Bundesministerium
Klimaschutz, Umwelt,
Energie, Mobilität,
Innovation und Technologie

Bundesministerium
Arbeit und Wirtschaft

FFG
Forschung wirkt.

Das Land Steiermark
Wirtschaft, Tourismus, Wissenschaft und Forschung

SFG
NEUES DENKEN. NEUES FÖRDERN.

ober österreich

UAR INNOVATION NETWORK

Stadt Wien

wirtschaftsagentur wien

LAND TIROL

HyTrain – Research Project

HyCentA Research GmbH, Graz 02.07.2024

Christian Zinner

TU Graz

HyTrain

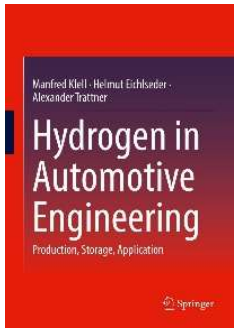
HyCentA
HYDROGEN CENTER AUSTRIA

HyCentA Research GmbH

Austria's research center for hydrogen technologies

Non-university research organization at Graz University of Technology (TUG)

- **90+ researchers** from mechanical engineering, physics, chemistry, process engineering, electrical engineering
- More than **70 funding projects and 500+ industrial projects** successfully completed
- More than **19 years of expertise** State-of-the-art testing & refueling infrastructure
- Teaching at TU Graz
- International network



Research along the Entire Value Chain

The three distinguished technological areas and one cross-cutting area are closely linked and essential parts of the entire value chain research.

RESEARCH AREAS HYCENTA

HyCentA K1 COMET Centre

Area 1
Electrolysis and Power-to-X

Material research, new electrolysis technologies, alternative processes (from materials to industrial applications)

Area 2
Green Energy and Industry

Storage and distribution (gas storage, hydrides etc.), electrochemical compression, stationary fuel cells, safety

Area 3
Green Mobility

Fuel cell research on materials, cell, stack and system; optimisation of entire powertrain system including hydrogen storage

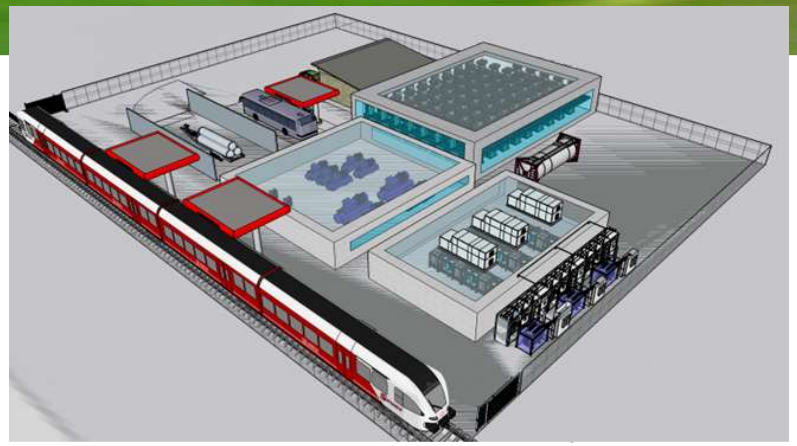
Area 4
Circularity and System Optimisation

Measurement and testing technologies, controls, diagnostics, modelling and simulation “digital twin”

! **Areas** include **all steps** along the **value chain**, from production to distribution and followed by applications

Overview

ZILLERTALBAHN zug · bus · dampf	**Project Operator** rail operation
fen systems	**Consortium Leadership** systemic H_2 competence
HyCentA HYDROGEN CENTER AUSTRIA	**Head of Research** technical H_2 competence
PROSE	**Project Partner** rail competence
WIVA P&G Energy Model Region	**Project Partner** network coordination



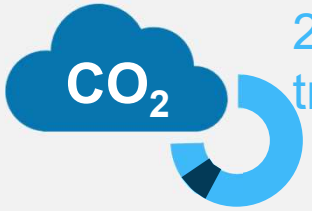
This project is supported with the funds from the Climate and Energy Fund and implemented in the framework of the RTI-initiative "Flagship region Energy".

powered by klima+ energie fonds
VORZEIGEREGION ENERGIE
FFG Promoting Innovation.

Motivation

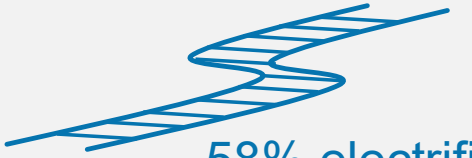
Emissions and Rail Network in the EU

3.2 Gt



29% by transport

→ one of the most environmentally friendly forms of mobility

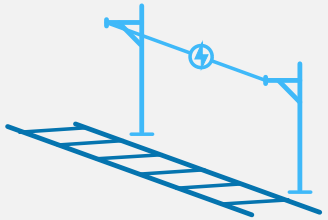


58% electrified (130,000 km)

Benchmark

Alternatives

Electrification of Regional Railways



substantial costs and resources

→ other zero-emission technologies as suitable alternatives

case-by-case decision analysis

References: eea, statista

Objectives

- Layout of production site
- Hydrogen refueling configuration
- Hydrogen refueling protocol
- Safety topics
- Different powertrains
- Optimization operation strategy
- Optimization Train efficiency → powertrain + auxiliaries
- Degradation of PEMFC

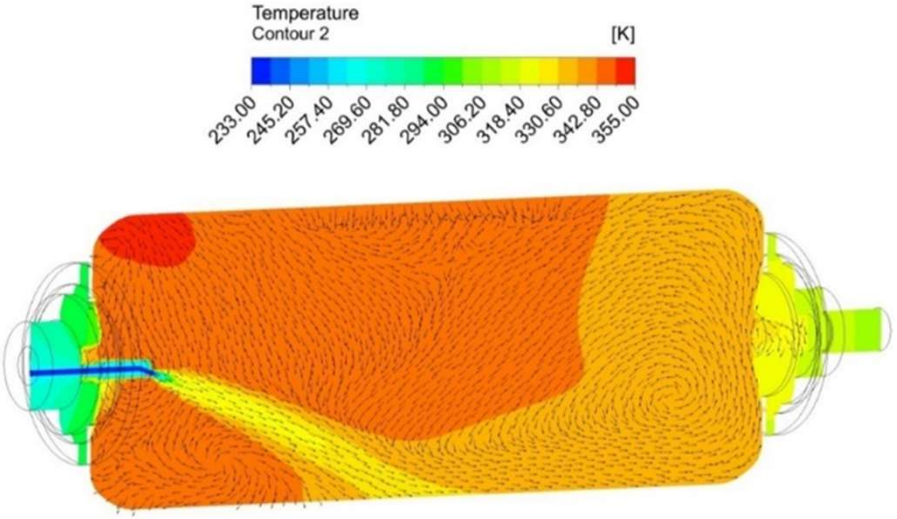
Refueling

Optimal refueling depends on:

- **Ambient conditions**
- **Pressure in cylinder at refueling start**
- **Tank Type** → max. temperature, max. pressure, …
  - Tank Type 4 usually needs Cold-Fill
  - Tank Type 3 usually no Cold-Fill
- **Configuration Hydrogen Storage System**
  - Tank position → vertical or horizontal → different distribution of temperature and gas
  - Tank size → Volume / Area ratio
- **Configuration of Infrastructure**

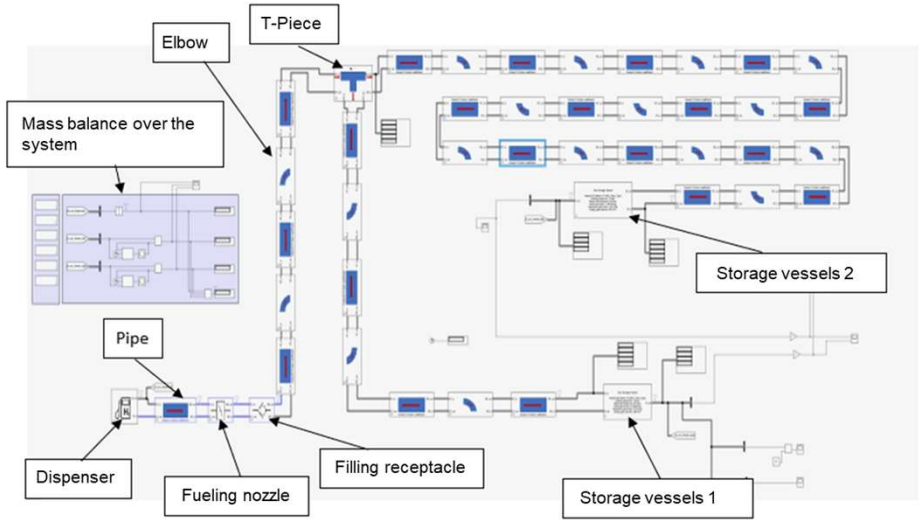
Distribution of Temperature – Horizontal Refueling

Standard cylinder
Max. Temperature: 349 K

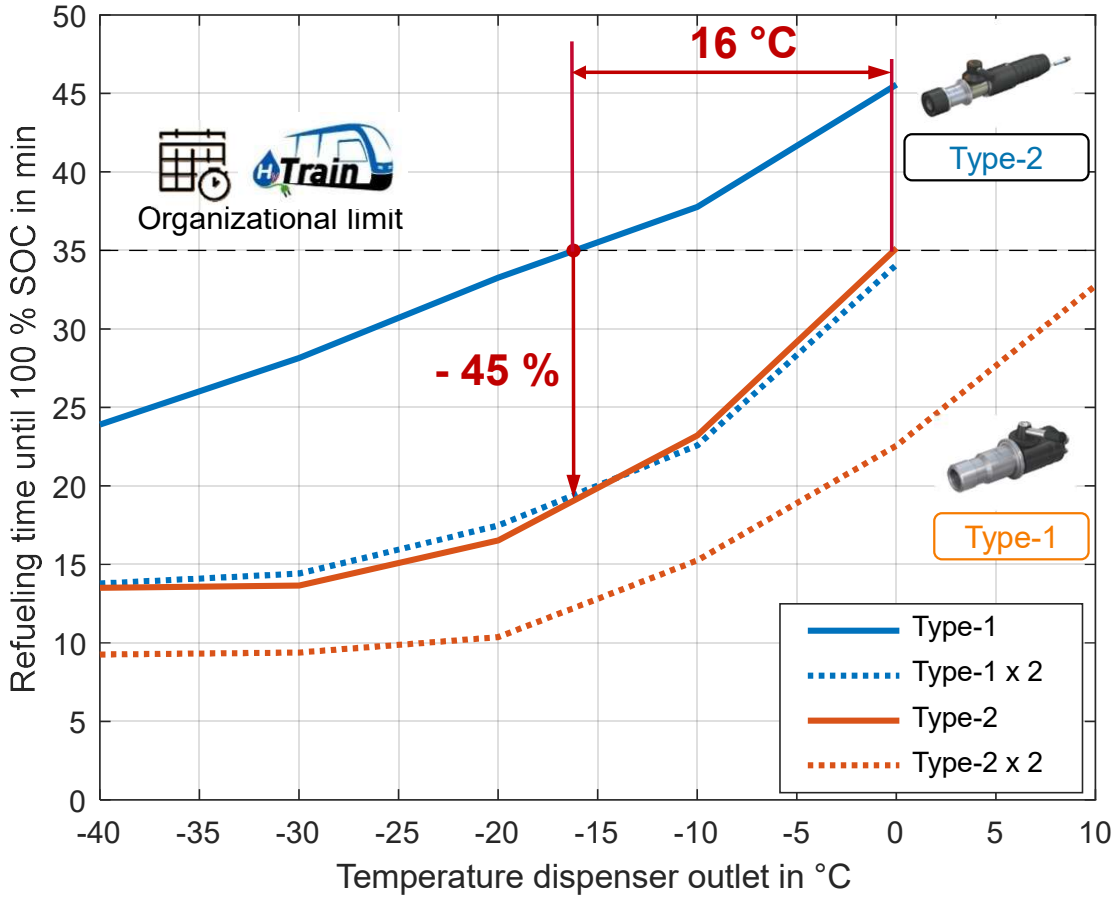


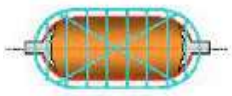
Strong dependency on several parameters → for rail application a optimization is possible

Refueling



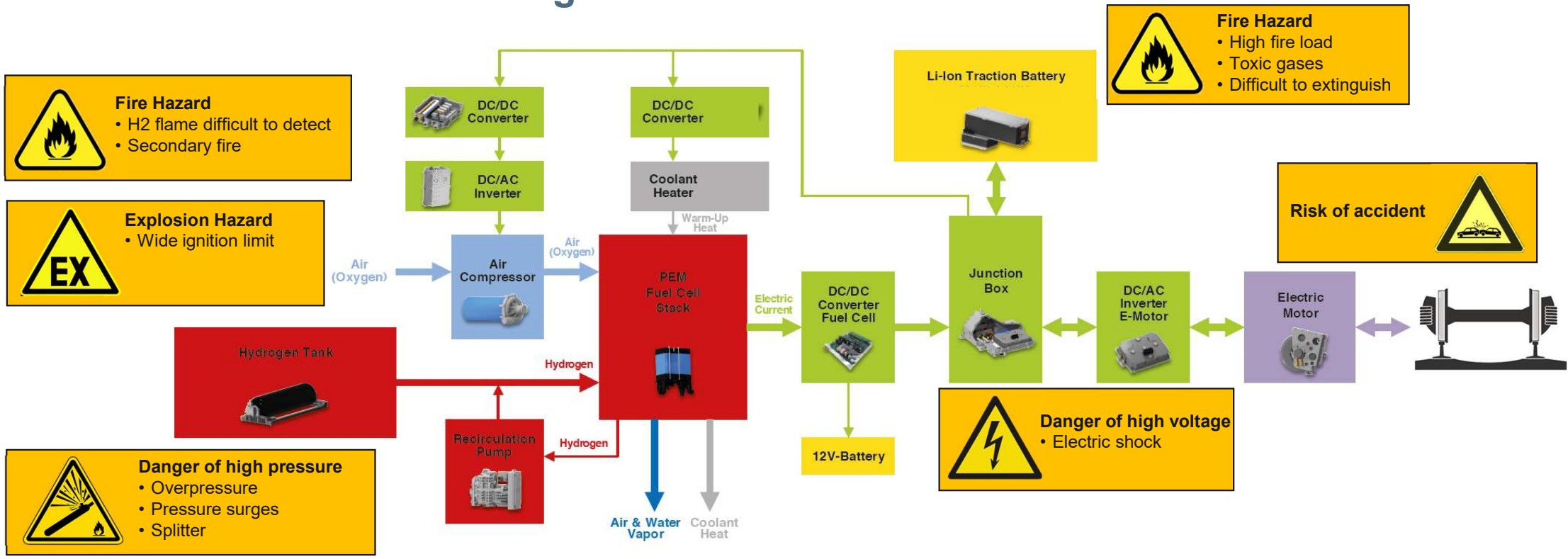
- 0D-Simulation model of the complete HSS
- Including all limits for refueling



Type IV  p_0 = 10 bar | **T_u = 30 °C**

Safety & Regulations

FC-Drivetrain and according hazards



Safety & Regulations

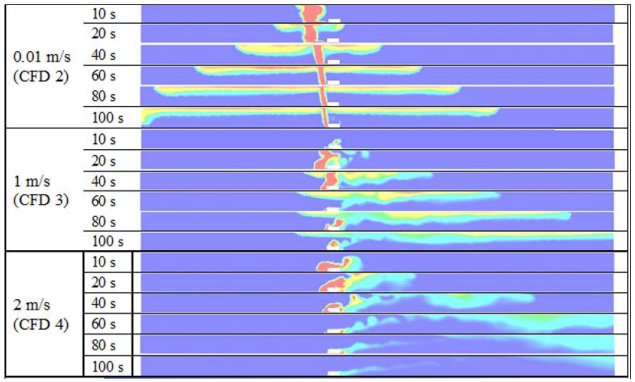
Hydrogen leakage:

- **Unignited release of hydrogen**
  - Suffocation due to oxygen depletion
  - Pressure peaking phenomenon & formation of ignitable cloud with oxygen
- **Ignited release of hydrogen**
  - Jet-Fire & Heat burns
  - Flames spreading to other components, vehicles, infrastructure
- **Explosion of hydrogen (deflagration, detonation)**

Source: HyResponse

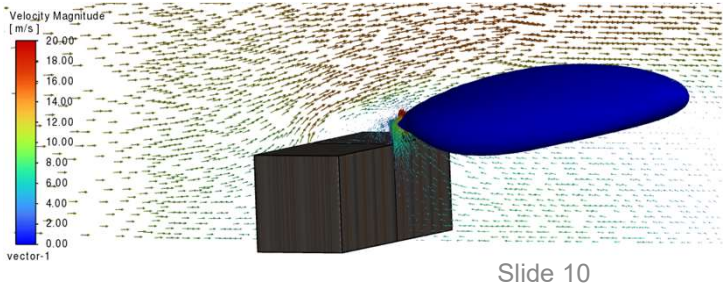
Tunnel safety - H2-Cloud propagation

- Accumulates on the ceiling
- Prevention of formation of flammable mixture

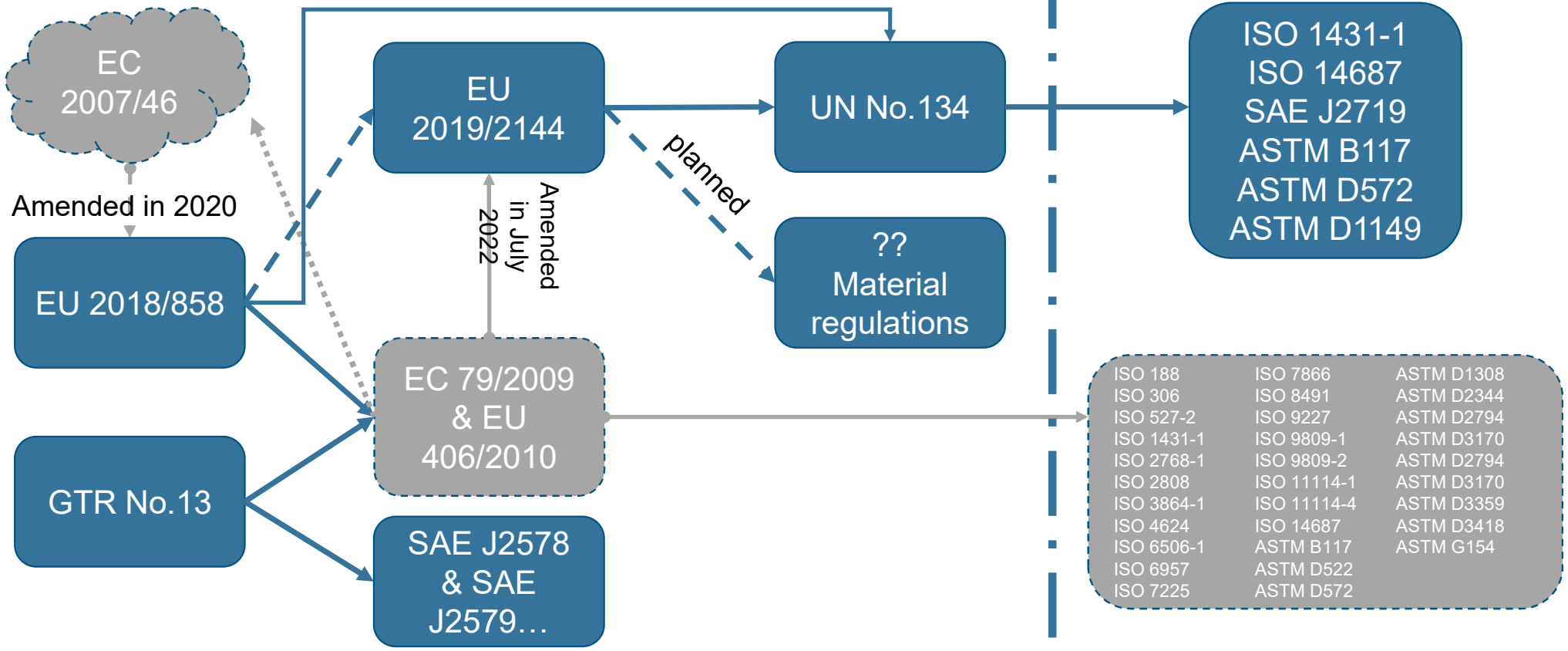


Infrastructure safety - H_2-distribution

- H_2-Propagation and H_2 distribution in container
- H_2-Propagation and explosion limit outside container



Safety & Regulations



Regulations (Obligatory)

Standards

Conclusion

Refueling

No standard refueling protocol for railway sector

Optimization for specific boundary conditions possible

Cold-fill requirements depend on HSS configuration

Safety

Special safety measures for H_2 handling necessary

No specific H_2 regulations for railroad available

Adaptions to existing regulations and new regulations necessary

Benchmark

Decarbonizing the Railway Sector

Alternatives

Bundesministerium
Klimaschutz, Umwelt,
Energie, Mobilität,
Innovation und Technologie

Bundesministerium
Arbeit und Wirtschaft

FFG
Forschung wirkt.

Das Land
Steiermark
Wirtschaft, Tourismus,
Wissenschaft und Forschung

SFG
NEUES DENKEN. NEUES FÖRDERN.

ober
österreich

UAR INNOVATION NETWORK

Stadt
Wien

wirtschafts
agentur
wien

LAND
TIROL

Contact

HyCentA Research GmbH

Inffeldgasse 15

A-8010 Graz

Phone: +43 316 873 9500

office@hycenta.at

www.hycenta.at

TU
Graz

HyCentA
HYDROGEN CENTER AUSTRIA