सत्यमेव जयते

Empowering Oil & Gas Markets through Shared Knowledge

पी एन जी आर बी
PNGRB

Foreword

Shri Anjani Kumar Tiwari
Member
PNGRB

As the national regulator for the natural gas and petroleum sector, the **Petroleum and Natural Gas Regulatory Board** is dedicated to fostering a robust regulatory and market framework that supports a cleaner and more resilient energy future.

This booklet compiles key studies that analyze critical policy, infrastructure, and market interventions essential for strengthening the role of natural gas and alternative fuels in India's energy landscape. It examines the impact of fiscal measures, such as excise duty waiver, in improving the cost competitiveness of natural gas, thereby encouraging the adoption of cleaner fuel. It highlights the importance of **strategic gas storage infrastructure**, drawing insights from global practices to enhance supply reliability and manage price fluctuations effectively.

In line with PNGRB's commitment to promoting **Compressed Bio Gas**, the study explores the introduction of **Renewable Gas Certificates (RGCs)** as a mechanism to facilitate transparent trading and ensure greater market liquidity. The booklet also addresses challenges faced by **gas-based power plants**, assessing financial and regulatory barriers and suggesting policy measures to reintegrate gas into India's power sector.

A key focus of this publication is the role of **hydrogen** in India's decarbonization efforts. The study evaluates the feasibility of hydrogen blending, its economic and regulatory aspects, and the necessary capacity-building initiatives required for large-scale deployment.

By bringing together **policy perspectives, regulatory strategies, infrastructure solutions, and global approaches**, this booklet serves as a guide for shaping India's evolving energy sector. PNGRB remains committed to facilitating a competitive, transparent, and sustainable gas market that supports India's long-term energy vision.

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Excise Duty & Other Taxation on CNG/LNG and NG Vehicles

31-01-2025

CNG Segment Overview

NG Transport Segment – Policy Interventions & Potential

01

~100% CGD Authorizations

NG transport sector is estimated to grow from present ~21 MMSCMD to ~63* MMSCMD by 2030 (ACU Case, 20% CAGR).

02

Infrastructure Development

-New Gas transmission pipelines
-17500 CNG Stations expected by 2030 (7395 stations as of 30th Nov'24.)
-~$67 billion investment envisaged in next 5-6 years

03

Priority Allocation to CGD

-Meets the increasing gas demand in CNG segment.
- However, allocation reduced to ~37% for CNG (T) (increased back to 51% eff. 16th Jan'2025.).

04

Plan For Single Levelized Tariff

- Zone wise levelized tariff already implemented.
- Ensures viable delivery of gas to regions away from gas sources.

Sustainability Goals

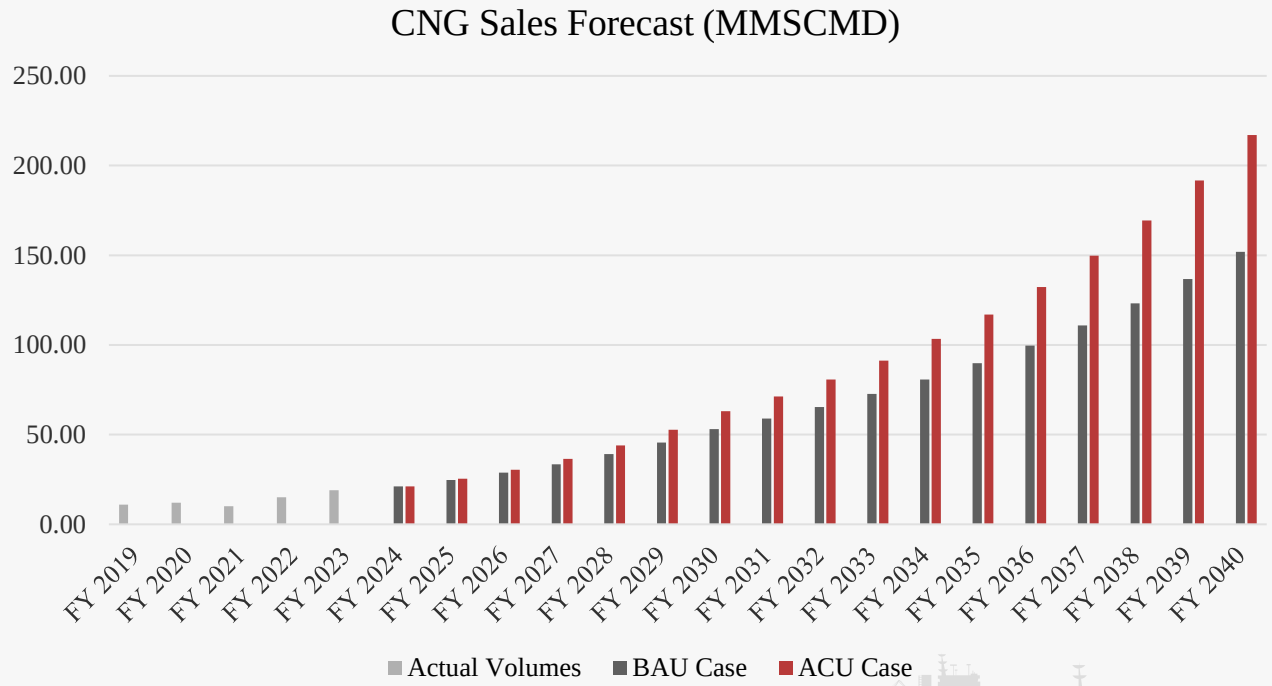
- Pathway to Net Zero by 2070.
- CO2 emission co-efficient (Kg.) per MMBTU of energy used : NG – 52, Petrol/Diesel - 76
- Contribute towards 45% reduction in emission target by 2030.
- LNG can replace diesel in highly polluting HDVs (India - ~700 vehicles, China ~8.5 lakh).

Energy Diversification

- Potential to leverage infrastructure for sustainable fuels like CBG and hydrogen.
- Availability of LNG from diversified global sources for import – Qatar (42%), USA (20%), UAE (11%), Angola (7%), others (20%) – in CY'24.

Press Information Bureau (pib.gov.in)
CO2 Emission Coefficient
Why natural gas is a strategic fuel in India's energy transition, ET EnergyWorld (indiatimes.com)
CNG Projections as per PNGRB Inputs., * PNGRB Projections

Transport Segment: Key Driver To Take Natural Gas Share To 15% Of India Energy Mix



CNG sales has been increasing at CAGR of ~14%.

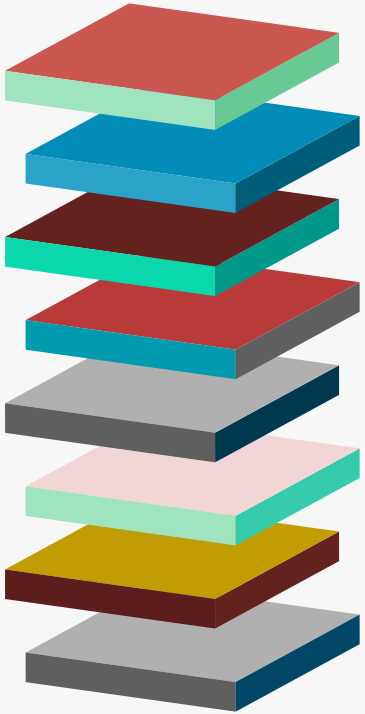
CNG vehicle sales have been increasing at CAGR of ~16%.

CAGR*

ACU – 15.7%
(FY'40 – 217mmscmd)
BAU – 13.2%
(FY'40 – 152mmscmd)

PPAC Source: PPAC, FY 25 data extrapolated from PPAC H1 Ready Reckoner, * PNGRB Projections

Three Crucial Proposals

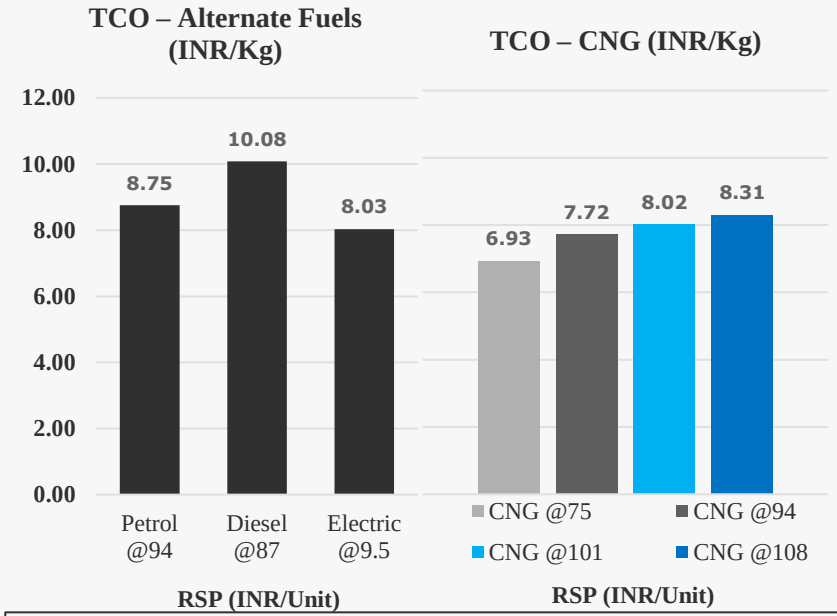


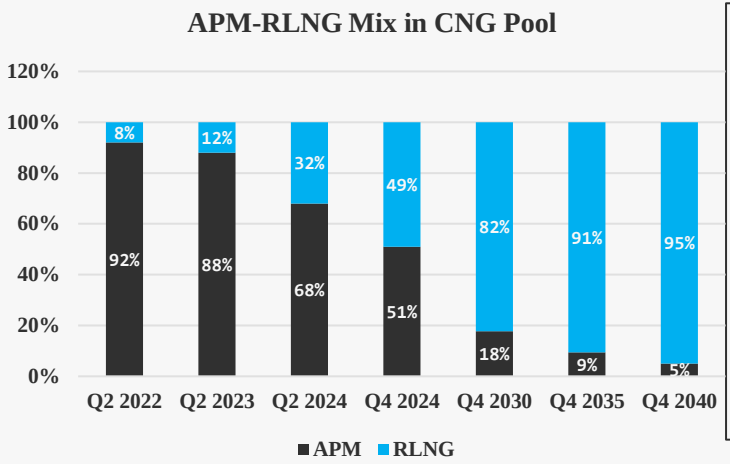
1. Waive off the excise duty on compression of CNG
2. GST on sale of CNG/LNG vehicles at par with EV
3. Waive off excise on CBG sold as co-mingled CNG
4. Waive off excise on LCNG

1. Excise Duty Waiver & Impact Analysis

CNG – Loses Advantage Over Petrol With Price Rise

~10%-15% discount over petrol prices has been the driving force behind growing CNG adoption by users.





CO2 Emissions (TTW)

(g/km)

- **CNG – 79**
- **EV* - 100**
- **Petrol - 117**
- **Diesel - 118**

Assumptions

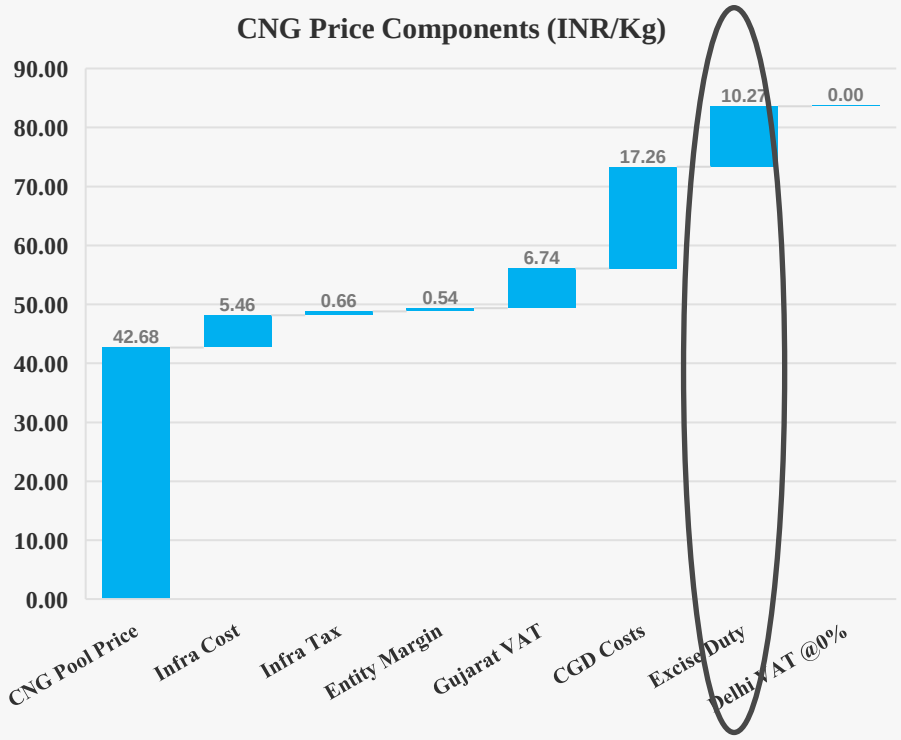
- Daily Running – 60km
- Total Life – 15 years (10 years for diesel)
- No subsidy considered for Evs
- 11mmscmd APM qty till CY2040

Power Cost – Rs.9.5/unit
Fuel Prices – ex Delhi

- It is important to maintain current prices of CNG in order to **maintain the discount for CNG over alternate fuels**.
- **Declining APM allocation** a major concern that can lead to price rise.

- RLNG @ 14$/MMBTU, APM @51% in CNG Mix, $/INR @86.5
- *EV Emissions considered from India power plant emissions as per CEA data.

Taxes Contributing To CNG Price



CNG RSP for Jan'25 (INR/Kg)

- Delhi – 75.09/-
- Rajasthan (Ajmer) – 86.44/-
- Uttar Pradesh (Kanpur) – 87.92/-

Tax Impact

Considering Delhi GA,

- **Excise duty accounts for ~12.3% of RSP**.
- **Gujarat VAT accounts for ~8% of RSP**.
- **Total taxation load comes to ~21% of RSP**
- For states with higher VAT, **taxation load can go up to 36%.**

CETA, 1944

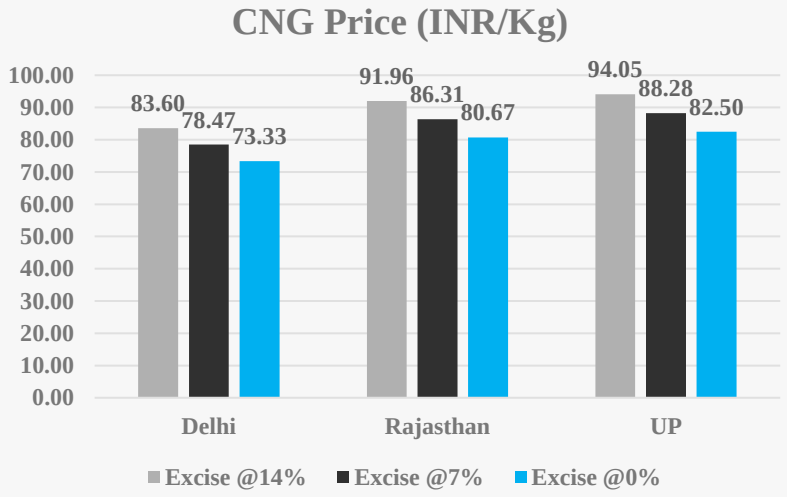
- Compression of NG is considered as **Deemed Manufacturing**
- NG is **compressed to only fill more fuel** in the tank & to increase vehicle range.
- Due to **no ITC**, excise becomes a cost to the CGD.
- **LCNG is also being charged excise duty** at same rate as CNG.

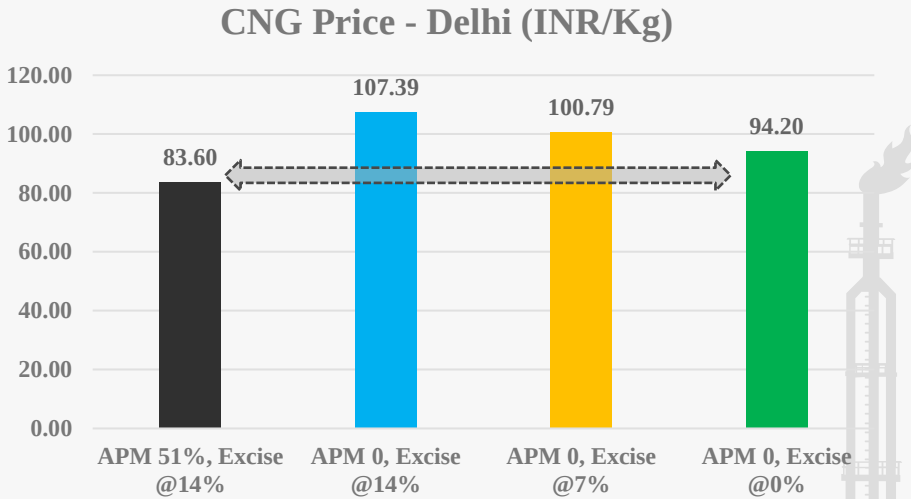
Assumptions:

- *APM considered @51% of the pooled mix.*
- *RLNG considered @14$/MMBTU*
- *APM considered @6.5$/MMBTU*
- *$/INR @86.5 ; Rajasthan @10%VAT – 91.96 Rs./kg, UP @12%VAT – 94.05 Rs./Kg*

Compression as Deemed Manufacturing, Infra cost and CGD cost Breakup

Reduction In Excise Duty Can Negate Impact of Declining APM





- With APM allocation headed towards zero in near future, **reduction in excise duty is necessary to keep CNG competent** as compared to alternates.
- Additional consumption of RLNG instead of APM (~11mmscmd) in CGD(T) sector will add ~Rs. 580cr./annum to exchequer through customs and GST on infrastructure.
- Excise reduction to 0% will have an immediate impact of **~ Rs. 6500 – Rs. 7000 cr/ year** on the exchequer.
- This reduction will immediately free-up the APM allocation towards CNG segment and can be diverted to other priority sectors.

- RLNG @ 14$/MMBTU, APM @51% in CNG Mix, $/INR @86.5
- APM Allocation Increased

Cost Benefit Analysis

Immediate Cost

Waiver of excise duty on compression of NG

~Rs. 6500 – Rs. 7000 Cr. Annually

- FY'25 CNG sale considered to be ~25mmscmd with average retail price of Rs. 85/Kg for excise revenue calculation.

Reducing GHG Emissions from EVs

- **Electricity for EVs is majorly produced from coal (~70%),** which is highly polluting.
- **Utilising gas fired power plants can help alleviate the issue of emissions from EV value chain.**
- Emission from **gas fired power plants (0.44 ton CO2/MWh)** are less than half as compared to **coal fired power plants (1.02 ton CO2/MWh).**

Benefits

Option 1:

Excise Benefit passed on to CNG Consumers:

- No change in domestic gas allocation for CNG (T).
- ~12.3% reduction in CNG Cost.
- Reduction in CO2 emissions (~30%) and PM in ambient environment.
- Reduction in healthcare expense (PMJAY Budget – Rs. 7500cr for FY'25) and ailments originating from polluted air.
- Gas Market Maturity leading towards GoI's mission to take the share of **NG to 15% of Energy Mix.**

Option 2:

Revival of Gas Based Power Plants:

- **~11 mmscmd** domestic Gas can be **diverted to run Gas Based Power Plants**.
- **~3.60 GW* of Gas based power capacity** can be revived at 60% PLF.
- **~Rs. 8800Cr*.** benefit as reduced cost of gas-based power.
- NPAs worth of **~Rs. 11500 Crores*** could be revived.
- Gas based power plants can be operated to cater peak power demand periods (e.g. - NTPC used ~ 3mmscmd RLNG in H1 2024).

There shall be **additional revenue in VAT** (for state govts.) on increased sale of Natural Gas through above reform.

PMJAY Budget
CO2 per MWh

*** ICF Internal Analysis**

2. GST Reduction on Sale of CNG/LNG Vehicles

Policy Support For CNG vs EV Vehicles

	EV Segment	CNG Segment
Subsidy Waiver	Under FAME I & II on following: a) Capital investment b) Registration & Road Tax c) Insurance d) Interest on loan for EV etc.	Support provided through APM allocations. But these allocations are gradually reducing.
GST on Vehicle Sale	5%	28%
Permission for Infrastructure	Minimal permissions required	DM, Forest, PESO, OISD, NHAI, etc.
CO2 Emissions	~100 g CO2/km* (Much higher emissions as ~70% of electricity is derived from coal.) (Includes emissions from power plants against fuel use, including AT&C losses)	~ 79 g CO2/km* (TTW Emissions Considered)

- **Further, LNG can be used as a clean fuel in HDV (Heavy Duty Vehicle) segment where use of EV technology is not yet feasible. GST on LNG HDVs also needs to be reduced from 28% to 5%.**

Press Information Bureau (pib.gov.in)
Press Information Bureau (pib.gov.in)
Science Direct GHG EV vs IC

*** ICF Analysis**

Cost Benefit Analysis Of Interventions

	Immediate Cost	Quantitative Benefits	Qualitative Benefits
5% GST on sale of CNG/LNG Vehicle	**~Rs. 16800Cr.** annually on account of reduction in GST by ~23%	**Average ~Rs. 200 Crore additional annual revenue in first 5 years:** • Rs. 44 Crs. GST on Regas charges. • Rs. 56 Crs. GST from Transportation Tariff. • Rs. 100 Crs. revenue from Custom Duty ~ **USD 67 Billion** investment expected till 2030 in energy sector.	• Progress towards incresing share of **NG to 15% of Energy Mix** • **Reduction in eCO2 emission by ~30%** as compared to petrol/diesel. • Reduced burden on exchequer related to health issues, specifically **respiratory problems**
23% GST on sale of CNG/LNG Vehicle	• **~Rs. 800Cr.** annual additional revenue (ACU case) on account of reduction in GST by ~5%. • **~ Rs. 7000Cr.** annual gain in tax collection expected FY30 onwards (ACU case).		

There shall be **additional revenue in VAT** (for state govts.) on increased sale of Natural Gas through above reform. Additional revenue is sum for initial 2 years.

Nitrogen Oxides (NOx) Emission from Fuels (engineeringtoolbox.com)
CO2 Emission Coefficient

3. Excise on CBG Sold as Co-Mingled CNG

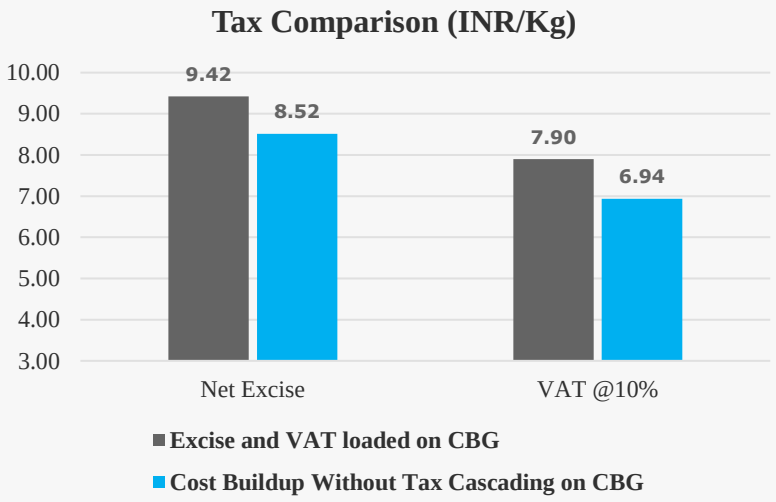
Compressed Bio-gas (CBG) Sector In India

CBG Snapshot of India (Nov'2024)	
No. of CBG Plants Commissioned	80
ROs with ongoing CBG Sales	253
Sale of CBG	23578 tons (0.13MMSCMD)
No. of CBG/Bio- CNG plants Registered (Gobardhan)	819 (Gobardhan Portal)
CBG Production Target under SATAT	~53 MMSCMD (15 MMTPA)
Union Budget '23-'24	Rs. 10,000cr. 200 CBG Plants 300 Community Plants

- **CBG being considered an important sustainable fuel with multiple advantages – domestic production capacity, reduce forex expense, promote circular economy and achieve Net Zero targets.**
- **MoPNG** order dated 27th Feb' 2024 has mandated the blending of CBG with CNG (T) and PNG(D). **CBO (CBG Blending Obligation) shall be kept as 1%, 3% and 4% of total CNG/PNG consumption for FY 2025-26, 2026- 27 and 2027-28.**
- **MoHUA – Urban 2.0 -** Central Assistance is provided to States and Union Territories for solid waste management. Additional Central Assistance of 25% /33%/50% (based on ULB population) for MSW based CBG plants.
- **MoPNG** has launched Sustainable Alternative Towards Affordable Transportation **(SATAT).** Under this initiative, OGMCs invite expression of interest from entrepreneurs to procure CBG for further marketing on long term agreement basis.
- **MNRE – Waste to Energy Program** provides Central Financial Assistance (CFA) to project developers and service charges to implementing agencies on successful commissioning of plants for the generation of Biogas.

PIB Notice
Gobardhan Policy Support
CBG Data from Gobardhan (14th Jan'25) and PPAC (Nov'24)

Additional Excise And VAT Charged On CBG



- CBG blending considered at 10% of CNG pool.
- CBG procurement considered at ~ Rs.68/Kg
- Additional excise and VAT lead to **~2% rise in CNG prices.**
- Impact on final price will increase as the blending of CBG increases.
- This will adversely affect the uptake of CBG as a transportation fuel.

CBG taxed under GST @5%. GST is paid to producers at the time of procurement.

CNG is not covered under GST. **Excise @14% and state VAT is charged** at applicable rates.

Only the amount of GST paid by CGD entity towards CBG procurement is allowed to be offset against excise duty paid. This still allows **cascading of ~9% (14% excise - 5% GST) excise duty** on top of CBG component.

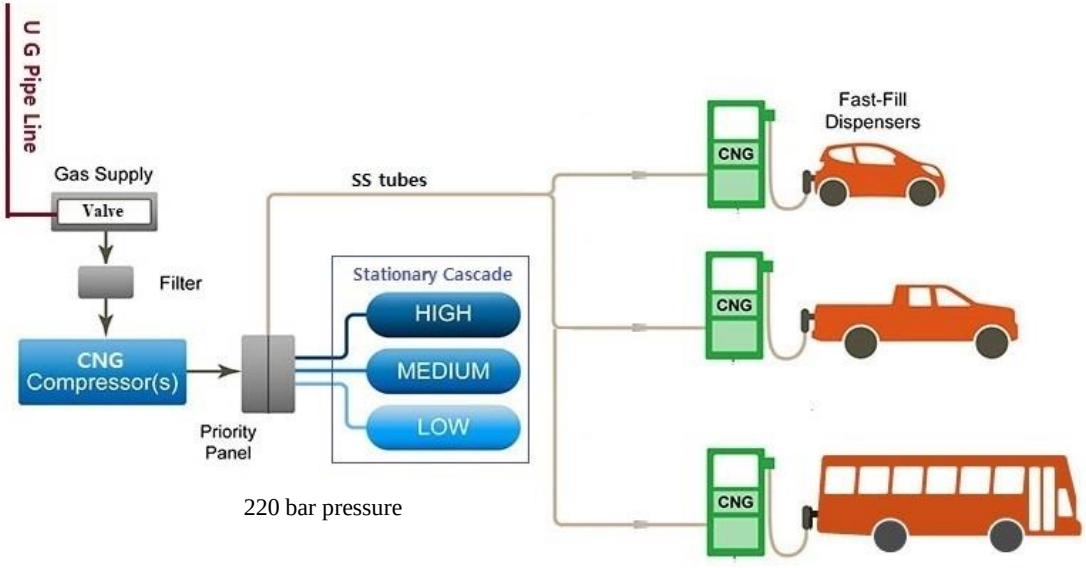
Additionally, since co-mingled product is sold as CNG, states levy VAT on co-mingled product at prevailing rates, say 10% (Rajasthan). **This 10% VAT is another cascading tax** in addition to 9% excise duty levied on CBG.

A product that was to be taxed @5% under GST is being taxed ~19%-30% excessive rates. **This nullifies the measures taken by GoI to promote usage of CBG as a sustainable fuel and promote energy independence.**

PIB Notice

4. Excise on LCNG

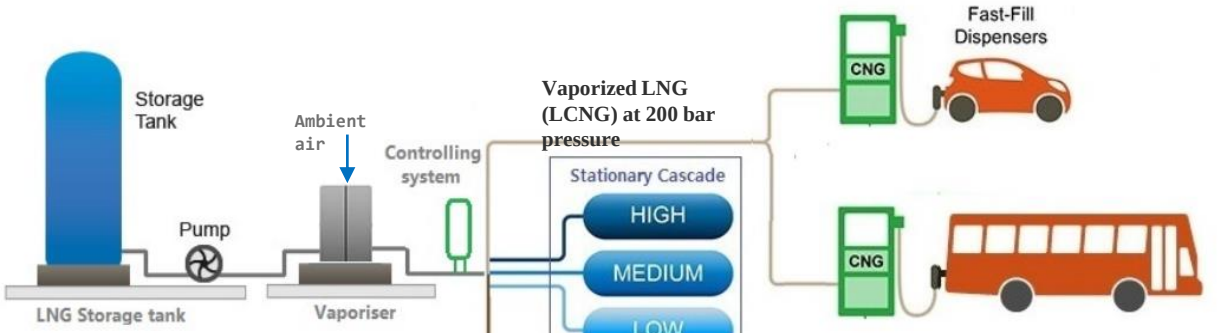
NG is compressed only to increase the vehicle range



Typical diagram of Online CNG station facility

- NG is compressed to fill more gas in tanks
- Compression doesn't change the properties of gas
- Consumers are technically buying NG, which is filled in tanks to attain 200+bar pressure
- The gas is again de-pressurized to be used as fuel in vehicles

LCNG doesn't involve Compression Activity



- **LNG transferred from Storage Tank to Vaporiser (at 200 bar) through Pump**
- **In LNG Pump, only less than 1/10th energy is used when compared to same volume of CNG by CNG Compressor**

Typical Diagram of L-CNG Mother facility

- LNG is vaporized to LCNG.
- In vaporiser, upon contact with Ambient air, LNG (-162 C) automatically gets vapourised.
- There is no "Process of compression of Natural Gas" (Refer figure)
- Removing excise duty on LCNG component can improve payback period by ~15% - 20% depending on the proportion of LCNG/LNG sales from retail outlet.

End of Report

LNG Strategic Storage | LNG Strategic Reserves

31-01-2025

Agenda

1. MoPNG Efforts
2. Why Strategic Storage
3. Gas Strategic Storage
4. Strategic Storage of Gas – Global Examples
5. LNG Strategic Storage – Quantum to pursue
6. Options for India to pursue Strategic Storage
7. Evaluation of Options
8. Role of PNGRB
9. Recommendations
10. Way forward

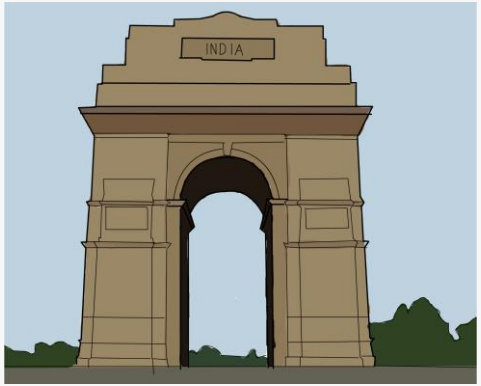
MoPNG's Efforts on Strategic Storage

Efforts of MoPNG

- MoPNG had created 2 committees to discuss & deliberate the task of creation of Natural gas Strategic Storage (late 2023 & early 2024)
    - **Committee 1** : UGS - Underground storage (ONGC, OIL, GAIL)
    - **Committee 2** : LNG - Existing Terminal Operators of India (GAIL, PLL, ATPL, Shell, IOCL)
- The LNG group was asked to discuss debate and deliberate ideas on creation of strategic storage.
    - The group was supposed to submit a report with recommendations.
    - The committee was asked to find out innovative business models to create SS in India.
- Current Status:
    - A consultant has been appointed* by ONGC to study UGS. The same is expected to be submitted by Feb 2025.
    - LNG Committee has prepared a report. The submission of same to MoPNG is pending.

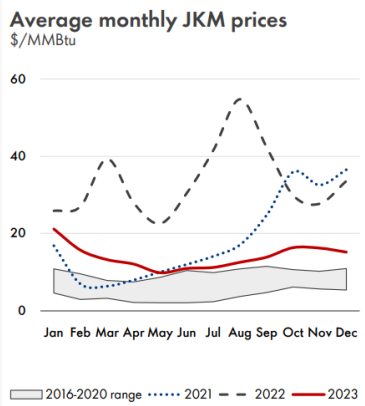
* Industry Sources

Why Strategic Storage?



India

- Commitments towards net-zero and increasing role for gas in economy.
- Going forward the share of imports (i.e. LNG) in total gas consumption will increase in view of rise in LNG fueled vehicles and falling domestic gas production.

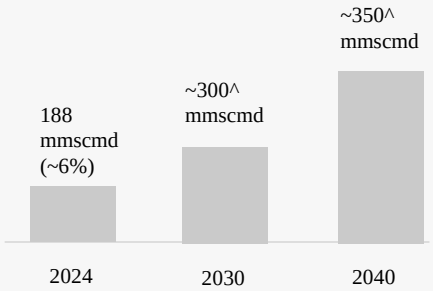


Volatile LNG markets*:

- Spot LNG prices fluctuating due to global events
- Some events also have potential to affect Oil prices (affecting LT LNG)

Events:

- Record cold winter in NE Asia (2021)
- US Gulf Coast outage due to winter freeze (2021)
- European Energy crisis (2022-23)
- Red Sea attacks (2024)



Energy Security

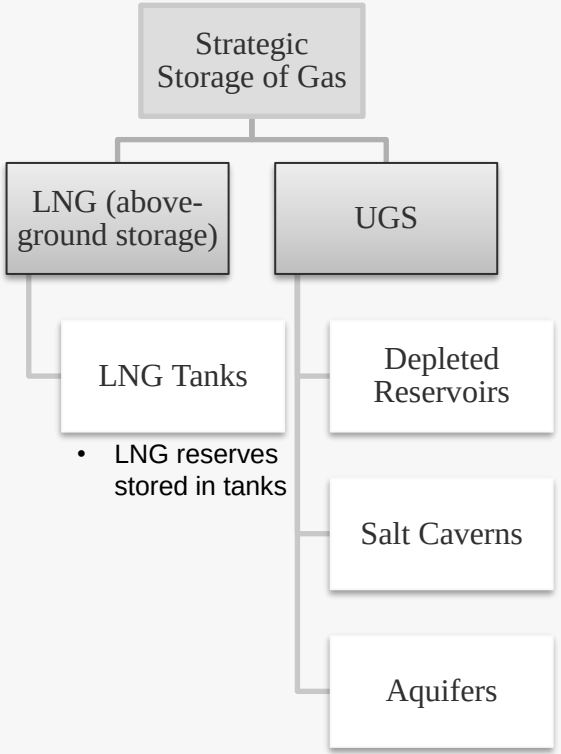
- Gas demand will grow more than ~350 mmscmd by 2040
- Increased reliance on NG should be supported by Energy Security.
- All developed economies with significant gas in energy mix has provision of 10-15% gas in storage (US, EU, China etc).
- Commercial benefits
- Commodity arbitrage opportunities

Important to secure & ensure Natural gas supply during disruptions and extreme price volatility

* - These events led to sustained unusual high LNG prices, for eg ~30-40 $/mmbtu vs. ~15 $/mmbtu in BAU scenario

^ - Assumed demand

Strategic Storage of Gas



- LNG reserves stored in tanks

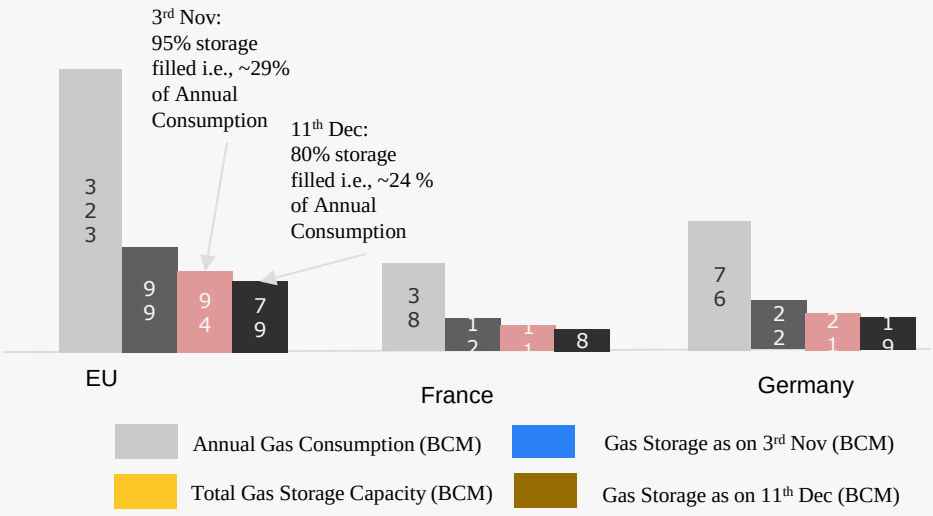
- most widely used type
- ~80% of UGS type
- Widely used in US, Europe

Parameter	Depleted Reservoirs	Salt caverns	Aquifers
Cushion gas	30 to 60%	20 to 40%	50 to 80%
Working gas volume	Medium to Large	Small	Large
Withdrawal flow rate	Medium	High	Medium
Injection period	150 to 250 days	20 to 40 days	150 to 250 days
Withdrawal period	100 to 150 days	10 to 20 days	100 to 150 days
Development duration	2-3 years	3-5 years	More than 5 years

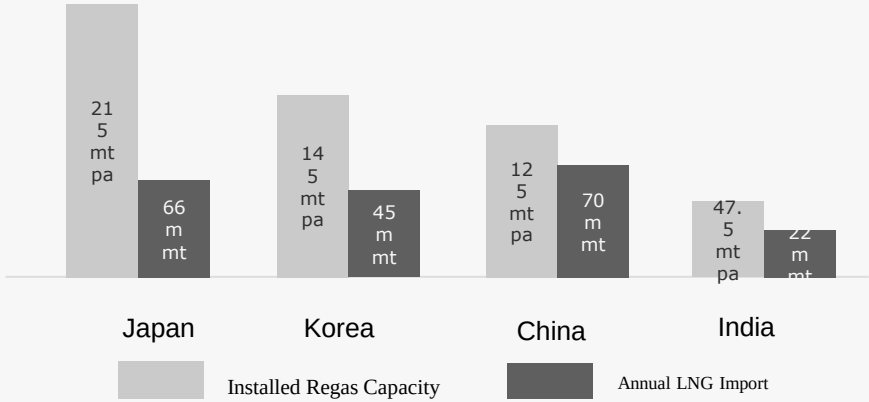
Internal Analysis

Strategic Storage of Gas – Global Examples

Annual Gas Consumption vs Storage in EU, France & Germany (2024)



Installed Regas Capacity Vs Annual LNG Import (2023)



The EU, France, Germany & Spain have stored/utilized **95-99%** of their underground gas storage capacity.

USA has strategic gas storage to **address ~30% of its gas consumption**. It is currently maintained at ~12%.

Japan & Korea (with no domestic gas production) have ~3.2 times capacity installed against their imports (operates at ~30%) & have **huge tank storage infrastructure**.

China rely on domestic production, LNG imports & pipeline imports. China has added significant regas capacity/ LNG tankage to cater gas supply security.

Avg terminal utilization in India stands at ~50%. Currently ratio of domestic to imports stands at ~50:50.

Mature economies relying on NG have built and maintained either significant underground gas storage or enough tank storage infrastructure based on their needs.

[k] - Underground (Depleted fields, salt/rock cavern, Aquifer | Data as on 03/11/24

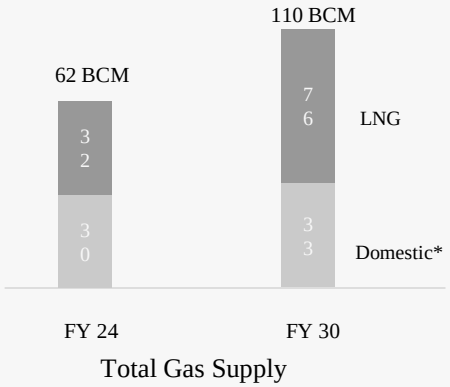
Source: https://agsi.gie.eu/, IGU, GIIGNL

EU data available in TWh; converted at 0.086 BCM/TWh

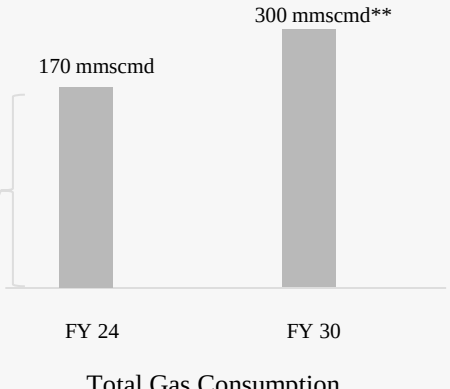
Quantum of Storage

Gas demand projections will play a big role is deciding the quantum of storage to be built.

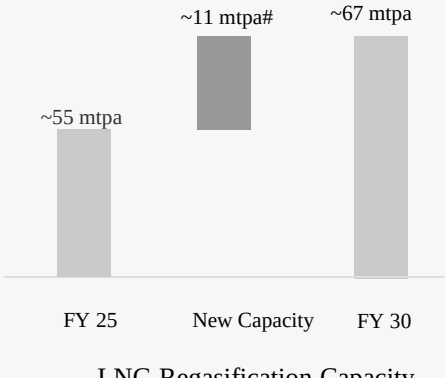
Natural Gas Snapshot India (FY 24 – 30)



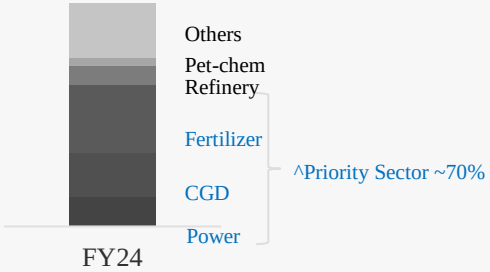
Total Gas Supply



Total Gas Consumption



LNG Regasification Capacity



* * Assuming ~8% growth p.a.

* refers to 'Net Production of gas for sale'

- Dahej(2.5), Dabhol(1.3), Gopalpur(5), Dhamra(2.5)

^Important considering factors like food security, no readily alternatives to NG that can be implemented quickly etc.

Not to scale

LNG Strategic Storage (Assuming General Scenario - 300 mmscmd demand by 2030)

Current Gas Consumption:

FY 24	BCM	MMSCMD	MMT
Net Production (sale)	30	83	23
LNG Import	32	87	24
Total Gas sale	62	170	47

Gas Consumption Projected:

FY 30 (estimated)	BCM	MMSCMD	MMT
Net Production (sale)	33	91	25
LNG Import	76	209	58
Total Gas Consumption	110	300	83

LNG Infrastructure Capacity (Projected):

	mtpa	Bcm storage*	mmscmd
LNG Capacity (FY 25)	55	2.4	199
Additional Capacity by FY 30	11	0.3	41
LNG Capacity (FY 30)	67	2.7	239
Assuming filed at 60%		1.6	

Strategic Storage Requirement (Calculation):

		Duration	BCM
	Gas consumption in FY 24	Yr	62
A	Gas consumption in FY 30	Yr	110
B=A*70%	Priority sector in FY 30		77
C=B*20/365	Priority sector req 20 days	20 days	4.2
D	Domestic gas for 20 days	20 days	1.8
E	LNG available on Emergency day		1.6
F=D+E	Total Gas available for 20 days	20 days	3.45
G=C-F	Short fall		0.78
G/0.1	Tanks required to bridge at 100%		~8

Conclusion:

1. India needs **8 LNG storage tanks** to **bridge** the **gap** of supplying to **priority sectors for 20 days**

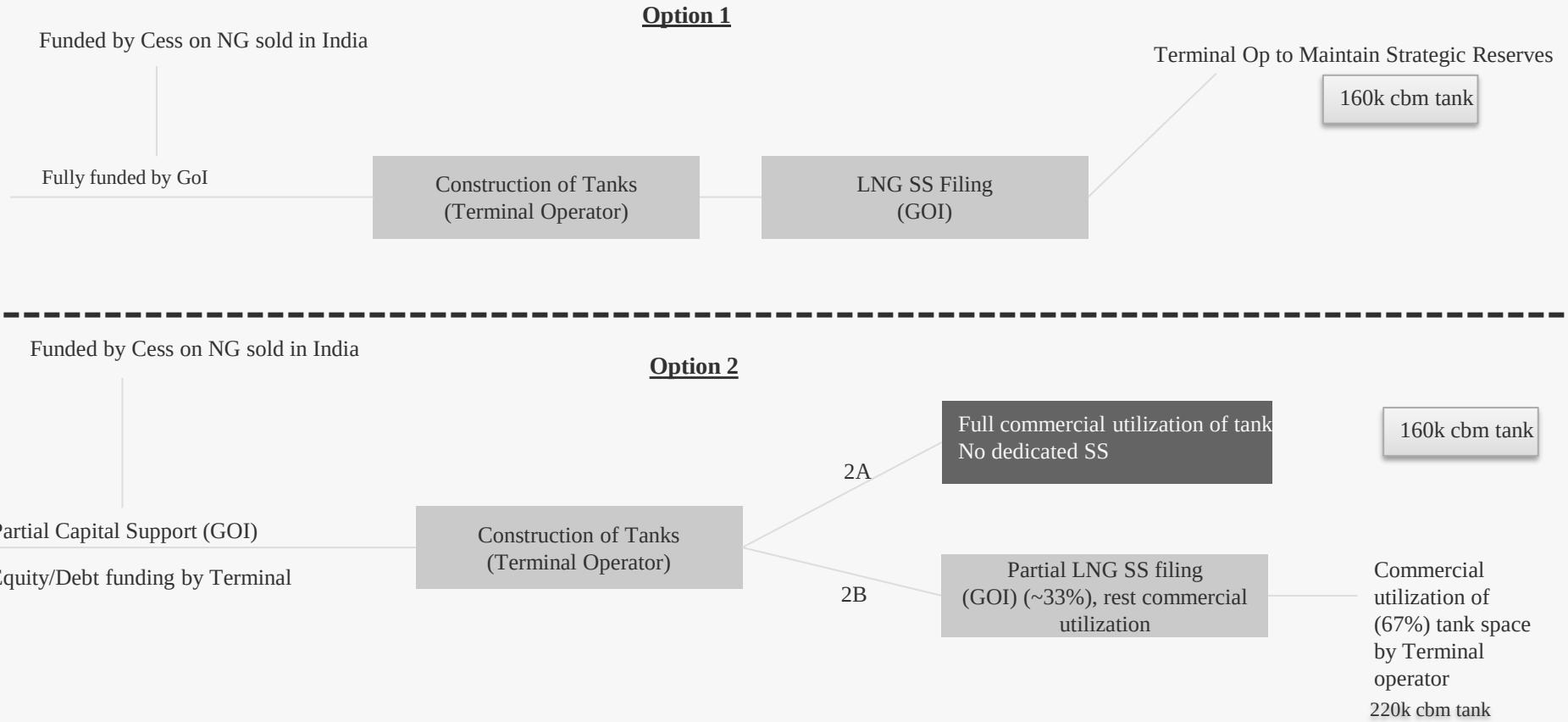
Assumptions:

1. India's total gas consumption will rise to 300 mmscmd by 2030 (~110 BCM)
2. India's domestic natural gas production in 2030 will be ~33 BCM (91 mmscmd).
3. The gap will be bridged by import of LNG ~76 BCM (~58 mtpa of LNG).
4. New LNG capacity addition assumed at ~11 mtpa.
5. Priority sector will remain at 70% of total gas volumes

1 LNG Tank = ~0.1 BCM = ~0.07 MMT Priority Sector includes Power, CGD & Fertilizers 1 mmtpa = ~3.6 mmscmd * Qty in tank when reasonable filled

Options for developing strategic storage

Strategic Storage of Gas – Options



SS- Strategic Storage

Capex Employed - Option 1 (Pure Strategic Model Fully Funded by GoI)

Investment

Tank Capex		
Tank EPC	INR Crs	600
Heel Cost	INR Crs	21
Land Lease Cost	INR Crs	13
Connectivity and Ancillary Costs	INR Crs	100
Contingencies @10%	INR Crs	73
Regasifier^^	INR Crs	100
IDC	INR Crs	0
Total Tank EPC	INR Crs	906
Tank Capex		906
Strategic Reserves*		300
Total Capex & Strategic Reserves	INR Crs	1206

Total Capex & Reserves cost to be recovered by means of Cess levied of Gas sales in India.

Funding /Recovery

Year of Construction		Yr 0	Yr 1	Yr 2	Yr 3
Year (Sample)		2025	2026	2027	2028
Total GOI Outflow	INR Crs		402	402	402
Gas Cons India	mmscmd	197	207	218	229
rLNG Cons India	mmscmd	91	96	101	106
Cess on total gas consumption	INR/mmbtu/tank	0.0	1.4	1.3	1.2
Cess on rLNG consumption	INR/mmbtu/tank	0	2.9	2.8	2.7
Cess on LNG regasification	INR/mmbtu/tank	0	2.9	2.8	2.7
Cess on total gas consumption			0.15%	0.14%	0.14%
Cess on rLNG consumption			0.33%	0.31%	0.29%
Cess on LNG regasification			4.46%	4.24%	4.04%

Note: The cess amount mentioned above is for a single tank. The amount will increase if decision is taken to construct more tanks.

Important takeaways:

a. This model provides fully functioning strategic storage for the use of GoI.
b. BOG would need to be maintained by the terminal operator.
c. Government may sell LNG at market price during emergency to key priority sectors

*Strategic Reserves : ~3.3 tbtu (145k cbm) at 10 $/mmbtu & 90 INR/$

^^ - Further possibility of reduction of cost if regasifier cost is ignored

Capex Employed - Option 2A (GOI Capital Support, no dedicated reserves & full commercial utilization of tank)

Investment

Tank		
Tank EPC	INR Crs	600
Heel Cost	INR Crs	21
Land Lease Cost	INR Crs	13
Connectivity and Ancillary Costs	INR Crs	100
Contingencies @10%	INR Crs	73
Regasifier	INR Crs	100
IDC	INR Crs	0
Total Tank EPC	INR Crs	906
Tank Capex		906
IDC		171
Total Capex incl IDC	INR Crs	1078
Source of Funds		
Equity		30%
Debt		70%
Equity (Before Capital Support)	INR Crs	272
Debt	INR Crs	634
Debt + IDC (this becomes total loan amount)	INR Crs	806

Capital Support

Capital Support		
Capital support (% of total tank EPC)		20%
Debt Support %		0%
Cap Support to Eq	INR Crs	181
Cap support to Debt		0
Total Capital Support	INR Crs	181

Revised Source of Funds		
Capital Support	INR Crs	181
Equity	INR Crs	91
Debt	INR Crs	634
IDC	INR Crs	171
Total Capex	INR Crs	1,078

Funding /Recovery

Year of Construction		Yr 0	Yr 1	Yr 2	Yr 3
Year (Sample)		2025	2026	2027	2028
Total GOI Outflow	INR Crs		60	60	60
Gas Cons India	mmscmd	197	207	218	229
rLNG Cons India	mmscmd	91	96	101	106
Cess on total gas consumption	INR/mmbtu/tank	0.0	0.20	0.19	0.18
Cess on rLNG consumption	INR/mmbtu/tank	0	0.44	0.42	0.40
Cess on LNG regasification	INR/mmbtu/tank	0	0.44	0.42	0.40
Cess on total gas consumption			0.02%	0.02%	0.02%
Cess on rLNG consumption			0.05%	0.05%	0.04%
Cess on LNG regasification			0.67%	0.63%	0.60%

Note: The cess amount mentioned above is for a single tank. The amount will increase if decision is taken to construct more tanks.

Important takeaways:

a. Least recommended option as government will provide funding to private player with no strategic storage

*Strategic Reserves : Not Applicable

^^ - Further possibility of reduction of cost if regasifier cost is ignored

Capex Employed - Option 2B (GOI Support, dedicated reserves & commercial utilization of tank)

Investment

Tank		
Tank EPC	INR Crs	800
Heel Cost	INR Crs	21
Land Lease Cost	INR Crs	13
Connectivity and Ancillary Costs	INR Crs	100
Contingencies @10%	INR Crs	93
Regasifier^^	INR Crs	100
Total Tank EPC	INR Crs	1126
Tank Capex	INR Crs	1126
IDC	INR Crs	213
Total Capex incl IDC	INR Crs	1339
Source of Funds		
Equity (before Capital Support)	INR Crs	30%
Debt	INR Crs	70%
Equity (Before Capital Support)	INR Crs	338
Debt	INR Crs	788
Debt + IDC (this becomes total loan amount)	INR Crs	1001

Capital Support

Capital Support		
Capital support (% of total tank EPC)		20%
Debt Support %		0%
Capital Support to Eq	INR Crs	225
Cap support to Debt	INR Crs	0
Total Capital Support	INR Crs	225
Cost of strategic reserve	INR Crs	159
Total government support	INR Crs	384

Revised Source of Funds		
Capital Support	INR Crs	225
Equity by Terminal	INR Crs	113
Debt	INR Crs	788
IDC	INR Crs	213
Total Capex	INR Crs	1,339

Funding /Recovery

Year of Construction		Yr 0	Yr 1	Yr 2	Yr 3
Year (Sample)		2025	2026	2027	2028
Total GOI Outflow	INR Crs		128	128	128
Gas Cons India	mmscmd	197	207	218	229
rLNG Cons India	mmscmd	91	96	101	106
Cess on total gas consumption	INR/mmbtu/tank	0.0	0.43	0.41	0.39
Cess on rLNG consumption	INR/mmbtu/tank	0	0.93	0.89	0.84
Cess on LNG regasification	INR/mmbtu/tank	0	0.93	0.89	0.84
Cess on total gas consumption			0.05%	0.05%	0.04%
Cess on rLNG consumption			0.10%	0.10%	0.09%
Cess on LNG regasification			1.42%	1.35%	1.29%

Note: The cess amount mentioned above is for a single tank. The amount will increase if decision is taken to construct more tanks.

Important takeaways:

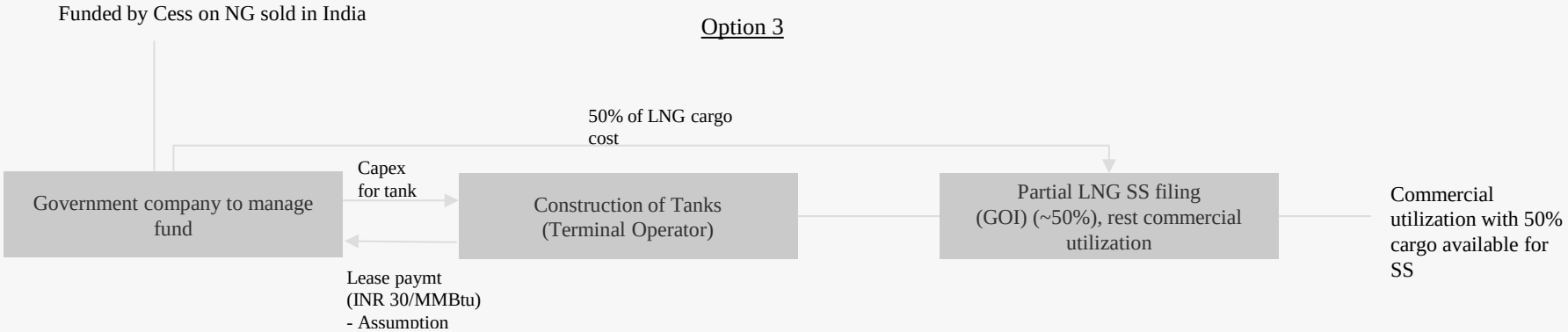
a. This model provides 1.7tbtu of strategic storage along with commercial utilization of tanks

*Strategic Reserves : ~1.7 tbtu (77k cbm) at 10 $/mmbtu & 90 INR/$

^^ - Further possibility of reduction of cost if regasifier cost is ignored

Strategic storage of Gas – Option 3

1. GOI to fix a funding amount for the tank – Assuming government to pay 900 Cr for a tank (approx. cost of tank)
2. Government will invite open bid by the terminal operator to construct and operate terminal for 25 years, with "lease payment" to GoI as bidding parameter.
3. Government will fund 50% of LNG in the storage tank, that would act as strategic storage
4. Terminal company may keep on operating the terminal providing they keep 50% of tankage as strategic storage and rest could be use at commercial model.
5. BOG would be maintained by the terminal company
6. The RLNG from the strategic storage will be provided to priority customers based on priority allocation (after adjusting for domestic gas) on market prices
7. Gradually this amount will be used for subsequent storages-built ups.



Financial analysis – Option 3

Investment by GoI

Tank Capex		
Tank EPC	INR Crs	600
Heel Cost	INR Crs	21
Land Lease Cost	INR Crs	13
Connectivity and Ancillary Costs	INR Crs	100
Contingencies @10%	INR Crs	73
Regasifier^^	INR Crs	100
IDC	INR Crs	0
Total Tank EPC	INR Crs	906
Tank Capex		906
Strategic Reserves*		158
Total Capex & Strategic Reserves	INR Crs	1064

Funding /Recovery

Year of Construction		Yr 0	Yr 1	Yr 2	Yr 3
Year (Sample)		2025	2026	2027	2028
Total GOI Outflow	INR Crs		355	355	355
Gas Cons India	mmscmd	197	207	218	229
rLNG Cons India	mmscmd	91	96	101	106
Cess on total gas consumption	INR/mmbtu/tank	0.0	1.2	1.1	1.1
Cess on rLNG consumption	INR/mmbtu/tank	0	2.6	2.5	2.4
Cess on LNG regasification	INR/mmbtu/tank	0	2.6	2.5	2.4
Cess on total gas consumption			0.13%	0.13%	0.12%
Cess on rLNG consumption			0.29%	0.27%	0.26%
Cess on LNG regasification			3.93%	3.74%	3.56%

Note: The cess amount mentioned above is for a single tank. The amount will increase if decision is taken to construct more tanks.

Important takeaways:

a. Additional revenue may be used by the government company to fund subsequent SS.
b. Expected annual revenue would be around **150** Crore assuming 25 days for tank to be emptied.
c. This would have a multiplier effect on developing new tankages as the fund may be utilized for developing new strategic storage for LNG tanks.

*Strategic Reserves : ~1.76 tbtu (80K cbm) at 10 $/mmbtu & 90 INR/$

LNG Strategic Storage option evaluations

	Op 1 Pure Strategic Storage	Op - 2A Capital Support	Op – 2B Capital Support	Op 3
Terminal - Brownfield/ Greenfield?	Existing Terminal	Existing Terminal	Existing Terminal	Existing Terminal
Description	GOI to fund Tank Cons	Partial Capital Support (Cess)	Partial Capital Support (Cess)	Partial Capital Support with bidding
Tank Size	160k – 180k cbm	160k – 180k cbm	220-240k cbm	160k – 180k cbm
LNG Reserves Responsibility	GOI, ~3.2 tbtu/tank (~145k cbm/tank)	No, NA	GOI, 1.75 tbtu/tank(~77 k cbm/tank)	GOI, 1.8 tbtu/tank(~80 k cbm/tank)
Tank Commercial Utilization	No Commercial utilization	Full Commercial Utilization by TO	Partial -65% Tank space Commercial Utilization by TO	50% Tank space commercial Utilization by TO
Op/Maint Responsibility	Terminal Operator	Terminal Operator	Terminal Operator	Terminal Operator
Tariff	NA	Existing tariff at terminal	Existing tariff at terminal	Existing tariff at terminal
Funding Options	1. Cess on NG sales, or 2. Tariff loading on rLNG	1. Cess on NG sales during construction, or 2. Tariff loading on rLNG	1. Cess on NG sales during construction, or 2. Tariff loading on rLNG	1. Cess on NG sales during construction, 2. Tariff loading on rLNG 3. Fund to collect revenue from bidding

Cess – means funding by cess levied basis duration and amount

TO – Terminal Operator

LNG Strategic Storage contd.

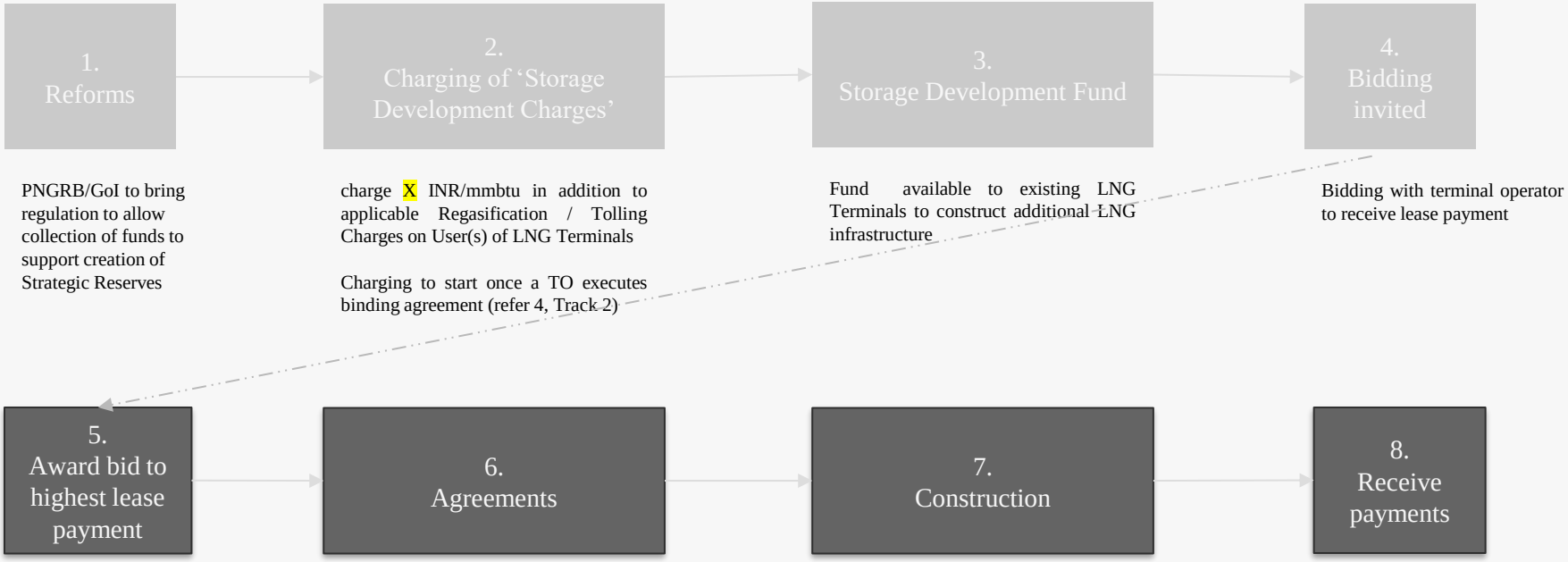
	Op 1 Pure Strategic Storage	Op - 2A Capital Support	Op – 2B Capital Support	Op 3
Pros	Strategic reserves of LNG will surely be available on the day of emergency.	Capital Support will promote creation of additional tanks. Increased tank utilization will boost % of LNG in India's energy mix. RLNG supply security will increase with more storage tanks.	Benefits of both the 'Pure Strategic Model' and the 'Capital Support (A) Model'. ~1.7 tbtu of LNG will always be available. Commercial utilization will increase % of LNG in India's energy mix. Thus, in an emergency, India will have dedicated reserves and additional LNG from utilization of newly constructed tanks.	Benefits of both the 'Pure Strategic Model' and the 'Capital Support Model'. It allows SS to be always available Bidding parameters would ensure that government will receive funding almost (50% of the cost of new strategic storage) and thus provide support to development of SS in India This would have a multiplier effect on developing tankages
Cons	BOG marketing would be key risk Significant investment would be blocked No precedence	Non – utilization of tanks will invalidate this model. Government would be funding private model without any strategic storage Least preferable option	No funding back as capital will be locked for developing SS Terminal may not be keen to lock up some volumes as strategic storage	Capex risks are being assumed by government Funding to the government will depend on terminal utilization

TO – Terminal Operator

Note: Approx. numbers

Model to Develop LNG Strategic Reserves

Model/Proposal - Process (Option 3 SS storage)



TO – Terminal Operator

What will be funded ?

Funded	Not Funded
• FEED	• Land Cost
• PMC	• Jetty/Trestle
• LNG Tank	• Any equipment that improves output/efficiency of existing plan
• Heel	
• Connecting Pipelines	
• Regasifier (optional)	
• Commissioning	
• Strategic storage	

TO – Terminal Operator

LNG Landscape India

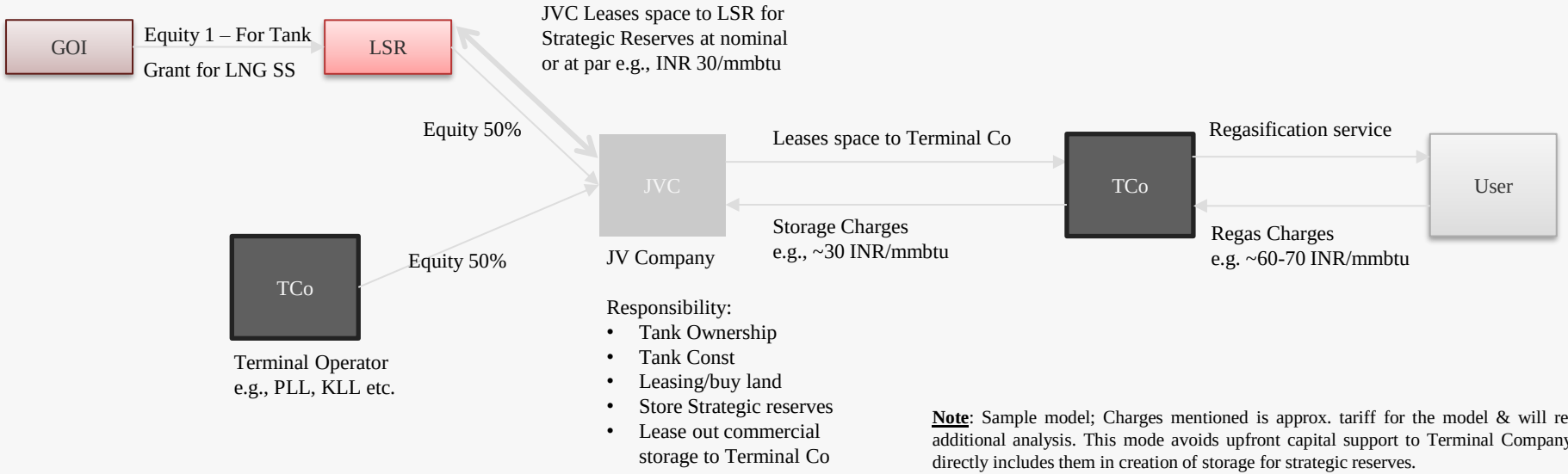
Existing Regas Terminals (2025)			
Location	Tanks	Storage Space, cbm	Capacity, mtpa
Dahej	6	9,60,000	17.5
Hazira	2	3,20,000	5.2
Dabhol	3	4,80,000	5
Kochi	2	3,20,000	5
Ennore	2	3,60,000	5
Mundra	2	3,20,000	5
Dhamra	2	3,60,000	5
Chhara	2	4,00,000	5
Total	21	35,20,000	52.7
Dahej Exp	2	360000	2.5
Total	23	38,80,000	55.2
Total Storage Space, BCM			2.43

New LNG Terminals / Expansion at Existing Terminals (2030)			
Location	Tanks	Storage Space, cbm	Capacity, mtpa
Dahej Exp			2.5
Dabhol			1.3
Dhamra	1	1,60,000	2.5
Gopalpur	2	3,20,000	5
Total	3	4,80,000	11.3
Total Storage Space, BCM			0.30

1 Cryogenic LNG Tank of 160k cbm stores ~0.10 Bcm of NG | mtpa: million tons per annum

Strategic Storage of Gas - Option 3a

1. GOI to create a new company – LNG Strategic Reserve Company (LSR Co) in line with ISPRL model.
2. LSR Co to create a JV with Terminal Company (TCo - PLL, Konkan LNG etc.).
3. JV to lease or buy land from Terminal Co. & construct LNG Tanks & provide storage space for commercial utilization to Terminal Co.
4. Terminal Co to charge (existing) commercial tariff from Users and pay lease/storage charges to JV Co.
5. LSR will buy LNG for strategic reserves and store at JV Tanks. LSR will pay lease/storage charges to JV
6. Business model to ensure nominal dividend to both shareholders after opex & debt service.



Note: Sample model; Charges mentioned is approx. tariff for the model & will require additional analysis. This mode avoids upfront capital support to Terminal Company and directly includes them in creation of storage for strategic reserves.

End of Report

Trading of Gas Certificates for CBG

31-12-2024

Outline of Green Certificate Scheme

Compressed Biogas (CBG) Sector In India

- CBG being considered an important sustainable fuel with multiple advantages:
  - **Domestic production capacity**
  - **Reduce forex expense**
  - **Promote circular economy**
  - **Achieve UNFCCC targets.**

- **MoHUA – Urban 2.0 -** Central Assistance is provided to States and Union Territories for solid waste management. Additional Central Assistance of 25% - 50% (based on ULB population) for MSW based CBG plants.

- **MoPNG** has launched Sustainable Alternative Towards Affordable Transportation (SATAT). Under this initiative, OGMCs invite expression of interest from entrepreneurs to procure CBG for further marketing on long term agreement basis.

- **MNRE – Waste to Energy Program** provides Central Financial Assistance (CFA) to project developers and service charges to implementing agencies on successful commissioning of plants for the generation of biogas.

CBG Snapshot of India (Nov'2024)	
No. of CBG Plants Commissioned	80
ROs with ongoing CBG Sales	253
Sale of CBG	23578 tons (0.13MMSCMD)
No. of CBG/Bio-CNG plants Registered (Gobardhan)	819 (Gobardhan Portal)
CBG Production Target under SATAT	~53 MMSCMD (15 MMTPA)
Union Budget '23-'24	Rs. 10,000cr. 200 CBG Plants 300 Community Plants

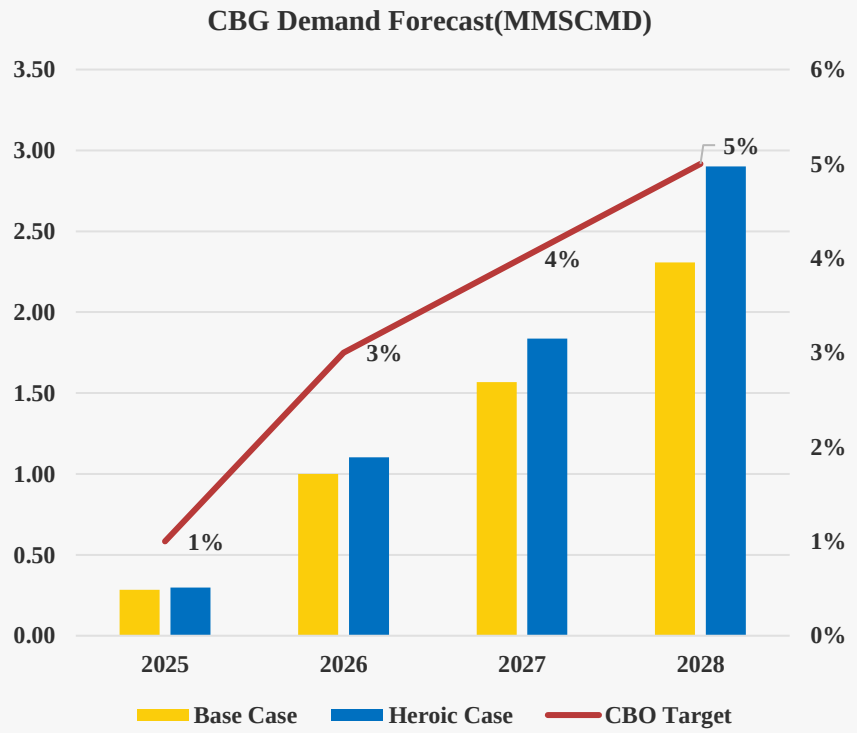
Impact Of CBG Blending Obligations (CBO)

What is CBO?

- Defined by MoPNG order No. L-16020/1/2023-GP-I (E-45649) dated 27.02.2024. Mandatory blending of CBG required in natural gas sold to CNG (Transportation) and PNG (Domestic) segment.

CBG Demand & Supply

- As per PPAC, CBG sale in FY'24-'25 is 0.13 MMSCMD. This is only ~52% of the obligated requirement (assuming 1% CBO).
- Current installed capacity of CBG in India is 0.72 MMSCMD.
- Target for CBG production under SATAT till FY'23-'24 was ~53 MMSCMD.



What are Renewable Gas Certificates (RGCs)?

What is CBG?

- Purified biogas to remove hydrogen sulfide (H2S), carbon dioxide (CO2), water vapor and thereafter compressed as Compressed Bio-Gas (CBG), which contains more than 90% methane (CH4). Standard defined by BIS IS 16087 : 2016

What is RGC?

- RGCs – Renewable Gas Certificates – shall represent 1 MMBTU of CBG produced.

What are objectives of RGCs?

- RGCs shall quantify the sustainability of CBG being produced. Through RGCs, value of CBG is necessarily split into 2 components:

1.Physical Commodity – Value of CBG if it is treated as any other natural gas.

2.Sustainability – Sustainable nature of value chain in CBG production shall be captured through this component as RGC value.

IS - CBG v/s CNG

Compressed Biogas is a common term used by the Ministry of Petroleum and Natural Gas. It can also be called as Bio-CNG. The standards and specifications are governed by IS 16087:2016 (**Annexure I**) of BIS.

IS 16087 : 2016 Standard		
S No.	**Characteristic**	**Requirement**
1	Methane percentage (CH_4), minimum	90.0 %
2	Only Carbon Dioxide percentage (CO_2),, maximum	4%
3	Carbon Dioxide (CO_2)+ Nitrogen (N_2)+ Oxygen (O_2) percentage maximum	10%
4	Oxygen (O_2) percentage maximum	0.5%
5	Total sulphur (including H_2S) mg/m^3, maximum	20 mg/m^3
6	Moisture mg/m^3, maximum	5 mg/m^3

The Standard also states the following:

1. CBG shall be free from liquids over the entire range of temperature and pressure encountered in storage and dispensing system.
2. The CBG shall be free from particulate matter such as dirt, dust, etc.
3. CBG delivered shall be odorized similar to a level found in local distribution (ref. IS 15319)

IS 15958 : 2012

Table 1 Requirements for Compressed Natural Gas for Automotive Purposes
(*Clause* 4.5)

Sl No. (1)	Characteristic (2)	Requirement (3)	Method of Test, Ref to (4)
i)	Wobbe index[1], MJ/ m^3, *Min*	48.8-51.0	IS 14504
ii)	Water content[1], mg/m^3, *Max*	5.0	IS 15641 (Part 2)
iii)	Hydrocarbons (volume percent of total organic carbon present):		
	a) Methane, *Min*	90.0	IS 15130 (Part 3)
	b) Ethane, *Max*	6.0	do
	c) C_3 and higher HC, *Max*	3.0	do
	d) C_6 and higher HC, *Max*	0.5	do
	e) Total unsaturated HC, *Max*	0.5	do
iv)	Corrosive components:		
	a) Total sulphur[2], mg/m^3, *Max*	20.0	ASTM D3246-05
	b) Oxygen, volume percent, *Max*	0.5	IS 15130 (Part 3)
v)	Carbon dioxide and nitrogen, volume percent, *Max*	3.5	do
vi)	Other species (mole percent):		
	a) Hydrogen, *Max*	0.1	do
	b) Carbon monoxide, *Max*	0.1	do
vii)	Methane number, *Min*	90.0	IS 15320

NOTE — The requirement of oil content shall be added at a later stage when the test method for the same is available.

[1] Requirements are according to IS 15126.
[2] Total sulphur includes the sulphur content of odorant.

Chain Of Custody Models

What is Chain of Custody?

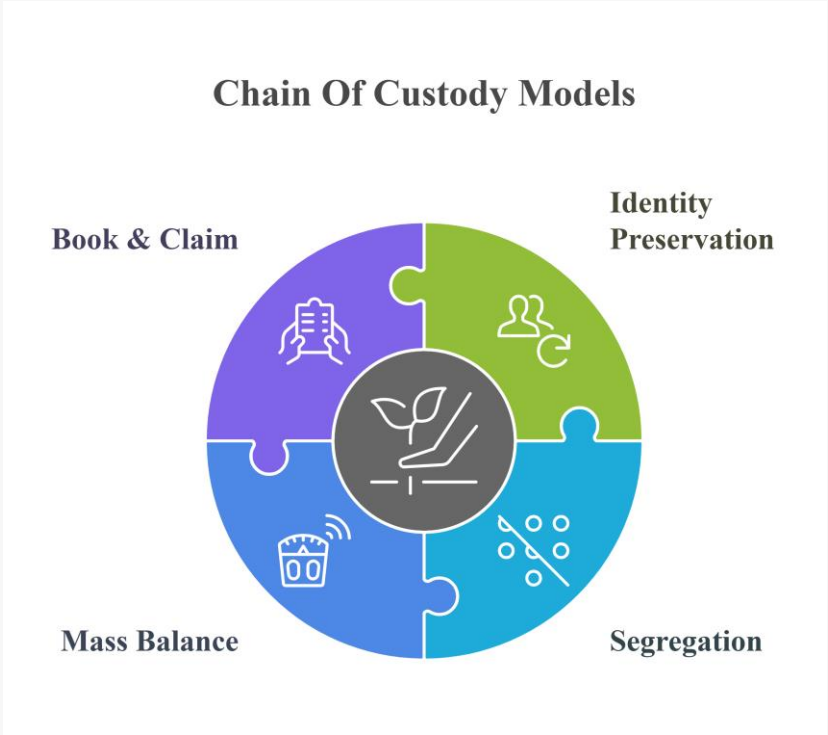
- It is process of following materials through stages of supply chain – sourcing, processing, shipping & retailing.

Why is it required?

- Chain of custody models are used to validate the claims about a product being sustainable.

What are the different models available?

1. Identity Preservation
   - Complete separation of certified product from other certified products.
2. Segregation
   - Allows mixing of certified products with other products sharing similar standards.
3. Mass Balance
   - Total sustainable content is tracked through production process and allocated appropriately to finished product.
4. Book & Claim
   - Sustainability certificates are generated and traded in marketplace that allow companies to claim sustainability.



RGC Trading

RGC Trading Mechanism

1. **CBG Producer** – Producers will be issued RGCs equivalent to CBG output. 1 RGC shall represent 1 MMBTU of CBG produced.

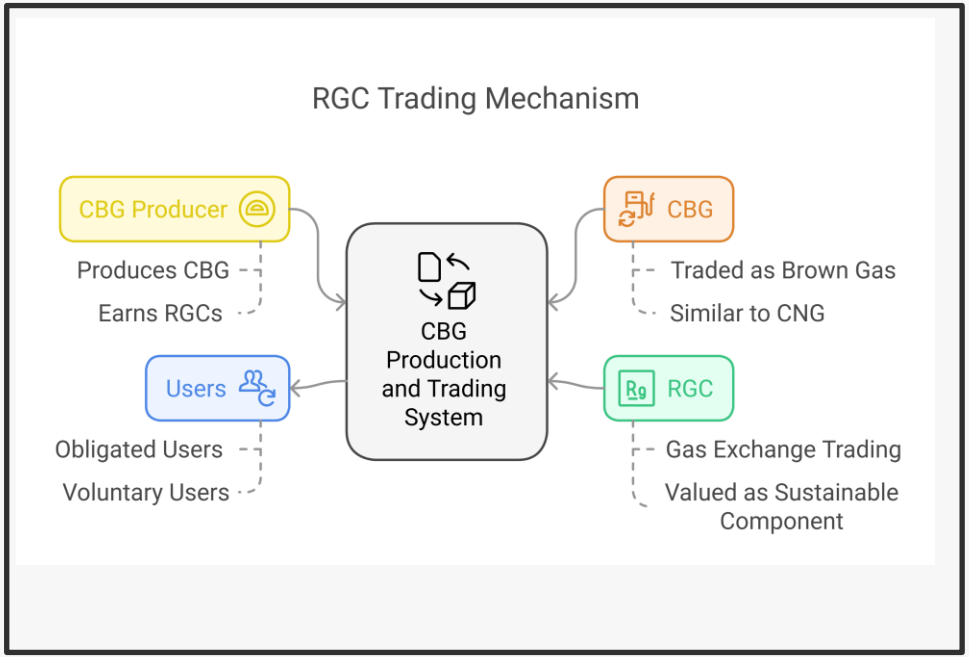
2. **CBG** – CBG produced can be traded as a brown gas – just like CNG from conventional sources.

3. **RGC** – Green component of CBG is valued as RGC and can be traded through gas exchange independent of the physical gas.

4. **Users** – Users can buy either CBG or RGCs or both as per their requirements:

    - **Obligated Users** – Such as CGD entities that must meet CBG blending obligations from Apr'25 onwards.

    - **Voluntary Users** – Such as industrial users, MSMEs (PNG Users) that wish to use a sustainable fuel in the product value chain.



Objectives of RGC Scheme

Introduction of RGCs shall accomplish multiple functionalities for the stakeholders in Indian market:

Quantification of Sustainability: RGCs shall allow distinct quantification of the sustainable nature of CBG production. The market value of the RGCs can then be monitored independently.

Benefit to Producers: Producers can greatly benefit through evaluation and subsequent market establishment of RGCs. This can boost the reward to risk ratio in favor of investors of sustainable projects.

CBO Targets: Virtual trading of RGCs independent of physical CBG shall allow far-off CGDs and obligated users to meet the CBO targets as defined by MoPNG.

Low Barrier to Entry: Enable a low barrier of entry to sustainable fuel markets for all downstream users – CGDs, MSMEs, industries, etc. Electronic trading via IGX shall be convenient, low-cost and efficient.

Enable market driven and transparent price discovery of sustainable nature of CBG.

RGC prices can act as potential indicator of sustainability demand in markets and regional hubs. Potential financiers and investors can make informed decision about infrastructure expansion plans based on the price index.

End of Report

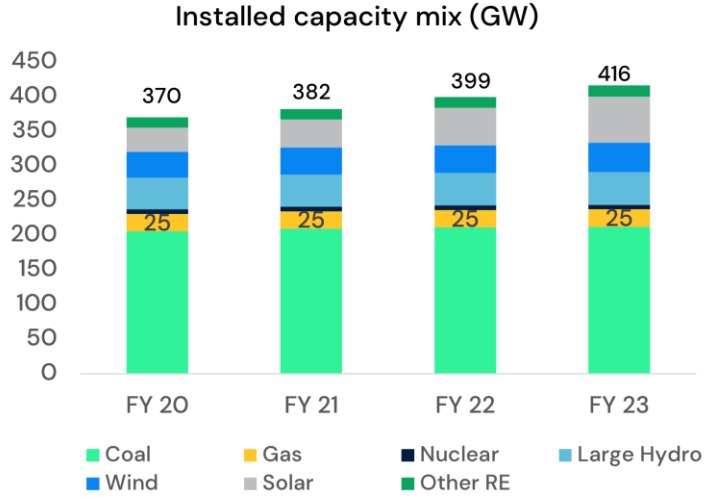
Revival of Gas Based Power Plants

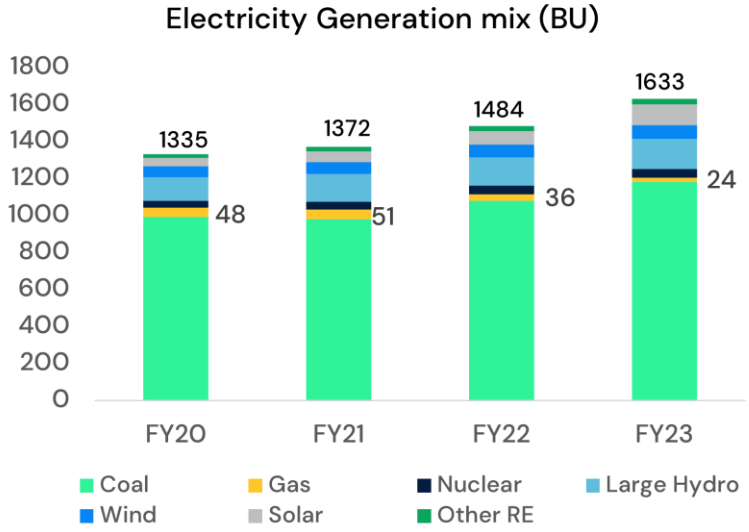
01 Current Status of Gas based Power sector

02 Possible Interventions / Recommendations

Agenda

Current Status

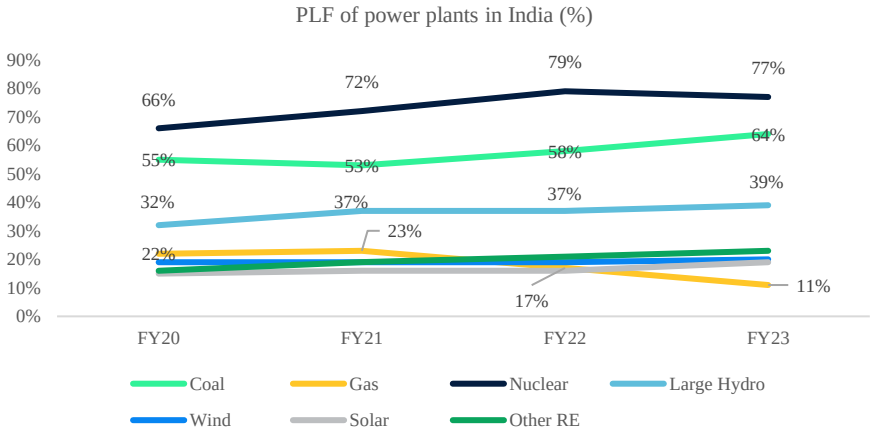


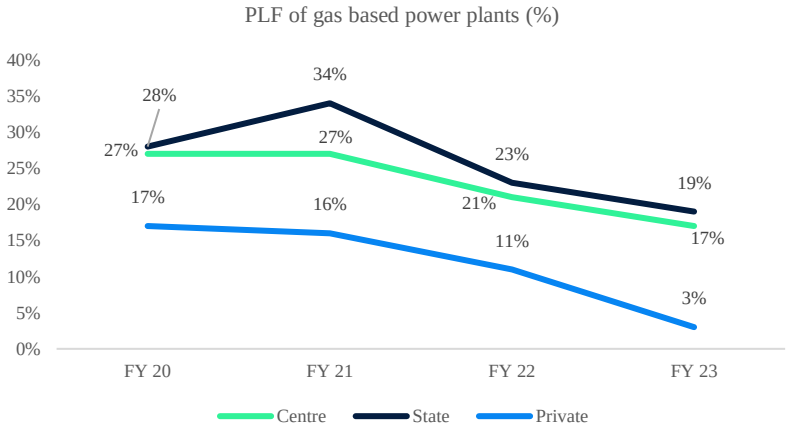


- Gas-based power plants: installed capacity not increased over the years; utility-based gas power plants remain at **~25 GW**^ (**~6%** of total installed capacity)
- Share of electricity generated from gas-based power plants has decreased from **3.6%** (FY20) to **1.5%** (FY23);
- Absolute generation from gas-based power plants has decreased at a CAGR ~21% since FY 2020 (from **~48 BU to ~24 BU**)

Generation from NG based plants have reduced by 50% from FY20

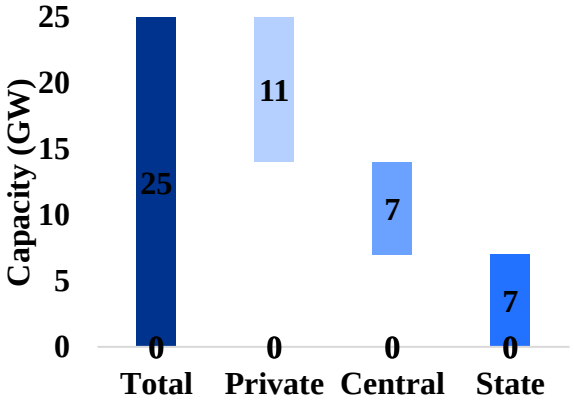
*Coal Includes coal, lignite and diesel ^As per MOSPI, there are ~25 GW of utility based gas power plants & ~7.4 GW of captive gas power plants
https://www.mospi.gov.in/sites/default/files/publication_reports/Energy_Statistics_2023/Energy%20Statistics%20India%202023_07022024.pdf, https://cea.nic.in/dashboard/?lang=en
https://cea.nic.in/annual-fuel-consumption-report/?lang=en, https://npp.gov.in/monthlyGenerationReportsAct

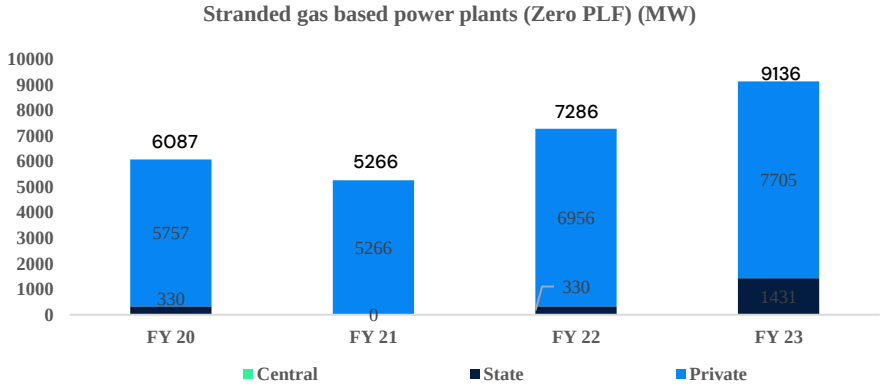




- The average PLF for all other types of power plants have increased from FY20 to FY23 except gas-based power plants-
  - ✓ Thermal (55% to 64%), Nuclear (66% to 77%), Large Hydro (32% to 39%)
  - ✓ The increase in PLF in Thermal, Nuclear & large Hydro is driven by **increase in electricity demand** in India (~7%) **&** relatively **less increase in** generation **capacity** (~4%)
- However, the PLF of gas-based power plants has reduced – from 22% in FY 2020 to ~11% in the year 2022-23
- Thus, despite increase in supply demand gap – the generation from gas based power plants is decreasing
- For Private gas power plant average PLFs has reduced to ~3% (2023) from ~17% (2020)

Gas based plants are the only type of power plants to register an average decrease in PLF (50%) from FY 20 to FY23





- So, around 9 GW (**~36%**) plants had **0** PLF in FY2023, of which 7.7 GW plants were in private sector while 1.4 GW plants were in the state sector
- So, plants stranded as % of total capacity
  - Private- **~70%** (7.7 GW out of 11 GW)
  - State- **~20%** (1.4 GW out of 7 GW)
  - Central – **0%** (0 GW out of 7 GW)
- This is driven by historic & current accessibility to low cost domestic gas
- 2 additional plants ~500 MW capacity (in AP) stopped getting power from H2 2024.

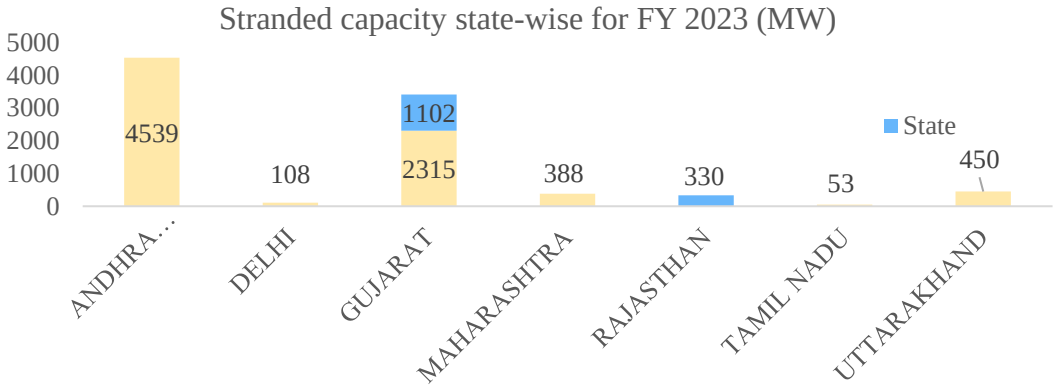
Stranded Gas based power plants

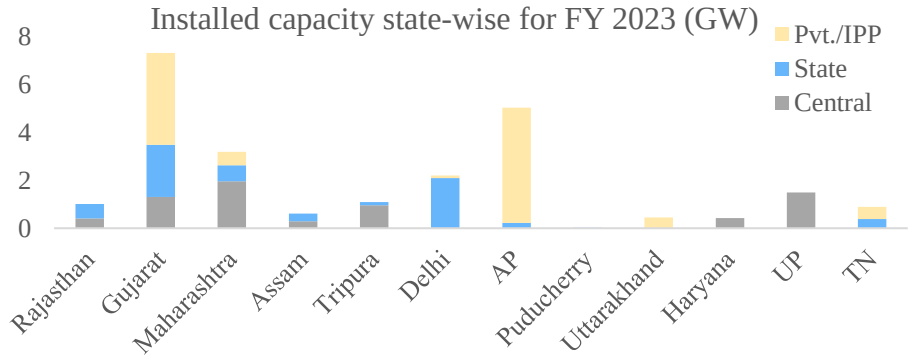
The stranded private gas based power plants are likely to be ~8.2 GW **(~75%)** in H2 FY24

Ownership	Name of Power Station	Installed Capacity (MW)	State	APM /Non- APM/PMT (MMSCMD)	KGD-6 (Firm) (MMSCMD)
State	DHOLPUR CCPP	330.00	RAJASTHAN	1.50	0.10
State	DHUVARAN CCPP(GSECL)	594.72	GUJARAT	0.25	0.44
State	HAZIRA CCPP(GSEG)	156.10	GUJARAT	0.80	0.01
State	HAZIRA CCPP EXT	351.00	GUJARAT	0.00	0.00
PVT/IPP SECTOR	RITHALA CCPP (NDPL)	108.00	DELHI	0.00	0.40
PVT/IPP SECTOR	GAMA CCPP	225.00	UTTARAKHAND	0.00	0.00
PVT/IPP SECTOR	KASHIPUR CCPP(Sravanthi)	225.00	UTTARAKHAND	0.00	0.00
PVT/IPP SECTOR	BARODA CCPP (GIPCL)	160.00	GUJARAT	0.36	0.09
PVT/IPP SECTOR	ESSAR CCPP	300.00	GUJARAT	0.00	1.17
PVT/IPP SECTOR	PAGUTHAN CCPP (CLP)	655.00	GUJARAT	0.13	1.30
PVT/IPP SECTOR	DGEN Mega CCPP	1200.00	GUJARAT	0.00	0.00
PVT/IPP SECTOR	MANGAON CCPP	388.00	MAHARASHTRA	0.00	0.00
PVT/IPP SECTOR	GAUTAMI CCPP	464.00	ANDHRA PRADESH	1.96	1.86
PVT/IPP SECTOR	GMR - KAKINADA (Tanirvavi)	220.00	ANDHRA PRADESH	0.00	0.88
PVT/IPP SECTOR	GMR-Rajamundry Energy Ltd.	768.00	ANDHRA PRADESH	0.00	0.00
PVT/IPP SECTOR	GODAVARI (SPECTRUM)	208.00	ANDHRA PRADESH	1.04	0.00
PVT/IPP SECTOR	JEGURUPADU CCPP (GVK) PHASE- II	220.00	ANDHRA PRADESH	1.34	0.88
PVT/IPP SECTOR	KONASEEMA CCPP	445.00	ANDHRA PRADESH	0.00	1.78
PVT/IPP SECTOR	KONDAPALLI EXTN CCPP .	366.00	ANDHRA PRADESH	0.00	1.46
PVT/IPP SECTOR	KONDAPALLI ST-3 CCPP (LANCO)	742.00	ANDHRA PRADESH	0.00	0.00
PVT/IPP SECTOR	KONDAPALLI CCPP (LANCO)	368.14	ANDHRA PRADESH	1.46	0.36
PVT/IPP SECTOR	PEDDAPURAM (BSES)	220.00	ANDHRA PRADESH	0.84	0.25
PVT/IPP SECTOR	VEMAGIRI CCPP	370.00	ANDHRA PRADESH	1.64	1.48
PVT/IPP SECTOR	PCIL POWER AND HOLDINGS Ltd*	30.00	ANDHRA PRADESH	0.00	0.12
PVT/IPP SECTOR	RVK ENERGY*	28.00	ANDHRA PRADESH	0.00	0.11
PVT/IPP SECTOR	SILK ROAD SUGAR*	35.00	ANDHRA PRADESH	0.00	0.10
PVT/IPP SECTOR	LVS POWER*	55.00	ANDHRA PRADESH	0.00	0.22
PVT/IPP SECTOR	VALANTARVY CCPP	52.80	TAMIL NADU	0.38	0.00
	Total	**9284.76**		**11.70**	**13.01**

In FY23, 4 State plants & 24 Private plants are stranded (Out of 62), no gas delivered for ~25 MMSCMD Domestic Gas Allocation

These plants are likely to have some dispatch in FY25 due to **Section 11** directions (GAMA & Sravanthi) & selling power with NVVN contract (DGEN Mega CCPP)





Majority of the gas Stranded Capacity is in Andhra Pradesh & Gujarat

In Overall installed capacity – Private gas based power plants are concentrated in Gujarat & Andhra Pradesh

Breakup of Stranded Gas based Capacity

Ownership	Name of Power Station	Installed Capacity (MW)	State	Actual Gen. (MUs)	PLF	APM /Non- APM/PMT (MMSCMD)		KGD-6 (Firm) (MMSCMD)	
						Allotted	Supplied	Allotted	Supplied
Central	NTPC, FARIDABAD CCPP	431.59	HARYANA	2.59	0.07%	1.46	0.00	0.35	0.00
Central	NTPC, ANTA CCPP	419.33	RAJASTHAN	133.99	3.65%	1.31	0.00	0.24	0.00
Central	NTPC, AURAIYA CCPP	663.36	UTTAR PRADESH	224.34	3.86%	2.17	0.00	0.30	0.00
Central	NTPC, GANDHAR(JHANORE) CCPP	657.39	GUJARAT	267.60	4.65%	2.56	0.00	0.63	0.00
Central	NTPC, KAWAS CCPP	656.20	GUJARAT	264.89	4.61%	3.64	0.00	2.08	0.00
Central	RATNAGIRI (RGPPL-DHABHOL)	1967.08	MAHARASHTRA	315.94	1.83%	0.90	0.00	7.60	0.00
State	PIPAVAV CCPP	702.00	GUJARAT	6.56	0.11%	0.00	0.00	0.00	0.00
State	UTRAN CCPP (GSECL)	374.00	GUJARAT	4.64	0.14%	0.00	0.00	1.45	0.00
PVT/IPP SECTOR	UNOSUGEN CCPP	382.50	GUJARAT	65.15	1.94%	0.00	0.00	0.00	0.00
PVT/IPP SECTOR	KARUPPUR CCPP (LANCO TANJORE)	119.80	TAMIL NADU	55.15	5.26%	0.50	0.11	0.00	0.00
PVT/IPP SECTOR	P.NALLUR CCPP (PPN)	330.50	TAMIL NADU	69.11	2.39%	1.50	0.00	0.00	0.00

Out of 62 power plants (~24 GW) analyzed, 39 plants (~16 GW) had PLF less than 5%

- 28 plants are stranded (~9.3 GW)
- 11 plants have less than 5% PLF but are not stranded (~6.7 GW)

→ **A lot of gas based power plants are not stranded but have very low PLF (<5%)**

Gas Power Plants in Isolated Gas Fields

Ownership	Name of Power Station	PLFs (FY23)	Installed Capacity (MW)
North East – Assam & Tripura			
State – Assam	LAKWA Replacement CCPP***	83%	70
Centre – Assam	KATHALGURI (NEEPCO)	66%	291
State – Assam	LAKWA GT (ASEB,Maibella)	63%	97
State – Assam	NAMRUP CCPP + ST (APGCL)	45%	162
Central – Tripura	MONARCHAK(NEEPCO)	84%	101
State – Tripura	BARAMURA GT (TSECL)	82%	42
Central – Tripura	TRIPURA CCPP (ONGC)	78%	727
Central – Tripura	AGARTALA GT+ST (NEEPCO)	72%	135
State – Tripura	ROKHIA GT (TSECL)	30%	95
Others			
State – TN	VALUTHUR CCPP	65%	186
State – TN	KUTTALAM (TANGEDCO)	58%	100
State – TN	KOVIKALPAL (THIRUMAKOTTAI)	18%	107
State - Puducherry	KARAIKAL CCPP (PPCL)	82%	33
State – Rajasthan	RAMGARH (RRVUNL,Jaisalmer)	55%	274

Assam – 4

Tripura – 5

Total Capacity ~1720 MW

Total Capacity ~700 MW

Gas Power Plants in operational due to special situations

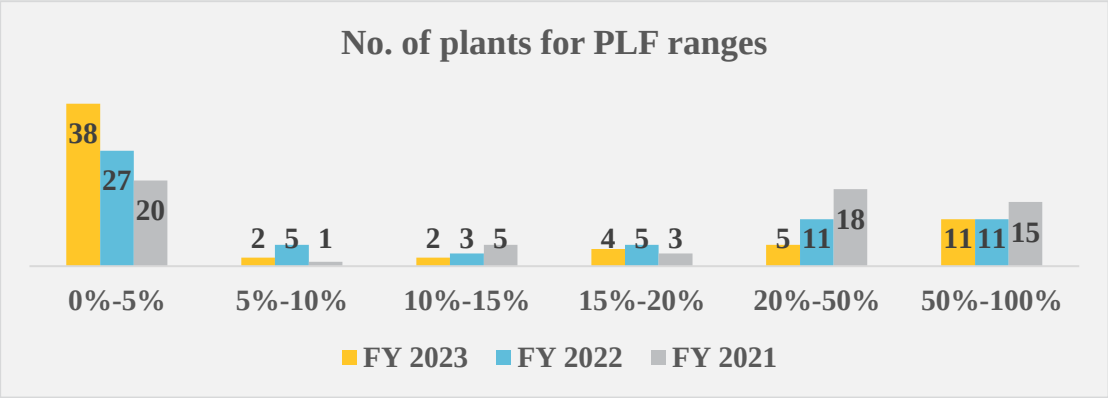
Ownership	Name of Power Station	PLFs (FY23)	Installed Capacity (MW)
.			
PVT/IPP SECTOR – MH	TROMBAY CCPP (TPC)	39%	180
State - Delhi	PRAGATI CCPP	30%	330.4
State - MH	URAN CCPP (MAHAGENCO)	25%	672
State – Delhi	PRAGATI CCGT-III	20%	1500
PVT/IPP SECTOR – GJ	SUGEN CCPP (TORRENT)	15%	1547
State - Delhi	I.P.CCPP	14%	332

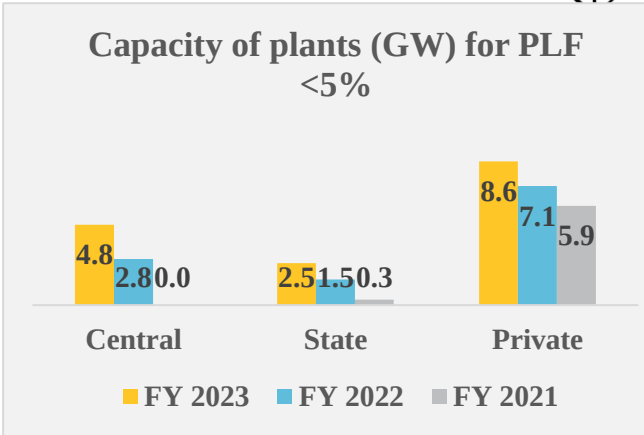
Specific Reasons - Low pressure gas for Maharashtra plants and Supreme court order for Delhi plants

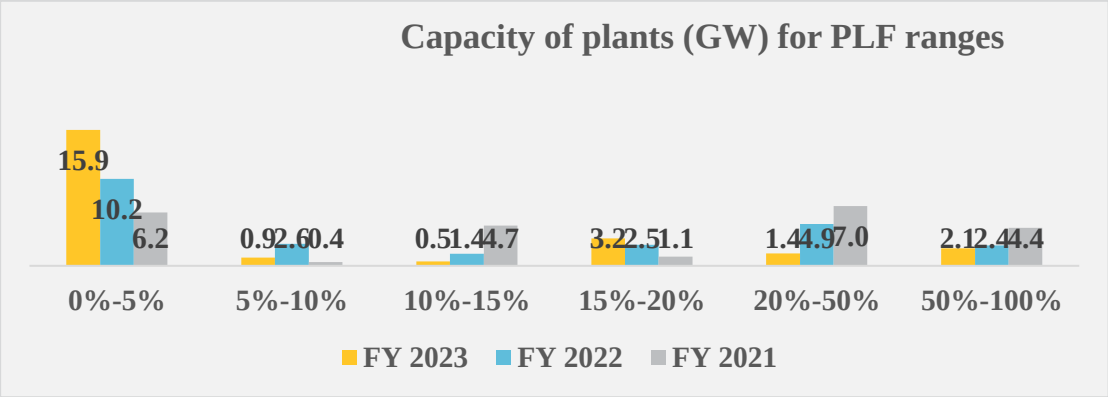
Overall ~4100 MW plants are operational due to special situations

~6520 MW gas power plants (or 20 plants) are operational as either they are in isolated gas fields (~2420 MW or 14 plants) or due to special situations (~4100 MW or 6 plants)

Gas power plants with high PLFs are either in isolated gas fields or are running due to special cases







- 65% in 2023, 47% in FY 2022 and 33% in FY 2021, gas based capacity have run below an annual PLF below 5%

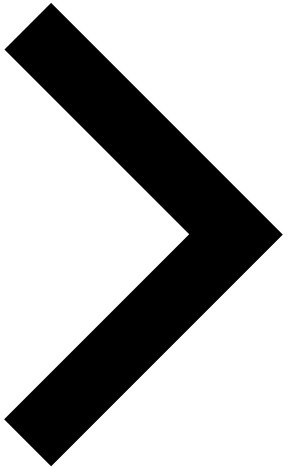
Majority of the gas-based power plants (~65%) have run below a PLF of 5% in FY 2023

Key Challenges & Drivers

Factor	Challenges and barriers for gas-based power plants
Price Volatility & Cost Economics	• The natural gas market has witnessed supply disruptions in recent years, coupled with a significant escalation in gas prices* • The cost of coal-based electricity typically ranges from INR 2 - 6 per kWh, while solar power generation costs fall within the range of INR 2.5 to 3.5 per kWh; Due to the high gas prices, the cost of generation from gas-based power plants has increased to more than ₹8/kWh.
Gas Availability	• Production from KG D6 not as per projected level leading to a shortfall in domestic gas availability for gas-based power plants • Gas allocation/supply to the CGD Systems and Fertilizers industry was placed under no cut category, consequently giving these sectors higher priority than power sector • Led to stranded assets and dependence on imports, thus higher generation cost and lower ranking in the merit order dispatch list
Financial status	• Unable to provide continuous services, many gas-based plants have become unable to service their debt obligations and are on the verge of becoming NPAs.
Operational Constraints	• The fluctuation in energy prices and subsequent generation leads to operational constraints for the gas power plants and is leading to degradation in the life of the plant • Existence of long-term PPAs are not flexible with volatile price movements due to the price sensitive nature of Indian power sector and has impacted the operations of gas-based power plants

Costly gas supply is key reason for lower power generation by gas fired power plant

*($8.87/MMBTU in Jan 2021 to $53.95/MMBTU in Aug 2022 (JKM gas prices))



Possible Interventions / Recommendations

Ensuring cheaper availability of gas to power plants	E-bid RLNG Scheme can be revived	Domestic gas allocation priority esp. over CGD (CNG)	Price pooling of NG for power sector	Assistance in LNG procurement
Tax rationalization	Natural Gas under GST (@5%)	Concessionary CST @ 2% for power sector	GST on gas transportation to 5%	GST on regasification to 5%
Operational Constraints for selling gas-based power on IEX	Day-ahead Pipeline capacity booking	Reduction in Take or Pay pentalty in regasification	Transport Tariff Reform	Short-term contract with flexibility in offtake & dynamic pricing
Subsidy / Concessions & incentives to boost cost economics	Reduction in regas charges & trasnport tariff	ISTS Charges & losses waiver	NCEF, PSDF fund – for sustaining the sector	Removal of direct / in-direct subsidy on coal
Ensuring demand / offtake for gas based power	Mandate for procuring gas power during summer peak	Gas based power purchase obligation	Bundling with low cost RE	Gas power to be in common merit order across states
Ensuring incentives for NG as a clean fuel for power generation	Carbon credit or Emission reduction certificates	National Clean Air Programme		

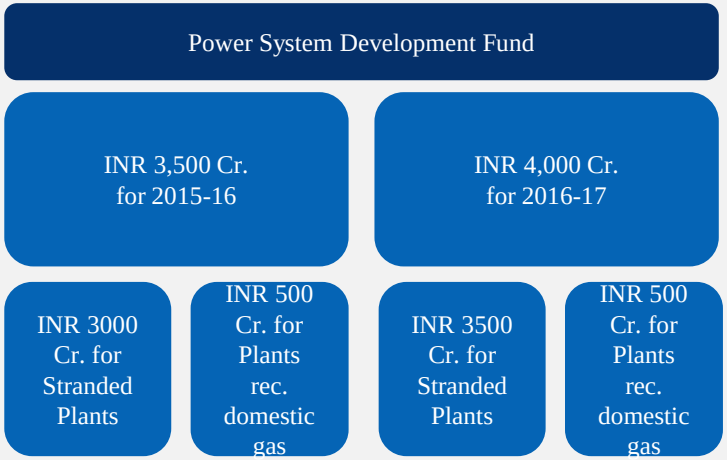
Possible Interventions / Recommendations

Ensuring Cheaper Availability Of Gas To Power Plants (1/2)

E-bid RLNG Scheme Can Be Revived

In order to improve utilization of gas-based capacity in the country, Indian Government sanctioned the **e-bid RLNG scheme** for **importing Spot RLNG** in 2015-16 and 2016-17 **for stranded gas-based power plants as well as plants receiving domestic gas.**

Funding:



Contribution by Stakeholders:

Central & State Governments, Power Developers & Gas Transporters were expected to make certain contributions collectively:

- **Customs Duty Waiver on imported LNG**
- **Waiver on VAT**
- **Reduction in Pipeline tariff charges**
- **CST, Octroi & Entry tax waiver**
- **Service Tax waiver on regasification and transportation**
- **Reduction in Marketing Margin**
- **Reduction in Regasification Charges**
- **Exemption on Transmission charges & losses for solar**
- **Provision for Co-Mingling & Swapping of Gases**
- **Capping on Fixed Cost Recovered by Stranded Developers**

e-Bid RLNG scheme

Sources: Parliament Digital Library, MSTC E-Commerce

	Phase-I (1st June to 30th Sept 2015)	Phase II (1st Oct 2015 to 31st Mar 2016)	Phase III (1st April to 30th Sept 2016)	Phase-IV (1st Oct 2016 to 31st Mar 2017)
Auction month	May 2015	Sept 2015	March 2016	Sept 2016
Total capacity for bidding (MW)	24149.77	24149.77	24149.77	24149.77
Target PLF by EPMC	35%	50%	30%	60%
Gas available for bidding (MMSCMD)	10	15	8	18
Gas Allocated in e-auction (MMSCMD)	9.40	13.89	7.62	9.63
Gas actually drawn (MMSCMD)	5.50	7.77	4.64	3.43
Total bid Capacity (MW)	10270.06	1177.64	5941.5	5069.5
Total generation as per Bids (BUs)	5.7	12.47	6.79	8.8
Actual Electricity generated (BUs)	3.68	7.17	4.14	2.99
Subsidy paid by Govt of India (Rs. crores)	496	790	-117	223

Phases of e-Bid RLNG

Sources: Parliament Digital Library, MSTC E-Commerce

The total financial support provided by the Ministry of Power from the PSDF to this Scheme was INR 1509 Cr. Finally, the Scheme has been discontinued on 31.03.2017 due to following reasons:

Reduced Demand from Coal Based Power Plants

A number of coal-based plants already did not have PPA's and had stranded assets due to lack of demand of power from state. Any additional generation from gas plants would further reduce their demand, thus transferring stress from gas-based plants to coal based plants

High Tariffs

The power produced under the scheme was to be supplied to the DISCOM at a tariff not exceeding Rs. 4.70/kWh in the case of stranded gas plants and Rs. 3.39/kWh per unit for the domestic gas plants. However, due to other capacity additions and cheaper tariff available from other sources, discouraging demand.

Lack of Support from States

Certain exemptions were initially given but later withdrawn by Gujarat, Maharashtra, MP and Jharkhand. Further in later phases, states like Telangana and AP declined to sign PPAs due to abundant affordable power. Thus, only few plants operated under the scheme, resulting in generation falling short of bidders' quoted amounts during auction.

Reasons for Discontinuation

Sources: Parliament Digital Library, MSTC E-Commerce

Name of the Project	Developer	State	Installed Capacity (MW)
RATNAGIRI (RGPPL-DHABHOL)	NTPC	Maharashtra	1967
PRAGATI CCGT-III	Pragati Power Corporation Ltd	Delhi	750
DHUVARAN CCPP(GSECL)	Gujarat State Electricity Corporation Ltd	Gujarat	488.3
UTRAN CCPP(GSECL)	Gujarat State Electricity Corporation Ltd	Gujarat	374
PIPAVAV CCPP	GSPC Pipavav Power Company Ltd	Gujarat	702
HAZIRA CCPP EXT	Gujarat State Energy Generation Ltd	Gujarat	351
GAUTAMI CCPP	GVK Gautami Power Ltd	Andhra Pradesh	464
GMR - KAKINADA (Tanirvavi)	GMR Energy	Andhra Pradesh	220
JEGURUPADU CCPP (GVK) PHASE- II	GVK Indutries Ltd	Andhra Pradesh	220.5
KONASEEMA CCPP	Konaseema Power	Andhra Pradesh	445
KONDAPALLI EXTN CCPP .	Lanco Power	Andhra Pradesh	366
VEMAGIRI CCPP	GMR Energy	Andhra Pradesh	370
SRIBA INDUSTRIES	PCIL Power & Holdings Ltd.	Andhra Pradesh	30
RVK ENERGY	RVK Energy	Andhra Pradesh	28
SILK ROAD SUGAR	SILK ROAD SUGAR	Andhra Pradesh	35
LVS POWER	LVS Power	Andhra Pradesh	55
GMR-Rajamundry Energy Ltd.	GMR Energy	Andhra Pradesh	768
KONDAPALLI ST-3 CCPP (LANCO)	Lanco Power	Andhra Pradesh	742
SAMALKOT EXP	Reliance Infra	Andhra Pradesh	2400
CCGT by Panduranga	Panduranga Energy	Andhra Pradesh	116
Rithala CCPP (NDPL)	NDPL	Delhi	108
VATWA CCPP*	Torrent Power	Gujarat	100
ESSAR CCPP	Essar Power	Gujarat	300
UNOSUGEN CCPP	Torrent Power	Gujarat	382.5
DGEN Mega CCPP	Torrent Power	Gujarat	1200
MANGAON CCPP	Pioneer Gas Power Ltd	Maharashtra	388
Gas Engine by ASTHA	Astha Power	Telengana	35
KASHIPUR CCPP(SRAVANTHI)	Sravanthi Energy	Uttarkhand	225
KASHIPUR SRAVANTHI ST-II	Sravanthi Energy	Uttarkhand	225
Beta Infratech CCGT	Beta Infratech	Uttarkhand	225
GAMA CCPP	Gama Infraprop	Uttarkhand	225
Total			**14305.3**

List of stranded Gas based Power Plants supported under the scheme

Plants not stranded currently or likely to be dispatched in future

Plants not stranded currently but less than 5% PLF

Ensuring Cheaper Availability Of Gas To Power Plants (2/2)

- Currently, CGD entities enjoy huge margins especially in the CNG sector
- Government has supported the CGD sector by providing its priority in domestic natural gas allocation.
- However, the CGD entities may not require support from the government to compete with other alternate fuels in their GAs

- Government should plan to reduce the domestic gas supply to the CGD sector for CNG in a phase-wise manner :
  - Year 1 – 10% to Year 5 – 50%
- Post that based on review future course to remove support from the CNG business of CGD can be contemplated
- Though, support to PNG could be extended.

Providing priority to Power plants in Domestic Gas allocation with CGD

PSUs like GAIL can procure LNG on behalf of gas-based power plants at an aggregate level

This would allow :

- Better negotiating power internationally for gas contracts pricing
- It would allow smaller players in the sector, who might have procured RLNG from any domestic RLNG supplier - to procure gas at low or no marketing margin,
- The entity could provide natural gas across power plants at pooled price
- Reduce uncertainty in case of demand fluctuation for an individual player – possible impact of take or pay charges of re-gas terminals would be reduced, gas availability at short notice (due to pooling of larger demand), pipeline capacity booking on short notice may be eased

Assistance in LNG sourcing at reasonable cost

Tax Rationalization

The Standing Committee on Energy (2018-19) in its 42nd report -

The Committee observe that while the Coal has been included and taxed at 5% GST, Natural Gas has been kept outside the GST purview. The Committee feel that natural gas being a cleaner fuel should not be placed at a disadvantageous position vis-a-vis other sources of energy like coal. The Committee, therefore, recommend that natural gas should be brought under GST, so that the taxes get rationalized and gas becomes cheaper and affordable

Possibilities:

- Bringing Natural Gas under GST (@5%) – already a declared policy of GoI . Also GST on coal is at 5%
- Meanwhile, allowing to purchase gas on concessionary CST @ 2% by providing C-Form

Tax Rationalization - Bringing gas sold to Gas based power plants to GST regime

- Natural gas unlike other commodities used for power generation, has been kept out of GST and hence supplier state's VAT / CST is applicable on purchase of natural gas in local market.
- Such VAT/CST varies from 3% to 24.5% among different states in India.
- Majority of Imported RLNG is available at PLL's Dahej terminal is Gujarat where VAT of 15% is applicable and similarly majority of Domestic gas is available from KG basin fields in Andhra Pradesh where VAT of 24.5% is applicable.
- Since, gas-based power producer unlike other consumer of gas, are not able to provide concessionary C-from on purchase of interstate gas, gas-based power producer has to pay full VAT / CST on procurement cost of gas which in turn increase the power generation cost by 15% to 24.5%.

Gujarat

Custom duty exemption is not applicable if RLNG is procured from any seller for generation of electricity.

If RLNG is procured within Gujarat, 15% VAT is applicable for generation of electricity unlike 6% VAT is applicable with other various industries.

Andhra Pradesh

Earlier electricity generators were allowed to buy domestic gas via interstate purchase on concessional CST tax (2%) applicable by providing C-Form. However, currently, electricity generators are not allowed to provide C-Form, resulting into higher tax applicability of Andhra Pradesh state VAT (i.e 24.5%), resulting into high power generation cost.

Tax Rationalization - Taxes on purchase of Natural Gas

Operational Constraints For Selling Gas-Based Power On IEX

- To reduce SOP charges, Rostering Effect / Charging consumer on actual transportation of gas / Allowing consumer to book capacity for lower tenure and promptly on spot basis can help.

- After booking capacity for Zone-1 tariff, Shipper should have flexibility to choose any entry point within the said zone without booking CT for each entry point.

- In case of non utilization of transportation capacity booked, shipper should be charged only fixed cost component of the transportation tariff.

- The deposit for transportation arrangement made by Shipper should be refunded by transporter once the capital cost for such arrangement is included for determination of tariff of such transporter.

- The penalty charges may be considered for only operating units only instead of units not operating for long time.

Transportation Tariff Reform

Subsidy / Concessions & Incentives To Boost Cost Economics

- National Clean Energy Fund (NCEF) was created out of cess on Coal at Rs. 400 per tonne to provide financial support to clean energy initiatives and an Inter Ministerial Group chaired by the Finance Secretary was constituted to approve the project/schemes eligible for financing under NCEF. The coal cess collected from 2010-11 to 2017-18 amounts to Rs. 86,440.21 crore, out of which only Rs. 29,645.29 crore have actually been transferred to NCEF. Whereas, the amount financed from NCEF for projects is only 15,911.49 crore i.e. only about 19% of the total amount collected as coal cess.

- This fund has been diverted to compensate GST losses.

- **The Standing Committee on Energy (2018-19)** in its 42nd report - Also, recommended that financial support should be extended to gas based power projects from **NCEF** for their sustainability as natural gas is also a clean energy source.

Utilization of National Clean Energy Fund (NCEF) or PSDF for ensuring sustainability of gas based power plants

Ensuring Incentives For NG As A Clean Fuel For Power Generation

National Clean Air Program	• **Launched by MoEF&CC in 2019 – emission norms revised in 2022 - Stringent compliance for all TPPs with respect to the emission norms** • **Phasing out older coal-based power plants and converting specific coal-based power plants to natural gas*.**	**Replacing phased-out coal plants with gas-based power facilities marks a significant step towards optimizing the usage of natural gas capacity**

***About 20 coal-based power plants units (1725 MW) within 7 non-attainment cities/ districts have been retired since NCAP launch. However, 22 old units with 43 MW capacity (≥40 years as on 31.12.2025) located in NCAP regions are yet to be phased out[2] (CEA, 2022).**

National Clean Air Programme

Source: https://loksabhadocs.nic.in/Refinput/New_Reference_Notes/English/15072022_173626_102120463.pdf
https://energyandcleanair.org/wp/wp-content/uploads/2023/01/Tracing-the-Hazy-Air-2023_-Progress-Report-on-National-Clean-Air-Programme-NCAP_10th-January-2023.pdf

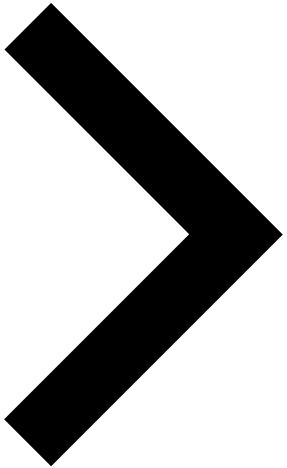
Emission reduction certificates may also be issued to Gas based generation (benchmarked to coal based plant emissions) – this carbon credit certificate can be traded and would effectively cushion the tariff.

Emissions – Carbon credit or Emission reduction certificates to NG based plants

Ensuring Demand / Offtake For Gas Based Power

The Committee note that in view of increasing Renewable Energy Capacity which is intermittent in nature, the Gas based Capacity can be utilized for peaking demand due to its higher ramp up rate and quick start time. These Plants can play a role in balancing of the Grid by maintaining uninterrupted electricity supply, especially when Solar Plants shuts down in the evenings and coal based plants take time to ramp up. The Committee, therefore, recommend that Gas based Plants can be operated as Peaking Plants as they can switch on quickly when there is high demand and running these plants as Peaking Plants will also optimize the use of scarcely available domestic natural gas.

Mandate procuring power from gas based plants during summer peak



End Of Report

Project 1: Legislative framework enhancement

Hydrogen Charter

20.03.2025

4 (c) – Recommended Changes Required in The PNGRB Act , 2006

S.No	Section of the Act	Present Provisions of the Act	Recommendation
1	Section 11 - Functions of the Board	Linked here	It is recommended that blending of hydrogen in natural gas is expressly included in the above section as part of the functions of the board
2	Section 2 - Definitions	Clause 2(zc) of the Act: *"Notified petroleum, petroleum products and natural gas' means such petroleum, petroleum products and natural gas as the Central Government may notify from time to time after being satisfied that it is necessary or expedient so to do for maintaining or increasing their supplies or for securing their equitable distribution or ensuring adequate availability"*	It is recommended that natural gas blends (with hydrogen) be notified under this section
		Clause 2(za), defines natural gas in the following manner: *'natural gas" means gas obtained from bore-holes and consisting primarily of hydrocarbons and includes-* *(i) gas in liquid state, namely, liquefied natural gas and degasified liquefied natural gas,* *(ii) compressed natural gas,* *(iii) gas imported through transnational pipelines, including CNG or liquefied natural gas,* *(iv) gas recovered from gas hydrates as natural gas,* *(iv) methane obtained from coal seams, namely, coal bed methane, but does not include helium occurring in association with such hydrocarbons;"*	Given the fact that all regulations stemming from the Act, utilize the term "Natural Gas", it is proposed that the definition of Natural Gas be expanded to include "Blended Natural Gas" within the umbrella term of "Natural Gas". It is also suggested to have a separate definition for blended natural gas to serve two purposes: 1. It would set a limit on the composition ratio of natural gas with hydrogen that is required to be maintained to be classified as "Blended Natural Gas" 2. Secondly, usage of blended natural gas in addition to wherever natural gas has been mentioned throughout the Act, would ensure that such blended natural gas is also subjected to the power of the board under the Act in the same manner as the traditional natural gas
3	Section 14: Register	*"……(a)Registered for-* *(i)Marketing notified petroleum, petroleum products or natural gas, or* *(ii)Establishing and operating liquefied natural gas terminals, or* *(iii)Establishing storage facilities for petroleum, petroleum products or natural gas exceeding such capacity as may be specified by regulations.* *(b)Authorised for –* *(i)Laying, building, operating or expanding a common carrier, or (ii)Laying, building, operating or expanding a city or local natural gas distribution network, as may be provided by the Board by regulations……"*	It is suggested that Section 14 of the PNGRB Act be amended to explicitly incorporate hydrogen-related activities within the scope of the Petroleum and Natural Gas Register. Specifically, subparagraph (a) should include entities engaged in marketing hydrogen and establishing and operating hydrogen related infrastructure including storage infrastructure.

4 (c) – Recommended Changes Required in The PNGRB Act , 2006

S.No	Section of the Act	Present Provisions of the Act	Recommendation
4	Section 16: Authorisation	*"No entity shall –* *(a)Lay, build, operate or expand any pipeline as a common carrier or contract carrier,* *(b)Lay, build, operate or expand any city or local natural gas distribution network, without obtaining authorization under this Act; ……"*	it is recommended to amend Section 16 of the PNGRB Act by the addition of a new clause (c) requiring separate authorization for "laying, building, operating or expanding any pipeline or city/local gas distribution network for transporting hydrogen" given that the long-term intention of the Government is to establish dedicated pipelines system for hydrogen.
5	Section 17: Application for Authorisation	Entities seeking authorization to lay, operate, or expand pipeline networks (including common carriers, contract carriers, and city/local gas distribution networks) must apply in writing to the Board.	Modify existing clauses (1) and (2): Include "or hydrogen" after "natural gas" to explicitly encompass hydrogen blending within the purview of authorization requirements for both common/contract carrier pipelines and city/local distribution networks.
6	Section 61: Power of the Board to make Regulations	The Board derives its authority to make regulations and rules pertaining to affairs of petroleum, petroleum products and natural gas through the provisions of Section 61	Additions to be made in order to empower the board to make regulations and include hydrogen in its purview: •Technical specifications and safety protocols for hydrogen storage and blending infrastructure. •Blending ratios and quality standards for hydrogen-natural gas mixtures. •Monitoring and reporting requirements for hydrogen blending operations. •Certification and accreditation frameworks for relevant entities and equipment. •Economic and financial incentives for promoting hydrogen blending projects. •Any other matter necessary for the effective implementation of hydrogen blending in India.

4 (c) – Applicable Regulations with respect to Hydrogen

- Petroleum and Natural Gas Regulatory Board (Authorizing Entities to Lay, Build, Operate or Expand City or Local Natural Gas Distribution Networks) Regulations, 2008
- Petroleum and Natural Gas Regulatory Board (Determination of Transportation Rate for CGD and Transportation Rate for CNG) Regulations, 2020
- Petroleum and Natural Gas Regulatory Board (Exclusivity for City or Local Natural Gas Distribution Network) Regulations, 2008
- Petroleum and Natural Gas Regulatory Board (Technical Standards and Specifications including Safety Standards for City or Local Natural Gas Distribution Networks) Regulations, 2008
- Petroleum and Natural Gas Regulatory Board (Code of Practice for Quality of Service for City or Local Natural Gas Distribution Networks) Regulations, 2010
- Petroleum and Natural Gas Regulatory Board (Access code for City or Local Natural Gas Distribution Networks) Regulations, 2020
- Petroleum and Natural Gas Regulatory Board (Integrity Management System for City or Local Natural Gas Distribution Networks) Regulations, 2013
- Petroleum and Natural Gas Regulatory Board (Determining Capacity of City or Local Natural Gas Distribution Network) Regulation, 2015
- Petroleum and Natural Gas Regulatory Board (Guiding Principles for Declaring City or Local Natural Gas Distribution Networks as Common Carrier or Contract Carrier) Regulation, 2020
- Petroleum and Natural Gas Regulatory Board (Technical Standards and Specifications including Safety Standards for Retail Outlets dispensing Petroleum, Auto LPG and CNG) Regulations, 2018
- Petroleum and Natural Gas Regulatory Board (Technical Standards and Specifications including Safety Standards for Liquefied Natural Gas Facilities) Regulations, 2018
- Petroleum and Natural Gas Regulatory Board (Codes of Practices for Emergency Response and Disaster Management Plan), 2010
- Petroleum and Natural Gas Regulatory Board (Petroleum and Natural Gas Register) Regulations, 2010 (Serial Number T in the list of applicable legislations
- Petroleum and Nature Gas Regulatory Board (Access Code for Common Carrier or Contract Carrier Natural Gas Pipelines) Regulations, 2008
- Petroleum and Nature Gas Regulatory Board (Affiliate Code of Conduct for Entities Engaged in Marketing of Natural Gas and Laying, Building, Operating, or Expanding Natural Gas Pipeline) Regulations, 2008
- Petroleum and Nature Gas Regulatory Board (Authorizing Entities to Lay, Build, Operate or Expand Natural Gas Pipelines) Regulations, 2008
- Petroleum and Natural Gas Regulatory Board (Determination of Natural Gas Pipeline Tariff) Regulations, 2008
- Petroleum and Nature Gas Regulatory Board (Determining capacity of Petroleum, Petroleum products and Natural Gas Pipeline) Regulations, 2010
- Petroleum and Nature Gas Regulatory Board (Guiding Principles for Declaring or Authorizing Natural Gas Pipeline as Common Carrier or Contract Carrier) Regulations, 2009
- Petroleum and Nature Gas Regulatory Board (Technical Standards and Specifications including Safety Standards for Natural Gas Pipelines) Regulations, 2009
- Petroleum and Nature Gas Regulatory Board (Integrity Management System for Natural gas pipelines) Regulations, 2010
- Petroleum and Nature Gas Regulatory Board (Imbalance Management Services Regulations) 2016
- Petroleum and Natural Gas Regulatory Board (Technical Standards and Specifications including Safety Standards for dispensing of Automotive Fuels) Regulations, 2018
- Petroleum and Natural Gas Regulatory Board (Commissioning and Gas Charging in Steel Pipelines for City or Local Natural Gas Distribution Networks) Guidelines, 2016

Recommended Amendments/Additions Required In Applicable Regulations

1- PNGRB (Authorizing Entities to Lay, Build, Operate or Expand City or Local Natural Gas Distribution Networks) Regulations, 2008

Regulation No.	Existing Regulation	Suggested Amendments / Additions
3 - Application	*(1) These regulations shall apply to an entity which is laying, building, operating or expanding, or which proposes to lay, build, operate or expand a CGD network.* *(2) A CGD network shall be designed to operate at a pressure as specified in the relevant regulations for technical standards and specifications, including safety standards for maintaining the volumes of supply of natural gas on a sustained basis to meet the following requirements, namely:-* *(a) customers having requirement of natural gas upto 50,000 SCMD shall be supplied through the CGD network; (.....)* *(b) customers having requirement of natural gas more than 50,000 SCMD and up to 100,000 SCMD shall be supplied, 5 [at the discretion of customer]-* *(i) through the CGD network; or (ii) through a pipeline not forming part of the CGD network;* *(c) customers having requirement of natural gas more than 100,000 SCMD shall be supplied through a pipeline not forming part of the CGD network.*	1. Given that CGD networks shall also be utilized for hydrogen blending, it is recommended that the technical standards and specifications including safety standards are revised to adhere to the technical and safety standards advised for the process, from a qualified technical authority. 2. Secondly, it is advised that in the application, clear demarcation and division is made for customers/consumers who shall be eligible to be supplied blended natural gas in accordance to their needs.
5 - Criteria for selection of entity for expression of interest route	*(1) The Board may carry out a preliminary assessment of the expression of interest with respect to the following, namely:-* *(a) natural gas availability position;* *(b) possible connectivity with an existing or proposed natural gas pipeline for supply of natural gas to the city gate of the proposed CGD network, including LNG supplies by tank trucks or tank wagons and CNG by cascades; and* *(c) any other relevant issue as the Board may consider necessary.....*	Addition of additional assessment point of Hydrogen availability position.
	(6)... *(b) (iv) entity has an adequate number of technically qualified personnel with experience in construction, pre-commissioning and commissioning of 6 [hydrocarbon steel pipelines] and also has a credible plan to independently undertake and execute the CGD project on a standalone basis.* *Explanation.- The entity shall have at least three technically qualified personnel on its permanent rolls having experience of not less than 7 [three year] in the following areas, namely:-* *(i) right of way acquisition or clearance securing;* *(ii) design and execution of a [hydrocarbon steel pipeline] project;* *(iii)pre-commissioning including hydro-testing and restoration; and* *(iv)safety of [hydrocarbon steel pipeline] and installations;*	For projects involving hydrogen blending, it is advised that entities are mandated to have technically qualified persons in case of hydrogen as well.
	..... *(g) the entity should have a credible plan for sourcing natural gas for supply in the proposed CGD network;*	It is suggested that along with sourcing of natural gas for supply in the proposed CGD network, eligible entities supplying blended natural gas, must also have an appropriate plan for sourcing hydrogen.

Recommended Amendments/Additions Required In Applicable Regulations

2- PNGRB (Determination of Transportation Rate for CGD and Transportation Rate for CNG) Regulations, 2020

Regulation No.	Existing Regulation	Suggested Amendments / Additions
4 - Determination of transportation rate for CGD and transportation rate for CNG and webhosting of information:-	*1. An authorised entity to which these regulations apply shall, within **five months** from the last day of the month in which CGD network has been declared as a common carrier or contract carrier, submit the transportation rate for CGD and transportation rate for CNG computed in accordance with the provisions specified in the schedule for the purpose of determination of such rates by the Board to be applicable during the initial period in accordance with subparagraph (1) of paragraph 6 of this Schedule.*	The current timeframe of five months from declaring the CGD network as a common/contract carrier might not be sufficient for accurately calculating rates with hydrogen blending. Consider extending this period to allow for gathering data and modeling the impact of blending on costs and operations.
	*2. An authorised entity to which these regulations apply shall, within **seven months** from the start of the financial year up to which the transportation rates have been determined by the Board,* ...	The seven-month timeframe from the start of the financial year might not be ideal for capturing real-time changes and uncertainties associated with hydrogen blending implementation. Consider more frequent submissions, perhaps quarterly or semi-annually, during the initial transition phase.
Schedule	*Methodology for determination of Transportation Rate for CGD and Transportation Rate for CNG (or Transportation Rates)*	Technical adviser to advise and propose the changes in the methodology for determining the rate of CGD once the hydrogen is blended with the natural gas.

3- PNGRB (Technical Standards and Specifications including Safety Standards for City or Local Natural Gas Distribution Networks) Regulations, 2008

Regulation No.	Existing Regulation	Suggested Amendments / Additions
5 - Intent	(b) The continuation of operation of existing CGD network shall be allowed only if it meets the following requirements, namely:- (i) The CGD system downstream of city gate station shall have been tested initially at the time of commissioning in accordance with ASME B 31.8 Chapter IV (with minimum test pressure of 1.4 times of MAOP for steel network and 1.4 time MAOP or 50 PSI whichever is higher for PE network). The entity should have proper records of the same. Such test records shall have been valid for the current operation. Alternatively, if such a record is not available, the entity should produce in service test record of the CGD network having tested at a pressure of 1.1 time of MAOP as per ASME B 31.8	It is recommended that the technical advisor advise the minimum test pressure to be maintained initially for the transportation of a blended natural gas network through CGD system.

Recommended Amendments/Additions Required In Applicable Regulations

4- PNGRB (Access code for City or Local Natural Gas Distribution Networks) Regulations, 2020

Regulation No.	Existing Regulation	Suggested Amendments / Additions
4 - Capacity declaration	*The capacity in a CGD network for open access on a cumulative basis at all entry points shall be at least twenty percent of the capacity of the CGD network and compression capacity or the maximum quantity of gas that has flowed in the CGD network or through compressors even for a period of one day in the past, whichever is higher. If such open access capacity in the CGD network falls below ten percent, the authorised entity shall increase the capacity of the CGD network so as to restore the open access capacity to at least twenty percent within a period of six months from the date it has fallen below ten percent.*	Technical adviser to advise and propose the minimum capacity to be maintained by the authorized entity of the CGD network pipelines that are utilized for transportation of blended natural gas.
8 - Gas Parameters	*The authorised entity shall, on a non-discriminatory basis, specify the threshold limits for gas parameters at the entry point, such as the acceptable ranges of pressure, temperature and calorific value and the acceptable threshold limits for other elements in gas, such as carbon dioxide (CO2), nitrogen (N2) and oxygen (O2) in the access arrangement:* *Provided that the aforesaid ranges or the threshold limits shall be in conformity with those specified in Schedule-VI. ....*	The threshold limit for gas parameters at the entry point in reference to the acceptable ranges of pressure, temperature and calorific value and the acceptable threshold limits for other elements in gas must also be mentioned for blended natural gas and hydrogen respectively. The ranges and threshold limits should also be populated in Schedule - VI of the regulation.

5- PNGRB (Codes of Practices for Emergency Response and Disaster Management Plan), 2010

Regulation No.	Existing Regulation (General observation)	Suggested Amendments / Additions	Rationale / Explanation
–	–	Considering the highly flammable nature of Hydrogen, it is advised to adopt necessary practice codes and response protocols for operations of pipelines with hydrogen blending.	It is suggested that an ERDMP (Emergency Response and Disaster Management Plan) is also formulated for pipelines carrying blended natural gas after due consideration with the appropriate technical authority given that the regulation mandates an ERDMP for pipelines carrying various components, development and adoption of an ERDMP for blended natural gas pipelines should also be adopted within the framework. In light of the above it is suggested that inputs and guidance from a technical authority be taken to develop such practices within the framework of this regulation, as is required for the safe introduction of blended hydrogen in the natural gas pipelines network.

Recommended Amendments/Additions Required In Applicable Regulations

6- PNGRB (Petroleum and Natural Gas Register) Regulations, 2010

Regulation No.	Existing Regulation	Suggested Amendments / Additions
3 - Contents of the Register	*(1) Register shall be divided into following five parts namely:-* *(a) Part I containing a list of all entities who have been registered for market notified petroleum, petroleum products and natural gas.* *(b) Part II containing a list of all entities who have been registered for establishing and operating LNG terminals or proposing to establish and operate LNG terminals;* *(c) Part III containing a list of all entities who have been registered for establishing storage facility for petroleum, petroleum products or natural gas exceeding such capacity as may be specified by regulations;* *(d) Part IV containing a list of all entities who have been authorized for laying, building, operating or expanding a common carrier or contract carrier pipelines; and* *(e) Part V containing a list of all entities who have been authorized for laying, building, operating or expanding a city or local natural gas distribution network* (2) ……..	The regulations to specify which part or parts of the register would contain lists of entities engaged in marketing hydrogen and establishing and operating hydrogen related infrastructure including storage infrastructure.

Recommended Amendments/Additions Required In Applicable Regulations

7- PNGRB (Access Code for Common Carrier or Contract Carrier Natural Gas Pipelines) Regulations, 2008

Regulation No.	Existing Regulation	Suggested Amendments / Additions
5 - Gas Parameters	*(1) The authorized entity as referred to in sub-regulation (2) of regulation 3 shall formulate the calorific value (CV) band for the natural gas to be transported through natural gas pipeline keeping in view the following parameters, namely:-* *(a) CV of its own natural gas proposed to be transported;* *(b) CV of firmed up contracted capacity of natural gas.* *(c) requirements of downstream consumers of natural gas on the pipeline;* *(d) technical requirement of the pipe line system; and* *(e) CV band of the inter-state pipelines either supplying natural gas into the pipeline system or receiving natural gas from this pipeline system.*	It is recommended that a technical advisor advises on the changes in CV Band for the hydrogen Blending.
7 - Measurement of Gas	*(1) The transporter shall ensure the provision of the entry and exit point equipment to measure gas composition, calorific value, pressure and temperature on a continuous basis as specified in regulation 9……* *(2) ……*	(Based on input from technical advisors) in the event different measurement equipment is required for hydrogen blended natural gas, it is recommended that provision be extended to provide for entry and exit point equipment to measure gas composition, calorific value and temperature for hydrogen blended natural gas.
9 – facilities at entry point and exit point	*(1) Shipper shall arrange to deliver gas at entry point on the pipeline system and shall provide all facilities, including measuring equipment, required for transfer of custody and deliver of gas to the transporter unless otherwise agreed to between shipped and transporter* *(2) Transporter shall execute hooking up facility of shipper to the entry point at the cost of shipper.* *(3) Shipper or his authorized nominee shall own, operate and maintain facilities upstream of entry points at his own cost and risk unless the facilities are provided by the transporter under a separate contract.*	Technical Adviser to consider and advise on the requirement of facilities at the entry and exit point with respect to hydrogen blended natural gas.
Schedule – II – Gas Quality Specifications (read with regulation 5(5), 8(1)(b)(i)	–	It is advised that parameter limit with respect to blended hydrogen is also added to the table for establishing gas quality specifications with respect to blended natural gas. Technical adviser to consider

Recommended Amendments/Additions Required In Applicable Regulations

8- PNGRB (Affiliate Code of Conduct for Entities Engaged in Marketing of Natural Gas and Laying, Building, Operating, or Expanding Natural Gas Pipeline) Regulations, 2008

Regulation No.	Existing Regulation	Suggested Amendments / Additions
3 - Applicability	*These regulations shall apply to an entity-* *(1) Which proposes to lay, build, operate or expand natural gas pipeline and is authorized to do so under the Petroleum and Natural Gas Regulatory Board (Authorizing Entities to Lay, Build, Operate or Expand Natural Gas Pipelines) Regulations, 2008; …* …. ….	Similar regulations would be needed for entities engaged in marketing of hydrogen and laying, building, operating or expanding dedicated hydrogen pipelines and pipelines carrying hydrogen blended natural gas. Government may consider if these existing regulations may be extended to apply to entities engaged in marketing of hydrogen and laying, building, operating or expanding dedicated hydrogen pipelines and pipelines carrying hydrogen blended natural gas. Or fresh analogous regulations are formulated for such entities.

Recommended Amendments/Additions Required In Applicable Regulations

9- PNGRB (Authorizing Entities to Lay, Build, Operate or Expand Natural Gas Pipelines) Regulations, 2008

Regulation No.	Existing Regulation (Reproduced Verbatim)	Suggested Amendment / Addition
4 - Initiation of proposal through expression of interest route or suo-motu by Board.	(1) An entity desirous of laying, building, operating or expanding a natural gas pipeline shall submit an expression of interest to the Board in the form of an application at Schedule A along with an application fee as specified under the Petroleum and Natural Gas Regulatory Board (Levy of Fee and Other Charges) Regulations, 2007. (1) The Board may suo-motu initiate a proposal inviting entities to participate in the process of selection of an entity for laying, building, operating or expanding natural gas pipeline along any route.	An adequate procedure to be set into place for authorizing entities desirous of laying, building, operating or expanding blended/non blended hydrogen pipelines. This may be done through expanding the applicability of these regulations to entities desirous of laying, building, operating or expanding blended/non blended hydrogen pipelines or preparing fresh regulations for this purpose.
5 - Criteria for selection of entity for expression of interest route.	(6) (c) states that to be technically capable of operating and maintaining a natural gas pipeline, an entity must have at least one year of experience or have a joint venture or technical assistance agreement with an experienced party or have adequate qualified personnel and a credible plan to operate independently. (6) (d) the entity has agreed to abide by the relevant regulations for technical standards and specifications including safety standards (6) (e) the entity has adequate financial strength to execute the proposed natural gas pipeline project and operate and maintain the same and shall meet some financial criterion	Government to consider if these technical and financial criteria are equally applicable to entities desirous of laying, building, operating or expanding blended/non blended hydrogen pipelines and if not, then separate criteria to be provided.
15- Quality of service standards	(1) The entity laying, building, operating or expanding a natural gas pipeline must comply with the quality of services standards as specified in Schedule F.	Recommended that quality of service standards is supplemented as appropriate for pipelines transporting blended natural gas Technical adviser to consider

Recommended Amendments/Additions Required In Applicable Regulations

10- PNGRB (Determination of Natural Gas Pipeline Tariff) Regulations, 2008

Regulation No.	Existing Regulation	Suggested Amendments / Additions
4 - Determination of natural gas pipeline tariff	*(1) The natural gas pipeline tariff in respect of an entity covered in regulation 3 shall be determined as per the procedure at Schedule A.*	It is recommended that either a separate Schedule is added in the regulation specifying the determination of hydrogen pipeline tariff or amendments are made to provide for inclusion of hydrogen pipelines in Schedule A

11- PNGRB (Determining capacity of Petroleum, Petroleum products and Natural Gas Pipeline) Regulations, 2010

Regulation No.	Existing Regulation	Suggested Amendments / Additions
5 - Determining capacity of a Petroleum, Petroleum Products and Natural Gas Pipeline.	*(1) The determination of capacity for the pipeline systems and for each section of the petroleum, petroleum products and natural gas pipeline shall be based on selected software package and flow equation approved by the Board under this regulation….* *(2) ……..* *……..*	It is recommended that software package and flow equation are also prepared for hydrogen. Further, it is recommended that new constant and variable parameters are specifically defined with respect to Hydrogen. Technical adviser to consider all the parameters set under the section and advise.
8 - Provisions relating to dedicated pipelines for transport of Petroleum, Petroleum Products and Natural Gas	*(1) In respect of existing dedicated pipelines, the following provision shall apply namely-* *(a) Entity having dedicated pipeline to transport petroleum, petroleum products and natural gas to a specific customer and which is not for resale before the appointed day shall submit details of the pipeline capacity as determined based on the provisions of these regulations to the Board within thirty days notification of these regulations;* *(b) The Board may, based on the examination of the information received, declare the capacity of such pipeline as capacity of dedicated pipeline*	These provisions may also make a reference to blended natural gas for abundant caution, although given the suggested changes to the definition of natural gas to cover natural gas blended up to certain percentage with hydrogen, this is not strictly necessary.

12- PNGRB (Guiding Principles for Declaring or Authorizing Natural Gas Pipeline as Common Carrier or Contract Carrier) Regulations, 2009

No need for change

Recommended Amendments/Additions Required In Applicable Regulations

13- PNGRB (Technical Standards and Specifications including Safety Standards for Natural Gas Pipelines) Regulations, 2009

Regulation No.	Existing Regulation	Suggested Amendments / Additions
–	The Standard for natural gas pipelines is a comprehensive set of technical standards and specifications for the design, construction, operation, and maintenance of natural gas pipelines, covering all aspects from materials and equipment to corrosion control.	Technical team to consider if the standards as currently provided are adequate for pipelines carrying natural gas blended with hydrogen. If the required technical standards and specifications are more onerous or different, then the standards should be suitably revised. ~~It is recommended that the T4S for blended hydrogen should be included.~~

14- PNGRB (Integrity Management System for Natural gas pipelines) Regulations, 2010

Regulation No.	Existing Regulation	Suggested Amendments / Additions
6 - Integrity Management System	*The development and implementation of IMS for NG Pipelines as described in Schedules 1 to 10.*	The schedules contain the framework for assessment of pipeline conditions; technical advisors to consider if these need to be amended in any way in light of the intermingling of hydrogen.

15- PNGRB (Imbalance Management Services Regulations) 2016

No need for change

Recommended changes to the PNGRB Act to regulate hydrogen

The Petroleum and Natural Gas Regulatory Board (PNGRB) can be designated as the regulatory authority for hydrogen energy in India to support India's transition to a low-carbon economy

Section 11:
Functions of the Board

It is recommended that blending of hydrogen in natural gas is expressly included in the above section as part of the functions of the board

Section 2:
Definitions

Natural gas blends (with hydrogen) be notified under this section

The definition to be expanded to include "Blended Natural Gas" within the umbrella term of "Natural Gas".

It is also suggested to have a separate definition for blended natural gas.

Section 14:
Register

Incorporate hydrogen-related activities within the scope of the Petroleum and Natural Gas Register.

Specifically, subparagraph (a) should include entities engaged in marketing hydrogen and establishing and operating hydrogen related infrastructure including storage infrastructure.

Section 17:
Application for Authorization

Modify existing clauses (1) and (2): Include "or hydrogen" after "natural gas" to explicitly encompass hydrogen blending within the purview of authorization requirements for both common/contract carrier pipelines and city/local distribution networks.

Section 61:
Power of the Board to make Regulations

Technical specifications and safety protocols

Blending ratios and quality standards for H2

Monitoring and reporting requirements

Certification and accreditation frameworks

Economic and financial incentives

PNGRB Regulations for which ICF has recommended amendments

CGD Regulations

- A.1 Authorizing Entities to Lay, Build, Operate or Expand City or Local Natural Gas Distribution Networks
- A.2 Determination of Transportation Rate for CGD and Transportation Rate for CNG
- A.6 Access Code for City or Local Natural Gas Distribution Networks

NGPL Regulations

- B.1 Authorizing Entities to Lay, Build, Operate or Expand Natural Gas Pipelines
- B.2 Affiliate Code of Conduct for Entities Engaged in Marketing of Natural Gas and Laying, Building, Operating, or Expanding Natural Gas Pipeline
- B.4 Determination of Natural Gas Pipeline Tariff
- B.6 Technical Standards and Specifications including Safety Standards for Natural Gas Pipelines
- B.7 Determining Capacity of Petroleum, Petroleum Products and Natural Gas Pipeline
- B.8 Integrity Management System for Natural Gas Pipelines

Other

- F.5 Petroleum And Natural Gas Register

PNGRB Regulations for which we recommend pilots and testing

CGD Regulations

- A.4 Technical Standards and Specifications including Safety Standards for City or Local Natural Gas Distribution Networks
- A.7 Integrity Management System for City or Local Natural Gas Distribution Networks
- A.8 Determining Capacity of City or Local Natural Gas Distribution Network

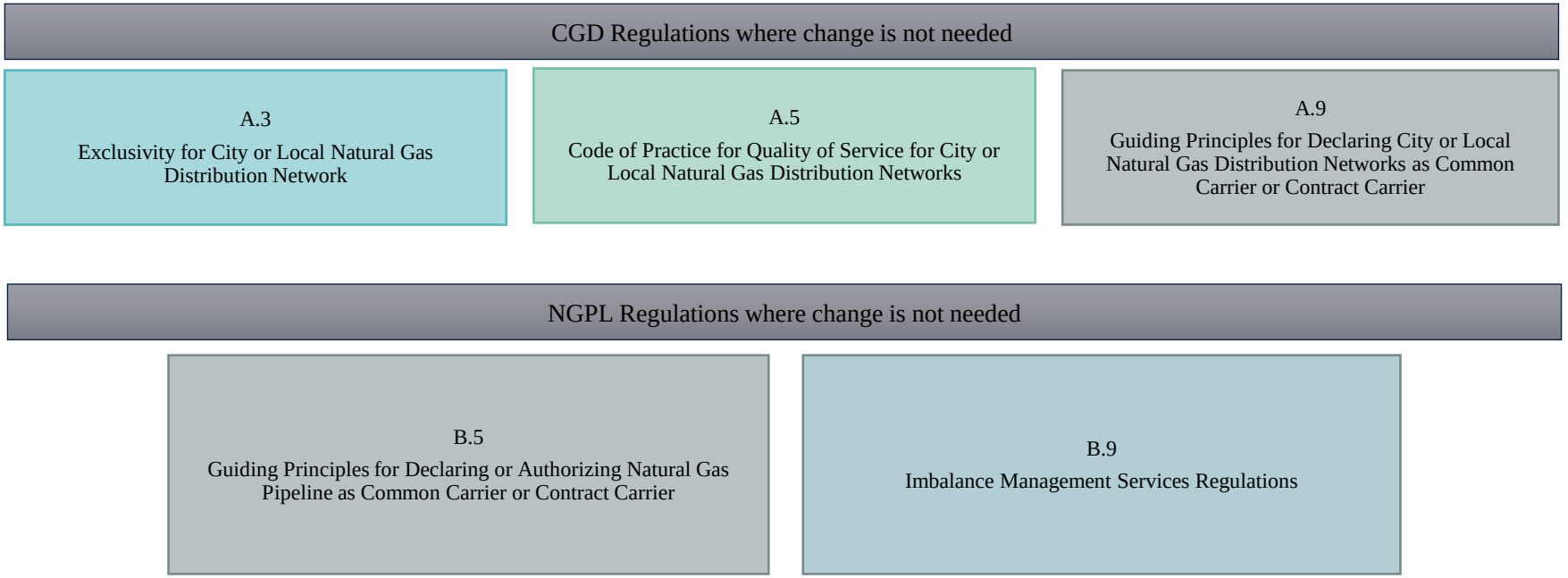
NGPL Regulations

- B.3 Access Code for Common Carrier or Contract Carrier Natural Gas Pipelines

T4S

- D.2 Emergency Response & Disaster Management Plan (ERDMP) Regulations

Regulations where change is not needed



Project 2: Test Beds

Hydrogen Charter

20.03.2025

Test Facility-Broad Overview

Definition

Controlled experimental setup used to evaluate and test the performance, safety, and efficiency of components, systems, or technologies under real-world conditions.

Purpose

Designed to evaluate the impact of hydrogen blended with natural gas on pipeline components, equipment, and infrastructure.

Aim

- **Assess Material Compatibility:** Test the performance of materials (e.g., pipes, valves, compressors) when exposed to hydrogen blends.
- **Evaluate Safety and Integrity:** Monitor the safety, leakage risks, and structural integrity of infrastructure under hydrogen-blended conditions.
- **Optimize Equipment Performance:** Ensure that existing natural gas systems can efficiently operate with hydrogen blends without significant degradation.

Intended Outcomes

Validation of Hydrogen Blends	**Validation of Hydrogen Blends:** Ensure that blending hydrogen into natural gas pipelines is technically feasible.
Infrastructure Adaptation	**Infrastructure Adaptation:** Assess how well current infrastructure can handle hydrogen's unique properties, such as its lower density and higher diffusivity.
Regulatory Compliance	**Regulatory Compliance:** Provide evidence for regulatory bodies on the safe integration of hydrogen blends into the energy grid.

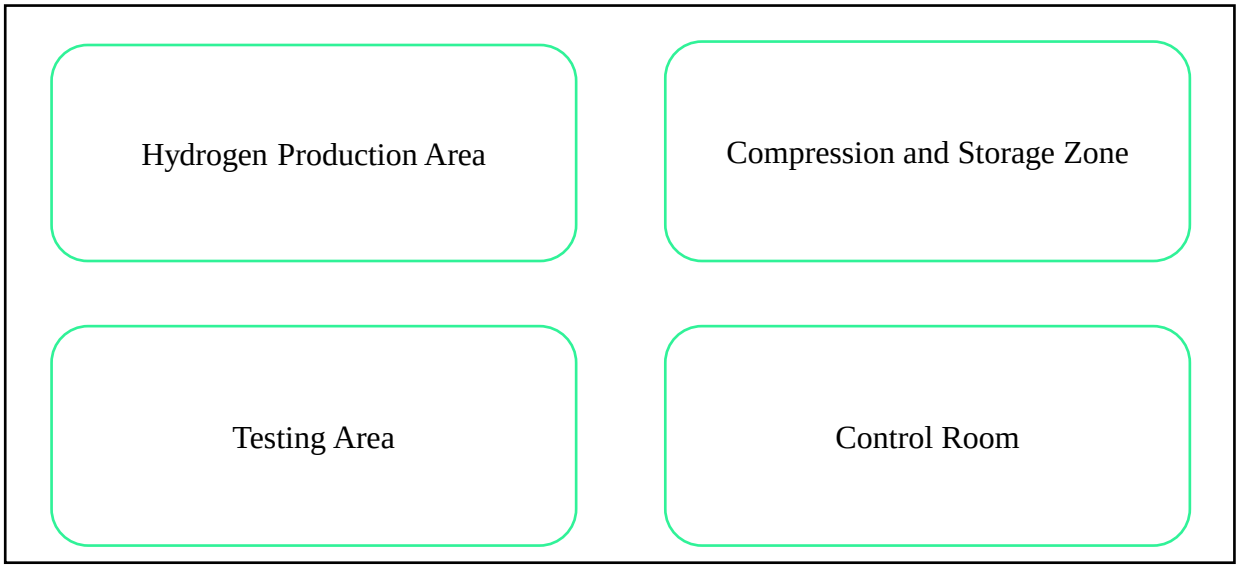
Test Facility-Configuration-(1/2)

Hydrogen Production Units	•**Electrolyzers:** Convert water into hydrogen using renewable electricity. •**Steam Methane Reformers (SMR):** NG to Hydrogen by Steam methane reforming(Grey H2)
Hydrogen Storage Units	•**High-pressure Storage Tanks:** Store hydrogen at pressures of 350-700 bar. •**Cryogenic Storage:** Stores liquid hydrogen at -253°C for behavior testing
Pipes and Piping system	**Pipes:** Made from materials compatible with hydrogen, such as composite materials. **Pipe Spools and Fittings:** Connect various parts of the system while handling high-pressure hydrogen.
Compressors and Valves	**Hydrogen Compressors:** Essential for pressurizing hydrogen for storage and transport. **Valves:** Shut-off, Check, and Control Valves: Tested for hydrogen handling safety.

Test Facility-Configuration-(2/2)

Flow Meters and Sensors	**Flow Meters:** Measure hydrogen flow rate. **Pressure Sensors:** Monitor pressure in pipelines and storage. **Hydrogen Detectors:** Detect hydrogen leaks for safety.
Safety Systems	**Pressure Relief Valves:** Prevent over-pressurization by releasing excess hydrogen pressure. **Leak Detection Systems:** Specialized hydrogen sensors integrated for leak detection. **Flame Arrestors:** Prevent ignition risks by stopping flames from spreading in the presence of hydrogen.
Data Acquisition and Control Systems	**SCADA Systems (Supervisory Control and Data Acquisition):** Monitors and controls test bed equipment, ensuring operational limits are maintained. **Real-Time Monitoring:** Allows remote monitoring of parameters like pressure, flow, temperature, and leak detection.

Test Bed-Layout



Hydrogen Production Area: includes electrolyzers, water treatment, and gas drying units.
Compression and Storage Zone: Compresses hydrogen into high-pressure tanks or cryogenic storage.
Testing Area: Controlled environment where components like valves, compressors, and turbines are subjected to tests.
Control Room: Gathers and analyzes data from sensors, managing test bed operations.

Testing Needs- Impact on properties

Wobbe Index

- Wobbe Index represents heatflux/ overall rate of energy output.
- According to the legal threshold imposed by Gas Safety (Management) Regulations (abbreviated to GS(M)R) laid out in 1996, modern H-band appliances in the UK must be supplied with fuel of WI value no lower than 49.75 MJ/Nm3 , it indicates that PH2 values of less than approximately 10% are required to satisfy the specification.

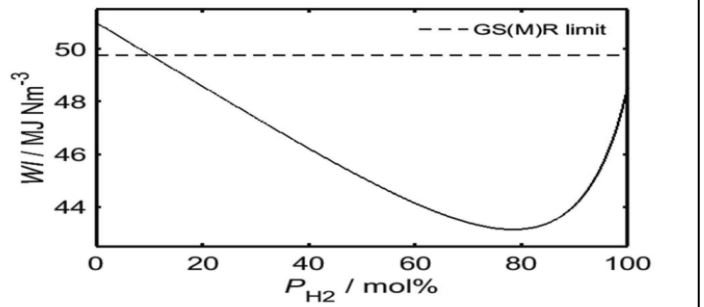
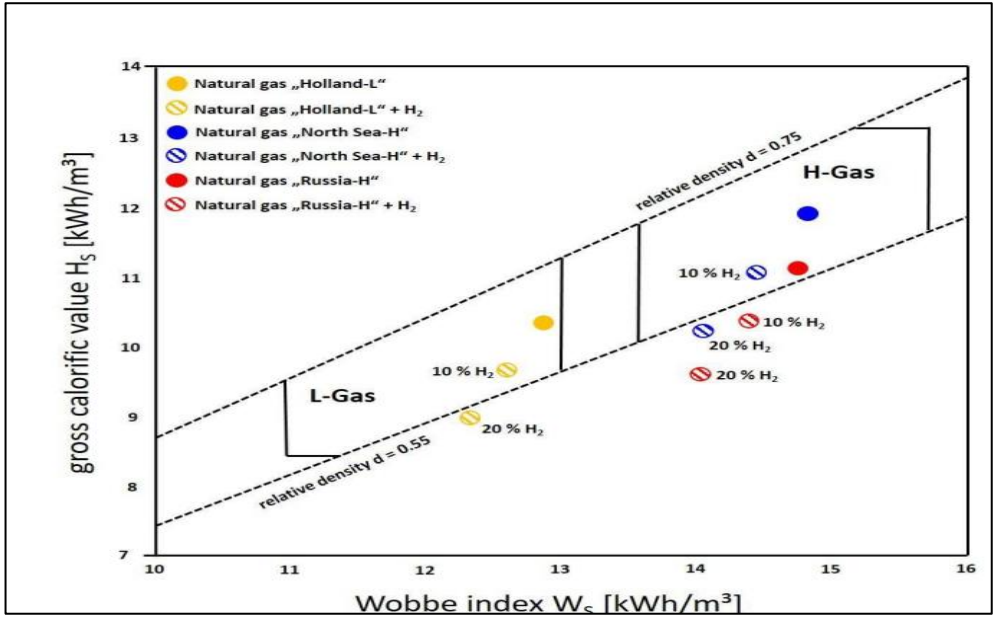


Fig. 1 Variation of the Wobbe Index, WI, defined using the higher heating value of the fuel, as a function of molar hydrogen percentage, P_{H2}, in HENG. Also shown is the legal threshold of WI imposed by the Gas Safety (Management) Regulations (GS(M)R) defined in 1996, plotted as a dashed line; this limit exists to eliminate the possibility of

Density Distortion

- As hydrogen is mixed in NG, its density decrease and there is a minimum particular density which must be there for NG. That limit reaches at around 10%-20%.



Source
1) Hydrogen-enriched natural gas as a domestic fuel: an analysis based on flash-back and blow-off limits for domestic natural gas appliances within the UK.
2) THE LIMITATIONS OF HYDROGEN BLENDING IN THE EUROPEAN GAS GRID

Testing Needs- Impact on properties

Flame Speed

There is a trend to increase flame speed with increasing hydrogen addition. There is typically a ~5 % increase of the laminar flame speed for hydrogen admixture of 10 %.

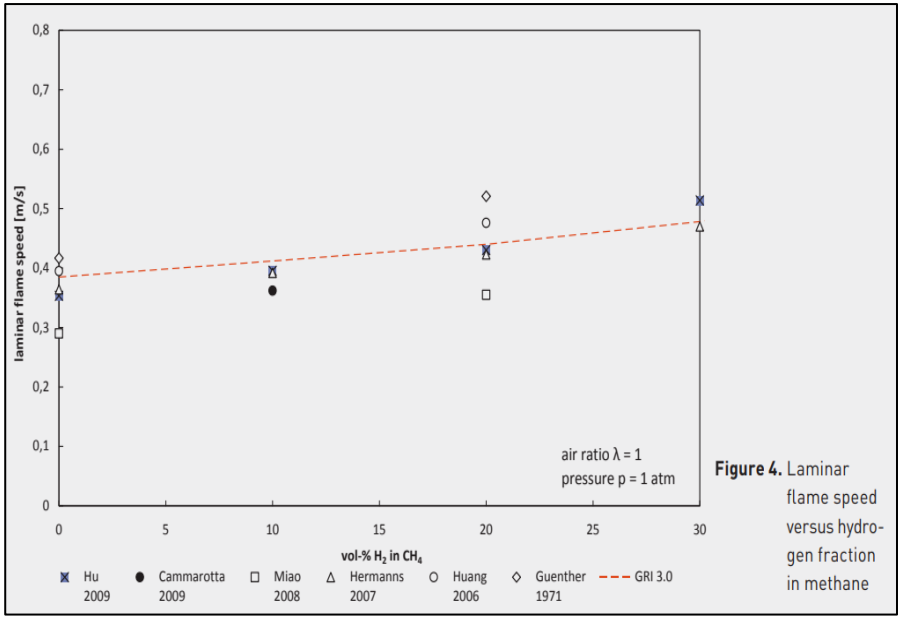
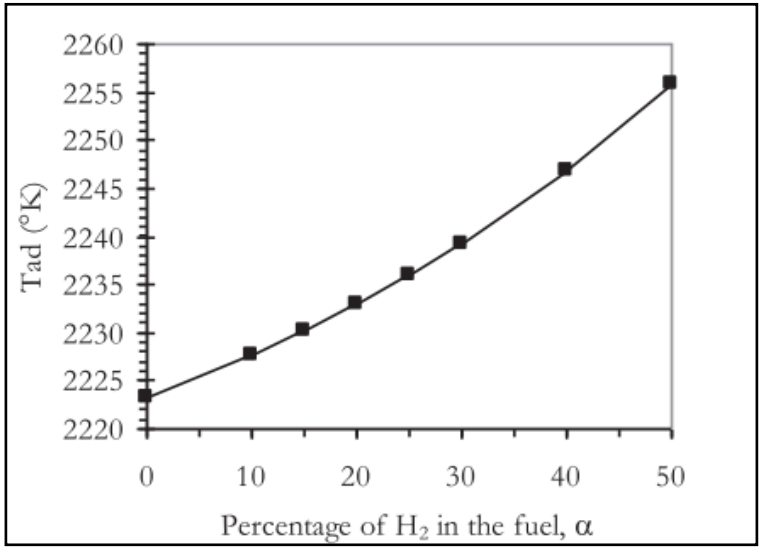


Figure 4. Laminar flame speed versus hydrogen fraction in methane

Adiabatic Flame temparature

- Higher flame temperature can damage the appliances.



Source
1) Admissible hydrogen concentrations in natural gas systems

Requirements of Testing-Material Integrity-(1/4)

Hydrogen Embrittlement → Process of reduction of strength and ductility within the metal due to hydrogen induced damage. It makes metal more brittle. With respect to steel, it adversely the main mechanical properties of steel e.g., tensile strength, toughness and fatigue resistance.

Major Mechanisms

Hydrogen enhanced decohesion (HEDE)	Cohesive strength of a material at the region of the crack tip is reduced upon hydrogen atom adsorption.
HELP (Hydrogen Enhanced Localized Plasticity)	Hydrogen atoms infiltrate the metal and occupy the interstitial sites within the crystalline structure. These hydrogen atoms facilitate dislocation motion by reducing the energy required for dislocations to move, causing localized plastic deformation under stress. This leads to brittle fracture.
Hydrogen Induced intergranular Cracking(HIC)	When hydrogen diffuses into metals, it tends to accumulate at grain boundaries, as these are regions of high energy and can act as traps for hydrogen atoms. The accumulated hydrogen reduces the cohesion between grains, weakening the material. Absorbed hydrogen species can combine in voids to form hydrogen molecules (H_2), creating pressure from within the metal leading to crack.
Hydride Formations	In some materials (such as titanium and zirconium), hydrogen can react with the metal to form hydrides. These hydrides are brittle and can lead to catastrophic failures if they form in critical areas of the material. Hydride formation is often associated with elevated temperatures or high hydrogen partial pressures.

Source
1) Hydrogen Blending Impacts Study

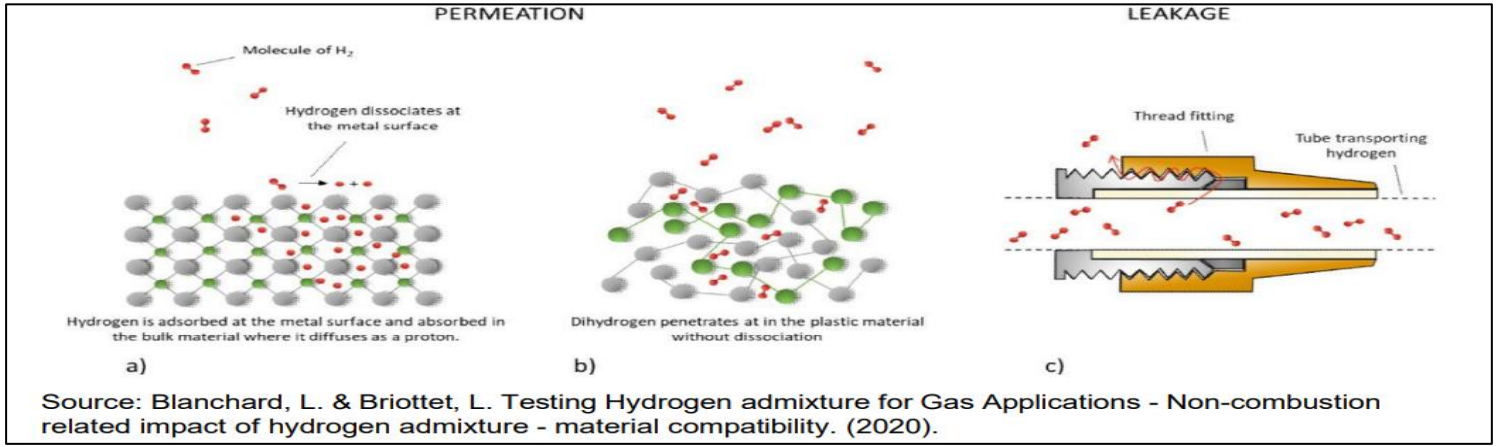
Requirements of Testing-Leakage Issues-(2/4)

Leakage Issues

Gas leaks can be characterized in several ways, depending on the mechanism of mass transfer. They include **permeation, diffusion**, and **pneumatic leaks.**

Major Mechanisms

- **Permeation-** Permeation through metals consists of adsorption on the metal surface, dissociation of hydrogen molecule, diffusion of hydrogen atoms through the metal, reassociation of molecules and desorption on the opposite side of the metal.
- **Diffusion-** Passing of hydrogen gas through polymer materials is accomplished by molecular diffusion.
- **Pneumatic leaks-** Occur through transfer of gas through a physical opening at the presence of a pressure gradient.



Source: Blanchard, L. & Briottet, L. Testing Hydrogen admixture for Gas Applications - Non-combustion related impact of hydrogen admixture - material compatibility. (2020).

Source
1) Hydrogen Blending Impacts Study

Requirements of Testing-Leakage Issues-(3/4)

Permeation Leaks(in Plastics and Polymers)

Hydrogen has a significantly higher permeation rate through polymers compared to natural gas. While the economic loss of hydrogen via permeation may be considered negligible by the industry, it raises safety concerns, especially if hydrogen accumulates in confined spaces.

Table 1: Calculated Gas Loss (ft^3/mile/year) for HDPE Pipes at 0.25, 3, and 60 psig.

Hydrogen Content	At 60 psig			At 3 psig			At 0.25 psig		
	H2	CH4	Total	H2	CH4	Total	H2	CH4	Total
0%	0.0	49.4	49.4	0.0	2.5	2.5	0.0	0.2	0.2
10%	32.9	44.5	77.4	1.6	2.2	3.9	0.1	0.2	0.3
20%	65.9	39.5	105.4	3.3	2.0	5.3	0.3	0.2	0.4
50%	164.7	24.7	189.4	8.2	1.2	9.5	0.7	0.1	0.8
100%	329.3	0.0	329.3	16.5	0.0	16.5	1.4	0.0	1.4

Calculation performed by GTI.

Source: Melaina, M., Antonia, O. & Penev, M. Blending Hydrogen into Natural Gas Pipeline Networks: A Review of Key Issues. *Contract* **303**, 275–3000 (2013).

Source
1) Hydrogen Blending Impacts Study

Requirements of Testing-Leakage Issues-(4/4)

Physical Leaks(in Metals)

- Under the assumption of continuum flow regime, hydrogen would leak at a volumetric rate of 1.29 times higher than methane for laminar flow, based on ratio of the viscosities of the two gases.(flow through joints, cracks comes under continuum flow).
- Under continuum flow that is turbulent in nature, hydrogen gas would leak at a rate of 2.83 times higher than methane, according to the square root of the ratio of the densities of the two gases. (flow through joints, cracks comes under continuum flow).
- In the case of molecular flow, hydrogen gas would leak at a rate of 3.15 times higher than methane, based on the molecular mass ratio of the two gases.

Practical Studies

- The Gas Technology Institute (GTI) conducted simulated leak experiments through orifices with diameters of 0.003 in, 0.01 in, and 0.03 in, for gas blends of 10%, 20%, and 40% hydrogen in methane**.** The experiments conducted at three different pressures (54 psig, 9 psig, 0.3 psig), indicated that while there **was no preferential leakage of hydrogen** through the orifices, the **gas blend leaked at higher rate with the increase of hydrogen concentration** in the blend. The study concluded that the **ratios of flow rates** of the simulated leaks were equivalent to the **ratios of the square roots of their specific gravities.**
- In another study GTI constructed three small gas test loops, comprised of components from residential natural gas distribution system, to evaluate operation with hydrogen compared to natural gas over a 6 months period. Several joints, a regulator, and a meter in two of the test loops were monitored individually for leakage. The study concluded that over the duration of the experiment, **pure hydrogen gas leaked through joints at rate of 3.8 to 4.6 times higher than natural gas.**

Source
1) Hydrogen Blending Impacts Study

Types of Testing-(1/3)

Mechanical Testing

S.No.	Type of Test	Purpose	Test Setup	Objectives	Equipment
1	Tensile Testing	Measure tensile strength and ductility of materials in hydrogen environments.	Apply uniaxial tensile load to samples in hydrogen atmospheres to determine ultimate tensile strength and elongation.	Assess if hydrogen exposure affects the tensile properties.	Universal Testing Machine (UTM), hydrogen containment chambers, extensometers.
2	Fatigue Testing	Evaluate durability under cyclic loading.	Subject samples to cyclic loading in hydrogen-rich environments.	Determine if hydrogen accelerates fatigue damage or reduces fatigue life.	Fatigue testing machines, environmental chambers for hydrogen exposure.
3	Crack Growth Testing	Study crack propagation under hydrogen influence.	Use pre-cracked specimens subjected to loading in hydrogen atmospheres.	Understand hydrogen's role in accelerating crack growth.	Crack growth testing machines, pre-cracked specimen holders, hydrogen chambers.
4	Toughness Testing (e.g., Izod Impact Test)	Measure resistance to sudden impact or shock loading.	Conduct Izod impact tests at various temperatures and hydrogen concentrations.	Identify if hydrogen reduces impact toughness.	Izod impact testers, hydrogen containment setups.
5	Hardness Testing	Determine changes in material hardness after hydrogen exposure.	Conduct standard hardness tests (Rockwell, Vickers) before and after hydrogen exposure.	Assess material's resistance to wear and deformation.	Rockwell hardness testers, Vickers hardness testers, microhardness testers.

Source
1) https://www.swerim.se/sites/default/files/2024-03/Mechanical%20testing%20with%20hydrogen%20gas.pdf
2) https://www.nationalgas.com/sites/default/files/documents/FutureGrid%20Phase%201%20Testing%20Guide%20Final.pdf

Types of Testing-(2/3)

Leakage Testing

S.No.	Type of Test	Purpose	Test Setup	Objectives	Equipment
1	Material Permeation Testing	Determine the extent to which hydrogen permeates through solid materials.	Hold hydrogen at high pressures (e.g., 70 bar) for extended periods and measure permeation rates.	Assess potential material risks to the transmission system.	Permeation cells, high-pressure hydrogen sources.
2	Flange Testing	Ensure that flanges continue to contain gas after transitioning to hydrogen.	Test common flange types with hydrogen and natural gas.	Validate the suitability of seals for hydrogen service.	High-pressure test benches, hydrogen supply systems, leak detection equipment.

Safety Testing

S.No.	Type of Test	Purpose	Test Setup	Objectives	Equipment
1	Explosion Risk and Fire Safety Testing	Understand how hydrogen blends behave under fire or explosion conditions.	Simulate real-world scenarios with hydrogen-natural gas blends.	Ensure pipeline safety by understanding risks.	Explosion chambers, fire testing facilities, gas analyzers.
2	Flammability Limits Testing	Determine the concentration limits within which hydrogen blends are flammable.	Conduct tests to establish flammability thresholds.	Maintain safety during pipeline operations.	Flammability limit testers, gas mixing systems, ignition sources.
3	Rupture Testing	Assess risks associated with pipeline ruptures.	Simulate ruptures and measure thermal radiation and overpressure.	Incorporate findings into overall risk models.	Burst test rigs, high-speed data acquisition systems, pressure sensors.

Source
3) https://www.aga.org/wp-content/uploads/2023/08/Impacts-of-Hydrogen-Blending-on-Gas-Piping-Ma_.pdf
4) https://www.royce.ac.uk/content/uploads/2022/05/Royce-Blueprint-UK-Hydrogen-Testing-.pdf

Types of Testing-(3/3)

Flow Dynamics Testing/Simulations

S.No.	Type of Test	Purpose	Test Setup	Objectives	Equipment
1	Flow Dynamics Simulations	Test how hydrogen blends flow through pipeline systems and the resulting pressure losses.	Simulate real-world conditions including friction losses and flow rate variations.	Understand flow behavior and pressure dynamics.	Flow loops, pressure sensors, computational fluid dynamics (CFD) software.

Properties Testing

S.No.	Type of Test	Purpose	Test Setup	Objectives	Equipment
1	Combustion Velocity Testing	Measure the increased combustion velocity due to hydrogen blending.	Conduct combustion tests in controlled environments.	Understand the impact on flame stability and risk of flashback.	Combustion chambers.
2	Flame Temperature Testing	Evaluate the higher flame temperatures resulting from hydrogen addition.	Measure flame temperatures in varying hydrogen-natural gas mixtures.	Assess the potential impact on appliances and safety.	Thermocouples, infrared cameras, gas analyzers.
3	Wobbe Index and Calorific Value Testing	Determine the impact of hydrogen blending on the Wobbe index and calorific value.	Measure the changes in these values with different hydrogen concentrations.	Ensure the quality and consistency of the fuel supply.	Calorimeters, gas chromatographs, Wobbe index analyzers.
4	Flame Speed Testing	Evaluate the trend of increasing flame speed with hydrogen addition.	Measure laminar flame speed at various hydrogen concentrations.	Ensure proper combustion performance and safety.	Laminar flame speed measurement setups, gas analyzers.

Source
5) https://www.dcceew.gov.au/sites/default/files/documents/hydrogen-impacts-on-downstream-installations-appliances-report-2019.pdf

Note- Tests mentioned are the minimum test requirements, actuals may vary based on the Specific test bed and system to be tested.

Companies supplying Testbed

Companies supplying Testbed

S.NO.	Company	Reference	Country
1	Sonplas	https://www.sonplas.com/innovation-project-hydrogen-test-bench/	Bavaria, Germany
2	Baker-Hughes	https://investors.bakerhughes.com/news-releases/news-release-details/baker-hughes-achieves-new-hydrogen-milestones-accelerate	USA
3	DAM Group	https://www.damgroup.fr/en/portfolio/leak-test-bench-for-high-pressure-hydrogen-piping-systems/	Alpes region, France
4	DNV	Future Grid Phase-1 Testing	Norway
5	AVL	https://www.avl.com/en-in/testing-solutions/hydrogen-testing-solutions/sofc-fuelcell-testing/sofc-system-test-bed	Graz, Austria
6	RISE	https://www.ri.se/en/what-we-do/test-demo/material-testing-in-hydrogen-environment	Sweden
7	Hyperfuel	https://www.accesswire.com/824656/hyperfuel-labs-launches-the-worlds-first-industrial-scale-testbed-and-accelerator-for-hydrogen-startups	USA

Test Bed Case Studies: A-Lulea University of Technology

Funding Agency	**The European Union, Swedish Agency for Economic and Regional Growth**
Location	**Pilot plant (of LTU Green Fuels) at Luleå University of Technology**
Research Initiative Name	**Centre for Hydrogen Energy Systems Sweden – CH2ESS**
Amount	**SEK 81 Million or USD 7.3 Million(Not yet Operationalized)**
Project Partner	**Project Owner: Lulea University of Technology** **Project Partners: LTU Green Fuels, PiteEnergi, Smurfit Kappa and H2 Green Steel.**

Source
1) https://www.ltu.se/en/about-the-university/organisation/department-of-engineering-sciences-and-mathematics/ltu-green-fuels
2) https://www.ltu.se/en/latest-news/news/news/2023-10-08-81-million-to-pilot-plant-for-climate-neutral-hydrogen-at-ltu-green-fuels

Test Bed Case Studies: B-California State University, Los Angeles

Funding Agency	**California Air Resource Board(Major Funding agency whose fund was utilized to Build station)**
Location	**Cal State LA**
Research Initiative Name	**Hydrogen Reaserch and Fueling Facility(H2 Station)**
Amount	**USD 2.7 Million(Operational Since May, 2014)**
Other Features	▪ **Research facility acts as Hydrogen re-fueling station(Retail station) for FCEVs as well.(H2 Production-60kg/day)** ▪ **Facility Exclusively for FCEVs**

Source
1) https://www.calstatela.edu/ecst/h2station

Test Bed Case Studies: C-EBARA Corporation, Japan

S.NO.	Particular	Details
1	Facility Name	Ebara Hydrogen Equipment Test and Development Center(E-HYETEC)
2	Location	Futtsu City, Chiba Prefecture (Company-owned land), JAPAN
3	Site area	Approx. 18,000 ㎡
4	Building area	Approx. 2,800 ㎡
5	Investment amount	Approx. 16 billion yen(103 Million USD)
6	Facility Details	Liquid hydrogen pump performance test facility, related elemental technology development facility, etc. (Closed-type indoor testing facility that is not affected by weather conditions)
7	Start of construction	January 2024
8	Completion of construction	June 2026 (planned) Part of the test facility is scheduled to be operational in 2025

Source
1) https://www.ebara.co.jp/en/corporate/newsroom/release/company/detail/1221153_10220.html

Project 3: Blending Pilots

Hydrogen Charter

02.12.2014

Blending Pilot-1: Western Australia-(1/2)

Project Name	Hydrogen Blending Trial Pilot
Funding Agency	The project is funded by the Western Australian Government through the Renewable Hydrogen Fund
Funding Amt.	1.97 Million USD
Location	City of Cockburn, Western Australia, focusing on urban gas distribution networks.

Key Partners

- **ATCO Gas Australia:** The lead organization responsible for conducting the trials.
- **University of Western Australia:** Collaborating on research and development aspects.
- **Western Power:** Involved in integrating hydrogen into the energy system.

Blending Pilot-1: Western Australia-(2/2)

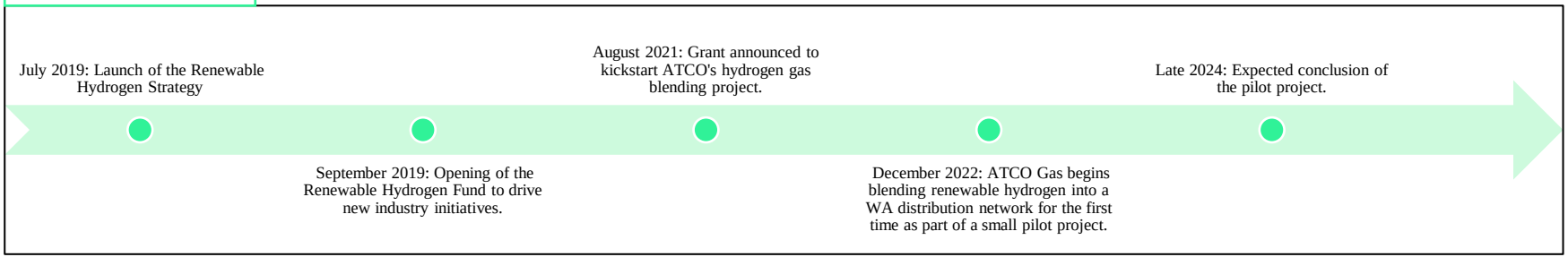
Key Results

- The project has successfully blended up to 5% hydrogen into the natural gas supply.
- There are plans to increase the blending to a maximum of 10% hydrogen by the end of the trial period.
- An estimated reduction of 21.4 tonnes of carbon dioxide is expected during the two-year trial period.

The pilot involves:

- Incremental blending of hydrogen into the natural gas pipeline, starting at lower concentrations and gradually increasing.
- Monitoring and measuring the composition of blended gas to ensure safety compliance.
- Assessing the impact on existing gas appliances used by approximately 2,700 customers in the area.

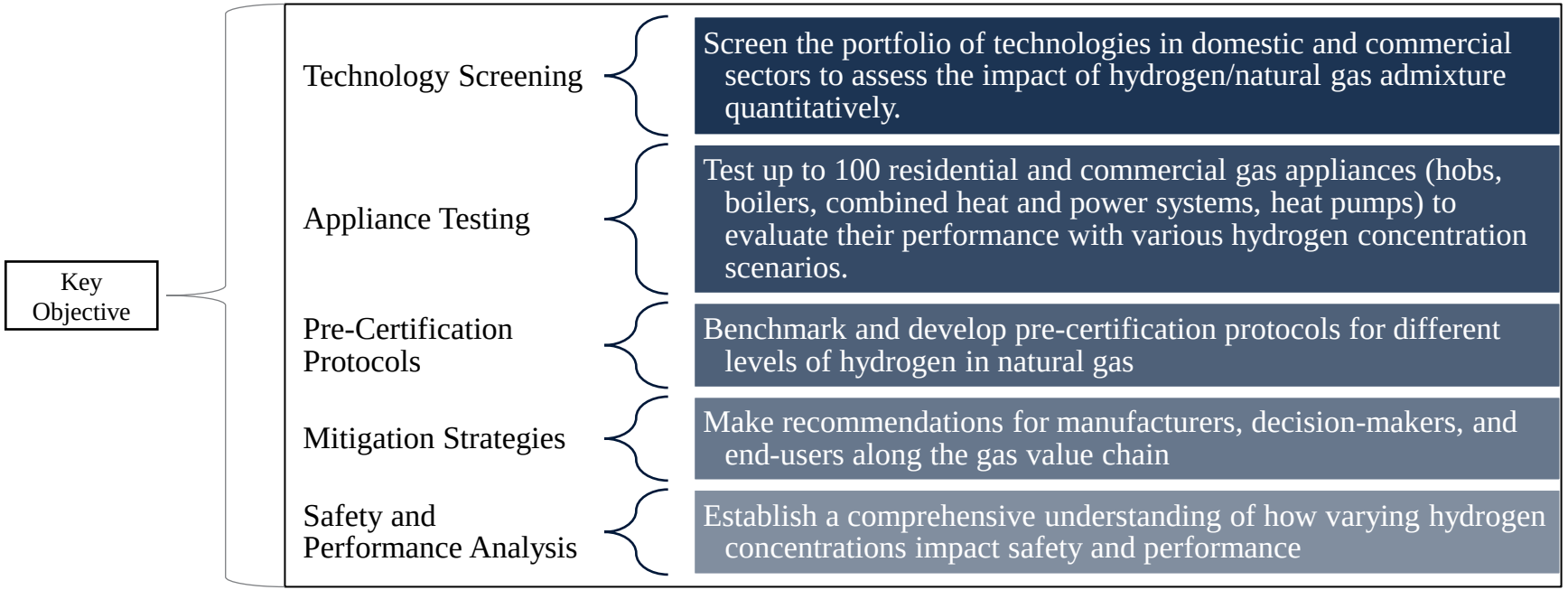
Timeline



Blending Pilot-2: THyGA (Testing Hydrogen Admixture for Gas Applications)-(1/3)

S.NO.	Particulars	Details
1	Project Name	THyGA (Testing Hydrogen Admixture for Gas Applications)
2	Funding Agency	European Commission under the Horizon 2020 program.
3	Project Partners	BDR Thermea, CEA, DGC , DVGW-EBI , ELECTROLUX, ENGIE, GERG (European Gas Research Group), GWI (Gas & Water Institute)
4	Location	Saint-Denis La Plaine, France
5	Major Focus	Integration of hydrogen into existing natural gas distribution networks used for residential heating, cooking applications, and combined heat and power systems.
6	Tests Conducted	Appliance Testing, Combustion Testing, Material Compatibility Testing, Safety Assessments
7	Total Budget	€4 million, with a maximum contribution from the Clean Hydrogen Partnership of about €2.5 million.
8	Total Duration	~3 Years(Jan 2020 to Mar,2023)

Blending Pilot-2: THyGA (Testing Hydrogen Admixture for Gas Applications)-(2/3)



Blending Pilot-2: THyGA (Testing Hydrogen Admixture for Gas Applications)-(3/3)

Major Results

- ✓ The flame stability range extends toward leaner conditions with hydrogen addition.
- ✓ Power output generally decreases with increasing hydrogen concentration.
- ✓ Appliance components do not overheat when using hydrogen blends.
- ✓ Flashback Risk Assessment:
  - Flashback was identified as a significant concern due to increased combustion velocity associated with hydrogen blends, which can impact flame stability.
  - The general conclusion regarding flashback was that it was not a major risk in blends of up to 30% hydrogen in household boilers or cooktops.
  - However, the risk of flashback increases significantly in mixtures of 50% hydrogen by volume and higher:
    - Of the 14 studies addressing flashback, only 3 analyzed blends of 60% hydrogen or more, all agreeing that flashback occurred at this concentration and higher.
    - Studies indicated that flashback was not a risk at blends up to 19%, with the first occurrence noted at 20%.

Blending Pilot-3:Enbridge Gas and Cummins Hydrogen Blending Project

S.NO.	Particulars	Details
1	Project Name	Markham H_2 Blending Pilot/ Enbridge Gas and Cummins Hydrogen Blending Project
2	Funding Agency	Sustainable Development Technology Canada.
4	Location	Markham, Ontario, Canada
5	Major Focus	Reduce greenhouse gas emissions by blending renewable hydrogen gas with natural gas, thereby contributing to a greener energy supply for Ontario homeowners and businesses.
6	Hydrogen Blended	2%
7	Total Budget	5.2 Million USD
8	Environmental Impact	The pilot project aims to provide blended gas distribution services to approximately 3,600 customers in Markham starting in fall 2021. It is expected to abate up to 117 tons of carbon dioxide equivalent emissions from the atmosphere annually.

Blending Pilot-4: HyDeploy(UK)-(1/4)

S.NO.	Particulars	Details
1	Project Name	HyDeploy
2	Funding Agency	Ofgem's Network Innovation Competition (NIC), which supports innovative projects aimed at enhancing energy networks.
3	Location	Keele University and Winalton, UK
4	Major Objective	To demonstrate the safe blending of up to 20% hydrogen in the UK's existing gas distribution network without requiring modifications to appliances, facilitating a pathway for decarbonization in heating.
5	Total Budget	▪ Initial funding of approximately £6.8 million for the first phase of trials at Keele University ▪ An additional funding of £14.9 million for HyDeploy2, which includes two field trials on public gas networks supplying around 1,500 homes
6	Project Partners	Cadent Gas Ltd, Northern Gas Networks, Keele University, Health & Safety Laboratory, ITM Power, Progressive Energy Ltd

Blending Pilot-4: HyDeploy(UK)-(2/4)

Project Consisted of 3 phases

Phase-1: Keele University

- Timeline: April 2017 - March 2019
- Objectives: Establish a comprehensive evidence base to support an application for exemption from certain regulations, allowing for hydrogen blending in the gas network.
- Key Activities:
  - Conducted extensive laboratory work to assess the safety and feasibility of blending hydrogen with natural gas.
  - Performed testing on existing gas appliances to evaluate their compatibility with hydrogen blends.
  - Engaged in risk analysis to identify and mitigate potential hazards associated with hydrogen injection.
- Outcome: Successfully demonstrated that hydrogen can be blended safely into Keele University's private gas network, leading to the UK's first exemption from the Health & Safety Executive (HSE) for injecting hydrogen at levels up to 20 mol%.

Phase-2: Winalton Trail

- Timeline: April 2019 - March 2023
- Objectives: Prepare for the practical implementation of hydrogen blending into a public gas network.
- Key Activities:
  - Constructed necessary infrastructure, including a 0.5 MW electrolyser and grid entry unit to facilitate hydrogen blending in Winlaton, Gateshead.
  - Installed monitoring equipment to analyze the blended gas composition throughout the network.
  - Engaged with local communities and stakeholders to inform them about the project and its benefits.
- Outcome: Successfully blended a 20% hydrogen mix into the public gas network serving approximately 668 consumers without any disruption to service. This trial provided critical data on the operational performance of blended gas in a public setting.

Blending Pilot-4: HyDeploy(UK)-(3/4)

Project Consisted of 3 phases

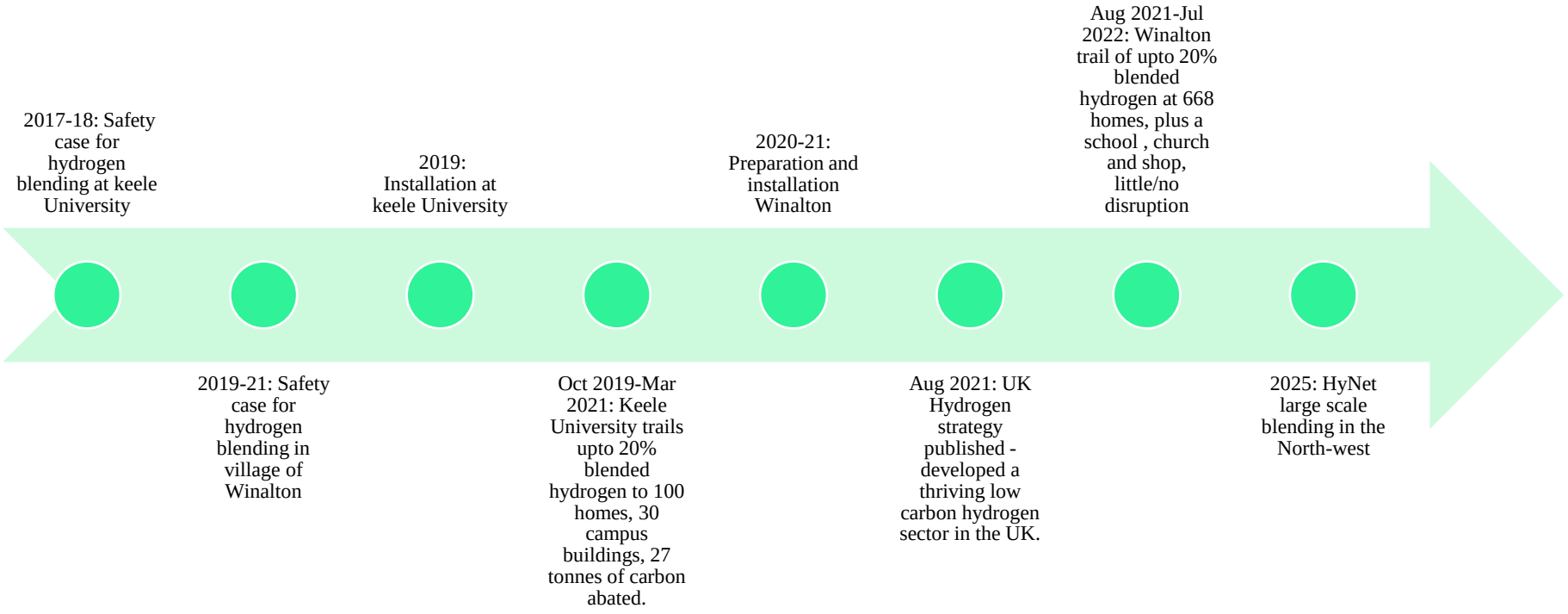
Phase-3: Enabling Government Policy

- Timeline: Ongoing since summer 2019
- Objectives: Engage with policymakers to develop a supportive regulatory framework for hydrogen blending in the UK gas network.
- Key Activities:
  - Conducted trials to gather data on consumer perceptions and operational performance of blended hydrogen in real-world settings.
  - Engaged with government bodies, including BEIS (Department for Business, Energy & Industrial Strategy), to inform policy decisions regarding hydrogen blending.
  - Developed recommendations for regulatory changes necessary to facilitate wider adoption of hydrogen blending across the UK.
- Outcome: Provided critical insights that will shape future government policies on hydrogen blending, aiming for regulatory approval by 2023. The project aims to unlock significant carbon savings by enabling large-scale deployment of hydrogen in heating.

Major Results

- Successfully blended up to 20% hydrogen into Keele University's gas network, serving approximately 100 homes and 30 faculty buildings without any reported issues.
- Validated that existing domestic appliances (such as boilers and cookers) can operate safely on a hydrogen blend, indicating minimal need for modifications.
- The project has highlighted the potential carbon savings associated with widespread adoption of hydrogen blending—estimated to be equivalent to removing about 2.5 million cars from UK roads if implemented nationally.
- Consumer acceptance studies conducted during the trials have shown positive feedback regarding the use of hydrogen in heating.

Blending Pilot-4: HyDeploy(UK)-(4/4)



Blending Pilot-5: H100 Fife Project, Scotland, UK-(1/2)

S.NO.	Particulars	Details
1	Project Name	H100 Fife
2	Funding Agency(s)	Consortium of industries that consists of SGN (Scottish Gas Networks),Cadent, Northern Gas Networks, Wales & West Utilities, Ofgem (Office of Gas and Electricity Markets), Scottish Government
3	Location	Levenmouth, Fife, Scotland
4	Total Budget	The total investment for H100 Fife is approximately £32 million

Key Activities

1. Hydrogen Production:

- The project utilizes a **7MW offshore wind turbine** located at Energy Park Fife to generate clean electricity for hydrogen production via electrolysis.
- Six above-ground storage vessels are being used to store hydrogen. Four of these vessels have already been installed, each approximately the size of a single-decker bus and weighing around 73 tons.

2. Network Construction:

- The construction of an **8.2 km hydrogen distribution network** has been completed. This network supplies hydrogen to approximately **300 homes** in Buckhaven and Denbeath. The network runs parallel to the existing natural gas infrastructure.

3. Hydrogen Demonstration Homes:

- Two demonstration homes have been constructed and are being fitted with hydrogen appliances. These homes will serve as an educational hub for residents and potential participants.

Blending Pilot-5: H100 Fife Project, Scotland, UK-(2/2)

Results Achieved so far

- As of now, the project has surpassed the minimum number of required participants (270 households) and continues to encourage more residents to opt-in.
- The construction phase has faced challenges due to supply chain issues but has made significant progress, with all major components in place as of late 2023.

Future Plan

- H100 Fife is expected to go live in **summer 2025**, with operations planned until **March 2027**. Following this initial phase, there are plans for potential expansion to service between **900 and 2000 homes**, depending on community interest and ongoing assessments.

Community Engagement and Incentives

- Residents in the targeted areas are encouraged to participate in this groundbreaking initiative. Those who opt-in will receive:
  - **Free installation of new hydrogen appliances**, including boilers.
  - A total incentive amounting to **£1,000**, structured as follows:
    - An initial payment of **£100** upon signing the contract.
    - Two subsequent payments of **£200** each in December 2024 and upon installation of new appliances.
    - An annual payment of **£250** for the duration of their participation in the project
- Community outreach efforts include public information events where residents can learn about hydrogen technology and its benefits. SGN has committed to maintaining open lines of communication through regular updates via newsletters and community meetings.

Blending Pilot-6: HyP SA (Hydrogen Park South Australia)-(1/2)

S.NO.	Particulars	Details
1	Project Name	Hydrogen Park South Australia (HyP SA)
2	Funding Agency(s)	South Australian Government, Australian Renewable Energy Agency (ARENA)
3	Location	Tonsley Innovation District, Mitchell Park, South Australia
4	Total Budget	Approximately $14.5 million, which includes a grant of $4.9 million from the South Australian Government's Renewable Technology Fund (RTF)
5	Major Aim	HyP SA aims to blend up to 10% renewable hydrogen with natural gas in the existing gas network.
6	Carbon Abated	Since its operational commencement in May 2021, HyP SA has successfully abated approximately 21,347 kilograms of CO2 emissions

Activities and Impact on Network

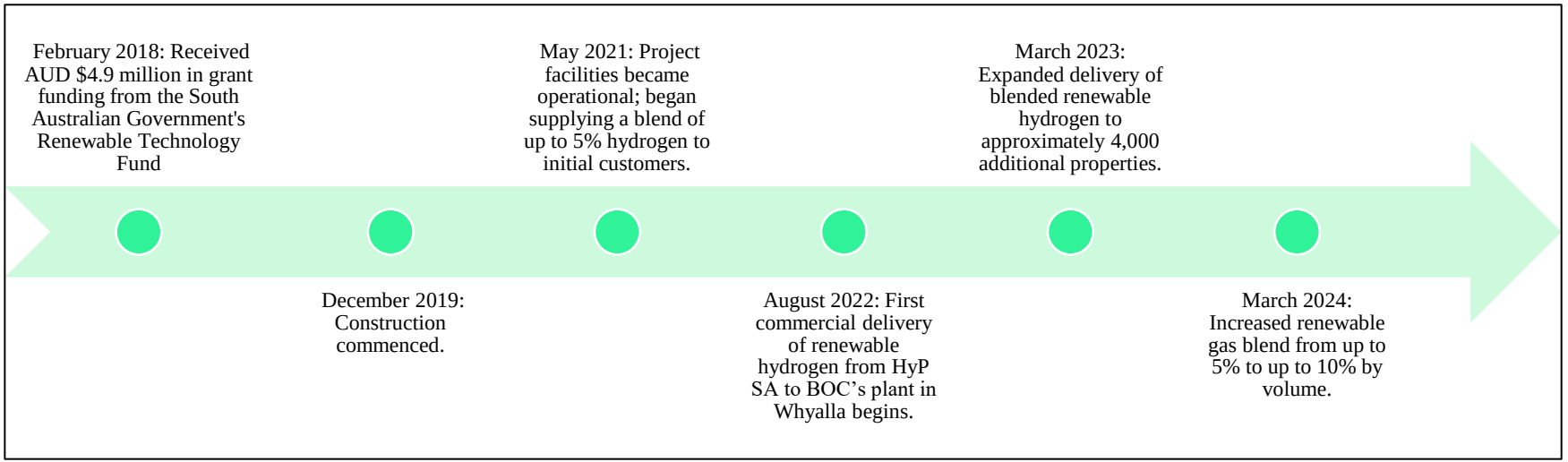
The blending process is conducted by **Australian Gas Networks (AGN)**, part of the Australian Gas Infrastructure Group (AGIG). The project blends renewable hydrogen into the existing natural gas distribution network.

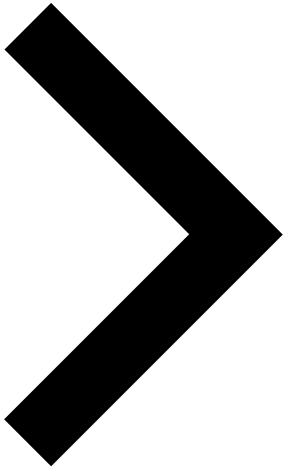
- Initially supplying a blend of up to **5% hydrogen by volume** to more than **700 homes**, this blend expanded to nearly **4,000 homes and businesses** in Mitchell Park, Clovelly Park, and parts of Marion as of early 2023.
- In March 2024, blending was increased from an up to **5%** to an up to **10%** (by volume) renewable gas blend.
- The blending of hydrogen has been monitored closely to assess its impact on the existing gas network. Initial results indicate that blending up to **5% hydrogen** has not caused any significant issues with gas quality or delivery, allowing for seamless integration into customers' appliances without requiring modifications

Blending Pilot-6: HyP SA (Hydrogen Park South Australia)-(2/2)

Activities and Impact on Network

- Since commencing operations in May 2021, HyP SA has delivered enough renewable energy to cook over **78,000 pots of pasta** or heat more than **12,400 hot showers**.
- The project has hosted numerous tours for stakeholders and community members, averaging more than one tour per week since opening. Over **3,000 visitors** have participated in these tours to learn about renewable gas technology.
- Customer satisfaction surveys indicate that **94%** of respondents feel positively about the project, demonstrating strong community support for its objectives.





End Of Report

Get in touch with us:

Puneet Goel

Director, Fuels & Resources

Email: *Puneet.Goel@icf.com*

Mobile: +91-9870353330

icf.com

linkedin.com/company/icf-international/

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