Hytruck Workshop

The development of a hydrogen refuelling stations network for long-haul heavy transport in the Baltic Sea Region.

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For whom are the hydrogen stations built?

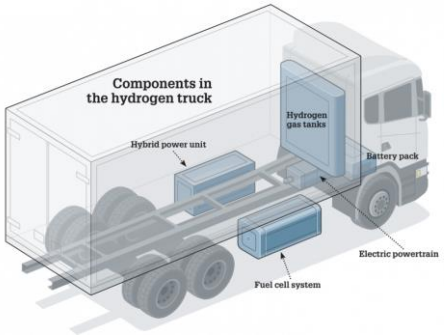
What is available today

Vehicle	Amount of hydrogen	Refuelling time	Range
Personal	4-6 kg	3-5 min.	400-700 km
Bus	25-40 kg	10-15 min.	400-600 km
Truck	40-50 kg	10-15 min	400-1000 km

Trucks - samples

Hyundai Xcient Fuel Cell
Medium distance
350 kW, 3400 Nm of torque.
8.2 kg of hydrogen H35 per 100 km
Range approx. 400 km.
350 bar

IVECO S-Way Hydrogen
Long-distance
400 kW, 1800 Nm
Range approx. 800 km
700 bar (?)



Hyzon Europe - Hydrogen tractor based on DAF XF
Long-distance,
n.a.

Scania Hydrogen Fuel Cell
Medium distance
Approx. 500 km. range

Small trucks from Stellantis

Scenic Concept

Van, chassis cab and city bus

Other


aramco


SEMAT
innovation


100% hydrogen
GAUSSIN
GAUSSIN

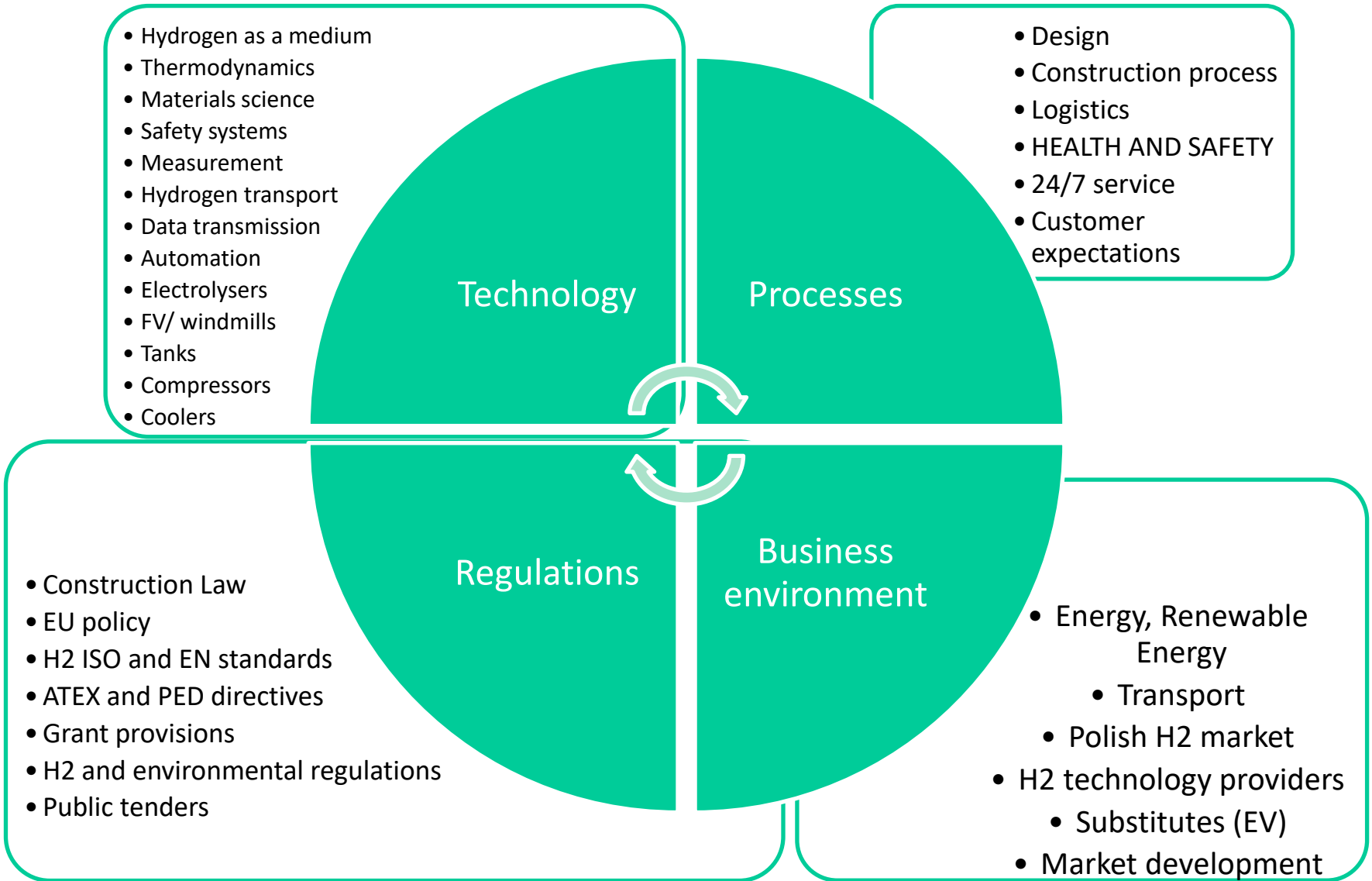

cyclHic
Borne hydrogène
la borne hydrogène dédiée aux véhicules légers...
FACILE
RAPIDE
FAIBLE


TOYOTA
FUEL CELL


RICHARD MILLE
TotalEnergies
24

What is driving or delaying the market for the construction of hydrogen refuelling stations?

Topics related to the construction of H2 station

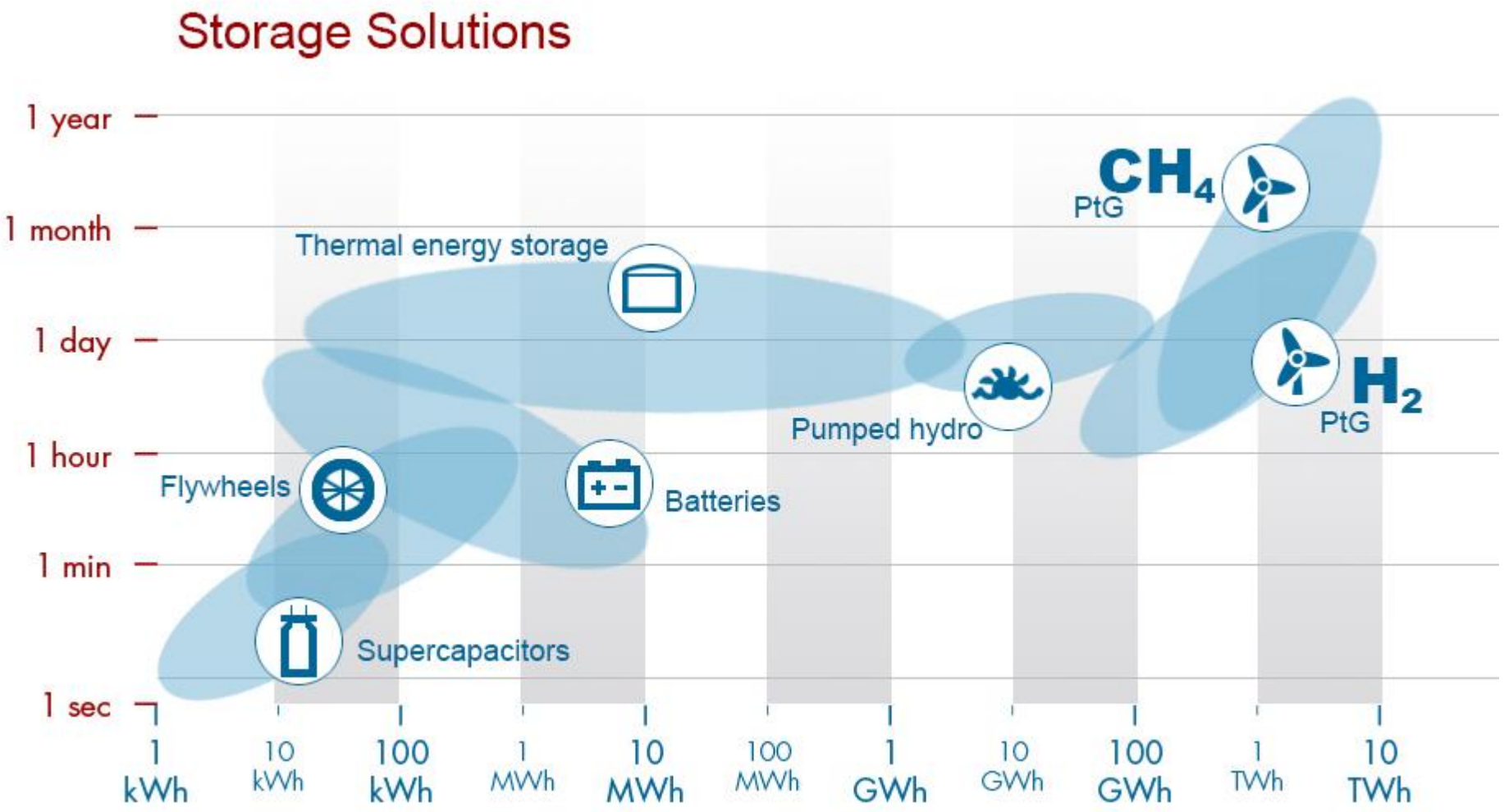


Hydrogen - calorific value

kWh/kg

Hydrogen 33.3
Crude oil 11.6
Petrol 12
Methanol 5.4
Methane 13.9
Propan 12.8
Natural gas 10.6-13.1
Town gas 7

Hydrogen is a scalable and long-term energy storage



https://www.ansaldoenergia.com/business-lines/hydrogen-technology

ETS and transport

EUROPE

FIT FOR 55
by 2030 a 55% reduction in CO_2 emissions compared to 1990

CHANGES TO THE ETS SYSTEM = MINI ETS

- Inclusion of construction
- **Inclusion of transport (sea and land)**

US

Inflation Reduction Act

Tax credit to the green hydrogen

$ 3/kg

Expected 5bilion $ investment till 2035

How to meet the EU's goals?

ZERO-EMISSION VEHICLES

ELECTRIC	HYDROGEN

(-) FUNDAMENTAL WEAKNESSES

BATTERY WEIGHT, CHARGE RATE, RANGE, TEMPERATURE EFFECTS, MINERALS, ELECTRICITY GRID	**VOLUME OF TANKS**, NUMBER OF MODELS, AVAILABILITY OF REFUELLING STATIONS, COST OF HYDROGEN

(+) KEY ADVANTAGES

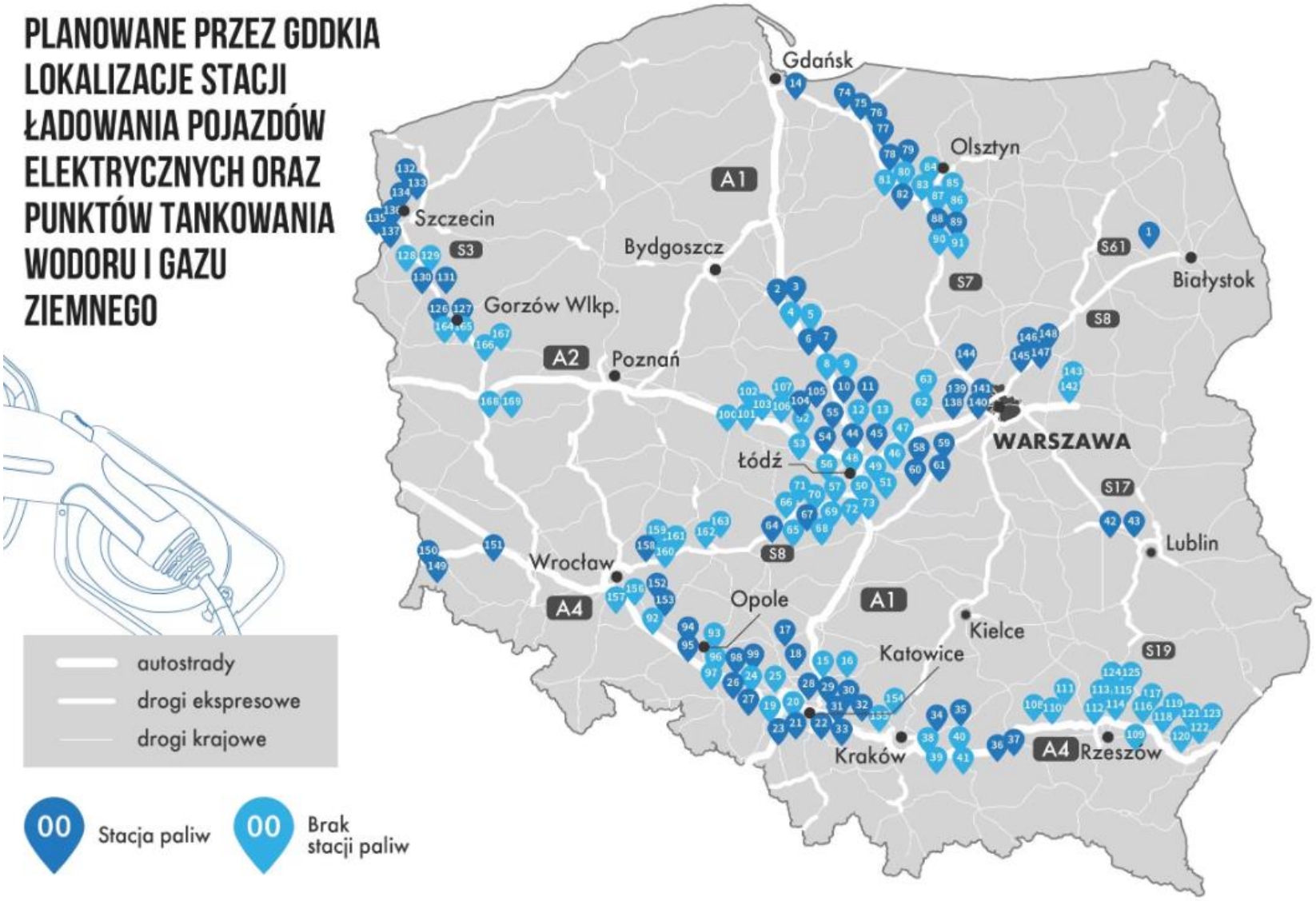
MODEL AVAILABILITY, MARKET MATURITY, ON ROOF FV POWER COST, PERFORMANCE	FUELING SPEED AND RANGE, EVEN IN WINTER, NO HABBITS CHANGE NEEDED

Electricity supply as the dealbreaker

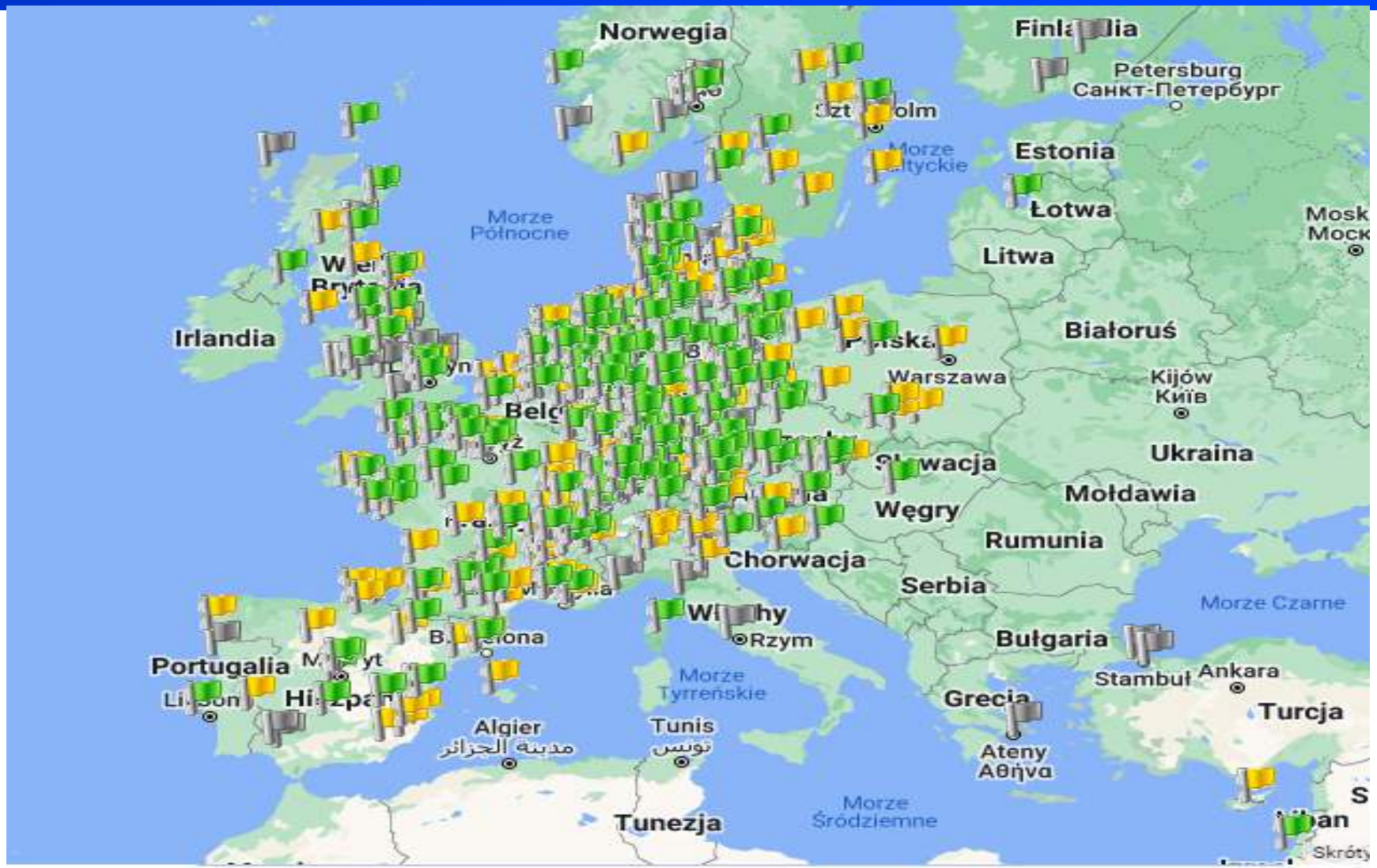
AFIR (EU Alternative Fuels Infrastructure Development Regulation) comes into force on 13 April 2024.

"Transport & Environment organisation calculates that 27,500 points in logistics centres and depots and 14,400 in public places are needed to charge 0.5 million electric trucks in 2030. The total cost of this infrastructure will reach €28 billion. T&E recalls that EU countries spend €100 billion annually on roads. At the same time, T&E is speaking out against gas-powered cars."

Plans for zeroemission stations on TENT

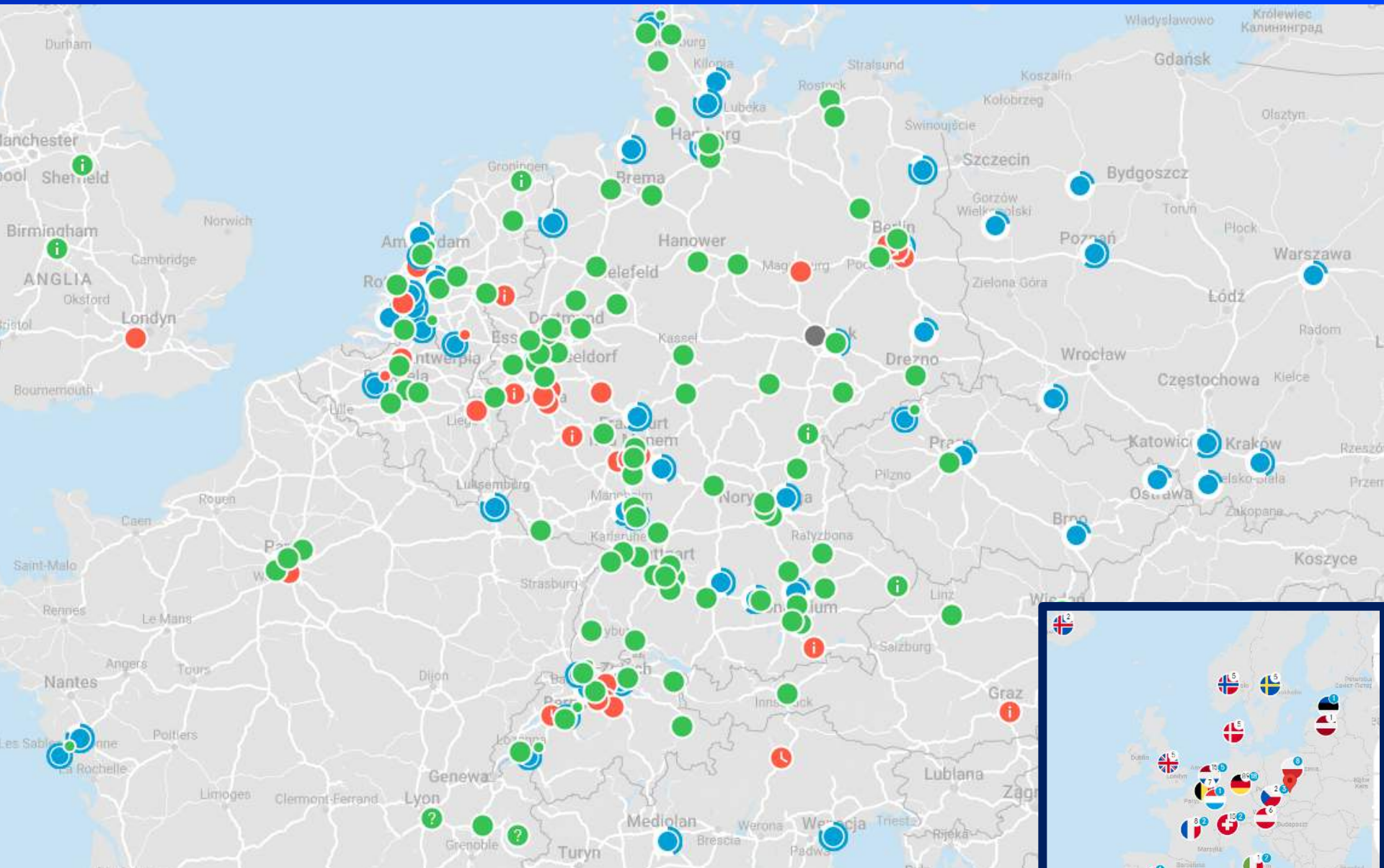


Hydrogen stations in Europe - H2 Stations.org

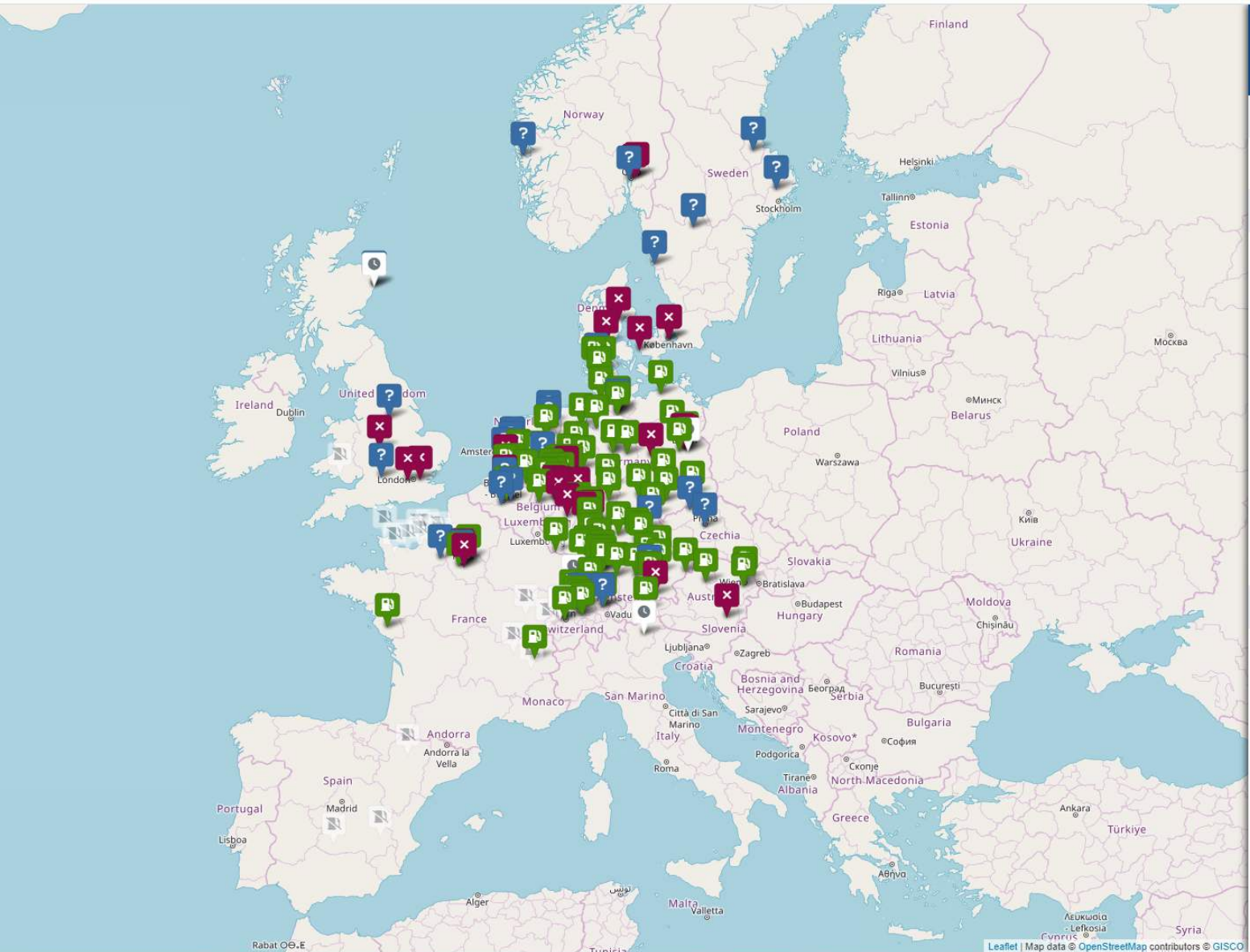


All ○ In Operation ○ Planned ○ Old Projects

Public including planned
H2 LIVE



Where do we refuel a passenger car? - EU Clean Hydrogen JU



HRS Availability Map

with data from the **European HRS Availability System**

Choose H_2 fuelling option

700 bar

Map legend

HRS status

- Available
- Limited availability
- Unavailable
- Availability unknown
- Outside opening hours
- 700 bar H_2 for cars not provided

Availability refers to the selected fuelling option only.

HRS statistics

Number of HRS

Σ total	174
700 bar	155
350 bar	52
350 bar	40

Download HRS List

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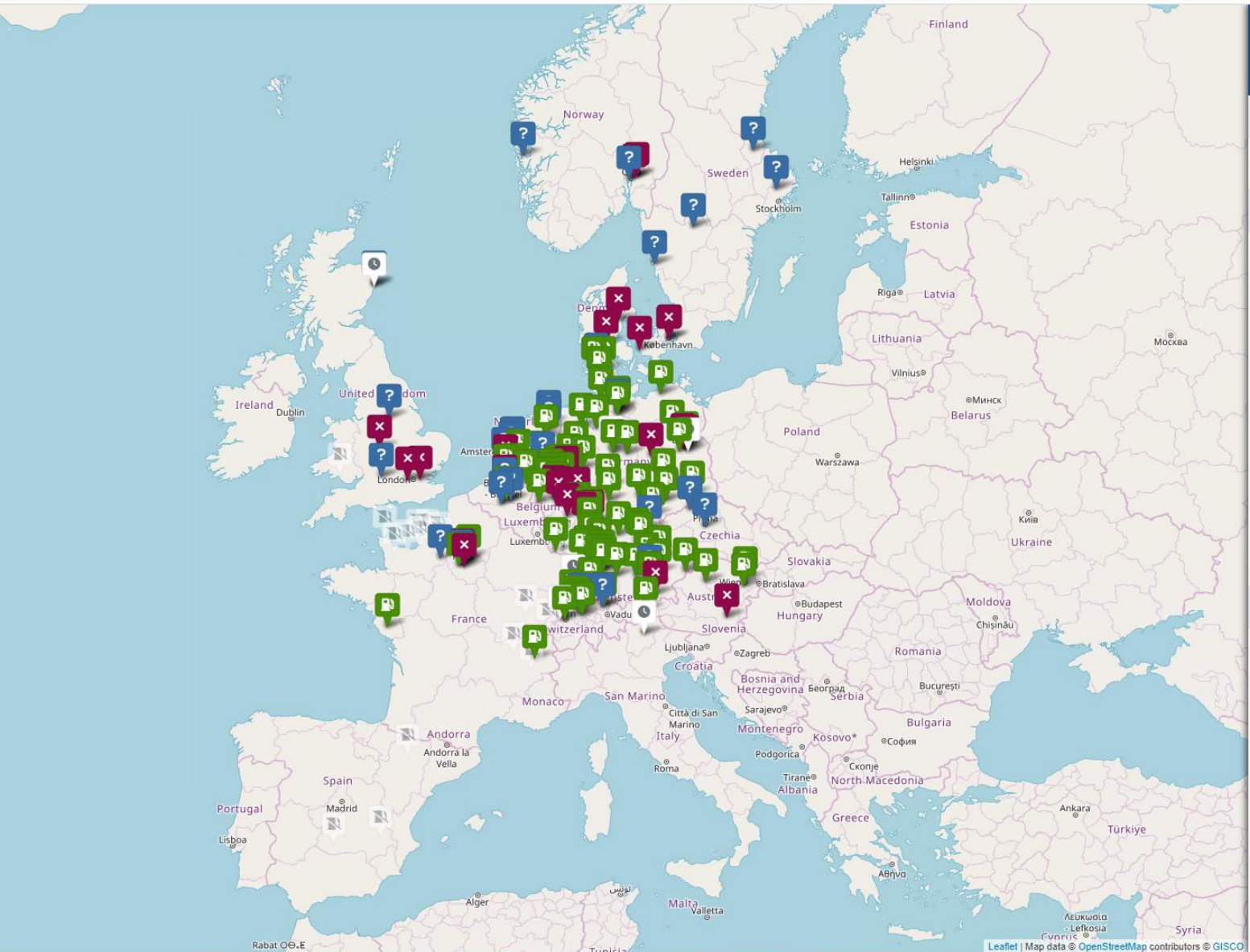
Clean Hydrogen JU · European Commission

Co-funded by the European Union

Where do we refuel a passenger car? - EU Clean Hydrogen JU



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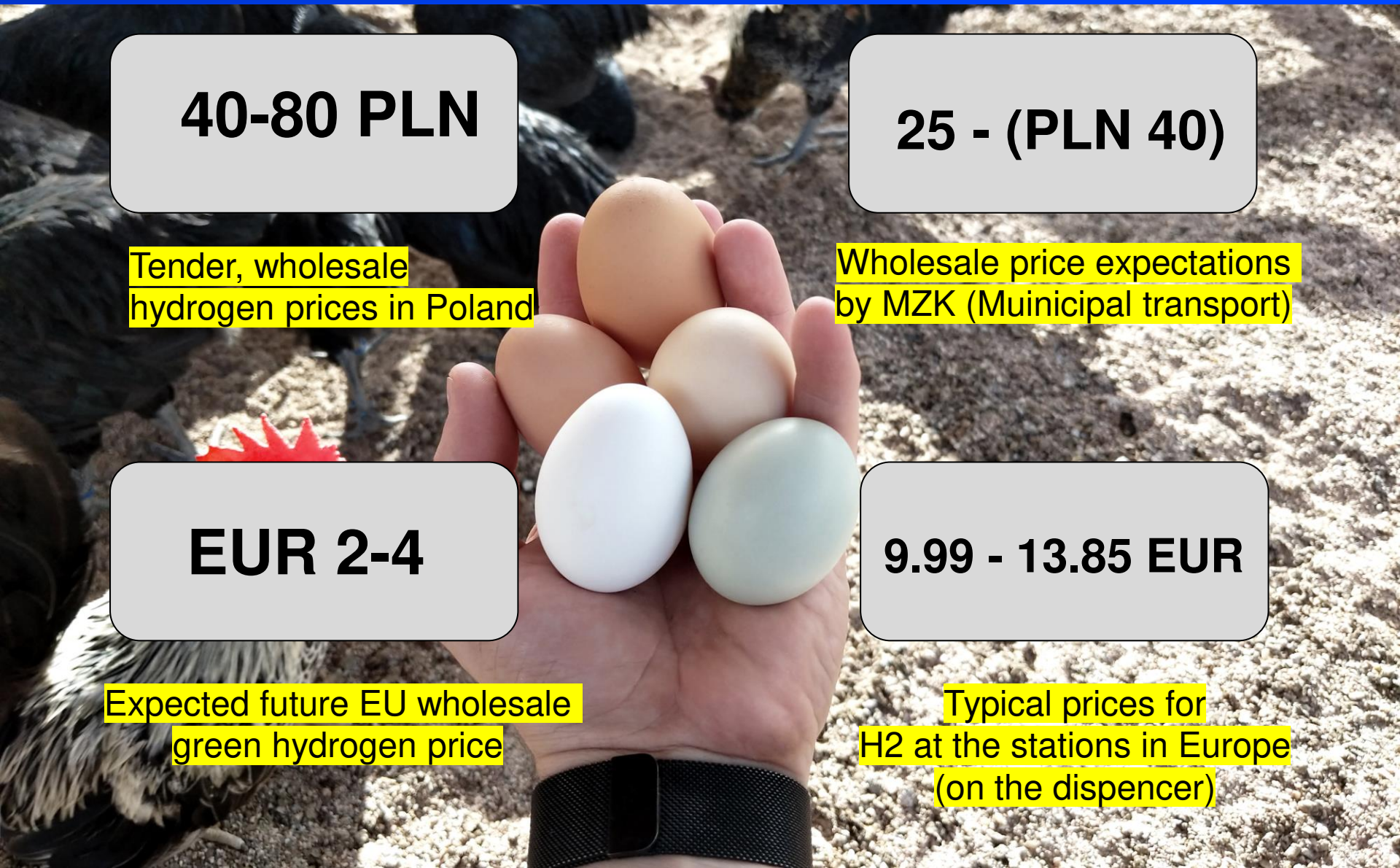
Recharging rate for zero-emission vehicles

Hydrogen dispencers	Fastest DC chargers
3000 kW	350 kW

Customers expecations

Vehicle	Finance	Fuelling time	Range and operational matters
Personal car	Fuel- standard car cost Purchase - standard car price	3-5 (10?) min.	400-700 km in all conditions
Bus	Fuel - diesel bus price Purchase - diesel bus price	10-15 (20?) min.	150-300 km/day in all conditions, also on hills
Truck	Fuel - diesel truck price Purchase - diesel truck price +20% (?)	15-25 min.	400 -700 km TIR 800-1000 km

Chicken & egg - the price of kg H2



40-80 PLN

Tender, wholesale hydrogen prices in Poland

25 - (PLN 40)

Wholesale price expectations by MZK (Muinicipal transport)

EUR 2-4

Expected future EU wholesale green hydrogen price

9.99 - 13.85 EUR

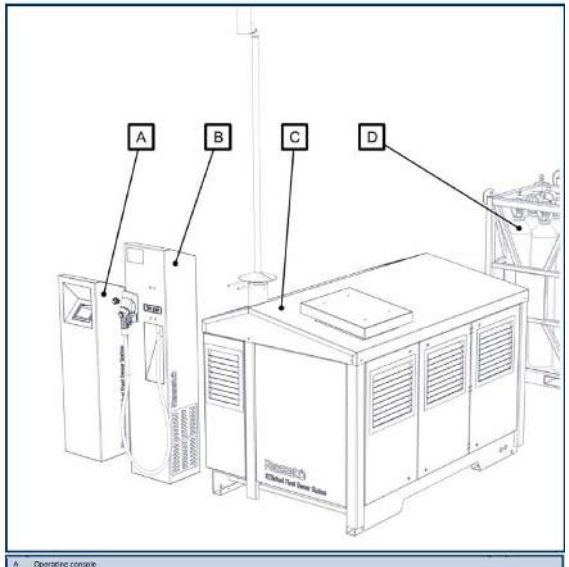
Typical prices for H2 at the stations in Europe (on the dispencer)

Hydrogen filling stations - the basics

Station types

Fleet - private

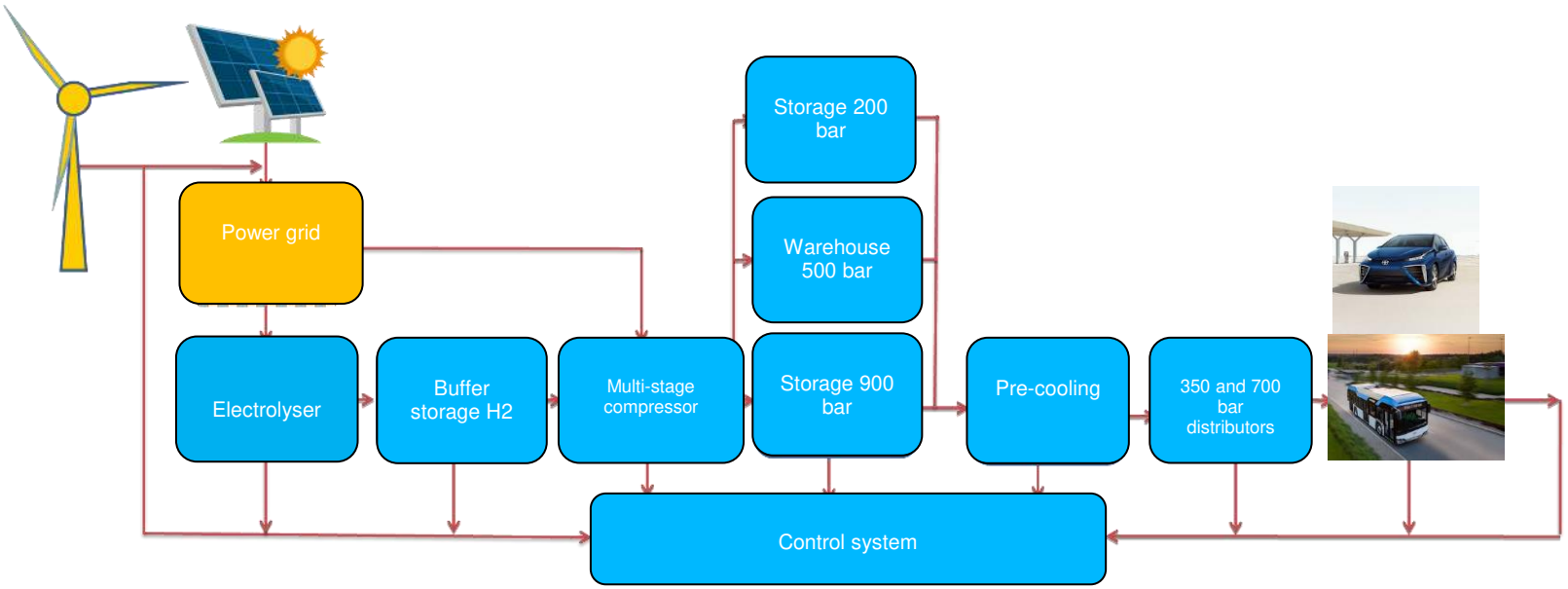
Publicly accessible



A	Operating console
B	Dispenser 700 bar
C	Boosting station
D	Hydrogen supply (Not included)

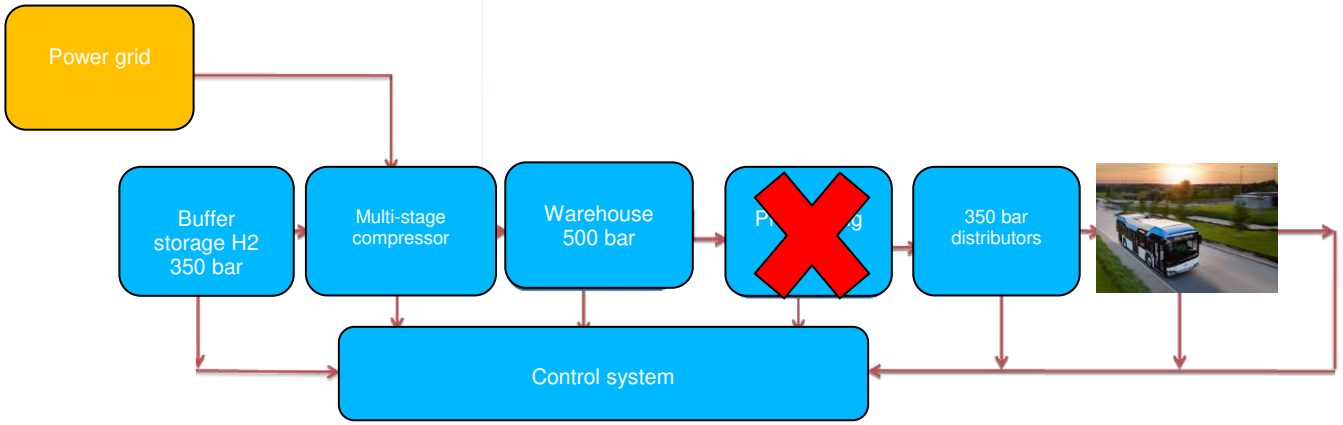
Hydrogen station systems

Full scheme, cars and trucks, hydrogen production



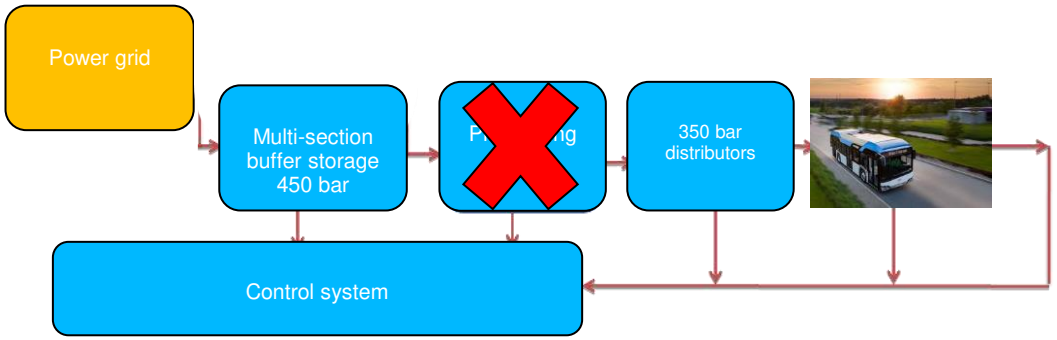
Hydrogen station systems

350 bar trucks or buses only,
hydrogen supplied at 350 bar



Hydrogen station systems

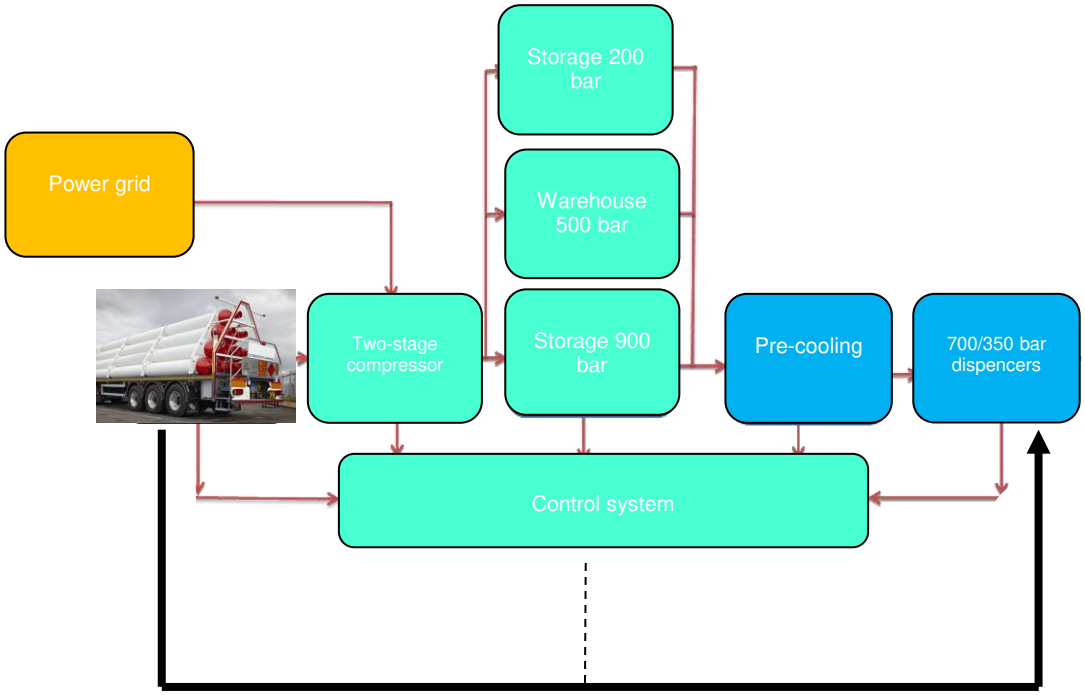
Trucks only, hydrogen delivered at 500 bar.....



Conclusion - the station should be adapted to current needs and optimised in terms of capital and operating expenditure

Trailer instead of buffer storage

Filling from the trailer



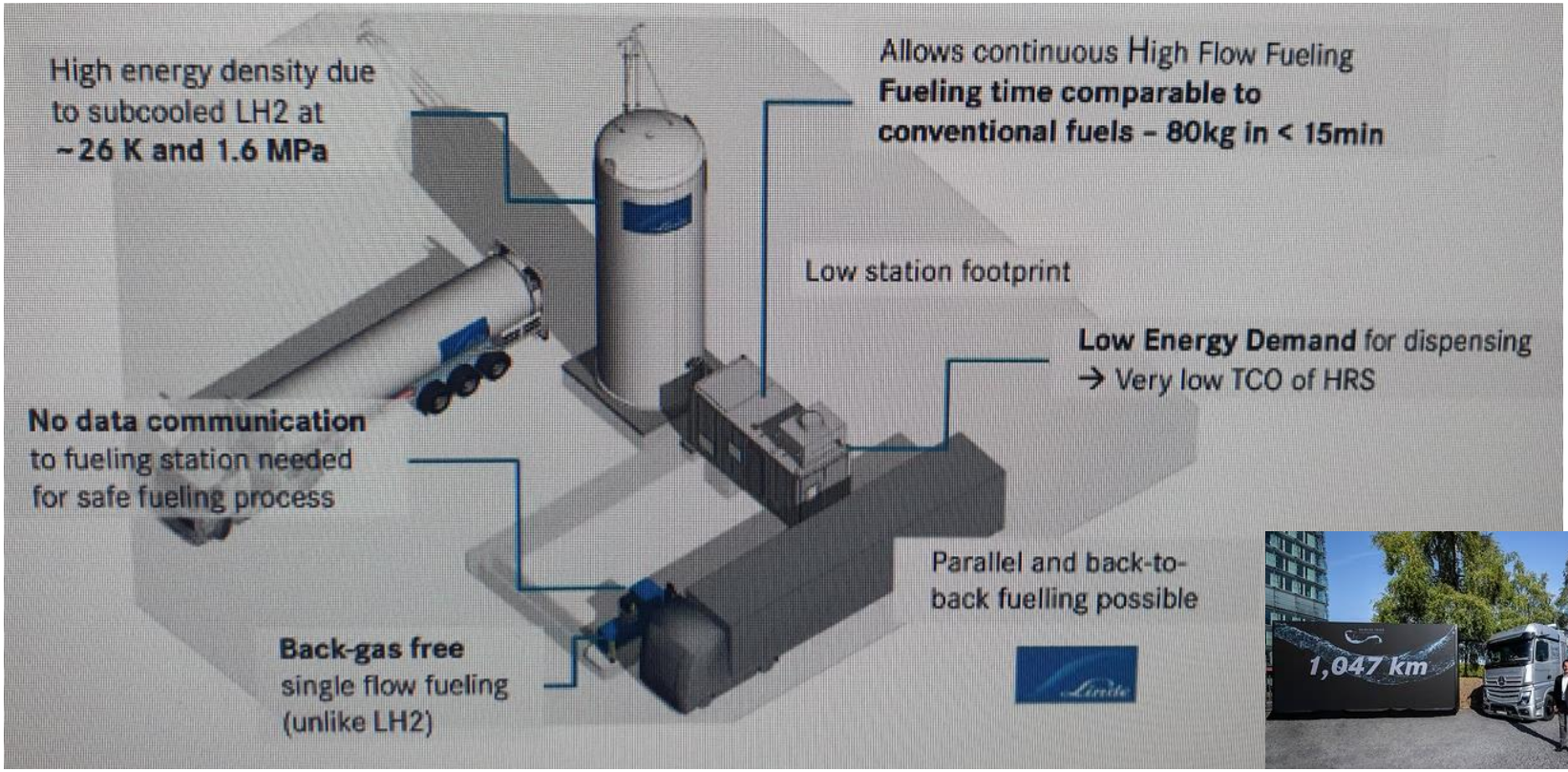
Bypass

The future? The use of liquefied and subcooled hydrogen

Involved among others; Daimler, Linde

sLH2

Regulations and protocols for refuelling until 2026

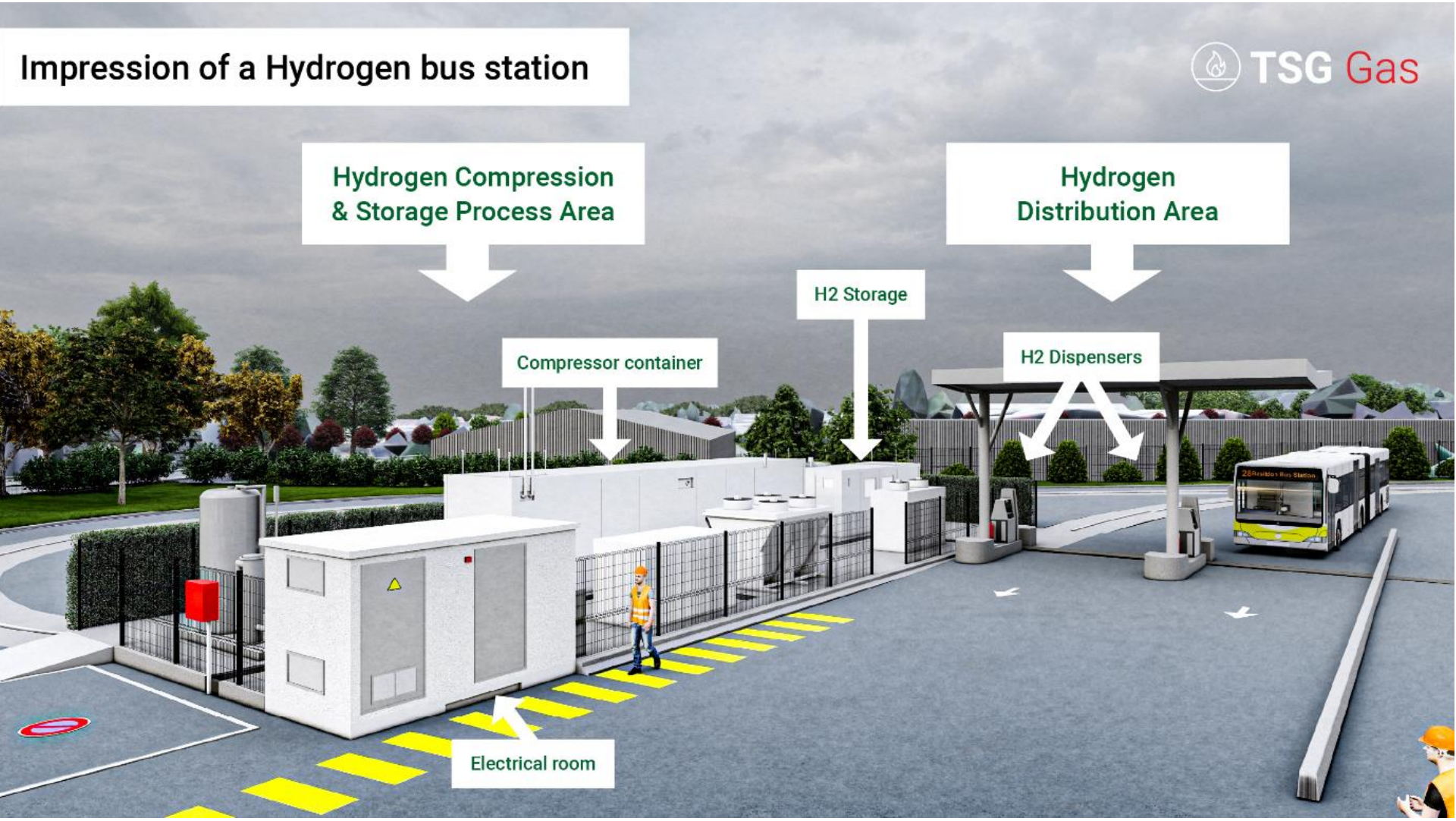


T_{kr} H2 = -240.18 ° C

(T_{kr} Methane = - 90 ° C)

What influence the costs?
Basic station components

Hydrogen station



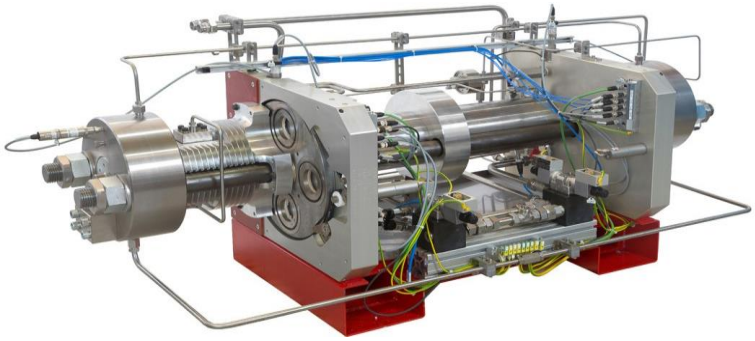
Compressor

- The most expensive component of the station (apart from the electrolyser)
  - 30-50% of the price
- Potentially the most vulnerable to failure.
  - Compression up to 1,200 bar (two-stage or multi-stage)
- Requiring regular maintenance.
  - This should be provided for in the organisation of refuelling or a redundant system should be built

Piston compressor

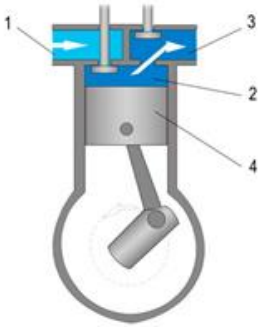
Compressors suitable for fixed and variable loads.

Maximator

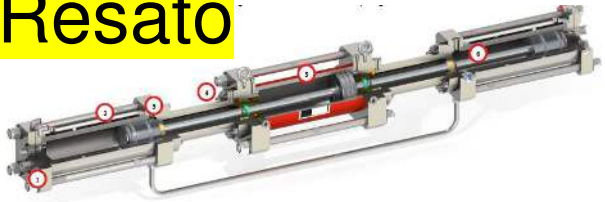


two steps (1:6 each).

- Min. inlet pressure 23 bar
- Max. inlet pressure 400 bar
- Max. discharge pressure 950 bar
- Max. capacity: 100 kg/h H2
- Average capacity: 50 kg/h H2
- Stroke speed (in one direction): 0.1 - 1 Hz
- Energy consumption: 1kWh/kg H2
- ASX technology (patent protected)



Resato



2 steps at the FOS station

4 steps at the FSS

- Min. inlet pressure 10 bar
- Max. inlet pressure 500 bar
- Max. discharge pressure 950 bar
- Capacity 45 kg/h @ 50 bar Ps
- Energy consumption: <1kWh/kg H2
- Intercooling for increased compression efficiency

Dispencer

Type of distributor

Pure 1*H35/H70

Resato 1*H35/H70

Maximator. H35 +H70

Type of nozzle

WEH

TK16

TK17

TK17 + IR

Pressure vessels

HP (900-950bar),
type IV tanks

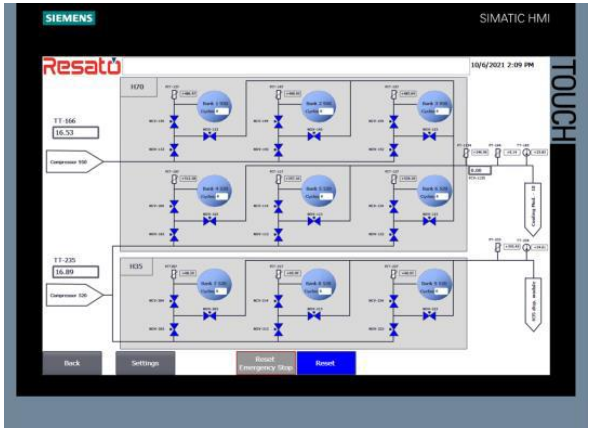
MP (450-550 bar), steel types I and II

Other components

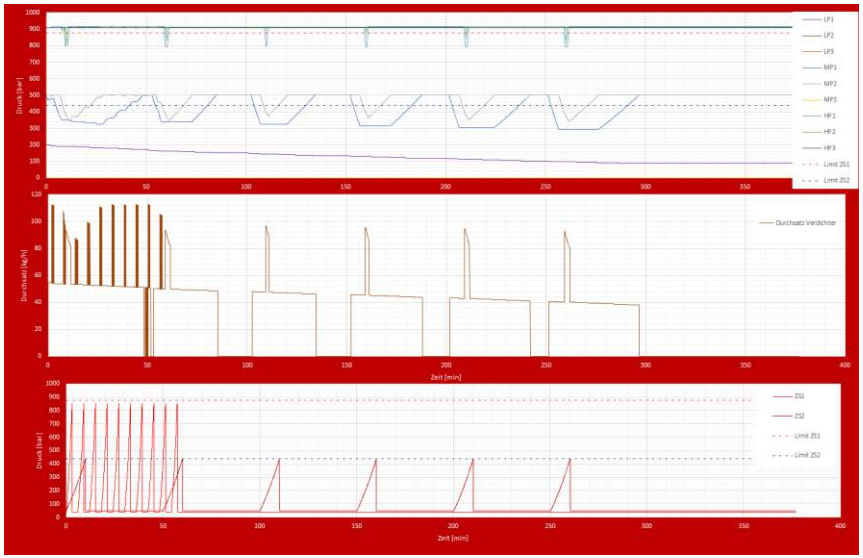
Cooler for H700 T40

Connection panel

Automation and station monitoring

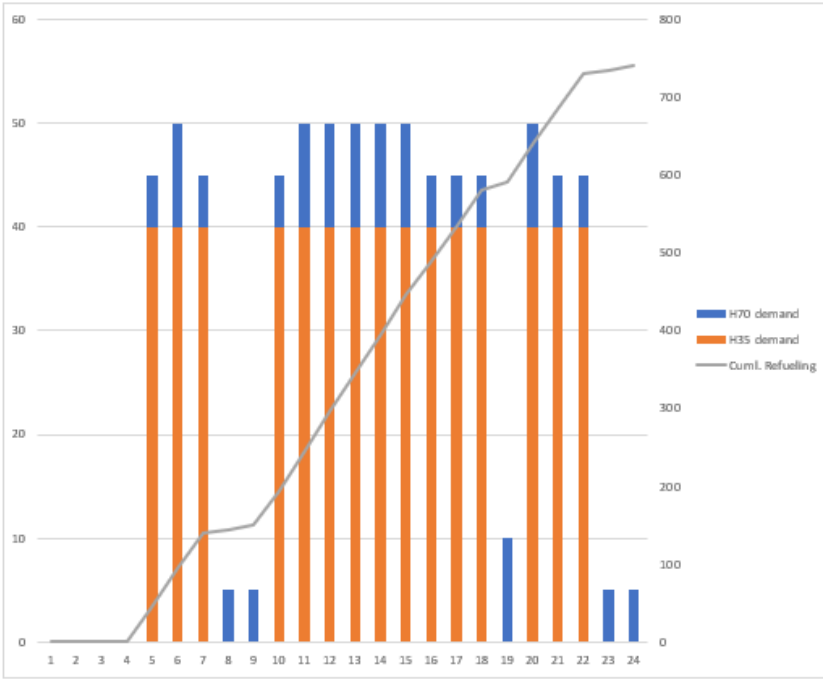


Optimisation of station operation



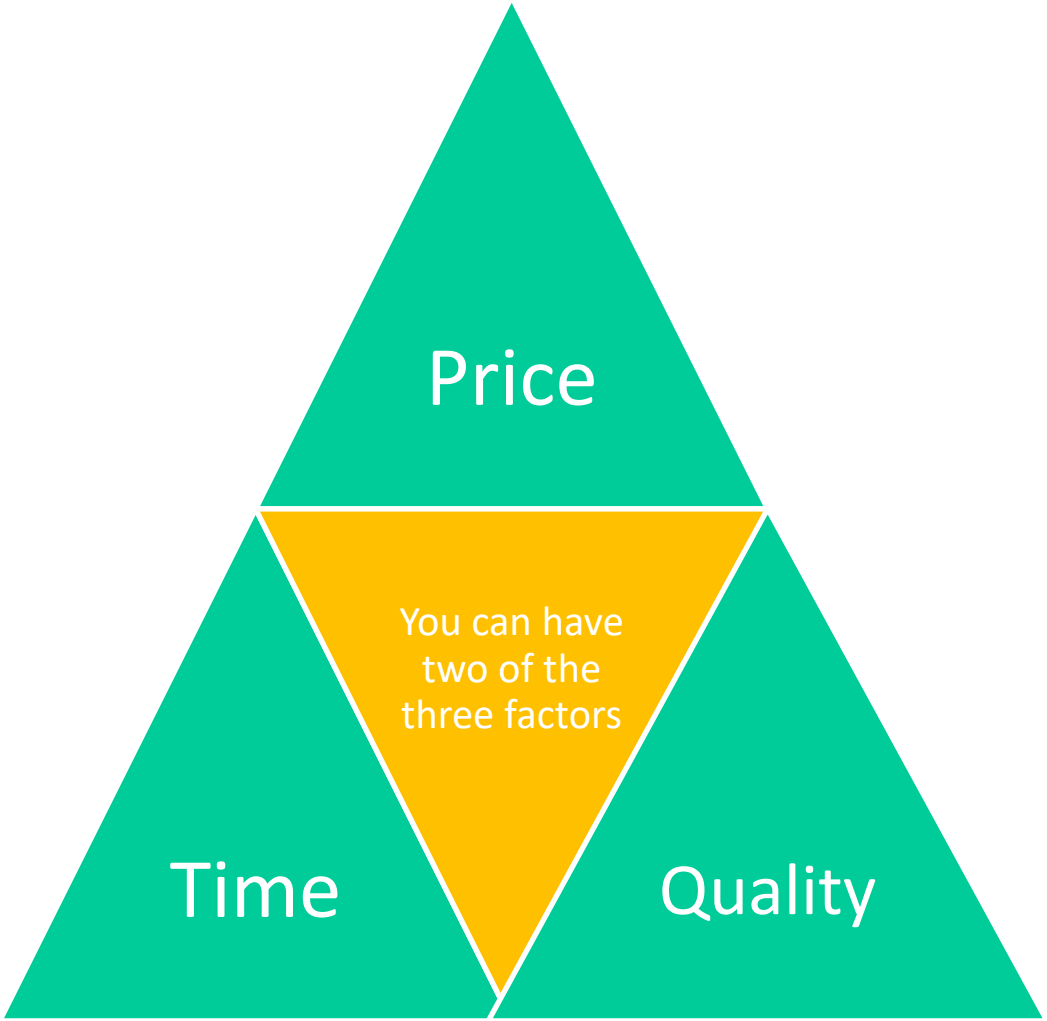
Supplier 1

Supplier 2



Station construction in Polish conditions

Basic principle of successful projects



Time considerations

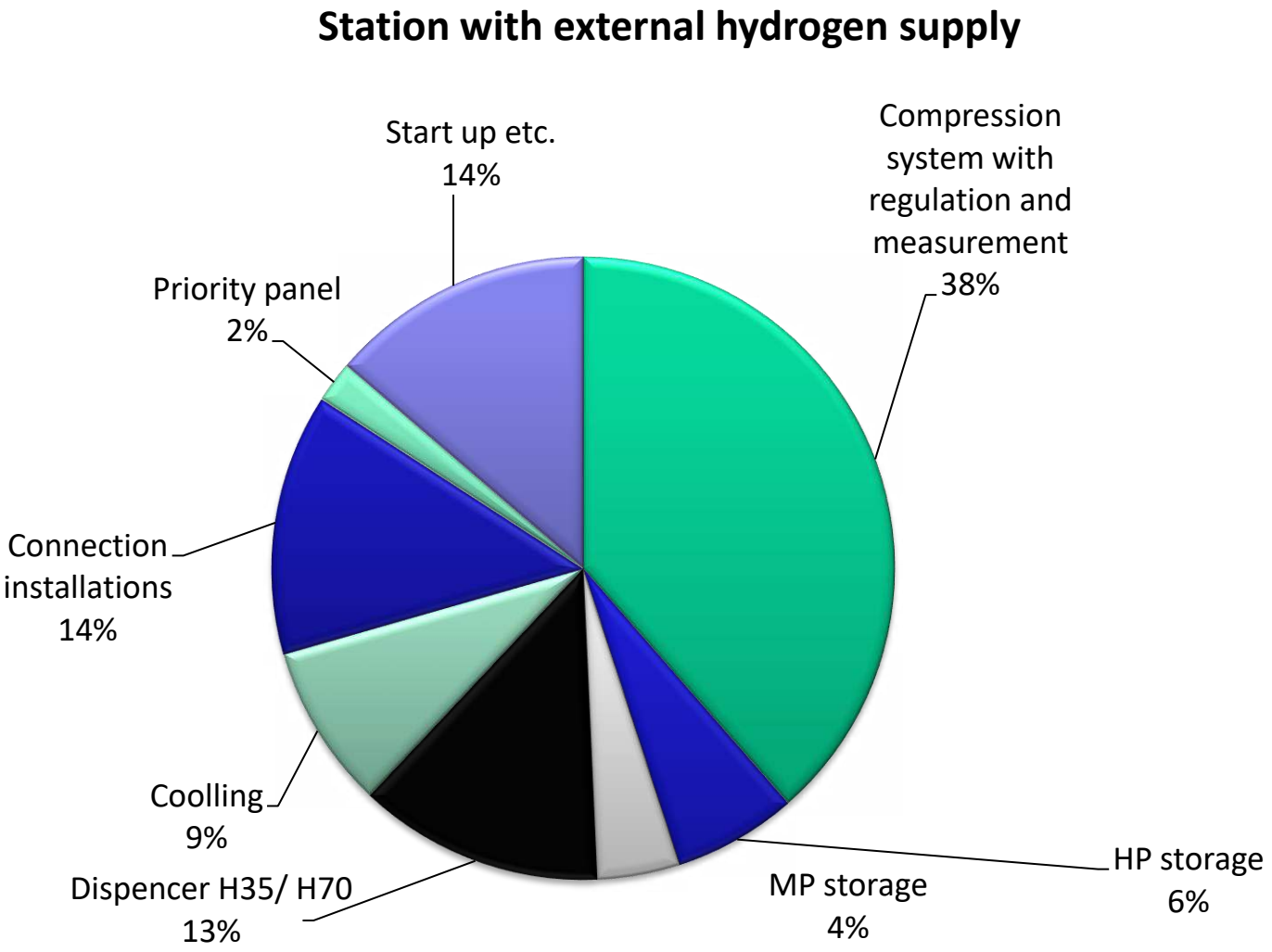
Current delivery times for components from reputable manufacturers, without commissioning and acceptance

14-16 months

Current expected completion date for all station construction in tenders

12-17 months

Component price share



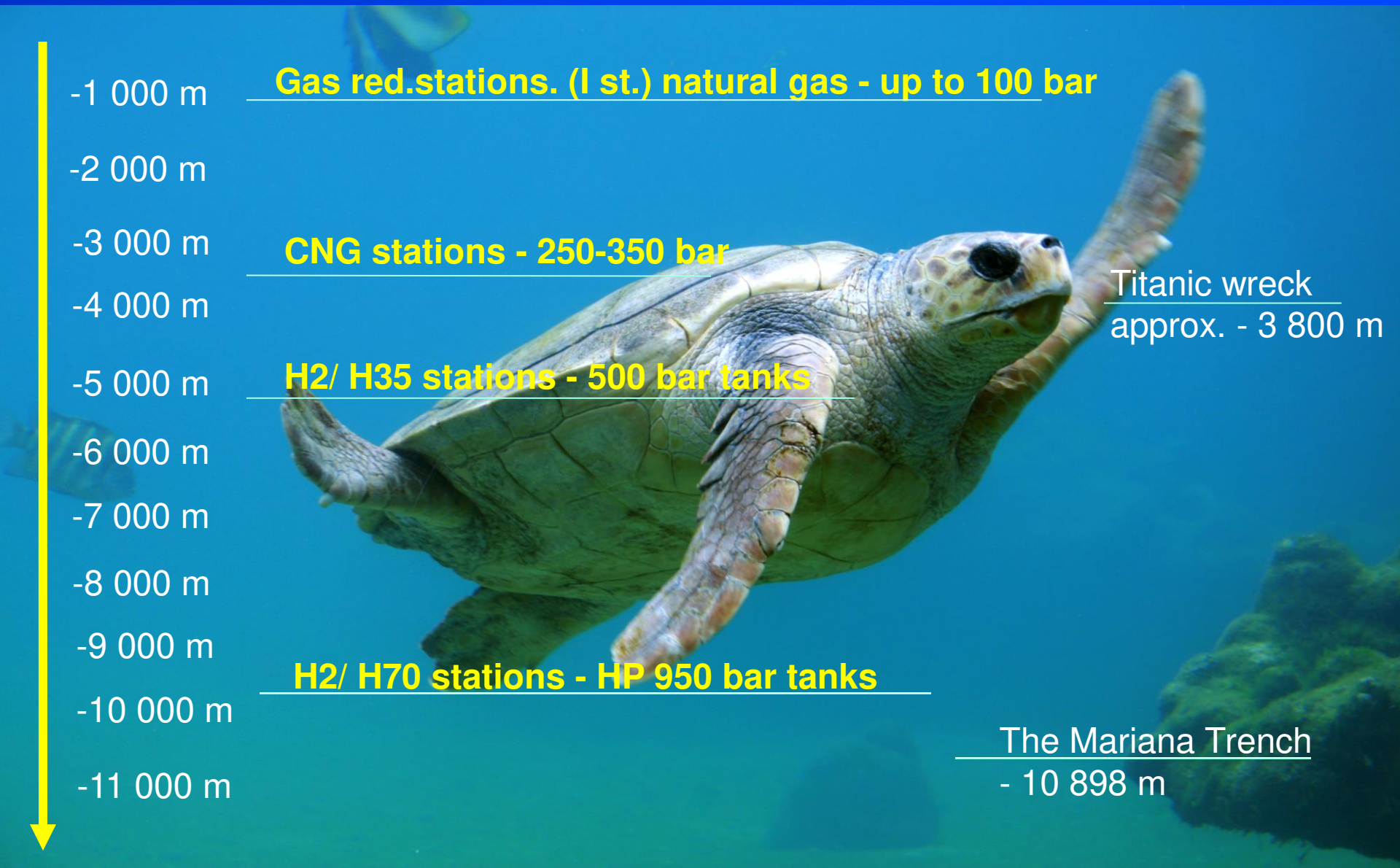
Operating costs

- *Depreciation*
- *Service costs*
- *Costs of parts*

- *Hydrogen loss costs*
- *Cost of hydrogen not used*
- *Costs of station unavailability*

MAINTENANCE AND REPAIRS

Important



-1 000 m

-2 000 m

-3 000 m

-4 000 m

-5 000 m

-6 000 m

-7 000 m

-8 000 m

-9 000 m

-10 000 m

-11 000 m

Gas red.stations. (I st.) natural gas - up to 100 bar

CNG stations - 250-350 bar

Titanic wreck
approx. - 3 800 m

H2/ H35 stations - 500 bar tanks

H2/ H70 stations - HP 950 bar tanks

The Mariana Trench
- 10 898 m

You won't repair it here....

You won't buy parts here....

The work must be carried out properly and without haste

Explosion of P2G hydrogen test plant in South Korea 23.05.2019

Cause - oxygen has entered the hydrogen tank

2 dead and 6 injured

Station explosion in Norway 10.06. 2019

The cause - a hydrogen leak from the high-pressure store - was caused by an incorrectly fitted connector.

3 people injured due to airbag deployment in cars

https://www.electrive.com/2019/06/11/norway-explosion-at-fuel-cell-filling-station/

https://www.aiche.org/chs/conferences/international-center-hydrogen-safety-conference/2019/proceeding/paper/review-hydrogen-tank-explosion-gangneung-south-korea

Example of station service plan

Inspection of tanks

Intervals	Year 1	Year 2	Year 3	Year 4	Year 5	Downtime per Service
6 Months	✓	✓	✓	✓	✓	2 - 10 Hours
12 Months	✓		✓			2 - 10 Hours
24 Months		✓				72 Hours
48 Months				✓		72 Hours
60 Months					✓	120 Hours
Valve Service (20.000 Cycles)	when valve cycles are reached in combination with a regular maintenance service					See above
4.000 Operating hours	when operating hours are reached					36 Hours
20.000 Operating hours	when operating hours are reached					120 Hours

Speed of repair expected in tenders

3-8 h

Time for reviews

3-8 h

Time for repairs
warranty

3-8 h

Time for repairs
post-warranty service, including
restoration after an accident

3-8 h

Time for repairs
out-of-warranty services, including
reinstatement after an accident

Standard availability H2 stations in Europe

90% ?

Older stations

94-97 %

Average producers

96-98%

Top manufacturers

How to ensure user expectations (MPK)?

SAMPLE CONDITIONS

- 20 buses for daily refuelling
- from time to time there will be a passenger car

THE MODEL CURRENTLY ADOPTED	PROPOSED MODEL
Station for 25 buses	One station 350 * 12 public buses
350 and 700 bar	Second station 350 * 12 buses for MPK only
Publicly accessible, also for cars	Additional small 700 bar station (fleet)
Repair and service within 6 hours	Service response 3 h, maintenance and basic service up to 24 h, main service

Advantage: reduced risks, interchangeable work, gradual development, easier projects.

Note: 700 bar passenger cars can also be refuelled to 350 bar!
There will only be less range - just like a partially charged EV

Thank you for your attention.

Marek Pinkas
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