COBLENDING ETBE AND ETHANOL THE MOST FAVOURED MIX

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The European Fuel Conference
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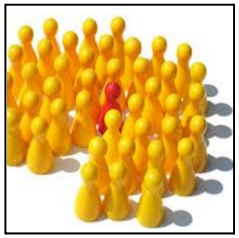
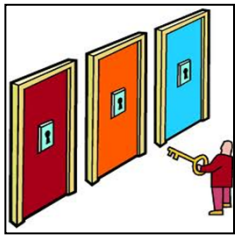
EFOA
The European Fuel Oxygenates Association

Addressing RED & FQD EU Directives

Ambitious Targets



Multiple Challenges



Limited Possibilities

Existing Solution

Challenges (examples)

FQD: Refiners Obligations vs. Actual “Control”

RED: Petrol/Gasoil Supply/Demand Unbalance

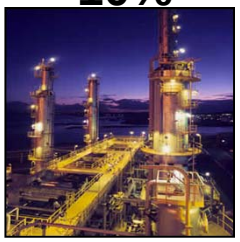
Balkanization of EU MS’s Implementation Rules

Consumers Resistance to “High-Bio” Grades

Fuel Specifications Limits

FQD & Refiners big Challenge:
Full Obligation vs. Partial "Control"

100%

4%	**10%**	**1%**	**85%**
			
Crude Production	Fuel Refining	Distribution Retail	Engine Combustion

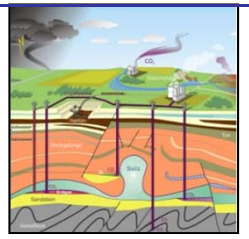
15% — **Oil Ind.**

85% — **Automotive Ind.**

- **6%** of total, **- 40%** of O.I. bit, **- 60%** of Refining one**!**

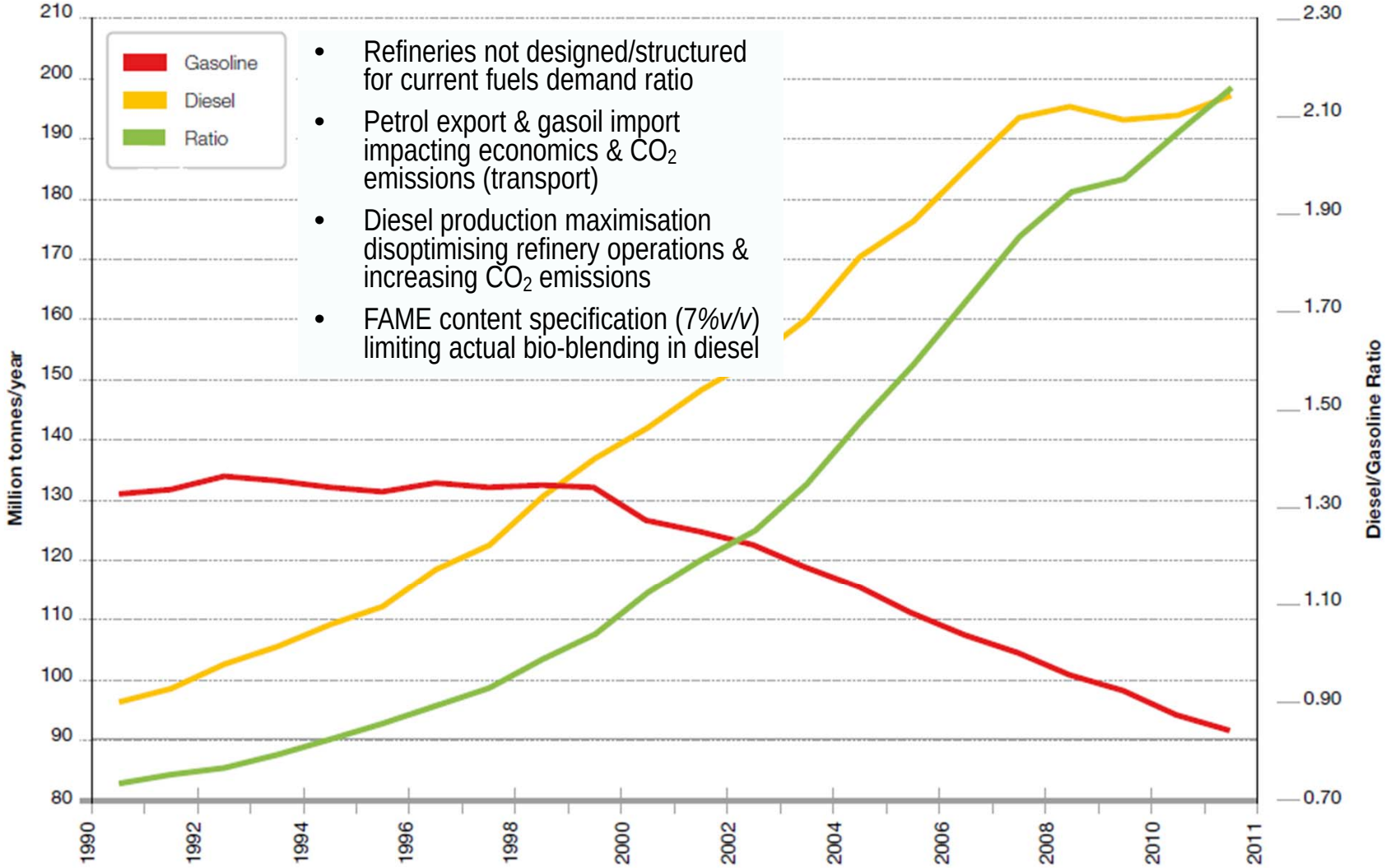
Operations Energy Efficiency

Bio-Fuels Blending



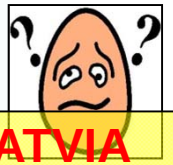
Carbon Capturing & Storage

Petrol/Gasoil - Supply/Demand Unbalance: EU Gasoil/Petrol Ratio Growing



Source: Wood Mackenzie, 2011

Balkanization of National Bio-Blending Obligations



IRELAND
5.75%(v/v)
Cumulative Target
Petrol + Gasoil

NETHERLANDS
5,25%(e/e)
Gasoil **3,5%**(e/e)
Petrol **3,5%**(e/e)

NORWAY
5,0%(v/v)
Parallel Targets
Petrol & Gasoil

FINLAND
6,0(e/e)
Cumulative Target
Petrol + Gasoil

LATVIA
5,0%(e/e)
Parallel Targets
Petrol & Gasoil

UNITED KINGDOM
4,5%(v/v)
Cumulative Target
Petrol + Gasoil

POLAND
6,2(e/e)
Cumulative Target
Petrol + Gasoil

FRANCE
7,0%(e/e)
Parallel Targets
Petrol & Gasoil

BELGIUM
4,0%(e/e)
Parallel Targets
Petrol & Gasoil

GERMANY
6,25%(e/e)
Gasoil **4,4%**(e/e)
Petrol **2,8%**(e/e)

CZECH REPUBLIC
Gasoil **6,0%**(v/v)
Petrol **4,1%**(v/v)

SLOVAKIA
5,75%(v/v)
Gasoil **5,2%**(v/v)
Petrol **3,1%**(v/v)

AUSTRIA
Gasoil **6,3%**(e/e)
Petrol **3,4%**(e/e)

SPAIN
6,5% (e/e)
Gasoil **7,0%**(e/e)
Petrol **4,10%** (e/e)

HUNGARY
4,0%(v/v)
Parallel Targets
Petrol & Gasoil

PORTUGAL
5,0%(e/e)
Gasoil **6,75%**(e/e)
Petrol **2,5%**(e/e)

ITALY
4.5%(e/e)
Cumulative Target
Petrol + Gasoil

BULGARIA
Gasoil **4.0%**(v/v)
Petrol **2.0%**(v/v)

ROMANIA
Gasoil **5.0%**(v/v)
Petrol **4.0%**(v/v)

Consumers Psychological Resistance to E10

"My car is on the E10 not-suitable list by OEM"

"It might damage my car"

"It will compromise my vehicle warranty"

"It will worsen car performances"

"It would provoke engine efficiency loss"

"I buy litres, but I need energy (oxygen doesn't burn)"

"If «they» discount it, there must be something dirty"

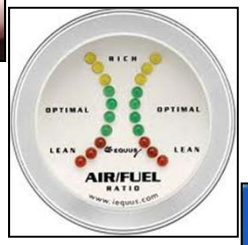
"High bio compete with food and feed"

"This thing is too new: let others be the guinea pigs"

Vehicle/Engines Compatibility/Operability

Fuel filter blockage

Galvanic corrosion



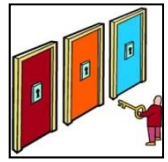
Enleanment

Drivability

Deposit formation

Material compatibility

Only Few Possibilities



CO_2 Reduction Effectiveness of Bio-components

High Bio-components Blending Percentage

Exploitation of «best seller» Petrol Grade (E5)

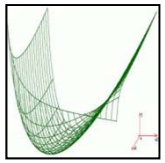
Existing Solution

Adopting Immediately Available Consolidated Options

Maximizing Actual Bio-energy Blending within E5

Optimizing Logistics & Operations

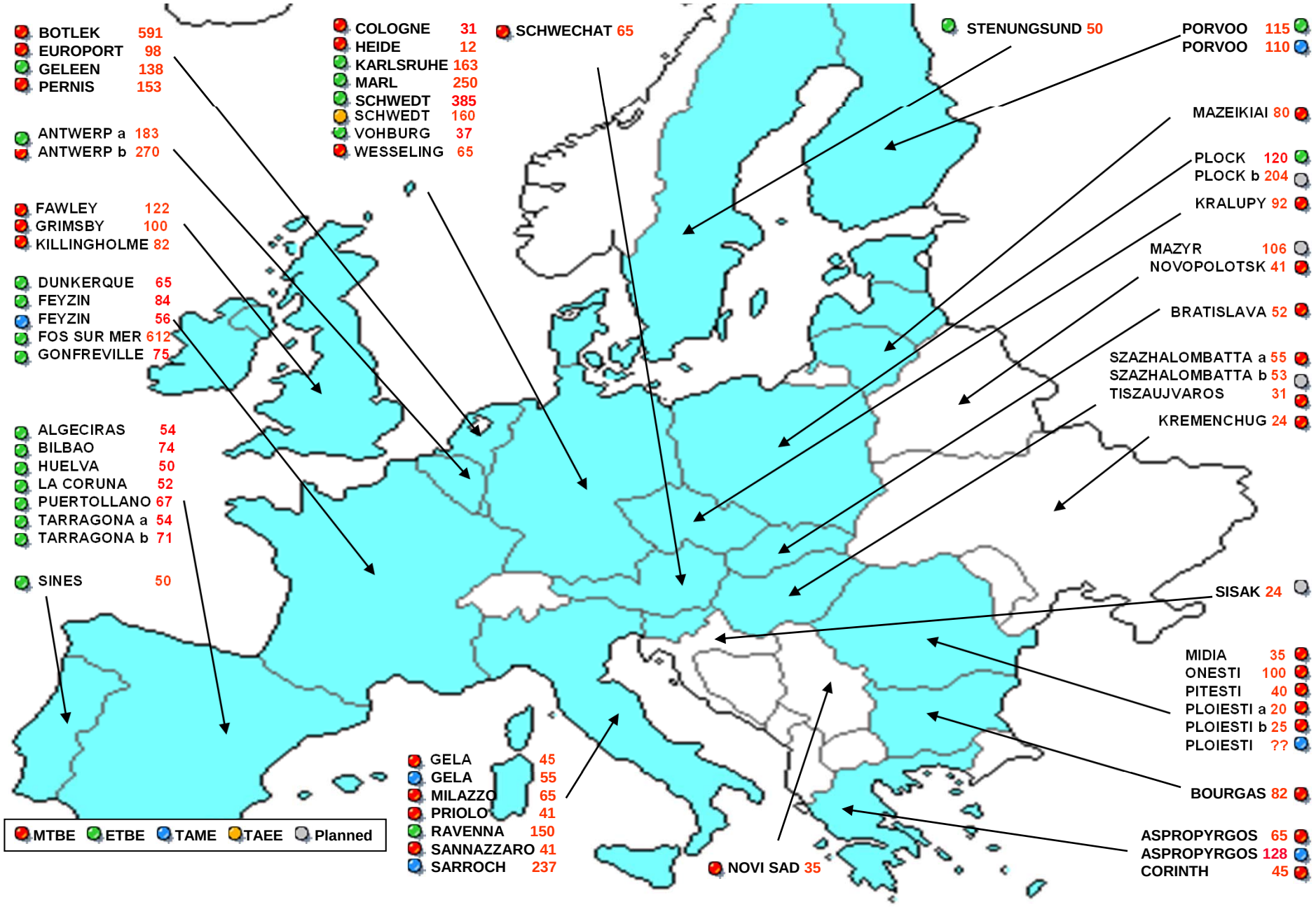
Capturing Bio-components WTW CO_2 Saving Potential



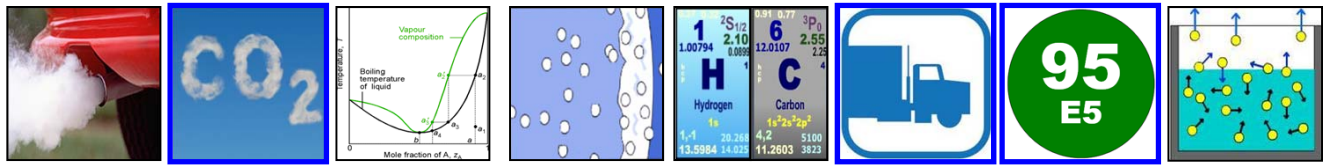
Harvesting Synergetic «Non-linear» Effects

COBLENDING
ETBE AND ETHANOL

European Fuel-Ethers Production Capacities 2011 (KT/Y)

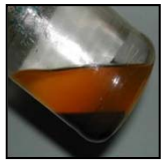


ETBE: A Multifaceted Benefits Carrier




COMINGLING

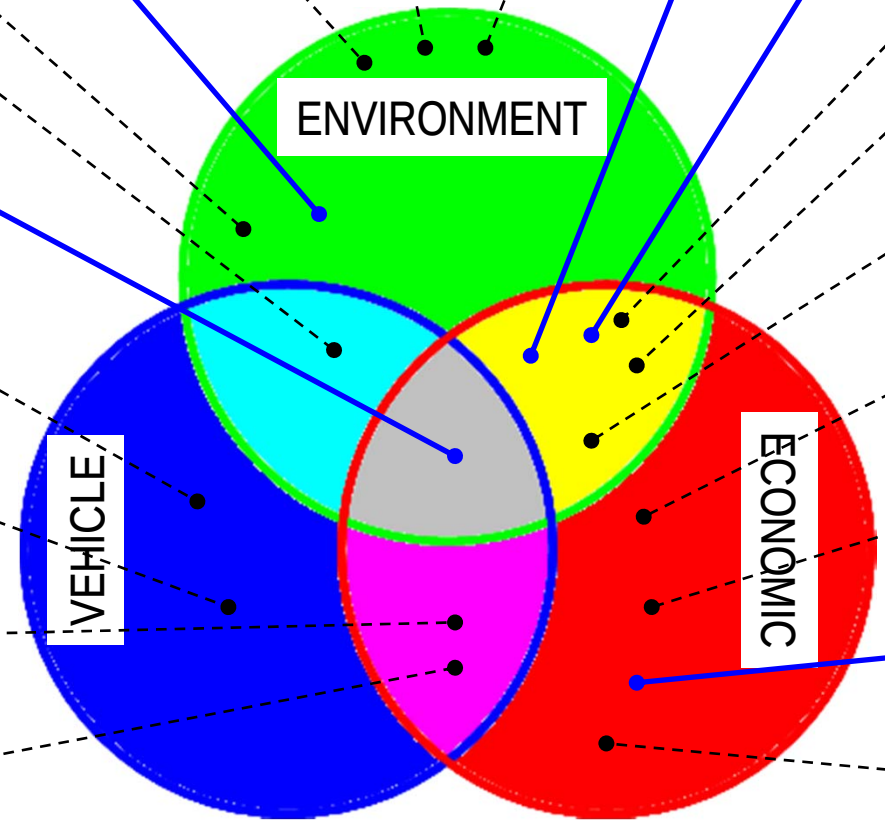

DISTILLATION


WATER TOLER.

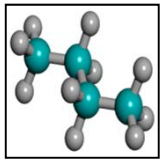

DRIVEABILITY


MATER. COMP.


HYGROSCOPY



ENER. EFFIC.


C4 UPTAKE

OCTANE BARR.

BLENDSTOCK


REF. FLEXIBILITY

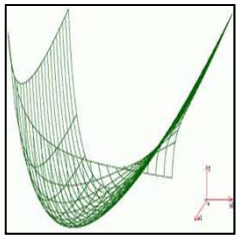

INVEST. SAVING

..and “Co-blending” further offers Additional Specific Benefits!

Blending more Bio-energy within Petrol Specs Limits

Capturing Bio-components' Well-to-Wheels CO_2 Saving Potential

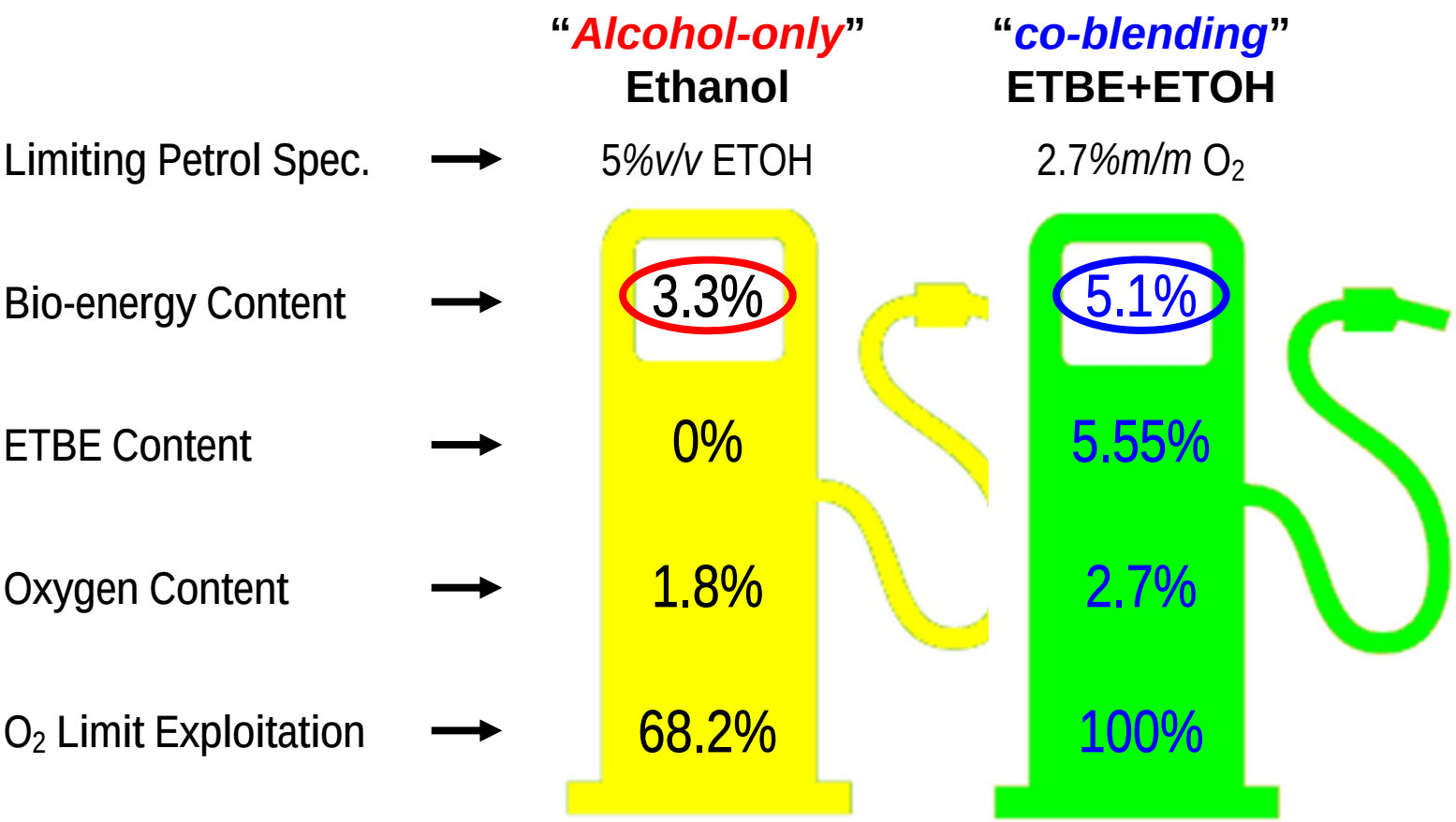
Minimizing Quality “Give-away” and fossil base-stock cost, via ETBE-containing “DBEB”[*] for E5/E10



Harvesting Synergetic "Non-linear" Effects of Bio-components

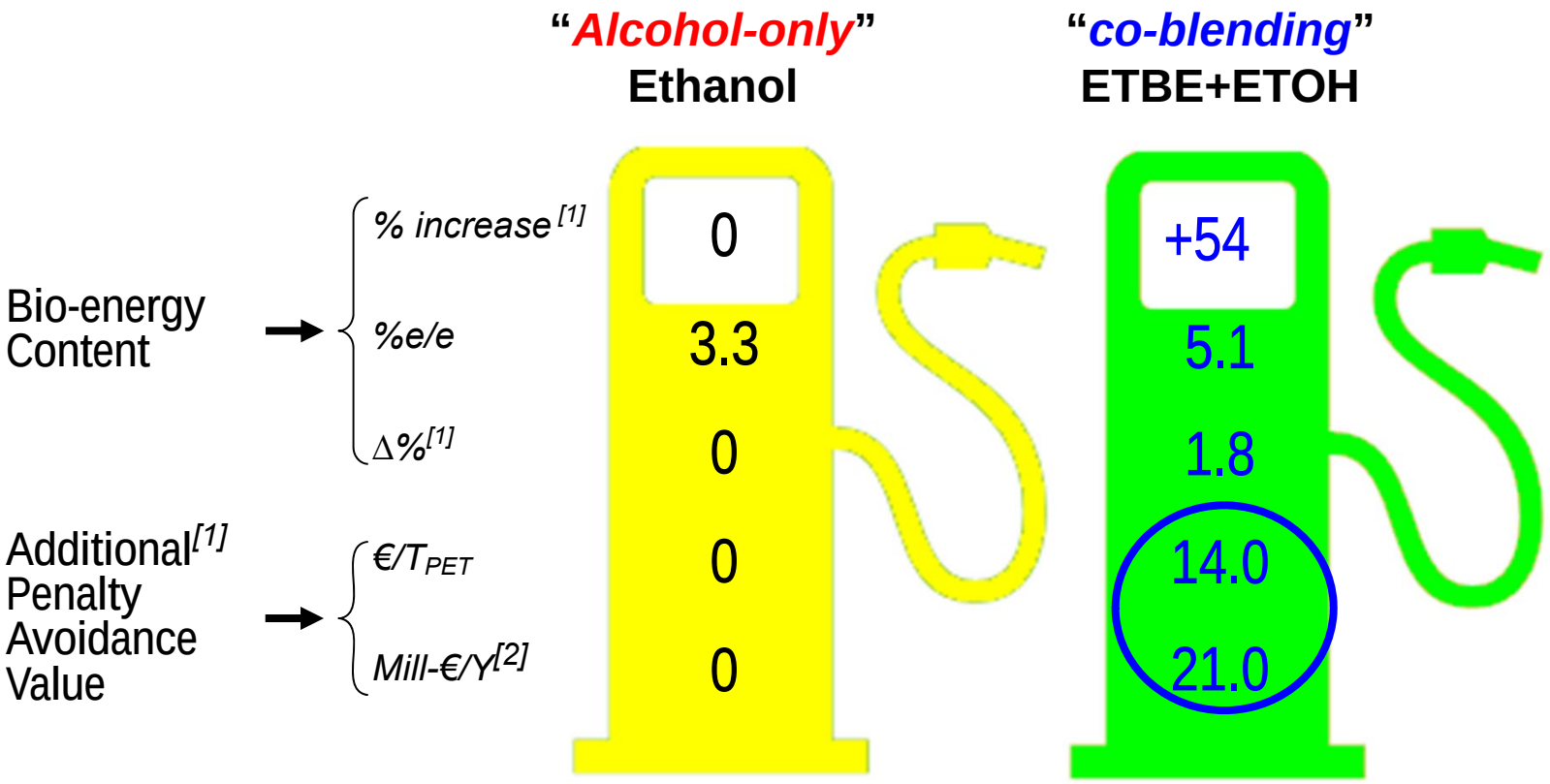
*[*] **D**ual **B**lend-stock for **E**thanol **B**lending*

53% more bio-energy into E5 via “Co-blending”



E5: “Co-blending” Enables Significant Non-compliance Penalty Saving

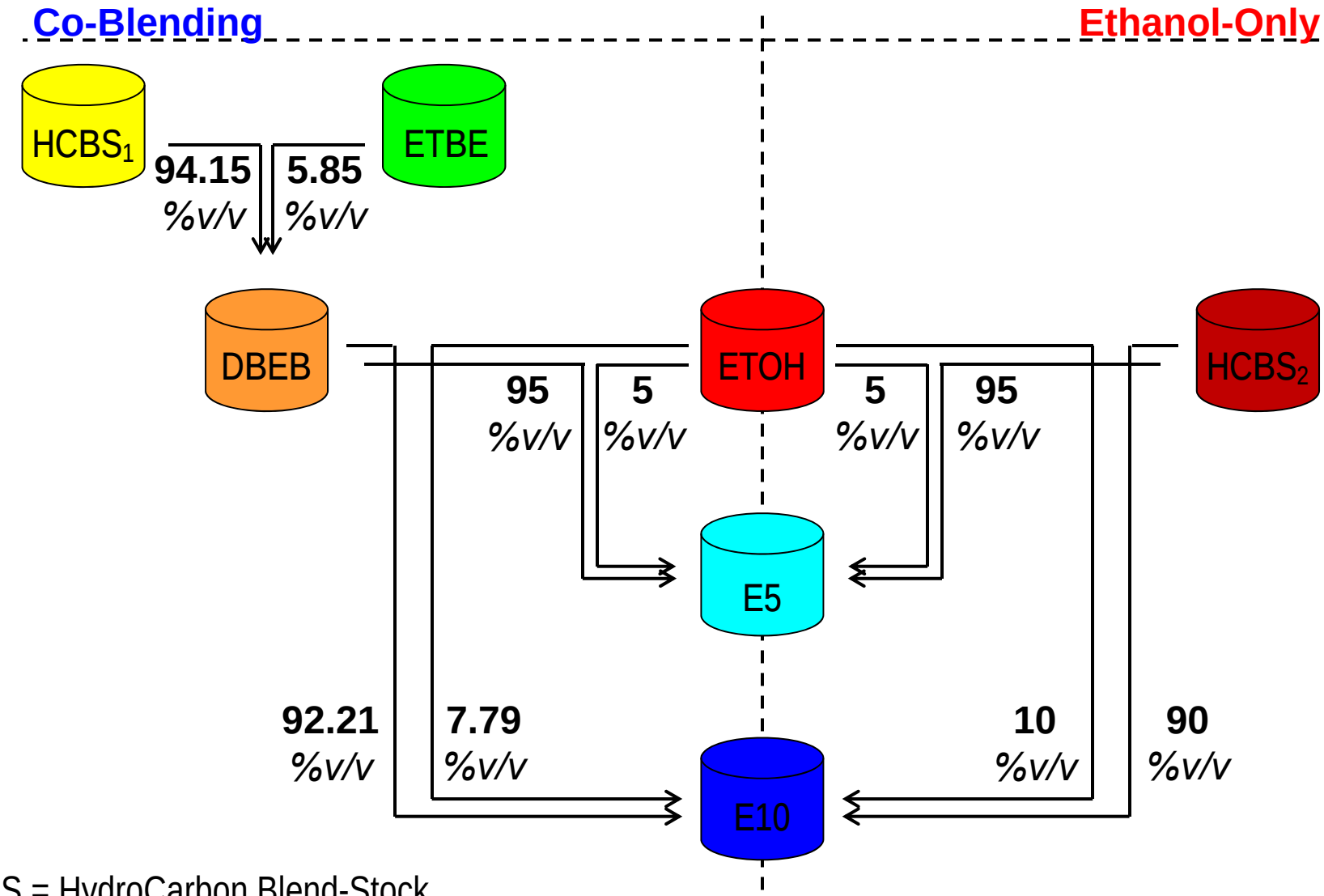
(German Example)



[1] On top of what achievable with 5%v/v ETOH directly blended into E5 “Protection Grade”

[2] Example based on an average refinery petrol production of 1.5 million tons per year

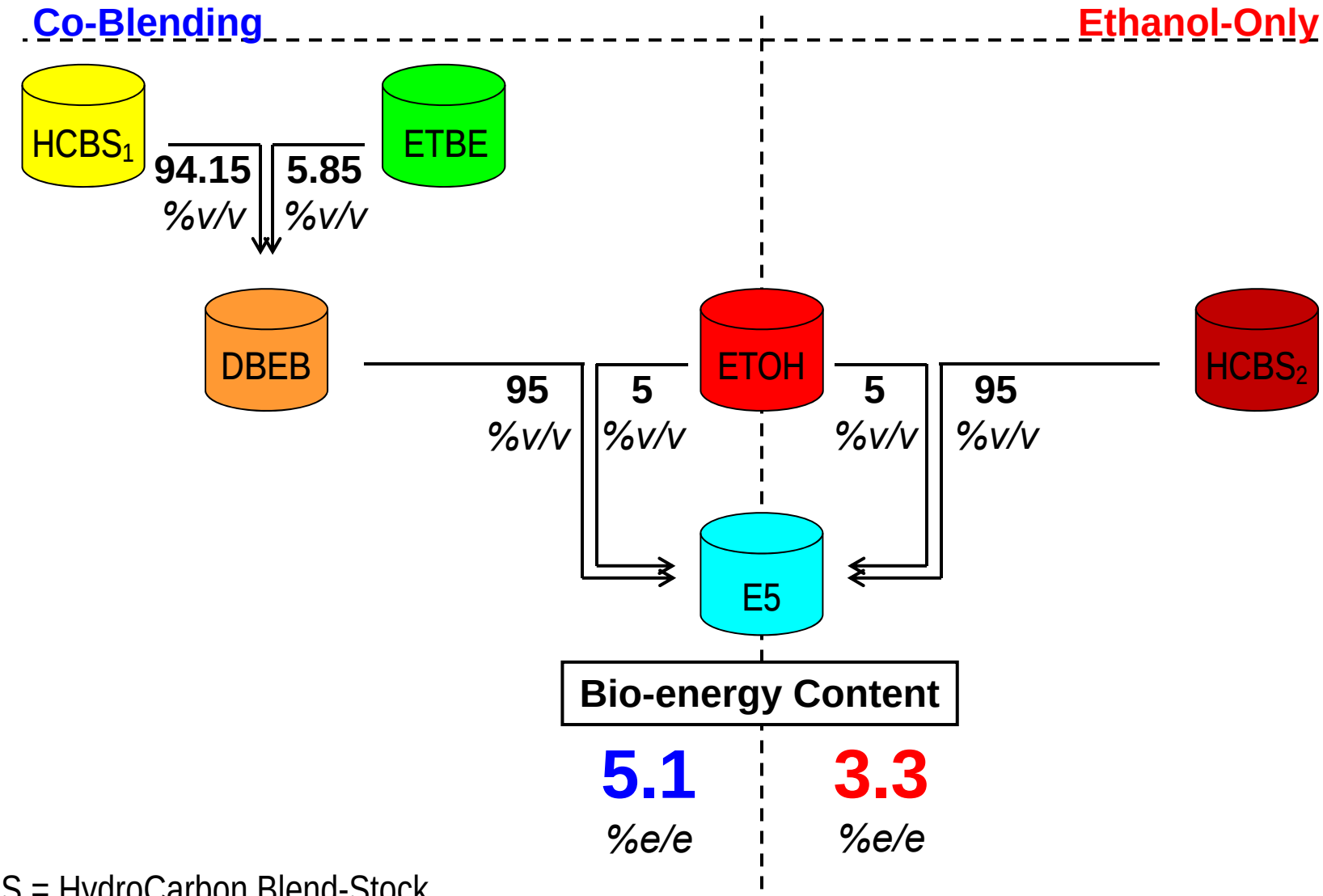
Co-blending vs. Ethanol only: 1) The Flow



HCBS = HydroCarbon Blend-Stock

DBEB = Dual Blendstock for Ethanol Blending

Co-blending vs. Ethanol only: 2) E5 Bio-energy



HCBS = HydroCarbon Blend-Stock

DBEB = Dual Blendstock for Ethanol Blending

Co-blending vs. Ethanol only: 3) Dual-BOB quality

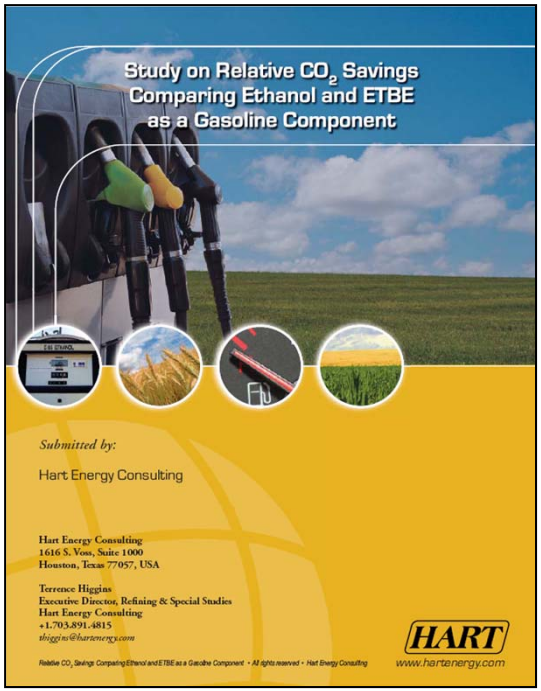
Co-Blending		Ethanol-Only
$HCBS_1$		$HCBS_2$
Motor Octane Contribution Saving[a, b]		
1.8	*MON*	**0.6**
Vapour Pressure Compensation Need[a, c]		
6.3	*kPa*	**7.8**
E5 RVP «Give-Away»[a, c]		
0	*kPa*	**1.84**
0	*%*	**3.06**

HCBS = HydroCarbon Blend-Stock

(a) vs. Finished Petrol Specs
(b) The Higher the Better
(c) The Lower the Better

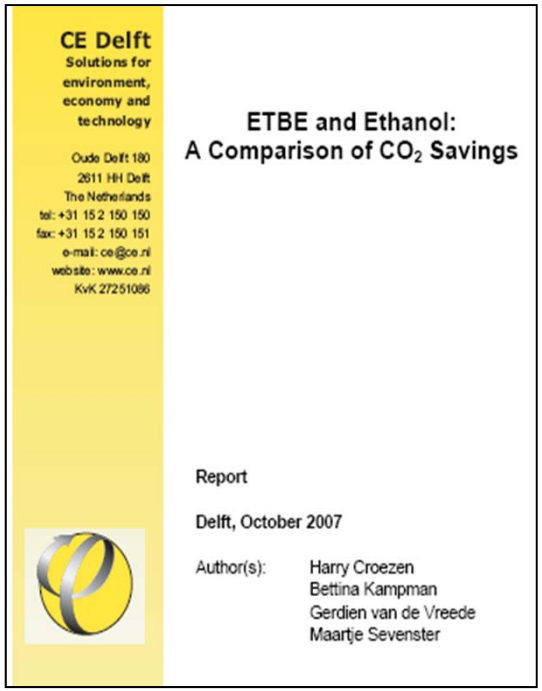
ETBE Further Reduces CO_2 Emissions

HART July 2007



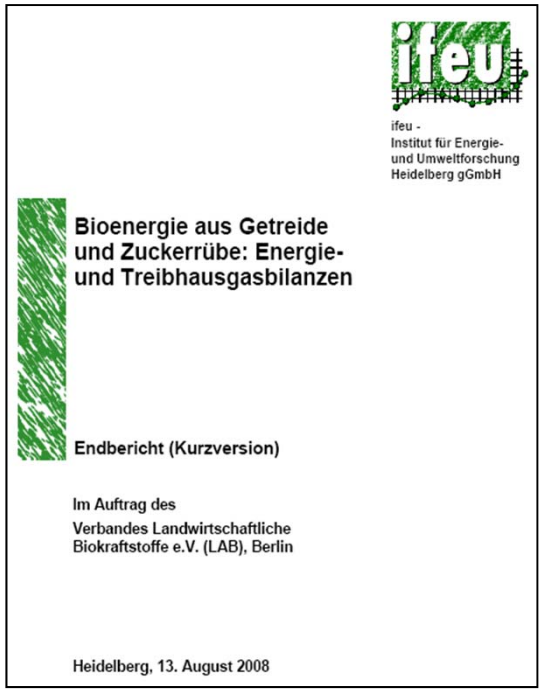
"The use of bio-ETBE reduces refining crude-oil need and processing intensity, requires less fuel and, implying relevant petrol composition changes, allows the reduction of carbon factor and lesser CO_2 emissions"

CE-Delft October 2007



"This study indicated that, when bio-ETBE is used, the resulting modification of refinery operations determine a significant reduction of greenhouse gases emissions"

IFEU August 2008



"Best results by far are obtained when ethanol is converted to bio-ETBE.
The use of ETBE can allow the saving of 4 times the primary energy required to produce its fossil alternative.
IFEU recommends to exploit the whole potential of bio-ETBE"

ETBE: Two Relevant CO_2 Saving Contributions

65% UPSTREAM **+54%** → **35%[1]** DOWNSTREAM **100%** FIELD-TO-TANK

0.618

0.335

= 0.953

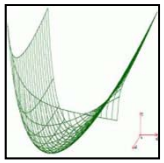
T_{CO2}/T_{ETBE}

[1]
Key ETBE blending properties, like vapour pressure, distillation characteristics and octane contribution, affecting fuel formulation, reduce refinery operations' CO_2 emissions, by reducing carbon and aromatics content as well as the use of refinery fuel.

The whole is more than the sum of its parts.

Aristotle, *Metaphysica*

Harvesting Synergetic "Non-linear" Effects of Bio-components



- Increasingly stringent technical and environmental petrol specifications, makes it relevant and urgent to try and fully exploit all the positive characteristics of various blend-stocks used by refiners for formulating finished fuels;
- Several studies have already demonstrated that co-mixing different blend-stocks can yield a better-than-linear blending performance;
- A specially interesting and relevant case is the co-blending of ethanol and ethers (ETBE), considering the key role that these two bio-components play in recent bio-fuels policies;
- Some of the chemical-physical reasons for the distinct synergetic blending effect of those oxygenated molecules comes from their polar nature, as well as from the hydrogen-bonding effects;
- New ad hoc studies are currently under going to better quantify and qualify those effects;
- Petrol specifications that benefit from the «co-blending effect» include volatility (BRVP), distillation curve (E70), octane performance (MON & RON) and water tolerance.

Several studies confirmed synergy

- "***Synergies Between Ethanol and TAME as Gasoline Oxygenates***". Sasol. 2002
- "***Accurate determination of ether / alcohol octane synergies in specific base fuel matrices***". Sasol. 2005.
- "***Addition of an azeotropic ETBE/ethanol mixture in eurosuper-type gasolines***". Federal University of Rio Grande do Sul. 2006
- "***Impact of Simultaneous ETBE and Ethanol Addition on Motor Gasoline Properties***". National Technical University of Athens. 2008
- "***Volatility and phase stability of petrol blends with ethanol***". Institute of Chemical Technology of Czech Republic. 2009

Conclusion

Harvesting the synergy of co-blending bio-ETBE and bio-Ethanol, represents an effective, immediate and practical avenue to address both EU and MSs ambitious bio-fuel targets. It actually enables significantly higher bio-energy content, while both enhancing environmental benefits and improving operators flexibility