BENEFITS OF COBLENDING ETBE AND ETHANOL

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European Fuel Oxygenates Association

Polish Bioenergy Market BioPol 2012
Warsaw, Poland  3rd October 2012
Addressing RED & FQD EU Directives

- Ambitious Targets
- Multiple Challenges
- Limited Possibilities
- Existing Solution
Challenges (examples)

FQD: Refiners Obligations vs. Actual “Control”

Directives Revision & ILUC

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"

- 6% of total, -40% of O.I. bit, -60% of Refining one!
Directives Revision & ILUC *(current draft proposal)*

2020 Energy Share from Food Crops Biofuels ≤ 5%

GHGs Saving Biofuels Produced in Units ≥ 1/7/2012 ≥ 60 %

ILUC Emission Factors *(gCO₂eq/MJ)*

- Cereals and other starch rich crops 12
- Sugars 13
- Oil crops 55
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 & CO₂ emissions (transport)
- Diesel production maximization disoptimising refinery operations & increasing CO₂ 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
- **UNITED KINGDOM**: 4.5% (v/v) Cumulative Target Petrol + Gasoil
- **FRANCE**: 7.0% (e/e) Parallel Targets Petrol & Gasoil
- **BELGIUM**: 6.25% (e/e) Gasoil 4.4% (e/e) Petrol 2.8% (e/e)
- **GERMANY**: Gasoil 6.3% (e/e) Petrol 4.10% (e/e)
- **AUSTRALIA**: Gasoil 6.3% (e/e) Petrol 4.1% (e/e)
- **POLAND**: 6.2% (e/e) Cumulative Target Petrol + Gasoil
- **CZECH REPUBLIC**: Gasoil 6.0% (v/v) Petrol 4.1% (v/v)
- **SLOVAKIA**: 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)
- **ITALY**: 4.5% (e/e) Cumulative Target Petrol + Gasoil
- **BULGARIA**: Gasoil 4.0% (v/v) Petrol 2.0% (v/v)
- **HUNGARY**: 4.0% (v/v) Parallel Targets Petrol & Gasoil
- **IRELAND**: 4.0% (v/v) Cumulative Target Petrol + Gasoil
- **POLAND**: 6.2% (e/e) Cumulative Target Petrol + Gasoil
Bio-blending Obligations 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

- CO₂ 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 CO₂ Saving Potential
- Harvesting Synergetic «Non-linear» Effects
European Fuel-Ethers Production Capacities 2011 (KT/Y)
Fuel-Ethers % Content % in UE27 Petrol

Fuel-Ethers Consumption EU 2010 ~5 million Tons

ETBE (55%)

TAME (5%)

MTBE (40%)

Source: Fuel Ether Reach Consortium, EFOA
ETBE: A Multifaceted Benefits Carrier

- **Environment**
  - CO₂
  - Azeotrope
  - Permeation
  - H/C Ratio
  - Logistics
  - Bio-energy
  - Volatility

- **Vehicle**
  - VOCs
  - CO₂

- **Economic**
  - Driveability
  - Water tolerance
  - Economic

- **Logistics**
  - Water tolerance
  - Material compatibility

- **Hydrosphery**
  - CO₂

- **Environmental**
  - Emission reduction
  - Energy efficiency
  - Fuel flexibility

- **Technology**
  - Octane rating
  - Blendstock
  - Refining

- **Future**
  - Future-ready
  - Sustainability

- **Integration**
  - Integration
  - Network

- **Innovation**
  - Innovation
  - Development

- **Regulatory**
  - Regulations
  - Compliance

- **Market**
  - Market
  - Demand

- **Policy**
  - Policy
  - Legislation

- **Incentives**
  - Incentives
  - Subsidies

- **Investment**
  - Investment
  - Savings

- **Technology**
  - Technology
  - Innovation
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 CO₂ 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

[^] Dual Blend-stock for Ethanol Blending
53% more bio-energy into E5 via “Co-blending”

<table>
<thead>
<tr>
<th>Parameter</th>
<th>“Alcohol-only” Ethanol</th>
<th>“co-blending” ETBE+ETOH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limiting Petrol Spec.</td>
<td>5%v/v ETOH</td>
<td>2.7%m/m O₂</td>
</tr>
<tr>
<td>Bio-energy Content</td>
<td>3.3%</td>
<td>5.1%</td>
</tr>
<tr>
<td>ETBE Content</td>
<td>0%</td>
<td>5.55%</td>
</tr>
<tr>
<td>Oxygen Content</td>
<td>1.8%</td>
<td>2.7%</td>
</tr>
<tr>
<td>O₂ Limit Exploitation</td>
<td>68.2%</td>
<td>100%</td>
</tr>
</tbody>
</table>
E5: “Co-blending” Enables Significant Non-compliance Penalty Saving (German Example)

“Alcohol-only” Ethanol

- Bio-energy Content
  - % increase [1]
  - %e/e
  - ∆% [1]
- Additional Penalty Avoidance Value
  - €/T PET
  - Mill-€/Y [2]

- Bio-energy Content
  - % increase [1]
  - %e/e
  - ∆% [1]
- Additional Penalty Avoidance Value
  - €/T PET
  - Mill-€/Y [2]

[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

Co-Blending

HCBS$_1$  
94.15\%v/v  
5.85\%v/v

ETBE

DBEB

ETOH

95\%v/v  
5\%v/v

E5

92.21\%v/v  
7.79\%v/v

E10

95\%v/v

HCBS$_2$

5\%v/v

10\%v/v

90\%v/v

Ethanol-Only

HCBS = HydroCarbon Blend-Stock

DBEB = Dual Blendstock for Ethanol Blending
Co-blending vs. Ethanol only: 2) E5 Bio-energy

**Co-Blending**

- HCBS$_1$ (94.15% v/v)
- ETBE (5.85% v/v)

**Ethanol-Only**

- DBEB
- ETOH (95% v/v)
- 5% v/v

Bio-energy Content

- E5 (5% v/v)
- 95% v/v

HCBS = HydroCarbon Blend-Stock
DBEB = Dual Blendstock for Ethanol Blending
### Co-blending vs. Ethanol only: 3) Dual-BOB quality

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Co-Blending</th>
<th>Ethanol-Only</th>
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<tbody>
<tr>
<td>Motor Octane Contribution Saving $^{(a, b)}$</td>
<td>1.8 MON</td>
<td>0.6</td>
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<tr>
<td>Vapour Pressure Compensation Need $^{(a, c)}$</td>
<td>6.3 kPa</td>
<td>7.8</td>
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<tr>
<td>E5 RVP «Give-Away» $^{(a, c)}$</td>
<td>0 kPa</td>
<td>1.84</td>
</tr>
<tr>
<td></td>
<td>0 %</td>
<td>3.06</td>
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(a) vs. Finished Petrol Specs  
(b) The Higher the Better  
(c) The Lower the Better

HCBS = HydroCarbon Blend-Stock
"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 CO₂ emissions."

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

"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

$\frac{T_{CO2}}{T_{ETBE}}$

<table>
<thead>
<tr>
<th>UPSTREAM</th>
<th>65%</th>
<th>+54%</th>
<th>DOWNSTREAM</th>
<th>35%$^{[1]}$</th>
<th>FIELD-TO-TANK</th>
<th>100%</th>
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<td>= 0.953</td>
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$^{[1]}$
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
- “Addition of an azeotropic ETBE/ethanol mixture in eurosuper-type gasolines”. Federal University of Rio Grande do Sul. 2006
- “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.