Bio-Ethers to Help OEMs Fulfilling their Sustainability Targets

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European Fuel Oxygenates Association

Biofuels in Central and Eastern Europe
Budapest, Hungary – 14th June 2012,

EFOA
The European Fuel Oxygenates Association

European Fuel Oxygenates Association

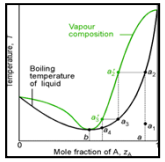
- **Non-profit Technical Organisation**
- **Founded in 1985**
- **~ 2/3rd of Total EU Etherification Capacity**

http://www.efoa.eu

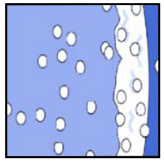
ETBE benefits for OEMs

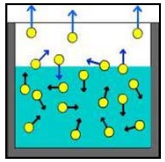

VOCs


IN-USE COMP.



AZEOTROPE


PERMEATION


VOLATILITY


COMINGLING

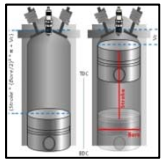

PM 2.5

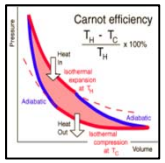
H/C RATIO

CO_2

BIO-ENERGY

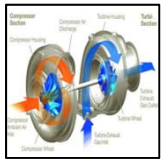

OCTANE

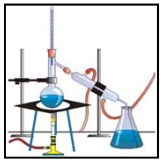

COMP. RATIO



ENER. EFFIC.

DOWNSIZING


TURBOCHARGE

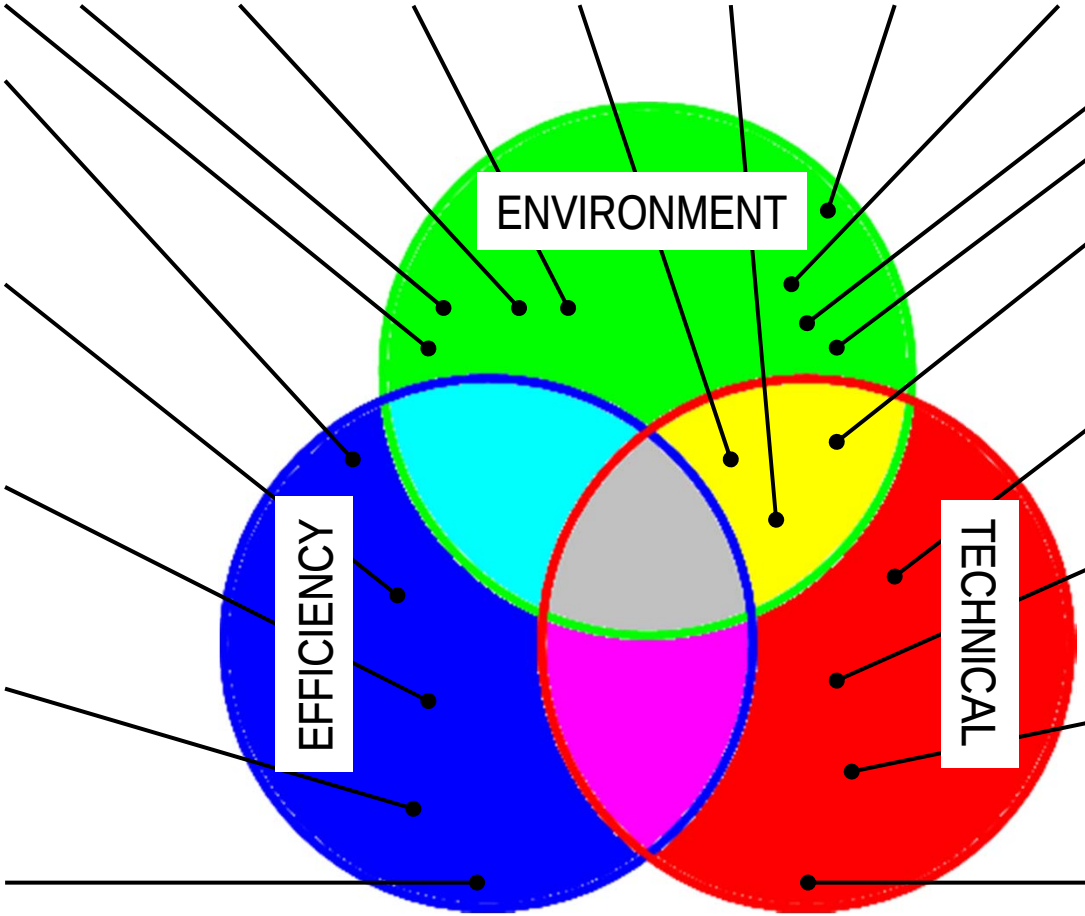

DISTILLATION


MATER. COMP.


DRIVEABILITY


WATER TOLER.

VAPOR LOCK



Car Efficiency Improvement Options: The Fuel Role

Fuel

Higher Compression Ratio

Displacement Downsizing

Turbocharging

Direct Injection and Lean Mixture

Start/Stop

Weight

Intelligent Alternator Control

Navigation

Hybrid-Drives, Electrification

Tires

Friction, Optimization

Aerodynamics

Fully variable Valve train

Dual Clutch, Automatic Transmission

Low Friction, Lube Oil

Air Conditioning

Thermal-Management Heat Recovery

Electrified Auxiliary Drives

Braking Energy Recuperation

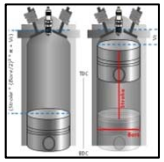
Fuel-related Options

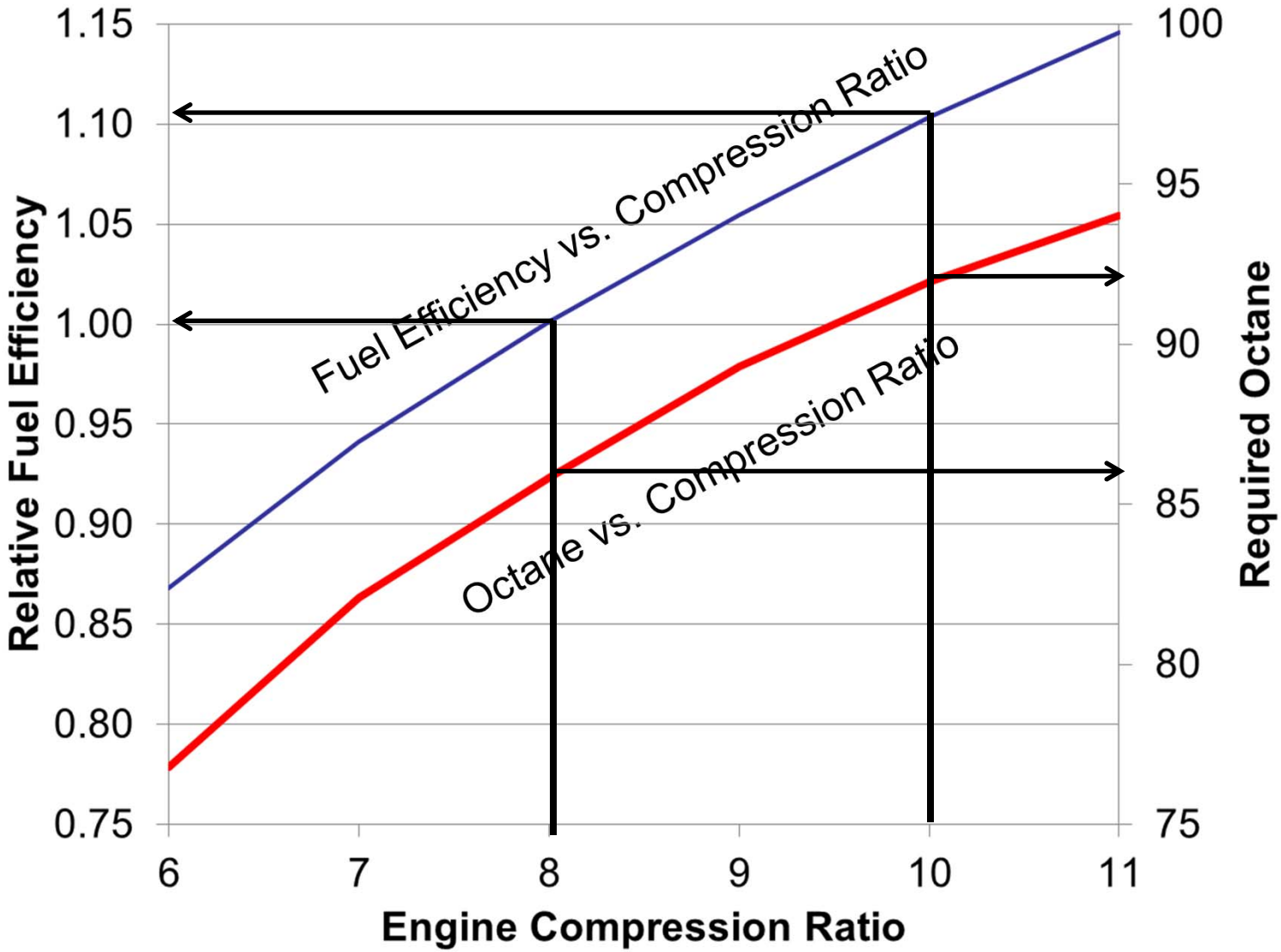
Higher Octane Benefits fort OEMs

- Higher fuel octane moves the knock limit further from normal operation:
  - Allows fully stoichiometric operation at high speed and high load
- Higher minimum fuel octane number helps reducing fuel consumption by improving the volumetric and thermal efficiency, enabling engine technologies such as:
  - Direct injection
  - Turbocharging or similar boost systems
  - Higher compression ratios
- Future powertrain solution will have a natural thirst for higher octane fuels
- Increased octane improves efficiency in current engines though reduced spark retard and enrichment at higher loads, and would unchain the performance of advanced SI engines technologies
- CO_2 benefit of 3–5% over drive cycles per higher ratio e.g., increase from 9.5:1 to 10.5:1 compression ratio

Source: FORD and RICARDO

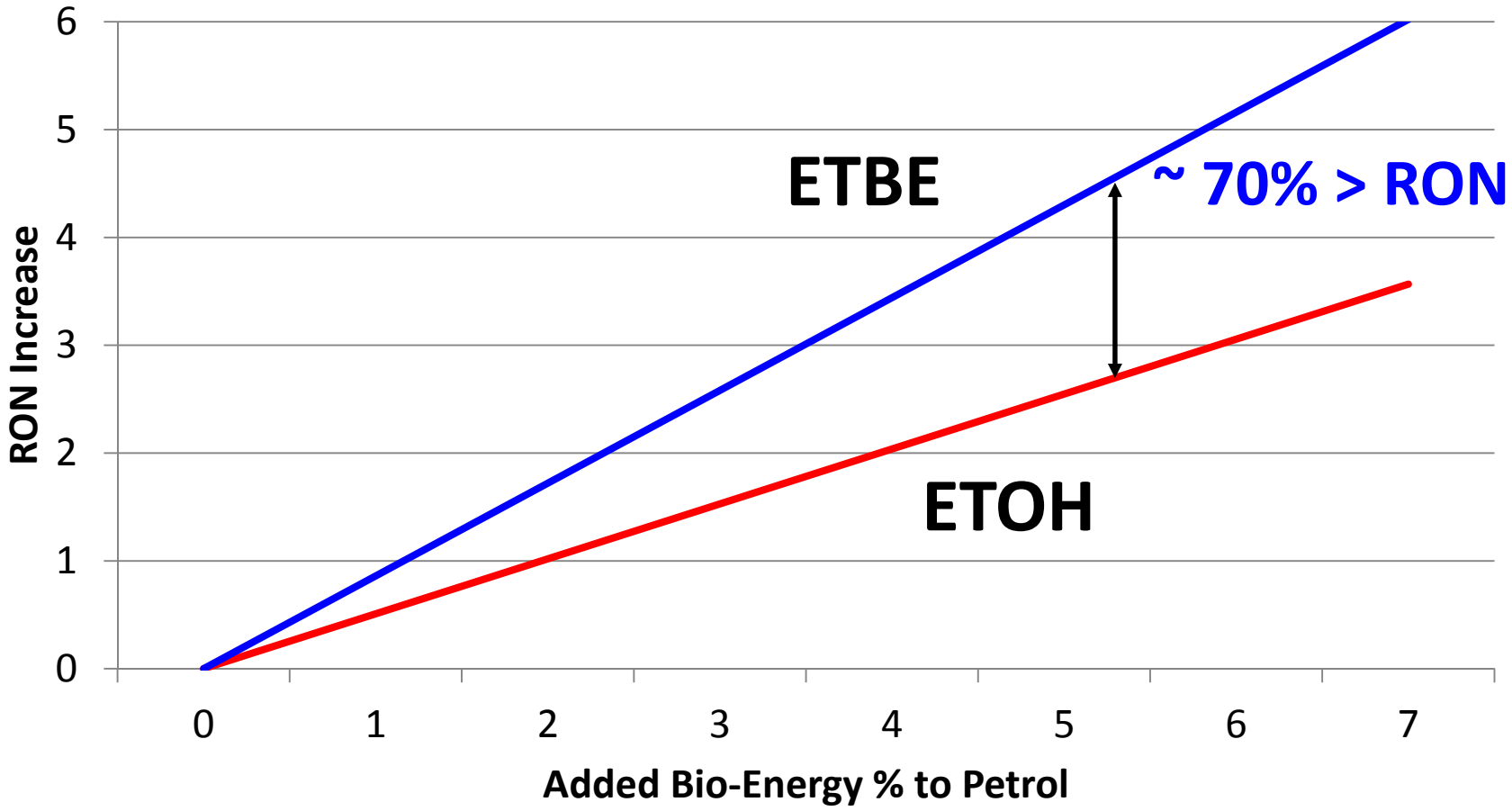
ETBE Octane Allows Improved Fuel Efficiency





With ETBE Significantly more RON @ same Bio-energy

(and with MON the effect is even significantly larger)



Octane Key for Engine Displacement Downsizing

- Downsizing and the use of the correct biofuels are both proven ways to reduce the well-to-wheels CO_2 emission of gasoline engine driven vehicles.
- For Downsizing to maintain full-load performance, pressure charging is required.
- This often results in a compression ratio reduction and an increase in over-fuelling at full load in order to protect exhaust components.
- Biofuels, which generally have higher octane ratings, seem therefore ideal for aggressively downsized engines, resulting in high levels of synergy.

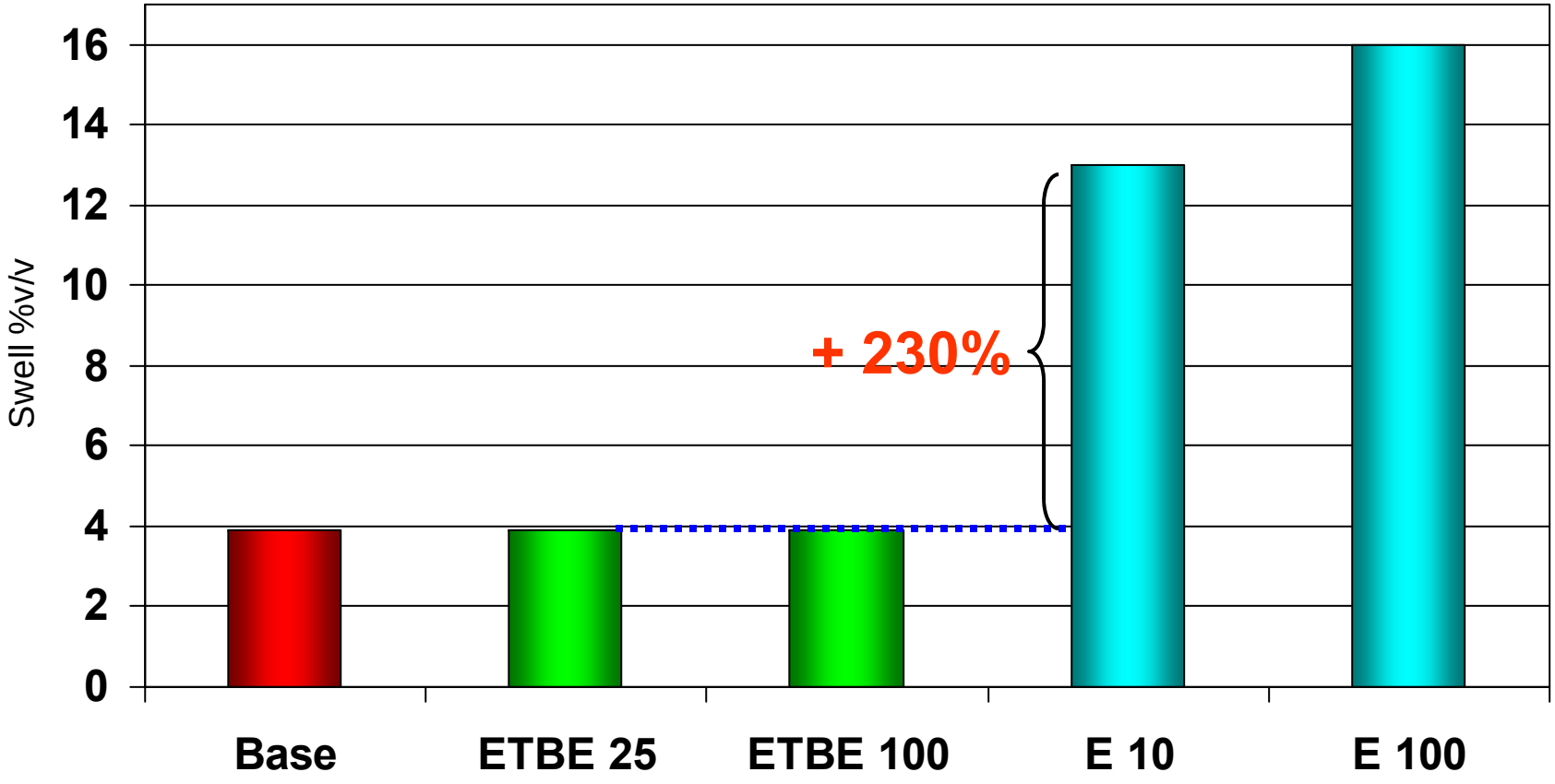
ETBE Prevents ETOH-Water Tolerance-related Risks

Phase Separation

- **Volume Loss**
  - Economic Damage
- **Octane Loss**
  - Engine Damages

Since ethanol and water readily dissolve in each other, when ethanol is blended to petrol, water will actually dissolve in the blended fuel to a much greater extent than in conventional gasoline. When the water reaches the maximum amount that the gasoline blend can dissolve, any additional water will separate from the gasoline. Phase separation in ethanol-blended gasoline, can be more damaging than with ether blends and straight gasoline. When phase separation occurs in an ethanol blended gasoline, the water will actually begin to remove the ethanol from the gasoline. Therefore, the second phase which can occur in ethanol blends contains both ethanol and water, as opposed to just water in ETBE blends and conventional gasoline.

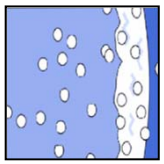
ETBE Fully Compatible with Fuel System

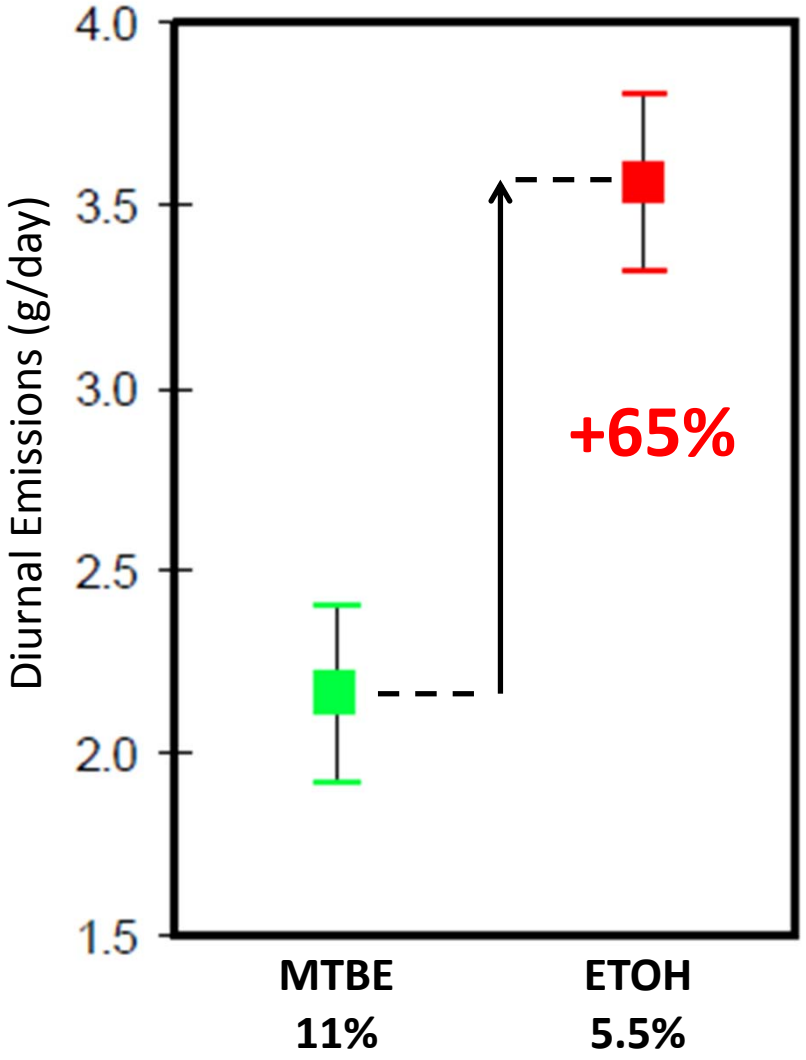


VITON TM A Fluor elastomer in Gasoline Blends and Neat Oxygenates Volume Swell after 168 Hours @ 23 C

Source: www-dupontelastomers.com/TechInfo/chemical.asp

Ethers Minimize Permeation Emissions

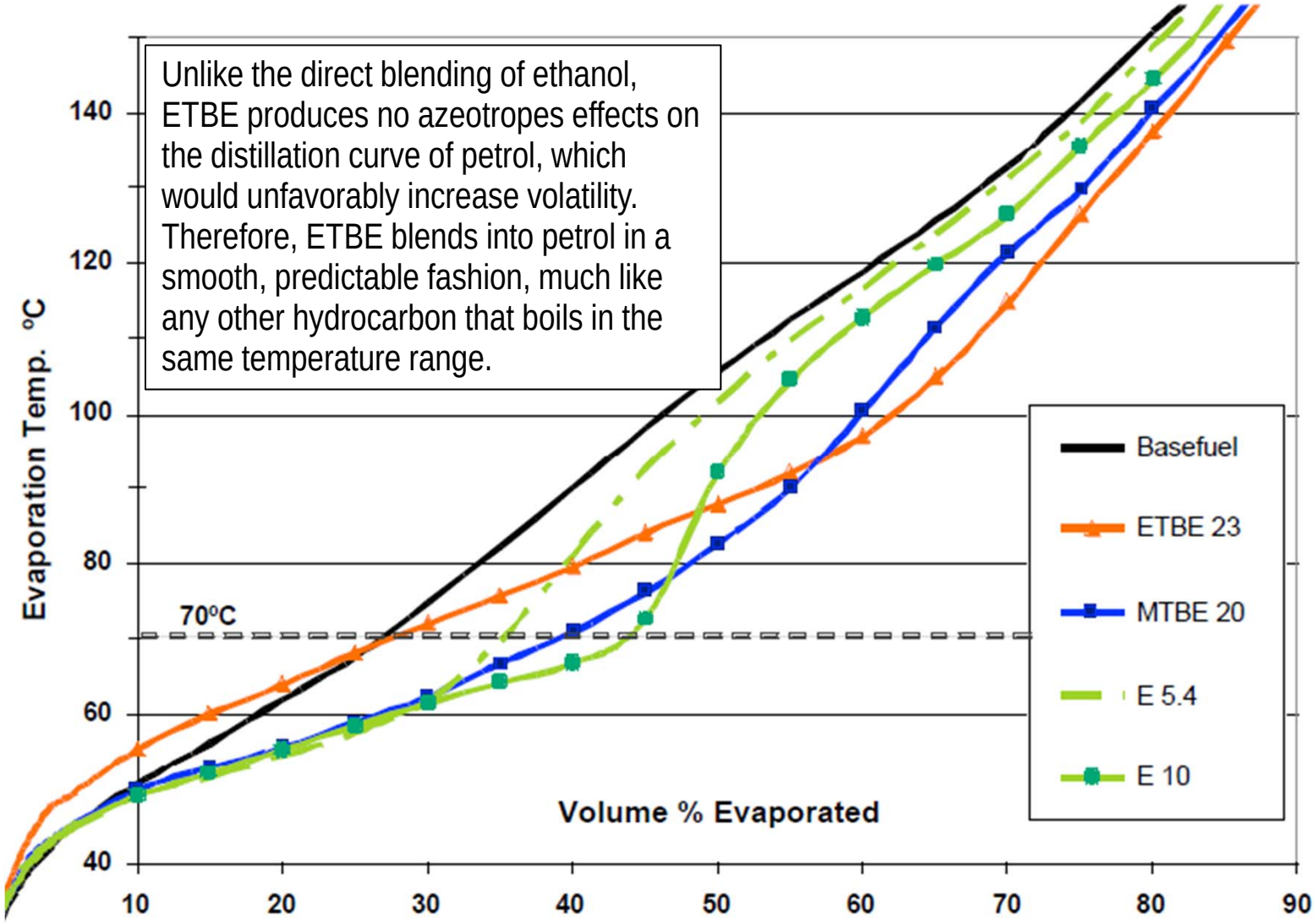




- Fuel permeation through polymer parts causes VOCs emissions.
- Permeation depends on fuel polarity, solvency and volatility.
- MTBE performs significantly better than ethanol.
- ETBE expected to look better than MTBE (lower solvency and volatility).
- Adding ethers to gasoline doesn't increase permeation emissions.

Source: "Fuel Permeation from Automotive Systems" CRC Project No. E-65 – Final Report (Sep. 2004)

ETBE Improves Petrol Distillation Profile Enhancing Drivability Performance Properties



ETBE Provides Low Vapor Volume for Better Hot Vapor Locking Performance

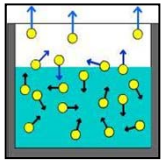
	Ethanol	Butane	MTBE	ETBE	C7 Isomer
Boiling Point (C)	78	0	55	72	79
Blending RVP kPa	138	379	54	28	24
M wt	46	58	88	102	100
Vapor/Liquid @ 70C	485	283	237	205	190
Vapor Ratio to C7	2.55	1.48	1.25	1.08	1.00

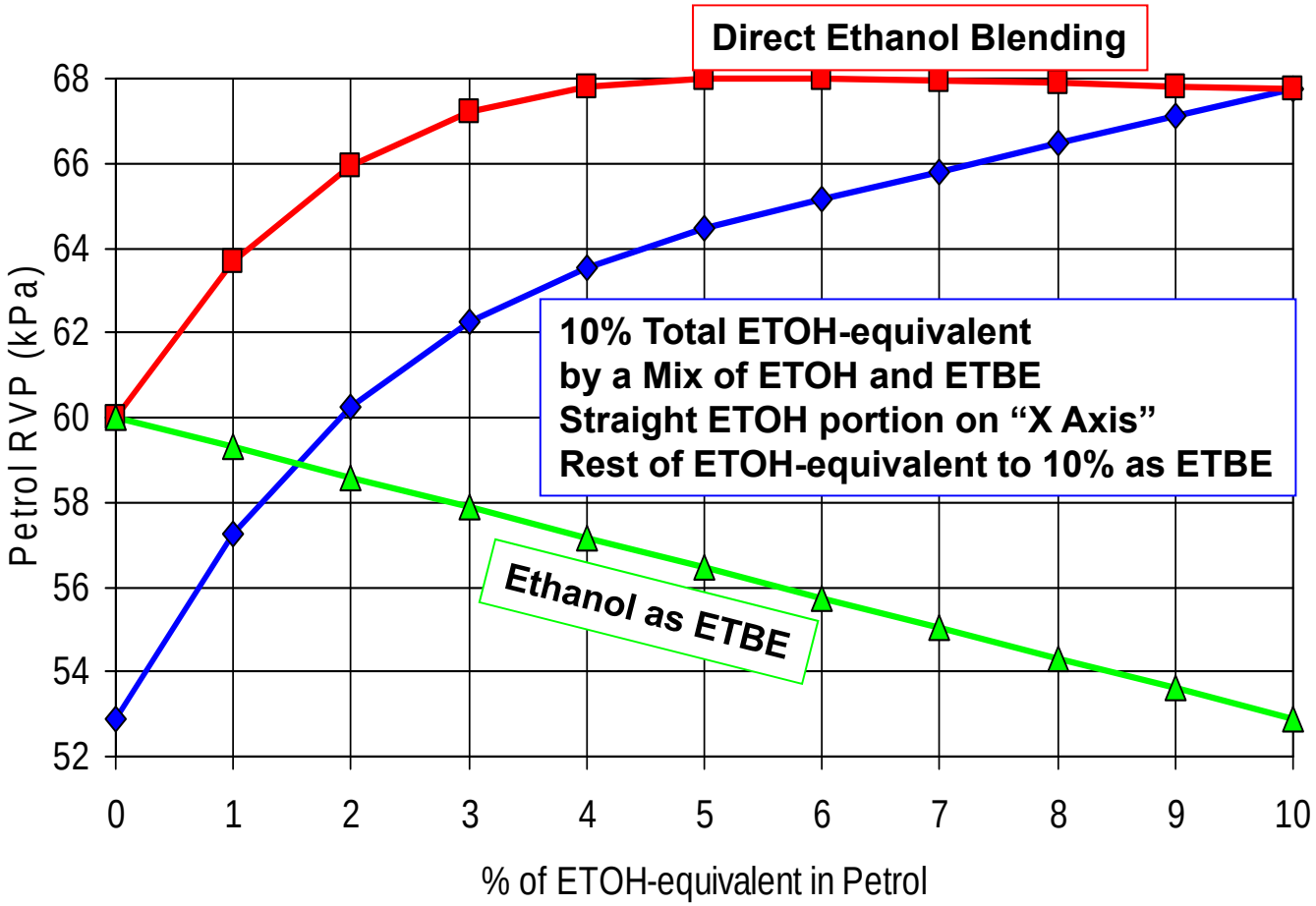
Increasing Vapor Volume During Volatization in Fuel Lines

Vapor locking occurs when vapor formation in the vehicle's hot fuel lines impedes the flow of liquid fuel to the engine. The amount of vapor volume generated during vaporization can make the vapor locking situation worse. The amount of vapor volume for vaporizing ETBE is similar to C7 hydrocarbons found in petrol. ETBE has much lower tendency than that for direct ethanol blending, by more than a factor of two.

Source: FUELS by HART Energy Publishing: "Bio-ETBE: The Right Road to High Quality 21st Century Motor Fuels"

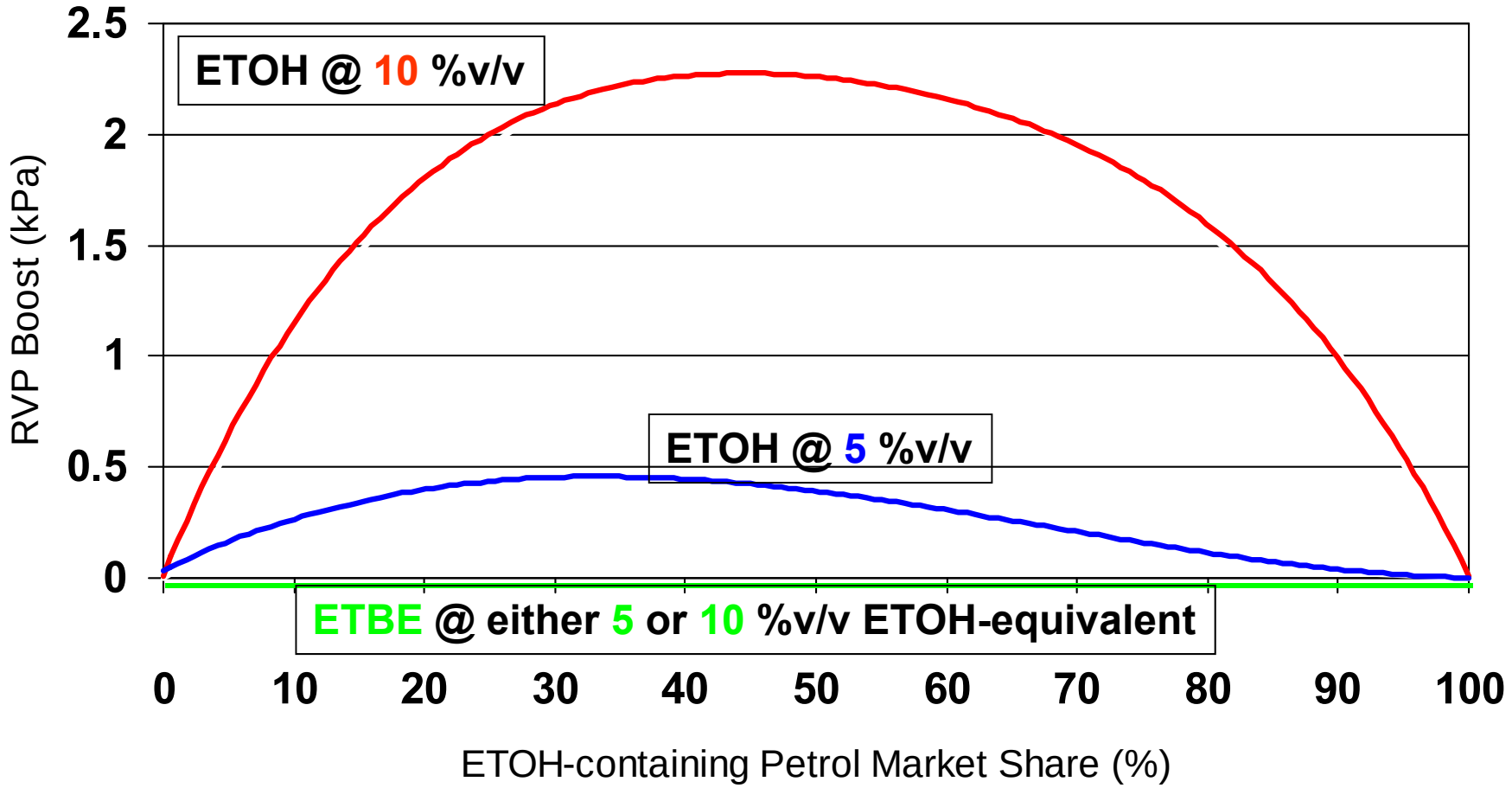
ETBE Addresses Ethanol Volatility





ETBE does not Cause Comingling

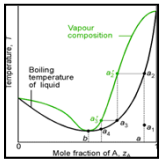
(and commingling makes pumps on-spec petrol to be off-spec in car tank)

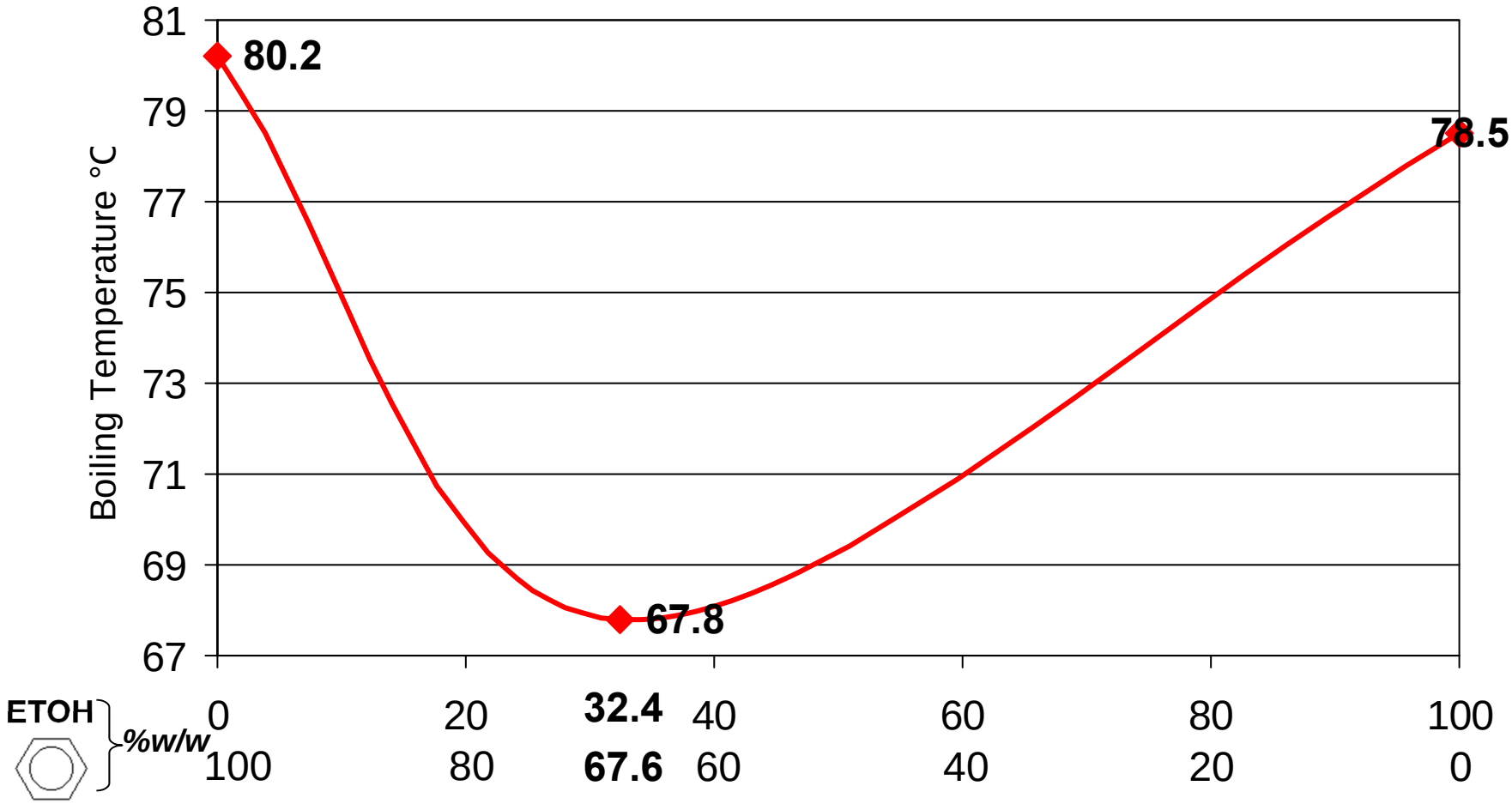


Source: Sierra, 2000

ETBE Avoids Ethanol Azeotropes Issue

(hence minimizing toxic emissions)



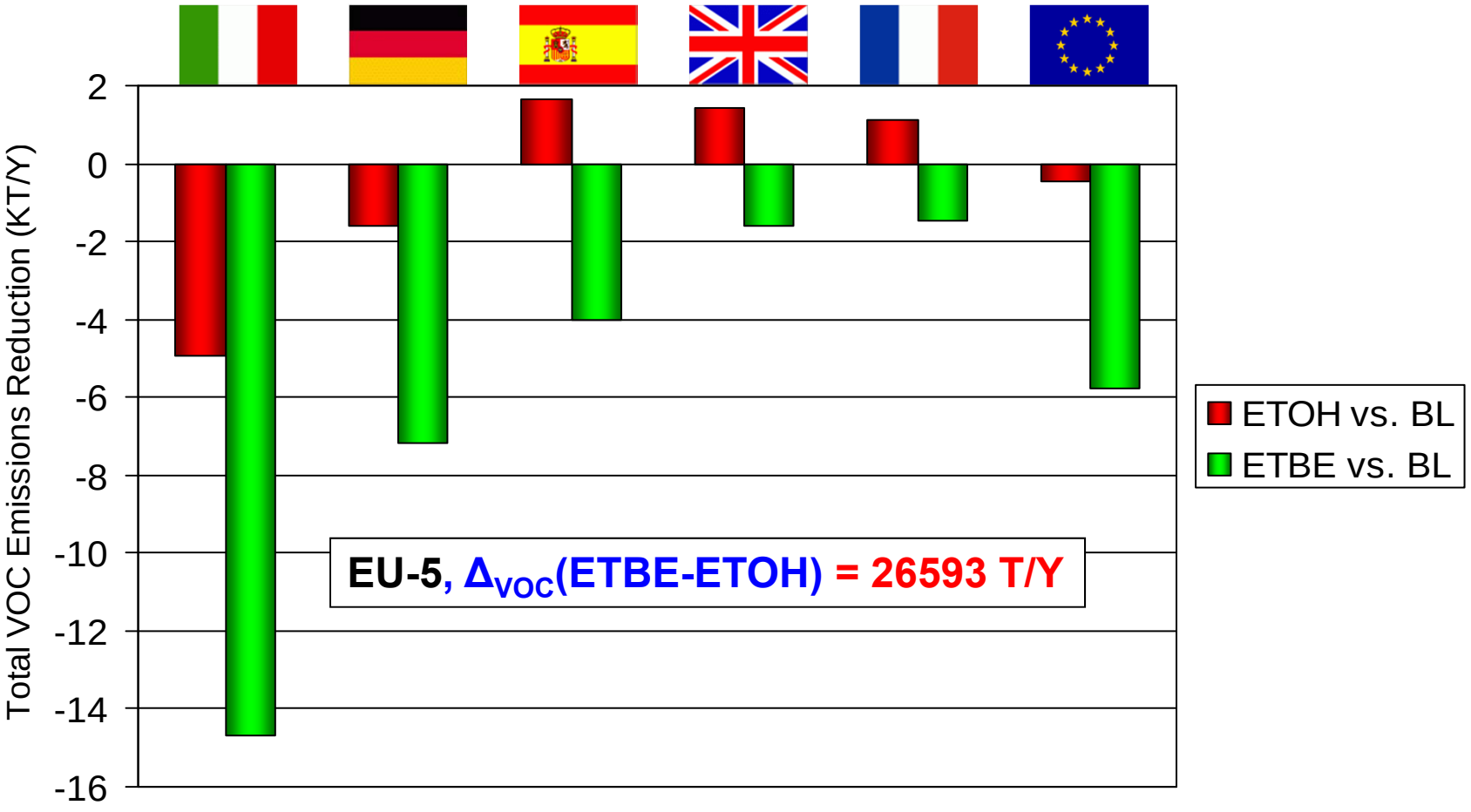


ETBE Improves “In-Use Compliance” Performances

- In addition to the legal commitment to design and build vehicles to meet emission standards for their useful life, an in-use compliance (IUC) program provides information about real life emission behavior of production vehicles and provides an early feedback of possible system failures.
- Since emissions of vehicles in the field are, in the end, the important fact, and can be substantially higher than the type approval data, Germany launched, already in 1988, an In-Use Compliance (IUC) testing programme.
- IUC Testing in Sweden has an even longer story.
- EU Commission is currently working to modify Euro 6 driving cycles to capture ‘real world’ or off-cycle emissions.
- Two among relevant causes of “real world” vehicle emissions: carbon canisters performance and permeation behavior.
- Fuel-ethers ensure significant better-than-ethanol in-use compliance performances, mainly due to their lower polarity, hydrogen-bonding and azeotropes.

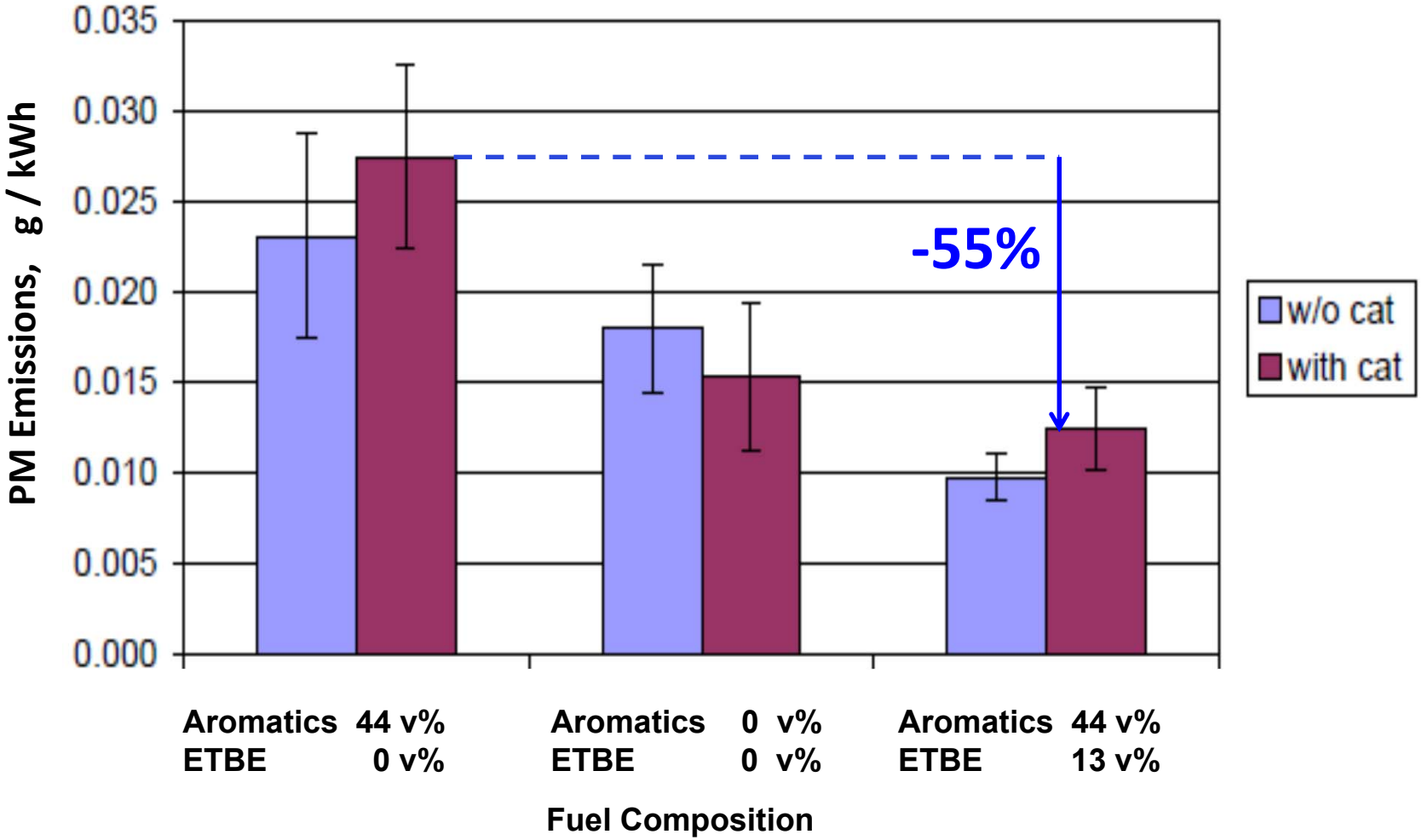
Greater VOC Reductions with ETBE

COPERT 2010



Source: Emissions and Health Unit - Institute of Environment and Sustainability - EC-JRC Ispra
"An assessment of the impact of ethanol-blended petrol on the total NMVOC emissions from road transport in selected countries"

ETBE Decreases PM Emissions



Source: Fuel Effects on Emissions from Non-Road Engines, VTT, 2003

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"

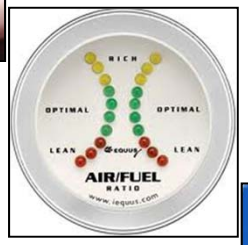
"High bio compete with food and feed"

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

Vehicle/Engines Compatibility/Operability

Fuel filter blockage

Galvanic corrosion



Enleanment

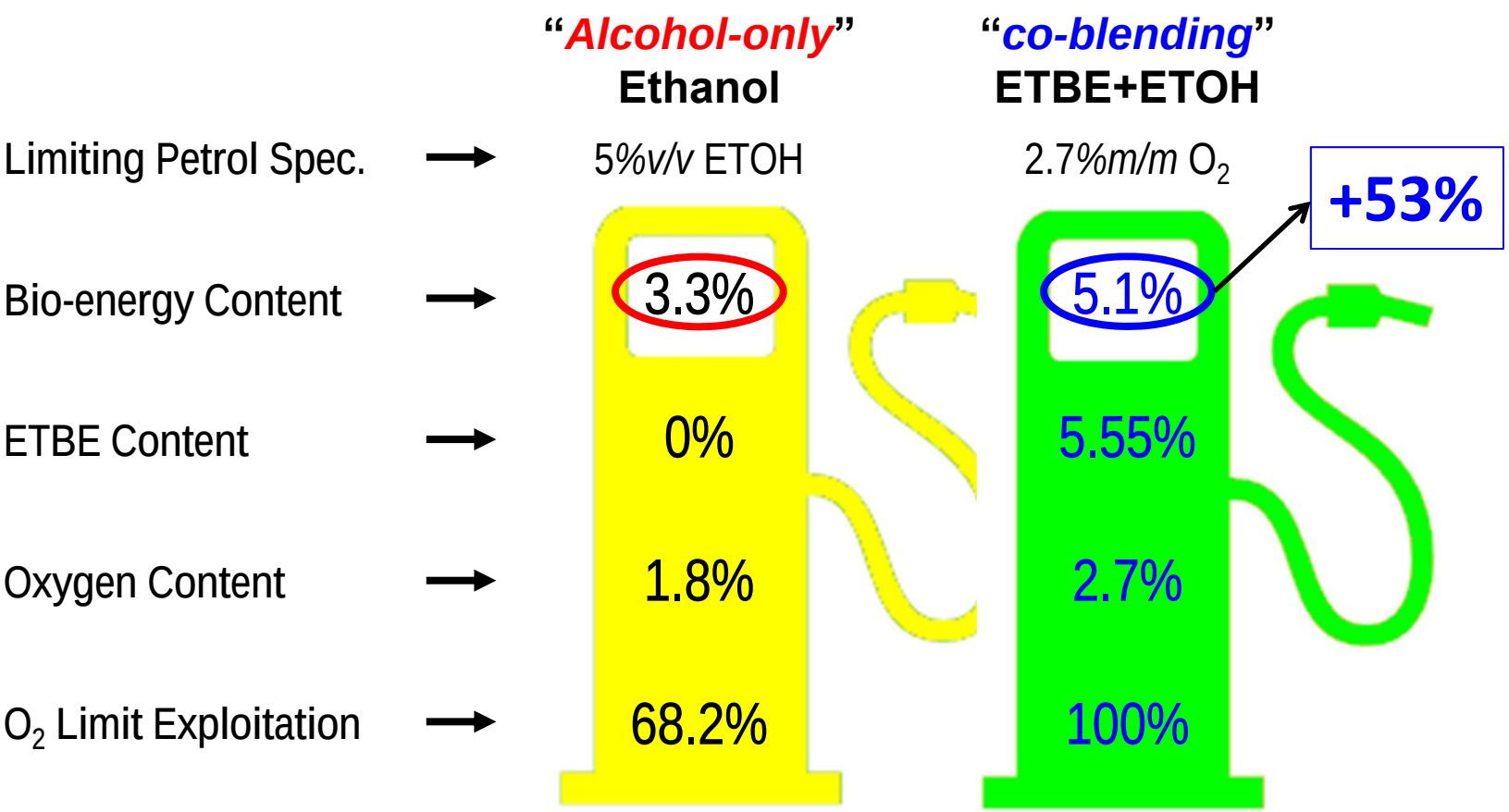
Drivability

Vapour Locking

Deposit formation

Material compatibility

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

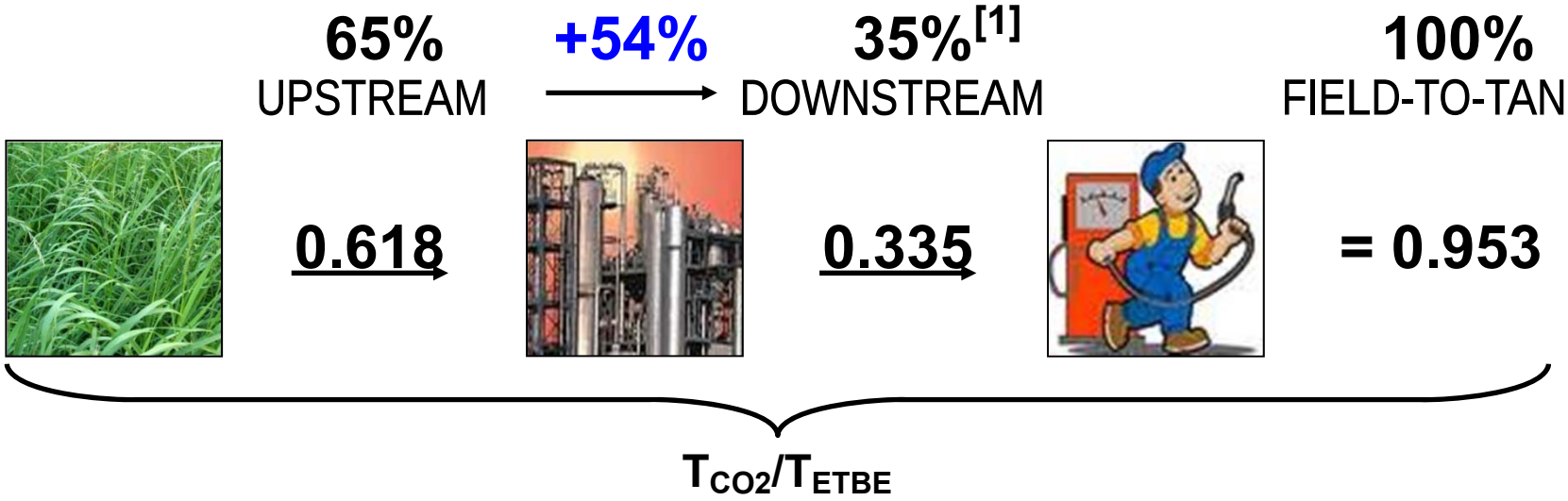


"Dual & Fully Fungible" E10

	ETOH	ETBE	ETOH-eq.	O_2	Vehicles Compatibility
	Max.				
	%v/v			*%m/m*	---
E5 (Protection Grade)	5	17.4	**5**/7.34	2.7	ALL
E10 ("Normal")	10	22	10	3.7	**OEMs List**
E10 "Dual & Fully Fungible"	**5**	22	**10**	3.7	**ALL?**

- Protection grade needed due to high-ethanol non-compatibility
- E10 needed to enable higher bio-energy blending
- E10 currently not usable by significant part of the existing car fleet
- An E10 with ETOH @ max. 5%v/v would both conjugate "*vehicle protection*" and "*bio-energy maximization*", and enable a "*single petrol grade*" on the market

ETBE: Two Relevant CO_2 Saving Contributions



[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.

ETBE CO_2 Performance Studies: References

Study on Relative CO2 Savings Comparing Ethanol and ETBE as a Gasoline Component
Hart Energy Consulting
July 2007

ETBE and Ethanol: A Comparison of CO2 Savings
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Bioenergy from grain and sugar beet: Energy and greenhouse gas balances
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Conclusion

ETBE, both blended alone or co-blended with ethanol, represents an effective, immediate and practical avenue to address car makers ambitious environmental and efficiency targets. It enables significantly higher bio-energy content, lower VOCs, CO_2 and PM emissions, more efficient engine technologies, while remaining fully compatible with old and new vehicles