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# Oil and Gas Energy in Indian Context

**Bhabesh Kumar Kar**
ONGC RIL, GSPC (Retired)
B1101, Giriraj Hiorzon, Kharghar, Navi Mumbai, Maharashtra
E- Mail: bkkar@yahoo.co.in

## Abstract

Oil and gas exploration and development in India began in the northeastern state of Assam, but momentum significantly increased following the discovery of hydrocarbons in the Bombay High offshore basin along the west coast. The demand for petroleum and natural gas has risen sharply with industrialization and urbanization. Public sector enterprises such as the Oil and Natural Gas Corporation (ONGC), Oil India Limited (OIL), and Gujarat State Petroleum Corporation (GSPC), alongside numerous private firms, are actively engaged in exploration and production. Currently, seven Category-I basins are under production, while Category-II basins like Kutch, Mahanadi-NEC, and Andaman-Nicobar show strong hydrocarbon potential but require further technological and financial inputs. India aims to reduce its oil import dependency from approximately 80% to 67% through enhanced exploration and production. Apart from conventional hydrocarbons, significant progress is being made in unconventional resources such as Coal Bed Methane (CBM), Shale Gas, Geothermal Energy, and Gas Hydrates, though these initiatives require further acceleration.

Keywords: Basin, Kerogen, Petroleum System, Source Rocks, Reservoir Rocks, Trap/Seal, Maturation, Migration, Coal Bed Methane (CBM), Shale Gas, Gas Hydrate, Geothermal Energy

## Introduction

India ranks as the third-largest consumer of oil and gas globally. The country's petroleum journey began in 1889 with the discovery of oil at Digboi, Assam. Under the leadership of Sri K.D. Malaviya, ONGC and OIL were established in the 1960s to promote self-reliance. However, domestic production, which once met 80% of national demand, has declined to around 18–20%. The government is now focused on revitalizing the sector through new exploration efforts, renewable energy integration, and ethanol blending initiatives.

At present, India produces oil and gas from seven major basins—Bombay Offshore, Cambay (Gujarat), Assam Shelf, Assam-Arakan (Tripura), Krishna-Godavari (Andhra Pradesh), Cauvery (Tamil Nadu), and Rajasthan. Natural gas, discovered in the 1960s, has become a critical clean energy source, fueling industries such as fertilizer, chemical, and power generation. India's gas pipeline network now spans approximately 16,800 km, with several new pipelines under construction. The estimated conventional hydrocarbon resource in India's 26 sedimentary basins stands at roughly 42 billion tonnes of oil and oil-equivalent gas.

### Sedimentary Rocks

Sedimentary rocks form from the deposition and compaction of mineral and organic materials over geological time. These rocks constitute the upper crust in hydrocarbon-bearing regions

and serve as the principal source and reservoir for oil and gas accumulation. Sandstone and limestone are the most favorable lithologies for hydrocarbon storage.

Figure 1a.

Sandstone, A typical clastic reservoir rock.

Figure 1b

Limestone, A common carbonate reservoir rock

**Sedimentary Basins of India**

India possesses 26 sedimentary basins covering about 3.14 million sq. km (onshore and offshore). These basins are classified into four categories based on commercial productivity and geological prospectivity (Figure 2 and 3).

Category I (7 basins): Established commercial production — Cambay, Assam Shelf, Mumbai Offshore, Krishna-Godavari, Cauvery, Assam-Arakan Fold Belt, and Rajasthan.
Category II (3 basins): Hydrocarbon indications but no commercial output — Kutch, Mahanadi-NEC, Andaman-Nicobar.
Category III (6 basins): Geological indications of hydrocarbons — Himalayan Foreland, Ganga, Vindhyan, Saurashtra, Kerala-Konkan-Lakshadweep, and Bengal.
Category IV (10 basins): Uncertain potential — Karewa, Spiti-Zanskar, Satpura-South Rewa-Damodar, Narmada, Deccan Syneclise, Bhima-Kaladgi, Cuddapah, Pranhita-Godavari, Bastar, and Chhattisgarh.

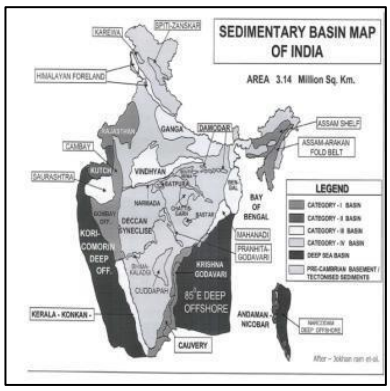


Figure 2.

Sedimentary basins of India (onshore and offshore)

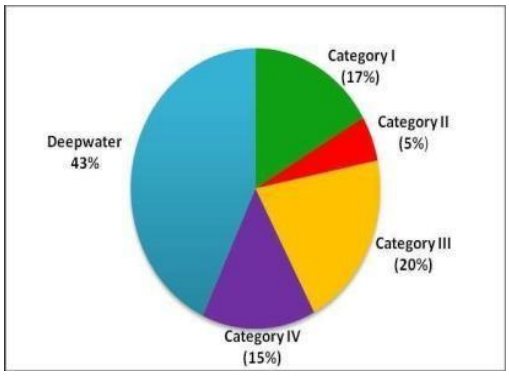


Figure 3.

Percentage-wise distribution of basin categories in India

## Plate Tectonics and Hydrocarbon Formation

The Earth's lithosphere consists of major tectonic plates that move and interact, forming rift valleys and sedimentary basins where hydrocarbons accumulate. The breakup of ancient supercontinents facilitated sediment deposition in these rift zones, making them prime targets for oil and gas exploration.

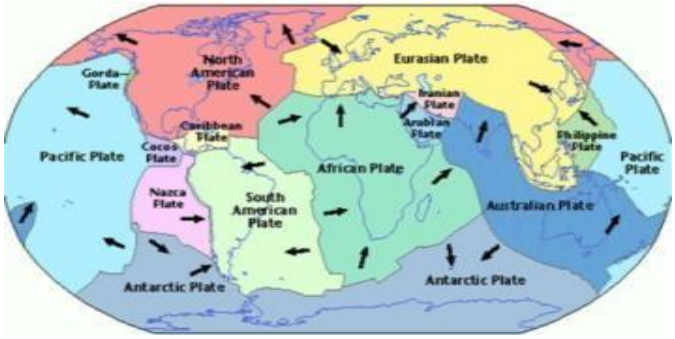


Figure 4. Major tectonic plates of the Earth's crust

## Origin and Occurrence of Oil and Gas

Oil and gas originate from the remains of marine microorganisms such as algae and plankton that settled in sedimentary basins under anoxic conditions. Over millions of years, heat and pressure transformed these organic materials into *kerogen*, which upon further thermal maturation generated hydrocarbons.


Figure 5. Formation of hydrocarbons from algal and planktonic organic matter through burial and heating

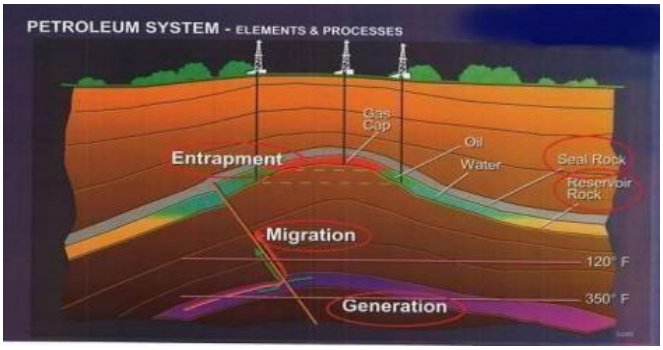

Figure 6. Conceptual model of a petroleum system showing generation, migration, and entrapment of hydrocarbons

**Petroleum System**

A petroleum system encompasses all geological elements and processes essential for hydrocarbon accumulation: source rock, reservoir rock, seal/trap, timing, and migration (Figure 6).

- Source: Organic-rich rock generating hydrocarbons.
- Reservoir: Porous and permeable rock storing hydrocarbons.
- Seal/Trap: Impermeable layer preventing upward migration.
- Overburden: Overlying strata contributing to burial and maturation.
- Migration: Movement of hydrocarbons from source to trap.

7. Methodology of Exploration

Oil and gas exploration follows systematic and multi-disciplinary approaches involving:

1. Geological and regional mapping
2. Geochemical and geophysical surveys
3. Seismic data acquisition and processing (2D & 3D)
4. Source rock and reservoir analysis
5. Structural and tectonic interpretation
6. Depth mapping and prospect delineation
7. Exploratory drilling and reservoir modelling


Fig.7

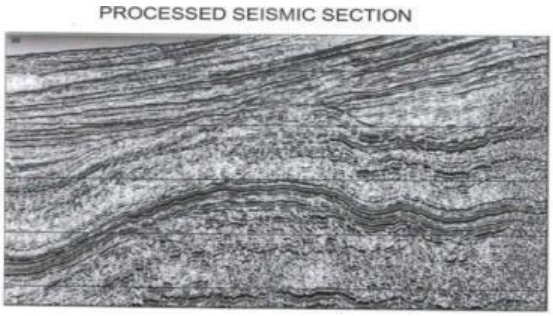


Fig.8

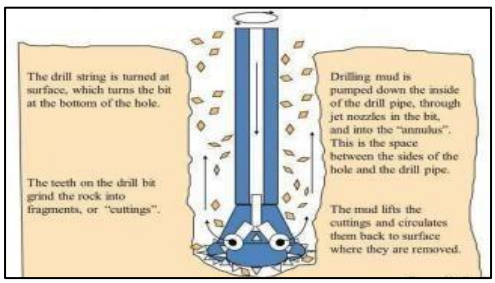


Fig.8

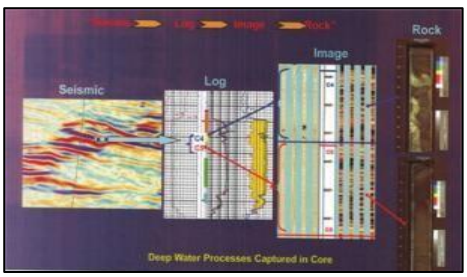


Fig.9

Figure 7. Offshore seismic survey vessel and data acquisition setup
Figure 8. Integration of seismic, well-log, and geological data for interpretation
Figure 9. Modern drilling rig and subsurface exploration illustration

## Conclusion

India's energy landscape is undergoing a transformation with increasing focus on deepwater exploration, unconventional hydrocarbons, and renewable alternatives. Although challenges remain in technological advancement and investment, sustained efforts in basin evaluation and resource development will strengthen India's energy self-reliance. The integration of geoscience, engineering, and policy reforms remains pivotal to achieving the goal of reducing crude oil imports and promoting indigenous production.

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