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How Auto Industry is gearing up to E20 fuel?

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India's GHG Commitment, Energy Security & Pollution Concerns

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- 3rd largest consumer of Crude Oil (India)
- More than 80% of India's Energy demand met with imported fuel
- India is 4th highest contributor to GHG emissions
- Reducing the energy emissions intensity: 33%-35% by 2030 as per the NDC targets agreed in COP 21 at Paris

'India' pledge at Copenhagen ,Dec'09)

...(India' pledge at COP21 ,Nov'15)

Improving India's Energy Security, GHG and Local pollution : Priority National objectives

Approach : Fuels diversification for National Priorities

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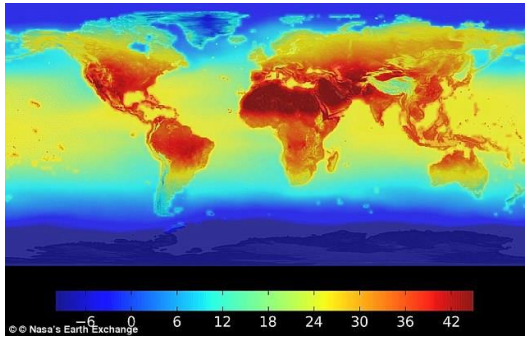

Industry is aligned to achieving National Objectives

Industry is committed to diversification of fuel to achieve

Lower CO_2

&

Reduction of Crude Oil imports

while also reducing Local Pollution

Auto-Industry tryst with alternate fuels

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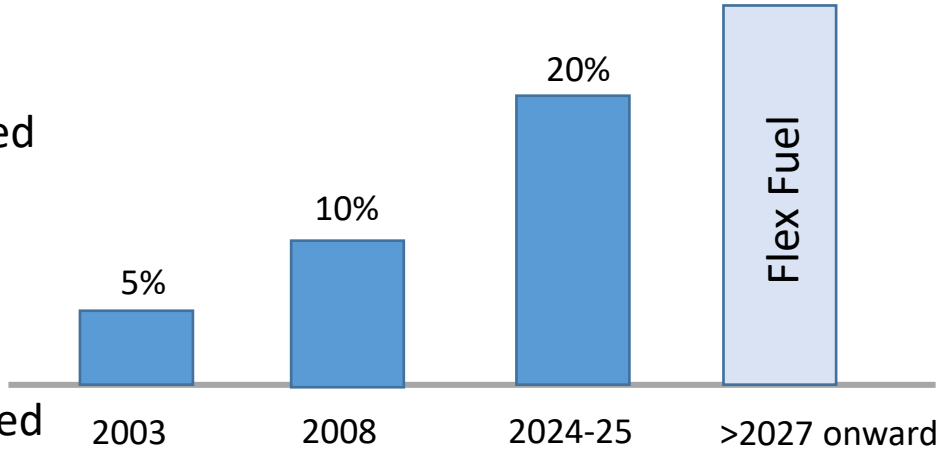
1. Natural Progression

- E10 Material compatibility ensured in all new production since 2008
- As Pan India E10 being targeted, Vehicles Performance & FE next step linked with RON 95 availability
- Technology upgrade to E20 new vehicles will be completed by 2024
- Existing Vehicles have concerns on E20, hence, protection grade E10 needed
- E20 could pave way for flex fuel Ethanol vehicles in future with fuel availability increase.



2. Customer Acceptance

- Ethanol Blended fuel has lower energy, hence, commensurate pricing essential
- Availability across the nation will help in achieving acceptability (Low Hanging fruit)
- Is less Corrosive and does not have major health issues, however, hygroscopic and water separaton issues

3. Fuel Availability

- Considering requirement across country, Ethanol requirement to be ensured across country to reap benefit with **"ONE NATION ONE FUEL "** anthem.

Demonstration of industry commitment

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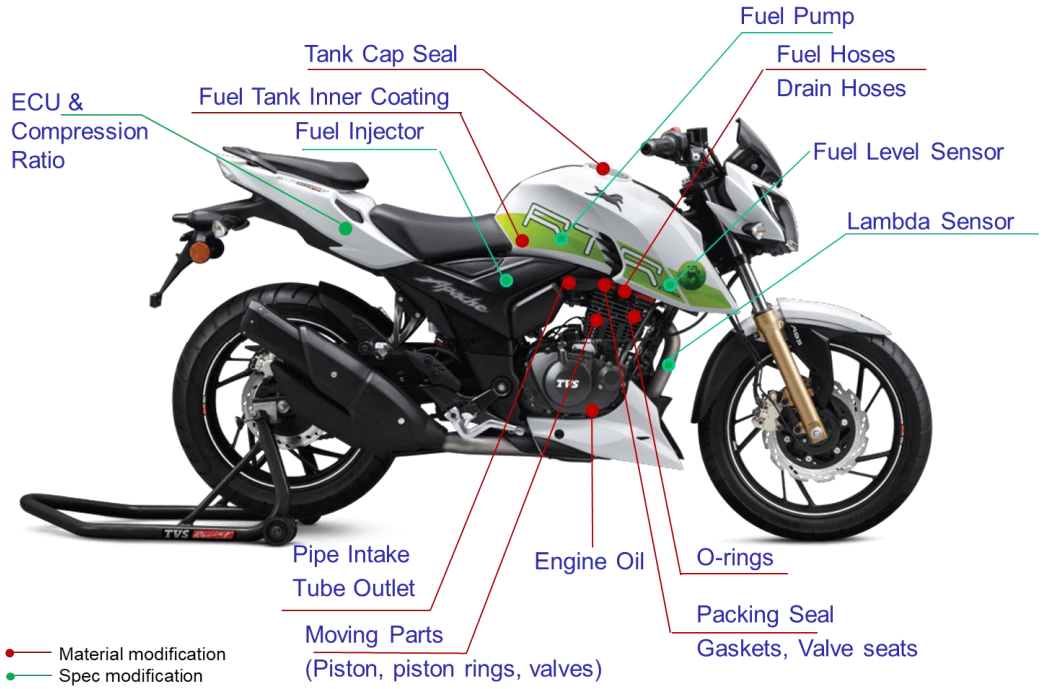
TVS Apache RTR 200 FI E100 vehicle - demonstrated in July 2019

Union Minister Nitin Gadkari, NITI Aayog CEO Amitabh Kant and TVS Motor Company Chairman Venu Srinivasan with TVS Apache RTR 200 Fi E100.

Experience of TVS on Ethanol vehicles:

- Apace RTR 200 FI E100 veh (monofuel, BSIV compliant)
- Two vehicles were run for 6000 km as part of durability test in and around Nagpur – from Aug '19 To Oct '19
- Used Anhydrous Ethanol for product durability tests
- **To test further with new standards for Fuels, as technology changed.**

Developmental Work done by TVS



- Redesign and development of fuel system, engine management system
- Elastomers, rubbers and other engineering changes required for E100 compatibility durability varies based on blend
- Fuel consumption is higher by 30% when compared to E5
- **Technology upgraded with Fuel Injection System. Future development is necessary.**

Demonstration of industry commitment

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Bajaj RE 3W and 2W – Demonstrated in Lucknow in Feb 2018
(E85 Capable vehicles)

Bajaj RE 3W and 2W – Demonstrated in Delhi in Jan 2018
(E85 Capable vehicles)

Development of E85 vehicles will enable adoption of Flex-fuel vehicles-Monofuel to flex fuel

Impact of Ethanol on Rubber, Sealants, Gaskets & Fuel Lines

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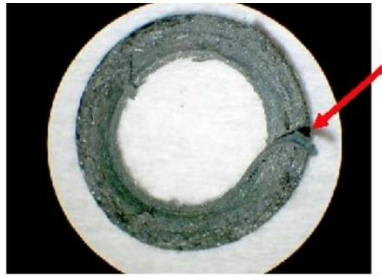
Impact of ethanol on Fuel lines and Rubber

Impact of Ethanol on Engine components

Head bolts discolored due to heat and carbon build up from exhaust gas blowing past bolt.



Bowl gasket swelled & lost seal.

Carburetor bowl mounting screw gasket attacked by E20 in few hours. Fuel containment seal.

Fuel containment sears get leaked

Fuel Cap gasket swelled & warped by E20 in 1 wk. Fuel containment seal & tank venting.

Fuel lines gets corroded, same for fuel tank

Impact of Ethanol on Engine components

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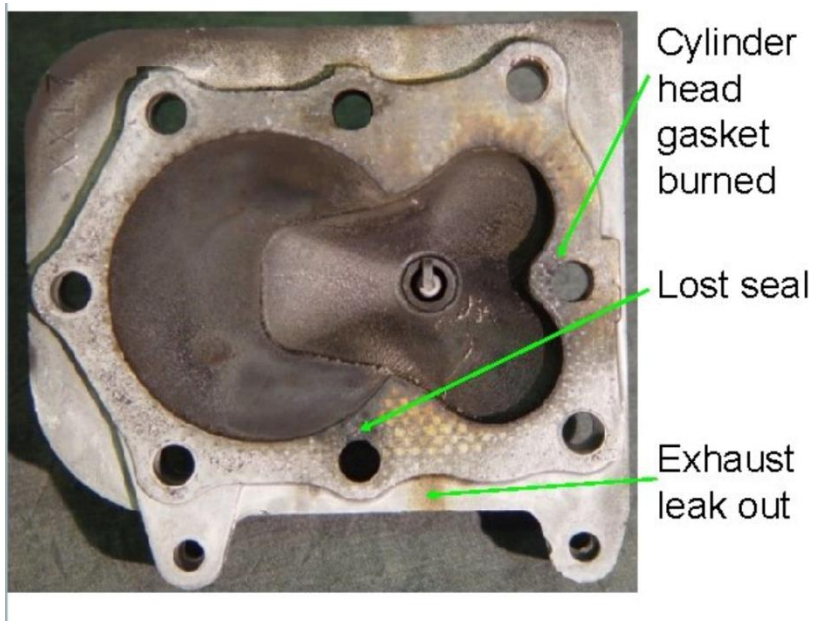
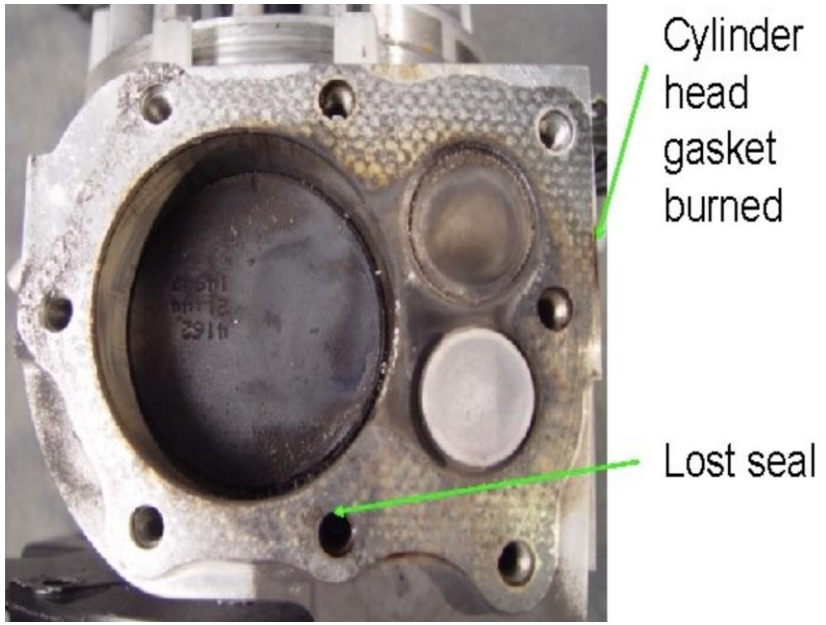
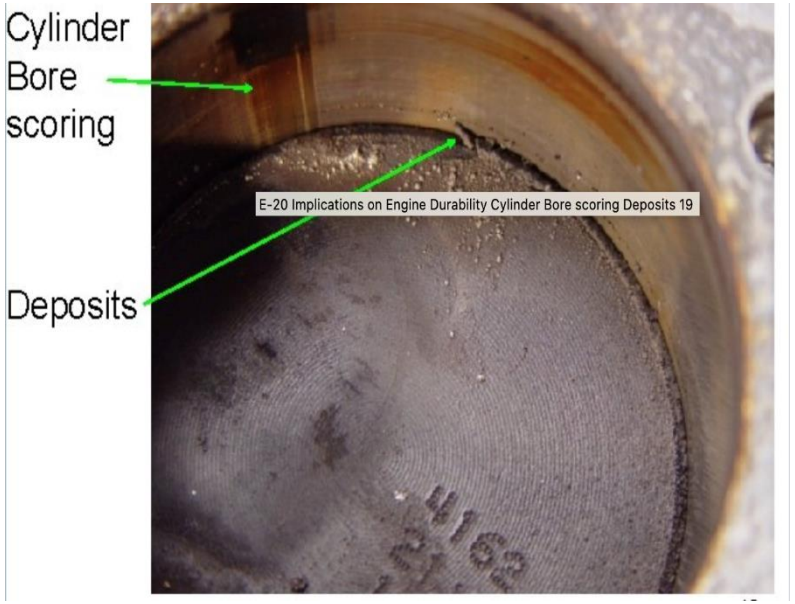
- Higher Exhaust Temperatures
- Combustion deposits (Ethanol cleans engine better)
- Failure in Cylinder Gaskets.
- Loss in compression ratio.
- Higher wear and tear.







Learning from Past Evaluation (Material testing): Analysis

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Previous evaluation reflects some materials performed much worse with E20 as compared to Gasoline

Material classification	Material	Critical change in property with E20 wrt Gasoline	Component usage / function	Image (actual usage)	Function	Impact on Functionality of actual part assessment	Evaluation Needed for objective Judgment
Plastics	**PA66**	IZOD change by 2022% Elongation change by ~100%	**-Canister body -Fuel strainer screen -Cup fuel cock**		-Collect & Hold Fuel vapors -Filtration of fuel for contaminants	-Increase in brittleness may lead to component rupture and fuel leakage in vehicle usage -Strainer ruptures → Loss of filtration leading to clogging & interruption in fuel supply	Evaporation test during fleet evaluation (Pre & Post fleet run)
Metals	**M1 (Al JIS 5302)**	Corrosion rate high	**Carburetor body & Piston**		-Provide housing for Air / Fuel mixture metering	High corrosion causes material wear causing decrease in strength of housing leading to 1. Fine particles getting inside engine → Engine wear & loss of performance and life 2. Breakage on impact → Vehicle non-operation	Evaluate performance at regular interval during fleet run

Based on previous evaluation **PA66 & Aluminum (JIS 5302) seems not compatible with E20**.

Need to refine test method to judge impact in actual usage

In addition to above, following material (in direct contact with fuel) need to be considered for future evaluation :

(1) HDPE (2) EG coated fuel tank sheet (3) Fuel tank paint.

Loss of properties will lead to reduced life of component (Eg: Fuel tank) & customer complaints

Test Protocol for Evaluation of E20 : SIAM, IOCL & ARAI Study

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Part performance

Evaluation	Part / System	Details	By	Test Method	Remarks
Part / System level	**Hoses**	Extractability	Test Agency	SAE J30	-Evaluation can reflect performance as expected in actual usage of existing market aged vehicle samples -OEM undertakes evaluation as per internal standard and share result and judgment with test agency
		Compression crack	OEM	Internal	
		Alcohol resistance test (with E20)	OEM	Internal	
		Heat Aging	OEM	Internal	
	Metal parts	Corrosion performance (weld areas in fuel tank & internal precoated sheet)	OEM	Internal	
	Plastics (HDPE)	Mechanical property change (laboratory & Fleet run)	Tests Agency & OEM	Fleet run (Test agency) Internal (OEM)	Material / part not included earlier. Need to be considered. OEM will share results and judgment
	Paint (Sheet Metal & plastic)	Immersion test of Part with applied paint	OEM	Internal	
Engine Durability	**Engine components**	Pre & Post metrology of Engine components	Test Agency	400hrs running @ 6000rpm	- To measure Engine power & Torque at Full load at regular interval to ensure engine health - Judgment methodology to be discussed between Test agency and OEM

Vehicle performance

Evaluation	Details	Test	Remarks
Emission testing	Type-I, II	Measure pollutants and Fuel economy as per AIS	Log Modal data of Emissions and Dyno forces for analysis of
	Type-4		
Start ability	Cold (-15 & -10°C)	Cold soak and starting	Engine RPM and AF trace to be logged during measurement along with Start emissions (Data Sampling to be done at ~ 0.1sec)
	Hot (35 & 45°C)		
Drive ability	Flat road acceleration	Verify objectively the difference in performance. Pass-by acceleration in different gears (1) Take off from rest (2) Gradient	As per CRC procedure To consider evaluation in Cold, Hot and Humid environment Measure & report time from tests conducted
	Hill Climbing		
Vehicle fleet	Hardware compatibility over life of engine / vehicle	-Evaluate Emission performance at regular interval until100k km mileage -Log Data (through OBD port) & component temperature (Eg: Catalyst) for failure monitoring	- City & Highway driving pattern including all weather conditions

On the path to higher blends of Bio fuels

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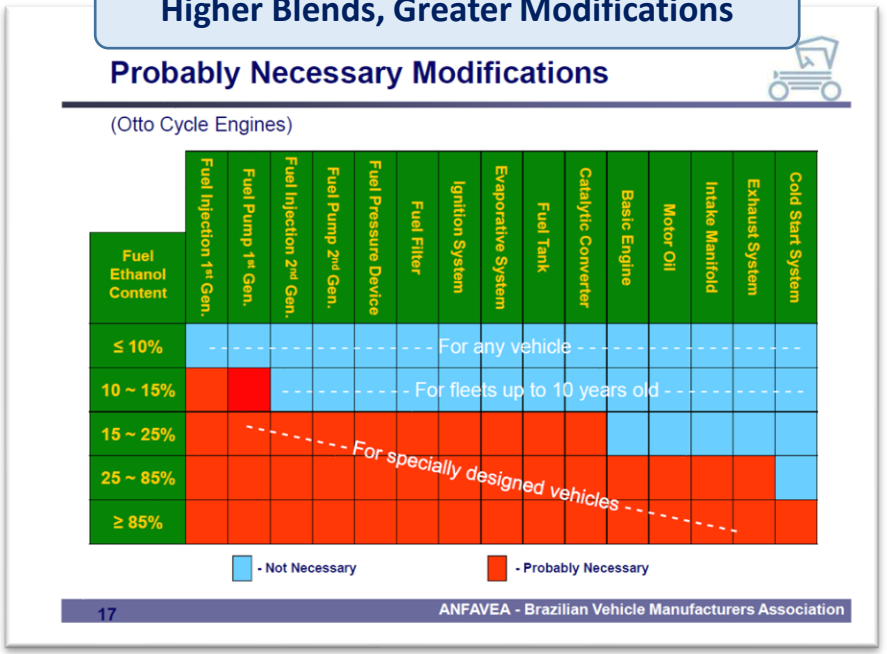
OE Lead time for Development

Development of Vehicles to run on ***"Post E10 fuel Blend"***

Meeting Performance, durability, safety from customer and Regulatory perspective

Developing to consider bad effects to environment

Higher Blends, Greater Modifications



Limited Evaluation Result Summary

Evaluation item	E20		M15	
	4W	2W	4W	2W
Material compatibility (Existing in-use vehicles)	X	X	X	X
Emission	Need detailed Study*	X	Need detailed Study*	X
Fuel economy	Need detailed Study*	X	Need detailed Study*	X
Drive ability	Need detailed Study*	X	Need detailed Study*	X

*Concerns seen in preliminary testing. Need to conduct full evaluation for future vehicle development

- **Basic studies conducted**: **Fuel System part materials for current vehicles are not compatible with E20.**
- **Safety critical** to adapt vehicles to higher blends → **Need to upgrade material (different for E20 or E85)**
- **Major Engine modifications required for Flex fuel vehicles (Pistons, Rings, Fuel Injection System, Engine control, etc., substantial cost escalation**
- Overcome challenges of Engine control for Emissions and OBD to meet customer and Regulatory requirements
- **Studies on 2W suggest that vehicles optimized for E10 do not work efficiently on E20.**

With clarity of fuel availability, Industry can work to design vehicles to be compliant with adequate lead time

Higher Blends & Flex fuel : Need specific Engine changes & Development

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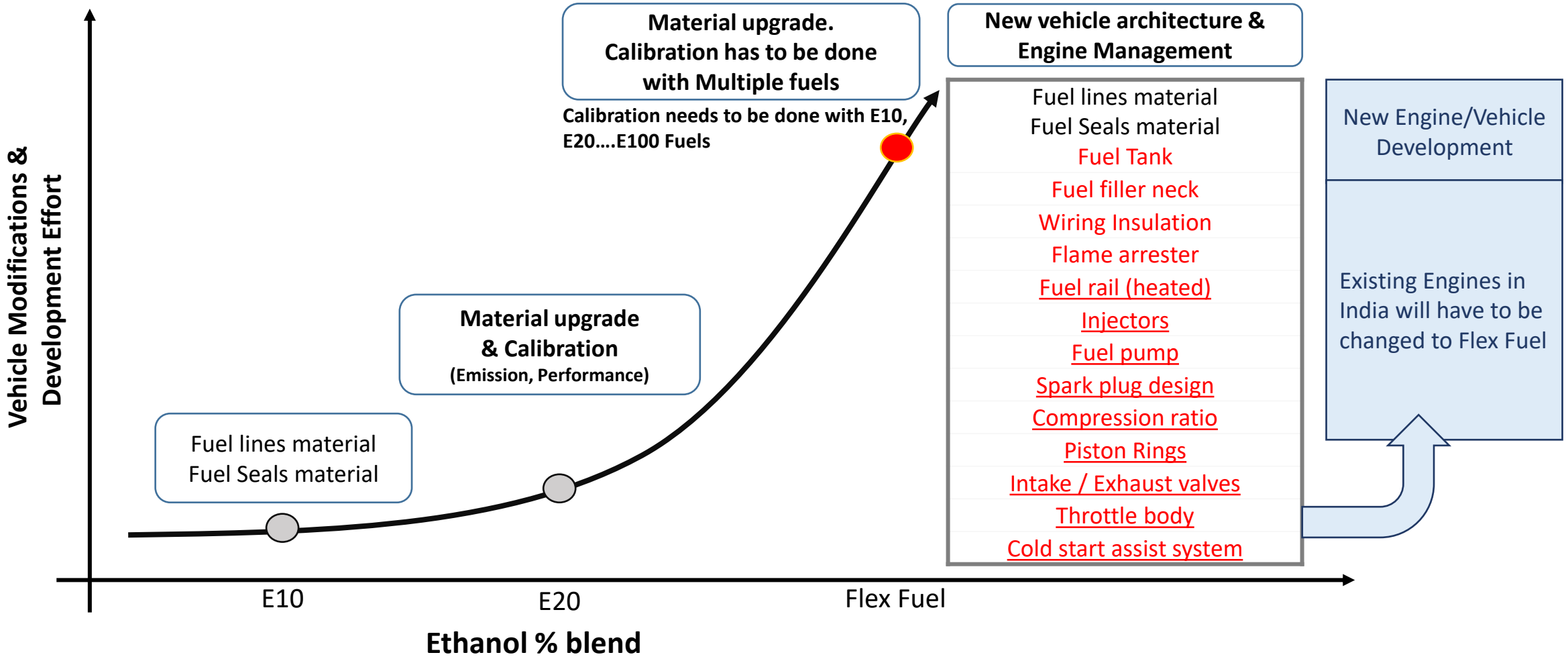

E20 → Flex Fuel : Significant vehicle upgrade & Development required on vehicle at PARC and new vehicles

Industry is committed to overcome these challenges

Impact of Ethanol on various components in vehicles

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Modifications made in Brazil for 100% Ethanol Fuel

Carburetor

The material of the carburetor body or carburetor cover cannot be aluminum or exposed Zamak; must have surface treatment or anodize;

polyamide 6.6 (Nylon) tmust be substituted by other material or protected; P12

The material of buoy, nozzle, metering jet, floating axle, seals, gaskets and o-rings must be Viton.

Engine

The engine compression ratio should be higher;

Camshaft with new cam profile and new phase;

New surface material of valves (intake and exhaust) and valve seats.

Intake Manifold

With new profile and less internal rugosity, to increase the air flow;

Must provide higher intake air temperature.

Fuel Tank

If the vehicle fuel tank is metallic, the internal surface of tank must be protected (coated);

Any component in polyamide 6.6 (Nylon) that has contact with the fuel must be substituted by other material or protected.

Higher fuel tank capacity, due to the higher fuel consumption.

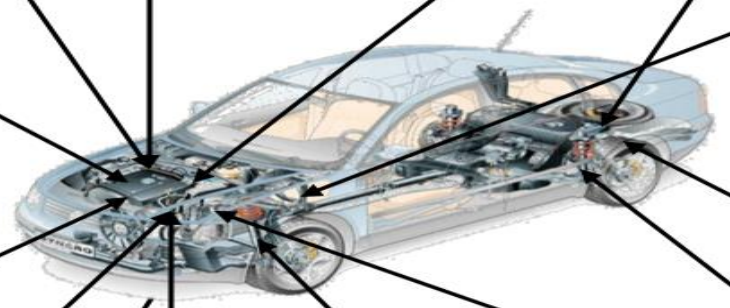
Electronic Fuel Injection

Substitution of fuel injector material by stainless steel;

New fuel injector design to improve the "fuel spray";

New calibration of air-fuel ratio control and new Lambda Sensor working range;

Any component in polyamide 6.6 (Nylon) that has contact with the fuel must be substituted by other material or protected.



Catalytic Converter

It is possible to change the kind and amount of noble metal present in the loading and wash-coating of catalyst converter;

The catalyst converter must be placed closer to the exhaust manifold, in order to speed up the working temperature achievement (light-off).

Fuel Pump

The internal surface of pump body and winding must be protected and the connectors sealed;

Any component in polyamide 6.6 (Nylon) that has contact with the fuel must be substituted by other material or protected.

The pump working pressure must be increased.

Exhaust Pipe

The internal surface of pipe must be protected (coated);

The exhaust design must be compatible with higher amount vapor.

Suspension

Adjusted to the higher vehicle weight.

Fuel Pressure Device

The internal surface of the fuel pressure device must be protected;

Any component in polyamide 6.6 (Nylon) that has contact with the fuel must be substituted by other material or protected.

The fuel pressure must be increased.

Motor Oil

New additive package.

Fuel Filter

The internal surface of the filter must be protected;

The adhesive of the filter element must be appropriated;

The filter element porosity must be adjusted.

Ignition System

New calibration of advance control;

Colder heat rating spark plugs.

Evaporative Emission System

Due to the lower fuel vapor pressure, it is not necessary evaporative emission control.

Ethanol's Impact on Octane Number

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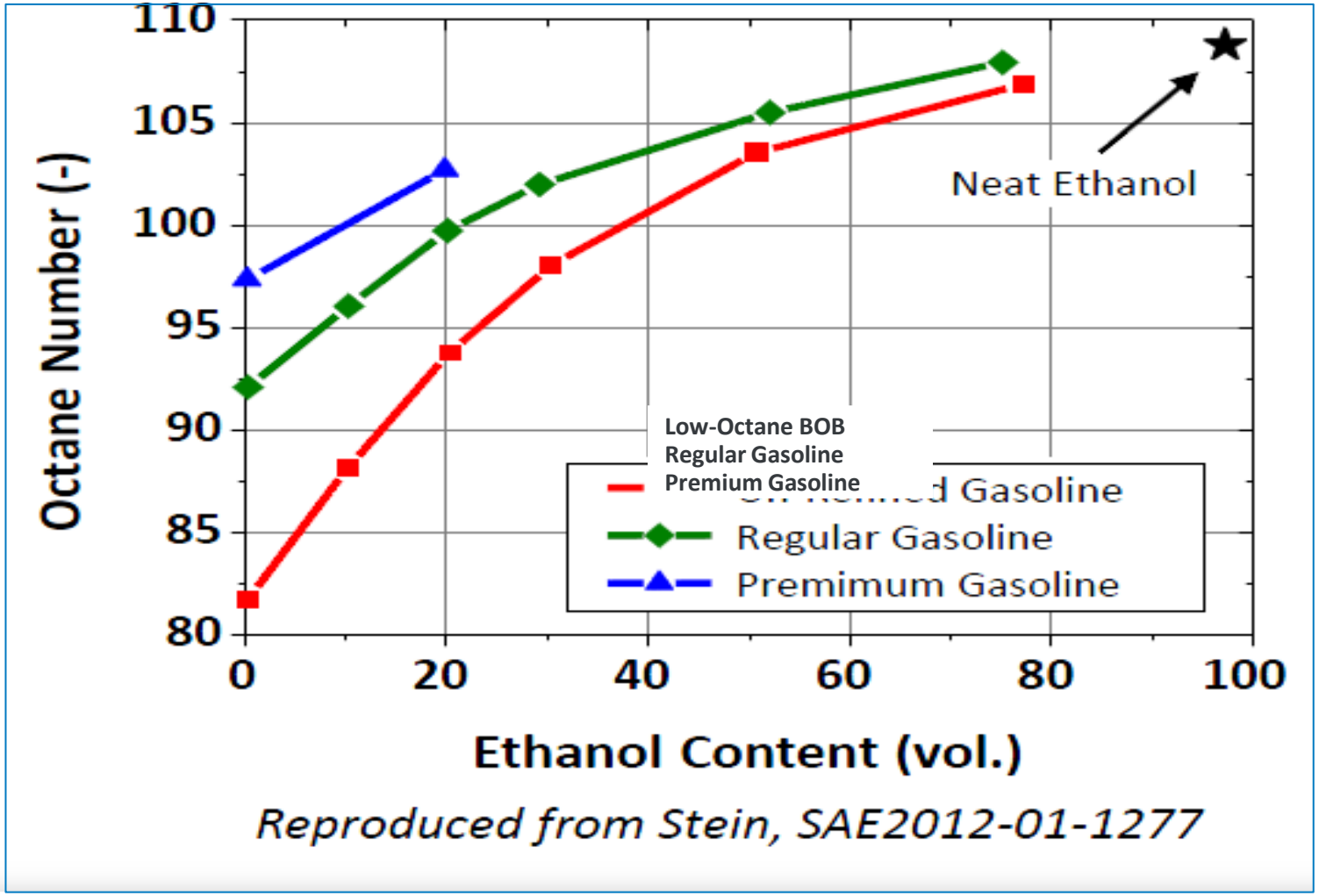
- **Ethanol is an octane booster**
- **Non-linear influence of ethanol content →most benefit at lower levels**
- **Optimum blend likely 20-40% ethanol**
- **This requires the adjustment of compression ratio and need development of engine.**



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Global Ethanol Production by Country-2020

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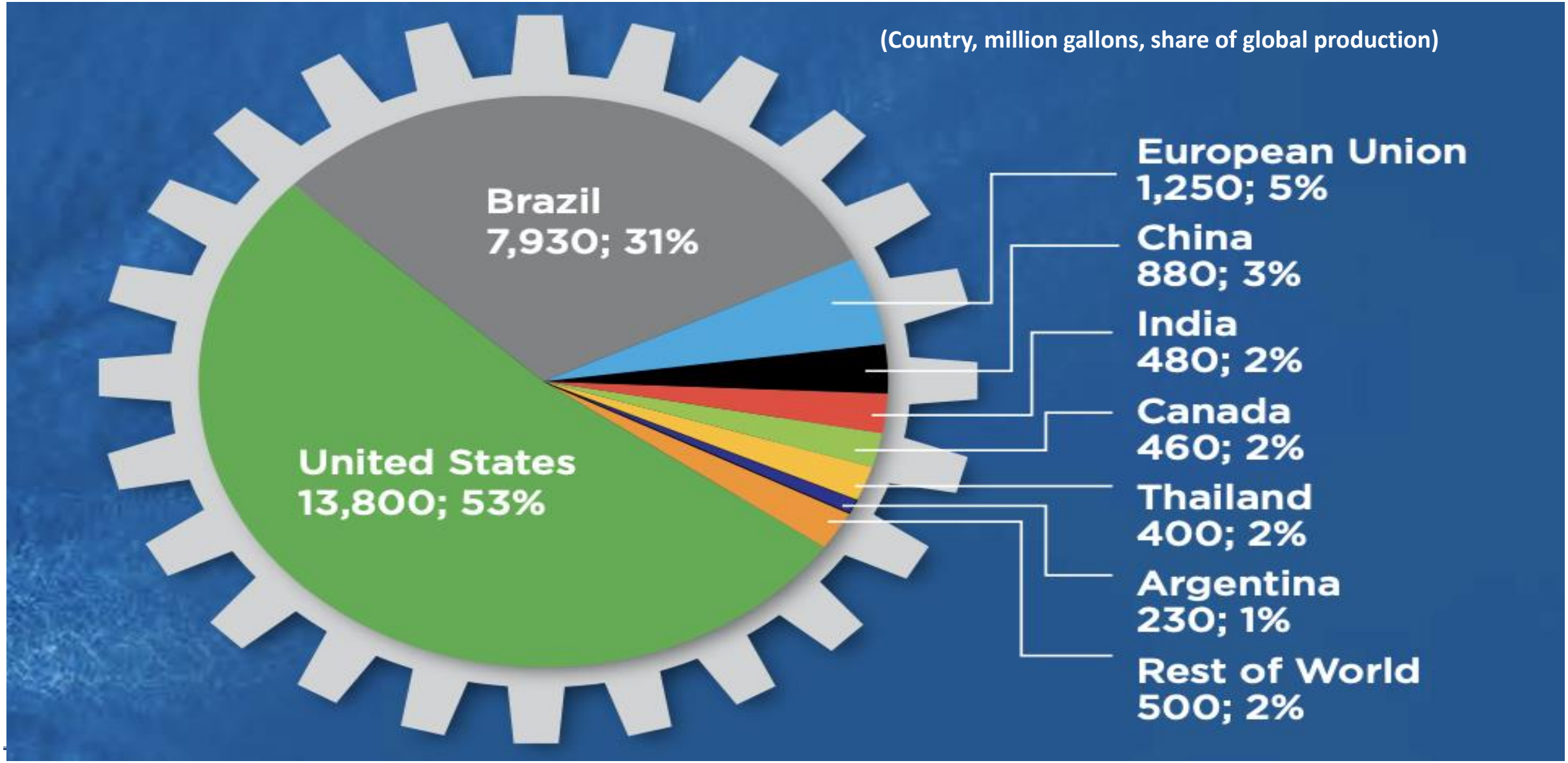

Indian Auto Industry Ethanol Vehicles Road Map

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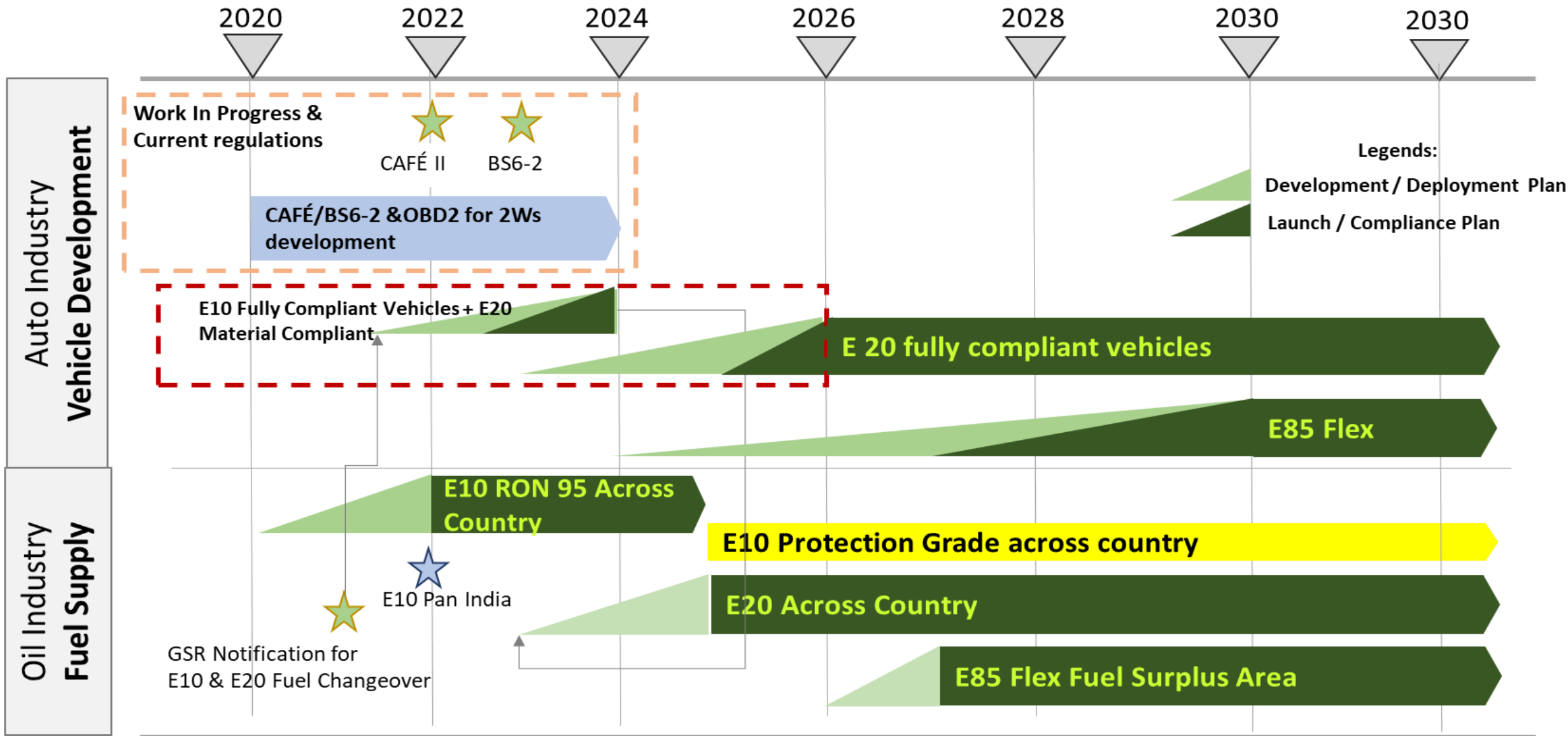

SIAM's way forward – Aligned with Government vision

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- Ethanol usage in transport sector is important to achieve energy security & reducing country's oil bill
- Ethanol, made from domestic agriculture resources can add to domestic agricultural economy
- In addition, Ethanol is Carbon neutral fuel and when made from waste sources, has potential of being carbon negative fuels considering life cycle analysis.
- Ethanol can help in achieving India's GHG goals and reduce transport sector GHG contribution.
- **Faster and sustainable realization of energy security and clean air goals require joint efforts of Government, Oil Marketing Companies (OMCs) and Auto Industry**

SIAM welcomes Government's move to ethanol economy and is committed to fuel diversification to achieve lower CO2, reduction of crude oil imports and local pollution

Moving together, moving ahead.

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