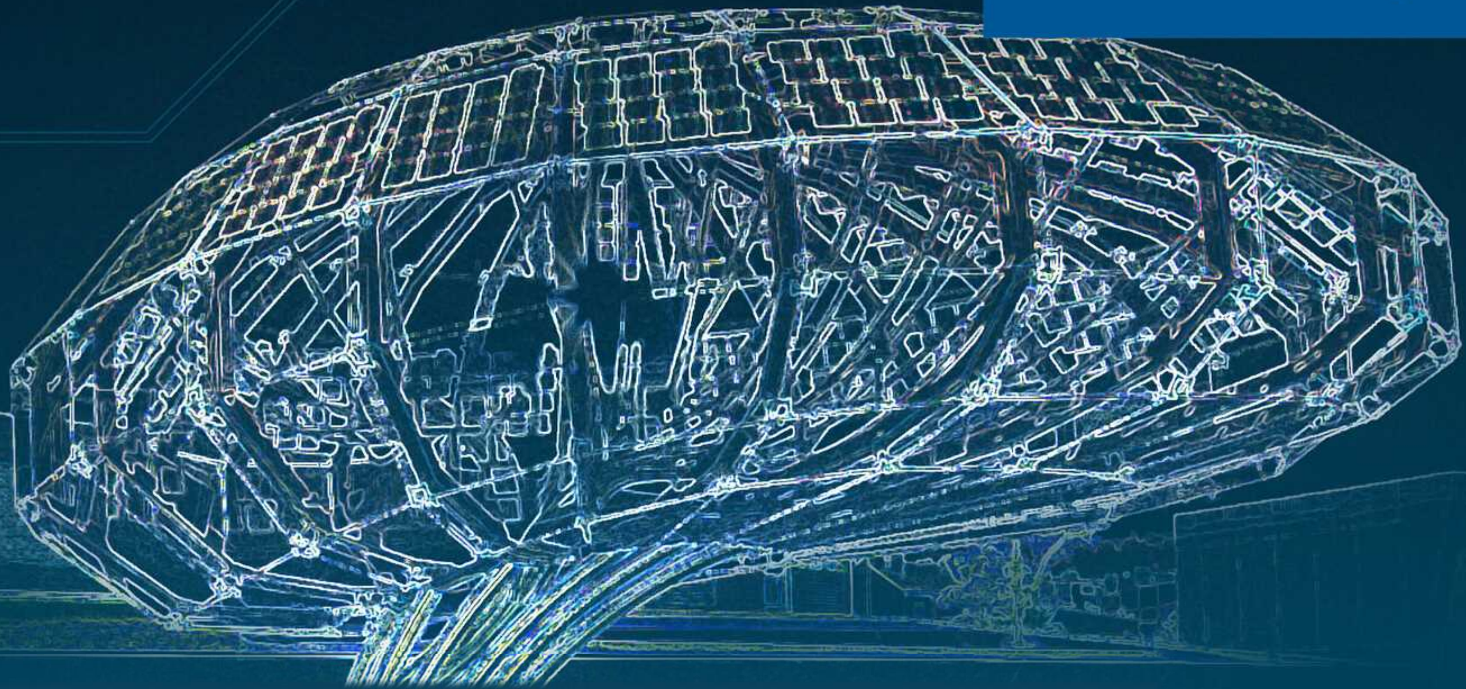
AVL List GmbH



Propulsion Systems in Transition

Joint symposium Waseda - AVL

Prof. Dr. Helmut List

AVL Corporate presentation

Solutions for all CUSTOMER SEGMENTS

Passenger Cars

2-Wheelers

Racing

Construction

Agriculture

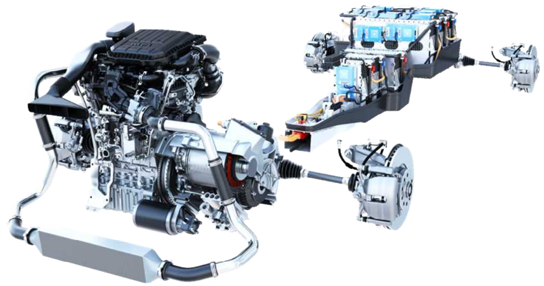
Commercial Vehicle

Locomotive

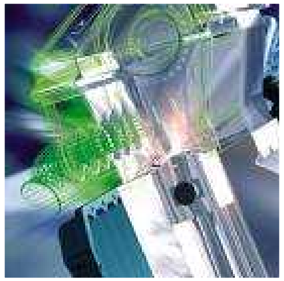
Marine

Power Plants

Powertrain Engineering



Development Platform



Simulation & Testing

Enterprise Development Automotive

RESEARCH 10%
of turnover in-house R&D

INNOVATION 1500
granted patents

STAFF

9.500 employees

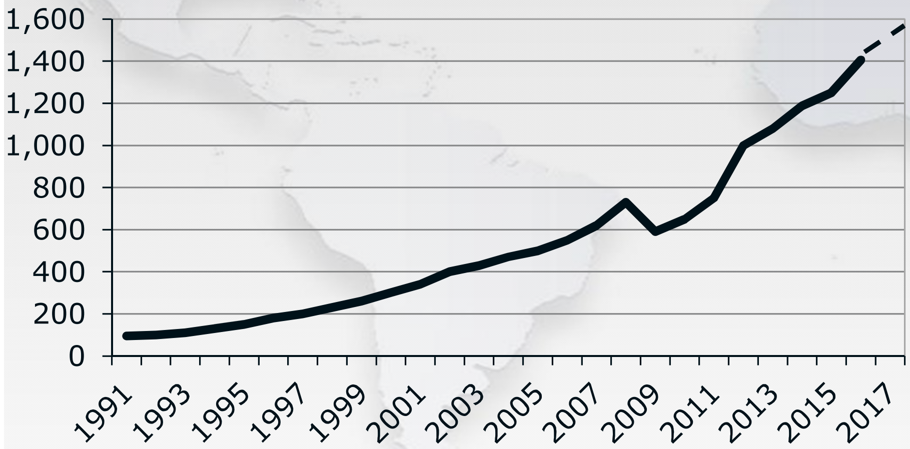
65% engineers and scientists

GLOBAL FOOTPRINT

40 engineering locations
21 of them with own test fields

- **>220** testbeds
- Global customer support network

GROWTH



SALES

1995:
0.15 billion €

2017:
1.55 billion €

Plan 2018:
1.71 billion €

EXPERIENCE
70 years !

POWERTRAIN
and its Integration in the Vehicle

ONE

PARTNER

AVL Powertrain –
a Network of Technical Centers



HQ Graz, **AUT**


Steyr, **AUT**


Graz, **AUT**


Budapest, **HUN**


Paris, **FRA**


Reggio Emilia**, ITA**


Neuenstadt, **GER**


Regensburg, **GER**


Remscheid, **GER**


Munich, **GER**


Södertälje,**SWE**


Istanbul, **TUR**


Basildon, **UK**


Coventry, **UK**


Ingolstadt, **GER**


Stuttgart, **GER**


Gotenborg, **SWE**


Haninge, **SWE**


Plymouth, **USA**


Lake Forest, **USA**


Ann Arbor, **USA**


Sao Paulo, **BRA**


Delhi-Gurgaon, **IND**


Shanghai, **CHN**


Tianjin, **CHN**


Seoul, **KOR**


Tokyo, **JPN**

+ another
13 Engineering
Offices

FACTS AND FIGURES AVL JAPAN

RESEARCH 10% of turnover in-house R&D

Supporting Member of AICE

STAFF

➢ **340** employees of AVL Japan

JAPAN FOOTPRINT

- 4 engineering locations
- 3 test beds (at JTC)
- Global customer support network

Long Term Cooperation Experience with Japanese customers

5 powertrain elements

Your
local
PARTNER

AVL JAPAN TECHNICAL CENTER

4-Dyno Powertrain & Vehicle Testbed

Battery Emulator

Light Duty Engine Testbed

Heavy Duty Engine Testbed

Virtual Testbed (HiL)

Propulsion Systems in Transition

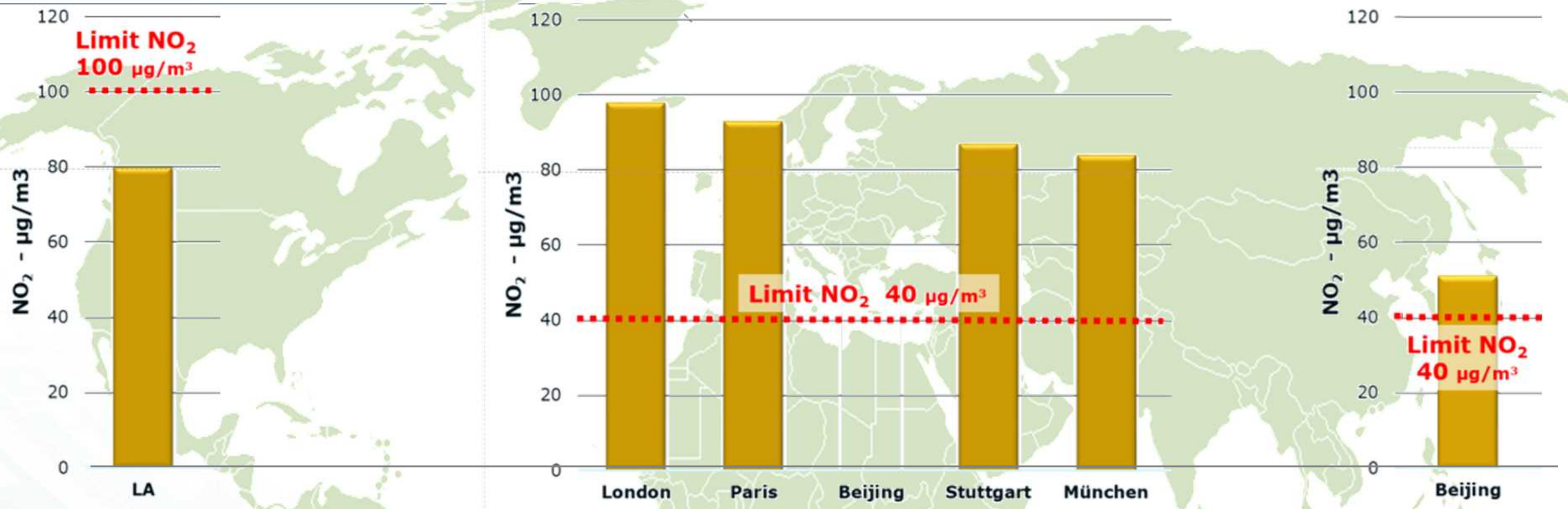
Challenges for Future Powertrains

Short Term

Mid Term

Long Term

Imission Situation in Large Cities



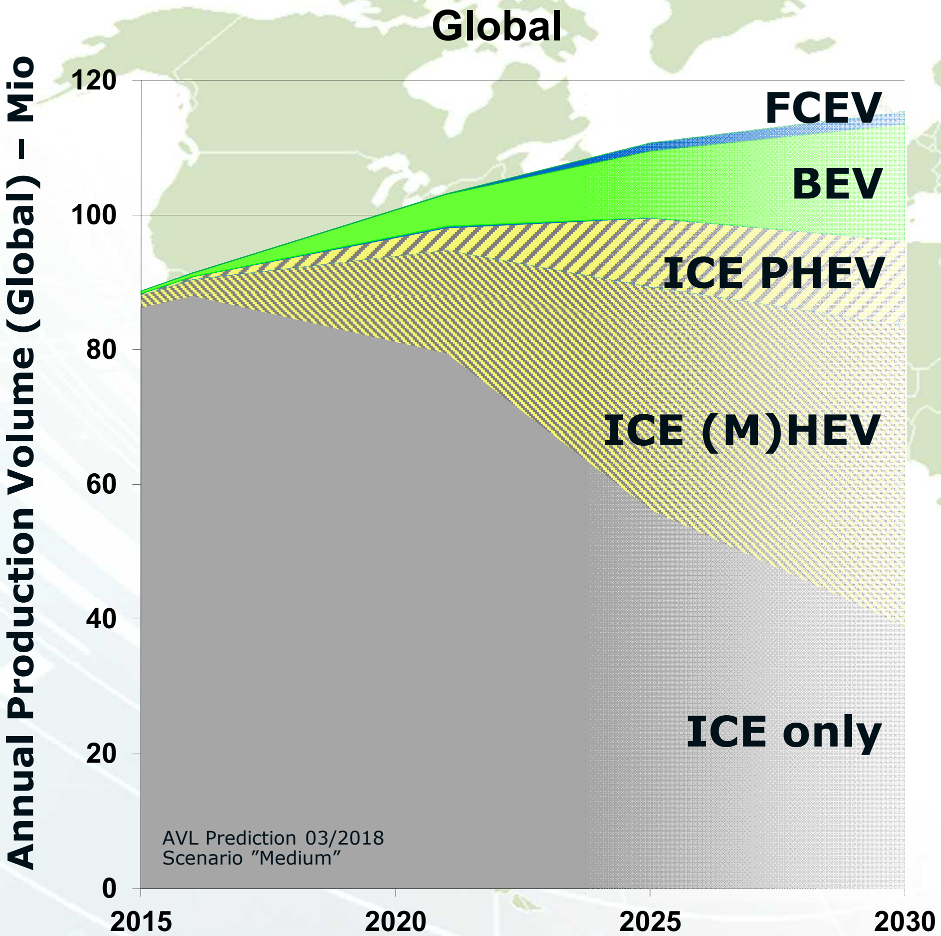
Imission
(snapshot values, 2015) [1)]

[1)] Representative values not necessarily yearly max

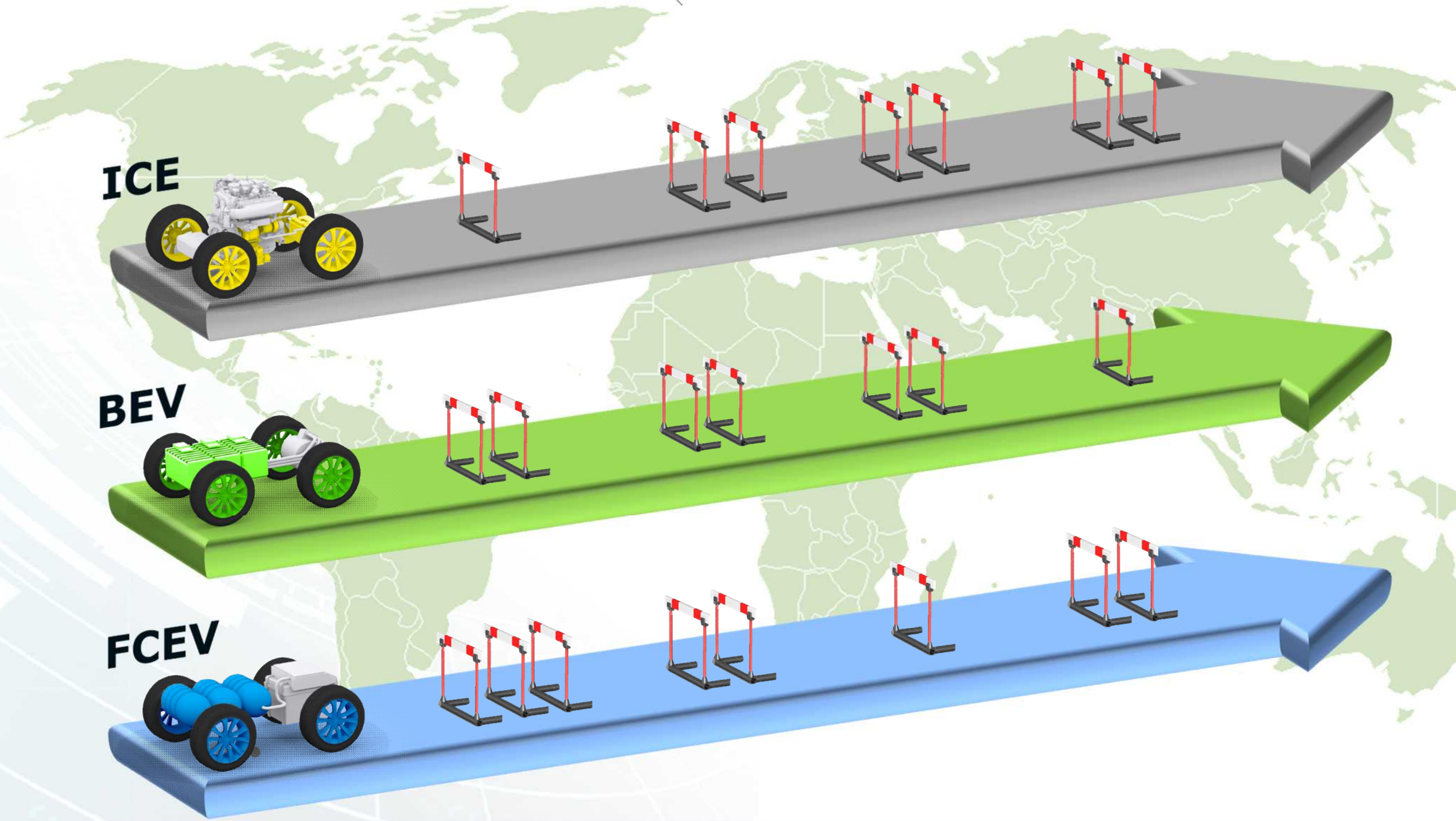
Source: Air quality index

Fundamental Change in Emission Compliance

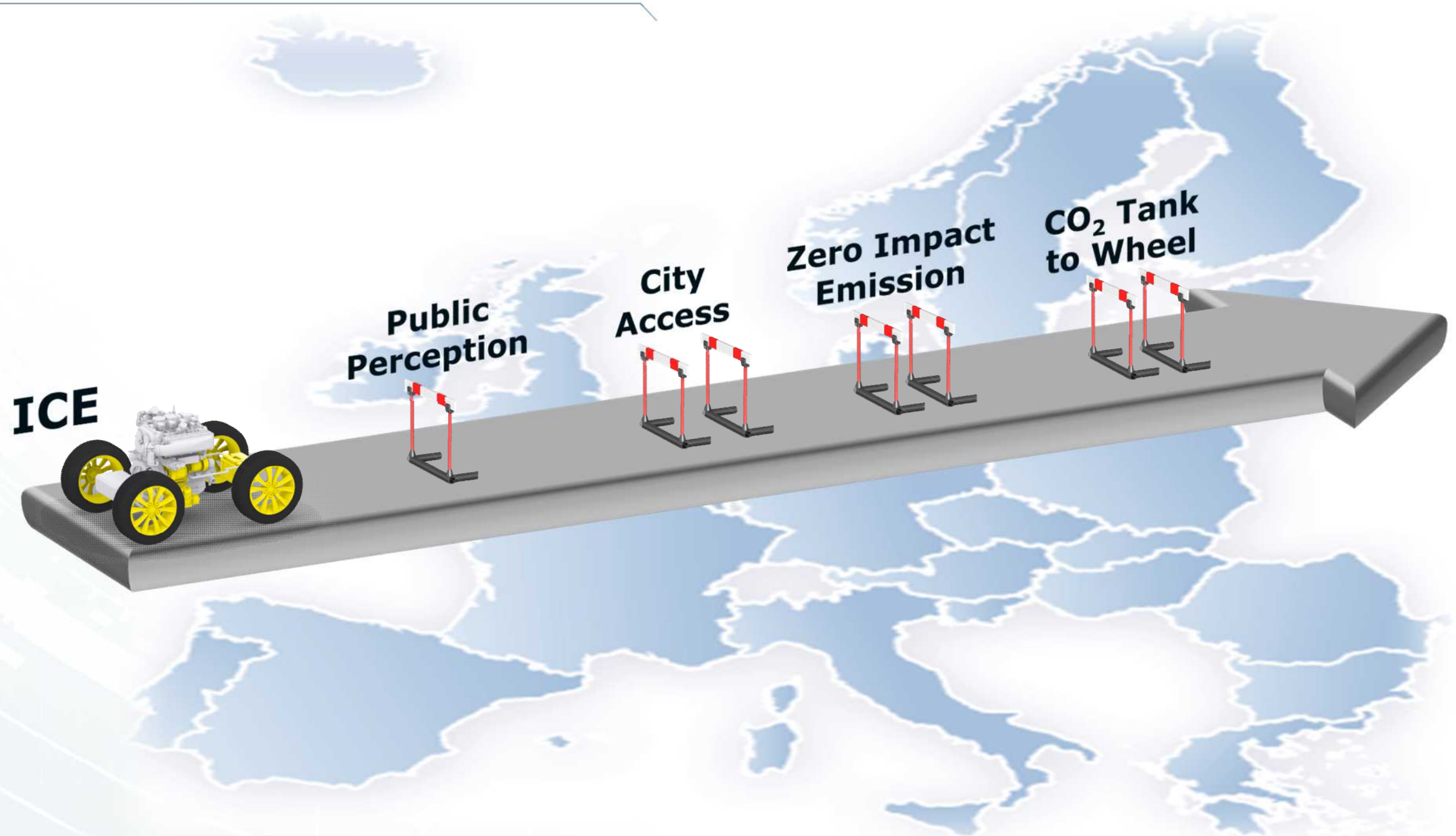
Global Technology Shares – One Potential Scenario



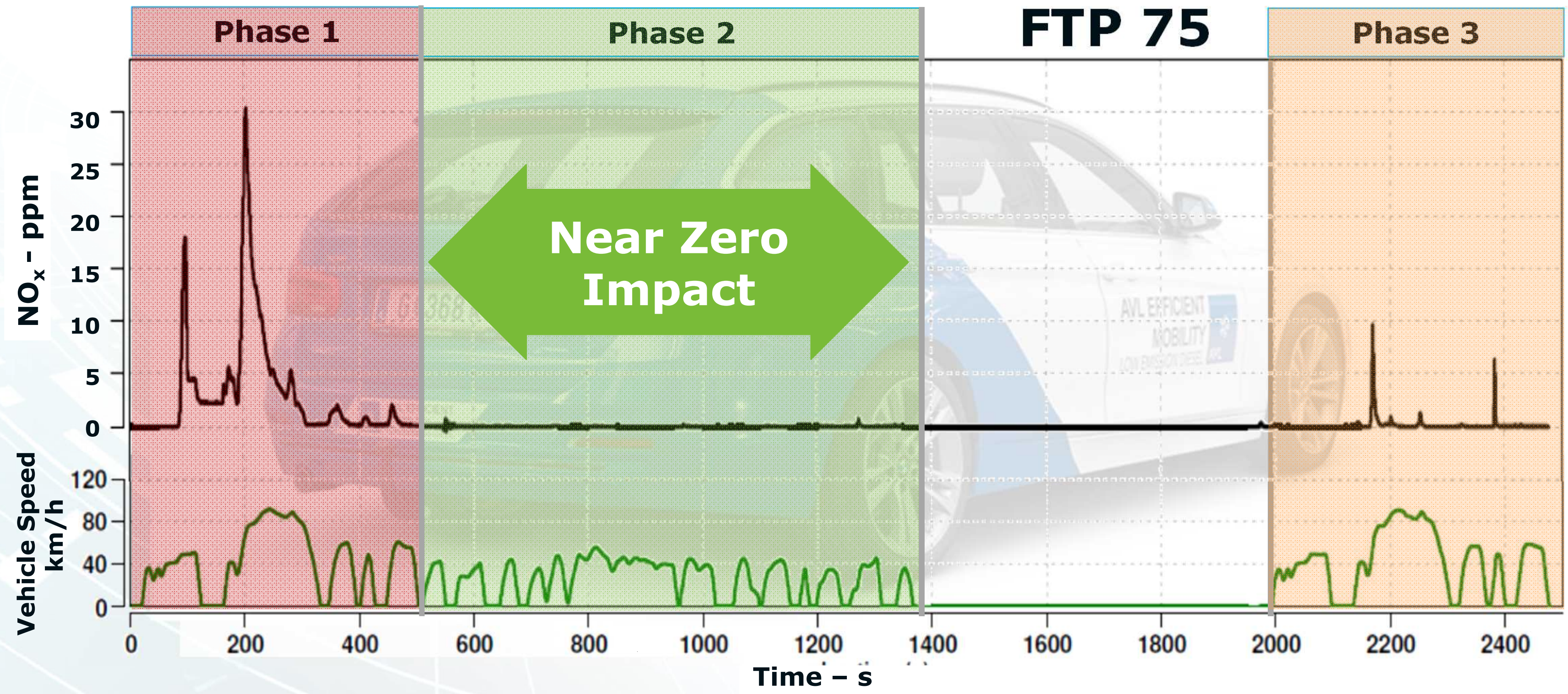
Powertrain Competition
Obstacles of Individual Technologies



Internal Combustion Engine – Challenges

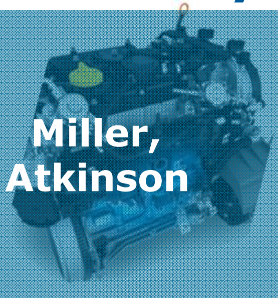


NOx Emission of a SULEV 30 Diesel Vehicle



Technology Trends - Spark Ignition Engines

today



Miller, Atkinson

tomorrow

VCR, HCCI, UHP, ...

Extended Miller,
Advanced Boosting

Mild Hybrid

Spark Ignited

e.g. extended 48V systems (20→30 kW)
as enabler for low emission & CO_2

HCCI.. Homogeneous Charge Compression Ignition   VCR Variable Compression Ratio, UHP .Ultra High Injection Pressure

Technology Trends – Diesel Engines

today

Lean NOx Trap + SCR

tomorrow

Advanced EAS & Temperature Management, Refined Operation Strategies

Mild Hybrid

Compression Ignited (Diesel)

e.g. extended 48V systems (20→30 kW) as enabler for low emission & CO_2

Synthetic Fuels

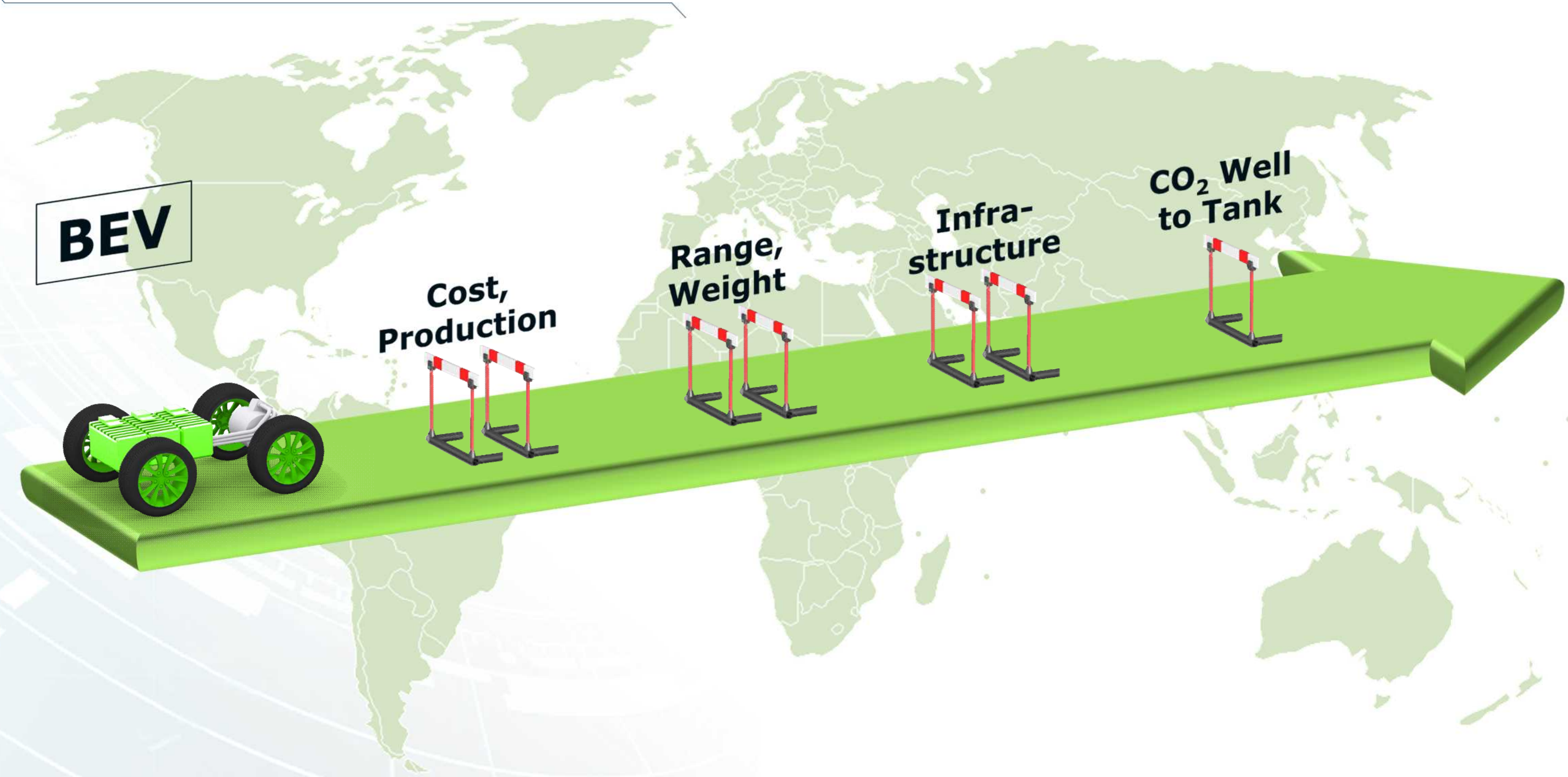
Advantages

- Simple storage and transport
- Utilization of existing infrastructure
- Re-use of established powertrain concepts
- Low CO_2 footprint

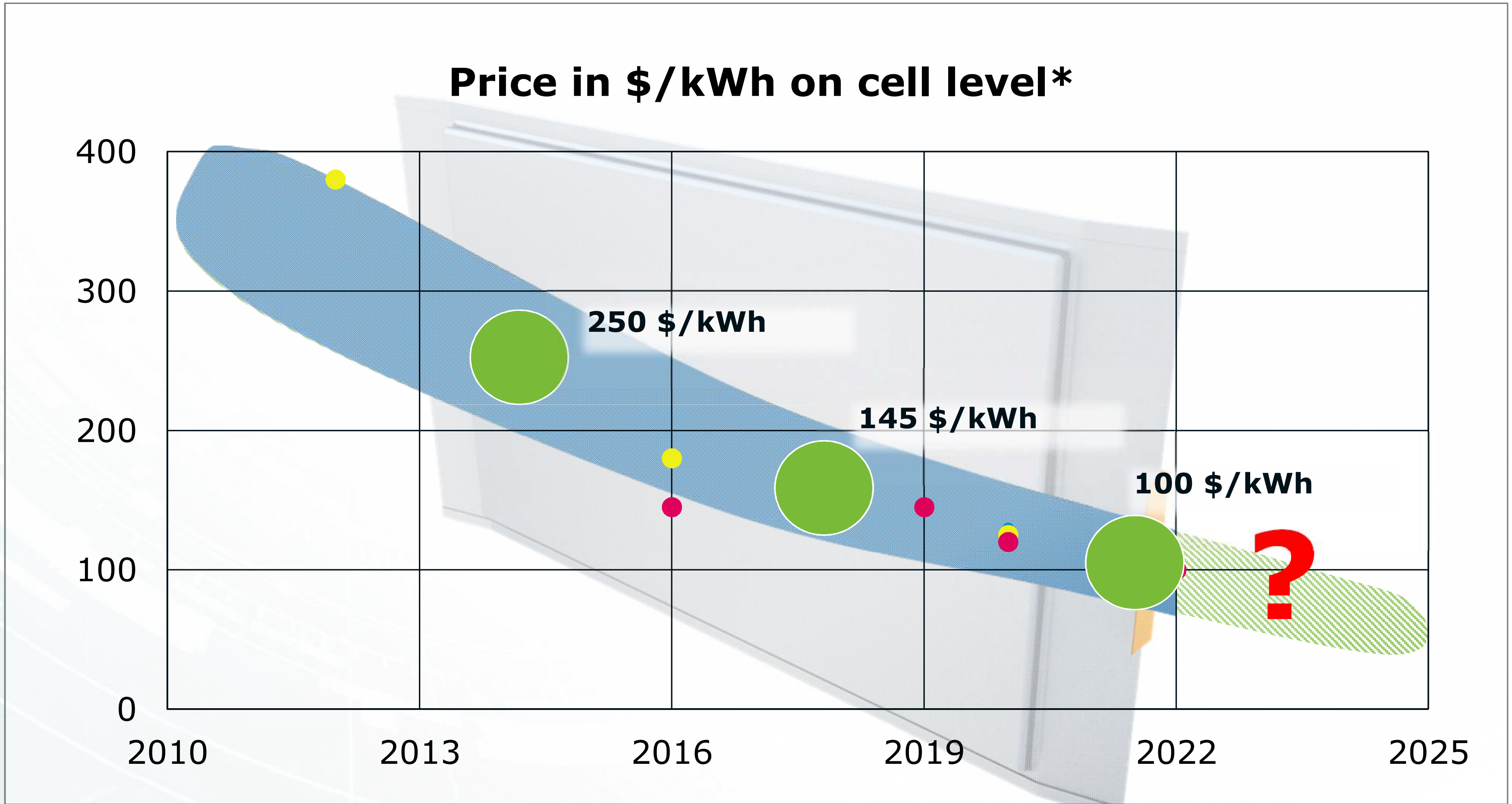
Challenges

- Synthetic fuels do not meet todays specifications
- Costs: Utilize advantages on local resources

Battery Electric Powertrain - Challenges

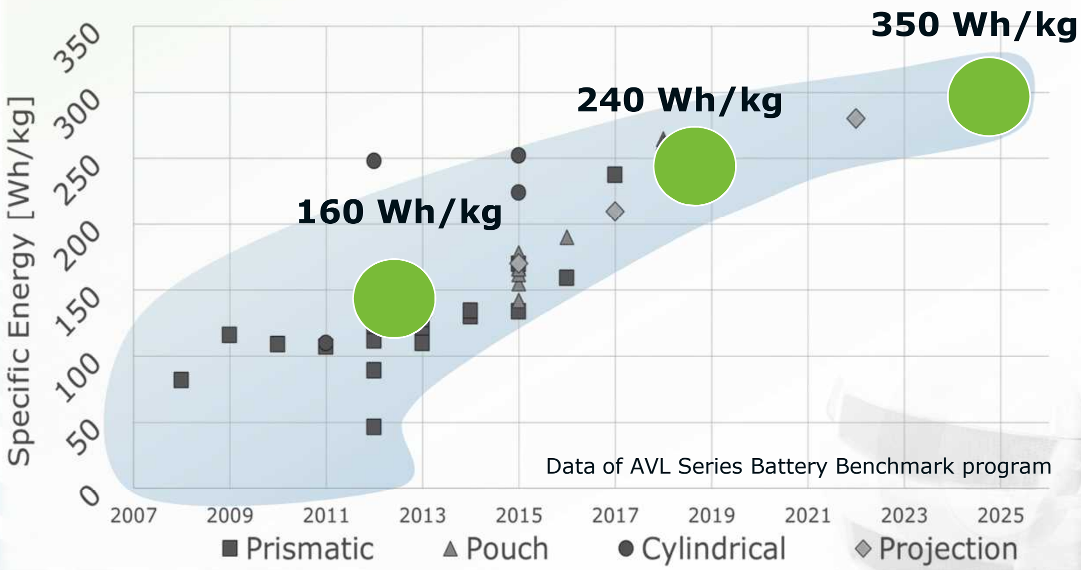


Development of Battery Cell Costs



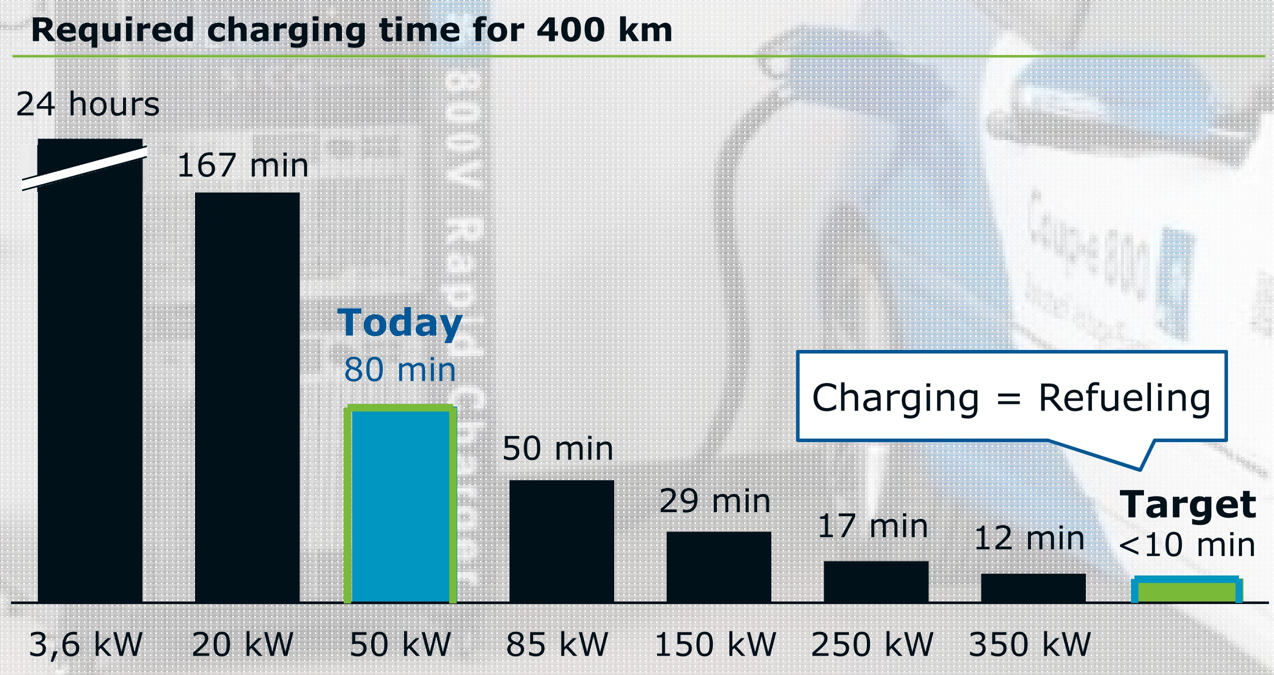
*Source: Anderman Report 2016

Power Densities of Batteries



Performance Prognosis of Li-Ion Cells		
SOP	**Wh/kg**	**Wh/L**
2015	175 - 225	400 - 500
2020	225 - 275	500 - 600
2025	275 - 350	600 - 750

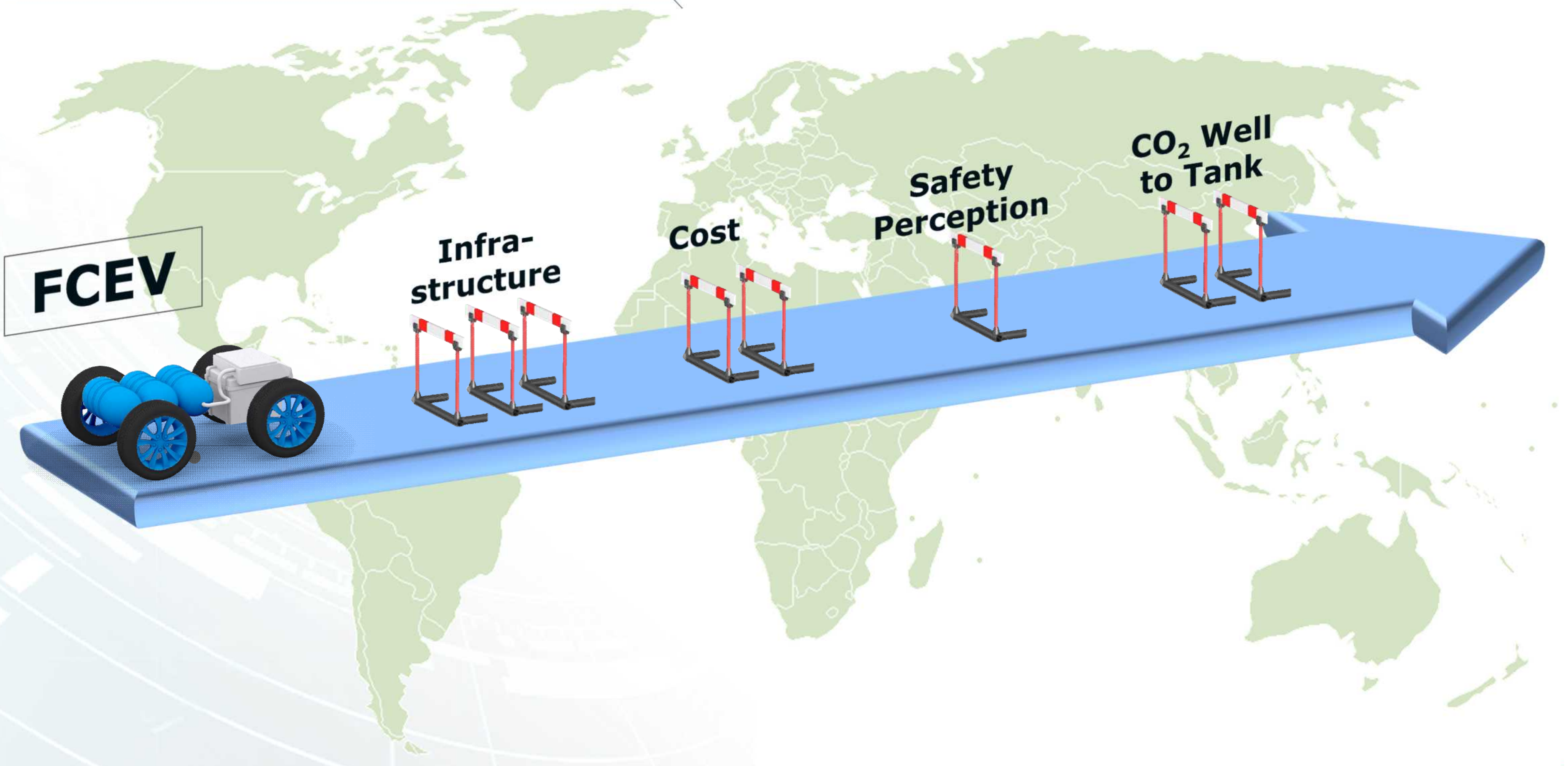
Required Charging Time for 400 km Range



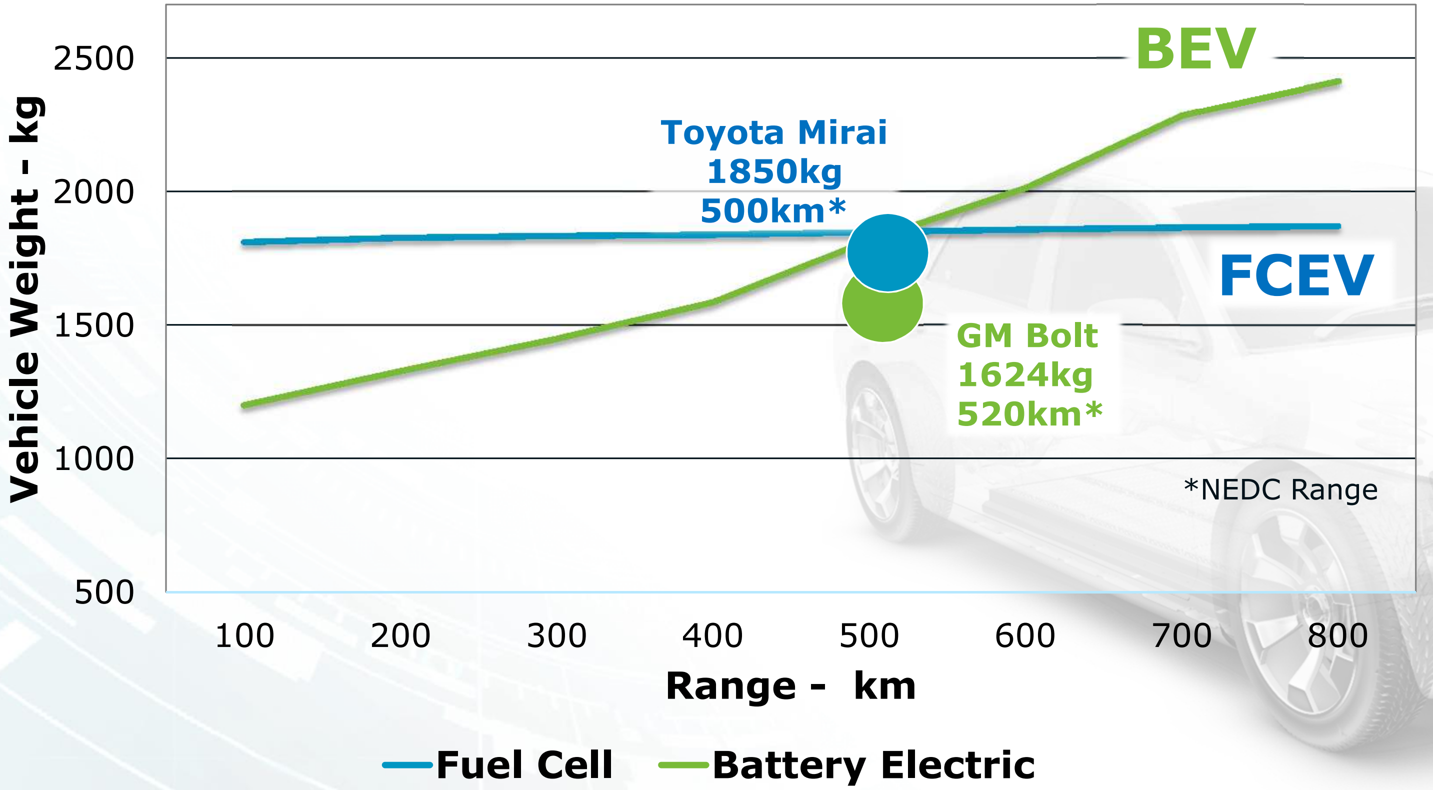
At home / at work	Parking	Long distance

Source: AVL, Strategy Engineers, Audi, bimmertoday

Fuel Cell Powertrain - Challenges



Range Impact on Vehicle Weight



Types of Fuel Cells

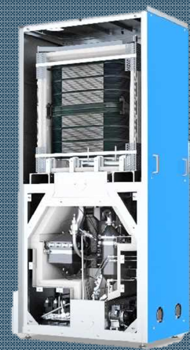
PEM
(Emission free)

PEM Fuel Cell Engine 20-150 kW

H_2

SOFC
(Pollutant free, only CO_2 emission)

SOFC APU/Range Extender 3-30 kW

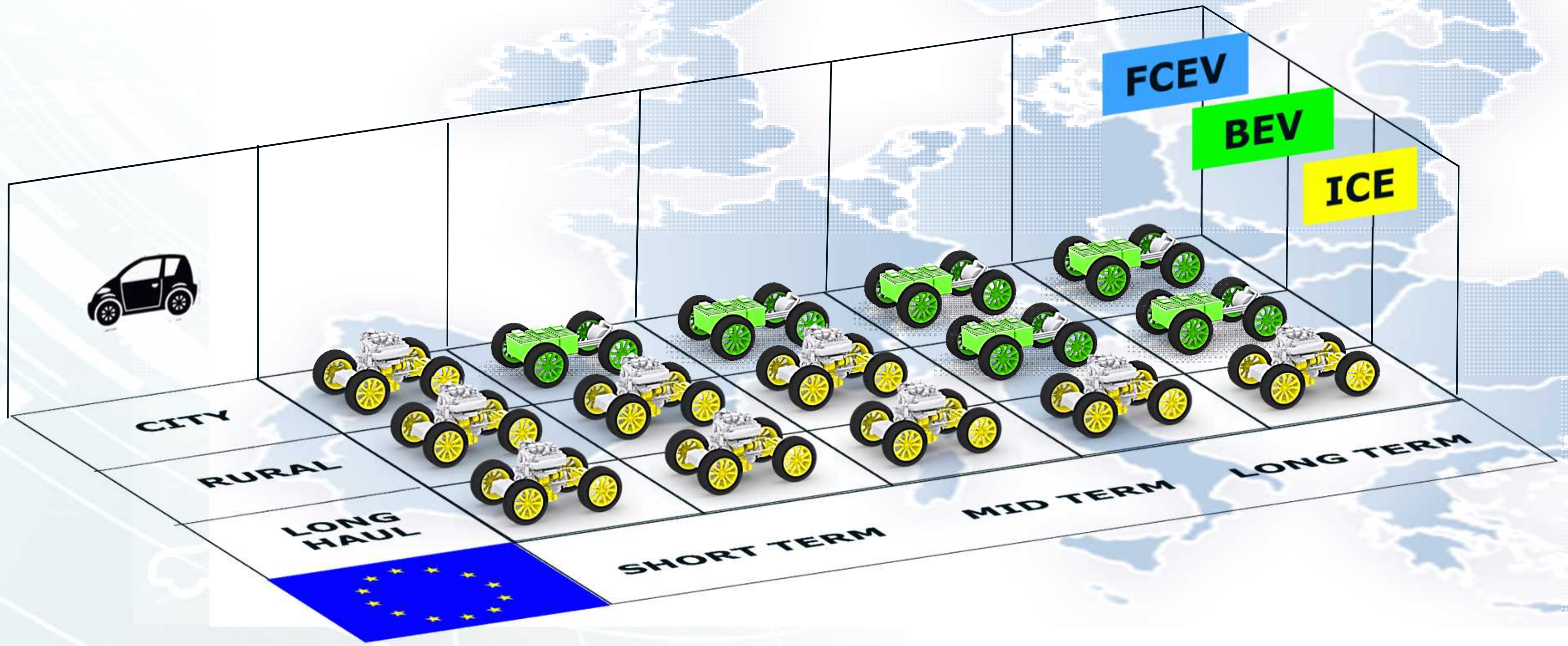


SOFC Stationary Power Generator kW-MW

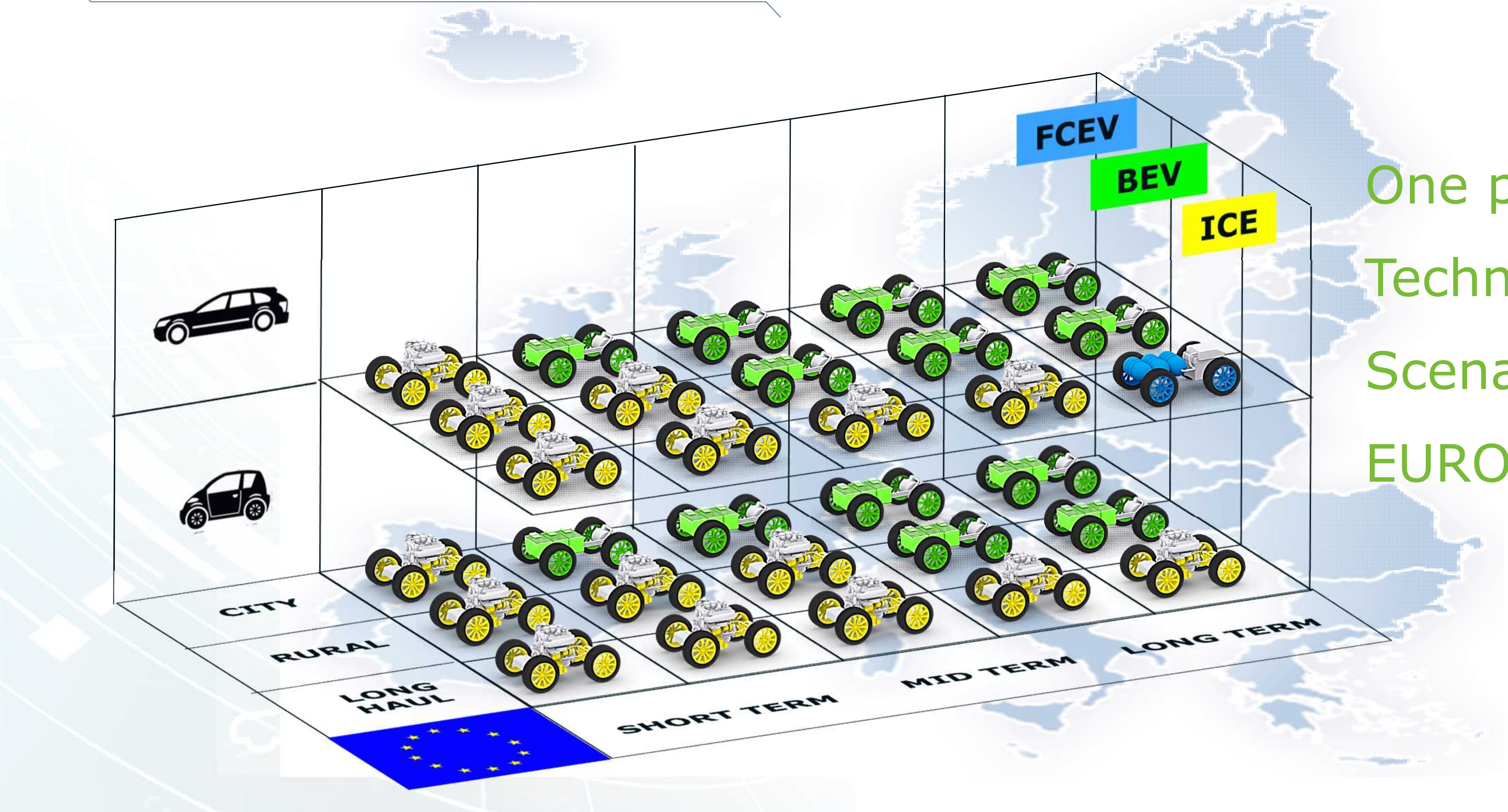
DIESEL | GASOLINE | CNG | e-Gas | LPG | H_2 | Ethanol | Methanol

Powertrain Competition

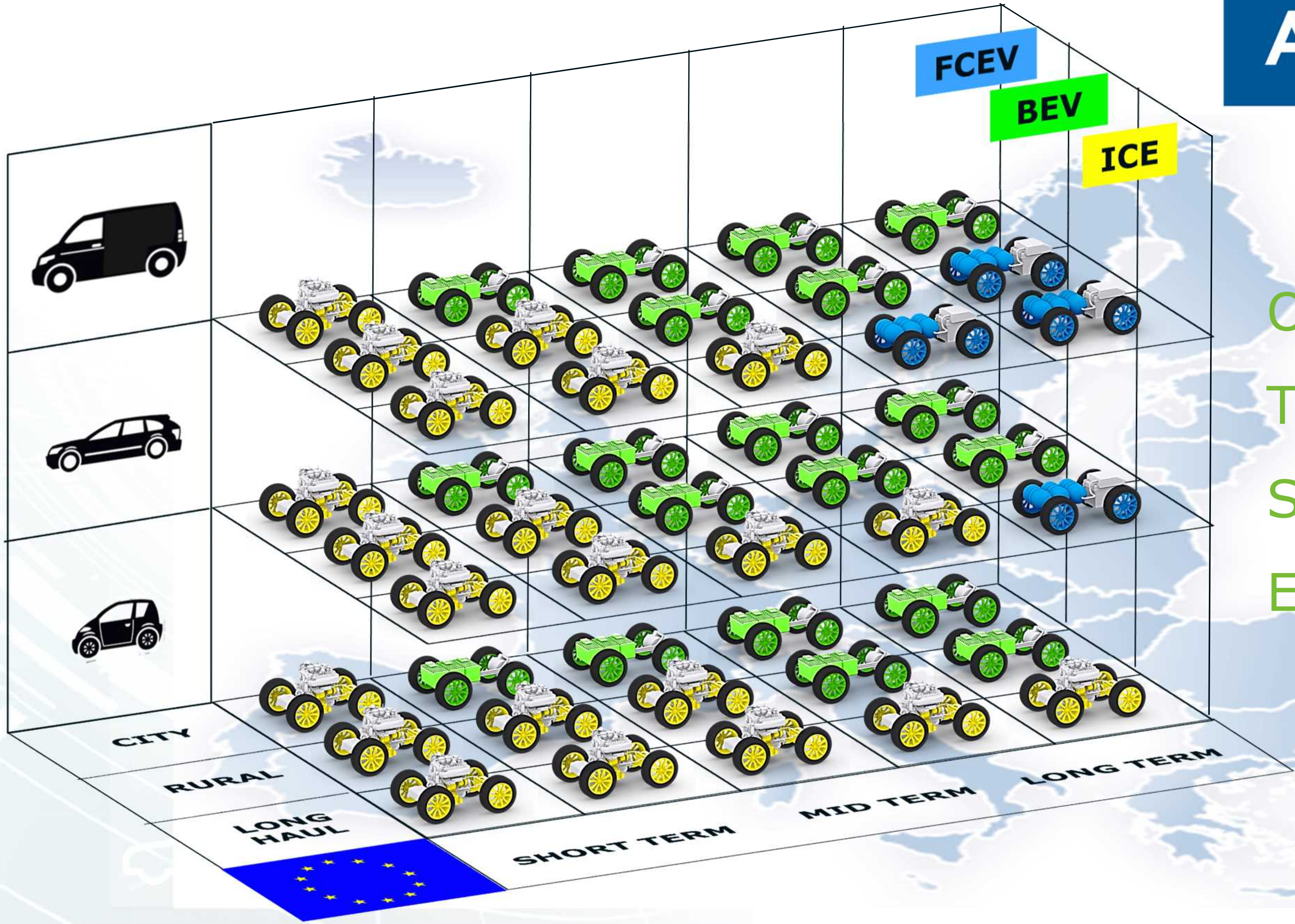
One possible Technology Scenario EUROPE



One possible Technology Scenario EUROPE



One possible Technology Scenario EUROPE



One possible Technology Scenario EUROPE

Conclusions (1/2)

- Long Term : Significant increase of electrical propulsion systems
- Current imission issue has anyway to be resolved by the ICE itself
- ICE will meet EU6d_{final} even w/o Hybridization
- With Hybridization, ICE has "Zero Impact Emission" potential
- Synthetic Fuels (PtX) will enable a CO_2 neutral ICE

➔ Any "disqualification of the ICE" in the technology race should be withdrawn

➔ The ICE remains also in the future an important contender

Conclusions (2/2)

- Complexity has to be seen not only as challenge, but as an enabler for extended flexibilities
- The practicability to put an increasing diversity of models into robust series solution will be decisive
- New approaches with shifting both development and validation more towards the virtual world are required

➔ The efficient connection of new development tools becomes key

➔ Not only the propulsion systems themselves are undergoing an essential transition, but also the respective development methodology and the development environment

Thank You

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