THE ADVENT OF COBLENDING HARVESTING THE ETBE ETOH SYNERGY

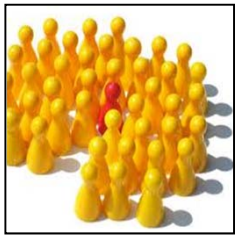
Dr. Walter R. Mirabella
Chairman Biofuels of European Fuel Oxygenates Association

6th Annual Global Refining Summit 2012
Barcelona– Spain 23rd May 2012

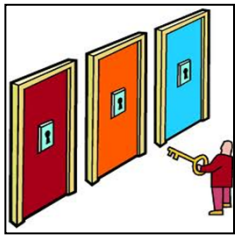
EFOA
The European Fuel Oxygenates Association

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

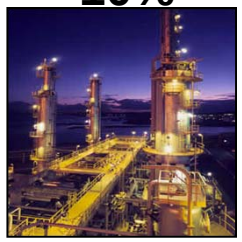
Balkanization of EU MS’s Implementation Rules

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

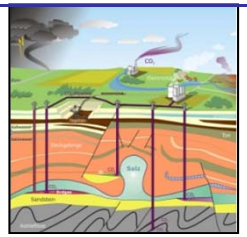
15% — **Oil Ind.**

85% — **Automotive Ind.**

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

Operations Energy Efficiency

Bio-Fuels Blending

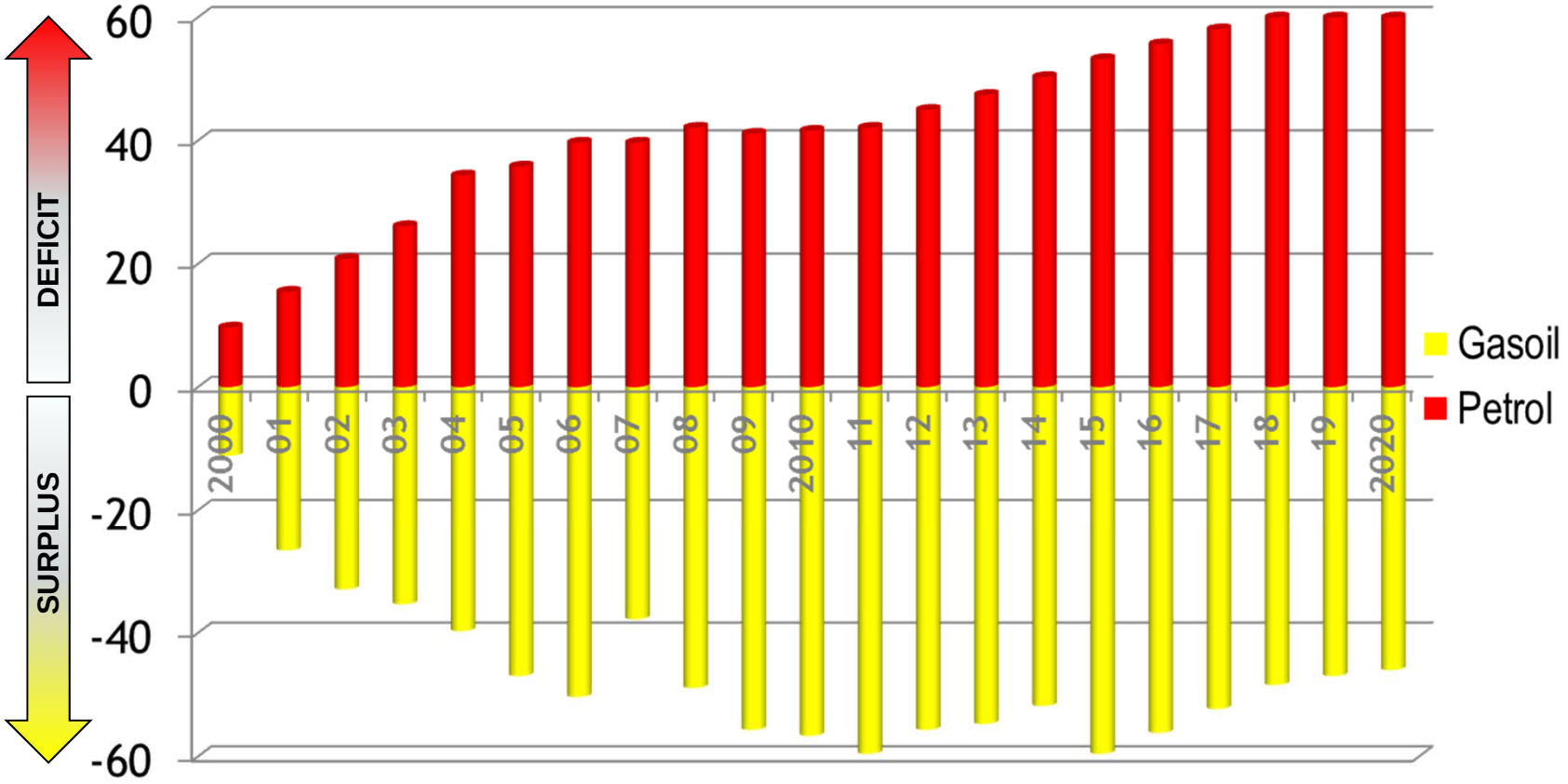


Carbon Capturing & Storage

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

- Refineries not designed/structured for current fuels demand ratio
- Petrol export & gasoil import impacting economics & CO_2 emissions (transport)

- Diesel production maximization disoptimising refinery operations & increasing CO_2 emissions
- FAME content specification (7%*v/v*) limiting actual bio-blending in diesel



Source: Total 2012

Balkanization of National Bio-Blending Obligations

IRELAND
4,0%(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

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

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)

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

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

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

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

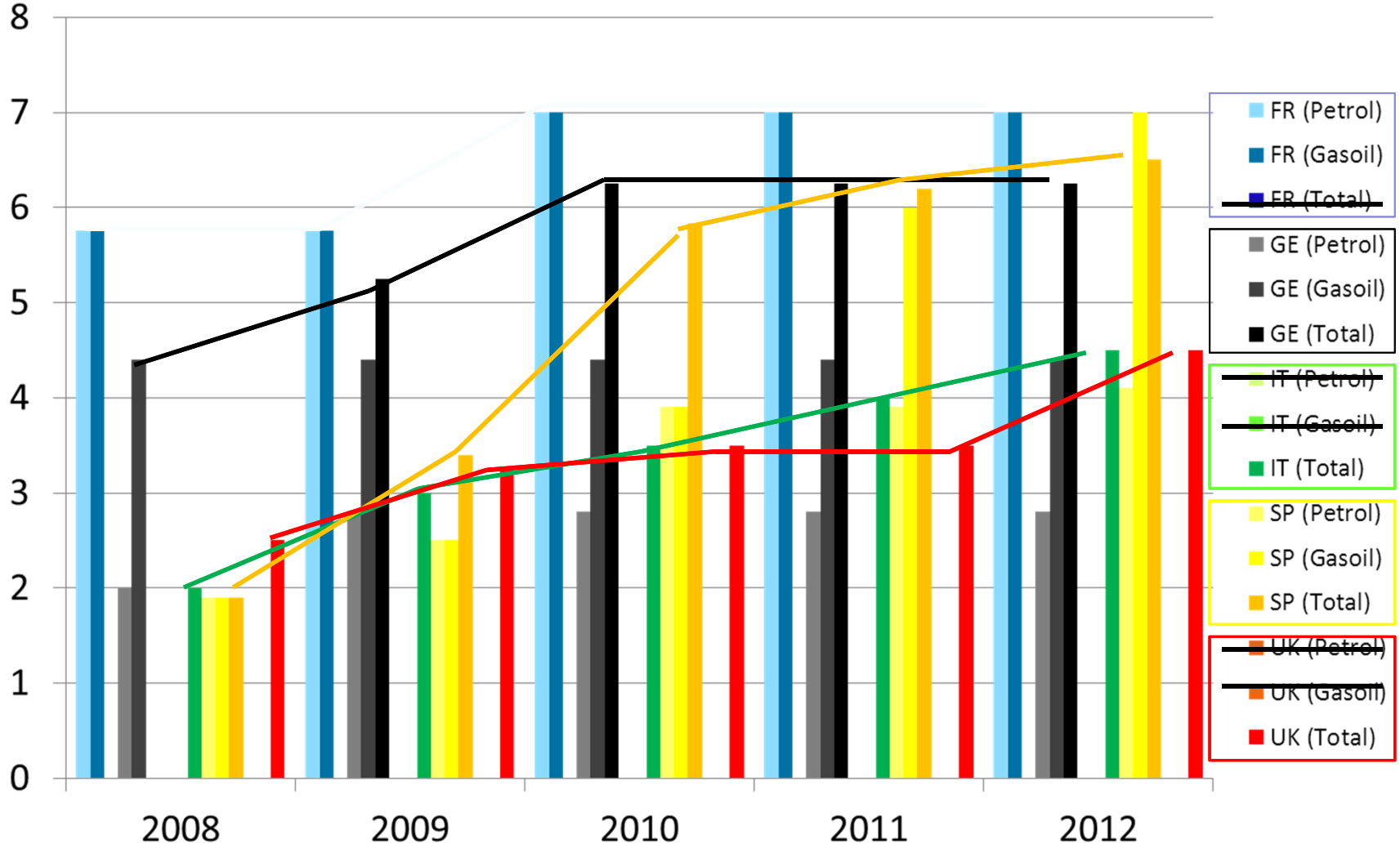
PORTUGAL
5,0%(e/e)
Gasoil **6,75%**(e/e)
Petrol **2,5%**(e/e)

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)

Bio-blending Obligatons
in Largest EU Fuel Markets



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”

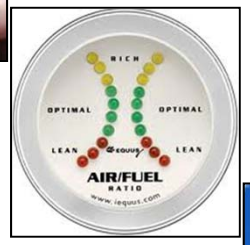
“High bio compete with food and feed”

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

Vehicle/Engines Compatibility/Operability

Fuel filter blockage

Galvanic corrosion



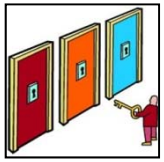
Enleanment

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)

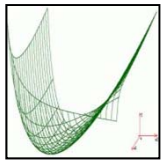
Existing Solution

Adopting Immediately Available Consolidated Options

Maximizing Actual Bio-energy Blending within E5

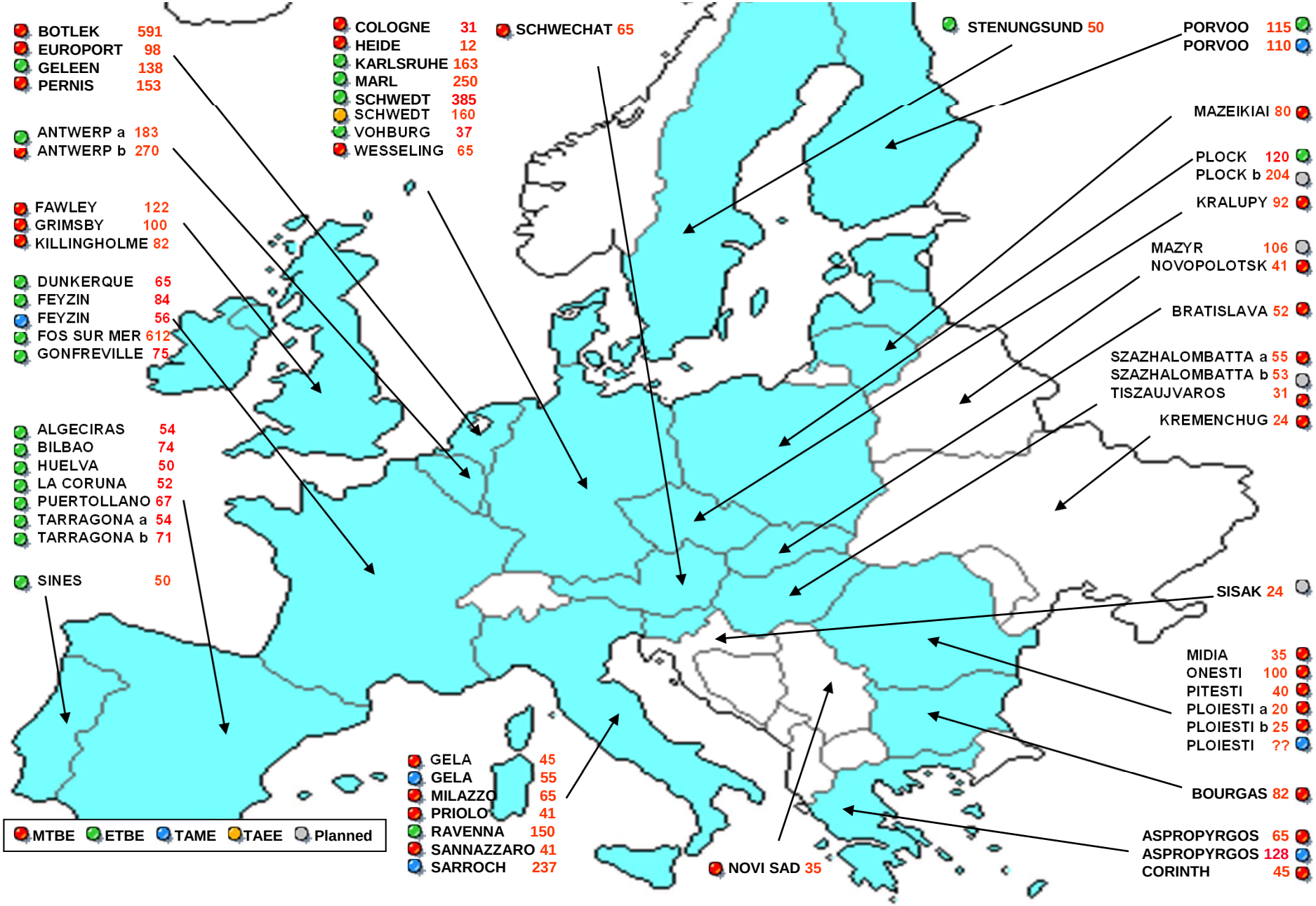
Optimizing Logistics & Operations

Capturing Bio-components WTW CO_2 Saving Potential

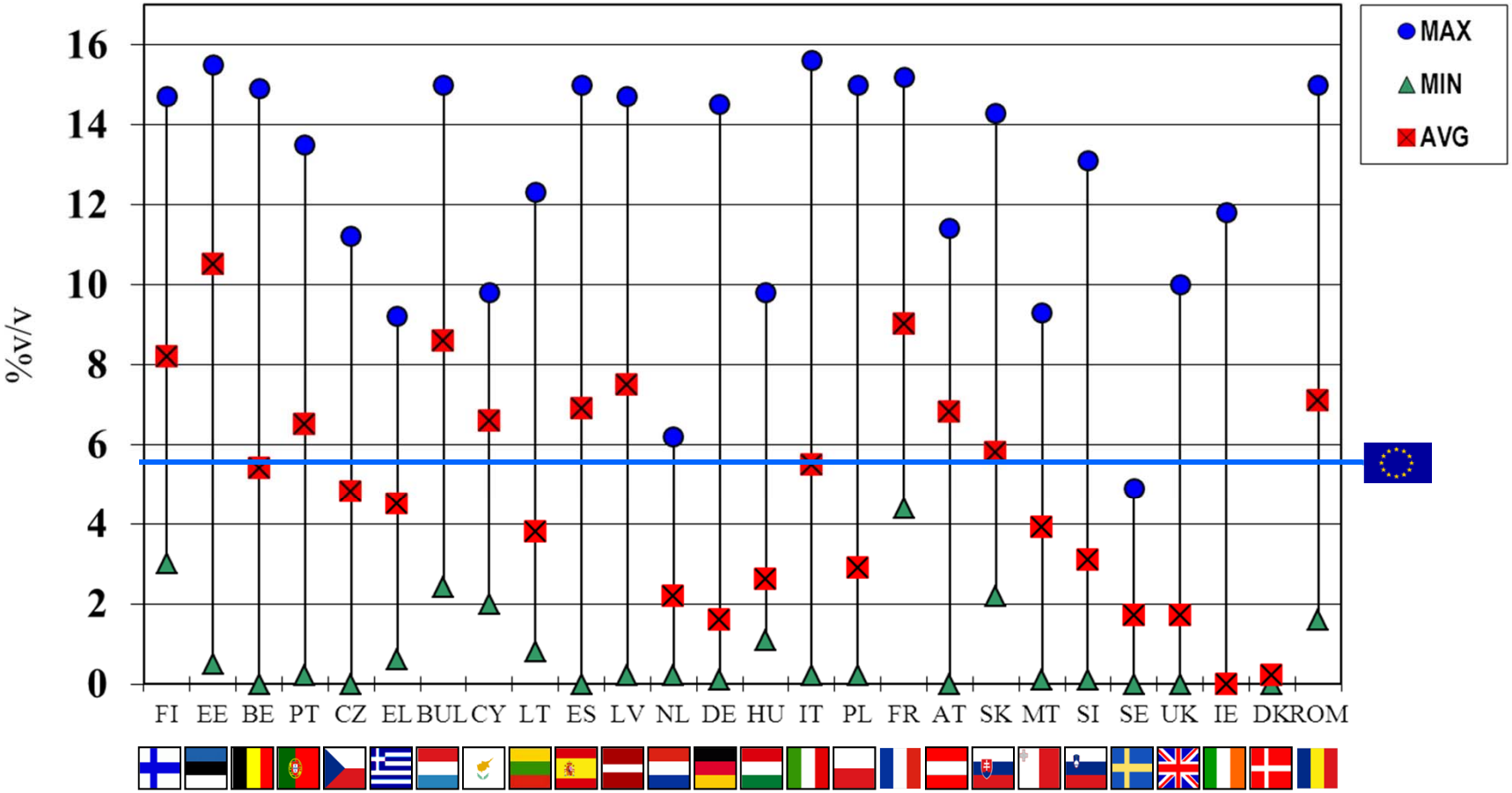


Harvesting Synergetic «Non-linear» Effects

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

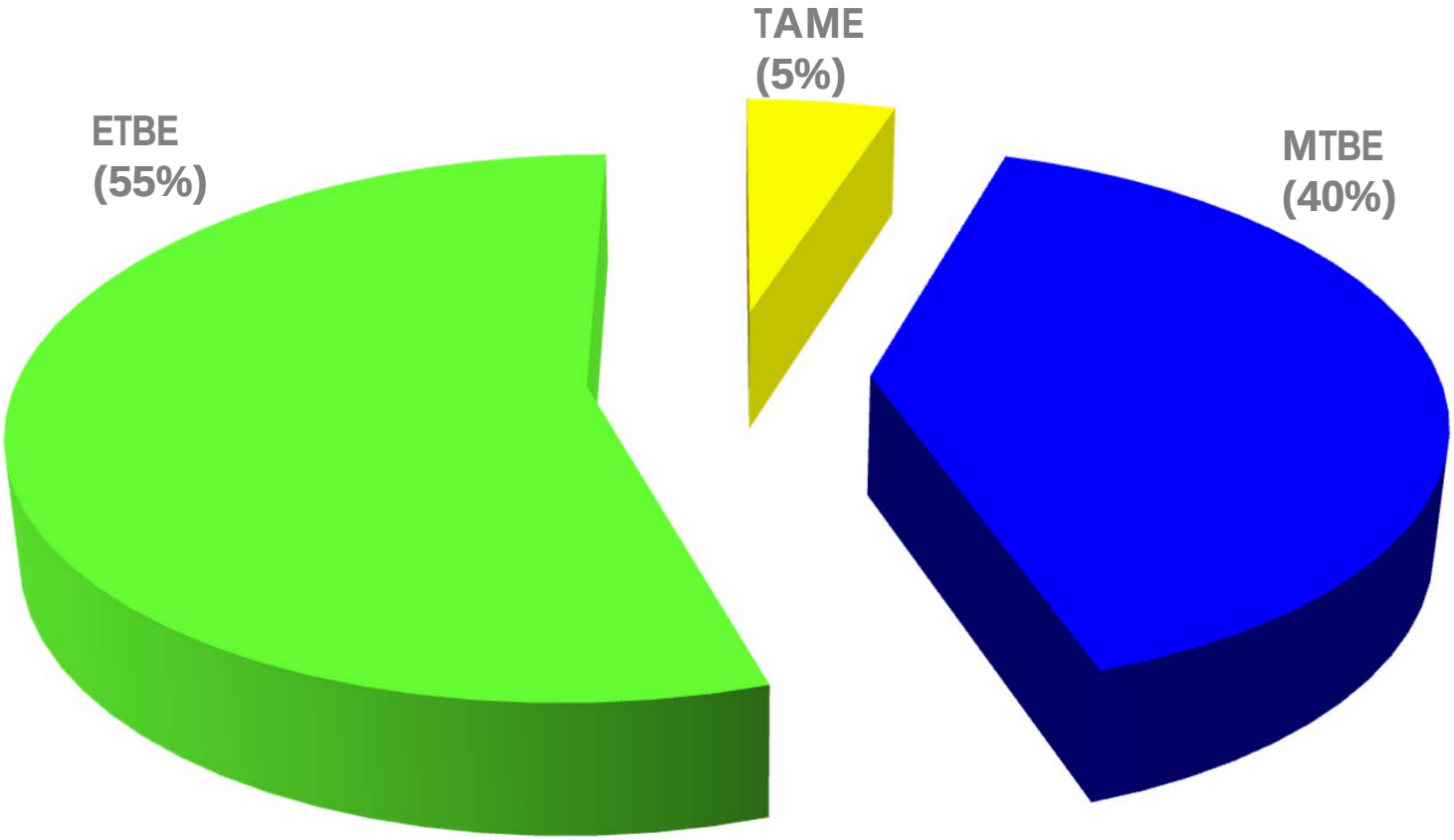


Fuel-Ethers % Content % in UE27 Petrol



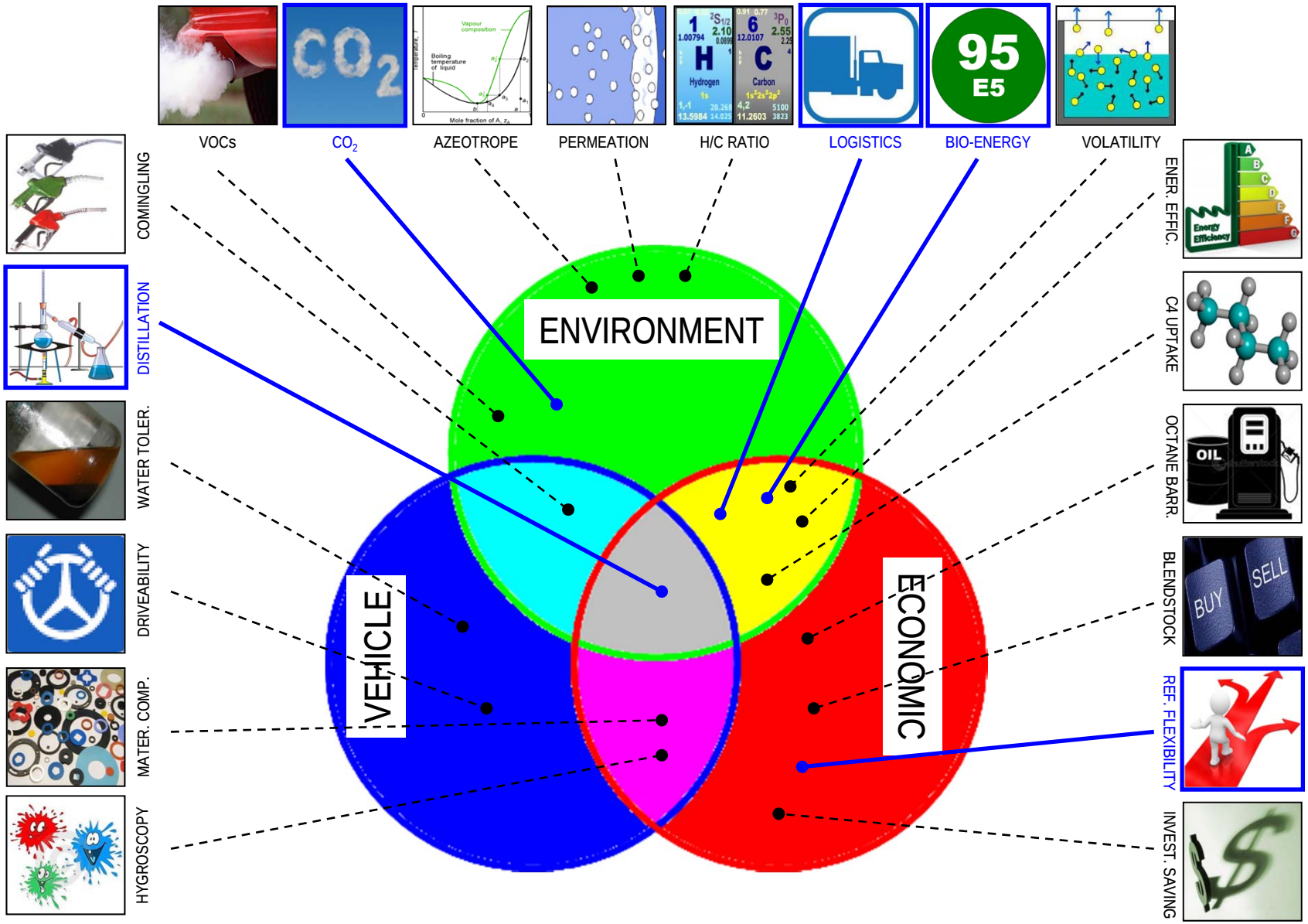
Source: EU Commission «2009 EU Fuel Quality Monitoring» Report

Fuel-Ethers Consumption EU 2010 ~5 million Tons



Source: Fuel Ether Reach Consortium, EFOA

ETBE: A Multifaceted Benefits Carrier



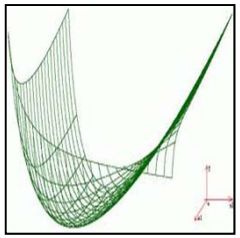
COBLENDING
ETBE AND ETHANOL

..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

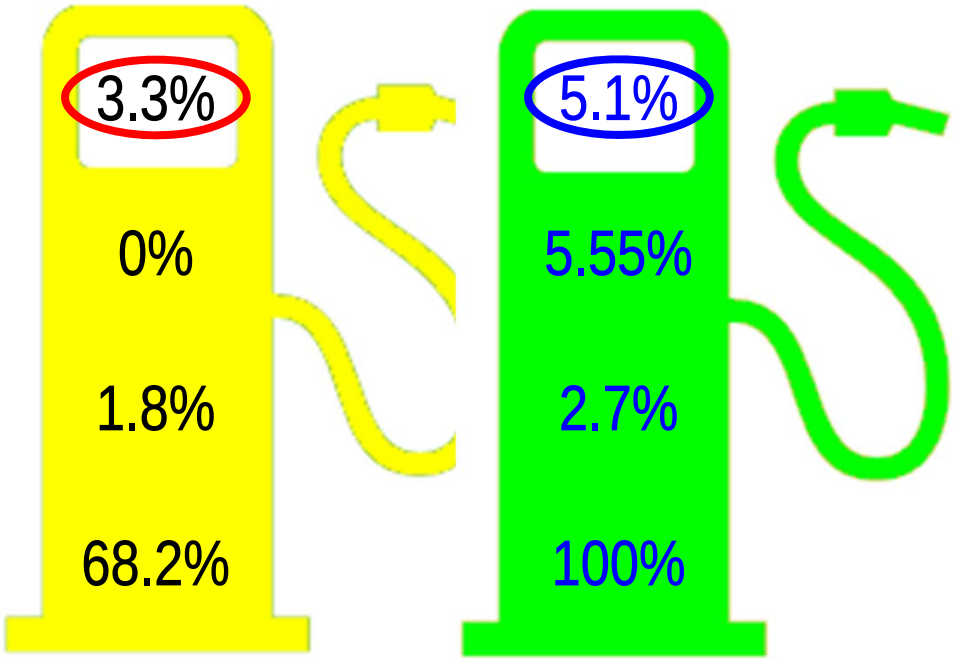


Harvesting Synergetic "Non-linear" Effects of Bio-components

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

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

	“*Alcohol-only*” **Ethanol**	“*co-blending*” **ETBE+ETOH**
Limiting Petrol Spec. →	5%*v/v* ETOH	2.7%*m/m* O_2
Bio-energy Content →	3.3%	5.1%
ETBE Content →	0%	5.55%
Oxygen Content →	1.8%	2.7%
O_2 Limit Exploitation →	68.2%	100%



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

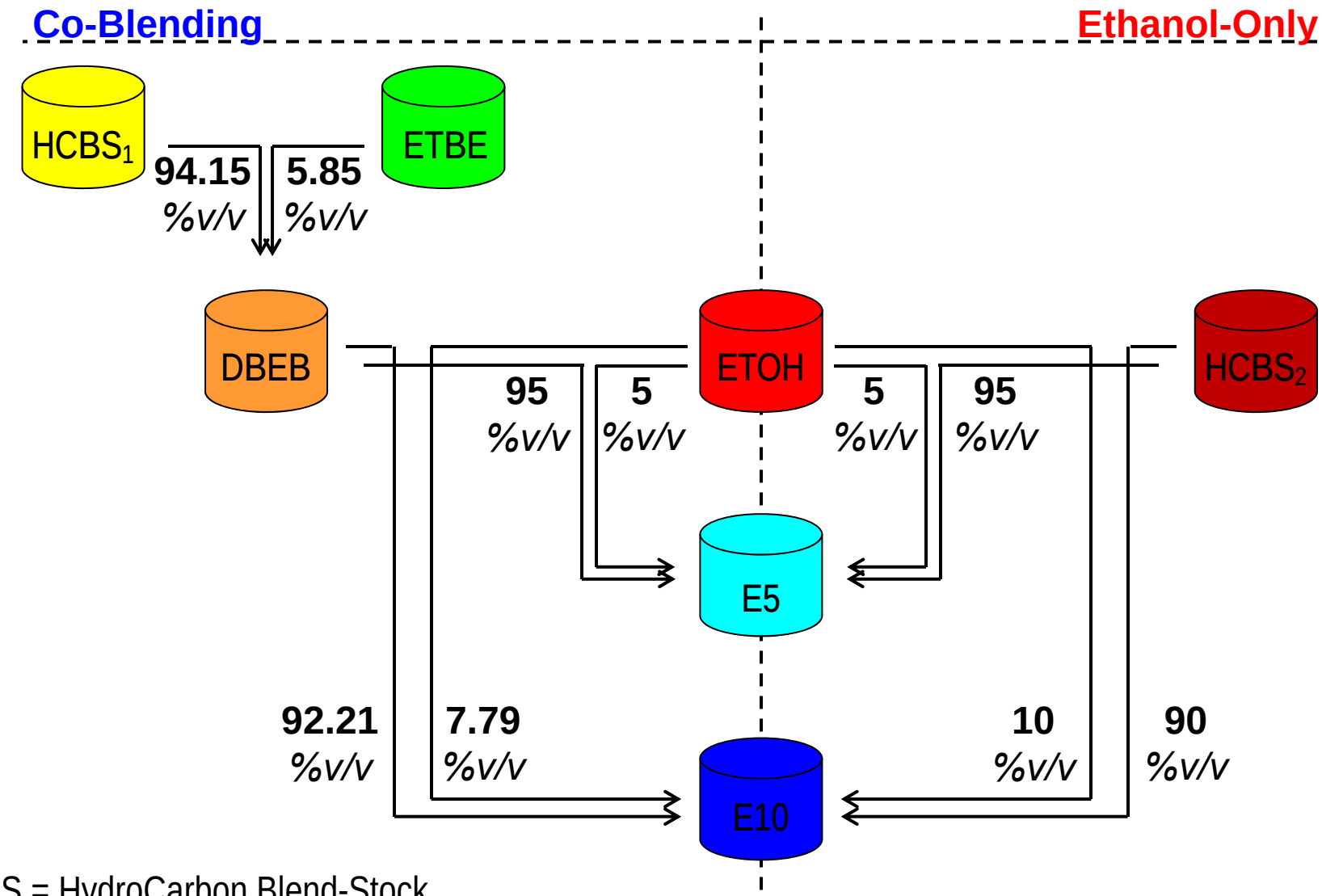
(German Example)

		“*Alcohol-only*” Ethanol	“*co-blending*” ETBE+ETOH
Bio-energy Content	*% increase* [1]	0	+54
	%e/e	3.3	5.1
	Δ% [1]	0	1.8
Additional[1] Penalty Avoidance Value	*€/T_{PET}*	0	14.0
	Mill-€/Y [2]	0	21.0

[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

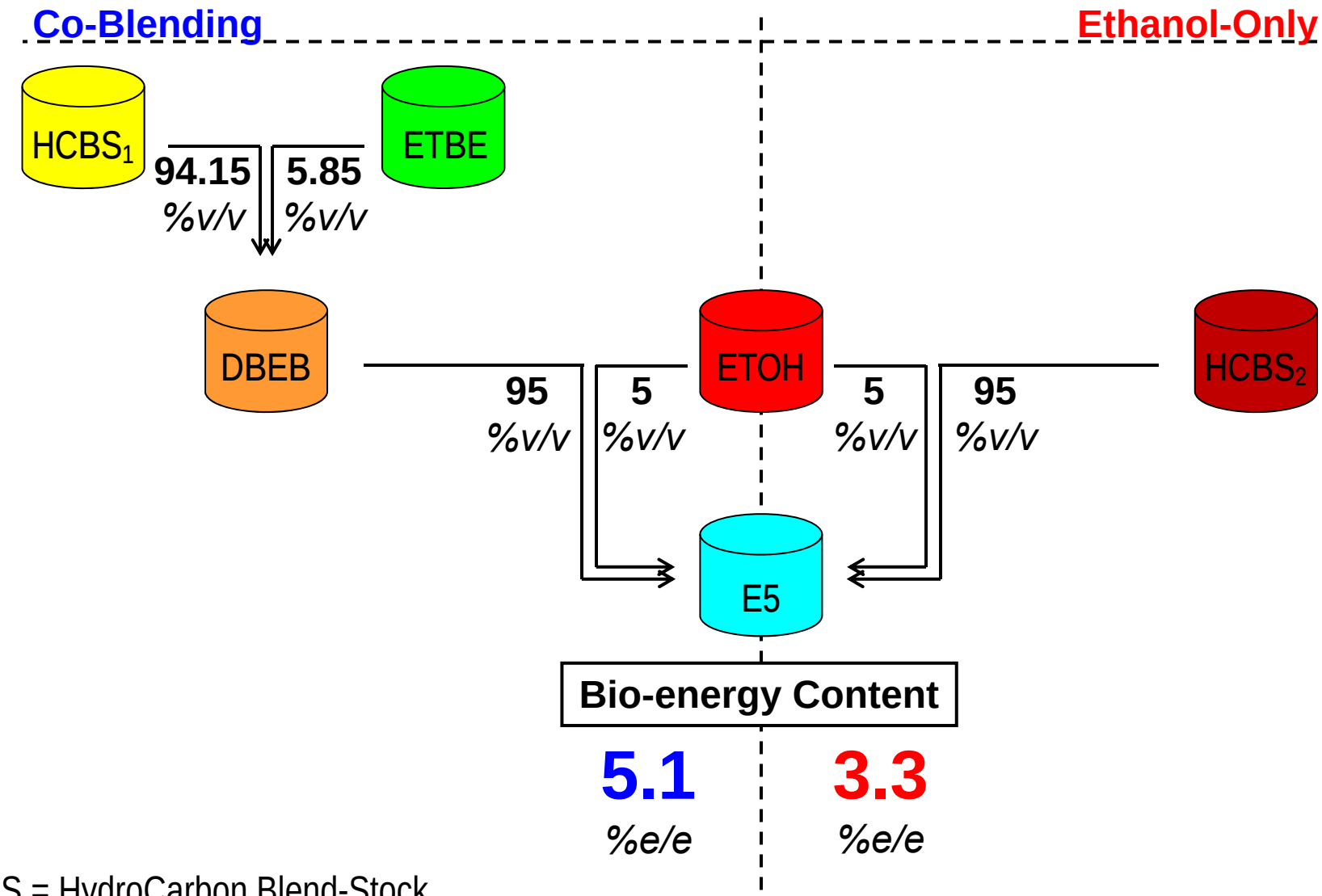
Co-blending vs. Ethanol only: 1) The Flow



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

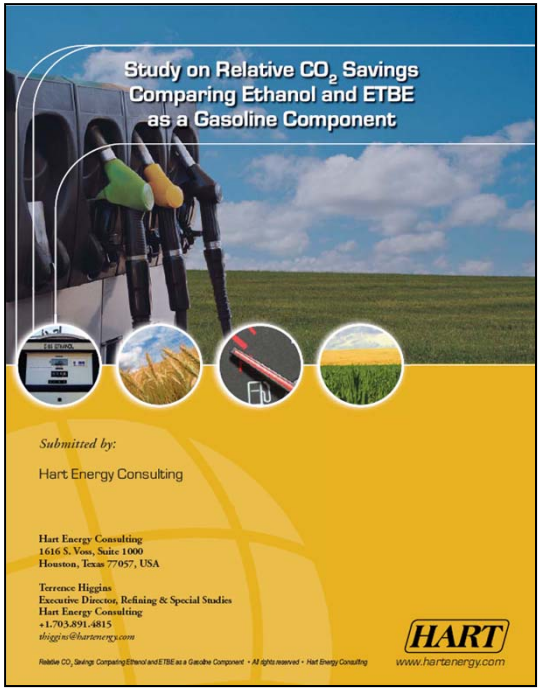
Co-Blending		Ethanol-Only
$HCBS_1$		$HCBS_2$
Motor Octane Contribution Saving[a, b]		
1.8	*MON*	**0.6**
Vapour Pressure Compensation Need[a, c]		
6.3	*kPa*	**7.8**
E5 RVP «Give-Away»[a, c]		
0	*kPa*	**1.84**
0	*%*	**3.06**

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

HCBS = HydroCarbon Blend-Stock

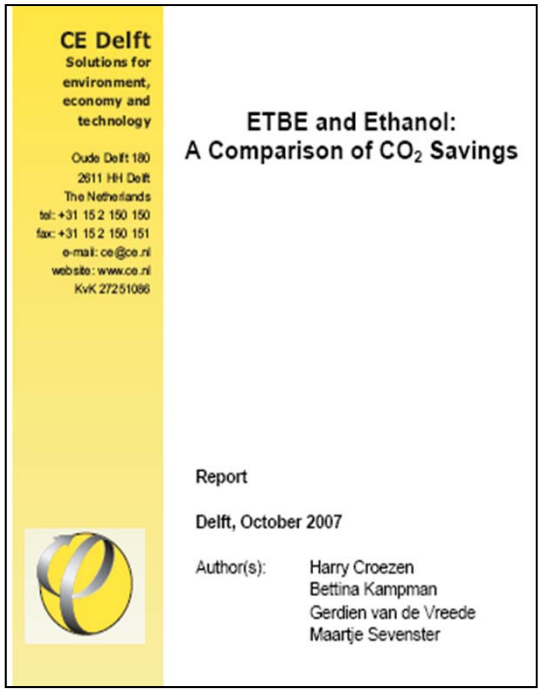
ETBE Further Reduces CO_2 Emissions

HART July 2007



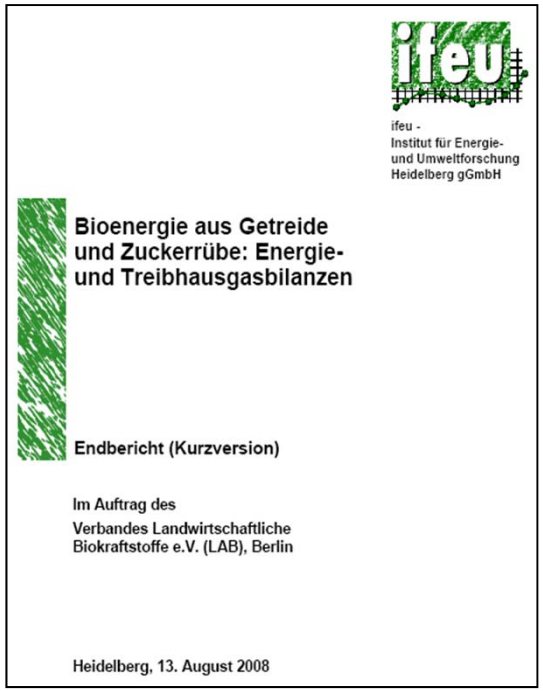
"The use of bio-ETBE reduces refining crude-oil need and processing intensity, requires less fuel and, implying relevant petrol composition changes, allows the reduction of carbon factor and lesser CO_2 emissions"

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

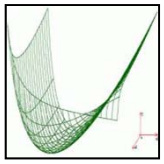
$$T_{CO2}/T_{ETBE}$$

[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