



Canola Biodiesel Manufacturing

Stewart J. Campbell, PhD, PAg.
S. J. Campbell Investments Ltd.
Cochrane, Alberta, Canada
sjcampbell_ltd@shaw.ca



This Presentation

- Target Fuel Markets
 - Canadian domestic diesel fuel pool
 - International diesel pools
- Product Focus
 - Near term - Canola ester platform
 - Long term - Next generation platforms
- Canola Feedstock
 - Seed
 - Crude Oil
- Canola Ester Manufacturing
 - Conversion processes
 - Product specifications
 - Quality control
- Cost and Margin Management



Targeted Fuel Markets

- Renewable Fuels
 - Domestic opportunity
 - Export opportunity
 - US and overseas
 - As seed, canola oil or canola ester
- Domestic Fuel Pool Categories
 - Diesel Pool – National, W. Can. & E. Can.
 - Gasoline Pool – National, W. Can. & E. Can
- Competition for Canola esters
 - Domestic animal fat ester
 - Imported US canola & soy oil and/or ester
 - Imported Asian palm oil and/or ester



Canadian Diesel Pool

- Fuel Market Segments
 - Road
 - Off-road
 - Agriculture
 - Forestry
 - Mining
 - Railway
 - Marine
- Opportunity for canola ester for biodiesel impacted by
 - New engine and fuel technologies
 - Transborder traffic – NAFTA compliances
 - Winter versus summer blends – in Canada & Europe
 - Western Canada versus Eastern Canada supply & demand
 - Distribution - North / Remote versus Populated & Serviced



Domestic Biodiesel Focus

- Canola Ester
 - Near term opportunity
 - Excellent fatty acid composition for biodiesel
 - Better fit than soy or palm esters for Canadian climate
- Three product positions for canola ester
 - Single component
 - Blend with other constituents to make the fuel
 - Additive – for lubricity, fuel efficiency & engine wear reduction
- Commercial biodiesel fuels
 - B100 – 100% ester
 - B20 ester blend with petroleum diesel base
 - B1 - B5 ester blend with petroleum diesel base



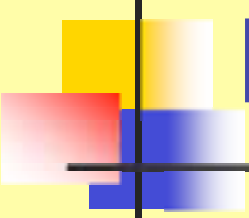
Specifications – 3 levels

- National CGSB Standards - diesel fuel in trade
 - Fuel performance addressing Canada's needs
 - ULSD petroleum diesel (new benchmark for diesel fuel)
 - B5 Biodiesel – specific for esters
 - Second Generation Biodiesel – allow for new technologies, provided standards are performance based and tested
- Trading Rules for Canola Ester – will emerge
 - Bilateral or multilateral – involves industry players
 - Includes terms of trade not covered by CGSB fuel standards
 - Agreed business processes - deals with exceptions
- Identity Standard for Canola Ester – technical reference
 - Useful for the canola industry to develop
 - Identify / distinguish / feature canola esters from other esters
 - Contract terms, marketing claims, adulteration, admixtures



Diesel Fuel Specifications

- **Automotive Low Sulfur Diesel Can/CGSB 3.517**
 - Benchmark in fuel business
 - On-Road, max. 15 ppm Sulfur, Sept, 2006
 - Off-Road, max. 15 ppm Sulfur, 2010
 - Locomotive and Marine, max. 15 ppm Sulfur, 2012
- **Biodiesel Standards**
 - **Canadian General Standards Board (CGSB)**
 - Can/CGSB 3.520 B1 - B5 – in draft, most advanced, esters
 - Can/CGSB 3.522 B5 - B20 and B100 – in development
 - **US ASTM 6751 D Biodiesel Blend Feedstock (B100)**
 - published, amendments coming for oxidative stability



National Standards



Canola Feedstock - Seed

- Annual production of canola seed
 - Food uses likely to have the top bids for the supply
 - Domestic ester production
 - Will compete with export canola seed and oil for seed supply
 - Important dynamic re: cost of seed for biodiesel
 - Many possibilities to increase total seed supply
- Grades of canola seed
 - Canada #1, Canada #2, Canada #3, Sample Heated
 - Green seed - primary visual indicator of seed quality
 - Supply of each grade depends on
 - Weather – growing season, early frost, swathing, storage
 - Variety or hybrid – not as important
- Low grade seed
 - Can be used for biodiesel
 - Requires proper processing equipment and quality control



Canola Feedstock - Seed

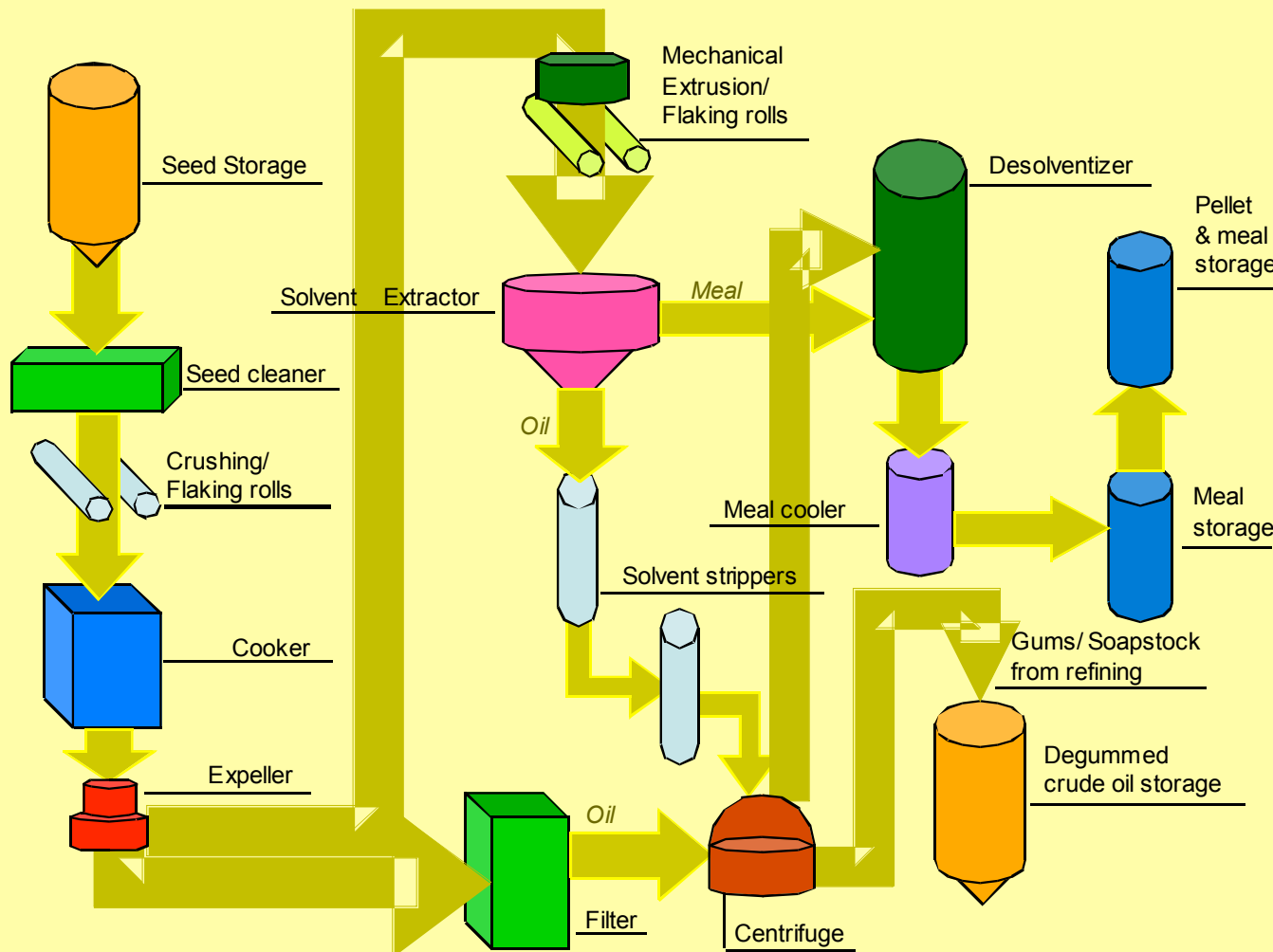
- Types of canola oil
 - Conventional canola fatty acid composition
 - Specialty canola – low linolenic / high oleics
 - Both excellent feedstock for biodiesel
- Important economic characteristics of Canola seed
 - Grade of seed
 - Oil content – yield of oil versus meal
 - Free fatty acids – a crude oil quality mark, impacts process
 - Phospholipids – a crude oil quality mark, impacts process
 - Other constituents – impact on quality and stability of final products – for both food oil and canola ester for biodiesel
- Differences between grades of Canola seed
 - Are real to the canola grower re: grade discounts
 - Are real to the canola processor re: processing costs
 - Best to avoid practices leading to low grade seed



Canola Oil Extraction

- Pure solvent extraction
 - Similar to the soybean process
 - Not used for extraction of whole canola seed / flakes
- Expelling followed by solvent extraction
 - Most common large-scale processing sequence for canola
 - Prepress expellers - recover ~ 60% of the oil, followed by solvent extraction of the presscake
 - Solvent extracted meal contains ~ 1% residual oil
- Double expelling
 - Two expelling stages – in series
 - Double presscake meal contains ~ 6 - 8% residual oil
- Cold pressing
 - Only used in relatively small volumes by specialty processors to yield high-value functional oil products

Canola Solvent Extraction

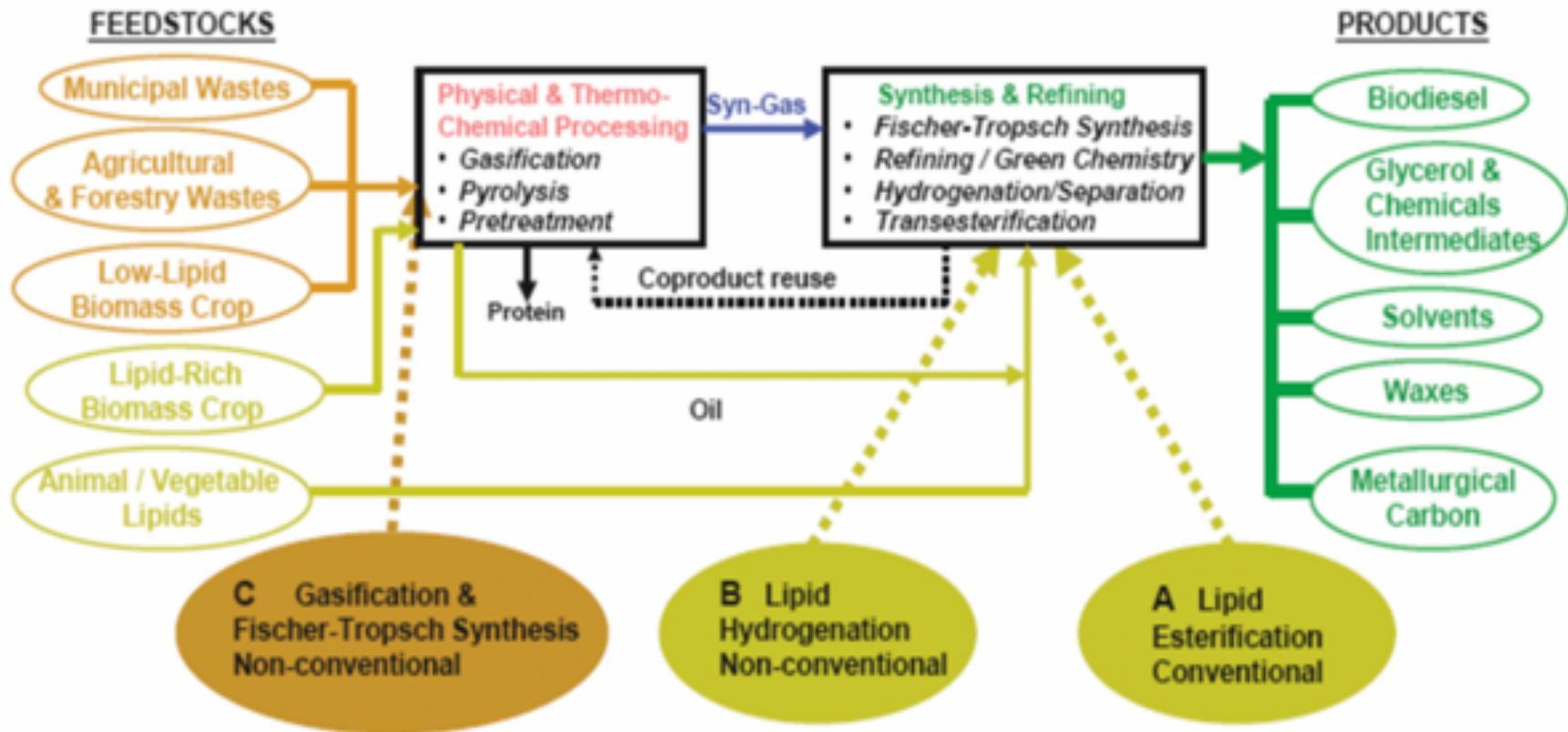




Pathways to Biodiesel

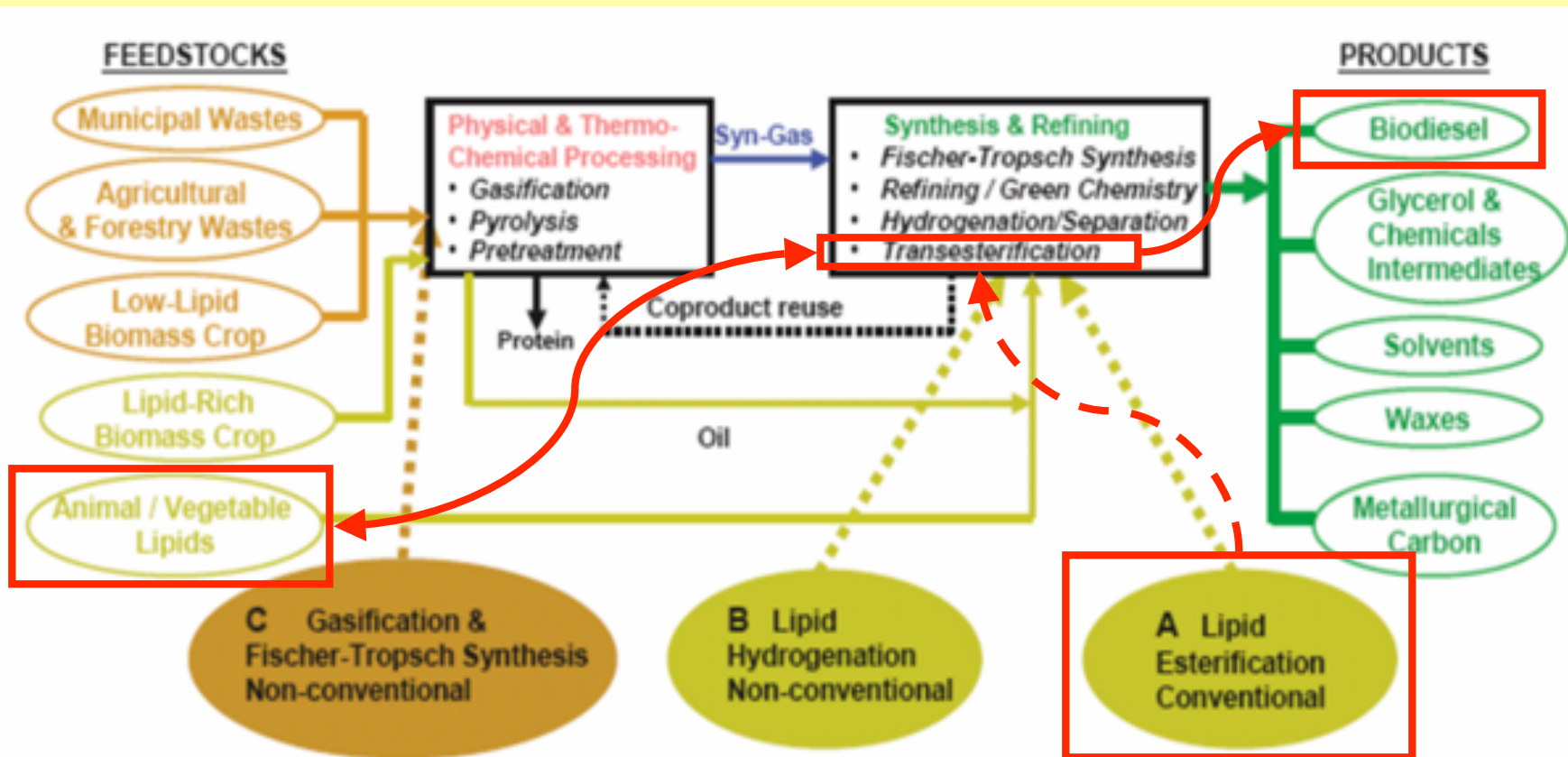
- FAME Technologies
 - Transesterification of fats and oils
 - Canola FAME – Canola fatty acid methyl ester
 - Base catalysis of once refined triglycerides
 - Most common for rapeseed, soy and palm oils
 - Acid catalysis of high acid fats & oils
 - Innovative processes emerging – BIOX, Axen's Esterfip-H
- Second Generation Biodiesel Fuels
 - Pilot plant or demonstration stage - international
 - Hydrogenation of fats and oils
 - CETC's Supercetane
 - Neste Oil's NExBTL
 - Gasification and Fischer-Tropsch Synthesis
 - Choren Industries / Shell partnership in Germany
 - Can utilize carbohydrate wastes

Pathways to Biodiesel



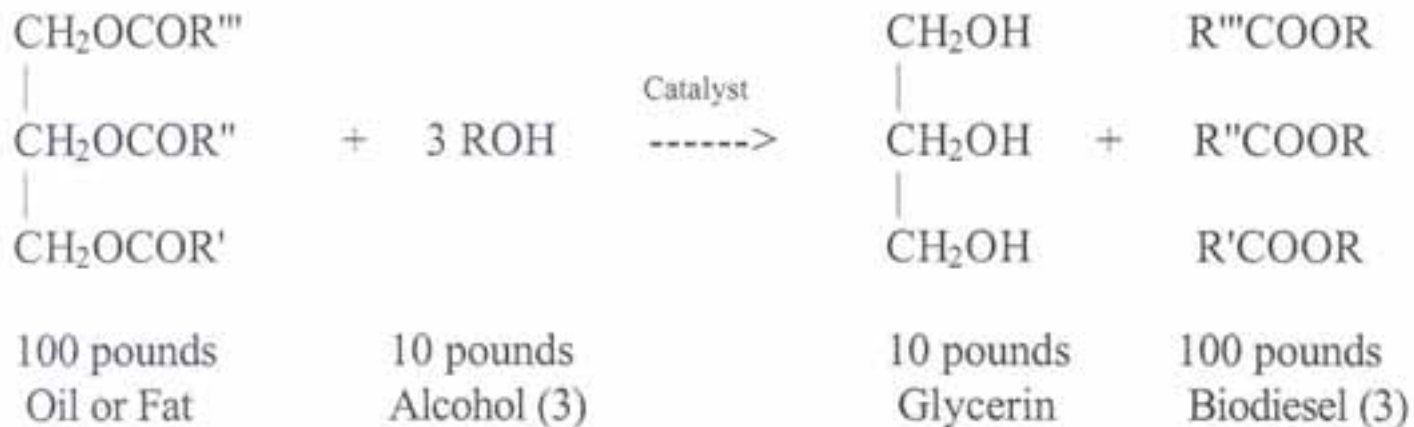
Source: Natural Resources Canada

Pathways to Biodiesel



Source: Natural Resources Canada

Canola Oil Transesterification



- Methanol: $R = \text{CH}_3$
- Canola Fatty acids:
 - $R', R'', R''' =$ mainly C_{18} fatty acids
 - Good fit as ester given seasonal parameters in Canada.
- Palm and animal fat esters – resolve cold flow property questions
- Soybean esters – resolve oxidative stability questions

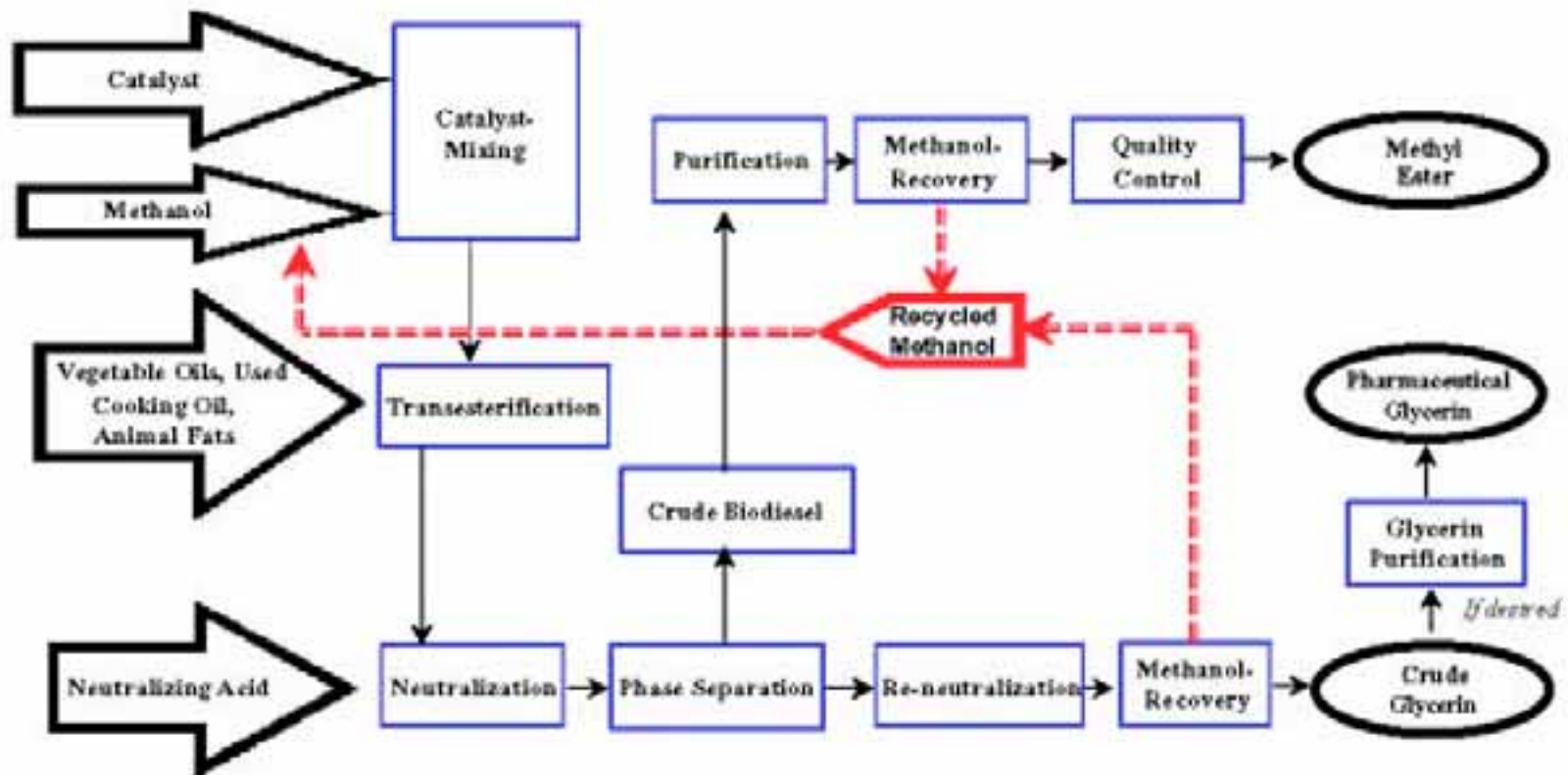
Canola Oil

Feedstock Quality Parameters

Parameter	CGSB Crude Degummed Oil from #1 Canola Seed	Off-Spec Canola Oils from various lower grades	Once Refined Oil from #1 Canola Seed
Free fatty acid	1% max.	1 – 4%	0.1% max
Phosphorus	200 ppm	200 – 400 ppm	40 ppm max
Chlorophyll	30 ppm max.	30 – 120 ppm	30 ppm max.
Moisture & Impurities	Per CGSB standard	Equal to #1	100 ppm max.
Oxidative Stability	good	Some expected to be unstable	good

Transesterification

Conventional homogeneous catalysis

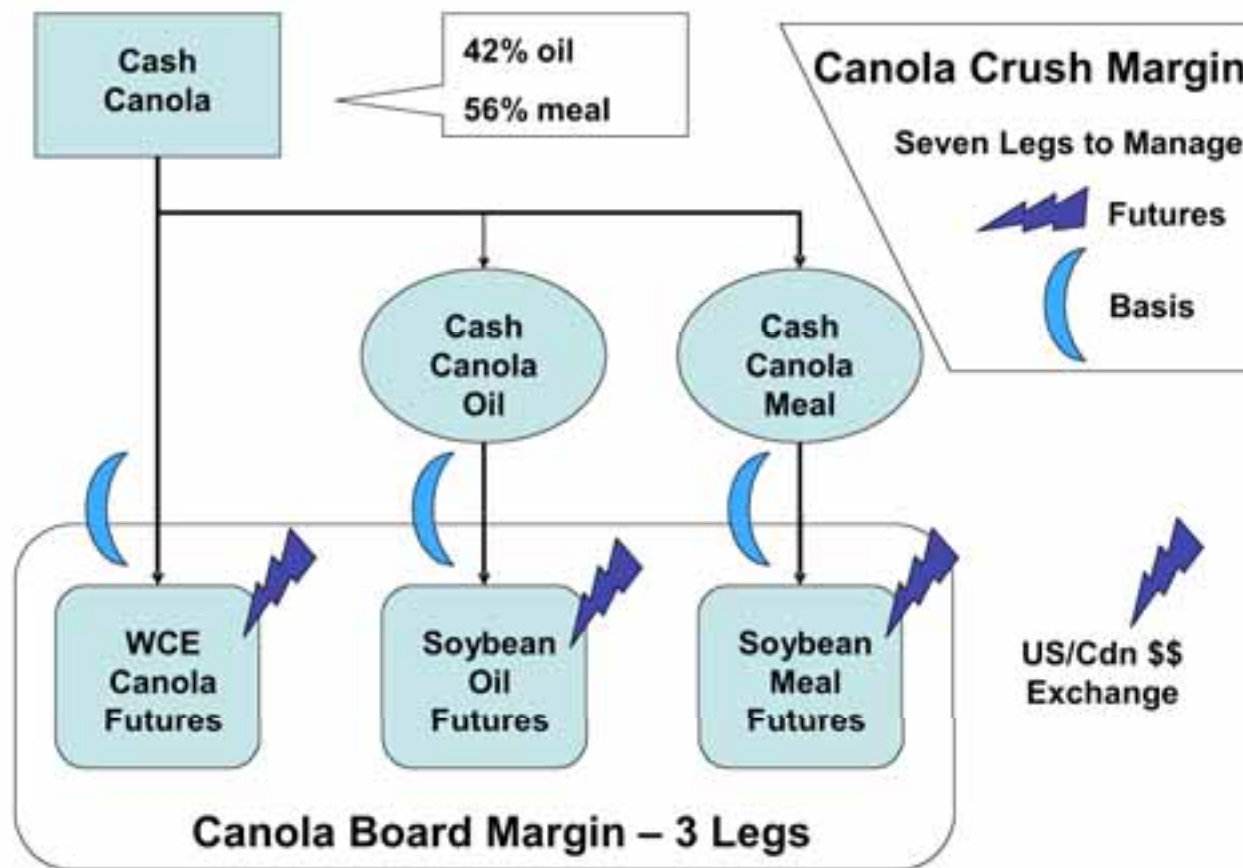


Canola Ester Manufacturing

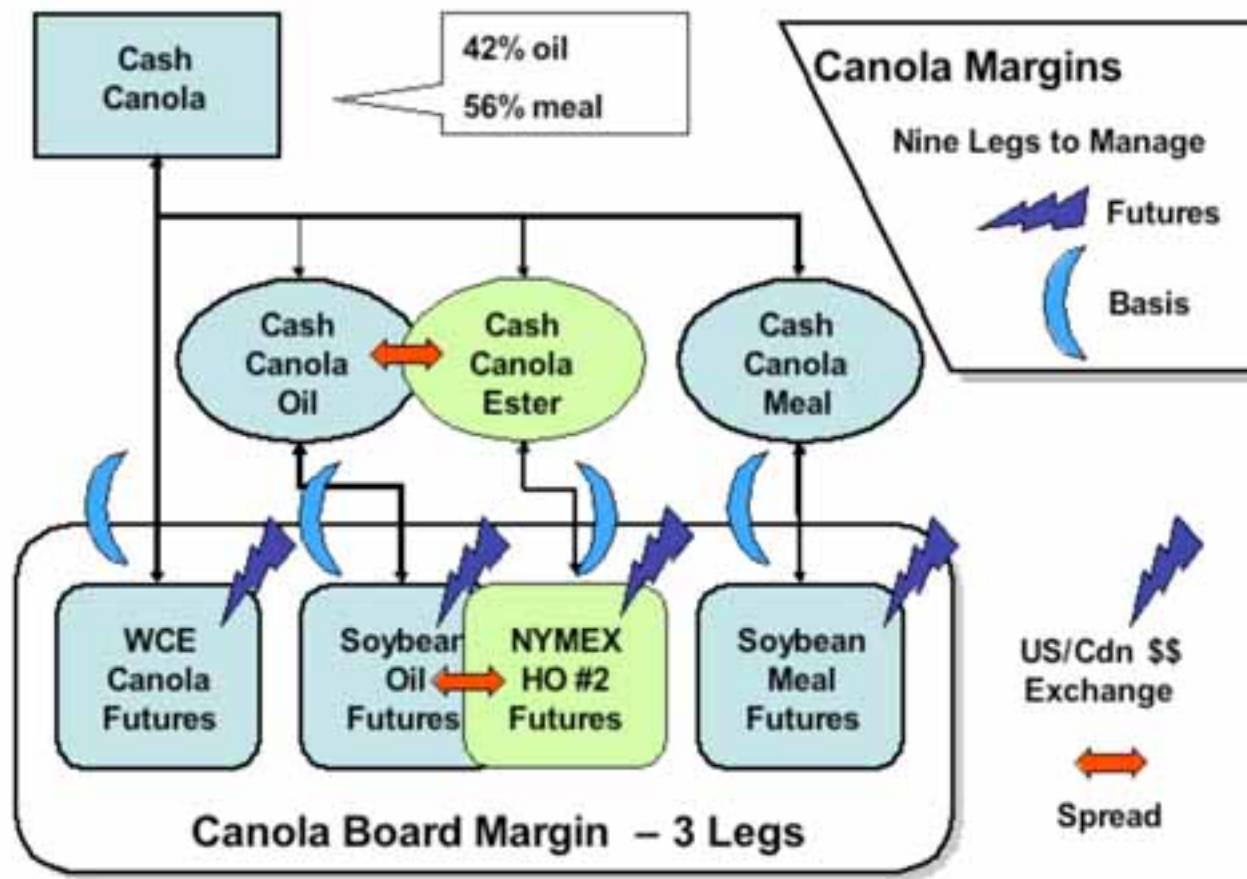
Capital Cost and Margin Analysis

- Comprehensive study by NRCan in 2004
 - prepared by (S&T)² Consultants and Meyers Norris Penny
- Key points
 - Top Line Revenue – determined by
 - Rack price for diesel fuel
 - FOB plant revenue for glycerine
 - Cost of Goods Sold
 - Cost structure dominated by cost of canola seed or canola oil
 - Contribution Margin
 - Negative in 2004 for direct fuel substitution
 - Recognition of fuel efficiency & engine wear reduction improves
 - Capital costs
 - Relatively modest compared to an ethanol plant
 - Influenced by the feedstock processed
 - Find cost reducing synergies with other manufacturing
 - Economies of scale important

Canola Crush Margin



Canola Margin Management – *more to manage with biodiesel*



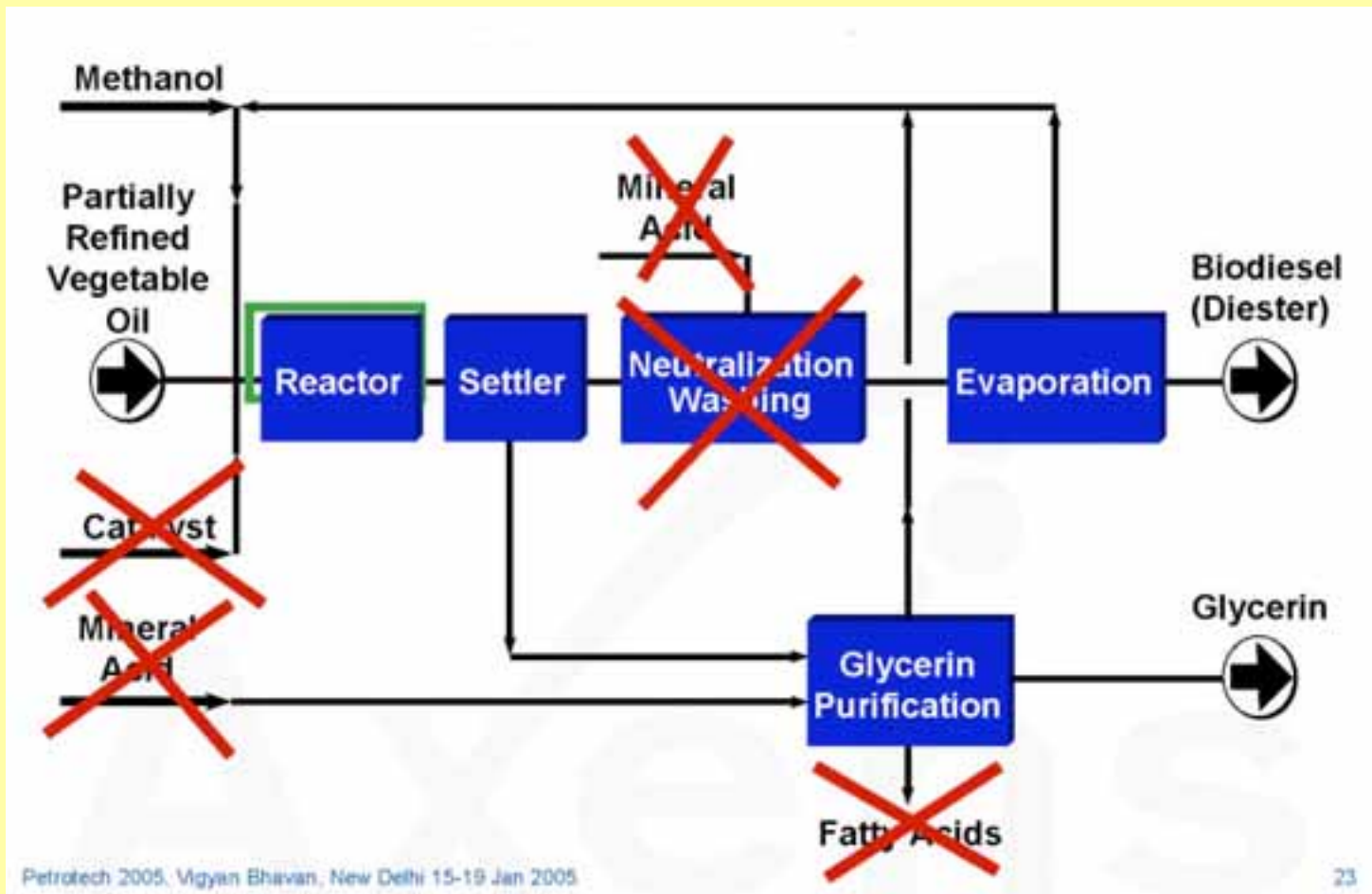


Second / Next Generation

- Many areas for innovation
 - Engine technologies
 - Emission controls
 - Diesel fuel formulation
 - Cold flow additives
 - FAME processing
 - Cost reducing processes
 - Synthetic biodiesel
 - Plant breeding
 - Biodiesel varieties

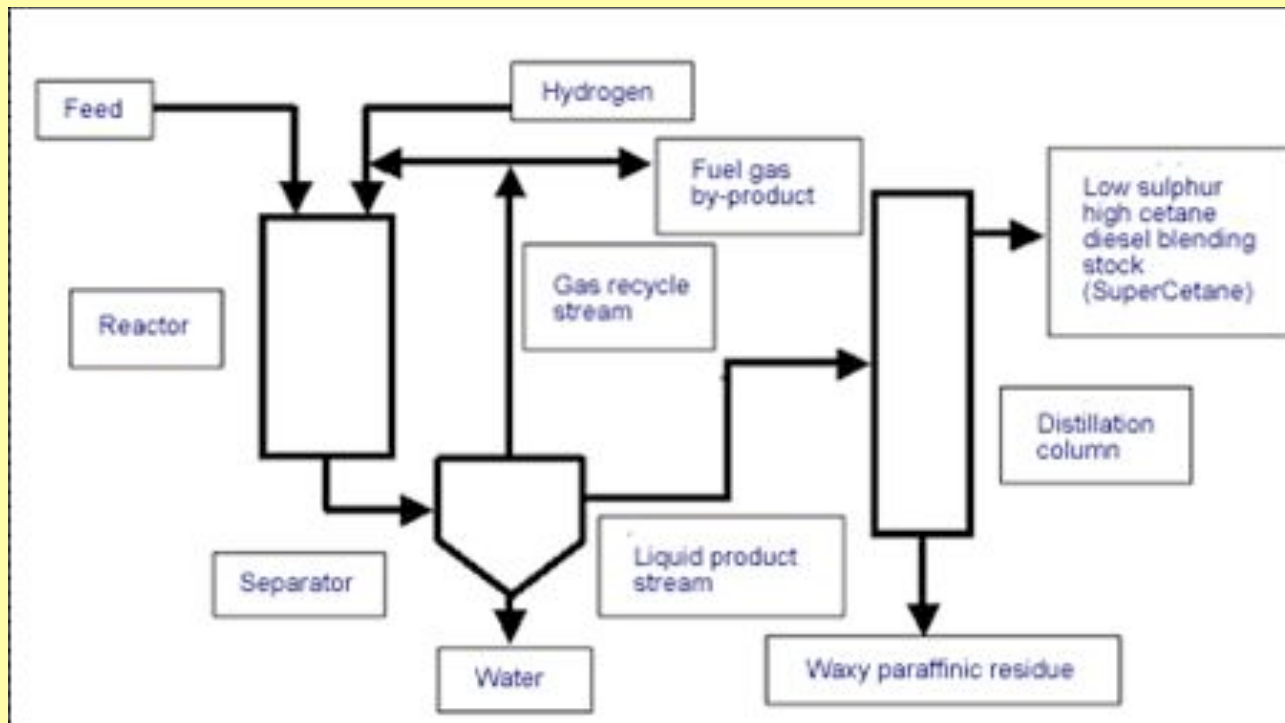
Transesterification of oils

Heterogeneous catalysis – Esterfip-H



Synthetic Biodiesel

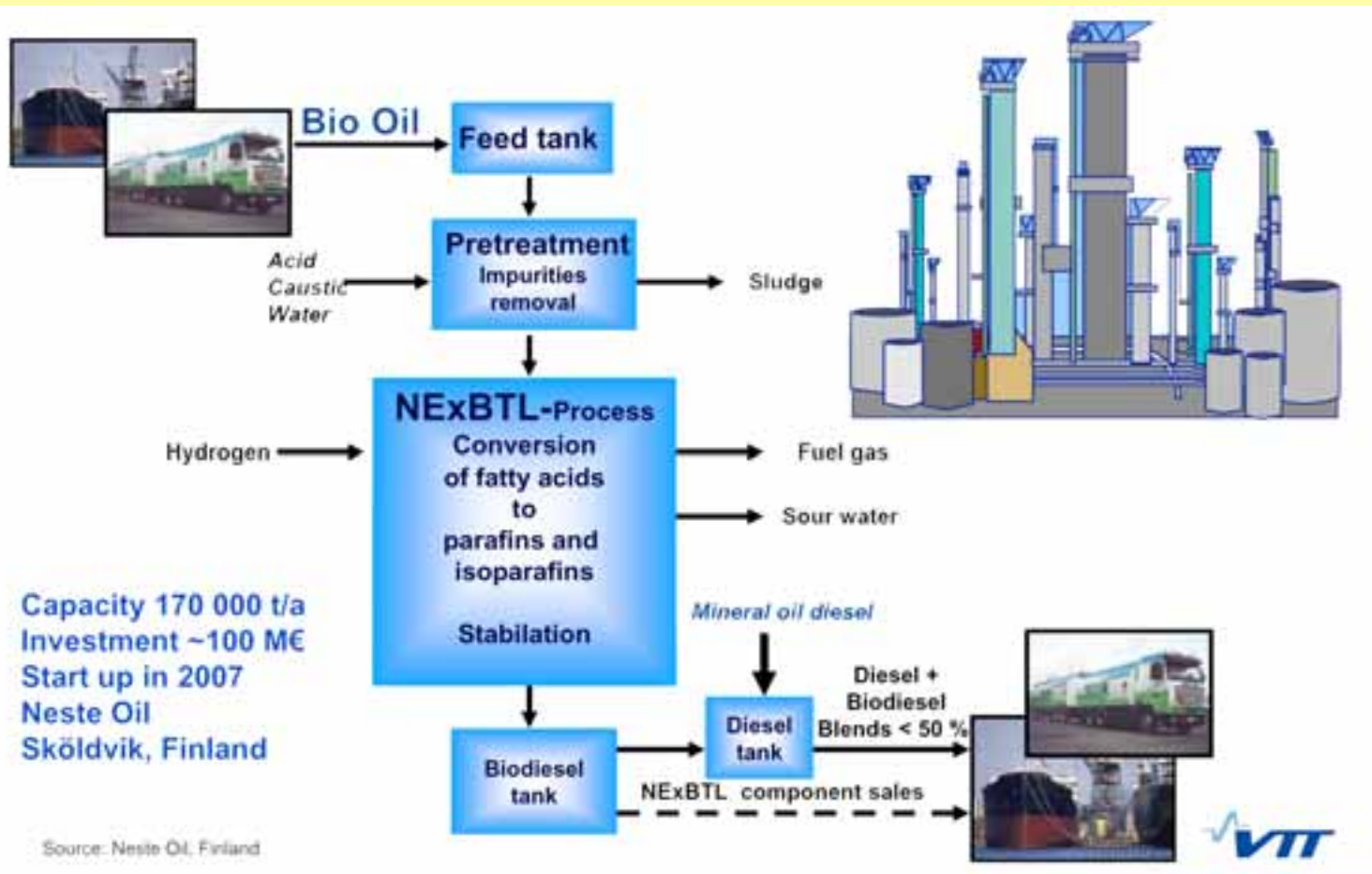
CETC Supercetane



- Hydrocracking - breaking apart of large molecules
- Hydrotreating - removal of oxygen
- Hydrogenation - saturation of double bonds
- Uses conventional refinery hydrotreating catalyst and hydrogen

Synthetic Biodiesel

NExBTL Process





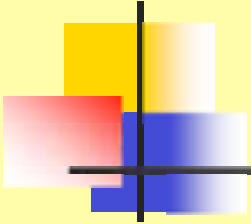
Gasification & Fischer Tropsch

- Several developments underway
- Diesel fuel derived from wood chips and other biomass
 - Wood chips gasified, then Fisher Tropsch to produce renewable hydrocarbon-based diesel fuel substitute
- Favorable life cycle analysis
- CHOREN Industries of Germany
 - SunDiesel
 - Moving towards commercialization
 - Partnership with Shell

Canola Esters for Biodiesel

Business Case Considerations

- **Domestic Diesel Pool**
 - The players – retail, distribution, fuel blenders, petroleum refiner, canola ester producers, canola crushers, canola producers
 - Market access
 - Ester cost to diesel pool = revenue to canola ester producer
 - Seasonal factors – winter / summer
 - Geographic factors – serviced / remote / north
- **Canola Feedstock**
 - Cost and availability
 - Competing uses for canola oil
 - Food versus Transportation Fuel
 - Platform chemical & polymer synthesis – in future
- **By-Products**
 - Disposition of canola meal and glycerine
 - Revenue contributions from canola meal and glycerine
- **Manufacturing Technologies**
- **Margin, ROI & Risk Management**



Thank you for your attention.

If you have questions or ideas to discuss,
please don't hesitate to contact:

Stewart J. Campbell, PhD, PAg.
S. J. Campbell Investments Ltd.
43 West Terrace Drive
Cochrane, Alberta, Canada

Phone: 403 932 2372 Fax: 403 932 2374
sjcampbell_ltd@shaw.ca