THE HYDROGEN AND FUEL CELL CENTER

ZBT

Hydrogen technology, fuel cells and electrolysis

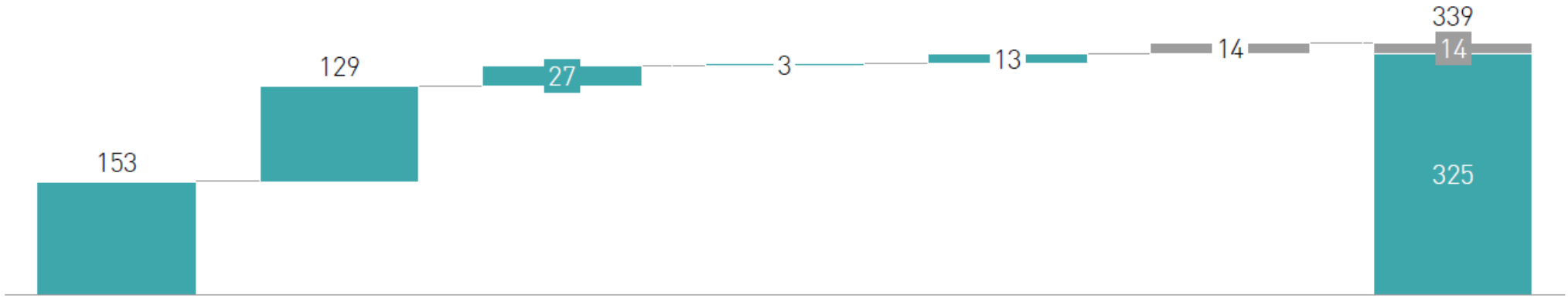
Technologies for a sustainable, climate friendly environment

Bernd Oberschachtsiek

Essen, May 2023

Hydrogen – Use of H_2 today

Total hydrogen use in the EU, in TWh



- Hydro-cracking
- Hydro-treating (e.g., fuel desulfuri-zation)
- Biorefinery

- Production of ammonia (for urea and other fertilizers)

- Production of methanol and derivatives

- Other chemicals (e.g., poly-mers, polyurethanes, fatty acids)

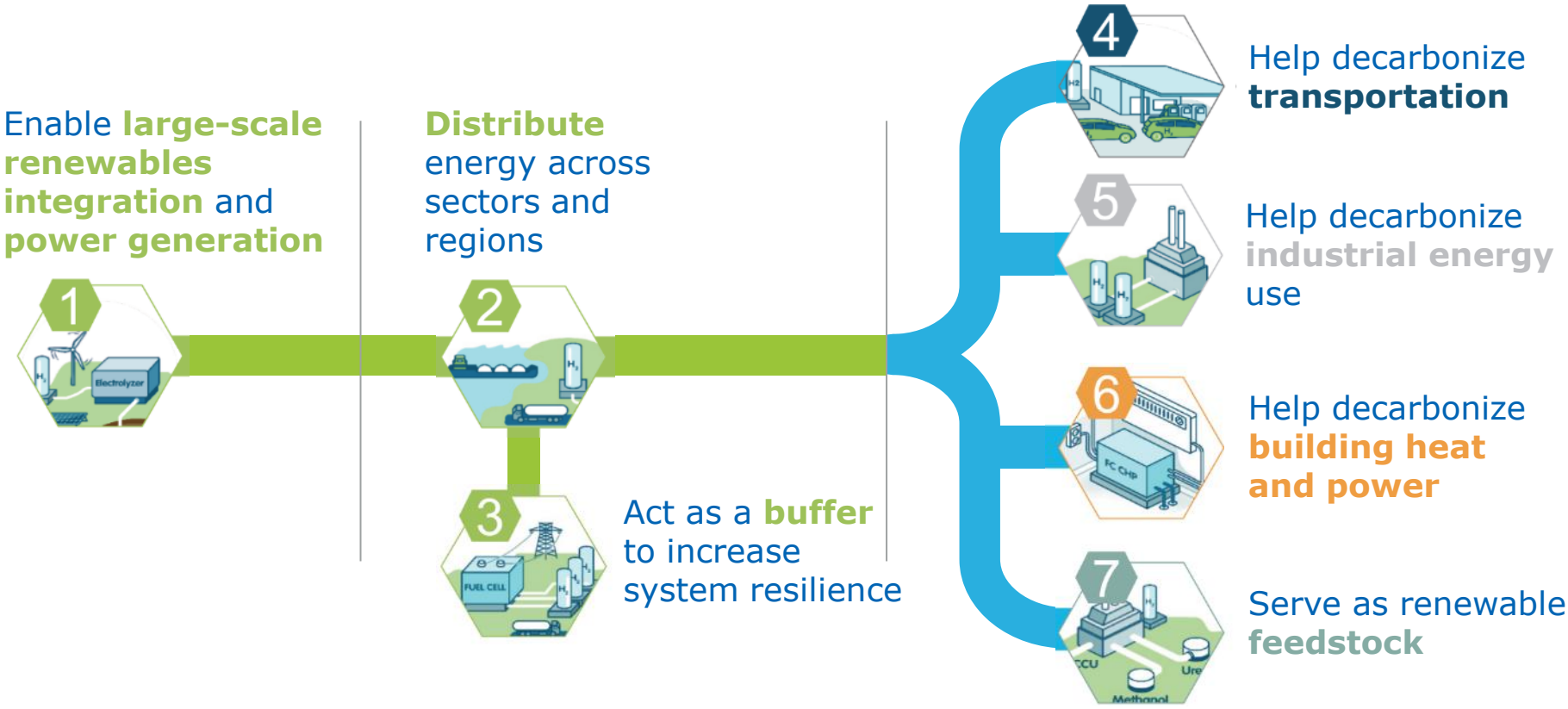
- Heat treating of steel
- Welding of metals
- Forming and blanketing gas
- Glass production

- Rocket fuel
- Automotive fuel
- Semi-conductor industry

1 Counted in transportation segment

(Why) Hydrogen – Technologies for a sustainable and eco-friendly world

ENABLE THE RENEWABLE ENERGY SYSTEM → DECARBONIZE END USES



Source: Hydrogen Council 2018

KEY FACTS

- Applied research and development: fuel cells, hydrogen and electrolyzer technology
- Focus on industry demand - Independent service provider and R&D partner
- GmbH/ltd. as daughter of University of Duisburg-Essen
- ~ 150 full time employees + ~30 student researchers
- Limited institutional funding by state of North-Rhine-Westphalia

UNIVERSITÄT DUISBURG ESSEN

Offen im Denken

EUROPEAN UNION
Investing in our Future
European Regional Development Fund

Ministerium für Wirtschaft, Industrie, Klimaschutz und Energie des Landes Nordrhein-Westfalen

Ministerium für Kultur und Wissenschaft des Landes Nordrhein-Westfalen

JRF MEMBER OF Johannes-Rau-Forschungsgemeinschaft

INFRASTRUCTURE

- 1.200 m² laboratory areas (chemical laboratories, reactor testing labs)
- High end media and material analytics
- 500 m² technical center / production technologies
- Modern CAE & Simulation tools
- ~ 1.000 m² hydrogen testfield

Laboratory 2023: HyTechLab4NRW

EUROPÄISCHE UNION
Investition in unsere Zukunft
Europäischer Fonds
für regionale Entwicklung

EFRE.NRW
Investitionen in Wachstum
und Beschäftigung

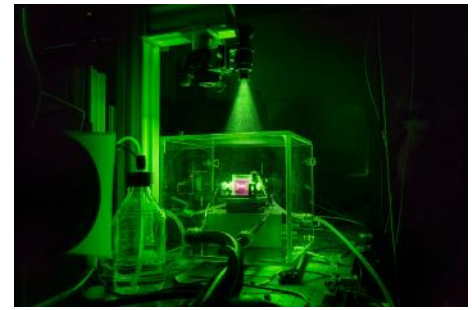
ZBT – The hydrogen and fuel cell center

Fuel Cells Hydrogen Electrolysis

… application oriented:

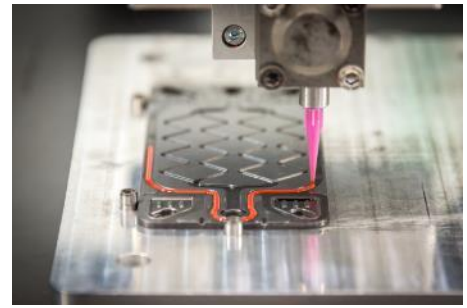
- Research
- Development
- Demonstration
- Transfer







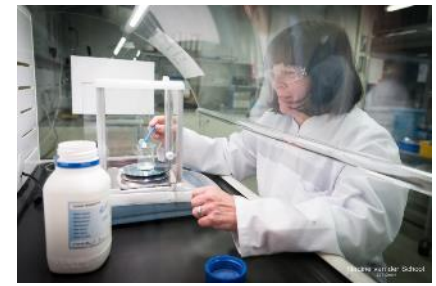





ZBT – The hydrogen and fuel cell center

… skills:

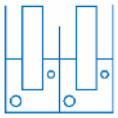
- Component and product design
- Analytics and quality testing
- Component testing and controls
- Production technologies



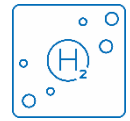



Our portfolio



Electrolysis

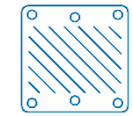
- Proton Exchange Membrane (PEM)
- Anion Exchange Membrane (PEM)
- ✓ Component development
- ✓ Cell development
- ✓ Small scale test cells and stacks
- ✓ Material & component characterization
- ✓ Stack testing



Hydrogen technologies

- CHG infrastructure
- ✓ Hydrogen distribution
- ✓ Hydrogen refueling
- ✓ Hydrogen quality

- Green ammonia synthesis, cracking and systems
- SNG synthesis and reforming
- ✓ Material characterization
- ✓ Reactor design
- ✓ System development
- ✓ Testing



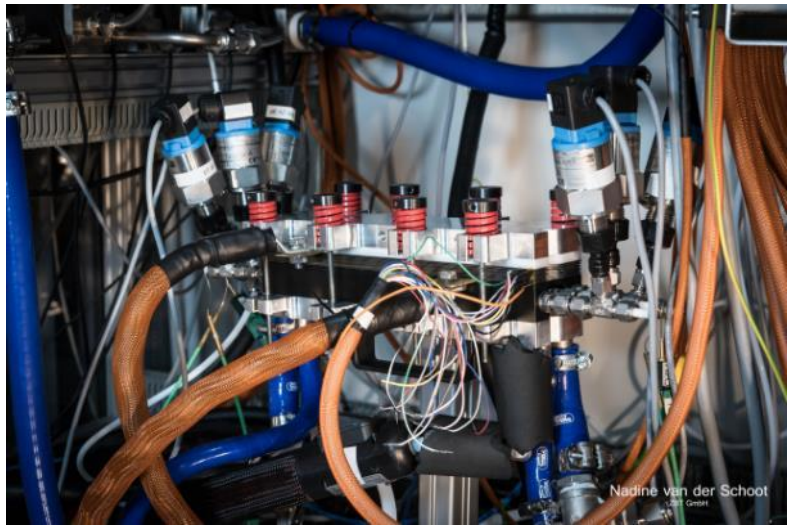
Fuel cells

- Proton Exchange Membrane (PEM)
- ✓ Component development
- ✓ Cell development
- ✓ Stack development
- ✓ Production technologies
- ✓ Material characterization
- ✓ Material validation

Development of test stations

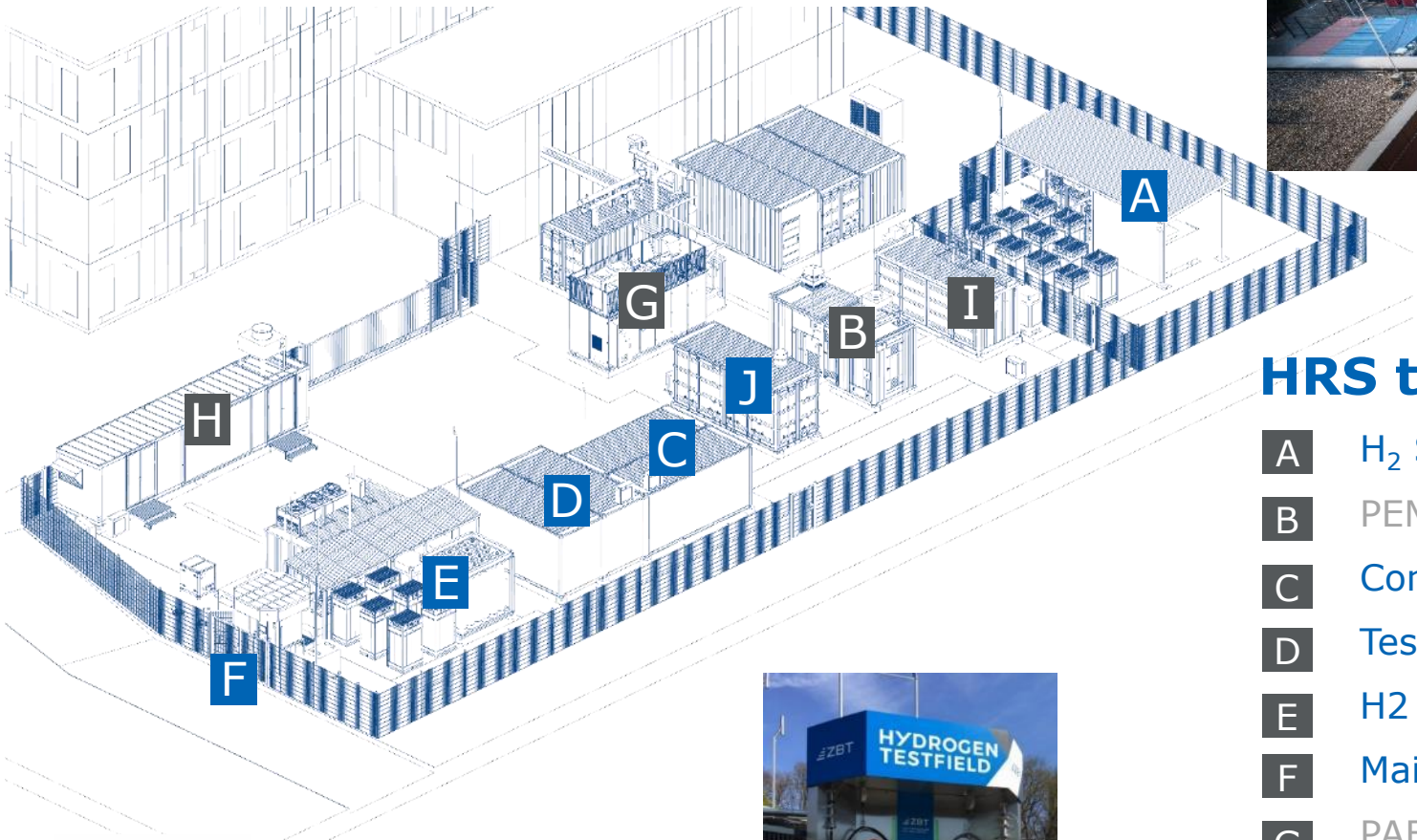
Electrolysis

Fuel Cells



HYDROGEN TESTFIELD

ZBT



HRS test station

- A H_2 Storage (200 bar)
- B PEM-Electrolyser (10 m³/h)
- C Control Room
- D Test Room
- E H2 Storage (480, 500 & 900 bar)
- F Main Dispenser (350, 500 & 700 bar)
- G PAFC (100 kW)
- H Direct Air Capture
- I Methanation (10 kW)
- J Electro-chemical compressor (tbb)

Gefördert durch: Bundesministerium für Bildung und Forschung; Gefördert durch: Bundesministerium für Verkehr und digitale Infrastruktur; Koordiniert durch: NOW; Gefördert durch: Bundesministerium für Wirtschaft und Energie aufgrund eines Beschlusses des Deutschen Bundestages

EFRE.NRW Investitionen in Wachstum und Beschäftigung

EUROPÄISCHE UNION Investition in unsere Zukunft Europäischer Fonds für regionale Entwicklung

Source: ZBT

Selected projects

Hydrogen refuelling for heavy duty application

PRHYDE - Protocol for heavy duty hydrogen refuelling

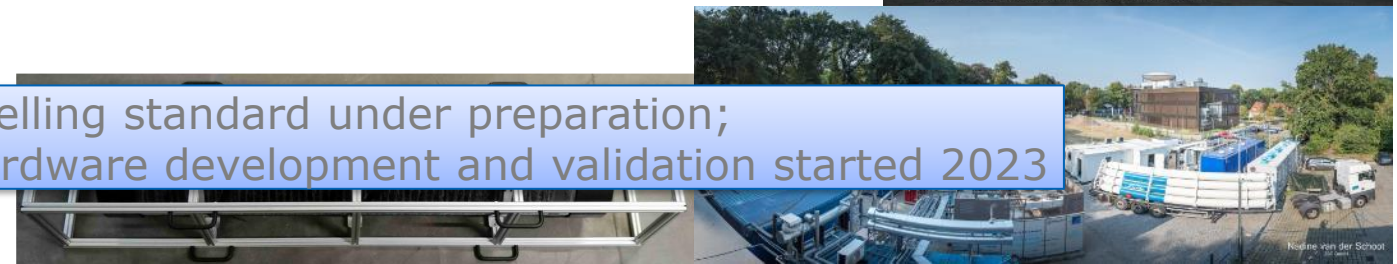
- Jan 20 / 3 years / H2020 / grant agreement No 874997
- Goals:
  - Determine relevant requirements for HDV fuelling
  - Determine limitations and gaps of current fuelling hardware capability (for HDV)
  - Develop concept(s) for HDV fuelling protocol(s)
  - Validate the impact of HDV fuelling protocol(s) concept(s) on achieving key metrics (temperature and pressure) on the vehicle side **through experimental validations on fuelling of tank(s) at station(s).**
  - Formulate recommendations for HDV fuelling protocol(s) for use in relevant standardization forums –with the aim of a globalized **standardization**.

Programme co-funded by the EUROPEAN UNION

PRHYDE
Protocol for heavy-duty Hydrogen refuelling

ludwig bölkow systemtechnik

Air Liquide · cea · ENGIE Lab CRIGEN · ITM POWER · MAN · nel · NIKOLA · TOYOTA · ZBT



Impact: European truck refuelling standard under preparation;
Follow-up project for HRS hardware development and validation started 2023

Hy-Lab

Impact: today > 50 HRS qualified by ZBT in Europe

Development of two independed laboratories for H2 quality measurement according to international standards

Partner: ZBT (coordination), ZSW & CEP (ass.)

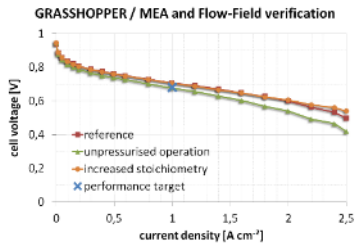
- Analysis of hydrogen quality according to ISO 14687
- Optimization of the actual sampling method
- Analysis of hydrogen from different sources (HRS etc.)
- Support of normative activities in Germany and EU

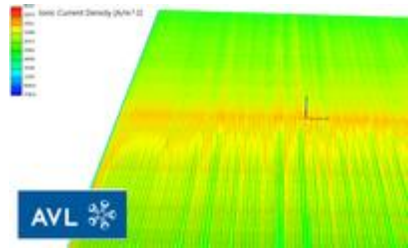
Goal: ZBT future independed partner for the hydrogen quality management at HRS

Stationary Stack Development GRASSHOPPER (EU H2020)

(GRid ASsiSting modular HydrOgen Pem PowER plant)

- FCH-02-07-2017: Development of flexible large fuel cell power plants for grid support
- Start / duration: Begin 2018 / 4 years
- Goals:
  - create a cost effective, flexible, MW-size FCPP unit
  - implementing newly developed stacks and MEA's
  - New control concept for grid stabilisation capability
  - Using by-product hydrogen from chlorine production
  - Installation at the AkzoNobel site in Delfzijl, the Netherlands.





www.grasshopperproject.eu

Impact: IPCEI project on stack production by NEDSTACK, European production plant in preparation

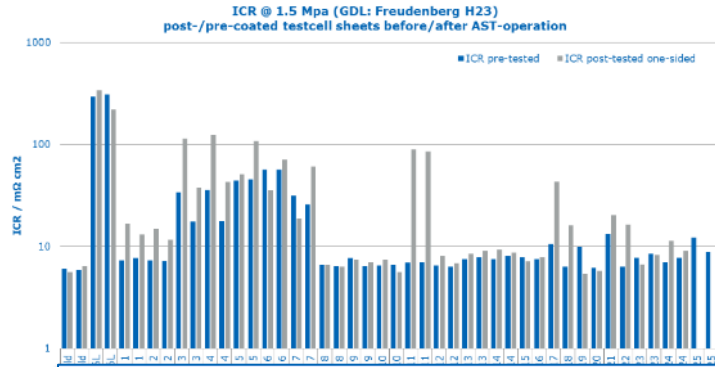
Standardized contact resistance measurement
ZBT reference project BePPel

BePPel: Development of standardized measurements for physical parameters of bipolar plates

- Electric contact resistance and conductivity
- Thermal conductivity
- Mechanical properties

Partners:

- DLR-Institut Vernetzte Energiesysteme
- Fraunhofer ISE
- Fraunhofer ICT
- FZJ IEK
- ZSW
- ZBT



Bundesministerium für Verkehr und digitale Infrastruktur

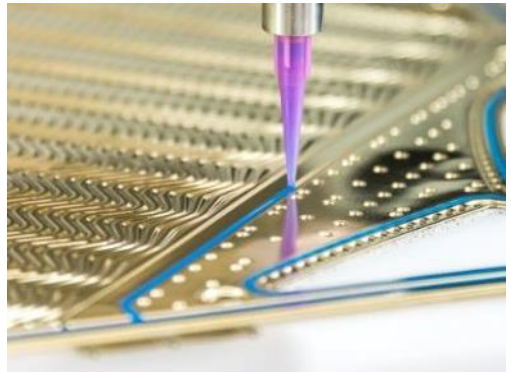
Duration:

01.04.2017 – 31.03.2020

Impact: ~ 1000 materials by commercial and scientific partners qualified
Standard test equipment sold to >4 commercial customers
German standard in preparation

References ZBT sealing solutions:
Sealing development for the German Aerospace Center DLR

- Design development support for a dispenser optimized bipolar plate design
- Integrated, very compact sealing contour design:
  - Optimized stack power density
  - Prevention of liquid water accumulation around the media ports
  - Optimized compression force distribution active area/seals
- Sealing application process development and production of initial samples for stack evaluation
- Sealing application on > 1.000 BPP



Impact: ~ 20.000 plates sealed for different customers
Production licensed to 2 commercial companies

"Thanks for the great cooperation – especially for the technical support regarding the design of the seals for our bipolar plates and the sealing application. We would be glad to work together again in future projects"

T. Knöri (DLR)

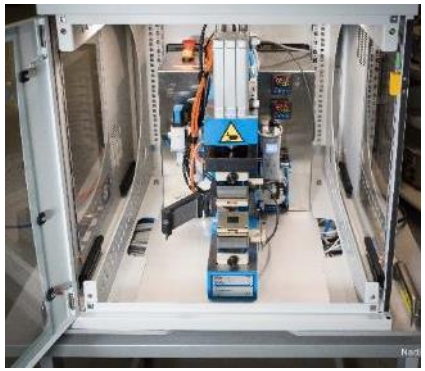
Sources: DLR: DLR PEM fuel cell stacks, DLR cargo bikes; ZBT: Dispenser based sealing application

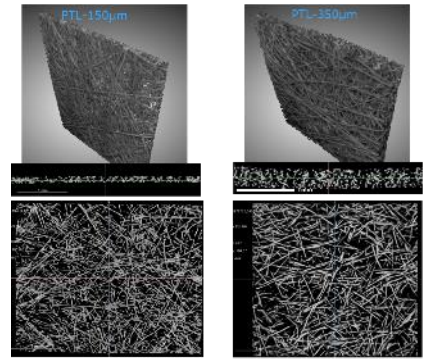
H2Giga PEP.IN
Sub project ZBT: Method development for quality assurance in series production

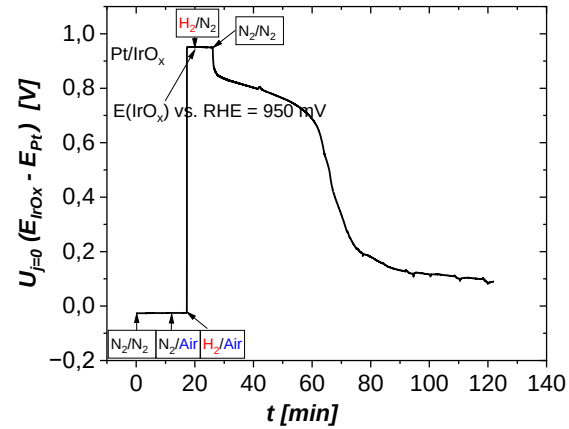
- Investigation / identification of possible measurement methods for quality assurance
- Proving of identified methods
- Definition of limits for quality control
- Validation of quality criteria

Leitprojekt H_2Giga

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung







Partners: MAN Energy Solutions SE, H-TEC SYSTEMS GmbH, AUDI AG, VAF GmbH, Fraunhofer Gesellschaft, FZ Jülich GmbH

EFRE.NRW: BipolarPilot
Set up a pilot plant for coating of bipolar plates for fuel cells

Funding: EFRE - 0500144

Project duration: 01.06.2021 – 31.03.2023

- Scale-up of coating system for metallic bipolar plates
- Design and evaluation of process scale-up series production
- Optimization of coating layer
- Characterization of prepared layers concerning corrosion stability and electrical conductivity

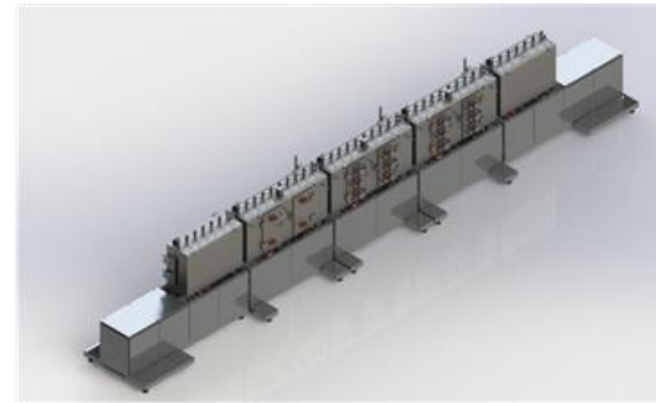


Abb. 1: Scale-up from Lab to pilot plant

Die Landesregierung Nordrhein-Westfalen

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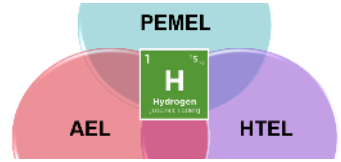
European Regional Development Fund

Leitmarkt Agentur.NRW

EFRE.NRW
Investitionen in Wachstum und Beschäftigung

H_2Giga - QT 2.1: Degrad-El3



Ki-gestützte Lebensdauervorhersage für PEM-Elektrolyse

Artificial neural network based life-time prediction for PEM-Electrolysis

- Stack testing – Data generation
- Analysis of degradation trends
- Machine learning - Supervised learning

Leitprojekt H_2Giga

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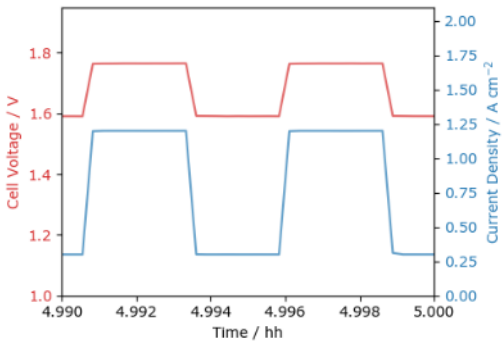

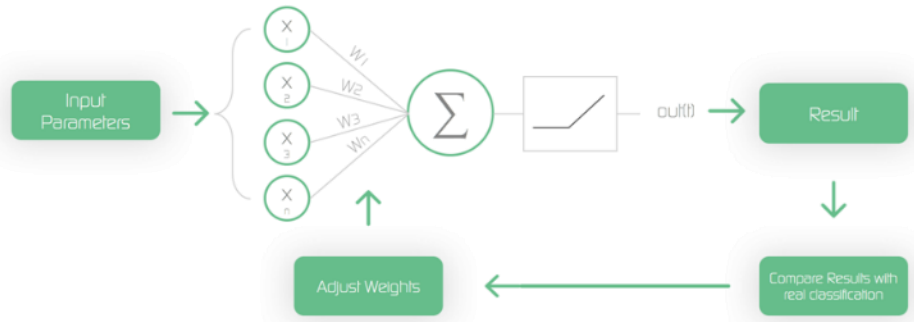

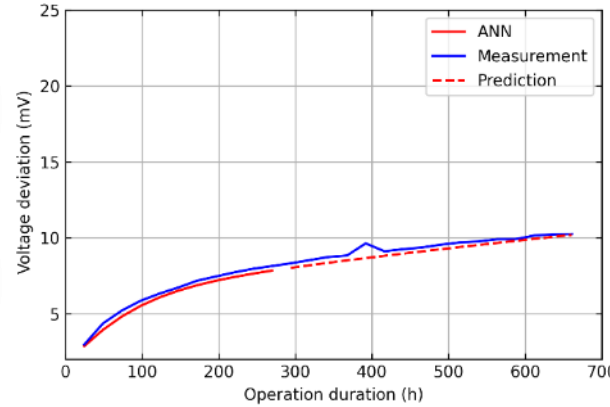

THE HYDROGEN AND FUEL CELL CENTER

Research, development, service

Zentrum für BrennstoffzellenTechnik GmbH
Carl-Benz-Straße 201 / D-47057 Duisburg

Bernd Oberschachtsiek
+49 203 7598 4280 – b.oberschachtsiek@zbt.de
WWW.ZBT.DE

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