



GAIL (India) Limited



WELCOME TO PRESENTATION ON HYDROGEN BLENDING WITH NATURAL GAS IN PIPELINES

2ND Knowledge Sharing Workshop for CGD Entities
On 14.02.2022

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HYDROGEN OUTLOOK FOR INDIA

CURRENT SCENARIO

- On 15 August 2021, the Government of India announced the launch of the National Hydrogen Mission (NHM) with an aim to cut down carbon emissions and increase the use of renewable sources of energy.
- Under this mission, GoI intends to promote and develop production storage/transportation/distribution of green hydrogen through policy and regulatory frameworks and support through R&D for which Rs 25 crore has been allotted in the Union Budget 2021-22 for the research and development.
- Hydrogen is mainly used in Fertilisers, refinery, steel etc. and may also find usage in transportation sector. Research on suitability of using hydrogen in transportation is being undertaken and it is learnt that increase usage of hydrogen in transportation sector may become reality.
- Hydrogen transportation, extensive infrastructure may be required either in form of storage/pipeline etc. Therefore, there is possibility of leveraging existing gas networks for hydrogen transportation.
- Therefore, in order to leverage the opportunity to utilise GAIL's networks for hydrogen, options for blending hydrogen with natural gas and CGD is being explored.
- As on date, although the initiatives are in nascent stage, given India's commitment to lower carbon emissions, hydrogen utilization may become a mandate in future.

HYDROGEN

- Hydrogen has the potential to play a key role in the de-carbonization of the energy industry, which is dominated by fossil fuels.
- Hydrogen blended in natural gas is a powerful fuel that can decarbonize the transport sector, industries like power, refineries, fertilizer and other domestic sectors, which are users of conventional natural gas
 - One of the purest form of energy carrier
 - Reduce CO₂ emissions
 - Improve air quality
 - Lightest and most abundant chemical substance available in universe
 - Applications in all end use sectors - as a feedstock or fuel
 - Reduce fossil fuel imports

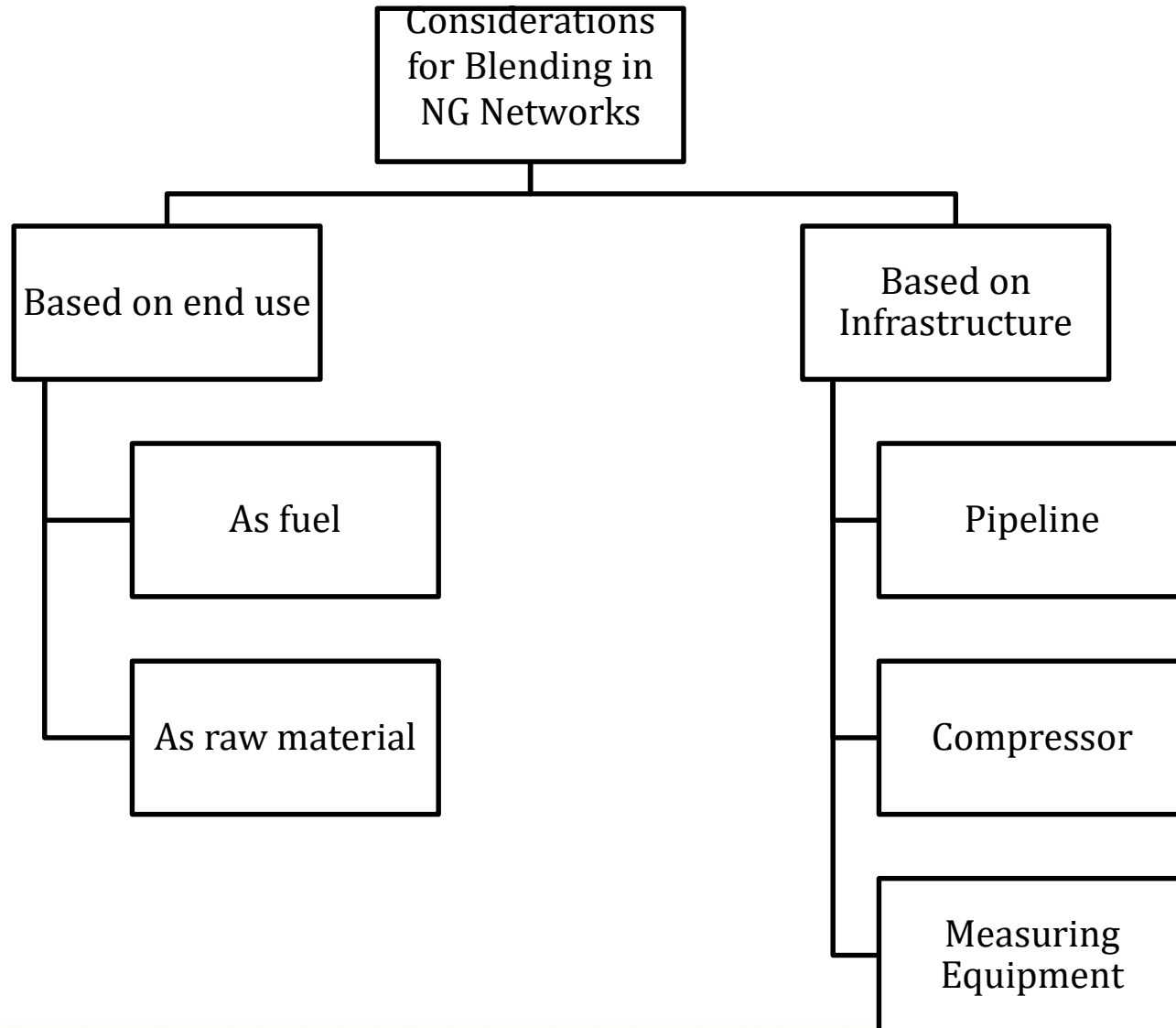
GAIL'S INITIATIVE FOR BLENDING OF HYDROGEN IN CGD/ NG NETWORK

To leverage the existing pipeline infrastructure , GAIL in consultation with MoP&NG has commissioned a study in Aug'2021 for assessment of blending of H₂ with Natural gas in 5 CGD networks Viz. Delhi, Mumbai, Bangalore, Ahmedabad and Indore

The study aims to ascertain the following :

- Maximum /Minimum % of H₂ blending in existing NG / CGD network with/ without any modification in the CGD infrastructure
- How to make future new gas pipelines / CGD networks ready for H₂ transportation through blending in Natural gas.

CGD NETWORK CLASSIFICATION FOR STUDY





PROPERTIES OF HYDROGEN VIS-À-VIS NATURAL GAS



| Parameter | Natural Gas | Hydrogen |
|----------------------|---|--|
| Physical properties | Naturally occurring hydrocarbon gas mixture. It is colourless , odourless, and explosive. Lighter than air | At standard conditions hydrogen is a gas of diatomic molecules. It is colorless, odourless, tasteless, on-toxic, and highly combustible. Lightest and smallest element. |
| Corrosive properties | Non-corrosive | Diffusible hydrogen may cause embrittlement in materials such as steel, copper etc. |
| Flame Color | Burns with a visible blue flame | Burns with a pale-blue, almost-invisible flame, making hydrogen fires difficult to see |
| Combustion | Clean burn, so its combustion does not produce solid particles or sulphur. | Combustion of hydrogen does not produce carbon dioxide (CO ₂), particulate, or sulfur emissions |

| Parameter | Natural Gas | Hydrogen |
|-------------------------------|--|-----------------------------|
| Ignition Point | 564 °C | 535 °C |
| Flammability Limits | ~5% - 15% (volume % in air) | ~4% - 74% (volume % in air) |
| Calorific value (in mass) | ~12500 kcal/kg | ~33000 kcal/kg |
| Energy density per volume | Hydrogen is 1/3 rd of Natural Gas | |
| Minimum Ignition Energy (MIE) | 0.2 mJ | 0.019 mJ |

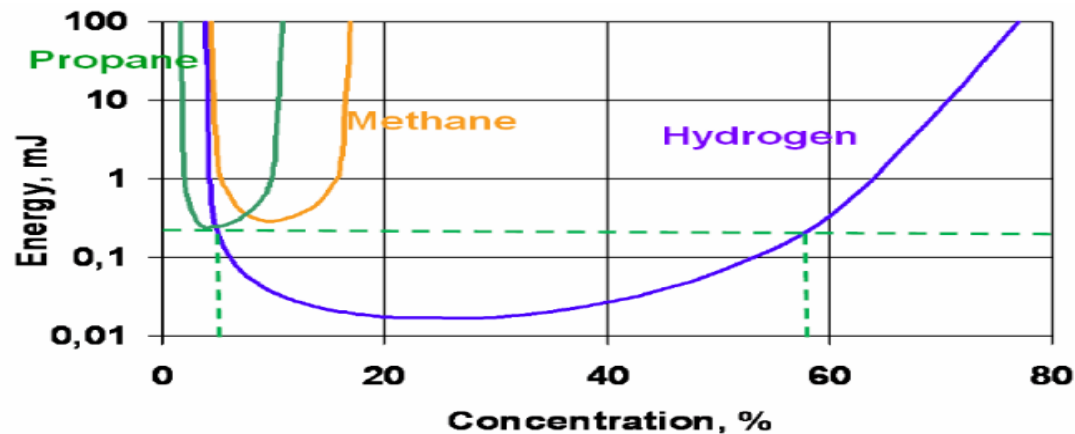


Figure: MIE of various components

ASSESSMENT OF HYDROGEN SERVICE

- Partial pressure is extremely important to assess the impact of gases in a gas mixture. Partial pressure is **the pressure exerted by a gas**. The sum of the partial pressures of all the gases in a mixture equals the total pressure.
- To summarize, *the total pressure exerted by a mixture of gases is the sum of the partial pressures of component gases*. We can write it mathematically as
$$P_{tot}=P_1+P_2+P_3+P_4\dots$$
- Partial pressure of a gas in gas mixture= **Total pressure * Mole fraction of gas in mixture**
- As per ASME B 31.12 (Hydrogen Piping and Pipelines) , for qualifying a pipeline as a hydrogen service pipeline blended natural gas and hydrogen mixture should be 90%: 10% by volume
- As per practice in vogue in industry , to qualify of pipeline system as Hydrogen service , the partial pressure of Hydrogen in gas mixture shall be more than 100 PSI

INJECTION OF HYDROGEN INTO GAIL'S NETWORK

- Hydrogen injection through pilot project is being explored in GAIL's Jagoti-Indore-Pithampur Pipeline (JIPPL). **City Gate Station (CGS) for Indore** operated by GAIL and supplying gas to Avantika Gas Limited (AGL) is considered for undertaking the pilot project in CGD network
- As per ongoing study, Indore CGD network is suitable for blending of hydrogen in natural gas up to 3 vol%, Considering the existing system components.
- PNGRB has provided a go-ahead for the pilot project at CGS Indore
- PESO permission has been obtained for hydrogen blending at CGS Indore. PESO has granted blending of hydrogen from 1.1%-2.0% v/v progressively for trial period of 4 months as below.
- The Hydrogen Blending project was inaugurated/ commissioned on 31.01.2022.



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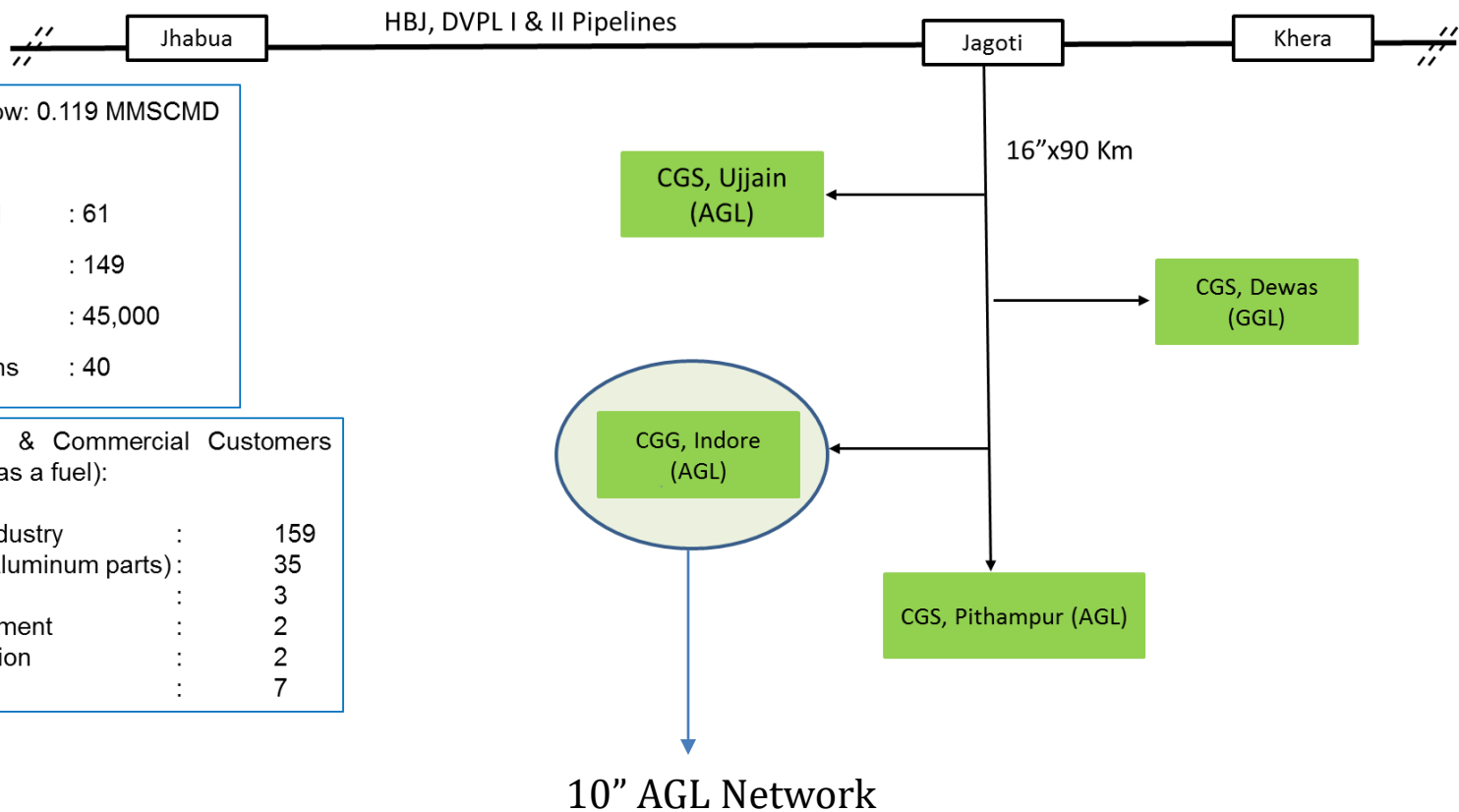


OVERVIEW OF THE PILOT PROJECT AT CGS INDORE

CGD Indore Overview

- This is a City Gate Station (CGS) for supplying gas to AGL, Indore. Through PRS, pressure to downstream customer is maintained at 19 kg/cm².
- Vacant space of ~750 m² is available within the station.
- Type of customers: Only CGD (CNG/PNG/Industries).

GAIL NETWORK - CGS INDORE



- Average Gas Flow: 0.119 MMSCMD
- AGL Customers:
 - Commercial : 61
 - Industrial : 149
 - Domestic : 45,000
 - CNG Stations : 40

Type of Industrial & Commercial Customers (using natural gas as a fuel):

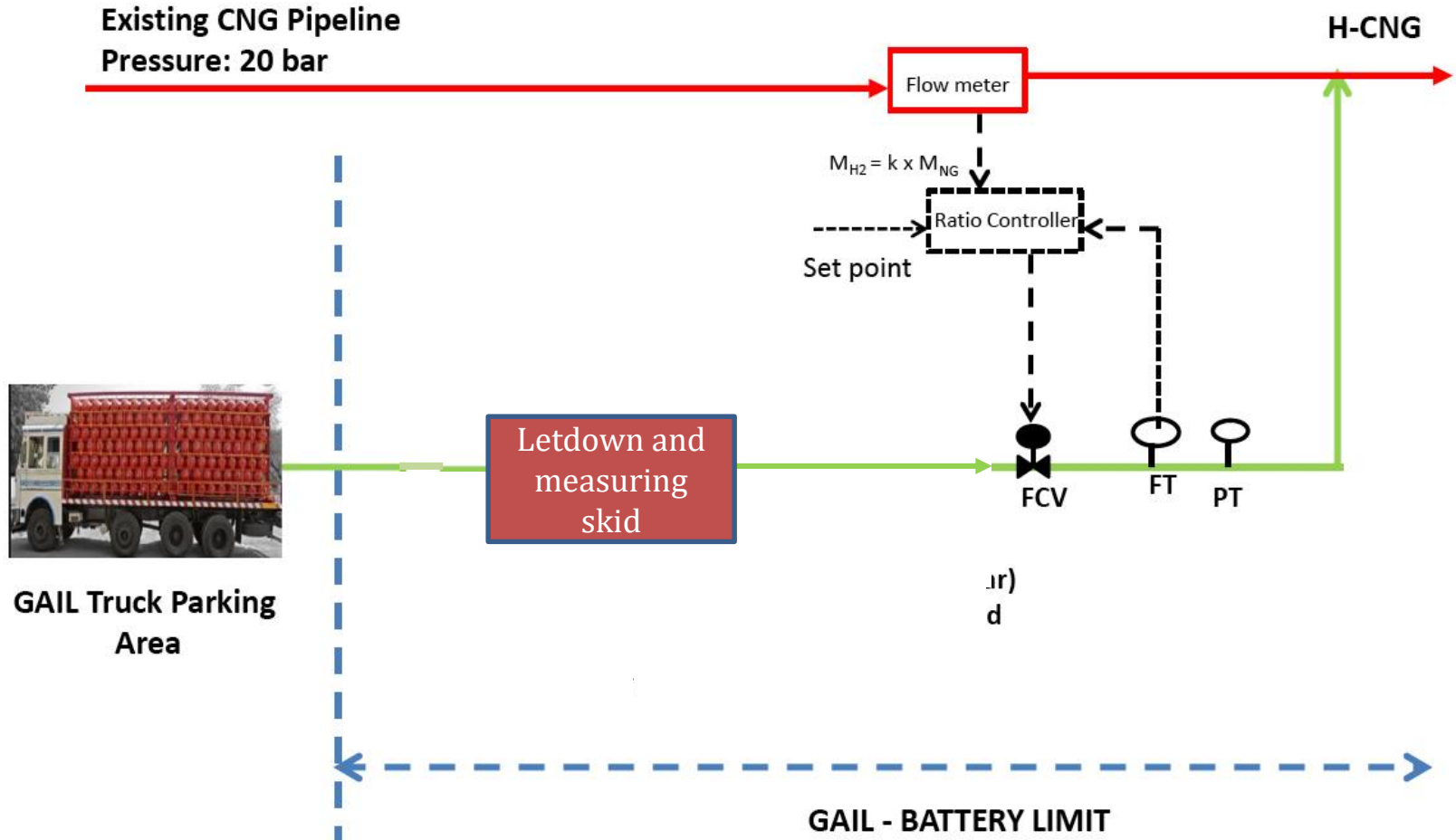
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|---------------------------------|---|-----|
| ○ Food related industry | : | 159 |
| ○ Foundry (Iron/Aluminum parts) | : | 35 |
| ○ Electrical parts | : | 3 |
| ○ Waste management | : | 2 |
| ○ Steam Generation | : | 2 |
| ○ Others | : | 7 |

PARAMETERS FOR HYDROGEN INJECTION INTO INDORE CGD

- Average Gas Flow : 7000 SCMH (Average flow)
- Green Hydrogen : 70 sm³/hr (~105 kg/day)
- Hydrogen Quality:
- Hydrogen: 99.998%
- Oxygen: < 1 PPM
- Moisture: < 2 PPM
- Initial Blending percentage: 1.1% v/v
- Blended gas will be supplied to AGL

As flow pattern of gas is irregular to CGD customers (sometimes becomes zero in night hours) – blending of Hydrogen to be regulated constantly through control systems.

HYDROGEN BLENDING FLOW DIAGRAM



FACILITIES INSTALLED FOR INJECTION OF HYDROGEN INTO CGD INDORE

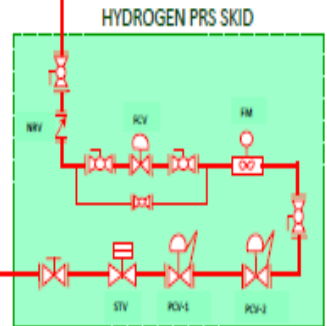
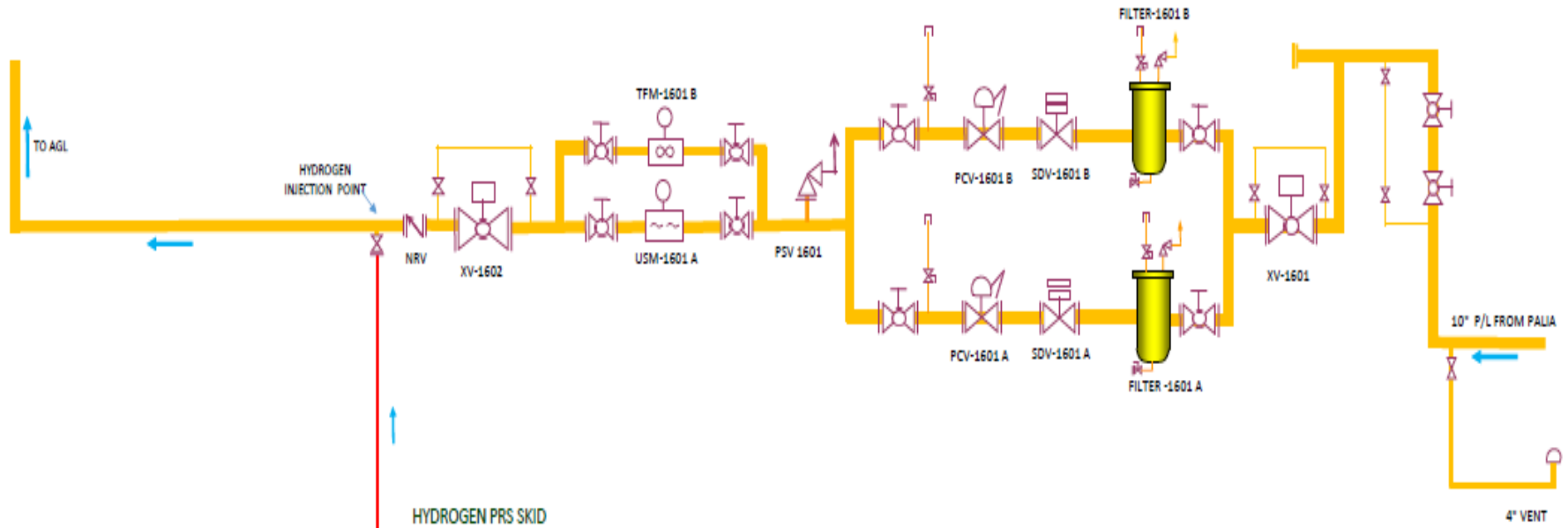
- Flow meters
- Flow controller
- Pressure Reduction skid
- Piping and Instrumentation

Note : The pilot project envisages that a moveable cascade shall be connected to the PRS upstream. Further facilities like storage cascade, compressors etc. shall be installed once the pilot scale is implemented.

STATION SCHEMATIC- INDORE CGS



STATION SCHEMATIC DIAGRAM
CGS-INDORE



| HYDROGEN PRS PROCESS DATA | |
|---------------------------|--------------------------------|
| FLOW : | 100Nm ³ /hr |
| INLET : | 30 to 200 Kg/cm ² g |
| OUTLET : | 21 Kg/cm ² g |
| PCV-1 SET PR. : | 25 Kg/cm ² g |
| PCV-2 SET PR. : | 21 Kg/cm ² g |



CGD INDORE





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THANK YOU