

Part 1 – Project Presentation WIVA P&G HyTrain



Introduction to the R&D Flagship Project WIVA P&G HyTrain

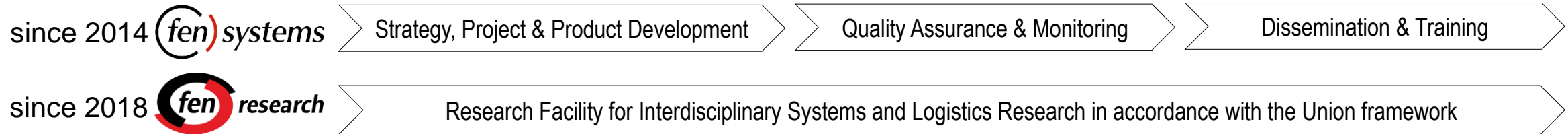
Niusha Shakibi Nia, FEN System

25th JUNE 2024 | 13:00 - 17:00

Green Energy Center Europe Technikerstrasse 1-3, Innsbruck



Dr. Niusha Shakibi Nia
25th June 2024 – Innsbruck, Austria



- **Project Acronym:** WIVA P&G HyTrain
- **Call year:** 2017/18
- **Call:** Energy Model Region - 2nd Call of the Climate and Energy Fund
- **Funding Instrument:** Flagship Project regularly evaluated by an independent international expert panel
- **Energy Model Region:** WIVA P&G – Wasserstoffinitiative Vorzeigeregion Austria Power & Gas
- **Project duration:** 01.09.2020 to 31.08.2024
- **% stage of implementation 25.06.2024:** 95 %
- **Total project budget:** 2.885.171,00 € excluding the demonstration of the developed technologies
- **KLIEN contribution:** ca. 1.954.146,84 €
- **Consortium Lead:** FEN Sustain Systems GmbH (**FEN Systems**)
- **Consortium Partners:** Zillertaler Verkehrsbetriebe AG (**ZVB**), PROSE GmbH (**PROSE**), HyCentA Research GmbH (**HyCentA**), Verein WIVA P&G (**WIVA**)



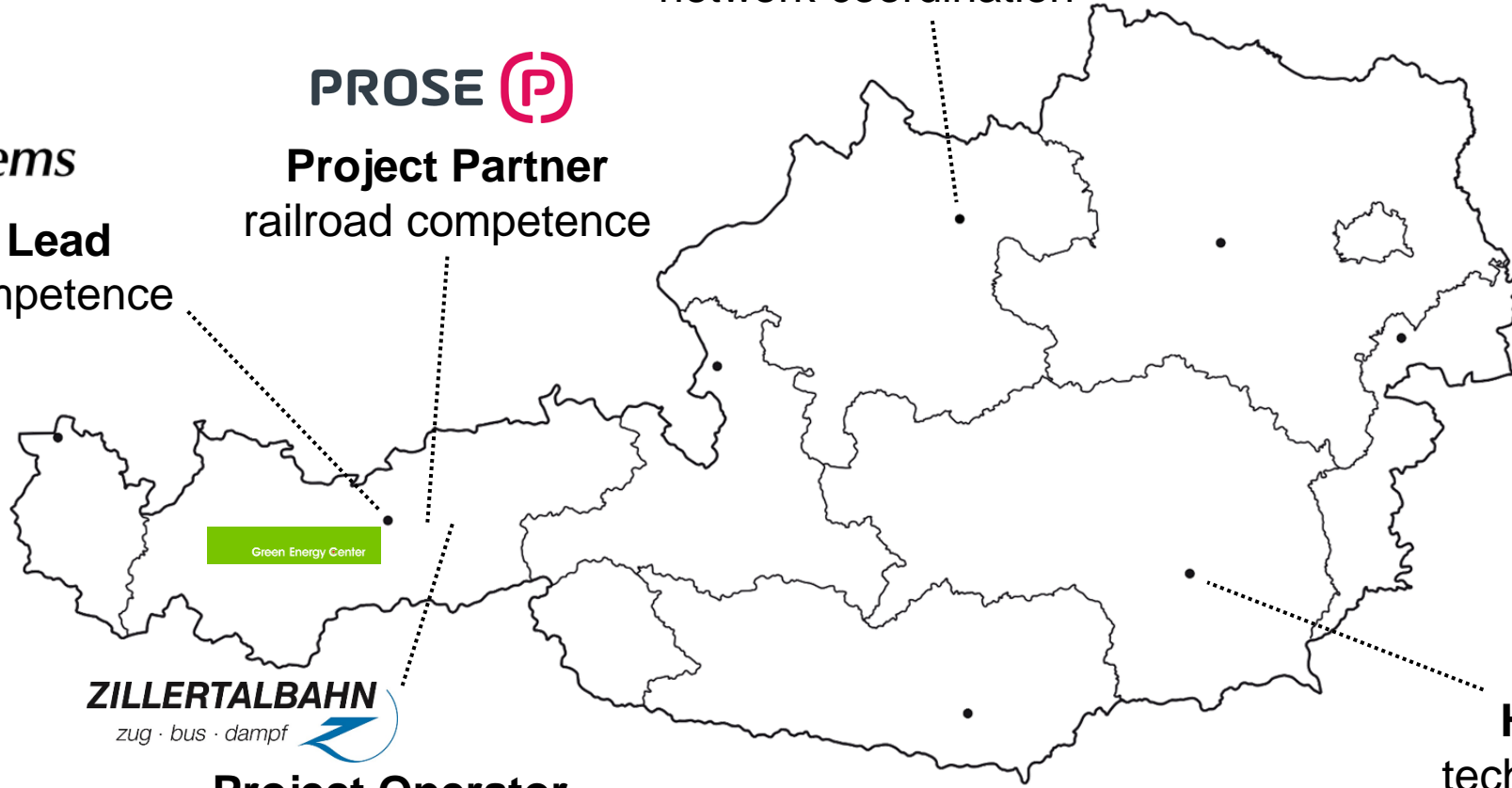
WIVA P&G HyTrain
Project Consortium



Project Partner
network coordination

fen)systems
Consortium Lead
systemic H₂ competence

PROSE 
Project Partner
railroad competence



Project Operator
rail operation competence

HycentA
HYDROGEN CENTER AUSTRIA
Head of Research
technical H₂ competence

This project is supported with the funds from the Climate and Energy Fund and implemented in the framework of the RTI-initiative "Flagship region Energy".



hosted by

Green Energy Center

- Establishment of the **state of the art** for **hydrogen (narrow gauge) trains** by means of:
 - Train simulation & test bench operations
 - H2-Infrastructure concept development and simulation
- Determination of criteria & parameters (standards) for the **quality assurance** and **risk minimization process** for Hydrogen Trains and corresponding H2-Infrastructure regarding:
 - Tendering,
 - Contracting,
 - Commissioning,
 - Acceptance,
 - Operation and
 - Warranty
- **Application of findings & results** to the implementation project

H2-Train

Main Research Topics

- Degradation Fuel Cell System
- Health monitoring & signal analysis
- Optimization operation strategy

Scope of Research

- Stack, system & vehicle level
- Simplification & robustness
- Real time recognition of FC state
- Improvement of operation strategies for lifetime, efficiency and performance

H2-Infrastructure

Main research topics

- Optimization hydrogen infrastructure
- Optimization refuelling strategy
- Multi-electrolyser operation

Scope of Research

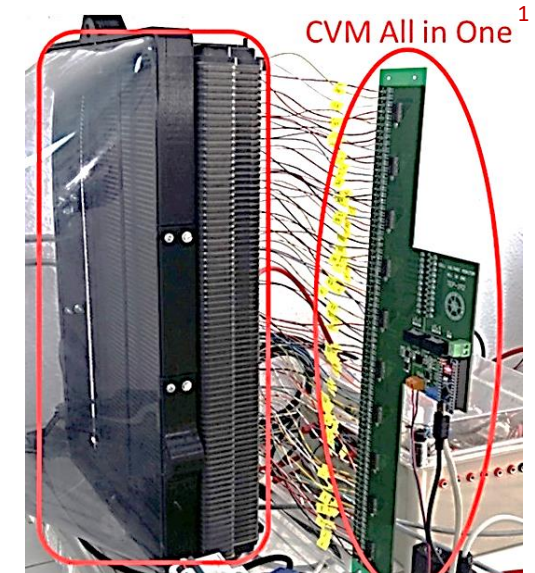
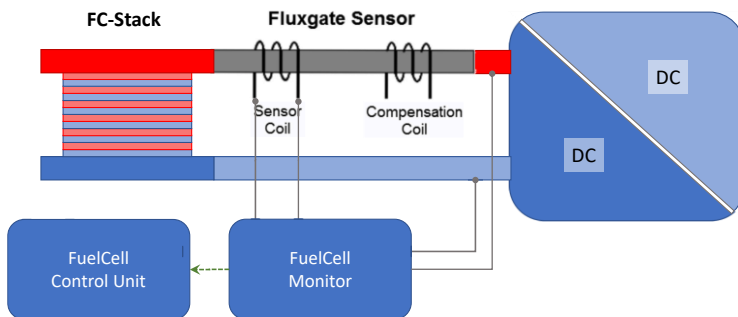
- Definition of interfaces between train and infrastructure
- Identification of hydrogen storage system limitations
- Definition of optimized refueling protocols for a refueling time < 35 min

- Status: Other than CVM no device available for FCS-Online-Monitoring
- Shortcomings: CVM is unreliable due to error-prone instrumentation
- WIVA P&G HyTrain Approach:

- Reduction of installation complexity
- New methods of signal analysis
 - Nonlinear response analysis (SoA: linear domain electrochemical impedance spectroscopy / EIS)
 - Time series analysis (TSA) (SoA: Frequency domain based via FFT)
 - Utilization of system caused FCS-perturbation (e.g., media pulsation caused by actuators / valves)

*Cell voltage monitoring (CVM):
Each cell cabled → error-prone*

*Fuel Cell Monitor with 2-Sensors
→ simplicity*



¹ <https://doi.org/10.1016/j.ijhydene.2018.12.172>

- Fuel Cell Monitoring Hardware^(*):

- Vertical, horizontal resolution: 24-bit & 50 kS/s
- Online-Processing capable

- Engineering Focus:

- System Integration
- Software Development

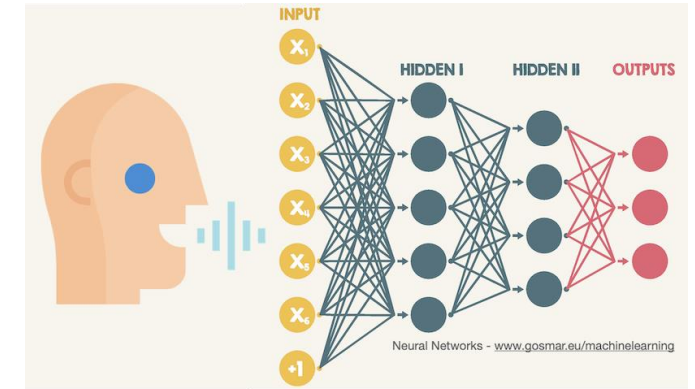
- Scientific Objectives:

- Establishment of TSA (time series analysis)
- Adaptation of speech recognition algorithms

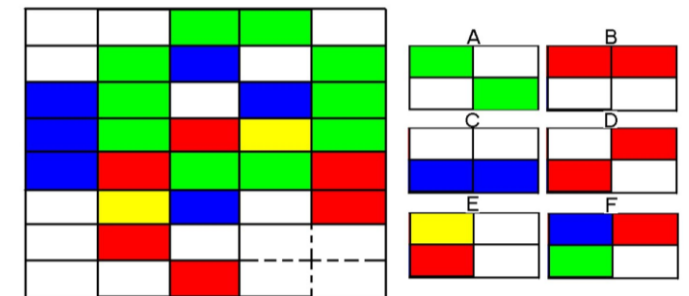


Novel techniques for FC-Monitoring:

- AI (Artificial Intelligence)

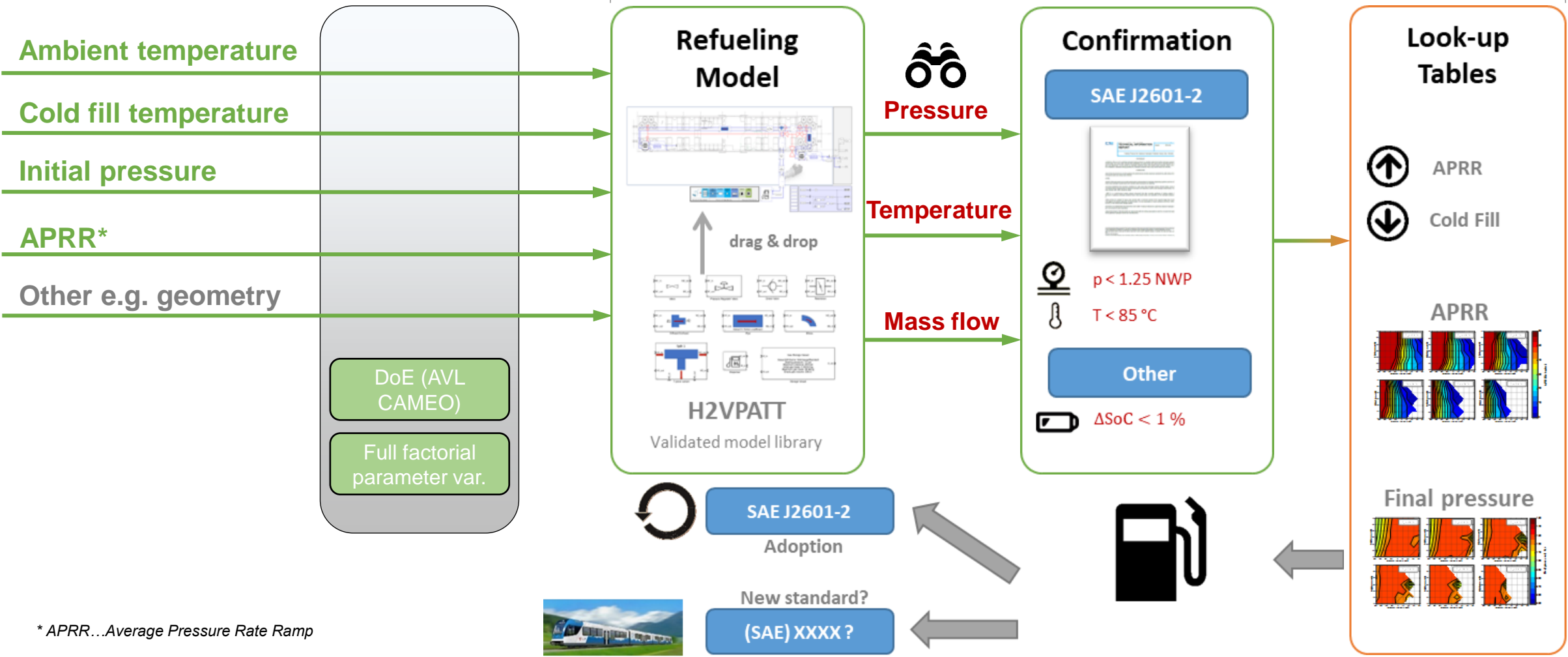


- PR (Pattern Recognition)

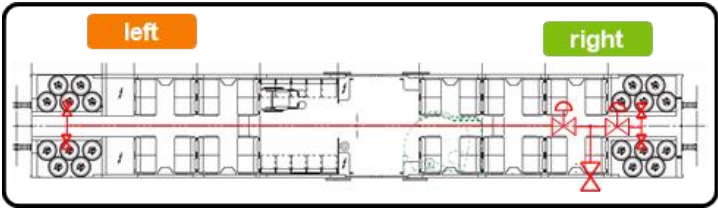
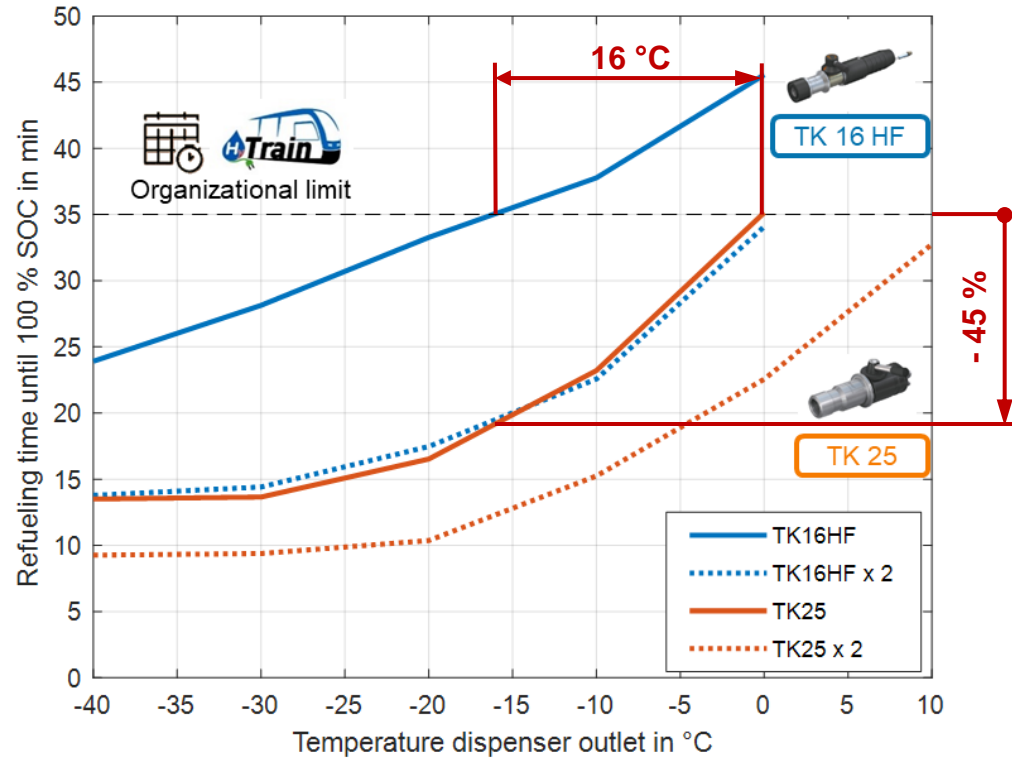
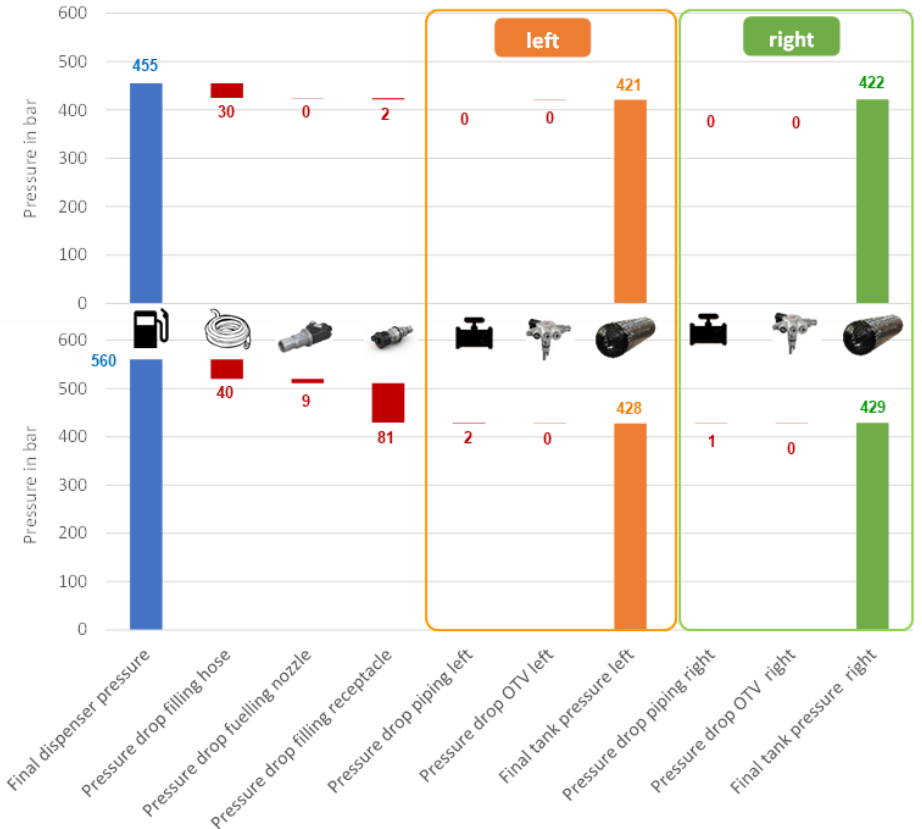


^(*) in collaboration with the Institute of Electrical Measurement and Sensor Systems (ems) of TU Graz

Automated script



* APRR...Average Pressure Rate Ramp



$p_0 = 10 \text{ bar}$
 $T_u = 30 \text{ °C}$
 $T_{disp} = 0 \text{ °C}$

- TK25 significantly - 45 % refueling time
- TK16 HF require - 16 °C cold fill
- Two TK16 nozzles can compensate higher Δp

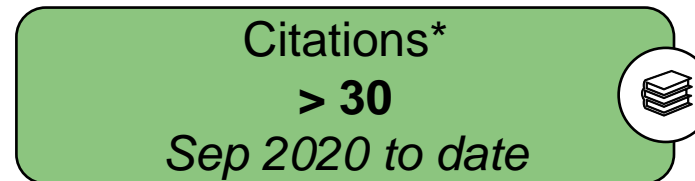
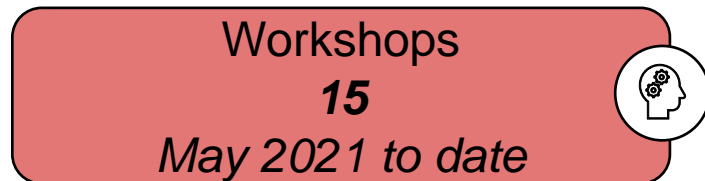
Concept Hydrogen Refuelling Station (HRS)

- ✓ Fundamental investigations on heavy-duty train **HRS concept** and **components**
- ✓ Elaboration of **refuelling protocols** of heavy-duty vehicles based on simulation results
- ✓ Preparational work for **safety workshops**

Energy Storage and Power Train System

- ✓ Elaboration of a **basic operation strategy** using *Longitudinal vehicle Dynamic Simulation* (LDS)
- ✓ Optimization of the operation strategy regarding **lifetime** and overall **energy consumption**
- ✓ Preparation of hardware and signal analysis for the **State of Health** and **State of Operation**

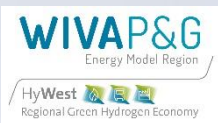
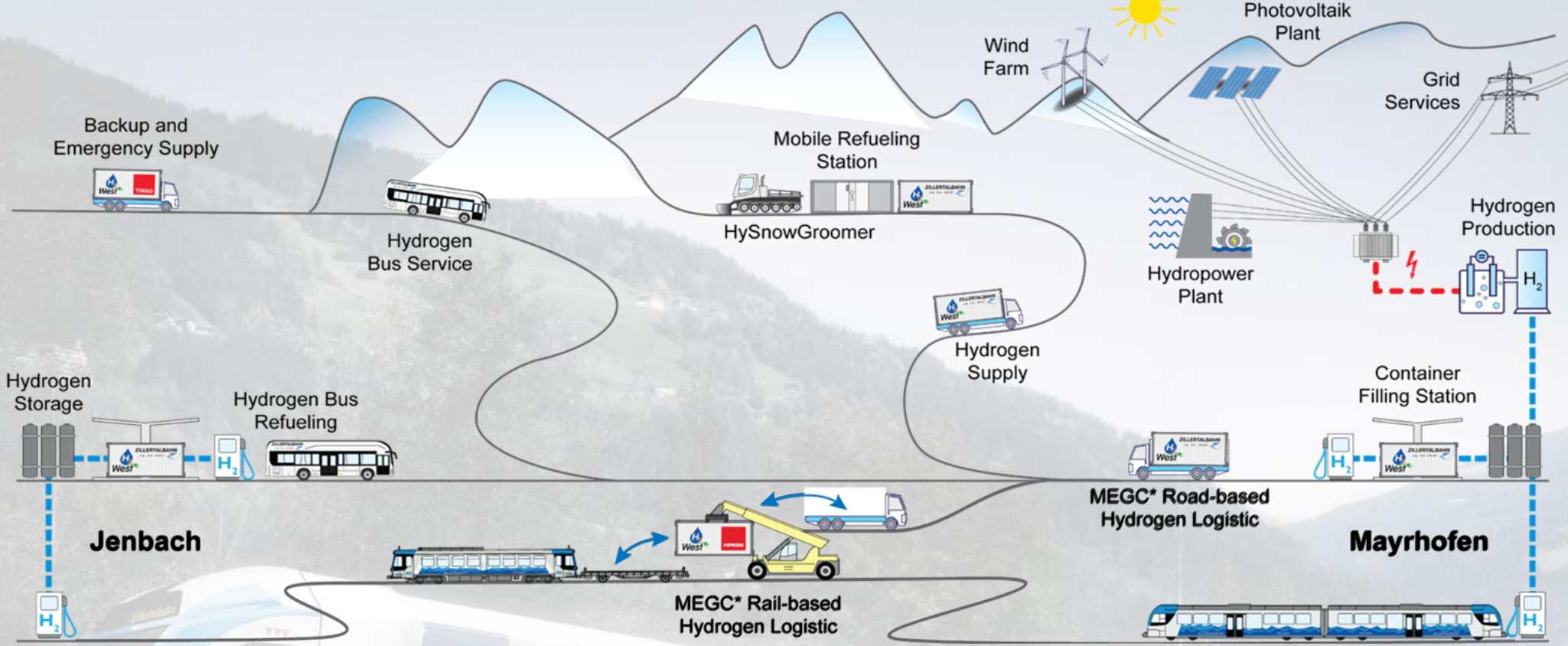
Dissemination, Communication & Exploitation





WIVA P&G HyTrain

Part of a Regional Green Hydrogen Economy Development



„Zillertalbahn 2020+ energy autonomous with hydrogen“

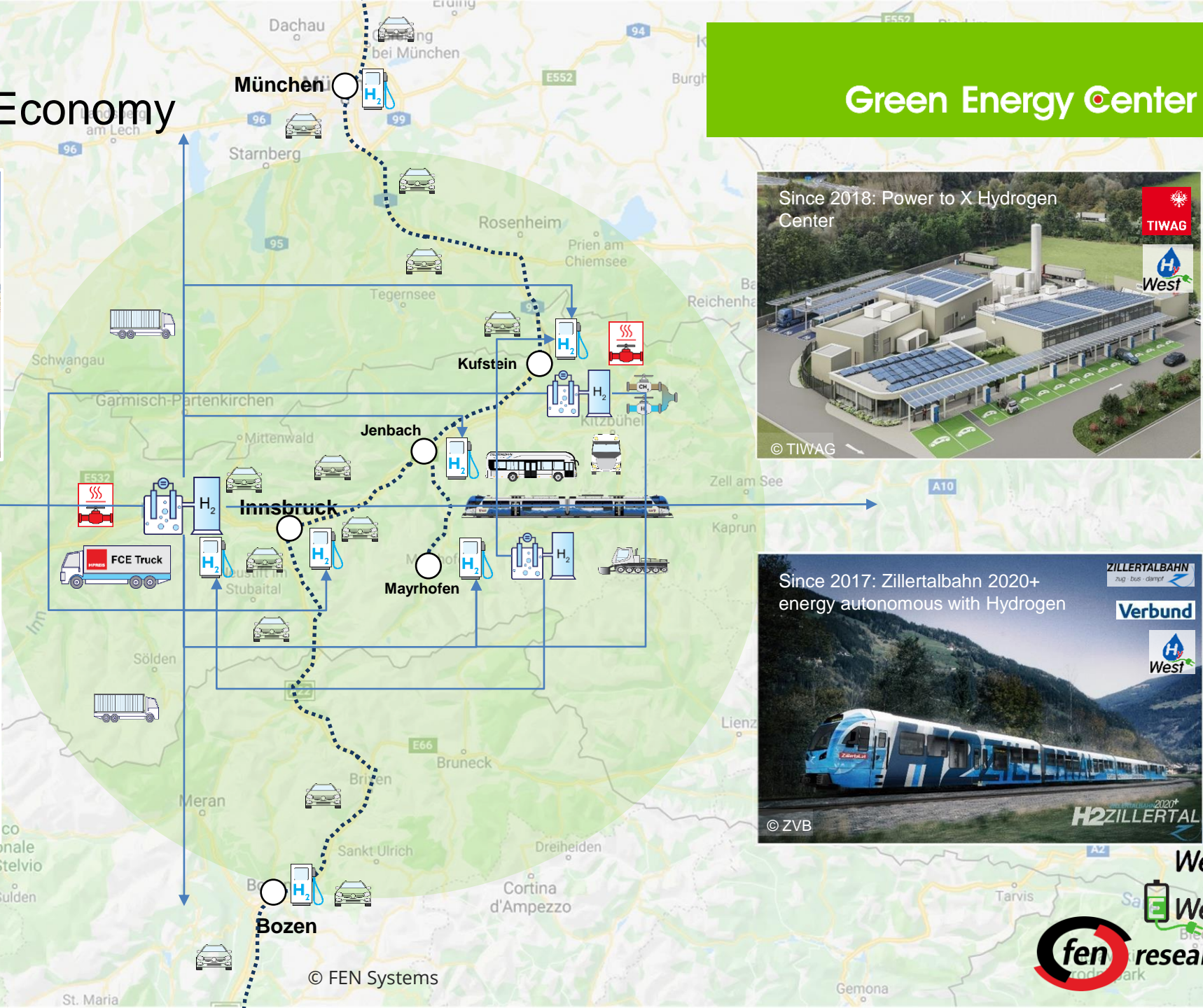
Substitution: 900.000 Liter Diesel/year = 2.400 tons CO2 equivalent/year





Establishment Green Hydrogen Economy

Green Energy Center





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