Engineering Options for Green Hydrogen Supply for Industrial Applications

6th March 2024

Alison Cartwright
Senior Project Manager
CNG Services Ltd
alison.cartwright@cngservices.co.uk
www.cngservices.co.uk
07746812649

cngservices

CNG Services Ltd

- CNG Services Limited (CSL) provides consultancy, design and build services to the biomethane industry, all focused on reducing Greenhouse Gas (GHG) emissions

- In the past 10 years our efforts have produced a material impact with an estimated 20 year project life reduction in CO2 emissions of 17,500,000 tonnes through:
  - Biomethane injection into the gas grid
  - Running trucks on Bio-CNG
  - Acting as developer and design and build contractor for the Highlands CNG Project

- Working on a number of Biomethane, H2 and CCUS innovation projects including:
  - Biomethane from manure with CCS
  - Biomethane direct into the NTS
  - Green H2 into the NTS and Hydrogen Business Model Projects
  - Reverse Compression to Create Capacity for Biomethane Injection

- CSL is an ISO 9001, 14001 and 45001 approved company and has also achieved Achilles certification. CSL is GIRS accredited for design and project management and has been certified as a competent design organisation for high pressure UK onshore natural gas works by DNVGL

cngservices

Industrial consumers moving to green hydrogen

- Industrial consumers that currently use large volumes of fossil gas want to reduce their CO_2 emissions

- Green H_2 helps reduce these emissions
  - 100% green H_2
  - Blend between 2%-100%
  - Many industrial customers do not have an electricity option

- Considerations
  - Making electricity from additional renewables is the key CO_2 driver in the 2020's
  - Industries often have complex processes and natural gas CHP used for electricity generation with waste heat utilisation
  - The gas grid provides the back-up supply to allow a resilient technical solution using Green H_2

- Number of government support mechanisms in place for CAPEX and OPEX support

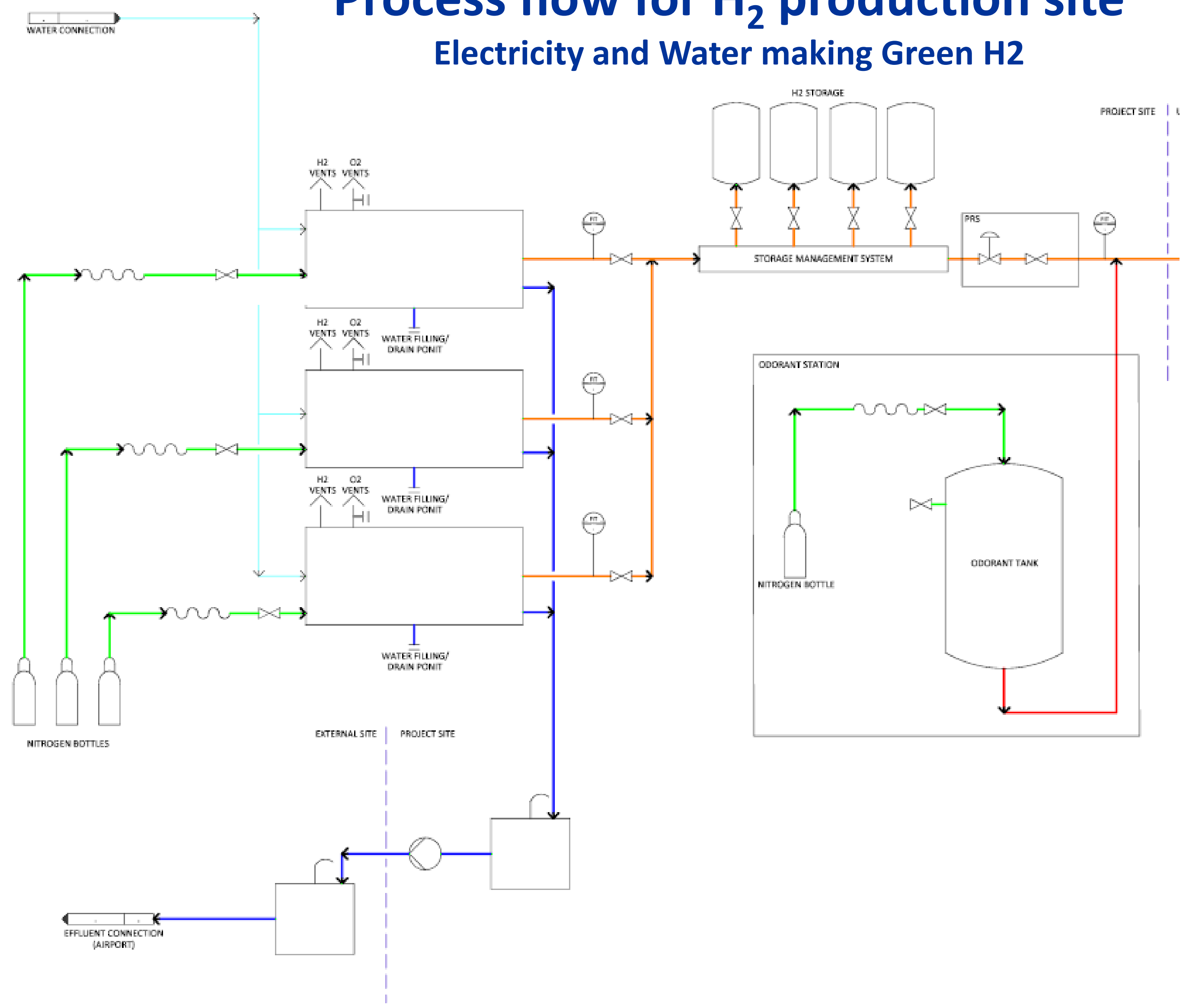
cngservices

What are the options for green H_2 supply?

- Inject into the distribution or transmission grid
  - Locate electrolysers where there is excess renewable energy
  - Consumers receive kWh of Green H2 in the form of kWh of natural gas with a certificate
- Locate the electrolysers at a location close to industrial user
  - Move the H_2 via new gas pipeline
  - Move the H_2 by road
- Locate the electrolysers on off-taker's site
  - If electricity is available and storage can receive planning consent then this is a very good option

Process flow for H_2 production site

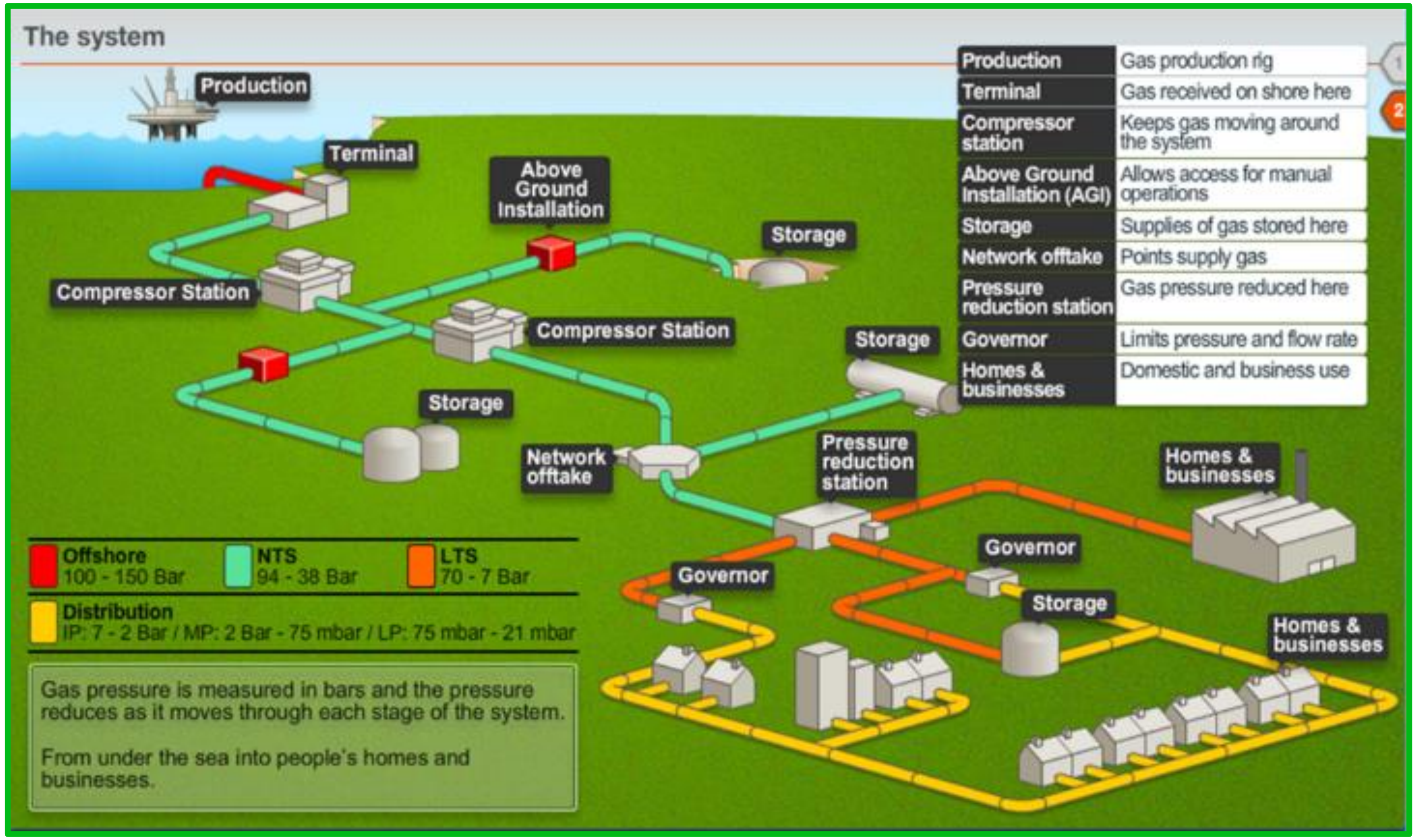
Electricity and Water making Green H2



Optional Odorant unit required for a dedicated H2 pipeline that operates <7 bar

cngservices

Injection into the gas grid
UK Gas Network



- **MP**
  - Lowest pressure tier used
  - Very high coverage across UK
  - PE or metal construction
  - 50 biomethane projects
- **IP**
  - 6.9bar Good coverage across UK
  - PE or metal construction
  - 40 biomethane projects
- **LTS**
  - Ranges from >12bar to 70bar
  - Usually 19 bar or 38 bar systems
  - All metal – however new high pressure PE up to to 100 bar is now approved
  - 25 biomethane projects
  - Ideal for Bio-CNG (eg Leyland/Erdington)
- **NTS**
  - 50 – 85 bar
  - 1 biomethane injection and 1 Bio-CNG Mother station

cngservices

Injection into the gas distribution grid

✓ Blend % means that some fossil gas kWh are displaced

- Around 30% reduction in GHG as $1m^3$ of Green H_2 has CV or around 30% of $1m^3$ of natural gas

✓ 13 years of biomethane injection experience

- 120 projects and 7 TWh/annum

✓ Lower pressure grid than transmission

- Helpful if Green H_2 produced at 40 bar as no compression required

✗ Gas thermal energy regulations

- CV target limits % H_2

✗ Capacity limited

- Demand (and hence capacity) is low in summer due to low gas demand for heating

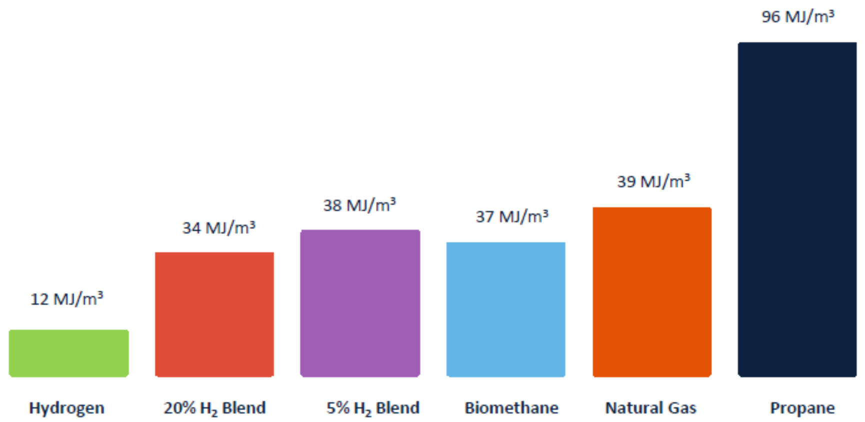
✗ Complicated and expensive processes for biomethane in GB

- Rules are not designed for such flows and gatekeeper costs in GB are more than double similar costs in Europe

cngservices

Technical Considerations for Pipeline Injection

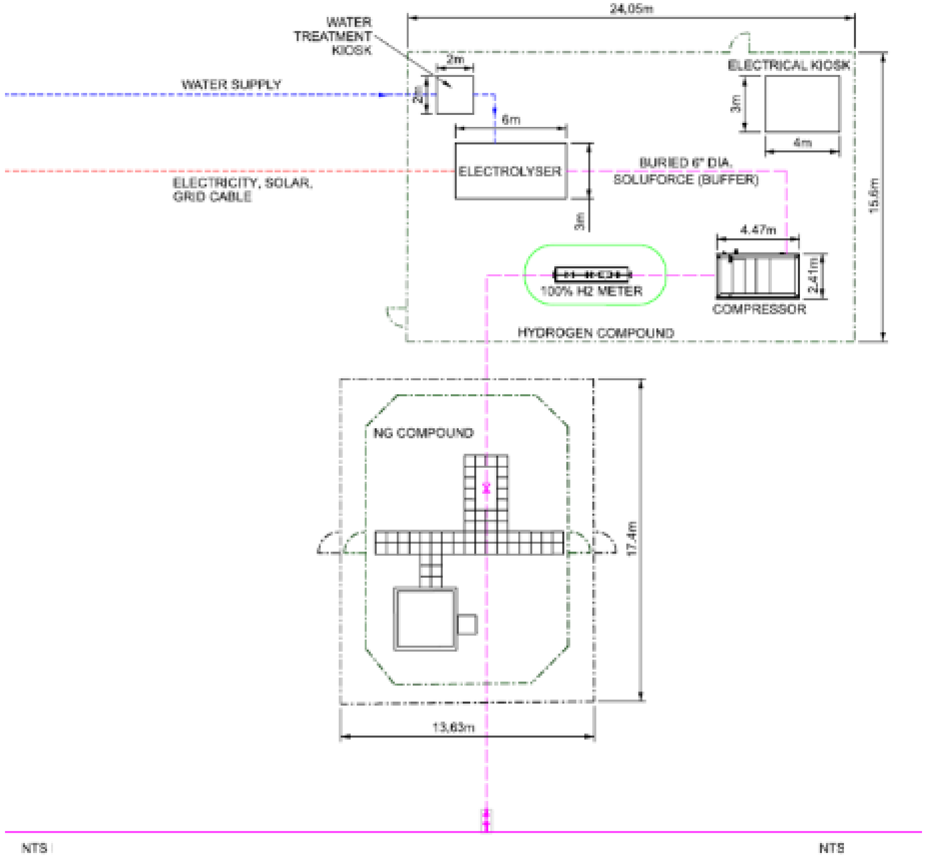
- Gas transmission pressures in the distribution network are 19 – 70 bar
  - Majority around 30 bar and this means compression may not be required which is a significant advantage
- Temperature on outlet of the electrolyser vs design temperature of pipework
  - Reverse Joules Thomson effect only raises the temperature if there is pressure reduction
  - Temperature specifications on distribution network often 20^0C if PE, 38^0C if steel
  - Extra CAPEX required for cooling into a PE pipeline
- Volume flow vs energy displacement



cngservices

Injection into the gas transmission grid

- ✓ Blend % means that some fossil gas kWh are displaced
- ✓ Large amounts of capacity
- ✓ Thermal energy regulations not applicable
  - NO CV target, key is wobbe and % of H_2 allowed
- ✓ In 2023 NGT has reformed the regime for injection of biomethane into the NTS
  - Simpler technical design, smaller facilities, shared ownership
  - Time reduced to 12 months for new green field connection with hot tap



cngservices

Injection into the gas transmission grid

Oil free reciprocating compressor 20 barg inlet to 75 barg outlet

LTS Hot Tap

cngservices

Locate the electrolysers at a location close to industrial user

- Install a pipeline from electrolyser site to industrial user

  - Pressure from electrolyser 20 barg – 35 barg
  - Soluforce H2T RTP pipeline MOP 42 barg and 50^0C
  - Unodorised with appropriate HSE regulations
  - Higher pressure means smaller diameter pipeline

OR

  - Pressure reduction to <7 barg
  - PE plastic pipe, temperature limit 20^0C
  - Odorisation required

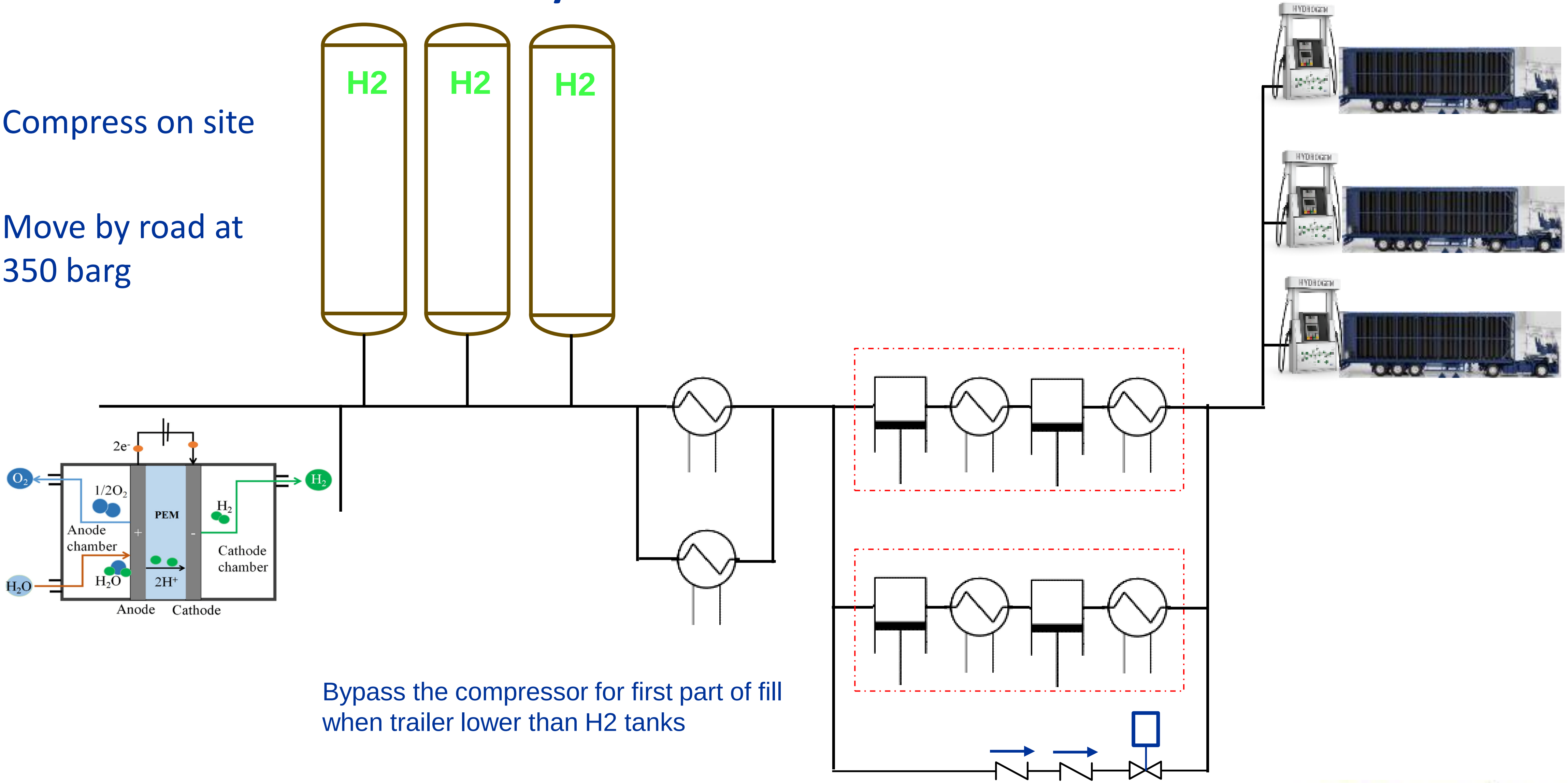
- Reduce pressure to appliance pressure requirement at point of use

cngservices

H_2 Pressure Reduction

Locate the electrolysers at a remote location away from industrial user

- Compress on site
- Move by road at 350 barg

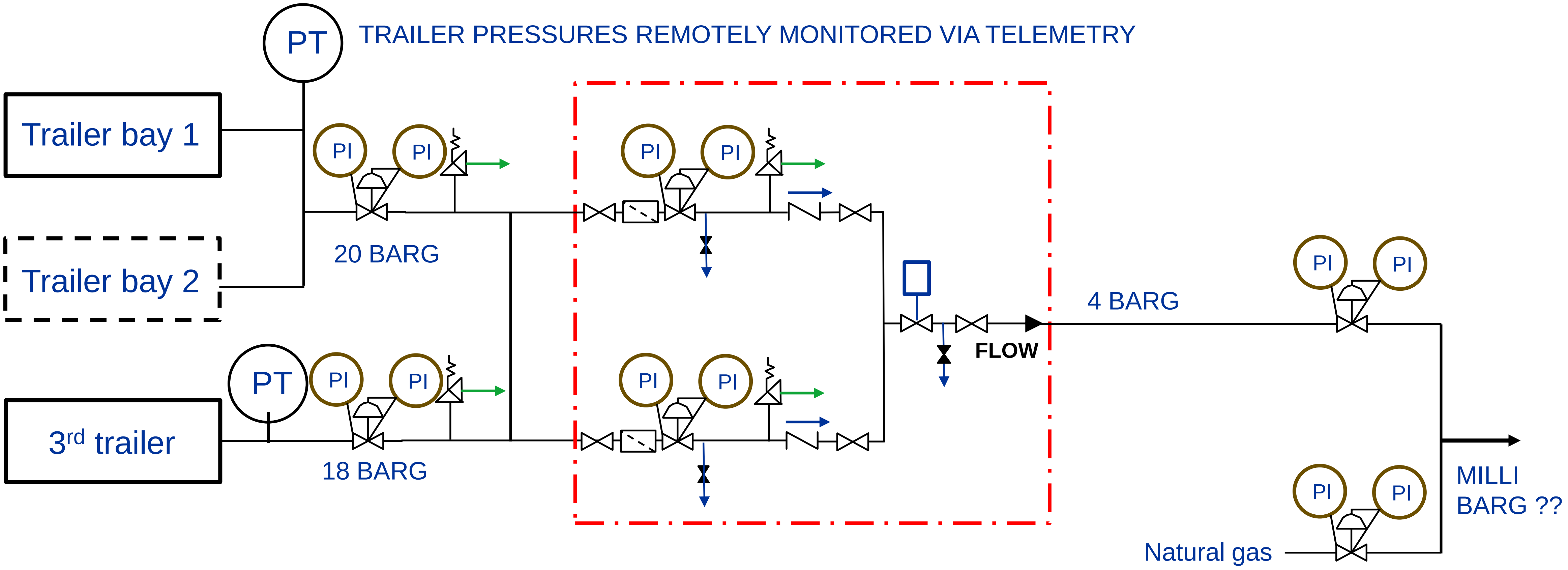


Bypass the compressor for first part of fill when trailer lower than H2 tanks

cngservices

Filling CNG Trailers

Trailers offload hydrogen at industrial user

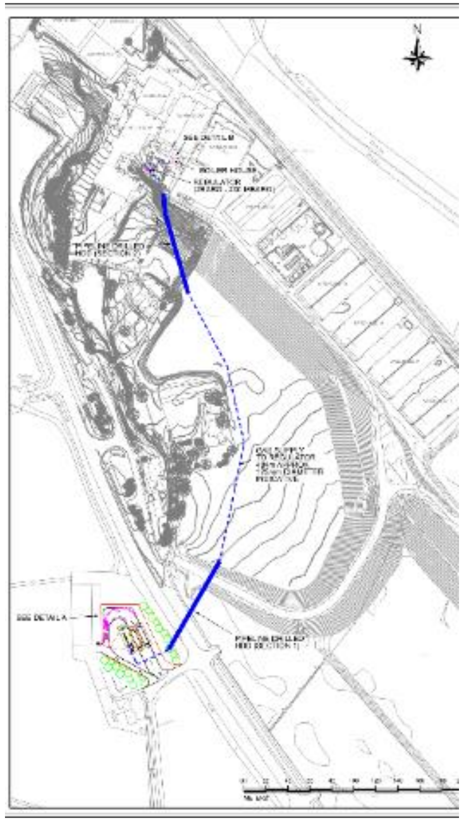


- Composite vs steel trailers
- CAPEX vs payload

Glenmorangie Decanting Station - 500m from the distillery

50 million kWh/annum or 1 truck per day

Would require 3 per day for Green H2



Locate electrolysers on or adjacent to industrial consumer site

- Water and electricity requirements on site
  - Planning considerations
  - HSC/COMAH
- Meet site H_2 demand with pipeline natural gas for resilience
  - 90% of annual kWh displaced?
- Requires storage for fluctuations and downtime
  - Key not to aim for 100% H_2 as this leads to a lot of additional costs
- Less CAPEX requirements especially if storage can be minimised

Summary

- Critical success factor is utilisation of the H2
  - Ideally displacing natural gas where no good electricity option
- Design with natural gas back-up from the grid to minimise capex and risk
  - Hydrogen backbone to connect industrial users to hydrogen grid
  - By 2050 this gas will be green gas as biomethane set for huge growth
- Ensure off taker has long term H_2 requirement and resilient business
  - Not locating to Texas
- Where possible locate electrolysers on site or close to site and connect by pipeline

cngservices