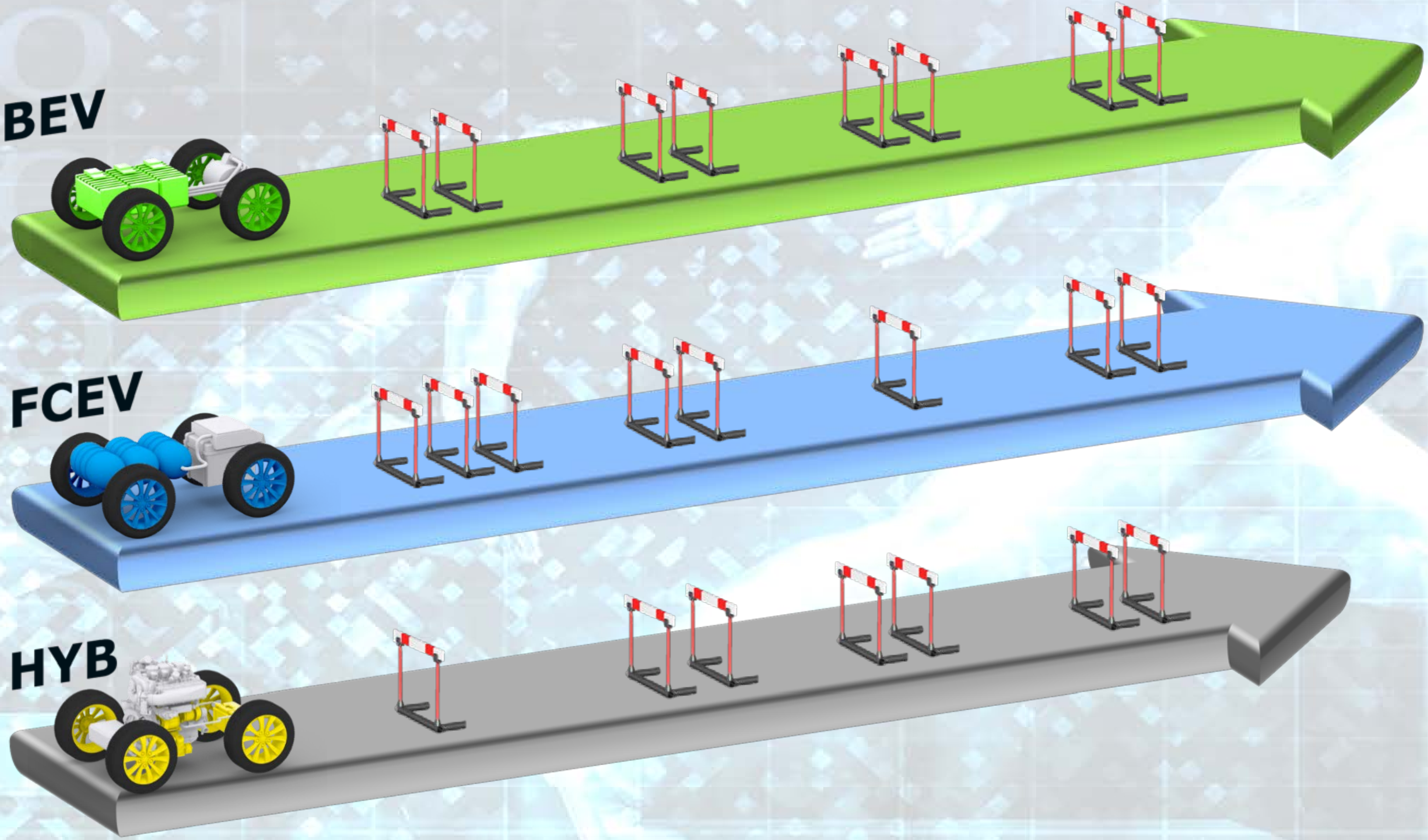
Antriebstechnologien und Energieträger für den Straßenverkehr der Zukunft

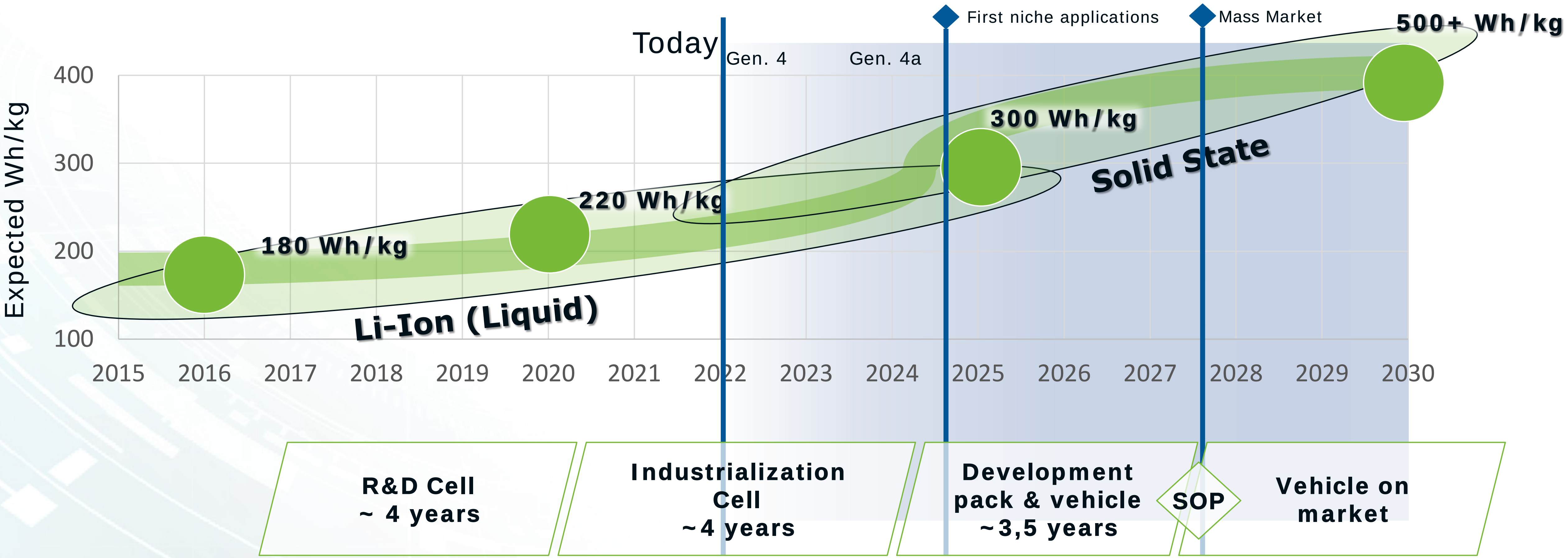
Peter Prenninger

Powertrain Competition
Challenges for Individual Technologies



There is no silver bullet – each technology has to master specific hurdles

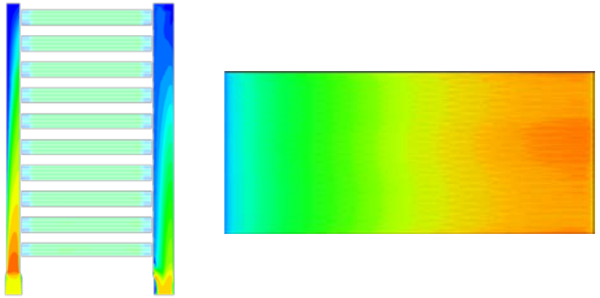
Future Battery Cell Technology



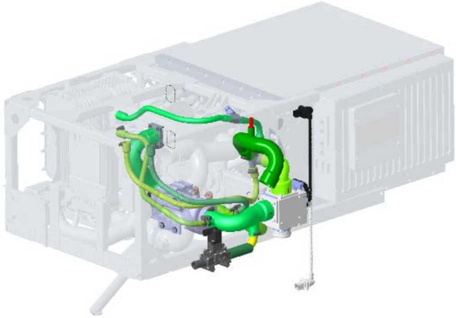
Fuel Cell Thermal Management

1. FC Stack

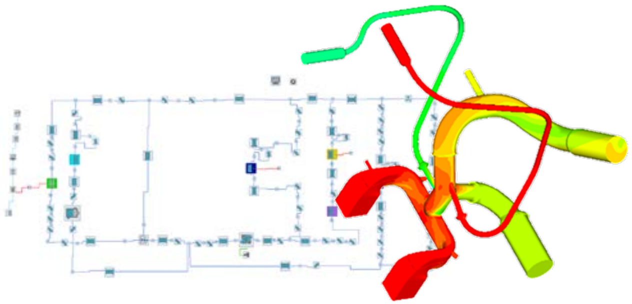
- Even coolant distribution between and within cells
- Even cell temperature distribution and effect on local reaction



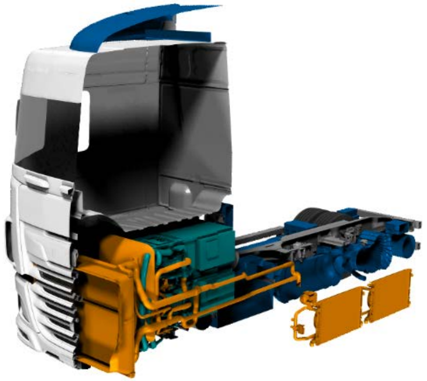
2. FC System



- Strategic thermal management of FC System
- Integration in thermal management of entire vehicle with thermal management of battery, power electronics and cabin

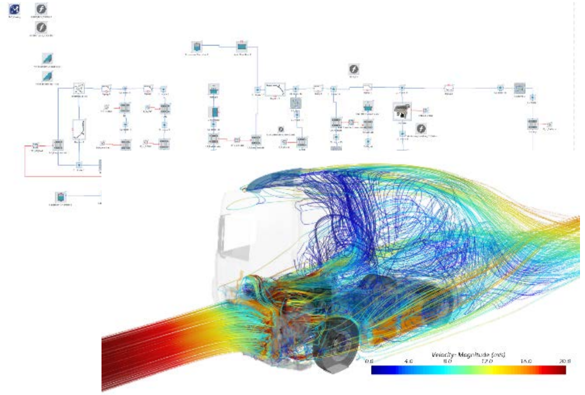


3. FC Truck



Heat rejection at:

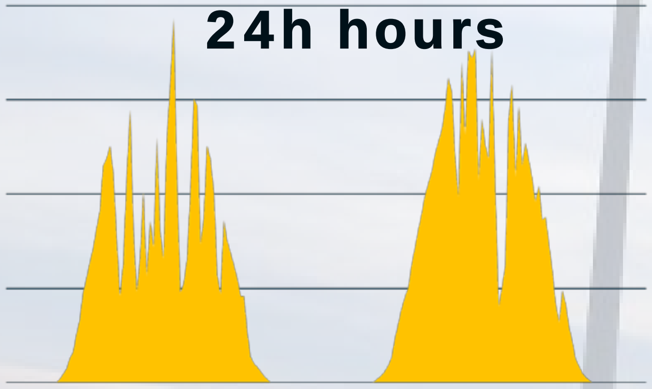
- Lower coolant temperature
- Under extreme ambient conditions
- With low air resistance



Key Challenge of Renewable Energy – Intermittency

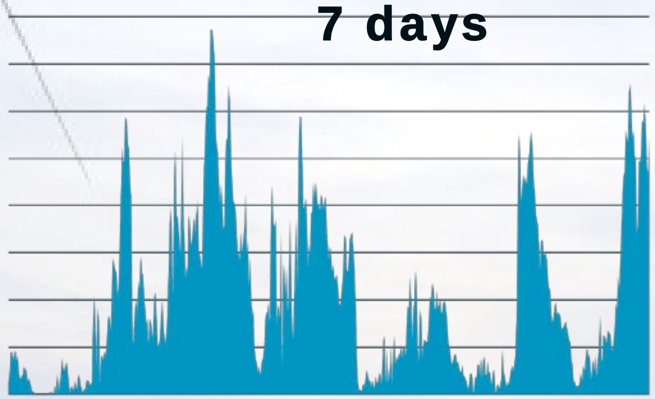
AVL

**Daily
24h hours**



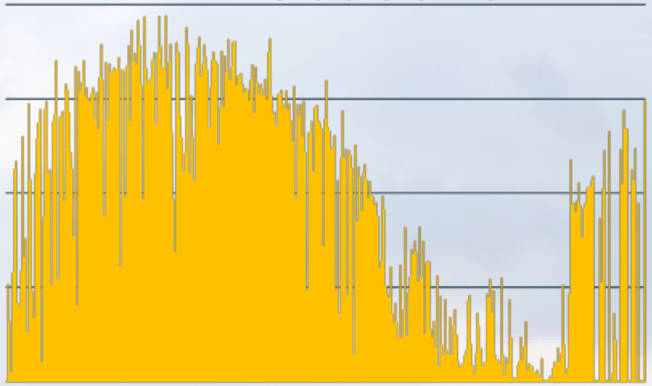
Photovoltaic Germany, 100 kW

**Weekly
7 days**

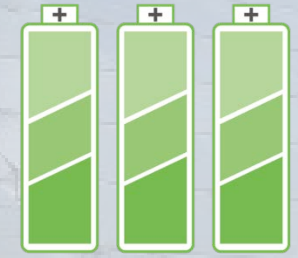


Source: wind park Germany, 2000 kW

Seasonal

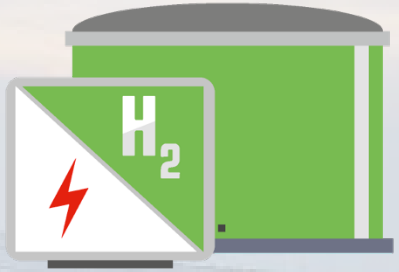


Photovoltaic Germany, 100 kW



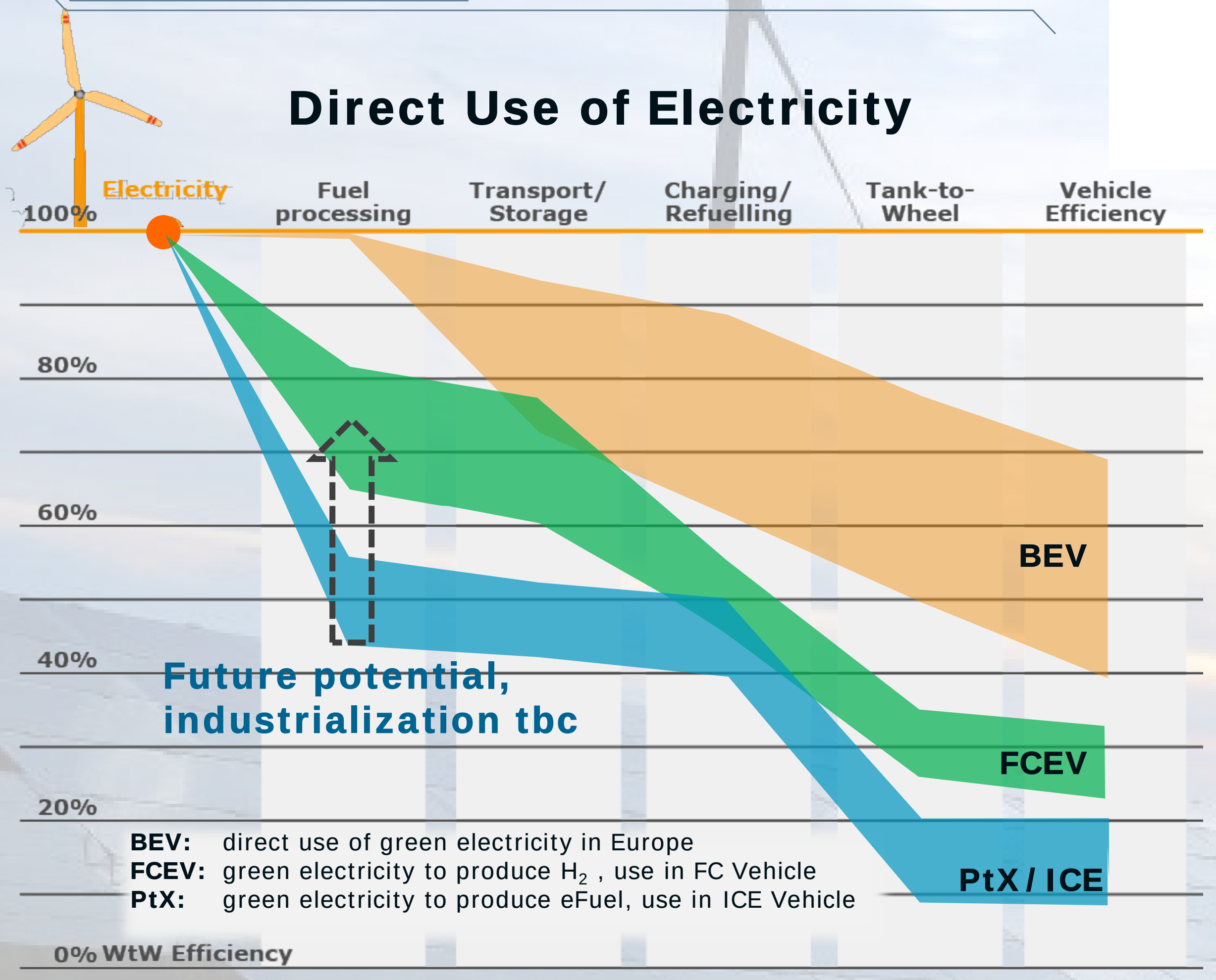
Electrochemical Storage (Decentral)

Chemical Storage (Central)



Different types of intermittency require different energy storage methods

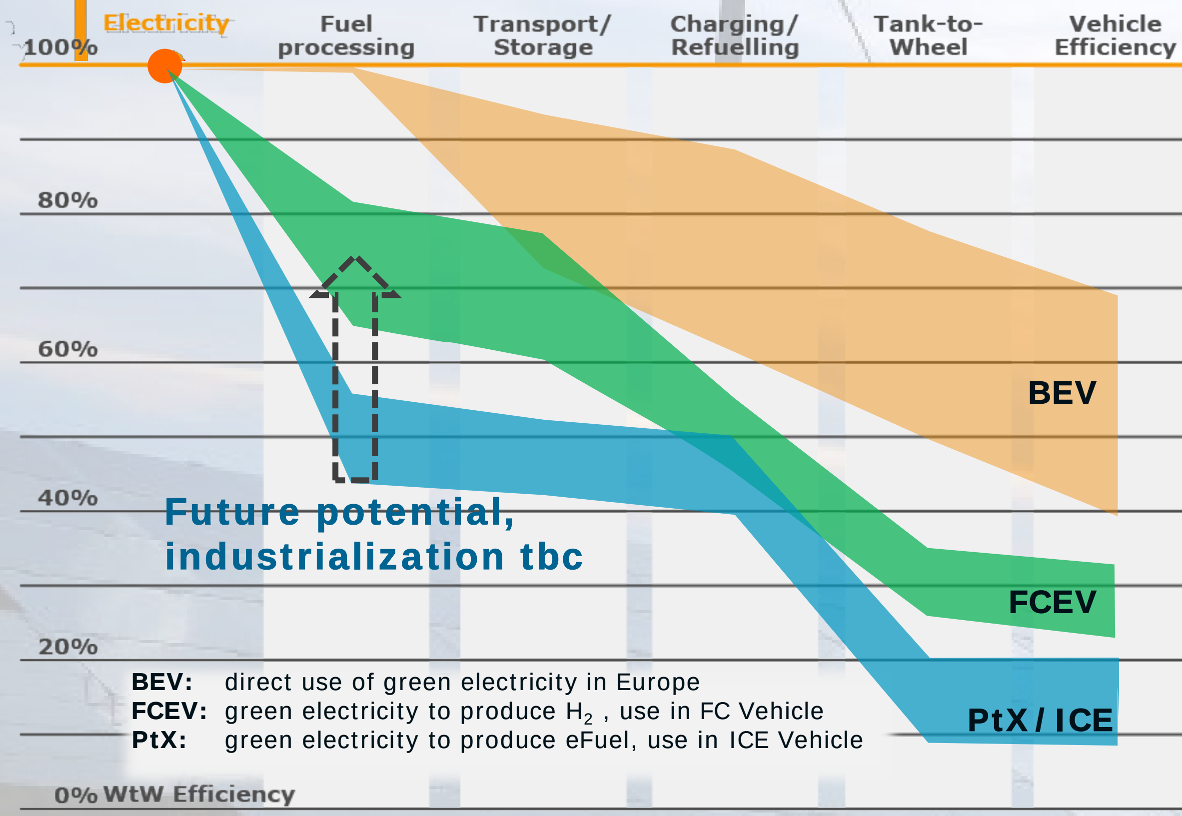
Efficiency Chain of Different Energy Carriers



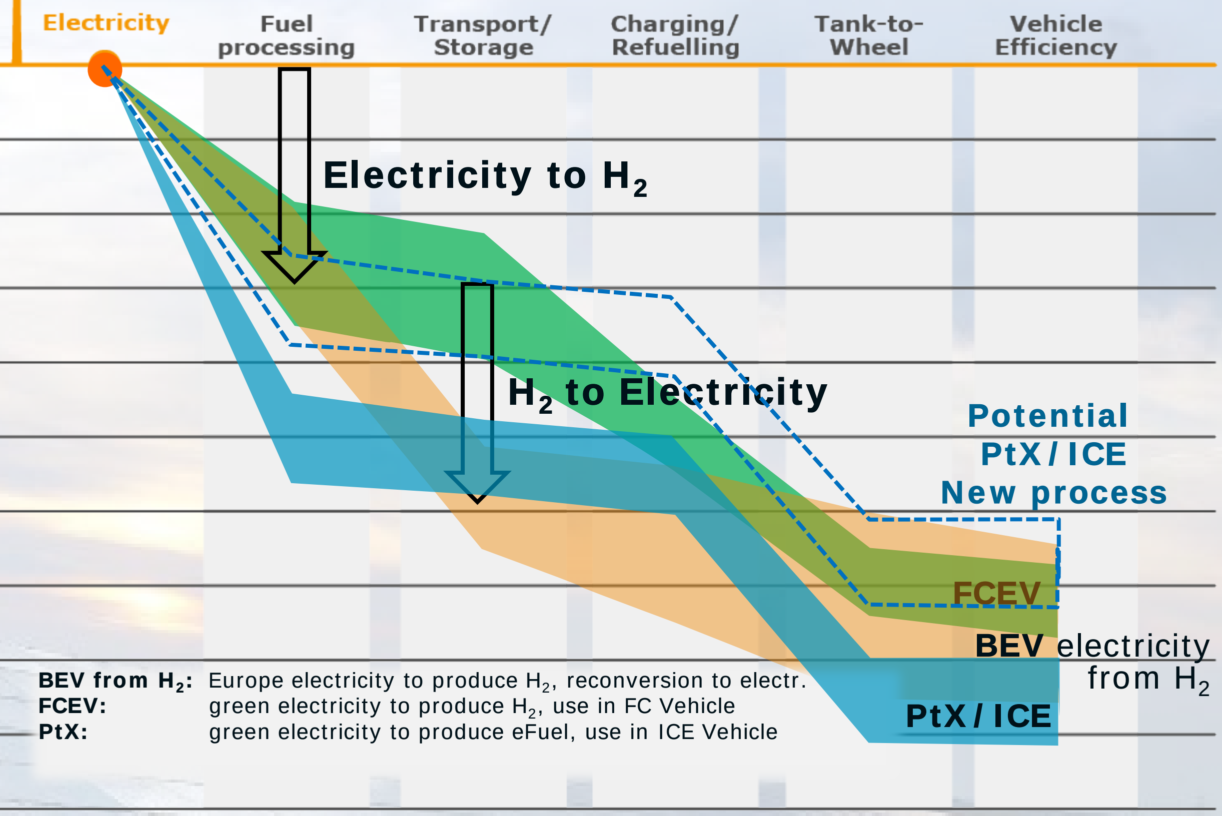
With direct use of electricity, BEV has by far the highest efficiency

Efficiency Chain of Different Energy Carriers

Direct Use of Electricity



Chemical Storage of Electricity

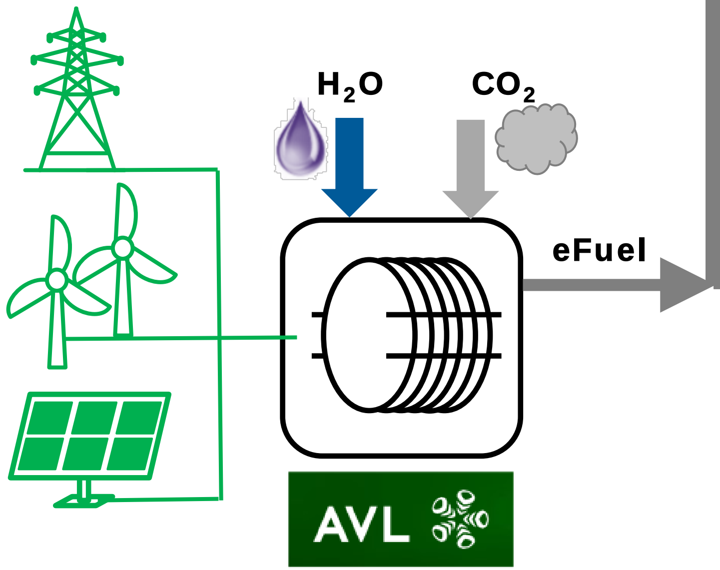


Source: AVL Energy Consulting Services

With direct use of electricity, BEV has by far the highest efficiency

Based on chemical energy storage, FCEV and PtX / ICE become highly competitive

Hydrogen & eFuel Production with SOEC



Product	AL & PEM	SOEC
Hydrogen	70%*	80%**
Methane	49%*	80%**
FT Diesel	40%*	50%*
Methanol	45%*	72%*
DME	53%*	65%*

Sources:
** Based on Literature:*
- *Tremel, 2017*
- *Becker, 2012*

*** based on AVL project results*

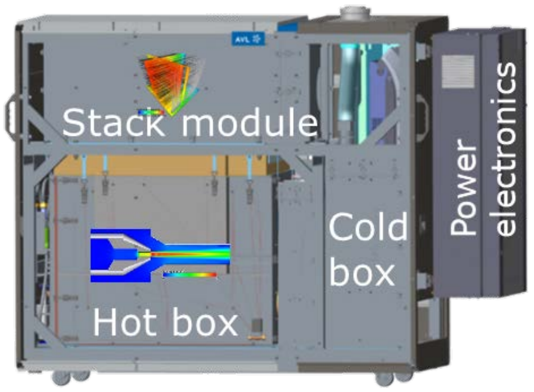
AVL SOEC Demonstrator

Projects

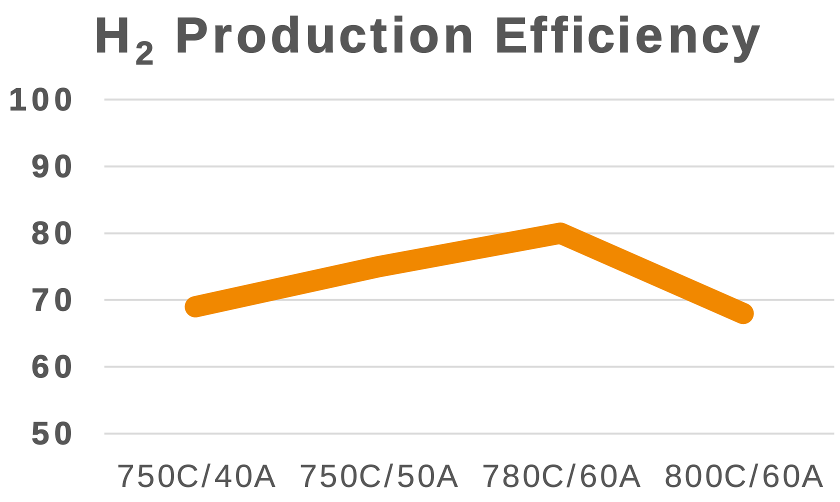
HydroCell

HydroMetha

iwo IFE



FFG
Project number: 864578




ERTRAC
Carbon-neutral Road Transport 2050
a technical study from a well-to-wheels perspective
Online
March 2021

Concept of the study

TTW

Which powertrains could be used in in 2050?

3 Powertrain Scenarios

Which efficiency improvements are possible by 2050?

Optimistic – Pessimistic ranges

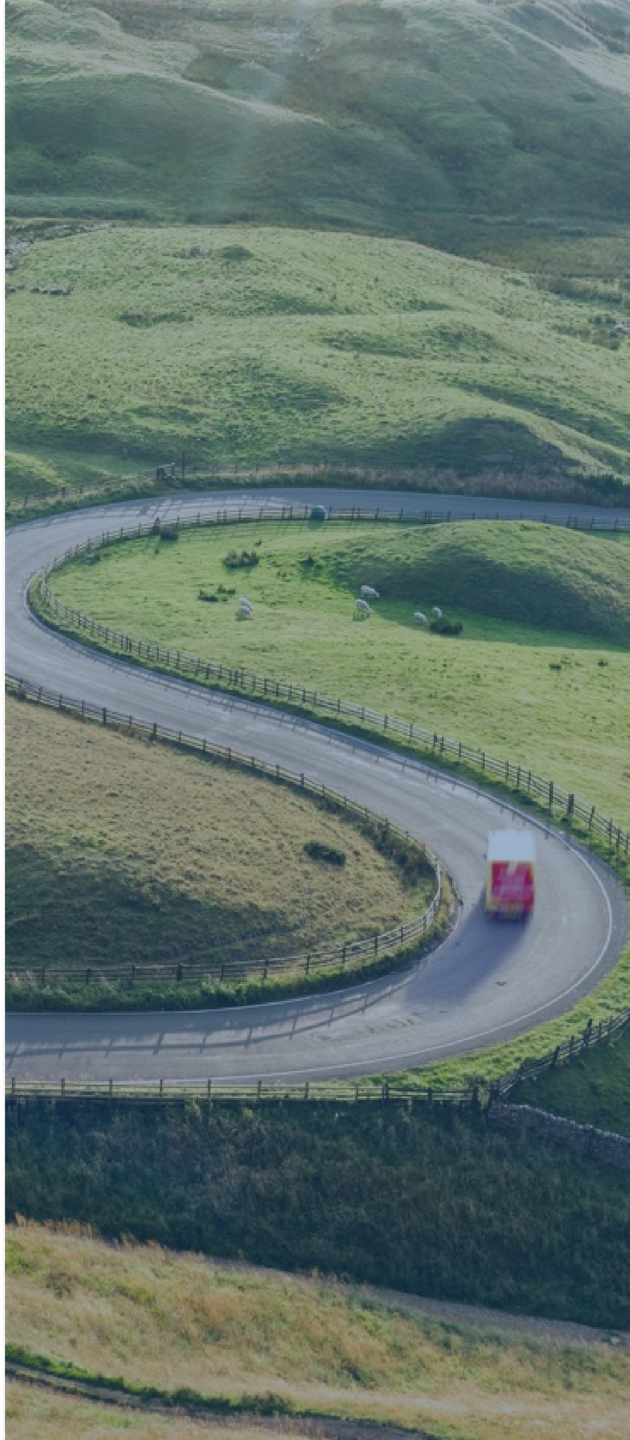
WTT

What will be the CO_2-footprint of electricity production in 2050?

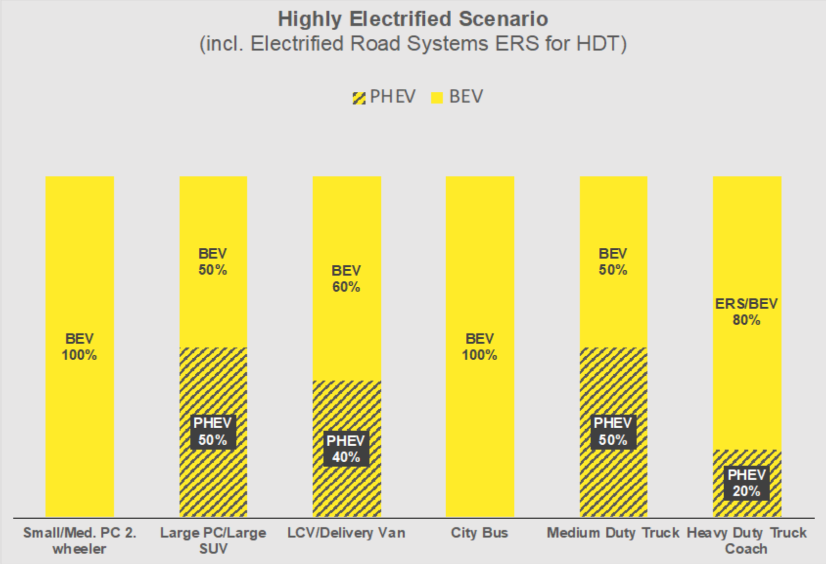
2 Electricity Scenarios: 100% Renewable (RES) & 1.5 Tech

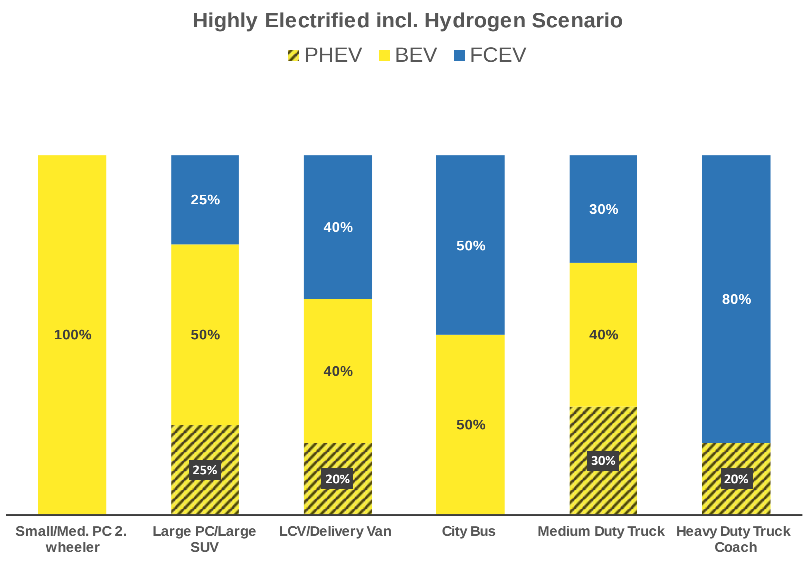
Which fuel production paths could be used in 2050?

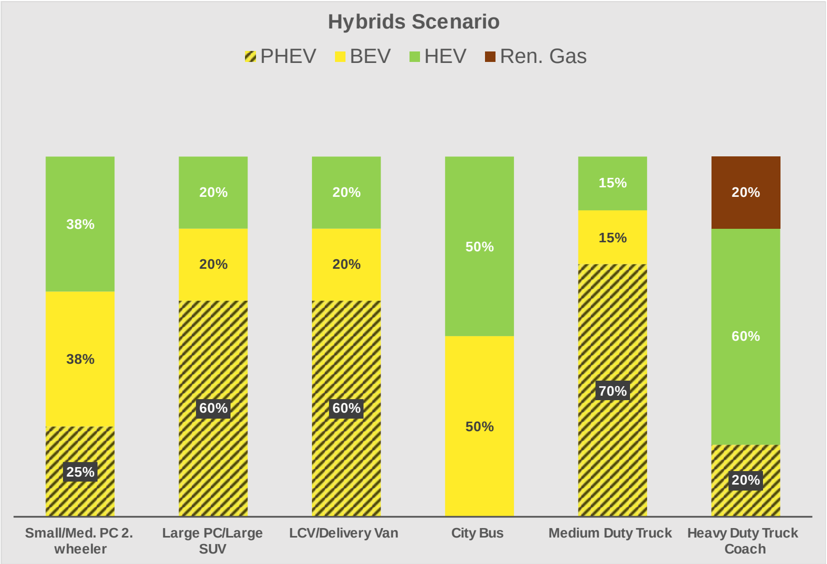
4 Fuel Scenarios: Biofuels, e-fuels, Mixed fuels and Limited fossil



3 Powertrain Scenarios 2050



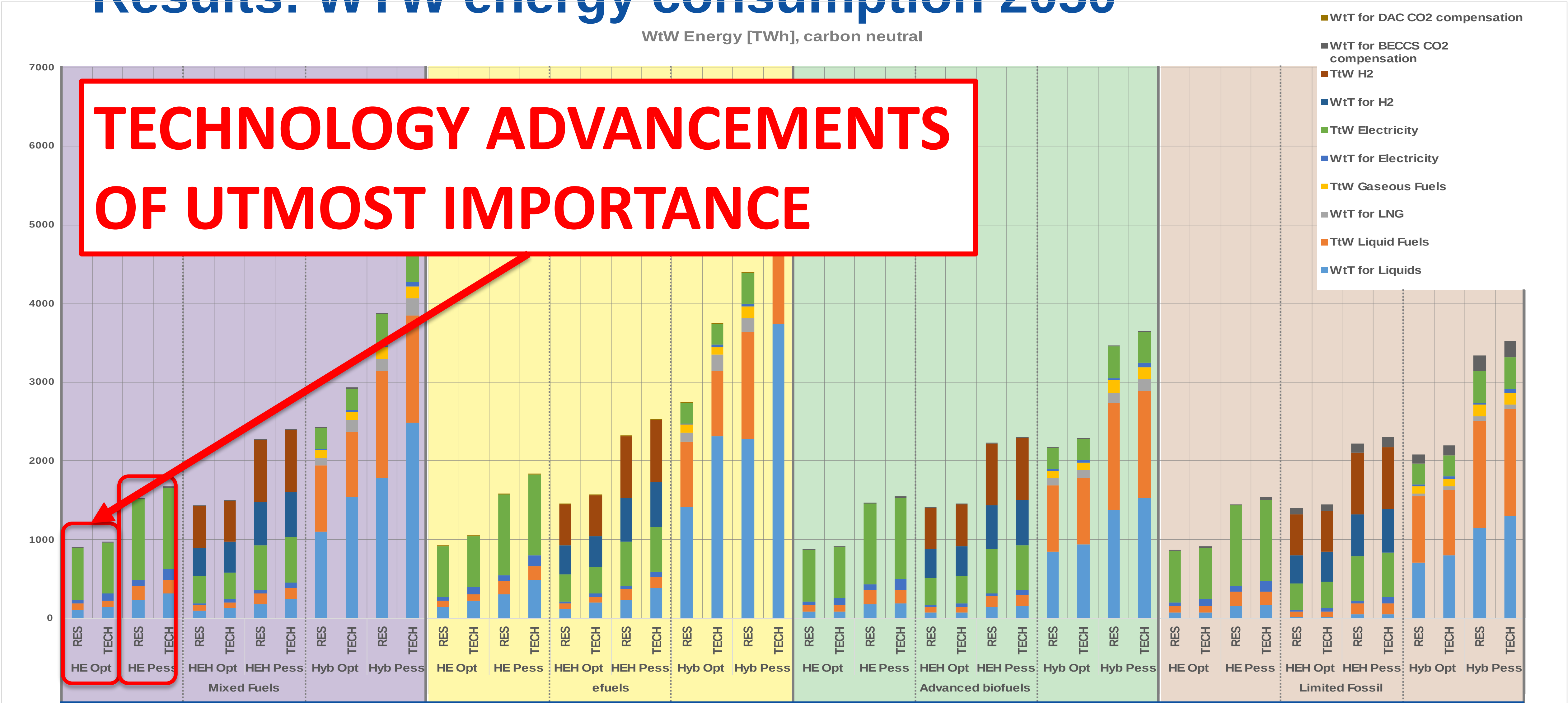




3 different powertrain scenarios analysed (corner-points):

- Highly Electrified incl. Electrified Road Systems (HE-ERS)
- Highly Electrified incl. Hydrogen (HE-H)
- Hybrids Scenario (Hyb)

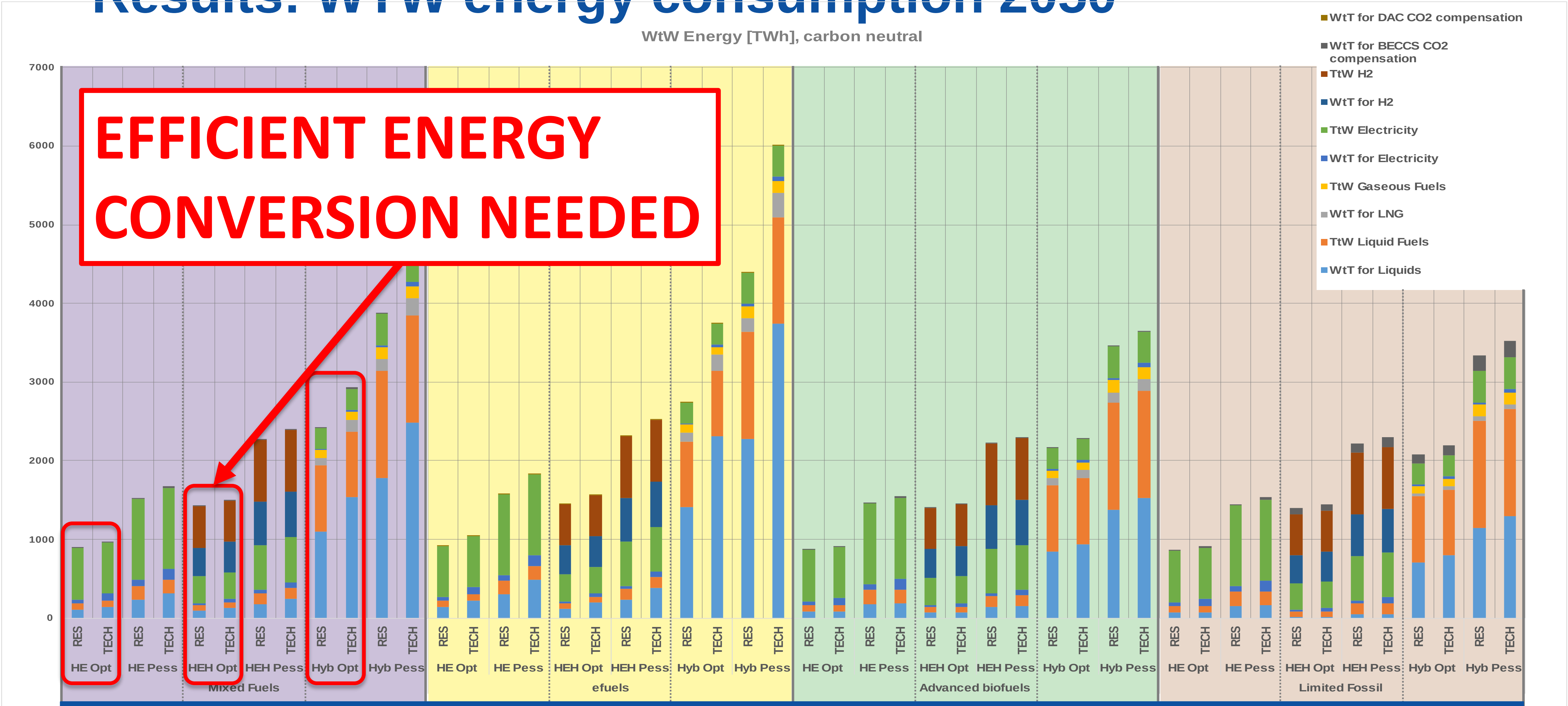
Results: WTW energy consumption 2050



Energy consumption by fuel, WTT and TTW, shown for

- → **4 fuels scenarios**
- → **3 Fleet scenarios** combined with Optimistic and Pessimistic measures
- → **2 Electricity production scenarios**

Results: WTW energy consumption 2050



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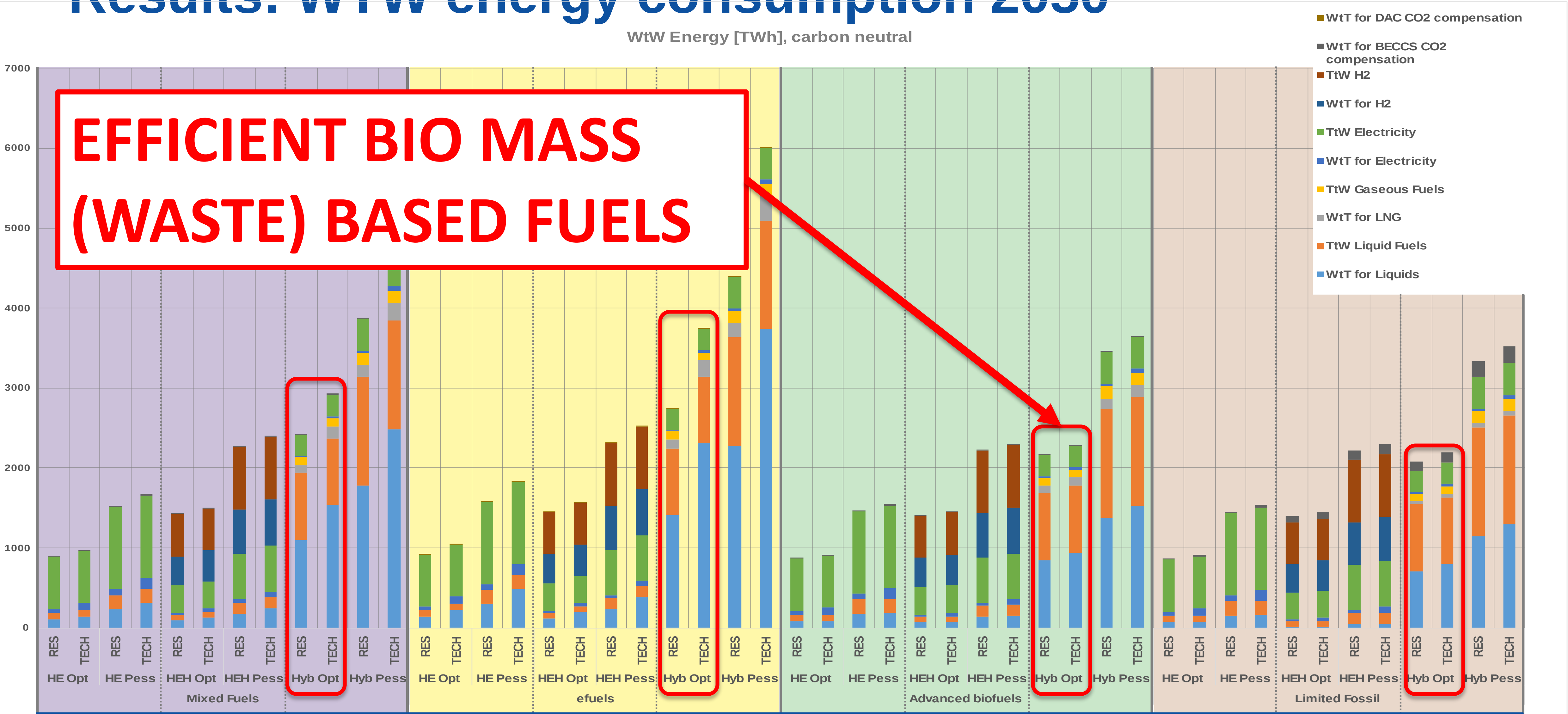

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FVV FUEL STUDY IV

Transformation of Mobility to the GHG Neutral Post Fossil Age

Most efficient pathways to carbon neutral mobility in 2050

International Symposium of Life-Cycle Emissions of Future Vehicles and Mobility (LIEF)
WebCon, 30 November 2021

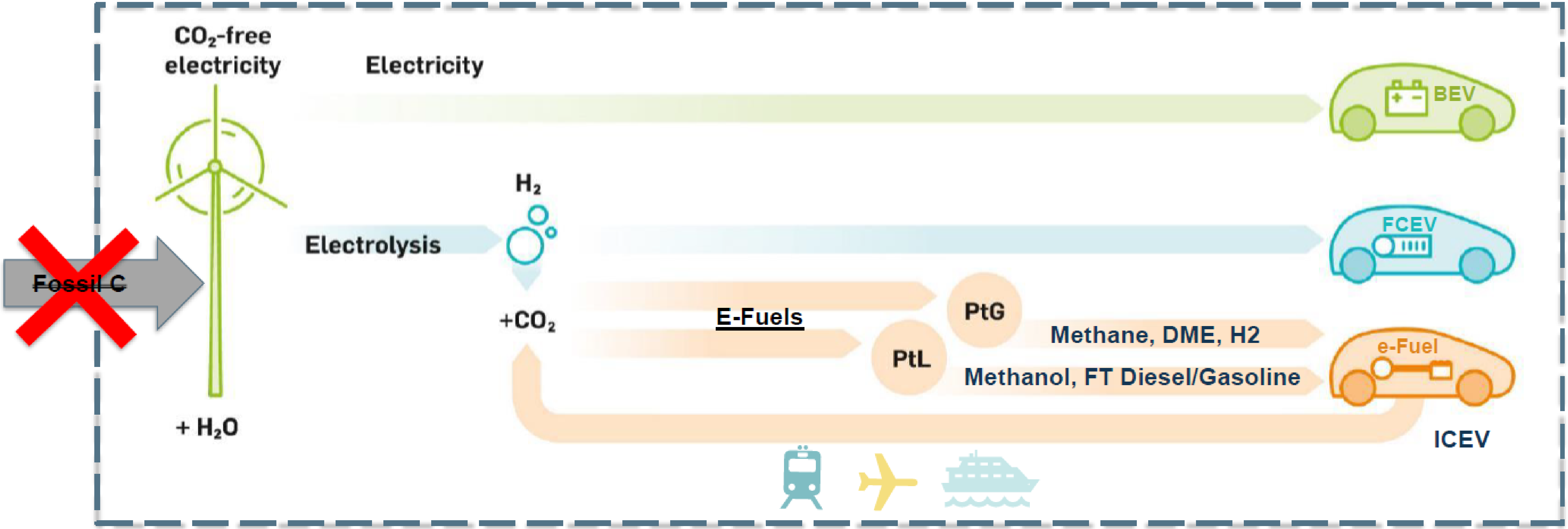
Dr. Ulrich Kramer, FVV (Ford-Werke GmbH)
Dr. David Bothe, Frontier Economics
Frank Dünnebeil, ifeu

AiF Member

No Fossil Carbon Enrichment in System Boundaries of FVV Fuels Study IV

WTW* Carbon Neutral European Mobility in 2050

100% Scenarios for GHG neutral (carbon neutral) mobility on a WtW* basis (photo year 2050)**



All future propulsion pathways require carbon neutral electricity (solar / wind).

Closed carbon circuit → no enrichment of fossil C in atmosphere

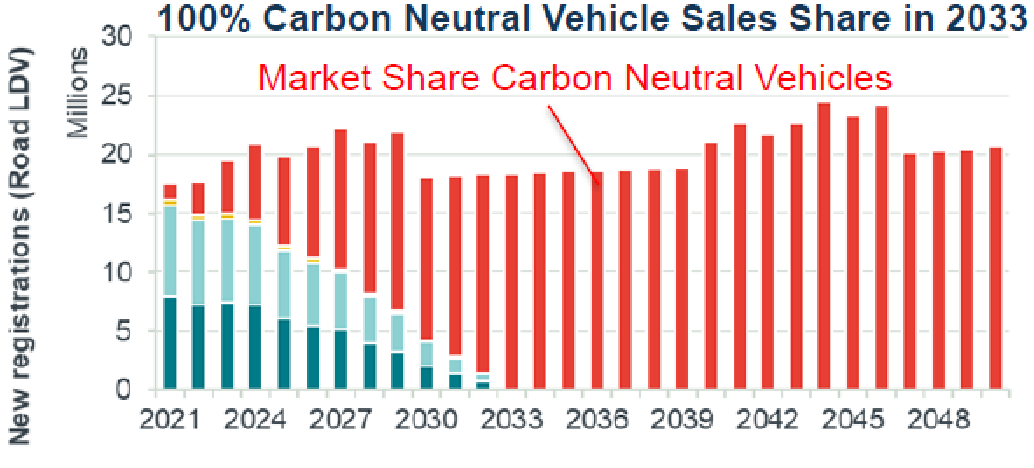
* WTW: Well-To-Wheel
** GHG: Green House Gas

BEV:	Battery Electric Vehicle
FCEV:	Fuel Cell Electric Vehicle
ICEV:	Internal Combustion Engine Vehicle

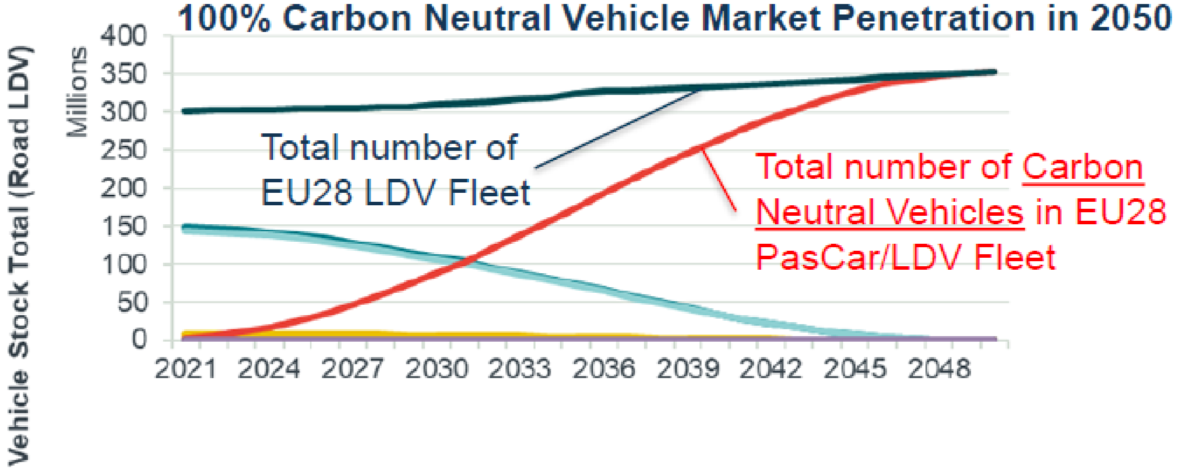
Fleet development (ramp-up) determined by vehicle lifetime

Example PasCar/LDV

Sales Share



Market Penetration



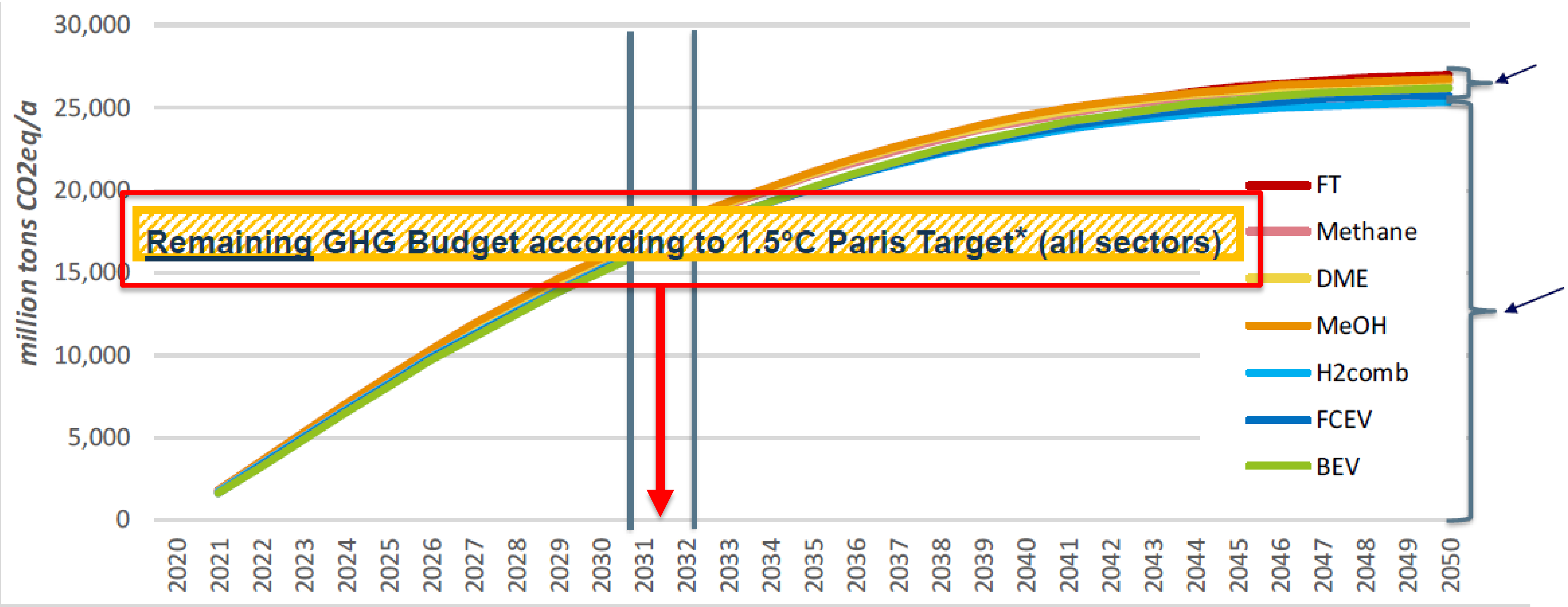
- Vehicles of out-phasing fleet, operated with fossil diesel
- Vehicles of out-phasing fleet, operated with fossil gasoline
- New carbon neutral vehicles, operated with defossilized fuel/energy
- Total number of vehicles (fleet stock)

- Theoretical ramp-up gradient, determined by fleet exchange rate.
- Same gradient for all pathways (also for drop-in FT fuel !)
- Further bottlenecks need to be defined in a follow-up study .

- **Target "carbon neutrality 2050" requires 100% carbon neutral vehicles in 2050**
- **Assumption: All new vehicles exclusively operated with renewable energy !**

Environmental impacts analysis

Comparison: Cumulative GHG emissions with remaining GHG budget



Cumulative bandwidth of future fuel / powertrain propulsion pathways

GHG emissions dominated by emissions of out-phasing fleet operated by fossil fuel

CO$_2$ EMISSIONS OF EXISTING FLEET TO BE REDUCED DRASTICALLY

- …l ramp-up determined by fleet exchange rate)
- **…oon (2031/32) just by transport**
  … & energy system production by 2030)
- …sting vehicle fleet

* **1.5°C 50th … 67th TCRE European share according to population share (6.5%)** for EU27+UK road transport (C2G basis: including build-up of fuel/energy supply infrastructure + vehicle production/disposal)