Decarbonizing the transport sector, an overview of the strengths, weaknesses and opportunities of different technologies.

>> *GenComm Meeting*

- ***Saarbrücken 24.02.2022***

Pedro Aguilar

Email: aguilar@izes.de

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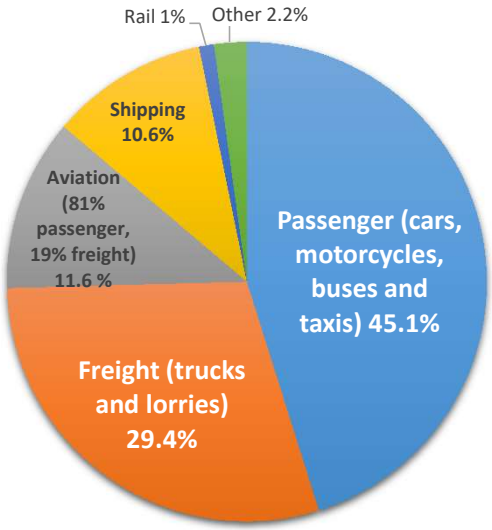
Introduction

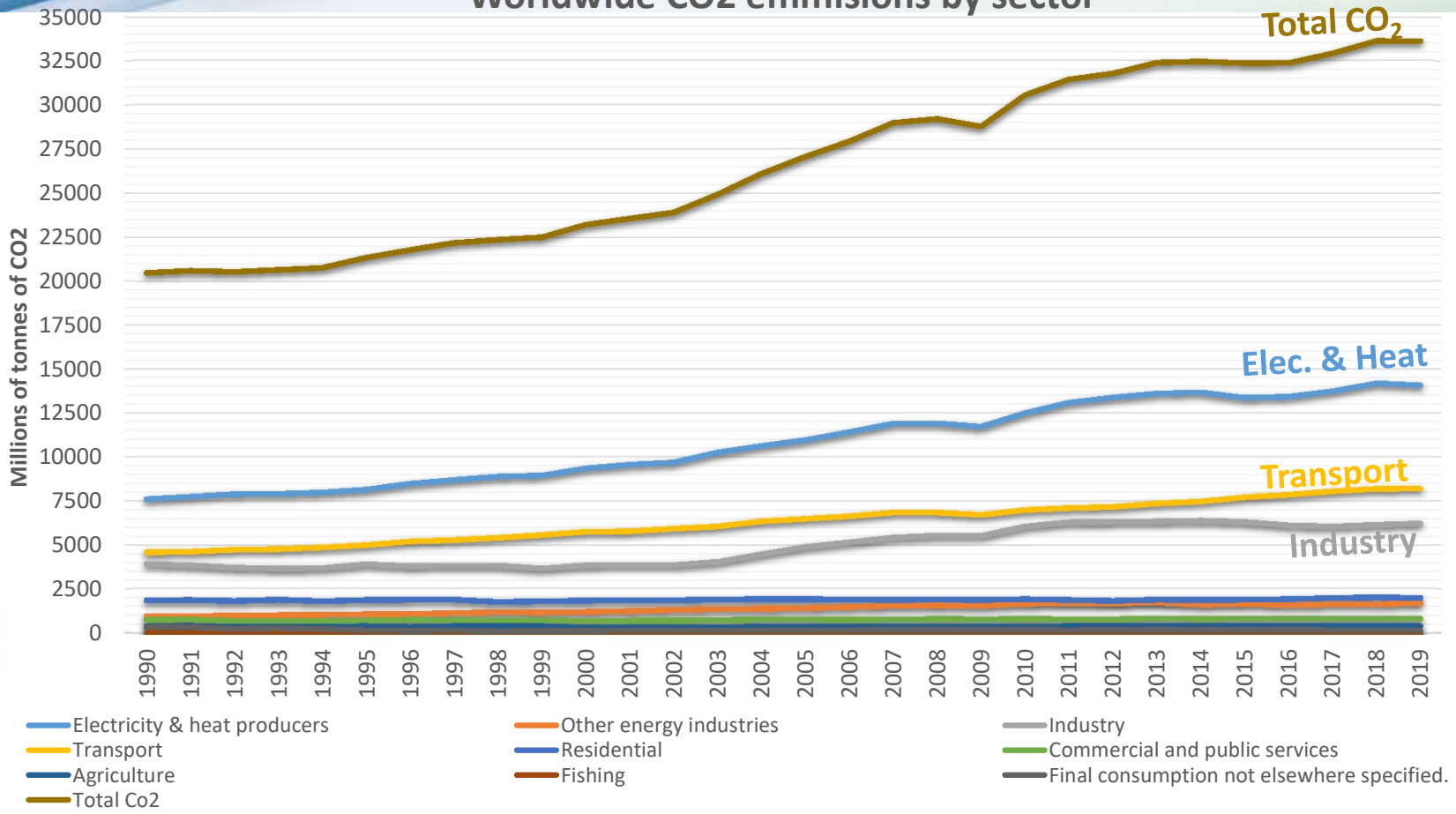
Introduction

- **Global warming**
  - Rising temperatures
  - Greenhouse Gases
  - Transport Sector= High influence

Global CO_2 transport emissions (2018)



Worldwide CO2 emmisions by sector



Data of CO2 by sector from [IEA1] and data of transport emissions 2018 from [OWD1]

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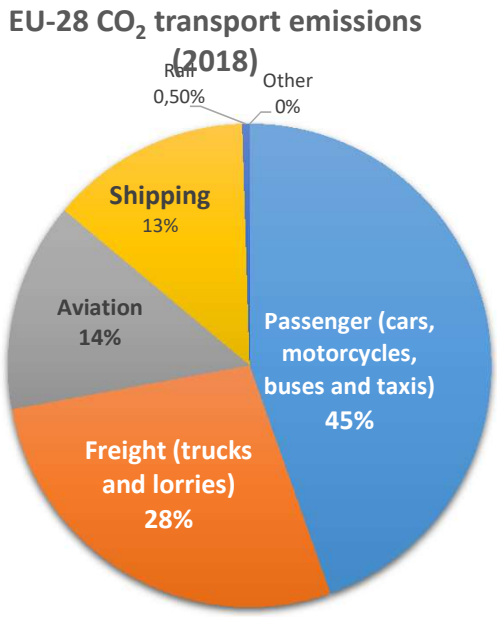
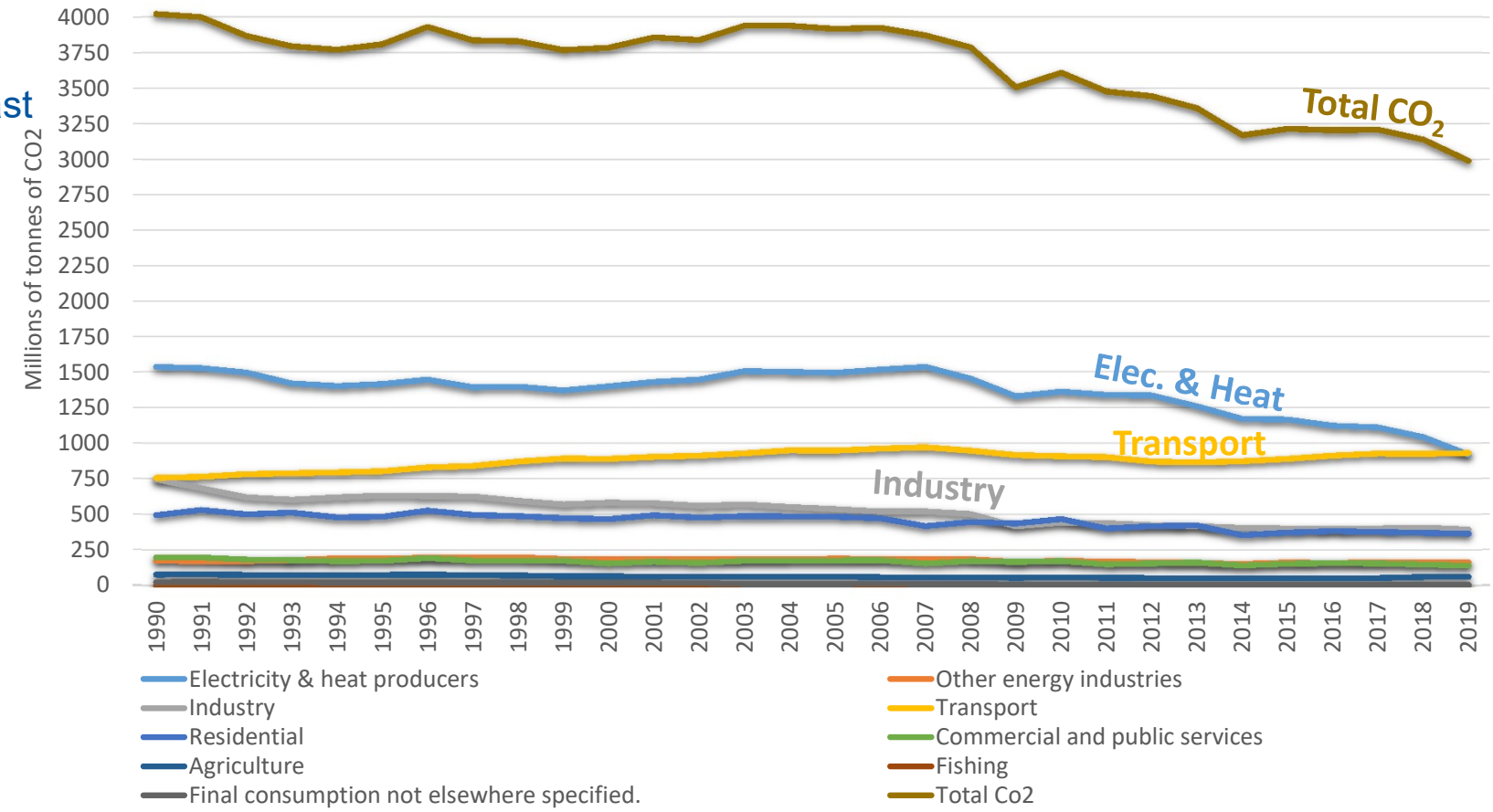
Introduction

EU-28 CO_2 emissions

- Significant progress have been achieved during the last decade.
- Transport sector emissions continue to increase.





Data of CO2 by sector from [IEA1] and data of transport emissions 2018 from [EEA1]

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The alternative solutions

		Considering:
Battery Electric Vehicles (BEV)	 *Image from [TSL1]*	- Electricity source. - Battery raw materials - Range/mass ratio - Price
Plug-in Hybrid Vehicles (PHEV)	 *Image from [CRP1]*	- Electricity source - Fossil fuels still an issue - Transition technology
Fuel Cell Electric Vehicles (FCEV)	 *Image from [TOY1]*	- Hydrogen source - Fuel cell and battery raw materials - Overall energy efficiency - Price & adoption.
Synthetic Fuels (E-fuel)	 *Image from [CRP2]*	- Overall energy efficiency - Cost - Electricity and raw materials source.

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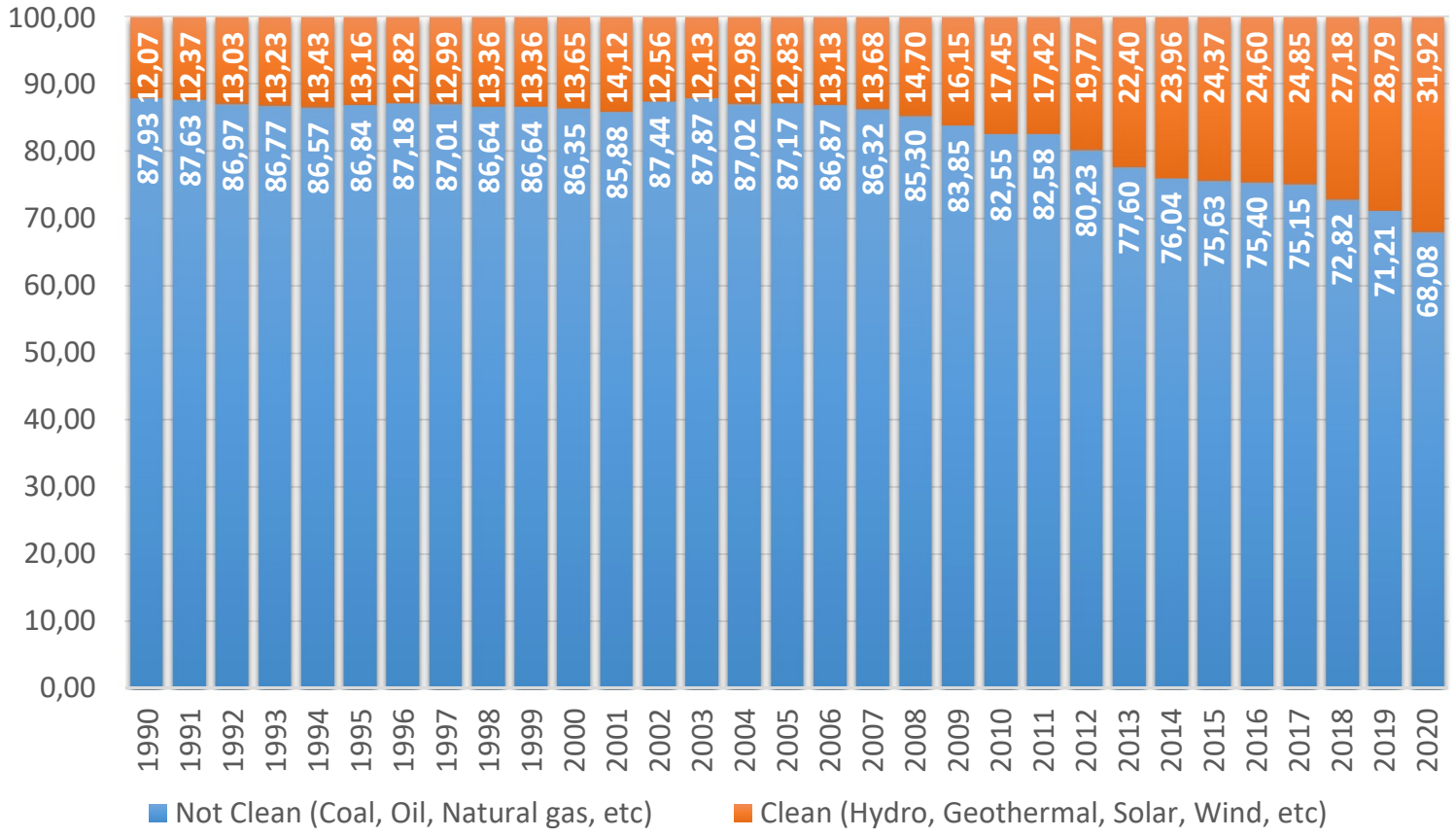
Battery Electric Vehicles & Plug-in Hybrid Electric Vehicles

BEVs & PHEVs

- **ZERO greenhouse gas emissions***
- Mass adoption.
- Growing infrastructure.
- Raw materials
- Price
- Range vs. Mass ratio.



*** When the electricity comes from 100% renewable sources & only electric driving is used (PHEVs)**

Data of electricity generation from [IEA1]

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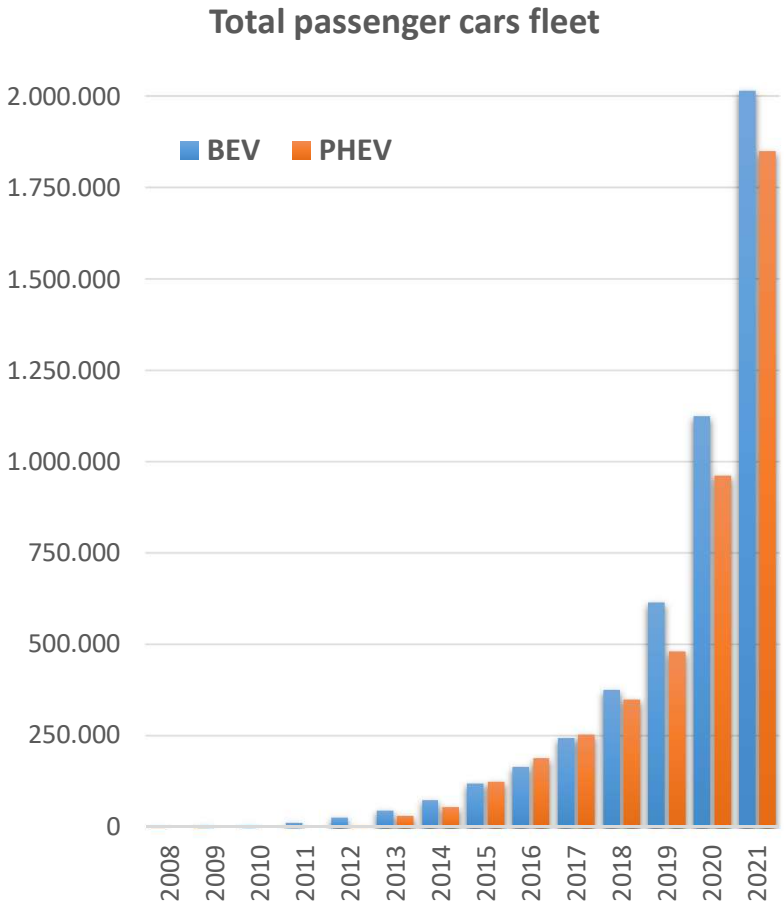
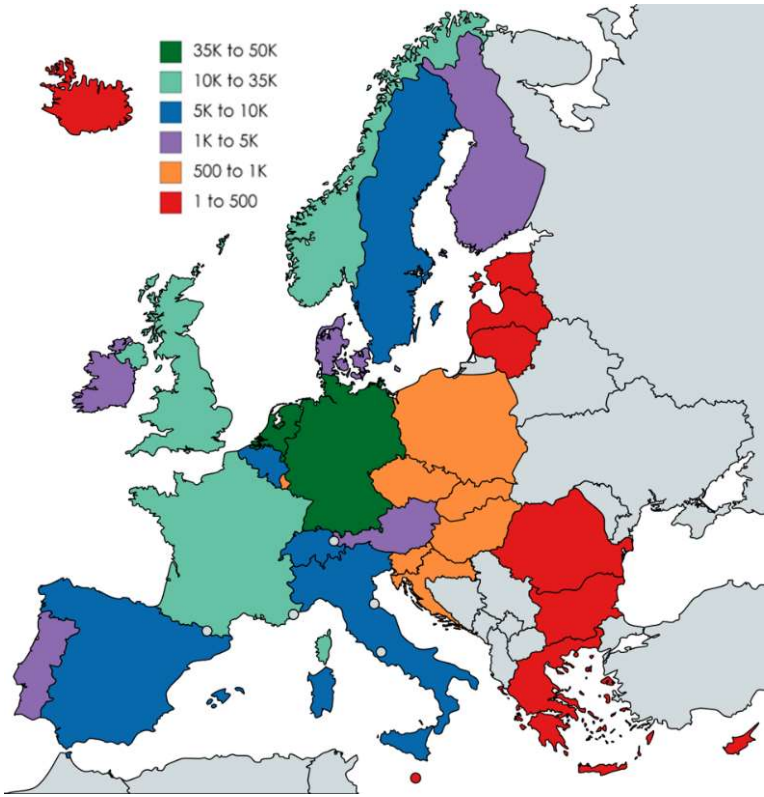
Battery Electric Vehicles & Plug-in Hybrid Electric Vehicles

BEVs & PHEVs

- ZERO greenhouse gas emissions*
- **Increasing adoption from the general public.**
- **Growing infrastructure.**
- Raw materials
- Price
- Range vs. Mass ratio.



Distribution of amount of charging stations in the EU at the beginning of 2020



*** When the electricity comes from 100% renewable sources & only electric driving is used (PHEVs)**

Data for passengers car fleet & charging stations from [EAFO]

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Battery Electric Vehicles & Plug-in Hybrid Electric Vehicles

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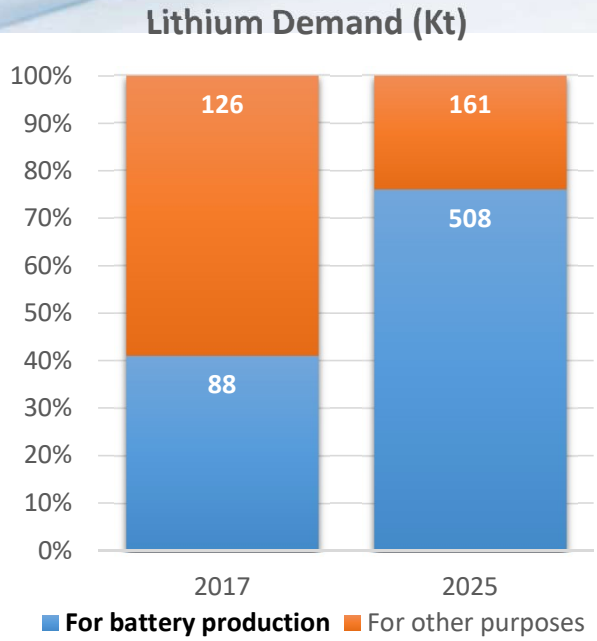
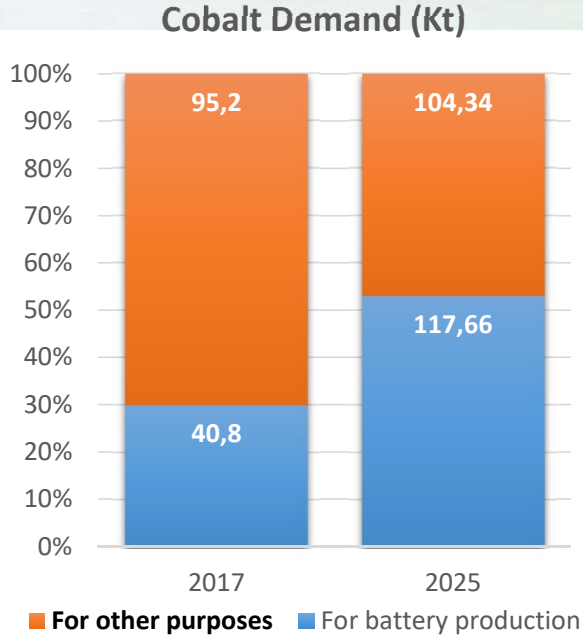
- **Raw materials**
- **Price**
- Range vs. Mass ratio.



- **Current capacity + reserves does not cover predicted demand for 2030.**
- Prices of the metal will increase as scarcity becomes more apparent.



- ~70% of extraction is located in the DRC
- ~60% of refinement facilities are in China
- Extraction occurs as by-product of copper or nickel
- Artisanal and unregulated mining in DRC
- Expected demand for 2030 on parity with reserves.

Data from [ACH18].

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Battery Electric Vehicles & Plug-in Hybrid Electric Vehicles

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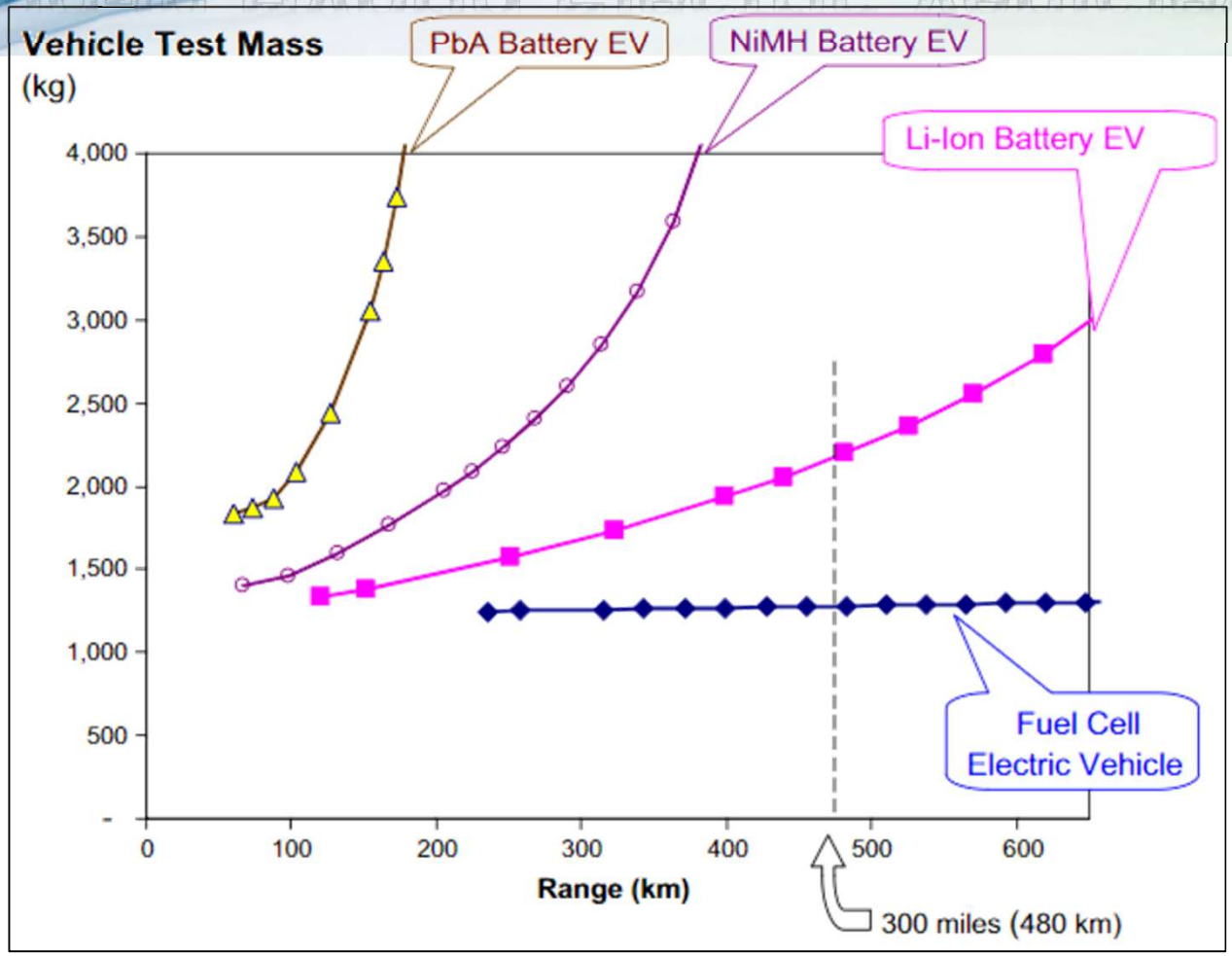
- Price
- **Range vs. Mass ratio.**



* When the electricity comes from 100% renewable sources & only electric driving is used (PHEVs)

Image from [Tho14]

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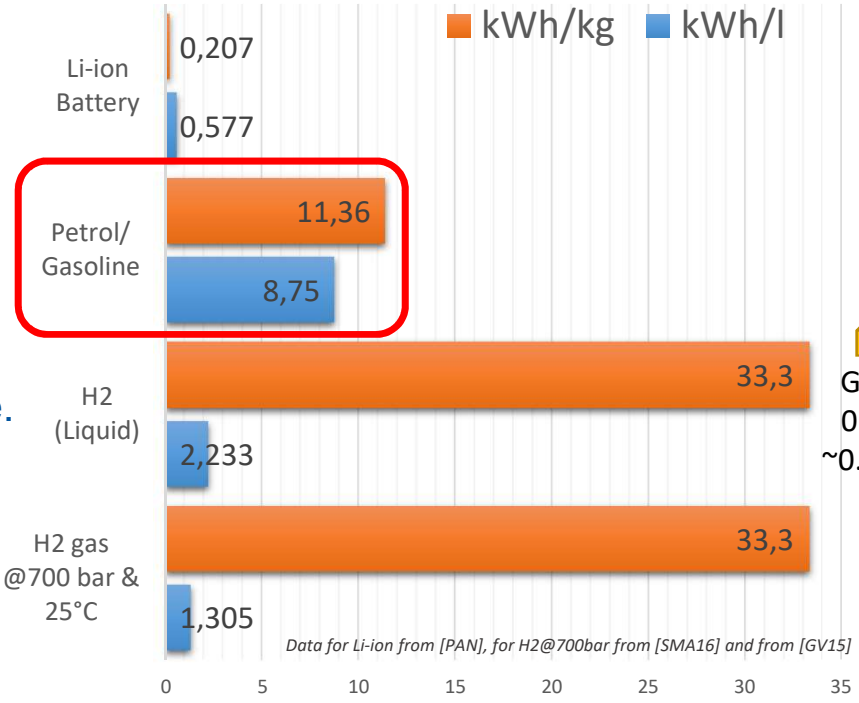
Fuel Cell Electric Vehicles

Specific Energy and Energy density

FCEVs

- **Range vs. Mass ratio.**
- The efficiency problem
- ZERO greenhouse gas emissions*
- Humble adoption from the general public.
- (Slow) Growing infrastructure.
- Raw materials & Price



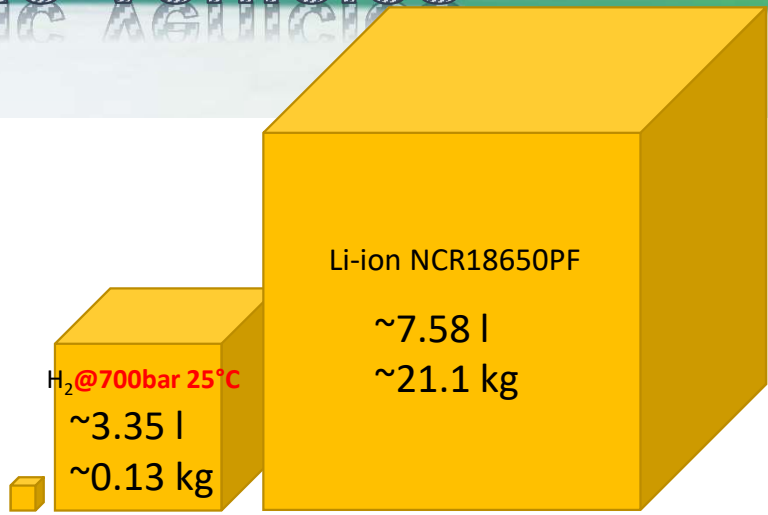


Image from [AIRB]

Image from [TOY1]


Image from [ECO]

Image from [MOT1]

Image from [ALST]

* When the Hydrogen comes from 100% renewable sources.

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Fuel Cell Electric Vehicles

FCEVs

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- **The efficiency problem**
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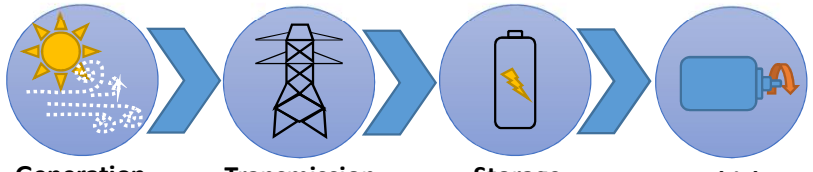
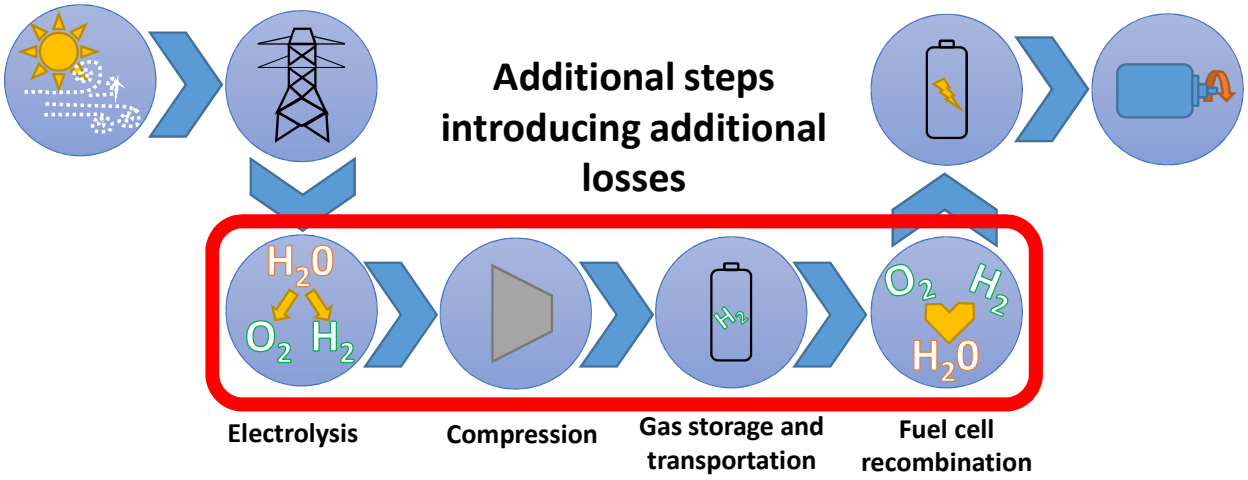
Energy path for a BEV



Energy path for a FCEV



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- **(Slow) Growing infrastructure.**
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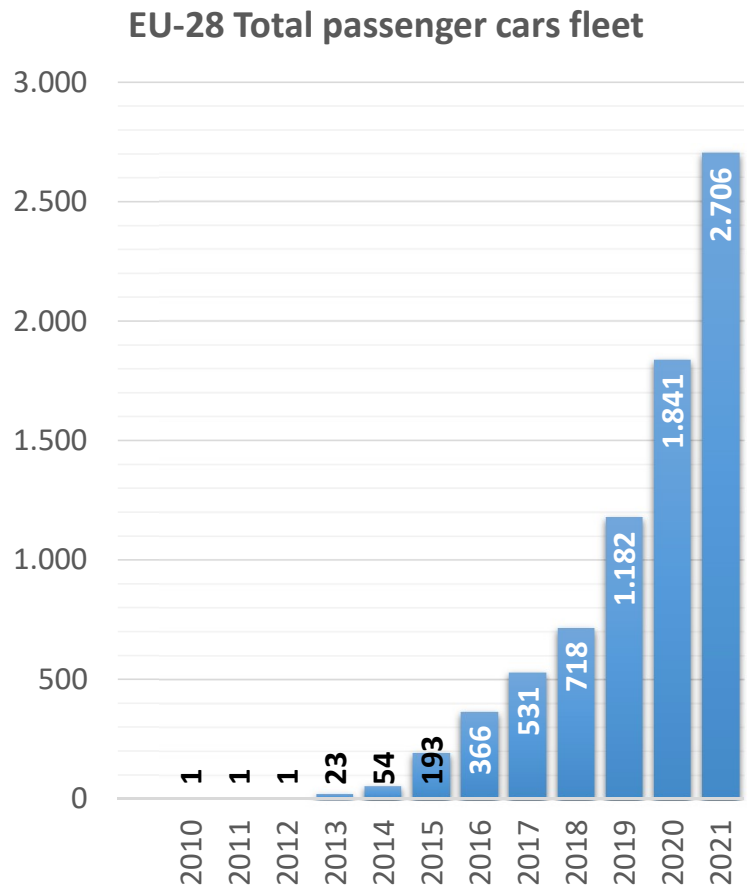
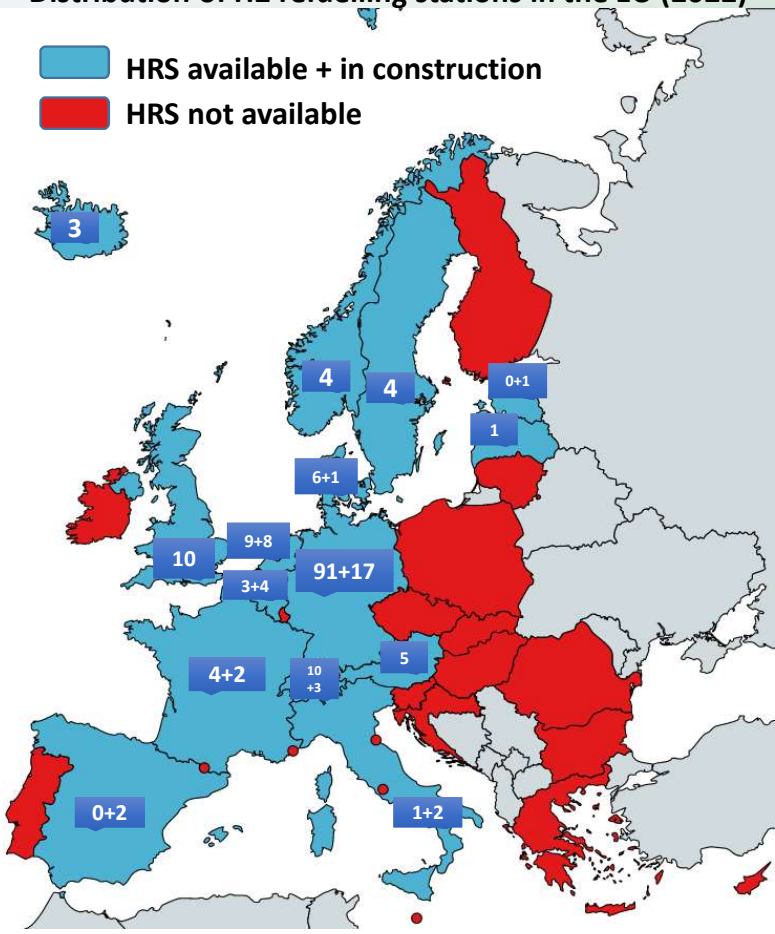


Distribution of H2 refuelling stations in the EU (2022)



Data for passengers car fleet vehicles from [EAFO] & charging stations from [H2I]

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Fuel Cell Electric Vehicles

FCEVs

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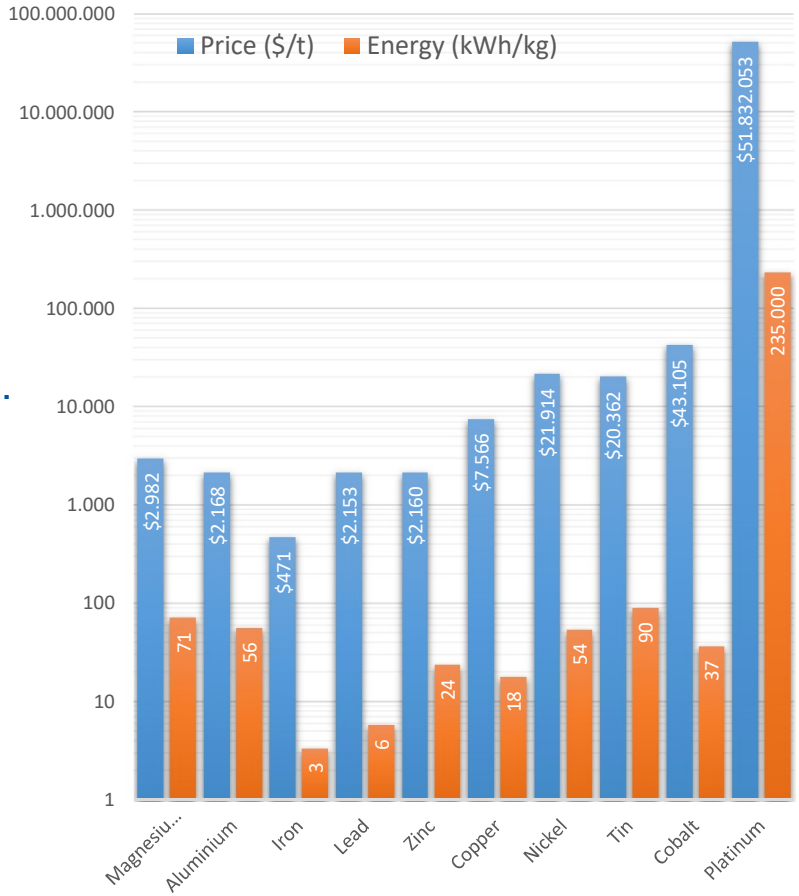
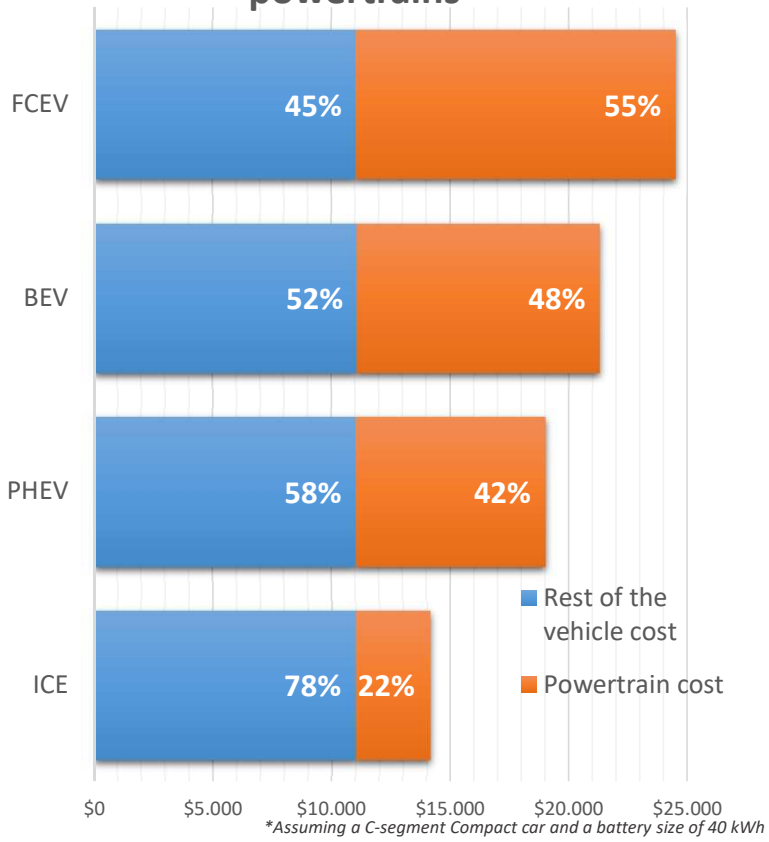
- **Raw materials & Price**

Energy consumption and price of different metals per tonne



Share of the cost of different powertrains*



* When the Hydrogen comes from 100% renewable sources.

Data of metals from [AFK12] & for powertrains from [MCK19]

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Synthetic Fuels (E-fuel)

E-fuels

- It gives continuity to state-of-the-art fossil-fuel-based technology.
- Current technology allows to manufacture E-fuels for all main mobility sectors
- Hydrogenated vegetable oils, Biodiesel, RME, methanol mixes are already in use in many regions.
- Efficiency and complexity of the processes go far beyond that of the case of H_2 ➔ lowest energy efficiency.

Image from [BUG]

Image from [LUFT]

Image from [ENV]

Image from [FARM]

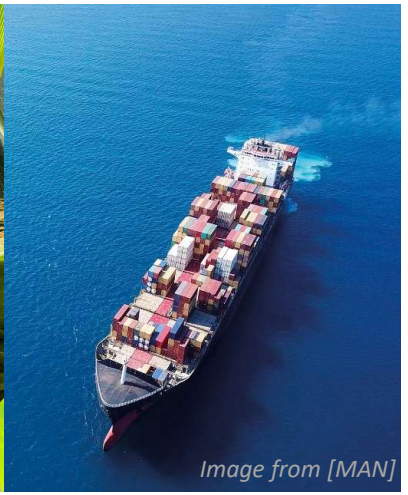

Image from [MAN]

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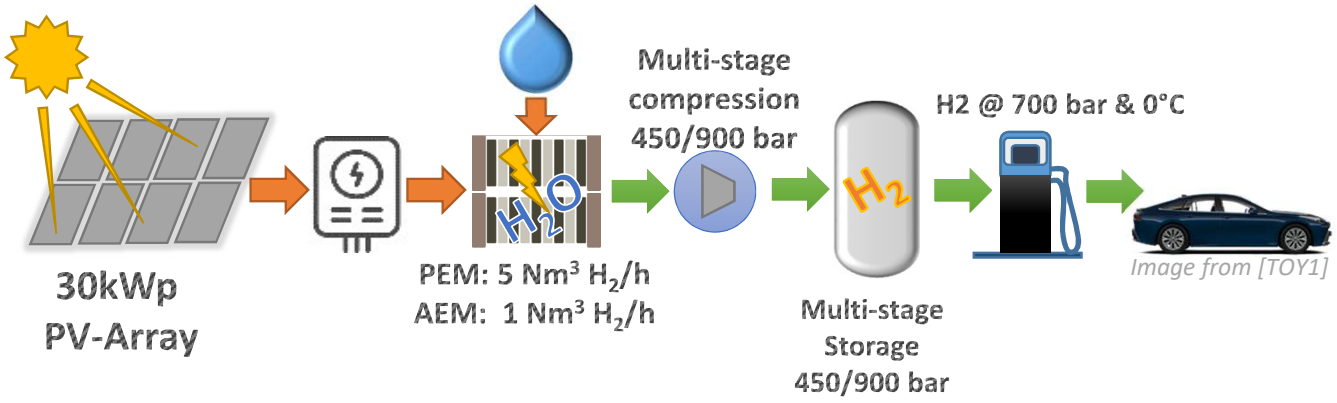
IZES

Hydrogen Refueling Station @ IZES

- At IZES we join the Hydrogen-based energy revolution with the installation of our own HRS.
- Green Hydrogen will be produced using solar energy coming from a recently installed PV array.
- The HRS is equipped with a PEM electrolyser and a AEM electrolyser.
- A Toyota Mirai has also been integrated to the fleet of the institute.



GenComm partners (+ new partners in CapCall)

- **Belfast Metropolitan College (UK);** Energia Group (UK); HyEnergy (UK); Pure Energy Centre (UK); National University of Ireland Galway (ROI); TK Renewables (UK); BURN Joint Research Group, Vrije Universiteit Brussels (BE); INSA Rouen Normandie (FR); ENSICAEN Caen (FR); IZES (DE); University of Luxembourg (LU)

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IZES

Hydrogen Refueling Station @ IZES

- The HRS is already in place next to the main building of the institute.
- Operation is expected to begin soon during this 2022.
- Future research aims to evaluate lifetime and degradation of the stacks, compare efficiencies of both devices and create a prediction model for future plants of similar layout.

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Conclusions

- None of the technologies offers a complete solution.
- The current state of affairs should be taken more like a collaboration instead of a technological competition.
- The decarbonisation of the transport sector requires faster deployment of renewable electricity generation plants and it goes hand in hand with the availability of clean electricity.

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