Oleochemicals

Cognis Oleochemicals Group

New Applications For Biodiesel Glycerine

OFIC 2008

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NEW APPLICATIONS FOR BIODIESEL GLYCERINE

Content

1. INTRODUCTION

- Glycerine or propane-1, 2, 3-triol is primarily produced from splitting oils and fats

  Triglyceride + Water → Glycerine + Fatty Acids

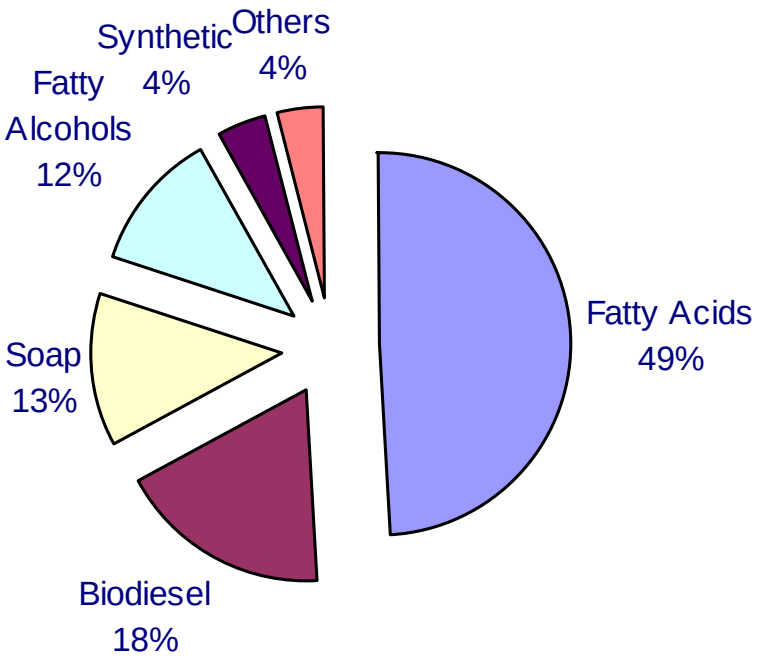
- Amount of glycerine in oils and fats depends on source e.g. coconut oil (15%), palm oil (11%), soya and tallow (10%), fish oil (9%).

- About 1.2 million tons of glycerine is used in wide variety of applications either as 99.8% pure or 86% aqueous glycerine.

- Glycerine price had fluctuated greatly over the years depending on supply and demand.

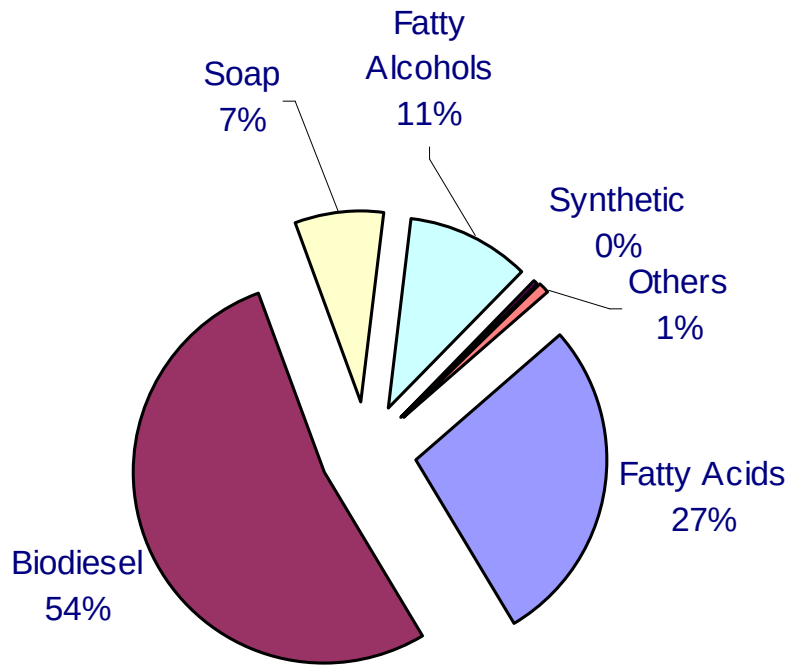
SOURCES OF GLYCERINE

2004



1,043 KTons

2008

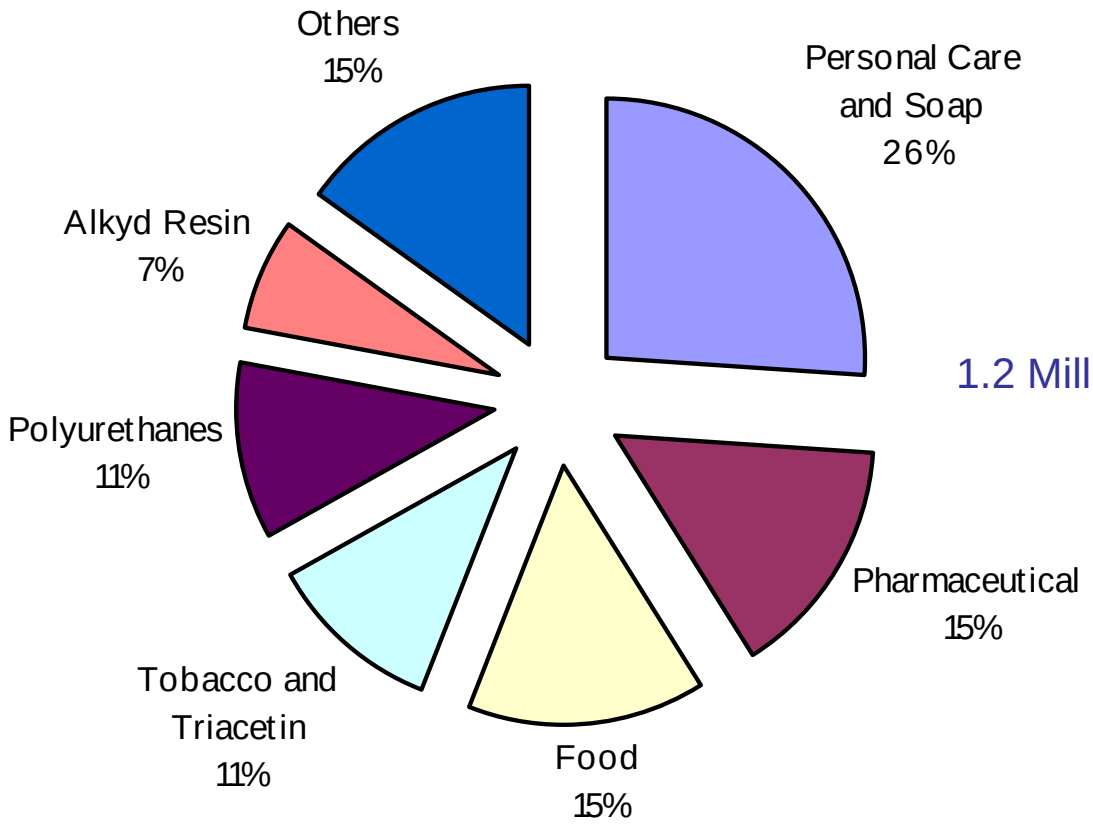


1,787 KTons

TRADITIONAL APPLICATIONS FOR GLYCERINE

Food and Food Ingredients	• Sweetener [as a sugar substitute] in cake and drink mixes. • Additives [E422] in food flavourings and extracts [vanilla]. • Texture improver in ice-cream. • Manufacture of mono and diglycerides as food emulsifier. • As a polyglycerol ester going into shortenings and margarines.
Pharmaceuticals	• Main 'body' in cough syrups and ear infection lotions. • Vitrification of blood cells for storage in liquid nitrogen. • Laxative when carried in a suppository. • Plasticizer in gelatin based capsules. • Prevents tannin precipitation in ethanol extract of plants and also as a substitute for ethanol in herbal extractions.
Personal Care	• Replaces lost moisture in skin lotions. • Improves flowability in shampoo. • Transparent soap bar formulation. • Component of glycerol soap for ultra-sensitive skin as it prevents dryness.
Tobacco	• Functions as humectant.
Technical	• Manufacture of triacetin, diacetins, MCT, GMS • Component for alkyd resin, polyether polyols production. • Manufacture of Nitroglycerine.
Industrial	• Mould release agent. • Manufacture of PU hard foams.

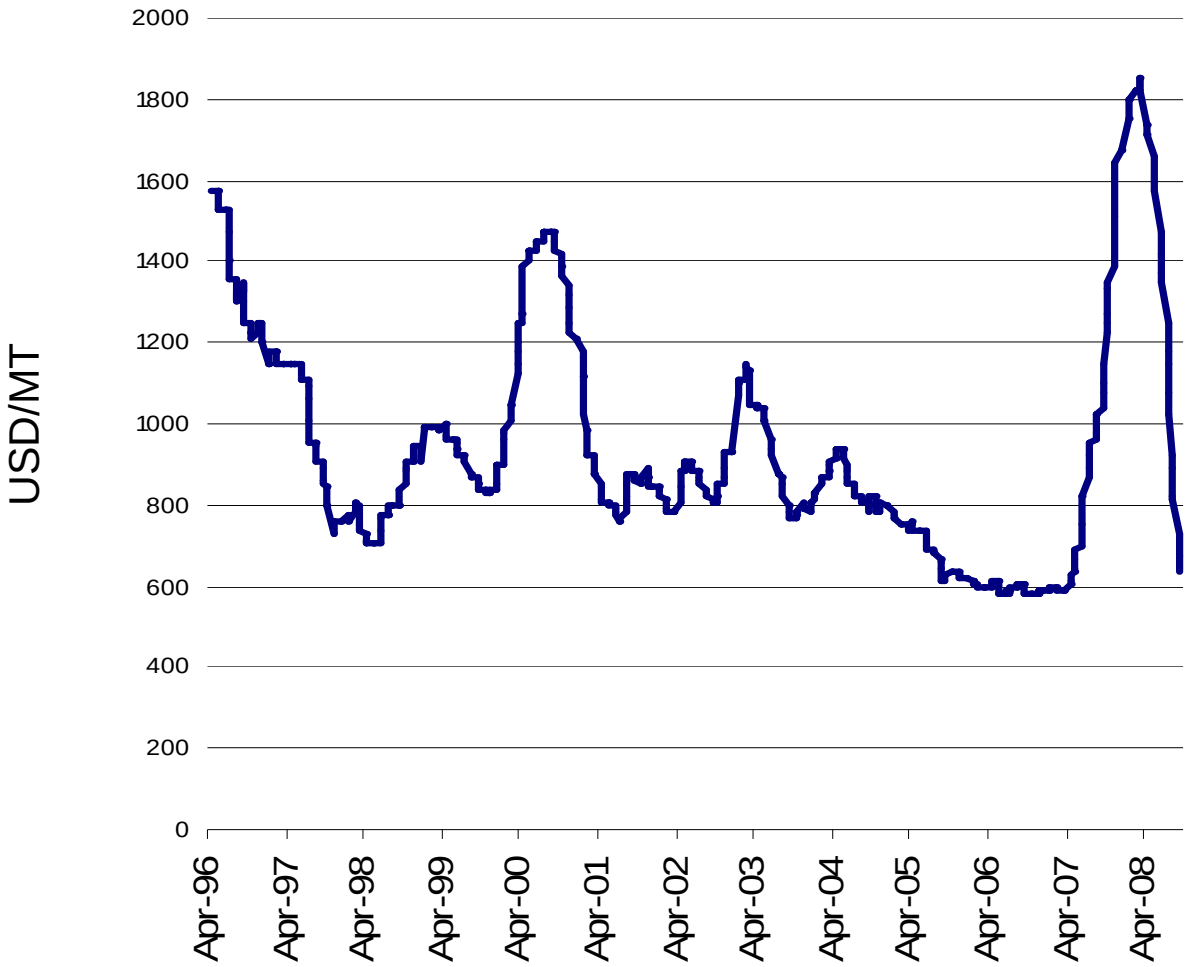
CONSUMPTION OF GLYCERINE



1.2 Million tons in 2007

SRI Consulting

GLYCERINE PRICE TREND



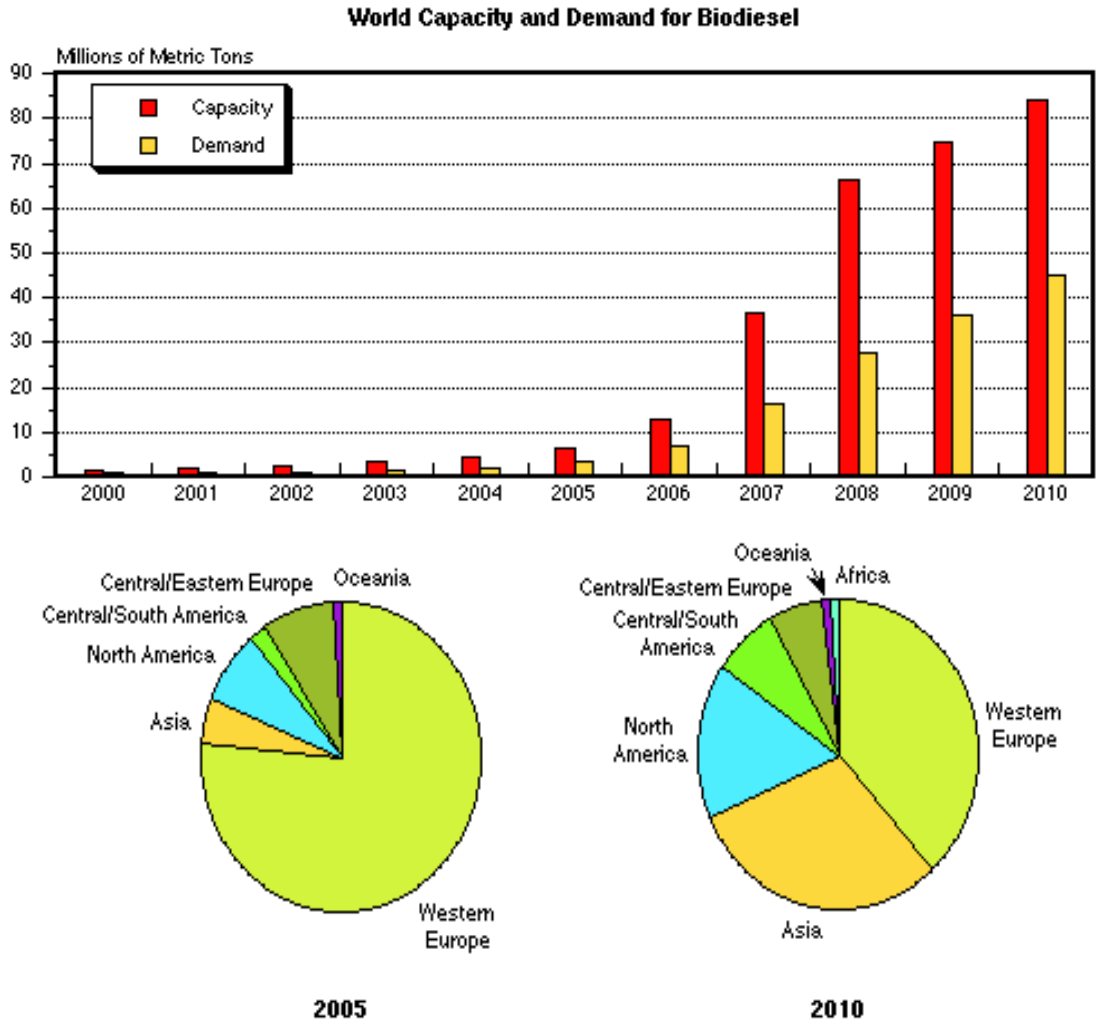
NEW APPLICATIONS FOR BIODIESEL GLYCERINE

Content

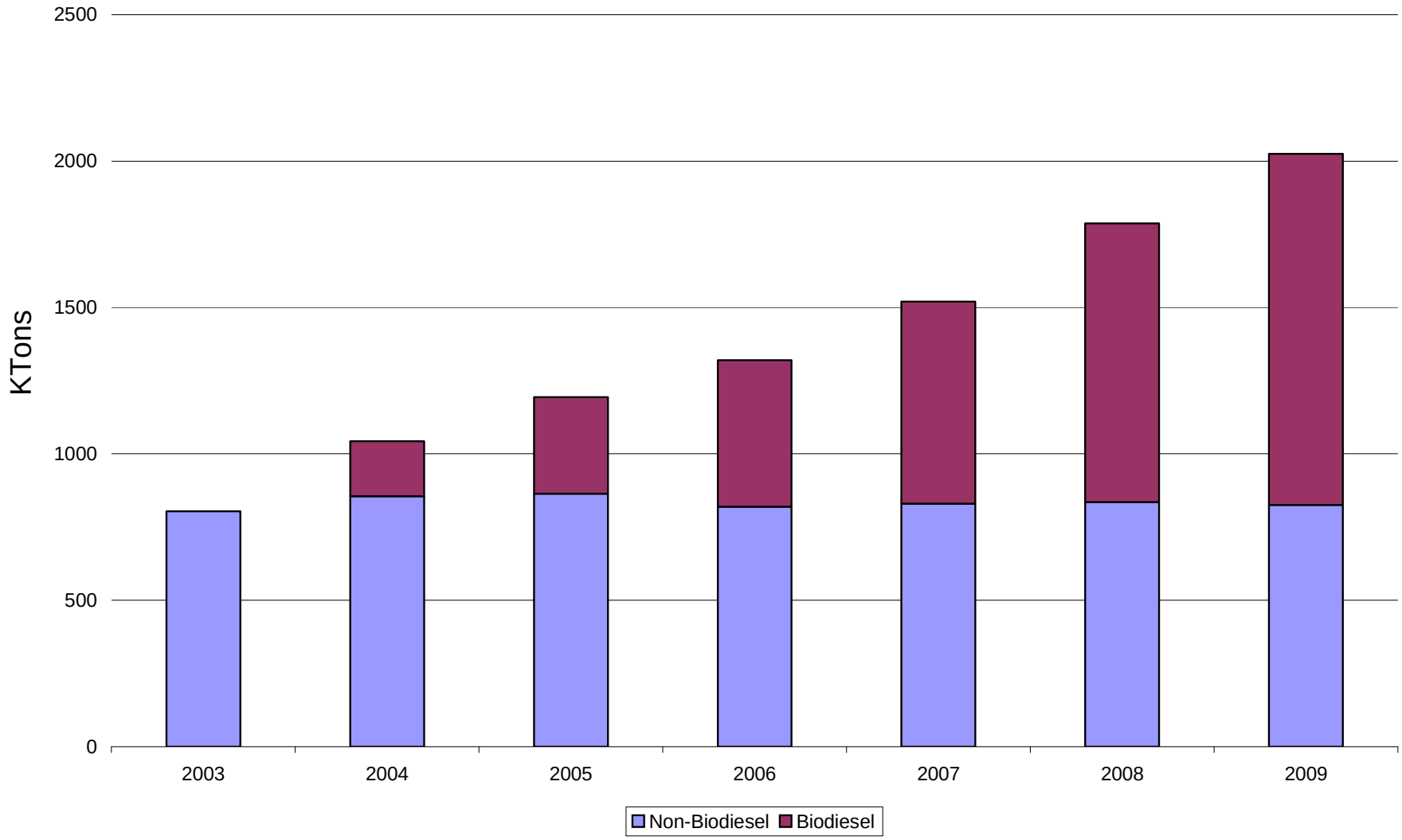
2. GROWTH OF BIODIESEL

- Significant capacity increase since 2003 driven by concerns of over-dependence on fossil fuels
  - supply security
  - renewable vs. depleting resources
  - green-house gas emissions producing global warming effects
- Recent concerns shifted to “food vs. fuel” debate, sustainability and CO_2 balance of certain oil crops.
- Despite government subsidies, economic viability seriously affected by surge in commodity prices.
- Created unintended consequences to oleochemicals by generating huge amount of by-product glycerine.

BIODIESEL CAPACITY SURGE



GLYCERINE SUPPLY TREND



NEW APPLICATIONS FOR BIODIESEL GLYCERINE

Content

3. NEW APPLICATIONS FOR BIODIESEL GLYCERINE

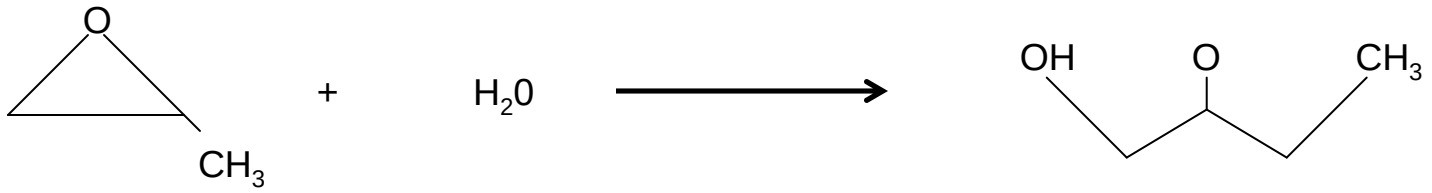
- New applications driven by abundance and low-cost of glycerine
  - expectations that biodiesel will continue to grow
  - limited refining capacities spawned applications for crude glycerine
  - high oil & gas prices make glycerine an attractive petrochemical feedstock
- New applications as product substitutes, feed / fuel components and petrochemical feedstocks.
- Green chemistry driving new R&D activities on natural, renewable and sustainable products and processes.

NEW APPLICATIONS FOR GLYCERINE

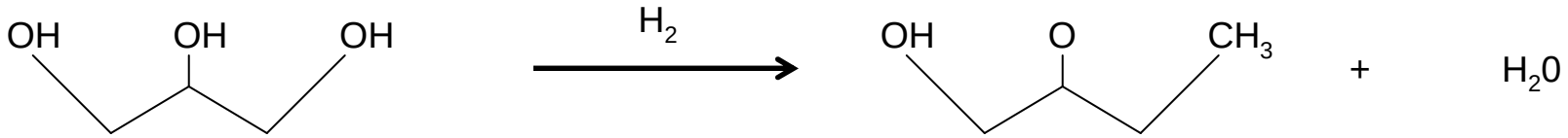
Product Substitutes	• Replacing Sorbitol in cosmetics and personal care products as a humectant and thickener, and as a laxative. • Replacing Propylene Glycol in antifreeze, solvent in food colourings and flavourings, fragrance oil carrier, main ingredient for deodorant sticks.
Feed and Fuel	• Animal feed • Compost additive • Biogas generation • Direct incineration
Petrochemical Feedstocks	• Commercialised: – Propylene Glycol – Epicholorhydrin • Under development: – Acrolein and Acrylics – Polyhdroxyalkanoates

GLYCERINE TO PROPYLENE GLYCOL

- Industrial Production from hydration of propylene oxide



- Continuous hydrogenation of glycerine to propylene glycol



- Announced projects:
  - 30 kt/yr by Synergy Chemical in S. East USA
  - 100 kt/yr by ADM in Illinois, USA
  - 65kt/yr by Ashland/Cargill in Europe
  - Dow Halterman and Huntsman in Texas, USA
  - Proving technology by Cognis, BASF, Davy, Virent Energy, UOP

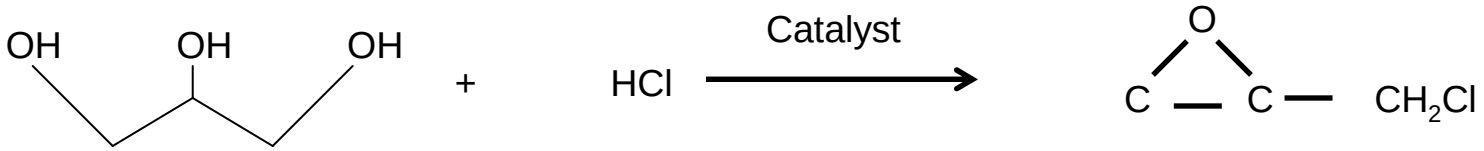
GLYCERINE TO EPICHLOROHYDRIN

- Conventional production from chlorination of propylene followed by epoxidation

Propylene + Chlorine ⟶ Allyl Chloride

Allyl Chloride + Hydroperoxide ⟶ Epichlorohydrin

- Epichlorolydrin is used for making synthetic glycerine, epoxy and phenoxy resins, rubber polymers, other derivatives
- Glycerine to Epichlorohydrin



- Announced projects:
  - Dow, 150,000 MT in China
  - Solvay, 10,000 MT in France, 100,000 MT in Thailand
  - Spolchemie, 10,000 MT in Europe

R & D ON GLYCERINE APPLICATIONS

Oligomerisation of glycerine	• Production of pure diglycerine from glycerine via 2-step reactive distillation process • Currently diglycerine is produced from Epichlorohydrin. • Main applications as moisturisers, non-ionic surfactants, food emulsifiers.
Carbonylation of glycerine	• Production of diacids and triacids from glycerol via a high pressure reaction. • Similar to production of acetic acid via carbonylation of methanol.
Telomerisation of glycerine	• Production of glycerol ether via the reaction of glycerol and butadiene • Potential applications as surfactants and as an emulsifier in cosmetics.
Green polyols	• Production of polyols via ozonolysis of vegetable oils and reaction with crude glycerine • Polyol is used in production of polyurethane foams and coatings.

3. NEW APPLICATIONS FOR BIODIESEL GLYCERINE

- New applications driven by abundance and low-cost of glycerine
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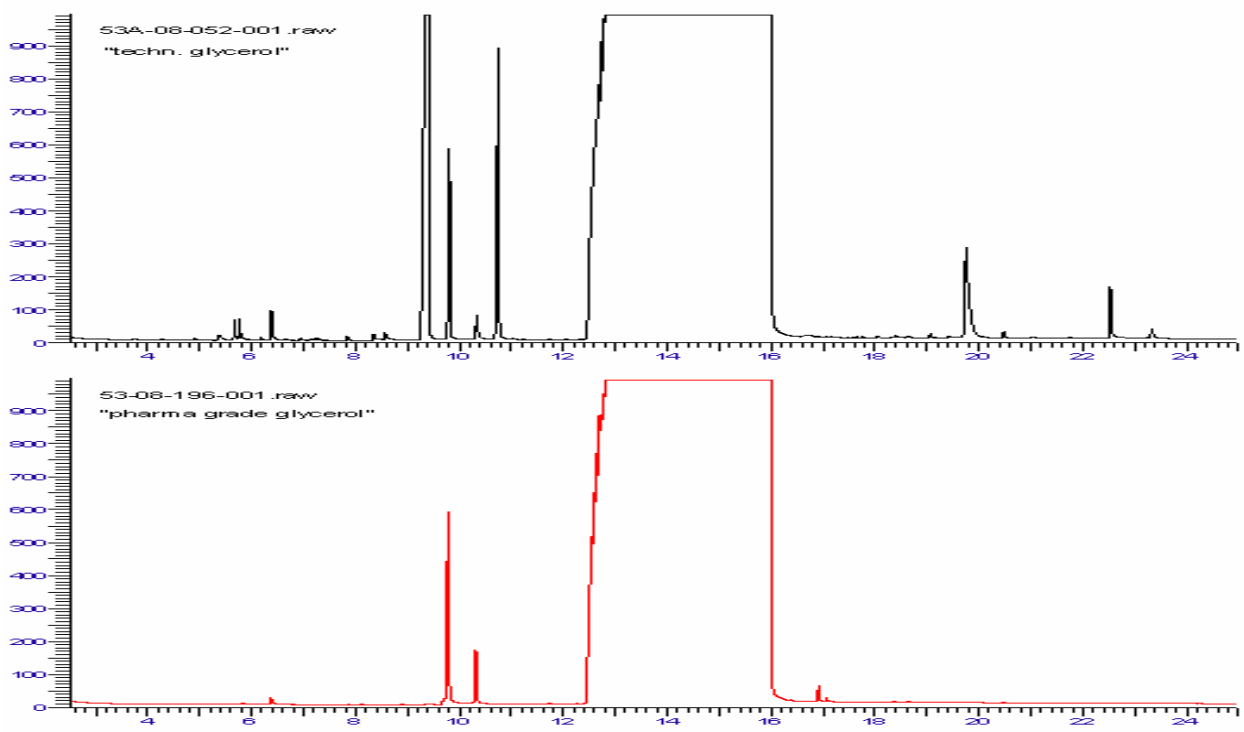
- New applications as product substitutes, feed / fuel components and petrochemical feedstocks.
- Green chemistry driving new R&D activities on natural, renewable and sustainable products and processes.
- Product quality differentiation excludes biodiesel glycerine from certain end-use markets
  - trace contaminants due to high processing temperatures, acidic or caustic catalysts, methanol
  - affects purity, odour or tastes.

GLYCERINE QUALITY COMPARISON BY GLC

1,2-Propandiol, 1, 3-Propandiol, Dihydroxyacetone, Monohydroxyacetone, Glycerol-Mono-Methylether (GMME)

Diglycerol, 1,2,4-Butantriol, Monoglycerides



Distilled Biodiesel Glycerine

Distilled Splitter Glycerine

low boiler glycerol high boiler

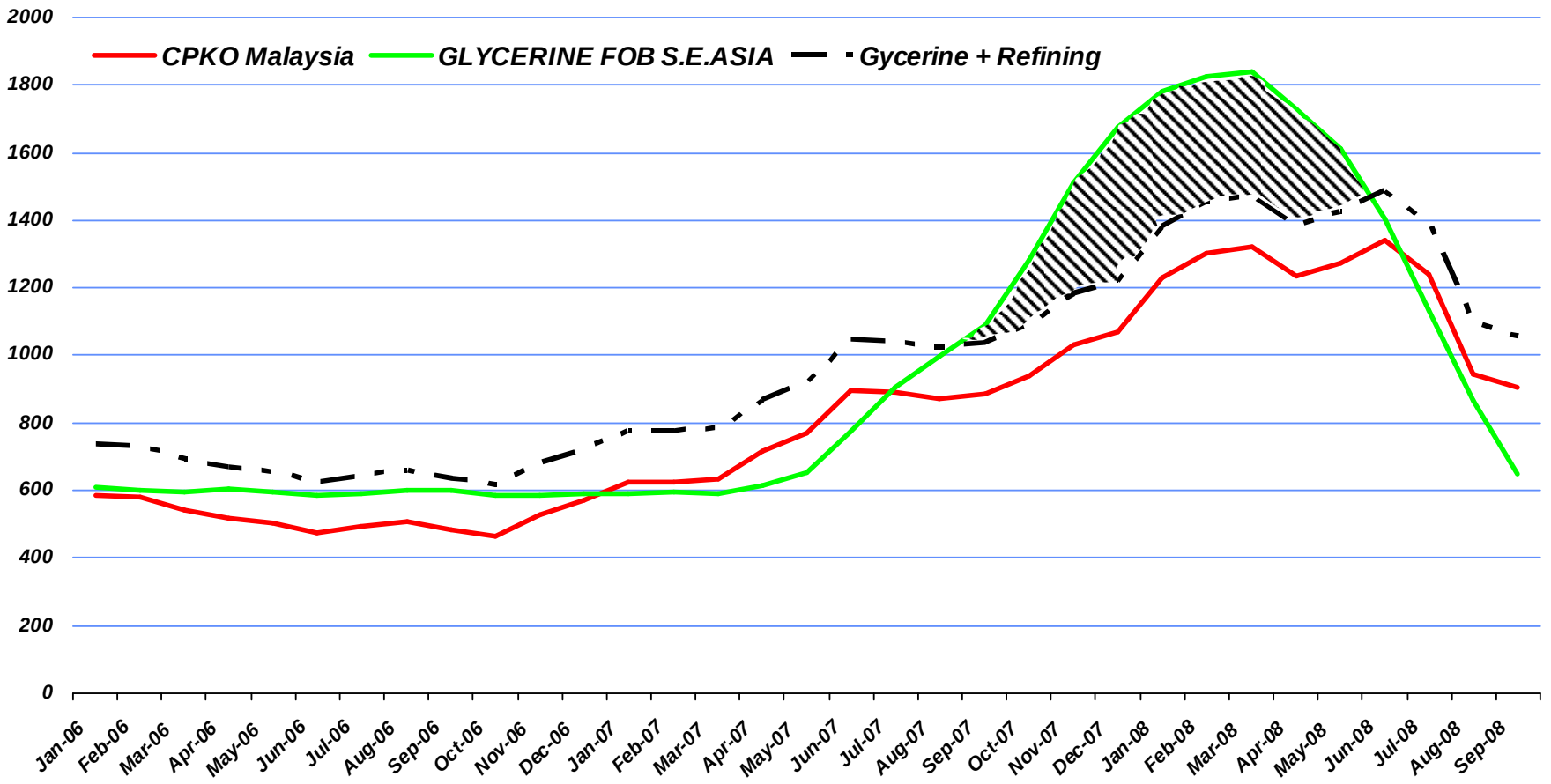
NEW APPLICATIONS FOR BIODIESEL GLYCERINE

Content

4. RISKS AND CHALLENGES

- Over-supply of glycerine or high vegetable oil prices result in value destruction.

GLYCERINE PROFITABILITY



4. RISKS AND CHALLENGES

- Over-supply of glycerine or high vegetable oil prices result in value destruction.
- Unpredictable supply and volatile prices discourage investments in new applications
  - Most PG and ECH projects are either delayed or completely shelved
  - Despite recent declines in glycerine prices, probability of new start-ups remain low
  - Stable glycerine supply and competitive pricing needed to support investments
- Without sustained demand, biodiesel glycerine will continue to disrupt oleochemical markets while remaining a disposal problem for biodiesel industry.

NEW APPLICATIONS FOR BIODIESEL GLYCERINE

Content

5. BUSINESS CASE FOR A PG PROJECT IN MALAYSIA

- Channeling surplus biodiesel glycerine into production of green PG based on a long-term cost competitive business model.
- Necessary conditions and critical success factors :-
  I. Right business environment for an investment
  II. Stable supply of glycerine
  III. Competitive pricing of glycerine
  IV. Strategic fit to palm, biodiesel and oleochemical industries

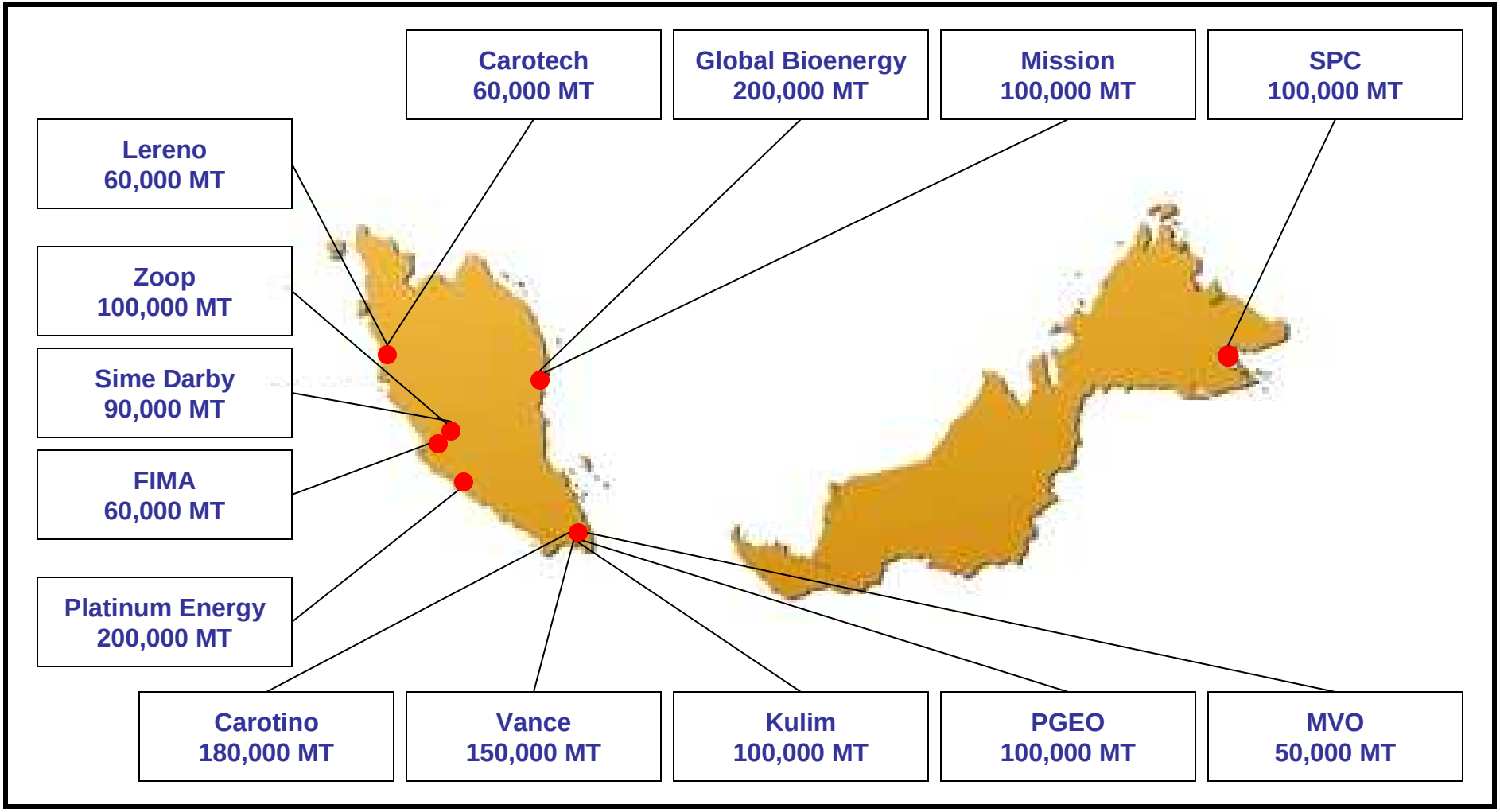
I. Conditions Supportive of a PG Investment

- Sizeable and growing market demand
  - Global market around 1.4 million tons, growing at 4% / year
- Available technology
  - Several commercial processes by Dow Chemicals, Huntsman, Senergy Chemical, Ashland / Cargill, Virent Energy and others.
  - Modest investment capex for a large-scale plant ($15-20m for 40-50 kt / year)
- Value of natural and renewable products
  - Increasing customer/consumer preference for green products
  - Production processes generally low energy, low emissions and non-polluting
  - Renewable resources provide security against crude oil prices and supply uncertainties
- Glycerine is cheap and plentiful again!

II. Ample Capacity / Supply of Biodiesel Glycerine

- Location and capacity of biodiesel plants in Malaysia.
- Crude glycerine generation vs. refining capacities.

BIODIESEL CAPACITIES IN MALAYSIA



BIODIESEL GLYCERINE REFINING CAPACITIES

COMPANY	BIODIESEL CAPACITY [MT/YEAR]	CRUDE GLYCERINE [MT/YEAR]	GLYCERINE REFINING [MT/YEAR]
Global Bioenergy	200,000	20,000	20,000
Platinum Energy	200,000	20,000	-
Carotino	180,000	18,000	-
Vance	150,000	15,000	15,000
Mission NewEnergy	100,000	10,000	10,000
SPC	100,000	10,000	-
Zoop	100,000	10,000	-
Kulim	100,000	10,000	10,000
Pasir Gudang Edible Oil	100,000	10,000	-
Sime Darby	90,000	9,000	-
Lereno	60,000	6,000	6,000
Carotech	60,000	6,000	-
FIMA	60,000	6,000	-
MVO	50,000	5,000	-
TOTAL	**1,550,000**	**155,000**	**61,000**

III. Competitively Priced Glycerine

- Ensuring fair and competitively priced glycerine by linking it to propylene oxide, the precursor to PG.

  Propylene → Propylene Oxide → Propylene Glycol

- Strong co-relationship between crude and vegetable oil prices provide natural arbitrage between PO and glycerine.
- Keep glycerine cost low by not investing in refining capacity or expensive processing steps.
- Creates a win-win for glycerine suppliers and PG producer.

IV. Strategic Fit to Related Industries

- Supportive of palm oil, biodiesel and oleochemical industries by enhancing value and stimulating demand.
  - Oleochemicals : diverting surplus glycerine away from established markets
  - Biodiesel : provides reasonable by-product value while reducing overall investment costs hence increasing competitiveness
  - Palm oil : increases local demand
- Catalyst for generating other non-food and non-fuel uses of palm oil, especially specialty chemicals.

NEW APPLICATIONS FOR BIODIESEL GLYCERINE

Content

6. CONCLUSION

- Sufficient demand and new applications to accommodate increased supply of glycerine from biodiesel. Real challenges are supply and price uncertainties.
- Viable, long-term solutions require collective and concerted effort by glycerine suppliers and major users.
- Opportunity exists for a sizeable PG project in Malaysia. However, biodiesel production must start-up which can only happen when government mandates blending.