



# Renewable Fuels for the Diesel Market

9th ISCC Global Sustainability Conference  
February 14, 2019

# Safe Harbor Statement

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This presentation contains certain forward-looking statements within the meaning of the Private Securities Litigation Reform Act of 1995 as amended, including statements regarding the possible retroactive reinstatement of the BTC for 2018, the estimated benefits to 2018 Adjusted net income and Adjusted EBITDA if the BTC is retroactively reinstated, our expectations regarding fourth quarter results and the possible joint development of a renewable diesel plant with Phillips 66. These forward-looking statements are based on current expectations, estimates, assumptions and projections that are subject to change, and actual results may differ materially from the forward-looking statements. Factors that could cause actual results to differ materially include, but are not limited to, potential changes in governmental programs and policies requiring or encouraging the use of biofuels, including RFS2; availability of federal and state governmental tax incentives and incentives for biomass-based diesel production, including that the BTC may not be retroactively reinstated for 2018 or that it may be reinstated on less favorable terms; changes in the spread between biomass-based diesel prices and feedstock costs; the future price and volatility of feedstocks; the future price and volatility of petroleum and products derived from petroleum; risks associated with fire, explosions, leaks and other natural disasters at our facilities; the effect of excess capacity in the biomass-based diesel industry; unanticipated changes in the biomass-based diesel market from which we generate almost all of our revenues; seasonal fluctuations in our operating results; competition in the markets in which we operate; our dependence on sales to a single customer; technological advances or new methods of biomass-based diesel production or the development of energy alternatives to biomass-based diesel; our ability to successfully implement our acquisition strategy; our ability to generate revenue from the sale of renewable chemicals, fuels and other products on a commercial scale and at a competitive cost, and customer acceptance of the products produced; whether our Geismar biorefinery will be able to produce renewable diesel consistently or profitably; and other risks and uncertainties described in REG's annual report on Form 10-K for the year ended December 31, 2017.

All forward-looking statements are made as of the date of this presentation and REG does not undertake to update any forward-looking statements based on new developments or changes in our expectations.



ewaba

European Waste-to-Advanced Biofuels Association



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MVAK

Mittelstandsverband abfallbasierter Kraftstoffe

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Sabio fuels  
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**REG** converts waste oils, fats, and greases into high quality renewable fuels and chemicals to meet growing global demand for cleaner products

# Nr. 1 in biomass-based diesel in North-America & leader in waste biodiesel in Continental Europe

**13** Biomass-Based Diesel Plants → **575** MMGY Effective Capacity<sup>1</sup>



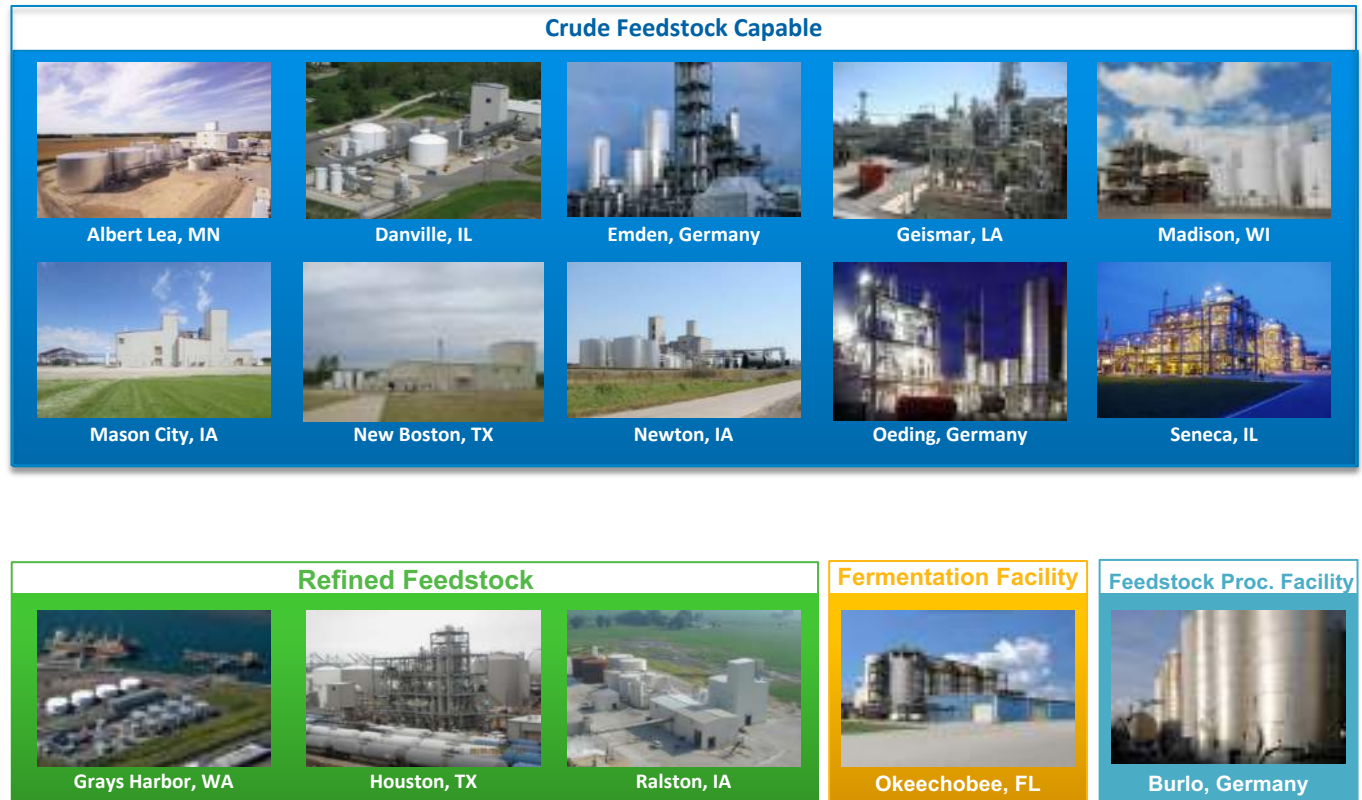
Note: 1. Effective capacity for 2017 - Represents the maximum average throughput that satisfies certain defined technical constraints  
 Source: REG Analysis

# Production Network

**13**  
Biomass-Based  
Diesel Plants



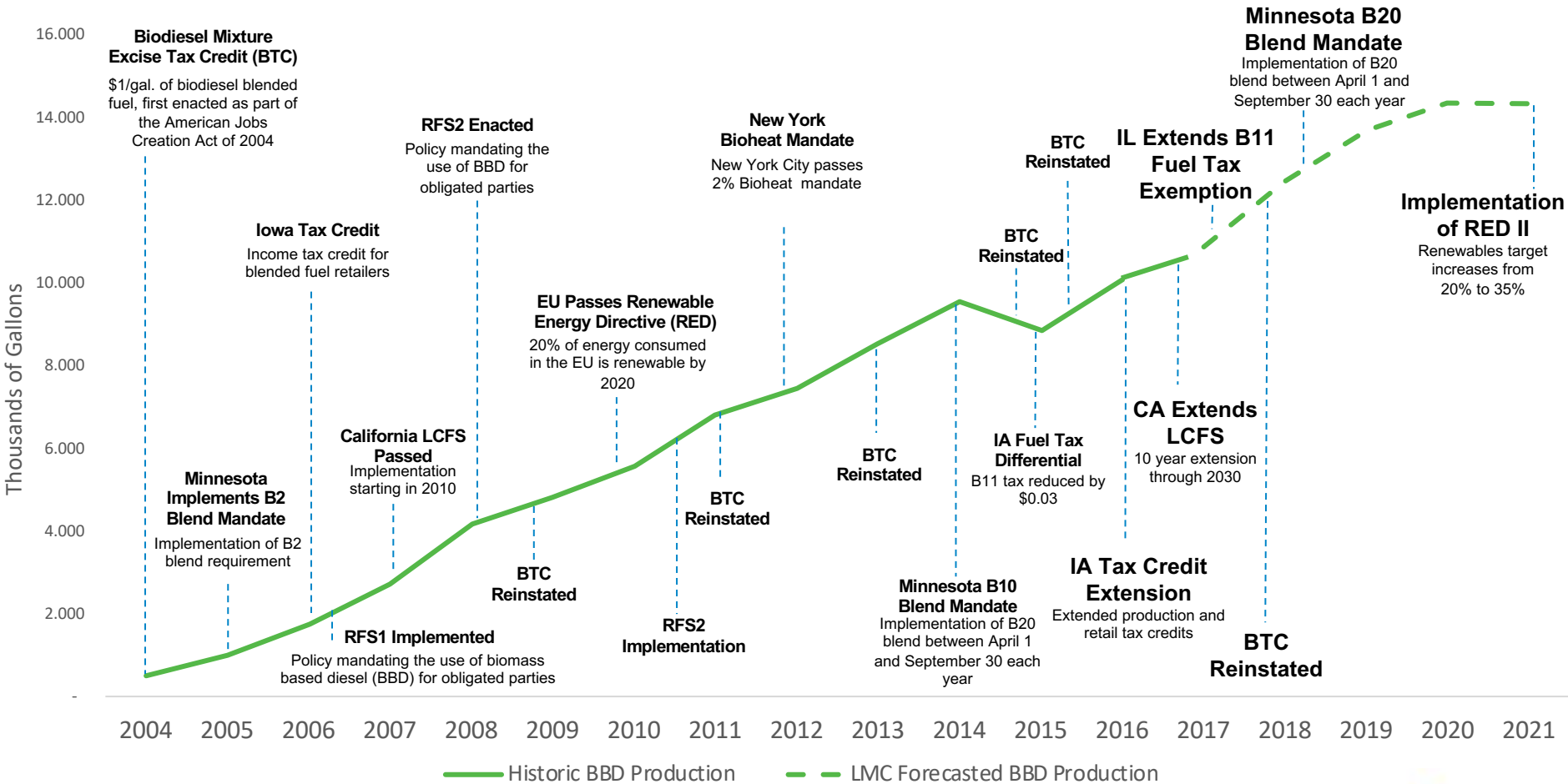
**575**  
MMGY  
EFFECTIVE  
CAPACITY





# World Demands Cleaner Fuel Solutions

## Historic and Forecasted Global BBD Production



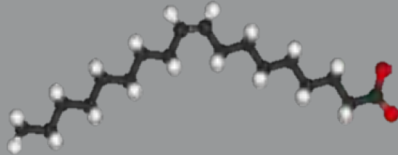
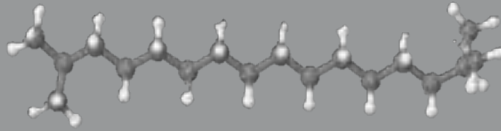
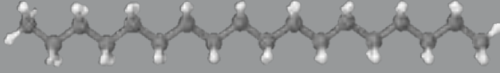
# Biomass-based diesel basics

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- **Biodiesel**: Fatty acid methyl esters, produced from reacting fats and oils with methanol
- **Renewable Diesel (HVO)**: Hydrocarbon-only diesel fuel made by processing fats & oils through hydrotreating and isomerization
- **Co-Processed Renewable Diesel**: Is a partially renewable diesel fuel created when fats, oils, or other renewable biomass is processed together with petroleum in the same process unit or refinery.



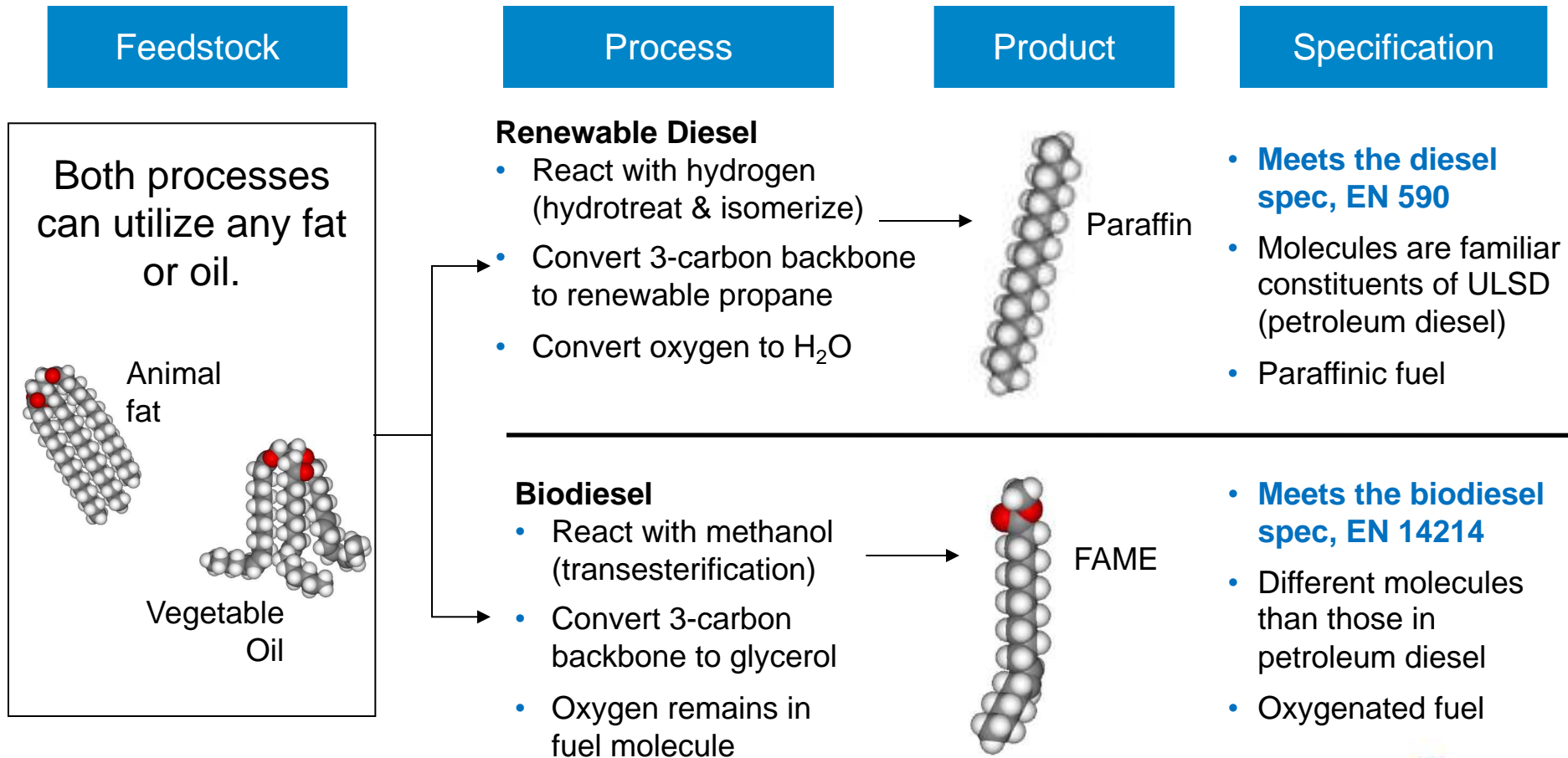
# Comparison of Critical Properties

	Biodiesel	Stand-Alone HVO	Co-Processed HVO
			
Cloud Point of neat fuel	1 – 8 °C	-10 – -14 °C	25 – 30 °C
GHG Reduction compared to petro diesel	88%	87%	?

- Biodiesel has higher GHG savings & is cheaper
- HVO has better winter performance & allows higher blends

# Biomass-based Diesel Overview

## Renewable Diesel and Biodiesel



# Biomass-based diesel feedstocks



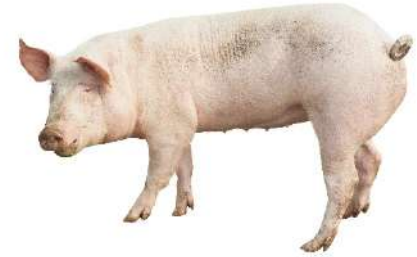
Soybean Oil



Distillers Corn Oil



Beef Tallow



Choice White Grease



Used Cooking Oil



Algae Oil



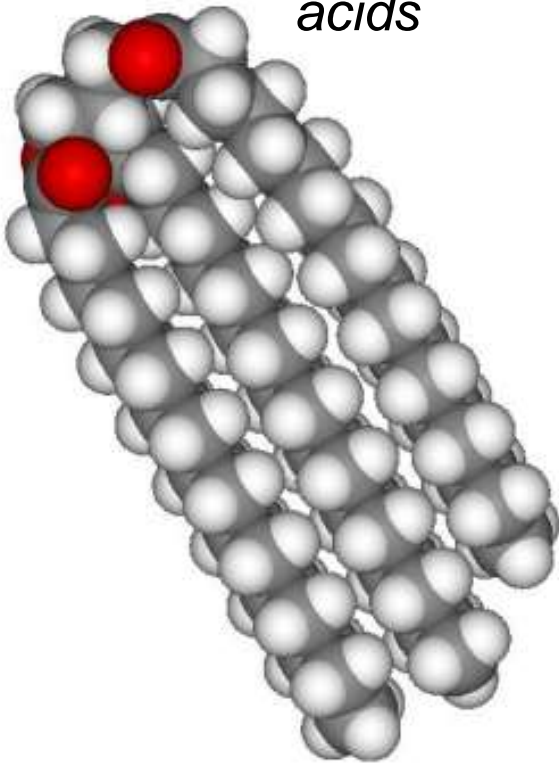
Rapeseed Oil



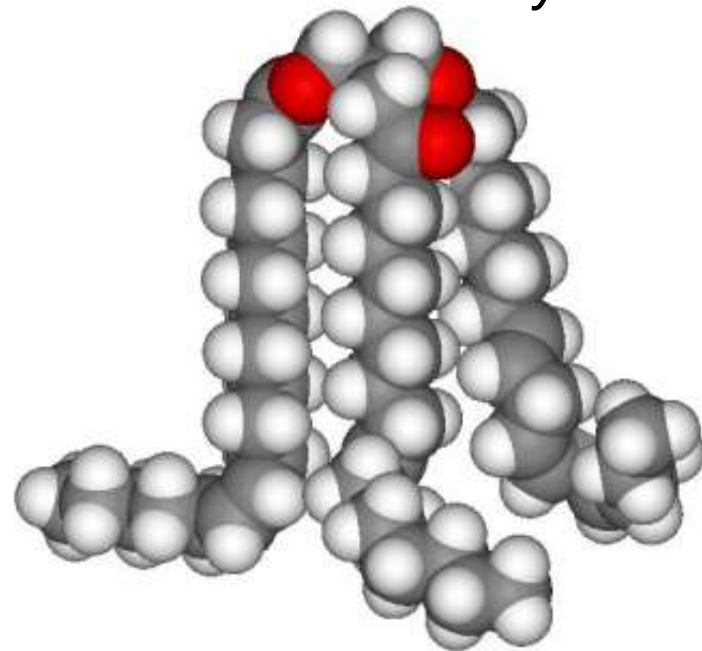
Carinata Oil

# Biomass-based diesel feedstocks

*Triglyceride with  
3 saturated fatty  
acids*

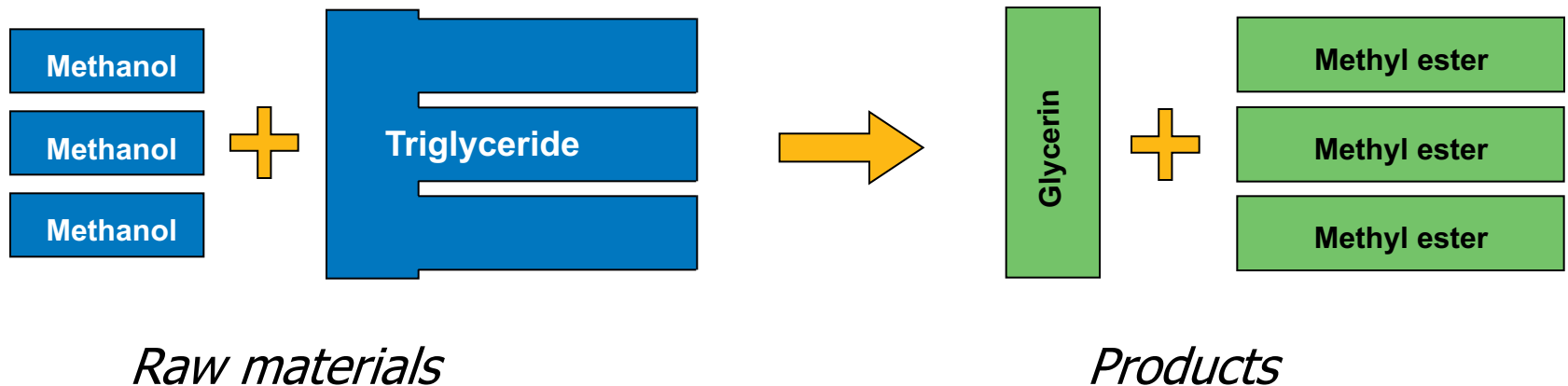


*Triglyceride with  
3 unsaturated fatty  
acids*



# What is Biodiesel?

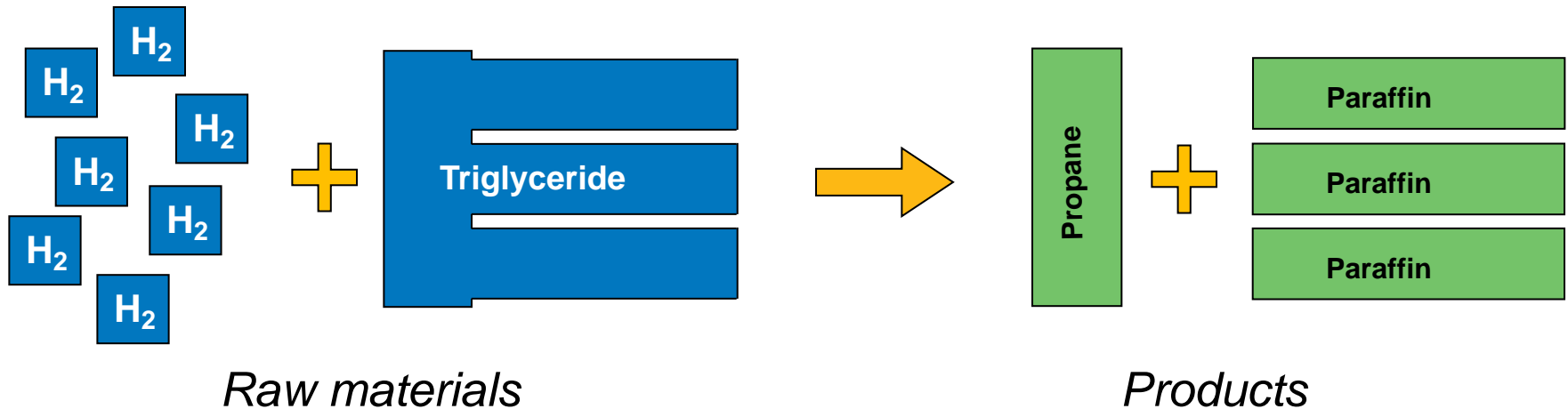
- Biodiesel is **methyl esters** made from biological oils and fats (**triglycerides**) by **transesterification**



Transesterification reaction

# What is Renewable Diesel?

- Renewable Diesel is **hydrocarbons** made from biological oils and fats (**triglycerides**) by **hydrotreating**

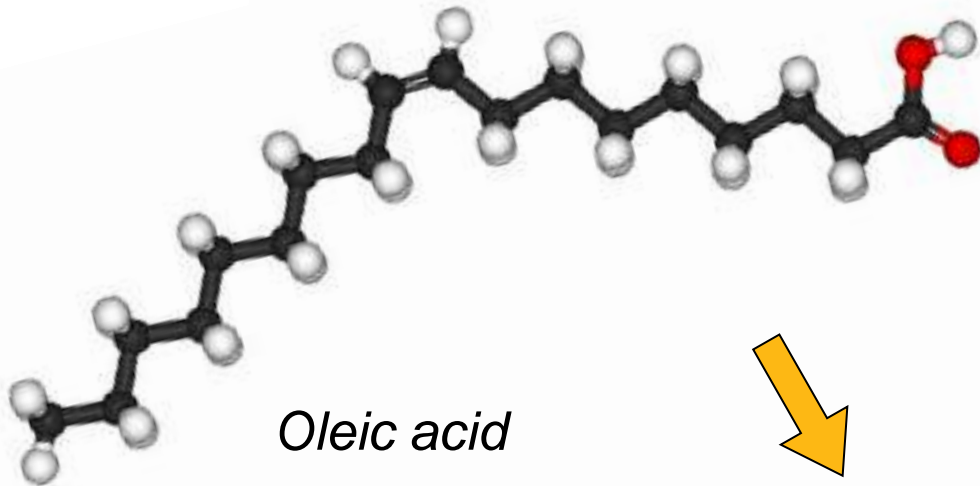


Hydrotreating reaction

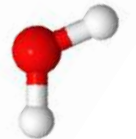
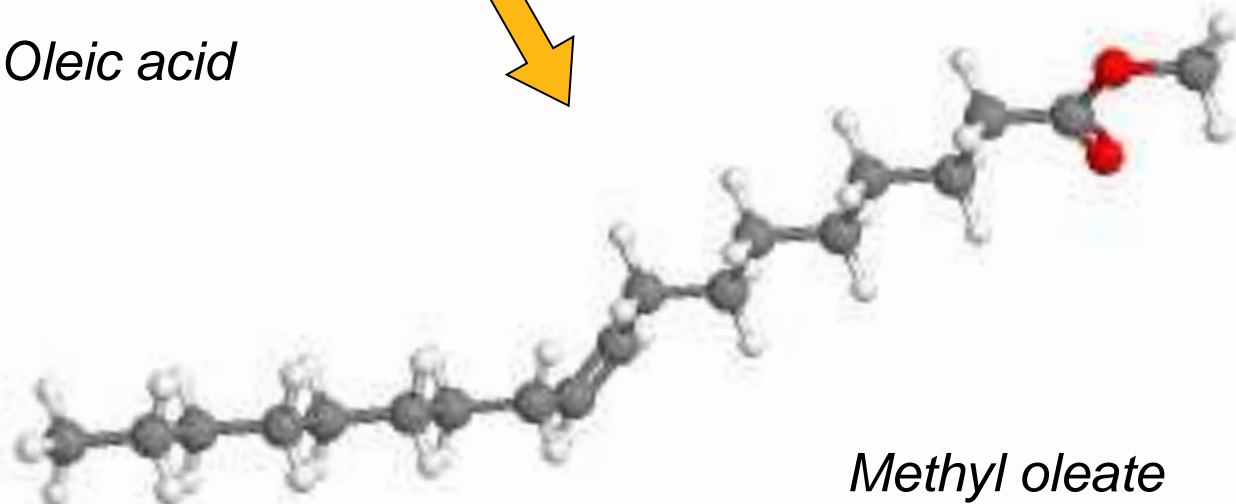


# Biodiesel example

Oleic acid to methyl oleate

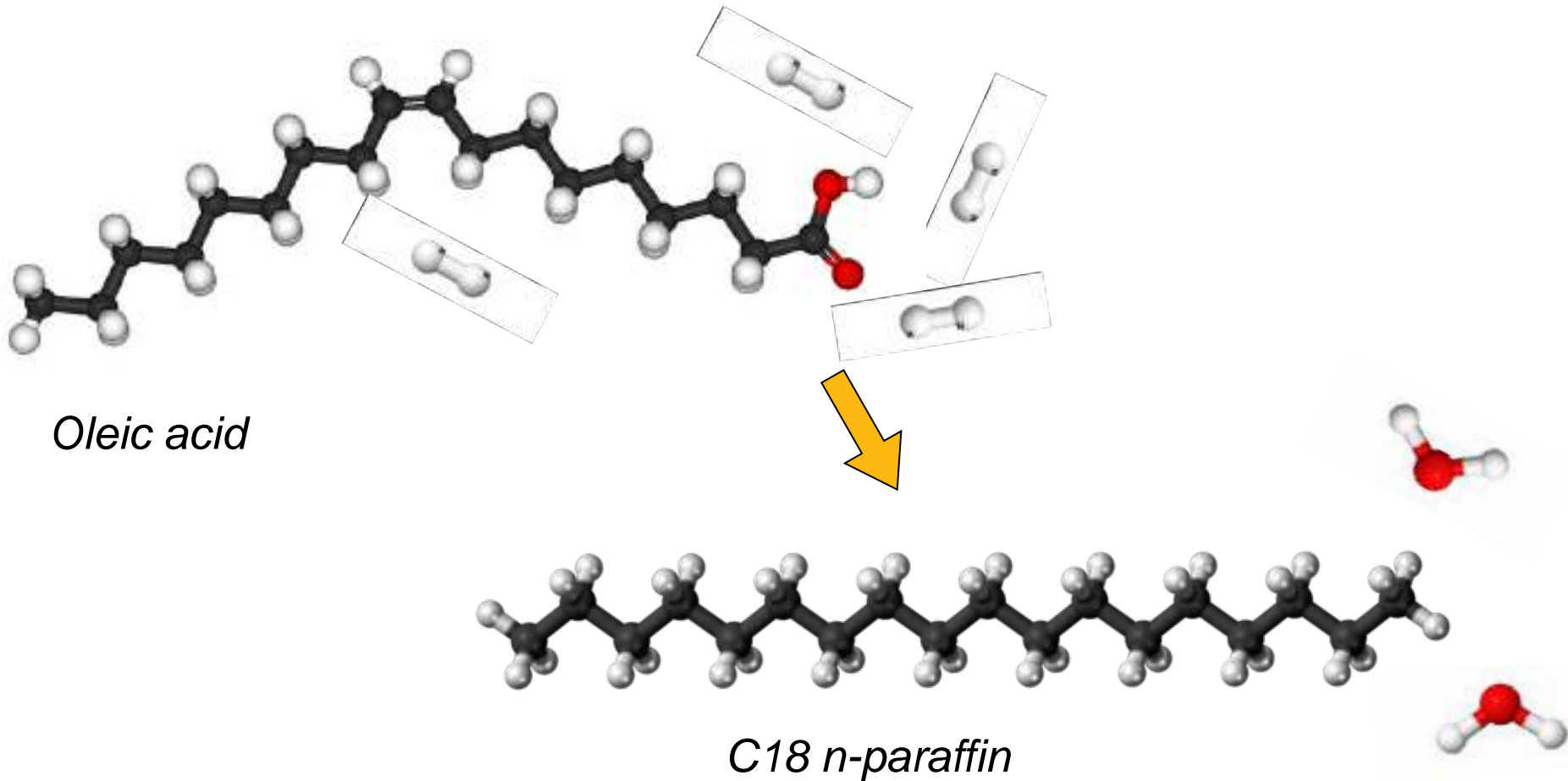


ChemEd.com



# Hydrotreating example

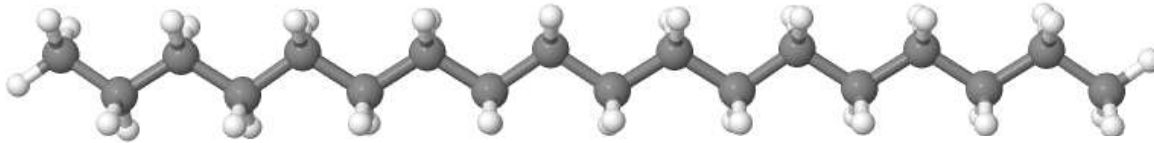
Oleic acid to C18 n-paraffin



# Isomerization example

Isomerization dramatically reduces melting point

*C18 n-paraffin (C<sub>18</sub>H<sub>38</sub>)*

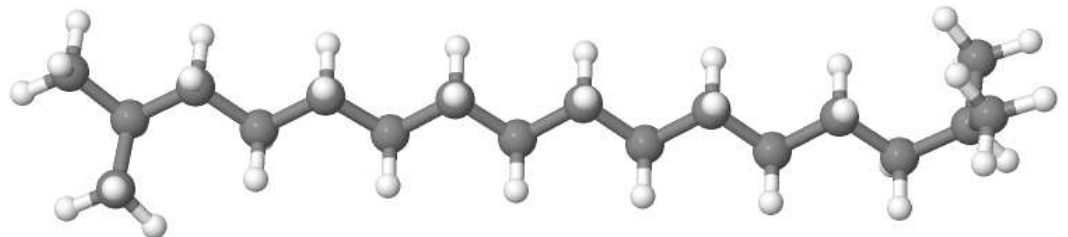


*Melting point > 28 °C*



*C18 isoparaffin (C<sub>18</sub>H<sub>38</sub>)*

*Melting point < -7 °C*



# HVO production samples



- Left: Crude Feedstock
  - Middle: Hydrocarbons after hydrotreating
  - Right: Finished (isomerized) HVO

# Benefits of HVO (Renewable Diesel)

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- Paraffinic fuel, which means:
  - Exceptional Cetane number
    - Greater than 65 (EU diesel specification requirement is 51)
    - Cetane number is an indicator of combustion quality
  - Reduced tailpipe emissions
    - In particular, NOx and carbon monoxide
    - Also particulate matter and total hydrocarbons
    - Virtually no sulfur
- Desirable Cloud Point
  - Cloud Point ranges from -10 °C to -20 °C
  - Winter pipeline specs for diesel are around -10 °C
- Can be blended at any level with diesel and biodiesel
  - Some users consider a 50% maximum (elastomer compatibility)

# Benefits of Biodiesel

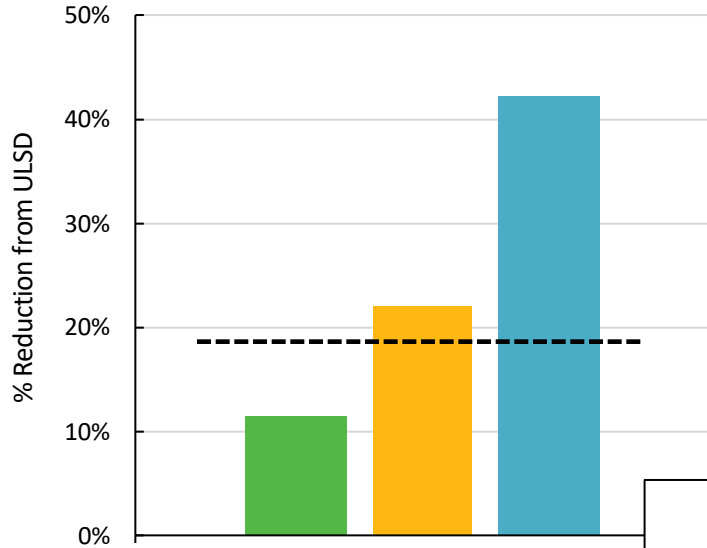
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- Oxygenated fuel, which means:
  - Reduced tailpipe emissions
    - Sulfur, carbon monoxide, hydrocarbons and particulates
    - Burn fuel instead of losing it out the exhaust
  - Enhanced lubricity
    - Excellent for ULSD and HVO (Renewable Diesel)
    - No lubricity additives needed with B2 or higher blends
- Comparable to vegetable oil for transport & handling requirements
- Can be blended at high level with diesel and HVO (Renewable Diesel)
  - 20% is a common maximum for general purpose use
  - Higher quality biodiesel performs better with HVO (Renewable Diesel) (CSFBT test)

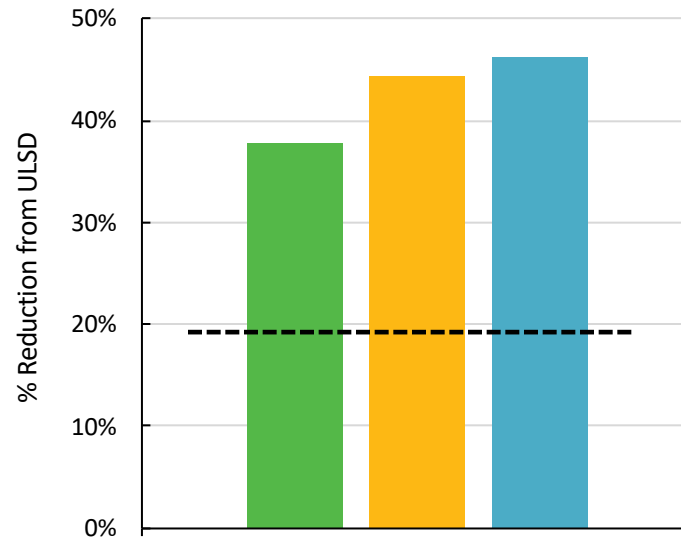


# Biomass-based diesel emissions

Total Hydrocarbons (THC)



Particulate Matter (PM)

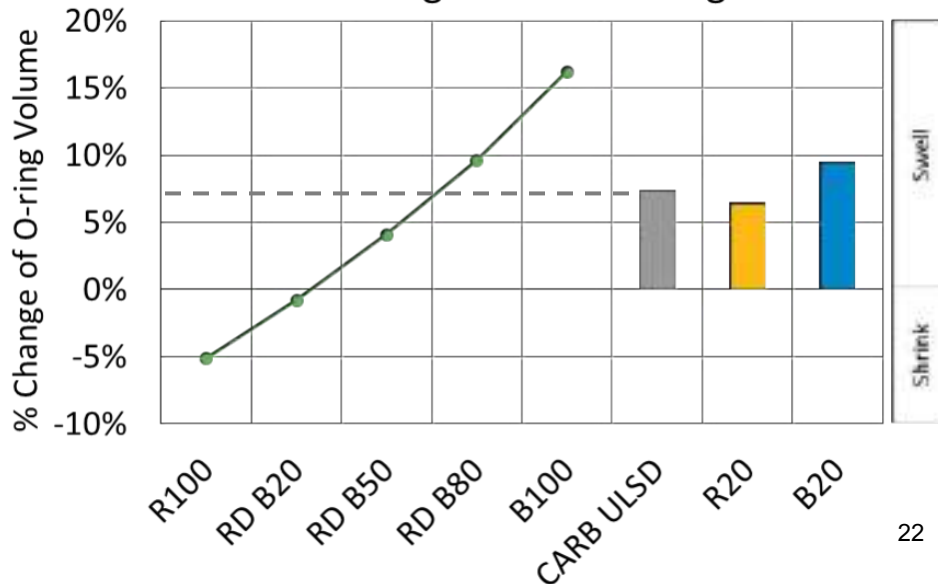


Note: Emissions estimates are derived from data for a 2006 Cummins ISM 370 on Federal Test Procedure driving cycle, as reported in Durbin, Thomas D., et al. "CARB Assessment of the Emissions from the Use of Biodiesel as a Motor Vehicle Fuel in California "Biodiesel Characterization and NOx Mitigation Study"." California Air Resources Board: Sacramento, CA (2011). Comparisons with Federal ULSD were conducted based on a linear comparison with CARB ULSD data. All biodiesel data shown are taken as an average of the means of high and low cetane biodiesel emissions results, where available.

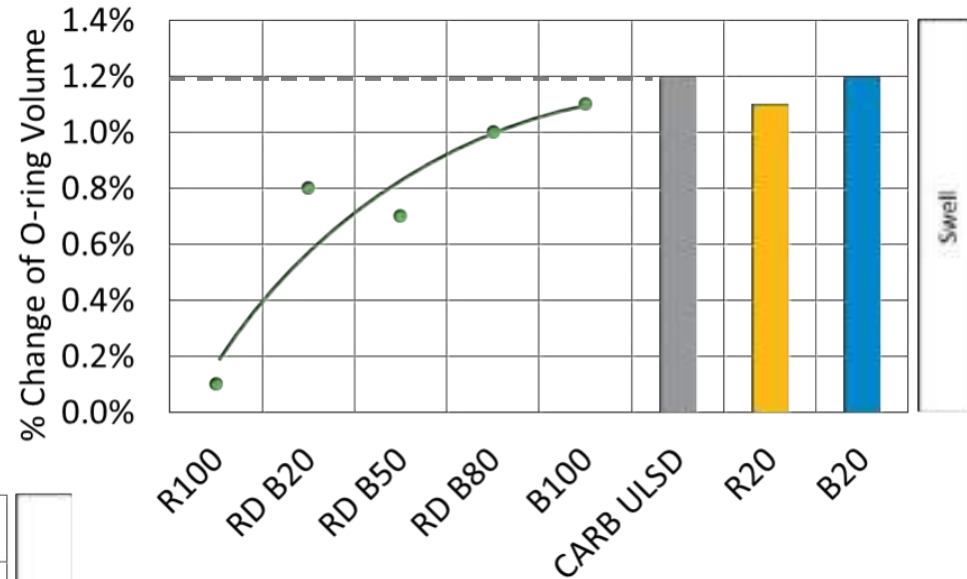
# Elastomer impact of diesel fuel options

- Volume change results indicate the extent of swell that occurs when an elastomer seal is exposed to fuel
- Volume change is a critical property for predicting seal performance in an engine
- Viton® seals (or equivalent) are typical for modern engines, while older engines often have NBR (nitrile rubber) seals

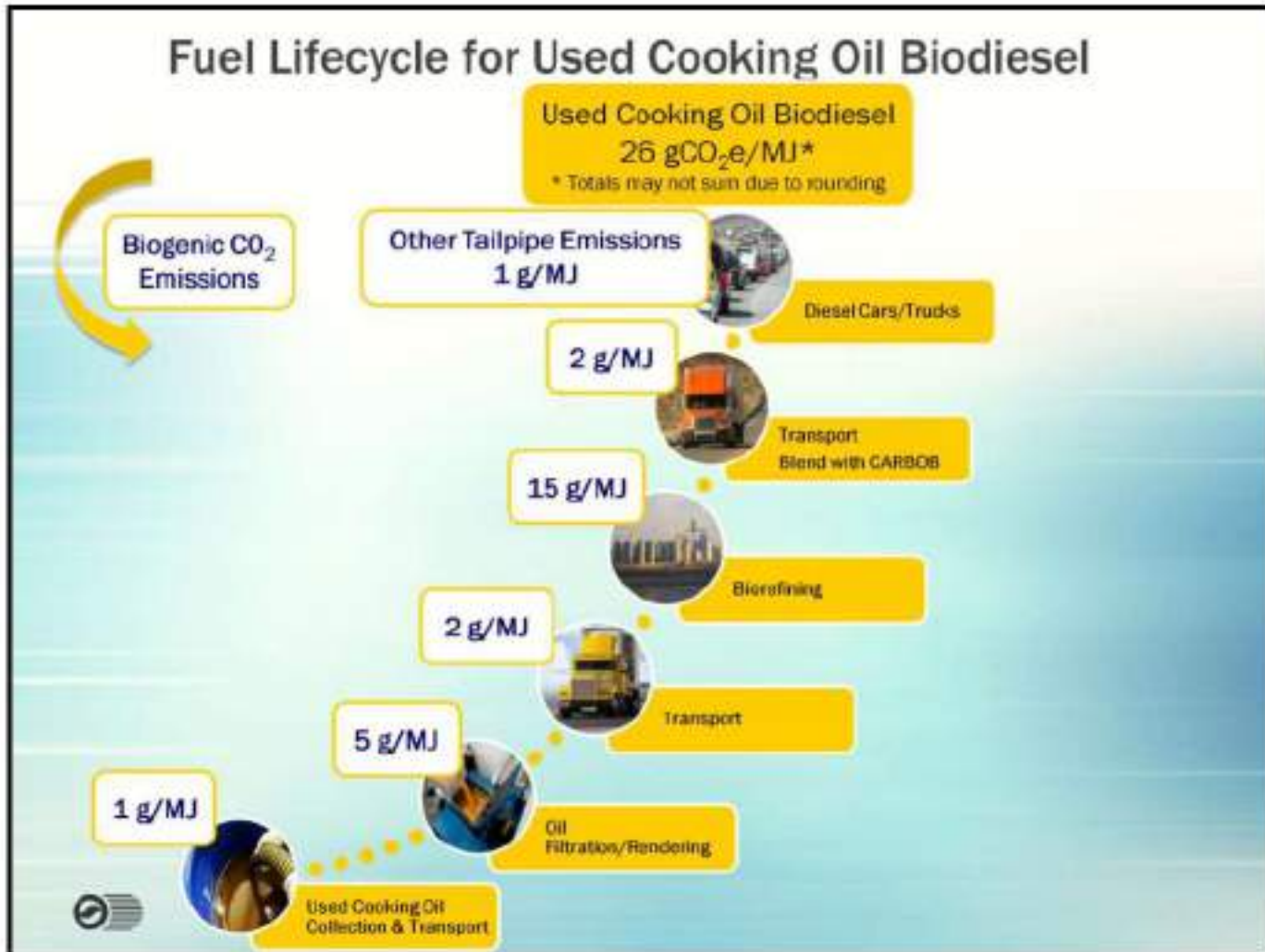
Volume Change of NBR O-Rings



Volume Change of Viton® O-Rings



# California Lifecycle Analysis Example



# GHG Values in Annex V

waste cooking <del>vegetable or animal</del> oil biodiesel	<del>88</del> ⇒ 83 ⇒ %	<del>83</del> ⇒ 77 ⇒ %
⇒ animal fats from rendering biodiesel ⇐	⇒ 79% ⇐	⇒ 72 % ⇐

- **Final values:**

- **Waste cooking oil: 88% / 84%**

- **Animal fats: 84% / 78%**

- 1% above UCO and Animal fats based HVO (even higher in real world)

**➔ WASTE BIODIESEL**  
**- SAVES MORE GHG**  
**- IS CHEAPER**