California Renewable Diesel Multimedia Evaluation Tier I Report

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Renewable Diesel Tier I Elements

- Background
- Study Approach—Life Cycle and Multimedia
- Release Scenarios
- Renewable Diesel Production, Storage, Distribution and Use
- Renewable Diesel Toxicity
- Transport and Fate
- Tier I Conclusions

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Background

- **Currently the majority of biological-source diesel fuels are fatty-acid methyl esters (FAME)**
- **Renewable diesel is different and now entering the market**
- **According to the Low-Carbon Fuel Standard (LCFS)**

"… a motor vehicle fuel or fuel additive which is all the following:

(A) Registered as a motor vehicle fuel or fuel additive under 40 CFR part 79; A-9

(B) Not a mono-alkyl ester;

(C) Intended for use in engines that are designed to run on conventional diesel fuel; and

(D) Derived from nonpetroleum renewable resources."

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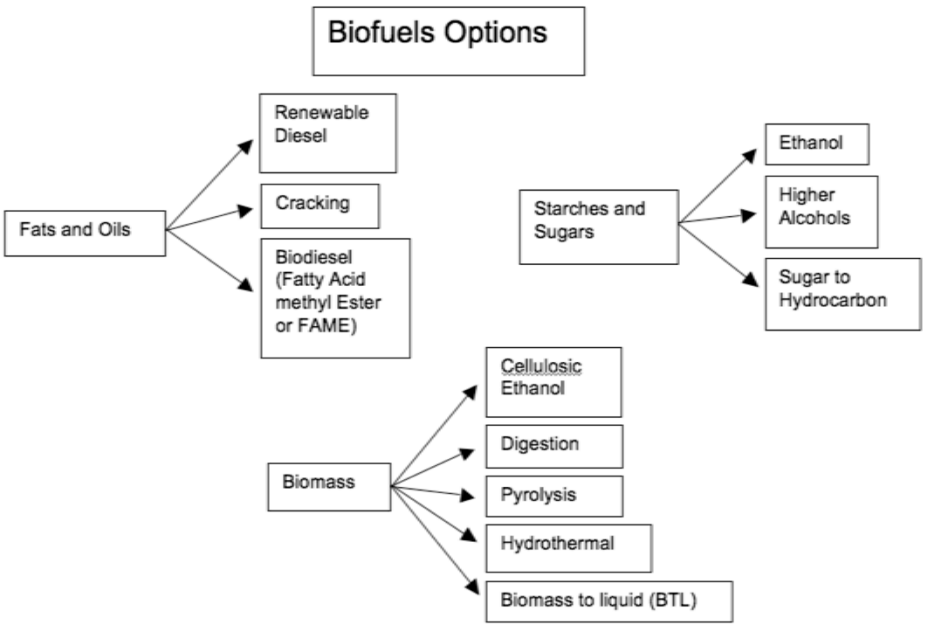

Study Approach

- **Life-cycle approach to impacts**
  - **Human health**
  - **Ecological risk**
  - **Resource stress and damage**
- **Identify key uncertainties and data gaps**
- **Address multimedia impacts**
  - **Air quality**
  - **Water resources**
  - **Soil**
  - **Infrastructure**
- **Excludes indirect environmental, ecological, and health impacts from biomass production (i.e. climate disruption)**

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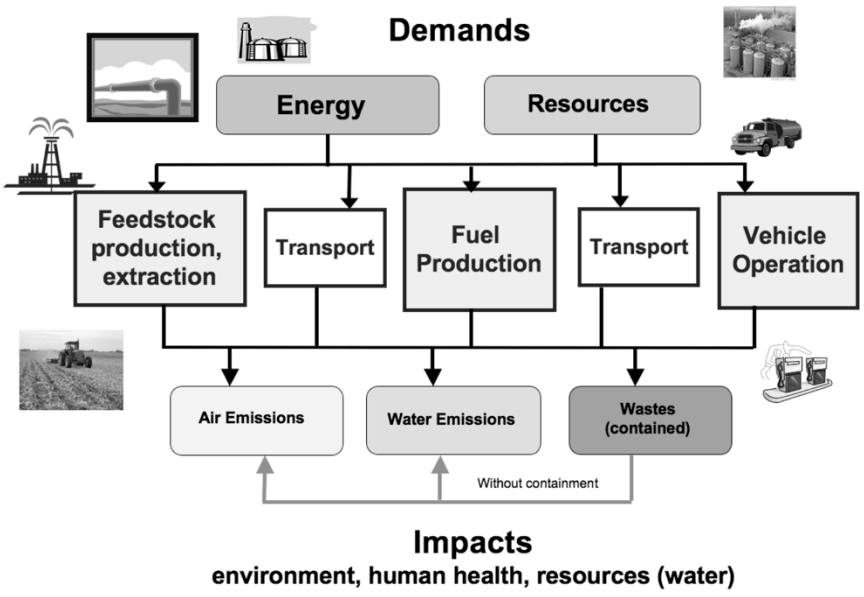
Life-Cycle Stages



Key LCA Studies Review

- **US EPA Life Cycle Assessment of Renewable Fuels**
  - **As part of its RFS2 rulemaking, EPA made a life cycle assessment of alternative and petroleum transportation fuels**
  - **EPA reported fuel use and production emissions**
- **National Research Council "Hidden Costs of Energy" Study (2009)**
  - **Life-cycle damage per vehicle-mile traveled (VMT)**
  - **Different combinations of fuels and vehicle technologies**
  - **VMT damages were remarkably similar**
  - **NRC urged caution interpreting small differences between fuel/vehicle combinations**

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Release Scenarios

- **Normal releases**
  - **Production emissions (in addition to refinery operation)**
    - Hexane or CO_2 released to the air during seed extraction,
    - Odors associated with waste biomass
    - Used process water discharges (pH and trace-chemicals)
  - **Use-phase (combustion) emissions**
    - Tailpipe emissions
    - Marine engine water releases
- **Off-normal releases—effectively the same as ULSD**
  - **Spills and leaks during production, distribution, and storage**
    - Above- or below-ground storage tank & associated piping,
    - Liquid-transportation vehicles--rail tank car, tanker truck, tanker ship
    - Bulk-fuel transport pipeline

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Production, Distribution, Storage and Use

- **Approaches to producing renewable diesel (RD)**
  - **Hydrotreating vegetable oils or animal fats to make Hydrogenation Derived Renewable Diesel (HDRD)**
  - **Partially combusting a biomass to get CO/H_2 (syngas) utilizing the Fischer-Tropsch reaction to produce complex hydrocarbons**
  - **Emerging approaches based on synthesis of hydrocarbons through enzymatic reactions**
- **Producing HDRD**
  - **Co-processing in a conventional petroleum production stream**
  - **Dedicated HDRD (or R100) production with distribution, direct use or dilution**
- **Specifications for additives to RD expected to be similar to ULSD**

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Production, Distribution, Storage and Use

- **Combustion emissions studies are ongoing**
- **Preliminary results suggest Renewable Diesel (RD) emissions & impacts that are within the range of ULSD emissions & impacts**
  - **Absence of sulfur and aromatic compounds in pure RD**
  - **Pure HDRD fuel showed significant emission benefits for CO, HC, NOx and PM—Secondary PM not yet addressed**
    Below 10% RD, blends can result in CO and HC reductions, but not PM, NOx
  - **Volumetric fuel consumption is 5% higher because of lower HDRD density**
  - **HDRD fuels avoid some biodiesel issues (oxidation, hygroscopicity, fouling, catalyst deactivation, etc).**

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Toxicity

- **Key challenge**
  - **RD is not a defined chemical formulation or a defined mixture of components**
- **Limited tests indicate that RD has low relative toxicity**
  - **Major differences in health and ecological impact between existing diesel and RD blends are more likely to be associated with additives than with the hydrocarbon mix**
  - **Chemical comparison to conventional diesel is important for determining whether or how much additional toxicity tests are required**

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Transport and Fate

- **The fate and transport of a fuel and its component chemicals in the environment depend on the multimedia transport properties of its constituent chemicals**
- **Based on similarities in chemical composition, the multimedia environmental behavior of renewable diesel should be be similar to ULSD**
- **Impact of additives to fate and transport need to be evaluated**

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Tier I Conclusions

- Renewable diesel (RD) is chemically similar to the ultra-low sulfur diesel (ULSD) fuel already in wide use in California
- RD is compatible with existing refining and distribution infrastructure and can be used in current diesel engines without modification
- Pure renewable diesel has reduced aromatic hydrocarbon content
- Limited toxicity testing on rats reveals that pure RD has limited inherent toxicity and unlikely to exceed the inherent toxicity or mutagenicity of standard diesel.
- Life-cycle health impacts of renewable diesel blends are not likely to differ significantly from those of petroleum diesel.

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Tier I Conclusions

- Knowledge gaps include
  - Additive impacts
  - Production, storage and distribution releases (off-normal)
  - Air emissions toxicity testing
  - Priority list of renewable diesel fuel formulations

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