Overview of Published LCA Studies

Biodiesel Technical Workshop

October 27-29, 2009

San Antonio, Texas

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CRC AVFL-17 Literature Review Project

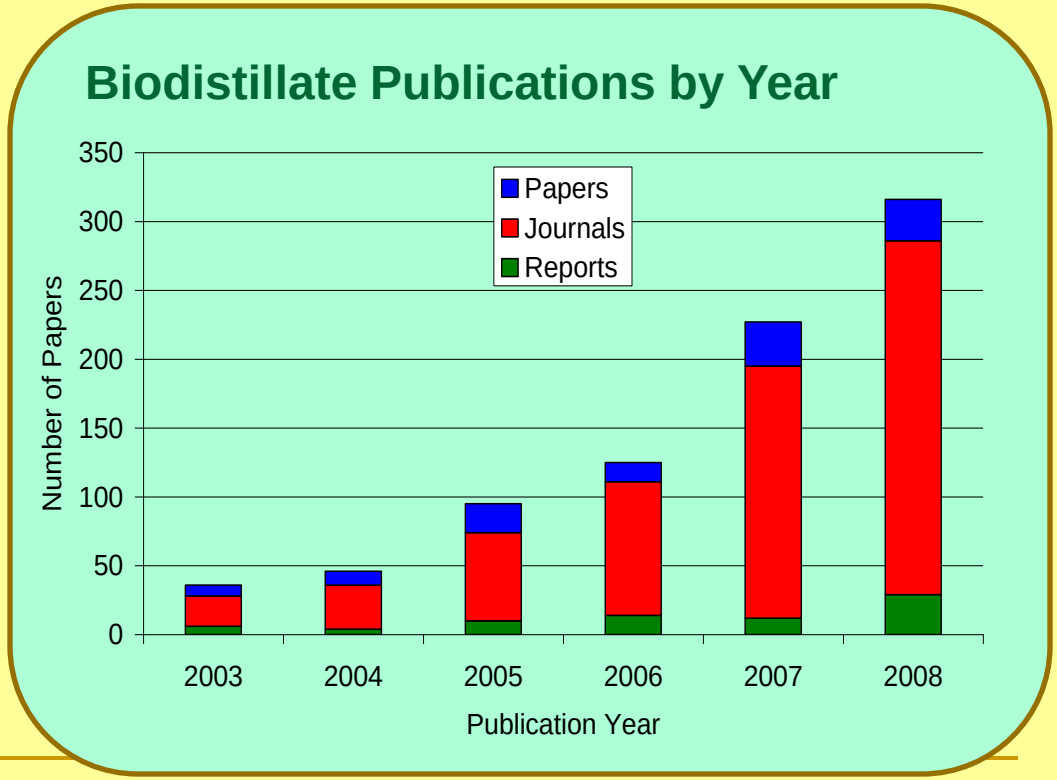
- Objective: Assess state-of-knowledge regarding bio-derived mid-distillate fuels
- Aspects covered:
  - Policy drivers
  - Biofuel feedstocks
  - Fuel production technologies
  - Fuel properties and specifications
  - In-use handling and performance
  - Exhaust emissions
  - **Life-cycle impacts**

- Final report is available from CRC website: www.crcao.org

Topic of Biodistillates is very active in the literature

Literature review focused on years 2000 to present

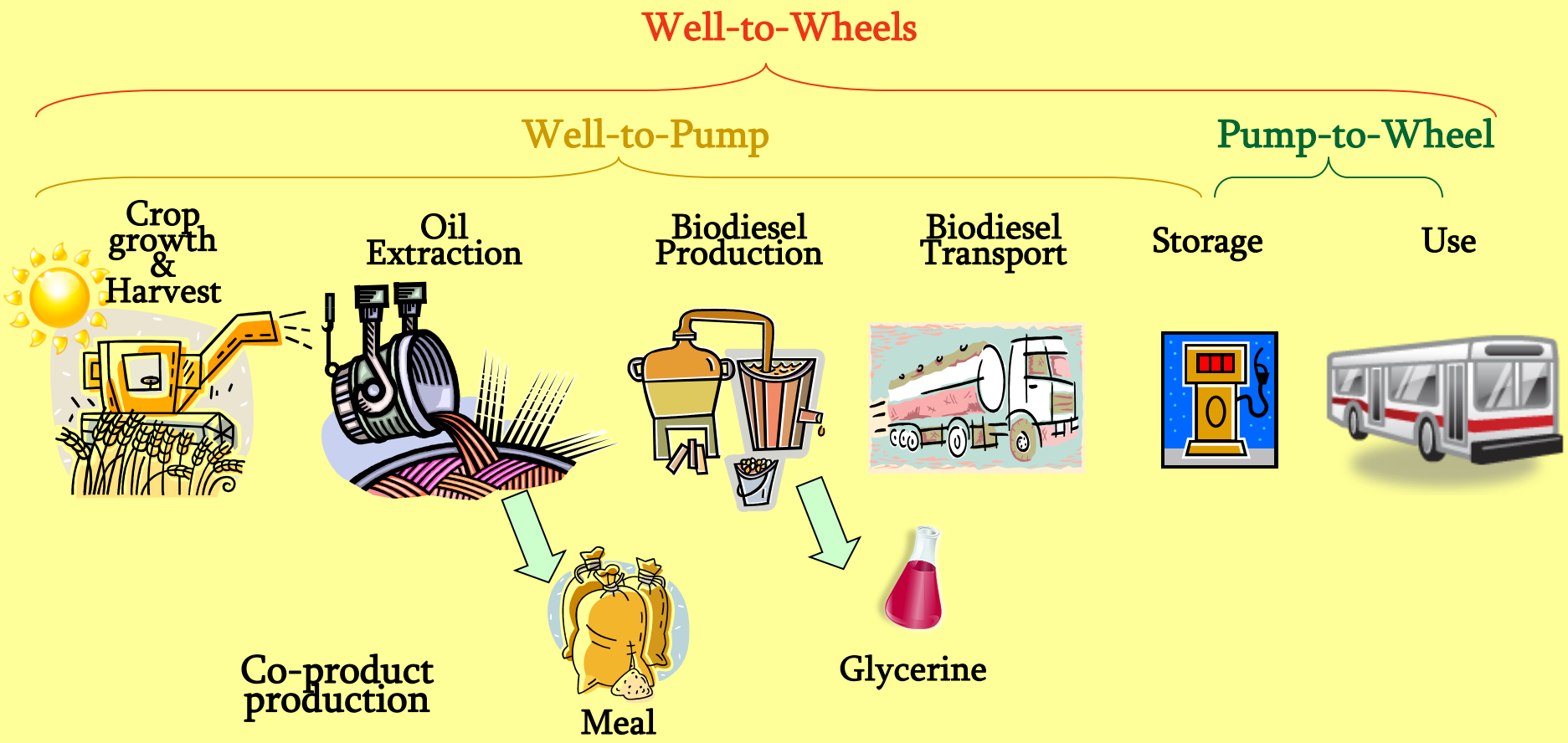
- Over 1000 items of interest identified
- Over 55 LCA studies, including both biodiesel and renewable diesel
- LCA studies being published with increasing frequency



Life Cycle Assessments of Biodistillates

Assessments of Energy Return (ER) and Global Warming Potential (GWP)

Cradle to grave impacts of producing and using a fuel



Clearly defined boundaries are crucial!

Key Issues in Biodistillate LCAs

- Nitrogen fertilizer for plant growth
- Conversion factor of nitrogen fertilizer to N_2O
- Crop yields
- Scale of production
- Other farming energy and chemical requirements
- Energy use in biofuel processing plants, including the type and amount of process fuel
- **Credits given to co-products**
- **Land use changes**

Source: Wang, M., "Life cycle analysis practicality," Workshop on Measuring and Modeling Lifecycle GHG Impacts of Transportation Fuels., 2008.

Dealing with Co-products

- ER and GWP impacts can be shared with co-products if they have value elsewhere in the market place
- Four common allocation approaches have been used:
  - **Physical Allocation —** based upon a common physical parameter (mass or energy)
  - **Economic Allocation —** based upon market price
  - **Expanded Allocation** (*Displacement or Substitution*) **—** byproducts are assumed to replace existing products. Impacts from the replaced products are subtracted from the impacts of the biofuel
  - **No Co-Product Allocation —** all impacts are attributed to the final biofuel

Land Use Change

Direct Land Use Change

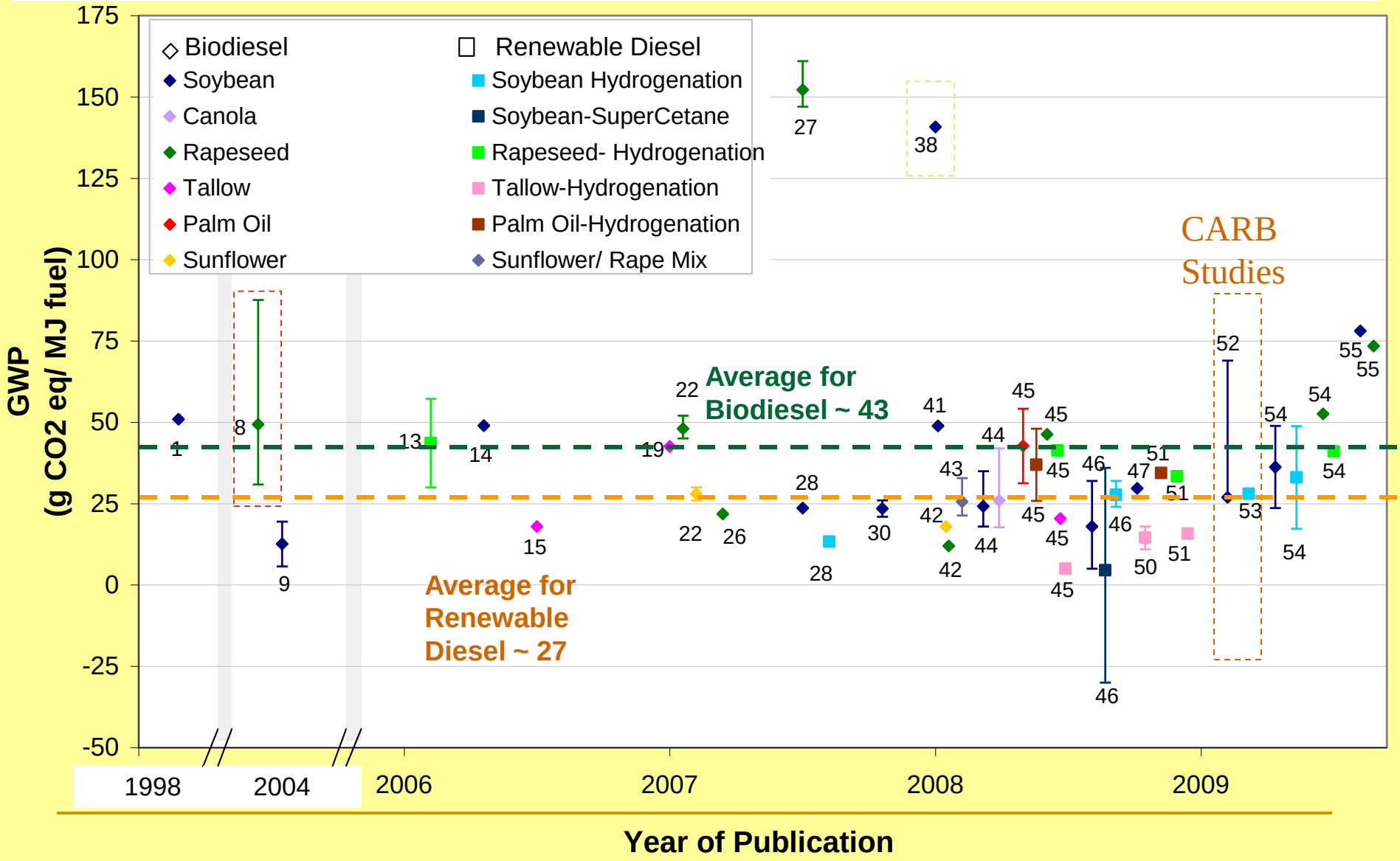
- Preparation of land may cause modifications to soil carbon.
- Nitrogen emissions from fertilizers (N_2O has GWP 296 times that of CO_2)
- Requires agricultural-related assumptions.
- Also called Attributional LCA

Indirect Land Use Change

- Changes to crop land or diversion of crops may lead to increased crop production elsewhere in the world.
- May reduce virgin lands, causing significant releases of CO_2.
- Requires economic modeling
- Also called Consequential LCA

Life Cycle Global Warming Potential of Biodistillate Fuels

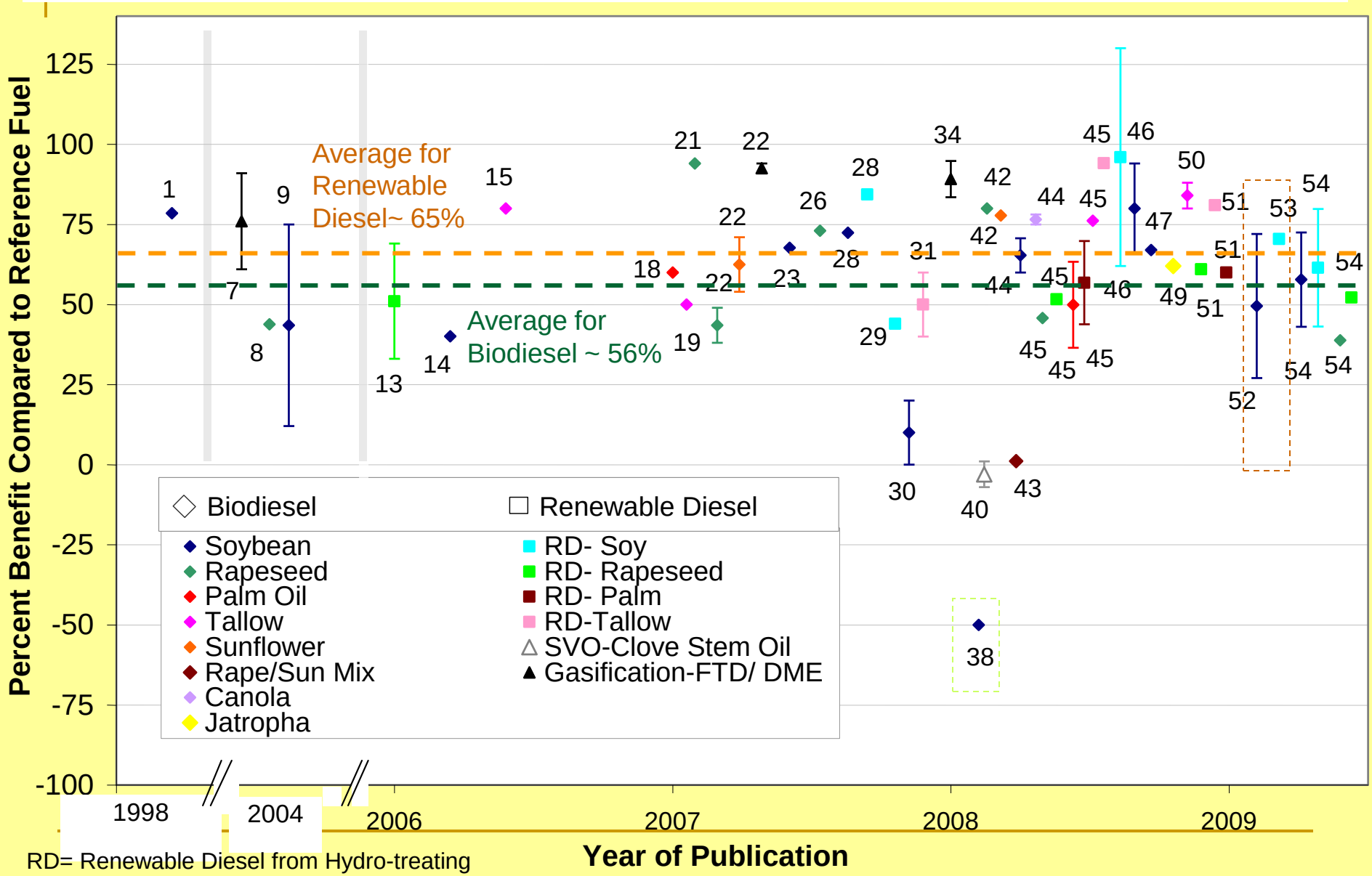
Published results from 55 studies



Numbering refers to study number detailed in SAE Paper 2009-01-2768

GWP Benefit of Biodistillate Fuels Relative to Reference Fuel

Published results from 55 studies



RD= Renewable Diesel from Hydro-treating

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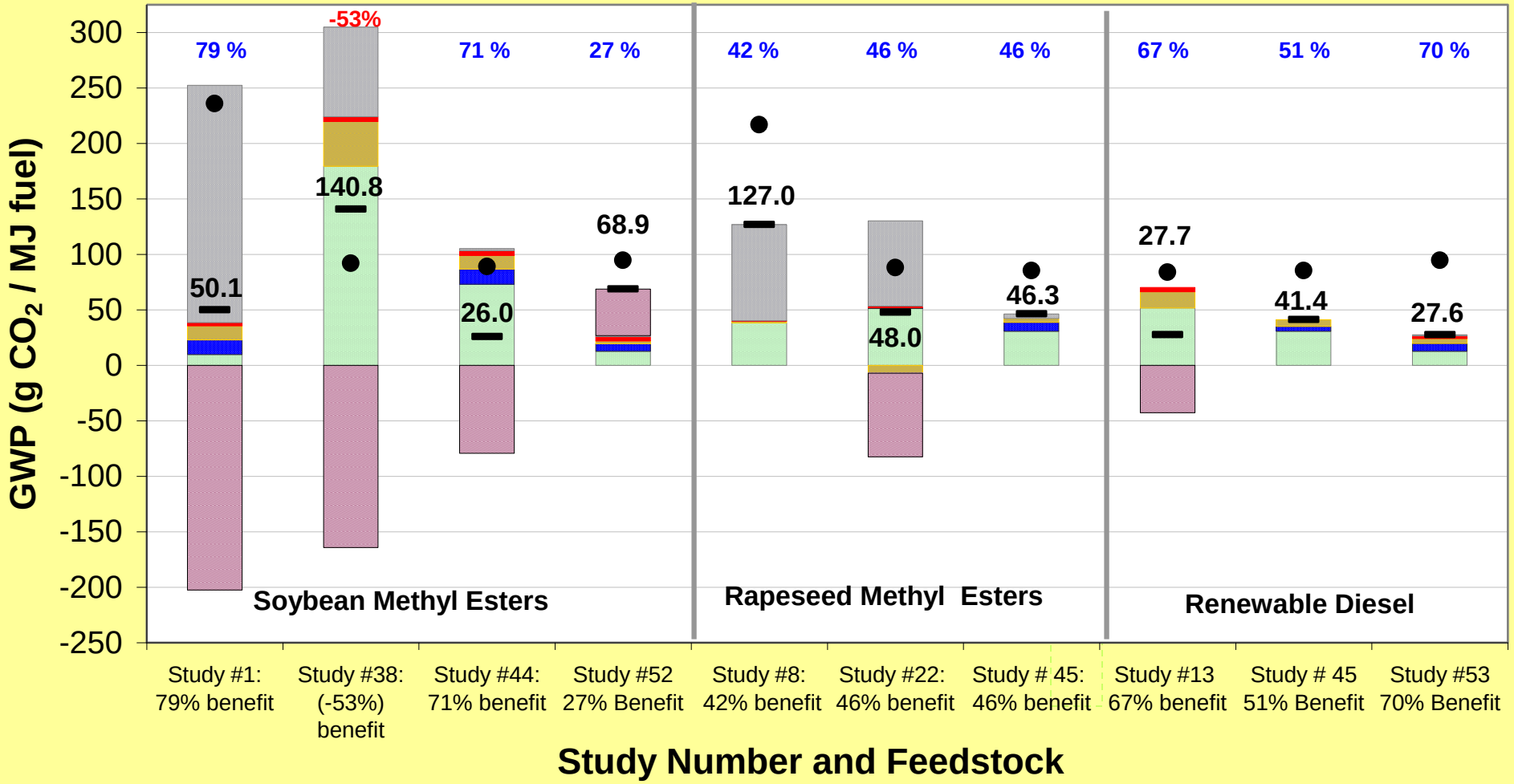
GWP Allocation by Category for Selected Studies



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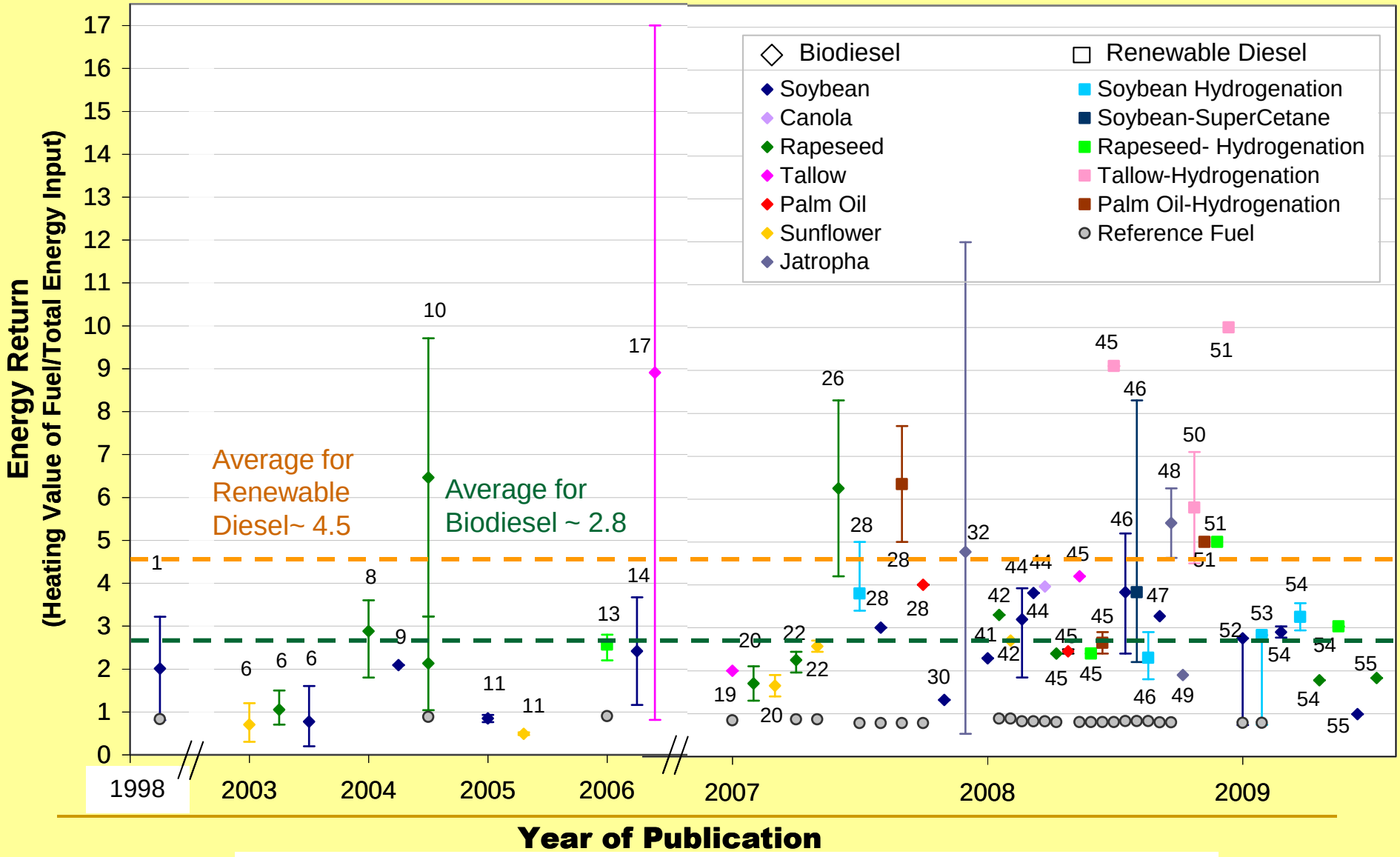
Life Cycle Energy Return of Biodistillate Fuels



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Summary and Conclusions (1 of 2)

- LCA models are critical tools to understand the benefits of biodistillate fuels compared to conventional fuels
  - Models are data intensive and specific to each case
  - The most critical model inputs have the greatest uncertainty
- LCA modeling studies are being conducted at an increasing rate
  - Most show substantial GWP benefit compared to conventional fuels (around 45-85%)
  - Most show substantial energy return benefit compared to conventional fuels (typically 3-5 times improvement)
  - Large variability in results from one study to the next.

Summary and Conclusions (2 of 2)

- Policy and regulations are requiring more extensive use of LCA approaches
  - Including consideration of indirect land use changes
  - Increasing need for modeling approaches that are flexible, transparent, reliable and verifiable
- LCA approaches are also useful for assessing other environmental impacts:
  - Water resources
  - Eutrophication
  - Acidification
  - Habitat disruption
  - Toxicity
  - Photochemical ozone potential

Acknowledgements

- Financial support: CRC
- Project guidance: CRC AFVL-17 Panel
- Literature acquisition: John Ford (DRI)
- Document preparation: Vicki Hall (DRI)
- Co-authors: Alan Gertler, Amber Broch, Curt Robbins, Mani Natarajan
- Additional contribution: Hong Jin (Conoco Phillips)

Life-Cycle Impacts published in SAE 2009-01-2768

AVFL-17 Final Report available on the CRC website at: www.crcao.org.

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THANK YOU