Creating a Sustainable Biomass Infrastructure

Market Issues & Challenges

P. Nair
UOP LLC, USA

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Biorenewables as transport fuels

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Drivers

- **Petroleum cost and availability**
- **Mandates and incentives**
- **GHG emissions**

Issues

- Availability
- Costs
- Transportation
- Composition

Biofuels – Market Drivers/Risks & Uncertainties

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Market drivers

- Higher crude prices: Longer term projections of >$50/bbl
- Energy Independence: Reduction of energy import dependence
- Geopolitical concerns affecting security of supply
- Global warming

Biofuels

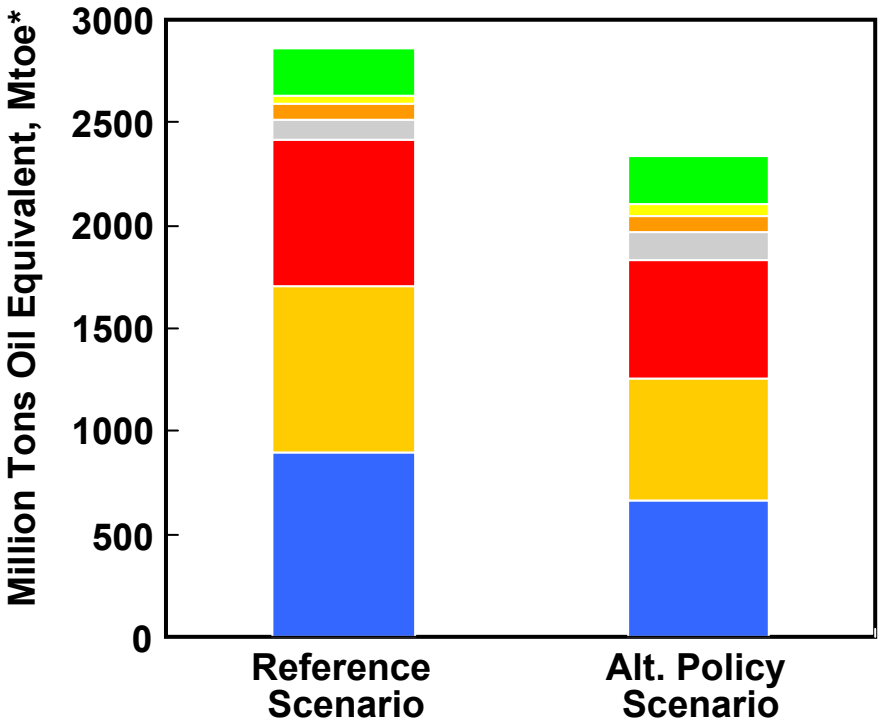
- GHG emission reduction
- MTBE replacement in RFG
- Government mandates and targets
- Fiscal incentives and tax credits
- Job creation for agricultural community

Risks & Uncertainties

- Feedstock availability
- Government policy towards renewables changing
- Crude prices declining significantly
- Distribution channels constraining market growth
- Fleet turnover with the right engine technology keeping pace with the growing biofuels market

Biofuels is the only renewable contributor to transport fuel mix

2004-2015:
Incremental Global Energy Demand



	Reference Scenario	*Alternative Policy*
Biomass waste other renewables	1.7% / yr	1.8% / yr
Hydro	2.5% / yr	2.6% / yr
Biofuels	12.1% / yr	15.1% / yr
Nuclear	1.2% / yr	1.6% / yr
Gas	2.5% / yr	2.0% / yr
Oil	1.7% / yr	1.3% / yr
Coal	2.6% / yr	2.0% / yr
Primary Energy	2.1% / yr	1.7% / yr

Shifting Towards Conservation & Alternatives

Biofuels are Fastest Growing Segment

Macromarket Summary: 2004-2015

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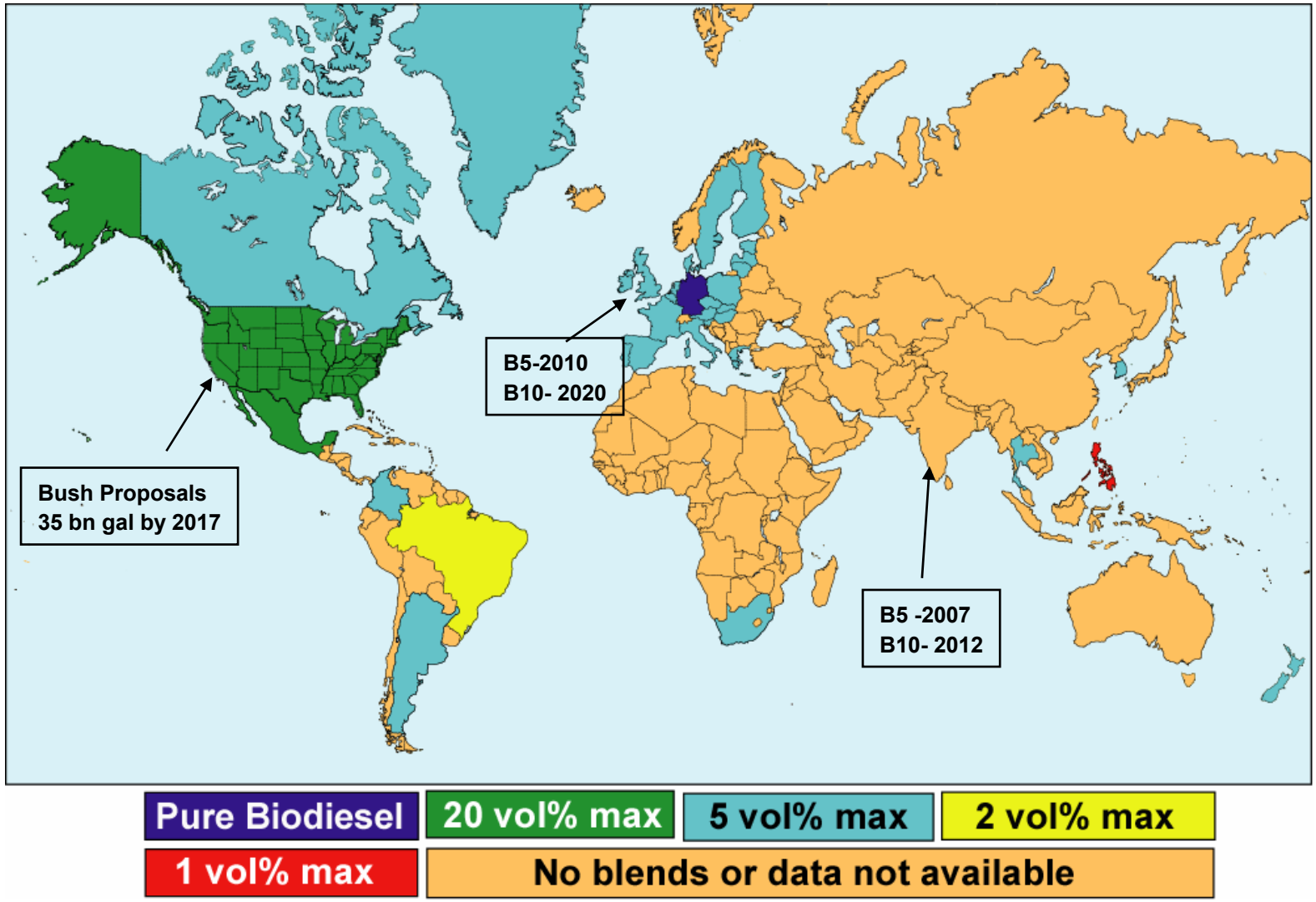
- **Global energy demand is expected to grow at CAGR 1.7%.**
  - **Fossil fuels are expected to supply 83% of energy and 95% of liquid transportation needs.**
  - **Alternate liquid transportation fuels are expected to grow at ~7.3%/yr from 2.3 million BPD to ~5 million BPD.**
  - **Biofuels are expected to grow at 15%/year:**
    - 2004 – 430,000 BPD
    - 2015 – 2.1 million BPD
- **Biofuels could grow to much higher levels, if the latest US and European targets become law.**
- **Feedstock diversity will become increasingly important over this period with coal, natural gas & renewables playing bigger roles.**

Biodiesel Blend Limits – 2006 Data



Source: IFQC, 2006.

Biorenewables in Oil Refineries

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Drivers
- Petroleum cost and availability
- Mandates and incentives
- GHG emissions

Issues
- **Availability**
- **Costs**
- **Transportation**
- **Composition**

Biomass Processing Routes - Diesel

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- **Feedstocks**
  - **Vegetable Oil**
    - Soy
    - Palm
    - Rapeseed/Canola
    - Sunflower
    - Jatropha - Inedible
  - **Tallow (Animal Fats)**

1st generation

  - **Biomass**
    - Corn stalks
    - Forest waste
    - Switchgrass
  - **Algal Oils**

2nd generation

- **Processing Routes**
  - **Current**
    - FAME
    - FAEE
    - Co-Processing
    - Hydroprocessing
  - **Development**
    - Pyrolysis Oil / Hydroprocessing
    - Algal Oils
    - Biomass Gasification
    - Direct Conversion (Hydrocracking)

Many feedstocks and potential processing routes. Generation 2 – no clear winners yet

Current Biofuels Production

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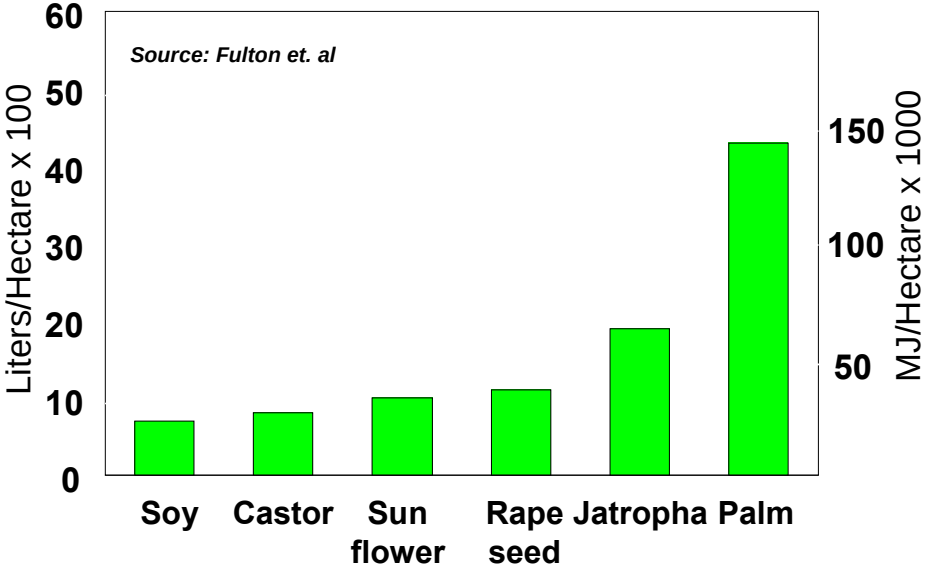
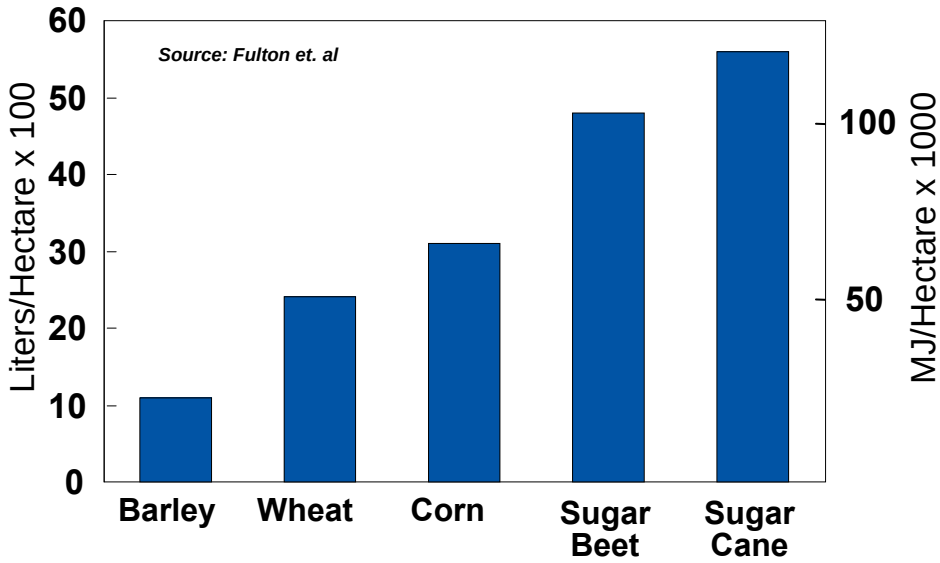
Biodiesel Production from Oils



Ethanol Production from Sugars



Source: Fulton et. al

India - Biofuel Substitution	*Jatropha* *Million Hectares*	*Sugar Cane* *Million Hectares*
10% Petrol Substitution		0.3
10% Diesel Substitution	6	

Basis
Diesel –50M MTA
Petrol - 10M MTA

Equivalent to the land masses of Kerala & Goa

Enablers for a Sustainable Biomass Infrastructure

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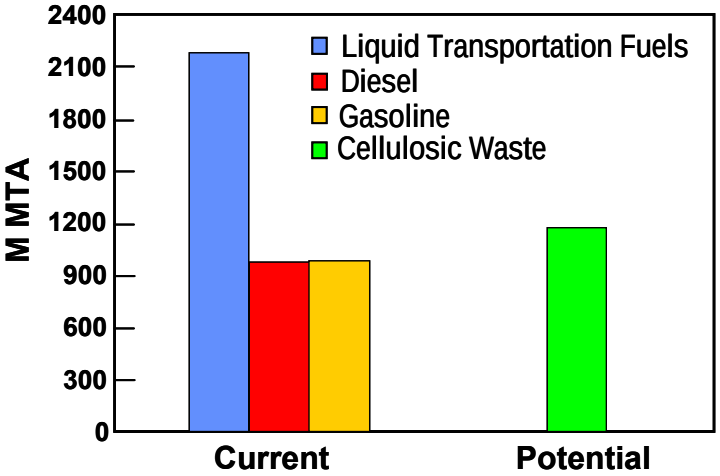
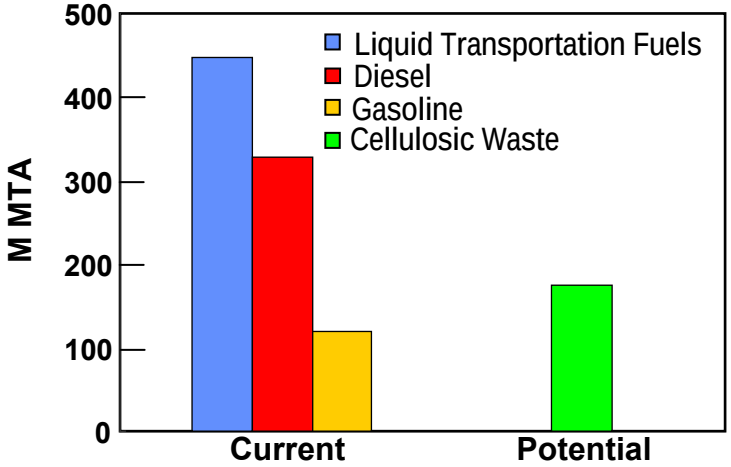
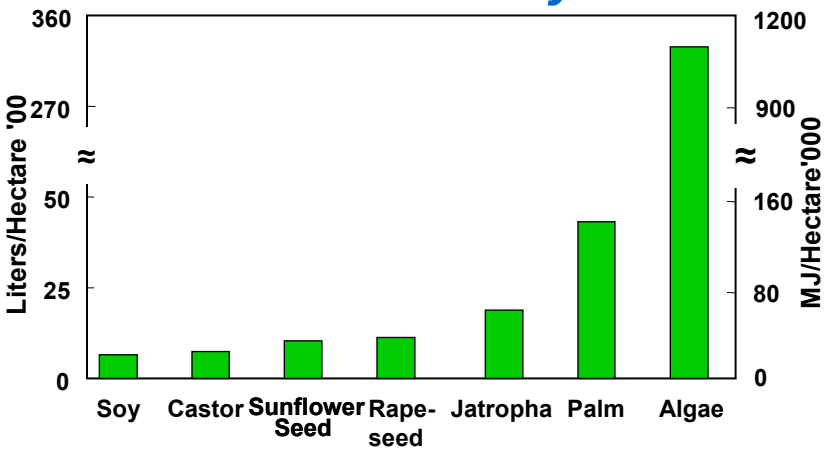
Global



EU



Oils Productivity



- **Cellulosic waste could make a significant contribution to liquid transportation pool.**
- **Algal Oils could enable oils route to biodiesel, green diesel and jet fuel.**

Increases Availability, Reduces Feedstock Cost
Technology Breakthroughs Required

Source: Transportation fuels are from Pervin & Gertz Tables II-3 and II-4, 2007 Consumption, Europe

Biorenewable Feeds: Costs

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Bio Feedstock	*Price ($/bbl)*	*Price ($/gal)*
WTI/Brent Crude	68	1.62
Rapeseed oil (Canola)	89	2.13
Soy oil	75	1.79
Palm oil	62	1.47
Jatropha oil	44	1.05
Pyrolysis oil-high	58	1.39
Pyrolysis oil-low	15	0.35

Palm oil prices have doubled over the past 2 years. Feedstock flexibility critical for biofuel production.

Biorenewable Feeds: Composition

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	Crude Typical	*Resid*	*Soyoil*	*Yellow Grease*	*Pyrolysis Oil*
% C	83-86	84.9	77.6	76.4	56.2
%H	11-14	10.6	11.7	11.6	6.6
%S	0-4 (1.8avg)	4.2	.0006	.04	-
%N	0-1 (.1avg)	.3	.0011	.03	.3
%O	-	-	10.4	12.1	36.9
H/C	1.8-1.9	1.5	1.8	1.8	1.4
Density	.86(avg)	1.05	.92	.89	1.23
TAN	<1	<1	2	30	78
ppm alkali metals	60	6	100	100	100
Heating value kJ/kg	41,800	40,700	37,200	37,200	15,200

Feed characteristics present processing challenges

Timeline of Commercialization of Technologies

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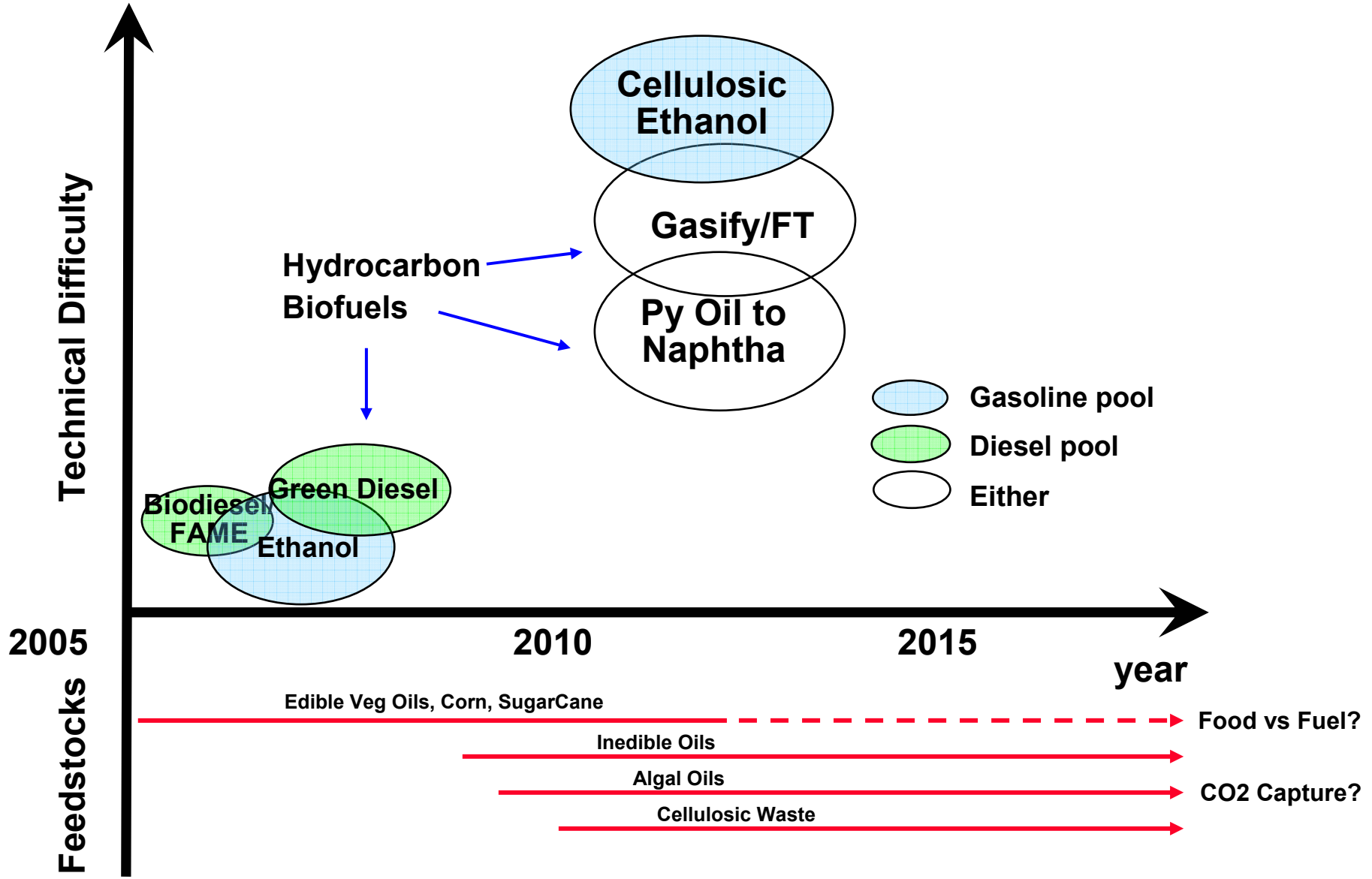

Gaps to Implementation of Today's Biofuels

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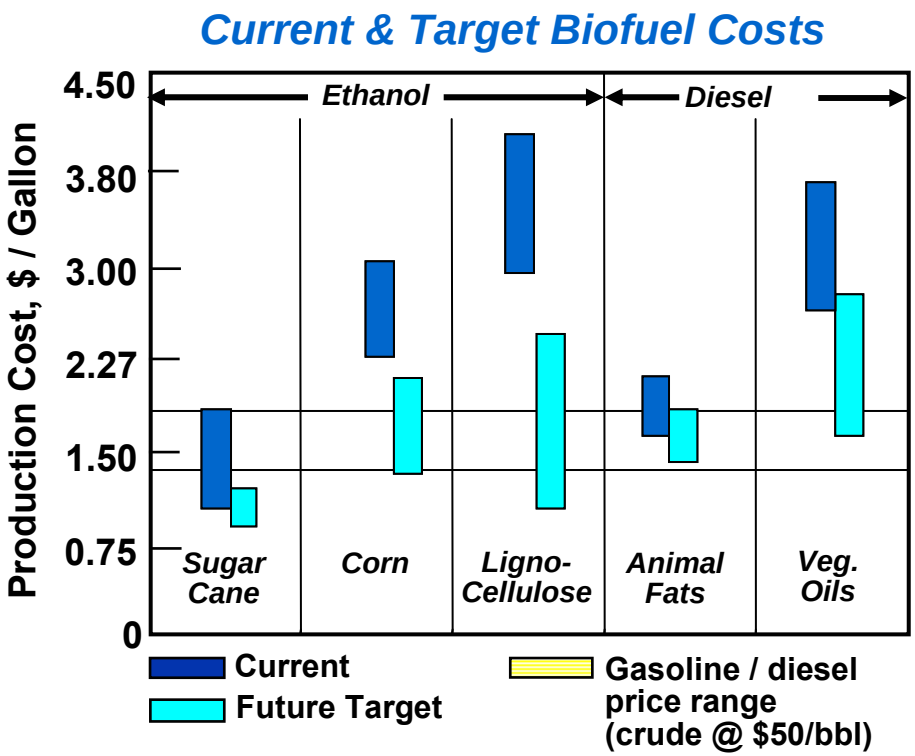

- **Enablers**
  - Feedstock prices/availability
  - Economies of scale
  - Technology breakthroughs
- **Infrastructure changes**
  - Distribution network
  - Transportation fleet

Major technological breakthroughs and infrastructure changes required over the next decade to enable today's biofuels

Waste Biomass to Liquid Transportation Fuels

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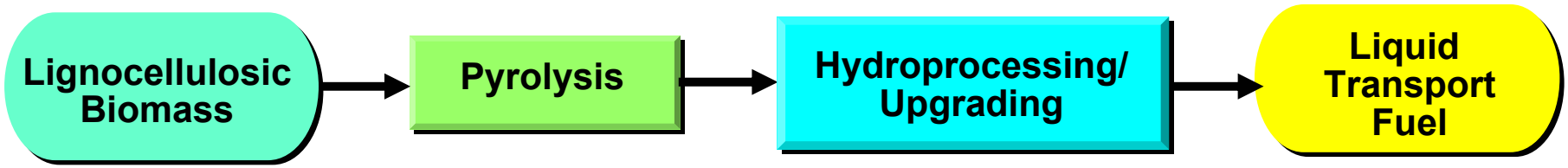
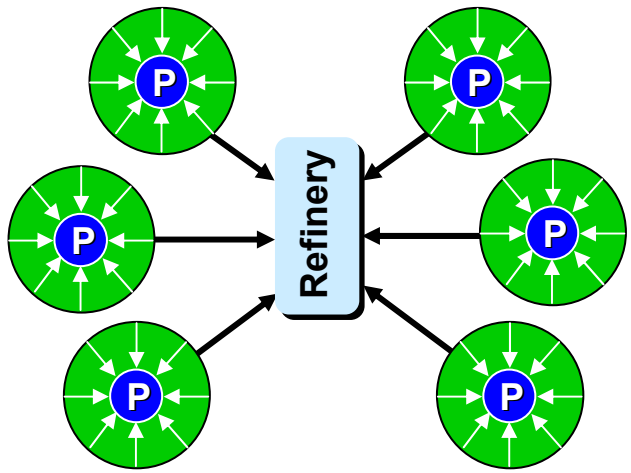


- Waste is converted to pyrolysis oil which is then upgraded to liquid fuels
- UOP working with US National labs (PNNL & NREL) to:
  - Provide a foundation for development of an economically viable process
  - Gain understanding of process sensitivity to pyrolysis oil properties
  - Complete technoeconomic analysis
  - Analyze process life cycle

Feed	*Wt%*	*bpd*
Pyrolytic Lignin	100	2,250
Products		
Lt ends	15	
Naphtha	30	1,010
Diesel (Heavier product)	8	250
Water, CO_2	51-52	



Biofuels Strategy

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Fuel Additives / Blends

Ethanol | Biodiesel

Fuels

Diesel | Gasoline

UOP's Bio-Fuels Technology Goals

Identify and utilize processing, composition, and infrastructure synergies to lower capital investment, minimize value chain disruptions, and reduce investment risk.

Generation 1

- Vegetable oils and greases to diesel, gasoline and JP-8 (military jet fuel)
- Flexible, hybrid technologies
  - Capability to process fossil and bio feedstock

Generation 2

- Lignocellulosic biomass and algal oils to fuels
- Process Integration
  - Flexible feedstocks
  - Combined fuel, power and chemicals production

Conclusion:

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- Crude pricing and government policies drive biofuels market
- Large scale adoption will be facilitated by non-food based feedtocks and technology breakthru's
- Maximizing use of existing transport and distribution infrastructure will hasten adoption.
- Technology neutrality essential to enable development of leading edge technologies