

From vegetable oil to fuel: Biodiesel production – An overview

Philip Hollins

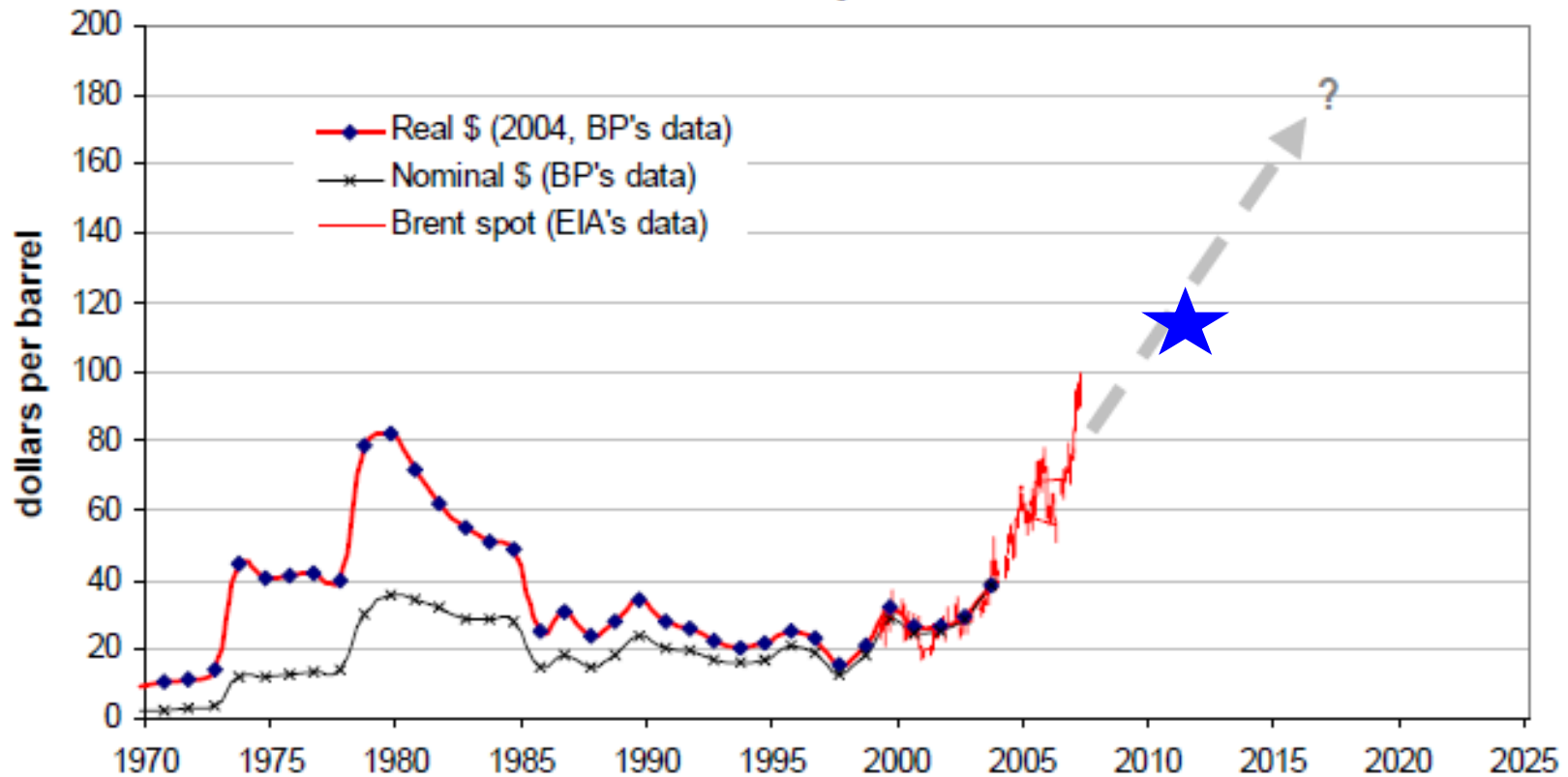
Phil.Hollins@Jamk.fi

Presentation overview

The topics covered will include:

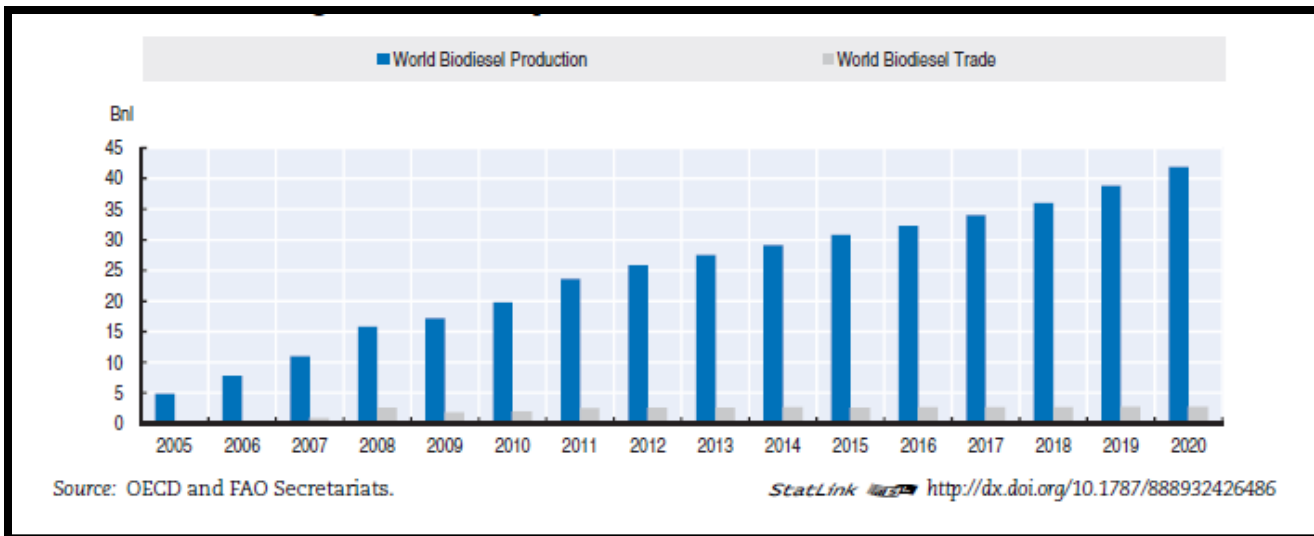
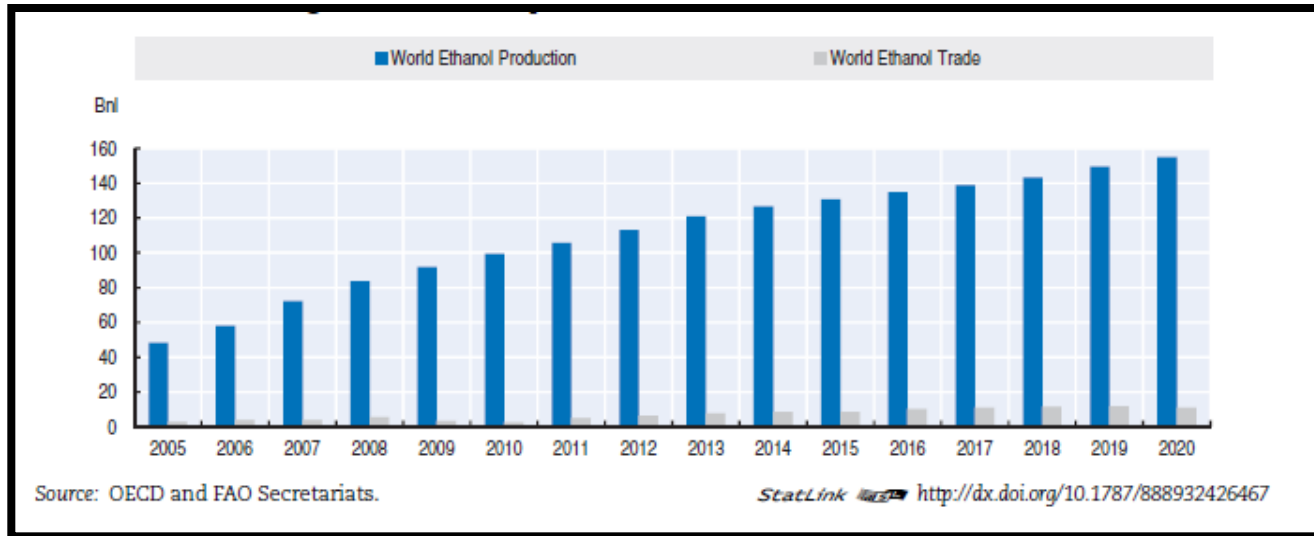
- Forecasted increase in biofuel production
- Biofuel classification
- Diesel engines and how they operate
- Demonstrate how to make transesterified biodiesel
- Case studies of small scale biodiesel production and use
- Presenting a typical home `biodiesel' processor
- Biodiesel production 2nd and 3rd generation production
- Future biodiesel development

Crude oil prices

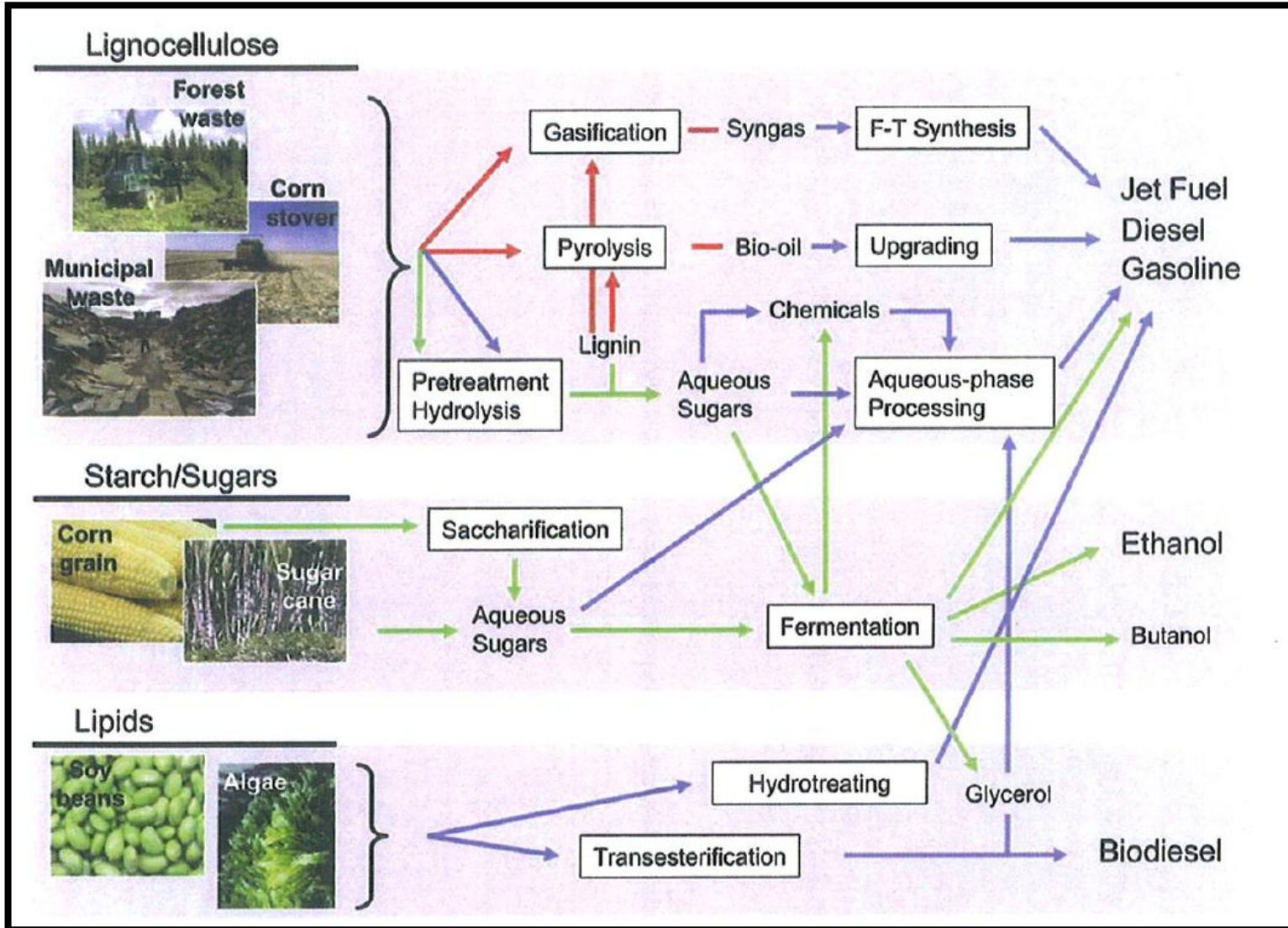


Source: <http://ourfiniteworld.com/>

Forecast for increase in biofuel production

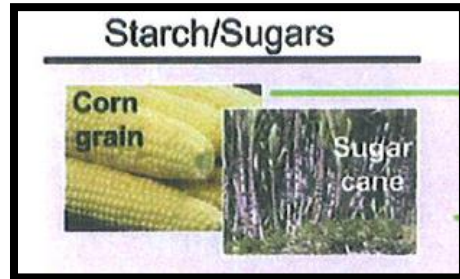


Consider liquid biofuels (complex).....



(Source: Serrano/Ruiz and Dumesic, Energy Environ Sci, 2011)

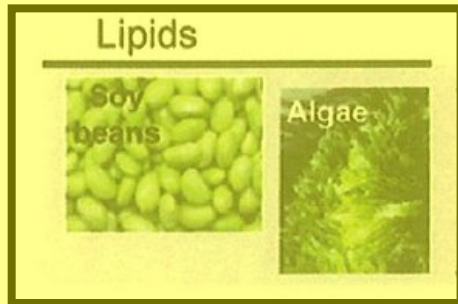
Consider liquid biofuels (simplified).....



Sources of carbohydrates

Petrol 'substitute'

(sugars and starches)



Sources of fats

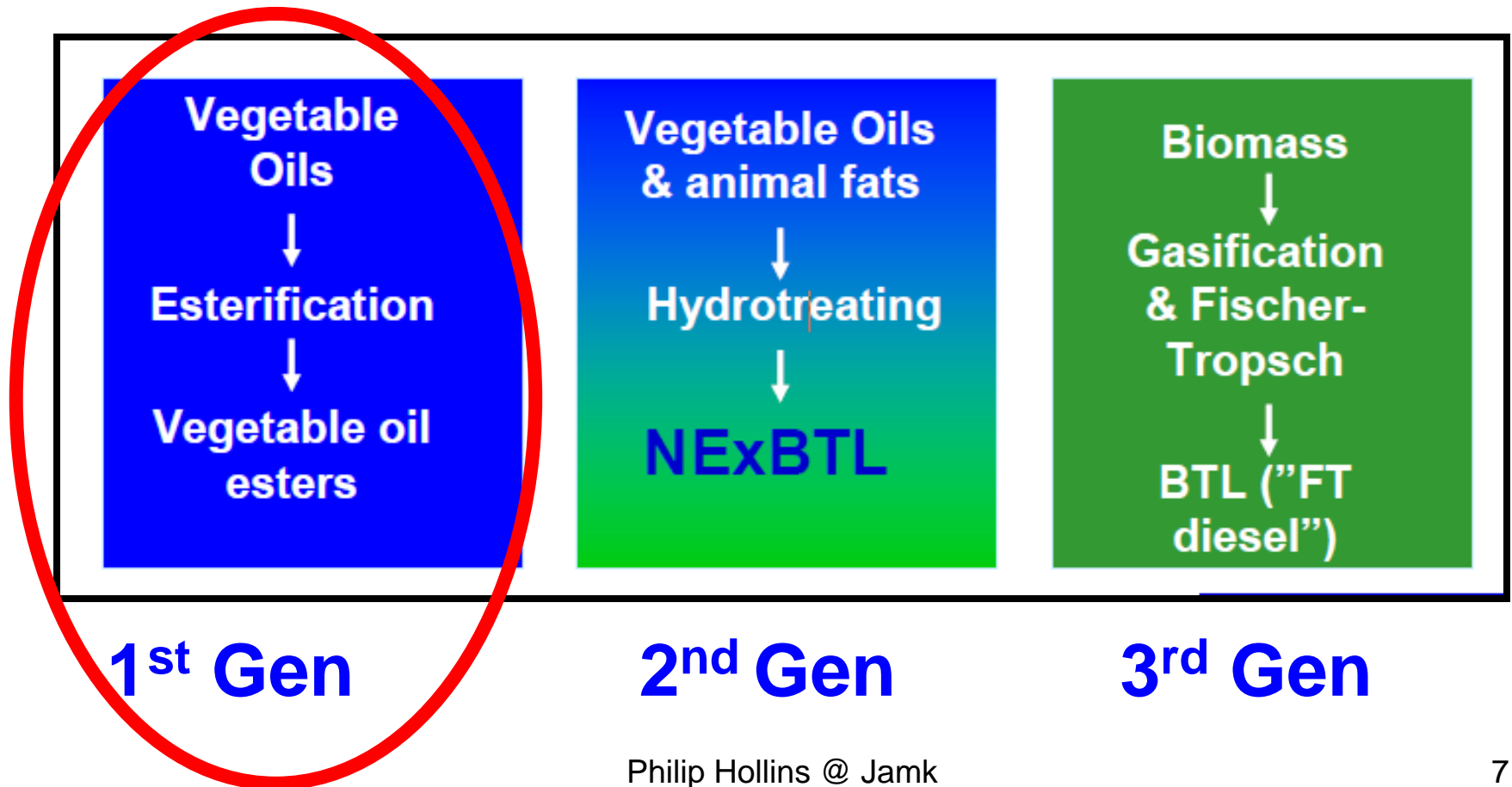
Diesel 'substitute'

(saturated, mono/polyunsaturated & fatty acids)

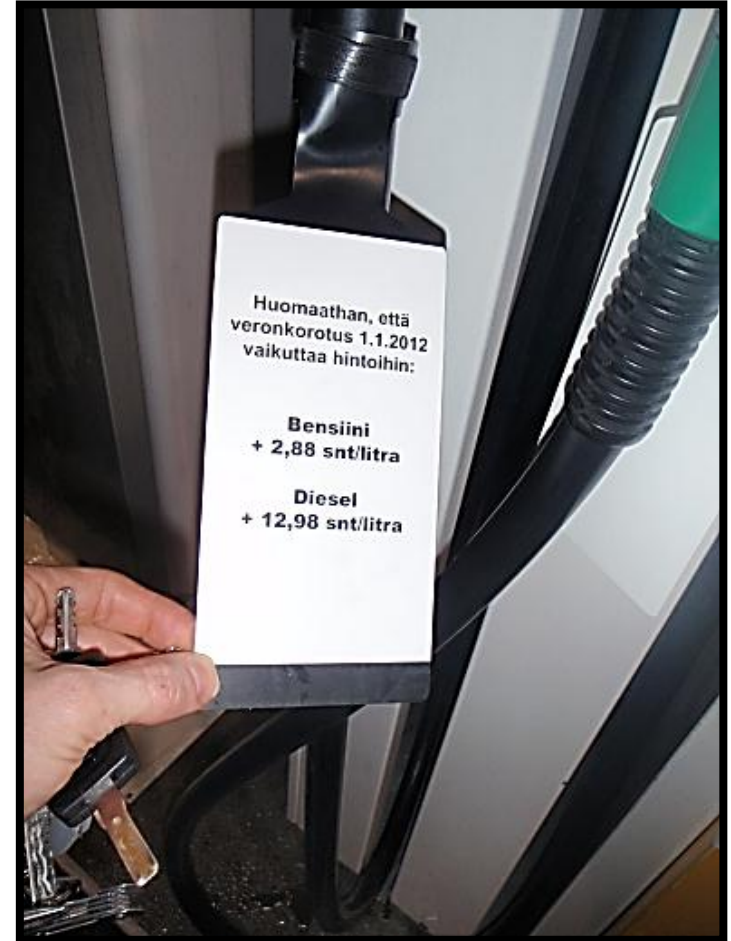
Liquid bio-fuel classification

(by conversion)

Neste (and others) define generation



Currently diesel costs ➡ Cost is increasing



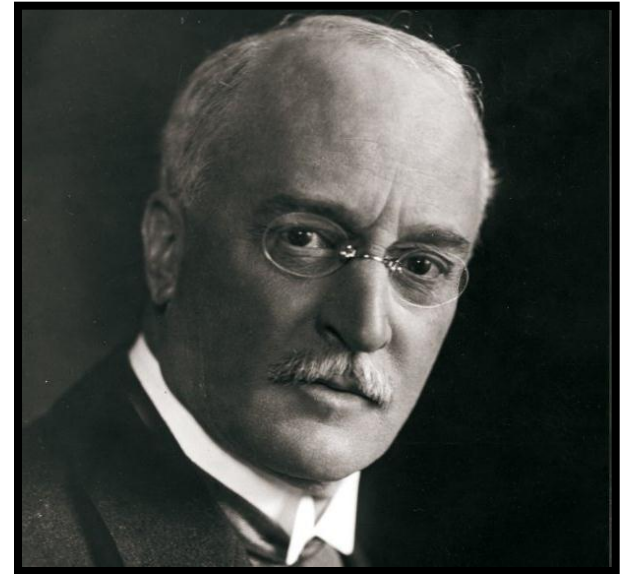
How about making it for 0.57cents !*

*** Including tax - assumes free labour and feedstock**

Rudolf Diesel

1892: Patent obtained

1897: First prototype developed



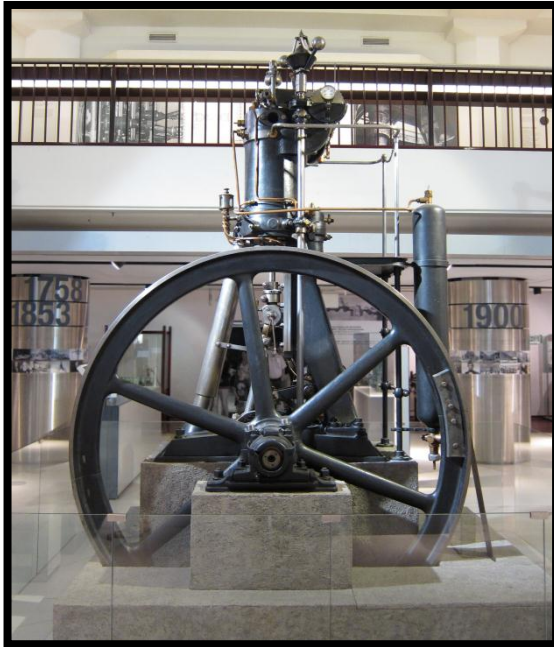
Born 1858

Died 1913

1900: Demonstrated World Exhibition in Paris running on **peanut oil**

1912: Presentation to the British Institute of Mechanical Engineers

1913: Died in 'mysterious' circumstances - found drowned in the English Channel

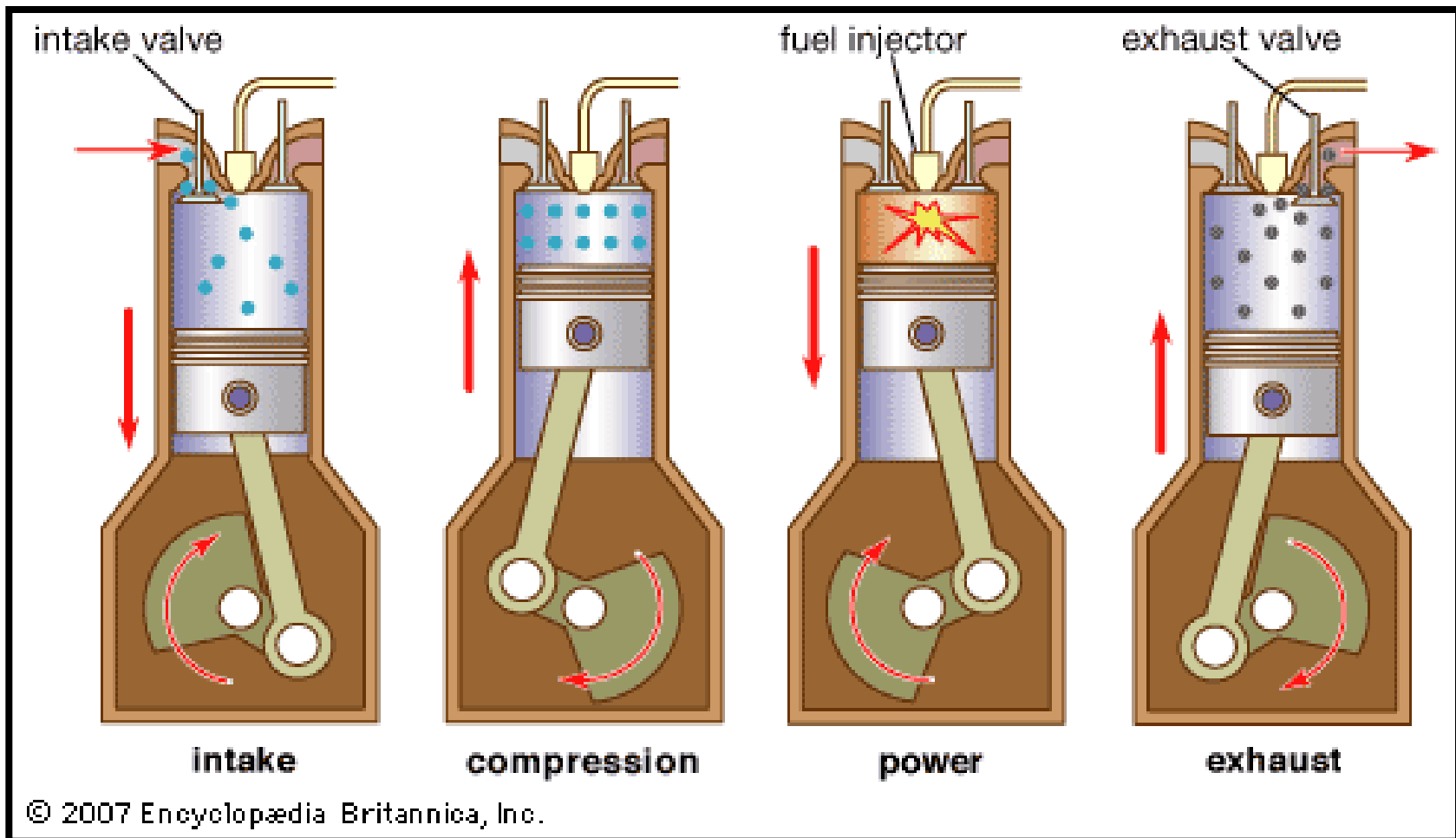


Deutsches Museum in Munich.



“The fact that fat oils from vegetable sources can be used may seem insignificant today, but such oils may perhaps become in course of time of the same importance as some natural mineral oils and the tar products are now” **(Diesel, 1912)**

How a diesel engine works (CI: Compression ignition)



[Hyperlink to video 1](#).....

[Hyperlink to video 2](#).....

[Hyperlink to video 3](#).....

Diesel 'substitute' vegetable oil yields

Crop	Litres oil/ha
Corn (maize)	712
Jatropha	1892
Lupin	232
Oats	217
Opium poppy	1163
Palm oil	5950
Rapeseed	1190
Soybean	446
Sunflower	952

Source: Adapted from www.journeytoforever.org

Fuel'	Viscosity @ 40 ^o Celcius
Diesel	2.50 Cst
Rapeseed	54.10 Cst
Soyaflower	35.40 Cst
Sunflower	35.20 Cst
Palm oil	47.80 Cst
Peanut oil	42.00 Cst

Source: Adapted from www.Green Team Alternative Fuels.com

Problems with vegetable oil.....

- Originally diesel engines where designed to operate using raw vegetable oil.
- Modern diesel engines **are too specialised** to reliably run on pure vegetable oil
- Vegetable oil is **too viscous** to use directly

Modifying the engine.....

Kevin Alford is a final year studying for B.Sc. in Agriculture.



Dual tank system

Diesel/(waste) veg' oil

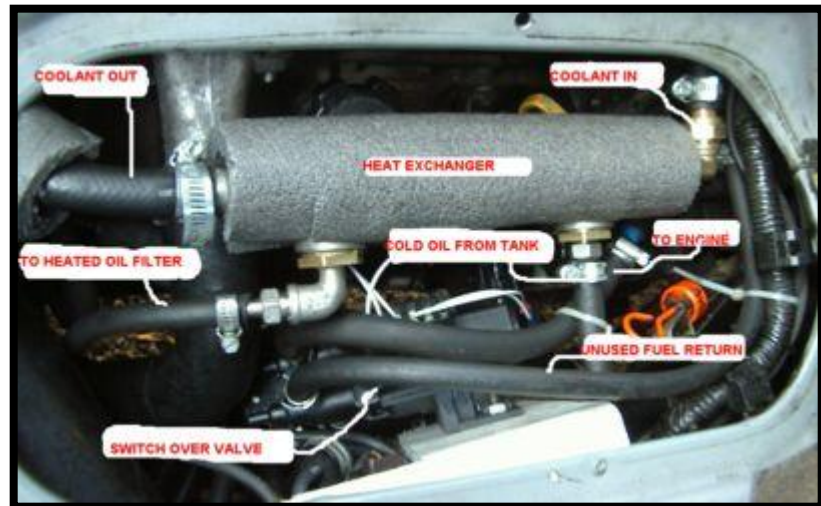
Start on diesel.....

**Engine heat exchanger
→ lower viscosity**



Switch to vegetable oil

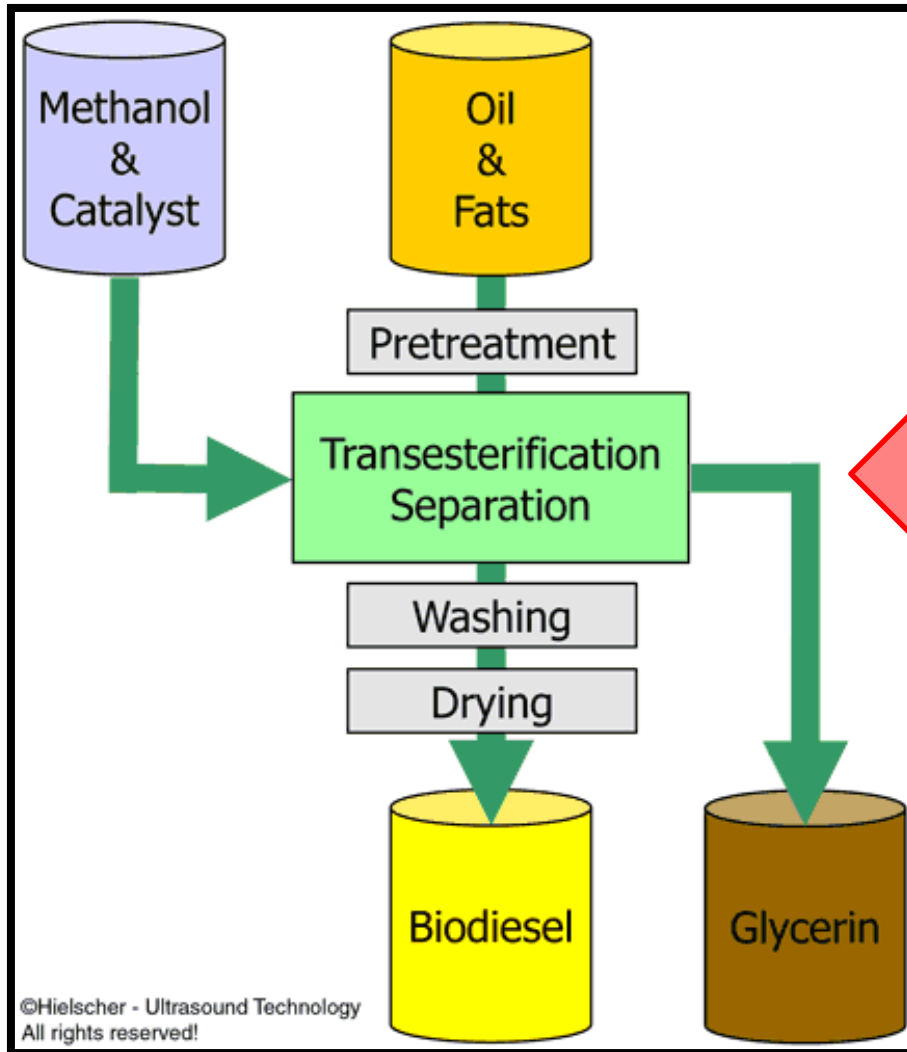
**Cost of system
→ fitted ~ €1600**



Example manufacturer: Elsbett

Home made system taken from : www.reuk.co.uk

Modifying the vegetable oil.....



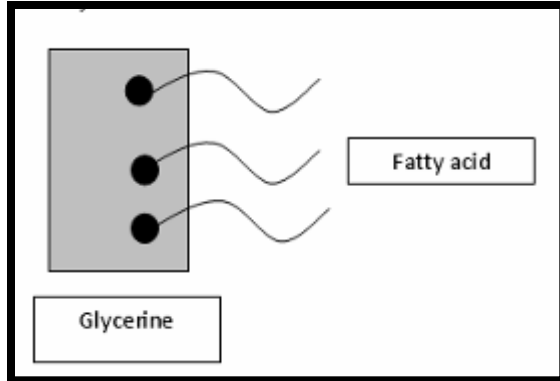
Transesterification process

→ remove glycerine molecule

→ reduces viscosity (x3)

Modifying the fuel (FAME).....

Convert vegetable oil to bio-diesel

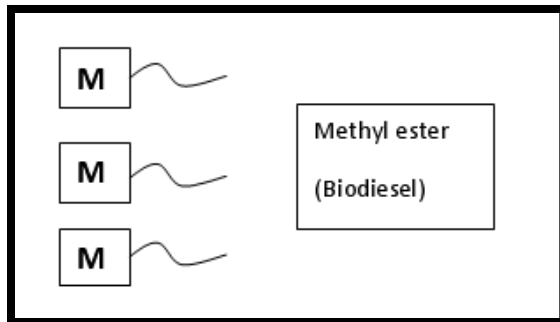


Vegetable oil → Triglycerine ester

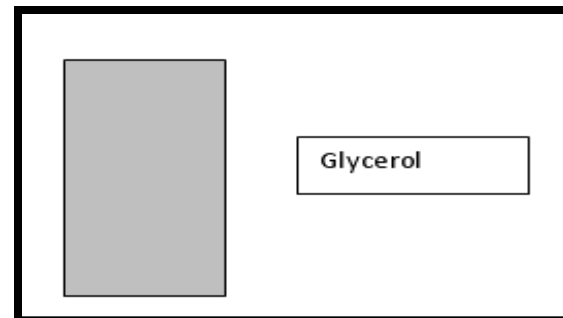
Large molecule → viscous

Transesterification process

→ reducing viscosity → remove glycerine molecule



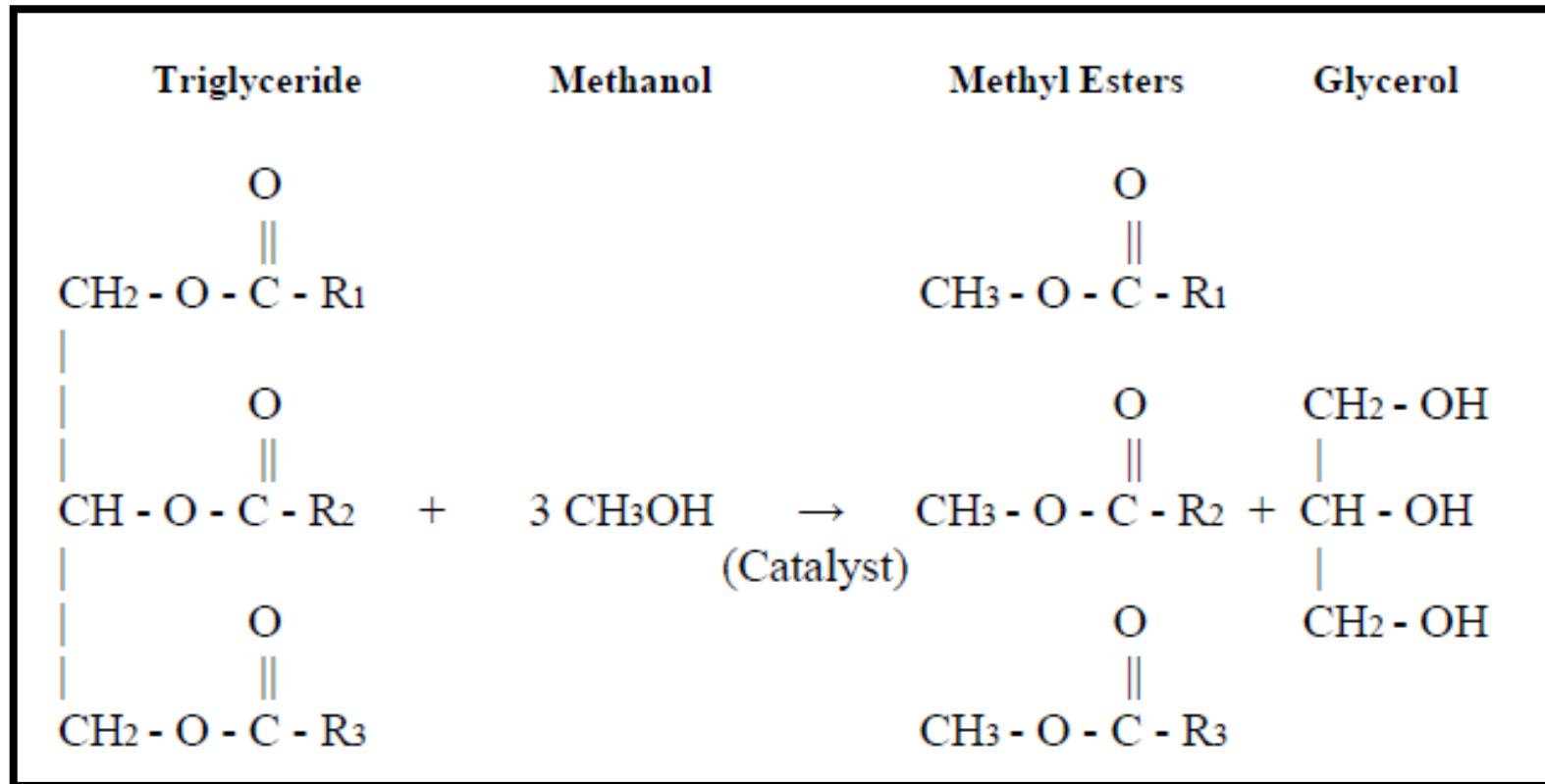
methanol
and
catalyst



Viscosity decrease x 3

Waste product → with uses

The chemistry



Methanol

SIGMA-ALDRICH				
SAFETY DATA SHEET				
according to Regulation (EC) No. 1907/2006 Version 3.3 Revision Date 12.12.2008 Print Date 01.07.2009				
1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND OF THE COMPANY/UNDERTAKING				
Product name	: Methanol			
Product Number	: M1775			
Brand	: Sigma-Aldrich			
Company	: Sigma-Aldrich Company Ltd. The Old Brickyard NEW ROAD, GILLINGHAM Dorset SP8 4XT UNITED KINGDOM			
Telephone	: +44 (0)1747 833000			
Fax	: +44 (0)1747 833313			
Emergency Phone #	: +44 (0)1747 833100			
E-mail address	: eurtechserv@sial.com			
2. HAZARDS IDENTIFICATION				
Risk advice to man and the environment Highly flammable. Toxic by inhalation, in contact with skin and if swallowed. Toxic: danger of very serious irreversible effects through inhalation, in contact with skin and if swallowed.				
3. COMPOSITION/INFORMATION ON INGREDIENTS				
Formula	: CH ₄ O			
Molecular Weight	: 32.04 g/mol			
CAS-No.	EC-No.	Index-No.	Classification	Concentration
Methanol				
67-56-1	200-659-6	603-001-00-X	F, T, R11 - R23/24/25 - R39/23/24/25	-
4. FIRST AID MEASURES				
General advice Consult a physician. Show this safety data sheet to the doctor in attendance.				
If inhaled If breathed in, move person into fresh air. If not breathing give artificial respiration. Consult a physician.				
In case of skin contact Wash off with soap and plenty of water. Take victim immediately to hospital. Consult a physician.				
In case of eye contact Rinse thoroughly with plenty of water for at least 15 minutes and consult a physician.				
If swallowed Do NOT induce vomiting. Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.				
Sigma-Aldrich - M1775 www.sigma-aldrich.com Page 1 of 6				

- Clear, colorless liquid odour like alcohol.
- Four milliliters can cause blindness and 80 to 150 milliliters can be fatal
- Inhalation of methanol vapor is the most common route of occupational exposure.
- Poisoning also possible from absorption through the skin

You will be using 100ml

Potassium Hydroxide (KOH)

SIGMA-ALDRICH	
SAFETY DATA SHEET	
according to Regulation (EC) No. 1907/2006 Version 5.1 Revision Date: 12.12.2008 Print Date 01.07.2009	
1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND OF THE COMPANY/UNDERTAKING	
Product name	: Potassium hydroxide
Product Number	: 484016
Brand	: Sigma-Aldrich
Company	: Sigma-Aldrich Company Ltd. The Old Brickyard NEW ROAD, GILLINGHAM Dorset SP8 4XT UNITED KINGDOM
Telephone	: +44 (0)1747 833000
Fax	: +44 (0)1747 833313
Emergency Phone #	: +44 (0)1747 833100
E-mail address	: eurtchserv@sial.com
2. HAZARDS IDENTIFICATION	
Risk advice to man and the environment Harmful if swallowed. Causes severe burns.	
3. COMPOSITION/INFORMATION ON INGREDIENTS	
Synonyms	: Caustic potash
Formula	
Molecular Weight	
CAS-No.	EC-No.
Potassium hydroxide	
1310-58-3	215-18
4. FIRST AID MEASURES	
General advice Consult a physician. Show	
If inhaled If breathed in, move person	
In case of skin contact Take off contaminated cloth	
In case of eye contact Rinse thoroughly with plenty	
If swallowed Do NOT induce vomiting. N	
Consult a physician.	
Sigma-Aldrich - 484016	



pH 13 - drain cleaner



Exposure Routes

inhalation, ingestion, skin and/or eye contact

Symptoms

irritation eyes, skin, respiratory system; cough, sneezing; eye, skin burns; vomiting, diarrhoea

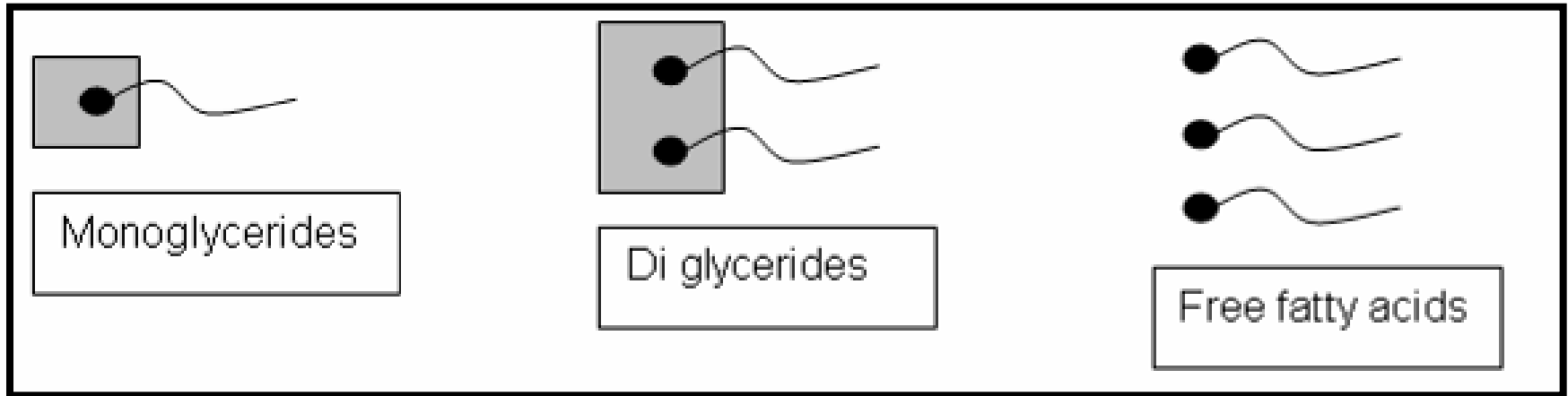
Target Organs

Eyes, skin, respiratory system

You will be using 14g max

Convert (waste) vegetable oil to bio-diesel

Waste vegetable oil contains:



Mono and Di-glycerides → no problem

Free fatty acids → problem

Neutralised by the addition of potassium hydroxide

Determined by pH test titration

Potassium hydroxide also acts as catalyst

Potassium hydroxide & methanol → methoxide

Sourcing the waste oil.....



The processing unit.....





GoldenRay

Save money Save the Planet

Biodiesel Processor Specialists

BIODIESEL PROCESSORS

01494 558221

lines open 7am - 10pm

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BIODIESEL - THE FACTS

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BIODIESEL EQUIPMENT

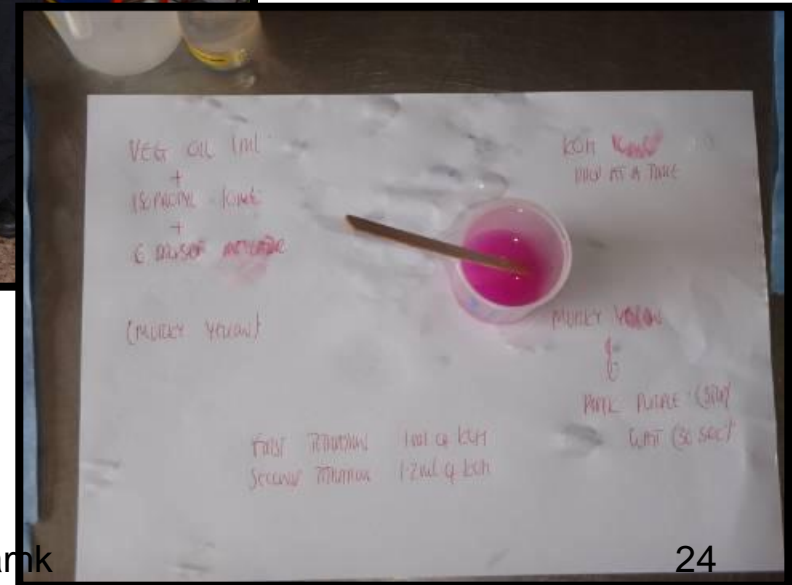
FREE OPEN DAYS

FAQ

Biodiesel Processors Comparison Chart

	GR50	GR120	GR250	
<p>Make greener diesel from used cooking oil for just 16p per litre!</p> <p>Golden Ray is the UK's leading Biodiesel Processor manufacturer.</p> <p>Each processor is primed and tested before leaving the factory and is delivered in true 'plug and go' fashion.</p> <p>In most cases your investment is repaid within 5 months!</p> <p>Prices start from £997</p> <p>Self load vegetable oil</p>	 <p><small>Todday Not included</small></p>			<div style="background-color: red; color: white; padding: 10px; border-radius: 50%; transform: rotate(15deg);"> <p>As seen on BBC TV's 'Working Lunch'</p> </div> <div style="text-align: center;">  <p><small>click to view video</small></p> </div> <div style="background-color: yellow; padding: 10px; border-radius: 10px; transform: rotate(5deg);"> <p>Try before</p> </div>
		✓	✓	

Testing the pH → titration.....



Determining the amount of 'neutraliser to add.....

NEW Oil (No Titration Needed)	
Methanol (L)	Amount of KOH required (grams)
24	1080

WASTE Oil (W.V.O.) Titration Chart		
Methanol (L)	Oil Titration reading (ml/s)	Amount of KOH required (grams)
24	1	1200
24	2	1320
24	3	1440
24	4	1560
24	5	1680
24	6	1800
24	7	1920
24	8	2040
24	9	2160
24	10	2280

Preparing and adding the methoxide.....



Removing the glycerol.....



[Hyperlink to video.....](#)



.....and testing batch quality

‘Washing’ the bio-diesel.....



Philip Hollins @ Jamk

‘Drying’ and filtering the bio-diesel...



Distributing the finished bio-diesel.....



Philip Hollins © Jamk



www.serd.ait.ac.th/eric

A Comparison of Costs of Biodiesel Production from Transesterification

Kulchanat Kapilakarn^{*1} and Ampol Peugtong^{*}

Int. J. Environ. Sci. Tech., 5 (1), 75-82, Winter 2008

ISSN: 1735-1472

© IRSEN, CEERS, IAU

Conversion

Abstract - Nowaday is a remaining pro condition by using ester (biodiesel) wa all units in the proc were reaction times Moreover the work found that the optin wt.), the reaction te the process with do reactors, it is found the equivalent size.

Keywords - Biodiesel

Production optimization and quality assessment of biodiesel from waste vegetable oil

¹*A. A. Refaat; ²N. K. Attia; ¹H. A. Sibak; ¹S. T. El Sheltawy, ²G. I. ElDiwani

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Received 6 November 2007; revised 26 November 2007; accepted 3 December 2007; available online 26 December 2007

ABSTRACT: Biodiesel production is worthy of continued study and optimization of production procedures because of its environmentally beneficial attributes and its renewable nature. In Egypt, millions L. of oil used for frying foods are discarded each year into sewage systems. Thus, it adds to the cost of treating effluent or pollutes waterways. This study is intended to consider aspects related to the feasibility of the production of biodiesel from waste/recycled oils in an attempt to help reduce the cost of biodiesel and reduce waste and pollution coming from waste oils. The variables affecting the yield and characteristics of the biodiesel produced from used frying oil were studied, the achieved results were analyzed and a set of recommendations was proposed. From the obtained results, the best yield percentage was obtained using a methanol/oil molar ratio of 6:1, potassium hydroxide as catalyst (1%) and 65 °C temperature for one hour. The yield percentage obtained from waste vegetable oil was comparable to that obtained from neat vegetable oil which reached 96.15% under optimum conditions. From the results it was clear that the produced biodiesel fuel, whether from neat vegetable oil or waste vegetable oil, was within the recommended standards of biodiesel fuel.

Key words: Biodiesel, waste vegetable oil, transesterification, optimization

Homebrew Tests Listed

Written by Rickdatech

Best of the Tests

Tests for Finished Biodiesel

ASTM Laboratory Testing
The pHlip Test
Clarity Test for Water
Cloud Point Testing
Gel Point Testing
The Methanol Test from JTF
The Dr Pepper Viscosity Test
The Dr Pepper Reprocess Test

Initial Feedstock Testing

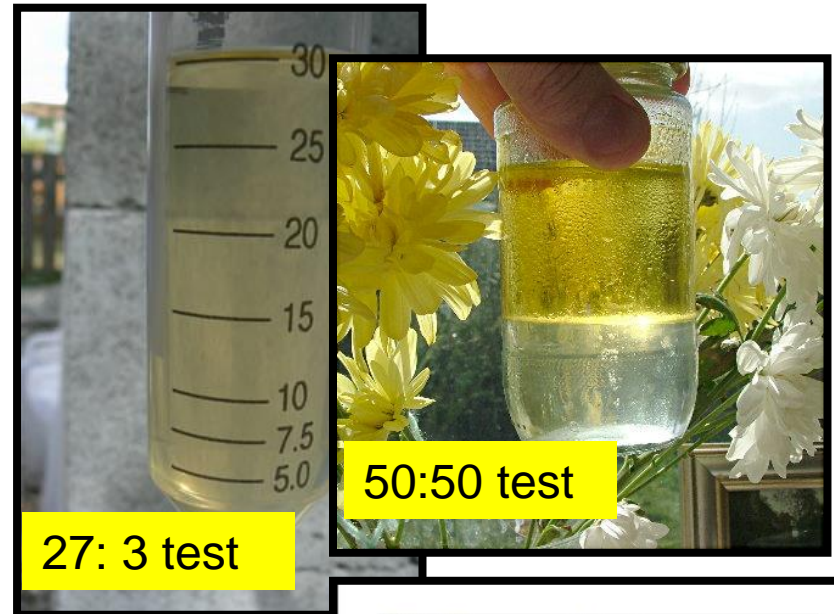
Titration Test for WVO
The Frying Pan Test
The Hot Pan Test
Quantitative test for water
Specific Gravity of Methanol

Mid Process Tests

Soap Test Titration
The Drying Test

The Rest of the Tests

pH Testing
Reprocess Test from JTF
Specific Gravity of Biodiesel
The Wash Test from JTF
The Shaker Up Test
Wash Water Clarity Test
pH Testing the Wash Water
Smelling for Methanol



Source: <http://www.make-biodiesel.org/>

Oilbits Biodiesel pHlip Test

Instructions for Use at Room Temperature

1. Use the squeeze bulb to transfer 8000 to a test vial of Indicator Solution, filling almost to the top, leaving approximately 4mm of airspace.
2. Tighten cap and flip the vial 10 times gently, then allow to stand for 10 minutes.
3. Look for 'Clear & Bright' fuel floating on the Indicator Solution, the Indicator Solution should remain 'Cherry Red' in color and have no turbidity (cloudiness) whatsoever.
4. Turbidity indicates contaminants are present that were insoluble in the fuel, over time they may concentrate on the Indicator Interface (see effect).
5. High quality ASTM B100 will create a 'mirror' on the smooth surface of the fuel and the Indicator Solution, if you see a good reflection the your B100 is of good quality.
6. If the fuel is slightly turbid, but the Indicator solution is transparent and the normal 'cherry red' color, then you probably have slightly aged fuel or traces of Glycerides or Glycerine left over from the production process.
7. If the Indicator Solution turns orange or yellow from acid accumulation, the fuel is probably aged.
8. If the Indicator solution is turbid, suspect soap. If the Indicator color is turning purple then you have catalyst (hydroxide) contamination—DO NOT use this fuel in an engine.
9. PH can be corrected using products such as Magnasol, PHCorrector, or Fuelite PD206.

Detection of catalyst contamination from poorly washed biodiesel fuels

Bright Reference Fuel
↑ Mirror Finish
Neutral pH Indicator

Hygroscopic Biodiesel samples become turbid

Alkaline pH creates purple color; soaps cause turbidity

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Biodiesel Fuel Testing EN-14214

Biodiesel fuel EN-14214 conforms to

Quality specifications for European Biodiesel for distillate fuels are confirmed by Intertek laboratory testing. Intertek biofuel laboratories offer complete testing to EN-14214 European biodiesel fuels. Biodiesel testing customised to your analysis, reliable results, and a complete service.

EN-14214 biodiesel testing:

- [Biodiesel Tests for Europe](#)
- [EN and ASTM Biodiesel Quality Specifications](#)
- [Diesel Fuel Testing](#)
- [Diesel Lubricity Testing](#)
- [Biodiesel Fuel Filter Blocking](#)
- [Biofuels Testing and Inspection](#)

Biodiesel fuel testing:

- [Biodiesel Fuels Testing](#)
- [Biodiesel Feedstock Testing and Evaluation](#)

ASTM Laboratory Testing

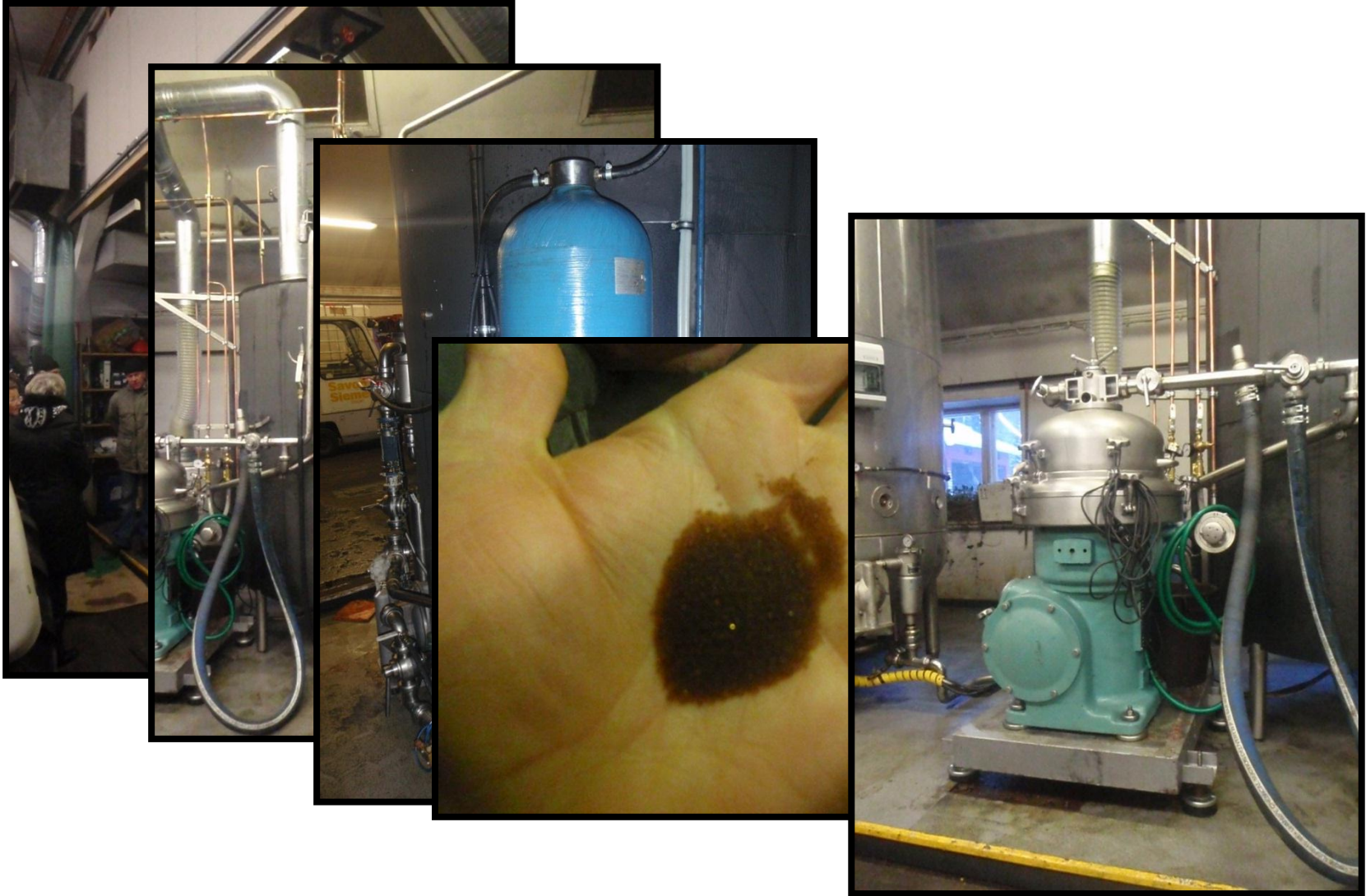
ASTM D6751 is a battery of tests that are the accepted American Standard for testing B100 biodiesel intended for use as blend stock. A full battery of tests cost from \$1000 to \$3000 per sample making it too expensive for homebrewing. It is not an accepted standard for neat or pure biodiesel. Below is a table that outlines the tests that compose ASTM D6751

Property.....	Method.....	Limits.....	Units.....
Flash point, closed cup	D 93	130 min	° C
Water and sediment	D 2709	0.050 max	% volume
Kinematic viscosity, 40 ° C	D 445	1.9 – 6.0	mm ² /s
Sulfated ash	D 874	0.020 max	wt. %
Total Sulfur	D 5453	0.05 max	wt. %
Copper strip corrosion	D 130	No. 3 max	
Cetane number	D 613	47 min	
Cloud point	D 2500	Report	° C
Carbon residue	D 4530	0.050 max	wt. %
Acid number	D 664	0.80 max	mg KOH/g
Free glycerin	D 6584	0.020	wt. %
Total glycerin	D 6584	0.240	wt. %
Phosphorus	D 4951	0.0010	wt. %
Vacuum distillation end point	D 1160	360 °C max, at T-90	% distilled

For more information on ASTM 6751 see Biodiesel Analytical Methods by the NREL. The actual test procedures are available from ASTM.com with the purchase of a membership or from Techstreet.com without membership.

My Opinion - What can I say.... This is the only official standard we have and it's too expensive for homebrewers to use as a standard.

Finland example 1 (Iisalmi, near Kuopio)



Finland example 2 (Leppävesi, near Jyväskylä)



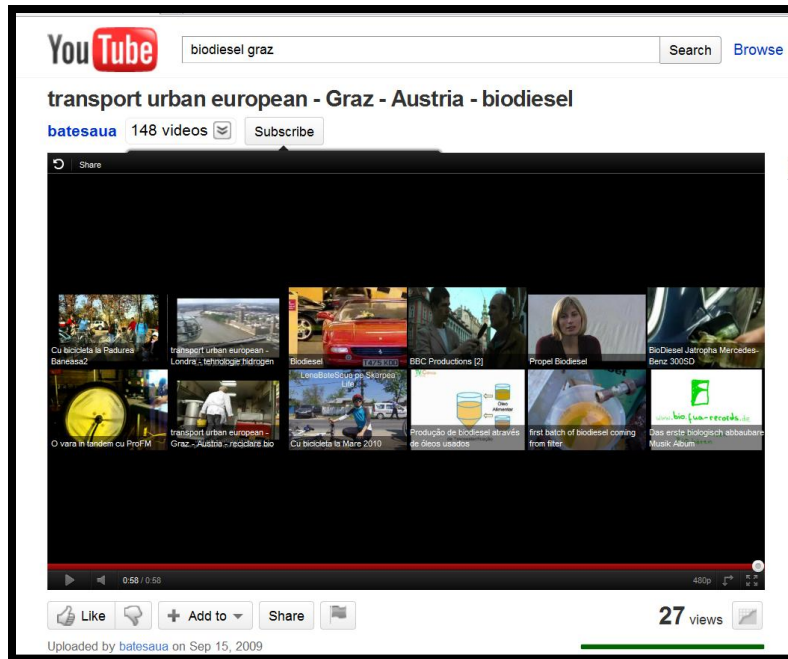
.....uses for the waste glycerol (Leppävesi, near Jyväskylä)



Types of waste used in anaerobic digester

Feed	m ³ CH ₄ per tonne dry matter
Pig Slurry	240
Dairy Slurry	180
Poultry Manure	250
Sewage Sludge	270
Maize	370
	500

Case study – Graz in Austria



‘From the pan into the tank’

Operational in Graz, Austria (since 1999)

Approx’ 56 buses (50% of public transport)

[Hyperlink](#)

A typical industrial scale processing unit



The Green Fuels FuelMaker up
to **8000 litres per day**

Made in batches of 600 litres

Cost £280,000 ~ € 336,600

*“For a fully installed biodiesel factory based on this model,
you need to approximately double the cost”*

Greenfuel representative

However, not all biodiesel is the same...

NESTE OIL

Generations of renewable diesel components

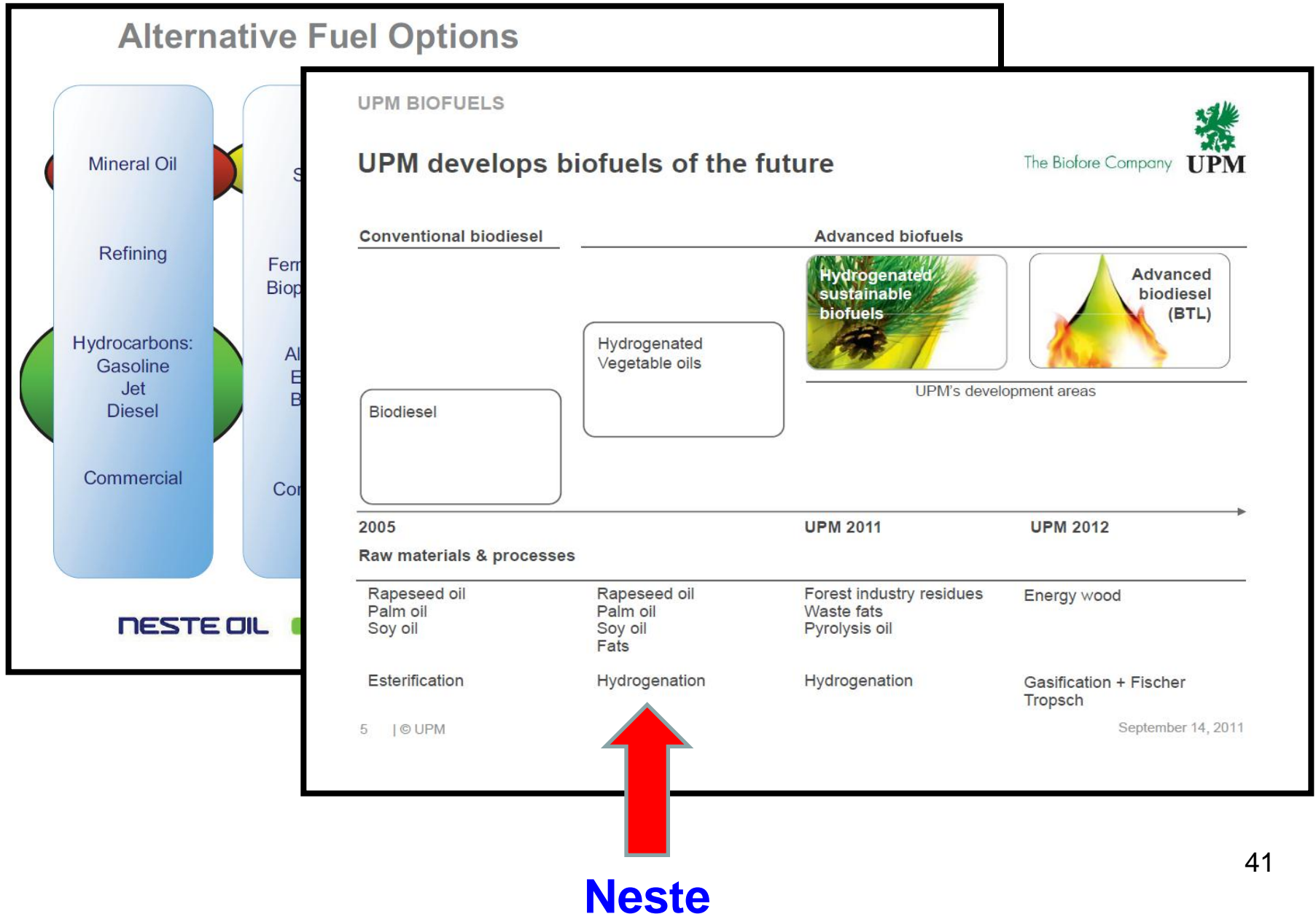
Generation	Commercial scale	Production process <i>Product</i>	Availability of feedstocks	Quality of product	Investment costs
1st	≈ 1995...	Esterification <i>Ester FAME</i>	-	-	+
2nd					
3rd					

+ Benefit - Disadvantage

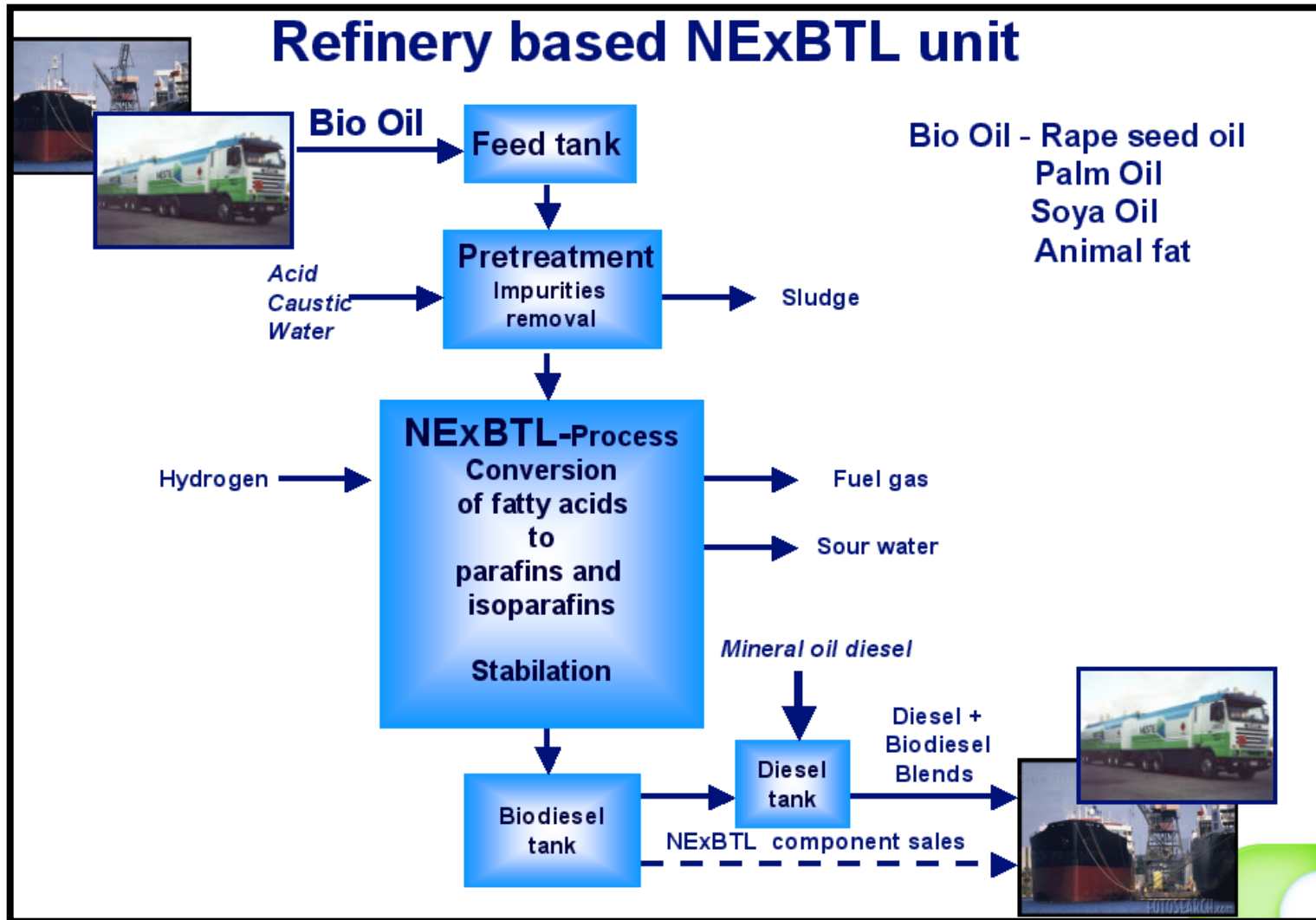
C_nH_{2n+2} = Paraffinic hydrocarbon



Neste and UPM are competitors.....



Hydrotreated vegetable oil: HVO



[Hyperlink \(Neste\)](#)

[Hyperlink \(Neste\)](#)

Neste NExBTL 100 Green Biodiesel



Despite.....

Neste Oil's targets for procurement of renewable raw materials in 2011:

Raw material	Planned share (%) in 2011
Crude palm oil	< 50%
Waste and side streams (waste animal fat, PFAD, stearin)	~ 40%
Others (e.g. rapeseed, jatropha, and camelina)	~ 10%

However, negative publicity.....

19 JAN 2009: **REPORT**

The Cost of the Biofuel Boom: Destroying Indonesia's Forests

The clearing of Indonesia's rainforests has profound effects – threatening indigenous people, and releasing carbon into the atmosphere.

BY TOM KNUDSON



[Hyperlink 1](#)

UPM to build the world's first biorefinery producing wood-based biodiesel

pangea

01/02/2012 12:45:00

Font size: — +



Second generation biodiesel

UPM is to invest in a biorefinery producing biofuels from crude tall oil in Lappeenranta, Finland.

(UPM, Helsinki, 1 February 2012 at 10.00 EET)

The industrial scale investment is the first of its kind globally. The biorefinery will produce annually approximately 100 000 tonnes of advanced second generation biofuel for transport.

Construction of the biorefinery will begin in the summer of 2012. The total investment will amount to approximately EUR 150 million.

"The biofuels business has excellent growth potential and has attracted significant interest among a wide range of customers. UPM is becoming a significant producer of advanced second generation biofuels as part of its strategy", says UPM President and CEO Jussi Pesonen.

UPM's advanced biodiesel, UPM BioVerno, is an industrial grade product, comparable to fossil fuels. The product's characteristics are suitable for today's vehicles and fuel distribution systems.

"Our biorefinery in Lappeenranta is the first significant investment in the ongoing transformation of forest industry", says Pesonen.

The construction of the biorefinery will offer work for approximately 50 people. The biorefinery will directly employ nearly 50 people and indirectly about 100 people during the project.

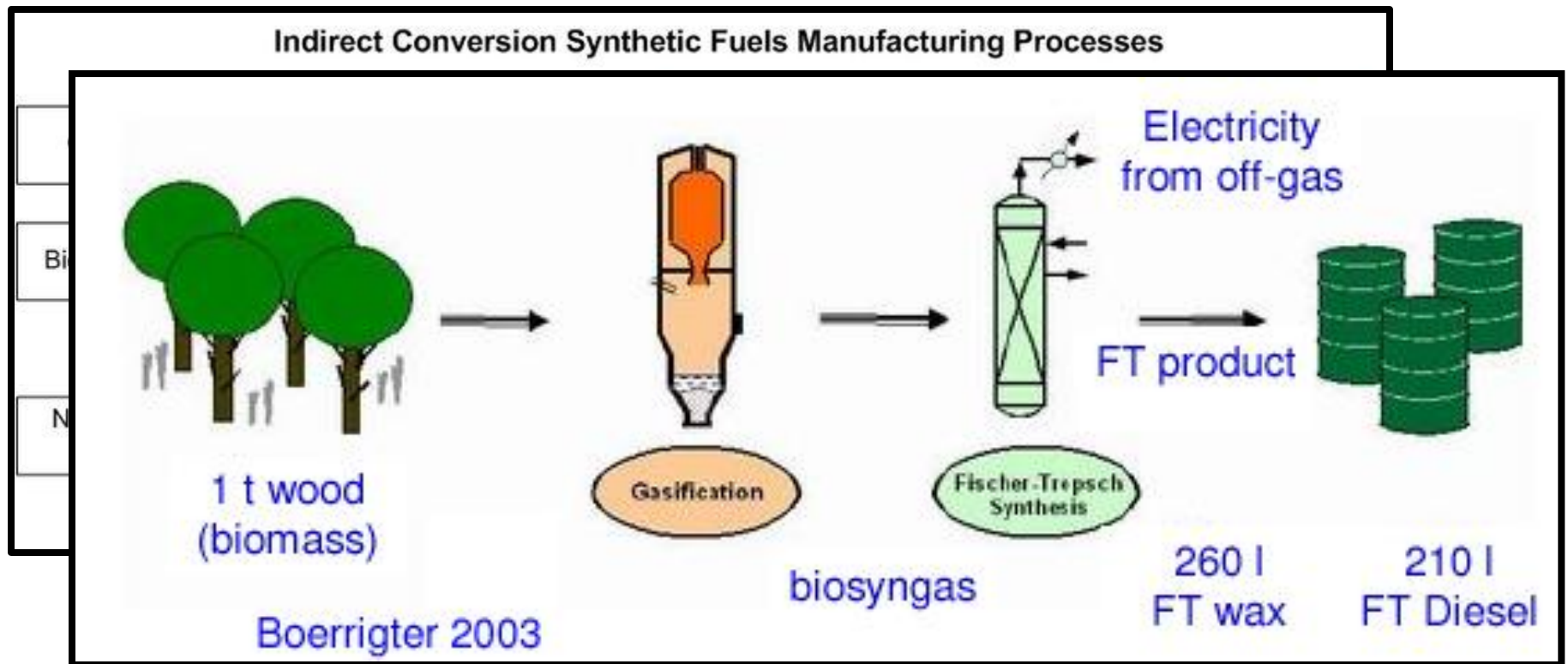
EU 2020 targets create demand for sustainable biofuels

The demand for biofuels is expected to grow by approximately 7 % a year in the EU. The target of the EU is to increase the share of biofuels in transport fuels to 10% by the year 2020. In Finland, the corresponding target is even more challenging with an increase of

UPM announced the beginning of 2012, that the company will invests (€ 150 million) in the world's first advanced wood based biodiesel production in South Eastern Finland, Lappeenranta. Process is using hydrotreatment technology and raw material will be sustainably produced crude tall oil.

Construction of biorefinery will start in the summer of 2012 and production (100 000 tonnes/year) of advanced second generation biodiesel will start in 2014. The production will cover about 25 percent of Finland's 20 percent biofuels target in 2020.

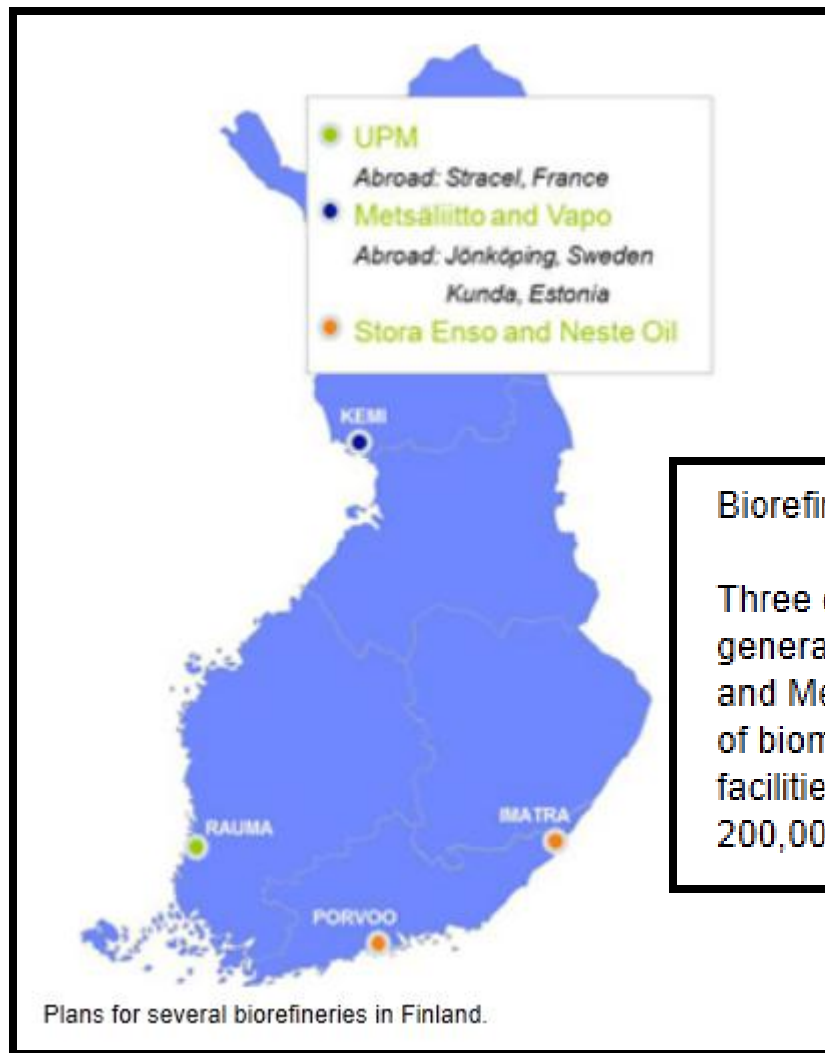
Fischer-Tropsch (FT) biodiesel*



- Also known as BTL, CTL AND GTL

[Hyperlink – UPM](#) (Fisher Tropsch)

[Hyperlink – Neste & Stora Enso](#)




Biorefineries planned for Finland

Three consortiums are presently planning to establish second generation biorefineries in Finland. Stora Enso/Neste Oil, UPM and Metsäliitto/Vapo are basing their designs on the gasification of biomass and the Fischer-Tropsch synthesis. The planned facilities would each have the capacity to produce 100,000 – 200,000 tonnes of biodiesel annually.

Source: www.forestindustries.fi

Neither of these processes are new.....





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Thanks for the Cheap Gas, Mr. Hitler!

How Nazi Germany and apartheid South Africa perfected one of the world's most exciting new fuel sources.

By Daniel Gross | Posted Monday, Oct. 23, 2006, at 3:30 PM ET

When it comes to racial policies, it may be somewhat hyperbolic to say that the [apartheid regime that came into power in South Africa in 1948](#) picked up where the Nazis left off. It's not at all hyperbolic to observe that the apartheid regime picked up where the Nazis left off when it came to producing gasoline from coal. Nazism, apartheid, and international sanctions created a fuel source that might never have existed in a better world.

The circuitous travels of the [Fischer-Tropsch process](#), a chemical technique to convert natural gas and coal into liquid fuels, provide an object lesson in historical irony. Used by the Nazis to make oil from coal during World War II, it was commercialized by the century's second-most-odious racial supremacist regime in the 1950s through South Africa's state energy company. Now, that privatized company, Sasol, may help liberate Western democracies (and non-Western ones, like India) from the grip of crude oil produced largely by loathsome authoritarian regimes.

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ERIN BURNETT
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Sasol is the ExxonMobil of South Africa, though its annual sales of about \$10 billion are around what Exxon Mobil does in about 10 days. With 30,000 employees, including the largest number of Ph.D.s of any company in the Southern Hemisphere, Sasol is one of South Africa's largest employers. It produces about 38 percent of South Africa's fuel needs and accounts for about 4.4 percent of the country's GDP.



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Ruins of the Nazi synthetic petrol plant (Hydrierwerke Pölitz – Aktiengesellschaft), in Poland

What is new, is the use of a sustainable feedstock



Sasol Ltd. (Afrikaans: *Suid Afrikaanse Steenkool en Olie*,
English: *South African Coal and Oil*)



The largest producer of motor fuels from coal (Bloomberg, 2011)

Future biodiesel developments.....?

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Harvesting the power of Algae, for a cleaner tomorrow.



Ed Begley Jr. of Planet Green's reality show "Living with Ed" filmed at SunEco Energy facilities in Imperial Valley

SunEco Energy and J.B. Hunt - Algae Power Hits the Road ...click here to read press release

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Imperial Valley works on growing algae industry

May 6-8, 2009 - SunEco sponsors IVEDC Alternative Energy Summit.

Neste Oil in Joint Algae Research

FINLAND - Neste Oil has launched a joint algae research programme with the Marine Research Centre at Finnish Environment Institute (SYKE)

The programme is part of Neste Oil's efforts aimed at producing NExBTL renewable diesel in the future.

Research with SYKE will focus on testing the lipid content of algae and analysing how the quality and quantity of algae can be adjusted under which algae cultivation programme will last two years.

At SYKE's Marine Research Centre, the use of algae has been studied since 2008 during several national research projects.

The main objective has been screening and isolating the algae strains isolated from the Baltic Sea.

"It is great to have the opportunity to tap into that SYKE has to support our own in-house Research Project Manager at Neste Oil.

"The new programme is intended to help ensure the production of cost-effective algae oil for our future needs.

Neste Oil is already working with a number of universities, and companies in the algae research field.

The company announced in the summer of 2009 that it had initiated several international algae research projects in Australia.

The suitability of algae oil for use in the NExBTL process is being studied.

Algae that produce and store lipids represent a promising material for NExBTL renewable diesel.

Algae grow rapidly and one hectare of cultivated algae can produce up to 10 tonnes of oil per year.

Algae oil is also an excellent alternative in the production of biofuels to compete with food production for supplies of oil.

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Neste Oil to build a pilot plant to produce waste-based microbial oil at Porvoo

15.12.2011

Neste Oil Corporation
Press release
15 December 2011 at 9 am (EET)

Neste Oil to build a pilot plant to produce waste-based microbial oil at Porvoo

Neste Oil is to build a pilot plant to produce waste-based microbial oil at its Porvoo refinery. It will be the first pilot plant in Europe designed to produce microbial oil for use in manufacturing renewable fuel from waste-based raw materials.

The plant will be used to develop microbial oil production processes and test various raw materials for producing microbial oil, such as straw and other agricultural residues, as well as industrial waste and residues. The plant will support Neste Oil's goal of using microbial oil to produce NExBTL renewable diesel in the future. The facility is due to be completed in the second half of 2012 and represents an investment of approx. EUR 8 million.

"In strategic terms, this is a very important decision for us, as the new pilot plant will enable us to progress to the next stage in our microbial oil development work," says Neste Oil's Vice President, Research and Technology Petri Lehmus. "The decision very much supports Neste Oil's strategy aimed at extending our raw material base."

Neste Oil has already succeeded in producing NExBTL renewable diesel from microbial oil at laboratory scale. The new pilot plant is an important step on the way to scaling up the technology to commercial capability.

"The next stages in our development work will concentrate on tuning the production process and enabling it to operate on an industrial scale. Commercial production of microbial oil is likely to be possible by 2015 at the earliest," says Lehmus.

Making use of waste and residues

Neste Oil applied for patents covering its microbial oil technology in fall 2010. The technology enables to produce microbial oil from waste and residues with the help of fungi for use as a raw material for producing NExBTL diesel. These microbes break down waste and residues into sugars to grow and produce oil.

"Our aim is to make use of waste and residue materials that offer the maximum potential for reducing greenhouse gas emissions. Waste-based microbial oil is a very promising raw material, in terms of its efficient production potential and sustainability," continues Lehmus.

As fungi do not require sunlight to grow, they can be grown virtually anywhere. Microbial oil production can be safely carried out in the bioreactors widely employed by today's brewers and biotechnology companies.

Finland is a pioneer in microbial oil production

Neste Oil has carried out pioneering collaborative work with Aalto University School of Chemical Technology on developing microbial oil technology, and this know-how has been used to develop practical applications.

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Source: www.thebioenergysite.com

Bio-based diesel - summary

- **FAME (Transesterification)**


- Production: Oil + alcohol = Fatty acid ester (+ glycerol)

-  Simple production, low emissions

-  Quality, food vs fuel, enough feedstocks

- **HVO (Neste)**

- Oils/fats + hydrotreatment => paraffin HC


-  Quality, emissions low, production at refinery level

-  Food vs fuel, enough feedstocks ?, deforestation, price?

- **Fischer-Tropsch (BTL)**

- Biomass => gasification => syngas ($\text{CO} + \text{H}_2\text{O}$) => (Fischer-Tropsch synthesis) => paraffin HC

-  Quality, emissions low, any biomass

-  Price, development stage, difficult process, small production so far

Source: Adapted from, Larimi and Tilli – Aalto University 2011

Thank you for listening

Any questions ?