Development of Alternative Fuel Engine Technologies

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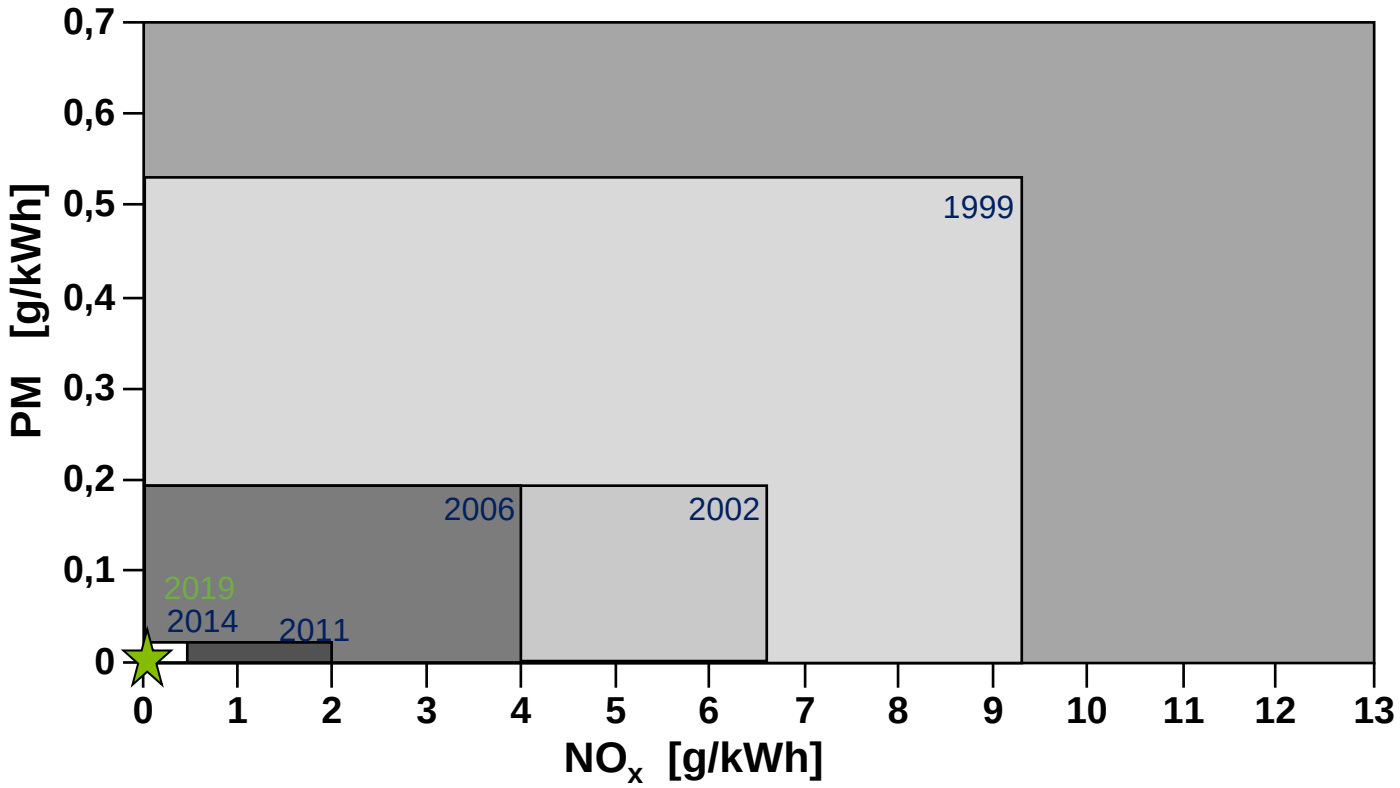
AGCO POWER AROUND THE WORLD

- 4 engine factories on 3 continents
- 1200 professionals globally
- Over 80 years of experience

Non-road exhaust emission development 1999-2019

Over 130 kW



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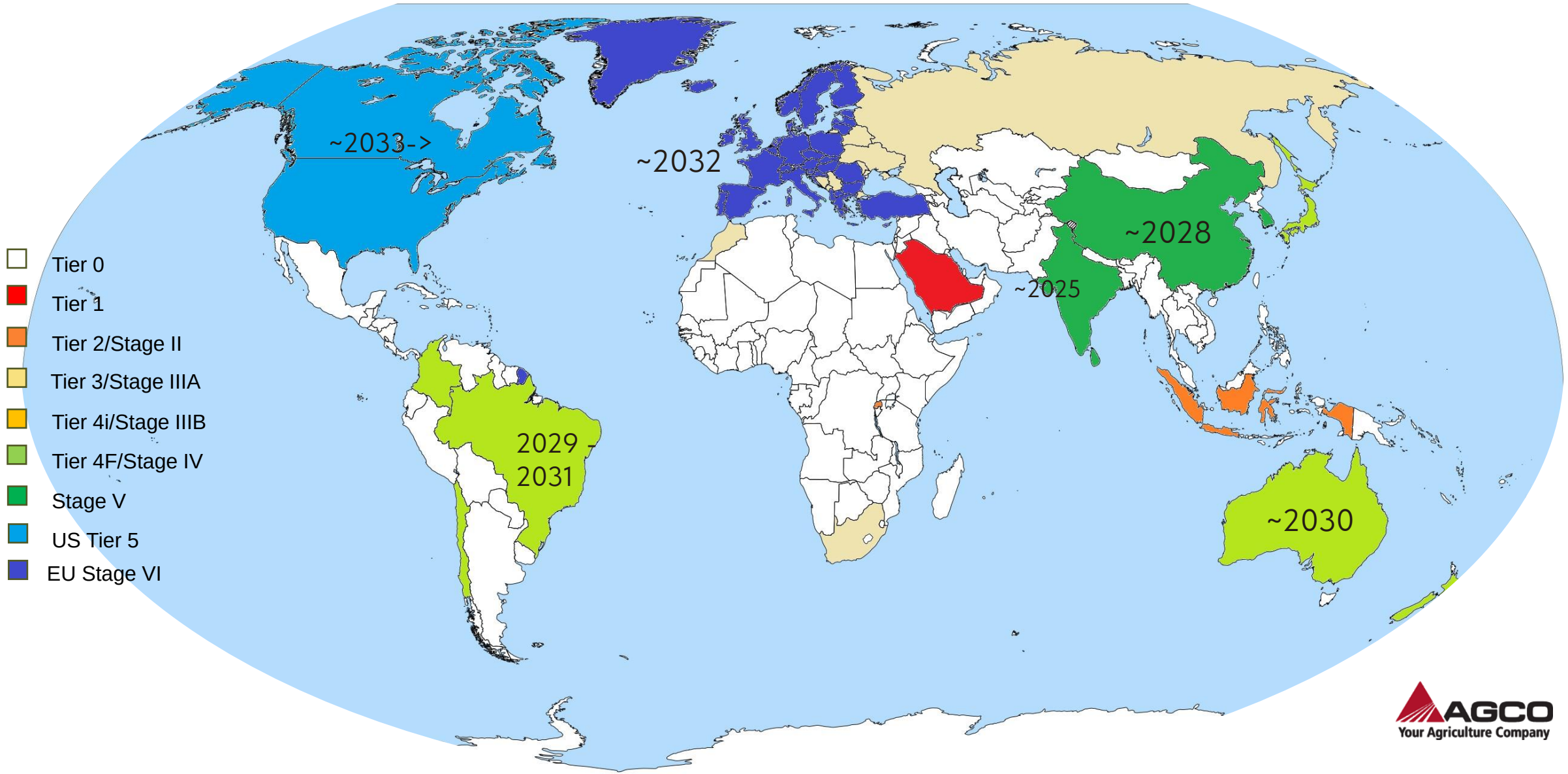
Off-road emission legislation outlook



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AGRITECHNOLOGY DIVERSITY









Multiple duty Cycles

Challenging ambient conditions

Remote locations

Specific engine installations

THE 11 GIGATON CHALLENGE

If we keep growing and farming the way we do now, agriculture will produce 15 gigatons of carbon dioxide. According to scientific studies, it should be reduced to 4 gigatons.

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WIDER SPECTRUM OF POWER

The power to renew.

HVO – Hydrotreated Vegetable Oil

- 90 % less CO_2-emissions
- Produced out of vegetable oil & grease
- Used as first fill in Suolahti plant. Linnavuori use in internal logistics between production halls.
- Properties equal to diesel
- Can be used in old equipment as well

GREEN+
UUSIUTUVA DIESEL

NESTE MY
Renewable Diesel

E-FUEL

PEMS

(Portable Emission Measurement System)

E-diesel tank

- VTT driven research project together with AGCO Power, Valtra and Neste
- Tested in Valtra T235 74 Stage V-engine
- Fuel properties equla to fossil diesel
- E-fuel carbon is collected from athmosphere or e.g. waste incinerator chimney
- Still very expencive to produce

BIOMETHANE TRACTOR CONCEPT

- Spark ignited engine
- Lower range compared to diesel
- On farm solution
- Biomethane feedback from the drivers:
  - *Difference between Diesel and Gas smaller than expected*
  - *Feels more or less like conventional tractor*
  - *Refuelling was considered easy and clean*
  - *Can't replace Diesel in all use cases, but sufficient for many*
  - *Engine immaturity of prototype influenced work performance*

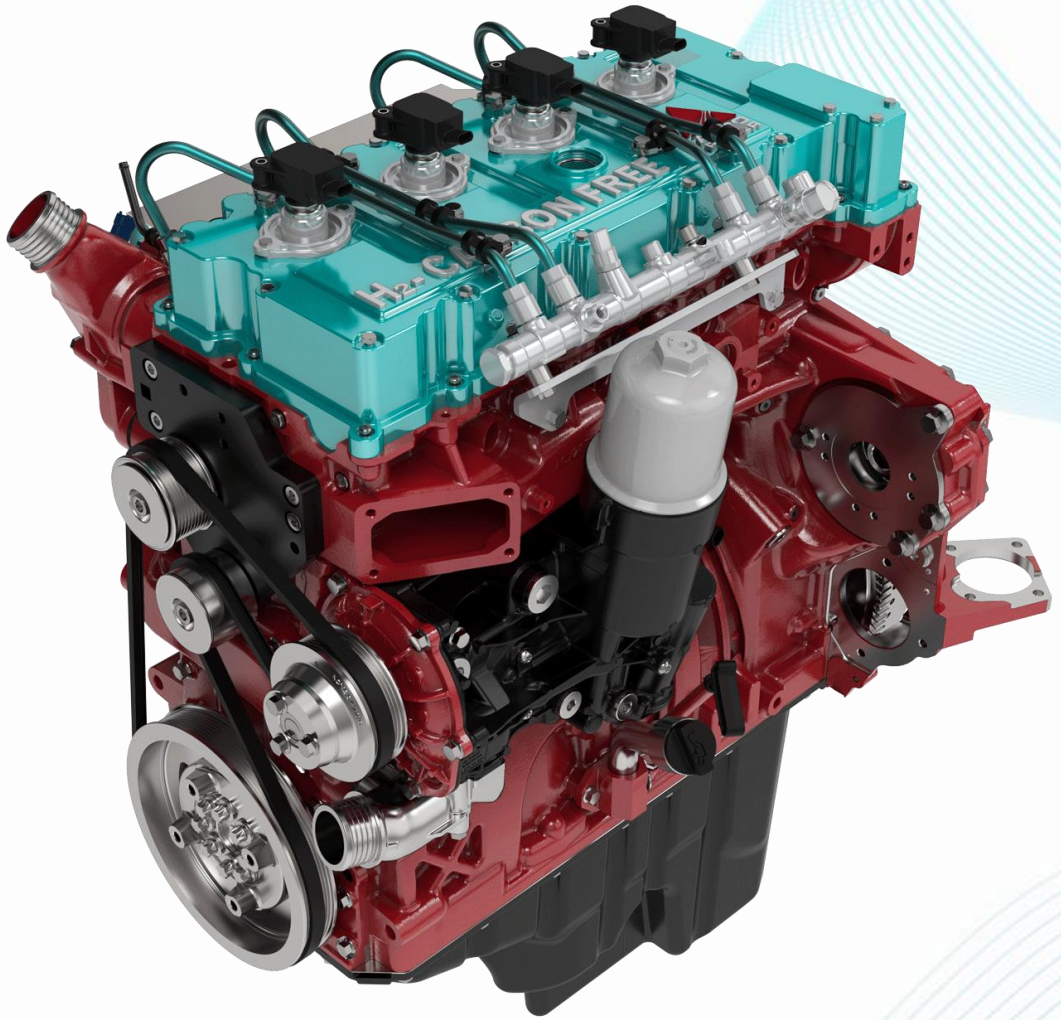
HYDROGEN TRACTOR CONCEPT (Fuel Cell)

Hydrogen fuel cell

- 100 kW PEM (Proton-Exchange Membrane) fuel cell systems build and tested
- System design, in-house control system design and development
- 100 kW FC installed to vehicle
- 5 pcs. H_2 -cylinders on cabin roof
- Fuel storage 21kg / 700 bar

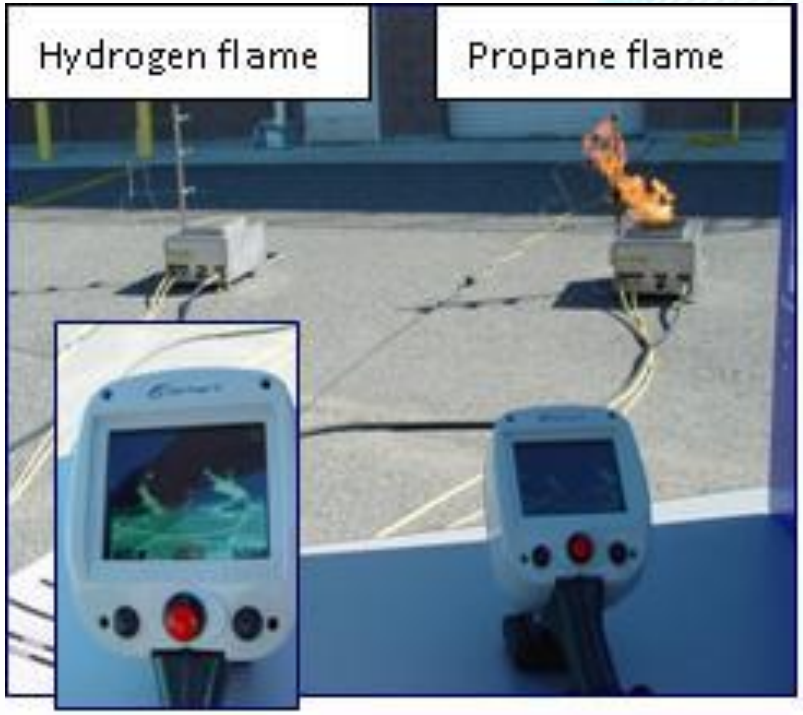
HYDROGEN COMBUSTION ENGINE

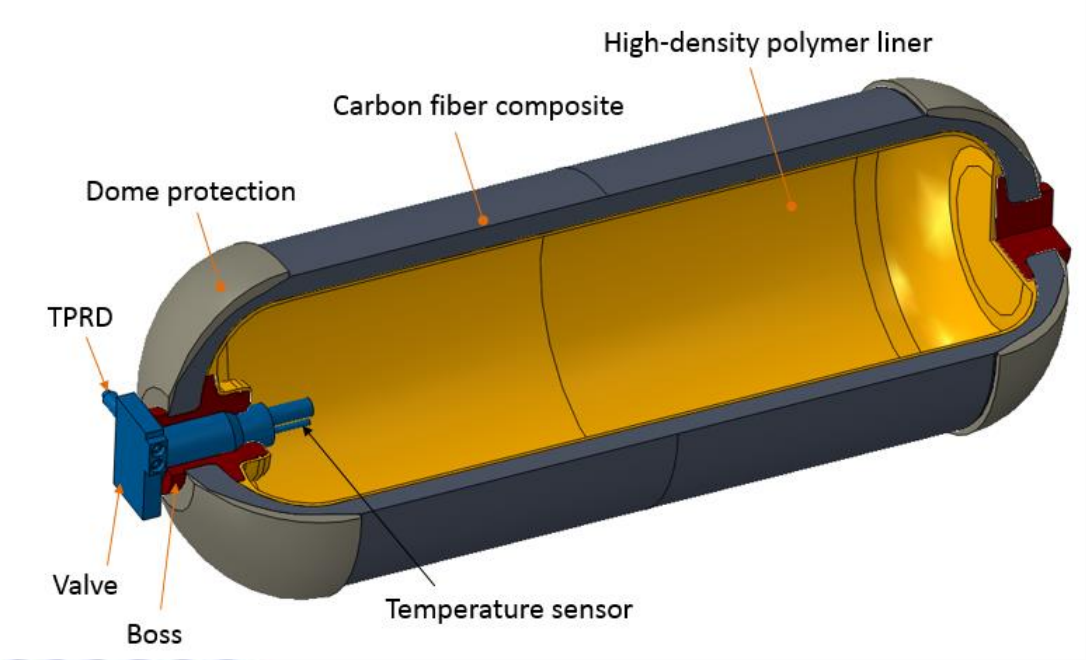
- CORE eHydrogen concept
- Enables traditional powertrain architecture
- 20 % new content
- Near Zero emission
- Exhaust mainly water
  (2 H2 + O2 → 2 H2O)



HYDROGEN PROPERTIES

- Highly flammable
- Boiling point -253 C
- Leaks thru metal walls (25 % / month)
- Difficult to detect – even when burning





• HYDROGEN INFRA – Expected by 2040

- Current plans for H_2-infra do not fully support off-road machinery

Source:https://gasforclimate2050.eu/ehb/

FENDT E100 V VARIO

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AGCO POWER RANGE EXTENDER CONCEPT

Methanol fuel cell

- Liquid fuel
- 15 kW power
- HT PEM fuel cell and reformer
- Usage as range extender in BEV

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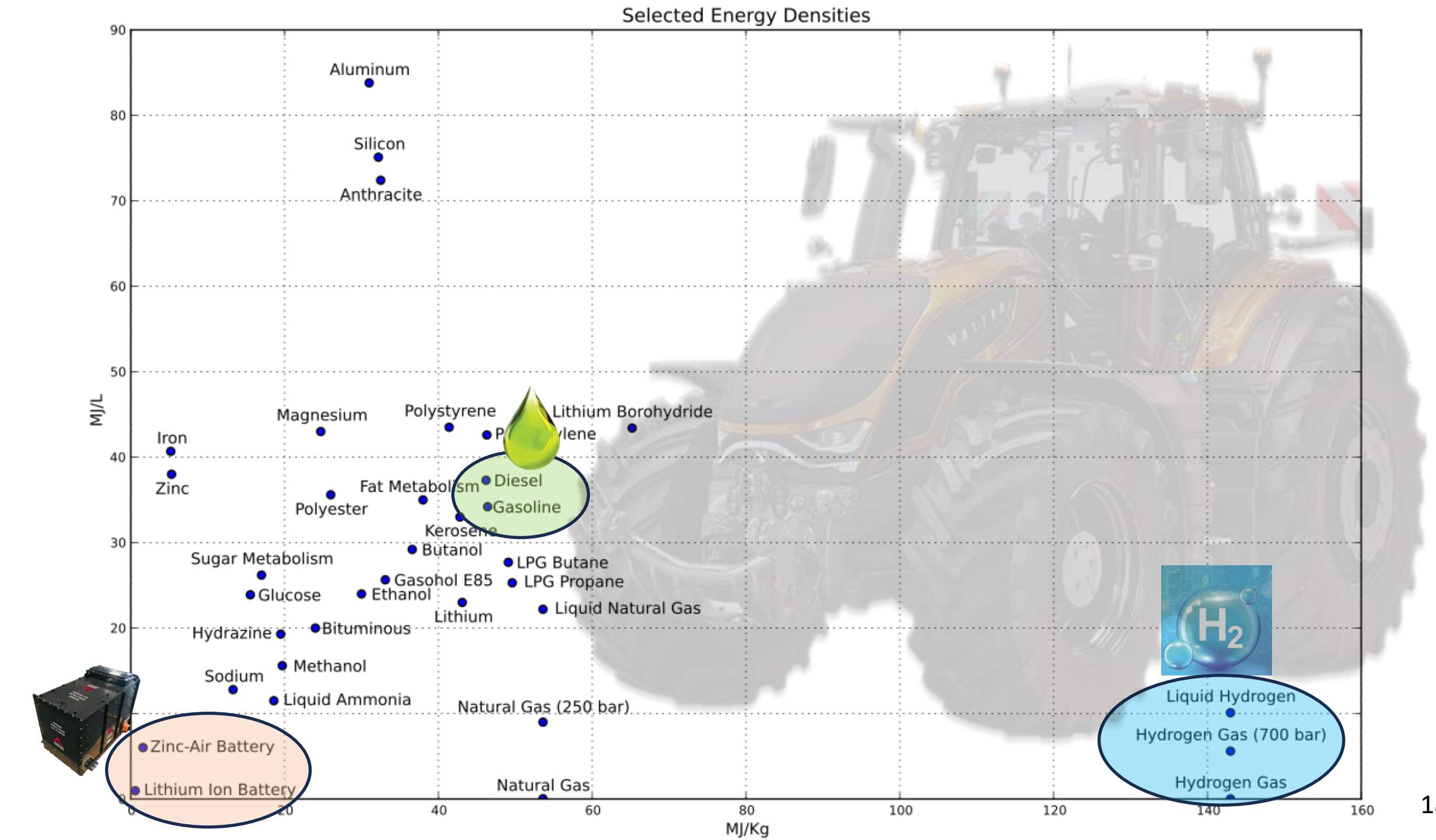
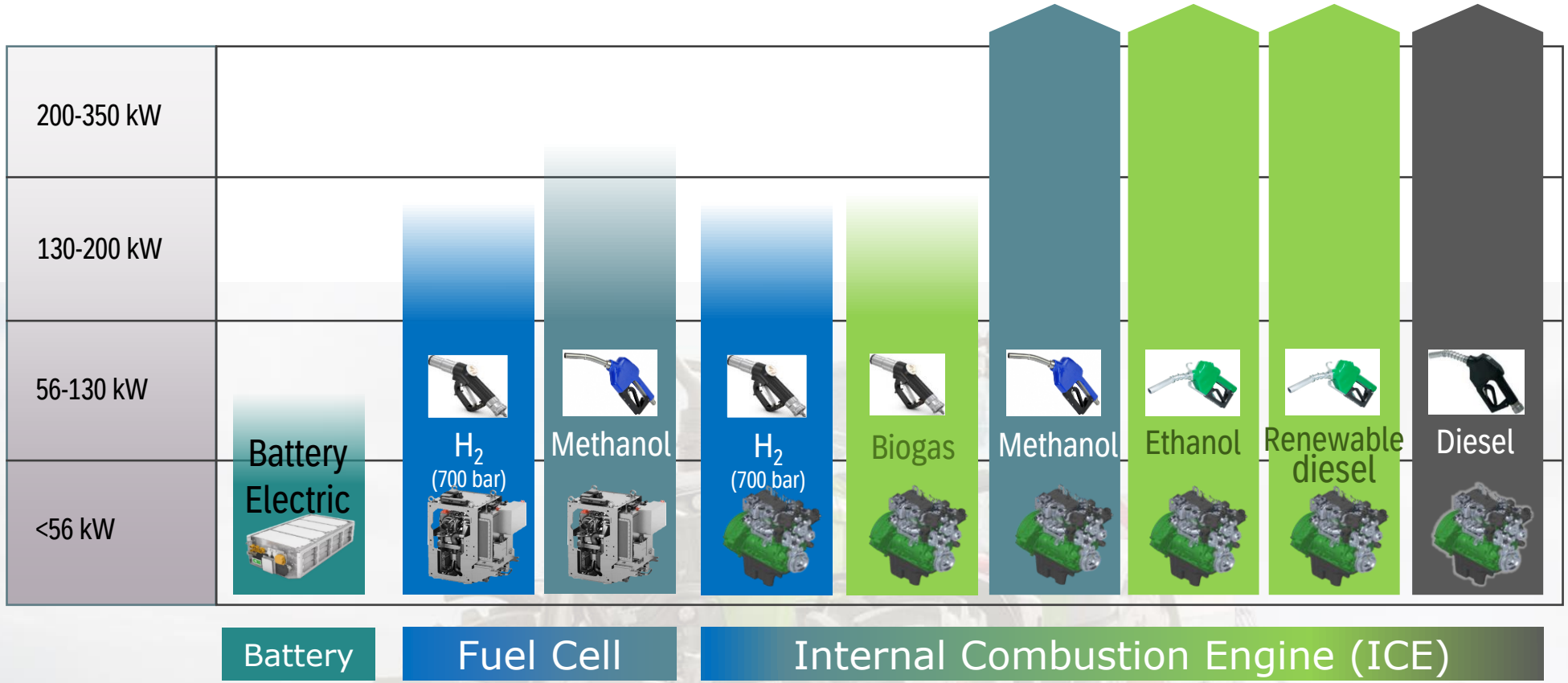
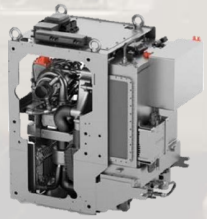

Selected Energy Densities
MJ/L
MJ/Kg
Aluminum
Silicon
Anthracite
Magnesium
Polystyrene
Lithium Borohydride
Iron
Zinc
Fat Metabolism
Diesel
Gasoline
Polyester
Kerosene
Butanol
Sugar Metabolism
LPG Butane
Gasohol E85
LPG Propane
Glucose
Ethanol
Lithium
Liquid Natural Gas
Hydrazine
Bituminous
Methanol
Sodium
Liquid Ammonia
Natural Gas (250 bar)
Zinc-Air Battery
Lithium Ion Battery
Natural Gas
Liquid Hydrogen
Hydrogen Gas (700 bar)
Hydrogen Gas
H2

Future technology options for off-road machinery





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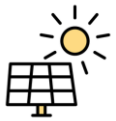
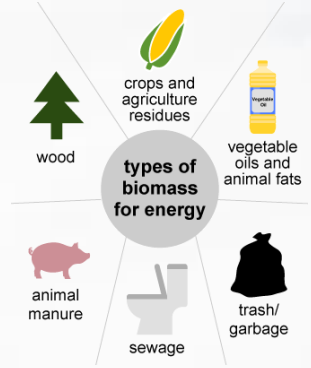
Potential power sources for off-road





Electricity

93-98 % efficiency

H_2O

Hydrogen 75%

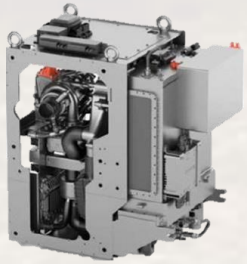
CO_2

Methanol 80%

CO_2

e-Fuel 25-50%

BEV eff. 93-98%



FC 45 -60 % efficiency

Fuel Cell

Biomass / Waste

Biomethane

Alcohols

HVO

ICE 40 -45 % efficiency

Multi-fuel ICE

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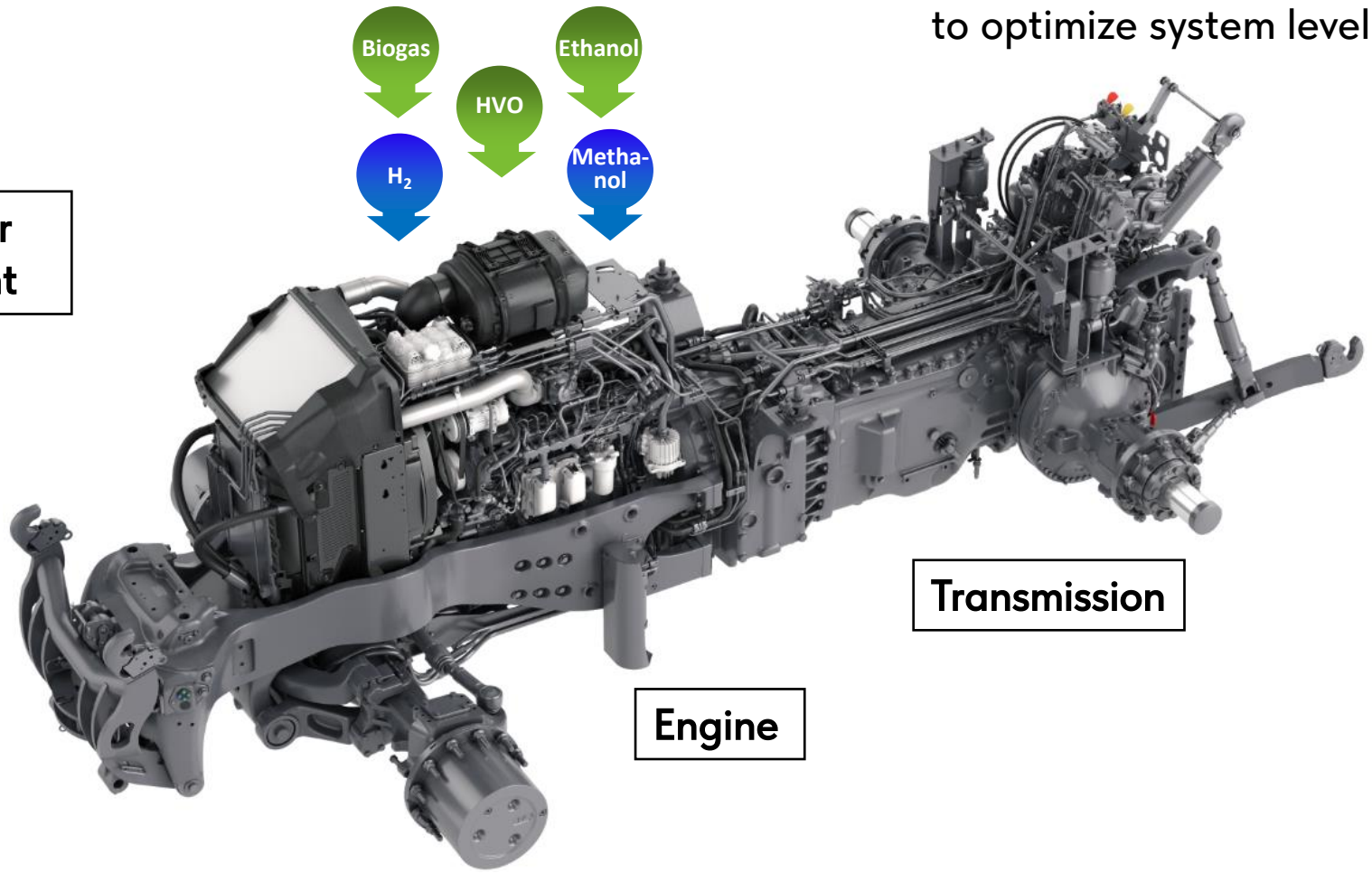
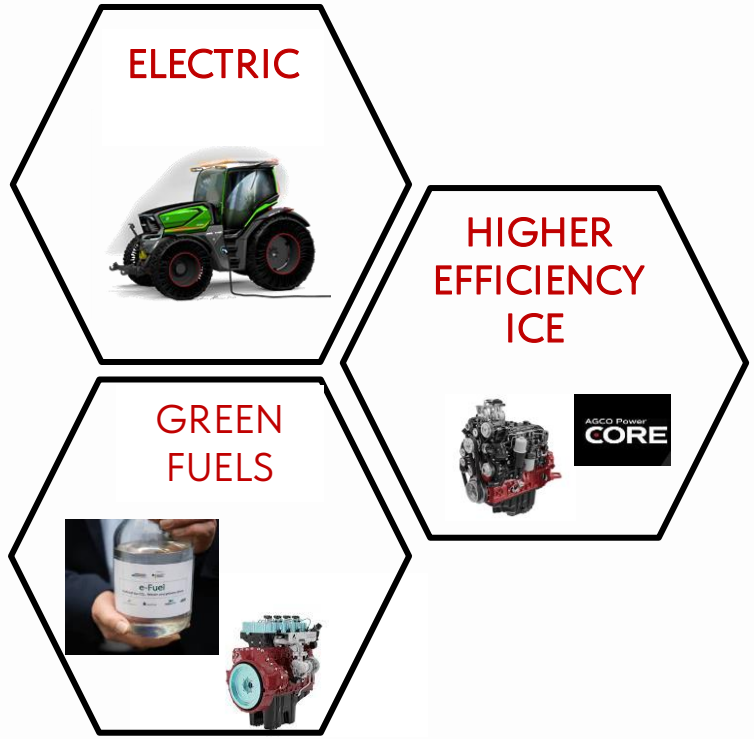
SYSTEM APPROACH IN POWERTRAIN DEVELOPMENT

Engine performance, cooling and transmisson fitted together in close co-operation with OEM to optimize system level design.



CLEAN ENERGY LABORATORY WILL BE AN IMPORTANT CATALYST FOR REDUCING PRODUCTS CO^2 EMISSIONS

Wider Spectrum of Power



Clean Energy Laboratory is part of a ~70M€ investment in AGCO Power to bring clean energy solutions to the market

- 2,200 m^2 lab space
- Enables faster and more robust validation including critical corner condition testing

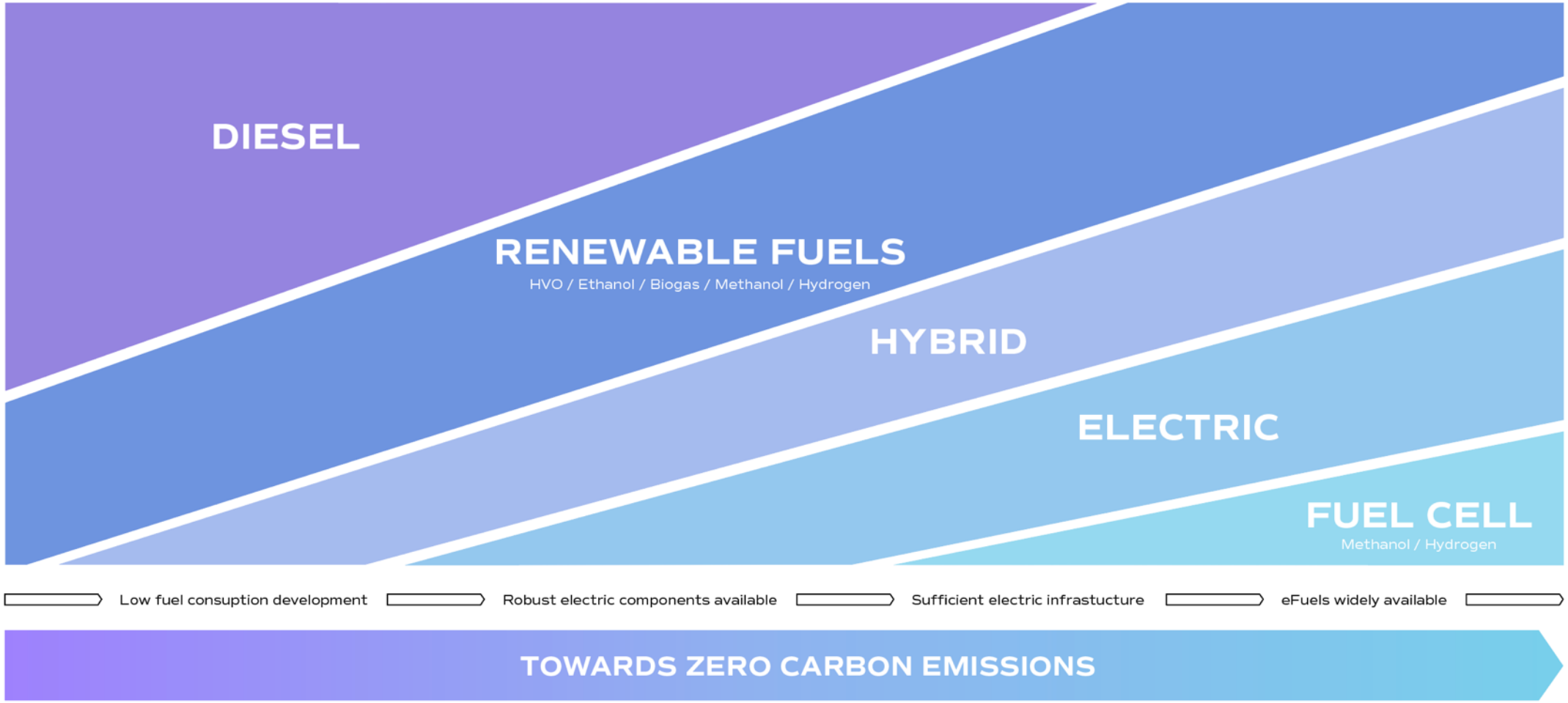
New Capabilities:

- Sustainable Diesel
- Hydrogen
- Electric Drives / Batteries
- Hybrid Drives
- Ethanol and others.

We are Co-Establishing an Engine Technology Research and Competence Center with the University of Vaasa – AGCO Power

AGCO POWER TECHNOLOGY ROAD MAP

Journey to zero



Thank you!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POWER
WIDER SPECTRUM
OF POWER
Times change. Power remains.