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Promoting Sustainable Biofuels Production and Use in Central and Eastern Europe

prepared for the

UNIDO
Regional Workshop

in Cavtat, Croatia
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General mistakes observed

- **Planning phase** is much too hasty and superficial.
- **Cost of plant** is seen as most important factor.
- **Feedstock supply** is relying on just one oil type, is of questionable quality, unreliable in supply and expensive.
- **Biodiesel marketing** concept is not well founded and short-term oriented. Competitive aspects are neglected.
- **Site** is located in the middle of nowhere causing high logistic cost levels for both input and output.
- Unproven, self-invented **process technology** of low yield and poor quality is used.

Gold rush mentality predominant

- **Germany:**
  - Overcapacity has developed within a rather short time.
  - Price battles decreasing profitability.
  - Government reacts with reduction of tax rebates.
  - Nevertheless new plants are appearing like mushrooms.
- **Austria:**
  - 4 new biodiesel plants (100.000 t each) at Danube harbours getting on stream in 2007.
  - One of them to expand to 400.000 t by 2008.
  - Risk of overcapacity.

Gold rush mentality predominant

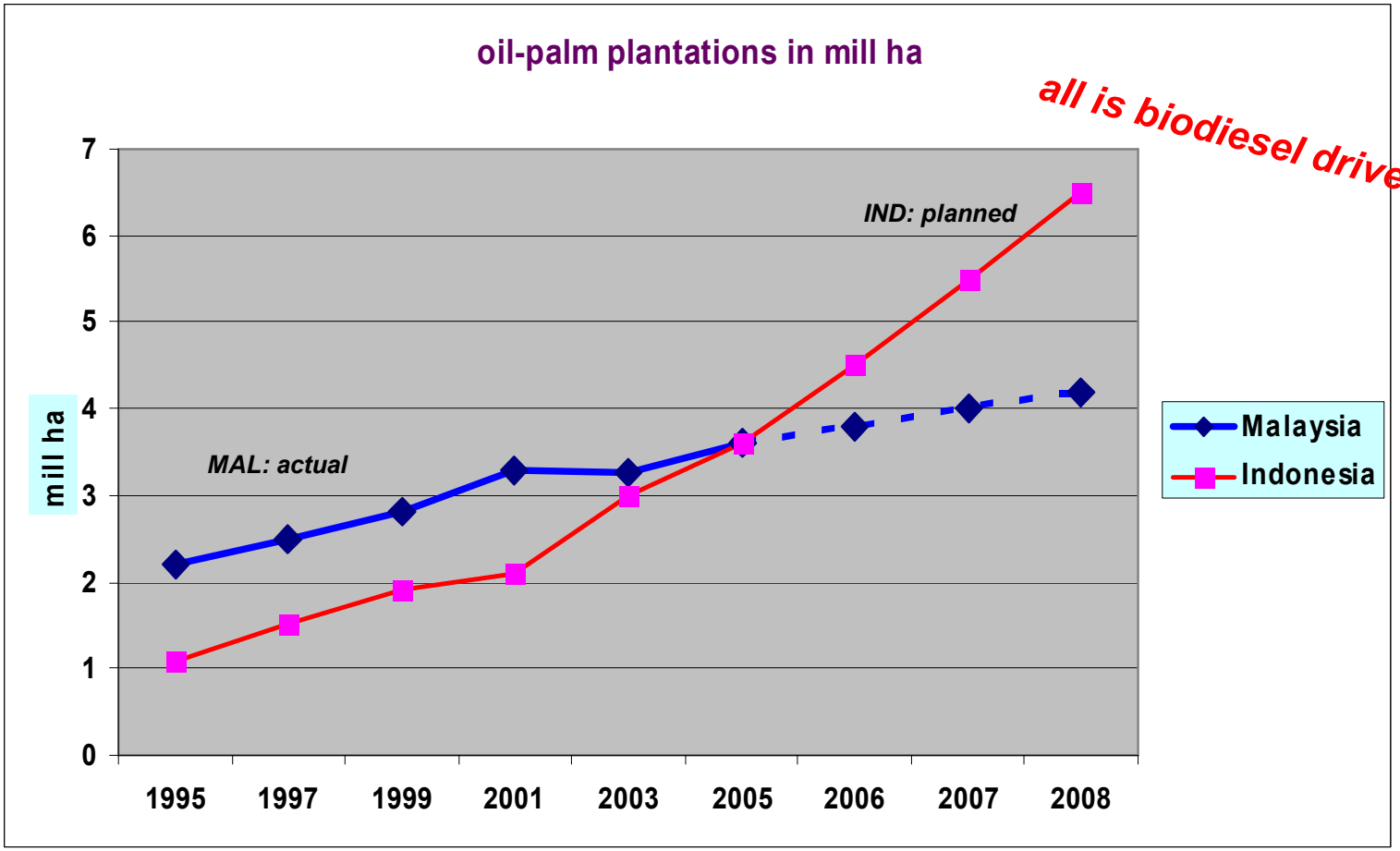
- **United Kingdom :**
  - Ineos Enterprises plans for a 500.000 t plant at Grangemouth to be in operation by 2008.
  - A 120.000 t/y biodiesel plant to be established at Rosyth in Scotland based on rapeseed oil.
- **Romania :**
  - The Portuguese company Martifer will finish construction of a 100.000 t biodiesel plant in December 2006.
  - Competition for the best site within the harbour of Constanza.
  - Rompetrol as largest privately owned oil & gas company to build a 60.000 t/y biodiesel plant based on multifeedstock.

A quiet place in South East Asia ……?

Gold rush mentality predominant

- **Malaysia:**
  - FC biodiesel demand growth: 3.2 mill t now to 10.5 mill t biodiesel in 2020.
  - capture 10 % of global market share for biodiesel by 2010.
  - 52 licences for biodiesel production, totalling 5 mill t/y.
- **Indonesia:**
  - state oil company Pertamina to produce 13 mill t by 2009.
  - is surpassing Malaysia in overall palm plantation acreage.

Indonesia to overtake Malaysia in palm oil acreage in 2007 ?



Source: FAO, The Economist

Gold rush mentality predominant

- **South Korea:**
  - Golden Hope (Malaysia) considering a 150.000 t/y plant.
- **Singapore:**
  - Peter Cremer establishing a 200.000 t / year plant for May 2007.
- **Thailand:**
  - Bangchak Petroleum considers a 80.000 t/y plant in Ayutthaya - not yet Cabinet approved.

Gold rush mentality predominant

- **Laos:**
  - Koalo Group of Korea investing € 25 mill in a biodiesel plant; - will plant non-food crop Jatropha on 100.000 ha
- **China:**
  - Intends to meet 10 % market share target by 2010
  - i.e.11 mill t biodiesel and then 15 mill t by 2020.
  - Austrian company BIOLUX invests into a 300.000 t biodiesel plant plus oil mill – investment is € 120 mio.

Everywhere on this globe !

Gold rush mentality predominant

- **Argentina:**
  - Argentine company BioDiesel to build a 33.000 t/y capacity for export to Europe until Argentina biofuels obligation begins in 2008.
- **Brazil:**
  - Petrobras launched the “biggest biodiesel project in the world” to produce 144 mill lt biodiesel in 24 months.
  - Incoa group of the state of Parana is going to build a 140.000 t biodiesel plant to be ready by mid 2008.

Please relax …..

- Is there a guidebook for a well planned and sustainably profitable biodiesel investment ?

- Not yet; ….. however there are a number of useful recommendations in the next minutes.

Investing wisely

Key criteria for an investor:

1. Meet the top criteria for biodiesel fuel quality
2. Choose a high security level for multi - feedstock supply in volume and cost
3. Select high efficiency and flexibility in process technology with high yields
4. Secure 345 days of uninterrupted production
5. Identify profitable markets with secure conditions
6. Take advantage of supportive legislation
7. Use all readily available information

Key trend: Biodiesel standards are getting tougher

The biodiesel standard development has come a long way:

- Austria 1991: ON C 1190 for RME – first world-wide
- **Austria 1997: ON C 1191 for FAME – first world-wide**
- **Germany 1997: DIN 51.606 for FAME**
- **USA 2002: ASTM - D 6751-02 FAME**
- **Europe 2003: EN 14214 for FAME**
  (together with VW, DC, Peugeot, Bosch, Shell, Total, etc.)
- **CEN – working on further improvements**

Accurate biodiesel quality assures market acceptance

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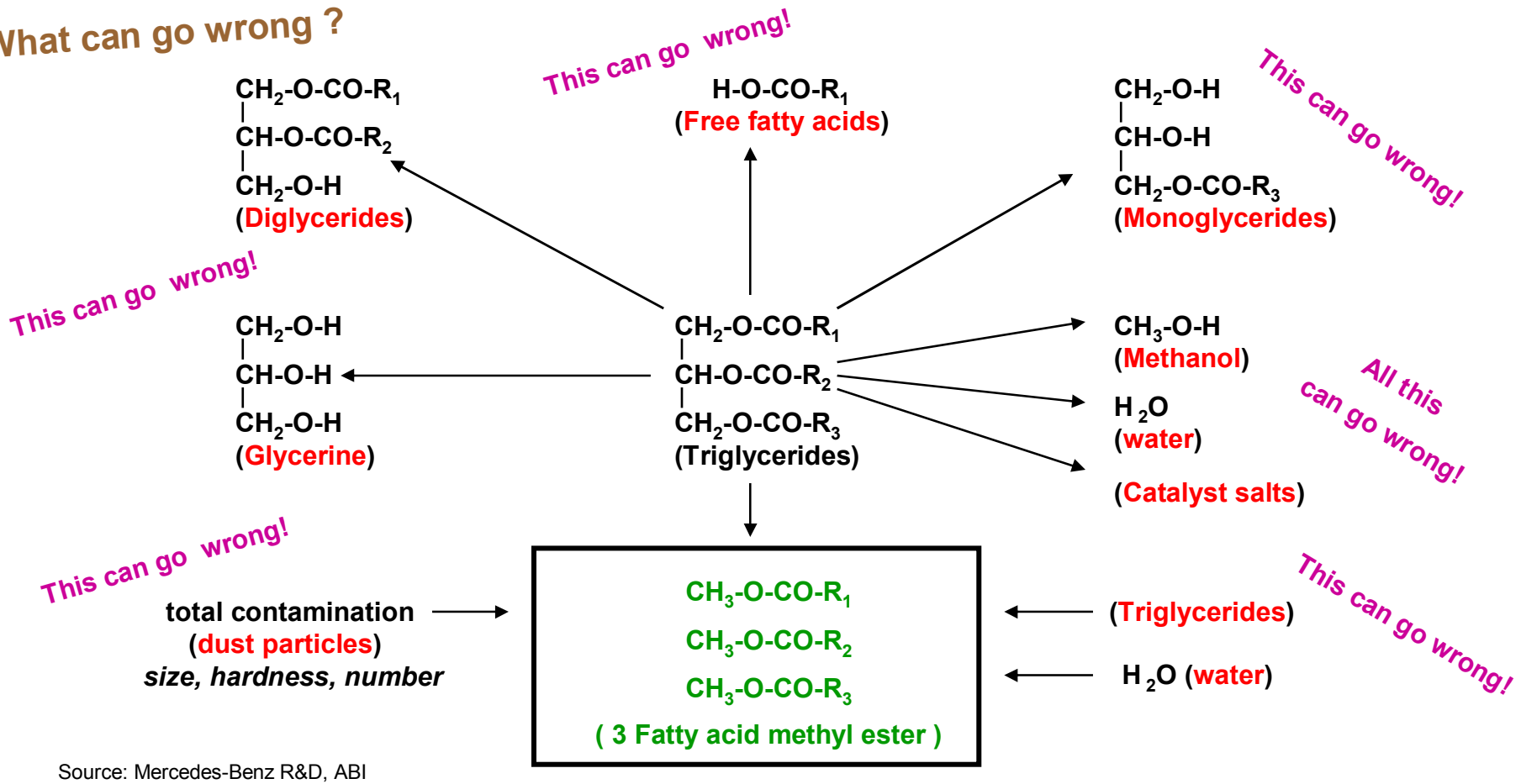
Biodiesel is derived from virgin or used oils and fats of vegetable or animal origin - it must have highest purity without any harmful contaminations

What can go wrong ?



Source: Mercedes-Benz R&D, ABI

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The biodiesel standard is complex and fine tuned

- triggered by ever growing demands in reducing exhaust emissions quality levels of any fuel have to be improved continuously
- - and process technology has to meet the new challenges

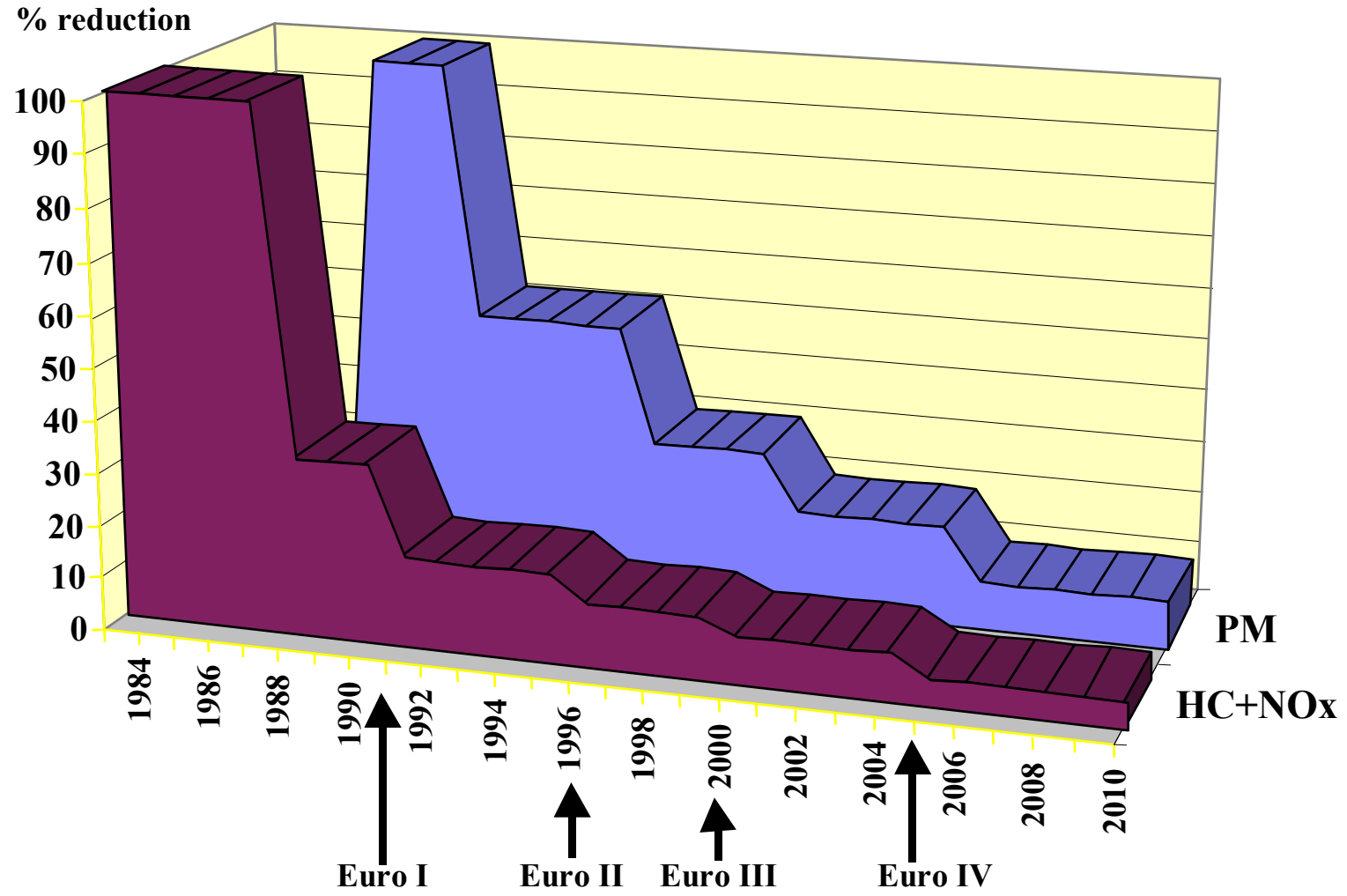
pr EN 14214 Fatty-acid-methyl-ester (FAME)		22.10.02
Parameter	Range	Unit
Ester content	≥96.5	%m/m
Density at 15°C	860 – 900	kg/m³
Viscosity at 40°C	3.5 – 5.0	mm²/s
Viscosity (-20°C)	≤ 48	mm²/s
Flash point	≥110	°C
CFPP →	see EN590	°C
Sulfur content	≤ 10.0	mg/kg
CCR / 10% distill. residue	≤ 0.30	%m/m
Cetane number	≥ 51.0	-
Sulfated ash	≤ 0.02	%m/m
Water content →	≤ 0.05	%m/kg
Total contamination →	≤ 24	mg/kg
Copper corrosion (3h at 50°C)	class 1	rating
Oxidation stability	≥ 6.0	h
Thermal stability	?	h
Storage stability	-----	----
Acid number →	≤ 0.50	mg KOH/g
Iodine number →	≤ 120	-
Polyunsaturated methyl esters: C 18:4 +	≤ 1.0	%m/m
Linolenic acid methyl ester	≤ 12.0	%m/m
Methanol content	≤ 0.20	%m/m
Monoglyceride content →	≤ 0.80	%m/m
Diglyceride content →	≤ 0.20	%m/m
Triglyceride content →	≤ 0.20	%m/m
Free glycerol →	≤ 0.02	%m/m
Total glycerol →	≤ 0.25	%m/m
Group I metals (Na/K) →	≤ 5.0	mg/kg
Group II metals (Ca-Mg) →	≤ 5.0	mg/kg
Phosphorus content	≤ 10.0	mg/kg

→

Key trend: further improvements are necessary and will be implemented

Key trend: further emission reductions !

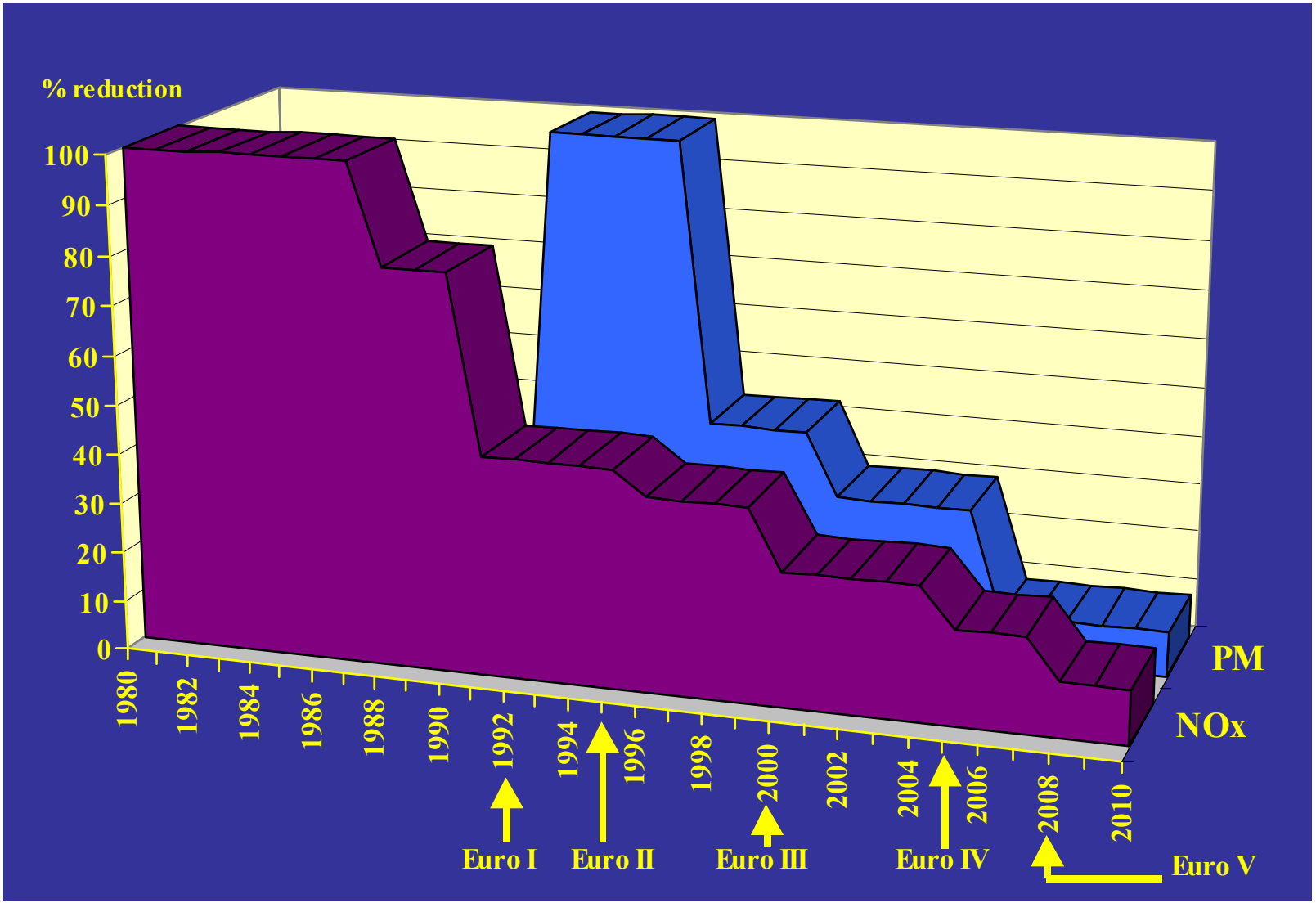
Europe: required emission reductions for Diesel cars



Source: European Commission

Key trend: further emission reductions !

Europe: required emission reductions for heavy-duty diesel vehicles



Source: European Commission

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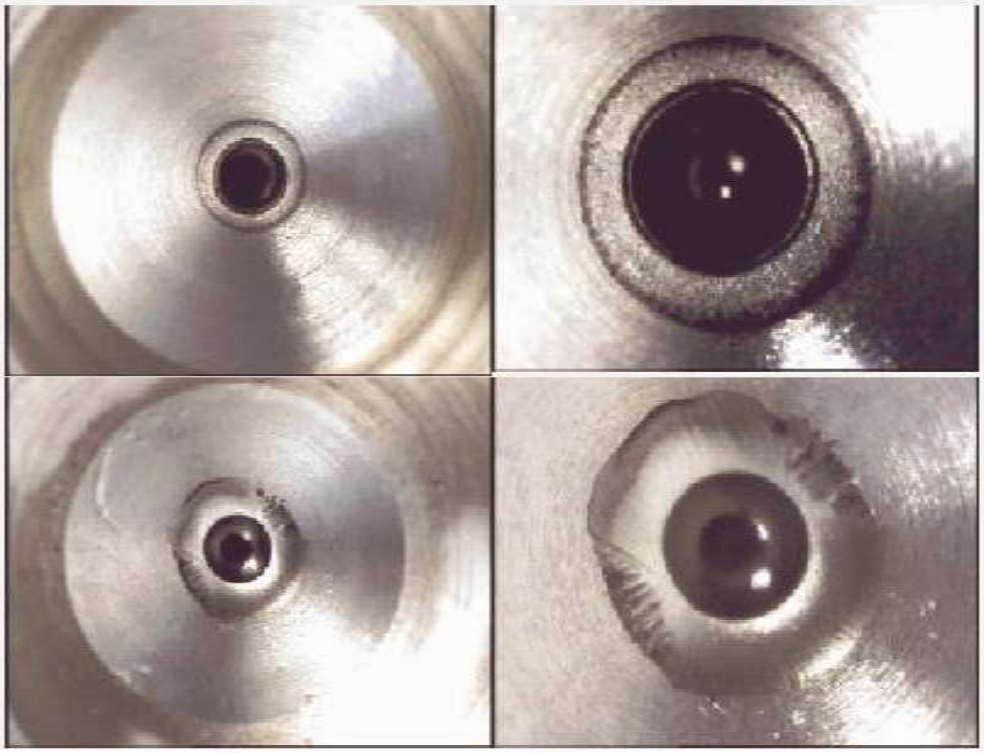
Key trend: Biodiesel must reach highest levels of purity

Variable measured

Abrasion causes injector seat wear. The increased **injection return volume** is taken as a measure for wear.



little wear

Abrasion leads to inefficient combustion and increase of emissions

high wear

Courtesy: Ford

Key trend: Advanced vehicle fuel systems requiring cleanest fuels

1. **Trends in vehicle fuel systems:**
   - * more precision,
   - * higher pressures,
   - * higher flow rates,
   - * smaller clearances, component sizes and tolerances
2. **leading to**
   - * higher fuel efficiency,
   - * lower fuel consumption and
   - * lower emission levels,
3. **requiring**
   - * cleanest, high quality fuels with reduced
     - * particles in hardness, size, number,
     - * free water content

Source: J. Bennett, Ford; R. Faucon, Renault

Key trend: improvement potentials are being exploited

Areas of improvement of Biodiesel :

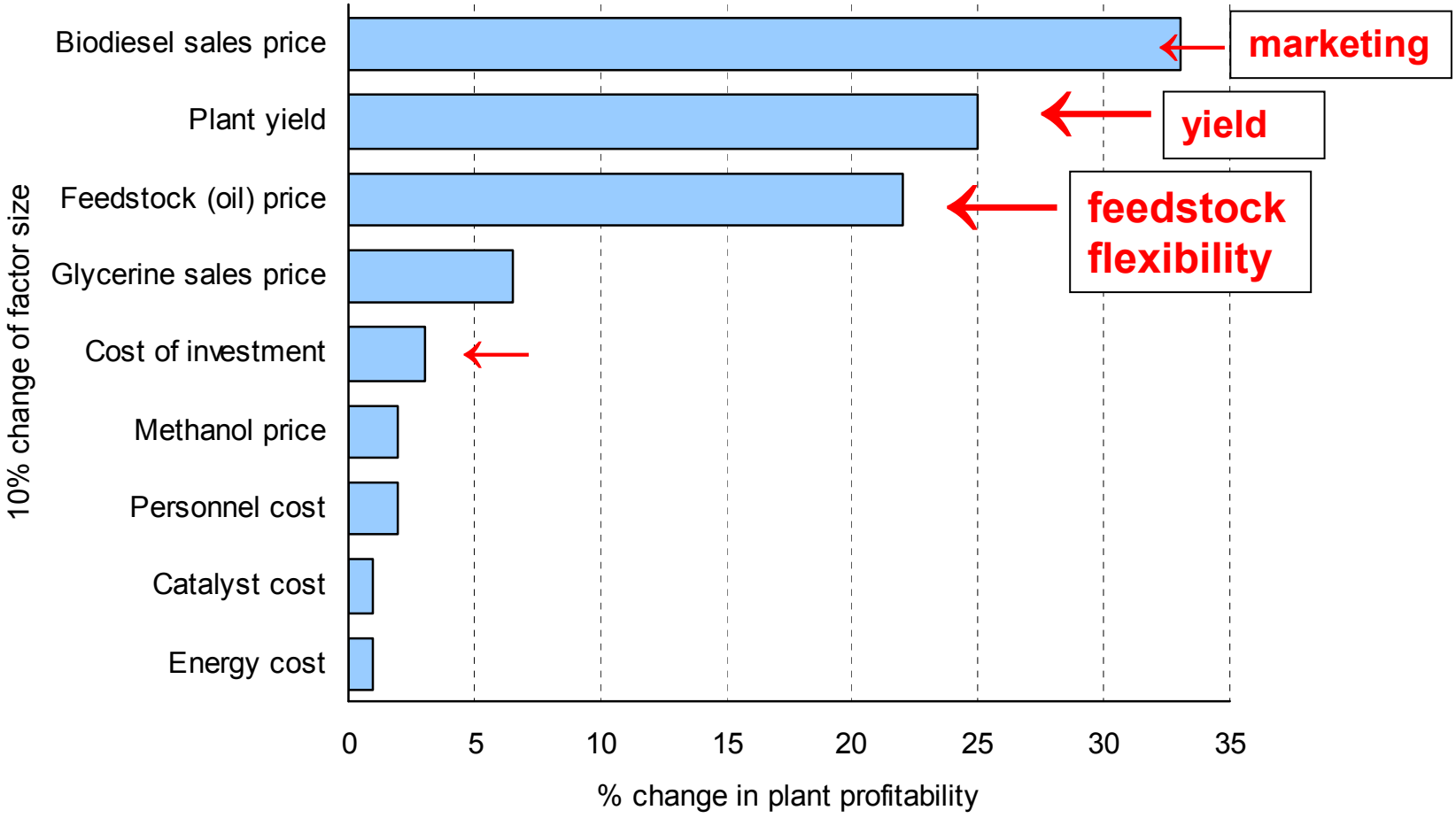
1. **Improved fatty acid composition by**

   * targeted breeding for dedicated oilseed plants
   * appropriate blending of various oils

2. **Improved Biodiesel production process**

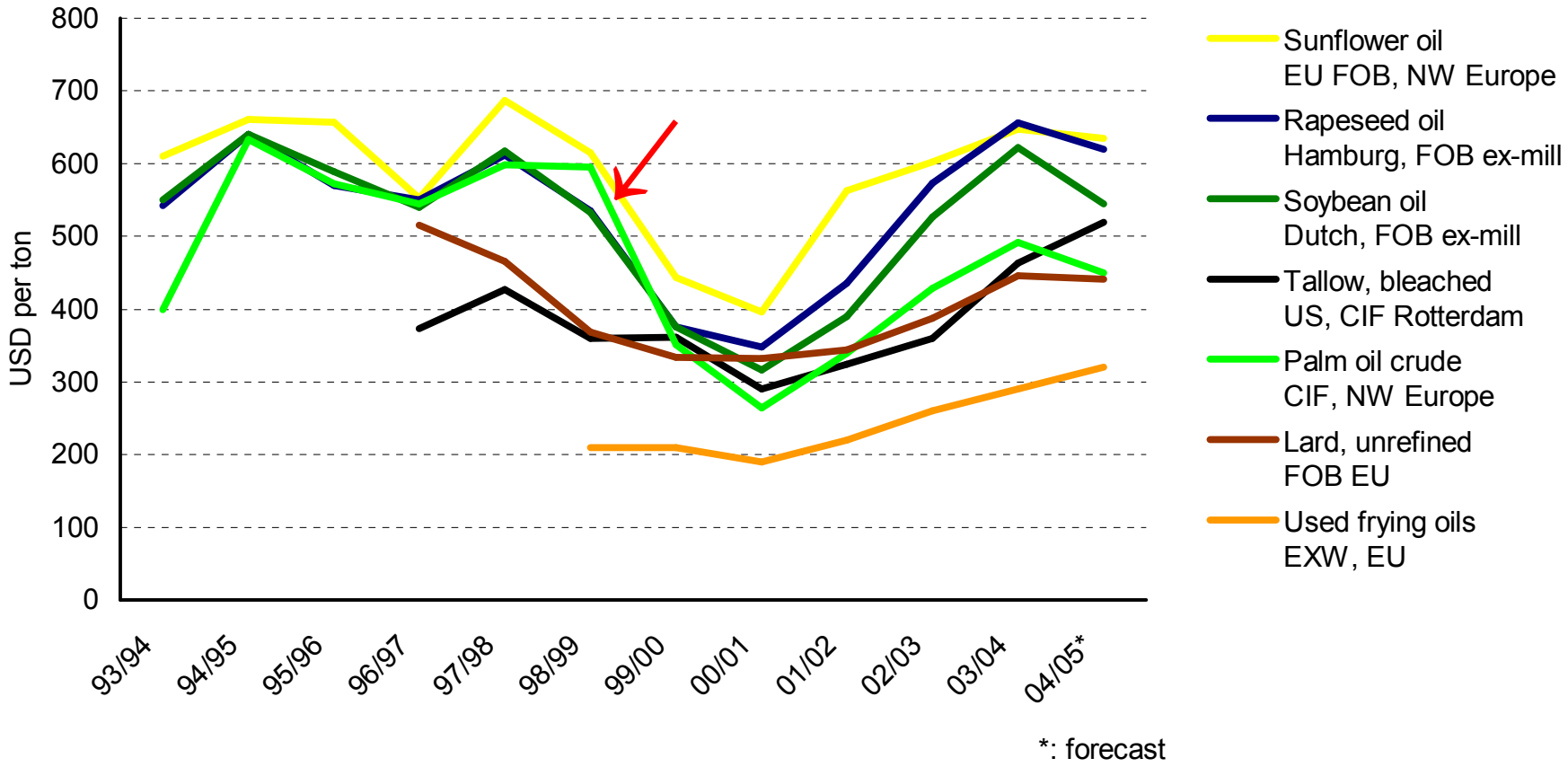
   * lowest water content levels
   * finest filtration for reduction of fuel contaminations with fine particles

Low feedstock cost is one key criteria for profitability:



Ups and downs of edible oil prices have a strong influence on profitability

A flexible multi-feedstock concept will contribute to cost reduction



*: forecast

Broader basis + lower cost of feedstock

vegetable oils :

not the best, but that's what we have !

- **used today :** rapeseed (00), soy, palm,
- **new sources:** sunflower (HO), rapeseed (HO, LL,) "Linola" (LL)
- **non-food oils:** Acrocomia, Babaçu, Buriti, Cornus, Jatropha, Pongamia,

very promising for less developed countries, but needs further R&D !

recycling oils: "McDonalds option", trap grease

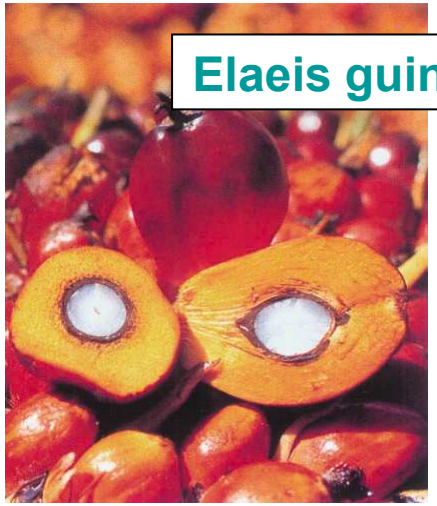
animal fats: beef tallow, lard, rendering fats

▶ **Sufficient supply of feedstock from food and non-food crops within international strategic partnerships**

▶ **Contributing to biodiversity**

Palm oil may become the leading feedstock source for biodiesel production world-wide

highest oil yields / ha



Elaeis guineensis

non-food oilseed crops – a new opportunity !

In India and Egypt, commercial plantations of Jatropha have been started in dry conditions and on marginal soils

Jatropha curcas

non-food oilseed crops – a new opportunity !

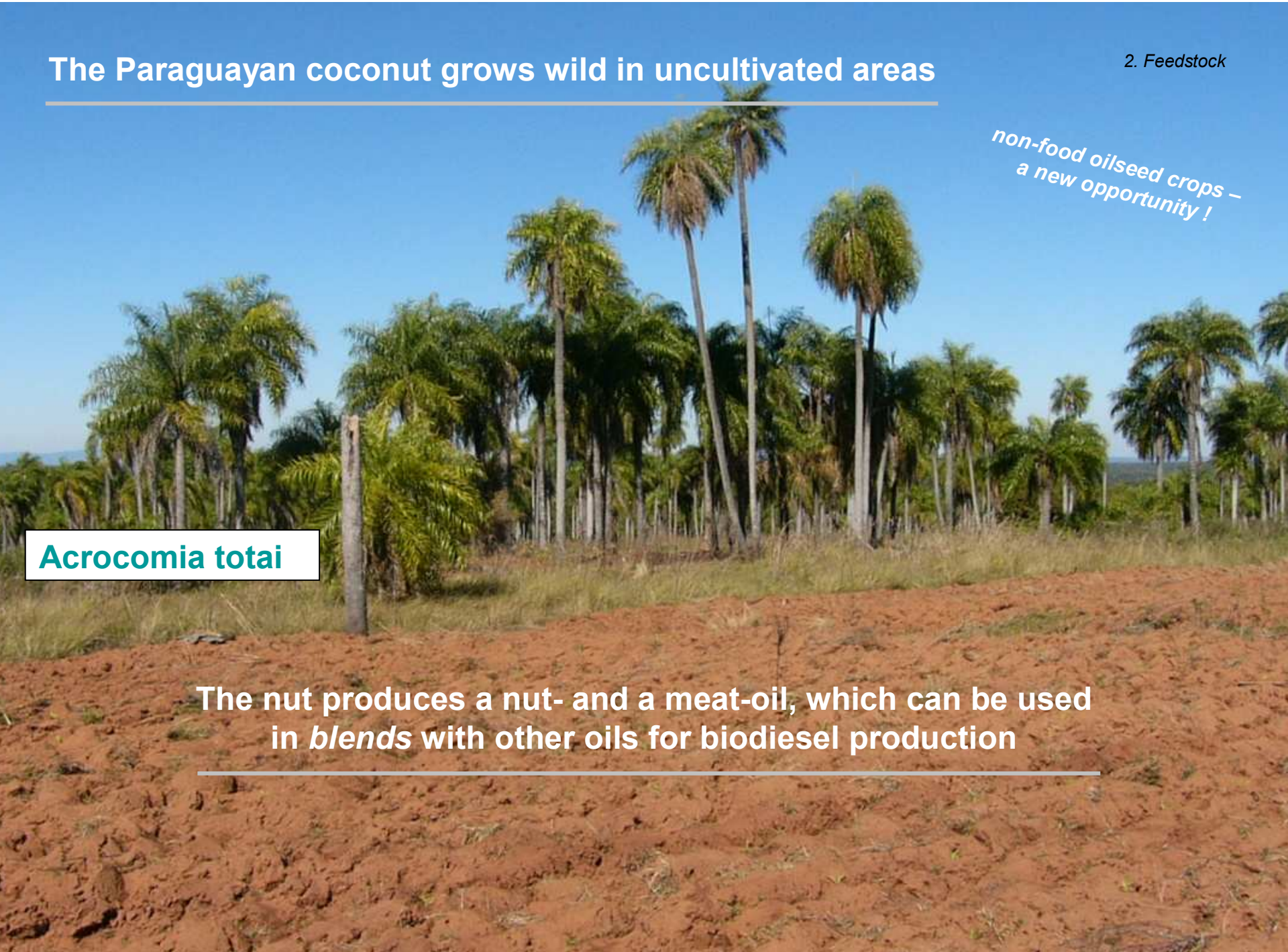
New non-food oilseed plants with highly suitable fatty acid profiles have been successfully investigated in China

Cornus wilsoniana - 光皮树

Camellia oleifera - 油茶

The Paraguayan coconut grows wild in uncultivated areas

non-food oilseed crops – a new opportunity !



Acrocomia totai

The nut produces a nut- and a meat-oil, which can be used in *blends* with other oils for biodiesel production

what is the "ideal" biodiesel ?

Selection of blends needs careful consideration

Influencing criteria:

1. Chain length: Trade-off between energy and oxygen content

2. High level of unsaturation leads to high instability

Fatty Acid pattern - selected oilseeds:						
FA in %	00-rape	HO-sun	palm	coconut	jatropha	HEAR
8:0				6		
10:0				5		
12:0				49		
14:0			1	18		
16:0	4	3	42	9	13	3
18:0	2	4	5	3	6	1
18:1	60	91	41	7	38	18
18:2	21	3	11	2	42	13
18:3 →	11				0	6
20:1						9
22:1	1					49
total sat.	7	7	48	91	19	5
Iodine-no.	117	84	54	9	106	106
oxygen %	10,8	11	11,3	14,4	11	9,9
CFPP °C	- 7°		+ 11°			

Stability

Winter operability

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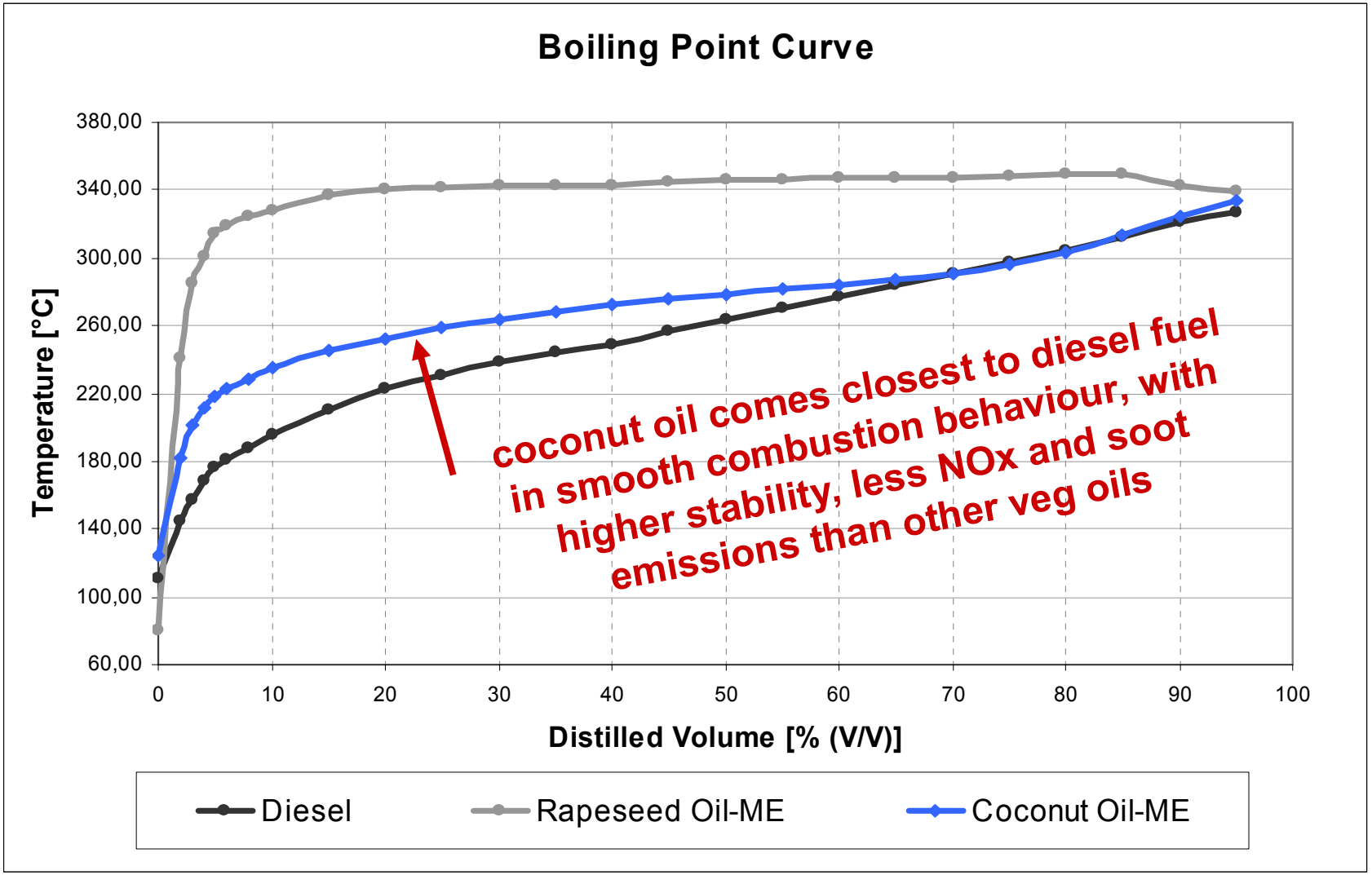
ranked by IV

all the world's oilseeds

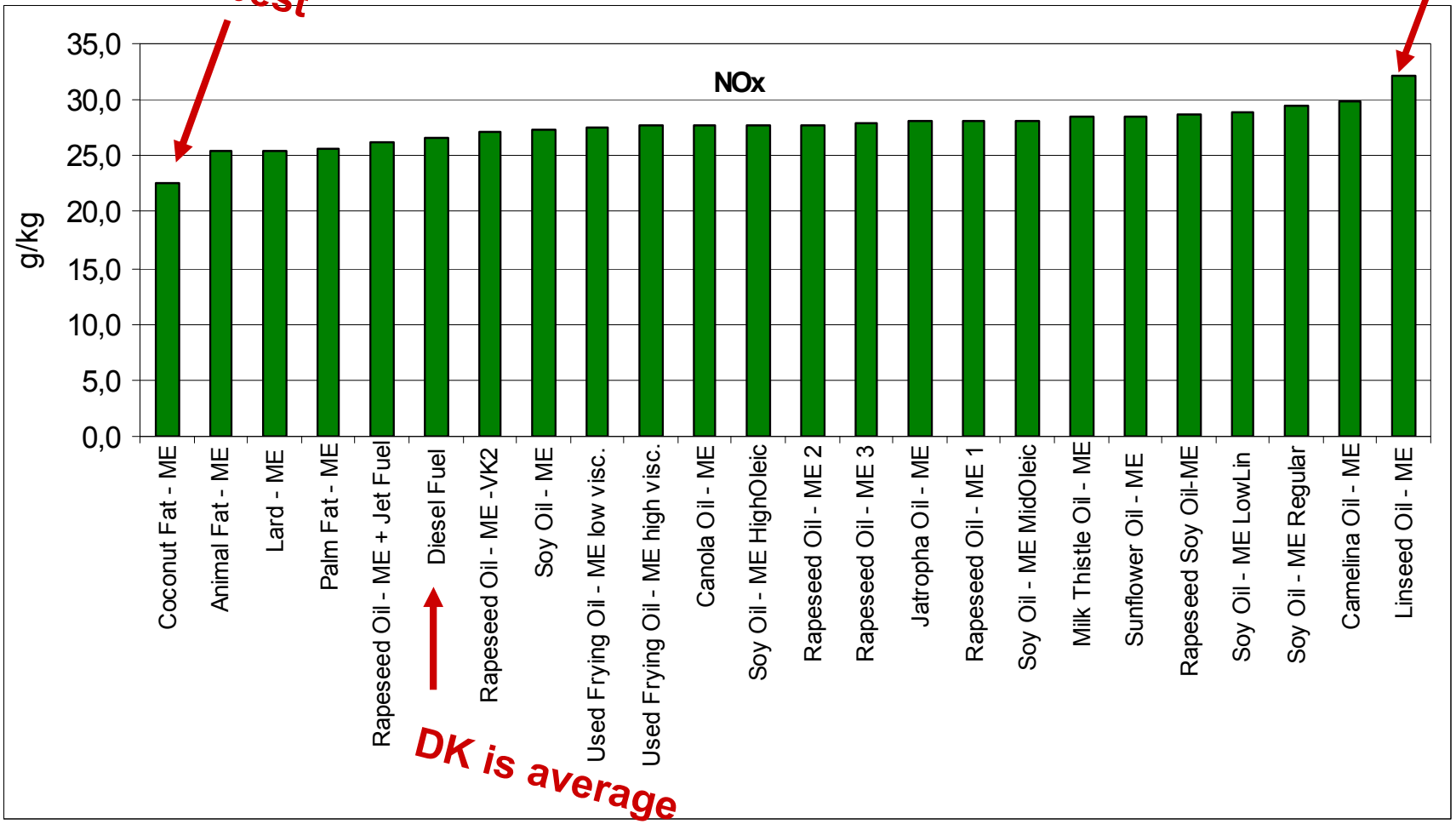
Can we find the ideal fatty acid profile ?

FAME	Labornr:	C 8:0	C 10:0	C 12:0	C 14:0	C 16:0	C 18:0	C 20:0	C 22:0	C 24:0	C 18:1	C 22:1	C 18:2	C 18:3	Gesamt: [%]	Iodine Value [g I2/ 100g FAME]
Coconut Fat - ME	05-308	7,0%	5,7%	42,4%	18,1%	11,3%	4,2%				8,7%		2,5%		100,0%	11,8
Acrocomia Nut Oil - ME	04-358	5,4%	4,5%	38,2%	8,8%	8,2%	3,3%				27,9%		3,6%		100,0%	30,2
Palm Fat - ME	05-141				1,3%	44,7%	5,4%	0,5%			37,2%		10,8%		100,0%	50,8
Lard - ME	04-319			0,4%	2,3%	29,6%	20,0%				33,2%		13,1%	1,5%	100,0%	55,0
Animal Fat - ME	05-107				2,3%	29,8%	17,1%				37,7%		11,5%	1,7%	100,0%	56,8
HO Sunflower Oil - ME	05-102					5,2%	4,2%		2,0%		78,7%		10,0%		100,0%	84,9
Soy Oil - ME HighOleic	05-710					5,4%	4,1%				81,3%		3,8%	5,3%	100,0%	90,4
Jatropha Oil - ME	05-728					17,7%	7,9%				37,8%		36,6%		100,0%	95,9
Used Frying Oil - ME high visc.	05-344					16,5%	5,9%	0,9%	1,2%		40,9%		26,8%	7,9%	100,0%	102,1
Canola Oil - ME	05-693					5,6%	2,4%	1,0%	0,8%		63,6%		23,4%	3,2%	100,0%	103,6
Used Frying Oil - ME low visc.	05-339					14,3%	5,0%	1,0%	1,2%		41,6%	0,8%	27,4%	8,8%	100,0%	106,8
Soy Oil - ME MidOleic	05-709					11,1%	5,0%	0,6%	0,9%		43,7%		35,5%	3,1%	100,0%	107,1
Rapeseed Oil - ME	05-333					6,0%	2,4%	0,9%			59,3%		28,6%	2,7%	100,0%	107,8
Milk Thistle Oil - ME	05-178					10,0%	6,2%	4,1%	3,9%	1,2%	22,7%		50,7%	1,2%	100,0%	110,4
Rapeseed Oil - ME	05-330					6,9%	2,5%	1,0%	0,8%		58,0%		20,9%	9,8%	100,0%	111,8
HEAR OIL - ME	05-093					4,3%	1,2%	0,9%	1,0%		14,0%	47,2%	15,5%	15,8%	100,0%	114,4
Rapeseed Oil - ME	04-260					6,3%	2,3%	0,9%			57,9%		22,2%	10,4%	100,0%	115,4
Rapeseed Oil - ME	05-348					5,7%	2,3%	0,9%	0,7%		57,1%		22,7%	10,5%	100,0%	115,9
Soy Oil - ME LowLin	05-701					12,1%	6,1%	0,5%	0,7%		24,2%		54,9%	1,5%	100,0%	119,8
Sunflower Oil - ME	05-078					8,0%	4,7%		1,2%		28,9%		56,5%	0,7%	100,0%	124,6
Soy Oil - ME	05-314					13,0%	4,9%	0,5%	0,8%		23,9%		49,6%	7,3%	100,0%	125,5
Rapeseed Soy Oil-ME	05-108					12,3%	5,6%		0,7%		22,1%		52,1%	7,3%	100,0%	128,3
Soy Oil - ME Regular	05-700					12,5%	5,2%				22,3%		50,2%	9,8%	100,0%	131,8
Camelina Oil - ME	04-321					6,7%	3,0%	2,3%	0,7%		14,3%	6,5%	18,2%	48,4%	100,0%	175,0
Linseed Oil - ME	05-166					6,1%	4,6%				17,5%		15,9%	55,9%	100,0%	188,9

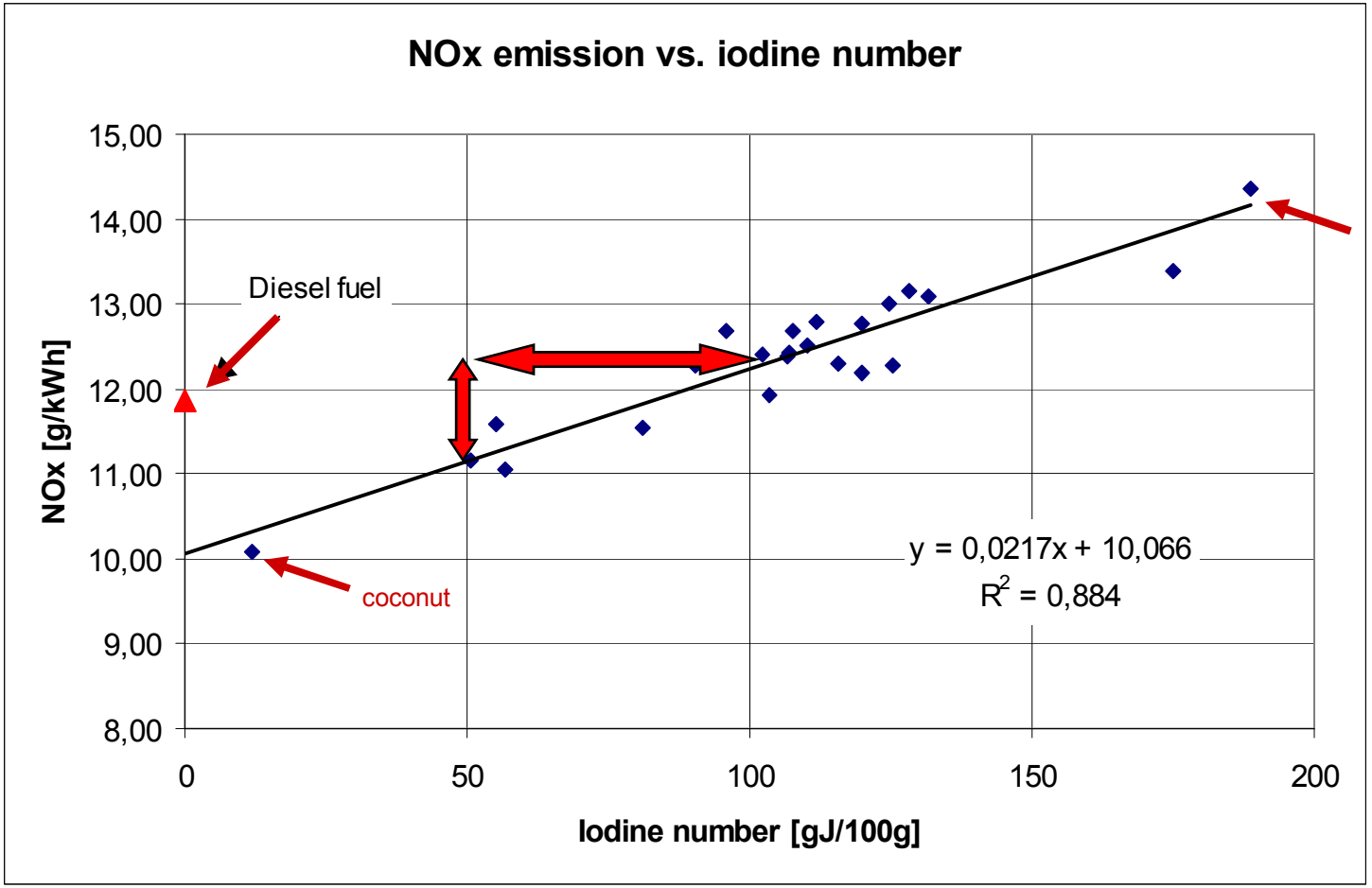
Distillation characteristics



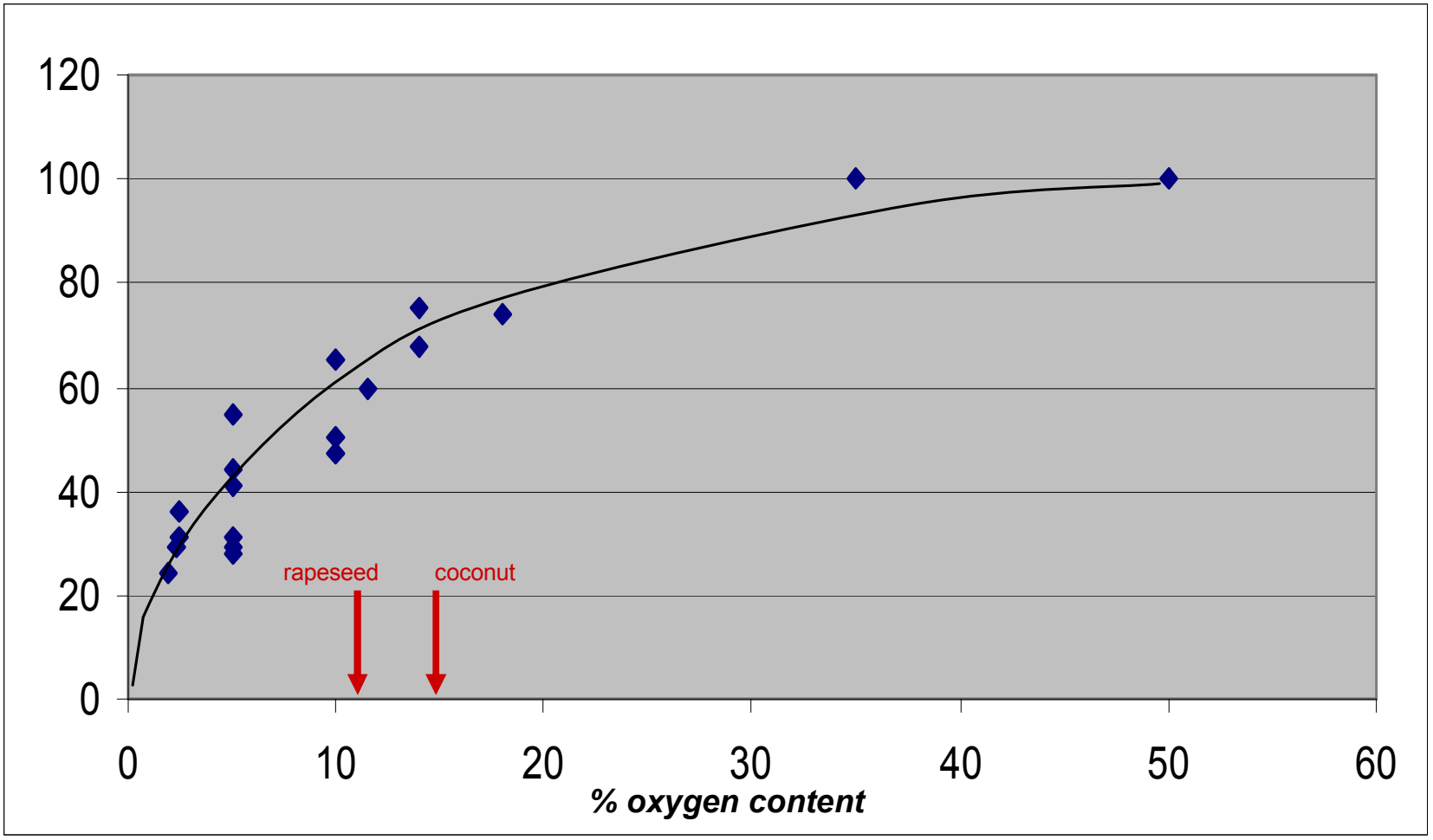
NO_x emissions



Correlation: the lower the Iodine number the lower the NO_x emissions

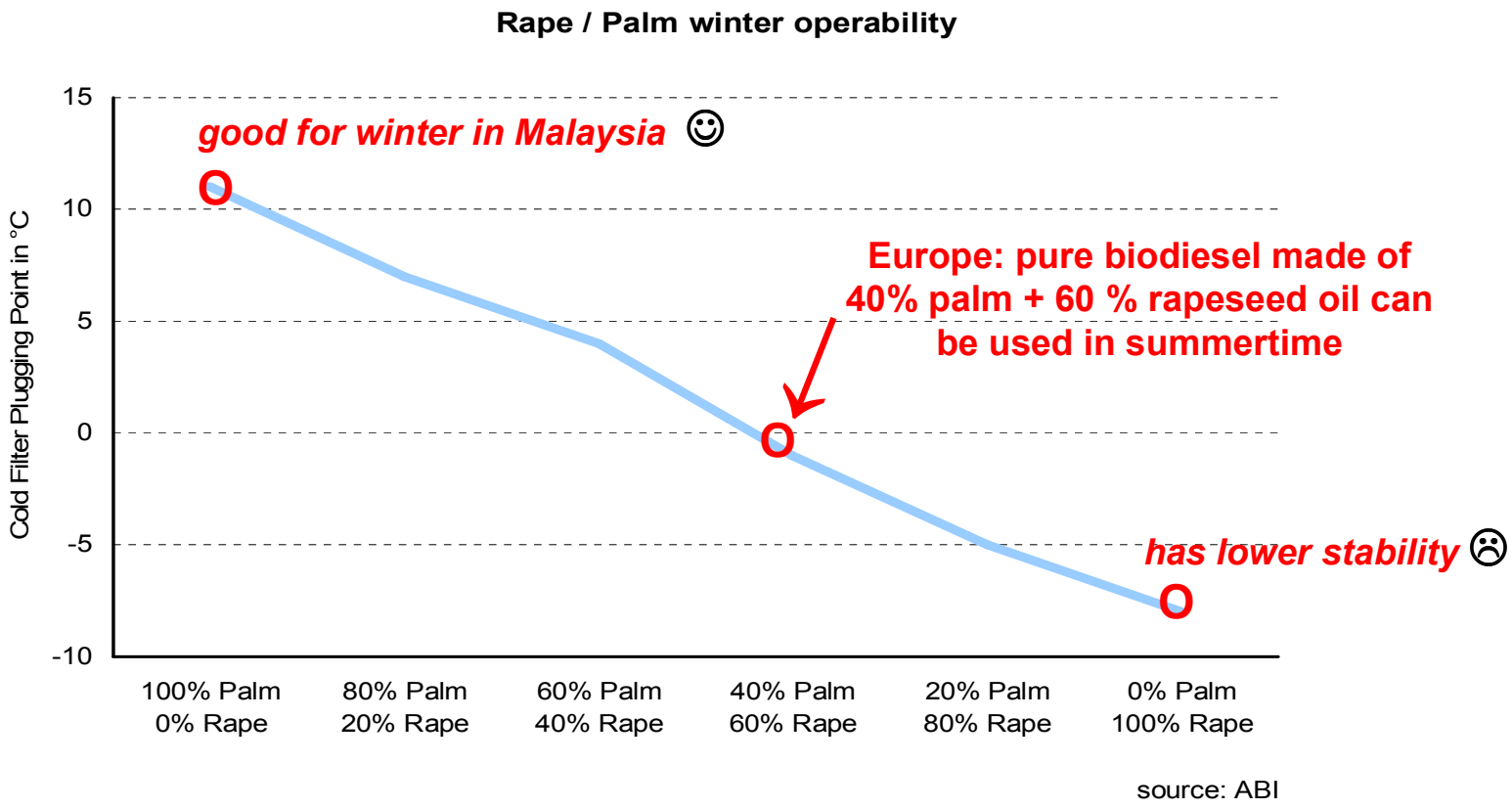


Correlation: the higher the oxygen content the lower the soot emissions



Source: TU Graz

Optimise feedstock cost by intelligent blending



source: ABI

Property trade-offs: short-chain vs. long-chain

properties:	SHORTCHAIN	←		→	LONGCHAIN
1. oxygen content	higher	←		→	lower
emissions	*reduced*	☺	PM + soot		*increased*
caloric value	*lower*	*	performance	☺	*higher*
combustion	*improved*	☺			*worse*
2. boiling line	lower	←		→	higher
emissions	*reduced*	☺	PM, HC		*increased*
3. CFPP	lower	←		→	higher
winter operability	*better*	☺	°C		*worse*

Property trade-offs: saturated vs. unsaturated

properties:	SATURATED	←		→	UNSATURATED
4. CFPP	higher	←		→	lower
winter operability	*worse*		°C	☺	*better*
5. Cetane	higher	←		→	lower
engine performance	*improved*	☺			*lower*
6. Iodine value	lower	←		→	higher
oxidation stability	*better*	☺			*worse*
polymerisation	*lower*	☺			*higher*

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Biodiesel process technology has become very efficient

- Level of **yield** obtained by the process - **not less than 99% .**
- Reducing cost by flexibility to **handle multi-feedstock** oils and fats - including “dirty” high FFA feedstock.
- Utilising **flexible process control** and multi-feedstock recipe data bank in the production plant.
- Installing a reliable **quality assurance** systems **(> EN14214)** able to produce higher quality.
- Produce at practically **no waste**, which is expensive.

▶ only the efficient and high quality biodiesel producer will succeed

▶ don’t reinvent the wheel !

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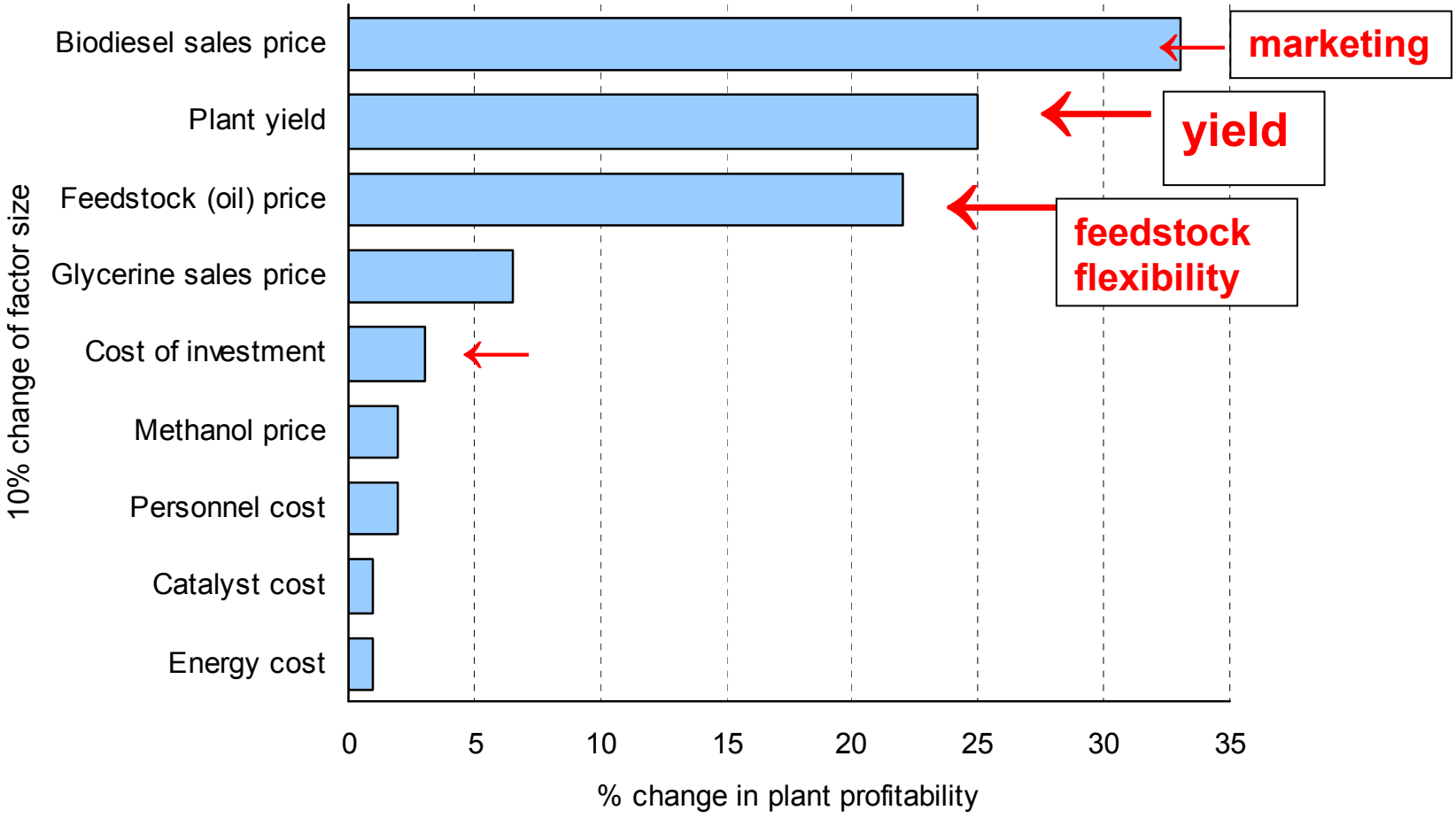
Process technology influences 3 key criteria for profitability:



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There is no single best biodiesel process technology

- There is only one best for each individual and complex investment
- All pros and cons have to be evaluated carefully case by case
- Price is the least, safe return on investment the most important criteria

- *The next slide about comparisons of various recognised biodiesel process technologies is an ambitious attempt*
  - *… to list and describe various criteria for selection,*
  - *… which can have a different weight for each individual case;*
  - *… it does not contain the aspects of engineering and construction,*
  - *… and it is not a recommendation for one or the other process.*

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work in progress !

There is plenty of choice among biodiesel process suppliers

Process technology company	Yield: % of triglycerides and FFA 1)	Ability to process feedstock with high ---------- low quality: 0 % Fully refined oil	< 1 % De-gummed oil	< 2	< 5 %	< 10 % Recycled oils and fats	> 10 % Rendering fats	Reference plants in operation / firm orders approx.	Required acreage for 250.000 t unit in m²	Plant sizes built / ordered in 1.000 t / y
AT-Agrartechnik	96 - 97	yes	n.a.	n.a.	yes	no	no	4/26	n.a.	53 - 75/ 250
Axens	n.a.	yes	no	no	no	no	no	1/2	n.a.	160/ 165
BDI	99	yes	yes	yes	yes	yes	yes	9/11	n.a.	5 – 50/ 100
Christof MB	102 2)	yes	yes	yes	yes	yes	yes	4/5	n.a.	5 – 30/ 250
Crown	n.a.	yes	n.a.	n.a.	n.a.	no	no	n.a.	n.a.	n.a./ 250
Desmet Ballestra	n.a.	yes	n.a	n.a	n.a	n.a	no	7/38	n.a.	100/ 250
Energea	99	yes	yes	yes	yes	yes	yes	3/ n.a.	1.190	40 - 250
Lurgi	95 - 97	yes	yes	yes	yes	n.a	n.a	7/14	n.a.	40 - 100/ 200
Westfalia	95 - 97	yes	n.a.	n.a.	no	no	no	3/ n.a.	n.a.	100 – 120/ 350

1) Basis: chemically degummed oil 2) Starting with water degummed oil

Source: technology company interviews, published information, ABI analysis

Today's biodiesel fuel standard is complex and fine tuned

Parameter	*Test*	*Unit*		*EN 14214*	*new plant*	*Optional*
acid value	EN 14104	mg KOH/g	max.	0.50	0.213	0.213
water content	EN 12937	mg/kg	max.	500	260	145
total contamination	EN 12662	mg/kg	max.	24	10	5
free glycerine	EN 14105	%(m/m)	max.	0.02	0.01	0.001
monoglycerides	EN 14105	%(m/m)	max.	0.80	0.51	0.42
diglycerides	EN 14105	%(m/m)	max.	0.20	0.19	0.15
triglycerides	EN 14105	%(m/m)	max.	0.20	0.05	0.05
total glycerine	EN 14105	%(m/m)	max.	0.25	0.16	0.14
Alkali content (Na+K)	EN 14108(9)	mg/kg	max.	5	1.4	0.73*
Alkali content (Ca+Mg)	prEN 14538	mg/kg	max.	5	< 0.5	< 0.93*

► **Further improvements can be reached by improved process technology**

Courtesy: Desmet Ballestra

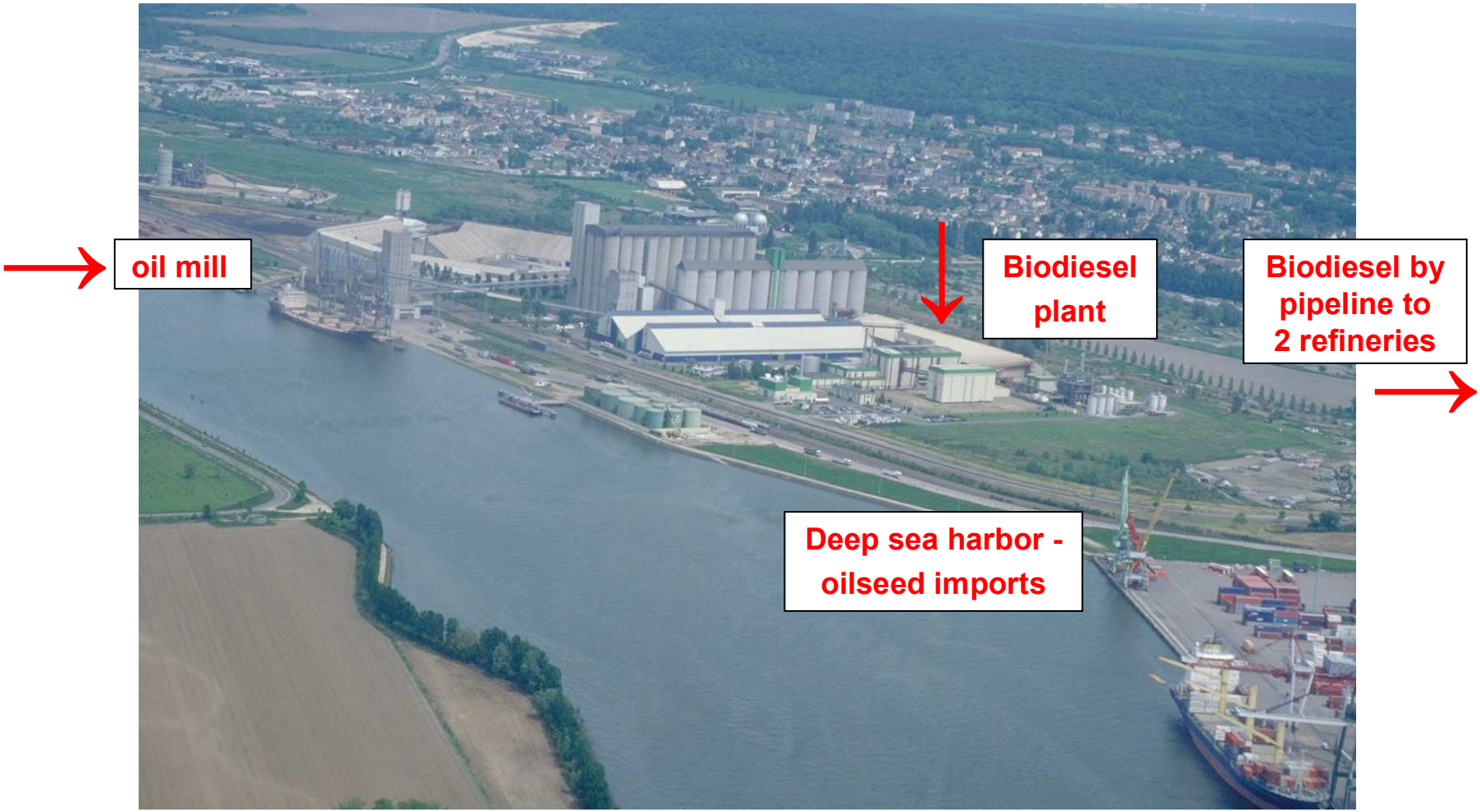
Beside process technology site selection is crucial

- Extent in exploiting synergies of existing industrial areas:
  - Chemical industry park (methanol, service)
  - Oilseed crushing plant
  - Shared personnel and maintenance cost
  - Oil refinery for direct blending
- best logistic and low transport cost locations:
  - Deep sea or river harbour
  - Train connections

site matters !

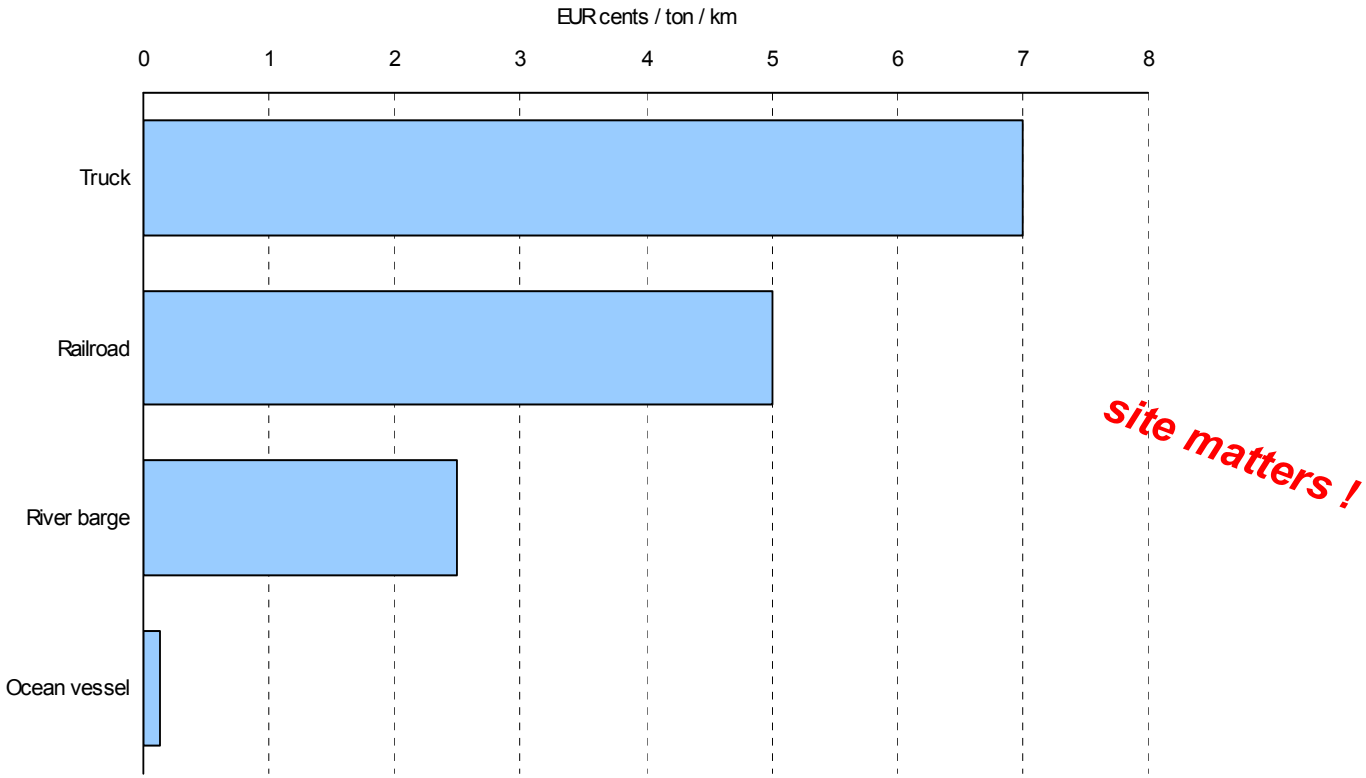
▶ Biodiesel production sites with synergies have an advantage

France: Diester & Bunge / Grand Couronne – expanding from 250.000 t to 500.000 t



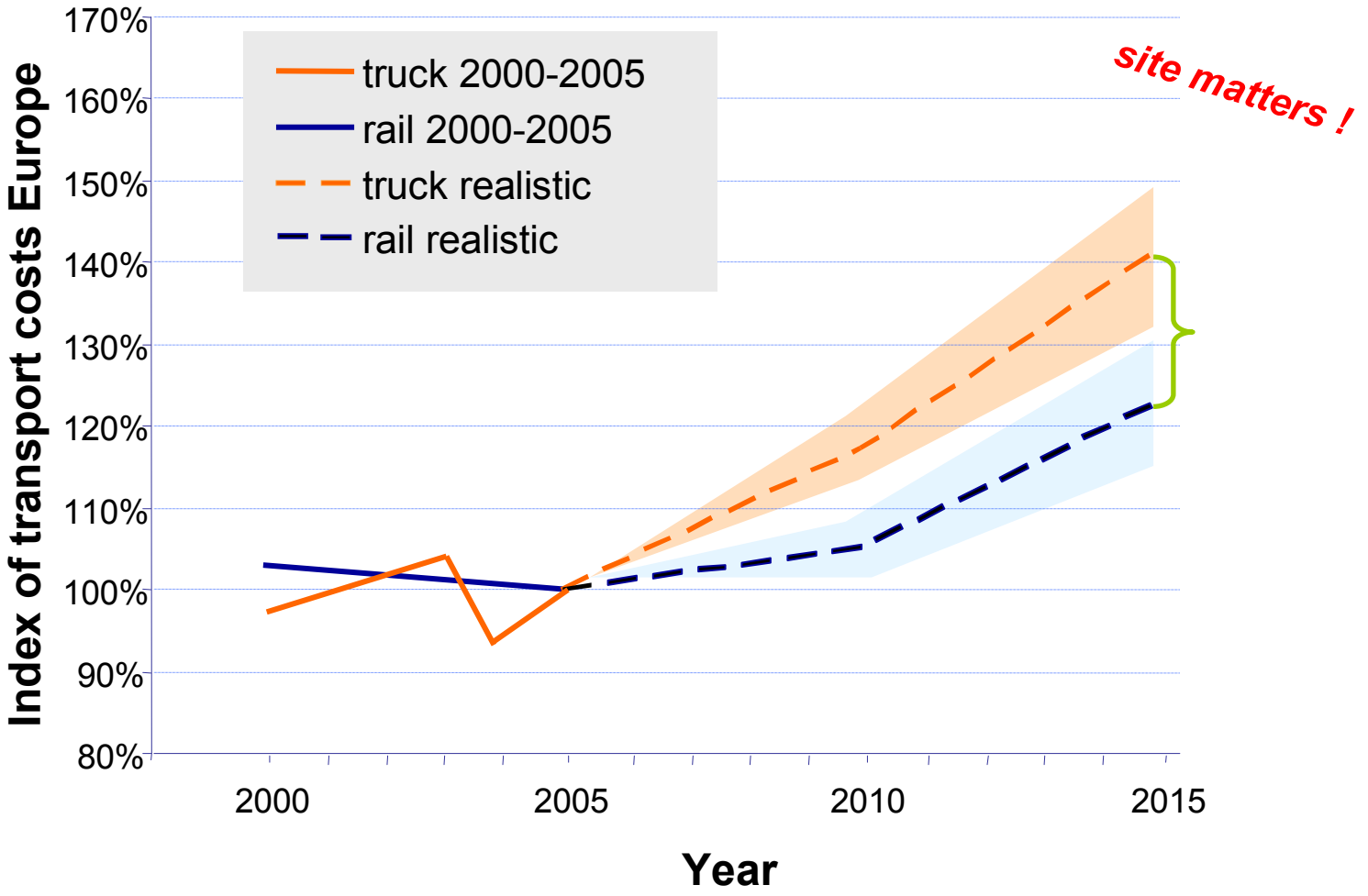
Transportation by water is more efficient than by land

Costs by mode of transportation



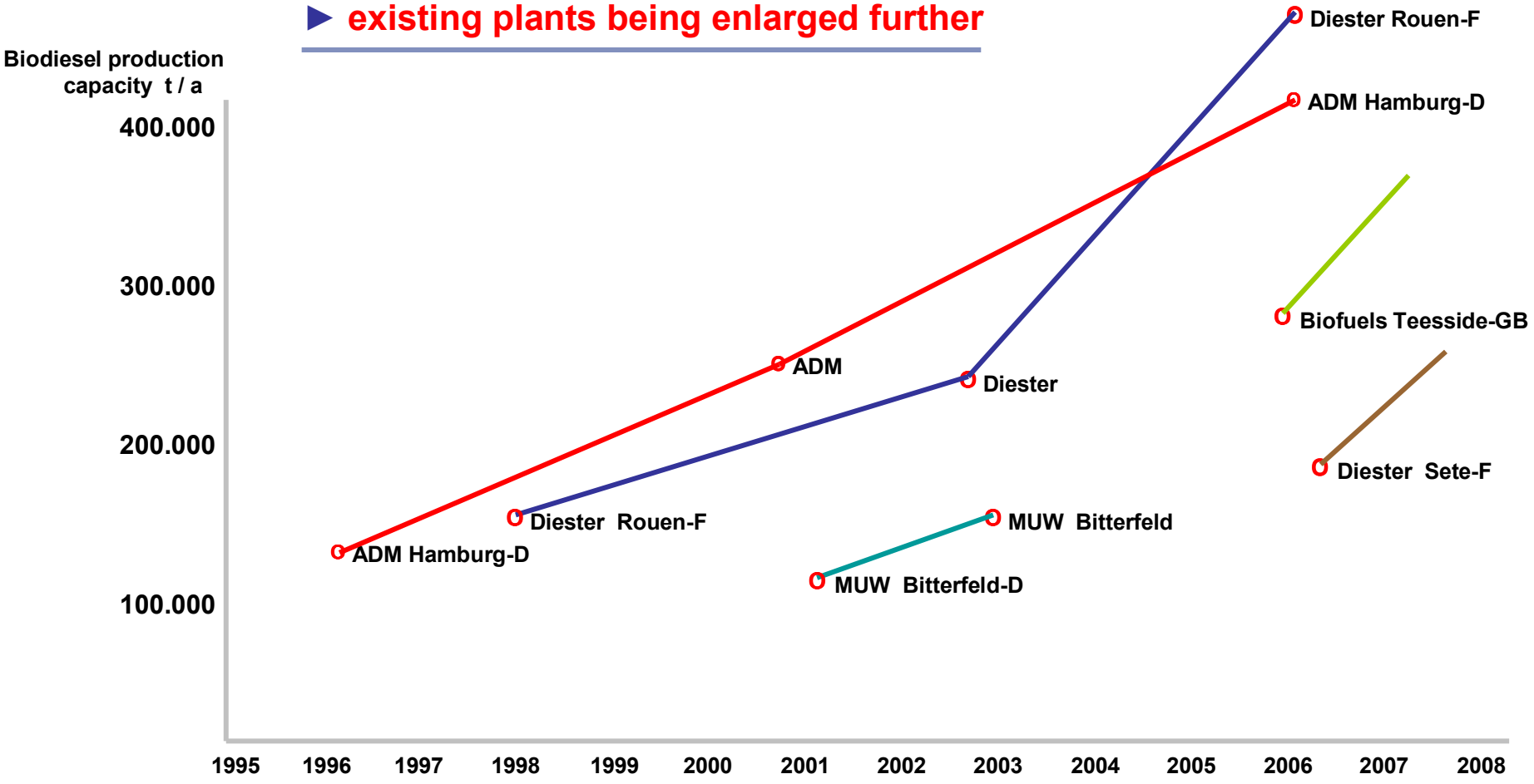
Source: Vienna University of Economics, Institute for Transportation and Logistics

European transport cost will rise substantially in near future



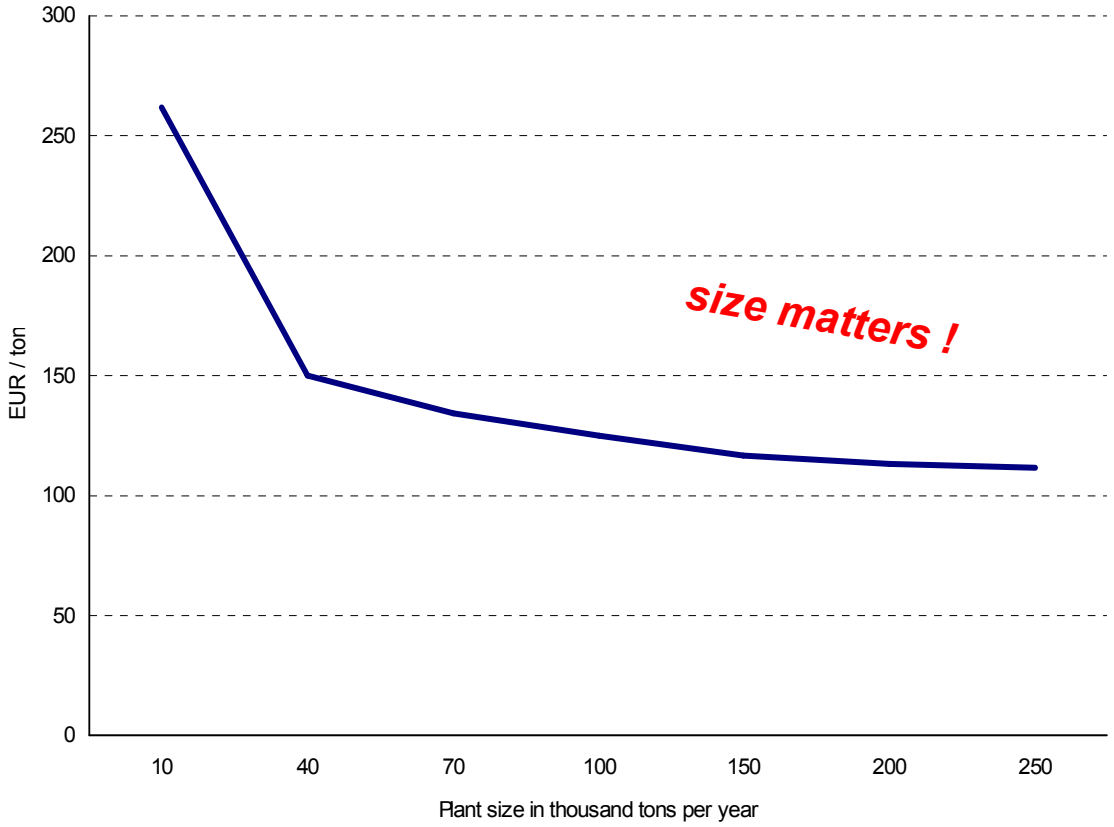
Challenge for process technology providers: dramatic increase in production capacity :

- new plants starting with sizeable volumes
- existing plants being enlarged further



The larger the plant, the lower the cost per liter

Estimated production cost per ton of biodiesel vs. plant capacity



Note

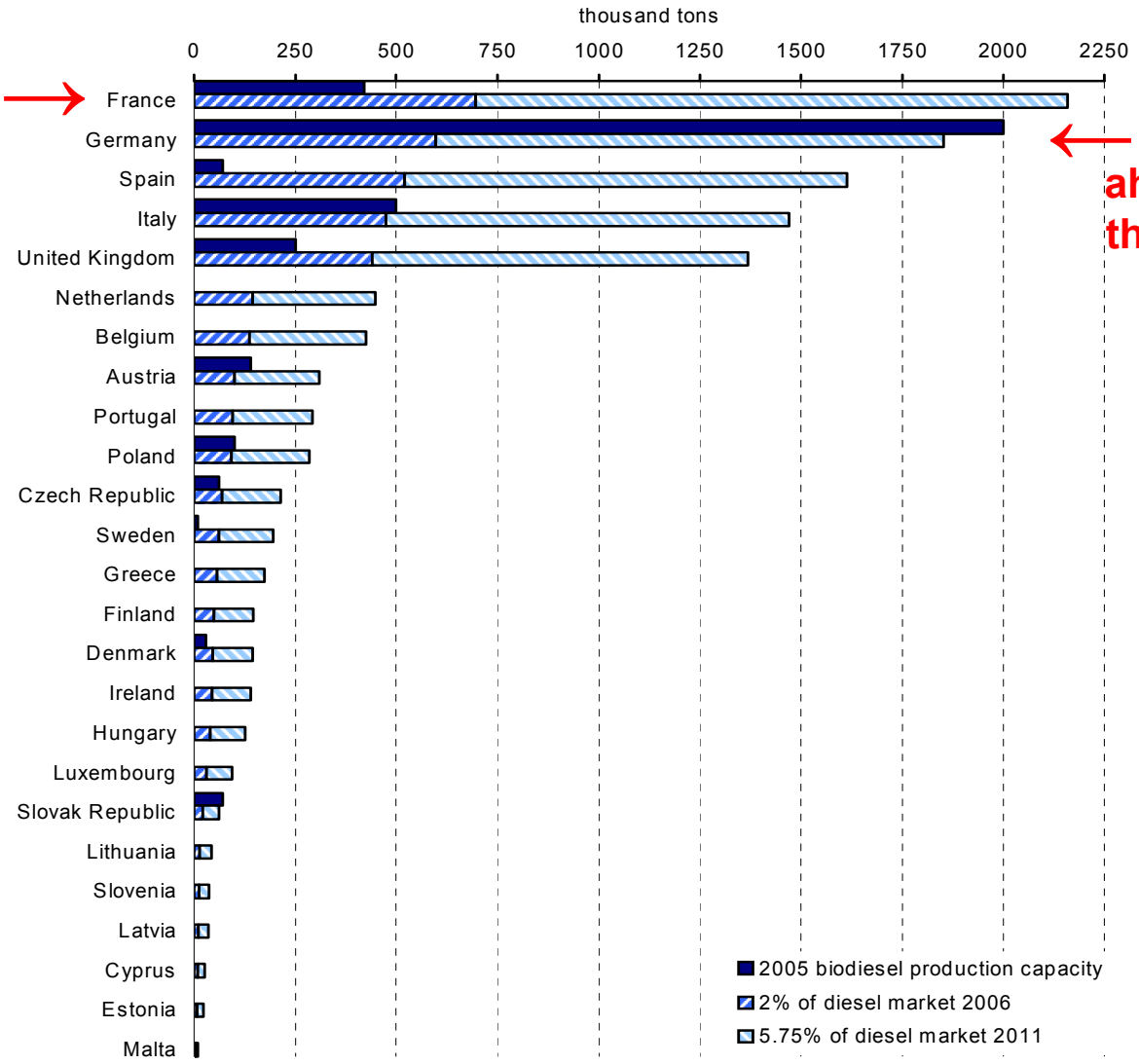
- Fully loaded production cost excluding feedstock oil cost. The feedstock oil price must be added to the production cost to determine the breakeven sales price for biodiesel per ton.
- As facility size increases, less fixed costs such as depreciation and interest are spread over each ton of product, so total production costs per ton approach the variable costs per ton.
- The kink from 10,000 to 40,000 tons capacity is due to the low number of plant offers ABI has seen at these sizes. If more offers were received, the curve would be smoother.

Source: Plant manufacturer offers, ABI analysis

Biodiesel capacity and EU targets by country

France is the largest diesel fuel consumer

Germany is far ahead and leading the biodiesel pack



source: UFOP, Eurostat, EU DG Energy and Transport

Marketing strategies are changing

- Biodiesel is / was sold as the cheap fuel at the public fuel pumps in Austria and Germany so far

→

← ←

- Biodiesel is no longer differentiated as the environmentally friendly fuel

- Biodiesel is going straight into the refineries for blending in fossil diesel

European Directive as strong impulse for fast expansion

Supportive legislative framework for Europe

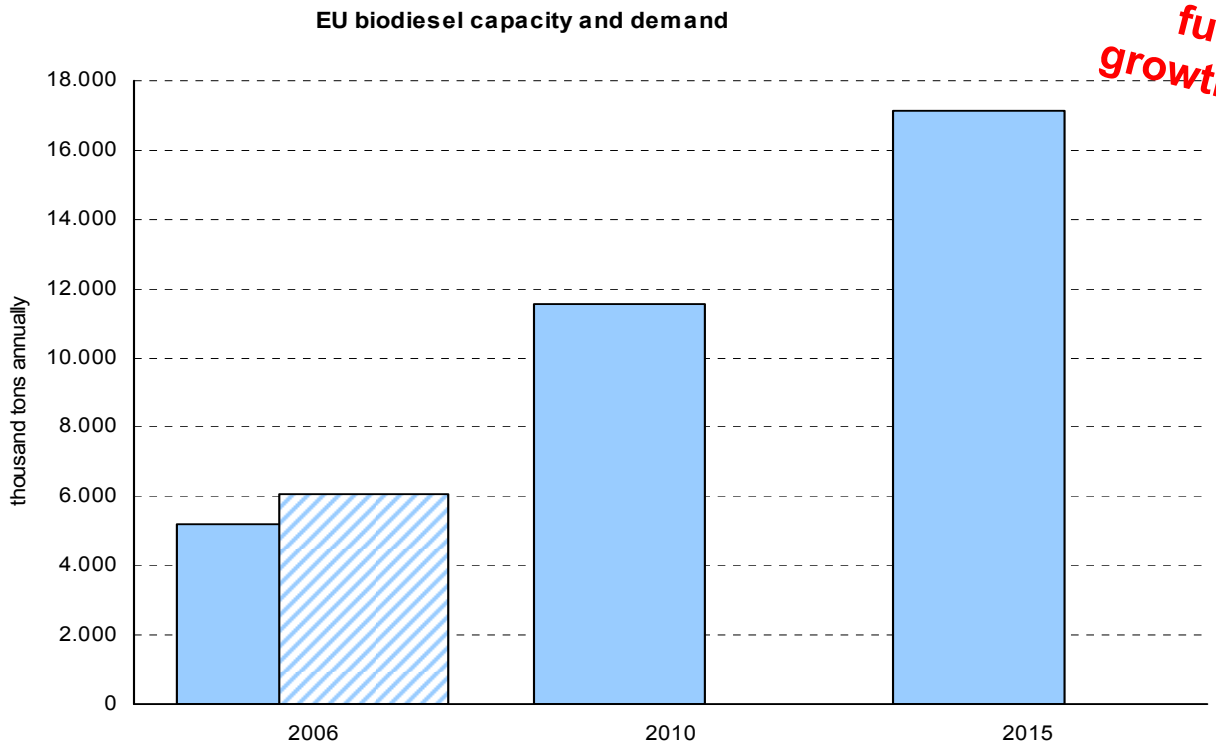
- **EC Directive for the Promotion of Liquid Biofuels:**
  Semi-obligatory market shares :
  - **2 % by 2005**
  - **5,75 % by 2010**
  - **10 % as intended target for 2020**
- **EC Directive for the Quality of Fuels**
- **EC Directive on Taxation of Fuels**

► **European legislation is pushing the markets thus creating export opportunities for many non-European countries with feedstock potential**

► **Intelligent national legislation can create attractive market conditions**

EU Biodiesel targets need additional biodiesel capacity

EU25 installed capacity	2006	2010	2015
Installed capacity EU25 mid 2006	6.069		
Targeted / expected EU25 demand	5.187	11.544	17.133



source: EBB, Eurostat, EU DG Transport and Energy, Total

A remaining visible market segment ? - may be the city bus fleet

Information availability has increased significantly

Recent studies published by the Austrian Biofuels Institute :

1. "Best Case Studies of Biodiesel Production Plants in Europe"
2. "Review on Biodiesel Standardisation World-wide" CD-ROM
3. "World-wide Review of Biodiesel Production" CD-ROM
4. "Biodiesel Process Technology Survey – Europe" *in completion !*

"Clean Transport for Modern Cities" – DVD *in 6 languages*

Websites of interest:

- www.biodiesel.at
- www.ufop.de
- www.blt.bmlfuw.gv.at
- www.aqqm-biodiesel.de

► **Easy access to a wide field of biodiesel know-how**

► **Overcoming barriers: broad communication - e.g. this meeting**

Thank you for your attention