Liquid Hydrogen BOG Management Systems

Dr Barry Prince
barry.prince@fabrum.nz

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PRESENTATION OVERVIEW.

Fabrum’s Liquid Hydrogen Systems.

Management strategies for hydrogen venting during liquid transfers.

Fabrum BOGM system.

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20 years of FABRUM.

14th April 2024

Key Shareholders

K1W1 K One W One Ltd.

Fortescue

OBAYASHI

APVentures ADVANCE & PIONEER

A LEADER IN DECARBONISATION.

We don’t talk much…. we deliver.

~200% YoY growth for past 3 years mostly attributed to emission reduction projects for heavy transport, mining and aviation.

>50% of our revenues come from offshore. $20B+ total addressable export market.

Our products and technologies will reduce >10 million tonnes of CO2e in the next 10 years globally.

We have the capability to significantly contribute to CO2e abatement in New Zealand. Current projects will abate about 3-5% of total New Zealand emissions.

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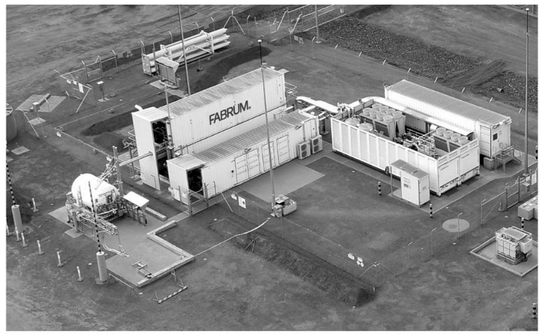
LATEST NEWS.

FABRUM. *February, 2024*



FABRUM MAKES LIQUID HYDROGEN

Fabrum. is proud to announce that with our partners Fortescue, we have Australia's largest liquid hydrogen plant up and running at Fortescue's Green Energy Hub in Western Australia.

Read more ›

FABRUM. *June, 2024*

NEW ZEALAND COMPANY FABRUM COLLABORATES WITH TOYOTA FOR LIQUID HYDROGEN STORAGE

Fabrum, a world leader in zero-emission transition technologies to enable a lower-carbon economy, is set to supply Toyota with its proprietary liquid hydrogen storage technology.

Read more ›

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FABRUM. OVERVIEW

Cryogenics	Hydrogen Refuelling Stations (HRS)	Composite Storage
Liquid Nitrogen (LIN) Liquid Oxygen (LOX) Liquid Hydrogen (LH_2) Boil-off-gas Management - LH_2 and LNG	1 MW fuel station 5MW fuel station	LH2 Storage Specialty LIN storage for high-speed rail

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FABRUM'S PROPRIETARY TECHNOLOGY FOR LIQUID HYDROGEN.

High Efficiency Pulse Tube Cryocooler

Over 20 years Knowledge and Experience of Cryogenic Storage Vessels

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PTC
PULSE TUBE CRYOCOOLER

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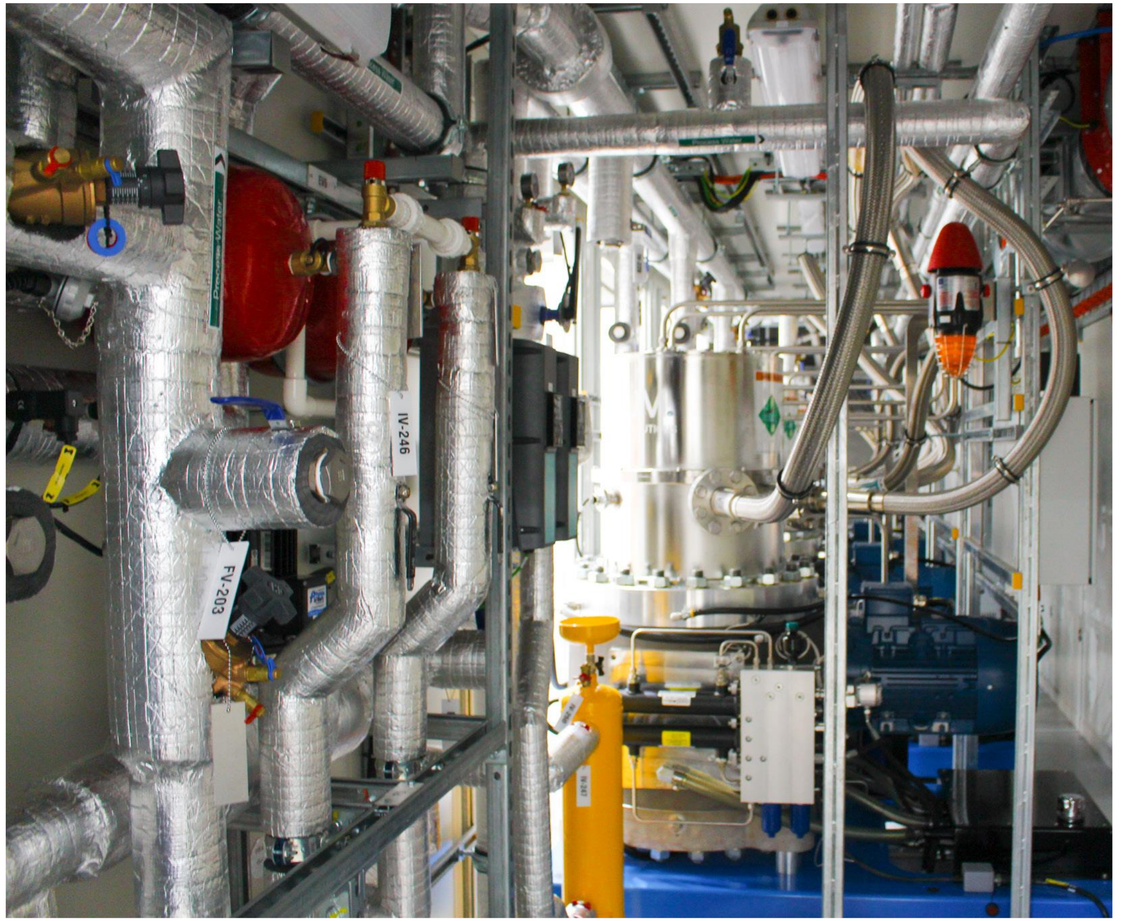
PTC330 AND PTC1000

- Patented dual-diaphragm system
- Large linear pulse tubes
  - Minimal setup
  - Modular and scalable
  - Low maintenance, servicing at 40,000 hours
  - Remote operation
- **Robust Industrialised Functionality**

PTC1000 – THE LIQUEFIER WORKHORSE

- Majority of the hydrogen cooling is carried out by the PTC1000
- Powered by 30-kW motor
- Cooling from 500 W to 3.5 KW between 50 – 150 K
- Six units drop temperature of hydrogen from ambient to ~50 - 60 K
- GM cold heads provide final cooling for liquefaction



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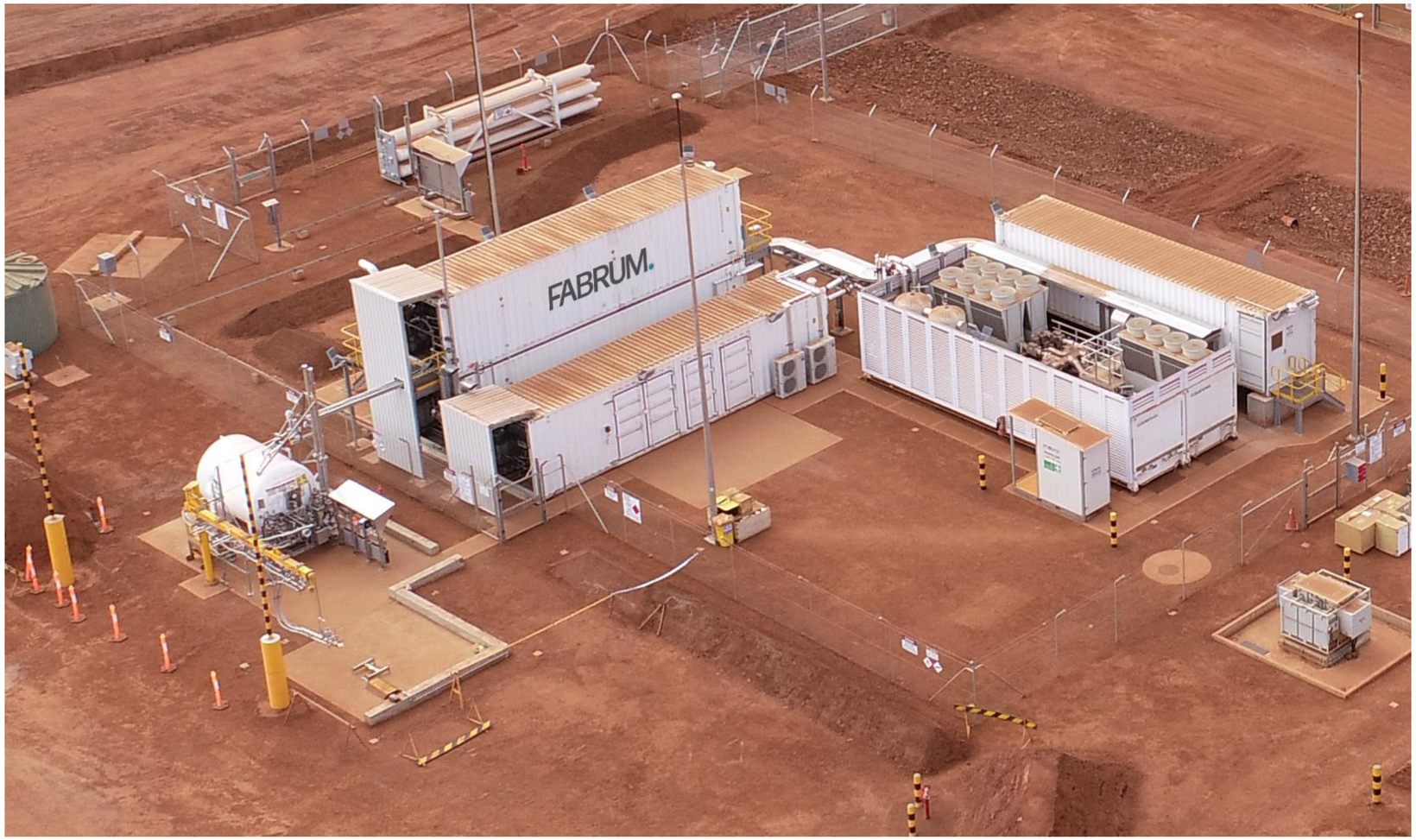
HYDROGEN LIQUEFACTION PLANT



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BOIL OFF GAS MANAGEMENT
BOGM

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IMPORTANCE OF BOGM FOR HYDROGEN

- NASA has documented the magnitude of liquid hydrogen loses during transport and storage
- Boil off gas management is essential for economic and environmental reasons
- 1 kg hydrogen = 33 kg CO_2 (GWP20)

  (1 kg methane = 83 kg CO_2)

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HYDROGEN BOGM – STORAGE LOSSES

Liquid	Density @ 1 bar(a) (kg/m3)	ΔT (K)	Latent heat (kJ/kg [kJ/mol])	NER (%/day)
Nitrogen	900	196	199 [5.6]	0.50
Natural Gas	439	162	511 [8.2]	0.33
Hydrogen	**71**	**253**	**461 [0.90]**	**3.54**

- Hydrogen losses from a cryogenic tank are greater than what might be expected from LN_2 or LNG due to the low density of hydrogen

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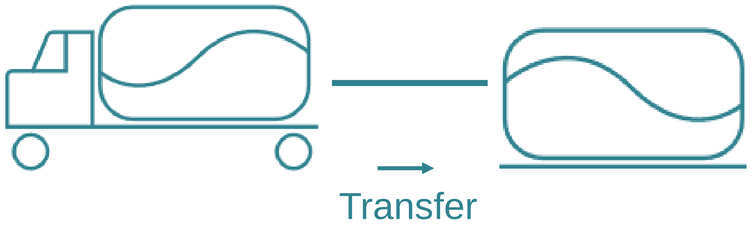
HYDROGEN BOGM – PRESSURE TRANSFER.

1

2



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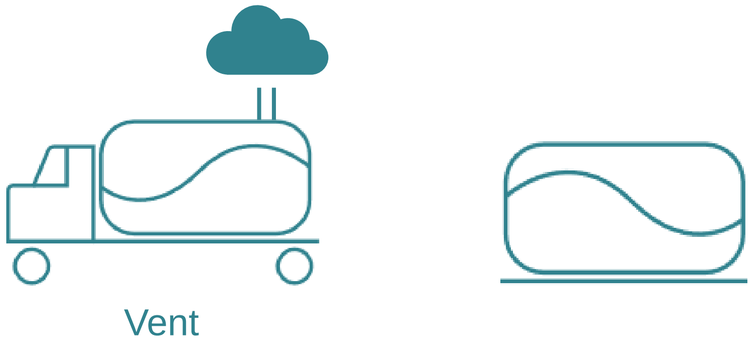

✓ Simple, low-cost infrastructure

✗ Significant losses to venting

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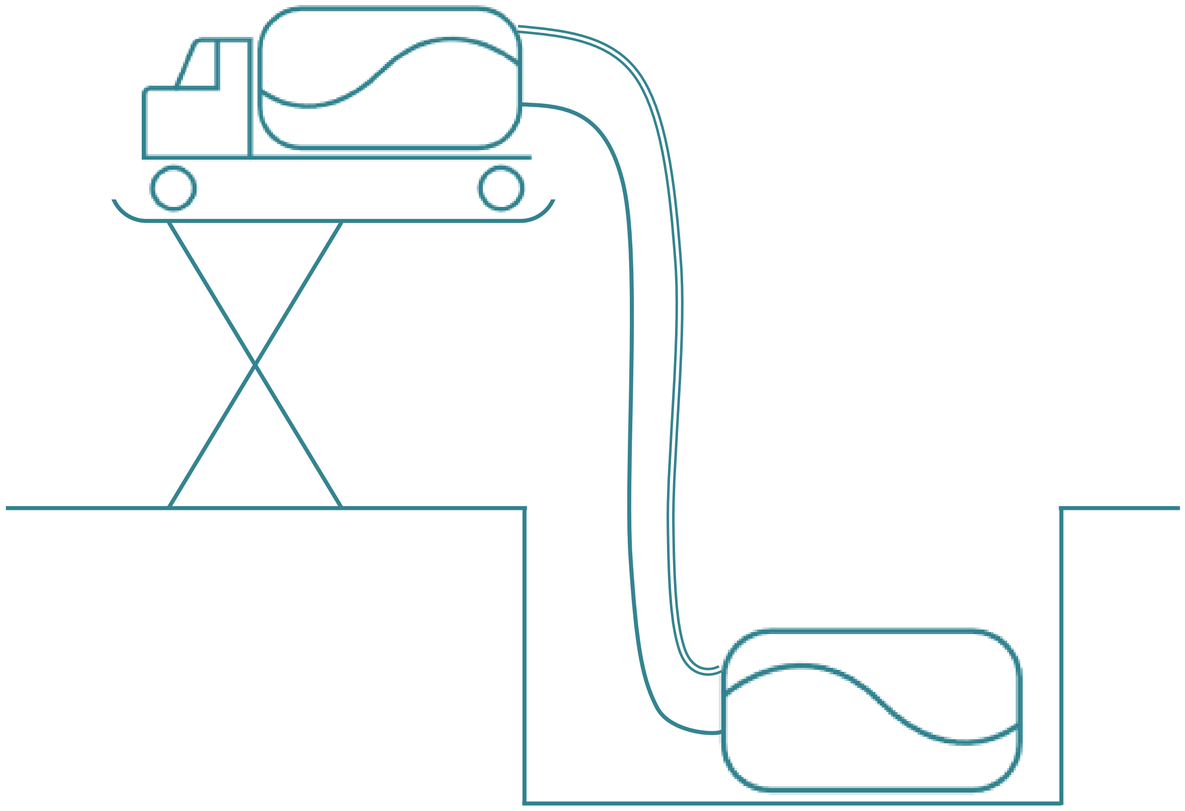
HYDROGEN BOGM – GRAVITY TRANSFER.



- ✓ Simple, low-cost infrastructure
- ✓ Vastly reduced venting
- ✗ Transfer speed dependent on head pressure
- ✗ Practicality?

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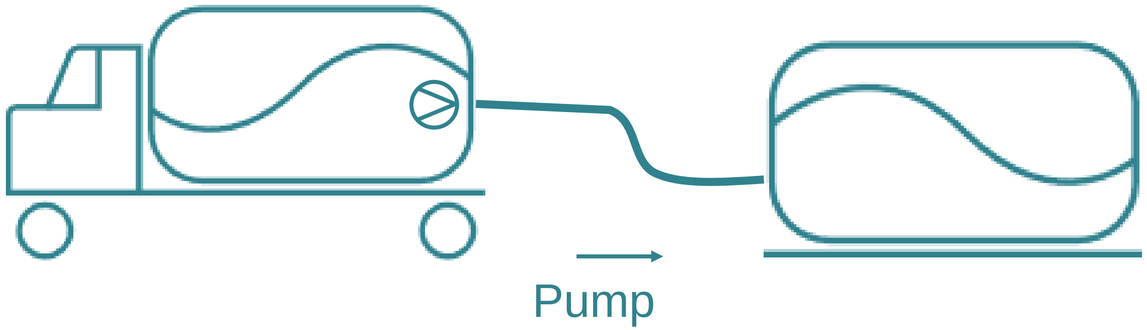
HYDROGEN BOGM – PUMP TRANSFER.



✓ Fast transfers

✓ Reduced venting

✗ Cost and reliability of LH_2 pumps

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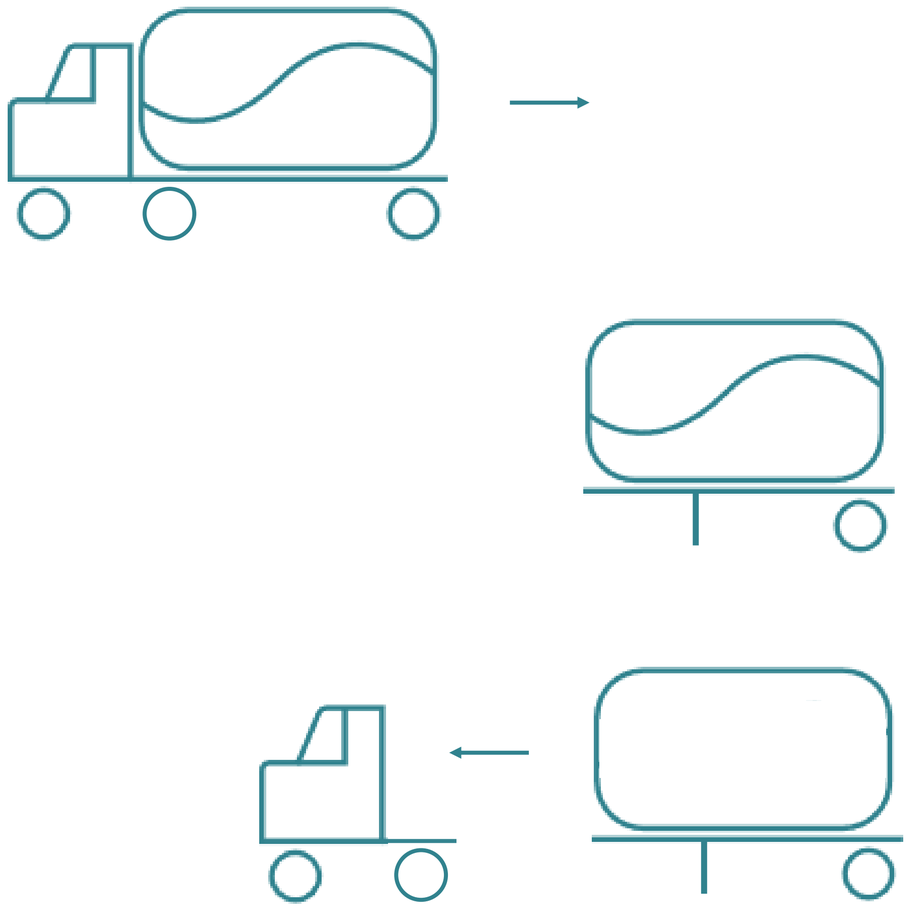
HYDROGEN BOGM – NO TRANSFER.



✓ Vastly reduced venting

✗ Infrastructure cost

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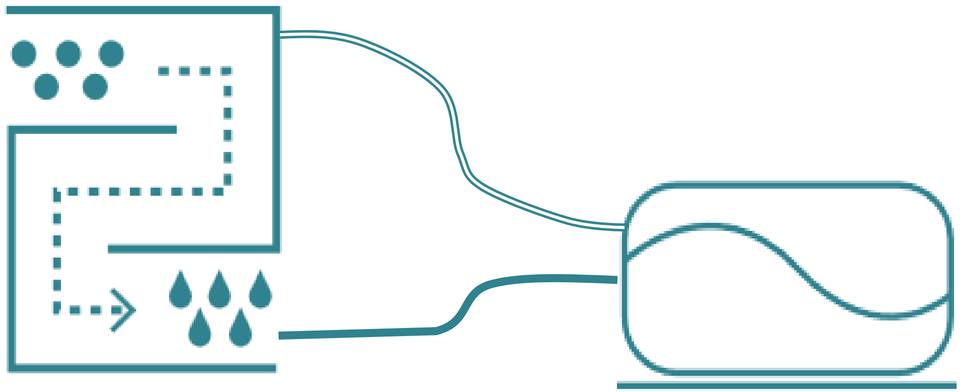
HYDROGEN BOGM – LIQUEFY ON SITE.



Onsite Liquefaction

✓ Eliminate all venting

✗ Liquefaction efficiency

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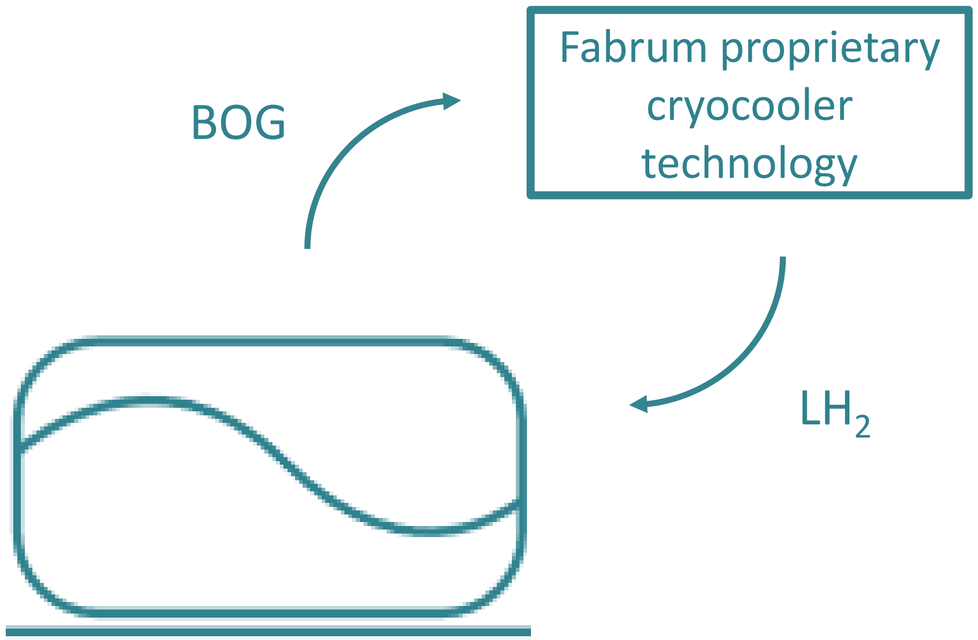
FABRUM'S BOGM SOLUTION

FABRUM BOGM SYSTEM.



Removes ~500W of heat at 25 K

Reliquefaction of 100 kg LH2 per day at saturation

OR

Sub-cool storage causing a reduction in pressure

REDUCE VENTING LOSSES BY 100 kg/day @ 15 kWH/kg

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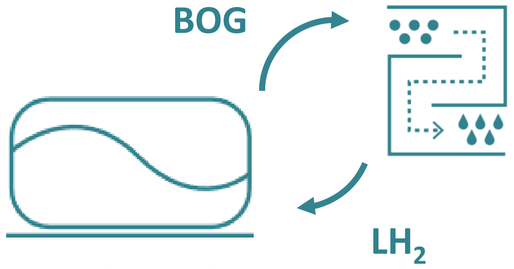
HYDROGEN BOGM – PRESSURE TRANSFER.

1



Sub-cool

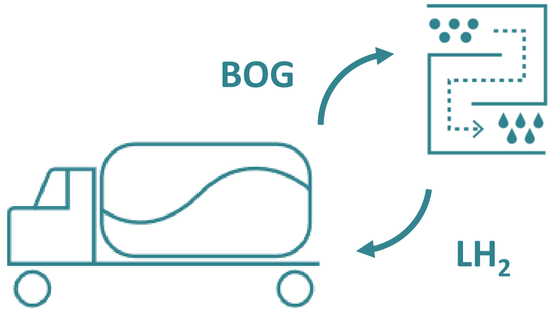
2

Pressure build

3

Transfer

4



✓ Vastly reduced venting

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FABRUM BOGM SYSTEM.

- Packaged in a 20’ shipping container
- Retrofit to existing storage, simply need offtake and return ports
- Modular scalable system
- Each unit saves 36,500 kg LH_2 per annum
- Payback <1 year per unit

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SUMMARY.

BOG management systems will be critical for an economically and environmentally viable LH_2 supply chain.

One of the more challenging areas to be addressed is the boil off generated during LH_2 transfers between storage vessels.

Fabrum's BOGM systems based on their proprietary cryocooler technology offer an attractive means for addressing BOG.

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Thank you