Diesel Fuel Properties

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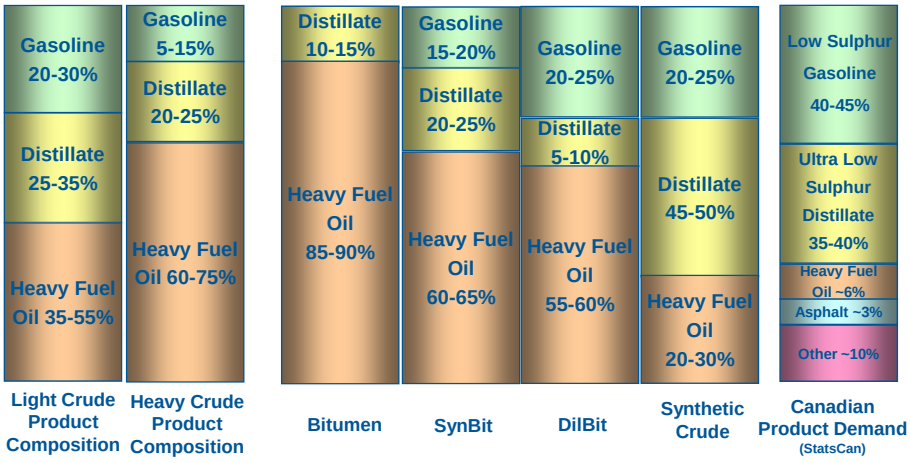
Crude Types



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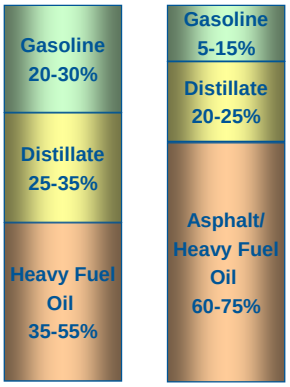
Refining Is The Process For Matching Crude Types With Market Demand



Light Crude Product Composition

Heavy Crude Product Composition

- Naturally occurring hydrocarbon molecules do not meet customer needs
- The refining processes must :
  - Change the size of the molecules
  - reshape them
  - remove contaminants

  to ensure they meet requirements for:
  - end-use performance
  - environmental performance

Canadian Product Demand (StatsCan)

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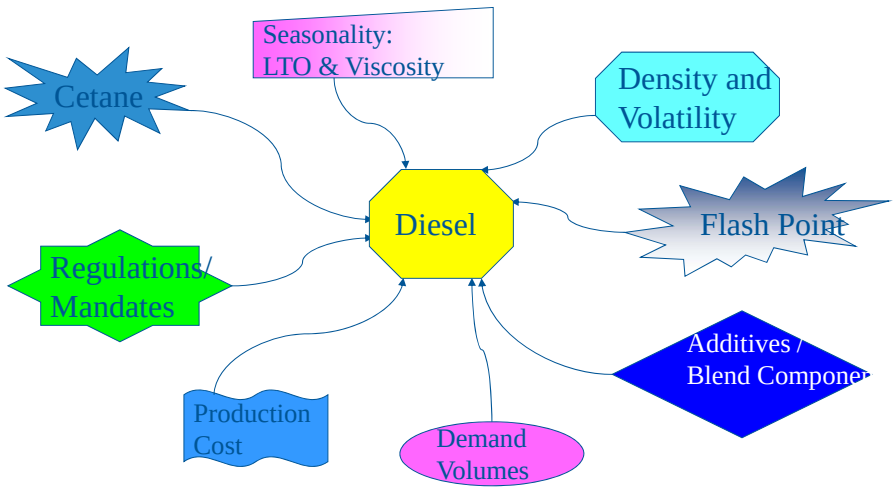
Diesel Blending- A Delicate Balance



Diesel: Density

- ***What is it?***
  - Density is the weight of fuel (in kilograms) per litre at 15 °C.
- ***Why is it important?***
  - Denser fuel has higher energy content - giving higher power output or greater fuel economy in a diesel engine. Since petroleum fuels expand at higher temperatures and contract at lower temperatures, density is measured at ambient conditions but converted to density at 15 °C to harmonize with international trading practices.
- ***What is the specification?***
  - While density is not a requirement of CGSB, the density of a batch of diesel fuel should be measured and reported on the Certificate of Analysis for quality control purposes and to allow calculation of the mass of a given volume of fuel.
    - Knowledge of the original density of a batch of fuel is useful to someone receiving the fuel. If the density of the fuel as received is significantly different from its original density measurement, it indicates possible contamination and is cause for further product quality investigation.

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Diesel: Low Temperature Operability

- ***What is it?***
  - Cloud point defines the temperature at which the smallest observable cluster of hydrocarbon crystals (wax crystals) first appears in a fuel upon cooling under prescribed test conditions. Cloud point is the most common measure of low-temperature operability.
  - Low-temperature operability can also be determined by the Low Temperature Filterability/Flow Test
- ***Why is it important?***
  - Wax crystals may block fuel filters on diesel engines and in distribution lines.
- ***What is the specification?***
  - Cloud point specifications are based on the 2.5% low-end design temperature data for the last 30 years for the location of intended use. However, when the 2.5% low-end design temperature is colder than -48°C, a fuel meeting a -48°C operability limit may be provided.

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Diesel: Cetane Number and Cetane Index

- ***What is it?***
  - Cetane Number is a measure of the ignition quality of diesel fuel. In its simplest terms, Cetane Number measures the delay between the start of fuel injection into the combustion chamber and the beginning of compression ignition (auto-ignition).
  - Cetane index is a calculated number used as a substitute for cetane number. Cetane index calculations cannot account for cetane improver additives, and therefore do not measure total cetane number for additized diesel fuels.
- ***Why is it important?***
  - Diesel engines rely on compression ignition (no spark) so the fuel must be able to auto ignite. A higher cetane number mean shorter ignition delay time and more complete combustion of the fuel charge in the combustion chamber. In turn, this results in smoother running, better performance and less emissions to atmosphere.
- ***What is the specification?***
  - Specified by CGSB
    - Minimum Cetane Number is 40.0 for Seasonal Diesel and No. 1 Diesel

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Diesel: Flash Point

- ***What is it?***
  - The lowest temperature at which a volatile material can vaporize to form an ignitable mixture in air
- ***Why is it important?***
  - It is used to help characterize the fire hazards so that it can be safely handled
- ***What is the specification?***
  - Specified by CGSB
    - Minimum flash point of diesel fuel in Canada is 40 °C
  - Specified by Suncor
    - Minimum flash point of diesel fuel at the Manufacturing facility is higher (typically 45 - 65 °C); however the specification at the Terminals is 43 °C, to guarantee a flash of 40 °C at point of sale
      - To account for any contamination with gasoline that occurred during movement of product from the refinery to the consumer.

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Diesel: Viscosity

- ***What is it?***
  - Viscosity is a measure of a liquid's resistance to flow. High viscosity means the fuel is thick and does not flow easily.
- ***Why is it important?***
  - Fuel with the wrong viscosity (either too high or too low) can cause engine or fuel system damage as the viscosity affects atomization and the fuel delivery rate.
    - High viscosity fuel will increase gear train, cam and follower wear on the fuel pump assembly because of the higher injection pressure. Fuel atomizes less efficiently and the engine will be more difficult to start.
    - Low viscosity fuel may not provide adequate lubrication to plungers, barrels and injectors, and its use should be evaluated carefully.
- ***What is the specification?***
  - Varies according to location. See product specifications for details (regionally and seasonally).

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Diesel: Volatility

- **What is it-**
  - Volatility is the ease of vaporization in the combustion chamber.
- **Why is it Important**
  - Distillation (boiling range) specifications limit the 10%, 90% and FBP (Final Boiling Point) in order to obtain more complete combustion of the fuel
  - Incomplete combustion means more emissions and less power/fuel economy (White Smoke - unburned fuel, Black smoke - partially burned fuel).
  - Higher boiling (heavier) components increase soot and deposits.
  - Only real “choice” is between Type B (Seasonal) - and Type A (#1/D50).
- **What is the Specification**
  - The 90% distillation point is a CGSB requirement
  - Suncor uses the 10%/90%/FBP

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Diesel: Summery Chart

Property	Performance/Effect	Long Term	Immediate
Flash	Safety		✓
Cetane	Cold Start/ Combustion/Emissions		✓
Cloud Point	Low Temperature Operability		✓
Volatility	Ease of starting	✓	✓
Density/HHV	Fuel Economy	✓	✓
Viscosity	Spray pattern/ system lubrication	✓	✓
Sulphur	Emissions/deposit/ wear	✓	✓
Stability	Tendency to Form insolubles	✓	
Lubricity	Fuel pump/ Injector wear	✓	
Water	Fuel Filters/Injectors	✓	

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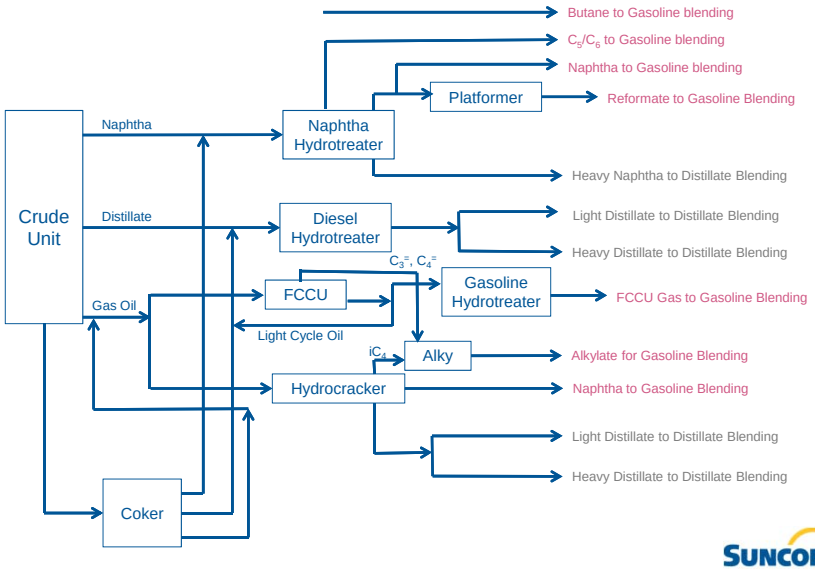
Simplified Gasoline and Diesel Production at a Refinery



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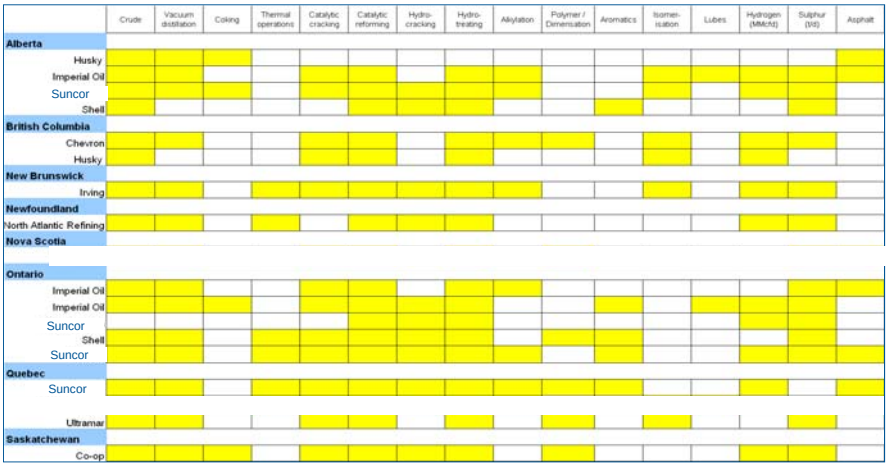
Canadian refining diversity “No two refineries are alike”



Yellow shading indicates presence of that process at that refinery.

Source: 2006 Oil & Gas Journal Survey

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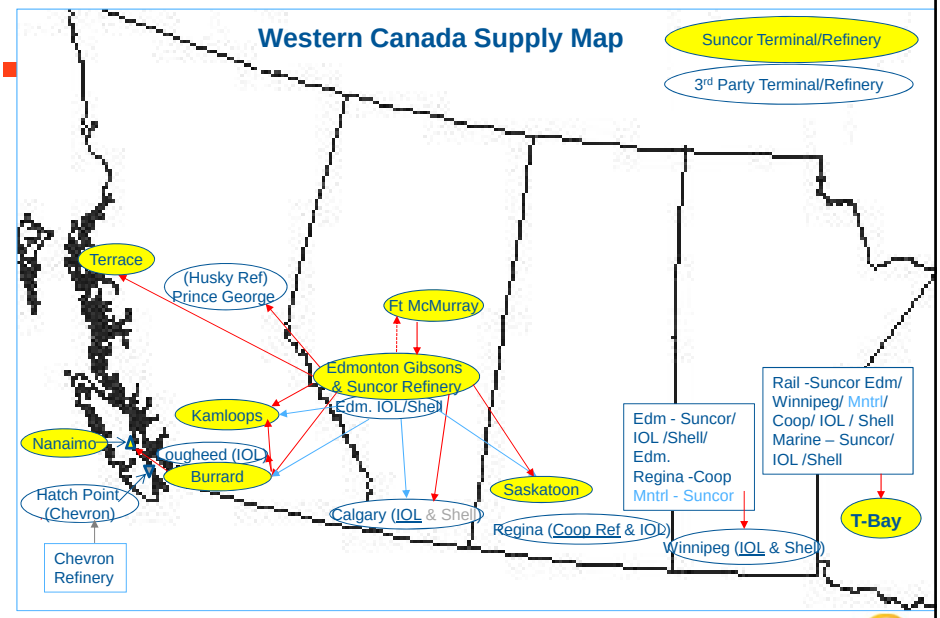
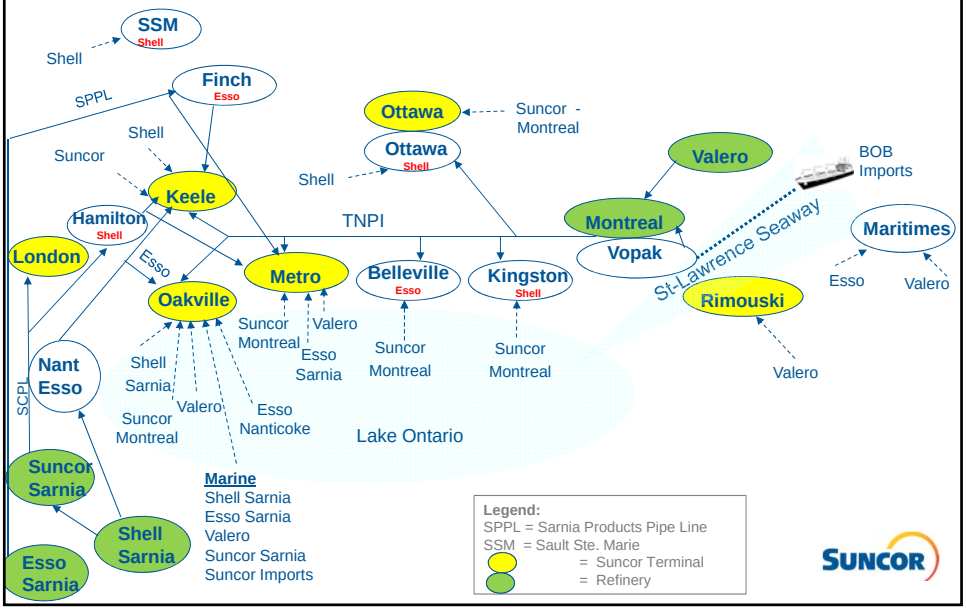
Western Canada Supply Map



Eastern Canada Supply Map



DIESEL / FAME / RENEWABLE DIESEL

	Diesel	FAME	Renewable
Density, kg/L	0.84 – 0.86	0.88	0.77-0.79
Energy Content., MJ/L	35.7 - 36.7	32.7	34.4
Cloud Point, ºC	0 - -55	15 - -3	-5 - -40
Flash Point, ºC	68 - 94	108 - 150	>61
Distillation FBP , ºC	307-352	340 - 355	265-330
Viscosity, cSt @ 40 C	2.04 - 3.23	4.0 – 5.0	2.00-4.00
Sulphur, ppm	1 - 10	1 - 8	<5
Cetane Number	41- 48	48-65	70-90
Stability	Good	Marginal*	Good
Oxygen Content, %	0	11	0
Lubricity	Good*	Excellent	Good*
* Additized to meet spec			

From: www.energyinst.org.uk

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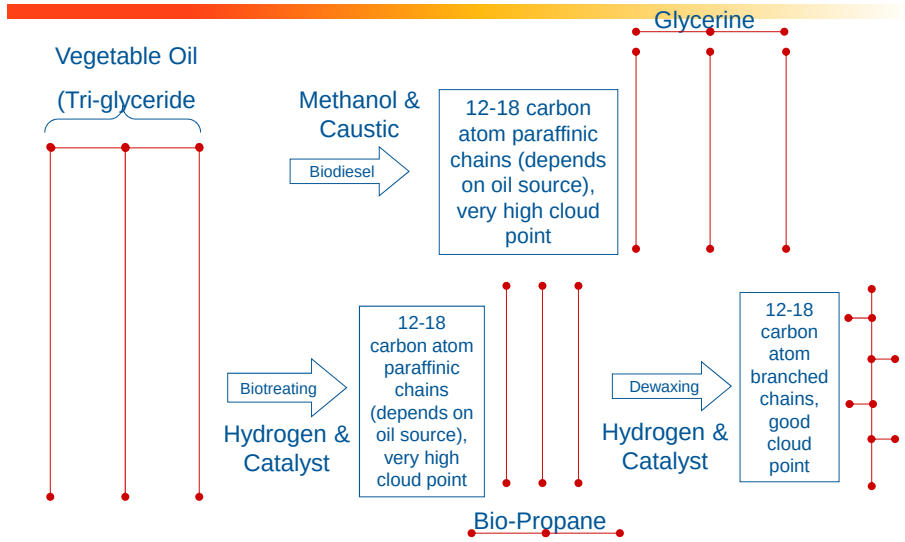
Biodiesel vs. Renewable Diesel



- Renewable diesel starts with the same feed, but produces a product virtually indistinguishable from petroleum diesel.

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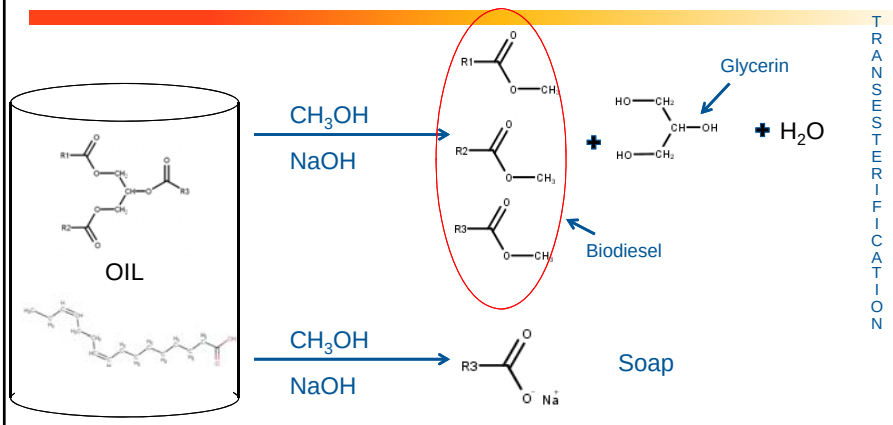
Conventional Biodiesel Production



- Excess free fatty acids promote generation of soap
- Soap complicates moisture removal in biodiesel finishing
- Conventional biodiesel plants limited to feedstocks with low FFA contents

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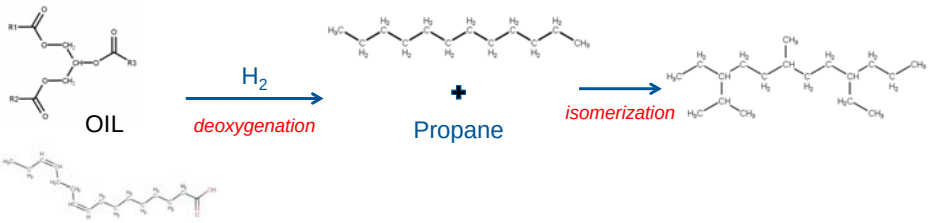
Neste Renewable Diesel – NExBTL



- Robust feedstock diet
- Insensitive to FFA content
- Two stage process:
  1. Deoxygenation reaction
     - Requires larges amounts of hydrogen
     - Exothermic
     - Generates propane, water and carbon dioxide
  2. Isomerization
     - Improves cold temperature properties
     - High temperature, high H_2 pressure (low consumption)

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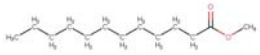
Biodiesel vs. Renewable Diesel

Biodiesel

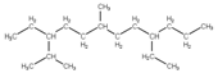
- Chemical Composition: Fatty Acid Methyl Ester (FAME)



- Max allowed Suncor blend = 5%
- Suncor approved feedstocks:
  - Canola
  - Corn Oil
  - Soybean

Hydrogen Derived Renewable Diesel (HDRD)

- Chemical composition: Highly-branched isoalkane



- Max allowed Suncor blend = 20-25%
- BCLCF approved feedstocks:
  - Crude Palm Oil
  - Palm Fatty Acid Distillate
  - Refined, bleached and deodorized palm oil (RBD)
  - Also known to be derived from beef/sheep tallow, castor oil, tall oil and many others

  - **Toyota is using sewage sludge to power its new electric car (Sept 20, 2016, Quartz)**

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Fatty Acid Methyl Ester (*FAME*) biodiesel solidifies at relatively high temperatures.

Biodiesel Cloud Points (degrees C):
Canola -3
Soy +2
Palm/Tallow +15

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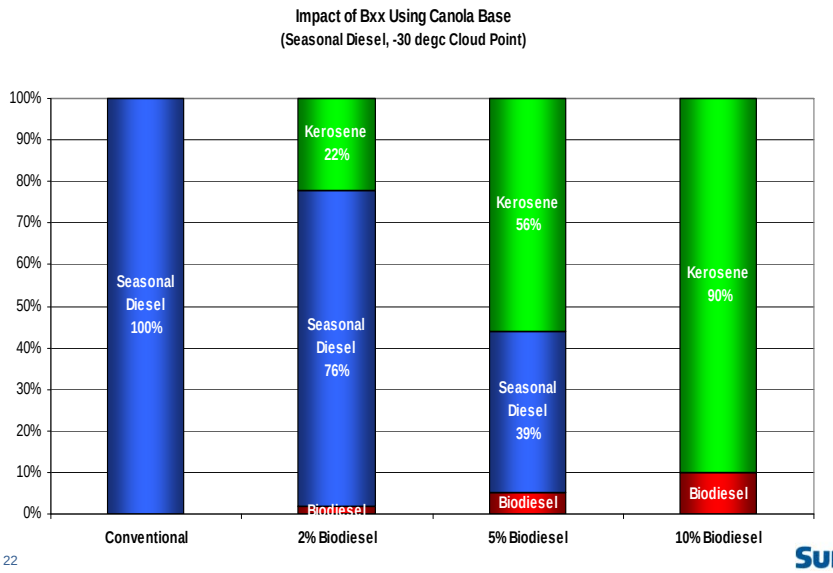
Biodiesels Have High Cloud Point Which Must Be Compensated For In Blends.



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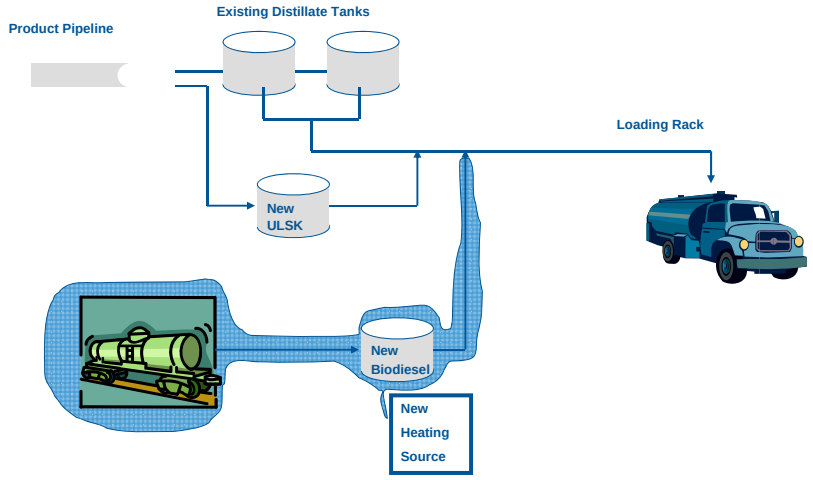
Renewable Fuel Blending at Terminals



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Conclusions

- Diesel properties can be manipulated
- Transportation logistics make specialty diesel geographically isolated
- Diesel additives exist but “move the needle” very little
- Biofuels can be both a help and a hindrance

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