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BRUSSELS, BELGIUM 6-9 OCT 2025

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EUROPEAN
ZERO EMISSION BUS
CONFERENCE 7th - 9th Oct 2025
@ **Busworld** Europe Brussels

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SESSION #8

09:00 -10:30

Delivering Reliable Hydrogen Refueling: A Handbook from Planning to Operation

BREAKOUT SESSION



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No More Refuelling Headaches: Hydrogen at Scale Relieves Bus Operators

Thomas Zorn

Managing Director, Tyczka Hydrogen



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No More Refuelling Headaches: Hydrogen at Scale Relieves Bus Operators

Gases for
tomorrow

Tyczka: Energy and gas supplier for over a century

Tyczka
HYDROGEN



Image source: Tyczka



Outside-in: Public Transport Operation is no walk in the park



Goal zero emission: First of all, new transport technologies need to work!



Hydrogen works: Here is what you need!

Tyczka
HYDROGEN



Image source: Hy2B Wasserstoff

Redundancy matters: Price is king, but availability is King Kong!



Scale matters: Get a robust and well-sized hydrogen station!



Expertise matters: Find a great company that takes care of it!



Image source: Tyczka

Hydrogen is ready – who is too?



How to Improve HRS Dependability

Lewechi Nkata

Senior Consultant, ERM



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Global Lessons for Hydrogen Refuelling

9TH OCTOBER 2025, BRUSSELS

LEWECHI NKATA

Sustainability is our business

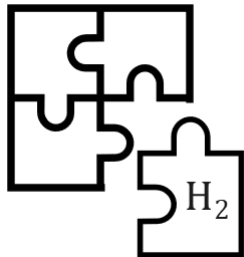
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The importance of dependable HRS

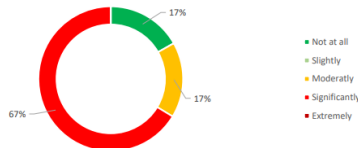
We need a dependable hydrogen mobility system now, to encourage future adoption



UK – Millions spent on hydrogen buses left stuck in depots due to lack of fuel

May 20, 2025 8 min read

To what extent have challenges with your HRS station impacted the deployment of FCBs in your area?



Hydrogen mobility is going to be needed for a resilient and decarbonised transport system.

A successful hydrogen mobility system needs to fulfil the needs of its users^{1,2}

We need strategies to address these problems soon to encourage further adoption.

Sources

1 - UK - Millions spent on hydrogen buses left stuck in depots due to lack of fuel - Hydrogen Central
2 - JIVE2_D4.4_Final_Report_Final_110325.pdf

Station 'dependability' is a function of three main factors



Equipment reliability

- Failures in equipment such as compressors
- Breaking of dispensing nozzles
- Hydrogen leakages



Maintenance arrangement

- Delays in spare part supply
- Insufficient staff available for servicing the station



Hydrogen supply and delivery

- Lack of supply redundancy
- Unexpected use patterns
- Non-standard connections

Underpinning the problems are a lack of stakeholder capacity and incentive

What goes wrong?

HRS equipment reliability

- Station design may be overcomplicated and does not meet actual requirements
- The equipment is not suitable for how HRS currently operates
- Integration or installation expertise is limited

Maintenance arrangement

- There are not enough trained maintenance personnel
- Insufficient local spare parts storage
- Lack of training or knowledge sharing within or between organisations

Hydrogen supply and delivery

- Single hydrogen source is unavailable or used to satisfy competing demands
- Non-standardised delivery equipment makes delivery impossible

What leads to these failures?

What stops it being fixed?

- Station design approach is flawed
- Equipment is unavailable

- Cost of resolution is higher than overall benefit

- No effective way to share learning



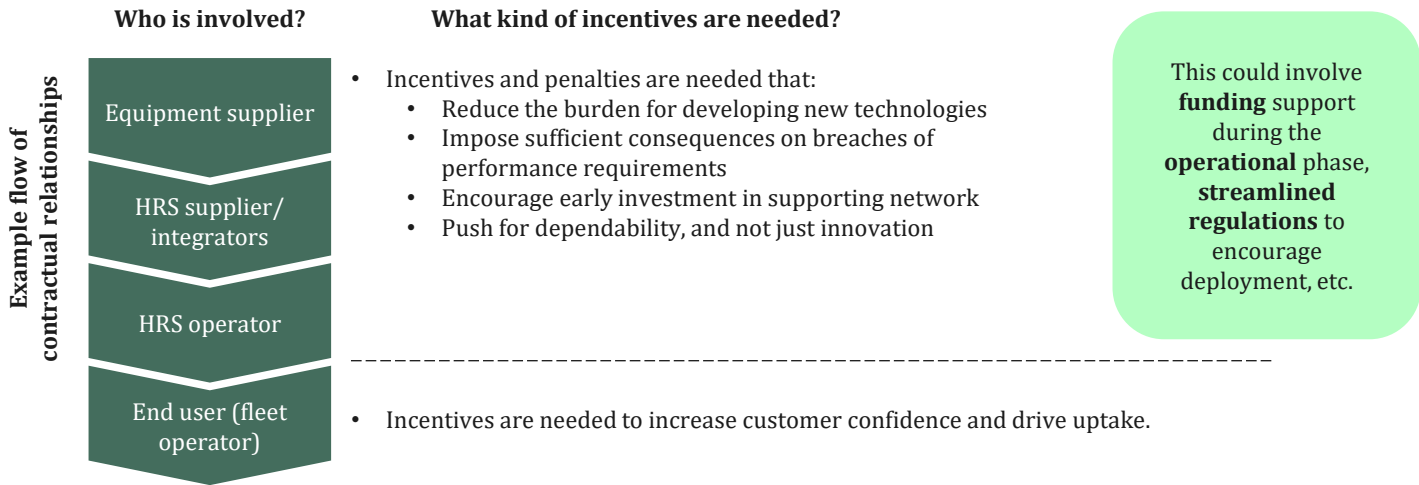


What can be done to improve HRS dependability?

Recommendation:

Align incentives to focus on uptime and throughput

If the HRS operator and OEM revenue is linked to ongoing performance, incentives should be aligned to keep stations functioning well



Recommendation:

Ensure contracting and tendering encourages dependability

Overall,

Contracts and tenders should incentivise problem-solving to reach dependability over penalisation

Specifically,

		Who?	Should do what?
Tender/contract content		HRS projects	Compile operational KPIs based on project experience to be used in tendering
		HRS owners	Use best practices on how to share penalty and risk between contractors
		Contracting bodies	Explicitly state responsibilities for the station
How it is scored		HRS owners	Increase weighting for the track record of HRS suppliers during tendering
Rules		European Commission, National ministries	Allow collaboration between HRS OEMs, owners and clients to develop the final tender specification in national tendering rules

Recommendation: Improve knowledge management and sharing

Overall,

Learnings and solutions need to be consistently captured, shared and incorporated into the design and operation of HRS

Specifically,

	Who?	Should do what?
Standardising approach	Professional organisations	Develop certifications for technicians working on HRS
	CH JU projects and other project developers	Create simplified reference designs for HRS, noting potential changes for different use cases and frequent failures
	Standardisation bodies e.g. ISO	Develop equipment standards for key HRS components to be used during design
Mandating knowledge sharing	Funding bodies e.g. CH JU	Mandate knowledge sharing workshops at project inception with previous project participants with prior experience
	HRS owners	Mandate training of staff and local maintenance workshops as tender condition
	HRS operators	Upskill local technicians in adjacent industries, such as high-pressure gas handling

The fundamentals are in place, and some have cracked the code. But more needs to be done, faster...

Hydrogen fuel at new giant refuelling station in China almost ten times cheaper than in US

The facility in Guangdong province can deliver 4,000kg of H₂ every day



The new hydrogen refuelling station in Guangdong province built by Yuntao Hydrogen Energy pictured at its opening ceremony. (Photo: Yuntao Hydrogen Energy)

A small town in Washington state makes its own hydrogen fuel for only \$4 per kg

July 30, 2025

By Matt Lister, Editor



Douglas County PUD hydrogen refuelling station, Washington State. (Image: Douglas County PUD)



Hy2B, Germany

10 €/kg delivered hydrogen price for passenger cars (700 bar) and 8 €/kg for trucks and buses (350 bar) achievable (with RFNBO certification).

Sources: Hydrogen Insight, Driving Hydrogen, Hy2B

Thank you

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Thanks goes to the stakeholders below who participated in interviews. The opinions and recommendations in this document are those of the authors alone.



Project coordination:

elementenergy
an ERM Group company

Project dissemination:



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Recommendations for improving HRS dependability

HRS Design Concepts and Strategies for High HRS Availability

Alexander Stiehl

Team Leader Plant Technology, Regionalverkehr Köln



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Delivering Reliable Hydrogen Refuelling

A Handbook from Planning to Operation

Alexander Stiehl, RVK

09.10.2025, Brussels



Wir bewegen die Region



Wir bewegen die Region



Wir bewegen die Region



Defining a Hydrogen Refuelling Station

Black Boxes

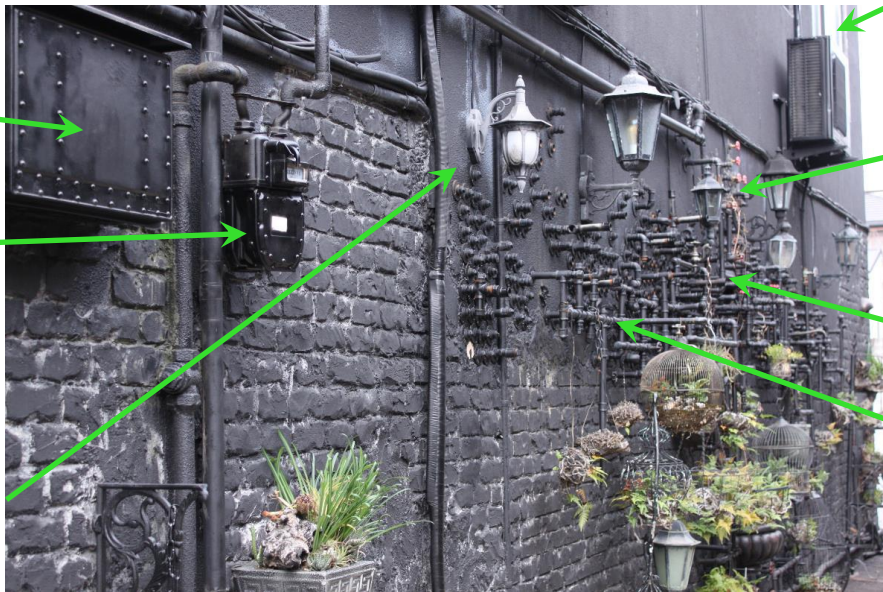
Compressor
Hydraulics
Dispenser
...

Measuring Equipment

Pressure
Temperature
Flow
...

Lights and Signals

Feedback of
Availability or Failure



ART or HRS? Found in the streets of Kyoto.

Heat Control

Heat of compression
Ambient Temperature
Hydrogen Cooling

Pipes and Instruments

Fitting requirement of
high pressure and
hydrogen attributes

Diversity

Covering specific
failures

Redundancies

Covering lack of
availability

Basic Design Hydrogen Refuelling Station

1 Black Boxes

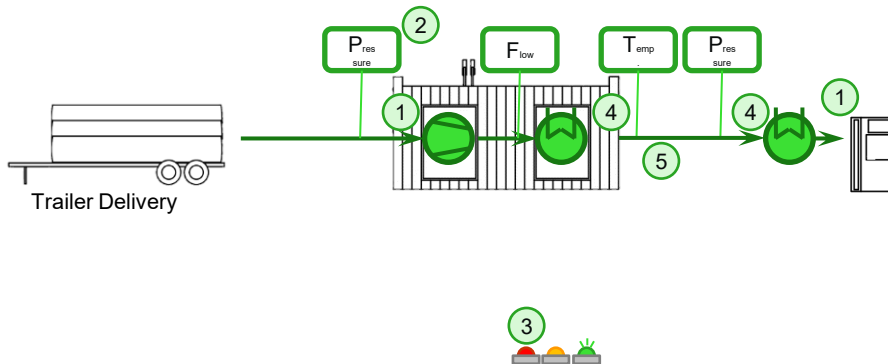
Compressor
Hydraulics
Dispenser
...

2 Measuring Equipment

Pressure
Temperature
Flow
...

3 Lights and Signals

Feedback of
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4 Heat Control

Heat of compression
Ambient Temperature
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Fitting requirement of
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Covering specific
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Resilient Upgrade Hydrogen Refuelling Station

1 Black Boxes

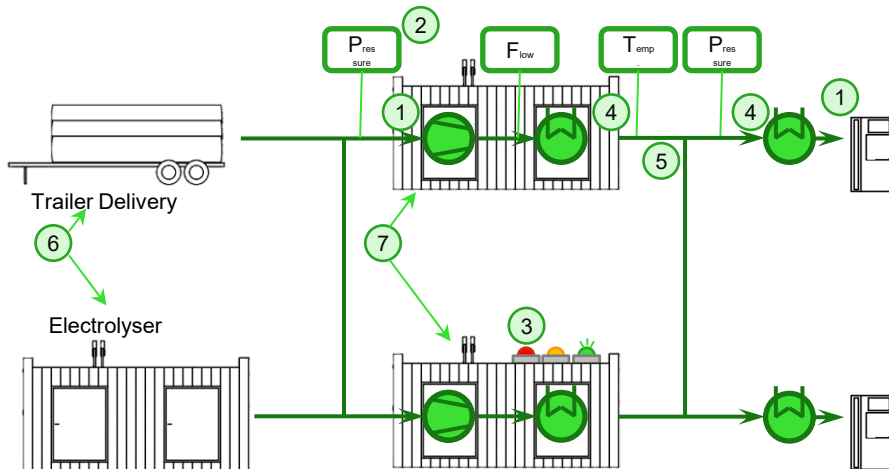
Compressor
Hydraulics
Dispenser
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2 Measuring Equipment

Pressure
Temperature
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4 Heat Control

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5 Pipes and Instruments

Fitting requirement of
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6 Diversity

Covering specific
failures

7 Redundancies

Covering lack of
availability

Stabilised Upgrade Hydrogen Refuelling Station

1 Black Boxes

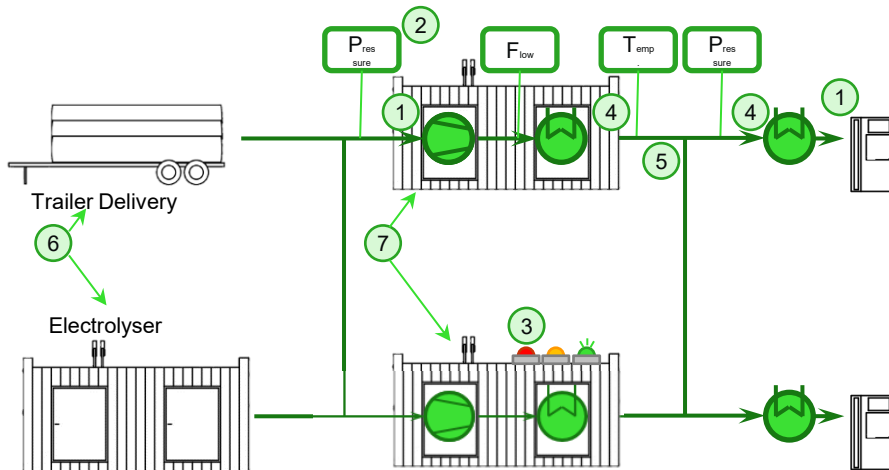
Compressor
Hydraulics
Dispenser
...

2 Measuring Equipment

Pressure
Temperature
Flow
...

3 Lights and Signals

Feedback of
Availability or Failure



4 Heat Control

Heat of compression
Ambient Temperature
Hydrogen Cooling

5 Pipes and Instruments

Fitting requirement of
high pressure and
hydrogen attributes

6 Diversity

Covering specific
failures

7 Redundancies

Covering lack of
availability

8 Stabilisation

Reducing volatile impact

- Down Scaling + Numbering Up
- Air Cooling instead of Water Cooling

Optimised Upgrade Hydrogen Refuelling Station

1 Black Boxes

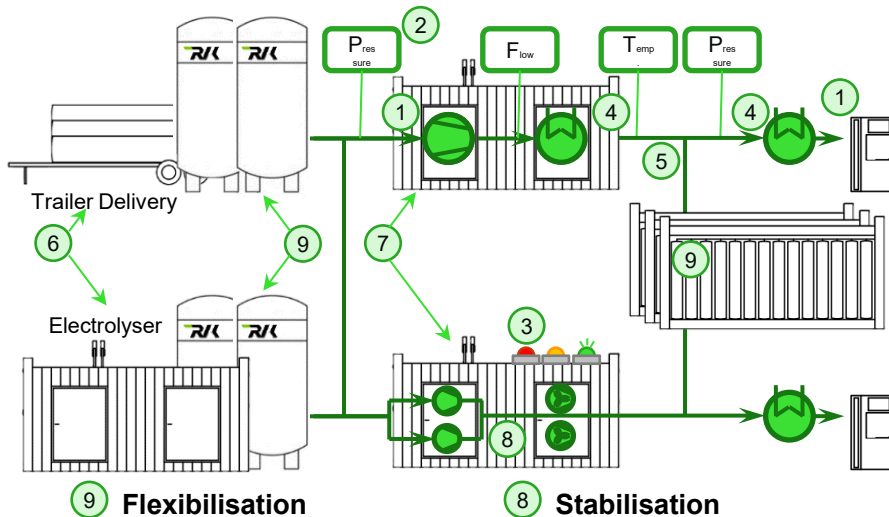
Compressor
Hydraulics
Dispenser
...

2 Measuring Equipment

Pressure
Temperature
Flow
...

3 Lights and Signals

Feedback of
Availability or Failure



4 Heat Control

Heat of compression
Ambient Temperature
Hydrogen Cooling

5 Pipes and Instruments

Fitting requirement of
high pressure and
hydrogen attributes

6 Diversity

Covering specific
failures

7 Redundancies

Covering lack of
availability

9 Flexibilisation

Increase Time to React
(Resilience)

- LPS: Delivery, Production
- HPS: Compressor Down Time

8 Stabilisation

Reducing volatile impact

- Down Scaling + Numbering Up
- Air Cooling instead of Water Cooling

Experiences of Operating a Hydrogen Refuelling Station

Hydrogen Delivery

Vessel Storage

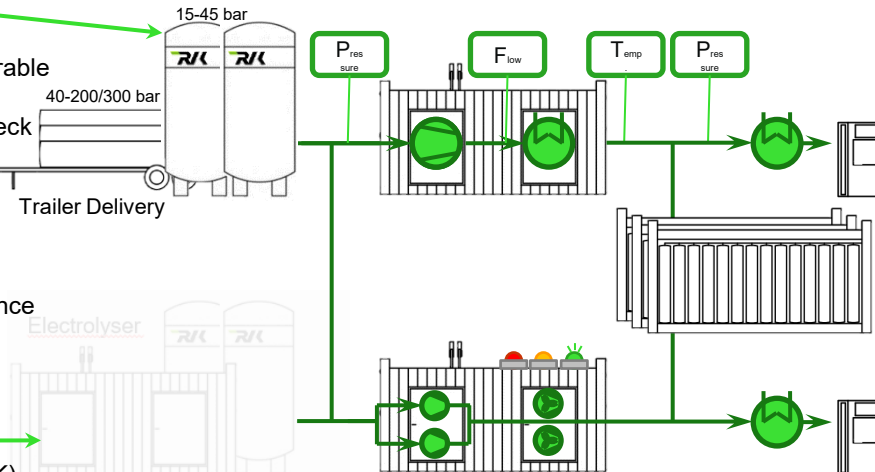
delivery on occasion
residual amounts deliverable
continuous supply
buffer for supply bottleneck

Trailer Storage

rental fee
delivery on demand
discrete supply
Interruption due to distance

On Site Production

no experiences yet (RVK)
estimated in the end of 2026
estimation of decreased costs
decouple from compressor runtime



low pressure buffer volume can enable flexibility

most common H₂ sources offer 200 or 300 bar

Note

low pressure buffer volume can enable flexibility
most common H₂ sources offer 200 or 300 bar

Experiences of Operating a Hydrogen Refuelling Station

Compressor Inlet Pressure

Low Pressure Storage

affects flow

$$p_{\min/\max} \rightarrow \dot{m}_{\min/\max}$$

Delivery

pressure use to change in range (e.g. 15-45 bar)

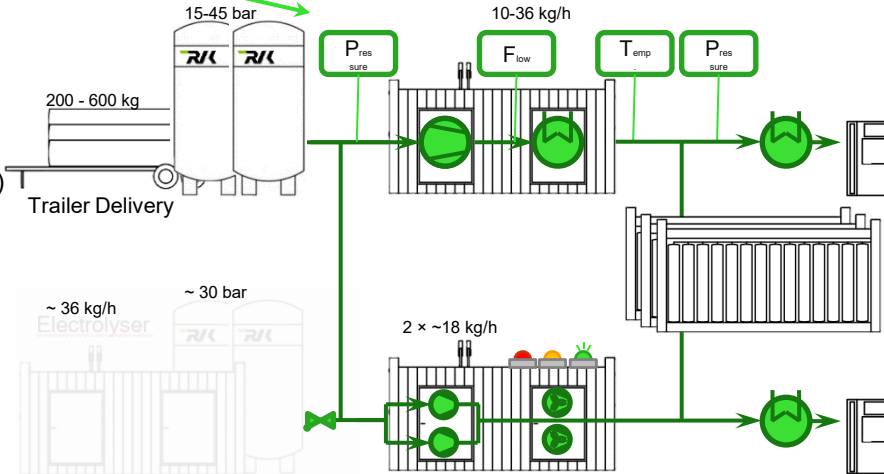
Range must consider fatigue life

→ huge storage volume

On Site Production

Pressure use to stay on a constant level if production rate equals compressor flow rate

→ buffer volume



volume of LPS depends on hydrogen source

flow rate must consider unsteady inlet pressure

Note

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- most common H_2 sources offer 200 or 300 bar
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Experiences of Operating a Hydrogen Refuelling Station

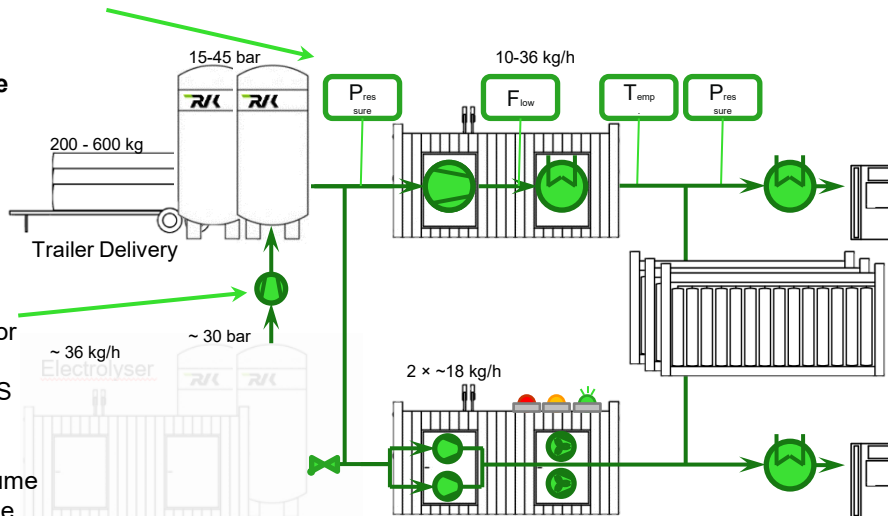
Compressor Inlet Pressure
Low Pressure Storage
 affects flow

$$p_{\min/\max} \rightarrow \dot{m}_{\min/\max}$$

On Site Production
 use of small compressor
 enables storing H_2 at
 higher pressures in LPS
 from on site production

→ decrease buffer volume
 increase LPS volume

→ flexibilisation of production
 considering costs and supply



Note

- low pressure buffer volume can enable flexibility
- most common H_2 sources offer 200 or 300 bar
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- storage of produced H_2 via pressure increase
- decouple production from compressor runtime

Experiences of Operating a Hydrogen Refuelling Station

Compressor Scale + Number

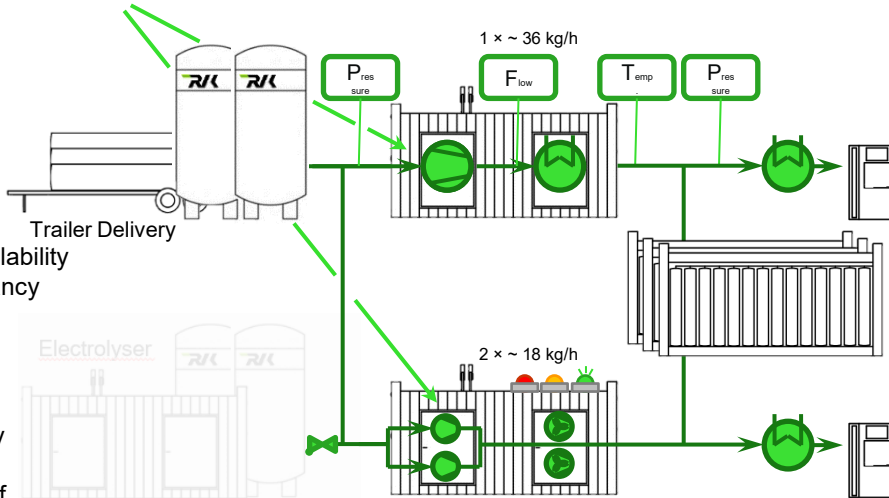
halving flow rate
+ doubling number

→ decrease risk and
impact of failures

→ enables ~100% availability
due to 50% redundancy

CAPEX vs. OPEX

increase number to
optimum of redundancy
(CAPEX)
consider equalisation of
compressor runtime to optimum
of maintenance frequencies
(OPEX)



scale and number depending on risk and impact

scale and number depending on financing

Note

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Experiences of Operating a Hydrogen Refuelling Station

Compressor Scale + Number

Effect on Compression Heat

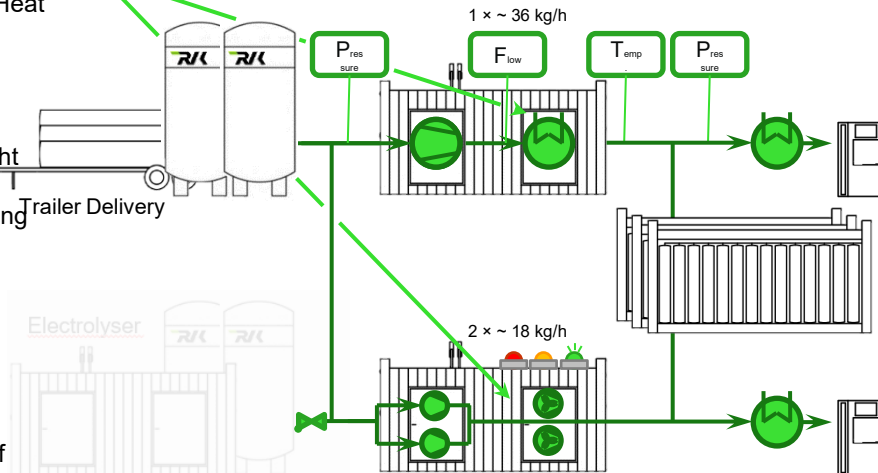
halving flow rate
+ doubling number

→ less heat built-up might
enable air cooling
instead of water cooling

→ less power demand
might enable direkt
drive instead of
hydraulic drive

→ possibility of
decreasing amount of
installed equipment

→ less potential of
downtimes



scale and number depending on energy control

scale and number depending on periphery

Note

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Experiences of Operating a Hydrogen Refuelling Station

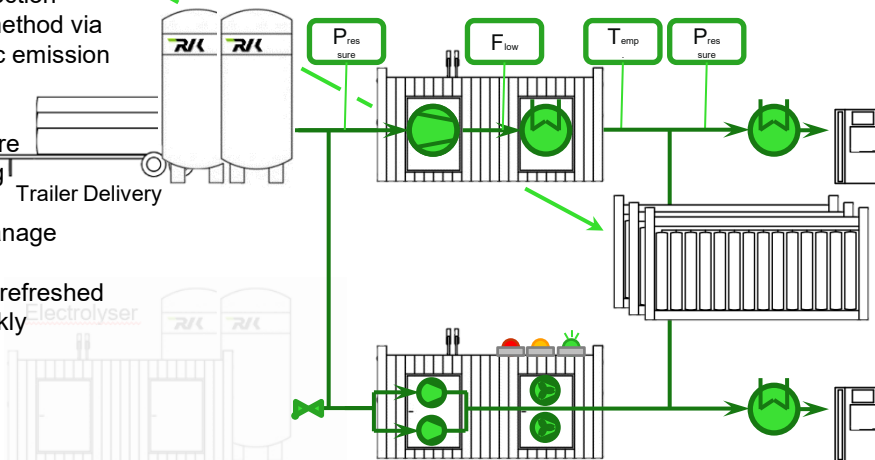
High Pressure Storage (HPS)

consider in-service inspection

- steel vessels: easy method via ultrasonic or acoustic emission testing
- type 4 vessels: deinstallation, pressure test with water, drying

consider partitions to manage taking and loading H_2

- small volume can be refreshed to high pressure quickly
- different sections of volume and pressure enable best pressure gradient
 - velocity
 - H_2 refuelling level



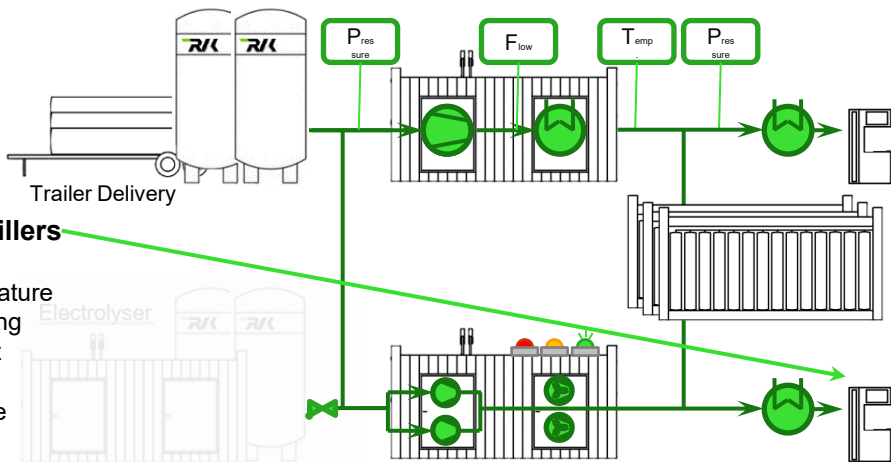
HPS scale depending on stored H_2 and material

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Experiences of Operating a Hydrogen Refuelling Station



Dispensers and Chillers

consider refuelling time

- low ambient temperature enable short refuelling
- chillers enable short refuelling at higher ambient temperature
- -20°C is common
- -5°C is possible also
- check if ambient temperature might be sufficient

ambient temperature might impact refuelling rate

less complex equipment at higher chiller outlet

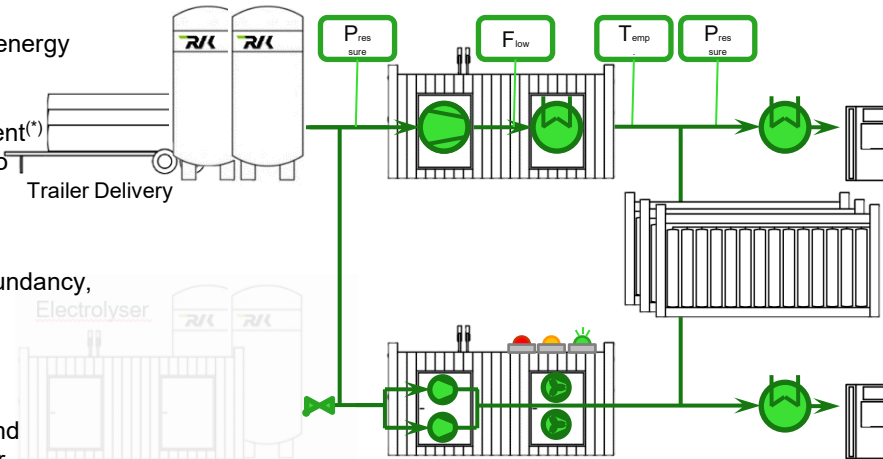
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Experiences of Operating a Hydrogen Refuelling Station

Reliability vs. Cost

- costs for operation
3 - 5 kWh/kg electric energy
- maintenance
→ 2 – 4% of investment^(*)
→ double costs due to redundancy
- depreciation
high costs due to redundancy, reserves, complex equipment
- adjustments and expansions difficult and expensive due to poor after sales service



complex plant design increase hydrogen costs

though 100% availability at nozzle is essential

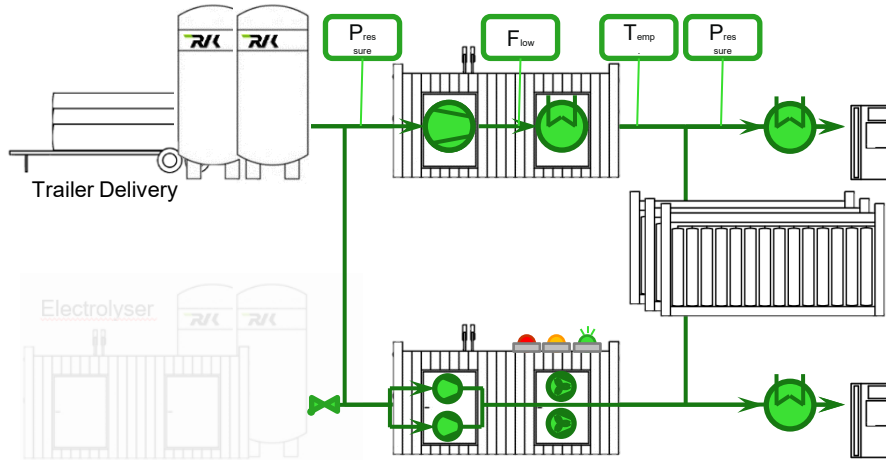
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^(*) Klaus H. Weber, Engineering verfahrenstechnischer Anlagen
Springer Vieweg 2. Auflage

Experiences of Operating a Hydrogen Refuelling Station

Most Simple Way of Refuelling H_2

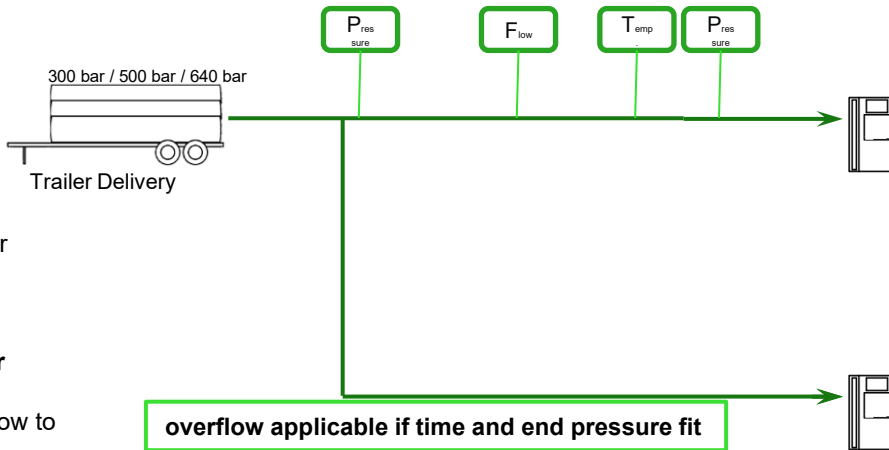


Experiences of Operating a Hydrogen Refuelling Station

Most Simple Way of Refuelling H_2

Mobile Fueler

process control system
calculates refuelling
ramp
15 – 20 min to ~350 bar



Mechanical Dispenser

throttle plate reduces flow to
minimum heat build-up
15 – 30 min to 180 – 260 bar

overflow applicable if time and end pressure fit

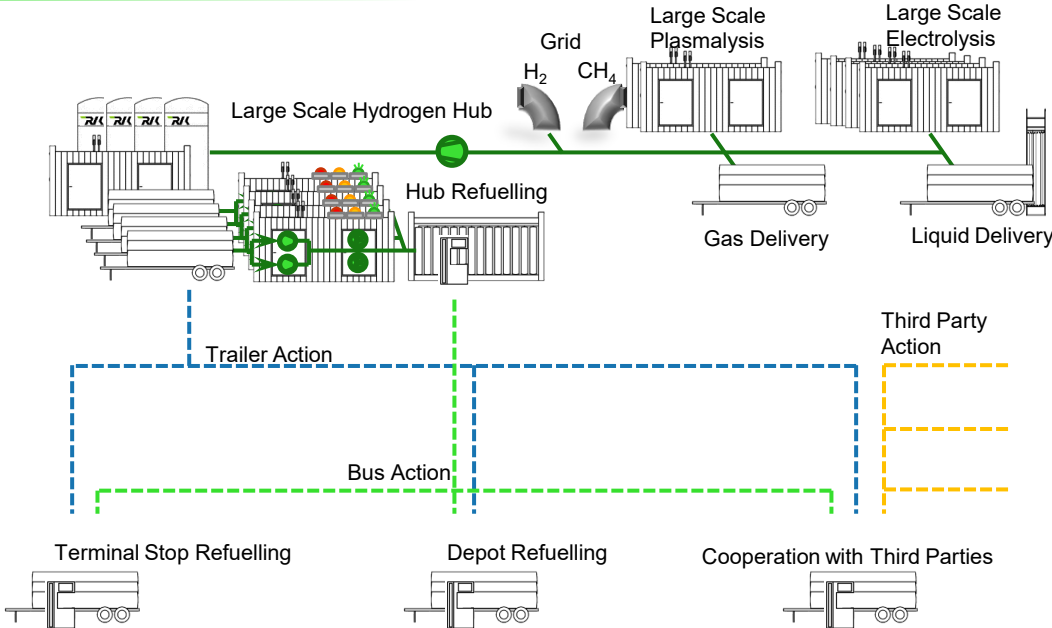
necessity of availability of high pressure source

short term from initiation to commissioning

Note

low pressure buffer volume can enable flexibility
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necessity of availability of high pressure source
short term from initiation to commissioning
...
space for more experiences

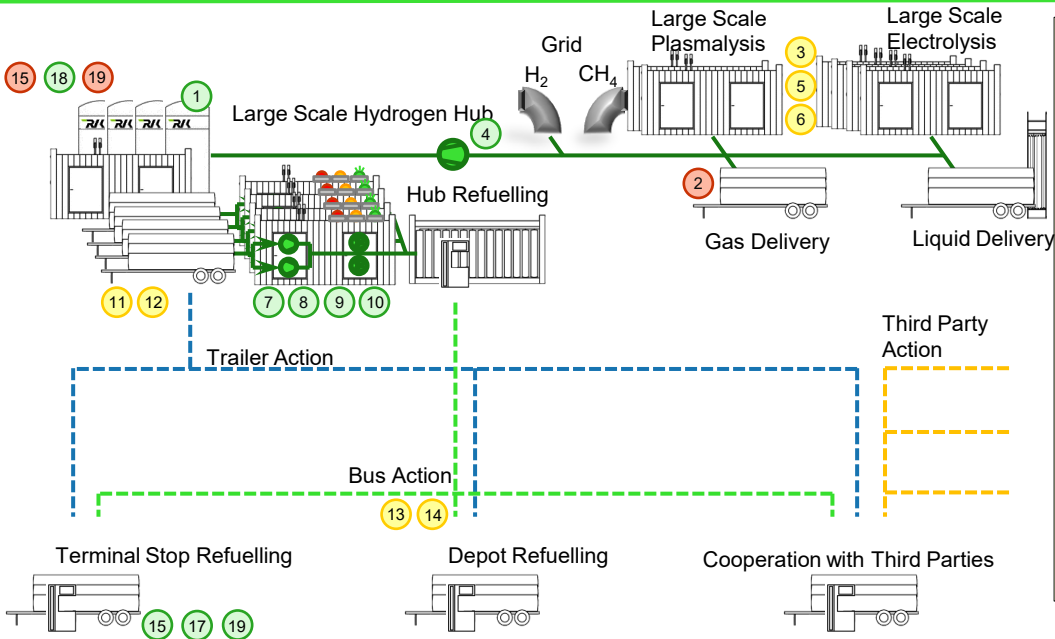
Restart From Scratch - What if ...?



Note

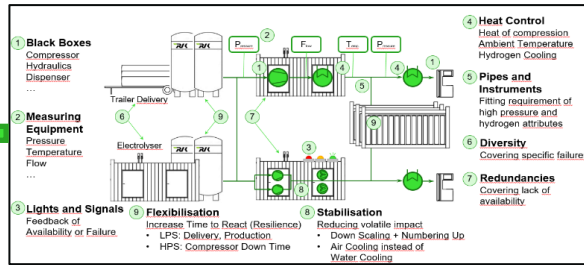
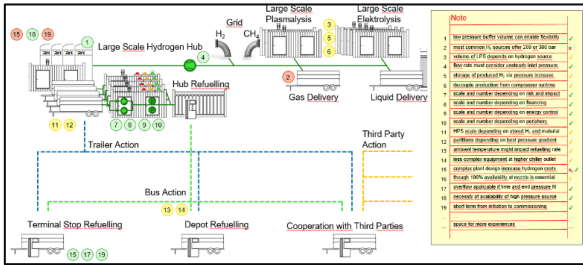
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-
- ... space for more experiences

Restart From Scratch - What if ...?



Note	
1 low pressure buffer volume can enable flexibility	✓
2 most common H ₂ sources offer 200 or 300 bar	✗
3 volume of LPS depends on hydrogen source	✓
4 flow rate must consider unsteady inlet pressure	✓
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16 though 100% availability at nozzle is essential	✓
17 overflow applicable if time and end pressure fit	?
18 necessity of availability of high pressure source	✓
19 short term from initiation to commissioning	✓
... ..	✓
... space for more experiences	...

SummarHy



- central hub and mobile type HRS as satellites
 - study if concept might reduce €/kg
 - consider time to market of hub system
 - decision of hydrogen source
 - grid
 - on site production
 - liquid delivery
 - development of trailers
 - pressure
 - partitions
 - capacity
 - consider schedule and location of refuelling

- applied principles
 - flexibilisation per diversity
 - stabilisation per down-scaling and numbering up
 - cost reduction per simplification
 - resilience per redundancies
 - time management per heat control



Don't forget to consider the green impact!

Successes & Learnings from Crawley's Liquid HRS

Erwan Bruneau

Solutions & Commercialisation Manager Hydrogen for Mobility Europe
and Africa, Air Products



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Case Study: Liquid hydrogen refuelling station in Crawley

How liquid hydrogen can support decarbonisation of bus fleets

Busworld
Zero Emission Bus Conference
09. October 2025

GENERATING A CLEANER FUTURE



AIR
PRODUCTS 



Erwan Bruneau

Solutions & Commercialisation Manager
Hydrogen for Mobility Europe & Africa

GENERATING A CLEANER FUTURE



AIR
PRODUCTS 

The world's largest hydrogen supplier

leading the transition to renewable and low carbon hydrogen production

The world's largest
hydrogen supplier with



**proven
reliability**

1,100+

kilometers of pipeline
> 32 billion Nm³/year



110+

production
facilities

65+ years

safely operating
hydrogen



250+

hydrogen fuelling
projects worldwide



30+

H₂ electrolyser
projects



20+

countries

unique product
offering for H₂ fuelling

1,500,000

fuellings per year



13 million
total fuellings

~50



patents

for hydrogen fuelling

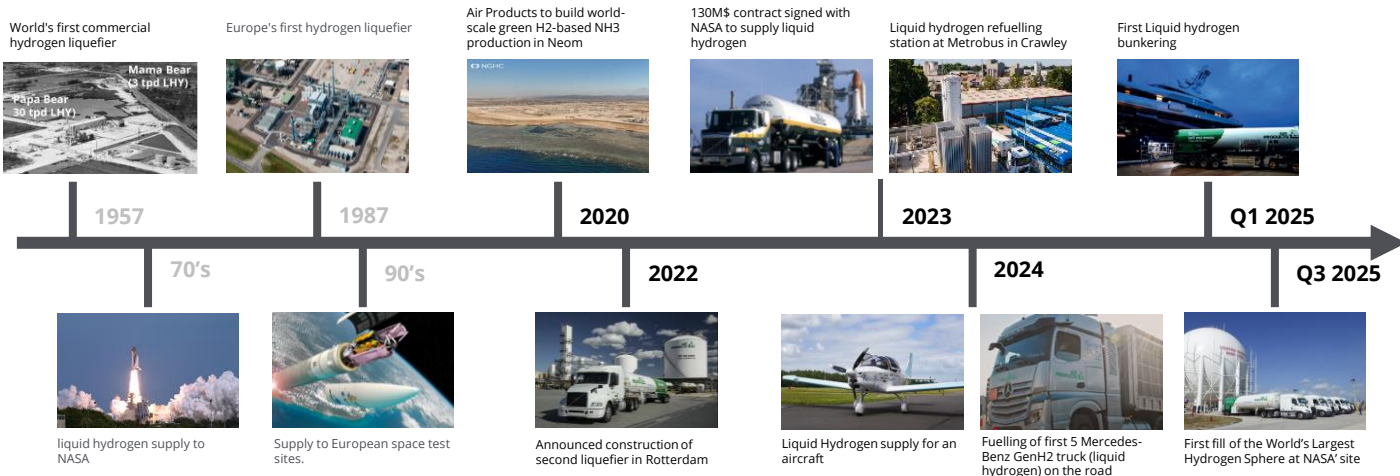
MEMBER OF:



**Hydrogen
Council**



Air Products has been answering the liquid hydrogen call for more than 65 years



Liquid hydrogen is the answer to large bulk demand

Liquefaction process gives hydrogen **3x** more density than in gaseous form at 300 bar



Reduce footprint

With **cryogenic storage tanks** and **cryogenic pumps** when required



Minimise power demand

With **cryogenic compression of liquid & gaseous hydrogen** through Air Products CHC technology



Simplify hydrogen logistics

By **larger delivered volumes** >3 t and fewer vehicles' movements in and out customer sites



Fuel cell buses can enable decarbonisation for intensive and constrained bus depots

Metrobus Crawley had a challenging case for decarbonisation



Intensive bus operation

Metrobus Fastway route buses operate **24/7**, 365 days a year and drive about **370 km a day**



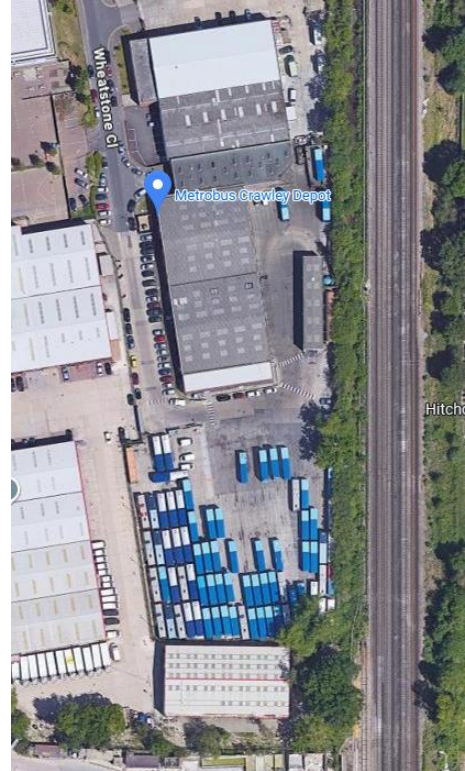
Space limitation

Crawley bus depot operates **>100 buses** with limited availability for implementing large infrastructures



Decarbonisation requirement

Metrobus requires **decarbonised** energy and a suitable fuel to convert **the entire fleet by 2035**



Air Products supply model and liquid hydrogen solution met the challenges of Metrobus



MOBILE REFUELLER

350 bar
20 - 200 kg per day



SAFETY 24/7

We have been operating
fuelling solutions safely
for 25+ years



GASEOUS BASED STATION

350 bar
200 - 750 kg per day



ALL-INCLUSIVE MOLECULE PRICE

We invest and build
the infrastructure



RENEWABLE FUEL CELL GRADE

We ensure a reliable
hydrogen fuel supply



LIQUID BASED STATION

350 bar or 350/700 bar
3,000 kg per day



HANDS-OFF OPERATION

We operate and
maintain the station with
our team of experts

Metrobus Crawley HRS Milestones in 2025

Following ramp up phase with mobile fueller, liquid HRS is operational

Largest bus fleet in the UK with **54 units** on the road and 43 more to come

About **1,200 bus fuellings** per month on average

Up to **54 buses** and **950 kg fuelled** in one fuelling window

METROBUS



AIR PRODUCTS



Key Performance Indicators

In its first year of operation, HRS performance is still improving



Footprint

485 m² (22x22m)



Energy efficiency

<0.4 kWh/kg



Fuelling speed

7-8 minutes on average



HRS availability

97% around the clock
with target >99%



Thank you.

Visit us at:

Air Products booth 618 in Hall 6!

Download our brochure:

Learn more about our buses & coaches hydrogen solutions

**GENERATING
A CLEANER
FUTURE**



PANEL DISCUSSION

Questions for the panel?
Ask them on [mentimeter.com](https://www.mentimeter.com):



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CONFERENCE 7th - 9th Oct 2025
@ Busworld Europe Brussels



**Valérie Bouillon-
Delparte**

Moderator

Clean Hydrogen
Partnership



**Flip
Konings**

Panellist

OV-bureau
Groningen Drenthe



**Callum
Stewart**

Panellist

Aberdeen City
Council

HRS life cycle

1. Getting Station Built

- Sitting
- Permitting
- Tendering



2. Making Them Work

- Commissioning
- Reliability
- Training
- Availability FCB and HRS



3. Service and Support

- Maintenance
- Service agreements
- Secure H2 demand



Picture: HRS in Auxerre

Additional considerations

- Preparation for **scale** (modular larger HRS, network of HRS)
- **Governance** and Ownership
- **Public Funding**



Flip Konings
Senior Policy Advisor Sustainability
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Energy Centre @ TECA

Coffee Break



Learn more at our sponsors' booths:
Air Products - Hall 6, Booth 618
Resato - Hall 11, Booth 1216

Next plenary session starts at 11:00 in Room 1123:

“Navigating Battery Degradation, Safety, and End-of-Life Management”



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