Global Marketing

Our Family of Brands

Biodiesel Forum and Technology Roundtable

Roger Organ
Los Angeles – South Coast Air Quality Management District

November 7, 2006

Content

- API Backgrounder
- Supply Demand – Why Biodiesel
- Biofuel Drivers and Characteristics – Customer Driven. Quality is Essential
- Some Biofuels Basic Facts and Figures
- Biodiesel Manufacturing – It's a batch process get the quality right.
  - Feedstocks
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- Refiner and Marketer's Perspective
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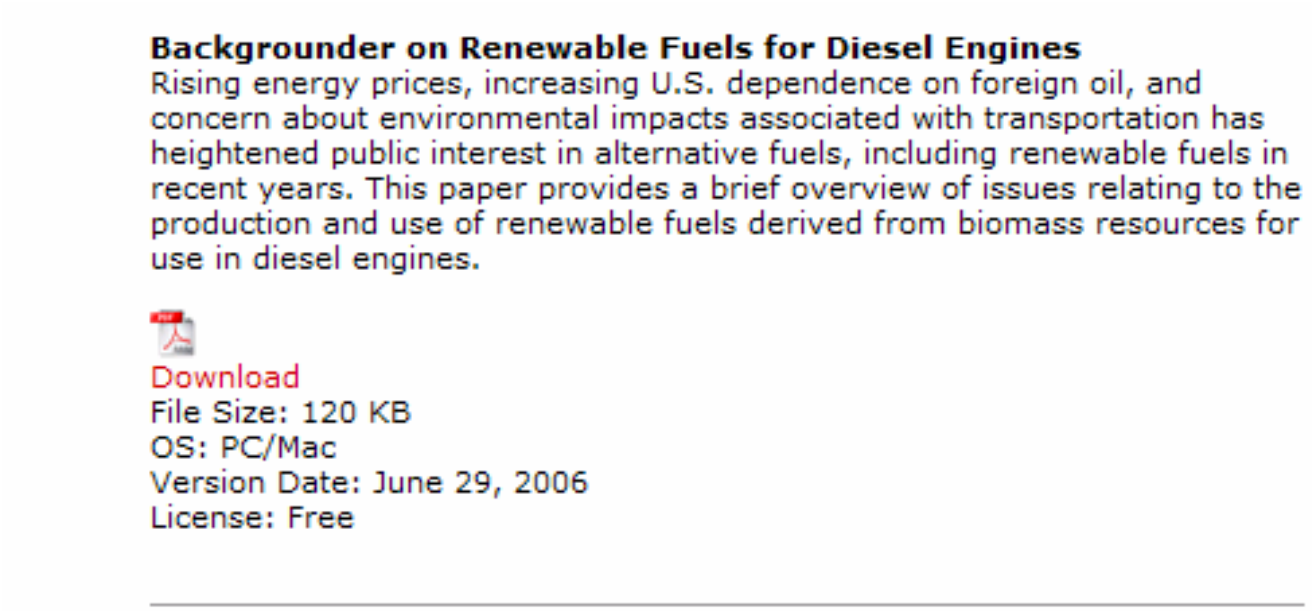
Backgrounder on Renewable Fuels for Diesel Engines

RECOMMEND VISITING THE API SITE BELOW

http://api-ec.api.org/aboutoilgas/sectors/segments/index.cfm



Backgrounder on Renewable Fuels for Diesel Engines
Rising energy prices, increasing U.S. dependence on foreign oil, and concern about environmental impacts associated with transportation has heightened public interest in alternative fuels, including renewable fuels in recent years. This paper provides a brief overview of issues relating to the production and use of renewable fuels derived from biomass resources for use in diesel engines.

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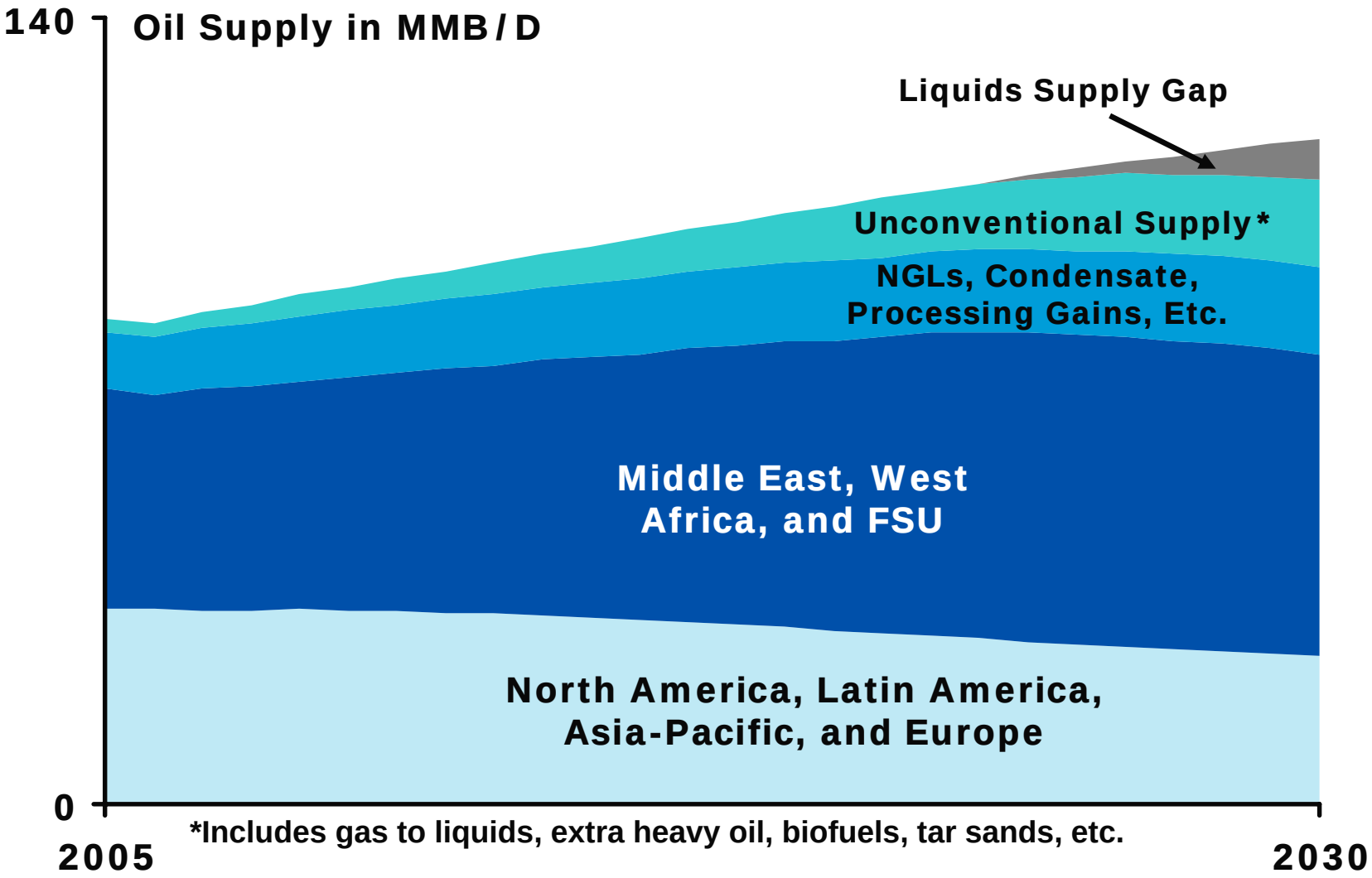
Chevron Global Energy Company

- Business in approximately 180 countries
- More than 47,000 employees
- 125 year history

Long-Term Oil Supply Outlook

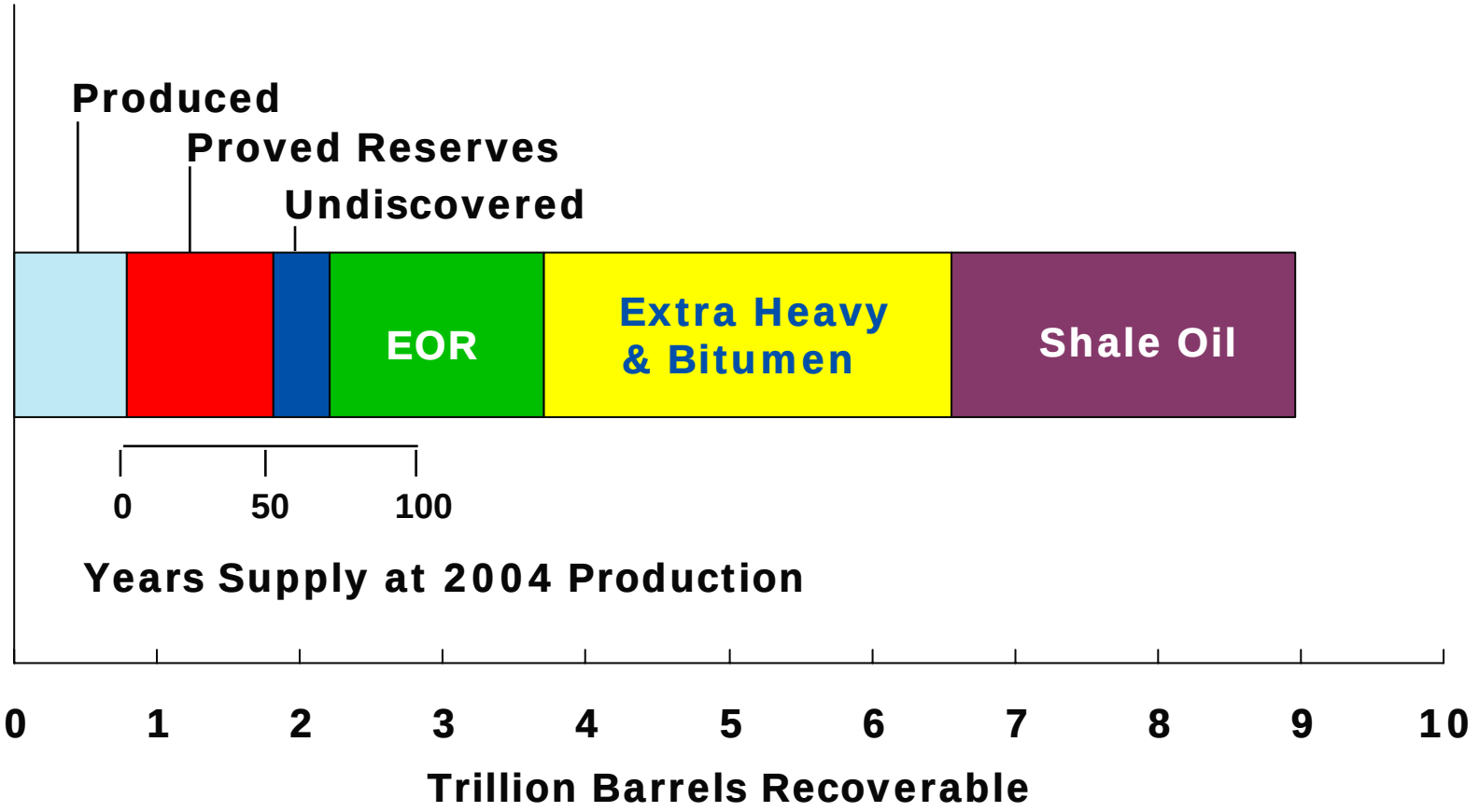


*Includes gas to liquids, extra heavy oil, biofuels, tar sands, etc.

Source: Consultant 'Consensus'

World Oil Resource Base

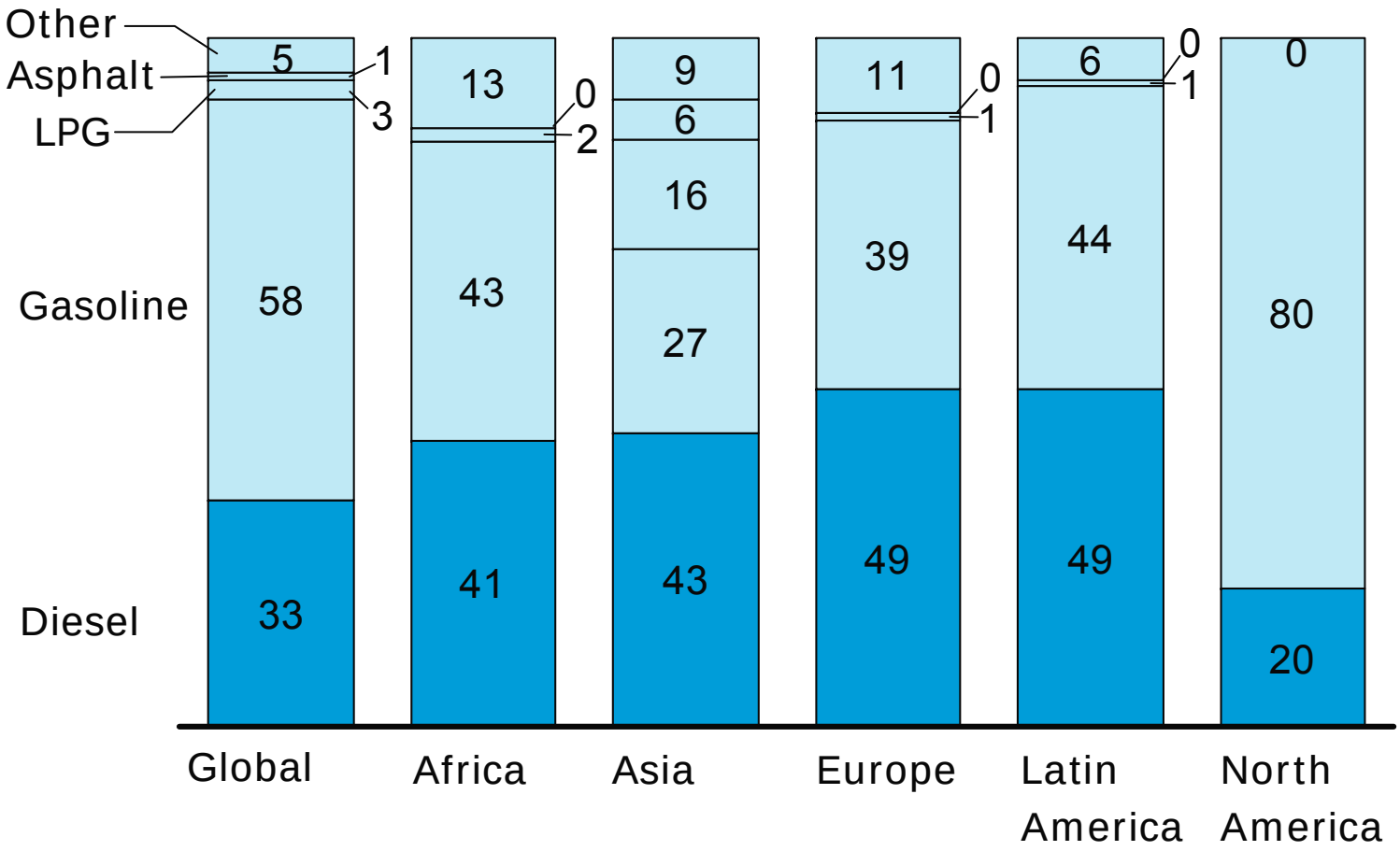
There's a lot of oil → We're not suddenly going to run out.
The long term question is price versus cost of alternatives.



Diesel Accounts For One Third Of Chevron's Global Volume

It is a Very Important Product For Us

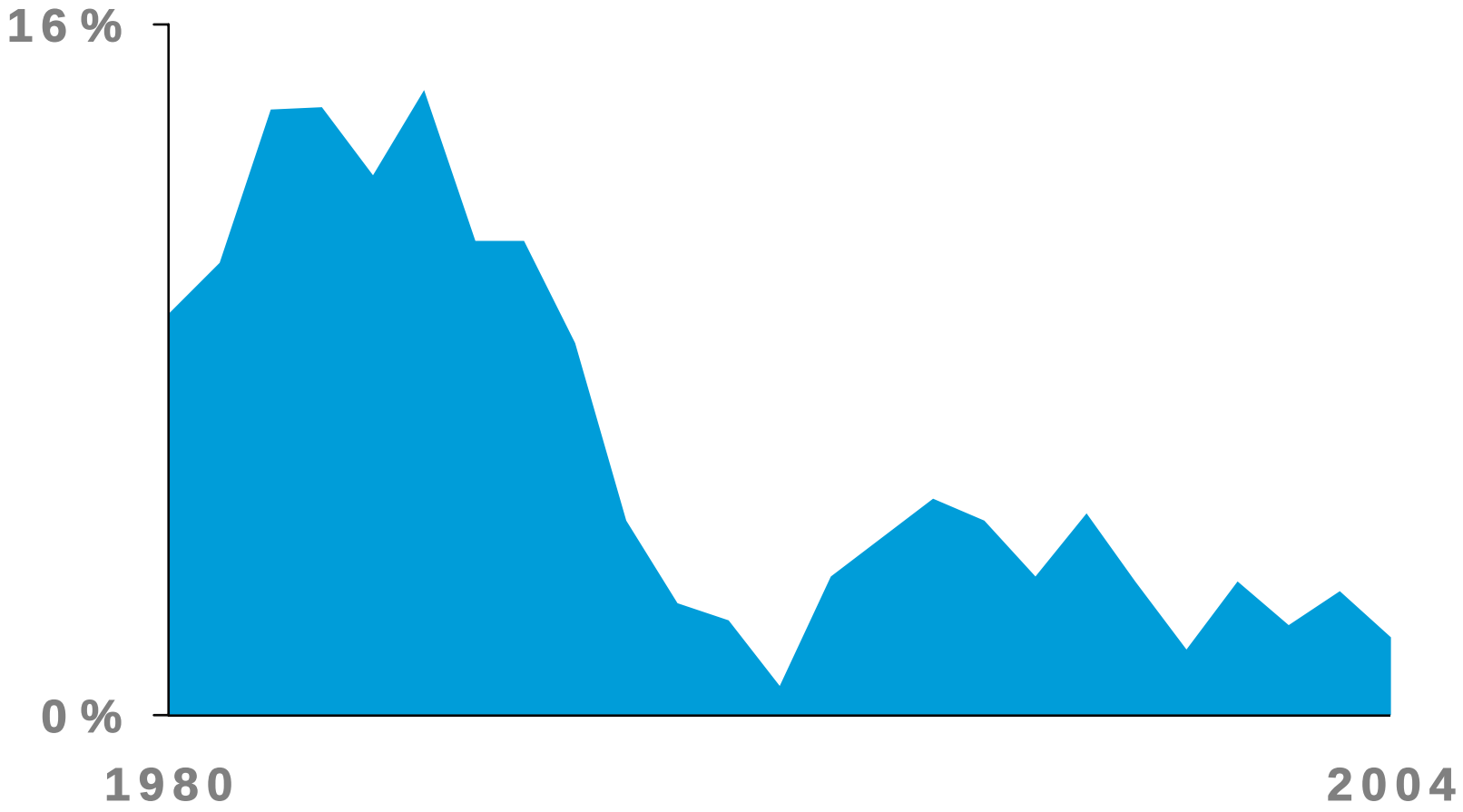
Percent



Source: CVX

Spare Capacity Dwindling…

Spare Oil Production Capacity
(% of World Oil Demand)



Source: IEA

Summary - Why Biodiesel

- Oil Prices are at or near historic highs
- Consumption is rising worldwide
  - World is up 18 pct since 2000
  - China is up 55% since 2000
    - Chinese auto sales up 50% over 2005
- Surplus oil capacity has dwindled
- Most oil reserves are held by National Oil Companies (NOC's)
- The world economy seems to have weathered the oil price increase better than most would have expected
  - No significant demand reductions foreseen
- Mobility is treasured by all societies and not easily given up even if oil price stays high
- Diesel is an important product and in some major markets Gasoline is long and Diesel is short. Biodiesel makes sense in meeting mandates especially in short diesel markets.
- **To fill the energy supply gap – Biodiesel has a place**

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Drivers for Fuels Characteristics – Including Biofuels

- Customer satisfaction (It starts and ends with the customer)
  - Starting, acceleration, fuel economy, etc., and satisfaction is best met by customer choice through free competition
- Performance specifications
  - ASTM is one such spec, often quoted by states in regulations
- Environmental regulations
  - Reduced vehicle emissions along with fuel specs enable vehicle devices to meet lower emissions, enforced by many jurisdictions
- Cost, petroleum concerns, aid to the farm sector, normally federal but states and local areas also involved
- The boundaries created by the simultaneous application of these drivers and constraints continues to shrink the tolerances of basic fuel characteristics

Key Fuel Characteristics – Compression Ignition (Diesel) Engines

- Cetane (essentially the opposite of octane)
  - High cetane for starting, lowering start-up white smoke, less noise, efficiency. Low for increased manufacturing (see aromatics)
- Sulfur
  - Low for emissions and enabling of catalytic emissions controls
- Density
  - High for fuel economy but low for ease of starting - related to viscosity and flow
- Aromatics
  - Low for cetane and toxics emissions, high for producibility in refinery
- Storage stability, cleanliness, deposit formation, materials compatibility, flow characteristics, flash point, secondary emissions dependencies (distillation), others

ASTM Standards

Derived and updated using a very thorough, lengthy, voluntary, multi-stakeholder consensus process

- Used by many states in regulations
- Ensures product quality and fungibility
- **Essential to protect quality of brand such as Chevron / Texaco / Caltex**
- SI engine fuel ASTM D4814
- Diesel ASTM D975
  - *No ASTM biodiesel blend specification exists, but it's coming*
- Fuel Ethanol ASTM D4806
- E85 ASTM D5798 (CARB has one, too)
- B100 (biodiesel blendstock, i.e., FAME) ASTM D6751

Biodiesel (FAME) Blendstock

The Good

- Readily miscible with hydrocarbon diesel
- Emissions reductions (HC, CO, PM)

The Not So Good

- Lower energy content
- Oxidation stability worse than diesel and variable with feedstock
- Increased NOx emissions (maybe?)
- Cold flow and higher viscosity

Biodiesel (FAME) Blendstock

A Real Challenge

- The different feedstocks result in blendstocks with different properties. **It is all about getting consistent quality.**
- Not adequately specified in the US… Yet
- Oxidation stability controls not well understood or easy to measure/predict
- High feedstock cost - not sustainable without subsidy

And The Unknown

- Injection equipment impacts, viscosity, corrosion, materials compatibility and long term stability

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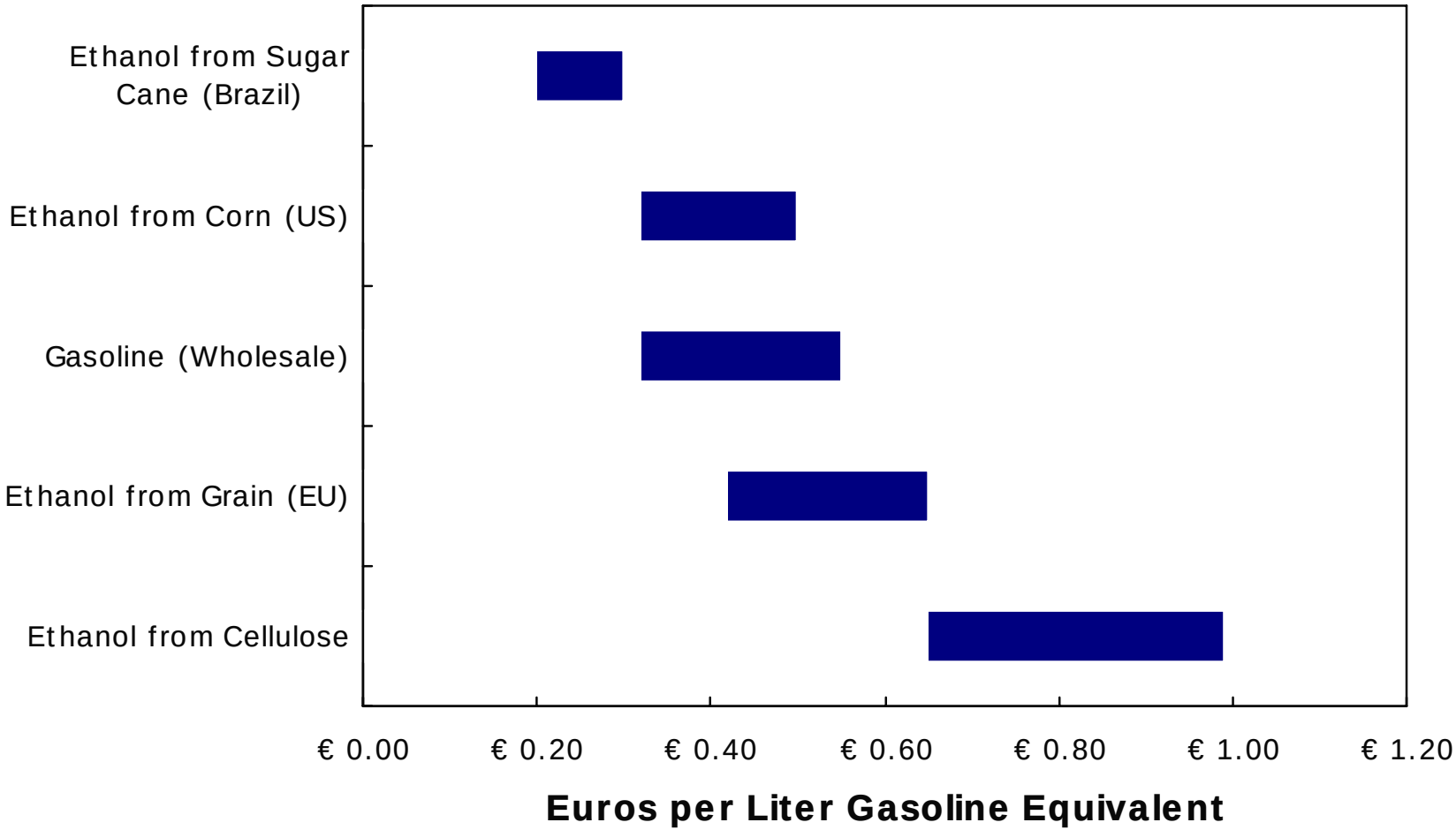
Top 5 Producers in 2005

Bioethanol

	Production Million Gallons (liters)
Brazil	4360 (16,500)
United States	4290 (16,230)
China	530 (2,000)
European Union	250 (950)
India	80 (300)

Cost Ranges of Ethanol/Gasoline Production 2006



1 Euro = 1.26 US $
3.784 liters = 1 US Gal

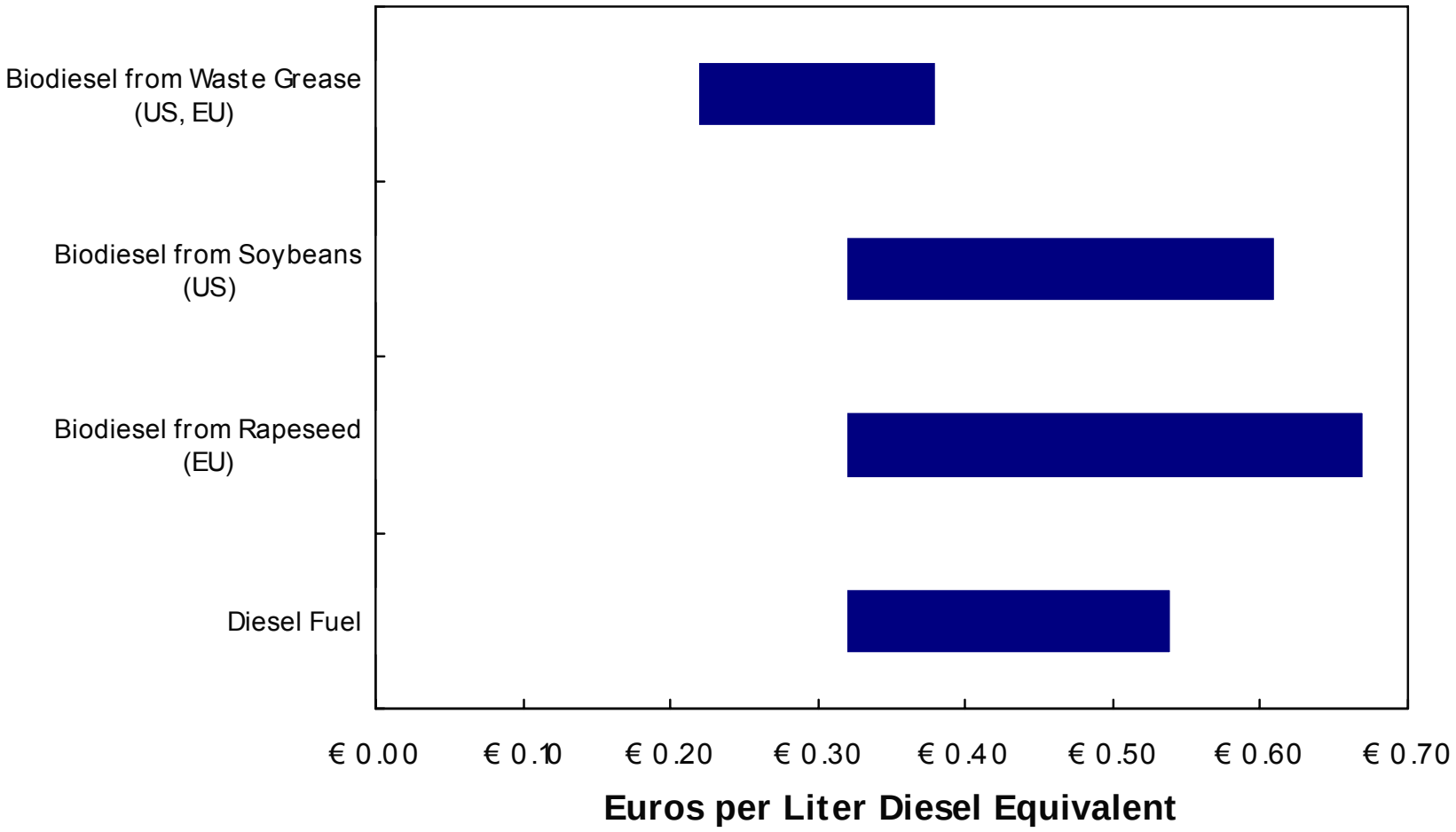
Source: IEA, Reuters, DOE

Top 5 Producers in 2005

Biodiesel

	Production Million Gallons (liters)
Germany	507 (1,920)
France	135 (511)
United States	77 (290)
Italy	60 (227)
Austria	22 (83)

Cost Ranges of Biodiesel / Diesel Production, 2006



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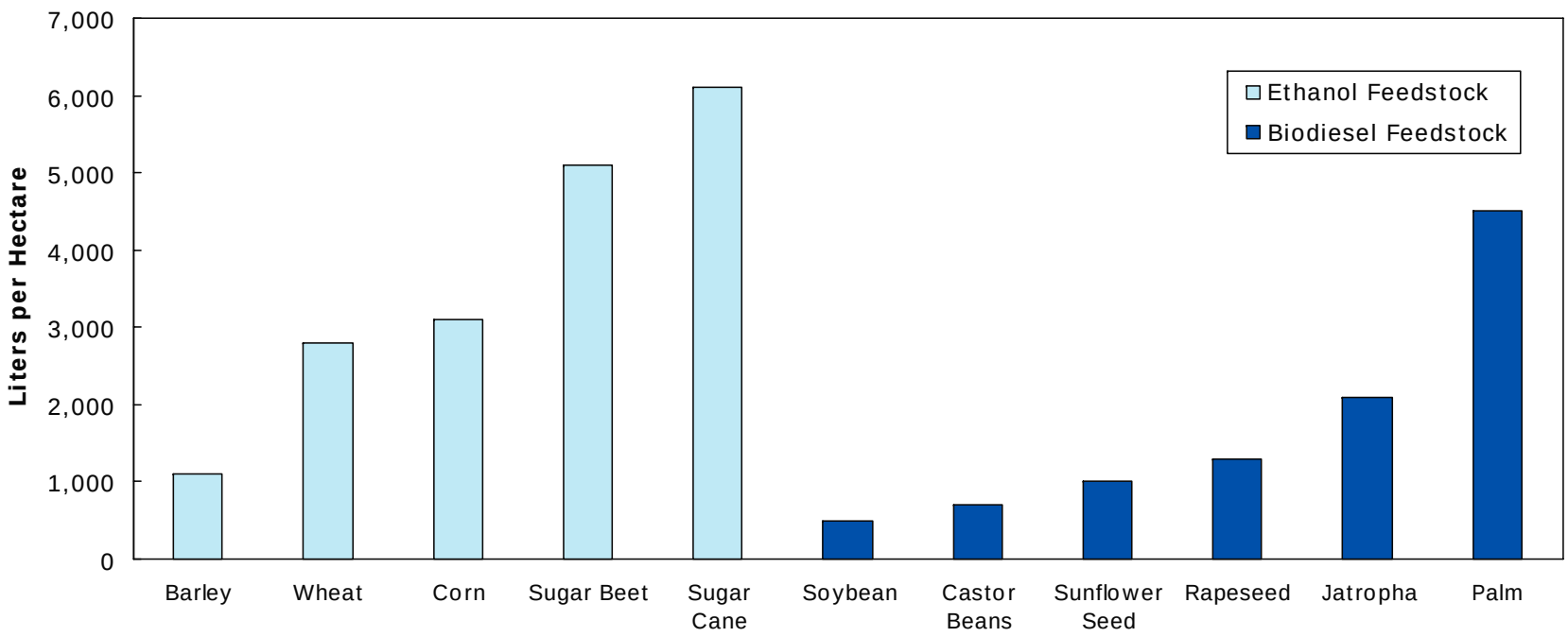
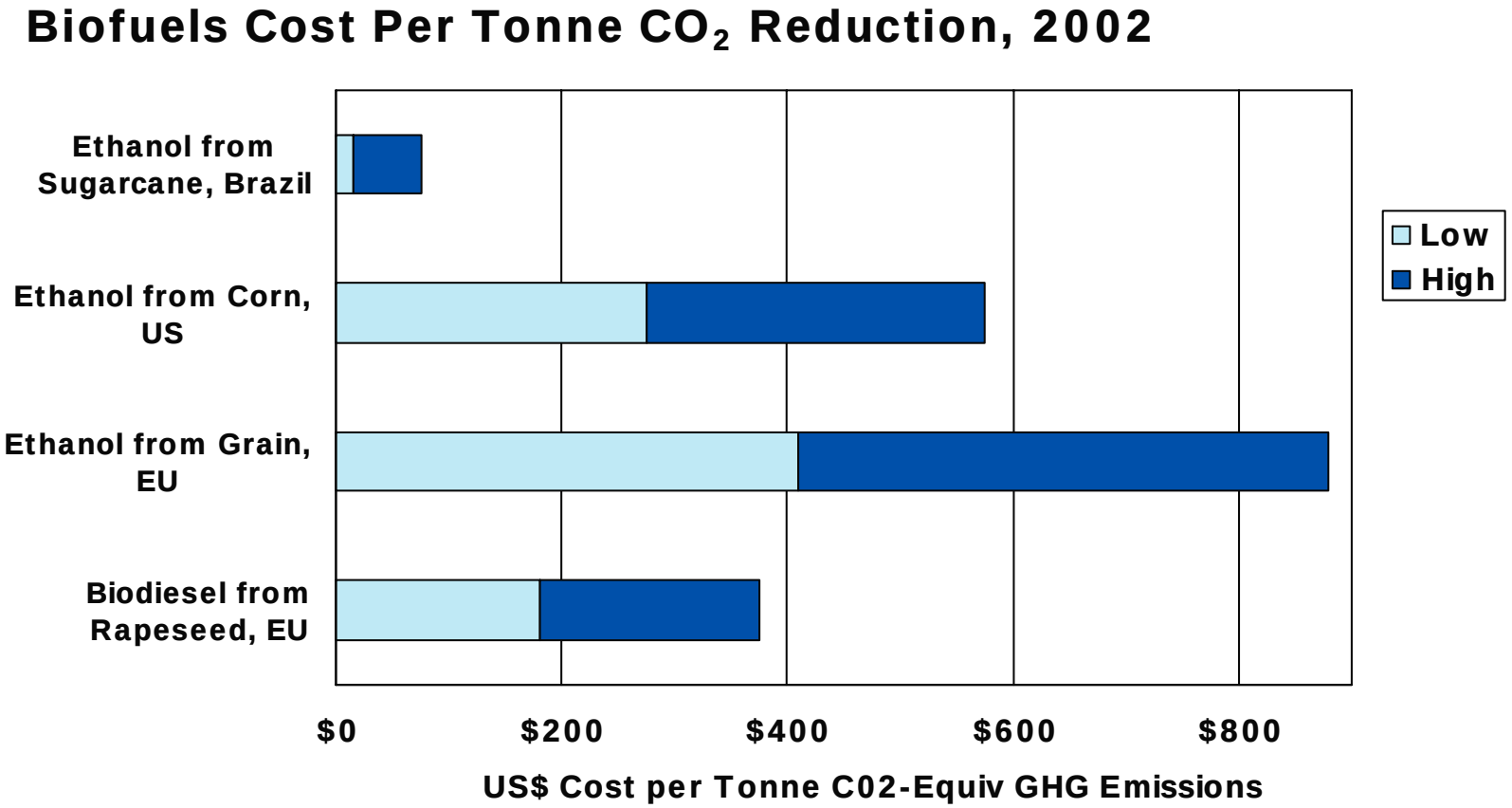
Source: IEA, Reuters, DOE

Biofuel Yields For Different Feedstock



Source: Fulton, et al.

Biofuels and CO_2 – Be Careful and Understand What is Included and What is Not Included



Source: IEA Estimates Based on a Review of Recent Studies

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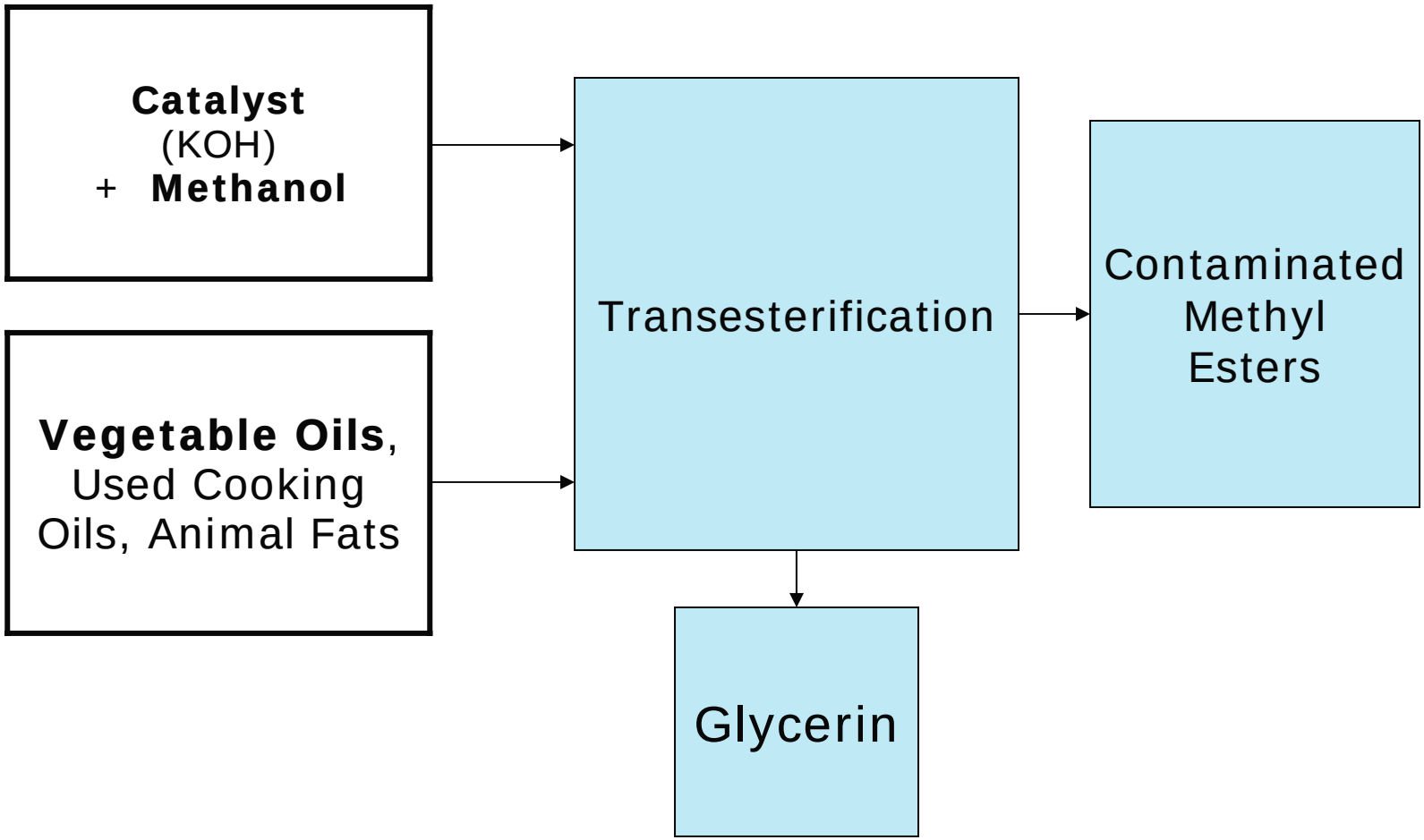
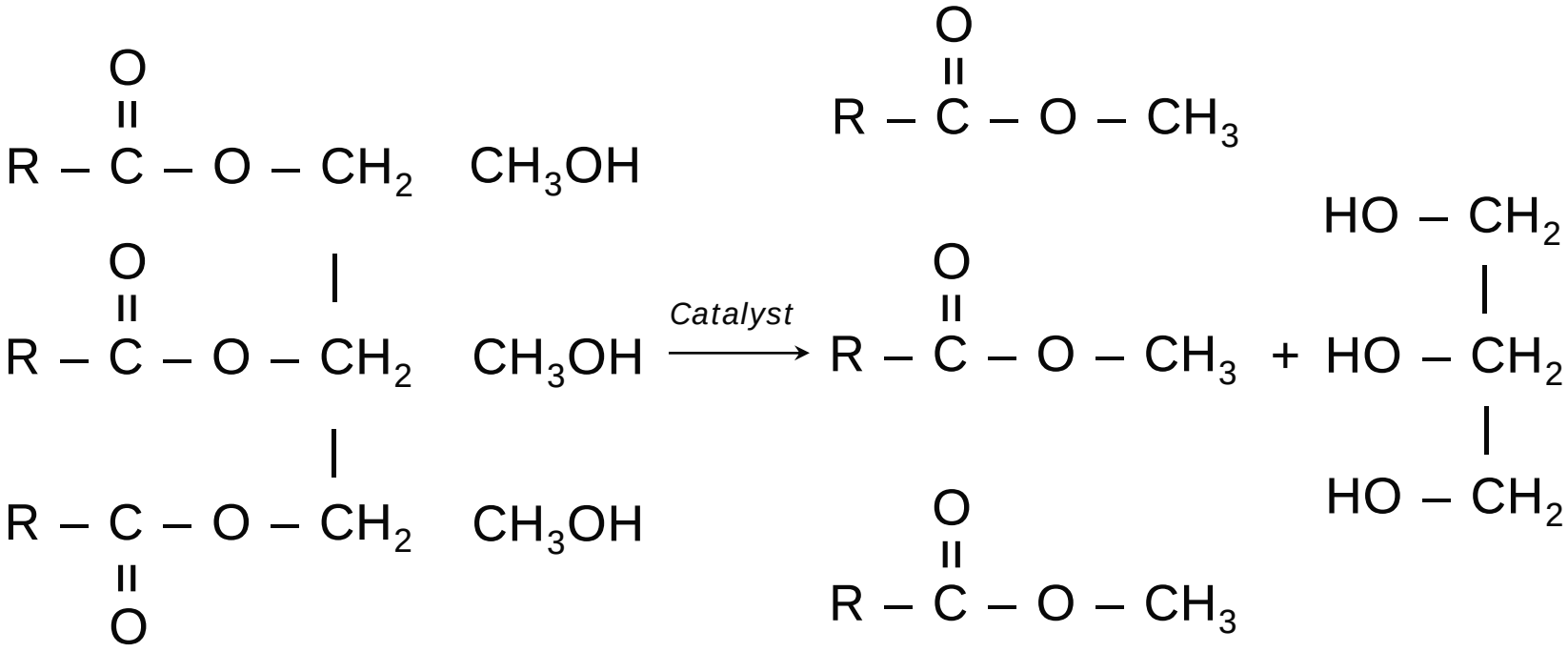
Transesterification Reaction



Transesterification of Vegetable Oil to Biodiesel



Triglyceride + 3 Methanol $\xrightarrow{\text{Catalyst}}$ 3 FAME + Glycerol

R is typically 16 or 18 carbons and may contain one to three carbon-carbon double bonds.

What Is Biodiesel ?

- Definition: A fuel comprised of mono-alkyl esters of long chain fatty acids derived from vegetable oils or animal fats, designated as B100
- Biodiesel = 100 % fuel, or B100
- Biodiesel blends are Bxx: B20, B5

Biodiesel Production - Feedstocks

- Biodiesel is produced from two main types of materials which are reacted along with a catalyst
  - Oils or fats
  - Alcohol
  - And a catalyst

Biodiesel Production - Feedstocks

- Oils and Fats
  - Chemically speaking they are long chain fatty acids joined by a glycerin backbone
    - Vegetable oil, animal fat, waste cooking oils, etc.
  - Fatty Acid Composition
    - Saturated – Contains no double bonds
    - More stable, less prone to oxidation
  - Unsaturated – Contains at least one C=C
    - Less stable, more prone to oxidation

Biodiesel Production - Feedstocks

- Alcohol
  - Methanol, Ethanol, Propanol, etc.
    - Methanol is most often used because of low cost and does not easily mix with glycerin (better yields). Note: methanol is most often derived from natural gas
  - Needs to be anhydrous, containing no water

Biodiesel Production - Catalyst

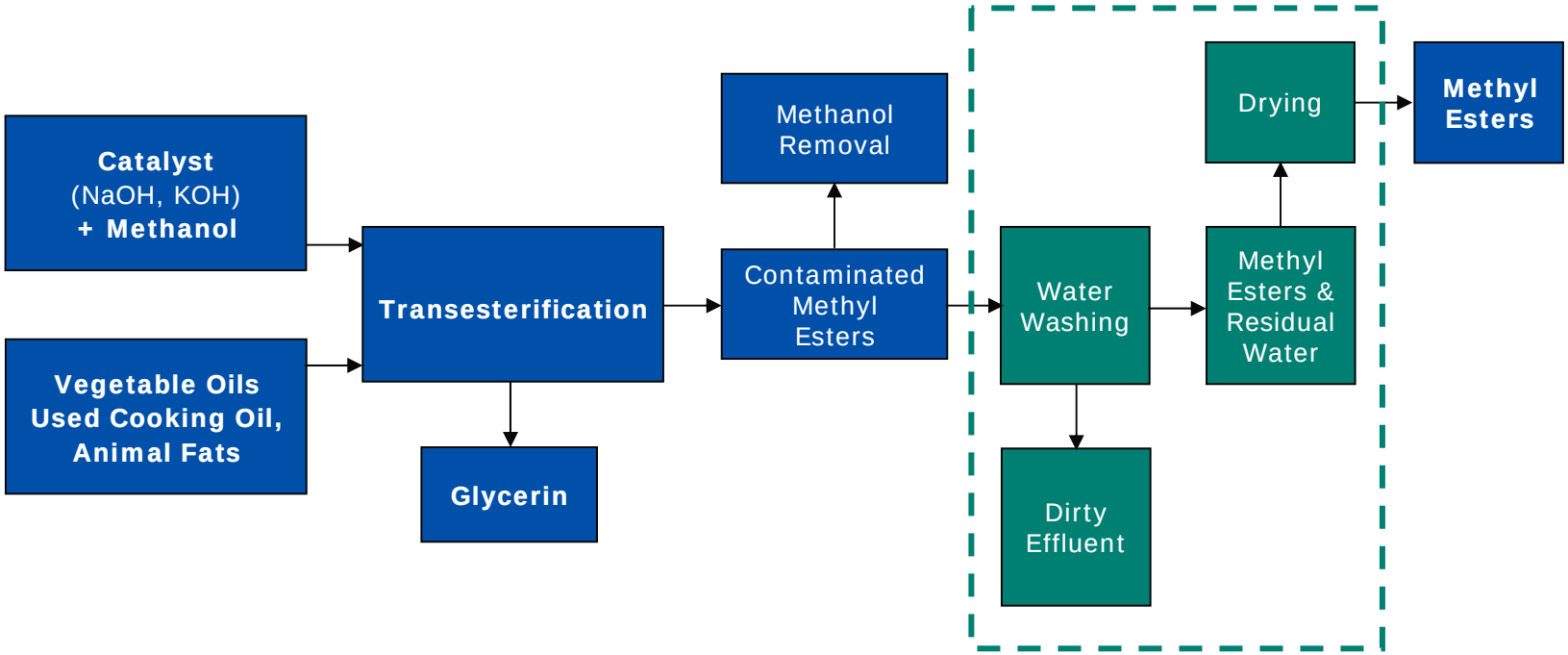
- The catalyst speeds the reaction and helps to move it to completion
  - Tranesterification - Basic – Sodium Hydroxide or Potassium Hydroxide are commonly used. Normally KOH
  - Direct Esterification – Acidic – Sulfuric Acid is used for direct esterification (pretreatment) of high Free Fatty Acid (FAA) feedstock
- The material/catalyst needs to be kept as dry as possible

Biodiesel Production – Post Reaction

- Glycerin Separation
  - A by-product of the reaction is glycerin, which must be separated from the methyl esters
- The methyl esters are **not biodiesel** until the proper specifications are met
  - Contaminants include Free Glycerin, Soaps, Metals, Excess Methanol, Catalyst, and many trace materials that are in the feedstock fatty acid depending on how and where it was harvested.

Biodiesel Production – Water Wash

Water Wash



Dallas Specialty Adsorbents

Biodiesel Production – Water Wash

- The “clean up” of the contaminated methyl ester is often done by means of a water wash
- Potential Issues with water wash
  - Inadequate water supply – May need pretreatment to soften
  - Decreased yield due to loss of esters in effluent
  - High soap levels can cause emulsions
  - Long gravity separation time or costly centrifuges
- Time and cost of drying methyl esters
- Effluent treatment and disposal costs

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Biodiesel Production - Challenges

- Consistency in feedstock
- Imcomplete reaction
  - Results from improper amount of catalyst or alcohol
  - Insufficient reaction time
  - Can lead to increased amounts of mono-, di-, and tri-glycerides
    - Will cause injector fouling, filter plugging and sediment formation
    - Poor shelf life which is not easy to measure or predict

Biodiesel Production - Challenges

- Incomplete Reaction – Out of Spec Biodiesel
  - After storage of B20 for six months

Dallas Specialty Adsorbents

Biodiesel Production - Challenges

- There are many possible production challenges
  - Soap formation
  - Emulsification
  - Insufficient Catalyst Removal
  - Poor separation of glycerin from methyl ester
  - High Acid Value
  - Insufficient alcohol removal
- All of the above can increase incidence of fuel filter clogging and gel formation
- When there have been “problems” with biodiesel usually found to be out of specification for un-reacted or partially reacted oils and fats

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Refiner and Marketers Perspective

- Prefer to add limited amount of FAME (up to 5 pct) and call it diesel. Can handle at refinery or terminal. If done at a refinery still need clarity on whether the product can be pipelined. In many cases will be limited to terminal blending like ethanol - costs of logistics in trucking FAME.
- Prefer to handle biodiesel above 5 pct as a niche product for niche markets and blend at terminals. Some costs involved in extra tankage.
  - Niche markets:
    - Government fleets, school buses, agriculture, others

Refiner and Marketers Perspective

- Need quality specs and controls
- May prefer to manufacture ourselves to be sure of quality (or to take a stake in manufacturing plants – especially as volumes grow). Vertical integration model.
- Unable to date to get sufficient quality assurances. This may change with larger and more efficient plants now coming on stream
- Product is new and prefer not to rush or be forced into using biodiesel. Let the market decide.

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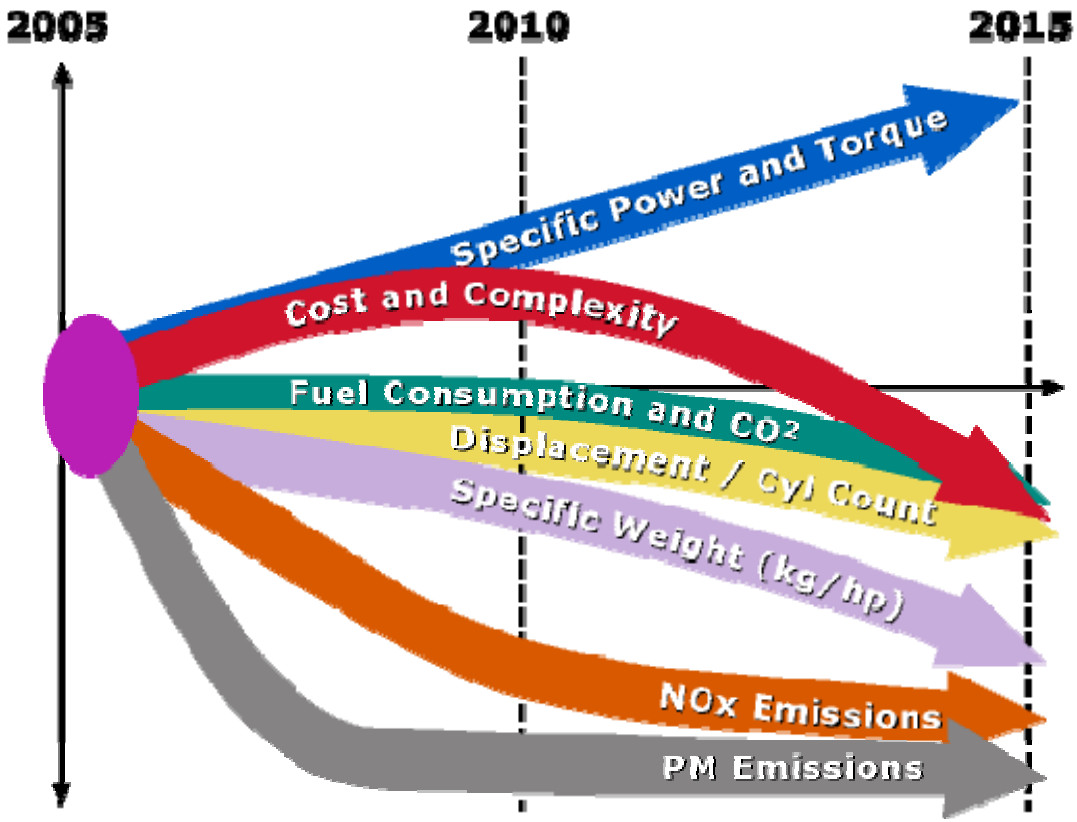
There Are Many Other Challenges To Biodiesel and Unanswered Questions

- Sustainability and social responsibility
  - Waste and marginal land being used to produce fuels
    - Fertilizer run off
    - Additional nematode action producing nitrogen oxides (GHG)
    - Biological oxygen demand in water run offs both from additional land cultivation and from the plant effluent streams
  - Methanol production is from natural gas
  - Biodeisel has higher NOx emissions (maybe) and exacerbates the problem of diesel emissions – Can be handled But needs further investigation….

What to Expect in 2015 Diesels



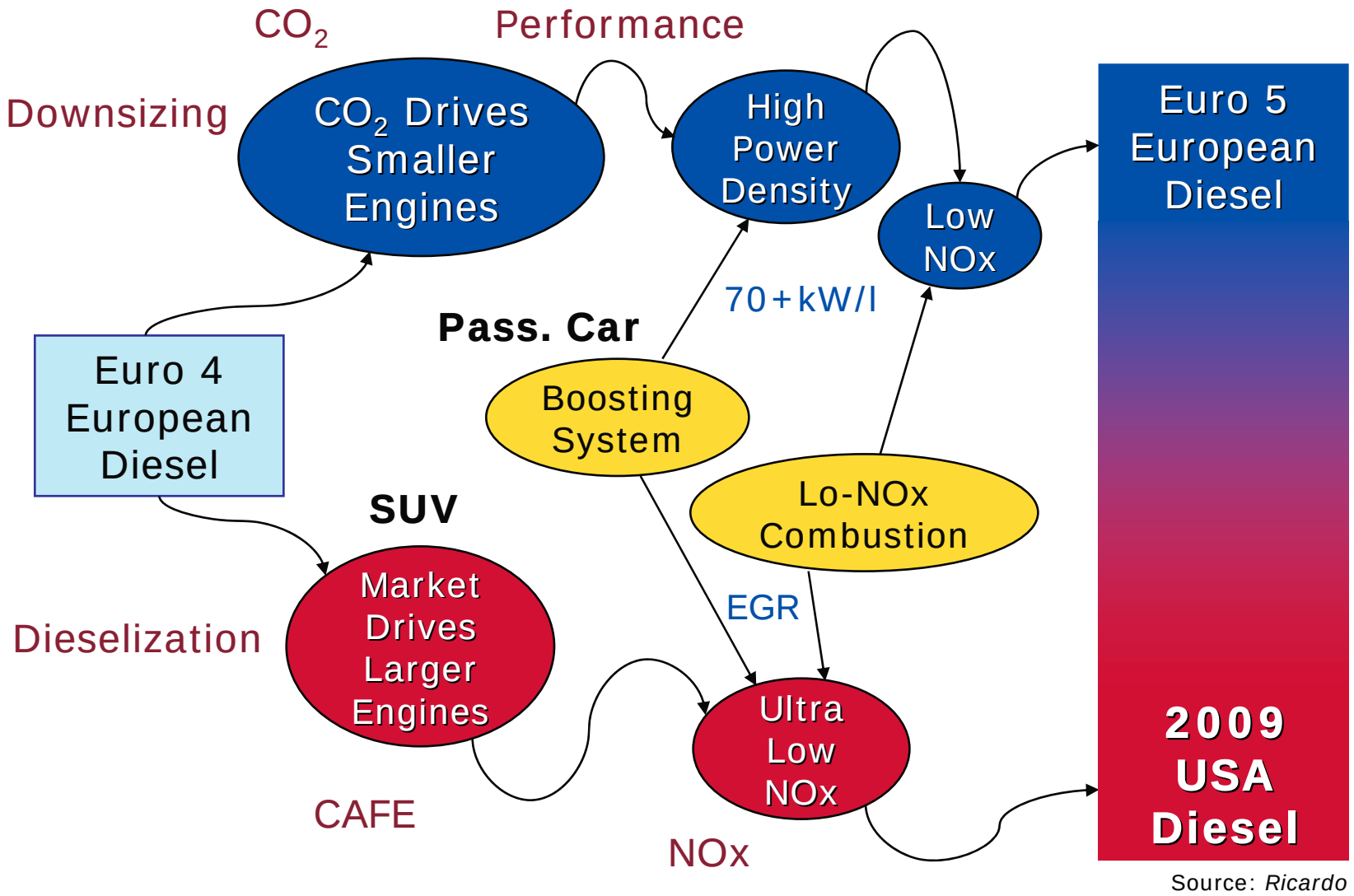
2015 Diesel Product Vision

- Enhance diesel positive attributes
- Reduce negative attributes to parity with gasoline

- Downsized high output engine
- Highly integrated engine systems
- Single multifunction aftertreatment unit
- Reduced cost and complexity relative to 2010
- Reduced diesel specific vehicle implications and cost

Source: *Ricardo*

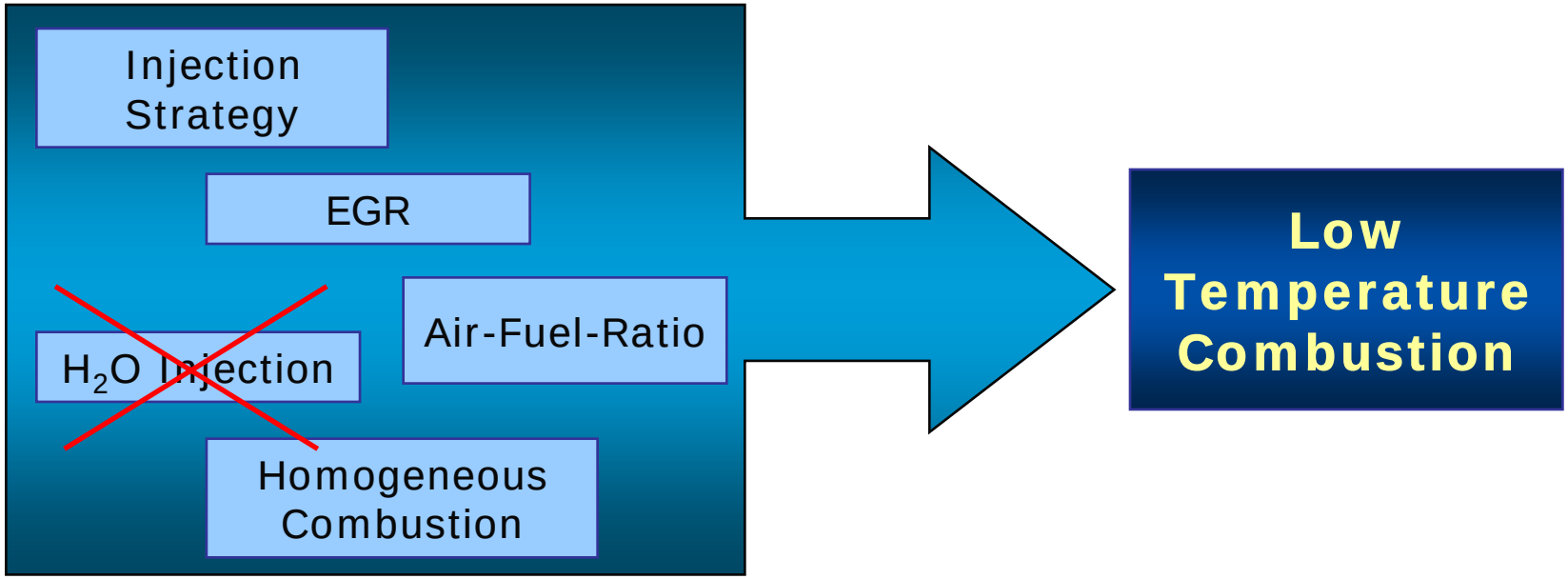
European and USA Diesel Paths Forward Are Different



Source: *Ricardo*

It's All About a Low NOx Combustion System – So Does Biodiesel Make Sense?

- U.S. Diesel Development Must Focus on Low NOx Solutions
  - NOx aftertreatment will be inevitable, but a low-NOx combustion system will minimize the pain
  - In-cylinder NOx formation must be reduced
  - What are the tools for low NOx?



Source: *Ricardo*

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Finding and Encouraging The Best Options …Enabling the Winners

- There is no single solution
  - Issues of dependency, reliability of supply, environmental footprint and cost apply to all fuels to some degree
- All economic fuels--plus conservation--will be needed to meet future demand
  - Market-based competition amongst technologies and fuels should not be inhibited
  - Consumers have the means to conserve and are beginning to respond
- Biodiesel not currently sustainable without subsidies
- Allow time for technology to advance
  - New technologies must offer tangible benefits to consumers and real-world well-to-wheels benefits to the environment
  - Discussions like this are a good way to make progress

Ongoing Chevron Steps

- As a major energy company, we are:
  - Providing analysis and experience on the full range of transportation fuel options to address environmental issues
  - Sharing our experience in addressing issues involving H2 and its infrastructure, and other alternative fuels
  - Participating in demonstration projects and developing new energy sources
- Chevron is committed to:
  - Investing in promising innovative energy technologies
  - Supporting flexible and economically sound policies that protect the environment
  - Increasing energy efficiency and reducing Greenhouse Gas Emissions

Final Thoughts

- Petroleum-based fuels will remain dominant for very good reasons
- Alternative fuels are making inroads as they become economically attractive
- There always have been significant consequences known and unknown to the use of any transportation fuel
- People value mobility highly
- The market does a good job of making the right decisions