Replacing the Whole Barrel
DOE Biomass 2011
July 27, 2011

SynTerra Energy

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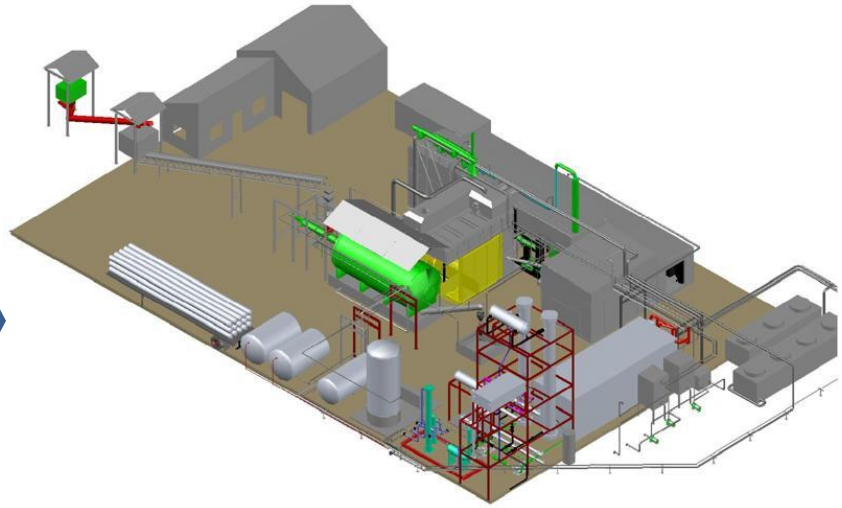
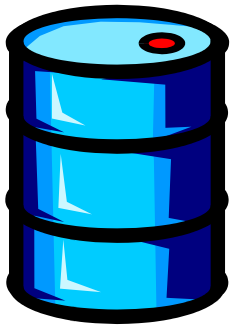
Opportunity

The opportunity for using waste biomass to replace the whole barrel exists with the right conversion pathway and technologies.

Waste Biomass



Conversion Technology



Opportunity to replace the whole barrel

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History

1999 to 2006

PRFC founders work on numerous pilot projects and identified key gaps in renewable energy conversion technologies.

PRFC is founded to address major technology gaps in biomass-to-energy

2007

RLB starts working on innovative Thermo Chemical Conversion Technology

PRFC conducts R&D on core technologies.

RLB builds 10 ton per day biomass to syngas pilot plant

PRF expands its core management and technical team.

2008

RLB makes significant technology improvements

PRFC secures additional investment to validate technology

Pilot demonstrations of technology conducted.

RLB operates plant and fuels University of Toledo Energy Center providing energy to local hospital

2009

Optimized pilot plant. performed integrated direct-to-diesel operations with PRFC

$25M DOE award to PRFC and partners to further commercialize Syntrex™ technology

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2010

Execution of DOE Toledo IBR Project

Execution of DOE Toledo IBR Project

2011

Planning and engineering for commercial plants

Planning and engineering for commercial plants

Requirements

- ✓ **Feedstock Flexibility –** platform should accept a wide variety of cellulosic and waste feedstocks with varying size, water content, and composition
- ✓ **Produces a Range of Products –** shifts in product selectivity should be possible with the potential to 'replace the whole barrel'
- ✓ **Produces 'Drop-In' Products –** system outputs are direct petroleum replacements that are infrastructure compatible
- ✓ **Functions Economically at Distributed Scales –** requires simplified process with high energy efficiency and efficient use of capital
- ✓ **Ability to Co-Locate –** where appropriate, platform can be co-located with refineries, blenders, other existing energy infrastructure
- ✓ **Ability to Gain Regulatory Acceptance –** no major stumbling blocks related to project permitting (water, air, ash, etc.) and product acceptance (EPA, ASTM, etc.)

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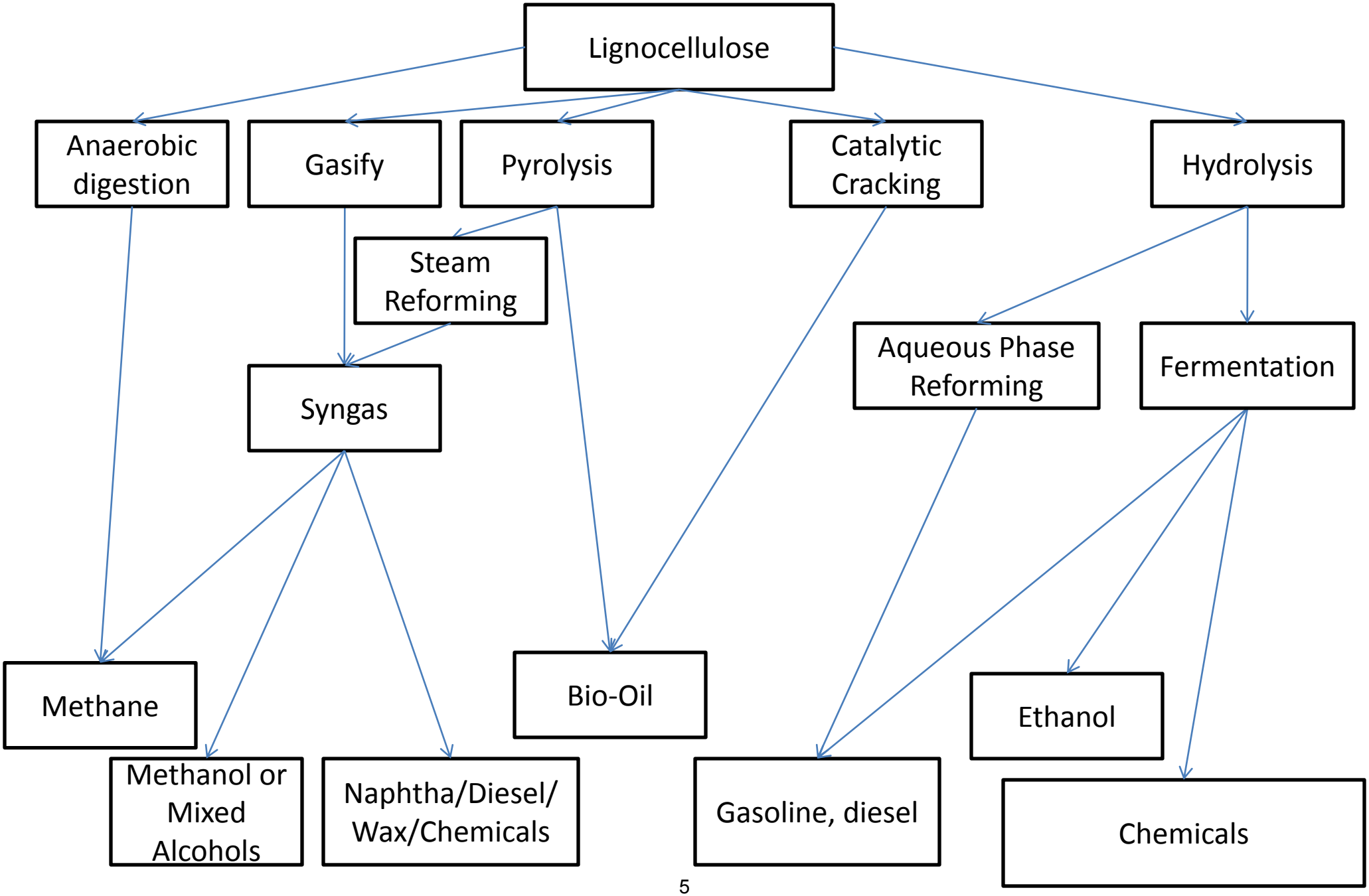
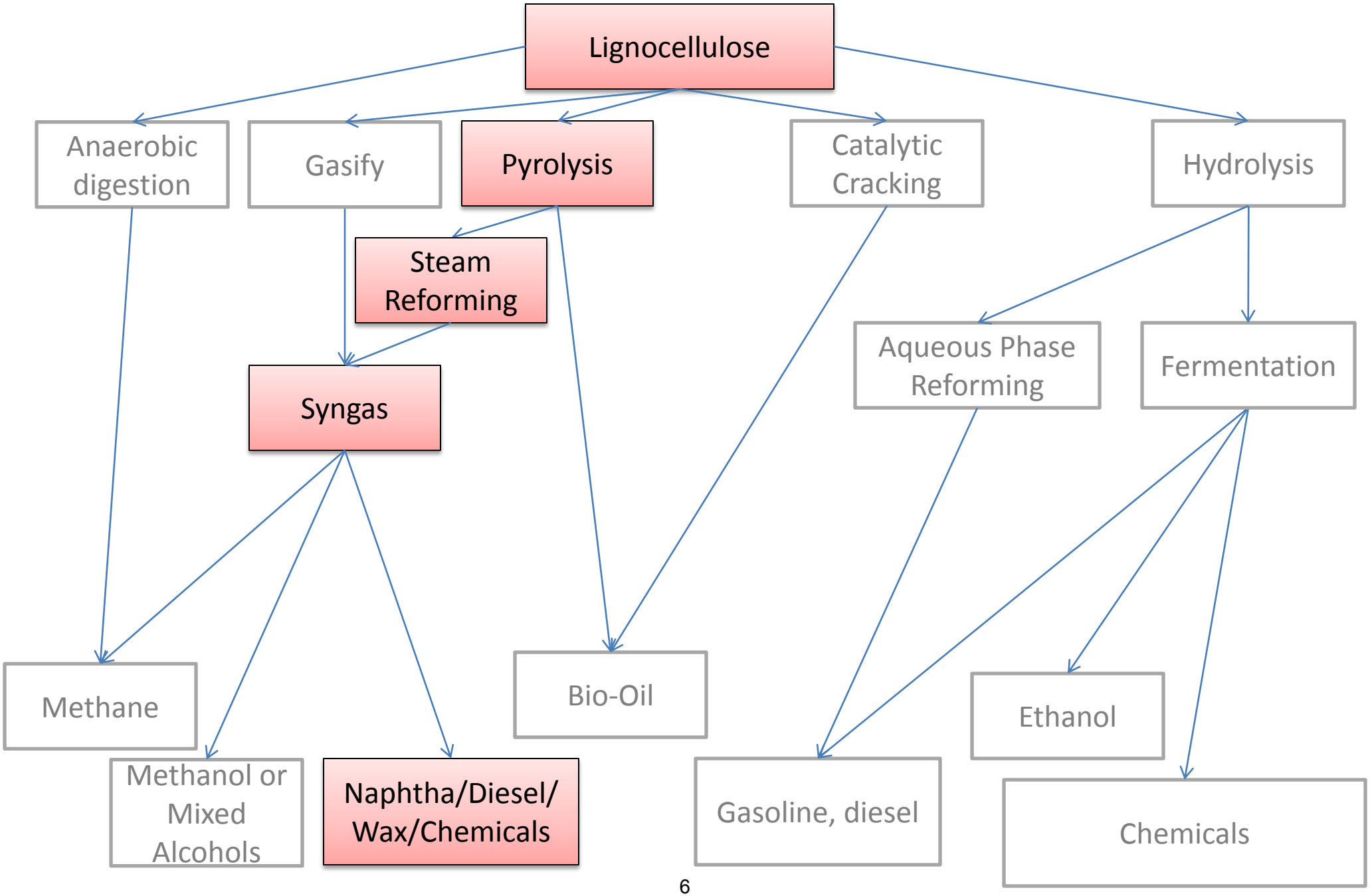
Pathways


Lignocellulose
Anaerobic digestion
Gasify
Pyrolysis
Catalytic Cracking
Hydrolysis
Steam Reforming
Syngas
Aqueous Phase Reforming
Fermentation
Methane
Bio-Oil
Ethanol
Methanol or Mixed Alcohols
Naphtha/Diesel/ Wax/Chemicals
Gasoline, diesel
Chemicals

Pathways


Lignocellulose
Anaerobic digestion
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Steam Reforming
Syngas
Aqueous Phase Reforming
Fermentation
Methane
Bio-Oil
Ethanol
Methanol or Mixed Alcohols
Naphtha/Diesel/ Wax/Chemicals
Gasoline, diesel
Chemicals

Pathway

Syntrex™ Process

Integrated Biorefinery System Designs
(300 – 2000+ tons per day)

Waste Biomass

Syntrex™ Thermochemical Conversion

(Pyrolysis + Steam Reforming)

Syngas

Syntrex™ Fuel Catalysts

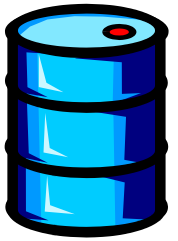
Syntrex™ Catalytic Reactor

Syntrex™ Chemicals Catalysts

Diesel Fuel

Syntrex™ Products

Product Fractionation



Hydrocarbon Products

Adaptive Control System Platform

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Technology

- ✓ **Feedstock Flexibility:**
  - ✓ Thermochemical platform that can utilize a variety of waste biomass feedstocks with the ability to accept high water content biomass
- ✓ **Produces a Range of Products:**
  - ✓ Unique pyro/SR design (in absence of oxygen/air) significantly reduces formation of syngas contaminants and dilution with N_2 typically encountered with air-blown gasifiers
  - ✓ Produces ideal syngas H_2/CO ratio for downstream processes, eliminating need for water-gas shift unit and thus reduces CO_2 formation and dilution of syngas
  - ✓ Syngas (H_2 + CO) is the ideal building block for many hydrocarbon products
  - ✓ Proprietary "designer" hydrocarbon chain-limiting catalyst produces direct-to-diesel product, eliminating the need for hydro-processing (wax upgrading) units
  - ✓ Product selectivity can be shifted heavier or lighter depending on catalyst / conditions

Secretary of Energy Steven Chu, Secretary of Agriculture Tom Vilsack, and Congresswoman Kaptur at $25M DOE Award

www.synterraenergy.com/media
(Effect of Oxygen on the Formation of Contaminants in Syngas)

Technology

Produces 'Drop-In' Products

- ✓ Products are compatible with existing transportation infrastructure

Functions Economically at Distributed Scales

- ✓ Process minimizes unit operations and has high energy efficiency
- ✓ The use of process water and tail gas, generated during the process, provides the plant with self-sustaining utilities following start-up

Ability to Co-Locate

- ✓ Where appropriate, plants can be co-located with existing refineries, blenders, chemical manufacturers, or power producers to provide lowest capital cost per unit of output product

Ability to Gain Regulatory Acceptance

- ✓ Water is recycled, minimizing water clean up and discharge; ash is benign
- ✓ F-T type products are well known

Syntrex™ Commercial Demonstration Plant
Toledo, Ohio

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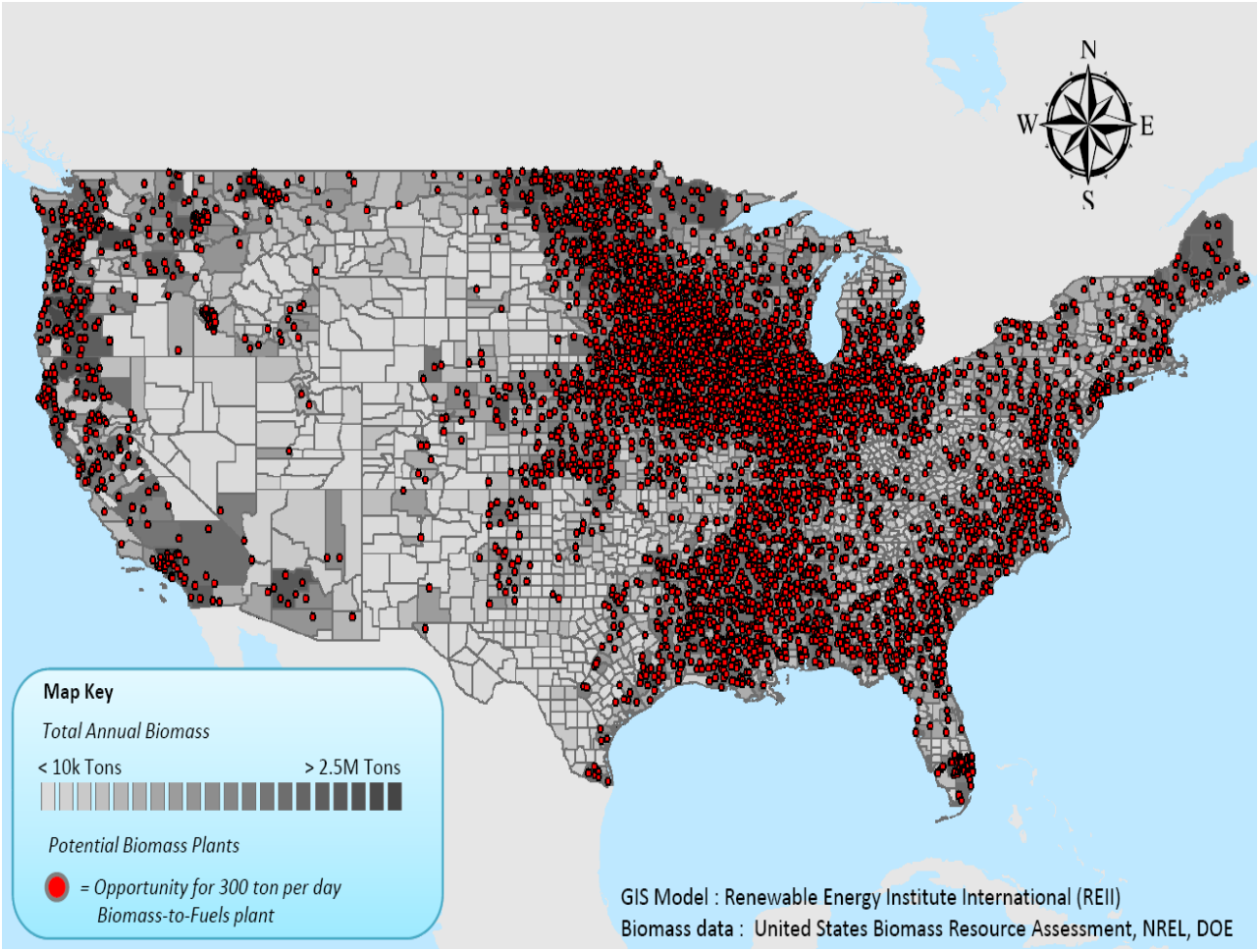
Market Potential

Over 1 billion tons of waste biomass are generated each year in the U.S., which can potentially supply 10,000 – 300 dtpd plants.



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Jobs

Number of New U.S. Jobs Created from the Deployment and Operation of Synterra Plants that Produce ~1.5 Billion Gallons/Year of Synthetic Diesel Fuel (2.5% of potential plants by 2030)

U.S. Job Category	# Direct and Indirect Jobs
Production of Components by U.S. Suppliers	5,100
Plant Construction (including component transportation)	3,145
Plant Operations, Management and Maintenance	5,984
Fuel Storage, Transportation and Distribution	2,720
Local Supporting Businesses (biomass suppliers, hotels, restaurants, real estate, etc.)	16,949
Research, Development, Product Testing & Marketing	6,520
Jobs created by Reduction in Oil Imports and Improvement in the U.S. Balance of Trade	40,344
Total	80,762

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Products from a Barrel

Gasoline = 47%
Diesel = 27%
Jet Fuel = 7%
LPG = 10%
Other = 9%

Source: EIA

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Replacing the Whole Barrel

Light Gases:

Typically used for parasitic load in Syntrex process

Renewable power

Bio-plastics

Economics challenging due to ample natural gas/LPG supplies in U.S.

Naptha/Jet:

Highly paraffinic, low sulfur, low aromatic content

Potential to blend with gasoline

2% blend of Syntrex naptha in the U.S. would require 1000s of plants

Other applications include: Solvents, drilling fluids

Diesel:

Syntrex product is clear liquid, free of sulfur, and has high cetane

Pour point properties similar to biodiesel

Offers up to 50% reductions in vehicle emissions

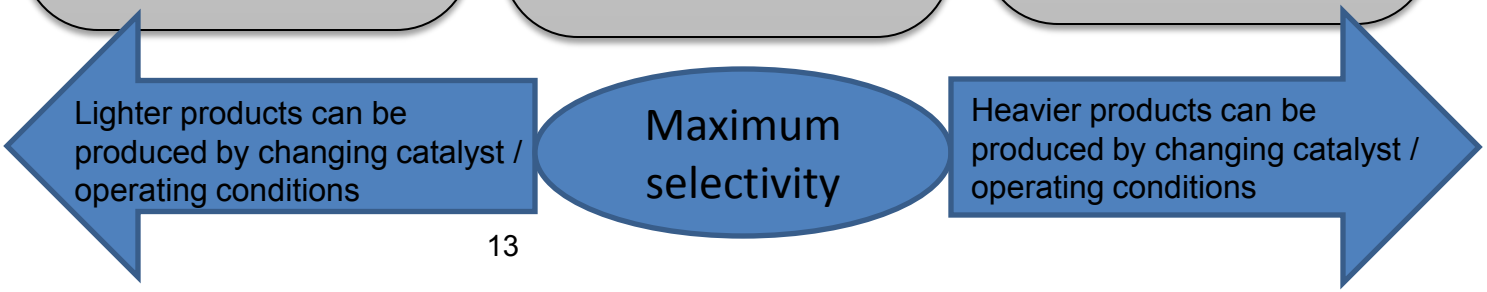
Ideal as premium blend stock, can be used neat in some markets

Wax and Specialty Products:

Waxes can be blended with oil and used in refineries

n-paraffins ideal as surfactant intermediaries

Other specialty chemicals possible including waxes, mixed alcohols



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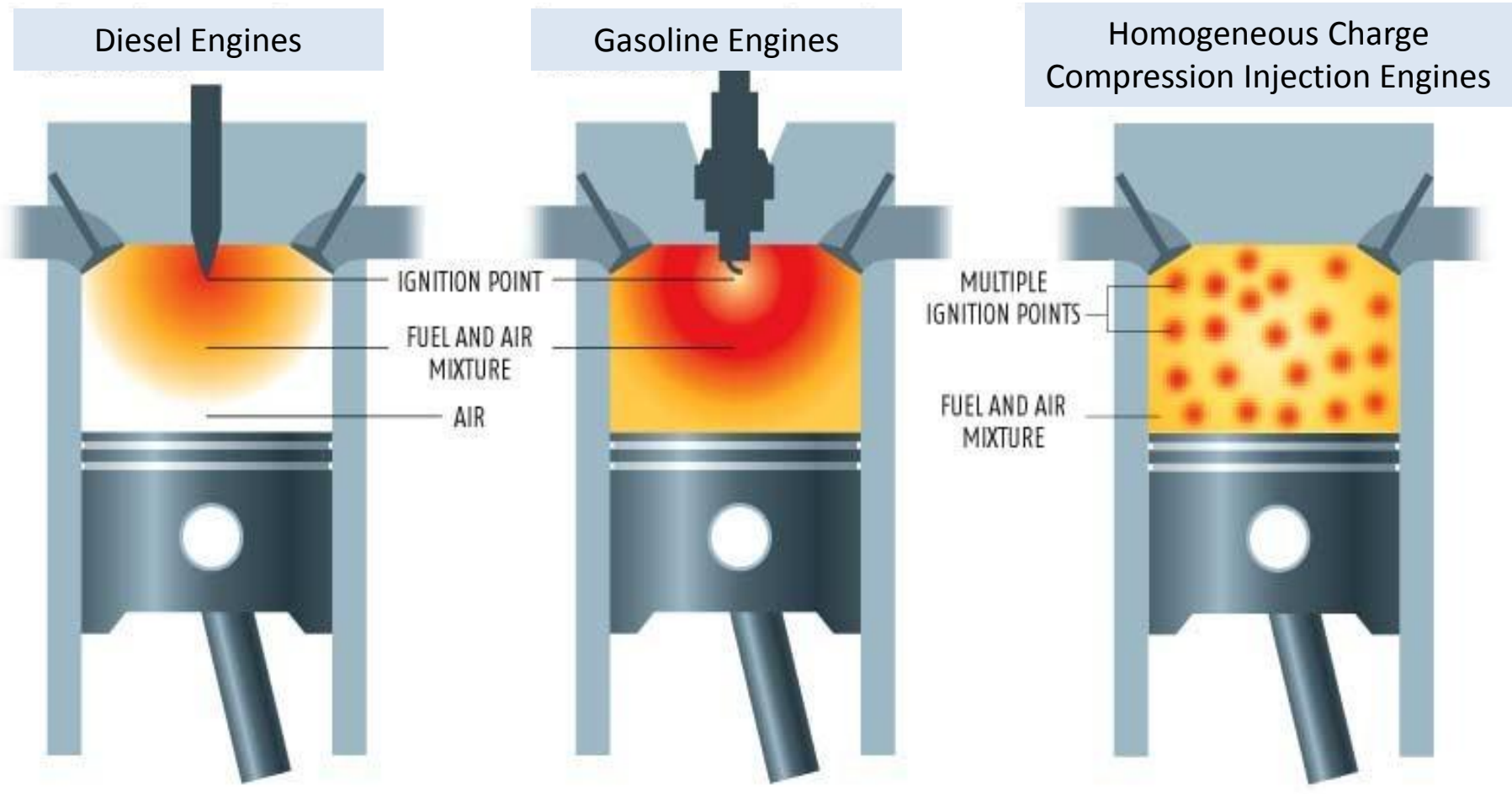
Ideal Fuel

Synthetic Fuels - Ideal for Current and Future Engines



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(HEI Paper – "The Future of Vehicle Fuels and Technologies")

Conclusion

- ✓ Integrated Bio-refinery Economics are most sensitive to:
  - ✓ (1) price of oil
  - ✓ (2) products produced
  - ✓ (3) capital and operating costs (including feedstock costs)
- ✓ The opportunity to replace the whole barrel using biomass feedstocks is possible

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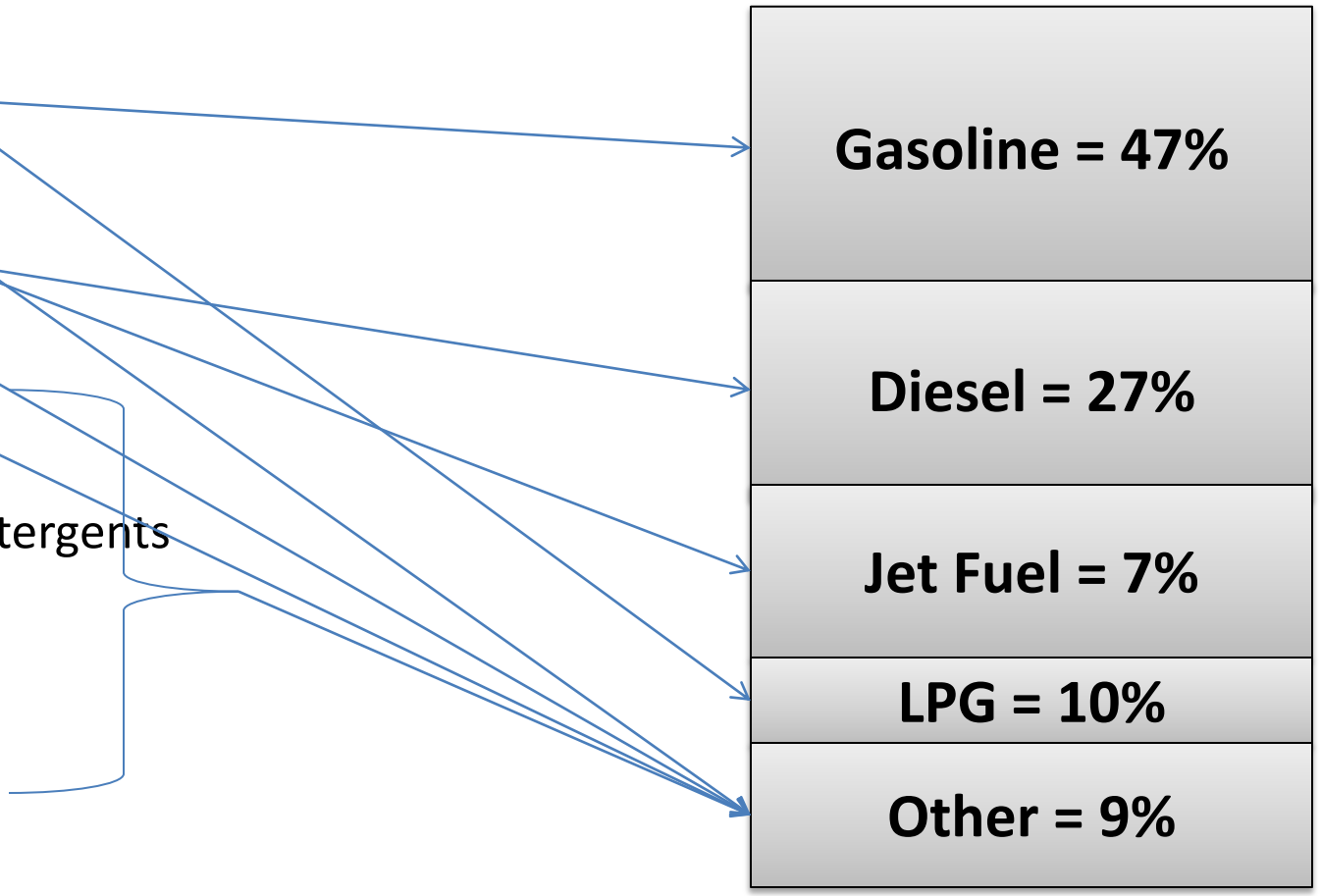
Replacing the Whole Barrel

- Light gases
- Naptha
- Jet
- Diesel
- Wax
- High purity solvents
- Steam cracker feed
- Linear alkanes for detergents
- Lamp oil
- Lubricant basestock
- Specialty waxes



Source: EIA

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