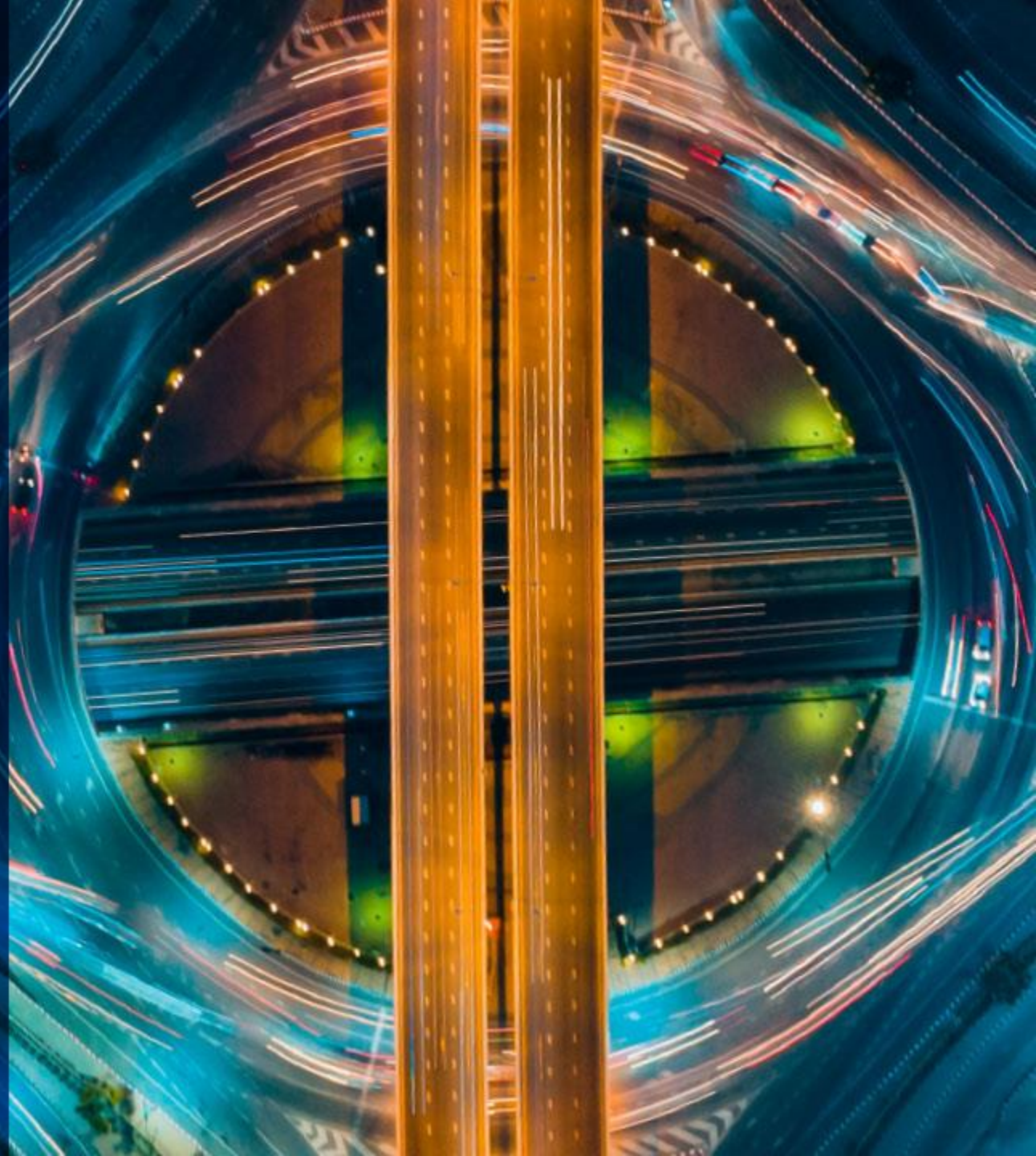
FUTURE ENERGY SOURCE FOR NON-ROAD MOBILE MACHINERY



Aalto 25.10.2022

Arno Amberla

PROVENTIA

VISION:
ZERO EMISSIONS

Proventia is an internationally operating technology company. We help our customers to industries develop energy-efficient products that save the environment and human health.

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TECHNOLOGY COMPANY

TEST SOLUTIONS

EMISSION CONTROL

THERMAL COMPONENTS

BATTERIES & CHARGERS

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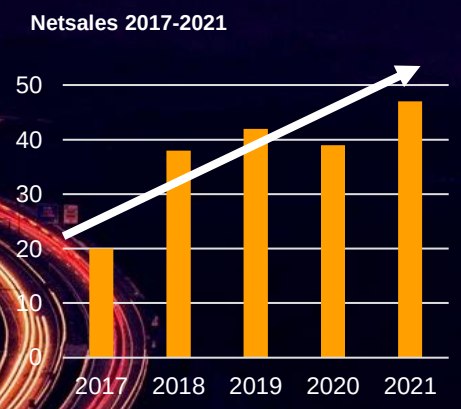
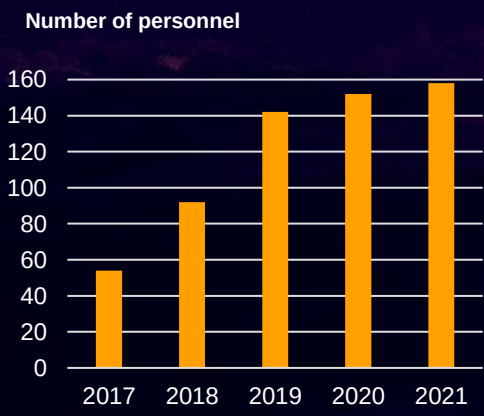
PROVENTIA IN BRIEF

Founded in Finland	Sales in 2021	Employees in 2021	Operating profit in 2021
1994	47 M€	170	4 M€

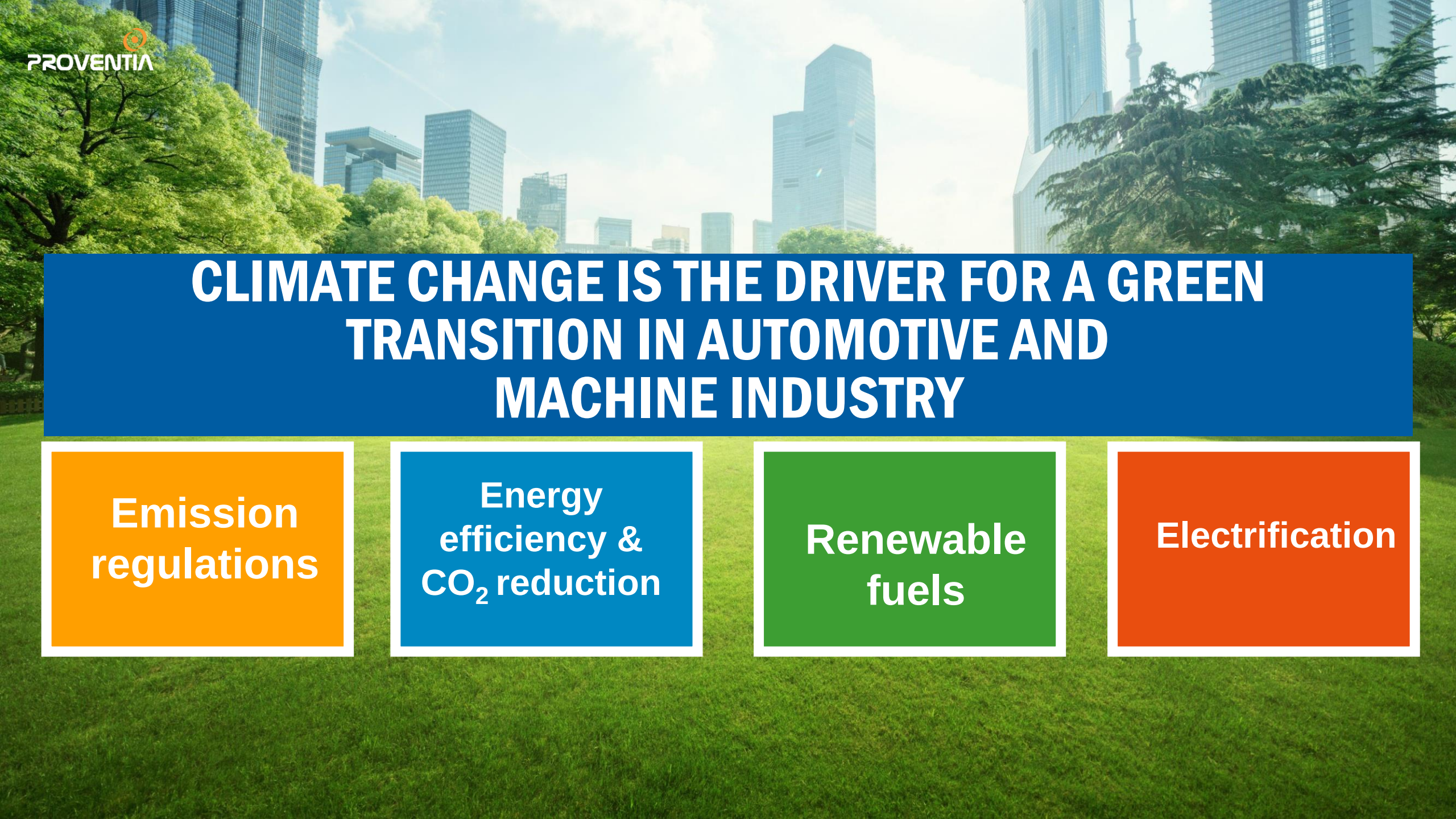
MAIN OWNERS

Head Invest and Elite Alfred Berg





OUR OFFICES AND FACTORIES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CLIMATE CHANGE IS THE DRIVER FOR A GREEN TRANSITION IN AUTOMOTIVE AND MACHINE INDUSTRY
Emission regulations
Energy efficiency & CO_2 reduction
Renewable fuels
Electrification

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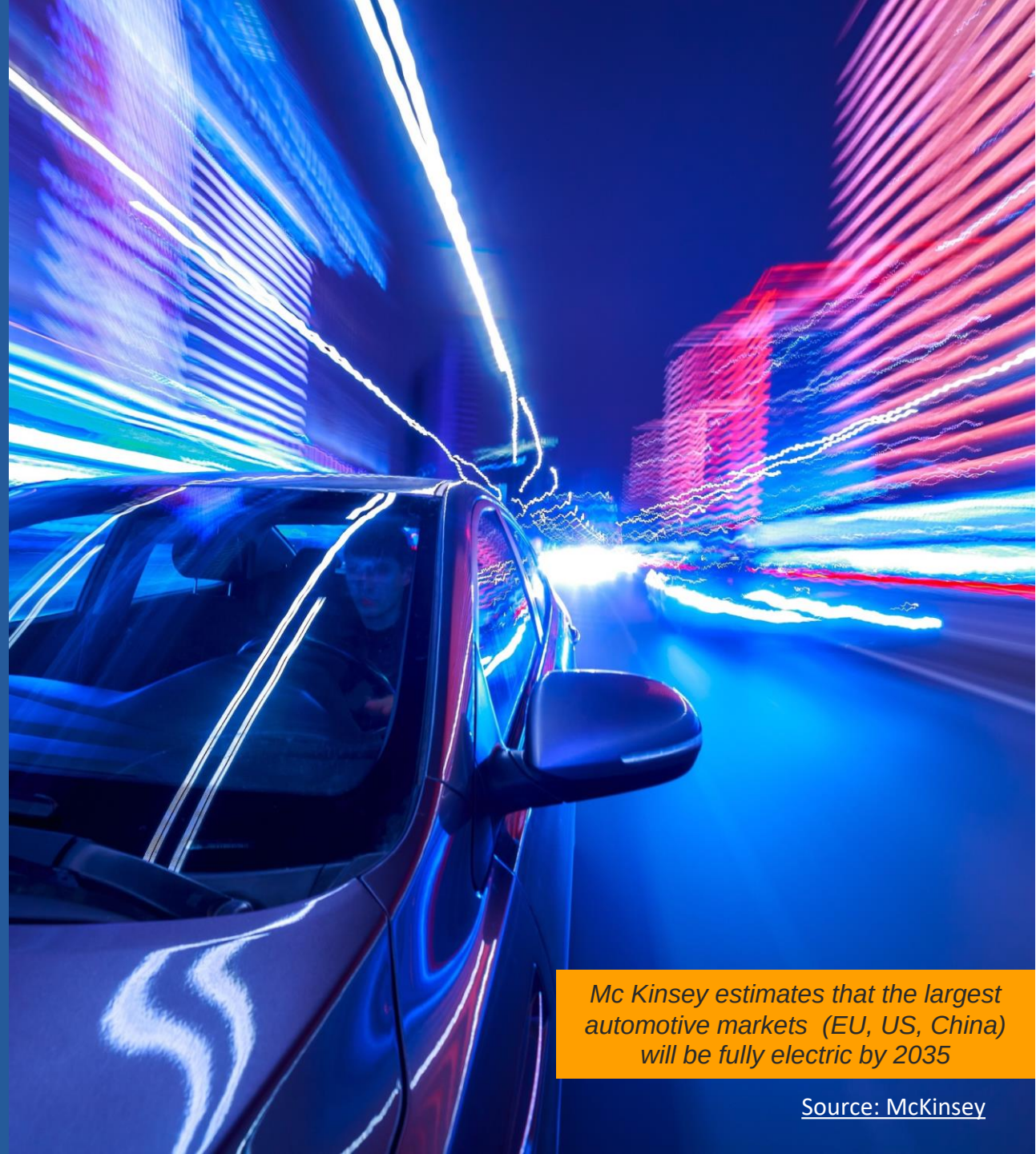
AUTOMOTIVE INDUSTRY

THE FUTURE OF PASSENGER CARS IS ELECTRIC

Electrification: a major shift in the entire automotive supply chain

- From ICE components to electric components
- EV and battery development and production capacity increase
- Acceleration in charging infrastructure buildup
- Many OEMs have stated to stop investing in ICE or have defined a specific date to end ICE vehicle production
- Several countries have announced accelerated timelines for ICE sales bans in 2030 or 2035.



Mc Kinsey estimates that the largest automotive markets (EU, US, China) will be fully electric by 2035

Source: McKinsey

HEAVY VEHICLE INDUSTRY

THE FUTURE OF HEAVY VEHICLES IS DIVERSITY OF TEHNOLOGIES

City buses and urban delivery vehicles are electrifying

Coaches, trucks and heavy transportation

- Various power sources will co-exist, ICE too, but in a sustainable way (renewable fuels)
- Hydrogen: hydrogen fuel cells, hydrogen engines

NON-ROAD MACHINES

THE FUTURE OF NON-ROAD MACHINES IS DIVERSITY OF TECHNOLOGIES

- ICE will remain a power source for quite a long time, but in a more sustainable way: renewable fuels, stricter regulations (EU Stage VI in 2028-2030?)
- Hybrid systems, mild & full
- Hydrogen ICE, and fuel cells are tested and developed
- Battery electric is suitable for low-power applications

Knibb, Gormezano & Partners estimate that by 2050 around 50-55% of the market will be zero-emission

(source: Knibb, Gormezano & Partners)


GREEN TRANSITION:
• STRONG INVESTMENTS IN R&D AND TESTING OF VARIOUS TECHNOLOGIES
• RAPIDLY GROWING BUSINESS OPPORTUNITIES

Future energy sources for non-road mobile machinery

- Availability and logistics
- Storage at vehicle
- Powertrain options
- Duty cycle, type of operation
- Location of operation

What are these non-road mobile machines?

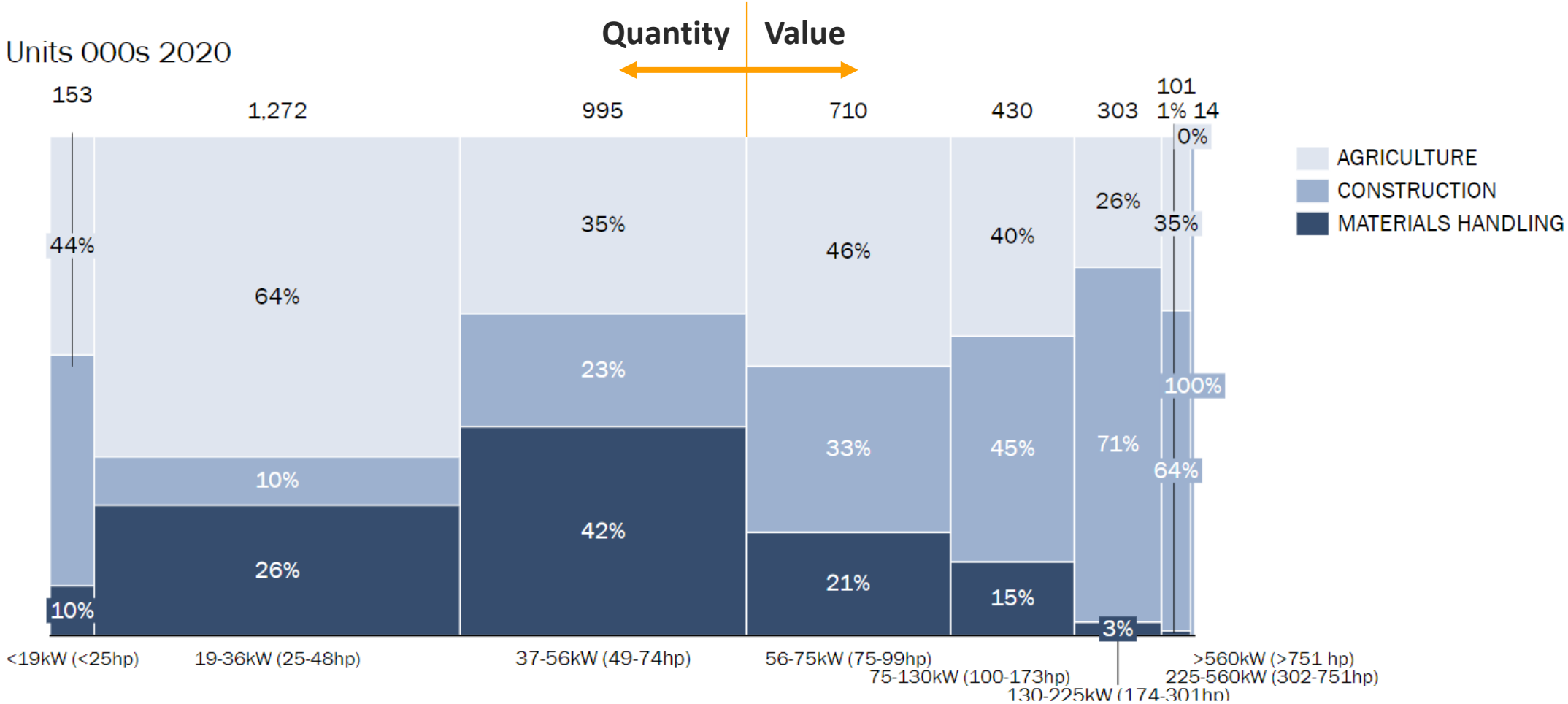
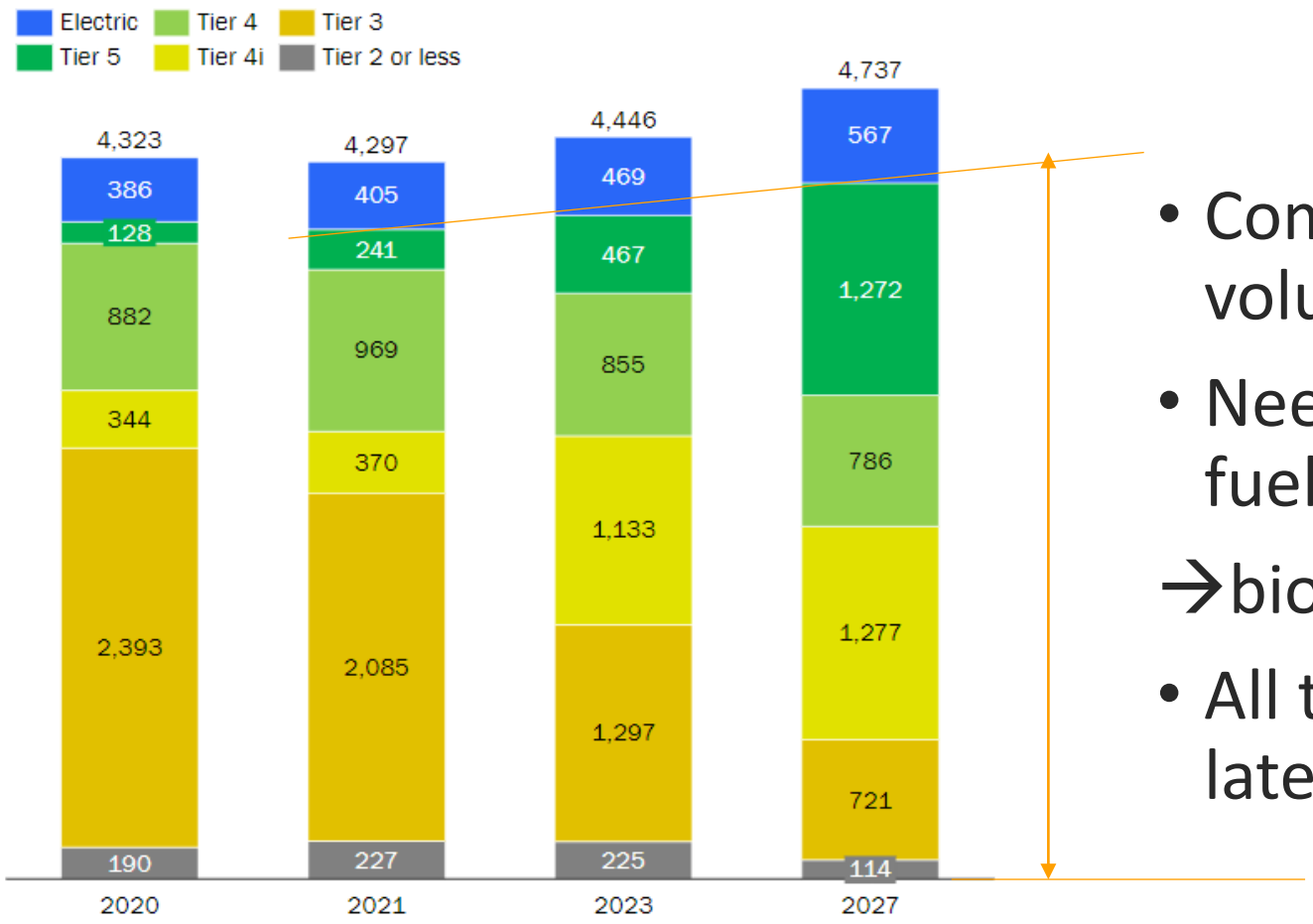


Figure 12. Non Road Production by Compliance

(Units '000)



KGP OHR Global Non-Road Powertrain Forecast GNRPTF Quarter 1 2021

- Combustion engines will grow in volume
- Need for fast decarbonization of fuels and electricity production

→biomethane, HVO, eFuels, H2

- All these need to be compliant with latest emission regulations

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Alternative fuel availability, demos at least…

	<19kW	19-56kW	56-130kW	130-560kW	560kW+
Battery Electric					
Other Electric					
Mild/Full Hybrid					
Electric Drive					
Fuel Cell					
H_2 ICE					

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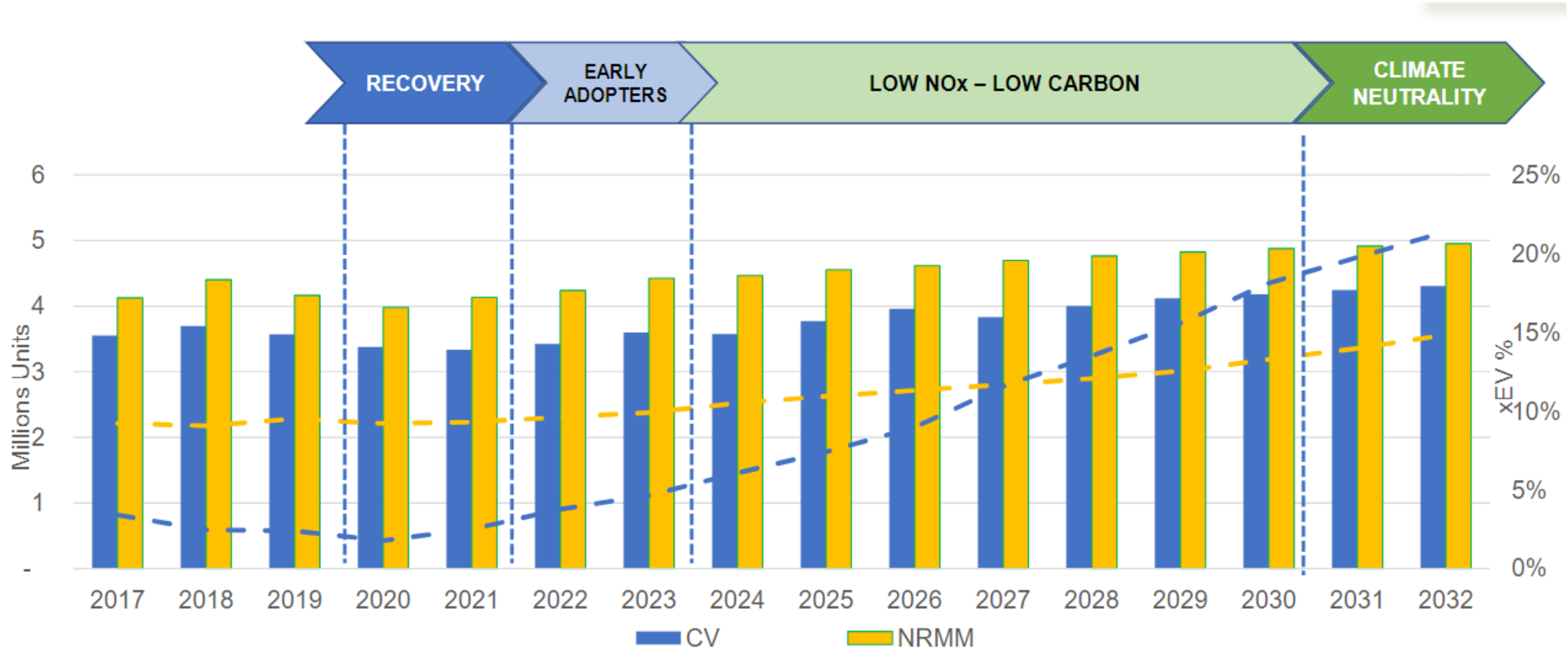
Electrification forecast, material availability will be limiting factor



Sources:
KGP Global Commercial Vehicle Powertrain Forecast Q4 20
KGP Global Non-Road Powertrain Forecast Q4 20

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Energy Carriers, low carbon as target

- Battery electric
- Fuel Cell electric
  - Hydrogen from source x
  - Battery supported
- Renewable liquid biofuels
  - HVO, hydrotreated vegetable oil
  - eFUELS
- Biomethane
- Hydrogen on ICE (internal combustion engine)

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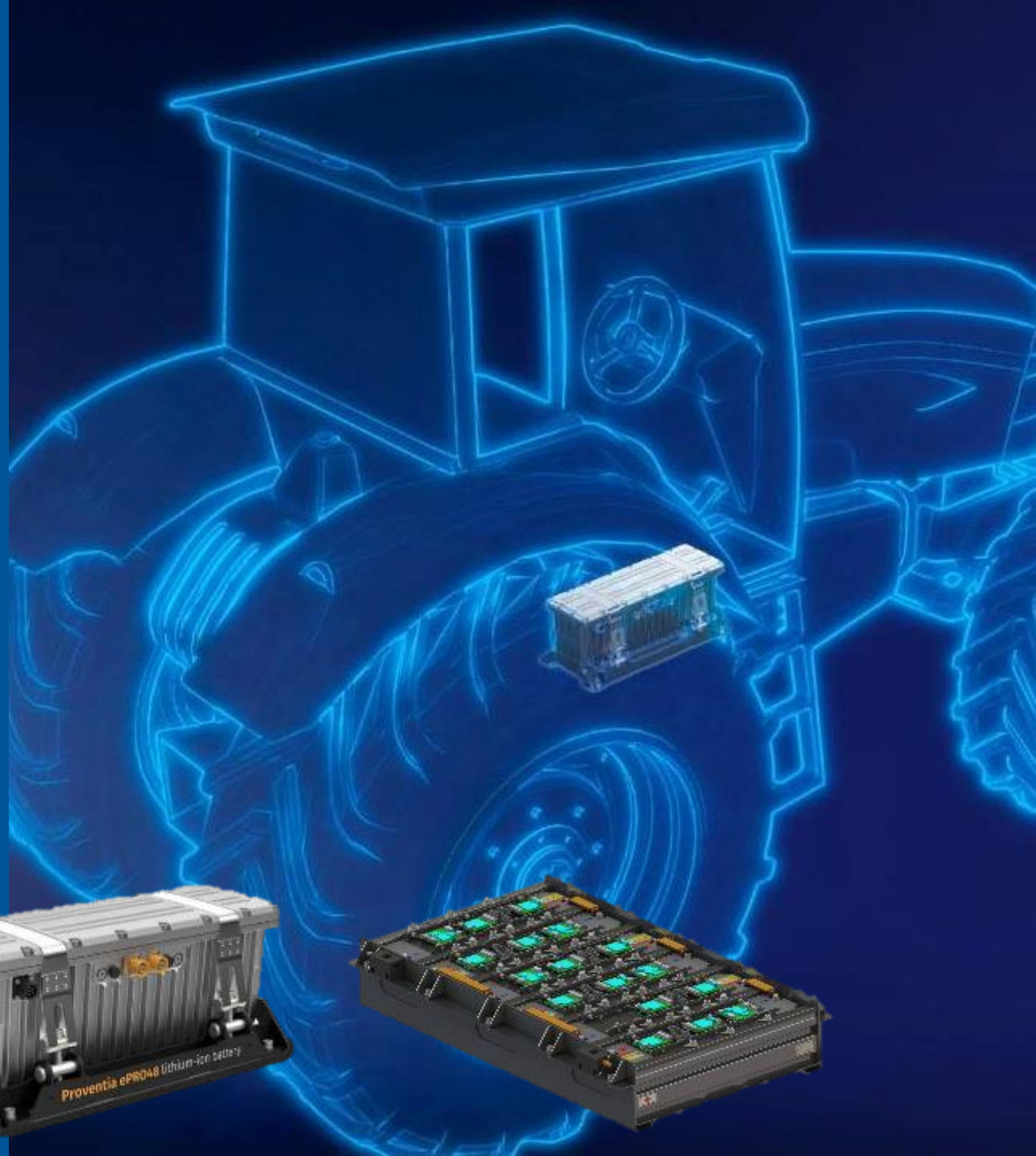
SWEET SPOTS FOR ELECTRIFICATION

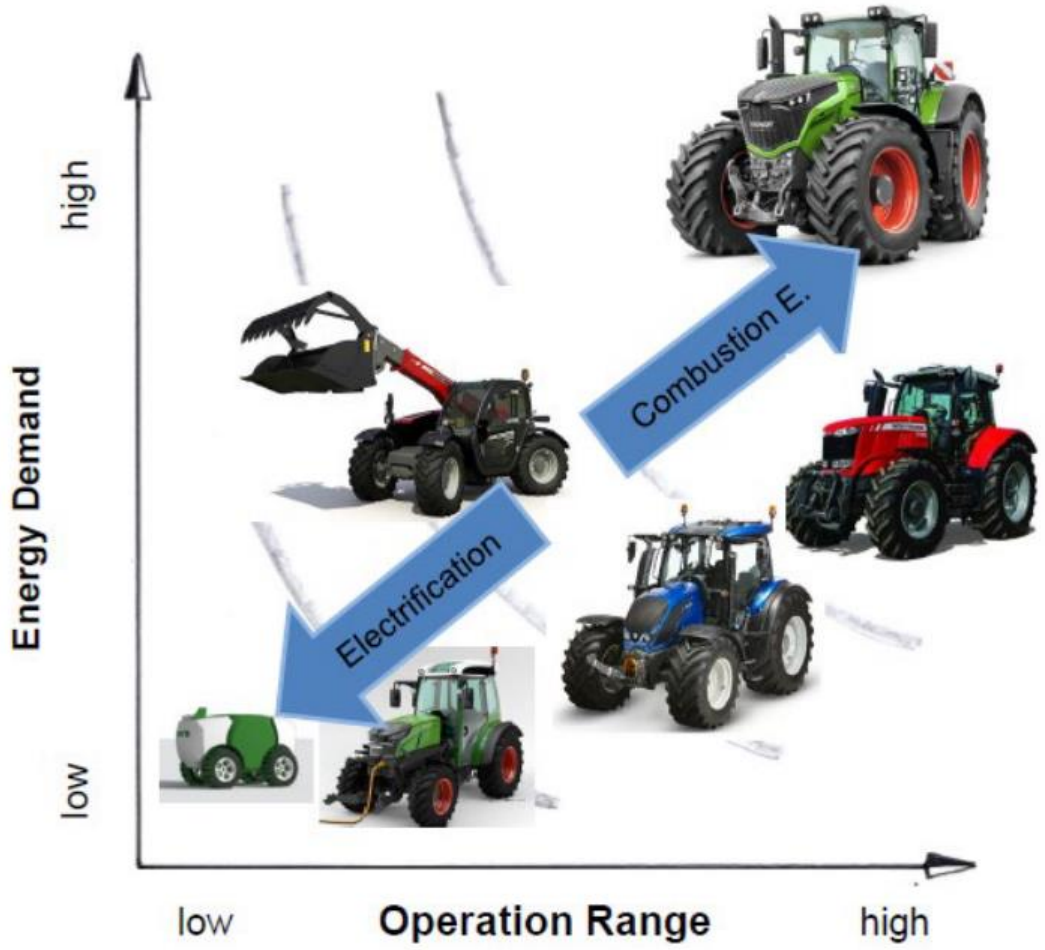
- Operating in known area where infrastructure is already built
- Powertrain is or will be electrified, commercial vehicle is such
- Low energy demand, low to mid range
- Low CO2 electricity is available
- Charging infra is sufficient – including grid and charger itself



Sweet spots for battery electric applications

Source AGCO

Battery electric, but where?



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ENERGY SOURCE COMPARISON – RELATIVE TO DIESEL

	Diesel (fuel only)	LNG (fuel only)	Hydrogen ICE (fuel only, 350 bar)	Hydrogen FC (fuel only, 350 bar)	Battery (Li-Ion)
Weight					
	100%(Baseline)	85 %	35 %	28 %	2 700 %
Volume					
	100%	170 %	1 800 %	1 450 %	1 900 %
Energy cost per day					
	100 %	75 %	37...82 %	30...67 %	48 %
Energy storage system cost					
	100 %	400 %	3 000 %	2 500 %	15 000 %

Source: AGCO Your Agriculture Company

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Energy storage at vehicle

- All alternatives to diesel (fossil or renevable) are much larger and/or much heavier
  - Weight and volume: LNG having smallest impact (as fuel only), batteries having greatest impact
  - Plastic or steel tank is very cheap way to storage liquid fuel, both on vehicle or as refilling system.
- Diesel (fossil) is 100 years old fuel and handling practices are safe and well known
- Hydrogen and other gaseous fuels are ”new” and need new safety measures

Hydrogen, but in to what?

- Hydrogen purity sets limitations
- Fuel cell stack has limited lifetime
  - Diesel engine lifetime >20.000h with min 8000h emission compliance
  - FC lifetime ~5000-8000h before replacement or major overhaul
- Fuel cell sweet operating spot at ~60% load
  - High load → short lifetime
  - Needs battery supported electric drivetrain
- H2 ICE
  - No need to modify drivetrain
- H2 tanks are big and surprisingly heavy

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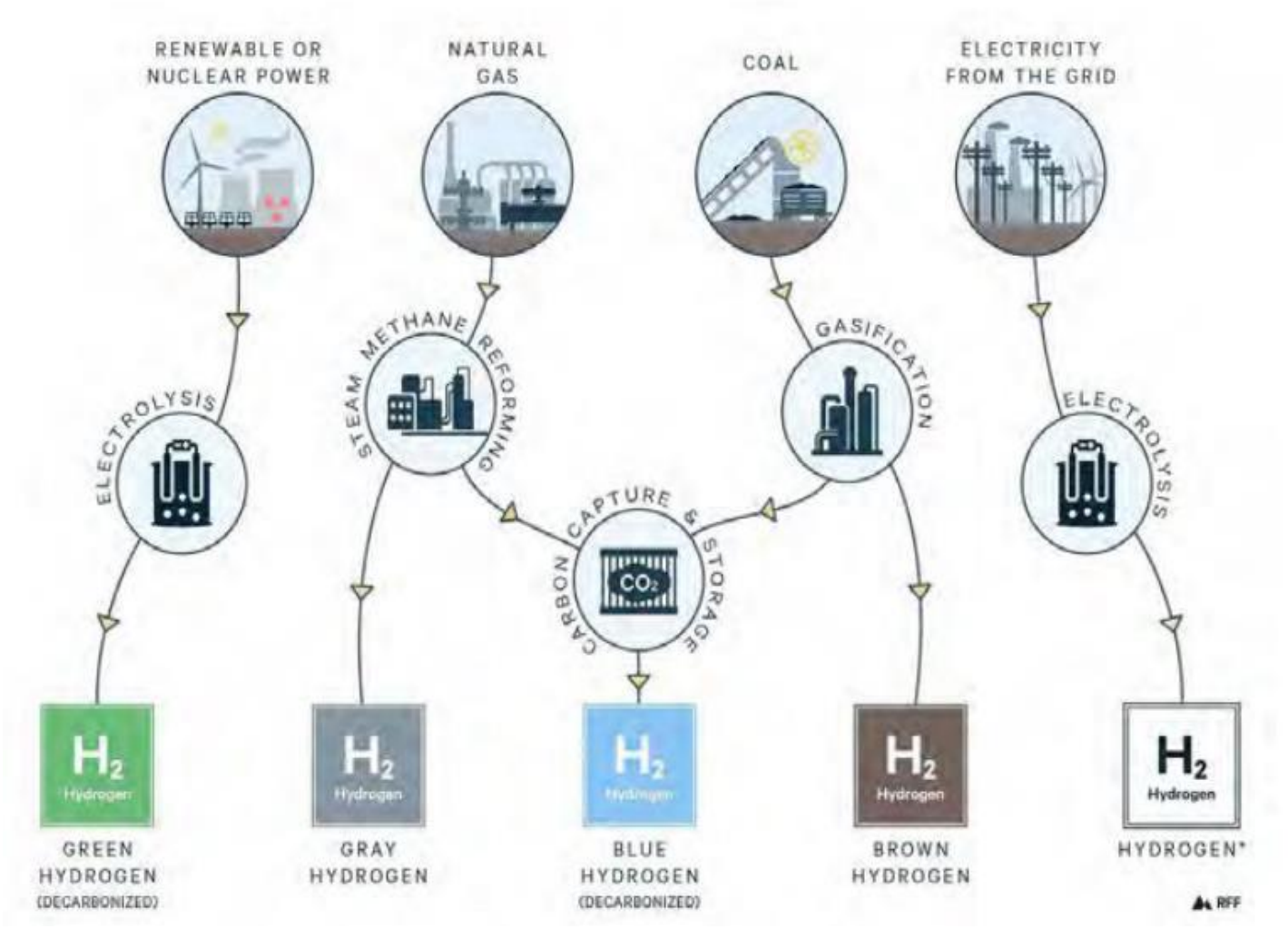
Hydrogen, but which color?



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Waste Heat Recovery

- **ICE**
  - Exhaust 150-600°C, variable mass flow
  - Coolant 90-100 °C
  - Peltier element, ORC
  - Turbo compound
  - E-turbo
- **FC**
  - Coolant 50-60 °C
  - Radiators are not getting smaller

Local sweet spots will emerge

- Critical mass of certain ”fuels” will be available in selected locations
  - Biogas, biomethane
  - eFuels (diesel / methanol / CNG-type of fuel from CO2 capture and H2 from green electricity)
  - Hydrogen
  - Full electricity – zero emission regulations, charging infra,…
- Need for back up? Multifuel capability?

Future for NRMM

- Main stream: Diesel ICE with more and more renewable fuel
- Small and low duty application: battery electric
- Niche and/or local applications: biomethane, H2 ICE, H2 Fuel Cell
- All machines: hybridization

THANK YOU FOR YOUR INTEREST

Proventia Group Oyj

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