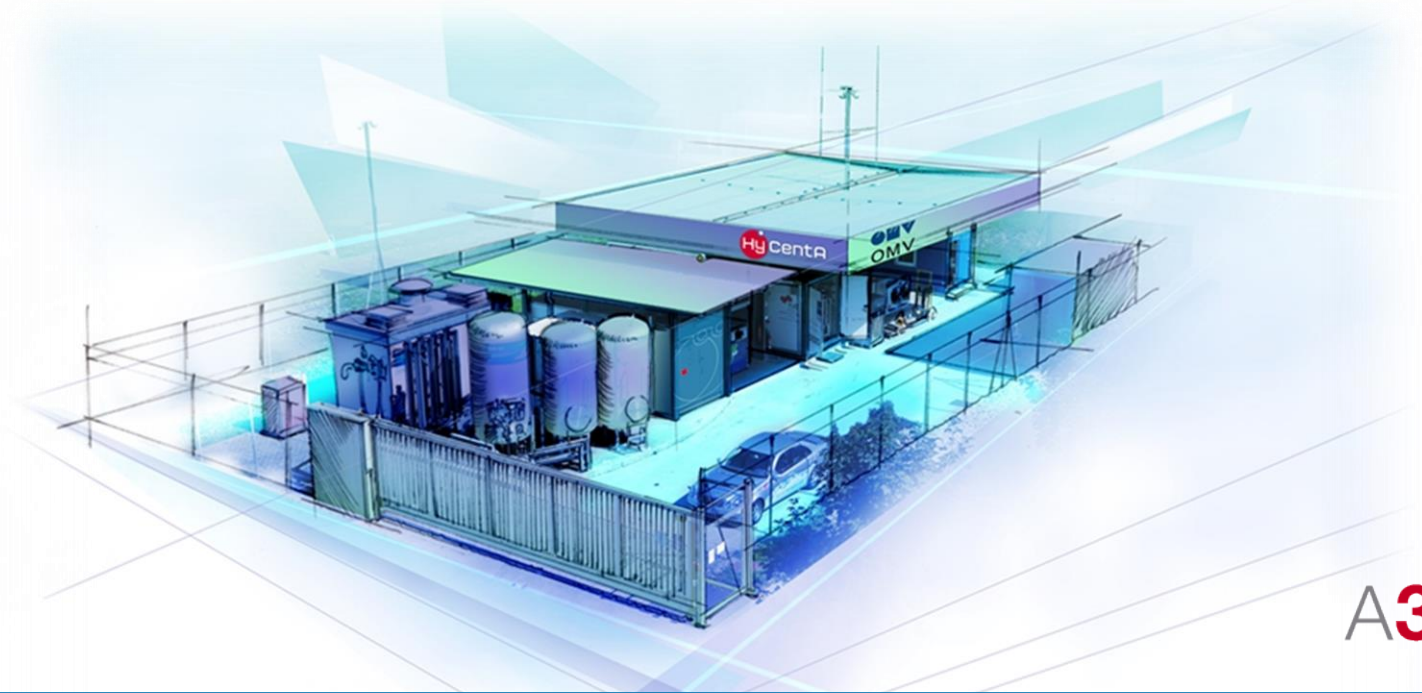

A3PS

FCH REFuel - MODULAR CONCEPT OF AN ON-SITE HYDROGEN PRODUCTION SOLUTION

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Vienna, November 2017

HyCentA HYDROGEN CENTER AUSTRIA · Fronius · SFL technologies · DB SCHENKER · OMV · BMW · bmvit · FFG

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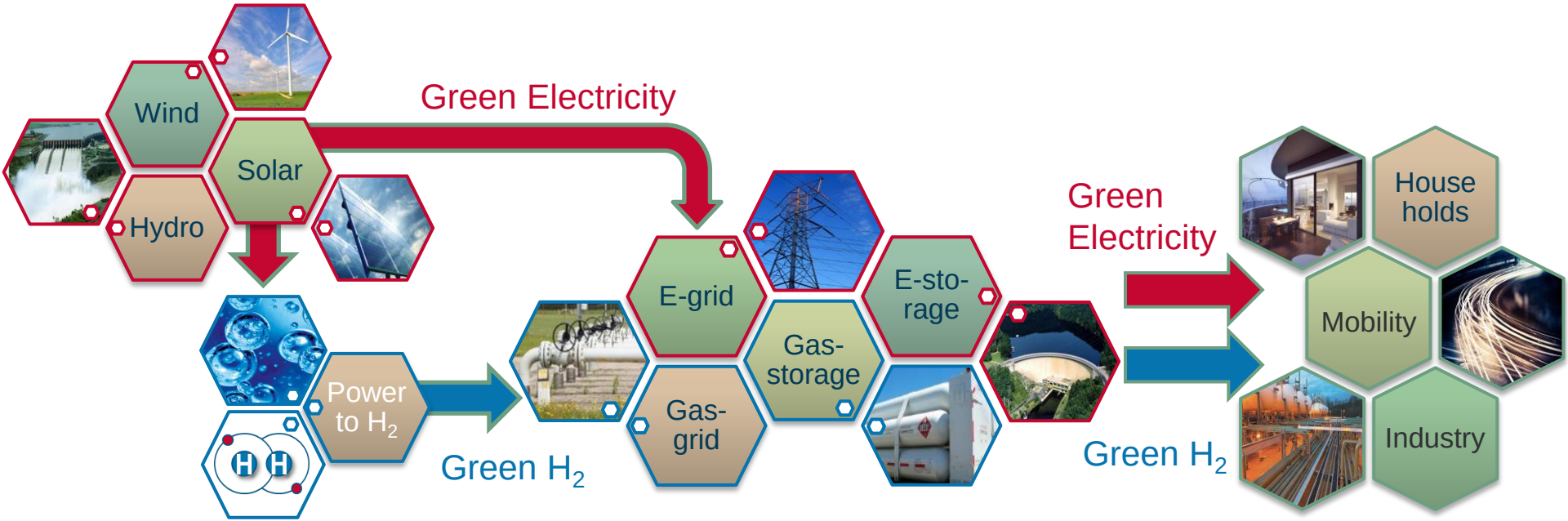
Introduction: Hydrogen a Clean Energy Carrier

Hydrogen is the key technology for increase of renewable energy production



Introduction: Hydrogen Refueling Stations

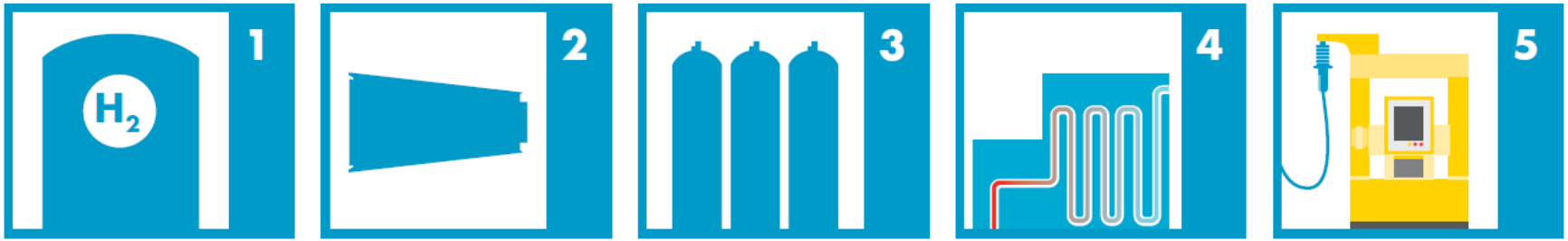
Status of HRS & FCEV's

- Around 270 stations in operation worldwide
- Approx. 3000 FCEV's

Introduction: Hydrogen Refueling Stations

Frequent Hydrogen Refueling Station (HRS) concept

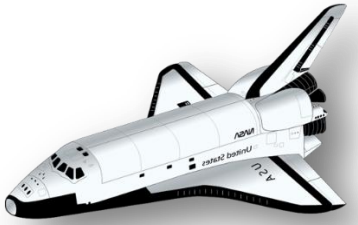
- Delivery of hydrogen to refueling stations
- Refueling at 70 MPa according to SAE J2601
- ~ 3 min to refuel a car with 5-6 kg; typical range of 600 km



Low Pressure Hydrogen Storage | Multi-stage Compression | High Pressure Storage | Hydrogen Pre-Cooling | Hydrogen Dispenser

Source: Shell, 2017

Introduction: FC = Zero-Emission Tank-to-Wheel







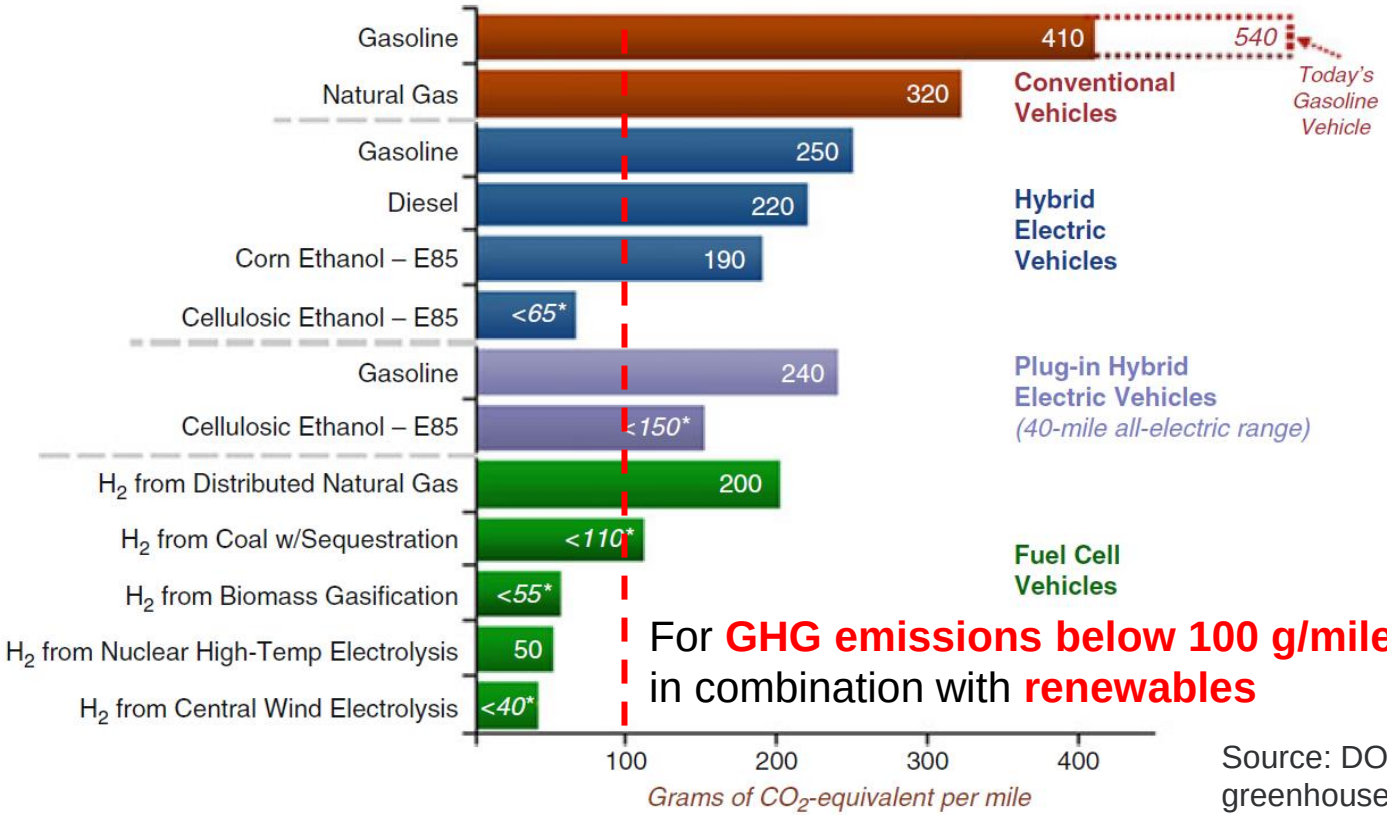

A technology of today!







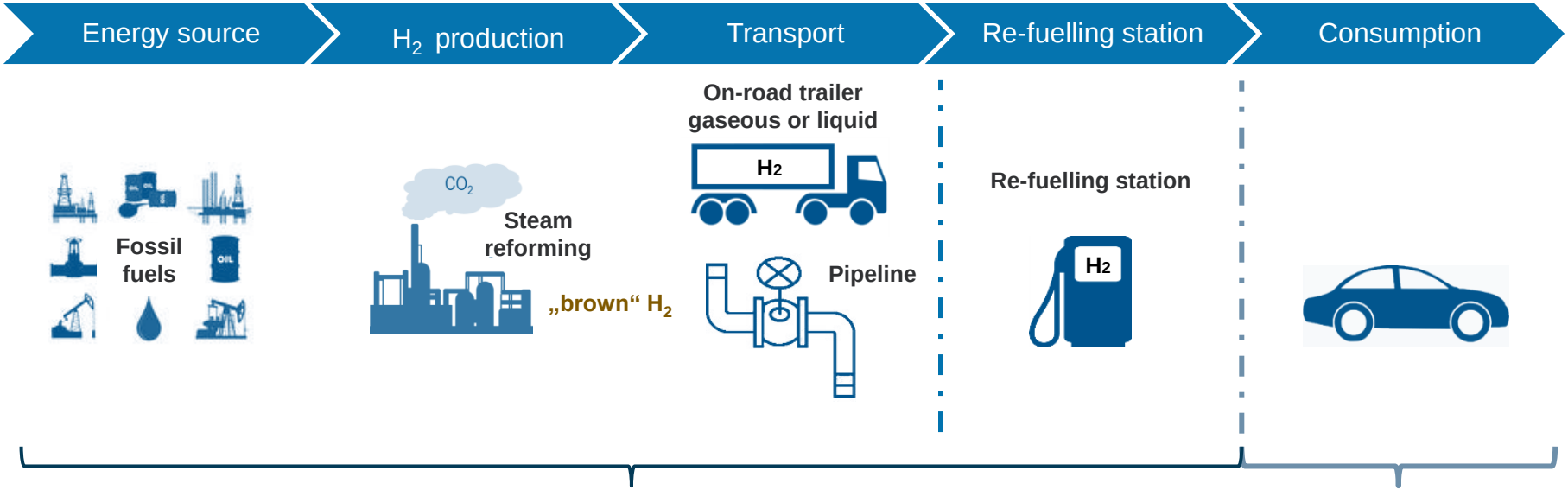

Introduction: Well-to-Wheel GHG-Emissions



For **GHG emissions below 100 g/mile FCEV and BEV required** in combination with **renewables**

Source: DOE US (2010) Well-to-wheels greenhouse gas emissions.

Off-Site H_2 Production



Well-to-Wheel
depends on kind of production and transport

Tank-to-Wheel
=
Zero Emission

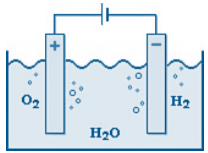
On-Site H_2 Production

Energy source | H_2 production | Transport | Re-fuelling station | Consumption

Renewable electricity

Renewable electricity

Electrolysis
„green“ H_2



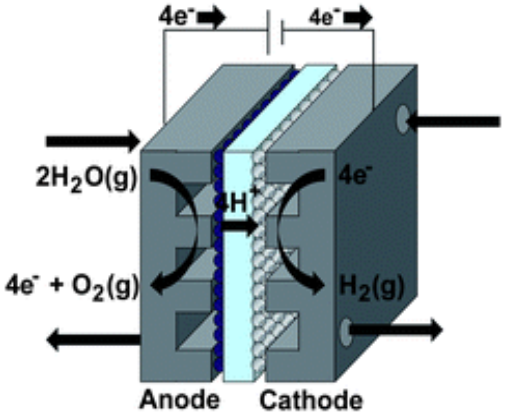
Re-fuelling station

Tank-to-Wheel
=
Zero Emission

Modular Concept: 35 MPa Module

- Asymmetric high-pressure proton exchange membrane (PEM) electrolyser
- Feed Water is purified to fulfill ASTM Type I
- Hydrogen purity of > 99.999 vol% (hydrogen 5.0)
- Module operates stand-alone

Key Specification	Value	Unit
H_2 Production Rate	~ 0.4	kg/h
H_2 Outlet Pressure	35	MPa
H_2 Purity	> 99.999	vol%
Maximum Power Input	32	kW



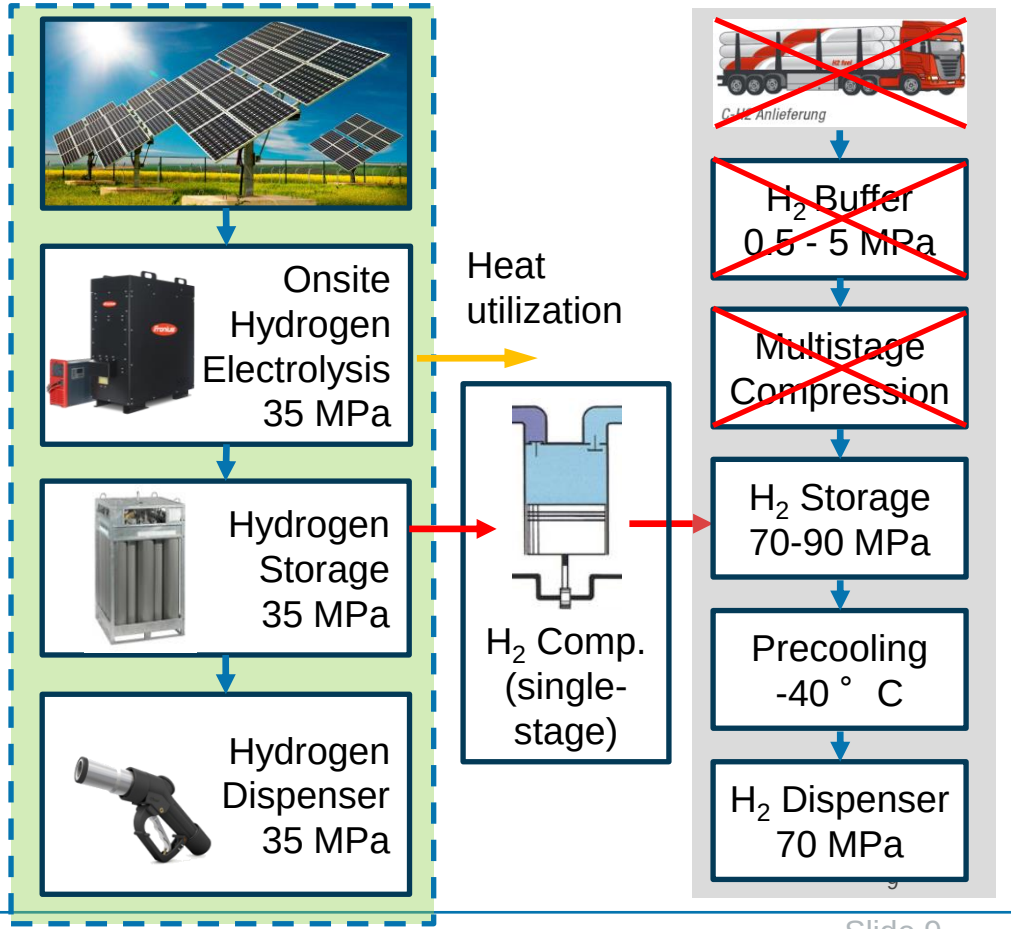
Modular Infrastructure Concept

Current H_2 refueling stations

- Mechanical hydrogen compression systems increase refueling costs

Modular approach

- No mechanical compressor needed for 35 MPa refueling
- Reducing compression stages from five to one for 70 MPa refueling
- Significant reduction of system complexity
- Increase of reliability
- Easily adaptable to actual hydrogen demand

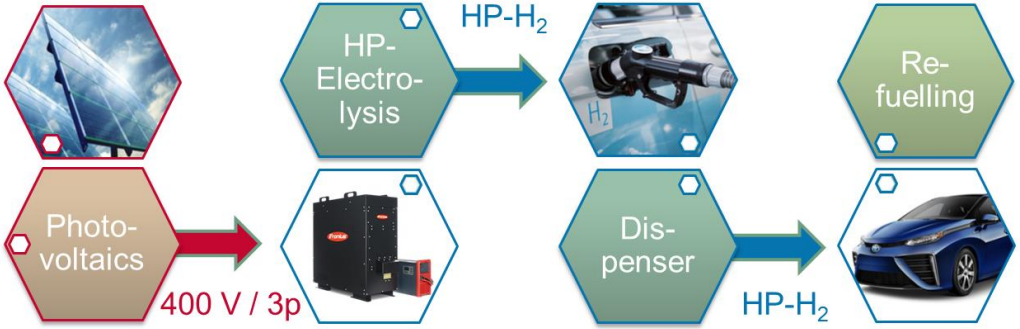


Modular Concept: Requirements of HRS

	Small-sized HRS	Medium-sized HRS	Large-sized HRS
Hydrogen Capacity	> 1.5 kg/d	< 54 kg/d per container	> 108 kg/d per container
Vehicles	~1 per day	~11 per day	~22 per day
Standard Size	Electrolysis module	20-ft container	40-ft container
Use Case	Home refueling	Industrial and Commercial	Commercial
Electricity Supply	PV-system	PV-system, Off-peak electricity	PV-system, Wind (PtG), Off-peak electricity
Power Input	16 kW	up to 250 kW	up to 450 kW

Modular Concept: Small-sized HRS

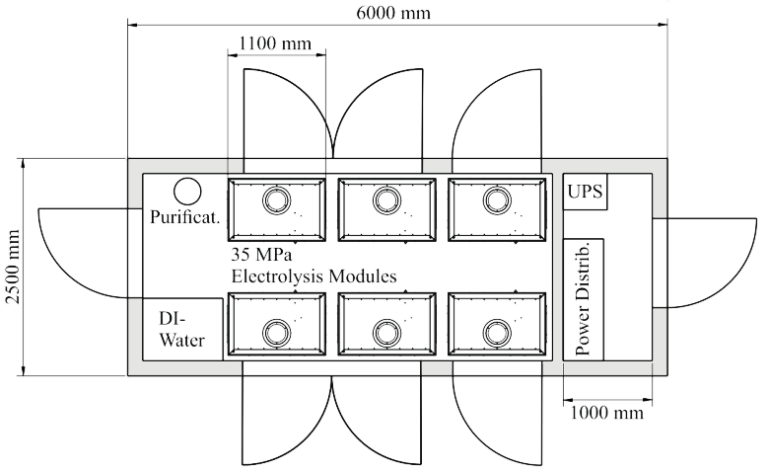
„**Home refuelling**“

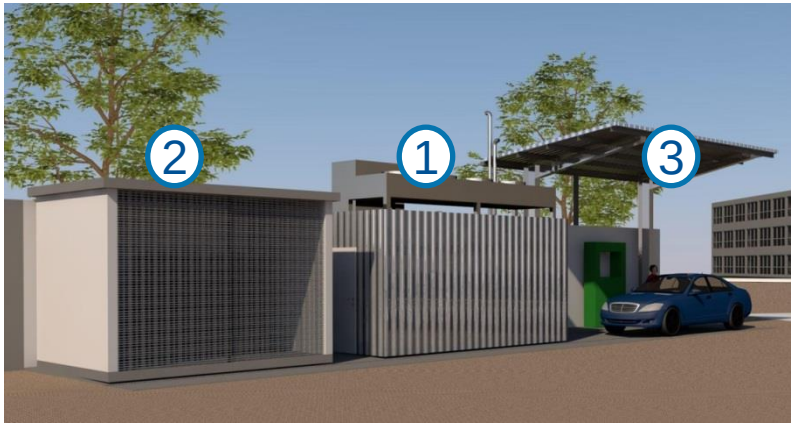


- Electrolyzer with one or two stacks: maximum 32 kW (with two stacks)
- Maximum production rate of 9 kg/day (with two stacks)
- Direct coupling with PV-plant possible
  - Full utilization: 8 hours per day
  - Max. production per day: 3 kg/day (with two stacks)
- One refueling per day at **35 MPa**

Modular Concept: Medium-sized HRS

- **Industry and commercial** application
- Hydrogen Production **at 35 MPa**:
  - 18 kg/d with two electrolyzers
  - **54 kg/d** with six electrolyzers (**11 vehicles**)
- 250 kW input power





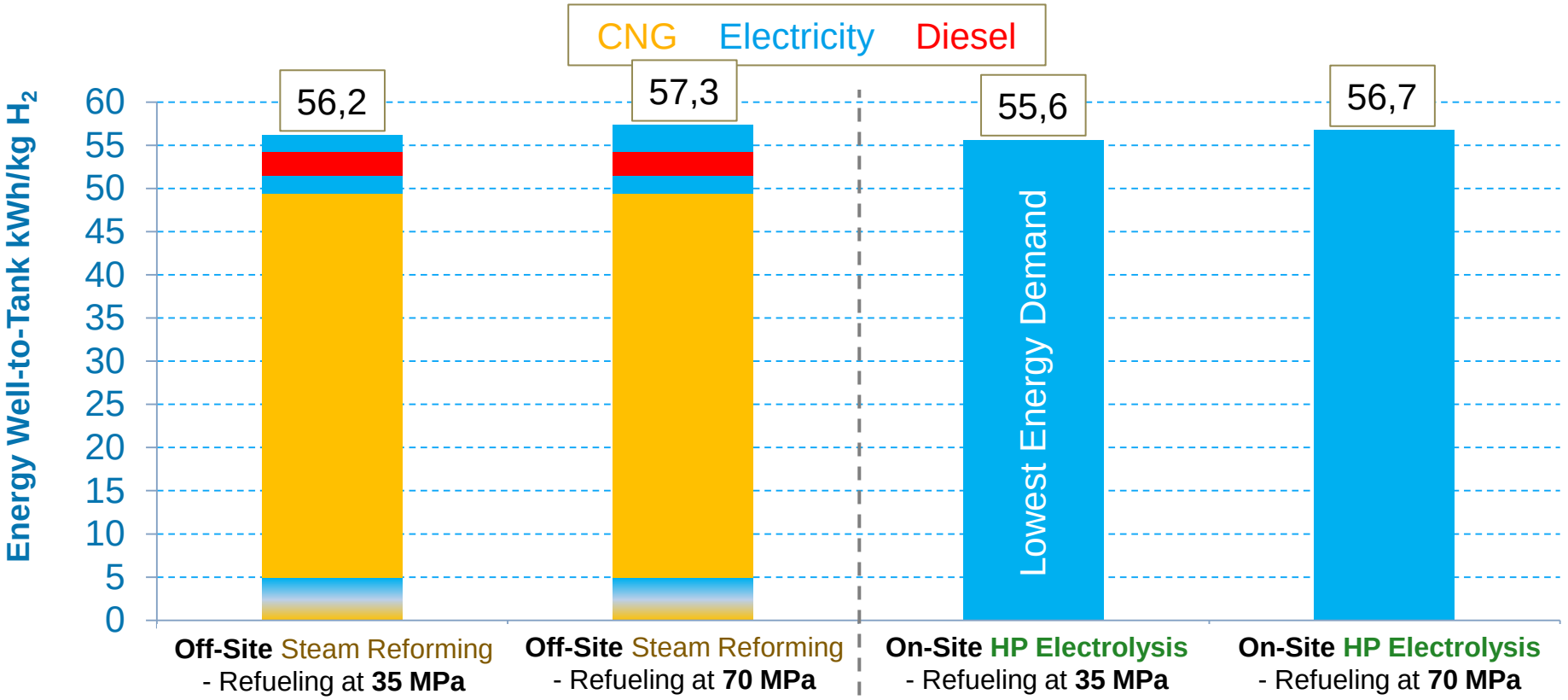
(1) Hydrogen Production
(2) Hydrogen Storage
(3) Hydrogen Dispenser 35 MPa

Modular Concept: Large-sized HRS

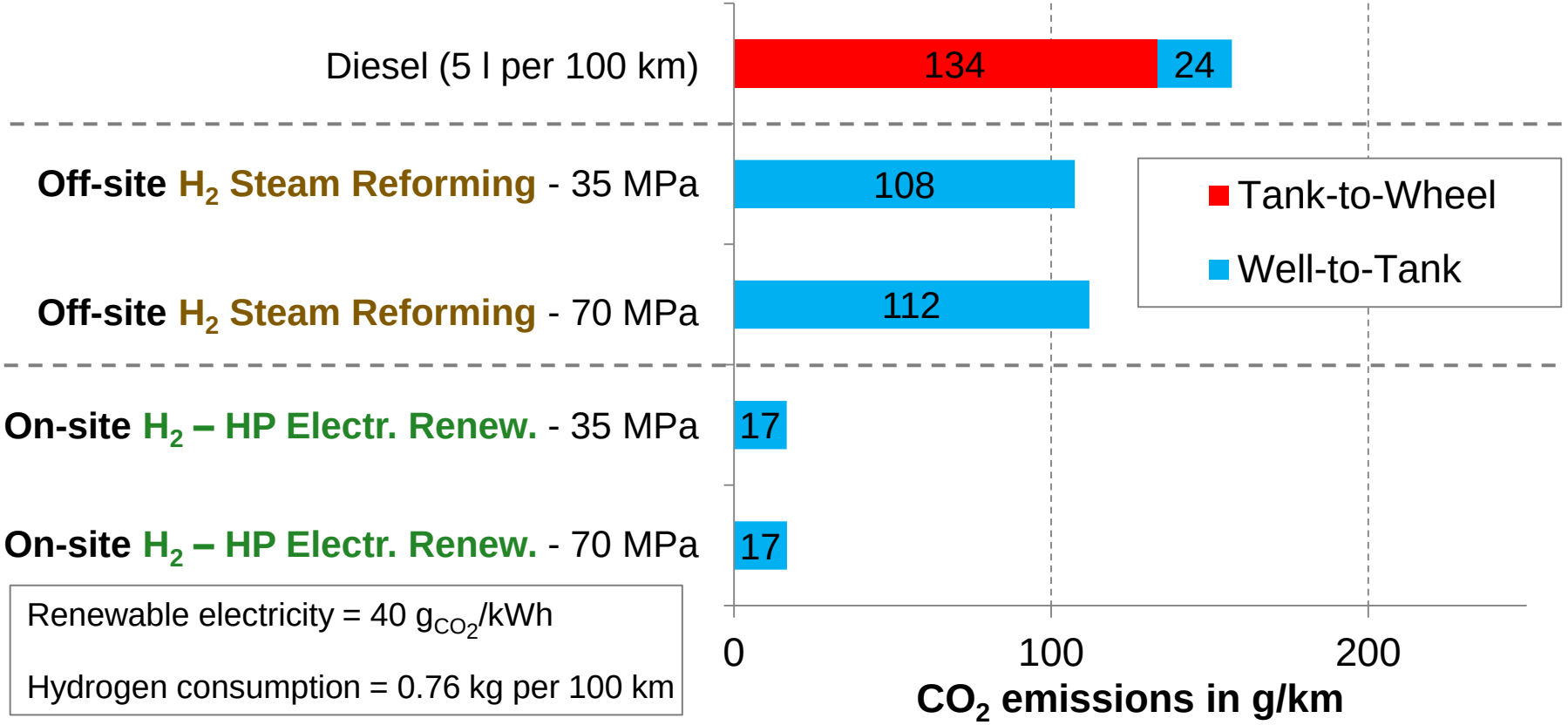
- Commercial application
- Container with 12 electrolyzer modules
- Overall production rate of **108 kg/day at 350 bar** (~22 vehicles)
- Overall power input of 450 kW

Power-to-Gas plant in Auersthal, Austria

Well-to-Tank Analysis of Energy Demand



Well-to-Wheel CO_2 - Mid-Size Vehicle



Renewable electricity = 40 g_{CO_2}/kWh

Hydrogen consumption = 0.76 kg per 100 km

DB Schenker – Linz Hörsching

- 10 industrial trucks in operation
- HP Electrolysis will be integrated in the course of FCH REFuel
- First European Indoor Refueling Station
- Energy Globe Award Fire 2014

Fronius - Thalheim

- **Demonstration of HP Electrolysis concept**

(1) Hydrogen Production
(2) Hydrogen Storage
(3) Hydrogen Dispenser 35 MPa

SFL – Stallhofen

- HP Electrolysis coupled to PV
- 350 bar Dispenser
- 10 kW Fuel Cell REX vehicle

Summary

Modular concept of high pressure PEM electrolysis

- On-site HP electrolysis improves Well-to-Wheel characteristics
- Coupling with renewable electricity possible
- Hydrogen production rate easily adaptable
- Higher reliability and improved maintenance
- 70 MPa possible – single stage compressor

Realization of three medium-sized HRS in Austria in 2017

- Improvements regarding investment and operational costs ongoing

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Vision

Das HyCentA (Hydrogen Center Austria) fördert die Nutzung der von Wasserstoff als regenerativem Energieträger. Mit einem Wasserstoffprüfzentrum und der ersten österreichischen Wasserstoffabgabestelle fungiert das HyCentA als Kristallisationspunkt und Informationsplattform für wasserstoffbezogene Forschungs- und Entwicklungsaktivitäten.