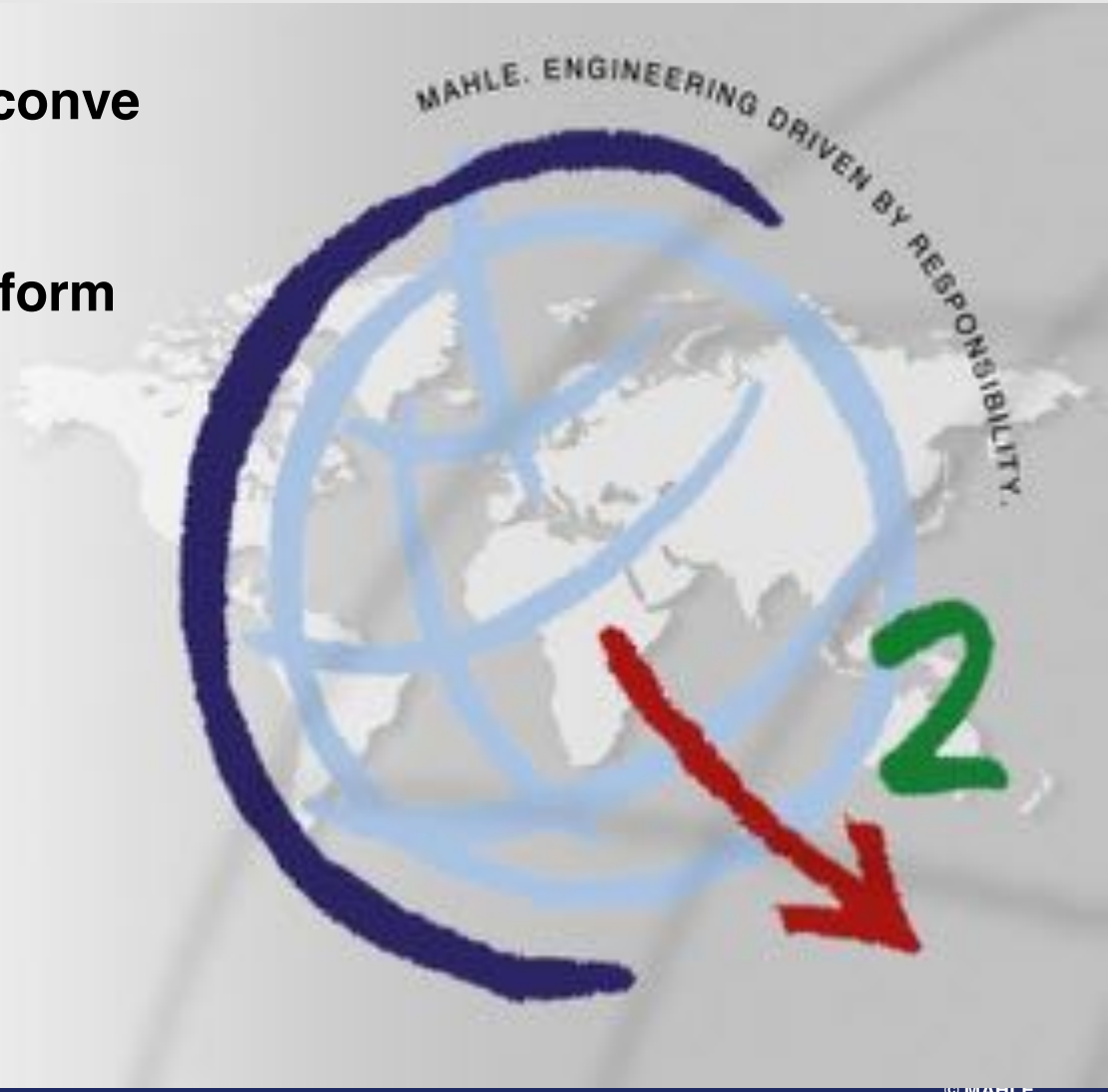
MAHLE

Driven by performance

RenovaBio - ROTA 2030 – Proconve

Integrated activities to attend Biofuel Policy & Biofuture Platform targets in Brazil



Ricardo Simões de Abreu

MAHLE Metal Leve S. A.

© MAHLE

MAHLE worldwide

MAHLE
Driven by performance

Employees: 77,000 (around 8.600 in SA)

More than 170 production locations in 34 countries and on five continents (7 Locations in SA)

Sales: EUR 12,3 billion (EUR 645,7 Mio in SA) (2016)

15 major development locations with around 6,000 development engineers and technicians in Germany, Great Britain, Luxembourg, Slovenia, the USA, **Brazil**, Japan, China and India

Confidential
© MAHLE

Government Programs that need to be interconnected

MAHLE

Driven by performance

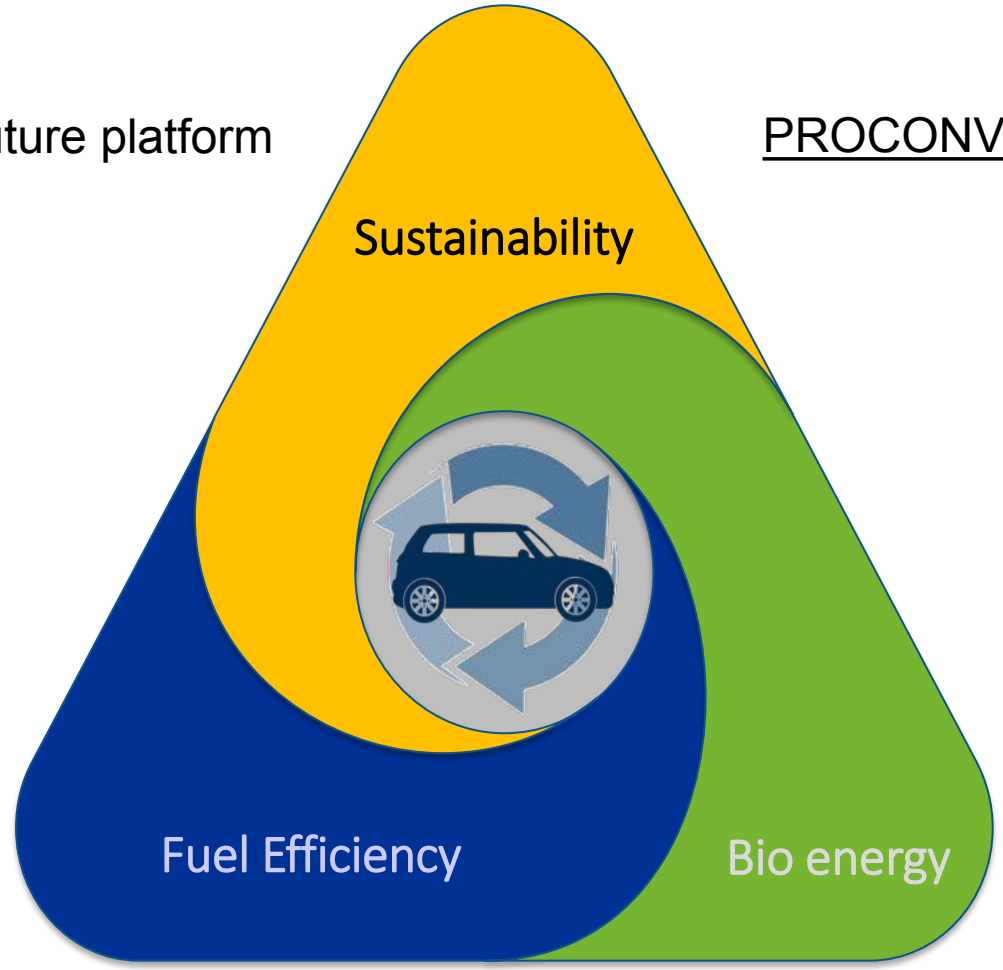
Biofuture platform

PROCONVE

Sustainability

Rota 2030

RenovaBio



Confidential
© MAHLE

Major Objectives of Energy Efficiency Policy and Environmental Commitments

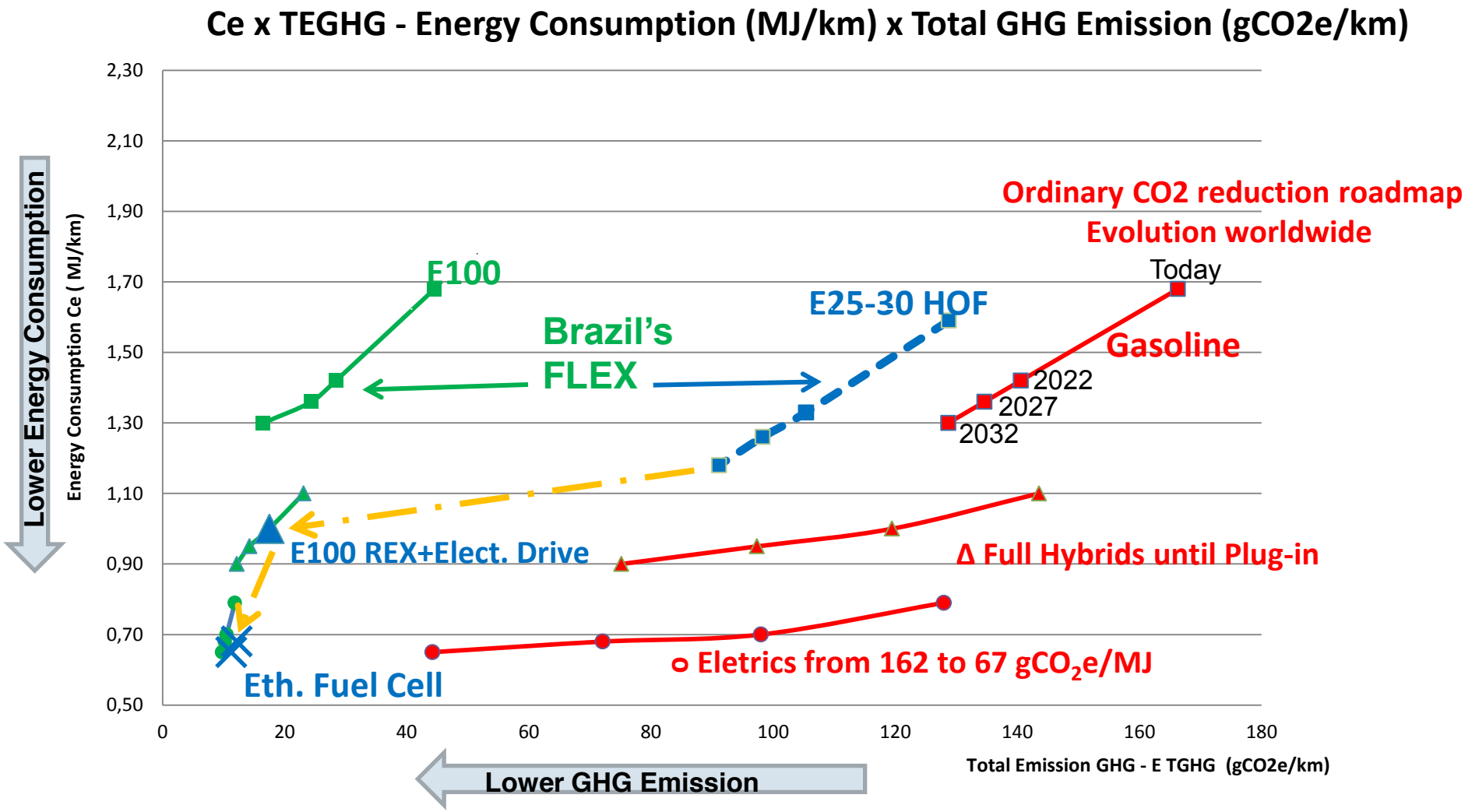
MAHLE
Driven by performance

It's not either ICE, or Electrification. it's both used in the best way, using biofuels!

© MAHLE

Ethanol route: Increase ICE energy efficiency using HOF, Hybrids to reduce **well-to-wheel** CO_2, leading to the use of SOFC.

MAHLE
Driven by performance

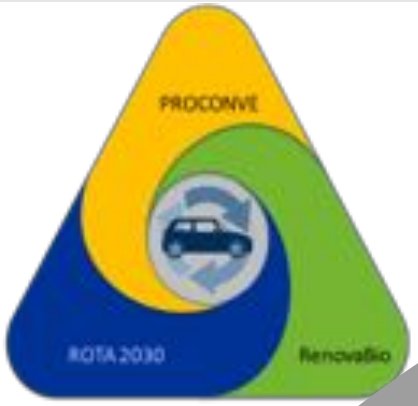


© MAHLE

Roadmap for efficient vehicles using ethanol as pure fuel or blending HOF gasoline

MAHLE

Driven [illegible]formance



Sustainable Energy Efficiency

- Consider GHG well-to-wheel
- Assurance of ethanol supply
-International Competitiveness

Global Fuel

- Implementing high octane fuel (HOF)
- Ethanol fuel with common specification.
- Fostering lower Carbon Intensity

New Ethanol/Flex Vehicle - worldwide penetration

- Efficient vehicles with ethanol and gasoline with hybridization
- Advantages on Route 2030 for increased efficiency with ethanol.
- HD Ethanol vehicle to urban centers with restrictions on particulate matter

Fast and effective contribution for reducing greenhouse gases (GHG)

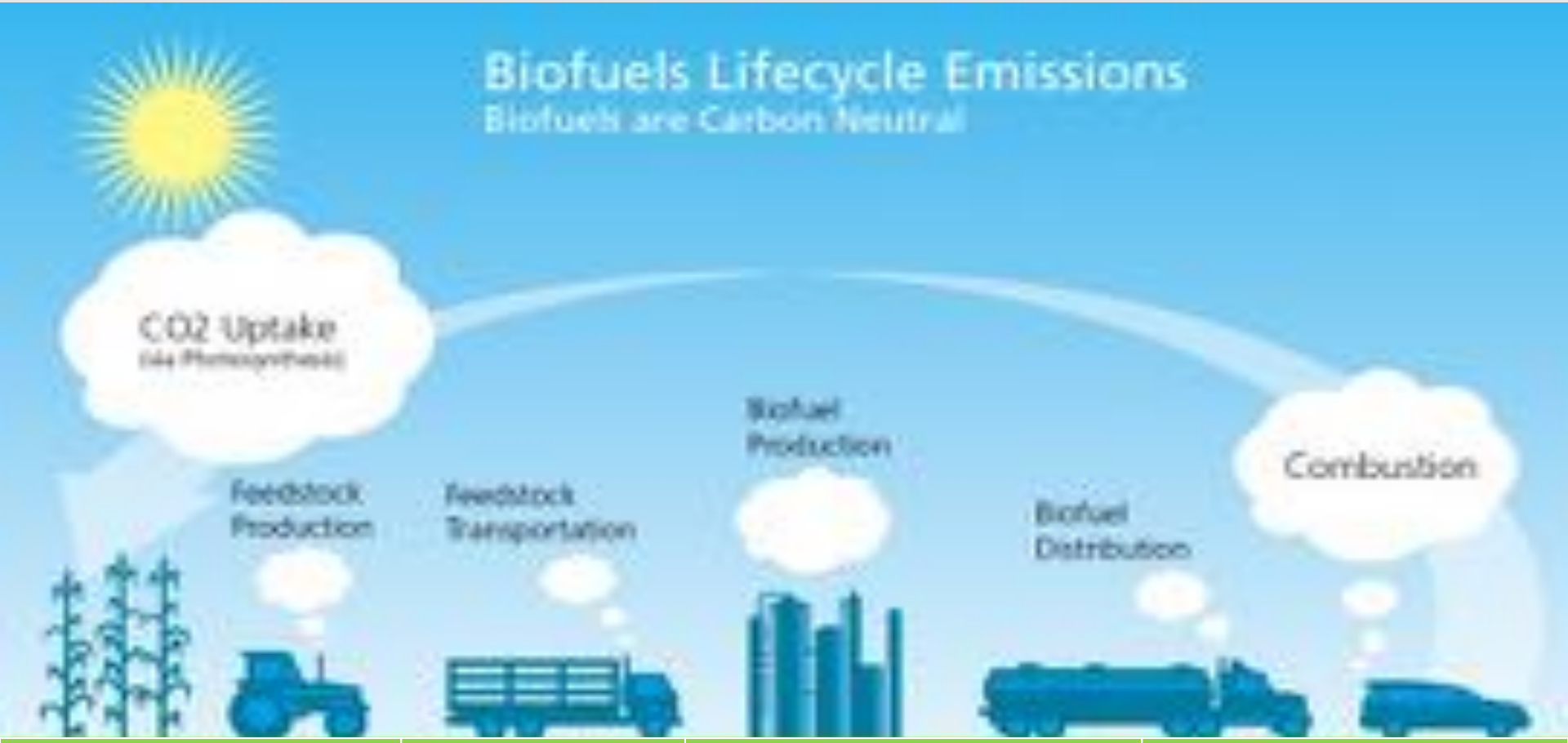
- Quick alternative for GHG reduction without large investments
- Bridge to the future in reducing CO_2 complementing the use of clean electricity
- Exclusive use of E100 on hybrid platforms and technologies such as Fuel cell

© MAHLE

Well-to-wheel activities
CI Reduction
Sustainable Energy Efficiency

MAHLE

Driven by performance



• Development and Certification of engines used on land machines • Improved maintenance	• Technologies for heavy engines with ethanol and biogas	• MBE2 • Special filters • Ethanol Dehydration • Stationary eth/biogas SOFC	• Hybrid Bus / REX Eth-H_2 • ROTA 2030 Eth bonuses • Special Technologies • SOFC Vehicles

Confidential
© MAHLE

Relevant facts with MBE2 Technology

MAHLE
Driven by performance

Competitiveness
~ 12% lower cost of cane ethanol production.

Sustainability
No increase in planted area or higher water consumption

Strategic Importance
Increases the production of Ethanol for pure use and as a mixture

Greenhouse gases
Reduces carbon intensity (CO_2/MJ) by 12%. The CO_2 emission from the well to the wheel in the vehicle is 12% lower.

Investment
Relative low value with fast return

Flexibility
Applicable to all generations of ethanol and crops.

Strictly Confidential
© MAHLE

Low Emission Vehicles using Ethanol can be an alternative for HD Vehicles

MAHLE
Driven by performance

The Diesel fleet in Brazil:
4% of vehicles and 46% of CO_2 emissions

"Almost zero emissions " NOx and particulate matter with ethanol is very low.

© MAHLE

Ethanol Fuel Cell

MAHLE

Driven by performance

- ✓ Chemical reaction of Ethanol+ water generates hydrogen
- ✓ SOFC Cell (solid oxide fuel cell) uses hydrogen + air and generates electric power to supply the battery that powers the electric motor

Source AVL

MAHLE

Driven by performance

Thank you !

Ricardo Simoes de Abreu
MAHLE Metal Leve S.A.

ricardo.abreu@br.mahle.com
+55 11 4589-0631