THE 16th GAIKINDO INTERNATIONAL AUTOMOTIVE CONFERENCE 2022

Advanced Green Mobility for The Bright Future

Milestones of Future Automotive Technology

Franz Kinzer, AVL

Facts and Figures

Global Footprint

Represented in 26 countries

45 Affiliates divided over 93 locations

45 Global Tech and Engineering Centers (including Resident Offices)

1948

Founded

11,000

Employees Worldwide

12%

Of Turnover Invested in Inhouse R&D

70+

Years of Experience

65%

Engineers and Scientists

1,500

Granted Patents in Force

1,7 Bn €

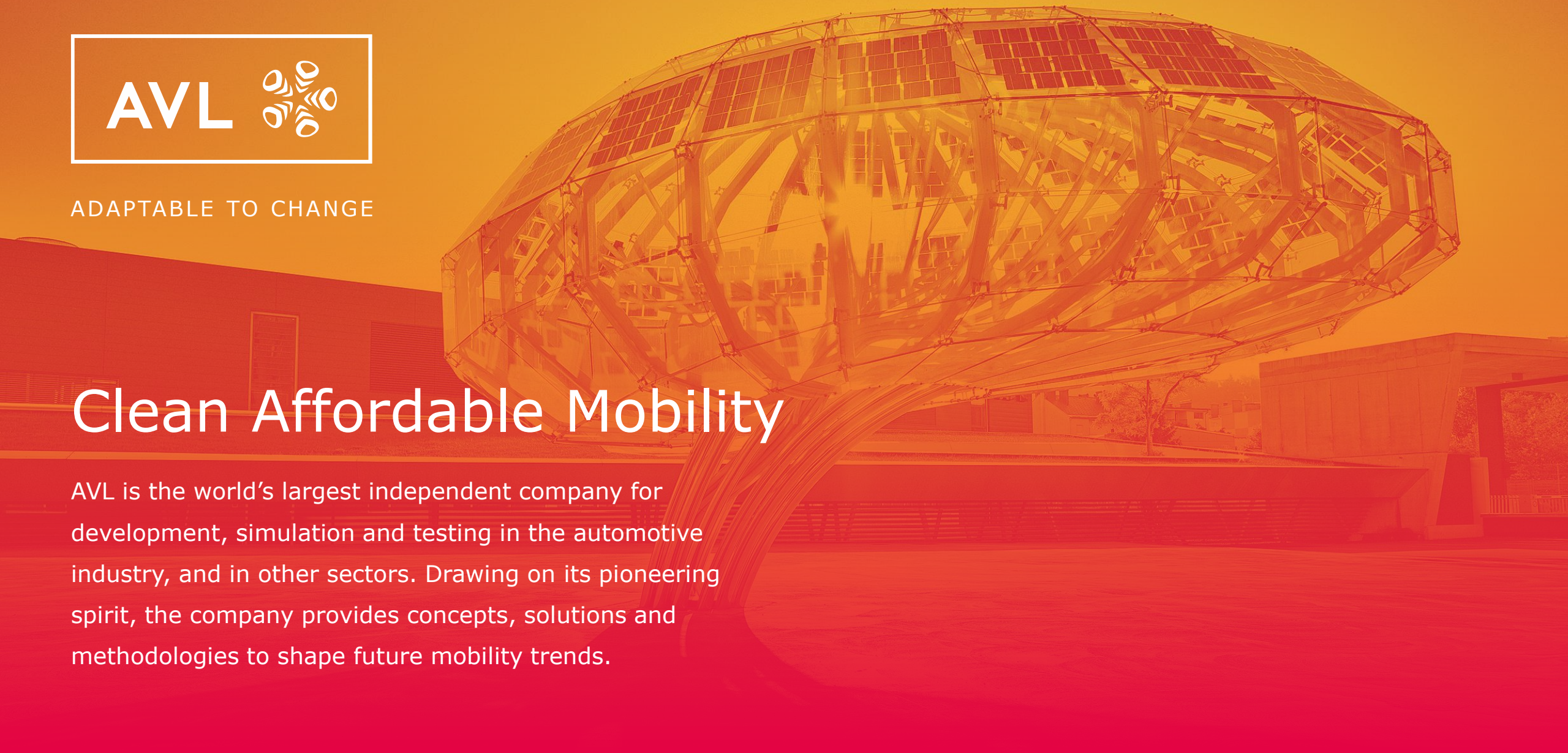
Turnover 2020

97%

Export Quota

AVL

ADAPTABLE TO CHANGE



Clean Affordable Mobility

AVL is the world’s largest independent company for development, simulation and testing in the automotive industry, and in other sectors. Drawing on its pioneering spirit, the company provides concepts, solutions and methodologies to shape future mobility trends.

We Owe It to the Planet

It is our duty as an organization to contribute to the resolution of social, cultural and global issues – especially with regards to **environmental protection**, **sustainability** and **global emission reduction**.

The Human-Centric Approach to Industry-Wide Value Creation

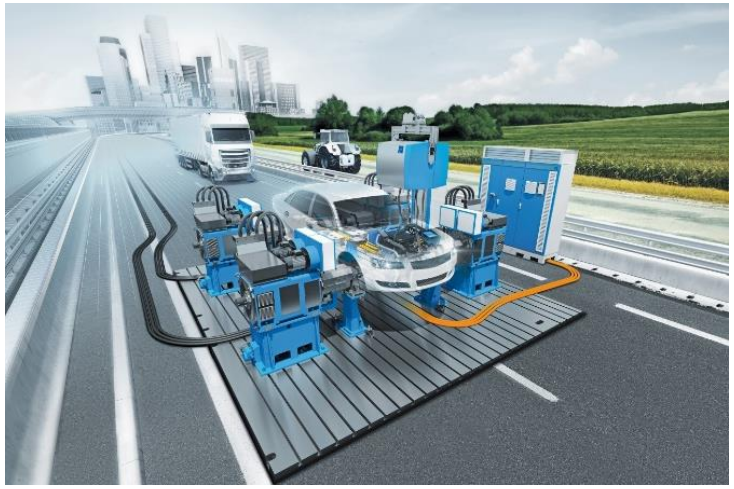
Our many decades of experience have resulted in a vast and diverse portfolio. With these tools, products and systems and the support of our global network of experts and facilities, we help OEMs and Tier1s to shape current and future industries. From future fuels to the connected vehicle ecosystem, we are driving innovation today, to build the mobility concepts of tomorrow.

- **Passenger Cars**
- **Commercial Vehicle**
- **On and Off-Road Vehicles**
- **Agricultural tractors**
- **Stationary Power Plants**
- **Motorsport and Racing**
- **2/3 Wheelers**
- **Marine**
- **Locomotive**
- **Aviation**

Three Disciplines Under One Roof

ENGINEERING SERVICES

- Design and development services for all elements of ICE, HEV, BEV and FCEV powertrain systems
- System integration into vehicle, stationary or marine applications
- Supporting future technologies in areas such as ADAS and Autonomous Driving
- Technical and engineering centers around the globe



INSTRUMENTATION AND TEST SYSTEMS

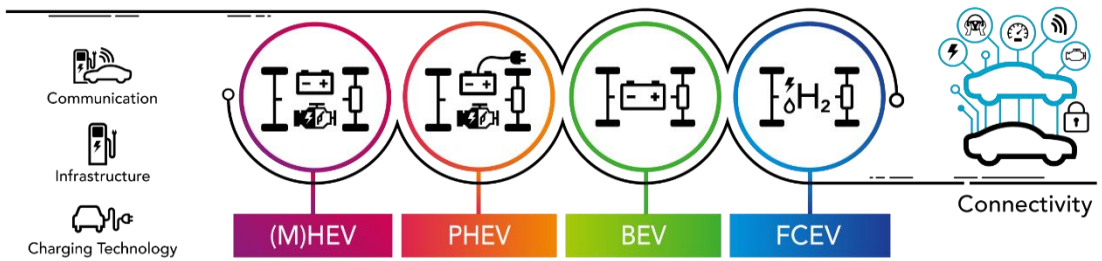
- Advanced and accurate simulation and testing solutions for every aspect of the powertrain development process
- Seamless integration of the latest simulation, automation and testing technologies
- Pushing key tasks to the start of development

ADVANCED SIMULATION TECHNOLOGIES

- We are a proven partner in delivering efficiency gains with the help of virtualization
- Simulation solutions for all phases of the powertrain and vehicle development process
- High-definition insights into the behavior and interactions of components, systems and entire vehicles

AVL ELECTRIFICATION

From Ecosystem to Propulsion System and the Complete Vehicle Lifecycle



- Electrified vehicles are widely considered key to reducing CO_2 and play an important role in tackling climate change.
- From mild and plug-in hybrids to battery electric and fuel cell electric vehicles, we have the expertise to support you in making the right architecture choice for your electrification portfolio.
- Our solutions cover development support, test and validation solutions, simulation tools and comprehensive know-how in these technologies.
- Our experience in modern propulsion system development also extends to new technologies and the ecosystem of the vehicle.

We are committed to contribute to a vision of clean, affordable, connected and intelligent mobility.

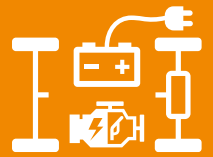
Engineering services and test systems for electrified vehicles

APPLICATIONS

Hybrid – MHEV

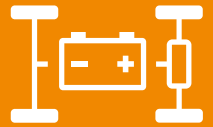
MHEV: Mild-Hybrid Electric Vehicle

Hybrid – PHEV



PHEV: Plug-in-Hybrid Electric Vehicle

Battery Electric BEV



Fuel Cell FCEV

COMPONENTS / TECHNOLOGIES (INCL. SOFTWARE)

Auxiliaries

e.g. Electric steering

E-Motor

from laminate to machine

48 -1.000 V Inverter

from IGBT to SiC

DC/DC Converter

LV and HV

E-Axles

from Passenger Car to Heavy Duty

Battery Mgmt. System

Charging

ON board

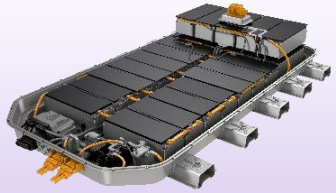
OFF board

SERVICES

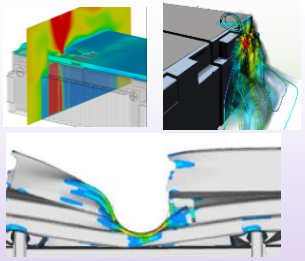
Prototyping A-Sample	Design Optimization	Software & Controls	EMC Simulation	DVP Testing	Benchmark
SOP Development	Technology Consulting	Component Integration	Calibration	Component Validation	Industrialization Service

AVL Battery Development Services and Test Systems

Benchmarking & Battery Cell Research



Concept Development



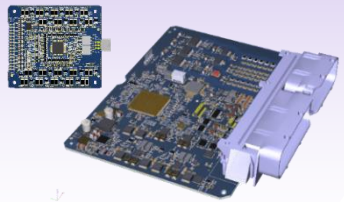
Module & Pack Simulation

Hardware Validation

Project References

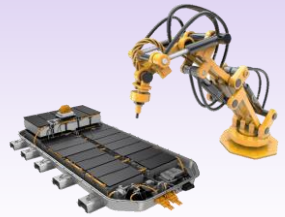
Battery Series Development

Battery Management System



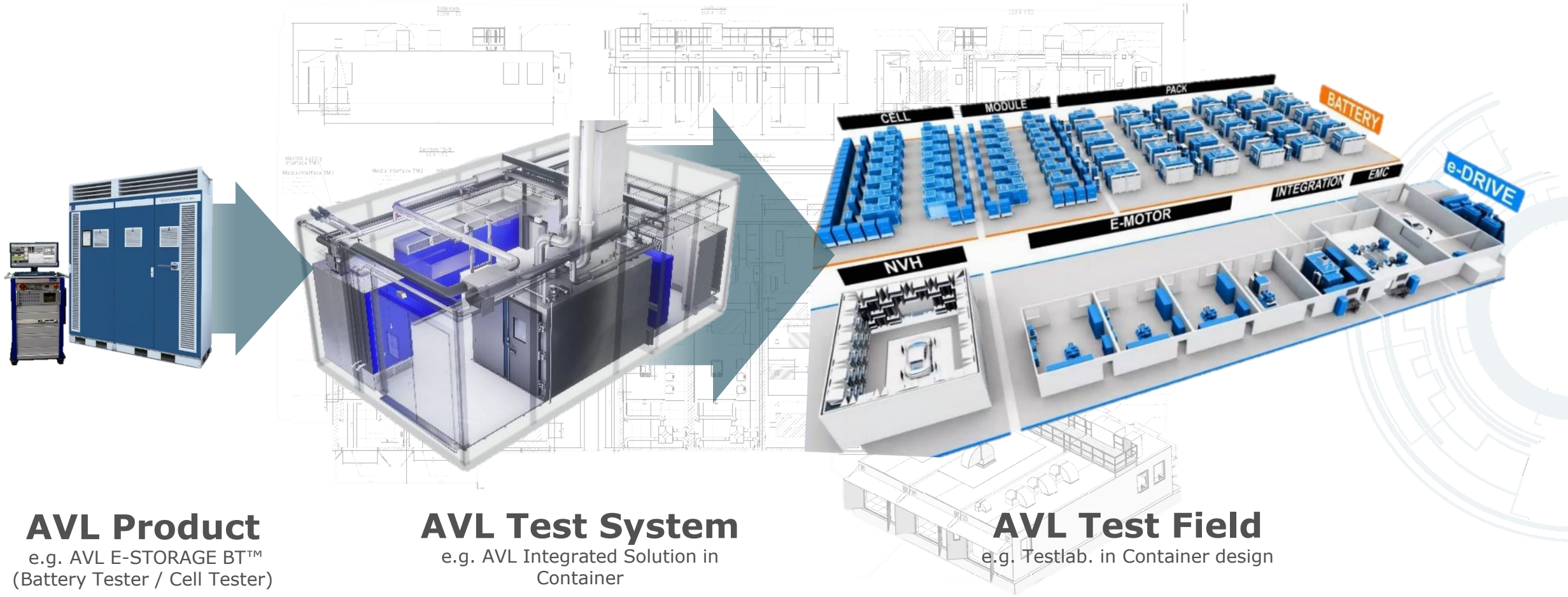
Prototype Built

Production & Cost Engineering



AVL supports **battery development** projects from first drawing to SOP with **battery module and pack development services**, as well as **BCU software** and **hardware**.

AVL Battery Development - From Cell to Pack Test System



AVL Product
e.g. AVL E-STORAGE BT™
(Battery Tester / Cell Tester)

AVL Test System
e.g. AVL Integrated Solution in Container

AVL Test Field
e.g. Testlab. in Container design

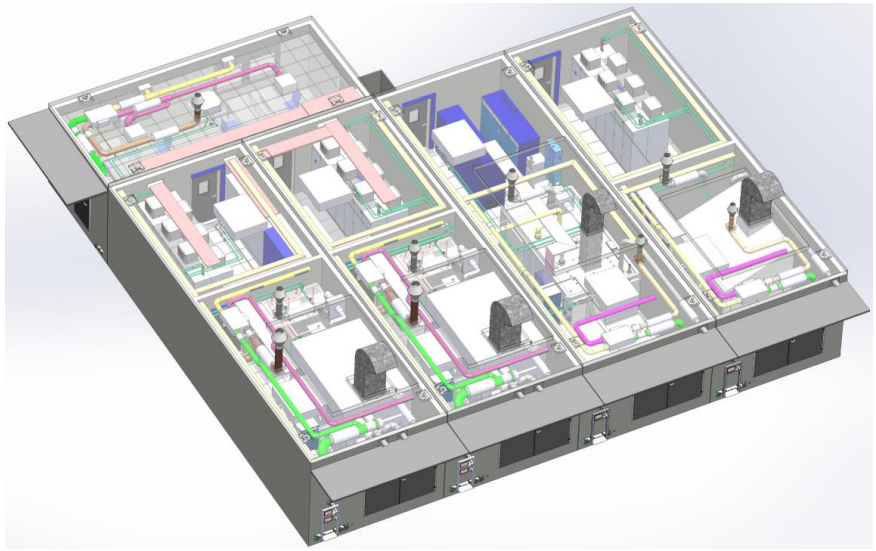
Battery Development Centers – AVL Project examles

VOLKSWAGEN Salzgitter

Building a highly efficient, effective
Battery Cell Lab

VALMET Automotive

Battery Pack Testing Laboratory
containerized solution



ISP Salzbergen

Battery Test Center
including facility and concept design

Stellantis Battery Lab Europe + North America, …
JLR Battery Lab, Bath University (UK), …

Milestones Future Mobility - Towards Sustainable Green Mobility

Energy Demand

GHG – Global Warming

Air Pollution

Mobility for everyone, Globalisation

Horse carriages | 1672
Steam powered vehicle | 1830
Electric car | 1886
Gasoline engine car | 1908
Mass production | 1933
Diesel engine car | 1966
Fuel cell car | 1970
Clean Air Act EPA
1 billion cars | 2011
Break through BEV | 2012
Modern FC EV | 2014
1,5 billion cars | 2022
EU Fit for 55, US -50 | 2030
EU ICE Ban | 2035
Carbon Neutral (EU, JP, US? ..) | 2050
Carbon Neutral (CN, … | 2060

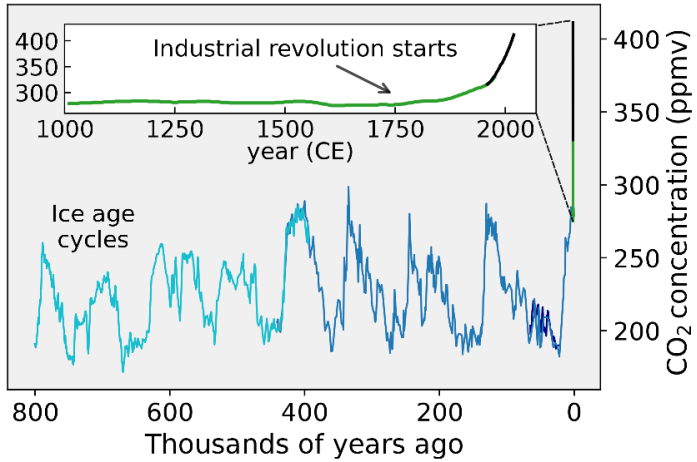
Milestones Future Mobility - Towards Sustainable Green Mobility

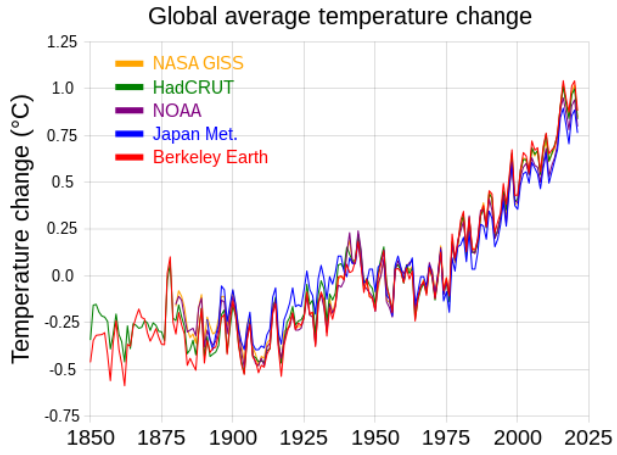
To achieve climate neutrality for transportation we need:

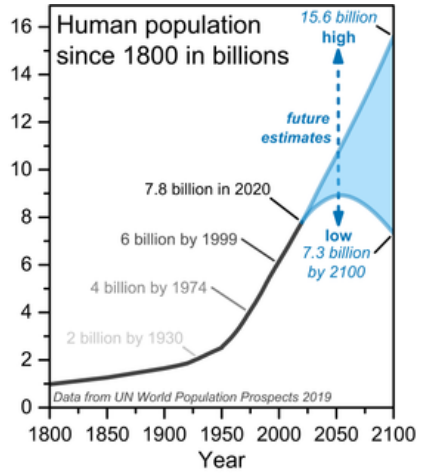
- **Clean Vehicles (GHG, Emission)**
- **Energy Efficient Vehicles (xEV)**
- **Cradle to Wheel Efficiency**

&

- **Clean Energy – Electricity, H2, PtG, PtL**
- **Efficient Energy Production & Storage**
- **Energy Security world-wide**





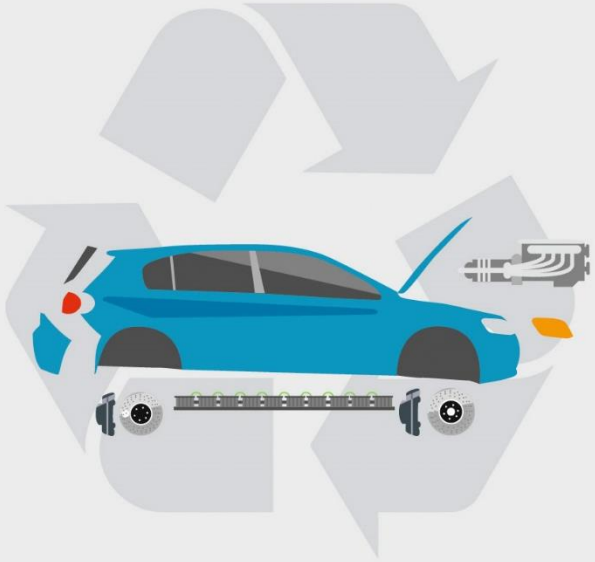


Milestones Future Mobility - Towards Sustainable Green Mobility

Energy for Transport

Reducing CO_2 Emissions
Reducing Fossil Fuels

Material and Production



Less Waste
Less Pollution
Towards a Circular Economy

Access to Mobility

Keep Mobility affordable & easy-to-use

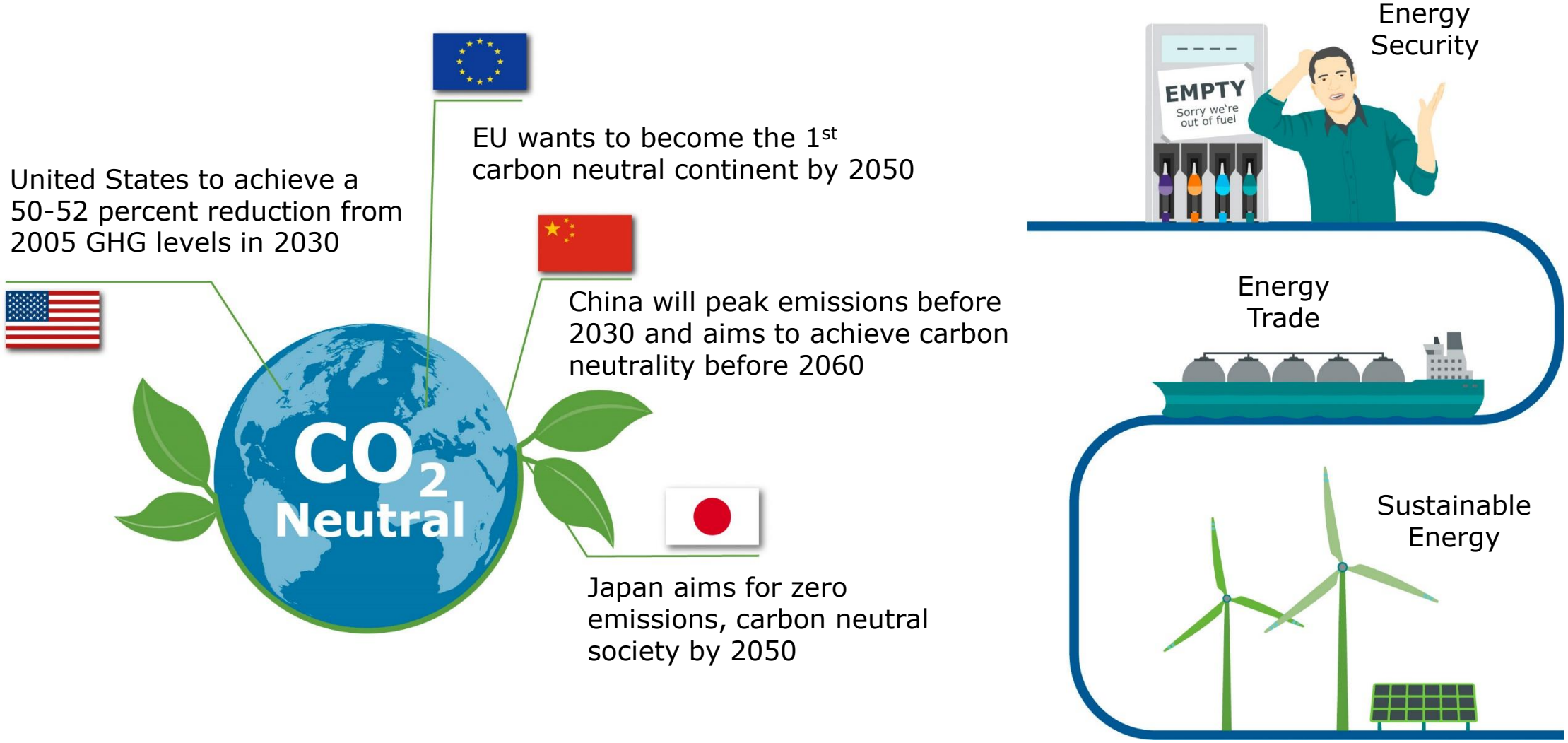
Strive for two goals: Climate-neutrality and energy security

United States to achieve a 50-52 percent reduction from 2005 GHG levels in 2030

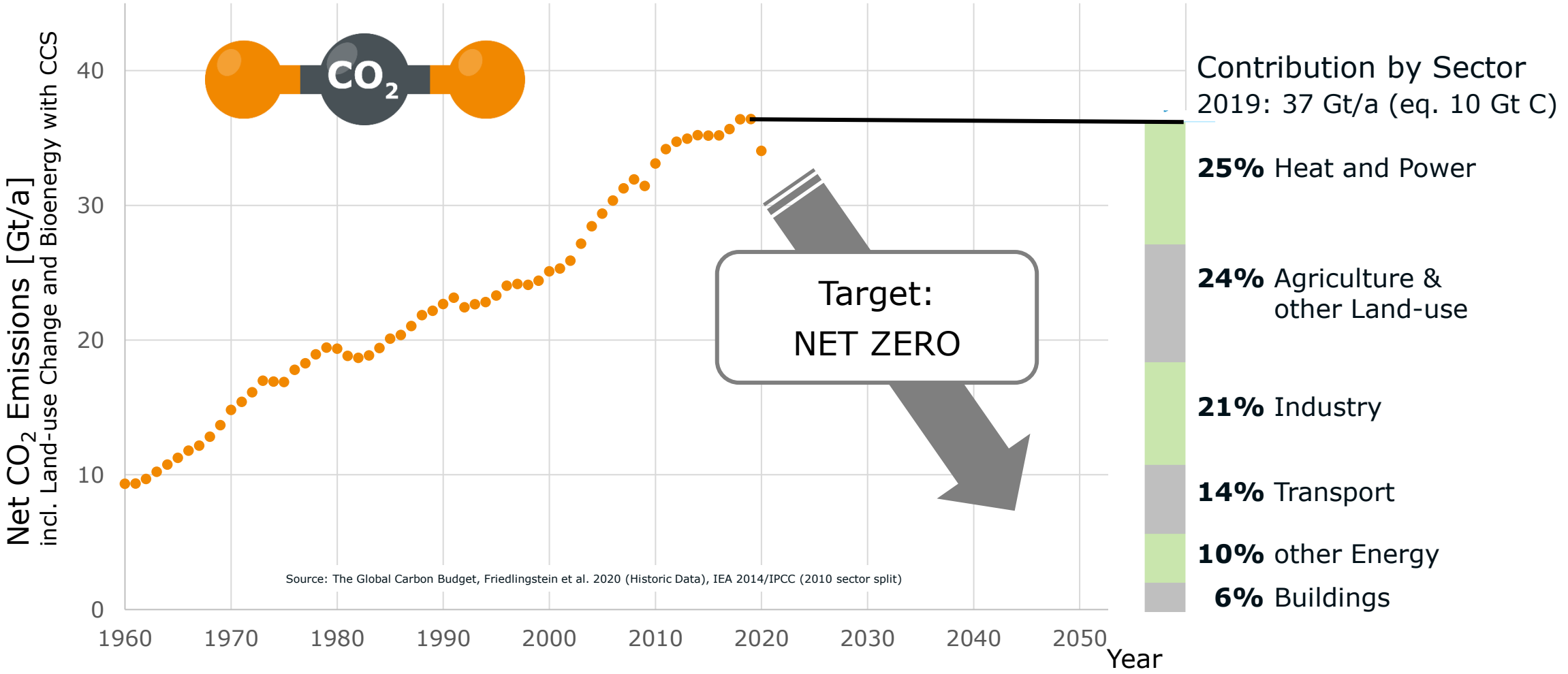
EU wants to become the 1st carbon neutral continent by 2050

China will peak emissions before 2030 and aims to achieve carbon neutrality before 2060

Japan aims for zero emissions, carbon neutral society by 2050



History of Global Human-made CO_2 Emissions



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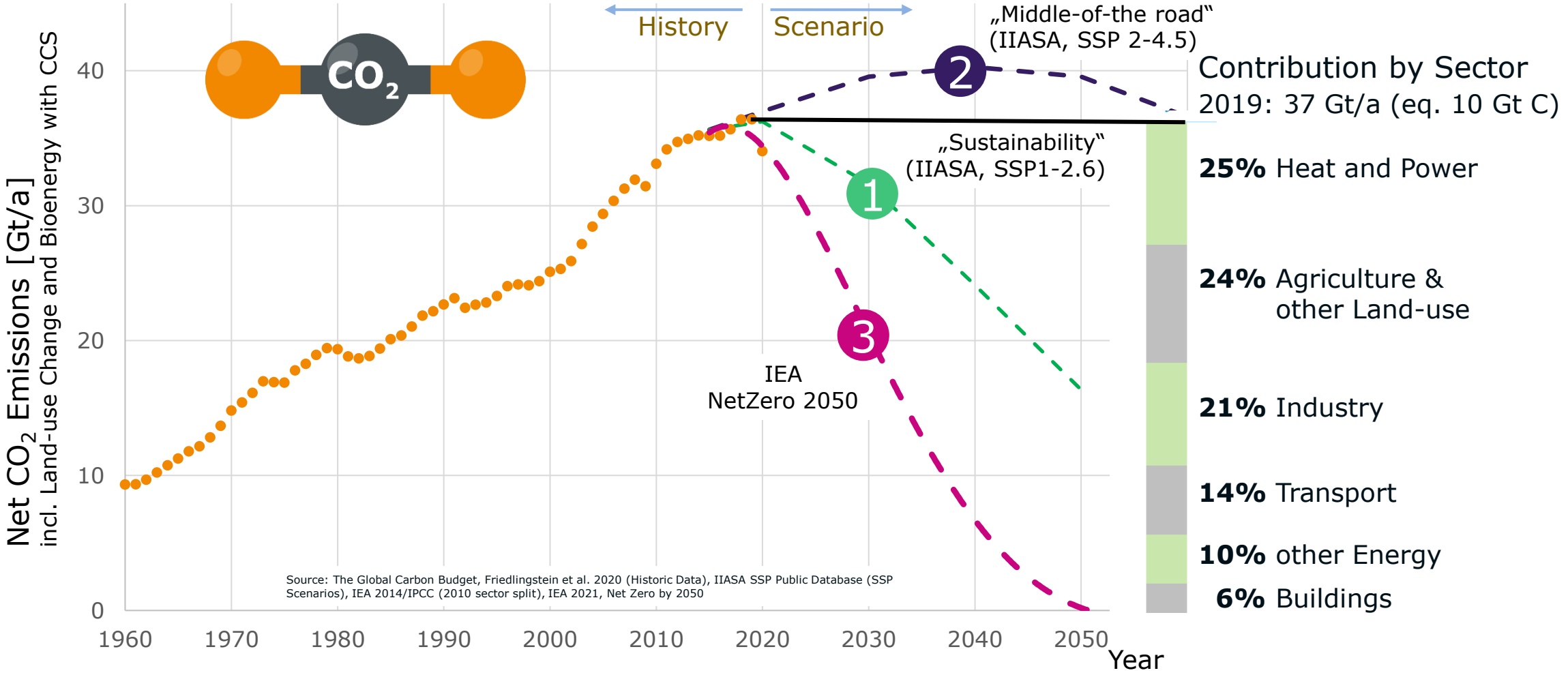
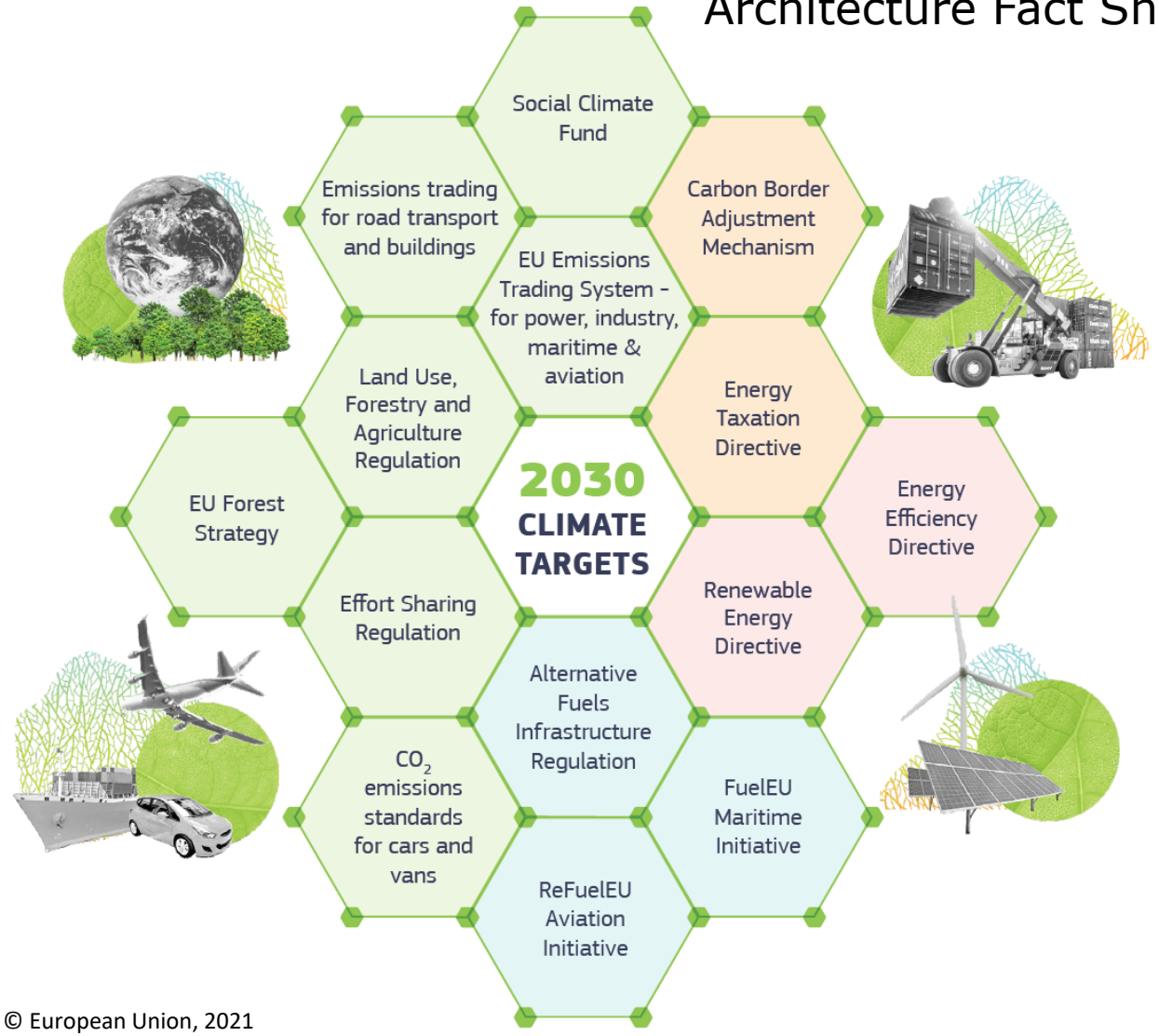


Drastic Measures for Emissions reduction required across **all Sectors**

Delivering the European Green Deal - The Decisive Decade

Architecture Fact Sheet

"Fit for 55"
The EU will **reduce its net greenhouse gas emissions by at least 55% by 2030**, compared to 1990 levels.*



*As agreed in the EU Climate Law. On 14 July 2021, the Commission presented proposals to deliver these targets and make the European Green Deal a reality.

Flashlight on PassCar Global Trends[1)]

- **Political focus on TtW CO_2 , WtW supported only by ETS[2)] and RED[3)], sector coupling remains challenge**
- **Dogma to push BEV by TtW CO_2 legislation ➔ e-fuels not appreciated by politics**
- **ENVI[4)] votes for 100% CO_2 reduction in 2035 (May 11th), other proposals (e.g.: 2035: 100%➔90%, 2030: 55%➔70% ?)**
  EU Parliament June 9th, 2022 voted to prohibit ICE by 2035
  EU: 68% BEV sales by 2030 [7)]
- **Vision for net zero established, mission for energy transition unclear**

- **Official focus on electri-fication. However, pragmati-cally balancing environmental and economical aspects ➔ both BEV+HEV**
- **Enormous technological progress targeting technology leadership**
- **Still various new ICEs under development – DHE[5)] and DHT[6)]**
- **OEMs exploring H_2 ICE also with PC**

Update 5/2022

- **Environmental policy has completely changed both regarding ICE and electromobility**
- **From focus on pollutant emissions to over-emphasizing of BEV for GHG reasons**
- **Political intention towards electromobility to be matched with infrastructure and customer demand**

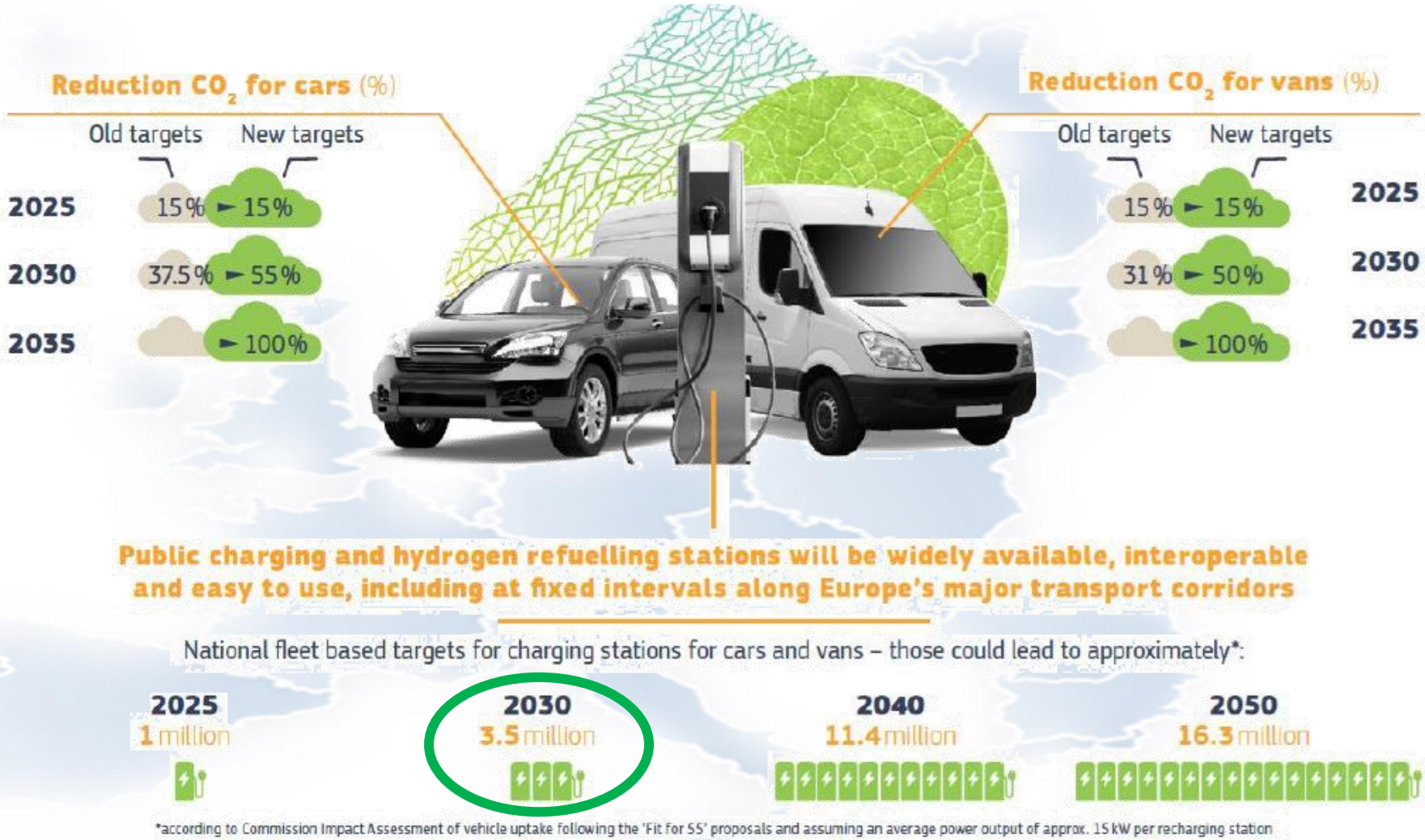
1) European Perspective 2) Emission Trading System 3) Renewable Energy Directive 4) Environmental Committee of EU Commission 5) Dedicated Hybrid Engines, 6) Dedicated Hybrid Transmissions 7) Agora

Different political priorities – Europe on most challenging path

Make Transport Greener (07/2021)
Current Situation in Europe – **Fit for 55**

More ambitious CO_2 emissions standards for new cars and vans to help grow the number of zero- and low-emission vehicles on European roads.

Binding requirements for the rollout of public charging and hydrogen refuelling stations for cars, vans and trucks.



Source: Make Transport Greener Factsheet, European Commission, 14.07.2021

European Green Deal
a) Well-to-Wheel

Architecture Fact Sheet

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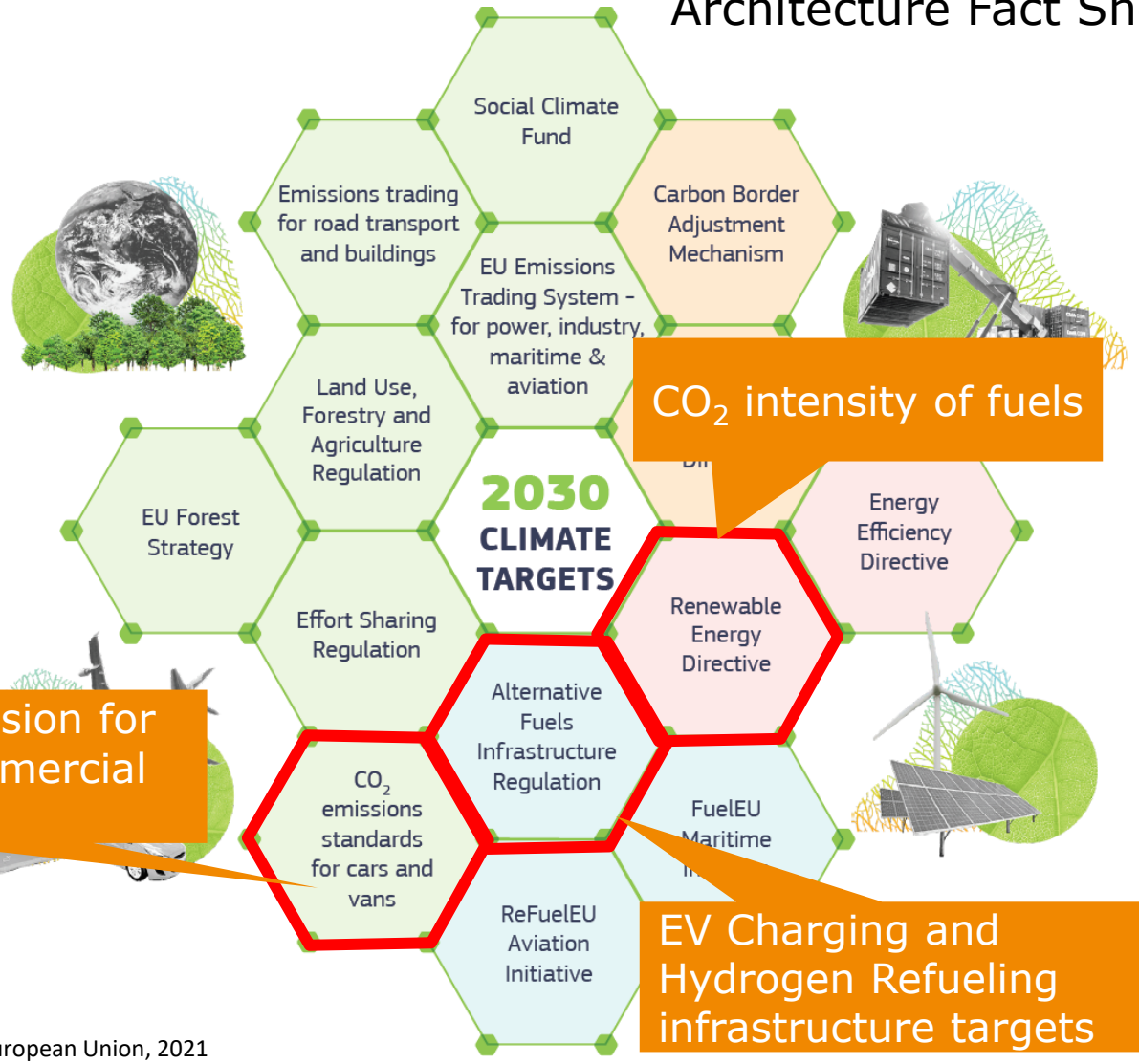

*As agreed in the EU Climate Law. On 14 July 2021, the Commission presented proposals to deliver these targets and make the European Green Deal a reality.

European Green Deal
b) Cradle to Grave

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Renewable Energy: Enough, but usually wrong place & time…

Annual Global Energy Potentials

Solar 200,000 PWh

Wind 219 – 613 PWh

Biomass 18 – 53 PWh

Hydro 26.3 – 35 PWh

Geothermal 3 – 17 PWh

Wave 1.8 – 17.5 PWh

Tidal 1.7 PWh

World Energy Consumption

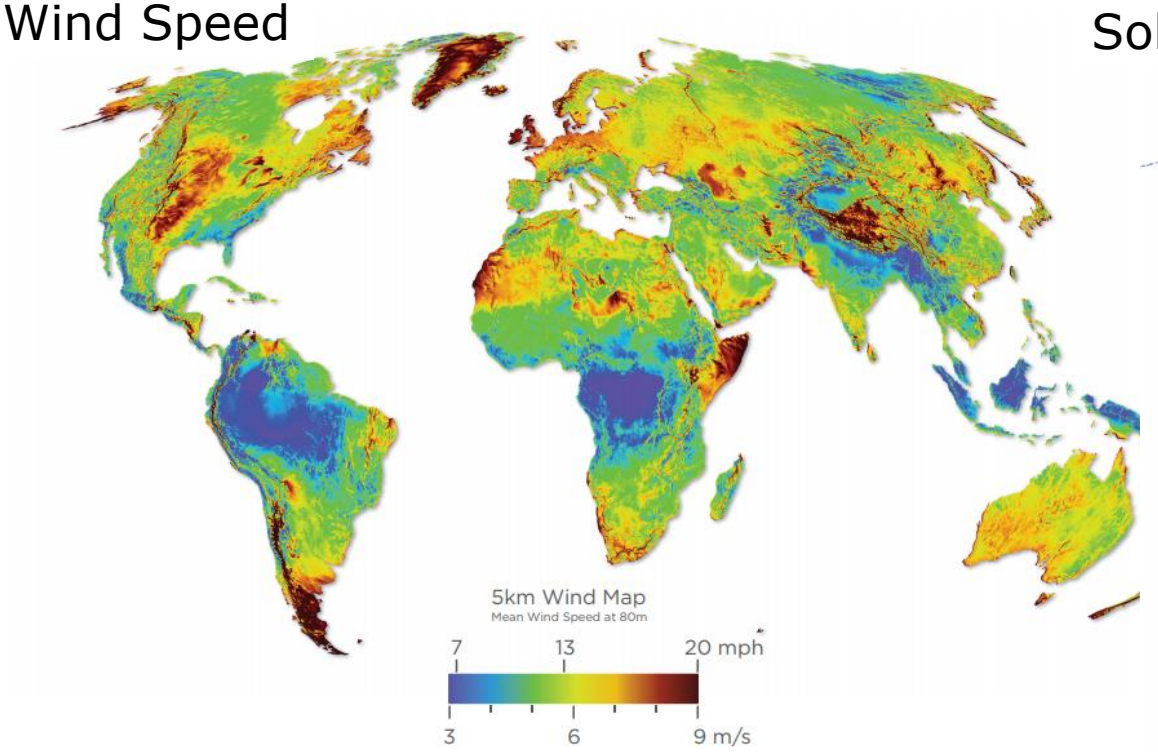
140 PWh/yr

Source: Perez, A fundamental look at energy reserves for the planet, 11/2015
1 PWh = 10^{15} Wh

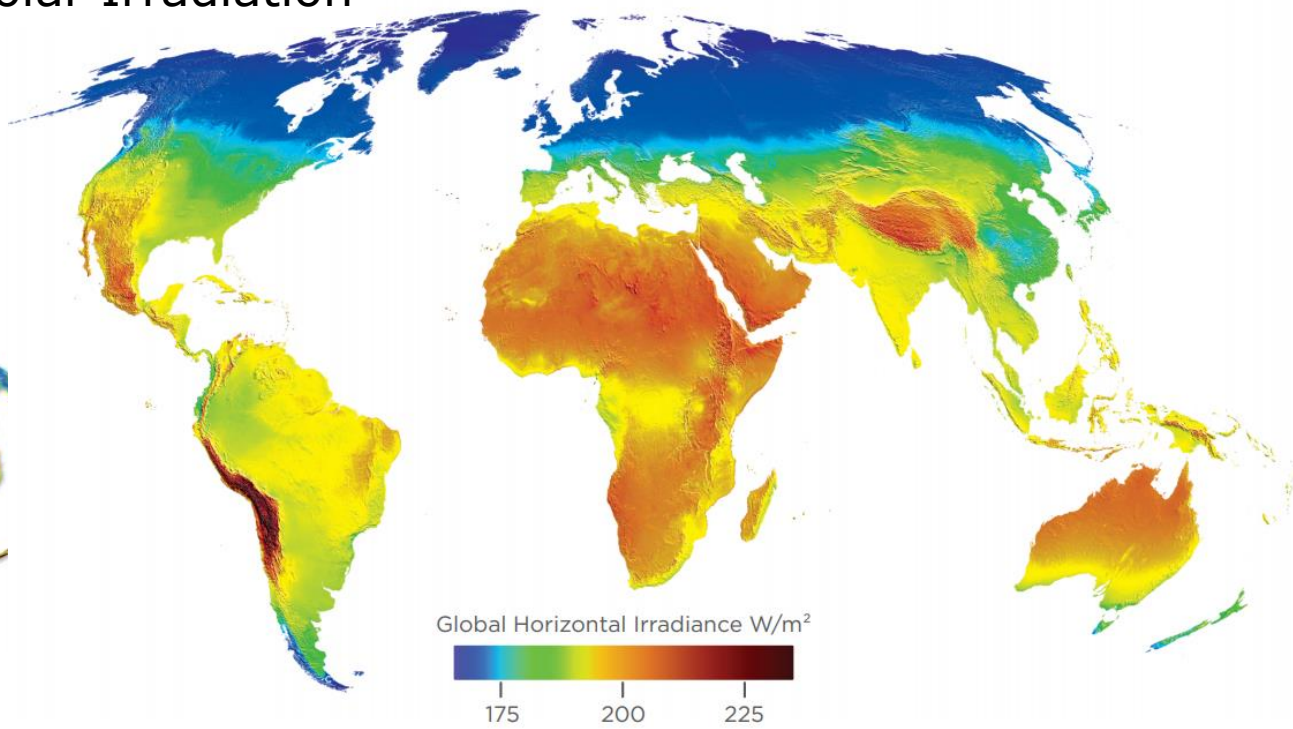
The Challenge:
Storage and Transport of Wind and Solar Energy

Production Potential is located far away from Demand Centers

Wind Speed

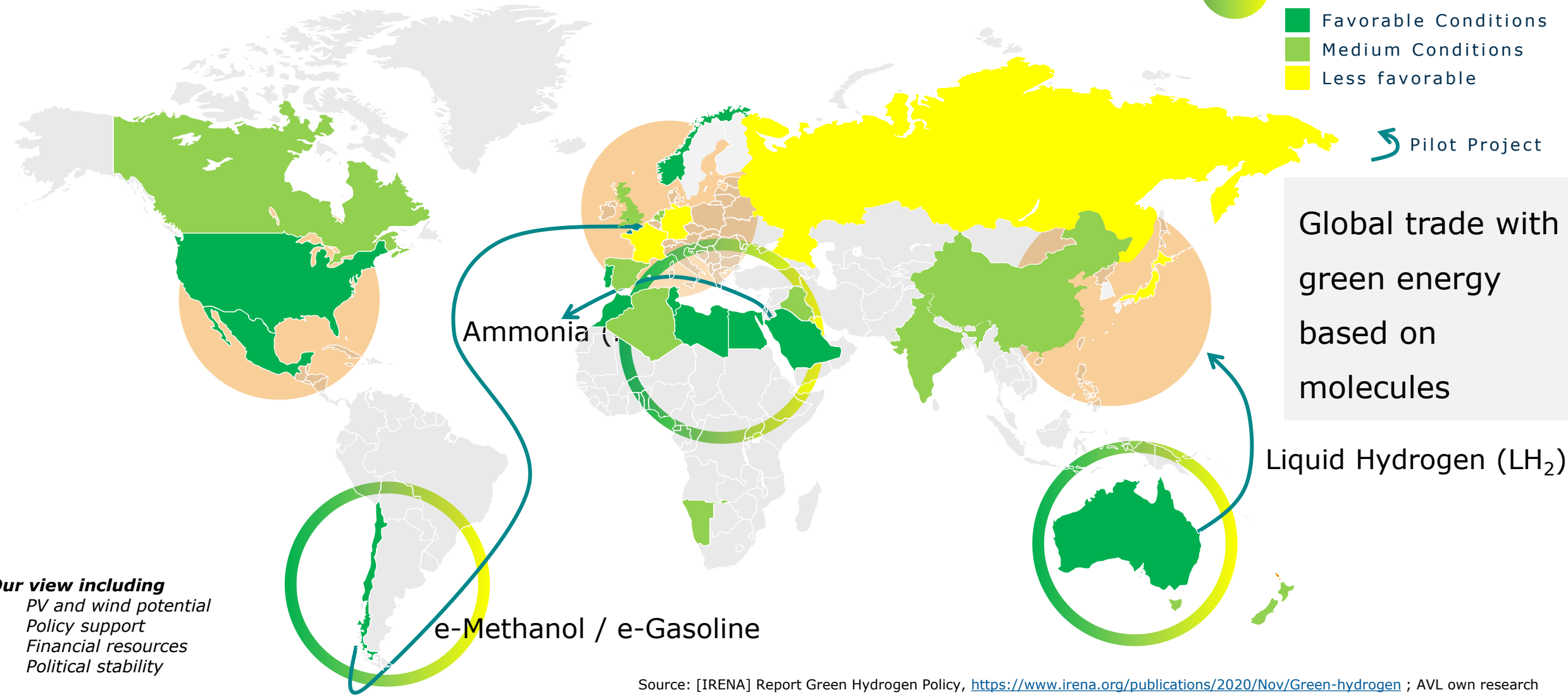


Solar Irradiation



Source:
https://www.vaisala.com/sites/default/files/documents/Vaisala_global_wind_map.pdf?utm_content=Wind-Map
https://www.vaisala.com/sites/default/files/documents/Vaisala_global_solar_map.pdf?utm_content=Solar-Map

Energy Trade Future:
Green Hydrogen Production and Demand



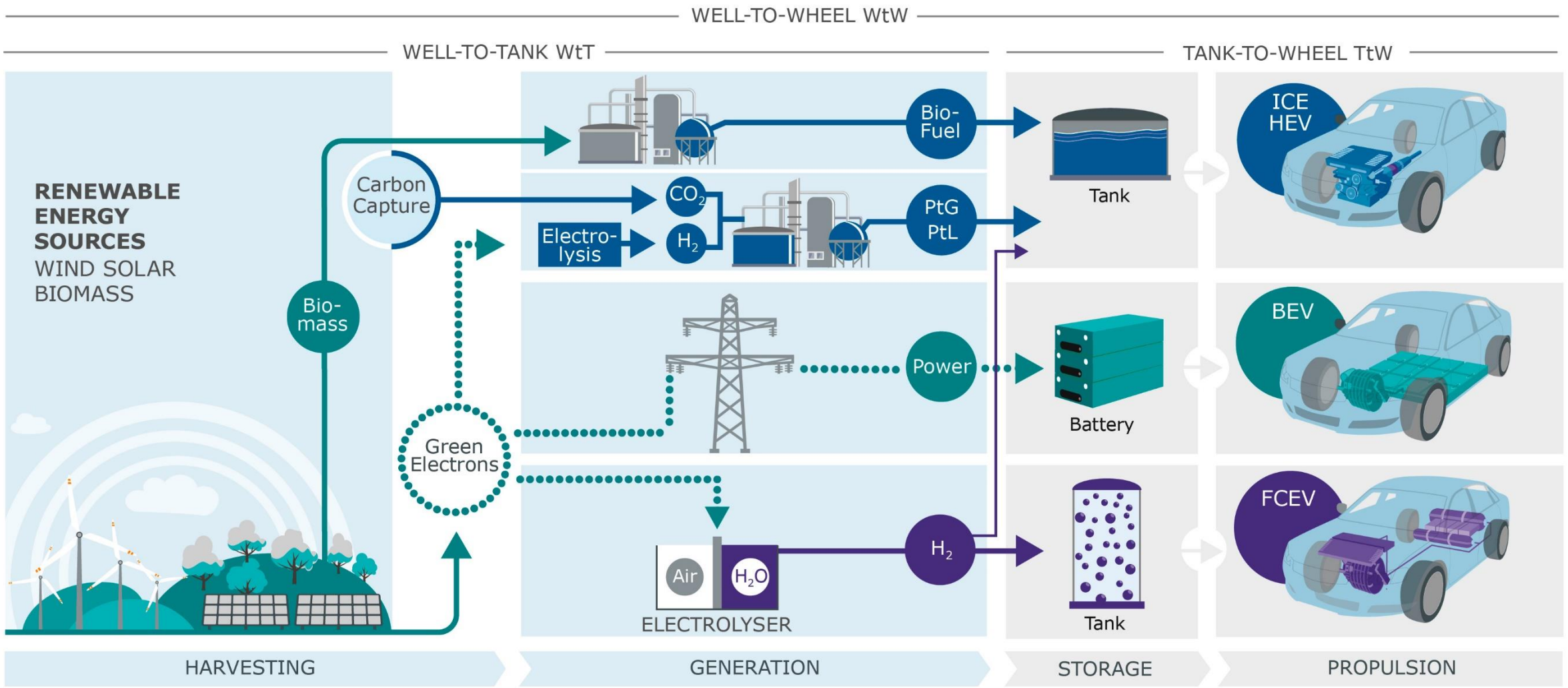
Global trade with green energy based on molecules

Our view including

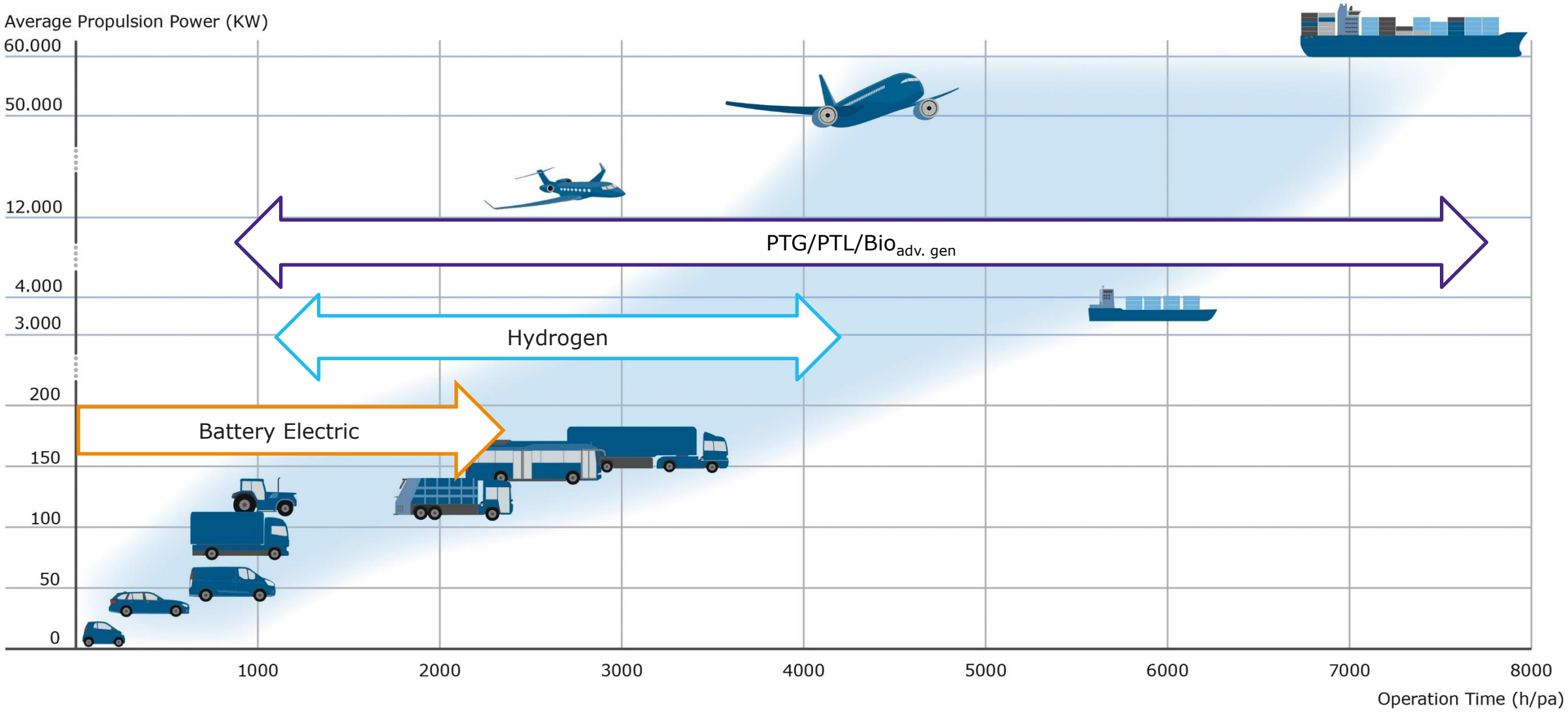
- *PV and wind potential*
- *Policy support*
- *Financial resources*
- *Political stability*

Source: [IRENA] Report Green Hydrogen Policy, https://www.irena.org/publications/2020/Nov/Green-hydrogen ; AVL own research

Pathways to clean and sustainable Propulsion Systems



Does energy availability drive the propulsion portfolio?



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