

Umicore products and services for the global Hydrogen & Fuel Cell economy

November 2021



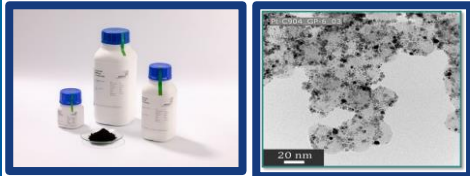
Umicore Fuel Cell Catalysts

Umicore is selling Fuel Cell Catalyst Powders for PEM-Fuel Cells and PEM-Electrolyzers
 Umicore is offering End of Life & production scrap recycling solutions to close the PGM loop



Functional materials catalyzing the electrochemical reactions in PEM Fuel Cells and PEM Electrolyzer Anode and Cathode Electrodes:

- Pt and Pt/Co Alloy Nanoparticles on Carbon Black support
- Supported Iridium Oxide – IrO₂ on oxidic support
- PGM containing products w/ high PGM contents (high double digit wt.-% range)



Umicore Fuel Cell Catalysts

Global presence and integrated product and service portfolio...

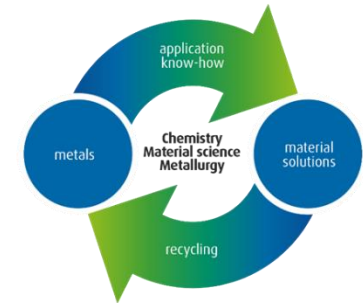
Research and
Product Development
since more than 30 years



Global presence and
production footprint



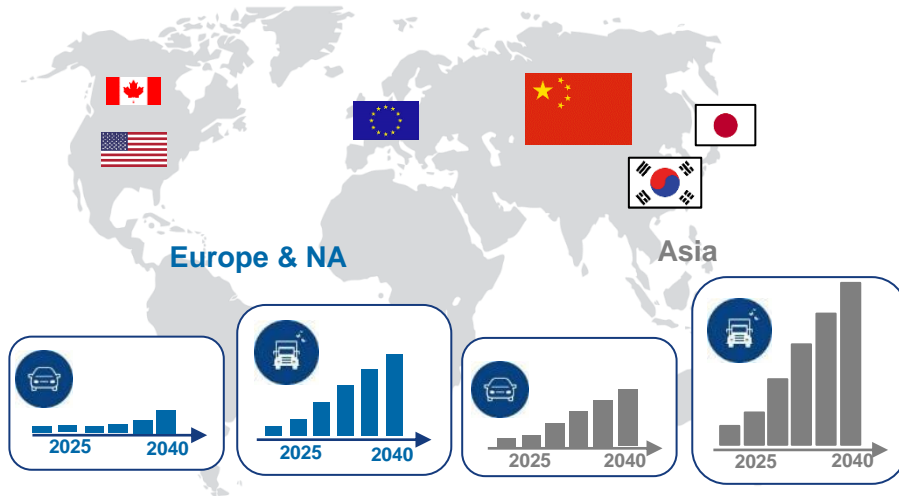
Closed loop
Business model



- Over 30 years more than 250 fuel cell patents filed around the world
- Qualified supplier of more than 10 OEMs across regions: car and truck OEMs as well as stack producers and system manufacturers - Considered benchmark catalyst materials by leading fuel cell & electrolyzer companies
- R&D and production capacity in Germany and Korea; mass production plant commissioned in Korea end 2019
- We are continuously investing in production capacity to cover the increasing global demand...

Automotive FC market will ramp up...

Massive Supply chain and OEM investments during this decade to reach mass production scale
 PEM Fuel Cell Catalyst market will reach three digits tons/a scale in 2030



Global H₂ policy initiatives and legislation

- Paris Agreement
- European Green Deal
- Hydrogen strategies
- Heavy Duty CO₂ & emission legislator

FC subsidy program framework

- Fuel Cell & Hydrogen City clusters nominated
- Subsidy scheme release + implementation in 2021

FC vehicle products & prototypes:

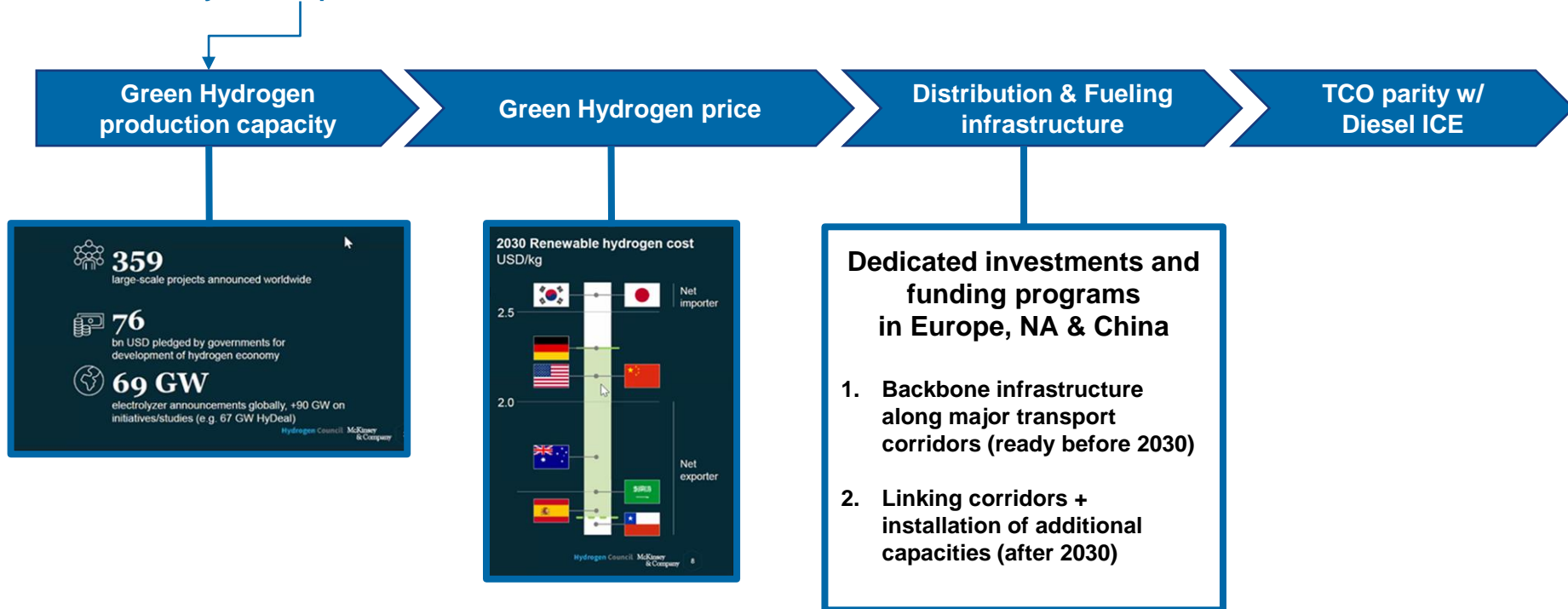


Pictures from OEM press releases + OEM web content sources

Fueling the broad FC vehicle deployment...

- 2030 (GREEN) H₂ production costs must reach necessary levels enabling TCO parity w/ Diesel engines
- Fast (GREEN) H₂ production capacity + fueling infrastructure installation mandatory for broad FC deployment → Mandatory multi billion investments in this decade...

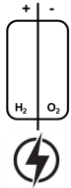
PEM Electrolyzers are part of the solution



Development trends & needs...



PEM Fuel Cell Drivetrains



PEM Electrolyzers

System cost reduction + PGM utilization improvement

- Supply chain maturation + economy of scales
- Continuous learning from fleet/field data...
- Minimizing Ir & Pt amounts/system during the next product development cycles...



Catalyst Technology Development

Process design + production technology Development



Recycling

Highest possible PGM recovery rates...

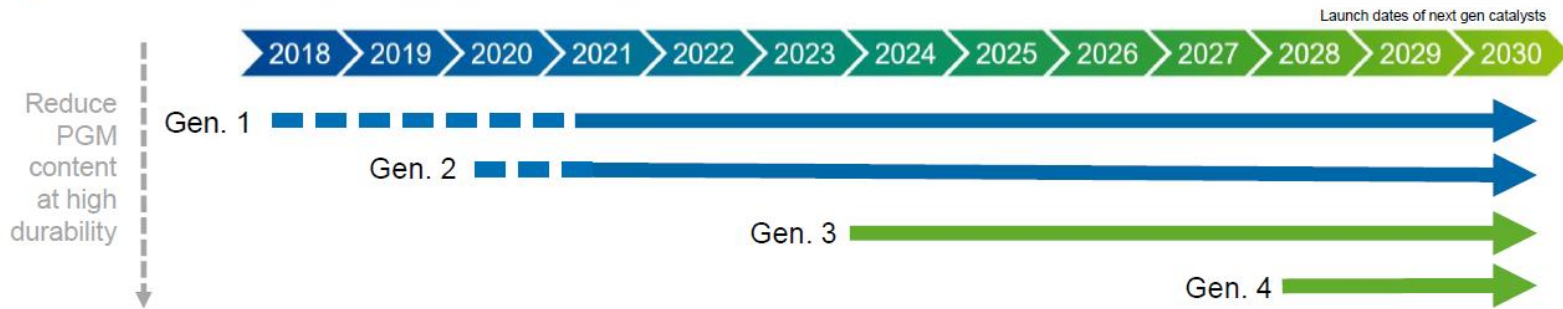
- Recycling Eco system installation for End of Life products
→ Highest possible return rates for used products



Recycling know-how, process design + engineering ...

Research & Development Roadmap...

Roadmap to reduce PGM loading and make fuel cell applications more cost competitive



Research network on fuel cells with key institutes in Europe, US and Korea

Open innovation with best-in-class academia and research institutes



Conclusion

- Umicore is offering a competitive catalyst portfolio for PEM Fuel Cells & Electrolyzers
- PEM Technology is ready to scale up – Umicore is and will be a reliable and strong partner & supplier for the industry
- Our contribution:
 - Reliable PGM handling and Catalyst production at industrial scale
 - Utilizing decades of experience as Automotive Industry supplier + existing global footprint
 - Helping to develop and install a closed loop PGM model for the industry
 - Ensuring continuous Catalyst property and production process improvements enabling higher PGM utilization and product cost reductions



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