#EnergizingPossibilities

GAIL (India) Limited

With Natural Gas in **TRANSPORTATION . HOMES . INDUSTRIES AND LIVES**

NATURAL GAS - INTERMEDIATE FUEL FOR ENERGY TRANSISTION & HYDROGEN BLENDED NATURAL GAS FOR CGD

Presented by
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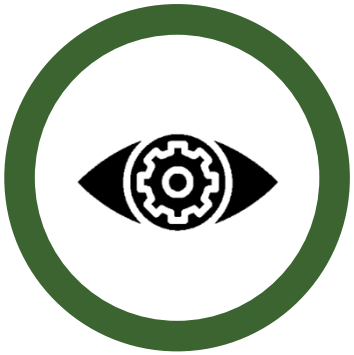
Overview of GAIL (India) Ltd.

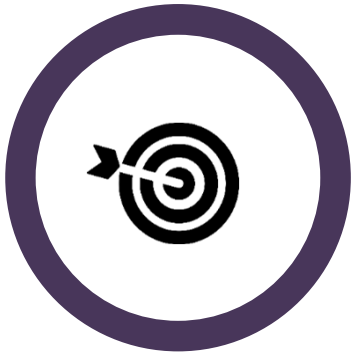
- **GAIL, formed on 16th August 1984, pursuant to Cabinet decision**
  - *Entrusted with processing, transporting and marketing of natural gas*

- **GAIL is aligned with the aspiration of a 'Gas based Economy' with new Mission and Vision**

Vision

Be the leader in natural gas value-chain and beyond, with global presence, creating value for stakeholders with environmental responsibility

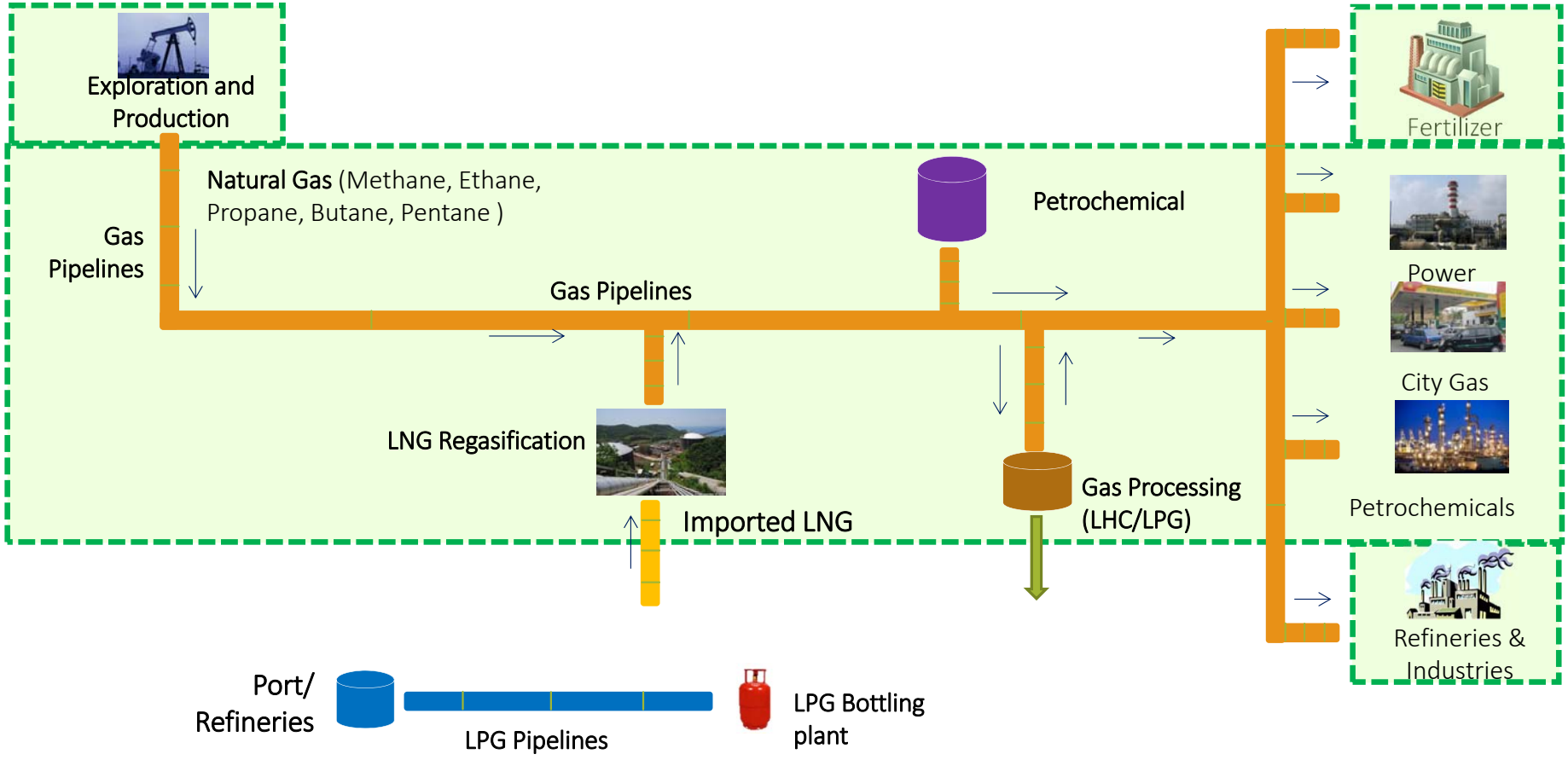




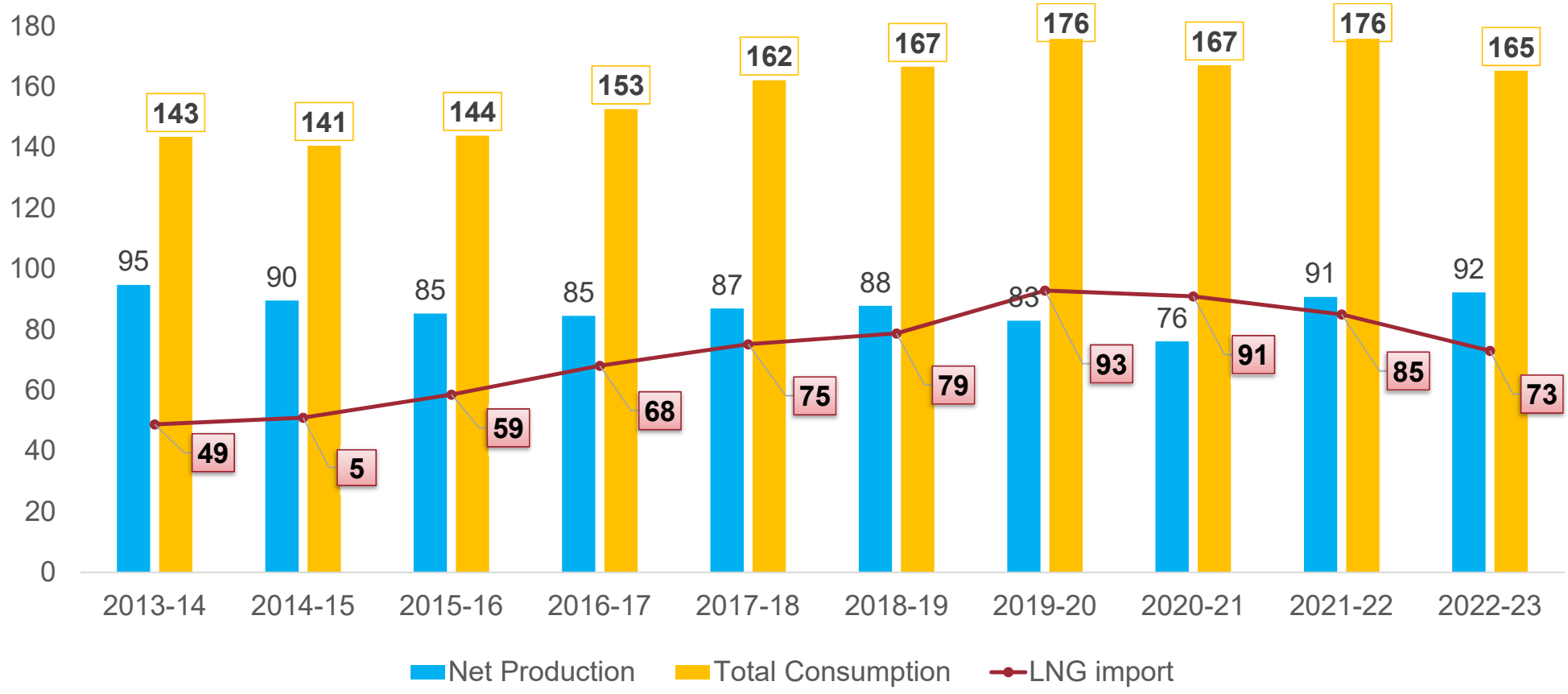
Mission

Enhancing quality of life through clean energy and beyond

GAIL has presence in entire gas value chain

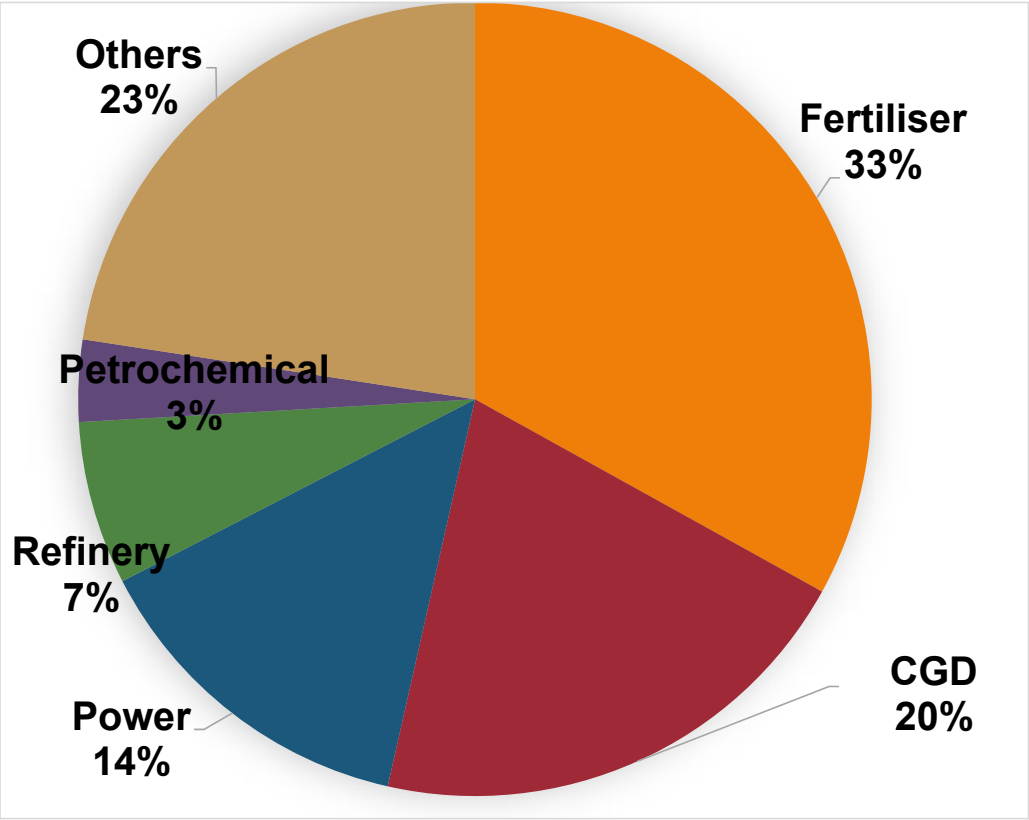


Natural Gas Consumption in India (MMSCMD)



Including internal consumption (~ 12 MMSCMD)

India sectoral gas consumption break-up (FY 23)

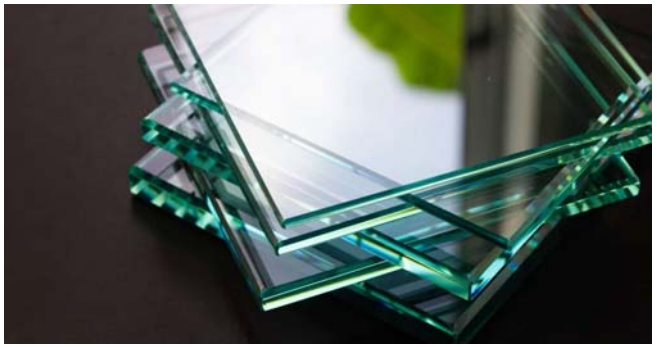


- GoI target to increase Gas share to 15% in Primary Energy mix by 2030
- Gas along with RE to play major role in achieving Net Zero by 2070
- GAIL marketed around 94.91 MMSCMD gas including overseas sales in FY23
- India's import dependency in natural gas is around 44%
- CGD is the emerging sector

Excluding internal consumption (~ 12 MMSCMD)

Other major consumers of Natural gas

FOOD



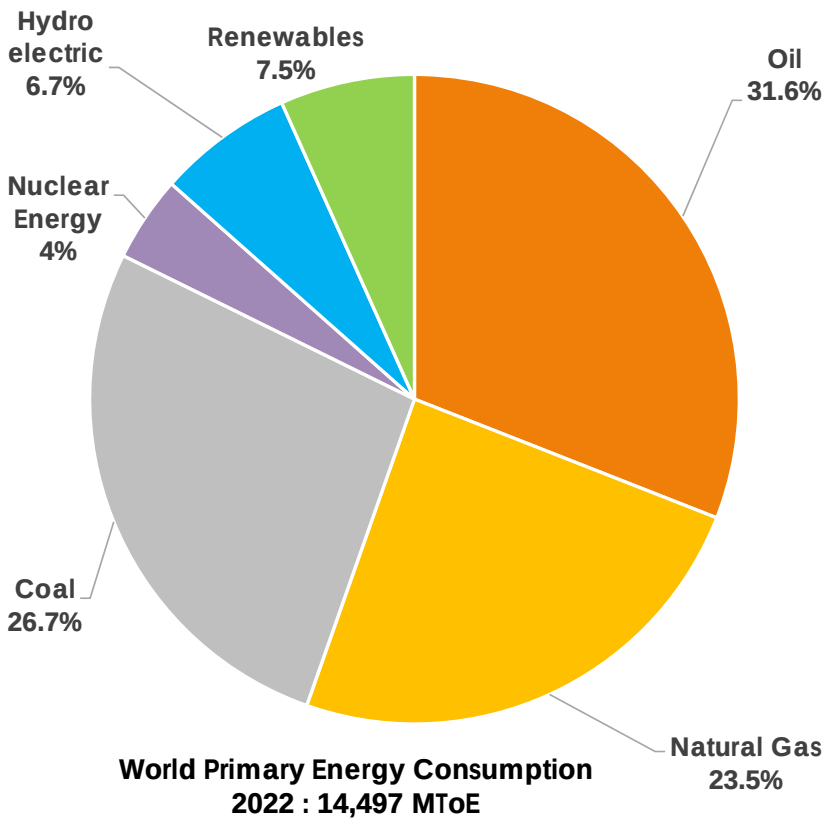
GLASS

STEEL

CERAMICS

AUTOMOBILE

World Energy Scenario



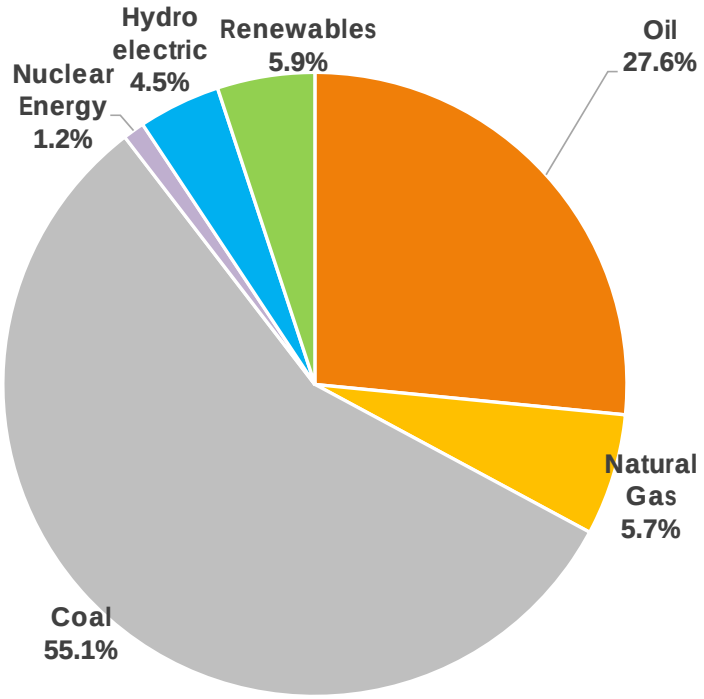
World Primary Energy Consumption
2022 : 14,497 MToE

Source BP Statistical Review 2023

- In 2022 - **1% increase** in primary energy consumption over the previous year.
- Renewables' (excluding hydroelectricity) an **increase of** nearly **1% over** the previous year.
- **Fossil fuel consumption** as a percentage of primary energy remained steady at **82%.**
- Natural gas demand **declined by 3%** in 2022 dropping just below the 4 Tcm mark achieved for first time in 2021.
  - Its share in primary energy in 2022 decreased slightly to 24% (from 25% in 2021).

- **Natural gas prices reached record levels in Europe & Asia:**
  - 3 times increase in Europe (TTF avg $37/mmBtu)
  - 2 times increase in Asian LNG spot market (JKM avg $34/mmBtu).
  - 50% hike in US HH to avg $6.5/mmBtu in 2022 – highest annual level since 2008.

India Primary Energy Mix

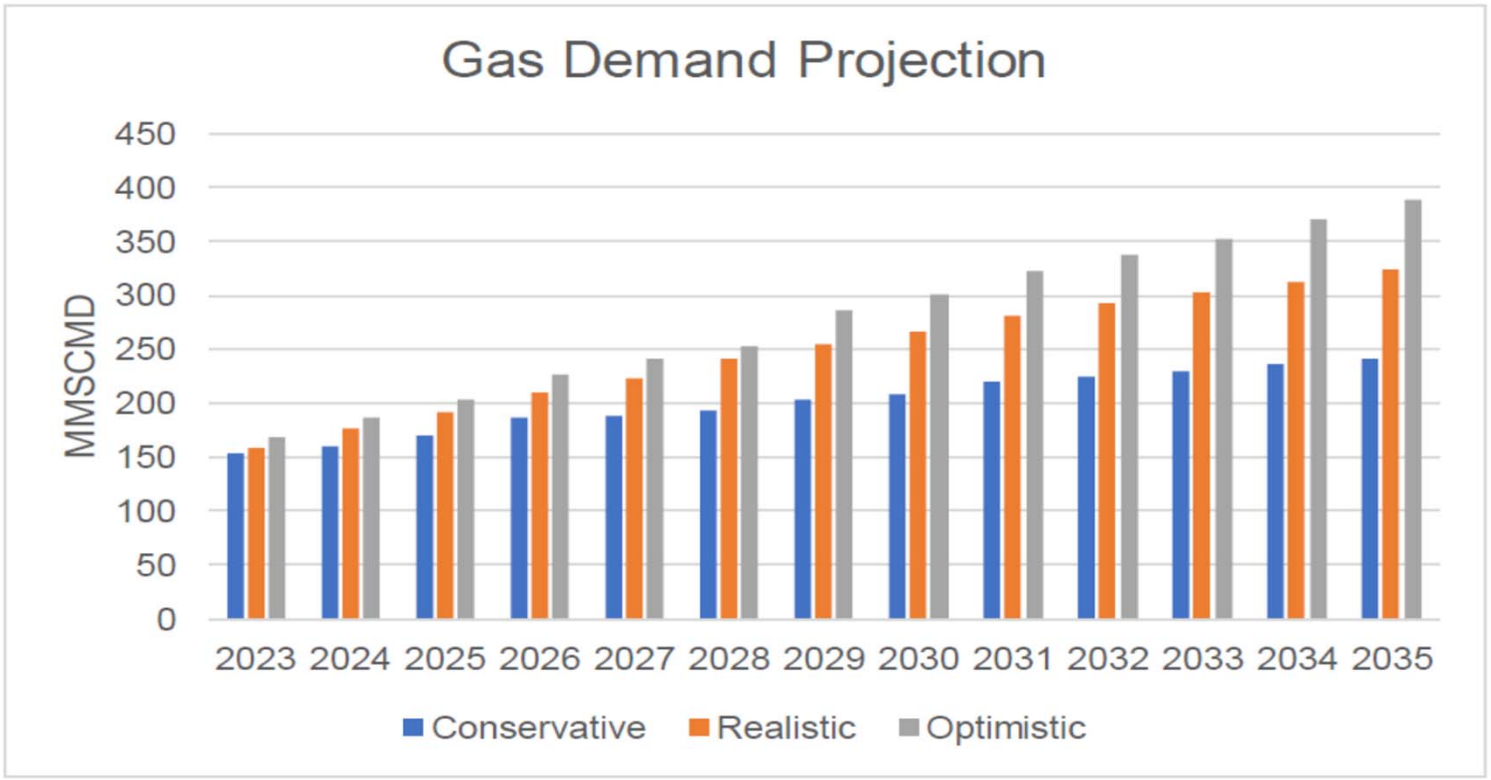


India 2022 Primary Energy Consumption : 875 MToE

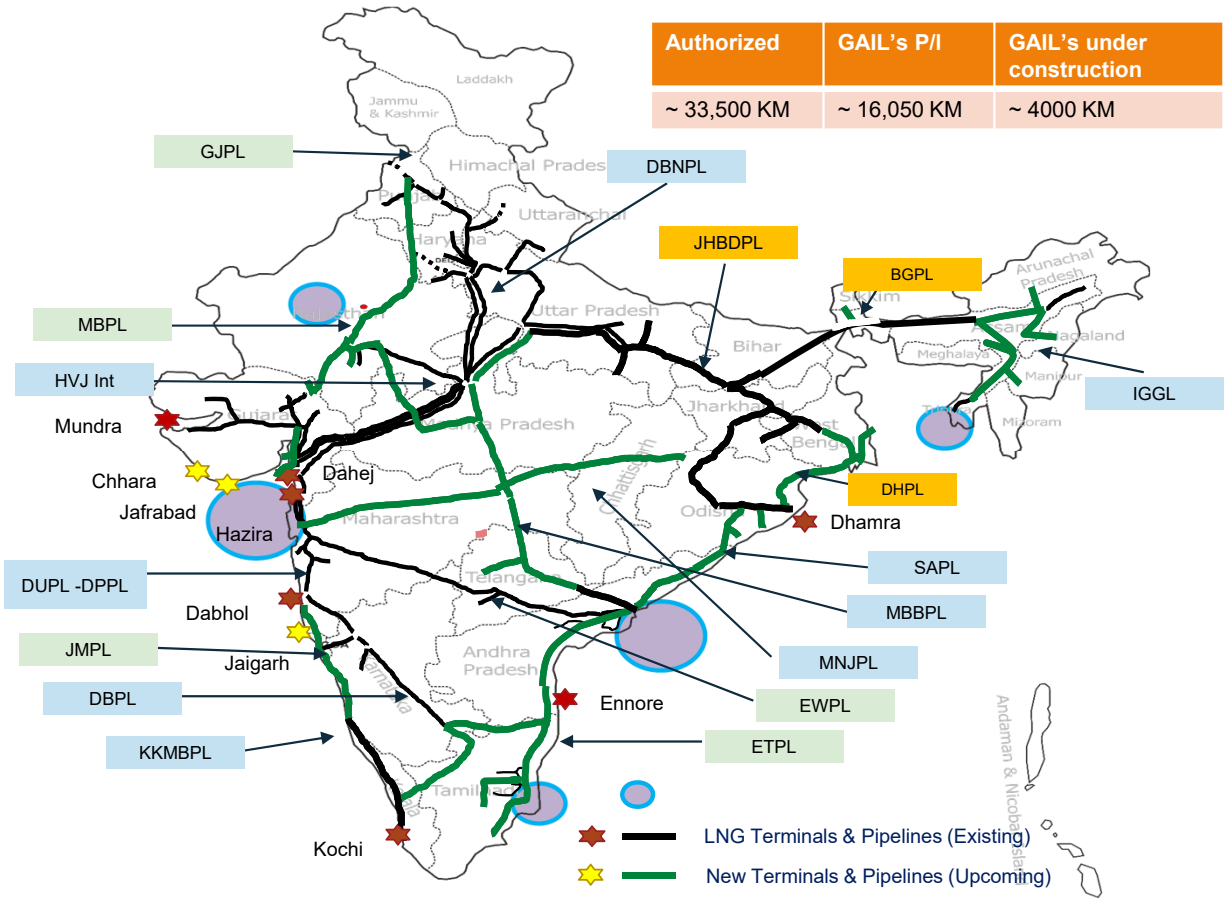
Source BP Statistical Review 2023

- **Third largest** primary energy consumer after China and USA
- **Fastest growing** among large energy consumers (India, China, USA)
- Primary energy basket is dominated by Coal and Oil. i.e. around **83%**
- Growing population, urbanization & standard of living, will need of greater demand of affordable energy
- Share of Gas in India's Primary Energy Mix **~5.7%**
- India facing trilemma of achieving higher energy access alongside high energy security and high sustainability
- **Gas based economy** is a step towards addressing these , increasing NG in energy mix to 15 % by 2030 is the target.

Estimated Gas Demand



Natural gas pipeline and LNG infrastructure: 'One nation, One grid'

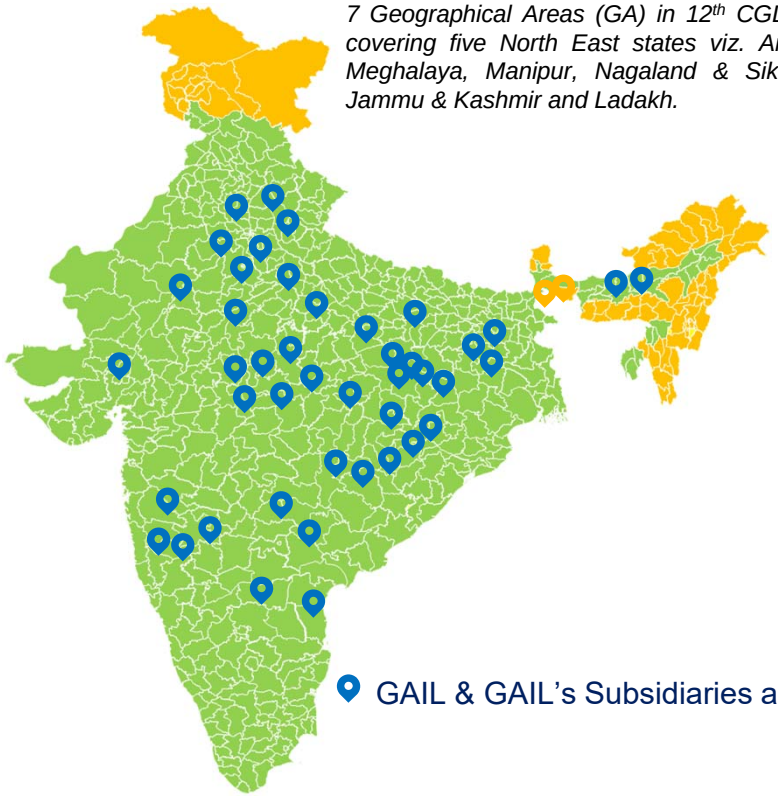


S. No.	Existing Re-gas Terminals	Re-gas Capacity (MMTPA)
1.	Dahej (Gujarat)	17.5
2.	Hazira (Gujarat)	5
3.	Dabhol (MH)	5
4.	Kochi (Kerala)	5
5.	Ennore (A.P.)	5
6.	Mundra (Gujarat)	5
7	Dhamra (Odisha)	5
	Total	**~ 47.7 (~170 MMSCMD)**

S. No.	Proposed / Upcoming Re-gas Terminals	Re-gas Capacity (MMTPA)
1.	Jafarabad (Gujarat)	5
2.	Jaigarh (Maharashtra)	4
4	HPCL Chhara	5
	Total	**~14 MMTPA (~50 MMSCMD)**

City Gas Distribution – Making gas accessible to public

7 Geographical Areas (GA) in 12th CGD Bidding round – covering five North East states viz. Arunachal Pradesh, Meghalaya, Manipur, Nagaland & Sikkim, and UTs of Jammu & Kashmir and Ladakh.



Subsidiaries

1. **GAIL Gas Ltd.**
2. **Bengal Gas Company Ltd.**
3. **Tripura Natural Gas Company Ltd**

JVs and Associates

1. **Indraprastha Gas Ltd.**
2. **Mahanagar Gas Ltd.**
3. **Maharashtra Natural Gas Ltd.**
4. **Avantika Gas Ltd.**
5. **Bhagyanagar Gas Ltd.**
6. **Central U.P. Gas Ltd.**
7. **Green Gas Ltd.**

CGD Coverage : Till 11th round, Potential to cover ~ 88% of country's area , ~98% of country's population, more than 600+ districts countrywide

*Source: *PPAC Snapshot of Oil and Gas Data , PIB*

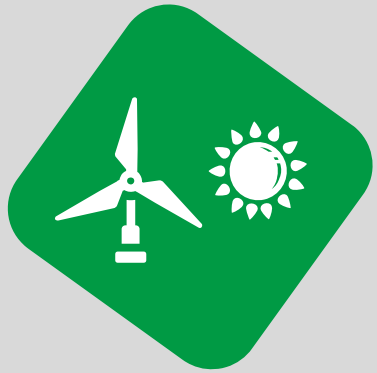
Natural gas is an environmentally benign fuel

Cleanest burning conventional fuel that exists

Produces **45% less CO_2** than coal used for power generation

25% fewer GHG emissions than diesel or petrol for transportation

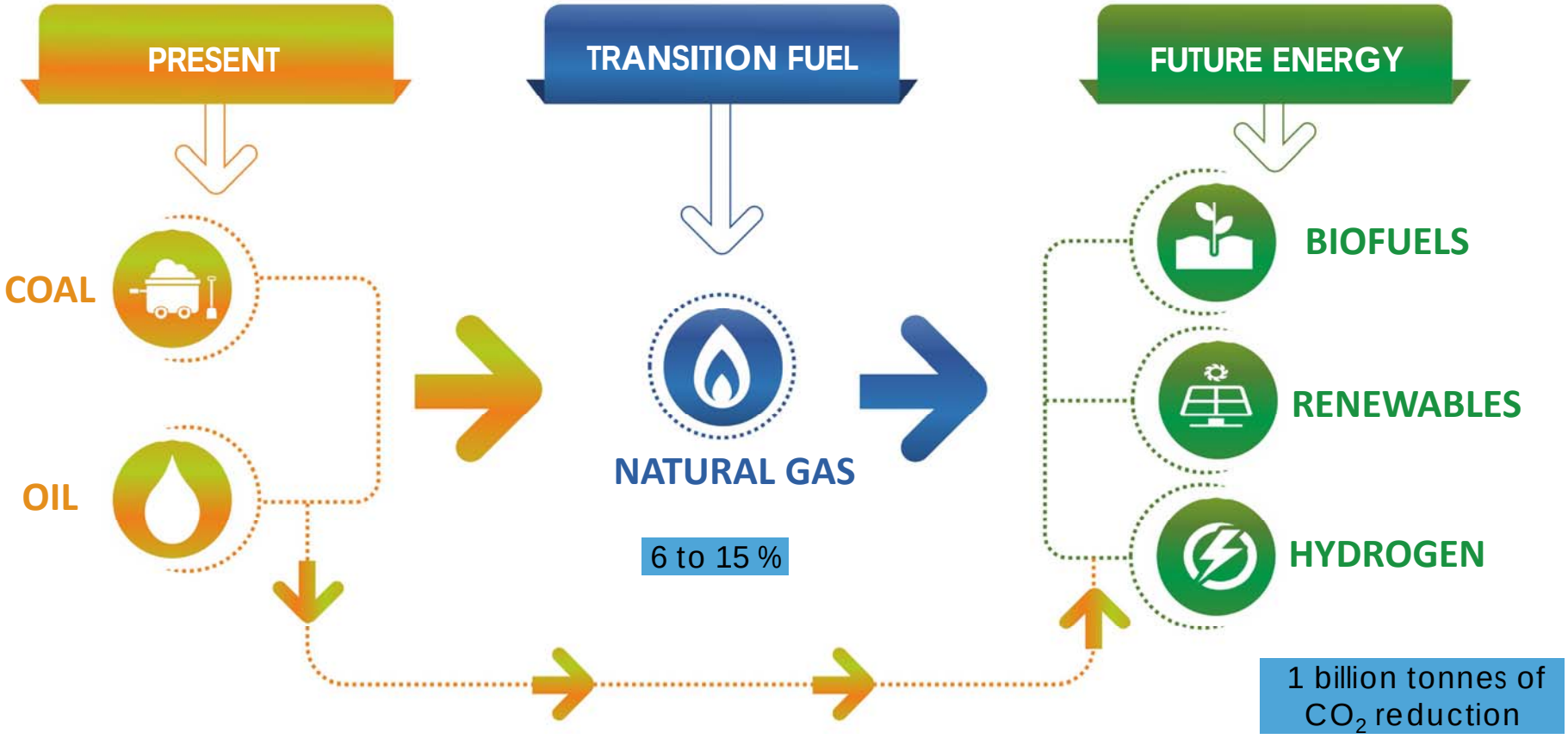
Produces **almost no sulfur-dioxide** or particulate matter



Provides **low-emission balance** power generation for solar and wind

Source: US Energy Information Administration (EIA)

INDIA's Energy Transition roadmap

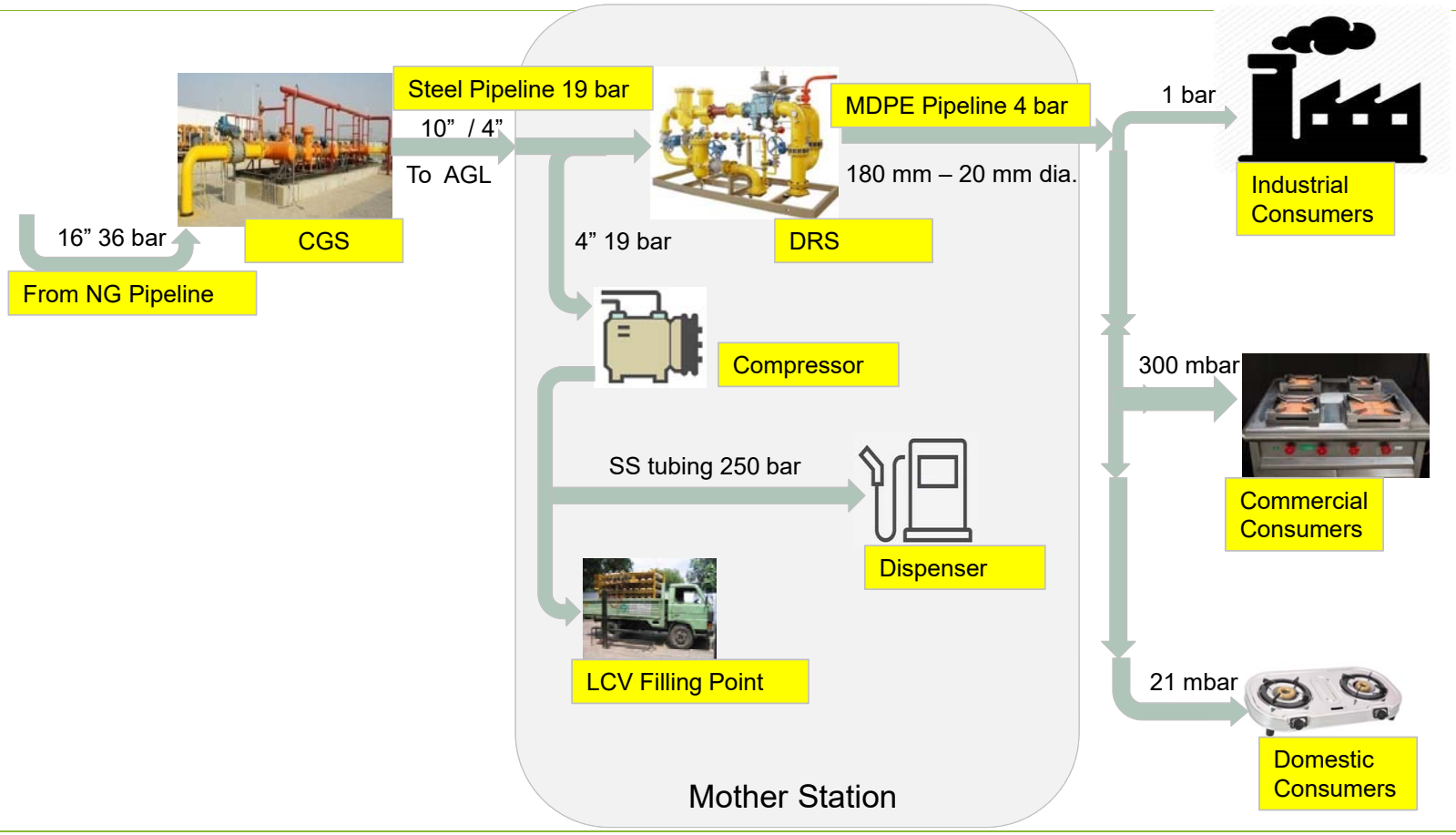


HYDROGEN BLENDING IN NATURAL GAS

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	It is colorless, odourless, tasteless, toxic, and highly combustible. Lightest and smallest element.
Corrosive properties	Non-corrosive	Hydrogen diffuses in metal interstitial sites and can 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 (CO2), particulate, or sulphur emissions
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 1/3rd of Natural Gas	

CGD NETWORK TYPICAL DETAILS



CONCERNS – HYDROGEN BLENDING IN CGD NETWORKS

- Steel Pipeline: Hydrogen can cause embrittlement of steel and cause reduced ductility (less load bearing) and cause cracking.
- Compressors & Gas Engine: Some of the OEM's suggest that new development may be required / bundle may have to be changed. Some have suggested that blending to a certain % (3 - 20 %) is acceptable.
- GC: Natural Gas GC are Thermal Conductivity (TCD) based and Helium is used as a carrier. The Thermal Conductivity of Helium and H2 are very close. So GC sensitivity level will be reduced with low H2 concentration(<2%).
- Dispenser: constitutes mass flow meter, SS tubing and other parts which are suitable for hydrogen blending in natural gas up to 10 vol%.
- End Use: As the hydrogen content in a gas blend increases, the adiabatic flame temperature increases. The metallic parts of the burner (combustion head, gas injectors, refractory etc. exposed to the hotter flame radiation may need to be adapted.
- Safety is a major concern as Hydrogen diffuses easily and has colorless flame. Flame flashback: Hydrogen has a much higher flame velocity as compared to natural gas. Higher flame velocity means higher chances of flame flashback at lower burner loads. Thus, with increasing hydrogen content in the natural gas, range of operability of existing burners may get impacted.

CGD NETWORK SUITABLITY : NG - HYDROGEN BLENDS

S. No.	Details	Findings
1	Pipeline material (upto X-52) Piping material	Suitable upto 10 V% H2 Suitable upto 10 V% H2
2	Carbon steel valve [*]	Suitable upto 10 V% H2
3	Instruments [*]	Suitable upto 10 V% H2
4	CNG Station Compressors [*] Compressor Engine [*] Generator Sets [*]	Suitable upto 20 V% H2 Suitable upto 3 V% H2 Suitable upto 5 V% H2
5	Domestic Burners	Suitable upto 10 V% H2
6	CNG Kits [*]	Suitable upto 3 V% H2
7	Vehicle manufacturers for vehicle engine	Suitable upto 3 V% H2
		[*]: As per Vendor Feedback

PILOT STUDY - INDORE

- A pilot project blending 2 % v/v of Hydrogen in CGD network has been implemented in Indore. Project started on 31.01.2022 and completed.
- Pilot Study with 5 % blending in PNG network (Low Pressure) commenced from 24-03-2023.

STEP – WISE INCREASE - HYDROGEN BLENDING v/v		
1.	1%	31.01.2022
2.	1% to 1.3%	2 months
3.	1.30% to 1.60%	1 month
4.	2.0%	Till 31.12.2022
5.	5 % (PNG)	From 22.03.2023

METERING & PRESSURE REDUCTION SKID

PIPELINE

CONSUMERS

HYDROGEN CASCADES

PRESSURE REDUCTION SKID & FLOW CONTROL

RESPONSES – CGD CONSUMERS

- The Feedback from Customer is being taken on fortnightly basis and reports are being submitted to PESO. In addition, exhaust from vehicle and industrial customers is also being monitored.

Certain outcomes of blending of 2% Hydrogen gas in CGD network :

- Effect on pipeline (X-42 Grade)
    - UT measurement – No significant / negligible effect
    - Elemental Analysis (test piece) – No significant / negligible effect
- Feedback was taken from different types of CGD consumers:
    - **Domestic** PNG Customer - Overall response was from Neutral to positive side
    - **Industrial** Customer - Overall response was Neutral side
    - **Vehicle** Customer - Overall response is Neutral
    - **Exhaust** Monitoring reports by third certified party. CO_2 , SOX and PM reduction observed.

THANKS