INOXCVA

HISTORICALLY FUTURISTIC

A GLOBAL MANUFACTURER OF
STANDARD AND ENGINEERED
CRYOGENIC EQUIPMENT

GREEN HYDROGEN STORAGE & TRANSPORTATION

ANUP SHAPETI
PRODUCT MANAGER (LNG & HYDROGEN)

International Conference On Green Hydrogen 2023
(ICGH 2023)

5th July 2023, Vigyan Bhawan, New Delhi

CONTENT

- Why Hydrogen & Why Now
- Colors of Hydrogen
- Green Hydrogen Eco system – Is Green, really Green..?
- Challenges – Storage, Transportation
- Challenges – Safety
- Hydrogen focus – INOX Preparedness

Industrial Gas

LNG

Cryo-Scientific

WHY HYDROGEN & WHY NOW

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1

Beginning

Discovery of H2 and production by electrolysis

1800

2

Fuel Cells

Combining H2 & O2 to generate electricity & water

1850

3

Hydrogen engine

- ✓ IC engines for trucks, buses – using Hydrogen and Hydrogen mixtures

1900

4

Space & Aviation

- ✓ Flights from Germany to US.
- ✓ Formation of NASA largest known consumer of LH2

1950

5

Hydrogen Economy

- ✓ OPEC Oil Embargo
- ✓ International Energy Agency (IEA) for R&D of H2 Technologies

1975

6

Green Hydrogen

- ✓ Solar powered Hydrogen
- ✓ Fuel Cell vehicle
- ✓ H2 Fuel station in Germany

2000

7

Climate Accords

Paris Climate Agreement for

- ✓ Reduction of Emission and
- ✓ Net zero by mid 21st Century

2016

8

GHM 0f INDIA

- ✓ Energy independent by 2047
- ✓ Net zero by 2070

2023

Information source: Fact sheet series – 1, The history of hydrogen by Hydrogen association. For more details see reference section.

COLORS OF HYDROGEN

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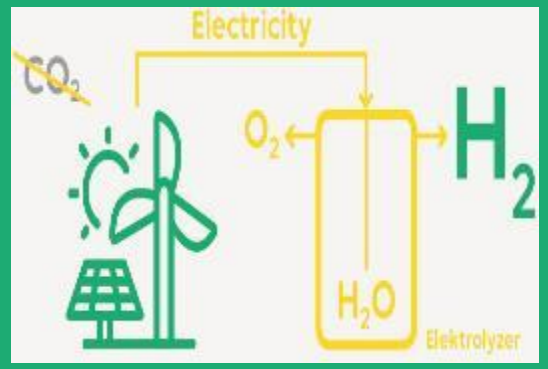
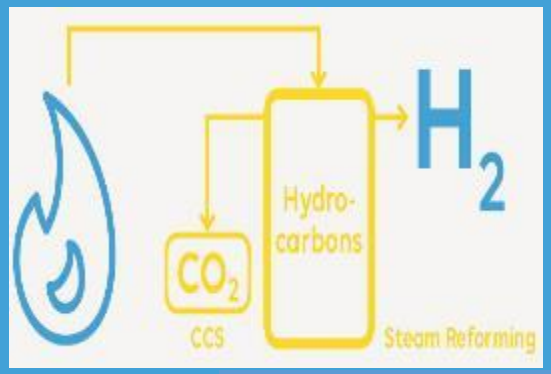
GREEN HYDROGEN



Wind / Solar (Renewable)

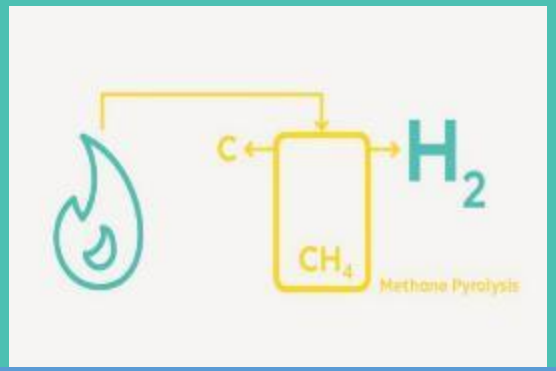
- Electrolysis of water
- Oxygen & Hydrogen
- O2 released to atmosphere
- Climate neutral

BLUE HYDROGEN



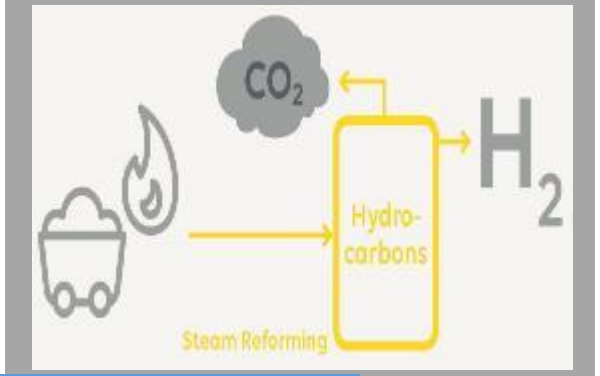
- Steam reforming of Methane
- H2 & CO2 (3~6 Kgs)
- Carbon capture & Storage (CCS)
- Long term impacts of storage – Uncertain
- Leakage can be harmful

TURQUOISE HYDROGEN



- Methane Pyrolysis
- H2 & Solid carbon (0.4 Kg)
- Solid carbon stored / used
- Low emission Hydrogen Storage & Energy used for thermal process

GREY HYDROGEN



- Steam reforming of Methane
- H2 & CO2 (11 Kg)
- CO2 is released to atm
- High emissions Harmful to climate

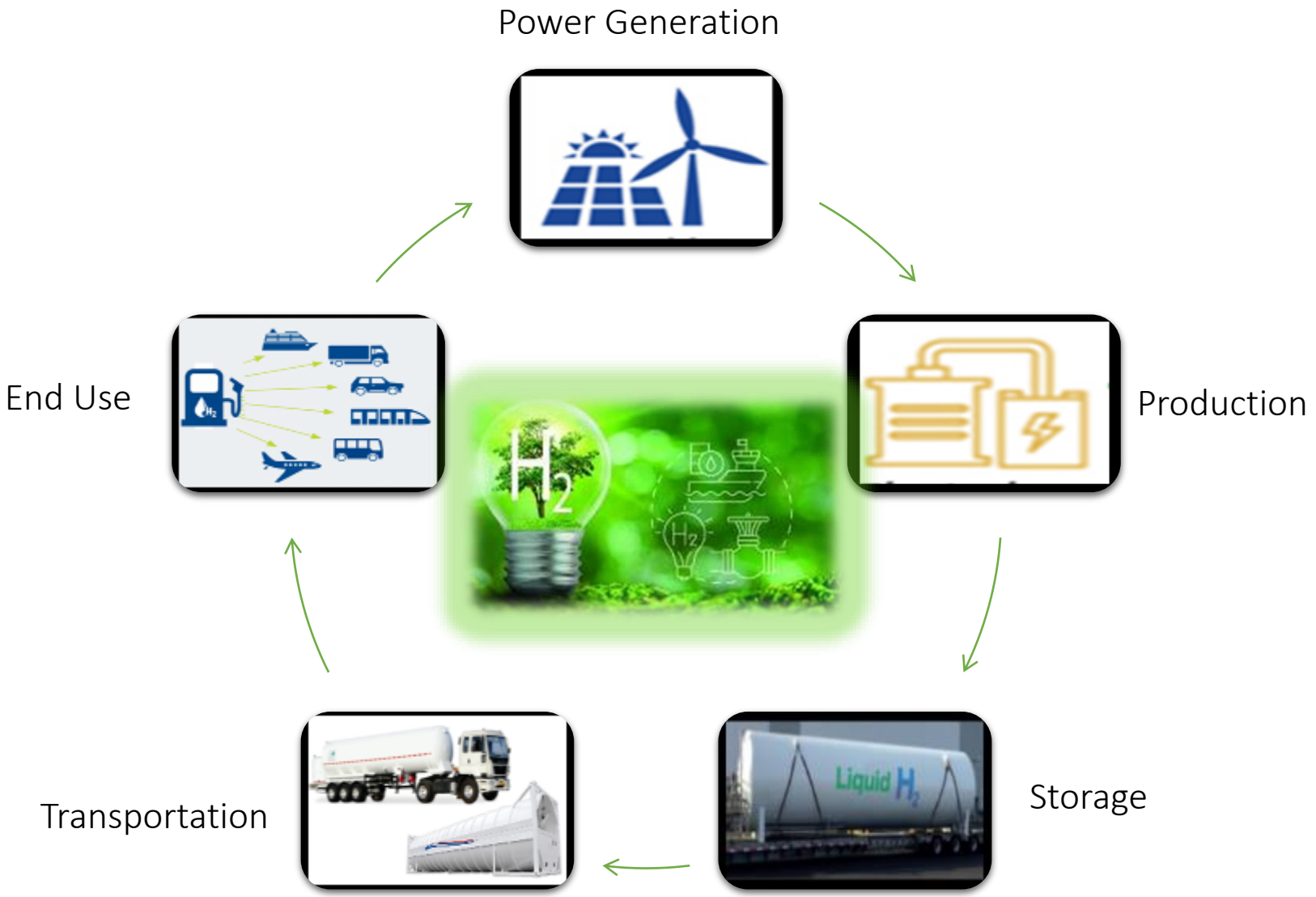
Depends on the carbon footprint of the energy source being used#

World Economic Forum defines **Green hydrogen** as *"Hydrogen produced by splitting water into hydrogen and oxygen using renewable electricity".* This definition does not actually consider the steps required to maintain the "GREEN STATUS" in its ECOSYSTEM like (i) Storage (Liquefaction / Compression) , (ii) Transportation & (iii) Storage/ Dispensing / End use

Energy sources can be (1) Fossil energy like Oil, Coal, Natural Gas OR (2) Nuclear OR (3) Renewable energy like Wind, Solar, Geothermal & Hydropower and so on …

Image source: EWE.com – The colors of hydrogen. Information source: EWE.com – The colors of hydrogen. & other general sources.

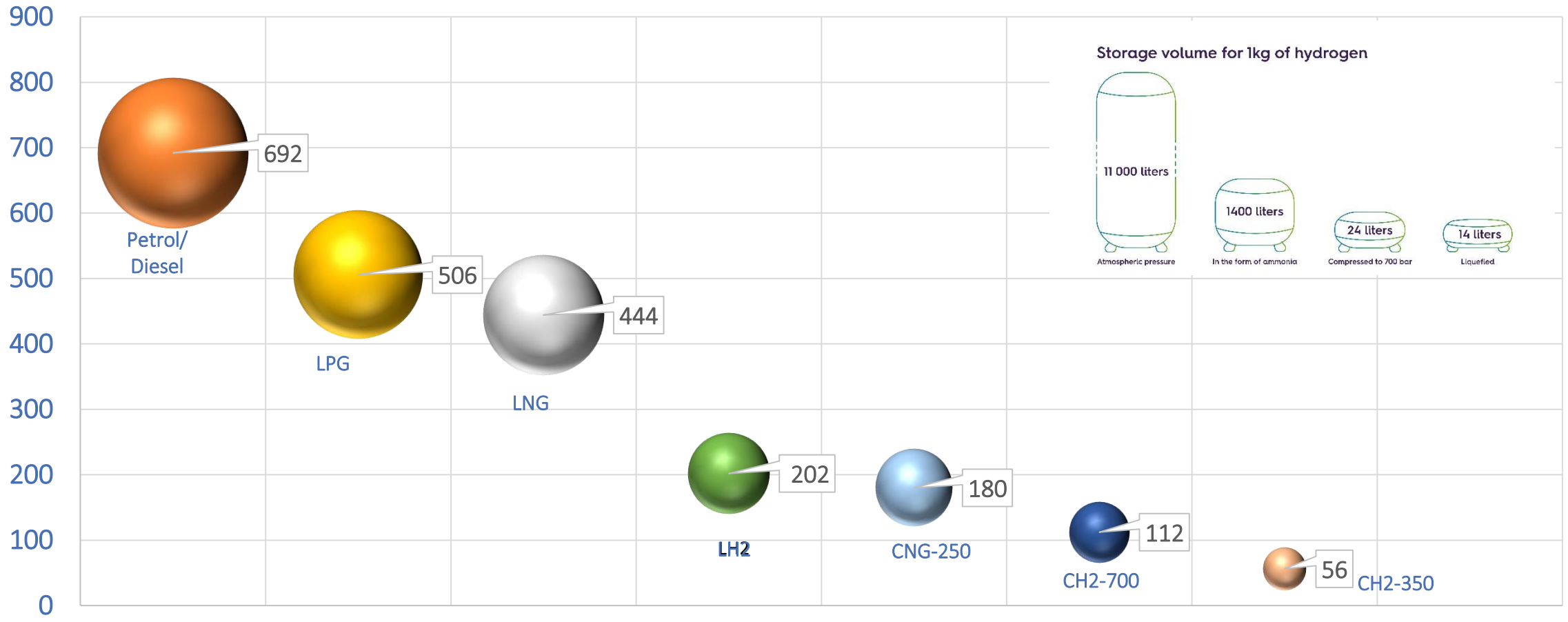
GREEN HYDROGEN ECOSYSTEM



CHALLENGES - HYDROGEN STORAGE

Volumetric capacity = 20,000 L (USG = ~5283)

Energy stored in GJ, for each fuel

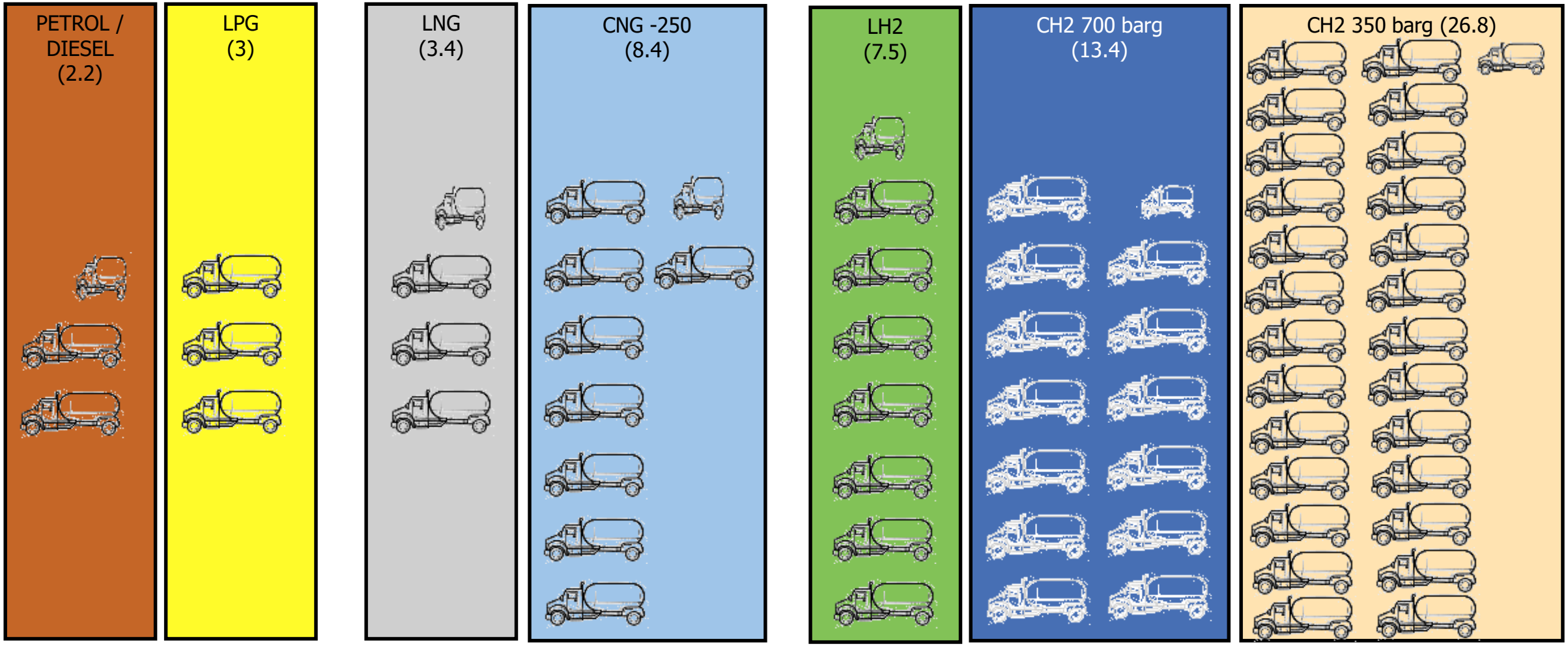


Information source: Energy per liter values - Hydrogen Production, Distribution, Storage and Power Conversion in a Hydrogen Economy - A Technology Review by Bernard Chukwudi Tashie-Lewis

CHALLENGES - HYDROGEN TRANSPORTATION

Volumetric capacity = 20,000 L (USG = ~5283)

Transportation target = **1500 GJ**



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CHALLENGES - HYDROGEN SAFETY

SAFETY & RISK MANAGEMENT - LHy behavior modeling

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Definition:

Rupture of vessel containing liquid at a temperature well above its boiling point at atmospheric temperature.

Consequence:

Blast, Fragments & in case of flammable liquids: radiating fire ball

Need:

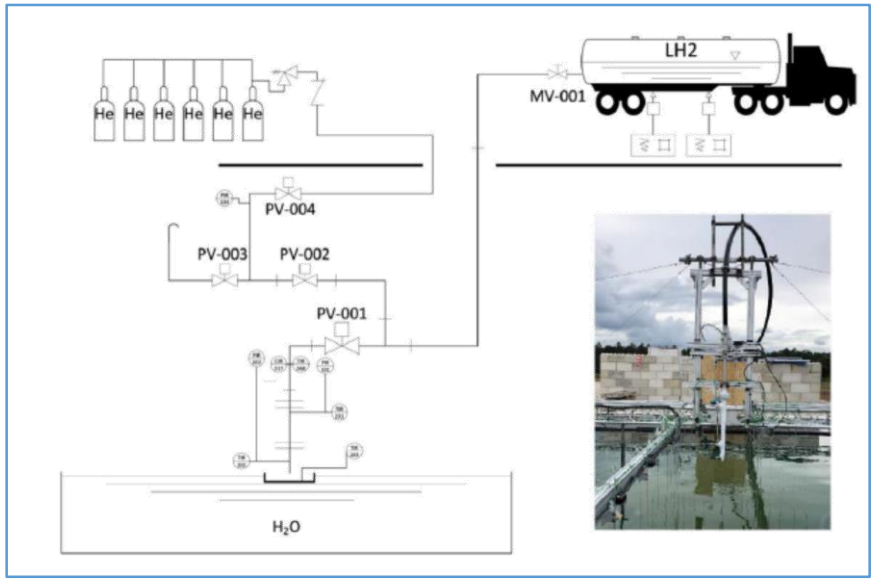
- Study the effects & consequences.
- Validation of theory & assumptions.

Gravimetric filling: 25 to 30 kg
Volumetric filling: ~350 to 400 L (35 to 40%)

Information & Photo source: Experiments to investigate the possibility and effects of BLEVE of storage tanks containing liquid hydrogen By Kees Van Wingerden

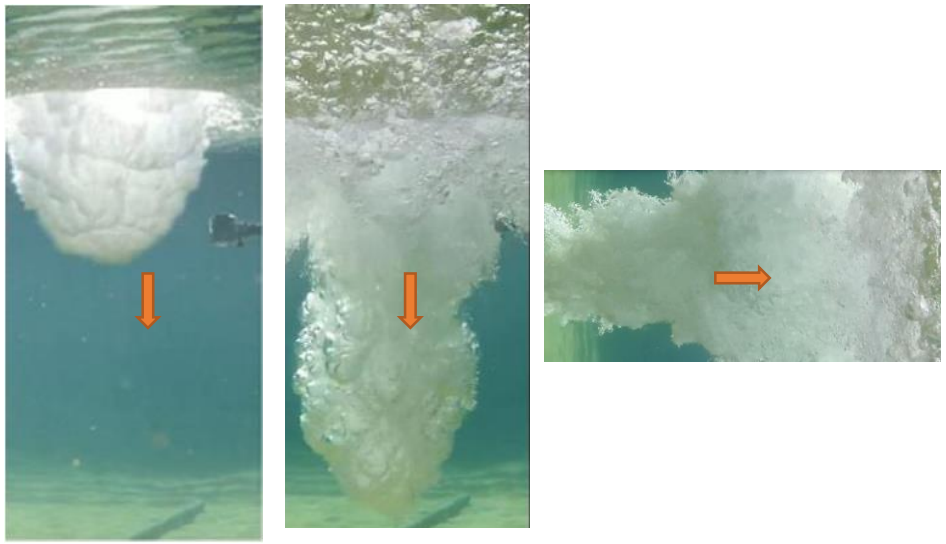
CHALLENGES - HYDROGEN SAFETY

SAFETY & RISK MANAGEMENT – LHy behavior modeling



Definition: Liquid rapidly changes phase to vapor, where by the large increase in volume causes a localized pressure increase which can give rise to air or waterborne blast wave.

Consequence: Blast wave, ignition in air



Information & Photo source: Accidental spill of liquid hydrogen and risk of rapid phase transition - Green Hydrogen Webinar Oct 2021 By L.H. Odsaeter

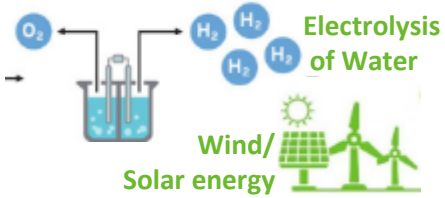
HYDROGEN – Lets go liquid way.!

- History repeats – Industrial gases or NG, liquid is the solution….?
- Within Hydrogen, Liquid provides the best volumetric energy density.
- Efforts are on to lower the liquefaction cost & its related infrastructure

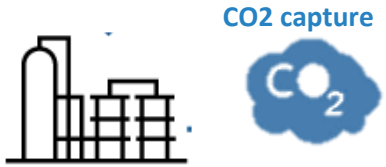
INOXCVA LIQUID HYDROGEN OFFERING

H_2 PRODUCTION

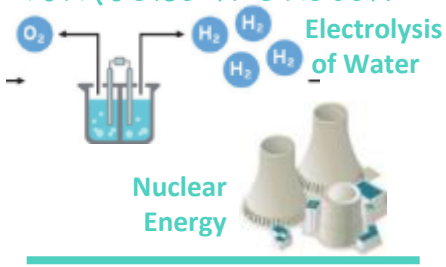
GREEN HYDROGEN



BLUE HYDROGEN



TURQUOISE HYDROGEN



GREY HYDROGEN

SPACE & RESEARCH APPLICATIONS

LIN SHIELDED LHY TRANSPORT SKID TANK

MULTI-CORE H2 / HE VJ TRANSFER LINES (ITER)

INDIA SPACE RESEARCH ORG (ISRO) SATELLITE LAUNCH PAD

STORAGE & DISTRIBUTION

STORAGE TANKS 10 TO 80M^3

ENGINEERED TANKS ~ 1000M^3

ISO & SEMI TRAILER - UPTO 47M^3

MARINE & TRANSPORATION

ONBOARD VEHICLE FUEL TANKS

LCNG DISPENSING STATIONS

MARINE FUEL SYSTEMS

MINI LNG RECEIVING TERMINAL

Other components for Package offerings:
Pumps and Compressors, High Pr. Storage cascades, Dispensers, Instruments, Vaporizers , VJ piping etc.,

H_2 APPLICATIONS

H2 FILLING STATIONS

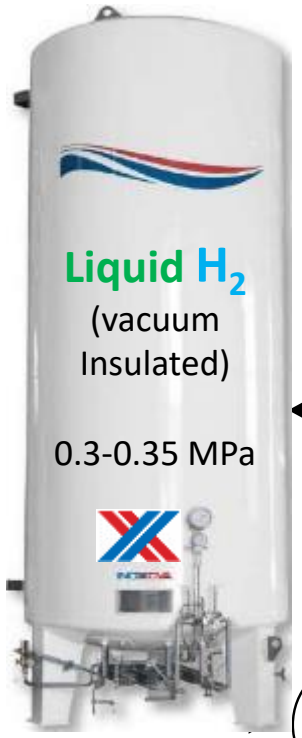
INDUSTRIAL USE

Chemical, Steel, Cement, Refineries, High heat power processes

RESIDENTIAL AND COMMERCIAL USE

H2 blending with NG Distributions systems

SLH2 STATION DEVELOPMENT STATUS



vent stack

safety valve
1.8 MPa

safety valve
2.5 MPa

control discharge
valve

backline for system
cool down

parking position

fuelling hose

main filling valve

sLH2 pump and vessel
400 kg/h @ max. 2 MPa

flow meter

filter

H2 purge gas

breakaway coupling

fuelling nozzle

Dispenser

INOXCVA Available

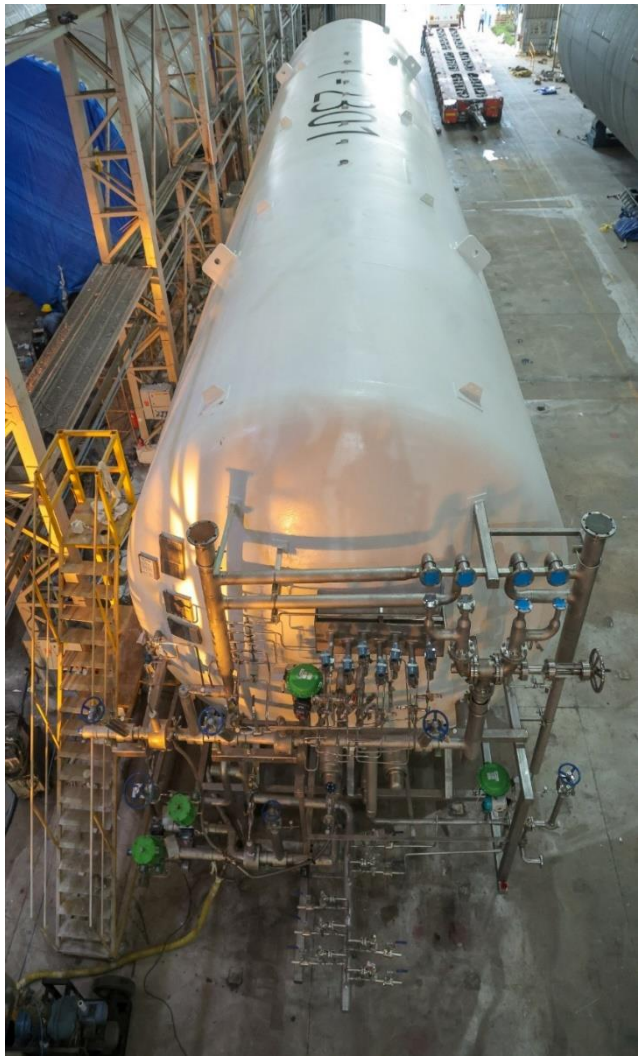
3rd Party Available

Under development (3rd Party)

LHy Cryogenic Tank - S Korea

1 No. X 238 KL Liquid Hydrogen Tank

4 No. X 311 KL Liquid Hydrogen Tank



THANK YOU

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30 YEARS OF EXCELLENCE

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