



# 6th International Workshop on Hydrogen Infrastructure and Transportation

## Development of an optimized sampling device for 700 bar HRS

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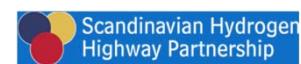
**Boston, 11.-12.09.2018**



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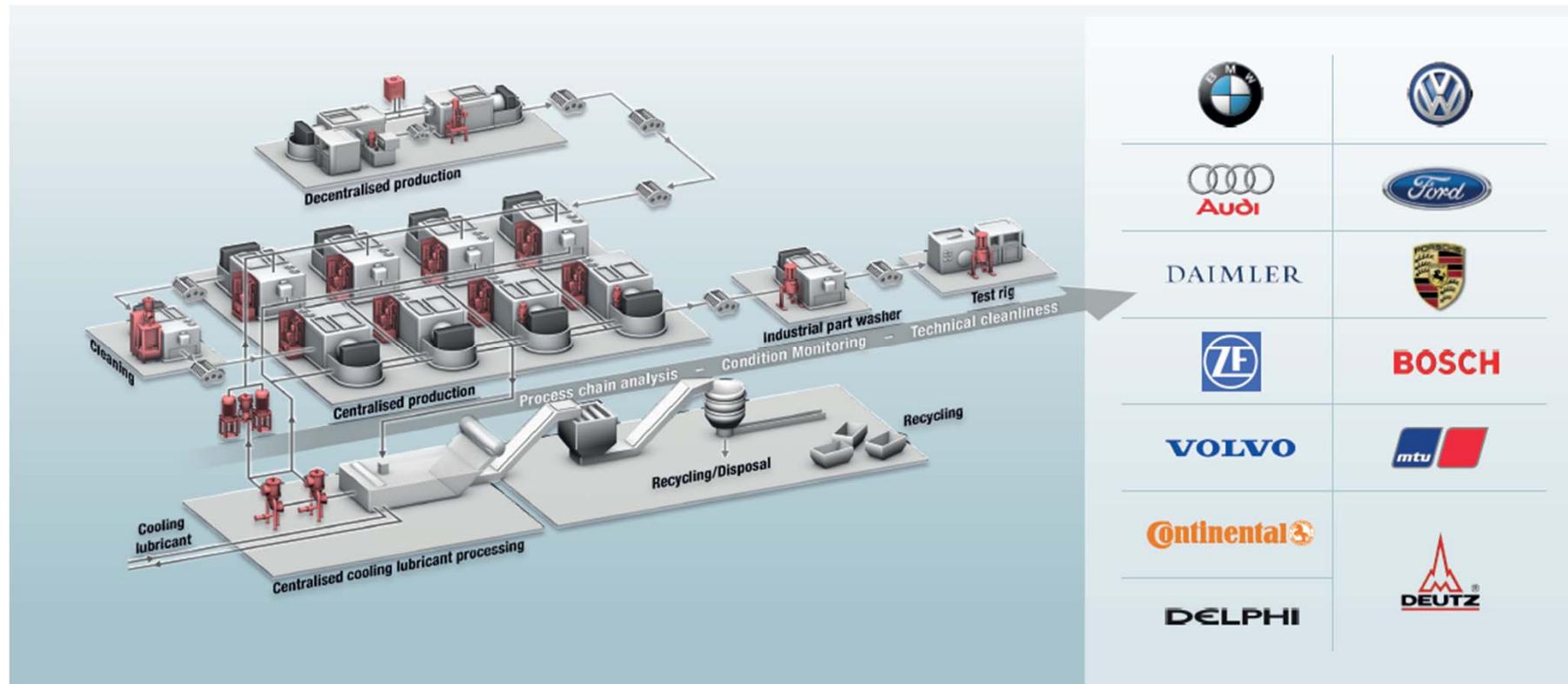
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# Particle Sampling Adapter

## Technical cleanliness - Background



# Particle Sampling Adapter

## History of development HYDAC PSA-H70



- Identified multiple problems with fuel cells and tank systems in F-Cell vehicles  
→ assumption particle contamination
- Specification of a test cell to verify the technical cleanliness of the hydrogen gas at 700 bar hydrogen refueling stations
- Development of the PSA-H70 by HYDAC Accessoires

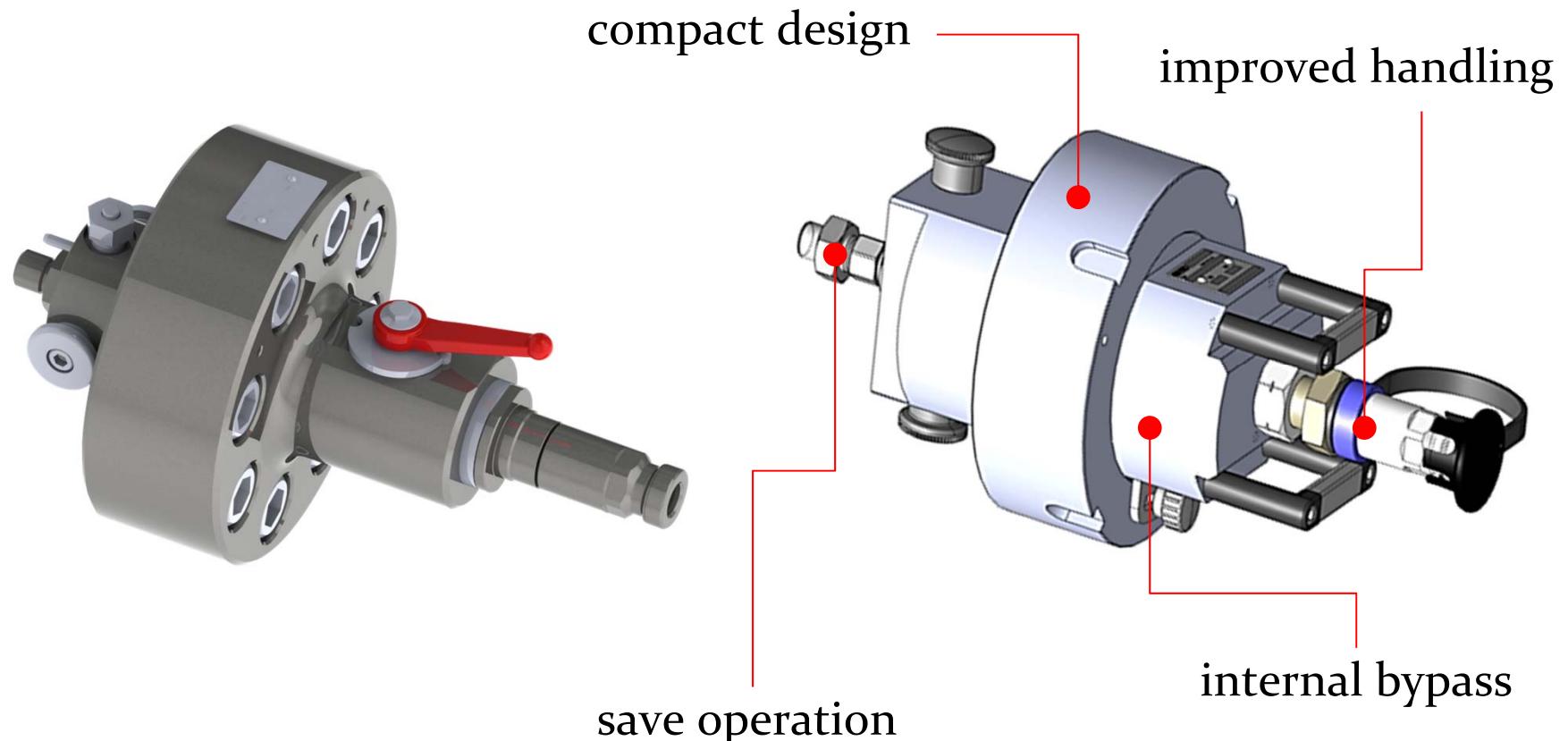
# Particle Sampling Adapter

HYDAC PSA-H70 hands on



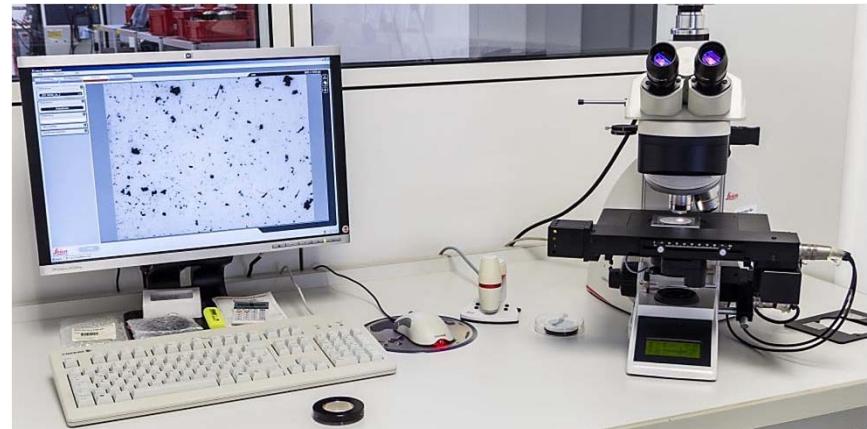
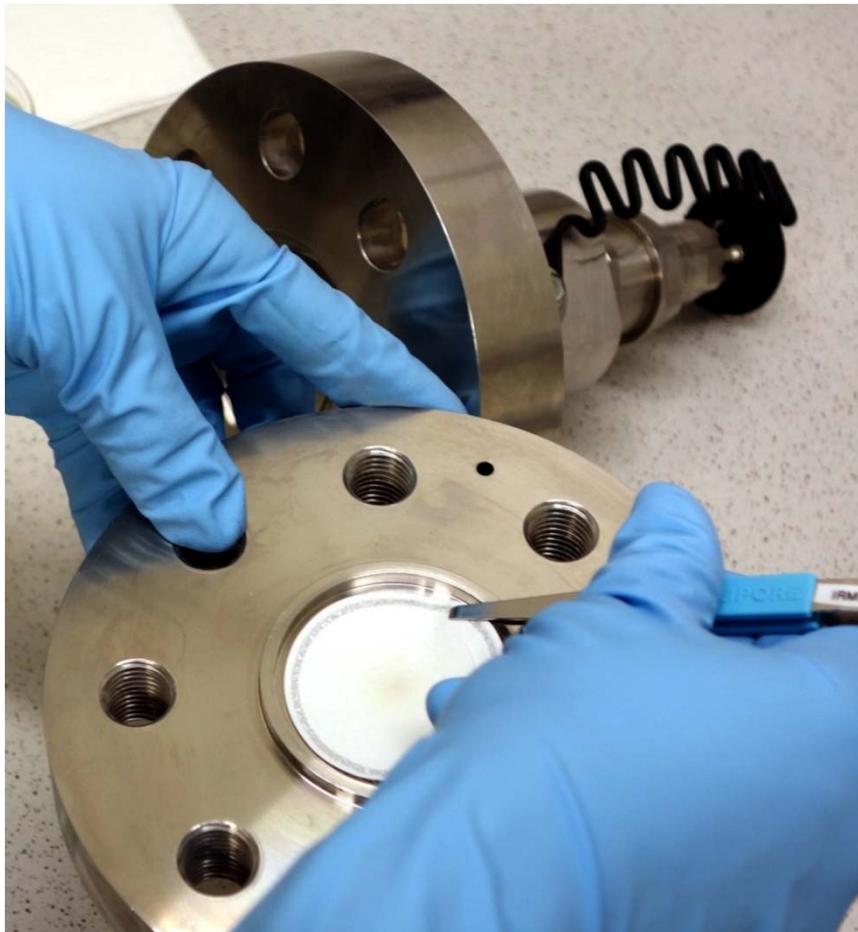
# Particle Sampling Adapter

HYDAC PSA-H70 – NEW Version



# Particle Sampling Adapter

HYDAC PSA-H70 hands on



# Particle Sampling Adapter

## HYDAC PSA-H70 sampling results

Particle size categories [µm]	Avarage amount of particles non reflecting	Avarage amount of particles reflecting
>1000	0,19	0,13
600 - 1000	0,38	0,25
400 - 600	1,44	0,88
200 - 400	24,25	8,44
150 - 200	25,81	4,94
100 - 150	72,25	10,75
50 - 100	315,56	32,56
25 - 50	766,63	40,63
Contamination min.	0,17mg/kg	
Contamination max.	3,53mg/kg	
Contamination average	0,847mg/kg	

# Particle Sampling Adapter

## Technical cleanliness \_ Background

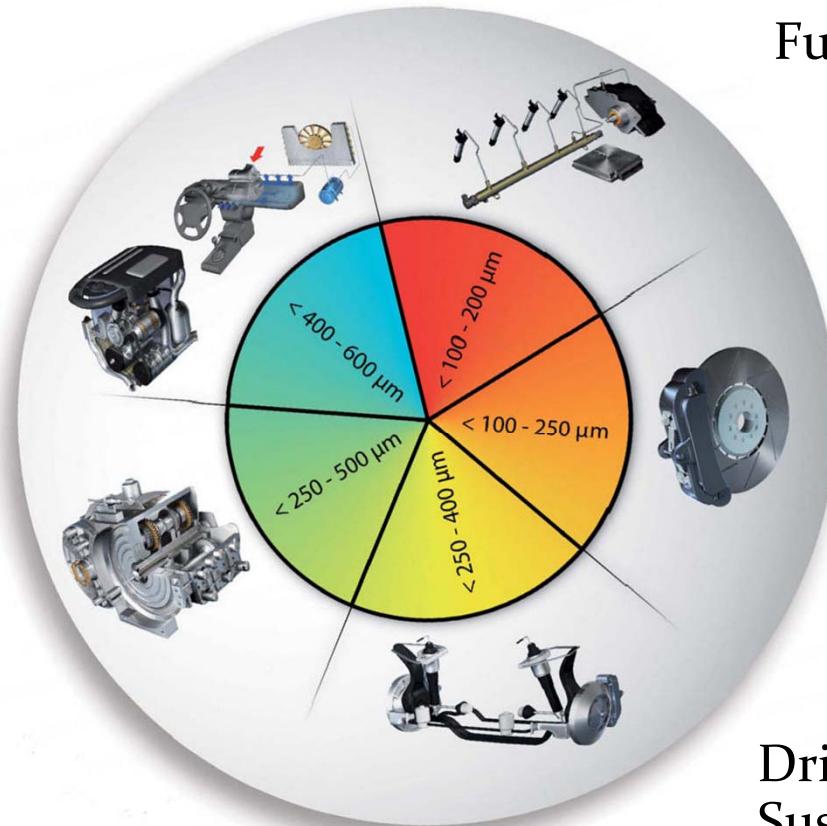
Engine,  
Steering and  
Air Conditioning  
Systems

Transmissions

Fuel Systems

Braking  
Systems

Drive and  
Suspension Systems



# Product Overview

## Hydrogen Refueling Stations and Fuel Cell EV's



# Hy-Lab – project

Setup of two independend H<sub>2</sub> quality labs



- Partner:
  - The hydrogen and fuel cell center (ZBT)
  - ZSW
  - CEP (ass.)



- Analytic methods for measuring the H<sub>2</sub> quality according to ISO 14687
- Optimization of the actual sampling method
- Inter-comparison on gas sample analysis with other laboratories
- Analysis of hydrogen from different sources (CEP-HRS etc.)
- Concept on FC based online sensor
- Support of normative activities in Germany and EU



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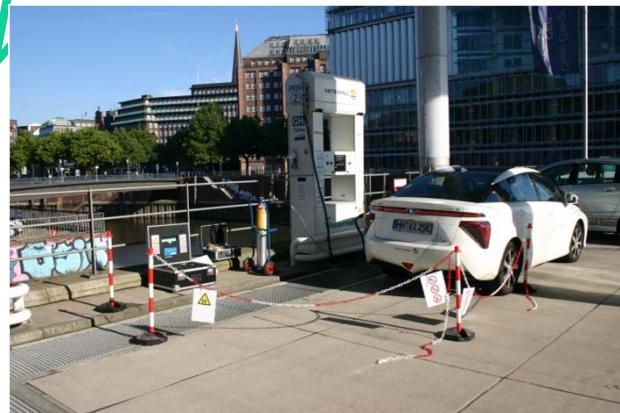
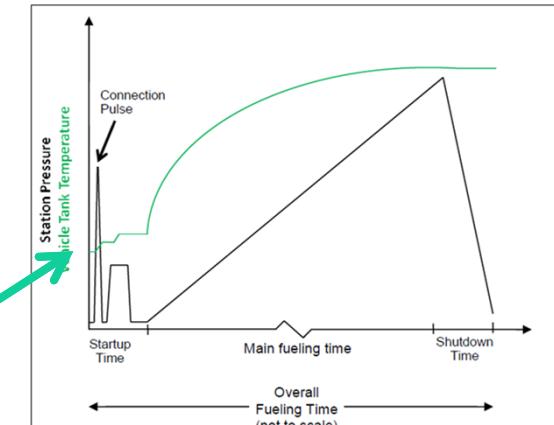
# Hy-Lab

## Sampling according to ISO 19880-1

Method	Sampling time	HRS fuelling override	Sink	Sample cylinder volume	Reference sample pressure
parallel	~ 3 min	no	FCEV	≤ 10 l	< 16 MPa
Serial	< 1 min/cylinder	yes	Venting	≤ 2 l	< 7 MPa
Direct	< 10 min	yes	Venting	47 l	< 12 MPa
Particulate	~ 3 min	yes/no*	FCEV	-	APRR according to SAE J2601**

\* Sampling while fueling into a CHSS (instead of venting)

\*\* Representative fuel passing the filter should be between 2,5-4,5 kg of hydrogen



H2 Qualitzer



US



Japan

Sampling methods and instruments conform to "The High Pressure Gas Safety Act" in JAPAN

Sampling Apparatus for High Pressure Hydrogen

NEDO R&D project  
(HySUT, Iwatani)



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Pictures: ZBT, 2016; Idemitsu Kosan Co., Ltd., 2015; Smart Chemistry 2018

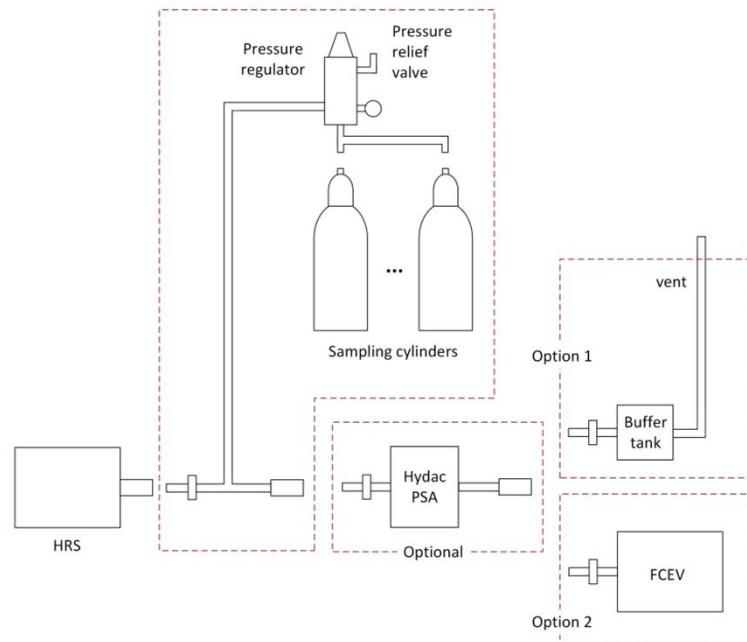


# Hy-Lab

## Hy-SaM sampling device (CE certified)

- No override of fueling protocol
- Option 1: No FCEV necessary
  - Venting of H<sub>2</sub> to HRS venting line (alternative: mobile venting system)
  - Buffer tank as sink
- Option 2: Using a FCEV as sink

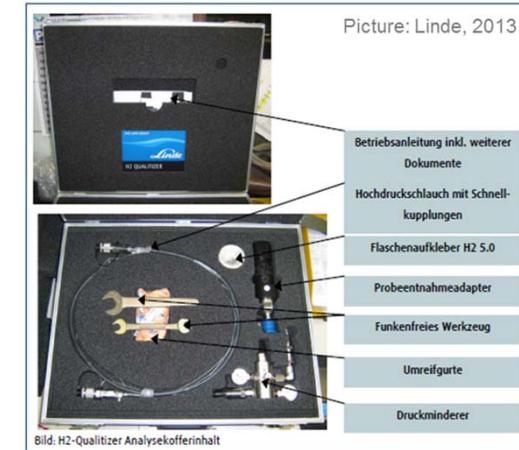
- Multiple sampling
- No COM interface, no electronics
- Coated parts and cylinders
- Sampling by one person
- General option:
  - Combination with downstream particulates sampling device (Hydac PSA)



# Hy-Lab

## HRS test campaign

- June 2018
- 17 HRS / 19 samples
- CEP limits
- Sampling with Linde H<sub>2</sub> Qualitizer
- Analysis at ZSW
- FCEV from ZBT/ZSW



Constituent	CEP limits	Analytics @ ZSW	
	µmol/mol	technique	determination limits
H2	> 99,7 %	-	
H2O	5	Capacitive sensor	1
Total HC	2	GC PDHID	0,2 (CH4)
O2	5	GC PDHID / Micro GC	0,1 / 1
He	300	Micro GC	1
N2	100	GC PDHID	2,4
CO2	2	GC PDHID	0,9
CO	0,2	GC PDHID	0,2

pulsed discharge helium ionization detector (PDID)

# Hy-Lab

## HRS test campaign

- Sample cylinders
  - 10 l aluminum bottles
  - pre-conditioned
  - Filled with 2 barg H<sub>2</sub> 6.0
- Purging during Sample procedure
  - Proof gas tightness and flushing of pressure reducer connection
  - Depressurization after sampling



Picture: Linde, 2013



# Hy-Lab

## HRS test campaign (results in ppm)

Constituents	HRS 1	HRS 2	HRS 3	HRS 4/I	HRS 5	HRS 6	HRS 7	HRS 8	HRS 4/II	HRS 9	HRS 10	HRS 11	HRS 12	HRS 13	HRS 14 *	HRS 15	HRS 16	HRS 17/I	HRS 17/II
H <sub>2</sub> supply	Delivery	GH2	GH2	GH2	GH2	LH2	GH2	GH2	GH2	GH2	GH2	GH2	GH2	LH2	GH2	GH2	GH2	GH2	
	Off-site Process	SMR	SMR	SMR	SMR	SMR	SMR	SMR	SMR	SMR	SMR	SMR	SMR	Biogas	SMR	SMR	SMR	SMR	
	Source	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	Biogas	NG	NG	NG	NG	
H <sub>2</sub> O	4	3	2	2	4	4	2	6	3	4	6	6	3	2	5	4	3	5	5
CH <sub>4</sub>	<0,2	<0,2	<0,2	<0,2	<0,2	<0,2	<0,2	<0,2	<0,2	<0,2	<0,2	<0,2	<0,2	<0,2	<0,2	<0,2	<0,2	<0,2	
O <sub>2</sub>	0,2	<b>1,27</b>	0,28	0,21	1,46	0,65	0,31	0,32	0,47	0,22	0,85	1,52	0,47	1,48	<b>5,56</b>	1,36	0,35	1,84	0,77
He	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	
Ar	<0,5	<0,5	0,7	0,7	<0,5	<0,5	<0,5	<0,5	0,8	<0,5	<0,5	<0,5	<0,5	0,6	<0,5	<0,5	<0,5	<0,5	
N <sub>2</sub>	<2,4	<b>6,4</b>	3,2	2,9	8,2	42,6	2,8	3,3	4,2	7,8	6,8	8,6	3,7	12,8	<b>22,9</b>	<b>94,8</b>	2,8	12,4	7,8
CO <sub>2</sub>	<0,6	<0,6	<0,6	<0,6	<0,6	<0,6	<0,6	<0,6	<0,6	<0,6	<0,6	<0,6	<0,6	<0,6	<0,6	<0,6	<0,6	<0,6	
CO	<0,2	<0,2	<0,2	<0,2	<0,2	<0,2	<0,2	<0,2	<0,2	<0,2	<0,2	<0,2	<0,2	<0,2	<0,2	<0,2	<0,2	<0,2	

0,75 x ISO limit < Xi < ISO limit

Xi > ISO limit

\* re-commissioning after being

out of service due to refueling of a car before

- Hydrogen contamination dominated by H<sub>2</sub>O, one violation of O<sub>2</sub> limit
- Two times possible air intake (corresponding O<sub>2</sub> and N<sub>2</sub> concentrations)
- Correlation between of impurities and H<sub>2</sub> supply chain not possible



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# Outlook

## Hydac PSA & Hy-Lab project

### PSA H70

- Flow-through filling of sample cylinders in combination with downstream particulates sampling device

### Hy-Lab project

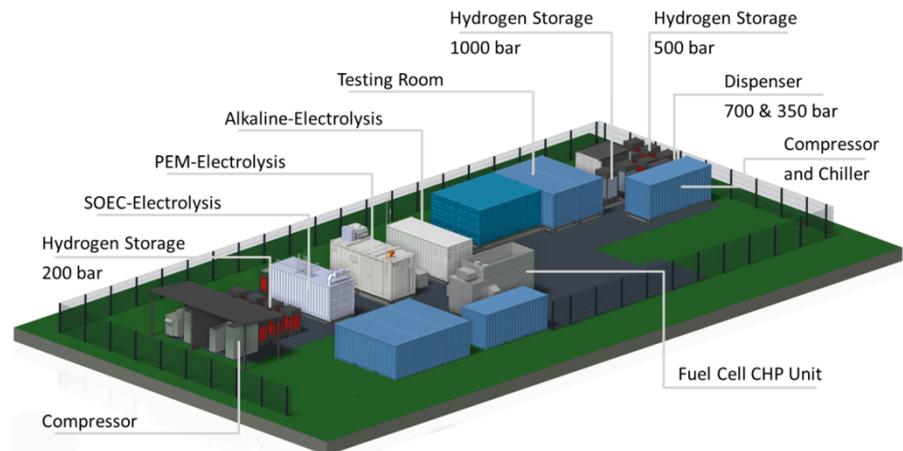
- H<sub>2</sub> quality labs at ZBT/ZSW online end of 2018
- Hy-SaM ready end of 2018
- Further test campaigns with full ISO scope in 2019
- Inter-comparison on gas sample analysis in 2019
- Further support of normative activities in Germany/EU

# Outlook

## Further H<sub>2</sub> infrastructure activities at ZBT

### Hydrogen test field

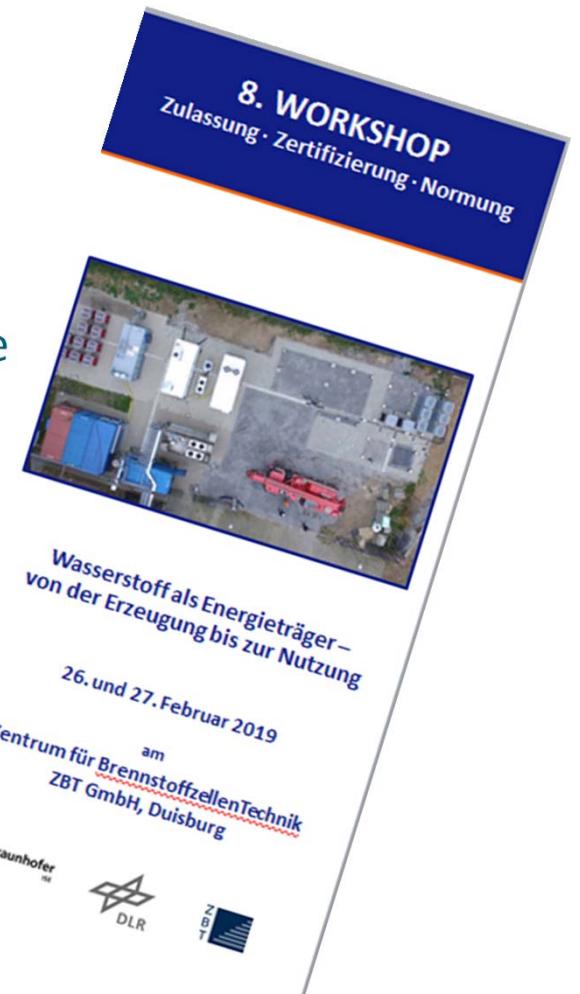
- PEM, AEM & SOEC electrolyzer
- Storage level 200, 500 & 1000 bar
- Capacity approx. 460 kg H<sub>2</sub>
- Piston compressor
- Dispenser (350, 500 & 700 bar)
- Test room with all pressure level
- Investigations
  - H<sub>2</sub> Quality & safety analysis
  - Maintenance
  - Efficiency & economics analysis
  - Environmental aspects
  - Future HRS (pressure levels, cooling etc.)



# Thank you!

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