Overview and Activities of the Advanced Fuel Cells (AFC)-TCP

IEA AFC TCP

Österreichische Energieagentur - Austrian Energy Agency
Guenter Simader | 29th June 2023

Agenda

- Worldwide market trends of fuel cell technology
- Introduction of Advanced Fuel Cells TCP
- Key outputs of TCPs
- Austrian Activities within AFC TCP
- Summary and Conclusion

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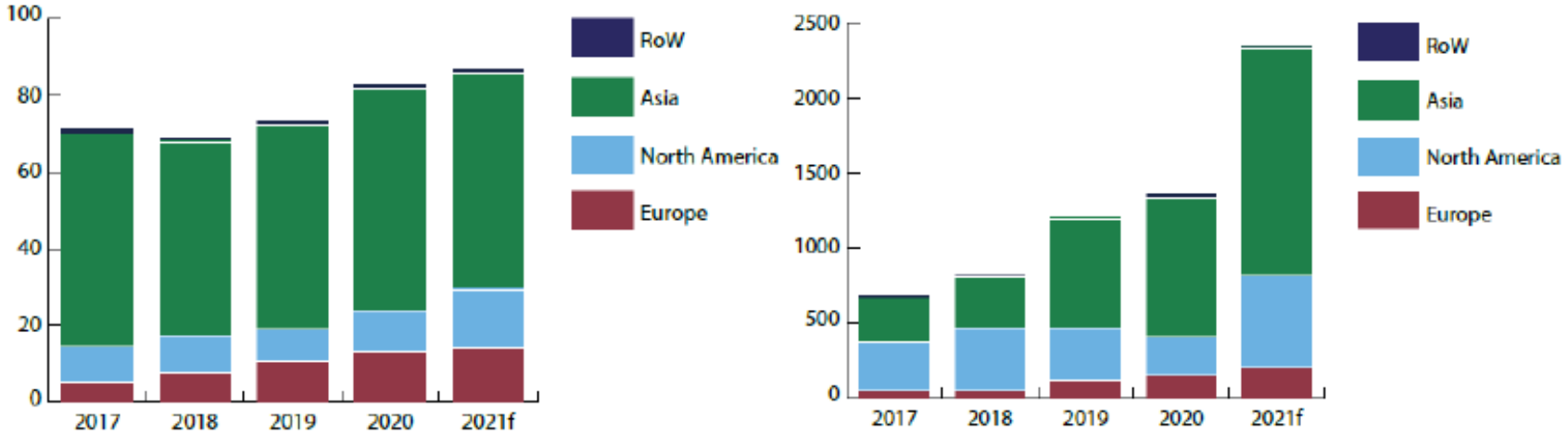
Introduction and Worldwide Market Trends of Fuel Cell Technology

Market Developments of Fuel Cell Systems



Reference: E4tech www.FuelCellIndustryReview.com, 2022

Worldwide shipments of fuel cells by region from 2017 to 2021

Left side: Megawatts by region (MW); right side: Number of shipments (in 1.000)

Participants of the Advanced Fuel Cells TCP (AFC TCP)

USA
Canada

Austria
Croatia
Denmark
France
Germany
Israel
Italy
Spain
Switzerland

VTT
(Finland)

China
Japan
South Korea

Country Members

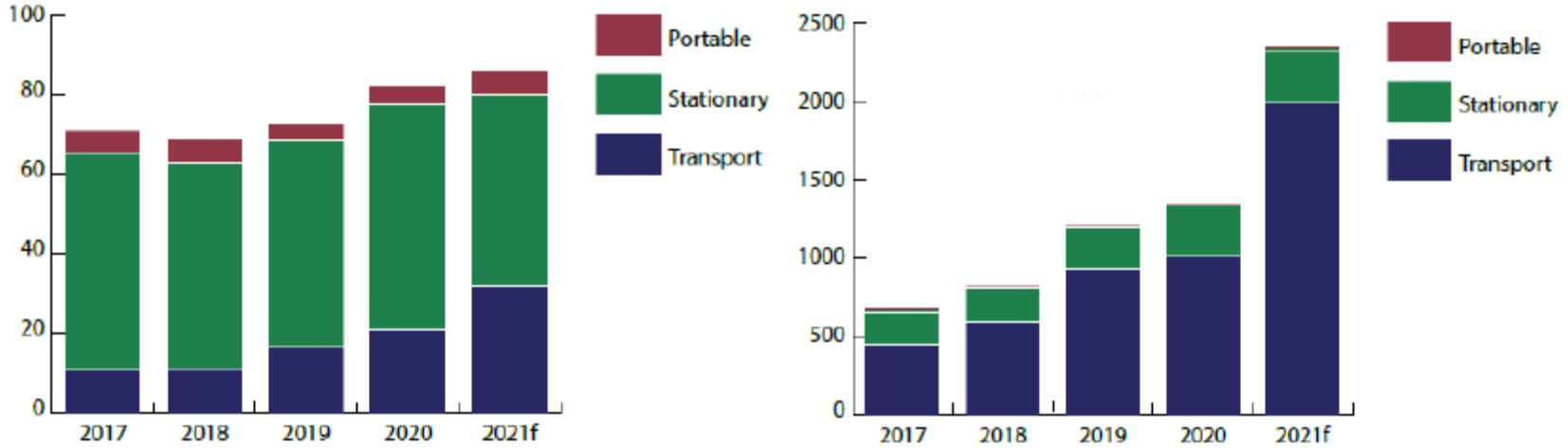
Austria, Canada, China, Croatia, Denmark, France, Germany, Israel, Italy, Japan, South Korea, Spain, Sweden, Switzerland, USA

Organizational Members (Sponsors)

VTT Technical Research Center of Finland

Reference: Advanced Fuel Cells TCP, 2023

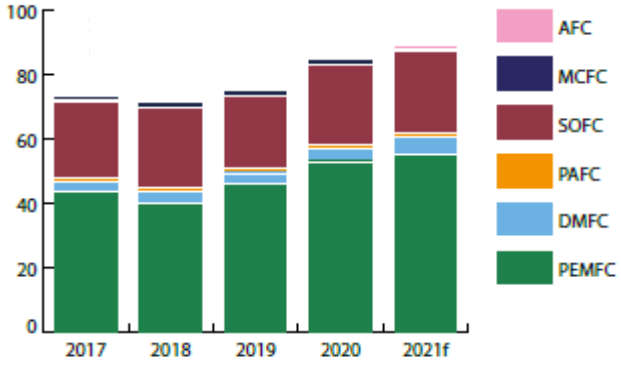
Worldwide Shipments by Application

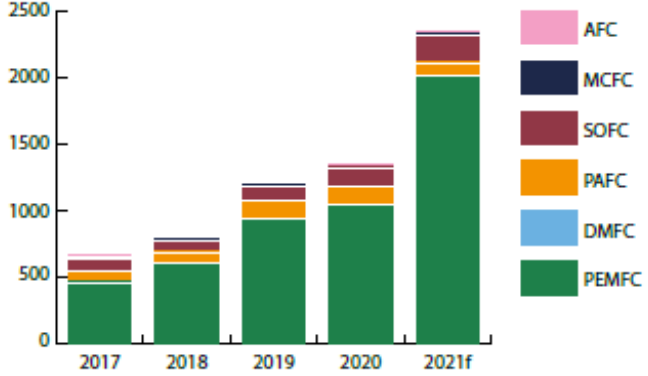


Reference: E4tech www.FuelCellIndustryReview.com, 2022

- **Worldwide shipments by applications by region from 2017 to 2021**
- Left side: Megawatts by region (MW); right side: Number of shipments (in 1.000)

Worldwide Shipments by Fuel Cell Type





Abbreviations:

AFC – Advanced Fuel Cell

MCFC – Molten Carbonate Fuel Cell

SOFC – Solid Oxide Fuel Cell

PAFC – Phosphoric Acid Fuel Cell

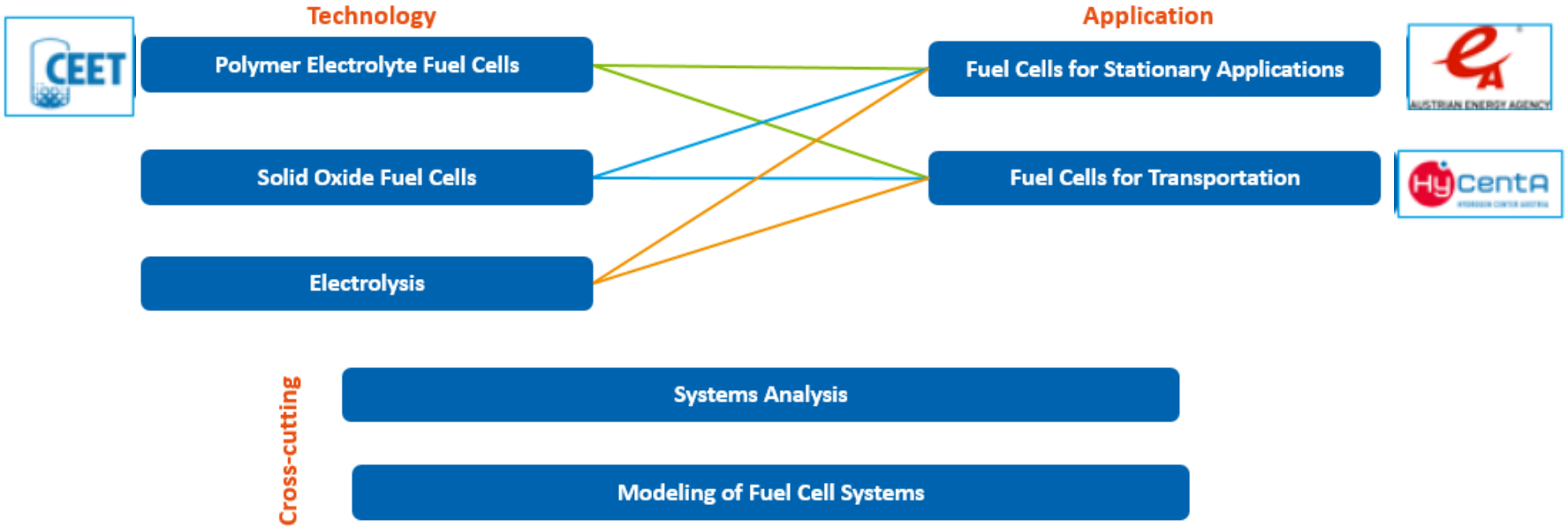
DMFC – Direct Methanol Fuel Cell

PEMFC – Polymer Electrolyte Fuel Cell

Reference: E4tech www.FuelCellIndustryReview.com, 2022

- **Worldwide shipments by fuel cell type from 2017 to 2021**
- Left side: Megawatts by fuel cell type (MW); right side: Number of shipments (in 1.000)

Task Structure of AFC TCP



Reference: Advanced Fuel Cells TCP, 2023

Advanced Fuel Cells TCP: Vision & Mission

Vision

- Contribute to opportunities and challenges to fuel cell research, development and commercialization

Mission

- Carry out coordinated research, technology development and systems analysis in the areas stationary, transportation & portable power, as well as technologies (PEFC, SOFC, electrolysis systems)
- Systems analysis to answer key overarching questions
- Contribute to IEA ETN activities
- Disseminate key findings and key messages of the AFC TCP with the R&D community, IEA, policy makers and the public as appropriate
- To further advance the state of understanding of all Contracting Parties in the field of AFC

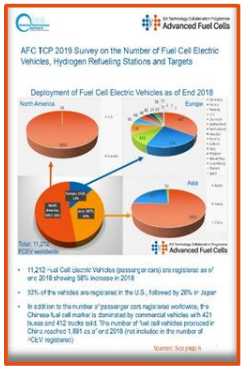
Output & Results

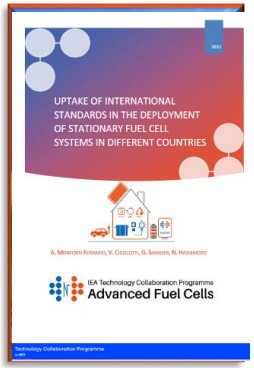
Analyses, Reports, Deliverables of AFC TCP

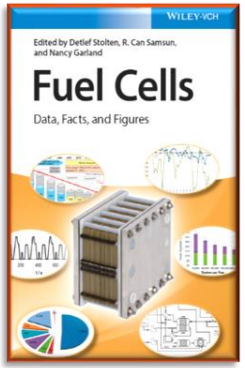
Deliveries of AFC TCP

AFC delivers analyses of research priorities and disseminate these as appropriate.

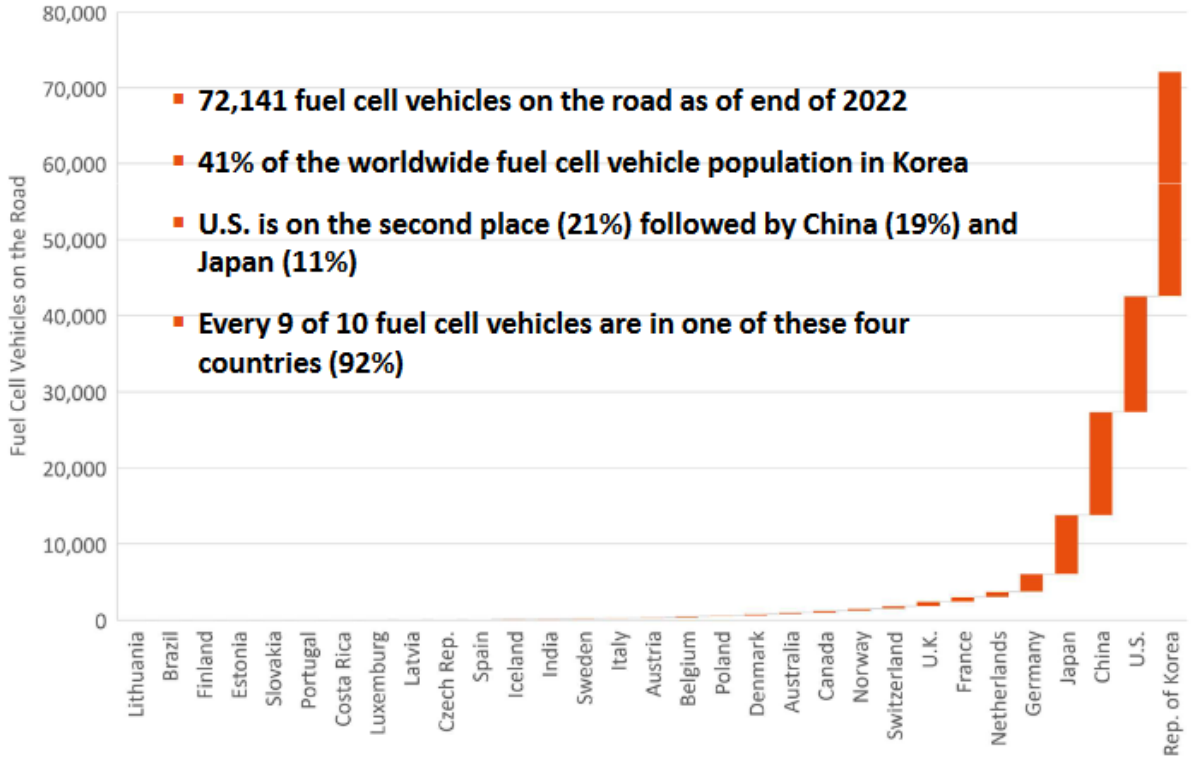
AFC releases strategic outlines and position papers based on the project work of the Tasks and the ExCo, furthermore AFC publishes on technical and economical issues of fuel cells via referred journal articles, books and booklets.

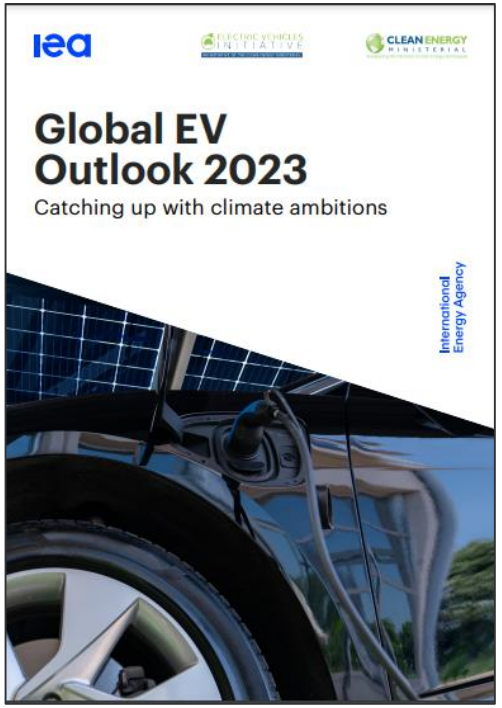






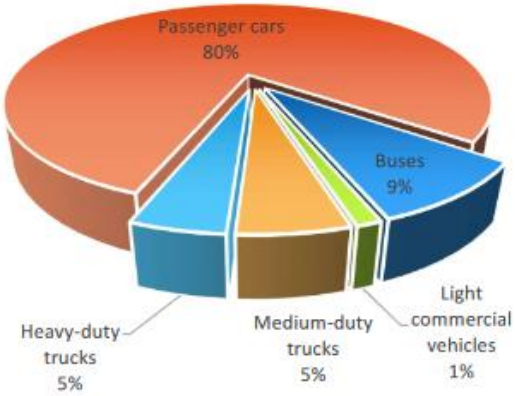
Worldwide Deployment of Fuel Cell Vehicles and Hydrogen Refueling Stations (HRS): 2022 Update

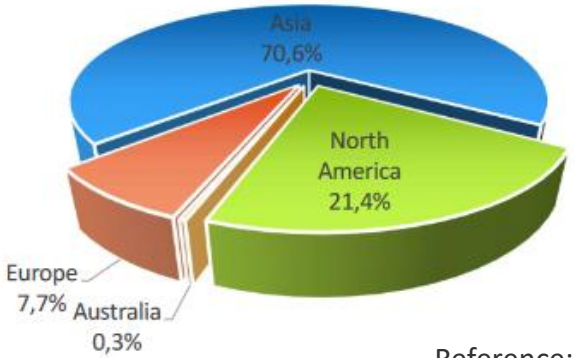




Reference: Advanced Fuel Cells TCP, 2023

Analysis of Fuel Cell Vehicles:
Shares worldwide – 2022 Update





Reference: Advanced Fuel Cells TCP, 2023

- four of five fuel cell vehicles are passenger cars
- remaining part almost equally shared between buses and trucks
- heavy-duty trucks have a similar share with medium-duty trucks

- more than two thirds of the vehicles on the Asian roads
- more than one fifth of the vehicles in North America
- Europe with a rather low share with 7.7%

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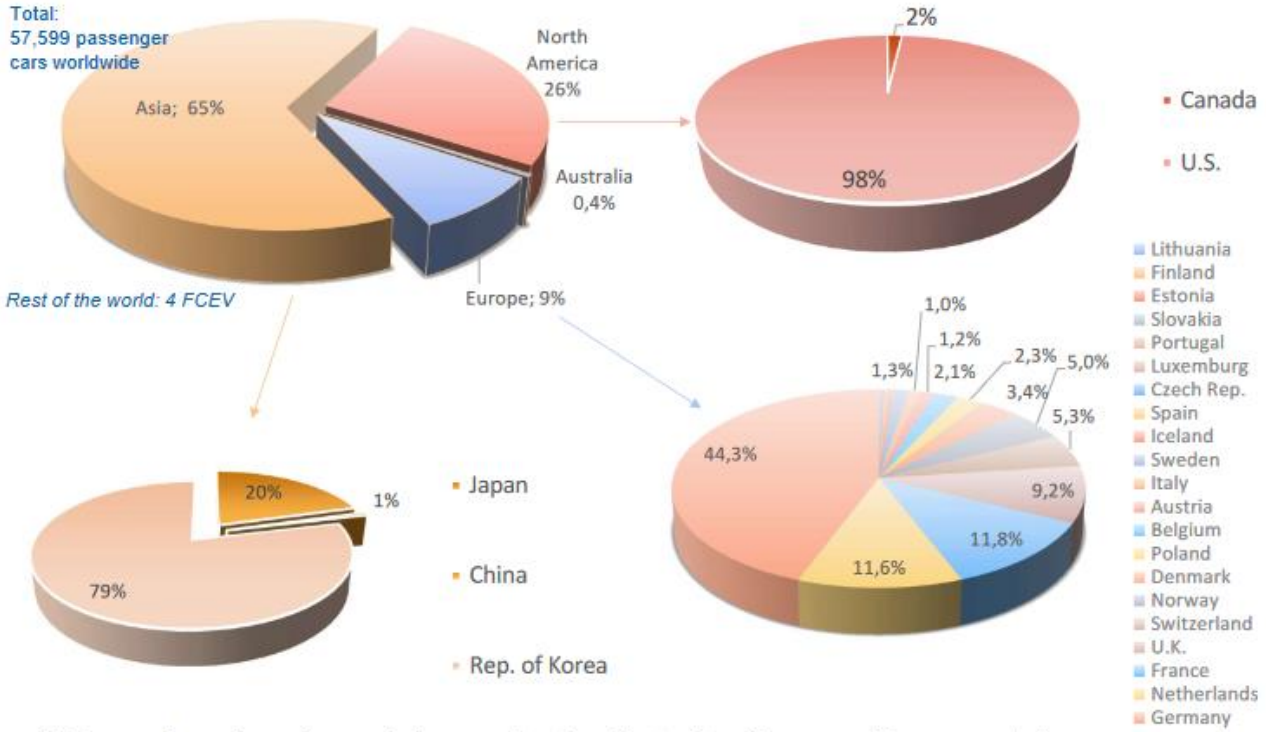
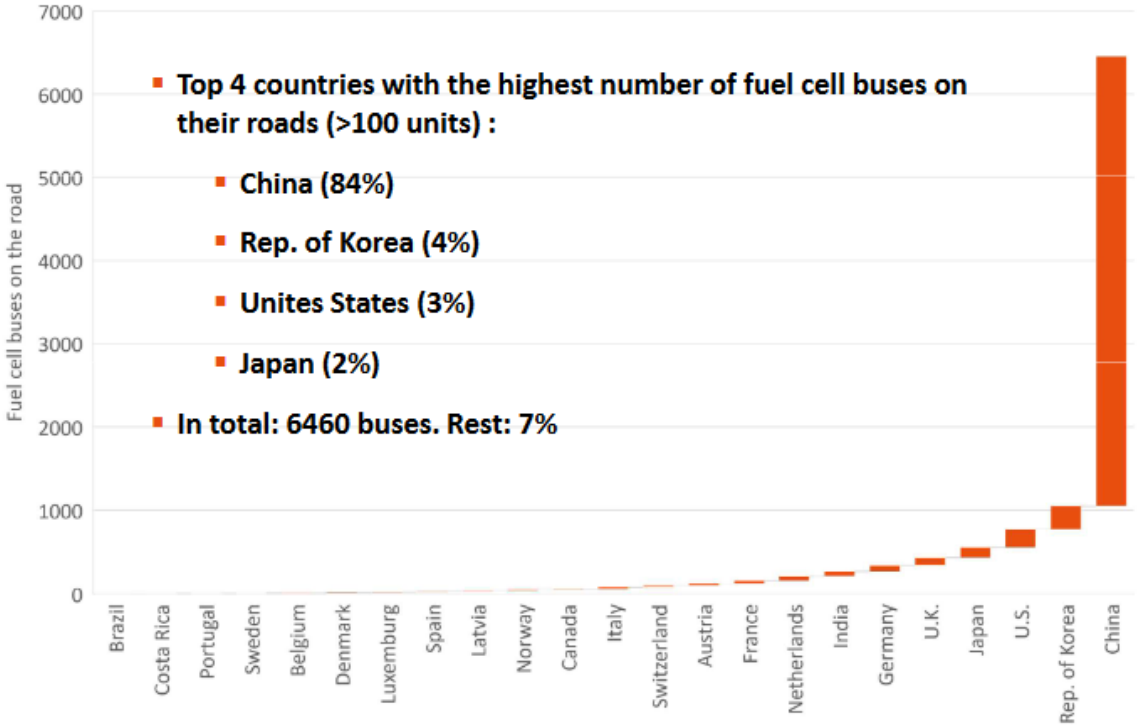
Fuel Cell Passenger Cars – 2022 Update



- **Highest share is again on Asian roads, distributed to Korea and Japan mainly.**

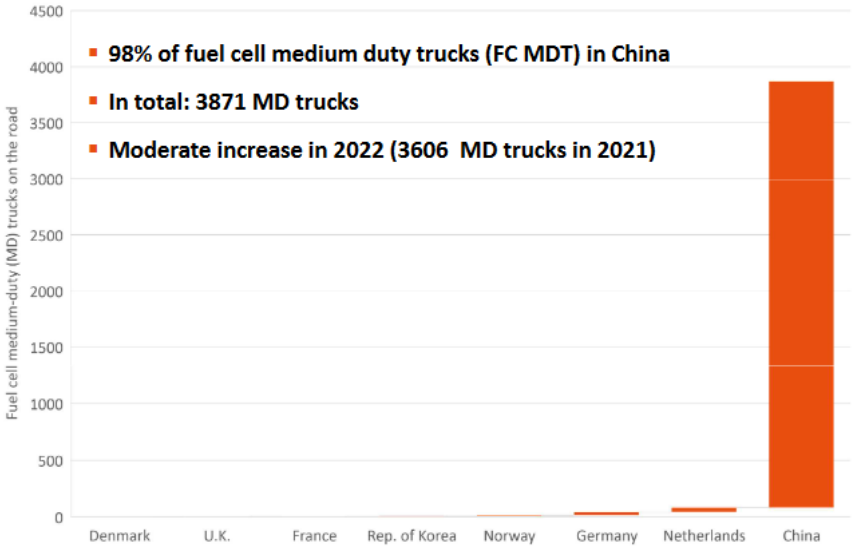
Reference: Advanced Fuel Cells TCP, 2023

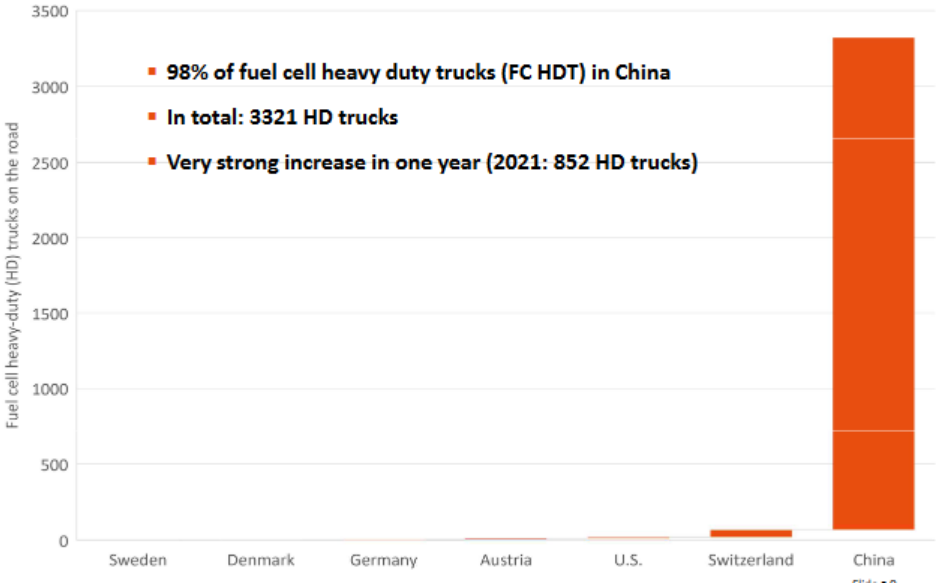
Fuel Cell Buses – 2022 Update



Reference: Advanced Fuel Cells TCP, 2023

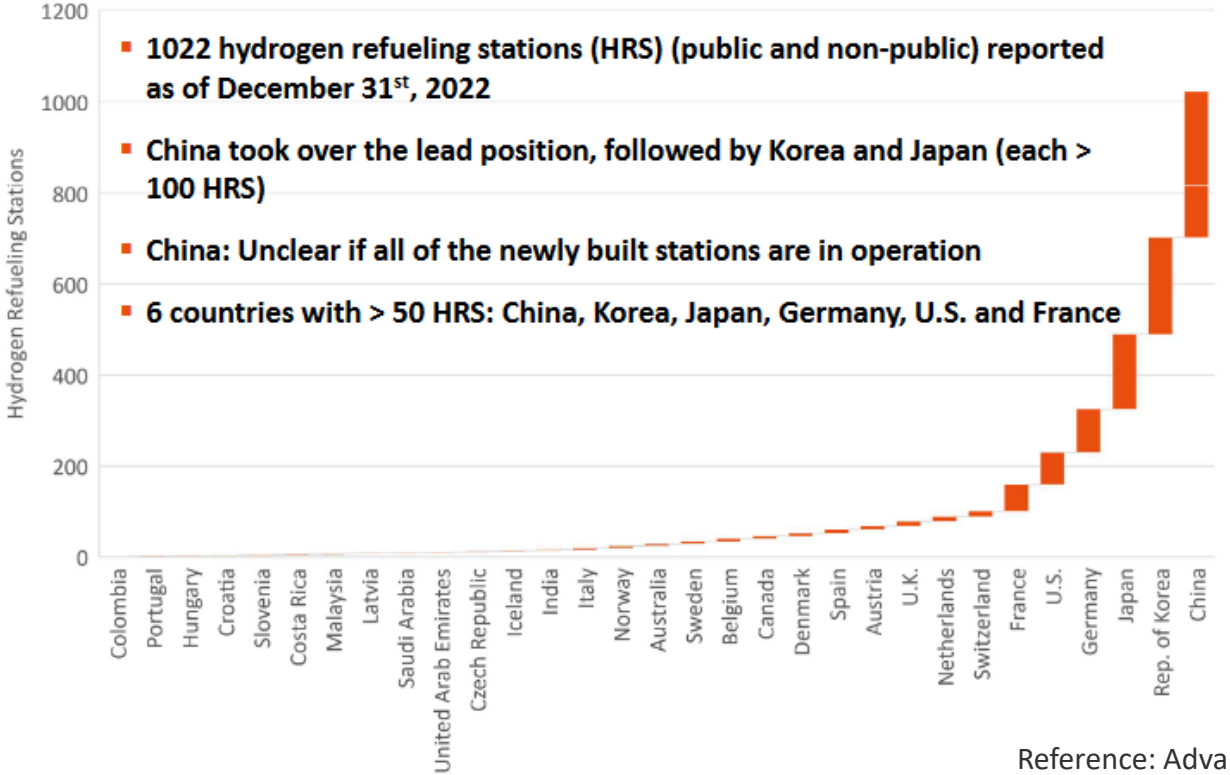
Fuel Cell Medium Duty & Heavy Duty Trucks – 2022 Update





Reference: Advanced Fuel Cells TCP, 2023

Hydrogen Refueling Stations (HRS) – 2022 Update



Reference: Advanced Fuel Cells TCP, 2023

Austrian Activities within AFC TCP

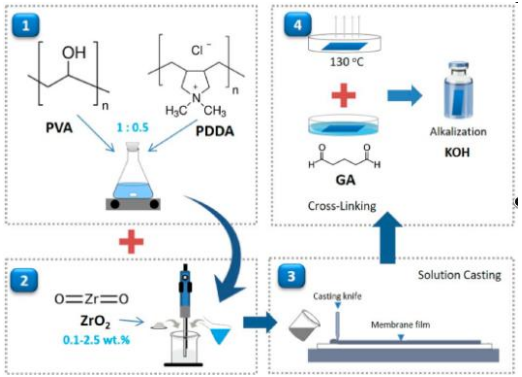
Task 31 – PEFC (Lead ANL)

Work content of Task 31 – key messages:

- Reducing cost and improving durability still remain the top priorities in fuel cell material and system R&D
- HDV Requirements for longer lifetimes (~25,000 hrs) compared to LDV (~5,000-8,000 hrs) – need more of a focus on durability
- Major technology breakthroughs, such as high-temperature membranes, durable catalysts, PGM-free catalysts. Alkaline exchange membranes, are important to light duty as well as heavy-duty fuel cell vehicle
- Transferring the laboratory technology to practical application in real-world should be accelerated

Activities of TU-Graz:

- Characterization and optimization of fuel cells
- Manufacturing of the membrane electrode assembly (MEA)
- Component and material development



Reference: Manufacturing method for fuel cell anion exchange membranes based on PVA/PDDA, from Samsudin et al.

Task 33 – Stationary Applications (Lead ENEA)

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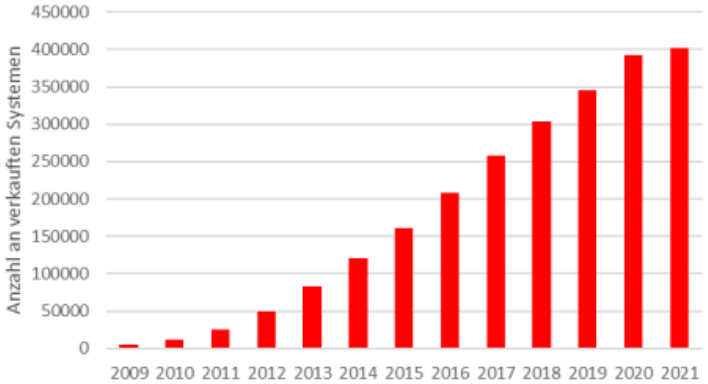
Key messages of Task 33:

- Small scale fuel cell systems for stationary µ-CHP applications have been recognized as key technology for energy efficiency & decarbonization
  - More than 30% of global final energy consumption
  - More than 40% of total direct and indirect CO2 emissions
- For the fuel cell based µ-CHP market, **Japan** and **Europe** are leading the market and the R&D activities, thanks to substantial subsidy schemes and programmes
- **Japan** results to be the main leader in CHP installations with more than 440,000 fuel cells installed
- **Europe** is keeping pace with Japan, with 4,100 of CHP units installed within three main actions (Callux, PACE and ene.field)
- For larger stationary applications, USA is leading the SOFC pictures, with a cumulated installed capacity of 500 MW; **Korea** has the leadership on large scale installations 711 MW in operation in 2022 and 7.1 MW in building - mainly PAFC by Doosan and SOFC by Bloom Energy & SK (Korean company)

Activities of the Austrian Energy Agency:

- Analysis of the Japanese residential EneFarm fuel cell programme and replication potential for Austria
- Analysis of neighborhood solutions based on decentralized hydrogen solutions with fuel cells including modelling of at least three different neighborhoods (development of typologies, planning tools)



Reference: Cumulative number of ENE-FARM systems sold of manufacturers in Japan (Source: Statista, 2023)

Task 34 – Mobile Applications (Lead ANL)

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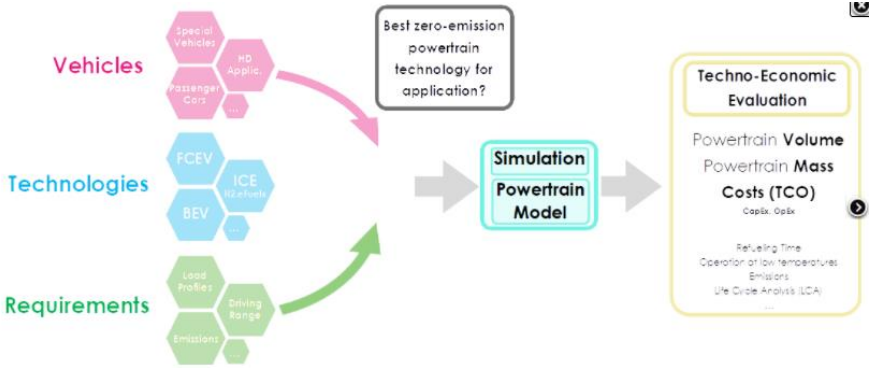
Key messages of Task 34:

- **Fuel Cell Technology:** Hybridization is viable for on-road and off-road applications with thermal management limitations. Examples include a 75-kW FCS with a 77-kWh ESS replacing a 185-kW diesel engine for Class-6 trucks, and a 175-kW FCS with a 183-kWh ESS replacing a 363-kW diesel for Class-8 long haul trucks
- **FCS Performance:** Hybrid FCS platforms improve fuel economy relative to diesel engines based on LHV. Improvement exceeds 200% for Class-6 trucks and reaches 12% for Class-8 long haul trucks
- **Stack Lifetime:** Concepts evaluated for 25,000-h lifetime and 2.5 kW/gPGM PGM utilization include oversizing, catalyst morphology, overloading, voltage clipping, and load sharing
- **H2 Storage:** Liquid hydrogen (LH2) storage considered for heavy-duty applications like Class-8 trucks, agriculture, construction, and mining. Initial results show LH2 storage systems exceeding 20 wt.% gravimetric capacity and 40 g/L volumetric capacity at cost below $6/kWh
- **H2 Production:** USDOE launched Hydrogen Shot initiative “1 1 1” to produce clean H2 at $1/kg in 1 decade. Germany announced AquaVentus initiative to produce 1 MMT of green H2 from 10 GW off-shore wind farm by 2035 at €2/kg-H2

Activities of HyCent-A:

- Development of recommendations and guidelines regarding the modularity of fuel cell systems for transportation applications
- Evaluation of different scenarios for the use of mobile fuel cells in vehicles, ships, and aircraft (including economic analyses)



Reference: https://nachhaltigwirtschaften.at/de/iea/technologieprogramme/afc/iea-afc-annex-34-arbeitsperiode-2022-2025.php

Summary and Outlook

- Global fuel cell shipments have exceeded 80 MW in recent years, with around 50 MW for stationary applications and the rest mainly for mobile use.
- The primary fuel cell systems are PEFC and SOFC, while other types like MCFC, DMFC, AFC, and PAFC have not succeeded commercially.
- Main activities are concentrated in Asian countries (Japan, China, Korea) and the USA, with Europe catching up in the last few years.
- Increased hydrogen efforts in Austria and Europe have led to focused fuel cell advancements in sectors like trucks and backup power, however the central focus of hydrogen is led to hard-to-abate sectors such as heavy industry and aviation (and presently not to fuel cells).
- The AFC TCP includes key players in the fuel cell industry worldwide. The Austrian institutions (TU-Graz, HyCent A, AEA) are involved and successfully contribute to the PEFC task, the stationary task, and the mobile applications task.

Ihr Ansprechpartner

Guenter Simader[Dipl.-Ing. Dr.]

Head of Division

IEA AFC Website: https://www.ieafuelcell.com/

Nachhaltig Wirtschaften: https://nachhaltigwirtschaften.at/de/iea/technologieprogramme/afc/

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