COMPENDIUM OF 20 SELECT STUDY PAPERS

पी एन जी आर बी
PNGRB

पेट्रोलियम एवं प्राकृतिक गैस विनियामक बोर्ड
Petroleum and Natural Gas Regulatory Board

पी एन जी आर बी

PNGRB

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Message from the Chairperson

Dr. Anil Kumar Jain

Chairperson, PNGRB

The Petroleum and Natural Gas Regulatory Board has a cadre of staff constituting those on deputation, Government officers, and contractual staff. Coming from diverse background, this team has been groomed to address the issues that the Board deals with. I am proud to say that the organization has served as a great nursery where this niche sector talent is being groomed.

It gives me great pleasure to present this compendium of research-driven study papers prepared by the officers of the Board. This body of work reflects the intellectual strength, analytical rigor, and deep commitment with which our teams engage in understanding the nuances of India's petroleum and natural gas sector. Covering a diverse spectrum of subjects—ranging from technical, operational & safety aspects to commercial frameworks and regulatory reforms—the compendium is a testament to our resolve to enable informed decision-making and to strengthen the foundations of a more robust energy ecosystem.

India's energy transition journey requires continuous innovation, sound policy support, and proactive regulation. In this evolving landscape, PNGRB, under the guidance and leadership of Hon'ble PM of India, Shri Narendra Modi and Hon'ble Minister of Petroleum and Natural Gas, Shri Hardeep Singh Puri, has remained dedicated to fostering competitiveness, facilitating investments, and ensuring consumer interests are safeguarded while expanding access to clean and sustainable fuels. The insights captured in these study papers highlight both the progress achieved and the opportunities that lie ahead for all stakeholders in the value chain.

I am confident that this compendium will serve not only as a record of the knowledge and research capacity within PNGRB but also as a resource for policymakers, industry participants, and academia. It is my sincere hope that these contributions will spark wider dialogue, encourage data-driven thinking, and inspire collaborative efforts in building a future-ready, energy secure economy for India. I take this opportunity to thank the authors of the study papers for their efforts and dedication.

From Member's Desk

Shri Jayanta Narayan Das

Member, PNGRB

This Compendium of 20 Select Study Papers is a reflection of PNGRB's continuing efforts to nurture a culture of research, analysis, and knowledge-sharing within the organization. Conceived under the guidance of our Hon'ble Chairperson, Dr. Anil Kumar Jain, the idea behind this document is to capture the learnings and insights that arise from our day-to-day regulatory work, and to translate them into structured studies that can enrich our sectoral understanding both from an Indian context as well as global best practices.

I take this opportunity to express my deep appreciation to the Chairperson for his visionary leadership and to my fellow Board Members for consistently reinforcing the importance of research-driven approaches in strengthening PNGRB's regulatory capacity. It is this collective emphasis on intellectual rigor and sectoral insight that has made such a compendium possible.

Equally, I wish to extend my heartfelt thanks to the officers and staff of PNGRB across all levels who have contributed to these studies. Their willingness to engage deeply with technical, regulatory, commercial, and operational issues—combined with their analytical clarity—has resulted in a rich and diverse set of case studies.

This compendium is an invitation to present and future generations of PNGRB officers to continue exploring, questioning, and documenting the sector's evolving dynamics. By doing so, they will ensure that PNGRB remains an adaptive, forward-looking regulator equipped to address the challenges and opportunities of India's energy transition.

Foreword

This compendium of study papers represents a collective endeavour by the Petroleum and Natural Gas Regulatory Board (PNGRB) to systematically capture knowledge, analysis, and insights emerging from India's rapidly transforming oil and gas sector. The study papers have been meticulously researched and authored by PNGRB staff, drawing on their direct experiences as well as sectoral challenges and opportunities identified in the course of regulatory oversight, market development, and stakeholder engagement.

The rationale behind compiling these study papers is rooted in the Board's mandate to foster an informed, competitive, and resilient energy ecosystem. These studies span a broad spectrum—covering technical incidents, market architecture, commercial innovations, regulatory reforms, and policy recommendations. Each paper serves as a window into real-world scenarios, illustrating complexities, solutions, and learnings that can benefit regulators, industry participants, and researchers alike.

The compilation process involved regular knowledge-sharing sessions, thorough review, and validation to ensure accuracy, relevance, and practical value. Contributions were solicited from teams across various functional areas, followed by structured editing and quality checks to maintain consistency. By showcasing both best practices and lessons learned from challenges, this compendium aims to be a living document, one that complements PNGRB's commitment to transparency and sectoral advancement.

Importantly, these research efforts are not an endpoint but a foundation for further evaluation and wider adoption. The compendium invites its readers to critically appraise the findings, adapt recommendations, and drive implementation—whether through pilot projects, policy modification, or commercial decision-making. PNGRB encourages ongoing dialogue, iterative testing, and feedback loops that can validate these approaches and multiply their impact. Going forward, selected study papers may be further evaluated and developed into sectoral guidelines, inform regulatory amendments, or spur collaboration with academia and industry partners.

This foreword seeks to acknowledge the dedication of PNGRB staff, and to encourage all stakeholders to view each study paper as both a reference and a starting point for building a stronger, more sustainable future for India's energy sector.

MARKET DEVELOPMENT THROUGH REGULATORY PATHWAYS

01

From Judicial Intervention to Regulatory Oversight: Lessons Across a Century

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1.1 Introduction

The petroleum and natural gas sector is of strategic importance globally. Ensuring its stability, affordability, and fairness requires a robust framework for market regulation, competition, and consumer protection. The United States' landmark Standard Oil judgment of 1911 and India's establishment of a sectoral regulator through the Petroleum and Natural Gas Regulatory Board Act, 2006 (PNGRB Act) represent two distinct yet complementary approaches to addressing monopoly power in petroleum markets.

This paper examines the judicial intervention that dismantled the Standard Oil monopoly and analyzes the proactive regulatory framework established by the PNGRB Act. Through a comparative analysis, it extracts key lessons and their relevance to modern energy governance.

1.2 The Standard Oil Case: Judicial Intervention (1911)

The judgement of U.S. Supreme Court case, *Standard Oil Co. of New Jersey v. United States (1911)*, is regarded as foundational case in U.S. antitrust law. It addressed the problem of monopoly in the oil sector, redefined the application of the Sherman Antitrust Act of 1890 and demonstrated the judiciary's power to correct market failure.

1.2.1 The Rise of a Monopoly

Founded in 1870 by John D. Rockefeller and his partners, Standard Oil achieved unprecedented market dominance through aggressive expansion and vertical integration, controlling exploration, refining, pipelines, transportation, and retail. By the 1880s, the company controlled approximately 90% of the refining capacity in the United States. While its efficiency, cost reduction, and innovative practices contributed to growth, its tactics included:

- **Predatory Pricing:** Deliberately lowering prices to drive competitors out of the market.
- **Secret Railroad Rebates:** Negotiating preferential freight discounts with railroads to disadvantage rivals.
- **Exclusionary Contracts:** Forcing partners and customers into agreements that limited competition.
- **Strategic Acquisitions:** Systematically acquiring smaller refiners to consolidate market power.

1.2.2 The Judgment and its Remedy

The U.S. Government challenged Standard Oil under the Sherman Antitrust Act, arguing its actions amounted an "unreasonable restraint of trade."under sections 1 and 2 of the Act. Chief Justice Edward Douglass White, delivering the Count's opinion, introduced the pivotal **'Rule of Reason'**, clarifying that not all trade restraints are unlawful, only those that are unreasonable and to public welfare. The Court found Standard Oil's conduct—systematically eliminating competition, manipulating prices, and creating barriers to entry—to be unreasonable.

In its 1911 ruling, the Supreme Court ordered the dissolution of Standard Oil into 34 independent companies. Major successors included Standard Oil of New Jersey (Exxon), Standard Oil of New York (Mobil), Standard Oil of California (Chevron), and Standard Oil of Indiana (Amoco). This structural remedy effectively dismantled the monopoly and reintroduced competition into the petroleum sector.

1.2.3 Significance and Legacy of the Ruling

The Standard Oil judgment established critical precedents for modern antitrust enforcement:

- It established the **'Rule of Reason'** as the guiding principle for assessing anti-competitive behavior.
- It affirmed that **consumer welfare** is a primary objective of competition law.
- It **restructured the petroleum industry**, leading to the rise of multiple global oil giants.
- It demonstrated the role of **judicial intervention in checking monopoly** power in strategic sectors.

1.3 The Petroleum and Natural Gas Regulatory Board Act, 2006 (PNGRB): Proactive Regulatory Oversight

The PNGRB Act was a direct outcome of India's economic liberalization in the 1990s. As the historically state-dominated oil and gas sector opened to private and foreign investment, the need for a neutral and an independent regulator became apparent. The dismantling of the Administered Pricing Mechanism (APM) in 2002, which deregulated product pricing and highlighted the necessity of transparent regulation.

Amidst India's transition to a gas-based economy with rising LNG imports and expanding pipeline networks, the natural monopoly of this infrastructure necessitated a regulatory framework. The government recognized that an independent regulator was essential to promote fair competition, attract investment, protect consumer interests, and enforce safety standards.

This led to the enactment of the Petroleum and Natural Gas Regulatory Board (PNGRB) Act in 2006, constitutionally anchored in Entry 53 of the Union List. The Board was formally established in 2007 with Dr. L. Mansingh as its first chairperson. The Act was a progressive reform, designed to balance industry liberalization with robust oversight and consumer protection.

1.3.1 Objectives of the Act

- Promote competition and ensure level playing field.
- Protect consumer interests by monitoring tariffs and services.
- Prevent restrictive trade practices and abuse of dominance.
- Ensure transparent and non-discriminatory access to pipelines and city gas distribution networks.
- Regulate technical and safety standards in infrastructure.

1.3.2 Functions of PNGRB

The PNGRB's core functions include:

i. Granting authorizations and licenses for pipelines and city gas distribution.

ii. Fixing and monitoring tariffs for transportation.

iii. Ensuring open access to common carrier and contract carrier pipelines.

iv. Adjudicating disputes.

1.4 Comparative Analysis of Standard Oil Judgment and PNGRB Act

The Standard Oil case and the PNGRB Act address the same fundamental risk—monopolistic control in petroleum sector—but from different philosophical and operational standpoints.

Aspect	Standard Oil Judgment (U.S., 1911)	PNGRB Act, 2006 (India)
Approach	**Ex-post (Corrective):** Judicial action taken after monopolistic harm occurred.	**Ex-ante (Preventive):** Proactive regulation to prevent monopolies from forming.
Legal Basis	Sherman Antitrust Act, 1890 (General antitrust law)	PNGRB Act, 2006 (Sector-specific legislation)
Remedy	Structural: Dissolution of the monopoly into 34 separate companies.	Regulatory: Authorisation, tariff regulation, penalties, and mandating open access.
Guiding Principle	Rule of Reason: Only unreasonable restraints of trade are illegal.	Fair Access & Consumer Protection: Ensuring non-discriminatory market conditions.
Consumer Benefit	Indirect – via restored competition	Direct – via tariff regulation and oversight
Scope	Broad – applies to all industries	Sector-specific – oil & gas downstream only

Table: Comparative Analysis of Standard Oil Judgment (1911) and PNGRB Act (2006)

1.5 Conclusion and Key Takeaways

The Standard Oil judgment and the PNGRB Act illustrate two complementary models for safeguarding consumer interests and ensuring fair competition in the vital petroleum and natural gas sector. While the U.S. case demonstrated the power of *ex-post* judicial intervention to dismantle an entrenched monopoly, India's framework institutionalized *ex-ante* regulatory oversight to prevent such market structures from emerging in the first place.

The jurisprudence under the Competition Act, 2002 provides important insights into how India addresses anti-competitive practices. India's approach is a **hybrid model** where a sector-specific regulator (PNGRB) works in tandem with a general antitrust authority, the Competition Commission of India (CCI). Landmark legal rulings, such as *CCI v. Bharti Airtel Ltd. (2018)*, have affirmed this structure, clarifying that specialized regulators like PNGRB should first address sector-specific technical and regulatory issues before the CCI applies general competition law.

PNGRB's actions, such as mandating transparent bidding for CGD networks and regulating pipeline tariffs in cases involving GAIL (India) Ltd., demonstrated this preventive oversight. This dual framework allows for continuous monitoring and proactive governance in a sector prone to natural monopolies, thereby avoiding the need for drastic, disruptive remedies like the breakup of Standard Oil.

Together, these historical and contemporary examples underscore a central principle: petroleum and natural gas markets must be structured to function competitively, transparently, and in the consumer interest. The combined legacy of these approaches highlights the importance of maintaining effective checks on economic concentration in vital sectors.

02

The Global Scenario and Indian Imperative for Open Access in Petroleum Product Infrastructure

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2.1 Introduction

Open access has emerged as a critical regulatory tool in the energy sector to enhance competition, optimize infrastructure use, and ensure resilient and efficient fuel supply chains. The principle is simple: grant third-party entities the right to use existing energy logistics systems—such as pipelines, storage depots, terminals, and jetties—on a transparent, non-discriminatory, and tariff-based basis, irrespective of ownership.

Historically, petroleum logistics in developing economies were dominated by vertically integrated monopolies that restricted infrastructure access to their own entities. This model created high barriers to entry, discouraged private investment, and often resulted in underutilized assets and regional supply imbalances.

In India, the petroleum sector was developed post-Independence by the public sector. The nationalization of foreign oil companies in the 1970s led to the creation of Public Sector Undertakings (PSUs) such as Indian Oil, Bharat Petroleum, and Hindustan Petroleum, that built extensive refineries and pipeline networks using public funds. As these pipelines and related infrastructure were built primarily with taxpayer money, they constitute national assets. Limiting their use for captive purposes diminishes their public value and operational efficiency.

To address these structural challenges, the Indian Parliament enacted the **Petroleum and Natural Gas Regulatory Board (PNGRB) Act, 2006**. This established an independent regulator with a mandate to: protect consumer interests, promote competitive markets, regulate transportation tariffs, ensure uninterrupted and adequate supply, enforce fair trade practices, and oversee the orderly development of the petroleum and natural gas sector. Within this framework, PNGRB is empowered to declare petroleum product pipelines as **common carriers** or **contract carriers**, mandating transparent, non-discriminatory access and cost-reflective tariffs. This principle is already successfully applied in India's natural gas sector, demonstrating its effectiveness. Given the structural and functional similarities between gas pipelines and petroleum product pipelines, extending this framework is a logical and necessary step to foster market liberalization, reduce entry barriers, attracts private investment, and safeguard consumer interests.

2.2 The Indian Scenario: A System of Captive Infrastructure

The objective of open access in petroleum product infrastructure is to decouple infrastructure ownership from product marketing to enhance competition, ensure equitable access, and improve utilization of

existing assets. Despite a clear regulatory intent, India's petroleum infrastructure operates under a predominantly captive model, presenting significant structural and competitive limitations.

2.2.1 The Captive Model and its Consequences

India's pipeline infrastructure, spanning over 21,000 kilometers, is primarily owned and operated by state-owned enterprises like IOCL, BPCL, and HPCL. These entities use the pipelines for their internal logistics, transporting products from their refineries to their own depots. While some pipelines are technically notified as common carriers, third-party access is minimal, often discouraged, or facilitated under opaque conditions.

This vertically integrated system entrenches the market dominance of incumbents and leads to several negative consequences:

- **Inefficient Asset Utilization:** Pipeline networks are frequently underutilized, with surplus capacity either undisclosed or reserved for the owner's future use. This leads to waste of national infrastructure assets.
- **Redundant Investments:** Private companies are often forced to build parallel logistics infrastructure, such as tanker fleets, leading to duplicated capital expenditure and a higher environmental footprint.
- **High Barriers to Market Entry:** The lack of access to essential pipelines disincentivizes new and smaller players from entering the fuel retailing market, resulting in oligopolistic market behaviour.
- **Lack of Price and Transparency:** Without a centralized digital platform for capacity booking or tariff publication, the system suffers from informational asymmetry and regulatory opacity.
- **Geographic Inequity**: Rural and landlocked areas remain dependent on inefficient, expensive road transport, leading to price disparities and supply chain fragility.

2.2.2 Limited Progress and the Path Forward

The PNGRB has initiated steps to address these issues, including releasing indicative capacity data and promoting infrastructure mapping under the **PM Gati Shakti National Master Plan**. However, progress remains limited. To align with global norms and unlock the benefits of a competitive market, India must transition away from the captive-use model. Key recommendations include:

- Mandatory functional unbundling of infrastructure ownership from marketing operations to avoid conflict of interest;
- Creation of a centralized digital portal for transparent pipeline capacity booking and tariff information;
- Strict enforcement of common carrier provisions with penalties for non-compliance;
- Introduction of incentives for private investment in multi-user pipeline and terminal infrastructure;
- Institutional strengthening of PNGRB to monitor, audit, and regulate infrastructure access effectively.

2.3 Global Benchmarks: Case Studies in Open Access

International experience demonstrates that separating infrastructure ownership from product marketing fosters competition, increases system efficiency, and reduces costs.

Jurisdiction	Regulatory Definition of Open Access	Key Features
Canada (CER)	All shippers must be given access to pipelines on a non-discriminatory basis [6]	Transparent tariffs, proration rules, open to all qualifying entities
India (PNGRB)	Pipelines classified as common or contract carriers with regulated access [7]	Non-discriminatory, first-come-first-served access; oversight of contract terms

Table: Comparative Perspective on Regulatory Definition for Open Access

2.3.1 *European Union*

The EU's approach to energy market liberalization, established through its **Third Energy Package**, mandates regulated Third-Party Access (TPA) to energy infrastructure. While initially focused on gas and electricity sectors, introduced regulatory model such as ownership unbundling, regulated third-party access (TPA), and transparent tariff-setting all of which now influence the governance of oil and petroleum infrastructure. Cross-border pipelines, designated as **Projects of Common Interest (PCIs)**, are subject to stringent open access requirements and regulated tariffs, and must demonstrate socio-economic and environmental benefits.

Thus, although not governed under a singular petroleum directive, the EU has created a comprehensive and enforceable regulatory environment that promotes third-party access to petroleum infrastructure, aligned with its internal market, competition, and energy security objectives.

2.3.2 *Canada*

Canada's petroleum infrastructure regime is built on a concept of common carriage principle, under **National Energy Board Act**. Later it was reinforced and modernized by the **Canada Energy Regulator (CER) 2019**. The CER mandates that federally regulated pipelines must provide transportation access to any shipper without discrimination, provided that operational and tariff conditions are met. Operators are required to conduct "open seasons" to allocate long-term contracts while reserving a portion of capacity for short-term shippers, ensuring equitable access for all market participants. Canada's open access regime is not only legal but also operationally embedded.

Thus, Canada's progression toward common carriage and open infrastructure access reflects a deliberate policy choice to balance market dynamics with public interest, supply chain efficiency, and non-discriminatory access.

2.3.3 *United States*

The U.S. has a long history of regulating oil pipelines as common carriers, dating back to the Hepburn Act of 1906. Today, the **Federal Energy Regulatory Commission (FERC)** under the Department of Energy Organization Act of 1977, oversees interstate oil pipelines by enforcing tariff publication, reviewing rates, and ensuring non-discriminatory access. This legal and regulatory framework enabled the development of large interstate refined product networks like the Colonial and Plantation Pipelines.

By mandating open and transparent access, the U.S. system has enhanced competition, lowered transportation costs, and improved market liquidity, although challenges such as regional capacity bottlenecks, ownership concentration, and security vulnerabilities—highlighted by the 2021 Colonial Pipeline cyberattack—continue to test the resilience of the system

Jurisdiction	Regulatory Approach	Key Features
European Union	Regulated Third-Party Access (TPA)	Ownership unbundling, transparent tariffs, oversight by national and EU-level regulators.
Canada	Mandatory Common Carriage	Non-discriminatory access, public tariffs, open seasons for capacity allocation, CER oversight.
United States	Common Carrier Obligation	Published tariffs, just and reasonable terms, prorationing (pro rata allocations) rules for over-demand.
India	Common/Contract Carrier (PNGRB)	Legal framework exists but is weakly enforced; dominated by captive use by PSUs.

Table: Comparative Perspective on Regulatory Approach

2.4 Challenges and Barriers to Open Access in India

The implementation of a true open access regime in India faces several systemic, institutional, and commercial barriers:

- **Infrastructure Concentration and Market Dominance:** With over 85% of pipelines and majority of storage infrastructure are controlled by three PSUs, there is a strong disincentive to share infrastructure with third party, as incumbents perceive them as a threat to market share rather than an opportunity for revenue optimization.
- **Institutional and Regulatory Limitations:** The PNGRB has been entrusted with the role of enforcing open access, it faces challenges in operationalizing its mandate. For instance:
  - There is no centralized pipeline access platform for real-time booking or tariff benchmarking;
  - Notifications for declaring pipelines as common carriers are often delayed;
  - Regulatory disputes often require intervention from the appellate tribunal or judiciary, leading to protracted resolution.
- **Operational Bottlenecks and Capacity Hoarding:** Incumbents can employ subtle denial strategies, such as overbooking internal volumes well in advance, citing maintenance shutdowns or technical incompatibilities or failing to publish available capacity, which are difficult to monitor and penalize.

  In India, the absence of mandatory digital infrastructure to track usage patterns and disclose spare capacity in petroleum pipelines exacerbates this issue.
- **Commercial Risks and Tariff Distortion:** The lack of a transparent and predictable tariff structure creates uncertainty for third-party users, hindering their ability to secure long-term logistics.

  However, in India, the PNGRB introduced the Petroleum and Petroleum Products Pipeline Transportation Tariff Regulations, 2024, effective from August 1, 2024. These regulations provide a stable financial environment for pipeline operators while attracting private investment in infrastructure, including a one-time option for operators to determine tariffs on a discounted cash flow basis when investing in pipeline upgrades or repairs. These guidelines already establish a transparent and predictable tariff framework tailored to petroleum product pipelines, reducing the need to rely on models developed for natural gas.
- **Political Economy and Policy Inertia:** Finally, open access is often politically sensitive. State-owned enterprises are not just commercial actors but also vehicles for public service delivery, employment, and regional development. In India, policy decisions on pipeline authorization, route optimization, and capacity sharing are often driven by ministerial discretion rather than market logic or independent regulatory planning. Moreover, there is a lack of coordination between central ministries, state governments, and sectoral regulators, leading to policy fragmentation and delayed infrastructure liberalization.

2.5 The Transformative Impact of Open Access

Effectively implementing open access in petroleum product infrastructure would yield significant and quantifiable benefits for India's economy, environment, and energy security.

- **Improved Infrastructure Utilization:** Implementing an open access model for petroleum infrastructure is critical for optimizing asset utilization and curbing redundant capital investment. Currently, restricted access for captive users results in sub-optimal pipeline utilization rates of 40-60% in India. Transitioning to a mandatory open access system, potentially managed by an independent system operator, would align India with global best practices, where utilization rates reach 80-95%. This strategic shift would not only unlock significant latent capacity in existing national assets but also foster a more efficient and competitive energy market.
- **Enhanced Market Competition:** By lowering entry barriers, open access would allow new entrants and private marketers to compete, fostering innovation and providing more choices for consumers, without the need to own logistics infrastructure.
- **Reduced End-Consumer Prices and Logistic Costs:** Lowering logistics costs through efficient

pipeline transport would translate into reduced end-user fuel prices.

- **Promotion of Private and Foreign Investment:** A transparent and fair access regime would attract private and foreign investment into multi-user pipeline and terminal infrastructure.
- **Supply Chain Resilience and Strengthened National Energy Security:** An integrated and interoperable logistics network enhances supply chain resilience, particularly during regional disruptions or demand shocks.
- **Environmental and Sustainability Benefits:** Shifting product transportation from road to pipelines would significantly reduce GHG emissions, road congestion, fuel consumption, and accidents. By ensuring fair and open access to its pipelines, India can better achieve its environmental goals as outlined in the Paris Agreement and the Energy Conservation Act.

Impact Area	With Open Access (e.g., EU, Canada)	Without Open Access (e.g., India)
Market Competition	High (multiple private players)	Low (PSU dominance)
Private Investment	Significant inflows in shared assets	Limited; high entry barriers
Supply Chain Resilience	High (multi-user, interoperable)	Low (siloed, captive systems)
Environmental Benefits	Reduced emissions via pipeline transport	High emissions from diesel tankers

Table: Impact analysis of markets with open access vs without open access to petroleum product infrastructure

2.6 Policy Recommendations: The Way Forward

To realize India's vision of a globally competitive, energy-secure, and investment-friendly economy, India must adopt a multi-pronged reform strategy in how petroleum product infrastructure is regulated and utilized. While the legal foundation for open access exists under the PNGRB Act, 2006, the actual practice remains constrained by entrenched monopolies, opaque access mechanisms, and regulatory inertia. Moving forward, India must implement structural, institutional, and market reforms that reflect both its domestic realities and the leading practices of international open-access models.

1. **Mandate Functional Unbundling of Infrastructure and Marketing:** Legally and functionally separate pipeline infrastructure ownership and operations from marketing activities within the PSUs to eliminate conflicts of interest.

   Recommendation: Adopt a model akin to the Independent System Operator (ISO) framework used in the EU and Canada, wherein pipeline operations are transferred to independent, neutral entities or subsidiaries ring-fenced from marketing decisions. This would ensure neutrality in capacity allocation and tariff negotiation.

2. **Develop a Centralized Digital Access Platform:** Provide real-time information on available capacity, tariffs, and booking slots to democratize access to infrastructure and reduce informal gatekeeping.

   Recommendation: Create a **National Petroleum Logistics Exchange (NPLE)**, a digital portal that:

   - Publishes real-time capacity data for all notified pipelines and terminals
   - Facilitates electronic capacity booking and payment
   - Provides tariff calculators, access rules, and historical usage logs
   - Ensures audit trails and public reporting

3. **Encourage Private and Joint-Venture Infrastructure:** Open access must be complemented by infrastructure diversification.

   Recommendation:

   - Offer Viability Gap Funding (VGF) and capital subsidies to private players or joint ventures setting up open-access compliant pipelines, terminals, or storage facilities

- Fast-track approvals for projects with declared third-party access conditions
- Allow foreign direct investment (FDI) up to 100% in multi-user petroleum infrastructure, subject to PNGRB oversight

4. **Align with National Logistics Policy and Gati Shakti Plan:** Fully integrate petroleum pipelines and terminals into the **PM Gati Shakti Master Plan** and the **National Logistics Policy** to ensure multi-modal infrastructure to improve supply chains.

   Recommendation:

   - Include pipeline corridors as part of multi-modal logistics parks
   - Ensure interconnectivity between terminals, pipelines, railheads, and inland waterways
   - Use the Gati Shakti GIS platform to map infrastructure gaps and plan for shared access zones

5. **Institutionalize Capacity Disclosure and Audit Mechanisms:** To ensure transparent and non-discriminatory access to pipeline infrastructure, a framework of mandated capacity disclosures and regular audits is essential. Without these mechanisms, operators may conceal available capacity, effectively creating unaccountable barriers to entry for third parties.

   Recommendation:

   - PNGRB should require monthly disclosures of installed capacity, booked capacity, and available unutilized capacity
   - Introduce third-party performance audits and whistleblower protections for access violations

6. **Promote Regional Energy Corridors:** India's strategic location offers potential for cross-border pipeline integration with Nepal, Bangladesh, and Sri Lanka. Open access infrastructure can be the backbone of regional petroleum product trade.

   Recommendation:

   - Develop common carrier pipelines and terminals along trade corridors
   - Harmonize technical standards and tariffs with neighbouring countries
   - Leverage platforms like BIMSTEC and BBIN for regulatory convergence

2.7 Conclusion & Key Takeaways

The imperative for open access in India's petroleum product infrastructure is no longer a regulatory ideal but a strategic necessity. This paper has demonstrated through global benchmark and a detailed evaluation of the Indian context, the success of open access frameworks is rooted not merely in legislation, but in their effective enforcement, institutional design, and alignment with market principles. Global experience has conclusively shown that transitioning from captive, vertically integrated models to open-access regimes deliver tangible benefits: improved efficiency, lower consumer prices, increased private investment, and more resilient supply chains. A key driver of their success has been the presence of strong, independent regulators backed by transparent digital platforms, enforceable tariffs, and a clear separation between infrastructure control and market operations.

While India has the foundational legal framework in the PNGRB Act for open access , its implementation has been hindered by the dominance of incumbent PSUs, the absence of transparent mechanisms, and regulatory inertia. This has resulted in an inefficient, opaque, and uncompetitive logistics system. The challenges are systemic, but they are not insurmountable.

A concerted reform strategy centered on functional unbundling, digital transparency, tariff rationalization, and regulatory empowerment can unlock the immense value of India's national infrastructure. By adopting a progressive, well-governed open access model, India can transform its petroleum logistics sector into one that is efficient, inclusive, and prepared for the future. Such a transformation will not only benefit consumers and investors but will also solidify India's position as a regional leader in downstream energy reform.

03

Global Regulatory Framework for LNG Terminals: Learnings for Indian Infrastructure Development

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3.1 Introduction

The global LNG market has grown rapidly over the past two decades, with regasification capacity expanding by more than 45% since 2013 to reach about 163 billion cubic feet per day across 55 countries by early 2024. As the world's fourth-largest LNG importer, India has developed 52.5 MTPA of regasification capacity, positioning LNG as central to its ambition of raising the share of natural gas in the energy mix from 6% to 15% by 2030.

To achieve this goal, India must strengthen its regulatory framework for LNG terminals. This paper draws on international best practices from the United States, United Kingdom, European Union, Japan, France, and Poland, with a focus on third-party access (TPA) models. While India's 2025 transformational LNG Terminal Regulations stop short of mandating TPA, global experience shows that transparent tariffs, non-discriminatory access, and performance-linked incentives are key features of mature LNG markets. The lessons highlighted here offer a strategic roadmap for India as it expands LNG infrastructure and works toward a more robust, market-driven gas ecosystem.

3.2 Status of India's LNG Infrastructure

3.2.1 Operational Capacity and Performance

India's LNG import infrastructure comprises eight operational terminals with a combined capacity of 52.7 MTPA, strategically located along its western and eastern coastlines. The Petronet LNG terminal in Dahej, commissioned in 2004, remains the nation's largest facility at 17.5 MTPA and operated at an impressive 89.9% utilization rate in 2024.

Despite this, significant underutilization is a persistent issue across the network, with an average utilization rate of only 31.8%. Terminals such as Ennore (Tamil Nadu) and Dhamra (Odisha) operate at 25.8% and 42.1% respectively, highlighting a mismatch between infrastructure and demand that a robust regulatory framework can help address.

India's position as the fourth-largest LNG importer—behind Japan, South Korea, and China—reflects its substantial energy needs and achievements in infrastructure development. In the 2024-25 fiscal year, the country imported 36.99 billion cubic meters (bcm) of LNG, a 15.4%

increase from the previous year. This growth trajectory is promising, with demand projected to rise by 78% to 64 bcm annually by 2030.

3.2.2 Future Projects and Strategic Expansion

India has a robust pipeline of seven major LNG projects, which are expected to add 35 MTPA of capacity between 2025 and 2027. This expansion includes a diversified mix of traditional onshore terminals and innovative Floating Storage and Regasification Units (FSRUs), signalling a strategic and flexible approach to infrastructure development.

This accelerated development will increase India's total capacity from 17.5 MTPA in 2004 to a projected 87.5 MTPA by 2027—a five-fold increase in just over two decades. The adoption of FSRU technology at upcoming projects in Jafrabad, Karaikal, and Jaigarh demonstrates an adaptation of cost-effective and flexible solutions pioneered in other international markets.

3.3 International Regulatory Frameworks: A Comparative Analysis

*3.3.1 **United States**: The FERC Authority Model*

The USA operates one of the world's most sophisticated LNG regulatory frameworks under the exclusive jurisdiction of the Federal Energy Regulatory Commission (FERC). Governed by Sections 3 and 7 of the Natural Gas Act, this centralized model has been instrumental in the U.S. becoming the global leader in LNG exports, with capacity growing from zero to 92.3 MTPA between 2016 and 2024.

FERC's oversight is comprehensive, covering siting, construction, safety standards, environmental compliance, and ongoing operational monitoring. A key feature is the mandatory development of Emergency Response Plans in coordination with the U.S. Coast Guard and other agencies, ensuring a multi-layered approach to safety. The framework's strict non-discrimination requirements and service quality standards ensure fair access for all parties, balancing market-driven development with robust public interest protections.

*3.3.2 **United Kingdom**: The RIIO Performance-Based Model*

The UK's RIIO (Revenue = Incentives + Innovation + Outputs) framework, overseen by the Office of Gas and Electricity Markets (OFGEM), represents a paradigm shift toward outcome-based regulation. This model directly links an operator's revenues to its performance, innovation, and consumer-focused outputs over eight-year price control periods. It incentivizes efficiency and penalizes poor performance, moving away from a traditional cost-plus approach.

OFGEM's regulations for LNG terminals emphasize non-discriminatory third-party access, in line with EU directives. While allowing for specific exemptions to encourage investment, the framework ensures transparent tariff methodologies and access conditions, fostering a competitive market while maintaining essential consumer protections.

*3.3.3 **European Union**: The Third Gas Directive*

The EU's regulatory approach, guided by the Third Gas Directive and Gas Regulation 715, establishes a framework for LNG terminal regulation across member states. It mandates third-party access based on published tariffs but allows for extensive exemptions, which has led to regulatory uncertainty and market fragmentation.

Key challenges within the EU include a lack of standardized information disclosure, variations in bundled services, and disparities in access conditions. This inconsistency can create operational inefficiencies and unequal opportunities for market participants. While the regulations emphasize transparency, their implementation varies, hindering the development of a fully integrated and efficient European gas market.

3.3.4 ***Japan**: A Model for Market Liberalization*

In 2017, Japan revised its Gas Business Act to establish a comprehensive Third-Party Access (TPA) regime. This framework applies to all terminals with a gross capacity exceeding 200,000 kiloliters, bringing significant infrastructure under regulatory oversight.

The cornerstone of Japan's TPA regime is the principle of "Identical Fees for Identical Conditions," which ensures equitable treatment between third-party users and an operator's own retail businesses. This prevents cross-subsidization and fosters fair competition. The pricing methodology requires detailed cost justification and regulatory approval, with ongoing monitoring to ensure tariffs remain reasonable and non-discriminatory.

3.3.5 ***France and Poland**: Differentiated Services and Performance-Linked Tariffs*

France's model, implemented by the Commission de Régulation de l'Énergie (CRE), distinguishes between regulated and unregulated terminal services. Core operations like unloading, storage, and regasification are regulated, while value-added services such as transshipment and truck loading are not. This approach combines site-specific, incentive-based tariff setting with a stable financial framework to balance investment returns with operational efficiency.

Poland employs a dual-component tariff structure that combines a fixed fee based on contracted capacity with a variable fee tied to the actual quantity of gas supplied. This model ensures cost recovery while incentivizing terminal utilization. The system also incorporates service quality discounts, creating strong incentives for operational excellence while protecting the interests of users.

3.4. India's Regulatory Evolution: The PNGRB Framework of 2025

The PNGRB, established under the PNGRB Act of 2006, is India's independent downstream regulator. In 2025, PNGRB introduced comprehensive LNG Terminal Regulations to strengthen oversight and promote orderly infrastructure development.

Key provisions of the new framework include:

- *Mandatory Registration:* All entities establishing or operating LNG terminals must obtain prior registration from PNGRB.
- *Pre-Investment Approval:* Entities are required to provide pre-investment intimation, accompanied by detailed feasibility reports, business plans, and evacuation strategies.
- *Enhanced Transparency:* The regulations mandate public disclosure of all terminal charges, regasification fees, truck loading charges, and boil-off gas handling costs. This addresses historical opacity and promotes competitive pricing.

This framework aims to integrate terminal planning with national gas market development, ensuring that new infrastructure aligns with market demand and helps address the low capacity utilization rates of only ~28% seen on average in newer terminals.

3.5 Conclusion and Key Takeaways for India

The regulatory frameworks of mature LNG markets like the U.S., UK, EU, and Japan offer valuable lessons for India. Their experiences consistently highlight the importance of transparent tariffs, non-discriminatory access, and performance-based service quality in fostering a competitive and efficient gas market.

While India's LNG Terminal Regulations of 2025 are a significant step toward strengthening regulatory oversight, they currently do not mandate third-party access (TPA). As India's LNG market matures and its infrastructure expands, incorporating a well-structured TPA regime will be crucial for enhancing terminal utilization, promoting competition, and ensuring that the benefits of a gas-based economy are realized across the country. By drawing on global best practices, India can build a regulatory framework that is not only robust and transparent but also adaptive to the evolving dynamics of the global LNG market.

TARIFF AND PRICING MANAGEMENT

04

Petroleum Product Pricing in India-Evolution, Challenges, and the Road Ahead

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4.1 Introduction

India's approach to petroleum pricing regime has evolved substantially since the early 2000s. Historically, the Government of India maintained stringent control over the prices of petrol and diesel. This frequently led to substantial "under-recoveries," or financial losses, for public-sector refineries when global crude oil prices surged.

A wave of major reforms commenced in the early 2000s, starting with the deregulation of Aviation Turbine Fuel (ATF) in 2002, followed by petrol in 2010, and diesel in 2014. Today, India largely operates on a market-linked pricing model for transport fuels. The country's three state-owned Oil Marketing Companies (OMCs)—Indian Oil Corporation Ltd. (IOCL), Bharat Petroleum Corporation Ltd. (BPCL), and Hindustan Petroleum Corporation Ltd. (HPCL)—determine the daily retail prices of petrol and diesel based on international crude prices and currency exchange rates.

However, the final prices paid by consumers are still significantly influenced by central and state government indirectly via fixed taxes and levies. While OMCs now review and adjust fuel prices almost daily under the oversight of the Petroleum Planning & Analysis Cell (PPAC), ensuring that domestic prices reflect global trends, government influence remains a key factor. This is evidenced by the period since May 2022, during which retail prices for petrol and diesel have remained largely unchanged despite considerable fluctuations in global crude oil markets, a measure often attributed to inflation management and political considerations.

This paper examines the evolution of petroleum pricing in India, details the inefficiencies within the current framework, and analyzes the fiscal impact of subsidies and under-recoveries. It provides a comprehensive overview of the journey from a regulated regime to a market-oriented system, highlighting the persistent interplay between market dynamics and government policy.

4.2 The Administered Pricing Mechanism (APM) Era (1976–2002)

From 1976 until 2002, India's petroleum sector operated under the Administered Pricing Mechanism (APM), a framework designed to ensure stability, affordability, and equitable distribution of fuels across the country. The core of the APM was a **cost-plus formula**, where the government determined fuel prices, reimbursing oil companies for their operational costs and guaranteeing a fixed post-tax return of approximately 12% on their net worth. This insulated the oil marketing companies from market risks and created a predictable, though rigid, pricing structure.

Key features of the APM included:

- **Retention Price System (RPS) for refineries:** Each refinery was assigned a unique "retention price" that covered its individual production costs plus the assured return. This price was assured regardless of the refinery's operational efficiency, protecting even high-cost producers. While it helped maintain refinery viability and encouraged capacity expansion during that period, it also reduced incentives for refineries to improve efficiency and competitiveness.
- **Price Pooling and Equalization:** The Oil Coordination Committee (OCC) managed a central Oil Pool Account to standardize fuel prices across the country. This meant consumers in remote regions paid the same price as those near coastal refineries, with freight costs averaged out nationally.
- **Cross-Subsidisation:** Prices for products like petrol, ATF and lubricants were set deliberately high to generate surplus revenue. This surplus was then used to subsidize socially sensitive fuels such as diesel, PDS kerosene, and domestic LPG, keeping them affordable for households, agriculture, and transportation.

4.3 Reason for abolishing APM

While the APM served important social and political objectives by cushioning vulnerable sections of society, it created significant market distortions. The mechanism lacked transparency, discouraged competition, and placed an increasing strain on public finances, with the Oil Pool Account deficit reaching approximately ₹12,000 crore by 2002. As India embarked on economic liberalization, the **need for a more transparent and market-driven pricing system became imperative, leading to the dismantling of the APM in 2002**.

4.4 After APM (Post-2002)

Following the 2002 dismantling of the Administered Pricing Mechanism, India linked its domestic fuel prices to international rates through a trade parity system. This granted oil companies commercial autonomy in refining and marketing. However, the government continued to protect vulnerable citizens by providing direct, transparent budgetary subsidies for essential fuels like PDS kerosene and household LPG, replacing the earlier, less-clear system of hidden cross-subsidies.

4.5 The Current Market-Linked Pricing Framework

Following the dismantling of the APM, India transitioned to a pricing mechanism linked to international markets. The current system benchmarks domestic fuel prices against international quotes from agencies like Platts and Argus, with the Arab Gulf market serving as the reference for diesel and the Singapore market for petrol. These international references reflect specific product qualities as published by these aforementioned agencies. If there is any deviation between the Indian product specifications and international benchmarks, a quality adjustment is factored into the Free on Board (FOB) price at the Arab Gulf or Singapore.

The price computation assumes the product is imported from the Arab Gulf for diesel or Singapore for petrol. The final retail selling price (RSP) is a build-up of several components:

1. **Trade Parity Price (TPP):** This is the benchmark for the Refinery Gate Price. It is calculated as a weighted average of the Import Parity Price (IPP) (80%) and the Export Parity Price (EPP) (20%). The IPP represents the cost of importing the product, including freight, insurance, import charges and customs duty, while the EPP reflects the price an exporter would receive.
2. Refinery Transfer Price (RTP): TPP is equivalent to Refinery Transfer Price at the port. The price at which OMCs procure fuel from refineries.

Figure: Port Locations for determining RTP in concurrence with TPP

Inland Freight and Marketing Costs: These costs are added to the RTP. A key feature is the use of notional freight calculation, where transport costs are computed from the nearest designated port to a depot, regardless of the actual, potentially closer, source refinery. This system can lead to logistical inefficiencies.

3. **Excise Duty, Dealer Commission, Delivery Charges and VAT:** Central excise duty, commission for the dealer and delivery charges are added. Finally, state-level Value-Added Tax (VAT) is applied to determine the final pump price.

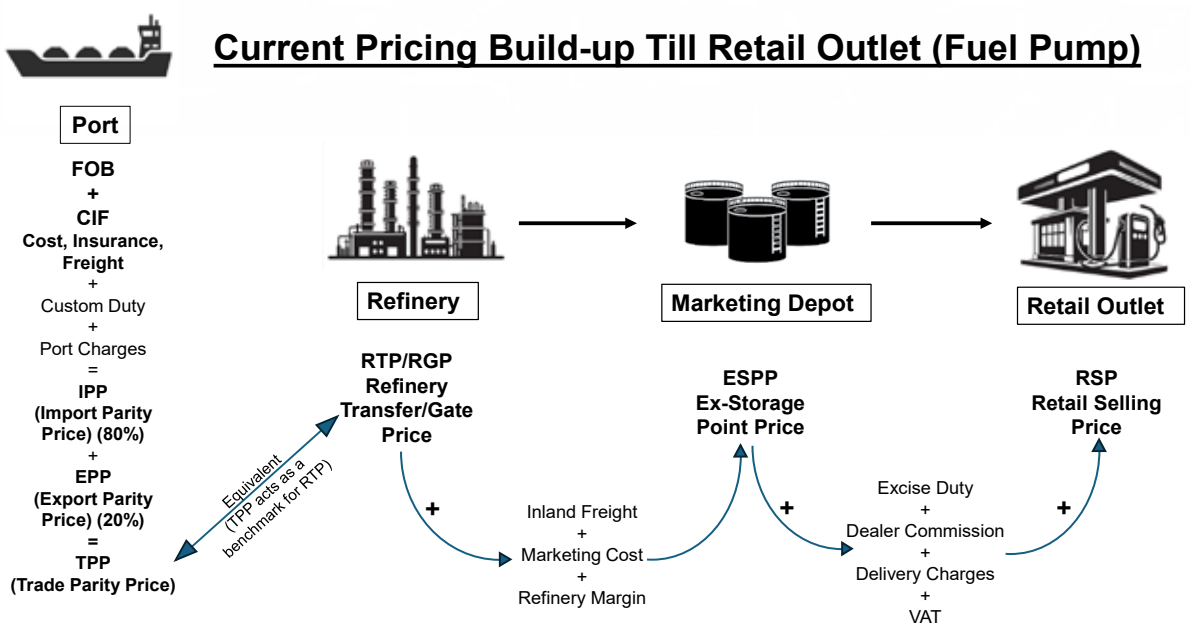

Figure: *Present Pricing Build-up of Retail Selling Price*

This structure ensures that domestic prices respond to global energy trends. OMCs adopted a **Dynamic Pricing Mechanism** in 2017, adjusting prices daily to reflect changes in international oil prices and currency exchange rates.

4.6 The Overarching Role of Taxation

Despite deregulation, government taxation remains the most significant lever of influence on fuel prices. Central and State taxes collectively constitute a substantial portion of the final retail price—often between 50% and 60%.

- **Central Taxes:** The Central government imposes multiple levies, including Basic Excise Duty, Special Additional Excise Duty, an Agriculture Infrastructure & Development Cess (AIDC), and an Additional Excise Duty for road and infrastructure.

- **State Taxes:** State governments levy VAT or sales tax, which varies significantly across the country. Rates can be as low as 1% (Andaman & Nicobar Islands) or over 30% (Andhra Pradesh). Many states also add other charges and cesses, such as road development cesses or air ambience charge or green cesses, further widening the price disparity between states.

  This heavy tax burden means that even when global crude prices fall, Indian consumers may not see a proportionate decrease at the pump, as the government often uses tax adjustments to manage fiscal revenue.

A Comparative Analysis of Fuel Taxation and Pricing Models

United States: Flat Tax Model

The U.S. employs a straightforward flat tax system, where taxes are levied as a fixed amount per unit of fuel, regardless of the retail price.

- Federal Tax: A fixed federal tax of 0.184 per gallon is applied to gasoline, which translates to approximately ₹3.6 per litre.
- State Tax: In addition, individual states levy their own taxes, averaging around $0.32 per litre.

This structure means the total tax amount remains constant, causing the tax percentage to decrease relative to the total pump price when global oil prices are high.

United Kingdom: Hybrid Tax Model

The U.K. utilizes a hybrid model, combining a fixed duty with a percentage-based value-added tax (VAT).

- Fuel Duty: A flat rate of 52.95 pence (approximately ₹58) is charged per litre.
- Value Added Tax (VAT): A 20% VAT is applied on top of the fuel's base price and the fuel duty.

This dual structure means that as pre-tax fuel prices rise, the absolute amount collected from VAT also increases. Consequently, total taxes can exceed 60% of the final pump price during periods of high global oil costs

In both the markets, private oil companies have freedom to price, and only taxes are centrally set.

4.7 Regulated Products and Fiscal Implications

While petrol and diesel are deregulated, the government continues to subsidize certain petroleum products to protect vulnerable consumers. The prices of domestic LPG cylinders and PDS kerosene remain regulated. When international prices for these commodities rise, OMCs incur 'under-recoveries', which are later compensated by the government through direct cash grants or budgetary transfers.

For example, in FY2024-25 global LPG prices surged while domestic LPG prices were kept flat; this generated over ₹41,000 crore in losses across IOCL, BPCL and HPCL (IOCL alone lost ~₹19,000 crore). The government then compensates the OMCs to keep supplies flowing. In August 2025, a ₹30,000 crore package was approved to offset recent LPG losses (adding to an earlier ₹22,000 crore grant from 2022). **According to the government, LPG is sold to consumers at regulated prices while global costs have risen.** The compensation "will help OMCs meet essential needs" and "maintain uninterrupted fuel supply".

This shift from the opaque cross-subsidies of the APM era to transparent budgetary allocations marks a significant improvement in fiscal discipline. However, these subsidies still represent a considerable expenditure and a continuing challenge for public finances.

4.8 Pricing In-Efficiencies and Reforms

Deregulation has increased the sensitivity of India's domestic fuel prices to global market fluctuations. Consequently, consumers directly absorb price increases driven by surges in crude oil prices. While this price transparency promotes economic efficiency, it also contributes to significant retail price volatility.

An effective pricing mechanism must balance two competing objectives: promptly transmitting changes in international costs and protecting consumers through targeted subsidies rather than broad, market-distorting price freezes. In India, the implementation of daily price revisions by Oil Marketing Companies (OMCs) has enhanced efficiency. However, significant distortions persist, primarily due to the taxation structure. High central and state taxes, often levied as a fixed amount per litre, prevent consumers from fully benefiting from decreases in global crude prices. As one analysis notes, even after deregulation, "Indian consumers have not benefited from lower international costs due to new taxes, resulting in consumers paying either the same amount or even more."

Policy reforms should therefore focus on tax rationalization. A gradual reduction of excise duties and VAT would allow for a more equitable transmission of price changes to consumers. The resulting revenue

impact could be offset through alternative fiscal measures or broader efficiency gains.

Furthermore, the government's influence on pricing remains evident in two areas. Firstly, it sets national fuel tax rates. Secondly, regulatory controls persist for specific products and markets. For instance, Aviation Turbine Fuel (ATF) and bitumen are still sold via tenders and fixed-price contracts rather than on the open market, limiting market-driven price discovery.

4.9 Key Takeaways and the Road Ahead

India's transition from the rigid Administered Pricing Mechanism to a market-linked system for petroleum products stands as a significant economic reform in the nation's post-independence history. This transformation has fundamentally reshaped the pricing, distribution, and consumption of petroleum products, yielding substantial benefits while also presenting persistent challenges.

However, the reform agenda remains incomplete. The practice of uniform freight equalization continues to distort regional cost structures. Furthermore, the dominance of central and state taxes, which can constitute over 50% of the retail price, often blunts the transmission of global price fluctuations to consumers. While subsidies for LPG and kerosene are now more transparently budgeted, they continue to strain public finances and raise questions regarding their efficiency and targeting.

The path forward requires a multi-pronged strategy. Key priorities include:

- **Rationalizing the complex tax structure**, which currently sees significant variation across states
- **Transitioning to a genuine freight-based pricing model** that reflects actual transportation costs
- Encouraging greater participation from private entities in the domestic petroleum sector is also crucial.

Such measures would **foster healthy competition**, leading to more equitable pricing and enhanced transparency for the end consumer.

These reforms, when coupled with India's broader transition toward cleaner energy sources, will ensure the petroleum sector can effectively support both economic growth and environmental sustainability.

Ultimately, petroleum pricing in India exemplifies the intricate balance between market dynamics and social objectives. While the past two decades have established a solid foundation, the next phase will test the nation's ability to reconcile fiscal sustainability with consumer affordability and energy security with climate commitments. As India progresses toward its 2047 development goals, an efficient, transparent, and future-ready petroleum pricing framework will remain a central pillar of this ambition.

05

The Impact of GST on CNG and PNG Pricing in India

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5.1 Introduction

India is navigating a significant energy transition, driven by the dual objectives of sustained economic growth and environmental sustainability. As energy demand rises, the nation is actively diversifying its energy portfolio away from a traditional reliance on coal and oil towards cleaner alternatives. Natural gas, particularly in the form of Compressed Natural Gas (CNG) for transport and Piped Natural Gas (PNG) for domestic and industrial use, is central to this strategy. It offers a cleaner-burning alternative to conventional fossil fuels, which reduces harmful emissions and greenhouse gases, aligning with India's goal to expand the share of natural gas in its energy mix from 6% to 15% and meet its international climate commitments, including those outlined in the Paris Agreement.

The **implementation of the Goods and Services Tax (GST) on July 1, 2017**, was a landmark reform in India's indirect taxation system, intended to create a **unified "One Nation, One Tax"** framework. However, key petroleum products, including natural gas, were kept outside the GST ambit. They continue to be taxed under legacy central excise and state-specific Value Added Tax (VAT) regimes. This exclusion has resulted in:

- Tax cascading
- Pricing inefficiencies
- Restricted Input Tax Credit (ITC)
- Lack of price uniformity
- Discouraged investment in city gas infrastructure.

As per Article 279A(5) of the Constitution, the **GST Council** is empowered to recommend the date for inclusion of natural gas under the GST framework, a step that is increasingly vital for achieving a gas-based economy.

5.2 The Challenge: Fragmented Taxation of Clean Fuels

The exclusion of CNG and PNG from the GST regime has created a fragmented and inefficient tax structure that undermines the government's objective of promoting these cleaner fuels. Currently, CNG

is subject to both central excise duty and state-level VAT, while PNG is taxed under state VAT. The VAT rates vary significantly across states, ranging from 3% to as high as 21%.

This inconsistent tax treatment results in several systemic challenges:

- **Price Disparities:** Consumers in different states face significantly different prices for the same fuel.
- **Increased Costs:** Non-availability of ITC for suppliers, increasing effective costs
- **Compliance Burden:** Suppliers must navigate multiple complex state tax regimes, increasing administrative overhead.
- **Deterred Investment:** The lack of a uniform and predictable tax structure reduces investor confidence in expanding CGD networks.

These factors lead to **higher end-user prices**, which discourages the adoption of natural gas and impedes progress towards national energy goals.

5.3 Proposed Solution: Integrating Natural Gas into the GST Framework

Bringing PNG and CNG under the GST framework would replace the multiple existing taxes with a single, uniform rate. This would streamline the tax structure, eliminate price distortions, and create a level playing field across the country.

The following table illustrates the potential impact of a 5% GST rate compared to the current system, using Bihar as an example where VAT is 12.5%.

Parameter	PNG (Current VAT)	PNG (Proposed 5% GST)	CNG (Current VAT+Excise)	CNG (Proposed 5% GST)
Basic Gas Price	27	27	44	44
Supply & Distribution	17	17	20	20
Entity's margin	1	1	6	6
Basic Selling Price	**45.00**	**45.00**	**70.00**	**70.00**
Excise Duty*	-	-	9.80 (14%)	-
Tax	5.63 (VAT @ 12.5%)	2.25 (GST @ 5%)	9.975 (VAT @ 12.5%)	3.50 (GST @ 5%)
Retail Selling Price	**50.63**	**47.25**	**89.78**	**73.50**

Table 1: Comparative Tax Structure Analysis (Price in ₹ per SCM)

*(*Note: Under GST, the central excise duty on CNG would be subsumed.)*

An introduction of uniform 5% GST would significantly reduce prices in states with high VAT rates while maintaining price stability in states with already low rates.

5.4 The Economic and Strategic Case for GST Inclusion

5.4.1 Impact on Consumer Pricing across States

A uniform GST would directly benefit consumers by mitigating the stark price differences that currently exist between states. For instance, consumers in state like Jammu & Kashmir, which have high VAT rates (21% VAT), pay considerably more for natural gas than those in Maharashtra (3% VAT). Delhi's (5% VAT) is moderate, whereas states like Gujarat apply 5%, but with variations in excise duties.

Case Example: Maharashtra vs Uttar Pradesh

- Maharashtra's low VAT rate promotes consumer affordability but limits state revenue.
- Uttar Pradesh's higher VAT rate increases prices, deterring consumers and slowing infrastructure investment.

5.4.2. Comparative Impact of Different GST Rates

The comparative bar chart below illustrates the impact of different tax regimes on the final retail price of Compressed Natural Gas (CNG) in India, taking a base price of ₹70. The following analysis demonstrates the potential price reduction for CNG at different GST slabs – namely 5%, 12, and 18% compared to the current VAT and excise system.

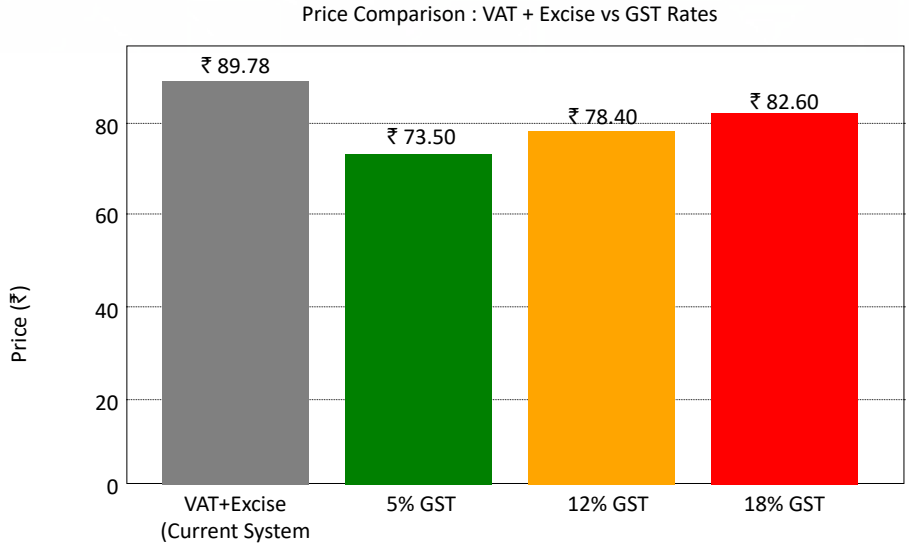

Figure: Comparative Price Analysis of VAT + Excise vs GST

Tax Regime	Final Consumer Price (₹)	Price Reduction vs. Current System (₹)
Current (VAT + Excise)	89.78	-
5% GST	**73.50**	**↓ ₹16.28**
12% GST	78.40	↓ ₹11.38
18% GST	82.60	↓ ₹7.18

Table 2: Impact of Different GST Rates on CNG Consumer Price (Base Price ₹70)

A 5% GST rate offers the most significant benefit, making clean fuel more affordable and encouraging its widespread adoption.

5.4.3The Input Tax Credit (ITC) Advantage

One of the most significant benefits of the GST regime is the availability of Input Tax Credit. Under the current VAT system, CGD companies cannot claim credit for taxes paid on inputs like steel pipes, compressors, and services, making this tax a sunk cost that increases project and operational expenses. However, under GST, these input taxes would be creditable, directly reducing costs for companies.

- **VAT Regime:** A tax of ₹100 paid on inputs (e.g., equipment, construction and services) cannot be offset against the output tax collected on gas sales. This ₹100 becomes an additional cost to the business.

- **GST Regime:** The ₹100 paid on inputs can be used to offset future GST liability on sales. This seamless credit flow reduces the effective tax burden, improves cash flow, and improves overall operational and financial efficiency.

This fundamental change would make investments in the CGD sector more financially viable and attractive.

5.5 Systemic Benefits : VAT vs GST

Feature	Current VAT Regime	Proposed GST Regime
Tax Rate	Varies by state (3%–21%)	Uniform (e.g., 5%)
Price Uniformity	No, significant regional variation	Yes, national price consistency
Input Tax Credit	Not available	Fully available- reduces overall cost burden
Compliance Requirements	Complex, multiple state- specific VAT filings and audits	Simplified, single GST return and lower compliance burden
Impact in High-VAT States	Higher PNG prices for consumers	Price reduction due to lower GST and ITC benefit
Impact on CGD Companies	Higher costs, complex operations	Cost savings, operational efficiency and investment boost

Table: Comparative Analysis of current VAT and proposed GST regime

5.6 Implications of Bringing Natural Gas Under GST

5.6.1 For Consumers

- In high-VAT states like Madhya Pradesh and Uttar Pradesh, consumers will benefit from lower PNG & CNG prices.
- Uniform pricing across India increases price transparency and fairness.

5.6.2 For CGD Companies

Operational Benefits:

- Eligibility for **ITC** on capital goods and services will reduce overall costs.
- Reduced compliance burden through centralized tax filing.
- Lower infrastructure and logistics costs due to ITC on project inputs.

Strategic Advantage:

- Encourages investment in gas infrastructure.
- Enhances competitiveness of PNG and CNG over conventional fuels.

5.7 Conclusion and Recommendations

The exclusion of natural gas (CNG and PNG) from the GST framework has led to inefficiencies, price volatility and limited competitiveness in the gas sector. Integrating CNG and PNG into the GST system at a conservative rate of 5% would unlock substantial economic and environmental benefits.

This reform would:

- **Lower consumer prices:** Inclusion in GST would make CNG and PNG more affordable, especially in states with high VAT rates.
- **Boost investment:** Access to Input Tax Credit will lower project costs, improve CGD profitability and attracting investment in the City Gas Distribution sector.
- **National price uniformity:** Eliminates regional price disparities, ensuring equitable pricing for all consumers.
- **Alignment with National Goals:** Directly supports India's vision to increase the share of natural gas to 15% in the energy mix.

  Such a measure aligns perfectly with India's broader strategic objectives, including enhancing energy security by reducing reliance on imported crude oil and advancing progress towards the Sustainable Development Goals (SDGs), particularly SDG 7 (Affordable and Clean Energy), SDG 12 (Responsible Consumption and Production) and SDG 13 (Climate Action).

  Therefore, bringing natural gas under the GST is not merely a fiscal adjustment but a strategic imperative that harmonizes environmental sustainability, economic prudence, and social welfare.

06

Enhancing PNGRB's Interest Income through a Modified, Risk-Calibrated Investment Policy

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6.1 Introduction

The Petroleum and Natural Gas Regulatory Board (PNGRB) is mandated under Section 39 of the PNGRB Act to manage the Petroleum and Natural Gas Regulatory Board Fund. This fund, constituted from grants, fees, penalties, charges, and other approved sums received by the Board, is utilized for the Board's operational and administrative expenses. A key responsibility is the prudent investment of surplus funds to generate optimal returns while safeguarding capital.

Historically, PNGRB's investment strategy was conservative, reflecting select features of the Department of Public Enterprises (DPE) guidelines for investment of Surplus Fund and various Instruments in which investment can be made. It focused exclusively on term deposits with a limited number of empanelled Public Sector Undertaking (PSU) banks. This approach, while secure, presented limitations in maximizing interest income due to a narrow competitive landscape. This paper outlines the successful transition from a restrictive investment policy to a dynamic, risk-assessed model that has significantly enhanced the fund's annual yield.

6.2 The Challenge: A Constrained Investment Framework

PNGRB's previous investment framework stipulated that funds be placed in term deposits with empanelled banks for minimum 1 year and maximum 3 years. The empanelment criteria for banks were stringent, requiring a minimum long-term credit rating of 'AA+' from SEBI registered rating agencies and capping investment limits at 10% of the bank's net worth subject to a maximum of ₹500 crore.

This restrictive policy resulted in two primary challenges:

- **Limited Competition:** Only seven PSU banks qualified under these criteria, narrowing the pool of eligible institutions and limiting competitive interest rate discovery.
- **Incomplete Risk Assessment:** The reliance on a single rating metric and net worth did not fully account for other critical indicators of a bank's financial health, such as asset quality and capital strength.

Recognizing these constraints, a revised methodology was developed to broaden the investment base while instituting a more comprehensive risk evaluation framework.

6.3 A Modified Approach: Integrating Comprehensive Risk Analysis

The new investment policy was designed to increase competition and make more informed decisions by incorporating a multi-faceted risk assessment model. The revised criteria for empanelling banks now include:

- **Credit Rating:** The minimum long-term credit rating requirement was adjusted to 'A+', which is five notches above the Reserve Bank of India's (RBI) minimum investment grade. This broadened the pool of potential banks without compromising on fundamental credit quality.
- **Capital Adequacy Ratio (CAR):** The Tier-I (or core capital) CAR was introduced as a key metric. CAR measures a bank's capital relative to its risk-weighted assets, serving as a crucial indicator of its ability to absorb potential losses.
- **Non-Performing Assets (NPA):** The level of NPAs was included to assess the quality of a bank's loan portfolio and its overall financial discipline.

Under this refined methodology, scores are assigned based on CAR and long-term credit ratings, which, coupled with the net worth, determine a bank's eligibility and investment limit. This dynamic approach allowed PNGRB to analyze all scheduled commercial banks including Public Sector Banks and Private Sector Banks based on their latest available Balance Sheet for FY 2023-24. For the fiscal year 2024-25, this resulted in the empanelment of all 12 qualifying Public Sector Banks, immediately expanding the competitive field.

6.4 Results and Impact

The implementation of the modified investment policy yielded immediate and substantial positive results. By inviting competitive bids from a larger panel of financially sound banks, PNGRB was able to capitalize on more favorable interest rates, often linked to specific time buckets where banks required liquidity.

The financial impact is demonstrated in the table below:

Financial Year	Interest Income (₹ Crore)	Average Annual Yield (%)
2023-24	33.46	7.64%
2024-25	39.73	8.01%
Increase	+6.27	+0.37%

Table: Financial Impact on Interest Income due to Modified Methodology of Investment of PNGRB Fund

The new strategy led to an increase of **₹6.27 crore** in interest income and a **37 basis point** improvement in the average annual yield in a single fiscal year 2024-2025.

6.4.1. Reduction in Repo Rate by RBI

The Reserve Bank of India (RBI) has cut the Repo Rate by 100 basis points (1%), from 6.50% to 5.50%, over the last two quarters (Q4 2024-25 and Q1 2025-26).

This reduction is intended to stimulate economic growth by:

- Making it cheaper for banks to borrow from the RBI.
- Increasing liquidity and money supply in the banking system.
- Encouraging banks to lend more at lower interest rates.

However, this has a negative impact on investors like PNGRB. The lower rates have caused interest earnings on their Term Deposits to fall from a range of 7.70%–7.90% in the previous fiscal year to a current range of 6.70%–6.80%.

6.5 Key Takeaways and Path Forward

This initiative successfully demonstrates that a well-structured, risk-calibrated investment strategy can significantly enhance returns without exposing the fund to undue risk. The key takeaways from this exercise are:

- **Diversification Enhances Competition:** Broadening the panel of eligible banks beyond a restrictive list fosters greater competition, leading to better interest rate discovery.
- **Comprehensive Risk Analysis is Crucial:** A holistic risk assessment model that includes CAR and NPA levels, in addition to credit ratings, provides a more robust foundation for investment decisions.
- **Adaptability to Market Dynamics:** The financial landscape is dynamic. The new policy allows PNGRB to adapt to changing market conditions, such as shifts in the RBI's repo rate, which directly impact bank term deposit rates.

Looking ahead, as macroeconomic policies may lead to a lower interest rate environment, it is imperative for PNGRB to continue exploring new avenues to sustain its income. A logical next step would be to extend the empanelment criteria to include qualified private sector banks, further diversifying the investment portfolio and potentially unlocking even greater value for the PNGRB Fund.

INFRASTRUCTURE, TECHNOLOGY, AND DIGITALISATION

07

Boil-Off Gas Concepts, Challenges, and Management in LNG Retail Operations

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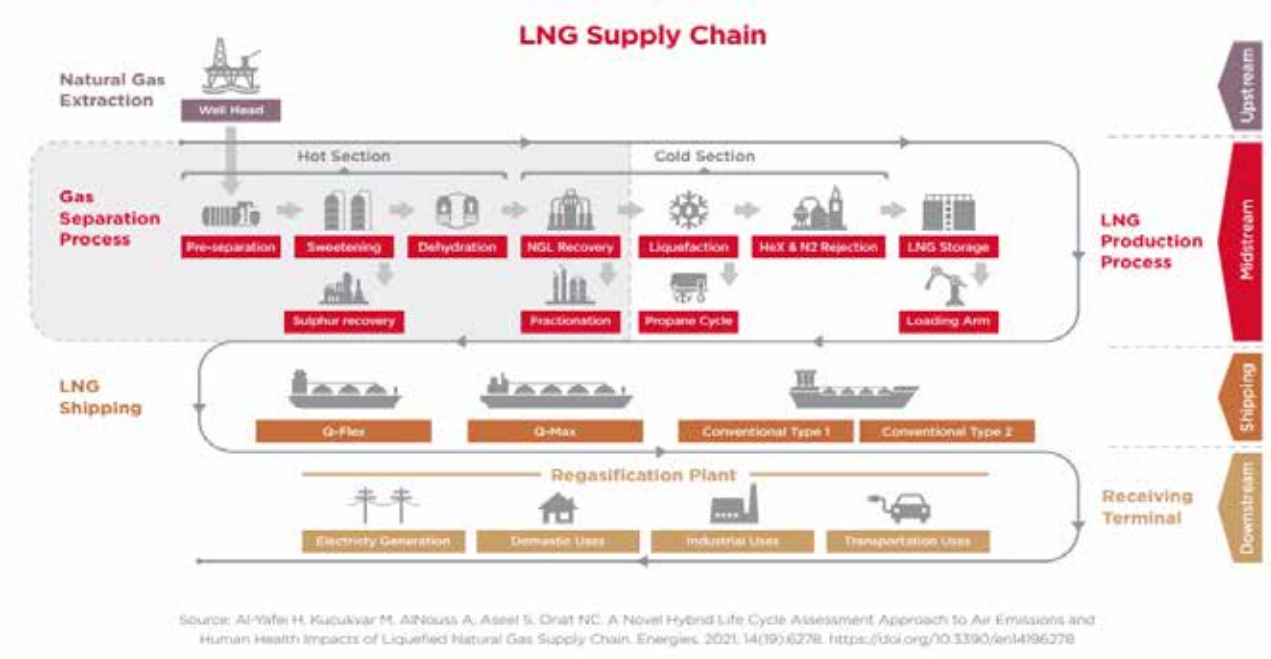
7.1 Introduction

Liquefied Natural Gas (LNG) is a cornerstone of the global energy market and plays a pivotal role in India's strategic shift towards a gas-based economy. However, the inherent cryogenic nature of LNG leads to a phenomenon known as Boil-Off Gas (BOG). The effective management of BOG is critical for ensuring operational efficiency, maintaining safety standards, and adhering to environmental regulations.

This paper examines the core concepts of BOG, analyses its generation within the specific context of LNG retail outlets, and outlines robust management strategies. Furthermore, it identifies gaps in the current regulatory framework and proposes recommendations for the Petroleum and Natural Gas Regulatory Board (PNGRB) to foster a sustainable and efficient LNG retail ecosystem in India.



Source: Al-Yafei H, Kucukvar M, AlNouss A, Aseel S, Onat NC. A Novel Hybrid Life Cycle Assessment Approach to Air Emissions and Human Health Impacts of Liquefied Natural Gas Supply Chain. Energies. 2021; 14(19):6278. https://doi.org/10.3390/en14196278

Figure: LNG Supply chain

7.2 Understanding Boil-Off Gas (BOG)

7.2.1. The Concept of BOG

Boil-Off Gas (BOG) means the process of vaporization of refrigerated product by heat conducted through the insulation surrounding the tank, or refers to the vaporized gas that escapes from cryogenic storage systems, typically in LNG (Liquefied Natural Gas) or other liquefied gases under low temperature and high-pressure conditions. Although stored in heavily insulated tanks, LNG is susceptible to ambient heat ingress during storage, transportation, and handling. This unavoidable heat gain causes a portion of the liquid to vaporize, increasing the pressure inside the storage vessel. If not managed, this pressure build-up can lead to product loss and significant safety risks.

As per PNGRB (Technical Standards and Specifications including Safety Standards for LPG Storage, Handling and Bottling Facilities) Regulations, 2019 **Rollover Effect** means 'the spontaneous and sudden uncontrolled movement of a large mass of liquid from the bottom to the top surface of a refrigerated storage vessel due to an instability caused by an adverse density gradient due to presence of stratified liquids of different densities and rollover can cause a sudden pressure increase and can affect vessel integrity'.

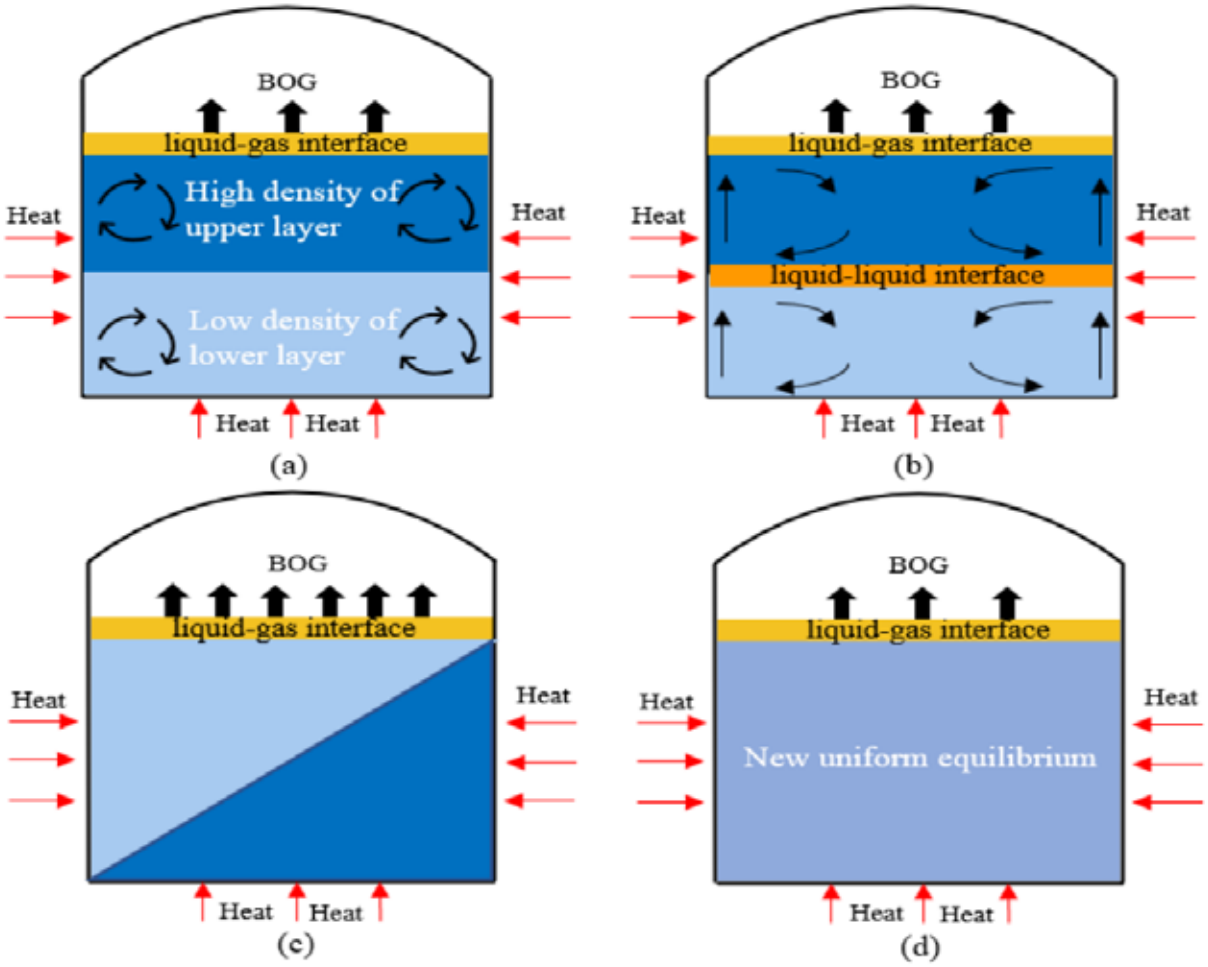


Figure: Rollover Effect in Tank Vessels

7.2.2 Primary Sources of BOG in Retail Operations

BOG generation in an LNG retail setting originates from multiple points in the handling chain:

- **LNG Storage Tanks:** LNG storage tanks are designed to keep natural gas in its liquefied state at cryogenic temperatures (~–162°C). Continuous ambient heat ingress through tank insulation is the primary cause of BOG.

- **Cryogenic Pipelines:** Cryogenic pipelines transport LNG between storage tanks, pumps, vaporizers, and other components in the supply chain. Heat transfer into pipelines during LNG circulation for system cooling or during transfer operations produces BOG.
- **Road Tankers:** LNG road tankers are mobile cryogenic vessels used for the distribution of LNG to various users or fueling stations. Heat absorption during the transportation and unloading of LNG generates BOG.
- Dispensing and Refueling Systems:
    - Vapor displacement during the transfer of LNG from the dispenser to a vehicle's fuel tank.
    - Return vapor from the vehicle's fuel tank back to the stationary storage tank.
    - The cumulative effect of warm gas returning to the storage tank, which increases the internal temperature and pressure, leading to a cascading BOG generation cycle.

7.2.3 Quantifying BOG at LNG Retail Outlets

The observations from LNG retail outlets indicate that BOG generation is highly variable and depend heavily on customer demand.

- **Medium Dispensing:** BOG losses are recorded in the range of **0.5–0.75 tonnes per day**.
- Low or Negligible Dispensing: BOG losses can increase to 1.2 tonnes per day.

  Some International studies have documented, that BOG losses at operating stations have been reported at levels of up to 10% of stored LNG inventory.

  The daily Boil-Off Rate (BOR), expressed as a percentage of the tank's inventory, can be calculated to quantify these losses. This measured BOG rate 0.5-1.2 tonnes per day at LNG retail outlets, equivalent to 1–4% of daily inventory, is significantly higher than "heat-leak boil-off rate" (BOR) of 0.05–0.15% per day seen in large storage tanks and LNG carrier ships. The gap is normal for retail stations with low offtake and frequent warm-start/cooldown/return-gas events —and that's where operational fixes and BOG systems deliver the biggest gains.

7.2.4 Potential Uses of BOG

Potential ways of using BOG

- Re-injection into LNG storage tanks (if reliquefication is available)
- Fuel for vaporizers, gensets, or compressors at the station.
- Feeding into nearby power generation systems.
- Use in microturbines or internal combustion engines.
- Export to pipelines (if processed)

7.3 BOG Management: Challenges and Strategies

7.3.1 Key Challenges in the Retail Sector

Managing BOG at the retail outlet storage presents a unique set of challenges:

- **Small Tank Volumes with High Surface-Area-to-Volume Ratio:** Smaller tanks at retail stations have a higher surface area to volume ratio, which increases rate of heat ingress and BOG formation.
- **Intermittent Dispensing Leads to Longer Idle Periods:** Irregular and infrequent refueling demand leads to long idle periods where LNG remains stationary in the tank, allowing for continuous heat ingress, BOG generation and pressure build-up.

- **Lack of Cost-Effective BOG Handling Technology:** Advanced BOG handling systems, such as reliquefication units or vapor recovery compressors, are often too capital-intensive for the smaller scale of retail operations.
- **Safety Risks due to Pressure Build-Up:** Unmanaged BOG can increase storage tank pressure beyond safe design limits, posing a risk of venting flammable gas or, in extreme cases, structural failure.

7.3.2. Strategic Approaches to BOG Management

Effective BOG management requires a combination of technological solutions and operational best practices. A comparative study by Kim and Cho (2022, Energies, 15, 8526) evaluated four distinct LNG refueling station designs:

- **Scenario a:** Basic LNG station with only a pressure relief valve.
- **Scenario b:** Station equipped with an LN_2 condenser.
- **Scenario c:** Station with a micro-reliquefaction system.
- **Scenario d:** An integrated LNG-CNG station where BOG is compressed and sold as CNG.

The study concluded that **Scenario 4 was the most economical and sustainable configuration,** demonstrating that integrating BOG into a secondary product stream can significantly enhance profitability. **It yielded the lowest minimum selling price ($17.15/MMBTU LNG) and a discounted cash flow rate of return of 13.22%, proving to be the most economical solution**.

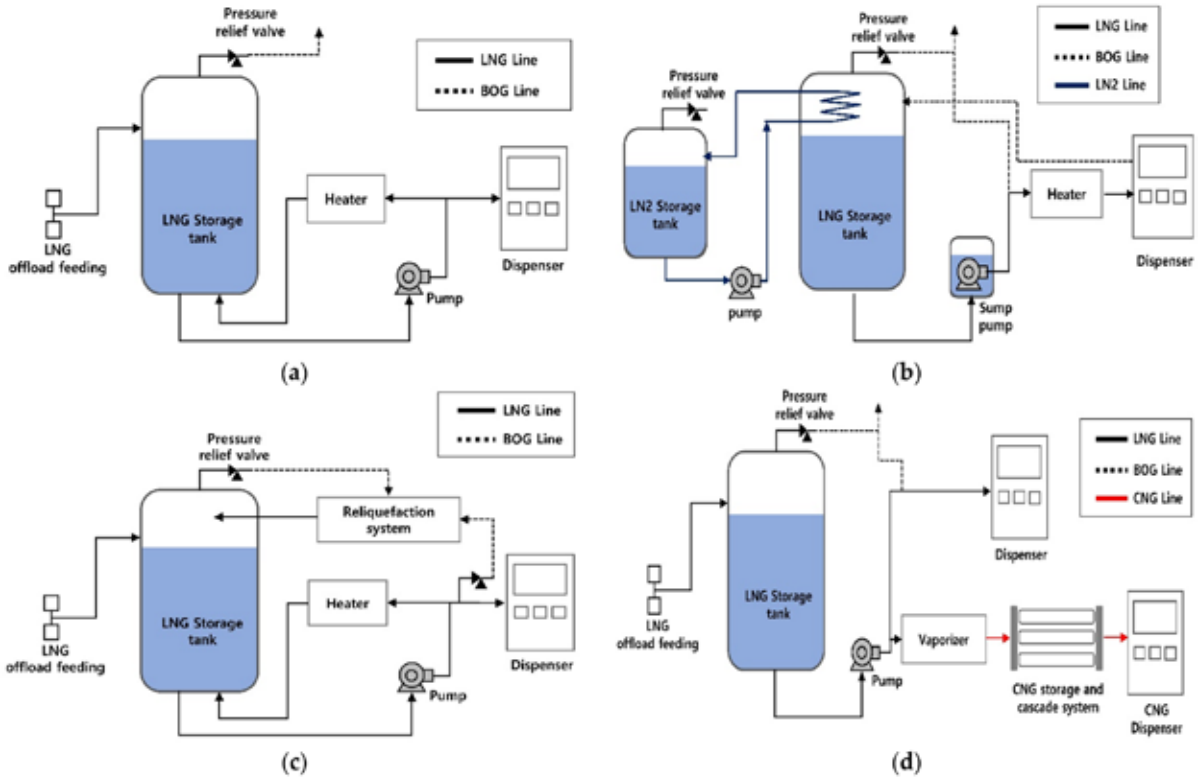


Figure 3. Schematic of the four different LNG refueling station scenarios: (a) Sc1: Basic LNG refueling station; (b) Sc2: LNG refueling station with LN_2 condenser; (c) Sc3: LNG refueling station with microreliquefaction system, and; (d) LNG and CNG refueling station. [source: Kim and Cho (2022, Energies, 15, 8526)]

Other proven management techniques include:

- Technological Solutions:
  - **Vapor Recovery Units (VRUs) to Compress and Store Vapor:** Capture and compress BOG for reuse as fuel or injected into the distribution network.
  - **BOG-Powered Generators to Produce Electricity:** Utilize BOG as fuel for on-site microturbines or gas engines to produce electricity for station operations.
  - **Mini Reliquefication Systems to Produce Electricity:** Re-condense BOG back into liquid form and return it to the storage tank, creating a zero-emission loop.
  - **Pressure Relief Systems for Controlled Venting:** Pressure relief valves automatically release excess pressure by venting BOG to the atmosphere in order to prevent overpressure incidents.
- Operational and Commercial Strategies:
  - **Operational scheduling to minimize idle tank time:** Minimize idle tank time through efficient logistics and demand management, and reduce BOG losses
  - **Supplying BOG to Nearby Consumers (e.g., City Gas Distribution):** Supply market surplus BOG to local City Gas Distribution (CGD) entities, industrial facilities, or captive power plants.
  - **Distribution of BOG through Light Commercial Vehicles (LCVs):** Collect, compress and distribute BOG to nearby consumers where pipeline access is unavailable but local demand exists.

Small-Scale LNG (SS LNG) stations face challenges with BOG, particularly significant at stations with low vehicle refueling frequency, leading to higher BOG accumulation and in some cases temporary shutdowns.

To address this, PNGRB constituted a working committee and, after deliberation, issued the following guidelines:

1. **Minimization of BOG** – Entities must adopt process and technology measures to continuously reduce BOG generation.
2. **Captive Use** – BOG may be utilized within the LNG station (e.g., power generation for station needs).
3. **Marketing to CGD Entity** – Surplus BOG may be marketed to the local CGD entity at a price not less than the APM ceiling price (on GCV basis) and not higher than the HPHT ceiling price, as notified by PPAC from time to time.
4. **Fallback Option** – If no agreement with the CGD entity is reached within one month, the concerned entity may approach PNGRB under applicable regulations.

7.4 PNGRB Regulatory Framework: Gaps and Recommendations

The PNGRB issued **Technical Standards and Specifications (T4S)** covering safety and design guidelines for LNG infrastructure.

7.4.1 Identified Gaps

- Lack of BOG-specific provisions for small-scale LNG retail operations.
- No mandatory requirements for Vapor Recovery Units (VRUs) or Mini Reliquefication Systems.
- A Lack of Prescribed Monitoring and Reporting Guidelines for BOG Emissions and Losses.
- Undefined Thresholds for Permissible BOG Emissions or Pressure Venting Events.
- Absence of retail-specific BOR/BOG performance standards.

7.4.2 Recommendations for PNGRB

Global Best Practice: Re-purposing Boil-Off Gas as a Valuable Resource

In global practice, a **key strategy in the management of Liquefied Natural Gas (LNG) is the repurposing of Boil-Off Gas (BOG).** This approach transforms BOG from a potential emission source into a valuable resource through three primary methods: on-site power generation, reinjection into the gas grid, or reliquefication.

Leading examples of this practice are found in countries such as Japan, South Korea, and the European Union. These jurisdictions have instituted comprehensive regulatory frameworks that serve as international benchmarks mandating BOG capture by utilizing technologies such as Vapor Recovery Units (VRUs), mini reliquefication systems, or direct on-site utilization for power. They have demonstrated that **high BOG recovery rates, specifically above 95%, are achievable** with right incentives and regulatory enforcements even in retail-scale operations.

To create a robust, safe, and environmentally responsible LNG retail sector, PNGRB can play a transformative role through the following strategic interventions:

1. **Mandate BOG Handling Infrastructure:** Introduce enforceable requirements for BOG management systems such as VRUs, pressure-relief standards, and closed-loop refueling systems, especially at new LNG retail stations.
2. **Standardize Monitoring and Reporting:** Implement mandatory BOG loss accounting and real-time monitoring protocols. This will promote transparency, enable performance benchmarking, and provide crucial data for policy refinement.
3. **Define Permissible Emission Thresholds:** Establish clear methane emission limits or allowable venting frequencies per unit of LNG dispensed, aligned with national climate targets and international best practices.
4. **Mandate BOG management for new stations** – Require a documented BOG management plan (VRU, reliquefication, compression to CNG or other utilization) as part of licensing for new stations and for any station undergoing significant equipment change.

Effective BOG management is not solely a technological challenge but also one of operational discipline and workforce competence. A structured capacity-building program should be developed, including:

1. Develop **comprehensive training modules** for operators, field technicians and contractors on BOG thermodynamics, system operation, safety protocols, emergency handling, and regulatory compliance.
2. Issue **Standard Operating Procedures (SOPs)** for BOG management, and ensure compliance through regular safety audits and drills.

7.5 Key Takeaways

The strategic management of Boil-Off Gas is a decisive factor in India's transition to a gas-based economy. While BOG presents operational and safety challenges, it also offers significant environmental and economic opportunities when properly harnessed.

Through proactive stewardship—anchored in rigorous standards, transparent monitoring, the incentivized adoption of advanced recovery technologies and building industry capacity—PNGRB can guide the industry to transform BOG from an unavoidable liability into a monetizable, climate-aligned resource. This paradigm shift will not only fortify the safety and operational resilience of India's expanding LNG retail network but will also crystallize India's ambition for a cleaner, more efficient, and globally benchmarked energy future.

08

Future-Proofing India's CNG Stations: A Case for Smart Technology and Automation

Author: ***Robins Raj***
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8.1 Introduction: The Imperative for Modernization

As India accelerates its clean energy transition, natural gas is poised to play a central role, with the nation aiming to raise its share in the primary energy mix from 6% to 15%. To achieve this, the PNGRB has authorized City Gas Distribution (CGD) networks across 307 Geographical Areas, supported by a Minimum Work Programme (MWP) target of 18,336 CNG stations by September 2034.

At the same time, India's CNG infrastructure stands at a critical juncture. Growing demand, coupled with areas of improvement in operations, safety and customer experience at traditional, largely manually operated stations, highlights the need for a fundamental transformation. Addressing these barriers requires a shift towards modernization—integrating smart technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), and advanced automation.

This paper examines how the adoption of these technologies can transform CNG stations into safer, more efficient, and customer-centric facilities. By enabling data-driven, automated operations, India can ensure the scalability, reliability, and sustainability of its CNG infrastructure, thereby strengthening its clean energy ecosystem and supporting long-term national energy goals.

8.2 Current Landscape and Prevailing Challenges

India is the largest consumer of CNG globally, with around 8,200 operational stations as of June 2025. Despite this scale, the majority of these facilities rely on manual systems for managing critical equipment like compressors and dispensers, as well as for safety monitoring. This dependence on manual oversight creates areas of improvement:

- **Operational efficiency:** Manual operations may contribute to equipment breakdowns, necessitating reactive maintenance that leads to possibility of downtime. This, combined with improvement possibility in queuing and service processes, results in waiting times for customers and underutilization of assets. Power supply interruptions and a shortage of skilled manpower may further exacerbate these inefficiencies.
- **Infrastructure and supply chain constraints:** The expansion of the CNG network has to develop in tandem with pipeline development. Due to lack of last mile pipeline development in some areas of the country there may be heavy reliance on CNG cascades for supply at some CNG

stations. This mode of delivery is logistically complex and prone to disruptions. Furthermore, some challenges in land acquisition may delay the construction of new stations, creating service gaps in key demand areas.

- **Possibility of Safety and Compliance issues:** CNG stations handle natural gas at very high pressures, posing inherent safety risks. Advanced, real-time monitoring and automated leak-detection systems in many older stations can significantly reduce the probability of hazardous incidents and compliance issues with stringent safety regulations.

8.3 Leveraging Smart Technology for Transformation

The integration of smart technologies offers a comprehensive solution to address the areas of improvement in the CNG sector. By creating a digitally connected ecosystem, operators can enhance efficiency, safety, and the customer experience.

- **Internet of Things (IoT) for Real-Time Monitoring:** The deployment of smart sensors on compressors, storage cascades, and dispensers allows for the real-time collection of critical operational data, including pressure, flow rates, and temperature. This data enables predictive maintenance, allowing operators to identify and address potential equipment failures before they occur, thereby maximizing uptime.
- **Intelligent Dispensing and Payment Systems:** Smart dispensers equipped with Radio-Frequency Identification (RFID) or Near-Field Communication (NFC) technology can automatically identify vehicles and link them to customer accounts. This facilitates precise fuel measurement, automates the billing process, and enables seamless digital payments, significantly reducing transaction times.
- **Advanced Safety and Security Systems:** Modern CNG stations can be equipped with automated gas leak detection systems that trigger instant alerts and automatic shut-off valves in the event of an emergency. This can be complemented by AI-enabled surveillance systems that monitor the premises for unauthorized access or safety protocol violations, ensuring a secure operating environment.
- **Digital Customer and Fleet Management Platforms:** A dedicated mobile application can provide customers with valuable information, such as the location of nearby stations, real-time queue status, and the ability to pre-schedule refueling. For commercial fleet operators, integration with telematics systems can optimize refueling schedules, track fuel consumption, and streamline fleet management.

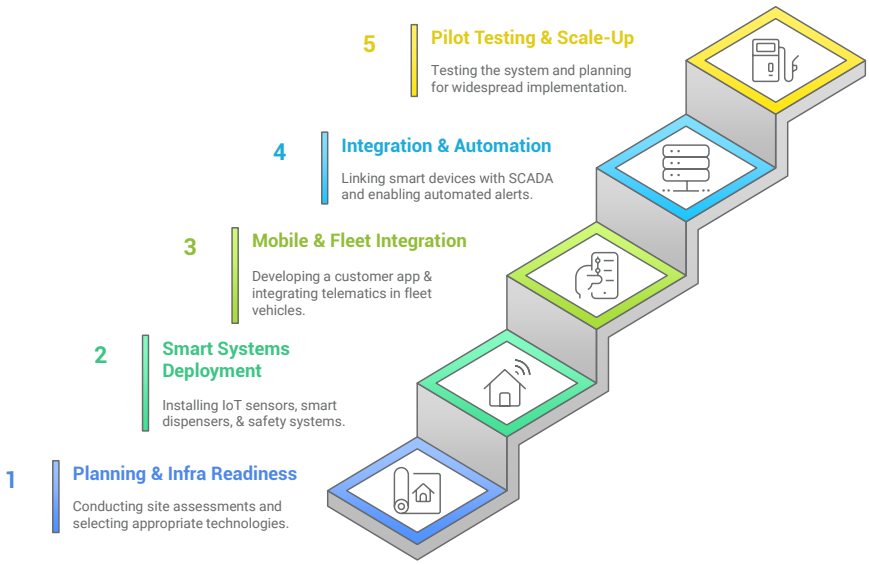
8.4 A Phased Implementation Framework

A structured, phased approach is essential for the successful integration of smart technologies across the national CNG network.

- **Phase 1: Planning and Readiness Assessment:** This initial phase involves conducting comprehensive site surveys of existing stations to identify necessary equipment and infrastructure upgrades. Key

Performance Indicators (KPIs)—such as station uptime, queue duration, and safety incidents—should be established to measure the impact of modernization. This is followed by the selection of appropriate IoT platforms, sensor technologies, and software solutions.

- **Phase 2: Smart Systems Deployment:** The second phase focuses on the physical installation of the selected technologies. This includes fitting compressors and pipelines with IoT sensors, upgrading to smart dispensers, and deploying automated safety and surveillance systems.
- **Phase 3: Integration and Automation:** Once installed, all smart devices and systems must be integrated with a central Supervisory Control and Data Acquisition (SCADA) or an equivalent control platform. This enables the creation of real-time operational dashboards for station managers. Automated alert systems for equipment faults or safety breaches should also be configured during this phase.
- **Phase 4: Pilot Testing and Scaled Rollout:** Before a network-wide implementation, pilot projects should be launched at a select number of stations. The performance data gathered from these pilots will validate the effectiveness of the chosen technologies and inform a data-driven strategy for a scaled national rollout.



8.5 Case in Point: Industry Adoption in India

Several CGD entities in India have already begun to embrace smart technologies, demonstrating their tangible benefits:

- **Indraprastha Gas (IGL) and Mahanagar Gas (MGL)** are utilizing AI models to predict demand fluctuations and optimize their gas supply logistics.
- **GAIL Gas** has implemented IoT-based safety monitoring at select CNG stations, significantly reducing any possible gas leakages risks
- **Torrent Gas** has deployed fully automated dispensers in Gujarat and Maharashtra, enhancing dispensing efficiency.
- **Adani Gas** and **MGL** have launched smart card payment systems to facilitate faster and more convenient transactions.
- **Bharat Petroleum Corporation (BPCL)** is leveraging cloud-based predictive maintenance at its smart CNG stations, resulting in a 25% reduction in equipment downtime.

8.6 Future Outlook: The Integrated Energy Hub

By 2030, the modernized CNG station is expected to evolve beyond its traditional role. It will become an integrated smart energy hub, offering a suite of services including CNG, EV charging, and potentially hydrogen fueling. Powered by automation, AI, and integrated renewable energy sources, these hubs will

be central to India's multi-fuel clean energy transition and its pursuit of net-zero emissions.

8.7 Key Takeaways

The modernization of India's CNG station network is a critical step in achieving the nation's energy goals. The following key takeaways emerge from this study:

- **Technology is a Necessity:** The adoption of smart technologies is not optional but essential for enhancing operational efficiency, ensuring safety, and improving the customer experience.
- **Data is a Strategic Asset:** Leveraging data analytics and AI for predictive maintenance and operational optimization is crucial for maximizing asset performance and profitability.
- **Customer-Centricity is Key:** Integrating mobile applications and digital payment systems is fundamental to meeting the expectations of modern consumers.
- **Strategic Implementation Drives Success:** A pilot-tested and phased rollout strategy is the most effective approach to de-risk technology adoption and ensure a successful network-wide transformation.
- **Continuous Improvement is Imperative:** The CNG ecosystem must commit to regular audits and ongoing technology upgrades to remain sustainable, competitive, and future-ready.

09

Optimizing CNG Distribution: An Analysis of Online CNG Stations to Reduce Cascade Movement and Associated Costs

Author: ***Nilesh Yadav***
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9.1 Introduction

Compressed Natural Gas (CNG), primarily methane (CH_4), is a widely used transportation fuel in India. Compressed to less than 1% of its volume and stored at 200–250 bar, CNG is lighter than air and disperses quickly, offering a favourable safety profile. As of June 2025, City Gas Distribution (CGD) entities operate 8,205 CNG stations nationwide to meet rising demand.

The CNG network comprises different types of stations, distinguished by whether they are fed directly by pipelines or supplied via road in mobile cascades. Reliance on road transport, particularly for Daughter and Daughter Booster stations supplied from a central Mother station, poses logistical, financial, and safety challenges.

This paper examines the operational and financial impact of shifting from a cascade-based transport model to pipeline-fed "Online" stations. It provides a comparative cost analysis highlighting potential savings, enhanced safety, and improved efficiency. Data and financials are based on market surveys, stakeholder inputs, and public sources, serving as indicative estimates for strategic evaluation.

9.2 Overview of CNG Station Infrastructure

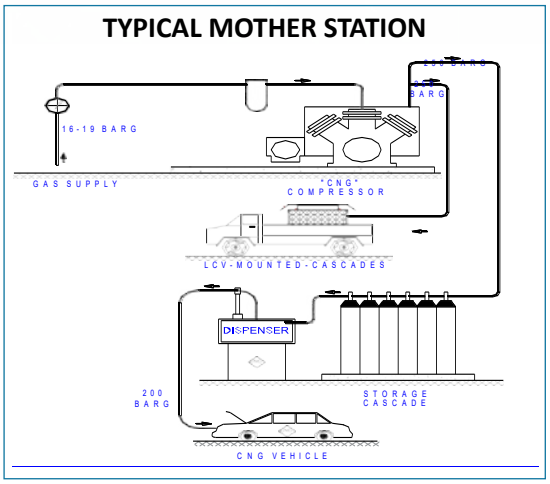
The functionality of the CNG retail network is determined by the design and connectivity of its stations. The primary types are:

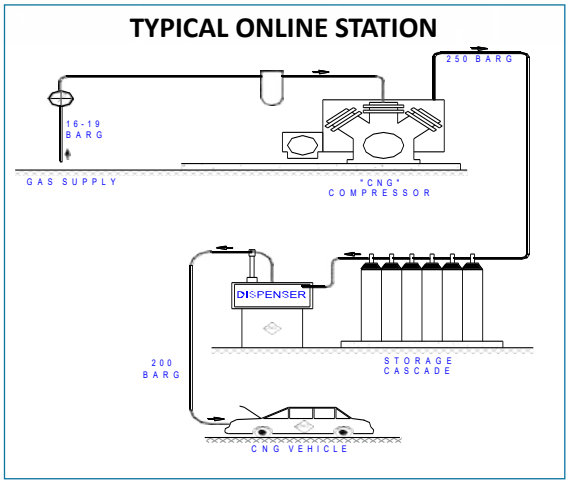
- **Mother Station:** Connected directly to the steel gas pipeline grid, this station uses high-capacity compressors (approx. 1200 SCMH) to compress natural gas from pipeline pressure (15-19 bar) up to 250 bar. It serves dual purposes: directly refuelling vehicles and filling mobile cascades for transport to other stations.
- **Online Station:** Also connected directly to the gas pipeline, this station's primary function is to compress gas for direct refuelling of vehicles through dispensers. If space permits, it can also function as a Mother Station to fill mobile cascades.
- **Daughter Booster Station (DBS):** Lacking a direct pipeline connection, a DBS receives CNG via mobile cascades from a Mother Station. It uses a booster compressor to transfer the gas from the mobile cascade to its stationary storage cascade, from which vehicles are refuelled.
- **Daughter Station:** This is the simplest type of station without a pipeline connection. It dispenses CNG directly to vehicles from the mobile cascade. The pressure depleted mobile cascade is refilled at mother station.

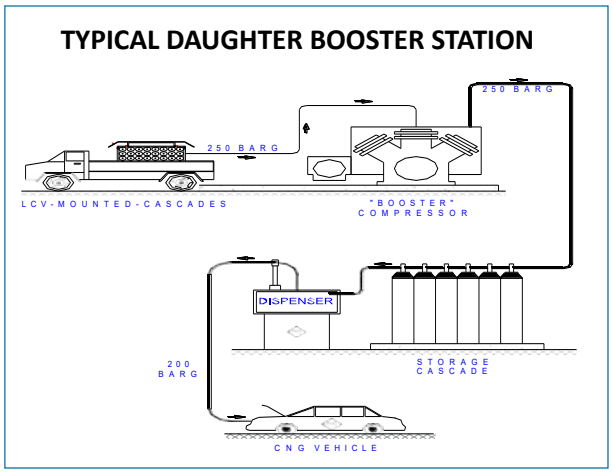
The transportation of gas between Mother and Daughter stations involves Heavy/Light Commercial Vehicles (HCVs/LCVs) carrying CNG Cascades—a series of interconnected high-pressure cylinders mounted on a frame.

CNG Compressor - It is a critical component of retail dispensing infrastructure, boosting natural gas from 2–25 bar to 200–250 bar using reciprocating or screw-type systems equipped with cooling and safety features for safe, reliable operation.

CNG Cascade - It is a robust frame-mounted system of high-pressure interconnected cylinders made of seamless chrome-moly alloy steel, used for storing and transporting CNG to ensure reliable supply in areas without direct pipeline connections, with capacities ranging from 3000 to 9000 WL.







Typical CNG Compressor

Typical CNG cascade

9.3 Financial and Operational Analysis

To quantify the benefits of minimizing road-based cascade movement, this analysis compares the total operating expenditure (OPEX) of two scenarios:

1. **Scenario A:** A Daughter Booster Station (DBS) supplied by a diesel-fueled HCV/LCV transporting a mobile cascade.
2. **Scenario B:** An Online Station receiving gas directly from a pipeline and using an engine-driven compressor.

9.3.1 Vehicle (or HCV/LCV) Operational Costs: CNG vs. Diesel

An initial comparison of fuel and operating costs for a commercial vehicle highlights the inherent efficiency of CNG.

Parameter	CNG-fueled HCV/LCV	Diesel-fueled HCV/LCV
Monthly Running	4,860 km (162 km/day)	6,810 km (227 km/day)
Mileage	7.05 km/kg	6.00 km/Ltr
Fuel Consumed	689.35 kg	1,145 Ltr
Fixed / Rental Charges	₹ 64,000	₹ 64,000
Kilometer Charges (@ ₹1.25/ km)	₹ 6,075	₹ 8,512
Toll Charges	₹ 10,000	₹ 10,000
Fuel Cost	₹ 65,282 (689.35 Kg * 94.70 Rs. / kg)	₹ 1,03,050 (1,145 Lt. * 90 Rs. / Lt.)
Total Monthly OPEX per HCV/ LCV	**₹ 1,45,357**	**₹ 1,85,562**

Table 1: Monthly Operating Cost Comparison for a Commercial Vehicle

This comparison demonstrates that CNG-fueled vehicles have a lower monthly operating cost, delivering savings of approximately ₹40,205 per vehicle compared to their diesel counterparts.

9.3.2 Comparative Analysis: DBS vs. Online Station

The core of this study compares the combined monthly costs of operating a DBS (vehicle + booster compressor) with the cost of operating an Online Station compressor.

Cost Component	Amount (INR)	Details
Daughter Booster Station – Booster operational cost (600 SCMH 37 KW Booster)		
Electricity Cost	₹ 71,040	37kW x 8 hrs/day x 30 days x ₹8/unit
Booster Maintenance Cost	₹ 1,25,000	
Total Booster Compressor OPEX	₹ 1,96,040	
Online Station (1200 SCMH engine-driven Compressor)		
Captive Fuel Cost (CNG)	₹ 1,74,720	28 kg/hr x 4 hrs/day x 30 days x ₹52/kg
Maintenance Cost	₹ 1,25,000	
Total Online Compressor OPEX	₹ 2,99,720	

Table 2: Monthly OPEX for Station Equipment (Daughter Booster vis a vis Compressor at Online Station)

9.3.3 Consolidated Operational Cost Comparison

Scenario	Total Monthly OPEX
Scenario A: DBS Operation (Diesel HCV/LCV + Booster Compressor)	₹ 3,81,602 (₹ 1,85,562 + ₹ 1,96,040)
Scenario B: Online Station Operation (Engine-Driven Compressor)	₹ 2,99,720
Monthly Operational Savings (Scenario B vs. A)	₹ 81,882

While the Online Station model provides significant monthly operational savings, it requires a higher initial capital investment.

- Capital Expenditure (CAPEX) Difference:
  - Price of 1200 SCMH Online Compressor: ₹ 1,00,00,000
  - Price of 600 SCMH Booster Compressor: ₹ 30,00,000
  - Additional Upfront Investment: ₹ 70,00,000

9.4 Key Takeaways and Conclusion

The analysis confirms that transitioning from a road-dependent cascade supply model to a pipeline-fed Online Station network offers substantial long-term benefits that extend beyond financial savings.

Key Takeaways:

1. **Reduced Operational Expenditure:** An Online Station offers monthly OPEX savings of approximately **₹81,882** compared to a Daughter Booster Station supplied by a diesel HCV.
2. **Enhanced Road Safety:** The primary benefit is the significant reduction in the movement of mobile cascades on roads. This directly mitigates the risk of traffic incidents. Data reported to PNGRB highlights the severity of this issue, with **231 road incidents causing 111 fatalities in 2024-25** and **139 incidents causing 75 fatalities in 2023-24** involving OMCs. Adopting the Online Station model is a crucial step toward minimizing these preventable tragedies.
3. **Improved Service Quality:** Online Stations ensure an uninterrupted and consistent supply of gas at stable pressures, eliminating the logistical challenges of fleet management and cascade rotation. This leads to reduced queuing times for consumers and higher station uptime.
4. **Environmental Benefits:** Eliminating the need for diesel-powered HCVs for gas transport reduces the carbon footprint and local air pollution associated with the CNG distribution network itself.

In conclusion, while the initial capital outlay for establishing Online CNG Stations is higher, the investment is justified by compelling long-term economic returns, dramatic improvements in public safety, and superior operational reliability. For India to sustainably expand its clean energy infrastructure, a strategic focus on developing pipeline-connected CNG stations is not just economically prudent but a critical imperative for ensuring public safety and environmental stewardship.

CONSUMER AFFAIRS AND STAKEHOLDER MANAGEMENT

10

Enhancing Consumer-Centric Practices in India's Oil & Gas Sector

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10.1 Introduction

India's Oil and Gas sector serves as a cornerstone of the nation's energy infrastructure, catering to millions of consumers through Piped Natural Gas (PNG), Compressed Natural Gas (CNG), Liquefied Petroleum Gas (LPG), and retail fuels. Amid rapid economic growth, the demand for reliable and affordable energy is escalating, necessitating a paradigm shift from a traditional supply-driven model to one centered on consumer welfare. This paper examines the evolution of consumer-centric practices across the sector, analyzing regulatory frameworks, industry-led digital innovations, and key policy interventions.

Drawing exclusively from internal analyses and stakeholder-provided data, this study assesses the initiatives of Oil Marketing Companies (OMCs), City Gas Distribution (CGD) entities, and government agencies. It highlights the progress in transparency, service delivery, and grievance redressal, while also identifying persistent challenges. The objective is to present a comprehensive overview of the sector's journey toward a holistic, consumer-first governance model built on digital integration, robust oversight, and consumer empowerment.

10.2 The Indian Oil & Gas Ecosystem: A Regulatory Overview

India's oil and gas ecosystem is governed by a multi-tiered structure. The Ministry of Petroleum and Natural Gas (MoPNG) formulates overarching policy, while its technical arm, the Directorate General of Hydrocarbons (DGH), oversees upstream exploration.

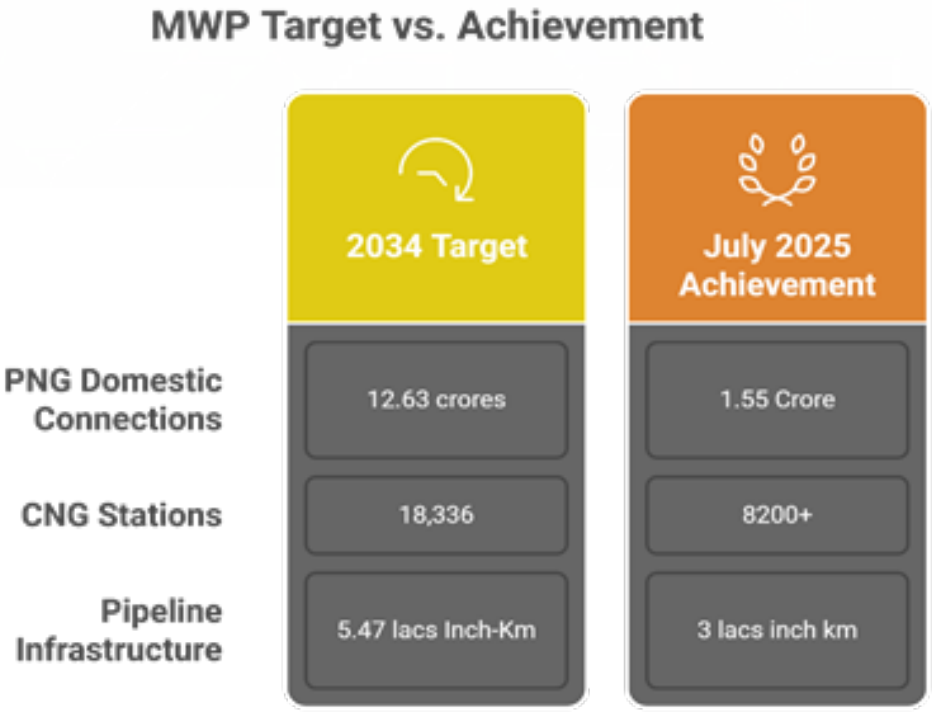
As the independent downstream regulator, the Petroleum and Natural Gas Regulatory Board (PNGRB), established under the PNGRB Act, 2006, is pivotal. PNGRB authorizes and regulates CGD networks and natural gas pipelines, sets tariff structures, ensures fair competition, and protects consumer interests. Its mandate has expanded to include insurance coverage frameworks, billing compliance, and consumer satisfaction surveys, firmly embedding consumer-centricity into the regulatory landscape.

The downstream segment is dominated by public sector OMCs—Indian Oil Corporation Ltd. (IOCL), Bharat Petroleum Corporation Ltd. (BPCL), and Hindustan Petroleum Corporation Ltd. (HPCL)—which manage extensive retail and LPG networks. They are complemented by a growing number of private entities in both fuel retail and the CGD sector, fostering a more competitive and innovative market.

10.3 Case Studies in Consumer-Centric Service Delivery

A. City Gas Distribution (CGD)

The CGD sector is at the forefront of delivering cleaner fuels to households (PNG) and vehicles (CNG). As of July 2025, authorized entities have provided approximately 1.55 crore domestic PNG connections and established over 8,200 CNG stations.



Regulatory Framework:

Operations are governed by PNGRB's 'Code of Practice for Quality of Service' regulations, which mandate:

- **Transparent Processes:** Clear timelines and procedures for new connections.
- **Accurate Billing:** Installation of certified meters and transparent billing with detailed charge breakdowns.
- **Service Reliability:** Defined limits on supply interruptions and mandatory emergency response mechanisms.
- **Grievance Redressal:** Establishment of 24x7 complaint cells, nodal officers, and a framework for an independent Ombudsman.

Industry Initiatives:

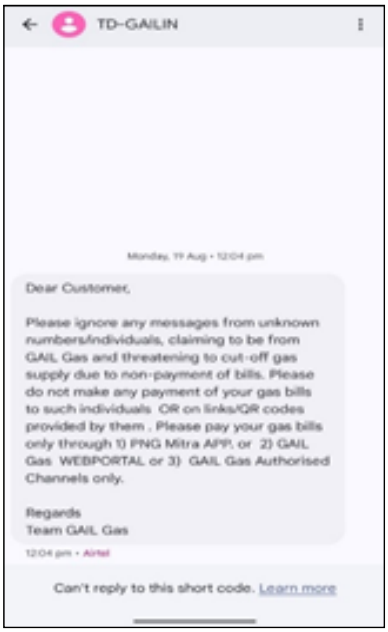
CGD entities have embraced digital transformation to enhance consumer experience:

- **Digital Access:** Mobile applications and web portals for bill payments, service requests, and complaint tracking (e.g., Adani Total Gas Ltd.'s *My Adani Gas* app, Green Gas Ltd.'s *GGL Engage*).
- **Billing Modernization:** Introduction of self-billing, prepaid smart meters, and seamless digital payment options via UPI, often with incentives.
- **Advanced Grievance Systems:** Multi-channel platforms with clear escalation matrices. THINK Gas has deployed an AI-driven platform, *NEURON*, to streamline complaint resolution.
- **Consumer Awareness:** Proactive communication on safety, tariff changes, and fraud prevention through SMS alerts, social media campaigns, and verified caller ID services.

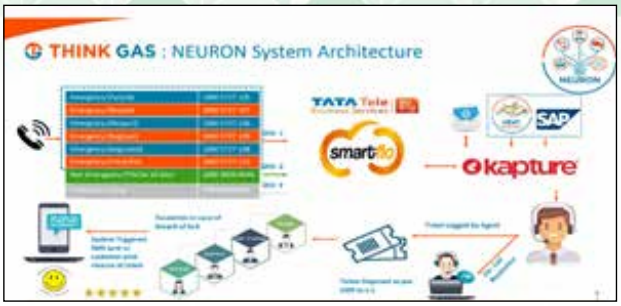
Despite this progress, challenges such as long queues at CNG stations and inconsistent service quality across different geographical areas remain.

Consumer Awareness Programs

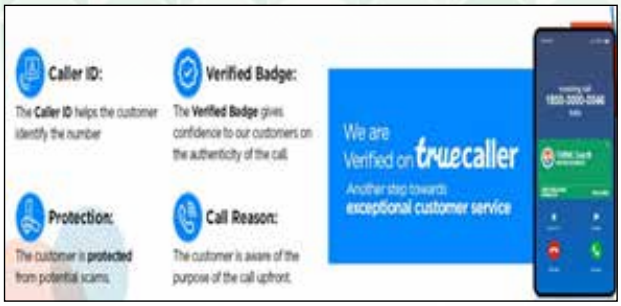
Pink CNG dispensers specially dedicated to female vehicle owners at mother stations for women empowerment.



Fraud Alert Initiatives

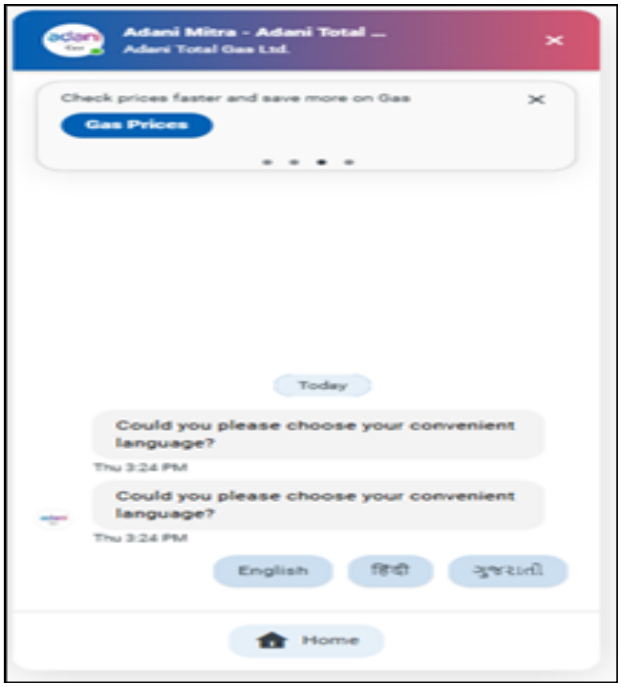


Advance CRM platform



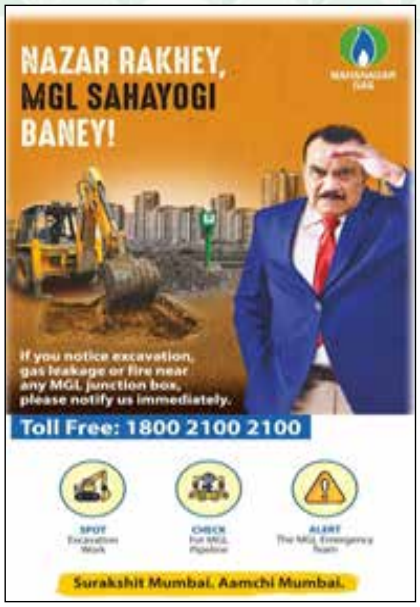
Verified account on Caller Identification app for Consumer Safety

Fleet Card for Vehicle Owners with multiple benefits



Consumer testimonials strengthening trust and confidence in adopting greener fuels.

Consumer Delight Initiatives



Safety Awareness Campaign by entity on Pipeline Damage

Referral Campaign to attract new DPNG consumers

Cash back offers to encourage consumers for timely online payments

Carbon Footprint Calculator on Entity Website

B. Liquefied Petroleum Gas (LPG)

With over 32 crore active consumers, LPG is a primary cooking fuel in India.

- **Universal Access:** The **Pradhan Mantri Ujjwala Yojana (PMUY)** has been instrumental in expanding LPG coverage to near-universal levels, providing over 9 crore deposit-free connections to women from low-income households.
- **Transparent Subsidies:** The **PAHAL (DBTL)** scheme, the world's largest direct benefit transfer program, has eliminated diversion and ensured subsidies reach intended beneficiaries directly in their bank accounts.
- **Enhanced Portability:** The "One Nation, One LPG" program allows consumers to switch distributors anywhere in the country, offering unprecedented flexibility, particularly for migrant populations.
- **Digital Services:** OMCs have launched mobile apps for booking refills, tracking subsidies, and registering complaints, integrating these services into unified government platforms like UMANG.

Challenges persist in last-mile delivery timelines and bridging the digital divide for less tech-savvy consumers in rural areas.

C. Fuel Retail

The fuel retail sector is increasingly focused on convenience, transparency, and integrated energy solutions.

- **Digital Transparency:** Mobile apps from all major OMCs (e.g., *IndianOil ONE*, *HP Pay*) provide real-time fuel prices, station locators, and digital payment options. QR code-based feedback systems at outlets, like BPCL's *DARPAN*, allow for real-time service quality monitoring.
- **Facility Upgrades:** Retail outlets are being modernized with improved amenities, including clean restrooms and digital displays showing fuel quality and density.
- **Transition to Clean Energy:** OMCs are actively expanding their networks to include EV charging stations and Compressed Biogas (CBG) outlets, transforming from traditional fuel retailers into integrated energy providers.

Inconsistent service quality and delays in complaint handling remain areas for improvement.

10.4 Regulatory Impetus: The High-Level Expert Committee (HLEC) Report and PNGRB's initiatives

10.4.1 HLEC Report

Recognizing the need for a harmonized consumer protection framework, PNGRB constituted a HLEC. The committee's report recommended a structured roadmap to institutionalize consumer rights, proposing:

- A unified complaint redressal framework with standardized service levels and timelines.
- Establishment of dedicated Consumer Protection Committees at the board level of entities.
- Nationwide awareness campaigns on consumer rights and safety.
- The eventual creation of an Ombudsman mechanism for unresolved complaints, modeled on successful frameworks in the banking and insurance sectors.

The report affirmed PNGRB's jurisdiction to adjudicate consumer complaints, positioning it as the primary quasi-judicial forum for the sector.

10.4.2 PNGRB's Consumer-Centric Initiatives: Strengthening Transparency, Protection and Trust

PNGRB has launched a series of consumer-focused initiatives to enhance trust, transparency, and protection in the oil and gas sector. These include –

- Strengthening grievance redressal through the Consumer Standardization and Redressal Mechanism (CSRM), driving transparency in billing practices for both PNG and CNG, and extending insurance coverage to D-PNG consumers, which has already benefited over 34 lakh households.
- Initiatives such as third-party consumer satisfaction surveys, pilot studies on PNG stove efficiency, and the proposed Ombudsman framework further reinforce consumer rights and service quality.
- In parallel, PNGRB has promoted awareness through Voluntary Consumer Organizations, NGOs, and state-wise publication of CNG/PNG prices, supported by workshops and outreach campaigns.

Collectively, these steps underscore PNGRB's consumer-first regulatory approach, ensuring fairness, accountability, and empowerment.

10.5 Global Regulatory Practices

United Kingdom – Ofgem

The UK's Ofgem is widely recognized for its strong consumer mandate. It enforces *Guaranteed Standards of Performance* (GSOP), requiring utilities to compensate consumers for service delays. Transparency is a cornerstone—complaint statistics are published, and centralized tools allow consumers to compare tariffs and service quality. Ofgem also conducts *Impact Assessment Reports* to gauge consumer and environmental effects of major decisions. Importantly, it runs a *Consumer Vulnerability Strategy* and *Priority Services Register* to ensure targeted support for elderly, disabled, or financially challenged consumers, while prohibiting winter disconnections.

United States – FERC

The Federal Energy Regulatory Commission (FERC) regulates interstate natural gas and LNG with a strong emphasis on consumer participation. It ensures tariff transparency, conducts formal hearings, and invites public comments before regulatory changes. FERC also manages centralized consumer complaint platforms with tracking systems, ensuring accountability in redress timelines.

China – NEA and Provincial Regulators

China's National Energy Administration (NEA), along with provincial bodies, requires mandatory publication of tariffs, outage notices, and grievance statistics. Widespread adoption of smart metering has improved billing transparency and real-time usage monitoring. Gas utilities like Beijing Gas and China Gas Holdings also use mobile and WeChat-integrated portals for bills, feedback, and emergency alerts—demonstrating how digital tools can enhance responsiveness and consumer trust even in heavily regulated systems.

Malaysia – Gas Malaysia Berhad (GMB)

Malaysia's Gas Market Board emphasizes service reliability and consumer feedback. A *reliability index* (SAIDI) is tracked to ensure minimal service interruptions, while regular customer satisfaction surveys capture consumer expectations. Though survey results are not always public, this practice reflects a proactive approach to incorporating consumer voice in regulatory oversight.

Country / Regulator	Global Best Practices	Suggested Action for PNGRB / India
UK – Ofgem	Guaranteed Standards of Performance (GSOP) with compensation for delays; complaint statistics disclosure; Impact Assessment Reports; Priority Services Register for vulnerable consumers	Service standards with compensation; PNGRB dashboard for tariffs/ complaints; mandatory consumer impact assessments; registry of vulnerable consumers and prohibition of disconnections
US – FERC	Transparent tariff-setting, public hearings, formal comments; centralized complaint portals	Strengthen PNGRB's online complaint portal with tracking; conduct structured public consultations before major tariff or regulatory changes
China – NEA	Mandatory publication of prices/ outages; grievance statistics; smart metering; consumer apps (WeChat, mobile portals)	Require real-time tariff and outage disclosures; promote smart metering; mandate multilingual mobile apps with usage tracking and emergency alerts
Malaysia – GMB	Service reliability index (SAIDI); structured consumer satisfaction surveys	Introduce PNG outage/reliability indices; publish entity-wise scores; release results of PNGRB's Consumer Satisfaction Surveys (CSS)

Comparative Table – Key Learnings for India

10.6 Recommendations for the future to address current challenges

India's Oil and Gas sector has made significant strides in becoming more consumer-centric. However, to build on this momentum and ensure uniform excellence, the following challenges must be addressed with targeted recommendations.

Challenge	Recommendation
a. Fragmented grievance redressal	Establish PNGRB's proposed unified grievance portal as a second-level escalation mechanism, while entities manage initial complaints. Incorporate multi-channel access (IVRS, WhatsApp) and analytical dashboards to track performance.
b. The Digital divide	Develop low-bandwidth applications, multilingual interfaces, and voice-command features to ensure inclusivity. Explore assisted digital kiosks at accessible community points to bridge the gap for non-digital natives.
c. Inconsistent consumer experience at Retail outlets	Standardize benchmarks for amenities like canopy coverage, safety signage, and digital price boards at all CNG and fuel retail stations. Address queuing at CNG stations by expanding dispensing capacity and introducing smart-token systems.
d. Low consumer awareness	Launch a nationwide awareness campaign, akin to "Jago Grahak Jago," focused on consumer rights, safety protocols, and grievance channels, particularly for first-time PNG users.
e. Lack of publicly available performance data	Mandate the public disclosure of key performance indicators (KPI) by entities, such as complaint resolution times, network downtime, and consumer satisfaction scores. This will foster healthy competition and empower consumers to make informed choices.
f. Poor upkeep of public facilities	Make clean, gender-segregated, and differently-abled-friendly washrooms mandatory at high-traffic retail outlets. Enforce compliance through displayed cleaning schedules, QR-based feedback, hygiene ratings, and surprise inspections.

10.7 Conclusion and key takeaways

The Indian Oil and Gas sector is at a pivotal moment in its transition towards a consumer-first service model. The convergence of progressive regulation, digital innovation, and industry initiative has laid a strong foundation for a more transparent, accountable, and responsive ecosystem.

Looking ahead, the focus must be on empowering consumers through awareness, ensuring inclusivity through accessible technology, and enforcing uniform service standards across all regions. By systematically addressing the remaining challenges, the sector can not only meet the evolving expectations of its vast consumer base but also set a global benchmark for consumer-centric governance in the energy domain.

11

An Ombudsman for the Piped Natural Gas Sector: A Necessity for Consumer Protection

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11.1 Introduction

The institution of the Ombudsman, originating in early 19th-century Sweden, was conceived as an independent authority to address grievances against maladministration. It has evolved globally into a vital instrument for administrative justice and consumer protection. It provides citizens with an accessible forum to address grievances against service deficiencies and unfair practices. In India, the Ombudsman has not been adopted as a constitutional office, however, the Ombudsman model has been successfully adapted for specific sectors like banking, insurance, electricity, and pensions where consumer issues are often technical and frequent. These precedents have demonstrated the indispensable role of an Ombudsman in bridging the gap between regulators, service providers, and consumers.

Against this backdrop, the rapid expansion of India's Piped Natural Gas (PNG) network as an essential household utility highlights a critical gap: the absence of a dedicated consumer grievance redressal mechanism. Although the Petroleum and Natural Gas Regulatory Board (PNGRB) is empowered to handle consumer complaints under the PNGRB Act, 2006, its current framework is centralized, procedurally complex, and often inaccessible to the ordinary household. This paper draws comparative insights from other regulatory sectors, examines the limitations in the PNGRB framework, and advances for the urgent establishment of a dedicated PNG Ombudsman to protect consumer interests and support India's clean energy objectives.

11.2 The Ombudsman Model in India: A Sectoral Perspective

India's experience with Ombudsman-like bodies offers valuable insights. Rather than a single, overarching constitutional authority, a sector-specific redressal mechanism approach has proven effective in addressing unique industry challenges.

11.2.1 Banking Ombudsman

The Banking Ombudsman is a quasi-judicial authority appointed by the Reserve Bank of India (RBI) to provide an accessible and efficient grievance redressal mechanism for customers. It ensures accountability and upholds fair practice standards by adjudicating disputes related to service deficiencies, wrongful charges, and digital transaction failures.

Key features include an informal, consumer-friendly process managed by senior RBI officials. The Ombudsman has the authority to award compensation up to ₹20 lakh, with an additional ₹1 lakh

for mental anguish and expenses, all handled through a centralized RBI processing system for uniform application.

Significance: First operational Ombudsman in India, providing inexpensive and time-bound consumer redressal in financial services.

11.2.2 Insurance Ombudsman

The Insurance Ombudsman serves as a specialized, independent authority to fairly and efficiently resolve disputes between policyholders and insurance companies.

It provides an accessible platform for grievances related to claim repudiation, settlement delays, premium disputes, and misrepresentation. The Ombudsman facilitates resolution through an informal process, prioritizing mediation. It can issue an award of up to ₹50 lakh, which is binding on the insurer but gives the policyholder the option to accept it or pursue other legal remedies if unsatisfied.

Significance: Introduced a specialised grievance redressal system in an evolving sector, balancing consumer protection with insurer accountability, strengthening trust in the sector.

11.2.3 Electricity Ombudsman

The Electricity Ombudsman is a statutory appellate authority that provides a final recourse for consumers dissatisfied with decisions from utility-level Consumer Grievance Redressal Forums (CGRFs).

Appointed by the State Electricity Regulatory Commission (SERC), the Ombudsman ensures that distribution utilities adhere to their legal obligations regarding consumer rights under the Electricity Act, 2003. It adjudicates disputes concerning billing, supply quality, and disconnection through a quasi-judicial but informal process, designed to be inexpensive and swift. The Ombudsman has the authority to issue binding awards, which can include directing monetary compensation, correcting bills, and restoring electricity supply.

Significance: First Ombudsman in India created directly through a parliamentary statute, marking a shift towards statutory recognition of consumer grievance forums.

11.2.4 Pensions Ombudsman

The Pension Ombudsman is a regulatory authority appointed by the PFRDA to address grievances for subscribers of the National Pension System (NPS) and Atal Pension Yojana (APY).

Its primary role is to safeguard subscriber interests in disputes against pension intermediaries such as pension funds, trustee banks, and record-keeping agencies. By providing an accessible, subscriber-centric justice mechanism outside of formal courts, it strengthens fiduciary accountability. The Ombudsman uses a conciliation-focused process but holds the authority to issue binding awards to grant redress, ensuring subscriber entitlements are protected under law.

Significance: Extended Ombudsman principles into retirement-linked financial regulation, enhancing systemic trust in pensions.

11.2.5 Securities Sector (SEBI – SCORES) – A Quasi-Ombudsman Model

The Securities and Exchange Board of India (SEBI) provides a quasi-ombudsman function through its SEBI Complaints Redress System (SCORES).

This online platform is a critical tool for investor protection in the securities market, where investors are often vulnerable in their dealings with listed companies, brokers, and other intermediaries. While not a formal adjudicatory body, SCORES effectively compels these regulated entities to address investor grievances within statutory timelines. This ensures regulatory compliance and provides a powerful mechanism for mediation and dispute resolution.

Significance: Represents adaptation of Ombudsman-like redress principles within the regulatory apparatus.

11.2.6 Telecom Sector (TRAI and TDSAT) – A Quasi-Ombudsman Model

In the Indian telecom sector, a formal Ombudsman is absent; however, a functionally equivalent, multi-tiered grievance redressal mechanism exists to protect consumers.

This system, mandated by the Telecom Regulatory Authority of India (TRAI), requires service providers to first establish internal processes for resolving consumer complaints like billing disputes or poor service quality. If a resolution is not achieved, consumers can escalate their grievances to appellate authorities and ultimately to the Telecom Disputes Settlement and Appellate Tribunal (TDSAT). This layered structure serves as a functional substitute for a traditional Ombudsman, ensuring institutional accountability and a formal channel for dispute resolution.

Significance: Demonstrates Ombudsman like adaptation in high volume consumer industry

These examples collectively establish a compelling precedent for a specialized, accessible, and efficient redressal system tailored to the specific needs of a sector.

11.3 The Case for a Dedicated PNG Ombudsman

As the PNG network expands, consumer grievances related to billing errors, connection delays, metering inaccuracies, and service quality are becoming more common. Although the PNGRB has regulatory powers, its current framework is not equipped to manage these grassroots issues for several reasons:

- **Centralization:** Complaint filing is restricted to PNGRB's headquarters in Delhi, creating a significant geographical and financial barrier for consumers across the country.
- **Inability to Address Minor Disputes:** The formal, quasi-judicial process is not cost-effective or practical for resolving the small-scale yet frequent disputes that most affect households such as billing error and delayed connections.
- **Procedural Delays:** Quorum requirements and procedural formalities can lead to stalled proceedings, leaving consumer grievances unaddressed for extended periods.
- **Consumer Disengagement:** Faced with an inaccessible and unresponsive system, consumers may abandon their PNG connections, undermining trust in the regulator and hindering the adoption of clean energy.

11.4 Policy Recommendations: A Framework for the PNG Ombudsman

To create a consumer-centric, transparent, and accountable PNG sector, the establishment of a dedicated Ombudsman is indispensable. Drawing from sectoral precedents and leading practices, the following can framework is recommended:

1. **Establish a Decentralized Ombudsman System**

   The foundation of reform lies in creating a **dedicated PNG Ombudsman framework** under the regulatory umbrella of PNGRB.

   - **Regional and State-Level Ombudsmen:** Create a network of Regional and State-Level Ombudsmen offices under PNGRB's regulatory authority to ensure geographical accessibility for all consumers. This is to ensure that the consumers from remote or semi-urban areas are not excluded.
   - **Regulatory Backing**: PNGRB should notify clear regulations governing the establishment, jurisdiction, and procedures of the Ombudsman offices to ensure legal certainty.

2. **Define a Clear and Comprehensive Jurisdiction**

   The Ombudsman must be empowered with a clear and comprehensive mandate, covering disputes that are frequent, recurring, and impactful in consumer life.

- **Subject-Matter Jurisdiction:** Should cover all common consumer-facing issues, including billing errors, wrongful disconnections, metering inaccuracies, delays in new connections, poor service quality, and other deficiencies.

3. **Ensure Procedural Simplicity and Consumer Accessibility**

   One of the hallmarks of the Ombudsman model worldwide is its **simplicity and accessibility**. The PNG Ombudsman must embody this principle.

   - **No Legal Representation Requirement:** Proceedings should be informal, with no requirement for legal representation, removing financial barriers for consumers and ensuring inclusivity.
   - **Conciliation and Mediation**: The primary focus should be on conciliation and mediation for swift and amicable resolutions ensuring efficiency and preserve relationships between consumers and entities.
   - **Digital Interface**: A dedicated digital portal and helpline should be established for easy filing, tracking, and resolution of complaints.

4. **Binding Nature of Settlement Agreements**

   For the Ombudsman to be credible, its decisions must carry **real enforceability**.

   - **Binding**: Settlement agreements and awards issued by the Ombudsman must be legally binding on the PNG entities to ensure compliance and accountability.

5. **Institute Robust Oversight and Feedback Mechanisms**

   The effectiveness of the Ombudsman depends not just on its accessibility but also on transparency and accountability.

   - **Annual Reporting to PNGRB:** Each Ombudsman office should submit an annual report to PNGRB detailing complaint statistics, nature of disputes, disposal rates, compliance rates of entities and systemic issues. These reports should be consolidated and published by PNGRB for public.
   - **Systemic Feedback Loop:** Ombudsman report should create a systemic feedback loop, enabling PNGRB to identify recurring problems and refine regulations, and improve industry oversight.
   - **PNGRB's Supervisory Role**: With the Ombudsman handling frontline dispute resolution, PNGRB can refocus on its core regulatory functions like ensuring fair competition, enforcing technical standards, and developing the sector.

11.5 Expected Benefits

The establishment of a PNG Ombudsman would generate far-reaching benefits, extending beyond mere dispute resolution and contributing to the overall strengthening of the natural gas sector. These benefits may be elaborated as follows:

- **Enhanced Accessibility for Consumers and Trust:** A localized and affordable system will make grievance redressal accessible to ordinary households, empower consumers to assert their rights without geographical barriers, restoring confidence in PNG as a reliable utility.
- **Affordability and Reduction in Litigation Cost:** Simple, non-adversarial procedures will ensure timely justice without the burden of high litigation costs.
- **Expeditious Resolution of Disputes:** In disputes over essential services like PNG, prompt resolution is vital to avoid consequences like service disconnection or incorrect billing. The Ombudsman process provides this necessary speed through conciliation and summary adjudication, ensuring timely justice and preventing minor issues from escalating.

- **Restoration of Consumer Confidence in PNG Services:** Due to unresolved grievances, many households may disconnect their Piped Natural Gas (PNG) service. Establishing a fair, impartial, and accessible Ombudsman would reassure consumers that their complaints will be handled effectively, thereby strengthening public trust in PNG's reliability.
- **Strengthening the functioning of PNGRB:** It is suggested that Ombudsman should be created to handle common consumer grievances. This would allow the PNGRB to focus on major policy and complex regulatory issues, leading to a more efficient justice delivery system. Furthermore, this initiative would improve the PNGRB's public image by showing it is a consumer-centric organization that prioritizes citizen welfare.
- **Institutional Accountability for Entities:** A credible and enforceable redressal mechanism will incentivize PNG entities to improve service delivery and adhere to regulatory standards, resulting in higher consumer satisfaction.
- **Promotion of Clean Energy and Policy Goals:** By ensuring a positive consumer experience, the Ombudsman will help retain and grow the PNG user base, contributing to India's clean energy transition.

11.6 Conclusion & key takeaways

While PNGRB functions as the expert regulatory body, its centralized structure and quorum-based operational model present significant impediments to the effective and timely resolution of household-level consumer complaints. This systemic inefficiency leads to widespread consumer frustration, arbitrary disconnections of Piped Natural Gas (PNG) services, and a critical erosion of trust. Such outcomes not only affect individual welfare but also jeopardize India's broader ambition of promoting natural gas as a clean, reliable, and mainstream household fuel.

The establishment of a dedicated PNG Ombudsman is the necessary intervention to correct this imbalance. An Ombudsman would introduce a decentralized and accessible grievance redressal mechanism, thereby lowering resolution costs, expediting outcomes, and systematically rebuilding consumer confidence. This framework would ensure that justice is not distant, expensive or unduly delayed for the average citizen.

Consequently, the institution of a PNG Ombudsman should be viewed not as a regulatory luxury but as a strategic necessity. It is a pivotal reform that will concurrently safeguard consumer rights, enhance the institutional credibility of the PNGRB, and significantly advance India's national clean energy transition.

12

Sectoral Insights into Effective Grievance Redressal Frameworks

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Executive Summary

Effective Grievance Redressal Mechanisms (GRMs) are fundamental to ensuring consumer satisfaction, operational efficiency, and institutional accountability. This paper examines exemplary grievance redressal practices across diverse regulated sectors in India—namely Banking, Telecommunication, Railways, Insurance, and Pensions—to identify strategies relevant to the downstream oil and gas sector. By analyzing these sector-specific approaches, this paper highlights the innovative tools, regulatory frameworks, and consumer-centric policies that have significantly advanced grievance resolution systems.

Key findings indicate a strong trend towards technology integration, such as the Indian Railways' unified "RailMadad" portal and the Reserve Bank of India's (RBI) jurisdiction-neutral Ombudsman Scheme. Similarly, the Insurance Regulatory and Development Authority of India (IRDAI) has implemented a centralized Integrated Grievance Management System (IGMS), while the Pension Fund Regulatory and Development Authority (PFRDA) utilizes a Centralized Grievance Management System (CGMS) with a multi-layered escalation structure. These systems emphasize transparency, accessibility, and time-bound resolutions.

This study synthesizes the critical elements of these successful models, including robust multi-tier escalation frameworks, independent oversight bodies, and proactive consumer awareness campaigns. It also spotlights recent initiatives by the Petroleum and Natural Gas Regulatory Board (PNGRB) to institutionalize consumer protection. The insights and recommendations presented aim to provide a roadmap for strengthening the grievance redressal framework within India's oil and gas sector, fostering greater consumer trust and regulatory excellence.

12.1 Introduction

In an increasingly consumer-centric economy, the efficacy of a grievance redressal mechanism is a key indicator of an organization's commitment to stakeholder trust and accountability. A robust GRM not only facilitates the timely resolution of complaints but also serves as an invaluable feedback loop for enhancing service quality and promoting transparency. Across industries, these mechanisms have evolved from simple complaint-handling functions into strategic assets that leverage technology and regulatory oversight to improve customer satisfaction and loyalty.

This study evaluates the grievance redressal frameworks of several key regulated sectors in India to identify best practices. The analysis is centered on five core principles of an effective GRM:

- **Timeliness:** Prompt resolution to minimize consumer dissatisfaction.
- **Accessibility:** Intuitive and inclusive platforms that cater to a diverse consumer base.
- **Transparency:** Clear, multi-level escalation processes with real-time status updates to build confidence.
- **Technology Integration:** The use of digital platforms, mobile applications, and data analytics to enhance efficiency.
- **Feedback Incorporation:** Systematically leveraging consumer insights to refine policies and services.

By examining the successful implementation of these principles in other sectors, this paper aims to derive actionable insights for the Petroleum and Natural Gas Regulatory Board (PNGRB) and its regulated entities.

12.2 Sector-Specific Grievance Redressal Frameworks

12.2.1 Banking Sector

The banking sector's grievance redressal framework is distinguished by its structured, multi-tiered approach and strong regulatory oversight by the RBI.

- **Multi-Tier Escalation:** The primary path for resolution begins at the branch level and escalates internally to a Nodal Officer and subsequently to a Principal Nodal Officer at the head office. This ensures that complaints are addressed at multiple levels within the regulated entity first.
- **RBI's Integrated Ombudsman Scheme IOS (2021):** A significant reform, the 'One Nation, One Ombudsman' scheme, consolidated three previous ombudsman schemes (1. Banking Ombudsman Scheme, 2006; 2. Ombudsman Scheme for Non-Banking Financial Companies, 2018; and 3. Ombudsman Scheme for Digital Transactions, 2019) into a single, jurisdiction-neutral framework. It provides consumers with a free-of-cost, third-party resolution forum if their complaint is not resolved satisfactorily by the bank within 30 days.
- **RBI's Alternate Grievance Redress (AGR) Framework**: It is designed to efficiently address consumer complaints against regulated entities. It consists of RBI Ombudsmen (RBIOs), who operate under the RB-IOS 2021 scheme, Consumer Education and Protection Cells (CEPCs), which handle cases outside the RB-IOS framework, and the Consumer Education and Protection Department (CEPD), which provides support to the Appellate Authority and manages appeal cases. Together, these components ensure a comprehensive and accessible system for resolving grievances, promoting consumer protection and regulatory accountability in the financial sector.
- **Centralized Complaint Management System (CMS):** The RBI's CMS portal is a single point of contact for lodging complaints against any regulated entity. It centralizes the receipt and initial processing of all complaints, whether submitted online, via email, or in physical form, ensuring streamlined handling.

Key Statistics (FY 2023-24):

- A total of 934,355 complaints were received under the RB-IOS.
- The disposal rate by the Office of the RBI Ombudsman (ORBIOs) was 95.10%.

- Over 88% of complaints were received through digital channels, indicating high consumer adoption of online platforms.

12.2.2 Telecommunication Sector

The Telecom Regulatory Authority of India (TRAI) has established a framework focused on service provider accountability, digital tools, and independent adjudication.

- **The Telecom Consumer Complaints Monitoring System (TCCMS)**: It is an online platform provided by TRAI that allows telecom consumers to lodge, track, and monitor grievances related to telecom services in real-time. While TCCMS facilitates the complaint process and enhances transparency, the primary responsibility for resolving customer complaints rests with the individual telecom service providers.
- **Two-Tier Redressal System:** The initial responsibility for complaint resolution lies with the service provider. If a consumer is not satisfied, they can escalate the issue to a designated Appellate Authority within the company for an independent and time-bound review.
- **Standardized Timelines:** TRAI mandates clear service level agreements (SLAs), requiring service providers to acknowledge complaints within 48 hours and resolve them within 7 days.
- **Digital Tools for Consumer Feedback:** TRAI has launched applications like "MyCall" for rating call quality and "TRAI Analytics" to provide public data on service quality indicators and complaint trends. These tools empower consumers and promote transparency.
- **Telecom Disputes Settlement and Appellate Tribunal (TDSAT):** As an independent judicial body, TDSAT serves as the final appellate authority for disputes, ensuring an impartial review mechanism is available to all stakeholders.

Key Statistics (FY 2023-24):

- 98% of billing and charging complaints were resolved within 4 weeks.
- Service Termination & Closure of Service less than 7 days
- 100% of security deposit refunds were issued within the mandated 60-day period.

12.2.3 Railways Sector

Given its vast scale of operations, Indian Railways has implemented a highly centralized and technology-driven grievance redressal system to serve millions of passengers daily.

- **RailMadad - A Unified Platform:** The "RailMadad" portal and mobile application is a comprehensive, one-stop solution for grievance redressal. It allows passengers to register and track complaints in real-time across various channels, including web, mobile app, helpline (139), email, and social media.
- **Integrated Helpline (139):** This 24/7 helpline, supported by a call center, serves as a single point of contact for all passenger issues and offers support in ten major Indian languages in addition to Hindi and English.

Key Statistics (FY 2023-24):

- The grievance redressal performance remained exceptionally high, with approximately 99.98% of all logged complaints resolved.

12.2.4 Pension Sector (PFRDA)

The Pension Fund Regulatory and Development Authority (PFRDA) has established a robust, multi-layered framework to address grievances for subscribers of the National Pension System (NPS).

- **Four-Level Grievance Redressal Mechanism**: The escalation path is clearly defined:
  1. **Level 1:** Complaint registered with the Central Recordkeeping Agency (CRA) or Nodal Office.
  2. **Level 2:** Escalation to the NPS Trust.
  3. **Level 3:** Appeal to the Ombudsman appointed by PFRDA.
  4. **Level 4:** Final appeal to PFRDA.
- **Centralized Grievance Management System (CGMS):** This digital platform allows subscribers to lodge and track complaints efficiently. It ensures accountability through unique reference numbers, automated alerts, and a mandated 30-day resolution period.
- **Securities Appellate Tribunal (SAT):** For subscribers unsatisfied with the final decision of PFRDA, the SAT provides an independent statutory forum for appeal, ensuring judicial oversight.

Key Statistics (FY 2023-24):

- The CGMS portal handled over 252,155 grievances, resolving approximately 98.6% of them within the year.

12.2.5 Insurance Sector (IRDAI)

The Insurance Regulatory and Development Authority of India (IRDAI) has created a consumer-centric framework focused on technology, awareness, and a clear escalation matrix.

- **Integrated Grievance Management System (IGMS - Bima Bharosa):** This centralized portal acts as a single window for policyholders to register and track complaints, ensuring seamless communication between the consumer, insurer, and regulator.

Grievance process in BIMA BHAROSA

- **Multi-Level Escalation Matrix:** The redressal process follows a clear path: from the insurer's internal mechanism to the IGMS portal, then to IRDAI, and finally to an independent Ombudsman for impartial adjudication.
- **Consumer Awareness Initiatives:** IRDAI actively promotes consumer education through its "Bima Bemisaal" campaign and a dedicated consumer education website, empowering policyholders with information about their rights and the redressal process.

Key Statistics (FY 2023-24):

- While the total number of grievances reported increased from 2.02 lakh in 2022-23 to 2.15 lakh in 2023-24, insurers were able to keep pace in addressing them (over 99% attended both years)

12.3 Spotlight on PNGRB's Consumer-Centric Initiatives

The PNGRB is committed to protecting consumer interests in the downstream oil and gas sector. Recognizing the need for a more structured framework, PNGRB has undertaken several key initiatives:

- **High-Level Expert Committee (HLEC):** An HLEC, chaired by Shri Ratan P. Watal (Former Finance Secretary), was constituted to review the sector's consumer protection framework. The committee's key recommendations included the establishment of an Ombudsman, specific Consumer Protection Regulations, and a unified grievance portal.
- **Strengthening Complaint Redressal:** PNGRB has mandated that City Gas Distribution (CGD) entities submit monthly complaint reports via the PNGRB e-portal. Additionally, a dedicated email (grievance@pngrb.gov.in) has been established as an escalation point for unresolved consumer complaints.
- **Complaint Standardization Committee (CSRM):** An industry committee was formed to develop a uniform classification system for complaints and to propose standardized Service Level Agreements (SLAs) and associated compensation mechanisms.
- **National Consumer Conclave:** PNGRB organized its first National Consumer Conclave in July 2025, bringing together policymakers, consumer groups, and CGD entities to foster dialogue on improving grievance redressal and consumer empowerment.

These initiatives demonstrate PNGRB's proactive approach to building a consumer-centric regulatory environment, drawing from the best practices observed in other sectors.

12.4 Key Recommendations for the Oil & Gas sector

1. **Integrated Grievance Platform:** Establish a unified, sector-wide portal with tracking, escalation, and dashboards for standardized handling.
2. **Consumer Awareness:** Run campaigns to educate consumers on rights and processes, ensuring multilingual accessibility.
3. **Feedback Loops:** Institutionalize surveys and structured channels to gauge effectiveness of grievance redressal.
4. **Collaborative Approach:** Engage regulators, service providers, advocacy groups, and experts to harmonize procedures.
5. **Data & AI Utilization:** Leverage analytics to identify trends, enable predictive interventions, and refine policies for a more resilient, consumer-centric system.

12.5 Conclusion and key takeaways

The examination of the diverse sectors reveals a clear consensus on the foundational elements of an effective grievance redressal mechanism.

Key takeaways

1. **Multi-tier structures are standard:** A layered escalation framework (entity-level → regulator/ ombudsman) is a proven model for ensuring internal accountability before regulatory intervention.
2. **Technology is a key enabler:** Centralized digital platforms (e.g., RailMadad, CMS, IGMS) are critical for providing accessibility, transparency, and efficient, time-bound resolutions.
3. **Independent oversight builds trust:** The presence of an impartial, third-party body like an Ombudsman or an appellate tribunal is essential for enhancing consumer confidence in the fairness of the process.
4. **Proactive Consumer Education is Crucial:** Informing consumers of their rights and the available redressal channels empowers them and encourages the formal logging of grievances.

Conclusion

An effective grievance redressal mechanism is no longer just a procedural formality; it is a strategic imperative for building consumer trust and ensuring regulatory credibility. The best practices observed in India's banking, telecommunication, railways, insurance, and pension sectors offer a clear and compelling blueprint. The common threads of structured multi-tier frameworks, technology-driven centralized platforms, independent oversight, and robust consumer awareness initiatives provide a proven path forward.

For the downstream oil and gas sector, the journey towards a future-ready GRM requires a collaborative approach involving the regulator, service providers, and consumers. By embracing these principles and implementing the recommendations outlined in this study, PNGRB can build a grievance redressal ecosystem that is not only efficient and transparent but also serves as a cornerstone of service excellence and consumer protection in India's energy landscape.

SAFETY MANAGEMENT AND RISK MITIGATION

13

Incident Investigation Methodology, Tools & Techniques

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"An accident is an incident that leads to noticeable consequences and affects humans, environment, society, assets, and reputations in an undesired way."

13.1 Introduction

The oil and gas industry operates in a high-risk environment where incidents such as explosions, fires, leaks, and equipment failures can lead to severe consequences, including loss of human life, environmental damage, and significant financial and reputational impacts. **Incident investigation is a vital process for systematically identifying the immediate events, underlying factors, and root causes of such occurrences.**

Figure: Incident Investigation overview

This paper outlines a structured approach to incident investigation, emphasizing the methodologies and tools that enable organizations to learn from past events, mitigate risks, and prevent recurrence. By employing techniques ranging from fact-finding and timeline reconstruction to in-depth root cause analysis, companies can uncover systemic weaknesses in processes, training, equipment, and safety culture. A thorough investigation not only facilitates the implementation of corrective and preventive actions but also fosters a proactive safety culture, ensures accountability, and aligns with national and international regulatory frameworks such as those from IOGP, OSHA, and PNGRB.

13.2 The Imperative of Incident Investigation

An incident investigation is a systematic process aimed at determining the causes of accidents, incidents, and near misses. The primary objective is to identify the root cause, learn from the event, and implement measures to prevent future occurrences. In the high-stakes oil and gas sector, specialized tools and methodologies are essential for a comprehensive analysis of major incidents.

According to the Center for Chemical Process Safety (CCPS), the main objectives of performing an incident investigation are:

- Discovering what has happened
- Prevent disasters
- Reducing the consequences of disasters if they reoccur
- Identifying root causes and factors contributing to the incident
- Suggesting corrective actions
- Discovering gaps and educational needs
- Correction of performed risk assessment
- Incident risk prioritization

13.3 Types and Impacts of Major Incidents

Incidents in oil and gas facilities can range from fires, explosions, and loss of containment to transportation accidents and equipment malfunctions. Each type of incident presents unique challenges and requires tailored investigative approaches to fully understand the causes. The impact of such events can be catastrophic, leading to fatalities, environmental disasters, regulatory penalties, and lasting damage to a company's reputation.

The Importance of a Robust Incident Investigation

A comprehensive incident investigation is fundamental to:

- **Preventing Future Incidents:** By identifying and addressing root causes, organizations can break the chain of events that lead to accidents.
- **Promoting a Safety Culture:** Thorough investigations demonstrate a commitment to safety, fostering a culture of responsibility and awareness among all personnel.
- **Minimizing Costs:** Preventing incidents helps avoid the substantial costs associated with medical expenses, equipment repair, lost productivity, and legal liabilities.
- **Building Employee Trust and Morale:** When employees see that incidents are taken seriously, it enhances trust, improves morale, and encourages proactive engagement in safety protocols.
- **Ensuring Accountability:** A fair and transparent investigation establishes accountability by identifying whether an incident resulted from individual actions or systemic failures.

"Unpreventable acts account for only 2% of all workplace accidents, Hazardous conditions account for less than 10 % of all workplace accidents & Non-Adherence of SOPs, Inadequate supervision & Violations of Work Permit System account for the 88% of all workplace accidents."

13.4 Understanding the Levels of Causation

To be effective, an investigation must look beyond the immediate events and uncover the deeper, systemic issues that contributed to the incident. Causation can be broken down into three levels:

- **Immediate Causes:** These are the most direct and visible reasons for an incident, such as a worker falling, a machine malfunctioning, or a chemical spill. While easy to identify, they are often symptoms of more significant underlying issues.
- **Underlying Causes:** These are the systemic and organizational factors that contribute to the conditions for an incident to occur. Examples include inadequate training, poorly designed equipment, or insufficient safety policies and procedures. By addressing underlying causes, organisations can significantly improve their safety culture and prevent future incidents.
- **Root Causes:** These are the fundamental, core issues that allow underlying causes to exist. They may include a lack of safety leadership, inadequate resource allocation, communication, or a poor safety culture. Identifying and addressing root causes is essential for making fundamental and lasting improvements to safety culture and prevent incidents from occurring in the future.

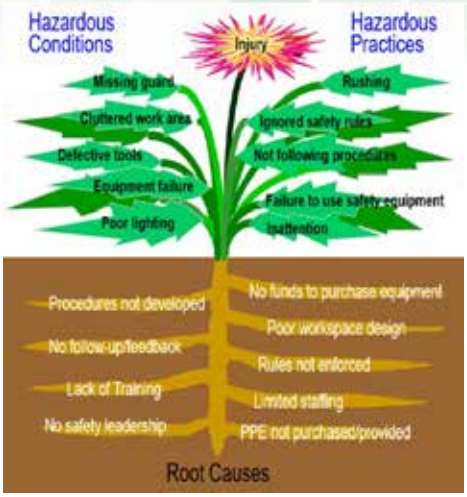

Figure: Incident Root Causes

Several models help to visualize the relationship between these levels of causation, including the **Domino Effect**, which illustrates how accidents result from a chain of sequential events, and the **Swiss Cheese Model**, which shows how failures in multiple layers of defense can align to allow an incident to occur.

The responsibility for the correction of unsafe work practices and conditions in the workplace lies with YOU.

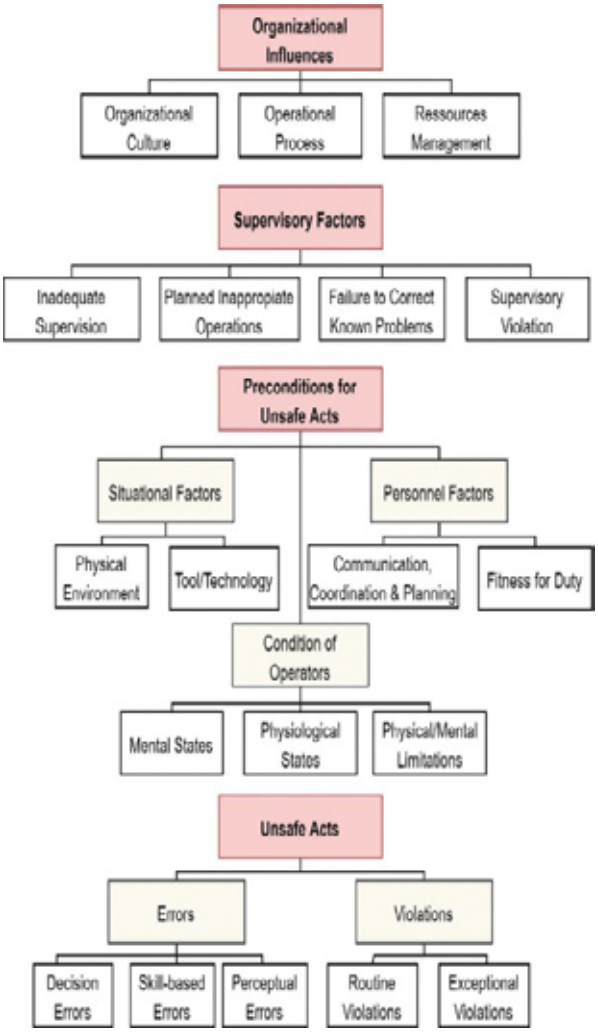

Figure: Model- Levels of Causation

13.5 A Structured Methodology for Incident Investigation

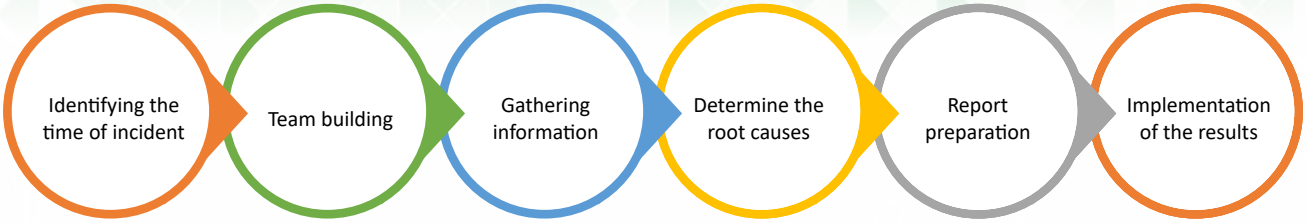

Figure: Incident Investigation Major Steps

A successful incident investigation follows a structured, phased approach to ensure a thorough and objective analysis.

13.5.1.Phase 1: Immediate Response and Team Formation

- **Secure the Scene:** The first priority is to ensure the area is safe and to address any immediate hazards.
- **Assemble the Investigation Team:** A multi-disciplinary team should be formed, including safety officers, engineers, subject matter experts, and a designated team leader. External experts may be engaged if specialized knowledge is required. Further, roles and responsibilities of the team members should be defined.
- **Determine Investigation Depth:** Decide how deep the investigation needs to go based on severity.

13.5.2. Phase 2: Planning and Data Collection

- **Define Scope and Objectives:** Clearly outline the boundaries such as safety, environmental impact, financial loss and goals of the investigation such as identifying root causes, complying with legal requirements.
- **Stakeholder Mapping**: Identify all parties affected by or involved in the incident to ensure comprehensive coverage.
- **Develop a Timeline**: Establish deadlines to keep the process on track.
- **Gather Information:** Collect all relevant data, including witness interviews, equipment logs, maintenance records, photographs, and procedural documents. Interviews should be conducted as soon as possible in a non-intimidating manner.

13.5.3 Phase 3: Analysis and Root Cause Identification

- **Reconstruct the Timeline:** Develop a clear, chronological sequence of events leading up to, during, and after the incident.
- **Conduct Root Cause Analysis:** Utilize established techniques to analyze the collected data and identify the immediate, underlying, and root causes.

13.5.4 Phase 4: Release the Scene

- **Assess Completion of Data Gathering:** Ensure all data has been collected.
- **Preserve Evidence:** Safeguard all physical and digital evidence.
- **Site Remediation:** Repair or clean up any hazards before resuming work.
- **Clearance for Work Resumption:** Approve the site for normal operations to restart.

13.5.5.Phase 5: Corrective Actions and Reporting

- **Develop Recommendations:** Formulate specific, actionable recommendations to address the identified root causes and prevent recurrence.

- **Prepare the Investigation Report:** Compile a comprehensive report that details the facts, findings, analysis, conclusions, and recommendations. The report should be clear, concise, and supported by evidence. Further, potential litigation implications should be considered before finalising the report.

13.5.6. Phase 6: Implementation and Follow-Up

- **Create an Action Plan:** Develop a detailed plan for implementing the recommendations, including assigning responsibilities and setting deadlines, addressing areas like policies, training or equipment.
- **Monitor and Review:** Regularly track the implementation of corrective actions and evaluate their effectiveness to ensure continuous improvement.

13.5.7. Phase 7: Review and Reflect

- Evaluate the investigation process itself to identify areas for improvement.
- Use feedback to refine investigation protocols/ for future incidents

13.6. Key Incident Investigation Techniques

A variety of analytical tools can be used during an investigation to understand the complex interplay of factors that lead to an incident.

- **5W1H and 5 Whys**

The 5W1H and 5 Whys problem-solving methods can be used interchangeably or together. These methods both aim to recognize existing problems and address them by offering effective solutions once the root causes are identified.

Their main difference, however, is that while the method of 5W1H asks other vital details like what, who, when, where, and how, along with why, 5 Whys progressively drills down on the reasons behind the situation until the main cause is identified by asking why 5 times.

If a scenario is too complex that it calls for a more comprehensive analysis, using these two together offers a higher chance in successfully achieving clarity or solution to a problem.

- **Fishbone (Ishikawa) Diagram**

A visual tool that helps to categorize the potential causes of a problem into key areas, such as People, Process, Equipment, and Environment. It is particularly useful for complex incidents with multiple contributing factors.

- **Fault Tree Analysis (FTA)**

A top-down, deductive failure analysis tool that uses a graphical model to map the various pathways that could lead to an incident. FTA is valuable for analyzing high-risk scenarios with multiple interdependent causes.

- **Bowtie Analysis**

A visual tool used to identify risk factors and safety controls. It is particularly useful in understanding how specific hazards can lead to major incidents and what preventive or mitigative measures can be implemented. A diagrammatic approach that connects causes to consequences via preventive and reactive controls.

- **Event and Causal Factor Analysis (ECFA)**

A timeline-based technique that traces the sequence of events and decisions that led to an incident, highlighting where failures or deviations from procedure occurred. It is particularly useful for investigating incidents with a clear sequence of events.

- **Failure Mode and Effects Analysis (FMEA)**

A systematic method for evaluating the potential failure modes of a system and their consequences. It helps to prioritize areas that require attention and improvement in terms of design and operation.

Technique	Key Advantage	Ideal Usage
5 WHYs/5W1H	Simple, iterative problem-solving technique	When the problem is straightforward
Ishikawa/ Fishbone Diagram	Visual representation of complex relationships	When there are many possible causes to a problem
Fault Tree Analysis (FTA)	Visual mapping of causal chains	High-risk industries where prevention is crucial
Event and Causal Factor Analysis (ECFA)	Timeline based	Investigating incidents with a clear sequence of events.
Bowtie Analysis	Diagrammatic	Connects causes to effects
FMEA	Proactive, preventative approach	Complex processes that could lead to serious consequences if failed

Table: Summary of key incident investigation techniques and their benefits

13.7 Regulatory Framework and International Standards

13.7.1 Petroleum and Natural Gas Regulatory Board (PNGRB), India

Incident investigations in the Indian oil and gas sector are guided by the procedures established by the **Petroleum and Natural Gas Regulatory Board (PNGRB)**. These procedures mandate a structured approach, including the submission of preliminary and final investigation reports.

1. Information of Incident	2. Analysis of Incident	2. Analysis of Incident
• Incident Reporting through Media (Social/Print) • Incident Reporting by Entity within 4hrs • Clarification from Entity about category: Major/Minor as per ERDMP Regulation clause 23.2 • Entity to submit Schedule VI within 48 hrs • Information to Board about the incident	• Thorough analysis of reported Major Incident at Board Level • Decision by Board to set up PNGRB Investigation committee • Mail to Entity for Internal enquiry seeking Preliminary & Detailed Investigation Report within 7 & 30 days	• In case PNGRB Board decides for its Investigation Committee, following actions are required: • Team Formation • Office order • ToR of the Investigation committee • Information to Entity about the plan & office order

4. Site Visit	5. Briefing at Site	6. Inspect Incident Location
• Seeking entire set of documentation from entity during movement to site • Internal planning within PNGRB Investigation Team • Identification of Nodal officer & Plant/location Incharge	• Briefing by Entity about the incident • Documents & facts sharing by Entity • Interviewing witnesses, supervisors, co-workers, victims & family • Recording of statements • Asking for Third Party/ external agency's presence, if necessary	• Visit to the actual Incident location • Visit to Hosiptal or District authorities • Photography/ Recording • Sketching /Labelling • Recreating the scene • Interviewing additional stakeholders, if deemed necessary based on seeing the incident site
7. Conclusion of Site Visit	**8. Report Submission**	**9. Compliances**
• Visit conclusion by seeing the facts, documents & interviewing witnesseses • Demand of additional documents, witness statements, if necessary	• Submission of Preliminary & Detailed Investigation Reports • Typical Report Contents • Background • Brief of incident • Methodology • Analysis of Incident • Observations/ RCA • Recommendations	• Presentation to PNGRB Board • Letters to Third Party/ Statutory Bodies, if required • Final Investigation Report by Entity & PNGRB within 30 days • Entity's Board Approved ATR submission to PNGRB • Letter to Entity for Compliance in 45 Days.

Figure: PNGRB Procedure for Incident Investigation

13.7.2 International Bodies & their approach of Investigation

Globally, organizations like the **International Association of Oil & Gas Producers (IOGP)** and regulations such as the **European Union's Seveso Directive** and the **United States' OSHA standards** provide comprehensive frameworks for incident investigation.

The International Association of Oil & Gas Producers (IOGP) Guidelines

The IOGP is a global industry association that provides guidance on safe operations in the oil and gas sector. Their guidelines for incident investigation emphasize the following:

- Reporting and Analysis of Incidents
- Root Cause Analysis (RCA)
- Blame-Free Culture

European Union's Seveso Directive (Major Accident Hazard Legislation)

The Seveso Directive, implemented by the European Union, establishes stringent requirements for investigating incidents in industries involving hazardous substances like those found in oil and gas operations. Its focus areas include:

- Identification of Immediate and Root Causes
- Post-Incident Analysis and Continuous Improvement

United States OSHA Standards

In the United States, OSHA standards provide a detailed framework for conducting investigations,

- Root Cause Analysis (RCA) and Failure Mode Effects Analysis (FMEA)
- Corrective and Preventive Action (CAPA)

Incidents led to shaping the safety landscape of the oil and gas industry and their lessons

A. Deepwater Horizon (2010)

Investigation Approach: Use of **RCA** and **FTA** to understand equipment failure, human error, and organizational issues. Recommendations focused on improving blowout preventer designs, operational procedures, and safety culture.

B. Texas City Refinery Explosion (2005)

Investigation Approach: Used **FMEA** and **RCA** to assess the breakdown of safety systems and failure to recognize high-risk conditions.

13.8 Key Takeaways

- **Systematic Approach is Crucial:** A structured and methodical investigation is essential for accurately identifying the root causes of an of accidents, incidents, or near misses to prevent recurrence and enhance overall safety.
- **Focus on Prevention, Not Blame:** The ultimate goal of an investigation is to learn from failures and prevent recurrence. The approach emphasizes promoting a safety culture, ensuring accountability, and complying with regulatory requirements, such as those outlined by PNGRB, IOGP, OSHA, and international safety standards. A blame-focused approach can hinder open communication and obscure the facts.
- **Go Beyond the Immediate Cause:** Effective investigations delve deep to uncover the underlying systemic and organizational factors, and root causes such as fundamental cultural and leadership deficiencies to comprehensively address the factors that contribute to incidents.
- **Utilize a Range of Tools:** Different analytical techniques are suited for different types of incidents. A skilled investigation team will select the most appropriate tools for the situation.
- **Implementation of corrective and preventive actions is Key:** An investigation is only successful if its recommendations are translated into concrete corrective and preventive actions that are implemented, monitored, and sustained over time.

Oil and gas companies should embrace a rigorous, learning-focused approach to incident investigations, and diligently implementing corrective and preventive actions. This holistic approach not only minimizes the recurrence of similar incidents but also strengthens organizational resilience, protects people and the environment, and is fundamental to achieving safe and sustainable operations.

14

Judicial Interventions and Safety Imperatives in India's Oil and Gas Sector

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14.1 Introduction

India's oil and gas sector plays a pivotal role in the nation's energy security and economic growth. However, its operations—spanning exploration, production, processing, and transportation—are accompanied by significant safety challenges. A history of major incidents, from refinery fires and offshores blowouts to hazardous material transport accidents, has resulted in loss of life, environmental degradation, and substantial economic disruption.

In response to these events, the Indian judiciary has frequently exercised its authority, often taking *suo moto* (on its own motion) cognizance to address systemic safety failures and lapses in regulatory oversight. The courts have consistently reinforced the principle that industrial and energy-related activities must not compromise public safety or environmental sustainability.

This judicial activism aligns with the core mandate of the Petroleum and Natural Gas Regulatory Board (PNGRB), established under the PNGRB Act, 2006. The PNGRB Act 2006 under Section 11 sub clause (i), mandates that, the Board shall lay down, by regulations, the technical standards and specifications including safety standards in activities relating to petroleum, petroleum products and natural gas, including the construction and operation of pipeline and infrastructure projects related to downstream petroleum and natural gas sector. This mandate has led to the creation of critical regulatory frameworks, including:

- Technical Standards and Specifications including Safety Standards (T4S Regulations)
- Emergency Response and Disaster Management Plan (ERDMP Regulations)
- Integrity Management System (IMS Regulations)
- Third-Party Conformity Assessment (TPCA Regulations)

This paper analyzes some of the most significant incidents where judicial intervention has been pivotal. It aims to highlight systemic gaps, critical lessons from these events and identify key takeaways for strengthening the regulatory framework governed by PNGRB.

14.2 Landmark Incidents and Judicial Observation

14.2.1 Visakhapatnam Gas Leak (2020)

On May 7, 2020, a catastrophic styrene gas leak occurred at the LG Polymers' plant in Visakhapatnam, Andhra Pradesh, leading to widespread panic, mass hospitalizations and multiple fatalities. The incident took place shortly after the plant resumed operations following the COVID-19 lockdown without conducting proper safety checks.

- **Identified Lapses:** Investigations revealed multiple safety failures, including improper storage of chemicals, malfunctioning refrigeration systems, a polymerization reaction, and a lack of emergency preparedness.
- **Judicial Intervention:** The Andhra Pradesh High Court intervened swiftly, suspending operations, seizing records, and ordering an inquiry. Subsequently, The National Green Tribunal (NGT) further held LG Polymers absolutely liable for loss of life and environmental damage, invoking the **Polluter Pays Principle**. The case reinforced the judiciary's stand that human life and environmental health cannot be compromised by industrial negligence.

14.2.2 Baghjan Oil Well Blowout, Assam (2020)

On May 27, 2020, a well operated by Oil India Ltd. (OIL) in Baghjan, Assam, suffered a major blowout, which ignited a massive fire. The disaster displaced over 9,000 people and caused extensive property and ecological destruction in the Dibru-Saikhowa National Park.

- **Identified Lapses:** A probe initiated by the judiciary identified significant deviations from safety protocols, failure of the blowout prevention system, and violations of biodiversity norms.
- **Judicial Intervention:** The NGT took *suo moto* cognizance, directing OIL to deposit ₹25 crore as interim compensation and appointing the Justice B.P. Katakey Committee to investigate. The judiciary's observations emphasized corporate accountability and mandated strict compliance with both environmental and operational safety laws.

14.2.3 Pasarlapudi Blowout, Andhra Pradesh (1995)

During exploratory drilling by ONGC in the Krishna-Godavari basin, an uncontrolled gas release triggered a massive fire that burned for over a month. The incident required the evacuation of thousands and caused widespread environmental damage.

- **Identified Lapses:** The disaster revealed severe inadequacies in upstream safety mechanisms, particularly the lack of effective Blowout Preventers (BOPs) and poor crisis management.
- **Regulatory Precedent:** This incident became a catalyst for systemic safety reforms in India's oil and gas exploration sector. Regulatory authorities

subsequently mandated the compulsory use of BOPs and instituted periodic safety audits for all drilling operations.

14.2.4 Mumbai High North Platform Fire (2005)

In July 2005, a collision between a supply vessel and ONGC's Mumbai High North offshore platform resulted in a devastating fire that claimed 22 lives and destroyed the platform.

- **Identified Lapses:** Investigations highlighted critical offshore safety lapses, including the absence of immediate firefighting support vessels and poorly coordinated evacuation procedures.
- **Regulatory Precedent:** In the aftermath, ONGC instituted robust safety protocols, including mandatory 24/7 firefighting support and stricter platform access controls. The Directorate General of Hydrocarbons (DGH) also issued mandatory offshore safety advisories.

14.2.5 Chala LPG Tanker Disaster, Kerala (2012-2013)

A road accident involving an LPG tanker near Chala, Kerala, resulted in a fire and explosion that killed 20 people and caused severe injuries to many others.

- **Identified Lapses:** The inquiry found that the accident was caused by poor vehicle maintenance and violations of regulations governing the transportation of hazardous goods.
- **Judicial Intervention:** In *K.B. Joy v. State of Kerala*, the Kerala High Court directed substantial compensation for victims and mandated long-term systemic reforms. These included stricter licensing for hazardous goods transport, promoting LPG transport by rail, and establishing new bottling units near railway hubs to minimize road transport.

14.2.6 Jaipur-Ajmer Highway LPG Tanker Blast (2024)

A collision involving an LPG tanker on the Jaipur-Ajmer highway led to a major fire, resulting in 14 fatalities and significant property damage.

- **Identified Lapses:** The incident exposed negligence in road safety management and the enforcement of disaster management protocols for hazardous cargo routes.
- **Judicial Intervention:** The Rajasthan High Court took *suo moto* cognizance and issued sweeping directives, including an inquiry against negligent authorities, adequate victim compensation, shifting of hazardous factories and godowns away from residential areas. In addition, directed strict implementation of disaster management laws and road safety improvements, including elimination of dangerous U-turns and better planning for hazardous cargo routes. The judgment reinforced the shared responsibility of state and central governments to prevent such incidents through proactive measures.

The series of judicial interventions across incidents like the Visakhapatnam Gas Leak, Baghjan Blowout, Mumbai High Fire, and LPG tanker disasters reveal a consistent stance of the Indian judiciary: industrial and energy activities cannot endanger human life or the environment. Courts have invoked principles such as **absolute liability** and the **Polluter Pays Principle**, while also directing systemic reforms in safety oversight, compensation mechanisms, hazardous cargo management, and environmental safeguards.

14.3 Key Takeaways and Strategic Imperatives for PNGRB

The examined incidents reveal recurring themes of inadequate safety oversight, weak corporate accountability, and gaps in regulatory enforcement. For PNGRB, the following interventional reforms are crucial:

1. **Strengthen Proactive Oversight:** Transition from periodic checks to a system of continuous, real-time compliance monitoring and stringent, unannounced safety audits.
2. **Mandate Quantitative Risk Assessments (QRA):** Require comprehensive QRA as a prerequisite for all project approvals to scientifically evaluate potential hazards and ensure mitigation measures are in place.
3. **Establish a Transparent Accident Reporting System:** Develop a centralized, publicly accessible mechanism for reporting all incidents, with significant penalties for non-compliance or concealment.
4. **Promote Public Safety Engagement:** Mandate that regulated entities conduct community awareness programs and regular, publicly-attended mock emergency drills in high-risk areas.
5. **Enhance Enforcement Powers:** Seek necessary amendments to the PNGRB Act to strengthen the Board's authority to impose deterrent penalties and revoke licenses for persistent safety violations.
6. **Foster Cross-Agency Coordination:** Lead the formation of integrated task forces involving central, state, and local agencies to ensure rapid and unified inspections and emergency response.
7. **Drive Digitization of Compliance:** Leverage AI and IoT-based technologies for real-time monitoring of critical infrastructure, enabling predictive maintenance and immediate anomaly detection.
8. **Institutionalize Post-Accident Audits:** Ensure that findings from every incident are systematically analyzed and integrated into evolving safety standards and operational codes.
9. **Implement a Robust Third-Party Inspection Regime:** Mandate audits by accredited independent agencies, with findings publicly disclosed to enhance transparency and accountability.
10. **Advance Capacity Building:** Develop mandatory certification programs for all personnel working in hazardous zones and continuously upgrade the technical expertise within PNGRB.

14.4 Conclusion

The Petroleum and Natural Gas Regulatory Board (PNGRB) ensures the uniform application of technical standards across the sector, prioritizing the safety of personnel, the public, and associated facilities. This is achieved through a comprehensive regulatory framework.

- **Emergency Response and Disaster Management Plan (ERDMP) Regulations:** These mandate the creation of concise plans for rapid emergency mitigation. The primary goals are to prevent the escalation of incidents, minimize harm to people, and reduce damage to property and the environment through a state of constant preparedness.
- **Integrity Management System (IMS) Regulations:** These regulations focus on proactive risk assessment to effectively allocate resources for prevention, detection and mitigation. The objective is to improve infrastructure safety and streamline operations to minimize the probability of system failures.

- **Third-Party Agency (TPA) Regulations:** These establish a mechanism for assessing entity compliance with all regulations. This conformity assessment is conducted either by the Board itself or by approved third-party agencies, for which the regulations specify clear eligibility and procedural criteria.

The proactive role of the Indian judiciary in addressing safety failures within the oil and gas sector highlights the gravity of these issues. Courts have consistently affirmed that corporate interests and the pursuit of industrial growth cannot supersede the fundamental rights to life and a safe environment.

For a regulator like PNGRB, these judgments are not merely critiques of past failures but a clear directive for the future of regulation. The imperative is to accelerate the transition from a reactive, incident-based approach to a **proactive, technology-driven, and community-centric safety framework.** By internalizing these lessons and fostering a culture of uncompromising safety and accountability, India can better secure its energy future while safeguarding its citizens and environment from preventable disasters.

15

PRISM: A Unified Framework for Process and Safety Management in India's Downstream Oil and Gas Sector

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15.1 Introduction

In industries managing hazardous materials and complex processes, safety is an absolute necessity. History provides stark reminders that the failure of safety management systems can lead to catastrophic outcomes. The 1984 Bhopal gas tragedy and the 2010 Deepwater Horizon oil spill, though decades apart, share a common lesson: inadequate risk management, poor maintenance, and a weak safety culture can result in devastating loss of life, environmental damage, and economic ruin.

These events, and others like them, have driven the evolution of structured safety frameworks. Learning from past failures is critical to preventing their recurrence.

In this spirit, Process Safety Management (PSM) and Safety Management Systems (SMS) were developed as two critical frameworks to enhance safety, mitigate risks, and ensure the integrity of industrial operations. While PSM focuses on preventing hazardous incidents within process industries, SMS provides a broader, structured approach to managing safety across an entire organization.

> ***"Those who don't know history are destined to repeat it."***
>
> ***- Edmund Burke***

This paper explores the synergy between these two frameworks and proposes an integrated model—Process Risk & Integrated Safety Management (PRISM)—as a holistic and streamlined approach for India's downstream oil and gas sector.

15.2 The Evolution of Safety Management: From PSM to SMS

The core causes of major process safety incidents often lie in hidden risks, inadequate leading and lagging indicators, and a "normalization of deviation" where unsafe conditions are gradually accepted. Both PSM and SMS are built on lessons from past incidents to prevent future recurrences.

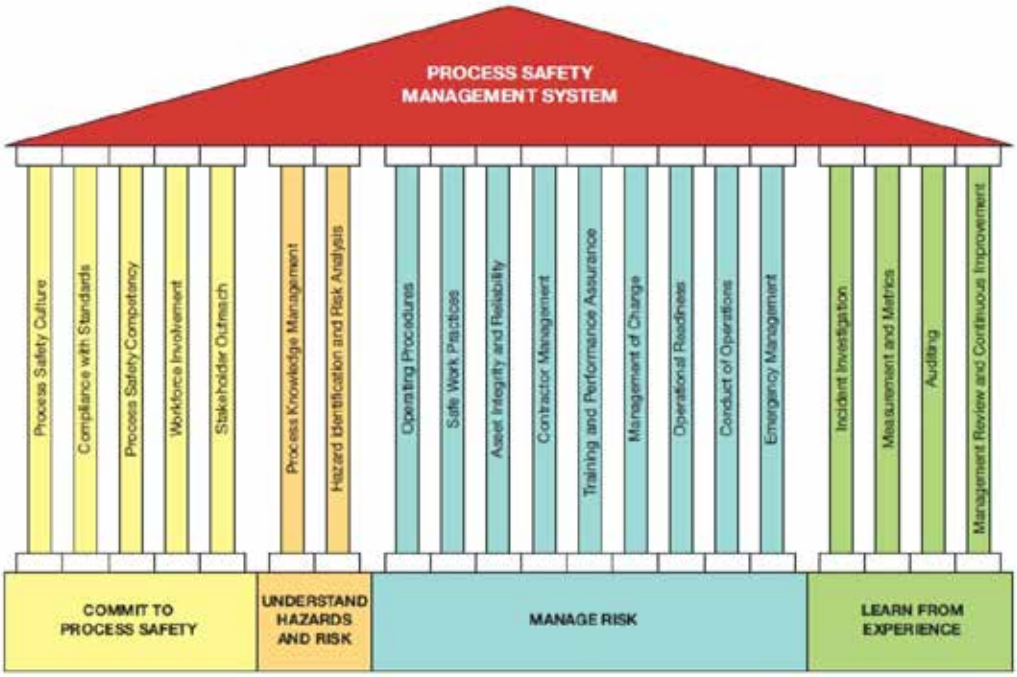
15.2.1 Process Safety Management (PSM)

PSM emerged from a need for comprehensive regulation following major industrial accidents like those in Flixborough (UK, 1974), Seveso (Italy, 1976), and Bhopal (India, 1984). It is a detailed, analytical framework for managing the integrity of operating systems and processes that handle

highly hazardous substances. Promulgated by OSHA in 1992, the PSM standard consists of 14 interconnected elements, including Process Hazard Analysis (PHA), Mechanical Integrity, and Management of Change (MOC).

Over time, this evolved into Risk-Based Process Safety (RBPS), a 20-element framework developed by the Center for Chemical Process Safety (CCPS). RBPS is structured around four pillars:

1. **Commit to Process Safety:** Establishing a strong safety culture.
2. **Understand Hazards and Risk:** Identifying and analyzing potential dangers.
3. **Manage Risk:** Implementing robust control measures.
4. **Learn from Experience:** Investigating incidents and driving continuous improvement.



15.2.2 Safety Management System (SMS)

SMS is a formal, top-down, organization-wide approach to managing safety risk. It provides the overarching structure—the policies, procedures, and practices—to ensure that safety is embedded in all business operations. A typical SMS is built on four components:

1. **Safety Policy and Objectives:** Defining management commitment and organizational goals.
2. **Safety Risk Management:** A formal process for hazard identification and mitigation.
3. **Safety Assurance:** Monitoring and measuring safety performance through audits and reviews.
4. **Safety Promotion:** Fostering a positive safety culture through training and communication.

Essentially, while PSM provides the technical "what" for managing process hazards, SMS provides the organizational "how" to ensure it happens consistently and effectively.

15.3 PSM and SMS in PNGRB's Regulations

The PNGRB has integrated key safety management principles into its Technical Standards and Specifications for Midstream and Downstream Infrastructure (T4S Regulations). Regulations for LNG Facilities, LPG Bottling Plants, Petroleum Installations, and Refineries & Gas Processing Plants mandate an SMS based on the Plan-Do-Check-Act (PDCA) cycle.

Many core elements of PSM—such as Process Hazard Analysis, MOC, and Mechanical Integrity—are already embedded within these regulations, particularly under the 'Operational Control' part of the PDCA cycle. However, PSM is only explicitly named and structured as a complete framework in the T4S Regulations for Refineries and Gas Processing Units. This creates an opportunity for a more uniform and integrated approach across the entire sector.

15.3.1 The Case for Integration: Introducing PRISM

While PSM provides technical rigor and SMS offers organizational structure, they have several overlapping elements. Implementing them as separate systems can lead to duplication of effort and potential gaps. A unified system is needed to merge these frameworks and address people, process, and technology under a single, cohesive umbrella.

PRISM (Process Risk & Integrated Safety Management) is a proposed model that combines the strengths of both systems into a streamlined, six-pillar framework.

The Six Key Pillars of PRISM:

1. **Leadership & Governance:** Securing management commitment, defining accountability, and integrating safety policy into core business goals.
2. **Hazard & Risk Management:** Unifying hazard identification processes, from technical PHAs to broader organizational risk assessments.
3. **Operational Controls & Asset Integrity:** Ensuring robust safe work practices, mechanical integrity, management of change, and contractor safety.
4. **Emergency Preparedness & Response:** Developing unified response plans and conducting drills to ensure readiness.
5. **Learning & Continuous Improvement:** Fostering a culture of learning through incident investigation, audits, and systematic feedback loops.
6. **Digital Integration & Reporting:** Leveraging technology for centralized dashboards, predictive analytics, and real-time risk monitoring.

15.3.2 Benefits and Challenges of the PRISM Framework

Adopting the PRISM model offers significant advantages, but also presents implementation challenges.

Key Benefits:

- **Simplification and Clarity:** Condenses overlapping elements into a clear, six-pillar framework, making it easier for entities of all sizes to adopt.
- **Holistic Risk Management:** Bridges the gap between technical process safety and organizational safety culture, addressing people, processes, and technology in tandem.
- **Regulatory Consistency:** Creates a common safety language and framework for all segments of the downstream oil and gas sector.
- **Performance-Driven Culture:** Shifts the focus from mere compliance to proactive safety performance by encouraging the use of leading and lagging indicators.
- **Future-Ready Framework:** Incorporates digital transformation, enabling real-time monitoring, predictive analytics, and data-driven decision-making.

Implementation Challenges:

- **Overcoming Legacy Systems:** Migrating from manual or outdated systems to integrated digital platforms can be time-consuming and resource-intensive.
- **Ensuring Management Commitment:** Leadership must champion safety as a core value, not just a compliance requirement, to avoid a "tick-box" culture.
- **Developing Robust Metrics:** Entities must establish and track a comprehensive set of performance indicators (both leading and lagging) to effectively anticipate and prevent incidents.
- **Addressing "Normalization of Deviation":** A proactive culture is needed to combat the tendency to accept minor deviations, which can lead to catastrophic failures over time.
- **Achieving Uniform Adoption:** Ensuring consistent implementation and regulatory oversight across all downstream segments requires a concerted effort.

15.4 The Way Forward: A Roadmap for Adoption

To effectively implement PRISM across the downstream oil and gas sector, a multi-pronged approach is recommended:

1. **Mandate Detailed Safety Reports:** Entities should be required to prepare detailed annual Safety Reports that demonstrate the effectiveness of their PRISM system, including performance metrics and risk mitigation strategies.
2. **Strengthen Audit Capabilities:** Audit protocols for Third-Party Inspection Agencies (TPIAs) should be revised to assess the maturity of an entity's PRISM implementation, moving beyond simple checklists to evaluate the overall safety culture.
3. **Promote Performance-Based Safety:** Encourage the use of a balanced set of safety indicators. This includes leading indicators (e.g., inspection compliance rates, audit finding closure rates) and lagging indicators (e.g., Process Safety Incident Frequency, Loss of Primary Containment events).
4. **Foster Stakeholder Engagement:** Organize industry-wide workshops and awareness programs to promote the value of integrated safety systems and share best practices.
5. **Incorporate PRISM Uniformly in Regulations:** Embed the PRISM framework consistently across all PNGRB Technical Standards to close existing regulatory gaps and ensure a uniform approach to safety management. A phased adoption plan with prioritized elements for each downstream segment is advisable.

While some industries like Refineries for instance are already effectively practicing PSM, inconsistencies remain across the broader downstream oil and gas sector. To address these regulatory and operational gaps, it is recommended that the entire downstream Oil & Gas installations adopt PRISM in a phased manner. To facilitate this, an indicative list of the most critical elements, prioritized for each downstream segment, is provided below:

Vertical	Predominant hazards	Elements to be treated as "utmost priority"
Refineries & GPUs	Processing of flammable/ toxic hydrocarbons, high-pressure systems, chemical reactions, explosions, fires, loss of containment.	1) PHA & HIRA 2) Mechanical Integrity 3) Work Permit 4) Operating Procedures (start-up, shutdown, abnormal/emergency operations) 5) Management of Change 6) Pre-Startup Safety Review 7) Emergency Planning & Response (fire, explosion, toxic release scenarios) 8) Contractor management 9) Training & Competence development 10) Incident Investigation & Learning 11) Compliance Audit 12) Digital Integration & Reporting
LNG facilities	Cryogenic releases, rapid phase transition, boil-off gas, ship/road loading-unloading, etc.	1) PHA (cryogenic/overpressure scenarios) & HIRA 2) Mechanical Integrity (tanks, valves, loading arms, hoses) 3) Operating procedures 4) Pre-Startup Safety Review 5) Emergency Planning and Response 6) MOC 7) Training & Drills 8) Work Permit 9) Incident Investigation 10) Compliance Audit 11) Digital Integration & Reporting
NGPL (Natural Gas Pipelines)	Line rupture, Flammable Gas Leak/ignition, Third-party damages, corrosion, Control Systems/SCADA anomalies, etc.	1) HIRA 2) Asset Integrity (Corrosion control/CP, Pigging, leakages, valves, line isolation) 3) Emergency Planning and Response (fire, mutual aid) 4) MOC (set-points, stations, SCADA changes) 5) Operating procedures (start-up/shutdown, line pack management) 6) Contractor management & Work Permit 7) Training & drills 8) Incident investigation 9) Compliance Audit 10) Digital Integration & Reporting

PPPL (Petroleum & Petroleum Products Pipelines)	Line rupture, Product Leak, Flammable Liquid Leak/ignition, Third-party damages, corrosion, Control Systems/SCADA anomalies, etc.	1) HIRA 2) Asset Integrity (corrosion control/CP, leakages) 3) Emergency Planning and Response (fire, spill containment, mutual aid) 4) Process Safety Information 5) Operating procedures 6) MOC 7) Contractor management & Work Permit 8) Training & drills 9) Incident investigation 10) Compliance Audit 11) Digital Integration & Reporting
CGD (City/Local Gas Distribution)	Public interface, Third-party damage, Flammable Gas Leakage/ignition, Non-odorization, high-pressure CNG hazards, etc.	1) Process Safety Info 2) Mechanical Integrity (leak surveys, odorization, CP) 3) Emergency Planning & Response 4) Operating procedures 5) PTW (excavation/hot work in public areas) 6) Contractor management 7) Training/competence & public awareness 8) Incident investigation & learning 9) Compliance Audit 10) Digital Integration & Reporting
Retail Outlets (RO)	Frequent contractor activity, ignition sources, confined spaces, etc.	1) Contractor management & supervision 2) Operating procedures (fuel receipt/dispensing, tank entry) 3) Emergency Planning & Response (Fire/spill, public/crowd management) 4) Training/competence 5) Incident investigation 6) Digital Integration & Reporting
LPG storage, handling & bottling	Catastrophic vessel release, BLEVE, filling operations, truck loading, etc.	1) PHA & HIRA 2) Mechanical Integrity (vessels, bullets, valves/PRVs) 3) Work Permit 4) Operating procedures (filling, truck loading/unloading) 5) Emergency planning & Response (BLEVE scenarios) 6) MOC 7) Contractor management 8) Training/competence 9) Incident investigation 10) Compliance Audit 11) Digital Integration & Reporting

Petroleum Installations (POL depots/terminals, incl. Aviation Fueling Stations)	Overfill/overflow, truck rack fires, Leakage and Ignition, tank farm integrity, hydrant systems, airport proximity, ATF spill/fire scenarios, etc.	1) PHA & HIRA 2) Operating procedures (receipts/transfers/overfill prevention, hydrant/apron operations, bonding/ earthing) 3) Mechanical Integrity (tanks, floating roofs, hydrant pits, refuellers, hoses, firewater/foam systems) 4) Emergency planning & response (firewater/foam, evacuation, coordination with airport fire service/ DGCA at AFS) 5) Work Permit 6) Contractor management 7) MOC 8) Training/competence 9) Incident investigation 10) Compliance Audit 11) Digital Integration & Reporting

15.5 Conclusion and Key takeaways

The oil and gas sector operates in a high-hazard environment where safety depends on both organizational discipline and technical rigor. While traditional PSM and SMS frameworks have provided a strong foundation, their complexity can limit practical adoption.

PRISM – Process Risk & Integrated Safety Management – offers a streamlined, six-pillar approach that unifies these systems into a clear and trackable model. By bridging technical process safety with organizational governance and incorporating digital integration, PRISM provides a dynamic framework that moves beyond compliance. It fosters a culture of resilience and continuous improvement, enabling the sector to adapt to evolving risks and technologies. The adoption of PRISM will not only enhance safety performance but also strengthen trust, accountability, and operational excellence across the entire oil and gas value chain.

16

Enhancing Integrity Management for City Gas Distribution Networks

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16.1 Executive Summary

City Gas Distribution (CGD) networks are critical infrastructure for delivering Compressed Natural Gas (CNG) and Piped Natural Gas (PNG) to transport, residential, commercial, and industrial consumers across India. Given the inherent risks of gas distribution, a robust Integrity Management System (IMS) is essential for ensuring public safety, operational reliability, and environmental protection.

In India, the PNGRB oversees and regulates the functioning of CGD networks and has notified the PNGRB (Integrity Management System for City or Local Natural Gas Distribution Networks) Regulations, 2013, to uphold network integrity through proactive risk identification, rigorous safety standards, and regular system audits. This system is built on proactive risk identification, rigorous safety standards, and comprehensive system audits.

This paper benchmarks India's IMS regulations against a leading international standard: the Gas Distribution Integrity Management Program (DIMP) established by the Pipeline and Hazardous Materials Safety Administration (PHMSA) in the United States. The comparison reveals opportunities to strengthen India's framework through more granular asset segmentation, structured performance metrics, and a data-driven risk management process.

Based on this analysis, the following key recommendations are proposed to enhance the PNGRB IMS regulations:

- **Introduce Risk Zoning:** Require CGD operators to categorize pipelines and assets into distinct regions based on similar characteristics (e.g., material, environmental factors, population density). This will enable the development of targeted and more effective risk mitigation strategies.
- **Specify Key Performance Indicators (KPIs):** Mandate a set of specific, measurable performance indicators—such as the number of hazardous leaks repaired (categorized by cause) and third-party excavation damages—to objectively evaluate the effectiveness of an operator's integrity management program.
- **Mandate Annual Performance Reporting:** Require all CGD operators to submit annual reports detailing their performance against the specified KPIs. This will enhance regulatory oversight and foster a culture of continuous improvement.

Adopting these recommendations will elevate India's CGD safety standards, aligning them with global best practices and reinforcing the nation's commitment to energy security and public welfare.

16.2. Introduction

CGD networks form the backbone of clean energy access in urban India, supplying natural gas for transport, domestic, commercial, and industrial use. The operational complexity and inherent risks associated with transporting natural gas necessitate a systematic approach to asset integrity. An IMS provides this crucial framework, focusing on the proactive identification, assessment, and mitigation of risks that could compromise the safety, reliability, and performance of the distribution network.

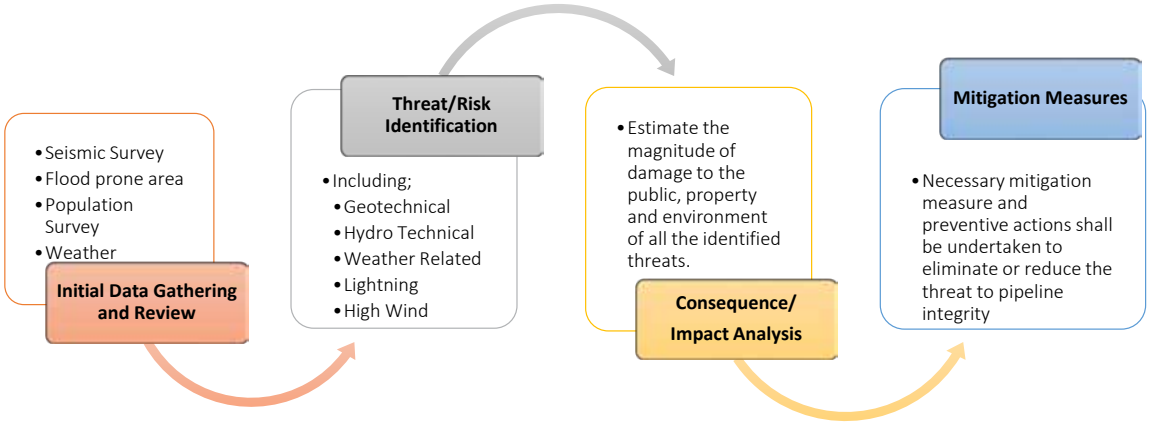
The PNGRB, as the sector's regulatory authority, established the legal foundation for this with the **PNGRB (Integrity Management System for City or Local Natural Gas Distribution Networks) Regulations, 2013**. These regulations aim to ensure that network safety is continuously upheld and risks are minimized.

This study analyzes the current PNGRB framework and benchmarks it against international best practices, specifically the regulations in the United States, to identify actionable insights for strengthening India's approach to CGD network safety.

16.3. Overview of India's PNGRB Integrity Management System (IMS)

Established under the PNGRB Act of 2006, the PNGRB regulates the midstream and downstream petroleum and natural gas sectors. A core part of its mandate is ensuring technical compliance and safety across the expanding CGD landscape, which now covers nearly the entire geographical area of the country. The primary objectives of the PNGRB IMS Regulations, 2013, are to:

- Evaluate risks systematically and allocate resources effectively toward prevention, detection, and mitigation.
- Enhance the safety of CGD networks to protect personnel, the public, property, and the environment.
- Promote streamlined and effective operations to minimize the probability of network failure.



Brief Scope of PNGRB IMS for CGD networks Regulations, 2013

The key components of the PNGRB's IMS framework include:

- **Safety Risk Assessment and Management:** The regulations mandate a lifecycle approach to safety, requiring regular risk assessments based on factors like pipeline age, corrosion, operational pressure, and third-party activity. Advanced leak detection systems and periodic safety audits are also stipulated.
- **Integrity Assessment:** Proactive and preventive maintenance is emphasized through regular visual and mechanical inspections, mandatory cathodic protection to prevent corrosion, and pipeline integrity tests to detect material degradation.

- **Regulatory Compliance and Oversight:** PNGRB enforces adherence to these standards through audits, ensuring every CGD entity implements and maintains a comprehensive IMS.
- **Data Management and Record Keeping:** The regulations require meticulous documentation of all inspections, maintenance activities, and risk assessments to support ongoing performance monitoring and informed decision-making.

  While the framework requires operators to define performance indicators, it does not specify a uniform set of metrics, presenting an opportunity for enhancement.

16.4 International Benchmark: The US PHMSA Gas Distribution Integrity Management Program (DIMP)

To identify areas for improvement, India's framework is benchmarked against the **Gas Distribution Integrity Management Program (DIMP)** from the U.S. Pipeline and Hazardous Materials Safety Administration (PHMSA). The DIMP framework is a globally recognized standard that requires operators to develop a written, data-driven plan based on the following core elements:

Key Element	Description
1. Knowledge	Operators must possess detailed knowledge of their infrastructure, including asset design, operational parameters, maintenance history, and material specifications. A system must be in place to capture data for all new pipelines.
2. Threat Identification	All potential threats must be identified, including corrosion, natural forces, excavation damage, equipment failure, and incorrect operations, using historical incident data, leak records, and surveillance reports.
3. Risk Assessment	Operators must evaluate and rank risks posed to the pipeline. This involves subdividing the network into regions with similar characteristics (e.g., material type, environmental factors) where similar mitigation actions would be effective.
4. Performance Measures	The program's effectiveness must be tracked using specific performance measures. Mandatory metrics include the number of hazardous leaks eliminated (by cause and material) and the number of excavation damages.
5. Periodic Evaluation	The entire integrity program must be re-evaluated periodically to assess threats and risks across the network, with the frequency determined by system complexity and changes in risk factors.
6. Reporting Results	Operators are required to report annually on the performance measures defined in their integrity management plan, ensuring regulatory oversight and accountability.

16.5 Recommendations for Strengthening PNGRB's IMS Regulations

The comparison with PHMSA's DIMP reveals three key areas where the PNGRB's IMS regulations can be significantly enhanced to align with global best practices.

Recommendation 1: Introduce Risk Zoning

The current PNGRB regulations require operators to identify generic threats across their entire Geographical Area (GA). To improve this, a more granular approach is recommended.

- *Proposed Change:* Mandate that CGD **operators categorize their pipelines and assets into "regions"** with similar characteristics. Examples include areas with high congestion of other utilities, networks in flood-prone or corrosive soil environments, or zones with specific pipeline materials.

- *Benefit:* This approach, known as risk zoning, allows for the development of targeted risk mitigation plans that are far more effective than generic, network-wide strategies. For each zone, a detailed plan with specific mitigation measures and implementation schedules should be integrated into the main IMS document.

Recommendation 2: Specify Standardized Performance Indicators

The current regulations allow operators to define their own performance indicators, making it difficult for the regulator to perform a consistent, sector-wide assessment of network integrity.

- *Proposed Change:* PNGRB should amend the IMS regulations to specify a **minimum set of mandatory performance indicators for all operators**. Based on the PHMSA model, these should include:
    - Number of hazardous leaks eliminated or repaired, categorized by cause (e.g., corrosion, third-party damage), material, and risk zone.
    - Number of third-party excavation damages.
    - Number of third-party excavation notifications received versus actual damages.
- *Benefit:* Standardized KPIs will create a uniform basis for evaluating the effectiveness of an operator's IMS, enabling objective benchmarking and fostering a data-driven approach to safety.

Recommendation 3: Mandate Annual Reporting of Results

Effective regulatory oversight requires consistent and transparent data. Currently, there is no formal requirement for operators to periodically submit performance data.

- *Proposed Change:* Introduce a provision in the IMS regulations that mandates all authorized entities to submit an **annual IMS performance report** to PNGRB. This report should detail the results for the standardized performance indicators mentioned above, alongside a summary of compliance status.
- *Benefit:* Annual reporting will create a powerful feedback loop, enabling PNGRB to monitor industry-wide trends, identify systemic risks, and hold operators accountable for their safety performance.

16.6 Conclusion and key takeaways

The PNGRB's Integrity Management System (IMS) regulations provide a robust foundation for ensuring the safety and reliability of India's rapidly expanding CGD networks. However, continuous improvement is essential in a sector where public safety is paramount.

By benchmarking against global best practices and adopting the proposed enhancements—introducing risk zoning, standardizing performance indicators, and mandating annual reporting—India can elevate its IMS framework to a world-class standard. These strategic improvements will ensure a more robust, data-driven, and transparent approach to managing network integrity, ultimately contributing to the nation's energy security and the well-being of its citizens.

17

Enhancing Safety at Petroleum Retail Outlets with the 'Drive-In, Drive-Out' Concept

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17.1 Introduction & Background

The Petroleum and Natural Gas Regulatory Board (PNGRB), established under the PNGRB Act of 2006, is the principal authority for regulating the refining, storage, transportation, distribution, marketing, and sale of petroleum, petroleum products, and natural gas in India. A core mandate of the PNGRB is to establish and enforce technical and safety standards across the downstream sector to protect consumer interests, ensure supply continuity, and promote competitive markets.

In line with this mandate, PNGRB notified the 'Technical Standards and Specifications for Dispensing of Automotive Fuels Regulations, 2018'. These regulations address the operational safety requirements at Retail Outlets (ROs) that dispense automotive fuels. A key operational safety protocol introduced by these regulations is the **'Drive-In, Drive-Out'** concept. This paper examines the framework, operational workflow, and significance of this concept in enhancing safety standards at Indian petroleum retail outlets.

17.2 The 'Drive-In, Drive-Out' Concept Defined

The 'Drive-In, Drive-Out' (DIDO) concept is a systematic operational procedure for managing the movement of tank lorries during fuel decantation (unloading) at a retail outlet. It is defined by the following principles:

- **Controlled Entry:** Tank lorries must enter the RO premises through a designated ingress route.
- **Forward-Facing Positioning:** The vehicle must be positioned at the unloading bay in a manner that its cabin faces the exit, allowing for a forward-only departure.
- **Safe Decantation:** The fuel unloading process must adhere to strict safety and compliance protocols.
- **Forward-Only Exit:** Upon completion of decantation, the tank lorry must exit the premises by moving forward through a dedicated egress path, completely eliminating the need for reversing.

This standardized approach mitigates the risks of collision and fire, particularly in the diverse operational environments of urban and rural retail outlets.

17.3 Importance of regulated fuel unloading at retail outlets (ROs)

Regulating the process of unloading petroleum products at ROs is a critical practice with far-reaching benefits. It establishes a framework of standardized procedures that enhances safety, protect the environment, and improve operational effectiveness. By enforcing strict protocols, these regulations mitigate the inherent risks associated with handling highly flammable materials, ensuring the well-being of workers and the public while preventing costly and damaging incidents.

Category	Key Importance & Benefits
1.Safety & Risk Mitigation	• **Prevents Fires & Explosions**: Enforces safety measures like grounding and bonding to prevent static electricity buildup, a common ignition source. • **Controls Spills**: Mandates spill containment systems and emergency protocols to minimize accidental releases. • **Manages Hazardous Materials**: Ensures staff are properly trained and equipped to handle risks associated with vapors, pressure, and leaks.
2.Environmental Protection	• **Reduces Environmental Impact**: Significantly lowers the risk of fuel spills, thereby preventing soil, water, and air contamination. • **Ensures Legal Adherence**: Guarantees compliance with strict environmental laws, helping to avoid legal penalties and fines.
3.Operational Efficiency	• **Streamlines Processes**: Standardizes unloading procedures, making them more predictable and efficient, which minimizes downtime and reduces on-site congestion. • **Improves Fuel Management**: Promotes accurate inventory control, reduces wastage, and helps maintain fuel quality by preventing contamination.
4.Regulatory Compliance	• **Meets National Standards**: Ensures adherence to mandatory regulations for safety and environmental protection, avoiding legal and financial consequences. • **Creates Industry Consistency**: Promotes uniform, high standards for fuel handling across all retail outlets, building public trust.
5.Worker & Public Safety	• **Protects Employees**: Requires proper training and personal protective equipment (PPE) for workers handling hazardous materials. • **Safeguards the Public**: Reduces the likelihood of accidents that could harm customers, pedestrians, or nearby communities.
6.Industry Best Practices	• **Encourages Continuous Improvement**: Motivates the adoption of new technologies and safer equipment, fostering a culture of safety. • **Promotes Skill Development**: Necessitates regular training, leading to a more skilled and competent workforce capable of managing risks.
7.Economic Considerations	• **Saves Costs through Prevention**: Reduces the risk of expensive incidents like spills, accidents, and equipment failure, saving on fines and repairs. • **Optimizes the Supply Chain**: Facilitates timely and efficient fuel delivery, preventing shortages and supporting smooth business operations.

17.4 Regulatory Mandate & Operational Scenarios

Recognizing the importance of regulated fuel unloading at retail outlets and to enforce the safety standards, PNGRB has mandated specific timelines and operational procedures for all retail outlets.

17.4.1 Compliance Mandate for Existing Retail Outlets

- **Modification:** Existing ROs where a drive-out position is not available must modify their layout to facilitate one, within 6 months of the PNGRB notification
- **Relocation:** If modification is not feasible, the RO must be relocated to a suitable location within three years from the notification of the regulation.

17.4.2 Operational Scenarios for Decantation

The regulations outline two distinct operational scenarios for fuel decantation:

Scenario A: Sales Halted During Decantation (For ROs where Drive-Out is Not Feasible)

For outlets awaiting modification or relocation, decantation can only occur under the following key safety conditions:

- **Complete Stoppage of Sales:** All dispensing activities must be halted.
- **Automated Interlocks:** The retail outlet automation system must automatically lock all dispensers when decantation begins.
- **Clear Exit Path:** The drive-out path must be clearly marked and kept free of obstructions using barricades or cones.
- **Restricted Access:** The area behind the tank lorry must be cordoned off to prevent vehicle or pedestrian access.
- **Mandatory Supervision:** The decantation process must be supervised by both the tank lorry crew and the RO supervisor.
- **Traffic Management:** A dedicated person must manage traffic to prevent any obstruction of the tank lorry's path.
- **Public Signage:** Prominent signage must be displayed at the entry and exit points, informing customers that unloading is in progress and sales are temporarily stopped.

Scenario B: Sales Continue During Decantation (For Compliant Drive-Out ROs)

Compliant ROs can continue sales during decantation, provided they meet these safety requirements:

- **Drive-Out Positioning:** The tank lorry must be parked in a forward-facing, drive-out position.
- **Physical Barrier:** The RO must have a masonry or non-perforated boundary wall of at least 1.2 meters in height.
- **Exclusion Zone:** A safety exclusion zone must be established and cordoned off. No dispensing or movement shall be permitted within:
    - A 9-meter radius from the center of the tank lorry.
    - A 3-meter radius from the center of the fill point.
    - A 4-meter radius from the corresponding vent.
- **Activity Suspension:** All other activities within the 9-meter radius (e.g., C-Store, ATM, EV charging) must be halted.
- **Supervision**: Decantation must be carried out in the presence of the tank lorry crew and retail outlet supervisor.
- **Clear Path**: A dedicated person must ensure the lorry's drive-out path remains unobstructed during decantation.
- **One-at-a-Time**: Only one lorry may be decanted at a time; simultaneous unloading of LPG, CNG, or LNG is prohibited.

17.5 Implementation Challenges in the Indian Context

While the regulatory intent is clear, implementation across India faces several practical challenges:

Challenge Area	Description	Impact
1.Space Constraints	Limited plot sizes, especially at older or urban ROs, lack the required turning radius.	Makes DIDO layout implementation infeasible without major overhaul.
2.High Modification Costs	Redesigning layouts involves significant capital expenditure for RO operators.	Financial burden can delay or deter compliance.
3.Business Disruption	Modification or relocation requires temporary closure of the outlet.	Results in loss of sales and customer inconvenience.
4.Operational Downtime	Non-compliant ROs must halt sales during decantation.	Reduces daily throughput and revenue.
5.External Factors	Encroachments, adjacent construction, and external traffic congestion block access.	Compromises tanker manoeuvrability and emergency response.
6.Automation Deficiency	Legacy outlets may lack automated interlocks to lock dispensers during decantation.	Increases reliance on manual processes and potential for human error.

17.6 International Best Practices

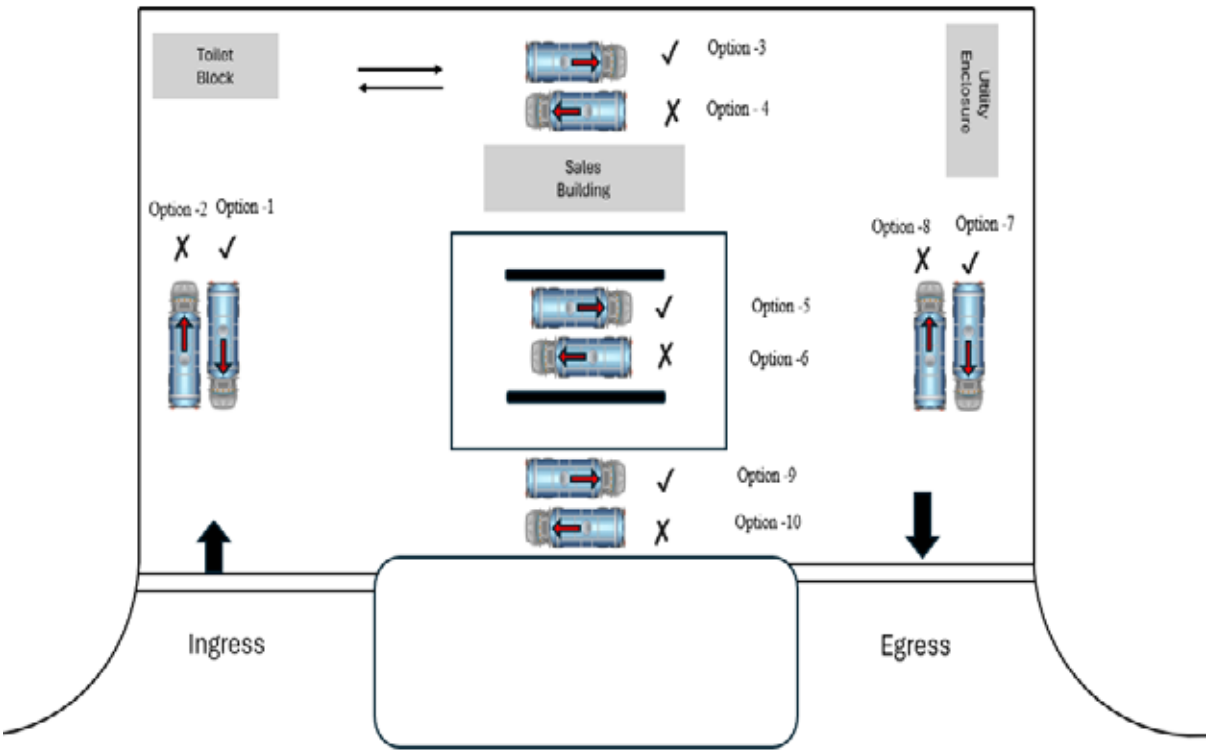
The 'Drive-In, Drive-Out' concept aligns with established international safety standards, which consistently prioritize forward-only tanker movement to minimize risk.

- **United States (NFPA 30A & IFC):** The National Fire Protection Association (NFPA) and the International Fire Code (IFC) mandate unobstructed egress and one-way traffic flow for tankers, eliminating reversing to enhance safety and allow for rapid emergency exit.
- **United Arab Emirates (ESMA Regulations):** In dense urban environments, ESMA standards require dedicated pathways for tankers to ensure smooth drive-out access without reversing, mitigating risks associated with manoeuvring large vehicles in confined spaces.
- **European Union (CEN Standards):** Guided by the European Committee for Standardization (CEN), EU regulations focus on drive-through delivery paths to prevent tanker reversing in hazardous zones, thereby reducing fire and explosion risks.
- **API RP 1615 (USA – Petroleum Institute):** The American Petroleum Institute's recommended practice advises separating bulk unloading operations from vehicle dispensing. A straight-through vehicle access path is a key implementation of this principle, ensuring the tanker can evacuate quickly in an emergency. An illustration of the standards and benefits is provided below -

Standard	Drive-In Drive-Out Benefit	Outcome
Separation of Operations *(No simultaneous dispensing and bulk fuel transfer)*	Ensures DIDO area is clear of consumer vehicles during decantation- Enables focused monitoring of the tanker unloading process	Reduced ignition risk- Enhanced decantation safety- Lower chances of operational confusion
Implementation- Delivery during off-peak hours- Barriers at pump islands- Signage and SOP training	Controlled tanker operations with no interference from customer activities	Efficient fuel transfer- Fewer operational interruptions

Straight-Through Vehicle Access *(No reversing posture)*	Enables seamless entry (Drive-In) and immediate forward exit (Drive-Out)- Avoids reversing hazards and delays	Minimized collision risk- Fast emergency egress- Simplified maneuvering in congested sites
Implementation- One-way dedicated delivery lanes- Turning radius-based access planning- Separate entry/exit gates	Optimizes tanker movement path- Avoids conflict with consumer vehicle paths	Reduced delivery time- Safer tanker routing- Compliance with site layout safety norms
Emergency Readiness & Spatial Safety *(Hazard isolation and evacuation planning)*	Straight-line DIDO path ensures tanker can evacuate in emergencies- Visual and physical access to safety equipment	Faster emergency response- Minimized exposure to flammable vapors- Enhanced driver situational awareness
Implementation- Emergency shut-offs along drive-out path- Signage visible from cab side	Aligns DIDO with API's emphasis on operational clarity and safety-first design	Operational resilience- Safer fuel handling- Compliance with global best practices

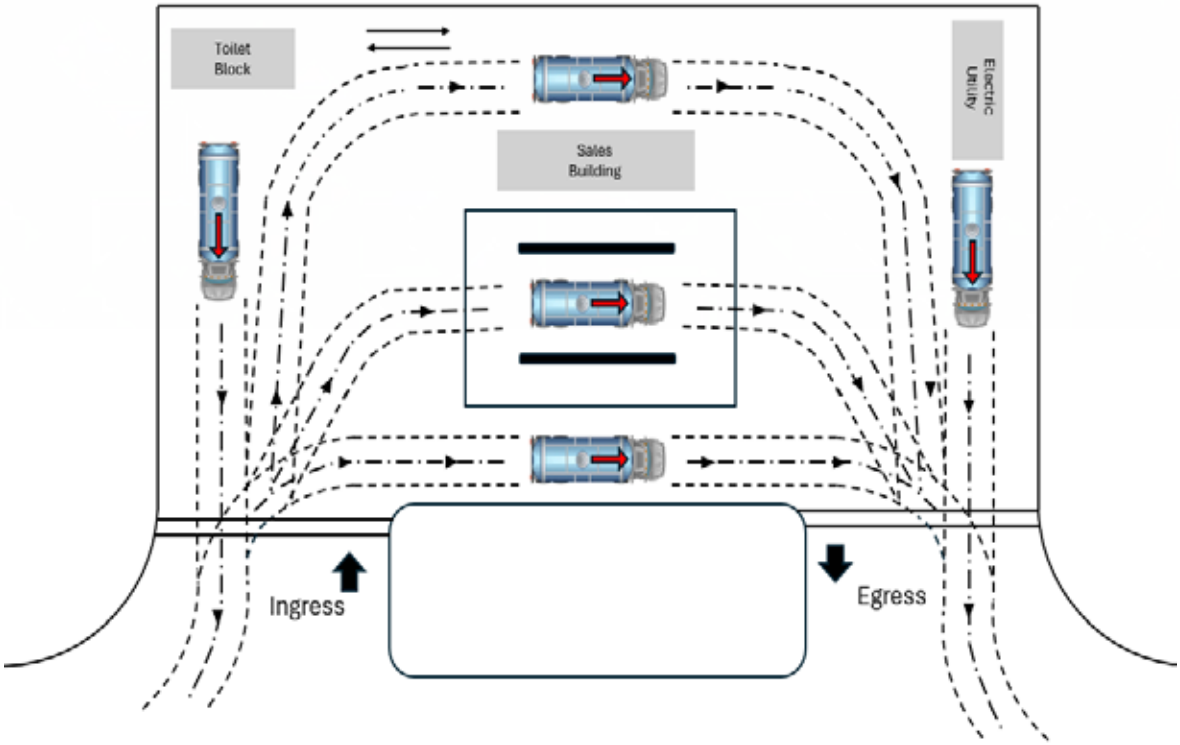
17.7 Suggested Schematic Diagram of TT Drive Out Position



TT Drive out possible positions

For a safe decantation, the tank truck must be positioned with the driver's cabin facing an entrance or exit. This ensures the truck has a clear, unobstructed forward path to exit quickly in an emergency.

Based on the schematic layout, positions 1, 3, 5, 7, and 9 are correct 'Drive-Out' options, as they allow the vehicle to be driven straight forward to safety.



Schematic Diagram Showing Drive Out Pathways

17.8 Conclusion & Key Takeaways

Conclusion and takeaways

The 'Drive-In, Drive-Out' framework is a critical safety evolution for India's downstream petroleum retail sector. By mandating forward-only tanker movement, it systemically reduces the risks of collisions, fires, and operational hazards associated with fuel decantation. It aligns India's safety protocols with global best practices, which universally prioritize the elimination of reversing maneuvers in hazardous environments.

While implementation presents challenges related to space, cost, and legacy infrastructure, the long-term safety benefits are undeniable. Effective enforcement by PNGRB, coupled with proactive investment and cooperation from industry stakeholders, is essential to ensure that every retail outlet in the country operates under these enhanced safety standards. This initiative not only protects assets and personnel but also strengthens public confidence in the safety and reliability of the fuel retail network.

Recommendations

To further strengthen the implementation of the 'Drive-In, Drive-Out' concept, the following should be considered:

1. **Standardized Layout Designs:** Develop and circulate model layout plans that incorporate optimal, forward-only tanker movement paths.
2. **Travel distance:** Travel distance should not be more than half the perimeter of RO.
3. **Clear Egress Paths:** The designated tanker travel path should be unobstructed and ideally not exceed half the perimeter of the retail outlet.
4. **Strict Segregation:** Ensure tanker movement paths are clearly segregated from customer service areas to prevent any overlap.
5. **No Reversing:** The layout must ensure that reversing is not required at any point during the entry, positioning, and exit phases.
6. **Robust Exclusion Zones:** Strictly enforce the 9-meter exclusion zone during decantation at all compliant outlets to prevent unauthorized access.

18

Toward World-Class Road Safety: A Comparative Analysis of India's Petroleum Transport Guidelines

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Assistant Consultant

Introduction

India's vast 6.3-million-kilometre road network plays a critical role in distributing energy across the nation, with road transport serving as the essential backbone for last-mile delivery of petroleum products. Despite its indispensability, frequent tanker accidents have exposed significant safety risks and eroded public confidence. In response, the Petroleum and Natural Gas Regulatory Board (PNGRB) released comprehensive safety guidelines for road transportation in 2025, mandating robust safety measures such as quarterly audits, night-driving restrictions, advanced vehicle technology adoption, and two-person crews.

This paper benchmarks PNGRB's new safety framework against four leading international standards: the European ADR Agreement, the U.S. DOT/FMCSA hazmat code, Canada's TDG Regulations, and Australia's HVNL Chain-of-Responsibility system. The cross-jurisdictional analysis examines journey management, vehicle and technology standards, driver qualification, and enforcement strategies, highlighting areas where PNGRB's approach excels—like telematics, nighttime curfews, and frequent audits.

However, the review identifies opportunities for further improvement, including digital hours-of-service enforcement, formal supply-chain liability, mandatory collision-avoidance technologies, and advanced emergency preparedness. *The study recommends: (1) compulsory Electronic Logging Devices linked to route-risk analytics, (2) regular hazmat driver recertification, (3) phased introduction of stability and braking technologies, (4) statutory supply-chain liability provisions, and (5) a digitized Emergency Response Assistance Plan architecture for high-risk cargoes.*

Adopting these global best practices will strengthen India's regulatory maturity, minimize the risk of major incidents, and establish a replicable safety model for other emerging economies. This benchmarking is thus vital to guide regulatory evolution, industry investment, and to cement India's position as a leader in energy transport safety.

18.1 Road Transport Protocols and Journey Management

18.1.1 PNGRB Guidelines

PNGRB mandates a formal Journey Management Plan (JMP) for each trip, detailing authorized routes, stops, accident-prone areas, and emergency protocols. A key provision is the prohibition of night driving for fuel tankers between 23:00 and 06:00 to mitigate fatigue-related incidents. Furthermore, the guidelines require a two-person crew to ensure sustained alertness. This

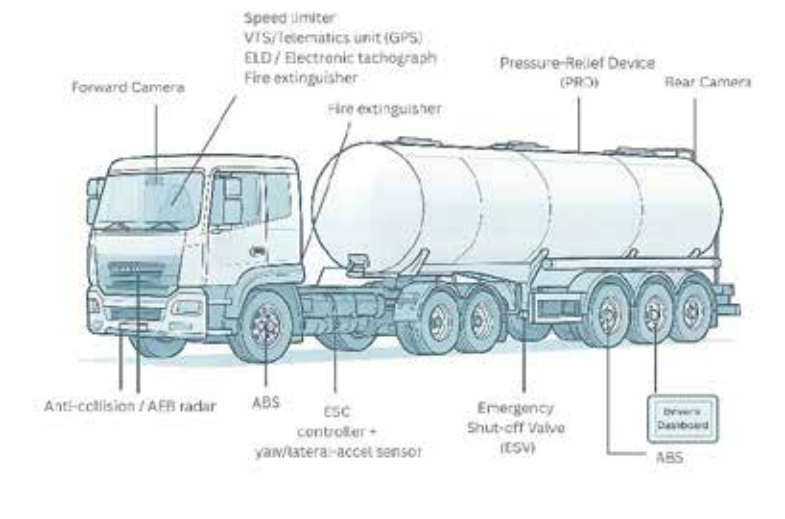
proactive approach, shaped by recent accidents, imposes broader operational restrictions than many international counterparts.

18.1.2 International Comparison

- **ADR (EU):** European regulations focus on route restrictions for high-risk loads (e.g., tunnels, urban areas) and enforce strict, digitally monitored hours-of-service (HOS) through tachographs. While general truck bans may exist at certain times, there is no specific blanket ban on night driving for dangerous goods.
- **US DOT/FMCSA:** The U.S. system relies on HOS rules enforced by Electronic Logging Devices (ELDs) rather than prescriptive JMPs. Specific route controls and security plans are required only for high-consequence materials. Team driving is a commercial practice, not a regulatory mandate.
- **Canada & Australia:** Canada mandates Emergency Response Assistance Plans (ERAP) for high-risk shipments. Australia's framework is distinguished by its Chain of Responsibility (CoR) principle, which extends legal accountability for safety to all parties in the supply chain, including schedulers and consignors. Both nations manage fatigue through HOS regulations rather than night-driving bans.

18.2 Vehicle Safety Design and Technology

18.2.1 PNGRB Guidelines



The guidelines require that all petroleum tankers be equipped with modern safety technologies, including Anti-lock Braking Systems (ABS), GPS-based Vehicle Tracking Systems (VTS), speed governors, front and rear cameras, and anti-collision devices. Continuous in-transit surveillance via telematics is also mandated to monitor route deviations. This technology-forward approach aims to leapfrog legacy fleet standards.

18.2.2 International Comparison

- **ADR (EU):** European standards mandate robust tank construction, certified safety fittings, and specific electrical safety measures. ABS and speed limiters are standard requirements. Advanced systems like Electronic Stability Control (ESC) and Automatic Emergency Braking (AEB) are being phased in through general vehicle safety regulations rather than the ADR framework itself.
- **US DOT:** U.S. regulations specify rigorous tank construction standards (e.g., DOT 406) and have mandated ABS and ESC for heavy trucks. However, forward-collision avoidance systems and cameras are not yet compulsory, and there is no federal mandate for speed governors.

- **Canada & Australia:** Both countries have standards comparable to the EU and U.S., including ABS and speed limiters (in certain provinces/territories). ESC is being progressively mandated. Australia's CoR laws incentivize the proper maintenance of safety equipment by holding the entire supply chain accountable.

18.3 Driver Qualification, Training, and Fatigue Management

18.3.1 PNGRB Guidelines

PNGRB emphasizes stringent driver qualification, vetting, and regular medical fitness checks. The guidelines enforce the Motor Transport Workers Act, 1961, limiting driving to eight hours per day and 48 hours per week—a stricter cap than in many developed nations. Biometric authentication at loading points is an innovative measure to ensure only authorized personnel operate the vehicles.

18.3.2 International Comparison

- **Training & Certification:** All benchmarked regions require specialized training and certification for hazmat drivers, with mandatory recurrent training every 3-5 years (ADR, Canada, US, Australia). PNGRB aligns with the initial training requirement but lacks a mandate for periodic recertification.
- **Hours-of-Service (HOS):** While PNGRB's daily driving limit is stricter, international systems achieve compliance through robust enforcement using digital tachographs (EU) or ELDs (U.S., Canada), which provide verifiable data trails.
- **Driver Monitoring:** The U.S. employs a Compliance, Safety, Accountability (CSA) points system that tracks driver violations. Australia's CoR laws hold companies accountable for pressuring drivers into unsafe practices. These systems create powerful incentives for internal compliance that complement PNGRB's approach.

18.4 Enforcement, Penalties, and Regulatory Coherence

18.4.1 PNGRB Enforcement Approach

PNGRB enforces its guidelines primarily through its regulatory authority over licensed entities, using contractual obligations as a key lever. The Board can impose penalties, suspend, or revoke licenses for non-compliance. However, PNGRB lacks direct on-road enforcement power, which remains with state transport and police authorities.

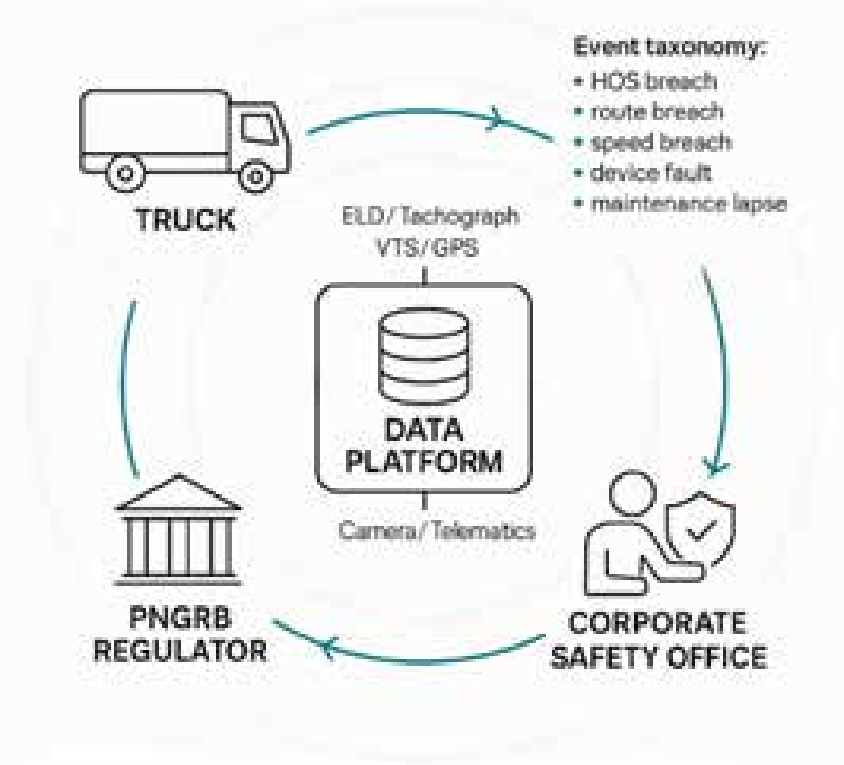
18.4.2 International Comparison

- **ADR (EU):** Enforcement is harmonized across member states through uniform roadside checks, shared data, and a tiered penalty system. A key feature is the mandatory appointment of a Dangerous Goods Safety Advisor (DGSA) within companies to oversee internal compliance.
- **US DOT/FMCSA:** A combination of roadside inspections and company audits is used. The CSA program provides a data-driven system for targeting high-risk carriers, creating strong commercial incentives for safety.
- **Canada & Australia:** Both have strong penalty regimes. Australia's CoR model is particularly effective, as it allows regulators to prosecute any party in the supply chain who contributed to a safety breach. This creates a culture of shared responsibility that PNGRB's framework currently fosters through contractual rather than statutory means.

18.5 Key Recommendations

PNGRB has established a strong foundation for road safety that, in several aspects, is more stringent than international norms. However, to achieve world-class standards, the following measures are recommended to address identified gaps:

1. **Mandate Electronic Logging Devices (ELDs):** Replace reliance on manual logs and night-driving bans with compulsory, tamper-proof ELDs to enforce HOS rules, aligning with global best practices for fatigue management.
2. **Enforce Periodic Driver Recertification:** Institute mandatory refresher training and recertification for all hazmat drivers every 3-5 years to ensure skills and knowledge remain current.
3. **Upgrade Vehicle Safety Technology:** Phase in mandates for proven technologies like Electronic Stability Control (ESC) and Automatic Emergency Braking (AEB) to prevent rollovers and collisions.
4. **Establish Statutory Chain of Responsibility (CoR):** Amend existing laws to create statutory liability for all parties in the supply chain—consignors, schedulers, loaders, and carriers—making safety a shared legal responsibility.
5. **Require Emergency Response Assistance Plans (ERAP):** For high-consequence loads like LPG, mandate pre-approved ERAPs to ensure specialized resources are available for en-route emergencies.
6. **Digitize Audits and Integrate Data:** Enhance the existing Third-Party Inspection Agency (TPIA) audit system with a digital platform that integrates with vehicle telematics. Use AI-driven analytics to identify high-risk patterns and enable predictive safety interventions.



18.6 Conclusion and key takeaways

PNGRB's 2025 road transport safety guidelines represent a significant advancement for India. The framework's strengths in journey management, crew requirements, and mandatory technology demonstrate a clear commitment to public safety. By addressing the remaining gaps through the adoption of digital enforcement tools, advanced vehicle technologies, shared accountability, and robust emergency planning, India can close the loop on compliance and establish a truly world-class safety regime.

The implementation of these recommendations will not only reduce accidents and protect lives but also position India as a global leader in the regulation of hazardous materials transportation. This proactive and data-driven approach can serve as a powerful model for other nations striving to build safer and more efficient energy logistics networks.

CLEAN ENERGY AND SUSTAINABILITY

19

Compressed Bio-Gas (CBG) and Renewable Gas Certificates (RGC) - A Pathway to India's Sustainable Energy Transition

Author: ***Neha Jain***
Deputy Consultant

19.1 Introduction: The Imperative for Sustainable Energy

India is at a pivotal moment in its energy journey, balancing the demands of economic growth with the urgent need for environmental sustainability and energy security. In this context, Compressed Bio-Gas (CBG) emerges as a powerful and transformative solution. Derived from organic waste, CBG offers a viable path to reduce dependency on imported natural gas, promote a circular economy, and achieve national climate goals.

Key government initiatives, including the Sustainable Alternative Towards Affordable Transportation (SATAT) scheme and the Compressed Bio-Gas Blending Obligation (CBO), are creating a structured framework to unlock India's vast biogas potential. This paper examines the technical foundation, strategic importance, and regulatory landscape of CBG. It also introduces the concept of Renewable Gas Certificates (RGCs) as a market-based instrument to accelerate investment and adoption, positioning CBG as a cornerstone of India's energy independence and net-zero ambitions.

19.2 Understanding Compressed Bio-Gas (CBG)

Technical Definition and Standards

CBG is produced by purifying raw biogas to remove impurities like hydrogen sulfide (H_2S), carbon dioxide (CO_2), and water vapor. The resulting product is a methane-rich gas (typically >90% CH_4) that is compressed for storage and use. Its composition makes it chemically identical to Compressed Natural Gas (CNG), allowing it to be used interchangeably in vehicles and industrial applications without any modification to existing infrastructure.

The Bureau of Indian Standards (BIS) governs the quality specifications for CBG, a fuel grade bio-methane, under **IS 16087:2016**.

Table 1: Key Parameters of IS 16087:2016

Characteristic	Requirement
Methane (CH_4) percentage, minimum	90%
Only Carbon Dioxide (CO_2) percentage, maximum	4%
Carbon Dioxide (CO2) percentage + Nitrogen (N2) + Oxygen(O2) percentage maximum	10%
Oxygen (O_2) percentage, maximum	0.5%
Total Sulphur (incl. H_2S) mg/m3, maximum	20 mg/m^3
Moisture mg/m^3 , maximum	5 mg/m^3

Note: The Indian Standard for methane, IS 16087:2016, is being revised. The upcoming second revision, IS 16087-2025, will increase the minimum required methane content from the current 90% to 95% further enhancing its quality and alignment with natural gas. This new standard is scheduled to become effective on February 1, 2026, after the proposed date of withdrawn of existing IS 16087-2016. It is important to note that the revised standard has not yet been published.

19.3 Strategic Importance for India

The development of a robust CBG ecosystem offers multi-faceted benefits for the nation:

- **Energy Independence:** As per MNRE (Ministry of New and Renewable Energy), with an estimated **domestic CBG production potential of 62 Million Metric Tonnes Per Annum (MMTPA)**, CBG could fulfil approximately 27% of India's natural gas demand. If this potential is achieved, CBG can play a big role in **making India energy independent.**
- **Import Substitution and Leading to reduction in Forex expense on gas imports:** India imports approximately 50% of the natural gas that it consumes. This is ~100 MMSCMD of natural gas imports. India plans to reduce the imports by half through mobilizing its CBG assets.
- **Promote Circular Economy:** CBG production valorizes organic waste from agricultural, municipal, and industrial sources that would otherwise end up in landfills, mitigating methane emissions—a greenhouse gas 27 times more potent than CO_2.
- **Climate Action:** As a renewable fuel, CBG aids in achieving India's commitments under the United Nations Framework Convention on Climate Change (UNFCCC), including the goals:
    1. Achieving **net-zero emissions by 2070**
    2. Reduce Emissions Intensity of its GDP by 45 percent by 2030, from 2005 levels.

Mobilizing national CBG assets and promoting CBG usage shall go a long way in fulfilling these commitments.

- **Rural Development:** The decentralized nature of CBG production can stimulate rural economies by creating entrepreneurship opportunities and generating local employment.

19.4 Feed Stock for CBG Production

India is ideally suited for large-scale Compressed Biogas (CBG) production, thanks to its rich and varied supply of organic raw materials, known as feedstock. These resources are plentiful across both urban and rural areas. Utilizing this feedstock for CBG presents a powerful dual benefit: it not only creates a source of clean, renewable energy but also contributes significantly to environmental sustainability by managing waste and curbing pollution. The continuous development of new feedstocks for CBG production signals an evolution in India's renewable energy sector. This progress is driven by a combination of technological advancements and the urgent need to address environmental challenges, paving the way for a more sustainable energy future.

19.5 Government Initiatives and Regulatory Framework

Recognizing the potential of CBG, the Government of India has launched several key policy initiatives to foster its growth.

19.5.1 Policy Thrust and Mandates

- **SATAT Scheme:** Led by the Ministry of Petroleum and Natural Gas (MoPNG), this initiative encourages entrepreneurs to set up CBG plants and guarantees offtake through long-term agreements with Oil and Gas Marketing Companies.
- **CBG Blending Obligation (CBO):** MoPNG has mandated a phased blending of CBG in the CNG (Transport) and PNG (Domestic) networks. The obligation is set to increase from 1% in FY 2025-26 to 5% by FY 2028-29.
- **Financial Assistance:** The Ministry of New and Renewable Energy (MNRE) and the Ministry of Housing and Urban Affairs (MoHUA) provide Central Financial Assistance (CFA) and other incentives to support the capital costs of new CBG projects.

19.5.2 Role of the Petroleum and Natural Gas Regulatory Board (PNGRB)

PNGRB is actively facilitating the integration of CBG into the national gas grid. It acts as a focal point for regulatory facilitation, technical coordination, and stakeholder engagement in the CBG sector. Key actions include:

- **Promoting Pipeline Connectivity:** Facilitating direct pipeline connections for CBG plants to ensure reliable offtake, reduce logistical costs associated with road transport, minimise gas loss, and enhance operational safety.
- **Data Management:** Creating a comprehensive national database of CBG plants categorized by type and source of feedstock to help stakeholders understand the landscape, identify operational challenges, and guide future investment.

CBG Snapshot of India	
No. of CBG Plants Operational	~160
No. of CBG Plants under construction	~244
No. of CBG/Bio- CNG plants Registered (Gobardhan)	1150
CBG Production Target under SATAT	~53 MMSCMD (15 MMTPA)

19.6 Market Acceleration through Renewable Gas Certificates (RGCs)

To overcome geographical constraints and create a transparent, market-driven mechanism for CBG, the introduction of Renewable Gas Certificates (RGCs) is proposed.

19.6.1 Objectives of RGCs:

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

- *Physical Commodity* – Value of CBG if it is treated as any other natural gas.
- *Sustainability* – Sustainable nature of value chain in CBG production shall be captured through this component as RGC value.

19.6.2 The RGC Mechanism

An RGC is a tradable, market-based instrument that represents the "green" or environmental attribute of CBG. The concept decouples the physical gas molecule from its sustainability value.

- **Issuance:** A CBG producer would be issued one RGC for every one Million British Thermal Units (MMBTU) of CBG produced and injected into the gas grid.
- **Trading:** The physical CBG can be sold as a commodity, while the RGC, a green component of CBG can be traded separately on a Gas Exchange.

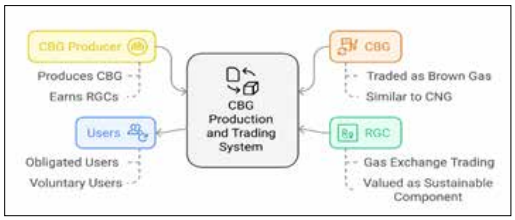


Figure: RGC Trading Mechanism

Compliance: Obligated entities, such as City Gas Distribution (CGD) companies, can purchase RGCs to meet their CBO targets without being physically connected to a CBG plant. Voluntary users can also purchase RGCs to meet their own corporate sustainability goals.

This model is inspired by successful international frameworks like the European "**Guarantees of Origin**" as stated in **Renewable Energy Directive (RED) of EU** and domestic mechanisms like the "**Energy Saving Certificates**" (ESCerts) under the PAT (Perform-Achieve-Trade) scheme.

19.6.3 Benefits of the RGC Scheme

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

- **Quantifies Sustainability:** Provides a clear market value for the environmental benefits of CBG.
- **Incentivizes Producers:** Creates an additional revenue stream for CBG producers through sustainable projects, improving project viability.
- **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 Entry Barrier**: Enable a low barrier of entry to sustainable fuel markets for all downstream users – CGDs, MSMEs, industries, etc. Electronic trading via Gas Exchange shall be convenient, low-cost and efficient
- **Transparent Price Discovery:** Enables the market to determine the true value of renewable gas, guiding investment and policy decisions.
- 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.

19.7 Key Challenges and Recommendations

While the policy framework is promising, certain regulatory and fiscal hurdles need to be addressed to unlock the full potential of the CBG sector.

19.7.1 Regulatory Ambiguity

Currently, the PNGRB Act does not explicitly include "biogas" or "CBG" in its definition of "natural gas." This places CBG outside the direct regulatory ambit of PNGRB, creating uncertainty.

- **Recommendation:** The PNGRB Act should be amended to include CBG within the definition of natural gas. Given that CBG is identical to natural gas in application and is blended into the same network, placing it under the purview of PNGRB—the regulator for natural gas infrastructure and markets—is a logical step for consistent and effective oversight.

19.7.2 Dual Taxation Structure

A significant fiscal challenge arises from the differing tax treatments of CBG and natural gas. CBG is subject to a 5% Goods and Services Tax (GST), while natural gas falls under the non-GST regime of Central Excise and state-level Value Added Tax (VAT). When CBG is blended and sold as CNG, it is subjected to both tax structures, leading to double taxation.

- **Recommendation:** To create a level playing field, the Government should exempt the CBG portion of blended CNG from Central Excise and VAT. This correction would eliminate pricing inefficiencies and make CBG more competitive, thereby incentivizing its adoption and stimulating investment in production infrastructure.

19.8 Conclusion and Key Takeaways

Compressed Bio-Gas represents a strategic asset for India, offering a decentralized, sustainable, and economically viable solution to the nation's most pressing energy and environmental challenges.

Key Takeaways:

- CBG is a direct substitute for natural gas, requiring no changes to infrastructure or end-user equipment.
- Strong government initiatives (SATAT, CBO) have laid the groundwork for a thriving CBG market.
- Renewable Gas Certificates (RGCs) offer a sophisticated, market-based tool to accelerate CBG adoption and ensure compliance with blending mandates.
- Critical regulatory and tax reforms are necessary to remove existing bottlenecks and provide long-term certainty for investors.

By formally appointing a national regulator like PNGRB and rationalizing the tax structure, India can provide the directional guidance and stable policy environment needed to scale its CBG sector. This will not only advance the country's clean energy transition but also establish India as a global leader in the circular economy and the production of sustainable gaseous fuels.

20

India's Net Zero Strategy through the Lens of Carbon Trading

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Consultant

20.1 Executive Summary

At the 26th COP26 in Glasgow, India committed to achieving Net Zero greenhouse gas emissions by 2070. This pledge is supported by ambitious 2030 targets, including establishing 500 GW of non-fossil fuel power capacity, reducing the emissions intensity of its GDP by 45% from 2005 levels, and sourcing 50% of cumulative electricity capacity from renewables.

To meet these commitments, carbon trading has emerged as a pivotal mechanism. By establishing a price on carbon, trading schemes enable industries to meet compliance targets cost-effectively, incentivise the adoption of cleaner technologies, and attract global climate finance.

This paper examines India's Net Zero strategy through the lens of carbon trading. It analyses international frameworks, India's updated Nationally Determined Contributions (NDCs), the evolution of its domestic carbon trading mechanisms, and the development of the Indian Carbon Market (ICM).

Key Highlights:

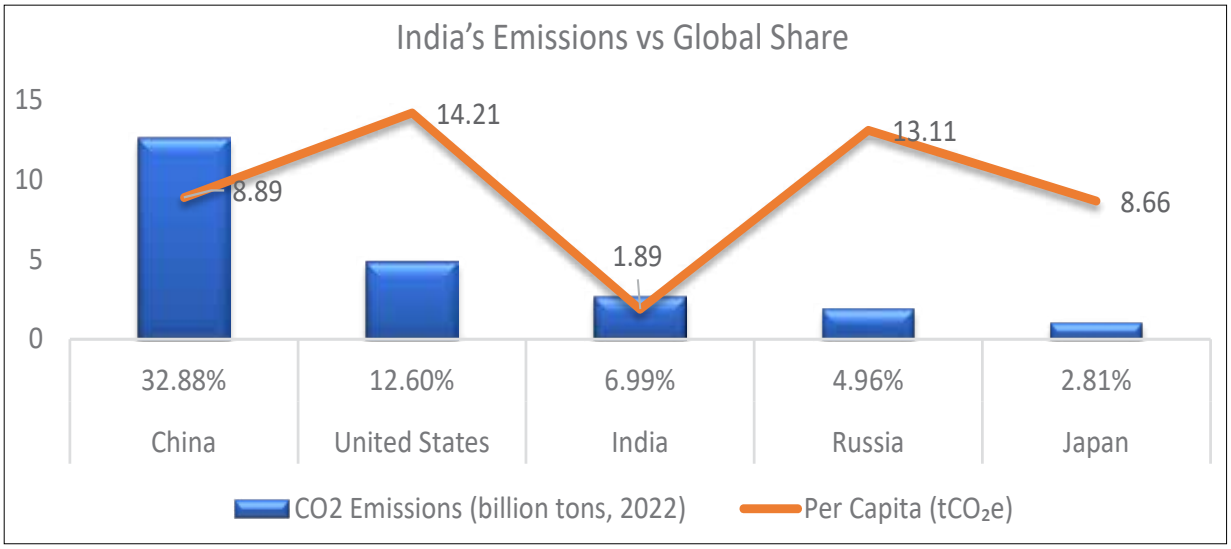
- **NDC Progress:** By June 2025, India achieved 50% of its installed electricity capacity from non-fossil fuel sources, five years ahead of schedule. The nation is also on track to meet its emissions intensity target, having already achieved a 36% reduction between 2005 and 2020.
- **Market Foundations:** The Perform, Achieve, and Trade (PAT) scheme and Renewable Energy Certificates (RECs) have collectively reduced greenhouse gas (GHG) emissions by over 100 million tonnes of CO_2 equivalent ($MtCO_2e$).
- **Global Participation:** India hosted 1,703 Clean Development Mechanism (CDM) projects, the second-highest globally, which generated approximately 246 million Certified Emission Reductions (CERs).
- **Future Roadmap:** The Carbon Credit Trading Scheme (CCTS) was launched in 2023, laying the groundwork for a comprehensive Indian Carbon Market (ICM) by 2026.
- **Challenges:** Key challenges remain in establishing robust Monitoring, Reporting, and Verification (MRV) systems, ensuring market liquidity, preparing MSMEs for participation, and facilitating transparent price discovery.

While not a standalone solution, carbon trading is a cost-effective and scalable tool to align India's developmental needs with its climate ambitions. Its success will depend on a robust policy framework, strong institutional capacity, active stakeholder participation, and strategic international linkages.

20.2. Introduction

Climate change presents one of the most significant challenges of the 21st century. As a large, rapidly growing economy, India is particularly vulnerable to its impacts, including rising temperatures, erratic monsoons, and sea-level rise. Projections indicate that unmitigated climate change could reduce India's GDP by up to 2.5% annually by 2050.

Simultaneously, India is on a significant developmental trajectory, requiring substantial expansion in energy, industry, and urban infrastructure. Although its per capita emissions remain low at 1.89 tCO_2e, India is the world's third-largest emitter due to its economic scale.



Source: Worldometer

The nation faces the dual challenge of fostering growth while transitioning to a low-carbon pathway. To achieve Net Zero by 2070, an estimated investment of USD 10 trillion is required, far exceeding current capital flows.

The carbon market offers a strategic policy tool to unlock private investment, link emission reductions to finance, and foster industrial innovation. It provides a viable pathway to reconcile economic growth with environmental sustainability and operationalise India's Net Zero ambition.

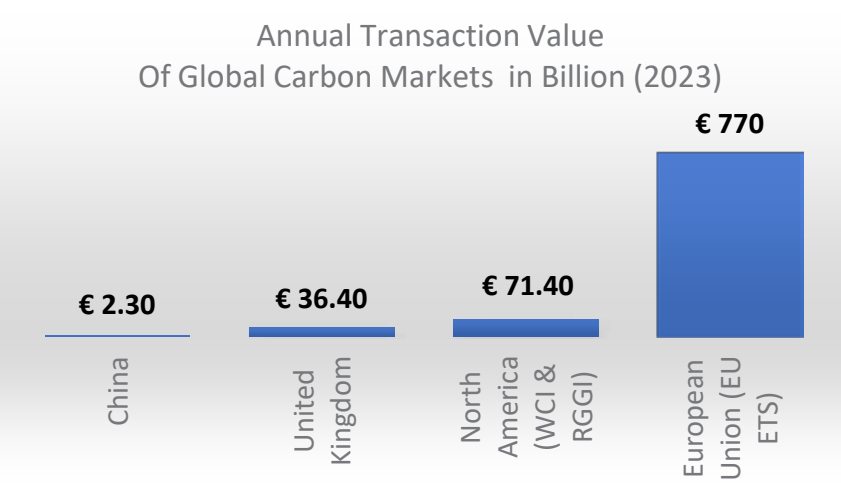
20.3. India on the Global Sustainability Stage

20.3.1 International Climate Commitments

India has been an active participant in global climate governance since the inception of the UNFCCC in 1994. Under the Paris Agreement (2015), India introduced its Nationally Determined Contributions (NDCs). At COP26 in Glasgow, India strengthened these commitments through its five-point "Panchamrit" pledge, which was formalised in its updated NDCs in 2022. A key component of the Paris Agreement is Article 6, which provides a framework for international carbon trading and cooperation, creating an opportunity for India to leverage its extensive experience from the CDM.

20.3.2 Global Carbon Markets

Globally, carbon markets have become central to climate strategies, with a total value of €881 billion (USD 949 billion) in 2022.



Key international examples include:

- **EU Emissions Trading System (ETS):** The world's most mature system, covering the power sector and heavy industries, and accounting for approximately 87% of global carbon market value.
- **China's ETS:** The world's largest market by covered emissions, regulating over 3,500 companies in the power, steel, cement, and aluminium sectors.
- **CORSIA:** A global market-based scheme to regulate international aviation emissions, aiming for carbon-neutral growth by requiring airlines to offset emissions with carbon credits.

These international systems offer valuable lessons for India on the importance of transparent price discovery, market stability, and robust MRV frameworks.

20.4 Carbon Trading: Concept and Mechanisms

Carbon trading is a market-based mechanism that reduces GHG emissions cost-effectively by placing an economic value on them. This transforms emission reductions into tradable assets, creating financial incentives for industries to adopt cleaner technologies. The primary systems are:

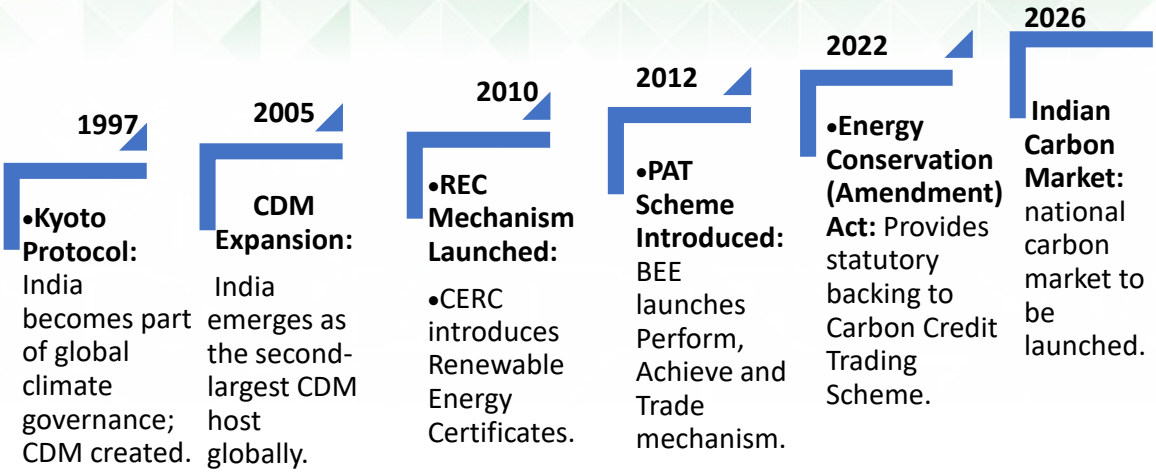
1. **Cap-and-Trade System:** A regulatory authority sets a "cap" on total permissible emissions and distributes allowances. Entities that emit less than their allowance can sell their surplus to those that exceed their limits.
2. **Baseline-and-Credit System:** Entities are evaluated against a pre-defined emissions baseline. Those whose emissions fall below this baseline generate credits, which can be sold to entities that fail to meet their own reduction targets. This flexible system is well-suited for developing economies like India.

   Carbon credits are generated from projects that reduce, avoid, or sequester GHG emissions, such as renewable energy deployment, energy efficiency improvements, and afforestation initiatives. A credible carbon market relies on robust Monitoring, Reporting, and Verification (MRV) systems, where independent verifiers ensure that claimed reductions are real, additional, and permanent.

20.5 The Evolution of Carbon Trading in India

India's engagement with carbon markets has progressed over two decades. The nation was a significant participant in the Kyoto Protocol's **Clean Development Mechanism (CDM)**, which allowed developing countries to generate carbon credits from sustainable projects.

Domestically, India introduced market-based schemes to drive energy efficiency. The **Perform, Achieve, and Trade (PAT)** scheme, launched in 2012, set energy reduction targets for energy-intensive industries. Facilities exceeding their targets earned Energy Saving Certificates (ESCerts), which could be traded. Alongside this, the **Renewable Energy Certificate (REC)** mechanism was established to help entities meet their Renewable Purchase Obligations (RPOs).



These foundational schemes have built institutional capacity and prepared Indian industries for a more comprehensive, economy-wide carbon market.

20.6 The Indian Carbon Market (ICM): A Roadmap

The Government of India has established carbon trading as a cornerstone of its climate strategy. The Energy Conservation Act, 2001, was amended to create the **Carbon Credit Trading Scheme (CCTS)**, launched in 2023. This scheme provides a roadmap toward a full-fledged Indian Carbon Market (ICM) by 2026.

The Bureau of Energy Efficiency (BEE) will serve as the administrator, while the Central Electricity Regulatory Commission (CERC) will regulate market design and ensure transparent price discovery. The CERC will regulate market design, supervise exchanges, and ensure transparent price discovery, with trading to occur on recognised platforms such as IEX and PXIL.

20.6.1 Sectoral Coverage and Operation

The ICM will initially cover nine energy-intensive sectors transitioning from the PAT scheme. Instead of absolute caps, the system will use emissions-intensity targets.

- Entities will be assigned targets over six-year cycles.
- Facilities outperforming their benchmarks will earn Carbon Credit Certificates (CCCs).
- Underperforming facilities must purchase CCCs to meet compliance.
- The scheme will cover Scope 1, Scope 2, and select Scope 3 emissions.

20.6.2 Expected Trading Volumes

Preliminary estimates suggest the ICM could mobilise trading volumes exceeding 200–250 million tCO_2e annually by 2030, positioning India among the top five global carbon markets. Revenue generated is expected to be reinvested into clean energy, R&D, and industrial retrofitting.

20.7 Progress and Key Achievements

- **Emissions Intensity:** India reduced the emission intensity of its GDP by 36% between 2005 and 2020 and is on track to achieve its 45% reduction target by 2030.
- **Renewable Energy:** Total installed renewable energy capacity has reached 220.10 GW. Renewables now account for over 50% of total installed capacity, achieving the 2030 target ahead of schedule.
- **Energy Efficiency:** The first three PAT cycles resulted in the issuance of 10.3 million ESCerts, driving industrial efficiency.

- **Afforestation:** India's forest and tree cover has increased to 24.6% of its land area, contributing to the goal of creating a carbon sink of 2.5–3 billion tonnes of CO_2e by 2030.
- **Emerging Sectors:** Initiatives like the National Electric Mobility Mission Plan (NEMMP) for promoting EV adoption, the National Green Hydrogen Mission, and the Sustainable Alternative Towards Affordable Transportation (SATAT) scheme for bio-CNG are further accelerating decarbonisation.

Since 2010, India's mitigation efforts have avoided 1.5–2 billion tonnes of CO_2 equivalent, demonstrating that significant emission reductions can be achieved while remaining one of the world's fastest-growing large economies.

20.8 Bottlenecks and Challenges

Transitioning to a robust carbon market presents several challenges:

- **MRV Gaps:** The current MRV framework is fragmented, and many industrial units, particularly MSMEs, lack accurate baseline emissions data.
- **Price Discovery and Liquidity:** Uncertainty around the future price of carbon credits can discourage investment and market participation.
- **Institutional Overlaps:** Integrating existing schemes like PAT and RECs into the unified ICM requires clear policy harmonisation to avoid overlapping compliance burdens.
- **Financial and Technical Barriers:** The high upfront cost of clean technologies remains a significant barrier for many industries.

20.9 Oil & gas Sector emissions: Scope 1,2, and 3

India's oil and gas sector spans upstream production, pipelines, and city gas distribution, and accounts for about 35–40% of the nation's carbon emissions. While Scope 1 and 2 operational emissions are significant, Scope 3 emissions from downstream fuel use dominate the sector's footprint. To address this, the government is driving reductions across all scopes through policies like the PAT scheme, Carbon Credit Trading Scheme, and the upcoming Indian Carbon Market, alongside a push toward cleaner fuels such as bio-CNG, hydrogen, and renewable natural gas.

20.10 Case Study: Carbon Audit of a Textile Plant

A carbon audit is a systematic process of measuring and verifying GHG emissions, which establishes a baseline for reduction efforts and participation in carbon markets.

$$CO2e\ (tonnes) = \sum(Activity\ Data \times Emission\ Factor)$$

Where:

- Activity Data = quantity of fuel consumed, electricity used, waste generated, etc.
- Emission Factor = standardised conversion factor (e.g., kg CO_2 per litre of diesel).

Carbon Audit case study (Illustrative): A textile plant has the following average monthly energy consumption:

- 7,00,000 kWh of purchased electricity
- 40 KL of furnace oil
- 60 tonnes of coal
- 10 KL of High-Speed Diesel (HSD)

Objective:

a) Calculate the total monthly energy consumption in Metric Tonnes of Oil Equivalent (MTOE).

b) Determine if the plant qualifies as a Designated Consumer under the Energy Conservation Act.

Solution:

1. Convert all energy sources to a common unit (kcal):
    - Electricity: 7,00,000 kWh * 860 kcal/kWh = 60.2 x 10^7 kcal
    - Furnace Oil: 40,000 L * 0.92 kg/L * 10,000 kcal/kg = 36.8 x 10^7 kcal
    - Coal: 60,000 kg * 3,450 kcal/kg = 20.7 x 10^7 kcal
    - HSD: 10,000 L * 0.885 kg/L * 10,500 kcal/kg = 9.29 x 10^7 kcal
2. Sum the total energy consumption:
    - Total kcal = (60.2 + 36.8 + 20.7 + 9.29) x 10^7 = 126.99 x 10^7 kcal
3. Convert total kcal to MTOE (1 MTOE = 10^7 kcal of oil equivalent):
    - Total MTOE (monthly) = 126.99 x 10^7 kcal / (10^7 kcal/MTOE) = 127 MTOE
4. Calculate annual consumption and assess qualification:
    - Annual MTOE = 127 MTOE/month * 12 months = 1,524 MTOE
    - The threshold for textile plants to be classified as Designated Consumers is 3,000 MTOE per year.

    Conclusion: With an annual energy consumption of 1,524 MTOE, this textile plant does not qualify as a Designated Consumer under the current norms. However, conducting this audit allows the plant to identify energy usage patterns and prepare for voluntary participation in the carbon market.

20.11 Key Takeaways

India's journey to Net Zero is complex but achievable. The creation of a robust and credible Indian Carbon Market is an economic and strategic opportunity, aligning national development with global sustainability goals.

- Carbon trading offers a cost-effective pathway to price emissions, drive innovation, and attract climate finance.
- Building on the foundation of schemes like PAT and REC, India is steadily progressing toward a unified, economy-wide carbon market.
- As demonstrated by the textile plant case study, carbon audits are essential for identifying reduction opportunities, generating tradable credits, and enhancing competitiveness.
- Embedding the carbon market within a broader industrial strategy—one that includes scaling renewables, green hydrogen, and biofuels—will bolster energy security, support rural livelihoods, and solidify India's position as a global climate leader.

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