ETHANOL USE AND THE AUTOMOTIVE INDUSTRY

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SUSTAINABLE MOBILITY: ETHANOL TALKS INDIA

MOBILITY CHALLENGES DRIVING ENGINES DEVELOPMENT

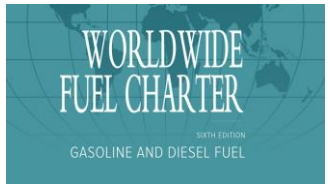
Focus on Alternative Fuels Improved considerably in the last decades – oil crisis

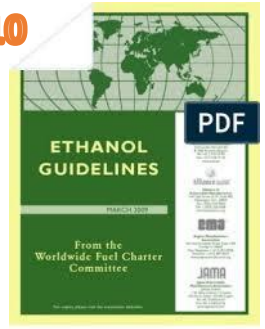
At the beginning big part of field problems in Brazil were caused by bad fuel quality and no experience on high % of Ethanol

Most of the material improvements were also needed for modern technologies, like fuel injection and turbocharging, standard today

E10 is accepted worldwide, higher blends up to E20 can be used checking compatibility with the OEM

Fuel Spec improved with E10 and Ethanol guidelines





Station Filtration on dispensers adapted for alcohols

Aluminum or steel coated when in touch with fuel

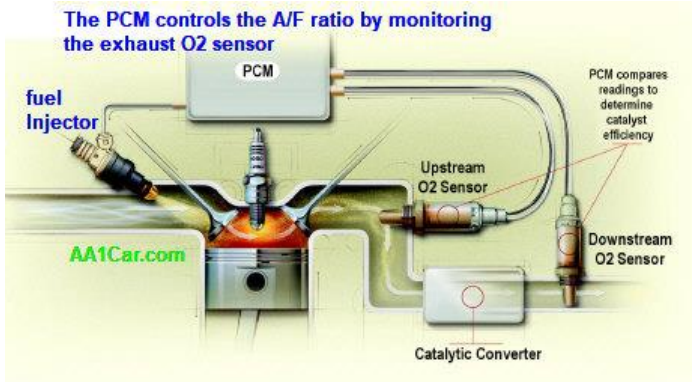
Plastics like PA 6.6 replaced by PA 12

Sealing, gaskets, o-rings made of Fluorinated Elastomers (VITON)

MOBILITY CHALLENGES DRIVING ENGINES DEVELOPMENT

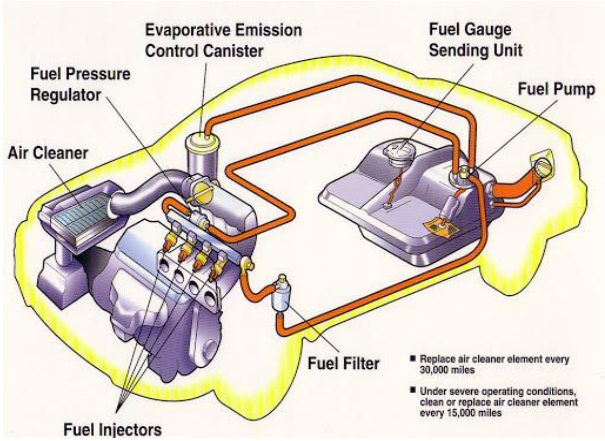
Emission control demands improved flexfuel capability

New fuel systems improved air-ratio control identifying changes on fuel composition or etanol blends



Brazil developed a flexfuel system without the need of an expensive fuel composition sensor using closed loop controls allowed ethanol content recognition.

New fuel systems to improve emissions and components durability work better for etanol blends as well . For legal reasons OEM defines the Ethanol blend compatibility.



In 2015 after tests carried out with on series vehicles with OEM participation, E27 was released in Brazil for local produced cars. imported vehicles run on E25

SUSTAINABLE MOBILITY: ETHANOL TALKS INDIA

ETHANOL BLENDS EFFECT ON POLLUTANT EMISSIONS DEPENDS ON ENGINE TECHNOLOGY.

MODERN ENGINES, GASOLINE DIRECT INJECTION (GDI) USES THE WHOLE ETHANOL PROPERTIES ADVANTAGES.

North Caroline State University

NCSU – E10 X E25 Current Fleet Vehicles **(SPI)**

- E25 less 30-40% UFP (ultrafine particulates)
- E25 reduced CO by 15-30%
- No change in NOx

University California Riverside

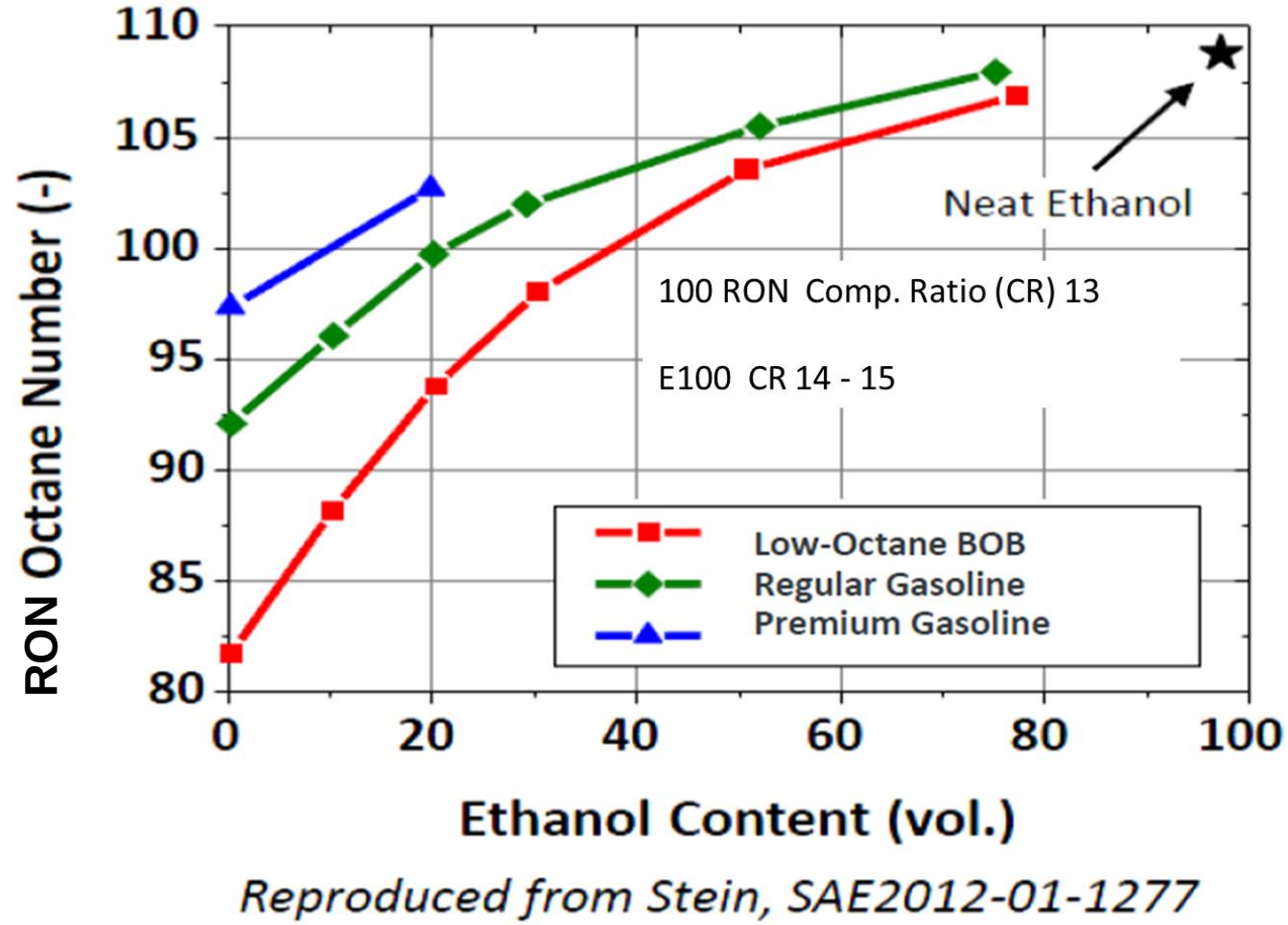
UCR – E10 x E25 Current Fleet Vehicles **(MPI)**

- E25 10-30% NOx reduction

EMPA, Swiss Federal Laboratories

- (E0) x (E10 and E85) Euro-5 **GDI**
- Particle number emissions E10 and E85 lowered by 97 and 96%
- CO dropped by 81 and 87%
- CO_2 reduced by 13 and 17%
- PAHs lowered by 67-96% - E10, by 82 – 96% - E85
- Genetoxic potentials dropped by 72 and 83%

ETHANOL BLENDING EFFECT ON OCTANE NUMBER

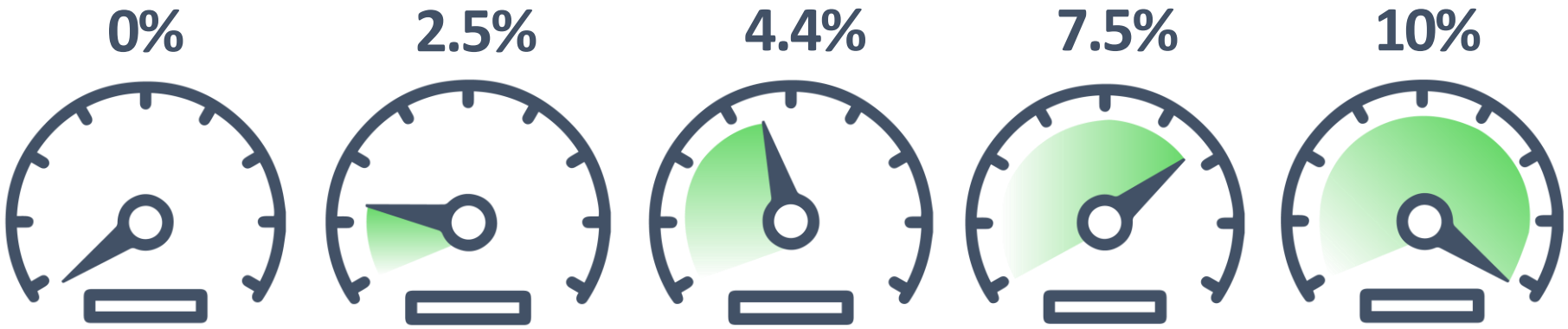


Reproduced from Stein, SAE2012-01-1277

EFFECTS OF IMPROVING OCTANE PROPERTIES RON AND SENSITIVITY

MON-Motor Octane Number the original method to indicate knocking resistance.

For downsized, down speed (rpm) and high compression ratios engines RON-Research Octane Number is more representative



Gasoline Sensitivity ~ 8 **Ethanol Sensitivity ~ 12**

The sensitivity (RON-MON) became an important indicator of fuel properties for modern engines

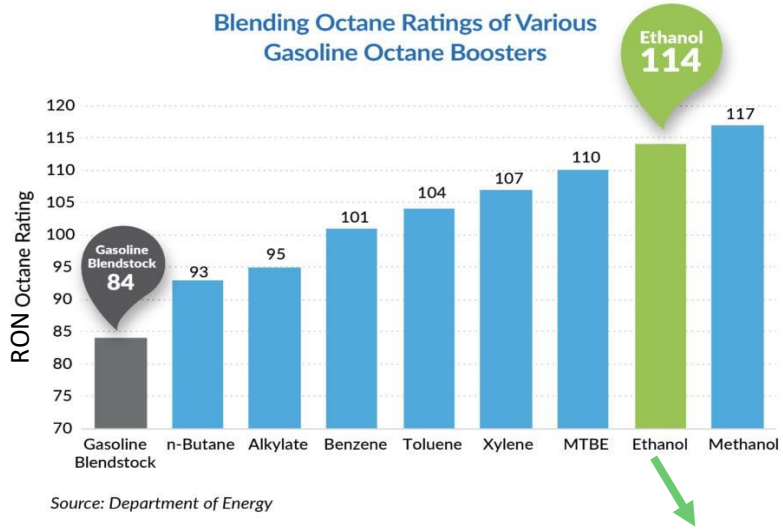
HIGH OCTANE FUELS (HOF)

Higher than 95RON

HIGHER OCTANE -> HIGHER COMPRESSION RATIOS -> INCREASE FUEL EFFICIENCY. ALLOW ENGINE DOWNSIZING AND DOWN SPEED TRENDS.

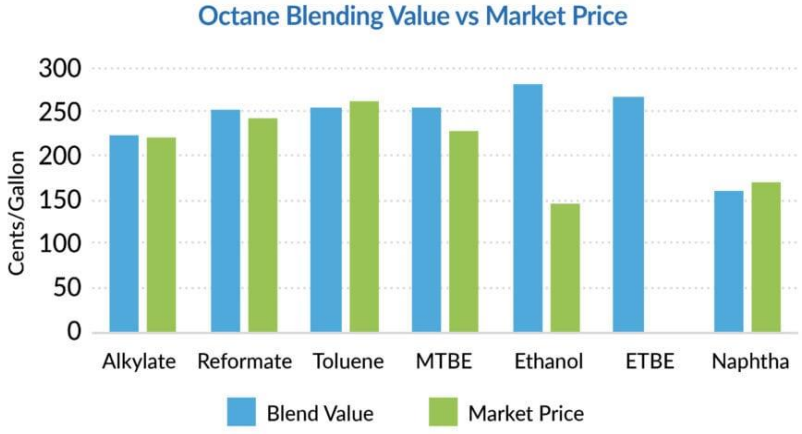
COMMON BOOSTERS TO OCTANE NUMBER:

- INCREASE THE VOLUME OF GASOLINE AROMATICS (BTEX) OR
- INCREASE THE VOLUME OF ETHANOL



Source: Department of Energy

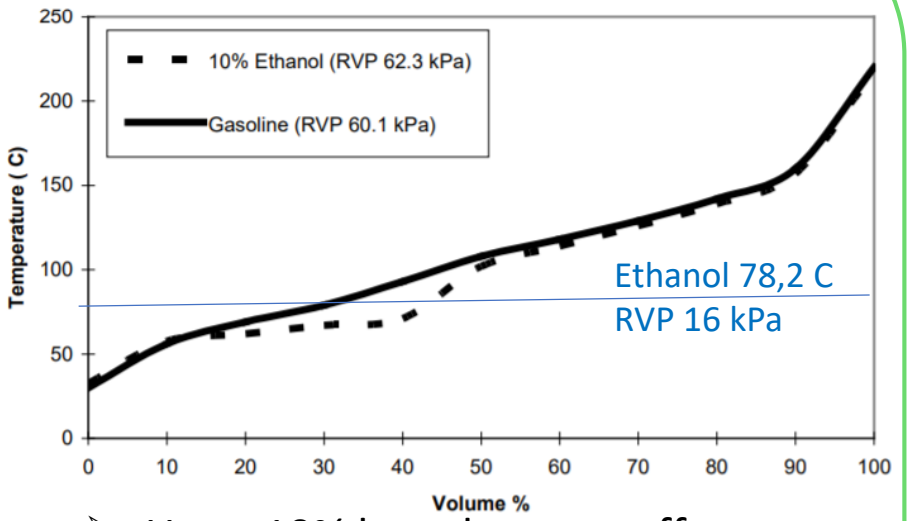
LOWER EMISSION and GHG



Source: Argus Media

Differences between Gasoline and Ethanol Properties

Distillation



- Up to 10% by volume no effect on engine adjustment.
- Up to 20% combustion sensors must learn the new % and adjust it
- Current systems are able to control up to E25

Differences between Gasoline and Ethanol Properties

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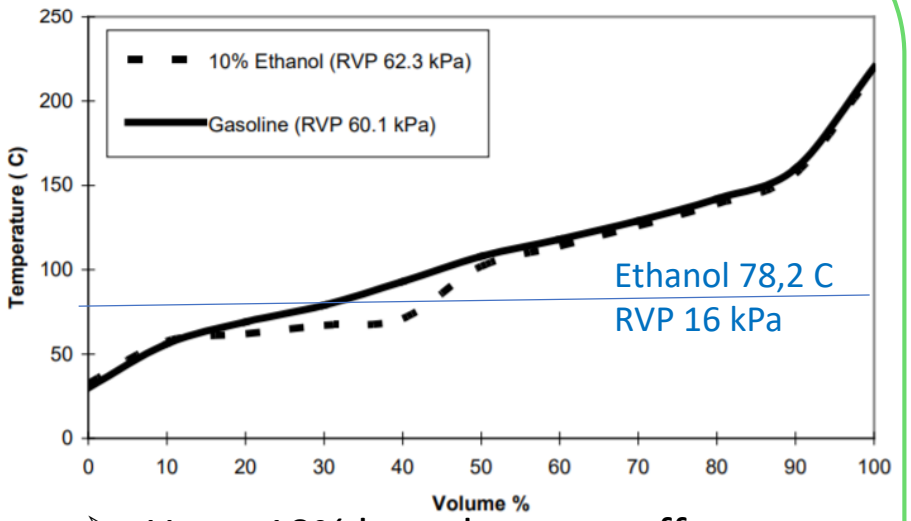

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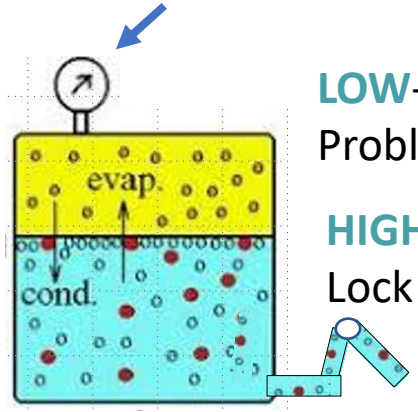
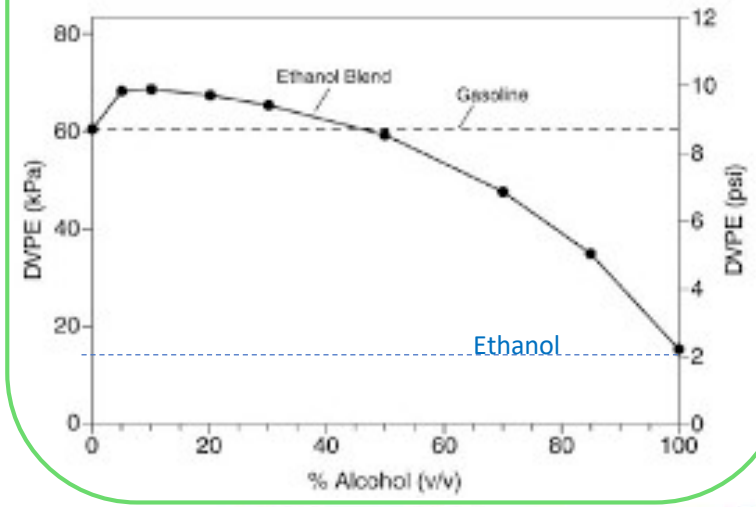
Vapor Pressure



LOW-Cold Start Problems

HIGH -Vapor Lock



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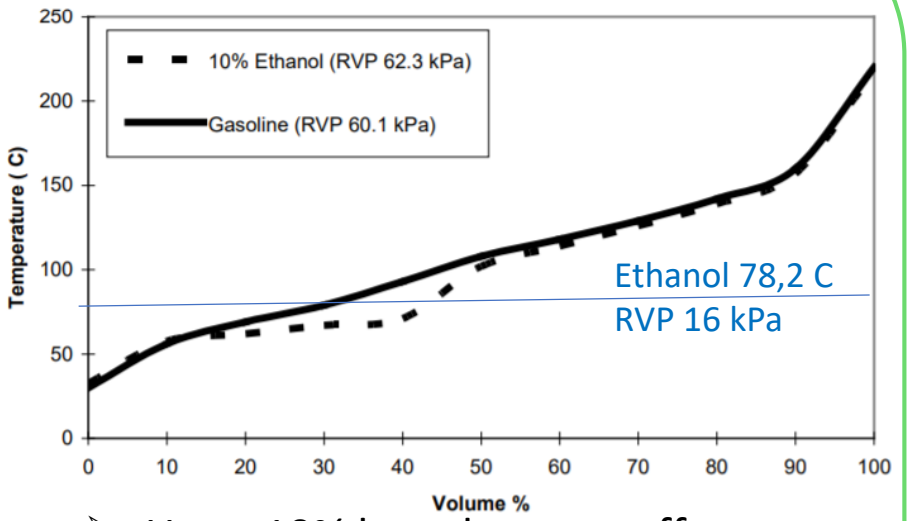

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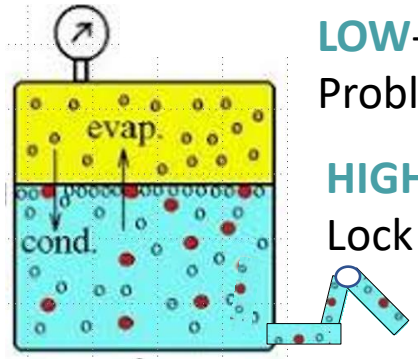

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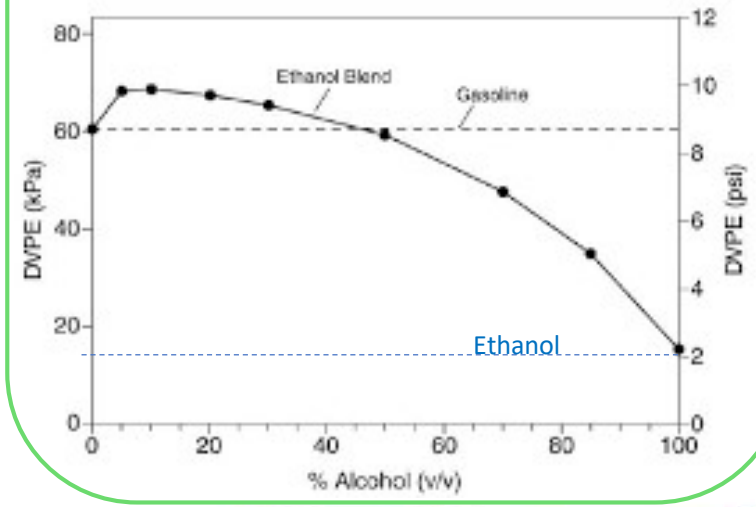
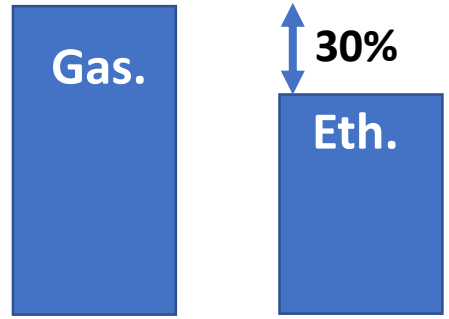


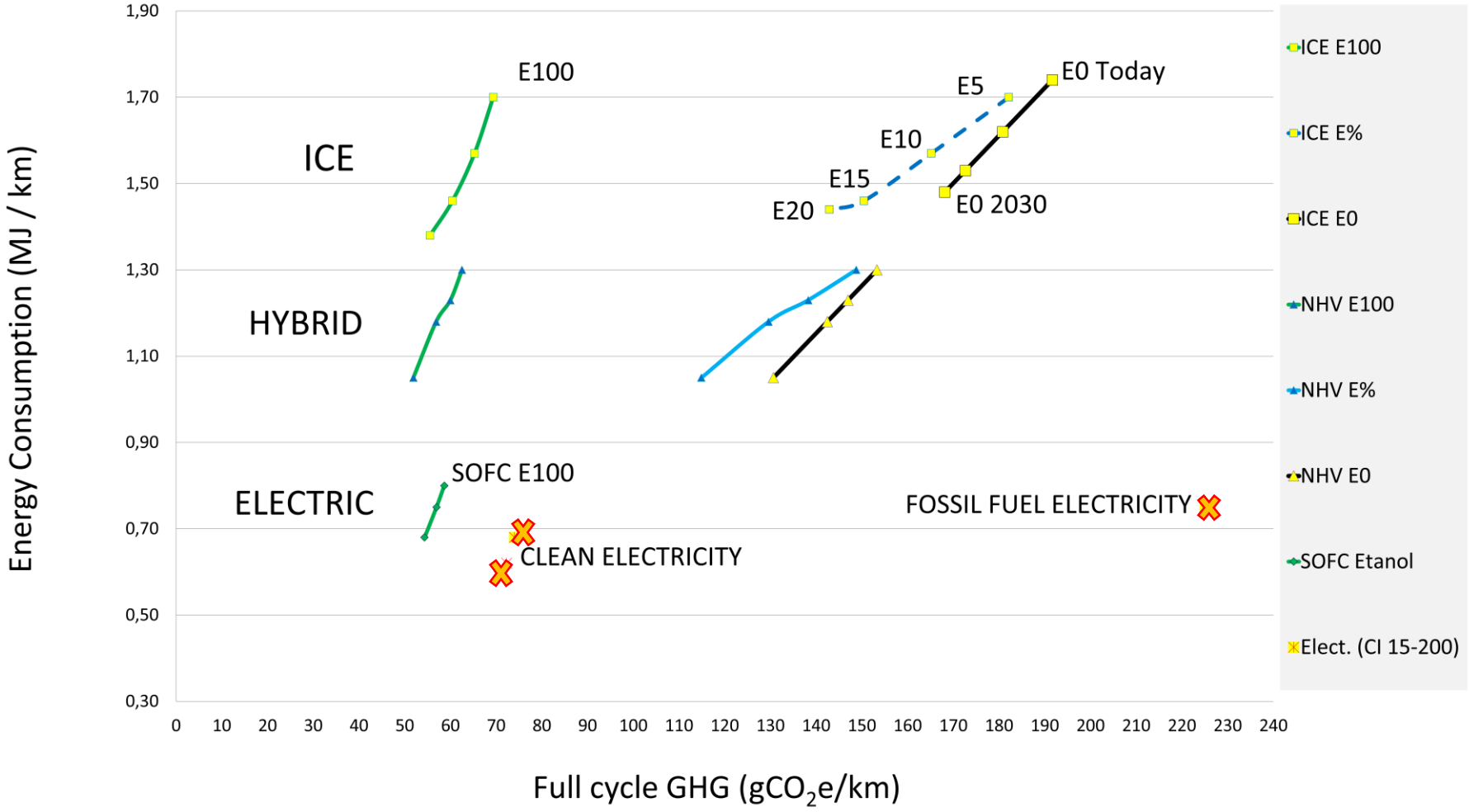
Energy Content by Volume



- E blends lower energy is offset by the higher RON.
- Fleet vehicles RON 95->98 became 3% more efficient.
- Matching engine and vehicle E10~E30 achieved same range.

ETHANOL BLENDS AND OTHER SOLUTIONS TO REDUCE MOBILITY ENVIRONMENTAL IMPACTS - GHG (Greenhouse Gas)

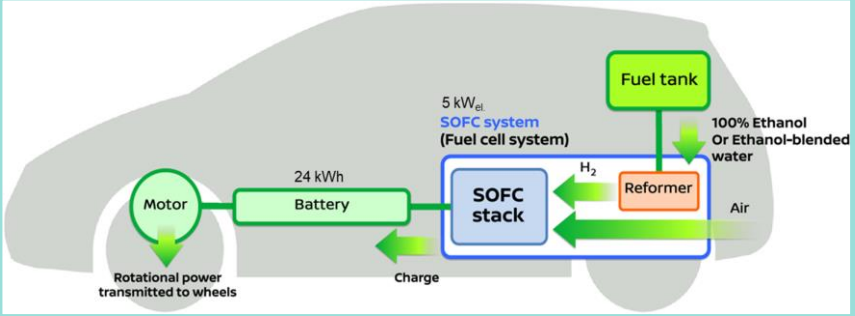
Vehicle Full Cycle GHG= Well-to-Wheel GHG + (Vehicle + Battery Production) GHG (gCO_2e/km)



FLEX HYBRID

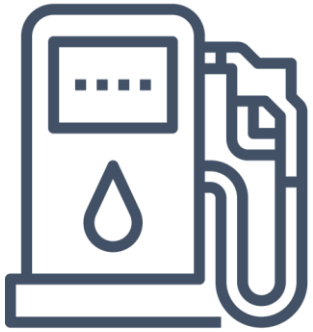
ELECTRIFICATION IS NOT "BATTERYZATION"

Battery 1,3 kW.h, Less than 5% than an electric vehicle

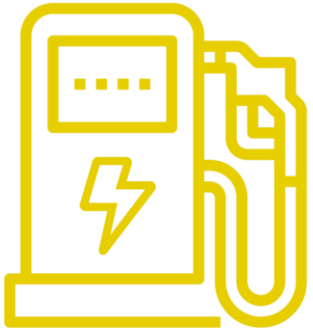


Ethanol is renewable "liquid hydrogen" when used in a Fuel Cell, eliminating the high cost cryogenic, titanium tank (700 bar)

ALL COMBINATIONS WILL BE NEEDED FOR A LOW CARB SOCIETY

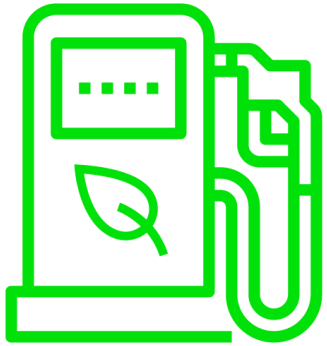


HC



Elect.

H_2



Bio

Ethanol allows a quick and sustainable transition

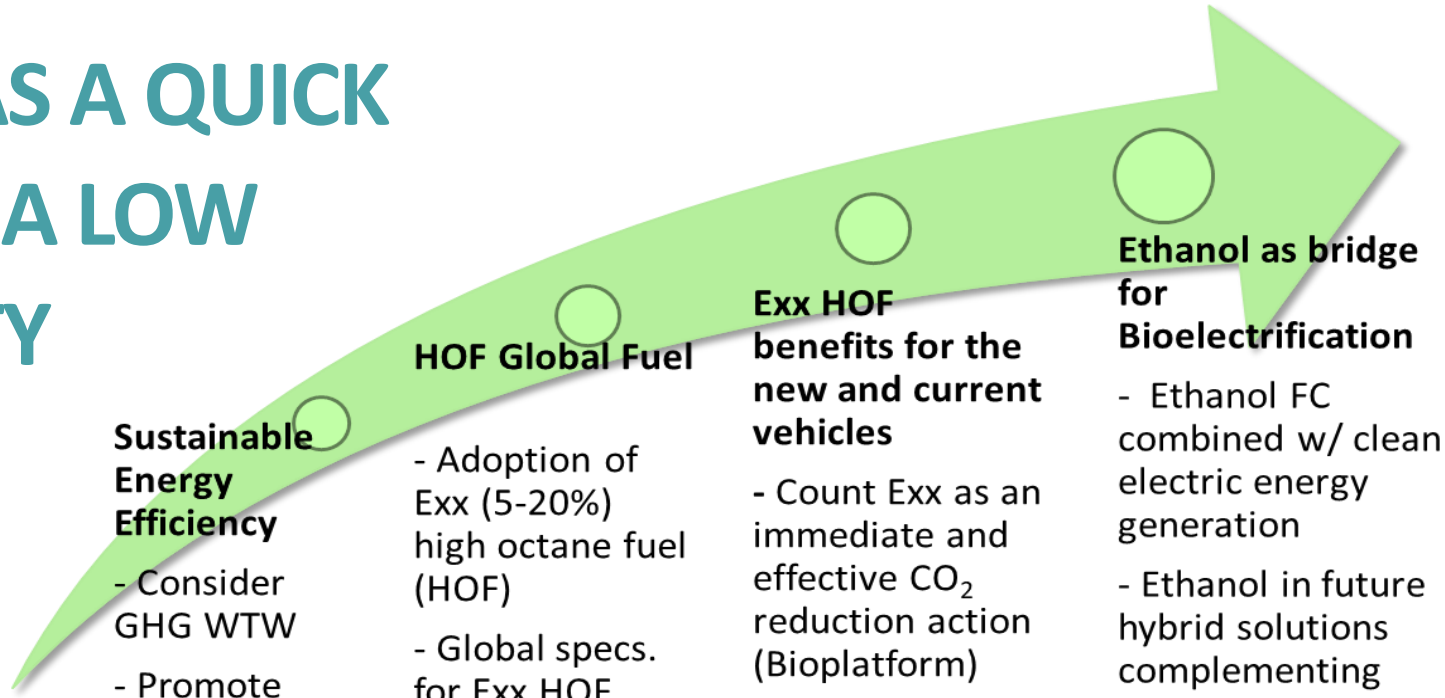
HC + Bio: extends fossil fuel use full life with lower GHG

HC + Elect.: with small battery reduces GHG by lowering HC consumption

Elect.+H_2: Fuel Cell improves Electric cars GHG by reducing battery size

Elect.+H_2 + Bio: Ethanol Fuel Cell, renewable, efficient and low GHG

ETHANOL HOF AS A QUICK TRANSITION TO A LOW CARBON SOCIETY



Sustainable Energy Efficiency

- Consider GHG WTW
- Promote ethanol as Octane improver

HOF Global Fuel

- Adoption of Exx (5-20%) high octane fuel (HOF)
- Global specs. for Exx HOF regular 95 RON and Premium 98 RON
-

Exx HOF benefits for the new and current vehicles

- Count Exx as an immediate and effective CO_2 reduction action (Bioplatform)
- Develop Exx hybrids - low GHG small batteries

Ethanol as bridge for Bioelectrification

- Ethanol FC combined w/ clean electric energy generation
- Ethanol in future hybrid solutions complementing bio electrification for Heavy Duty Vehicles

SUSTAINABLE MOBILITY: ETHANOL TALKS INDIA

REALIZATION:

isma™ indian sugar mills association

BRAZIL Sugarcane Bioenergy Solution

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