chemicals

Oxygenated Biofuels

Ethanol

Biodiesel

Renewable Energy

Fuel & Power

Hydrocarbon Biofuels

Diesel

Jet

Gasoline

"Other" Oils: Camelina, Jatropha

First Generation

Natural oils from vegetables and greases

Second Generation

Overview of Co-processing

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- **Renewable Fuel Oil (RFO) Refinery Co-processing**
  - Co-processing of Renewable Fuel Oil (RFO) with vacuum gas oil (VGO) in a Fluid Catalytic Cracking Unit (FCCU) to produce fully fungible, renewable gasoline and diesel
  - RFO is produced from biomass by a technology known as Rapid Thermal Processing (RTP™)
  - Strong value proposition for refiner – small incremental capital cost and strong potential upside from regulatory credits
- **RFS2 value generation**
  - RFS2 credits generated *at the refinery*
- **UOP technical support**

Advantages of Co-Processing

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- RFO is a cost-effective renewable refinery feedstock
  - Produces gasoline and diesel – no blending/blendwall issues, no dedicated downstream infrastructure
  - Reduces compliance cost volatility with biofuel price linked to biomass cost
- RFS2 credits generated at the refinery
  - Reduces cost of compliance due to RIN validation tracking
  - Potential to convert regulatory exposure to profit generator
- Easy to implement – minor capital costs related to RFO storage and feed injection equipment
- UOP can provide equipment and operations expertise

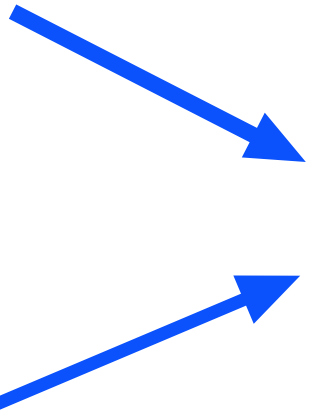
Roles

UOP

- Engineering & Supply of RTP™ Equipment to RFO production projects, with performance guarantees
- Specification of RFO delivery equipment & supply of key equipment to refiners
- FCC Technical Service

Ensyn Corporation

- Developer of RTP™ technology
- Developer of projects producing RFO
- Contracts with refiner for RFO supply



Biomass to Fuels via RTP™ and FCC Processing

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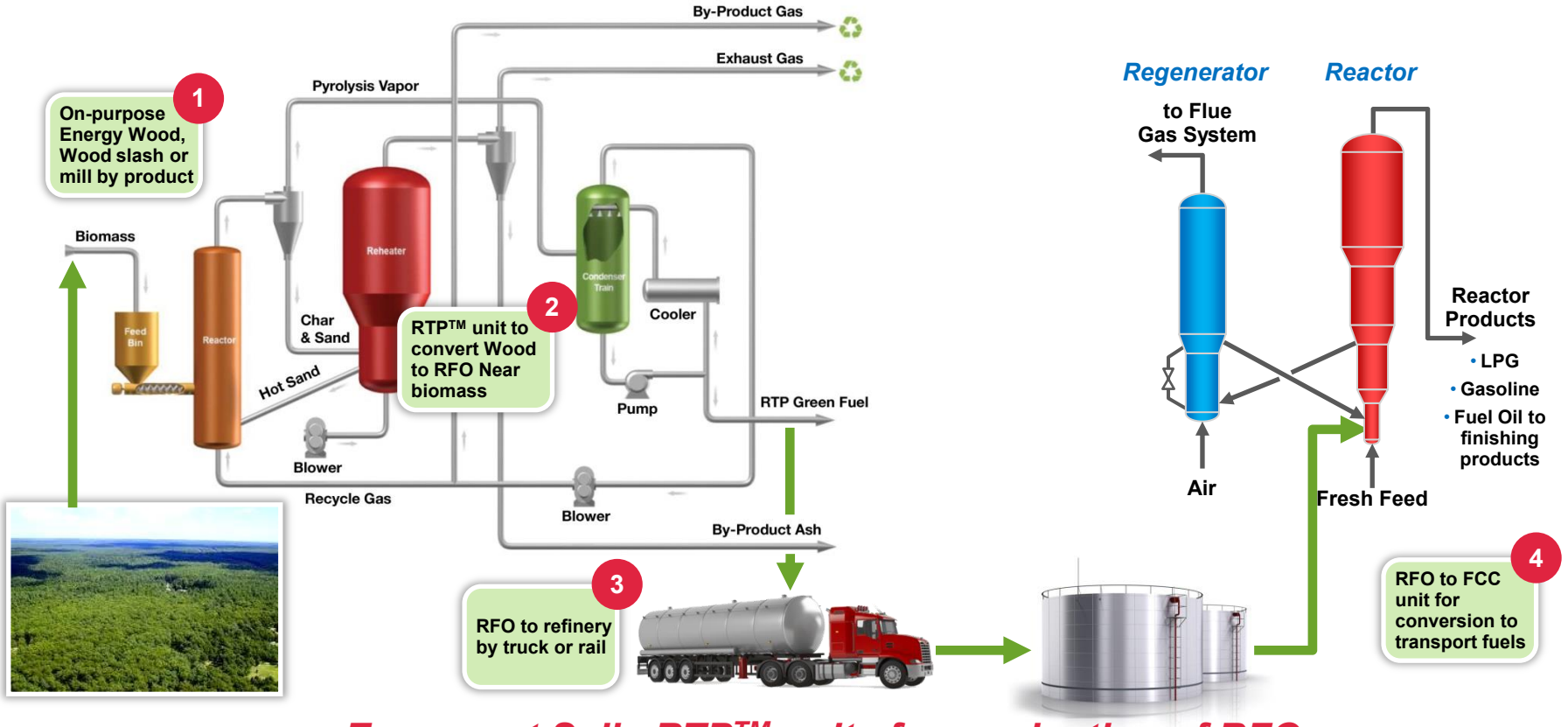
Key Supply Chain Steps

1) Use locally available woody biomass
2) Convert it to RFO at nearby RTP™ unit
3) Ship RFO to Refiner who has an FCC unit
4) Refiner injects RFO into FCC to make transport fuels



Envergent Sells RTP™ units for production of RFO

UOP Sells Service, License, Equipment, & Engineering into FCC Markets

RFO Properties

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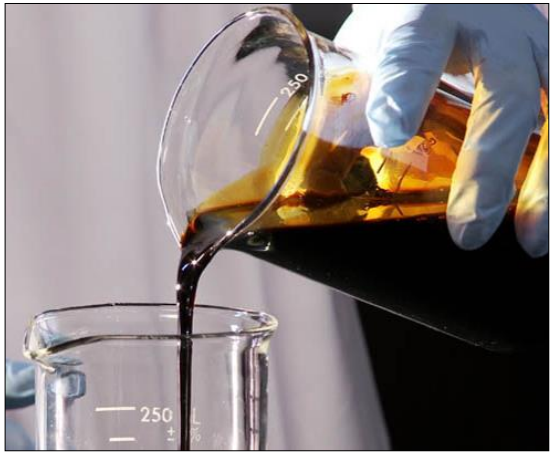
- RFO is a liquid product made from non-food, woody biomass using a fast thermal conversion process known as Rapid Thermal Processing or RTP™
  - RFO is essentially "liquid wood"
  - Complex mixture of carbon, hydrogen and oxygen containing compounds (aldehydes, phenolics, acids, alcohols, etc.)
  - Typically contains ~20-30% soluble water
  - Specific gravity ~1.1-1.2
  - pH typically ~2-3
  - Single phase liquid, susceptible to solidification or phase separation if exposed to temperatures above ~200°F

- Viscosity of RFO is more temperature dependent than petroleum oils; typically fluid at 70°F but tends to get very viscous below ~50°F



Basic Concept of FCC Co-processing

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- Refiner can inject RFO at low concentration (typically < 5 vol% of total feed) in FCC riser
- Ensyn can supply RFO for short-term trials via truck and can also supply a skid-mounted pumping system to transfer to the FCC unit
- UOP can supply injection equipment
- Refiner can make connections for meter flows, etc.
- Long-term RFO can be supplied initially from existing Ensyn facilities and later from newly-built RTP™ units owned by project developers (large forest products companies, etc.)

Desirable FCCU Characteristics For Co-Processing

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1. Unit operating under capacity (room to add more feed)
2. Unit with excess regenerator capacity (capacity to burn additional coke) or in partial burn operation, excess CO boiler capacity (ability to combust additional CO)
3. Smaller units (~20,000 BPD or less) can facilitate initial RFO supply, but this is not limiting
4. Long term supply of RFO is not an issue, as dedicated RTP™ capacity will be constructed per the off-take agreement between Ensyn and the refiner
5. Increased coke production can be accommodated in one of two ways:
   - In high delta coke units, the incremental coke from RFO is not significant; more heat can likely be handled by existence of a cat cooler
   - In low coke yield units, where main column bottoms (MCB) recycle or torch oil are being used to generate heat, RFO could produce heat instead
6. Well mass-balanced gas concentrator so small flow changes due to yield from the RFO addition can be determined
7. Units targeting max distillate with no petrochemical propylene production or alky unit

Future Plans

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- **Multiple independent trials**
  - Lab scale tests
  - Circulating Riser/Regenerator Pilot Plant trials
  - Commercial refinery demonstrations
- **Performance may vary depending on the FCC unit operation**
  - Catalyst type
  - Feedstock
  - Heat balance

Questions?