

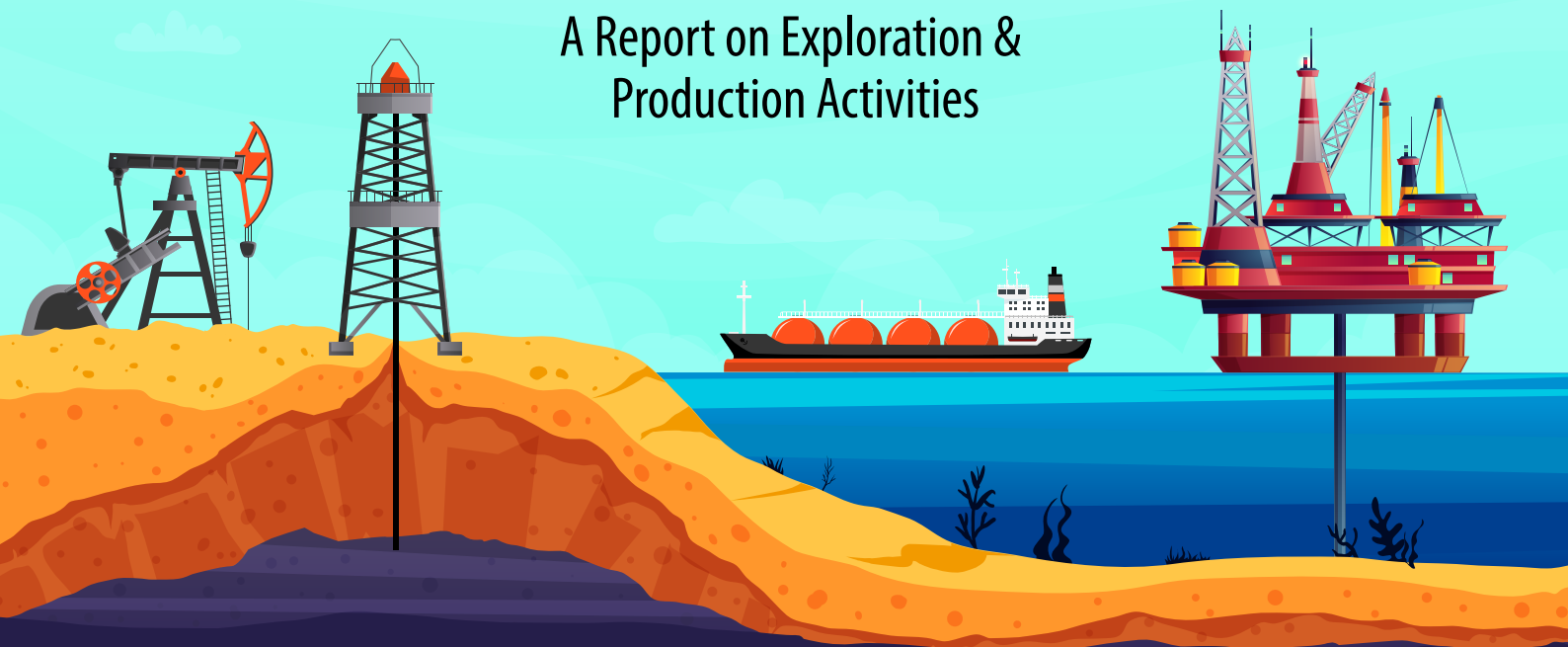


INDIA'S HYDROCARBON OUTLOOK

30
1993
2023
*Celebrating
30 years...*

2022-2023

A Report on Exploration &
Production Activities



Directorate General of Hydrocarbons
Ministry of Petroleum and Natural Gas, Government of India



Creation

Directorate General of Hydrocarbons was formed through a Government of India resolution dated 08.04.1993 under the administrative control of Ministry of Petroleum and Natural Gas.



Objective

To promote sound management of the oil and natural gas resources while having a balanced regard for environment, safety, technological and economic aspects of the petroleum activity.

Disclaimer

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The statistics given in the report are collated from different E&P Companies operating in India and available sources in public domain. The correctness of information given herein, is therefore, subjective to that extent.

Maps are schematic, if not shown with scale.



हाइड्रोकार्बन महानिदेशालय
पेट्रोलियम एवं प्राकृतिक गैस मंत्रालय | भारत सरकार
Directorate General of Hydrocarbons
Ministry of Petroleum and Natural Gas | Government of India

भारत का हाइड्रोकार्बन परिदृश्य
अन्वेषण व उत्पादन गतिविधियों पर एक रिपोर्ट 2022-23

India's Hydrocarbon Outlook
A Report on Exploration & Production Activities 2022-23

KEY HIGHLIGHTS OF 2022-23 (PROVISIONAL)



29.2 MMT

Crude Oil Production



34.5 BCM

Natural Gas Production



51,112 Sq. Km.

Exploration acreage awarded under OALP-VI & VII bid rounds



11 Hydrocarbon Discoveries

ONGC Nomination: 5, OIL Nomination: 1, Contract Regime: 5



63 Active PSCs

9 Pre-NELP Exploration, 21 Pre-NELP Fields, 33 NELP PSCs



168 Active RSCs and 12 Active CBM Blocks

RSC: 119 in HELP & 49 in DSF



358 Active Nomination Acreages

8 PEL and 350 PML Acreages



624 Wells Drilled

111 Exploratory/Appraisal, 513* Development Wells (including CBM)



6690 certificates for purchase of indigenous goods issued

** including side track wells*

MMTOE (Million Tonne Oil Equivalent)



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Hardeep S Puri

हरदीप एस पुरी

पेट्रोलियम एवं प्राकृतिक गैस;
आवासन और शहरी कार्य मंत्री
भारत सरकार

Minister of Petroleum & Natural Gas;
Housing and Urban Affairs
Government of India

India's energy demand is projected to increase at a rate of 3% till 2040 as the country aims to achieve a 10 trillion-dollar economy. The energy sector plays a crucial role in sustaining and accelerating India's economic growth. The country has already made progress in adopting cleaner energy. PM Modi's vision of providing clean and affordable energy for all is central to India's energy policy. India has committed to become net zero by 2070, with five promises (Panchamrit) made at Glasgow COP26.

India is focusing on expanding the use of renewables, including bioenergy, to ensure energy security and reduce energy imports. The country is committed to mitigating climate change by increasing its non-fossil energy capacity to 500 GW, reducing its carbon intensity to 45% by 2030, fulfilling 50% of its energy requirement through renewable energy, and reducing one billion tonnes of carbon emissions.

To support India's upstream hydrocarbon sector, the Government has introduced systematic reforms to provide consistency, certainty, and transparency in the E&P ecosystem. The vast sedimentary areas, that were previously off-limits, have now been opened for exploration, creating attractive upstream openings for global investors. To make the sector more appealing for investments, the Government has taken significant steps to facilitate ease of doing business, offering globally comparable investment opportunities.

Achieving energy security requires continuous and collaborative efforts from the Government, industry leaders, E&P companies, and stakeholders. The Government is committed to revitalizing the oil and gas ecosystem and establishing a conducive business environment. The Directorate General of Hydrocarbons has played a pre-emptive role in shaping the Indian E&P sector for the past 30 years. The release of 30th Annual Publication **"India's Hydrocarbon Outlook: 2023,"** captures all major developments in the Indian E&P sector during the year.

Hardeep S Puri

24 March 2023
New Delhi

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Rameswar Teli

रामेश्वर तेली

राज्य मंत्री

**पेट्रोलियम एवं प्राकृतिक गैस और
श्रम और रोजगार
भारत सरकार**

Minister of State for
Petroleum and Natural Gas &
Labour and Employment
Government of India

India's economic progress is closely linked to energy demand; therefore, as the economy expands, the need for energy will grow considerably. Even though our per capita energy consumption is still one-third of global average, our energy demand is expected to grow at an average rate of 3% per annum till 2040, while the global energy demand is projected to grow at 1%. India thus is the fastest growing energy market.

Oil and gas contributed 33% share in India's primary energy mix and demand for oil and gas is expected to grow till 2040. The hydrocarbons sector plays a vital role in the economic growth of the country. Thus it is necessary to have a long-term policy for the sector, which would facilitate the infusion of technologies, capital and expertise to enhance domestic production to meet the future needs of the country.

To meet ambitious goals of energy security, self-reliance, equity, and accessibility of affordable energy to its people, the Exploration & Production (E&P) sector becomes more important for India due to high import dependency.

India has laid an impetus to accelerate domestic exploration and production and build strong energy security. One key step in this direction is furthering greater wider opportunities for exploration, development, and production in the E&P business encompassing wider stakeholder consultations for stability and creating policy and regulatory reforms.

On the demand side, there have been sustained efforts towards managing the demand of petroleum products through energy efficiency and push for gas use and ensuring the availability of affordable fuel to the common people.

I am confident the stakeholders will take advantage of the large and attractive opportunities in India's E&P sector and join hands in making India self-reliant.

The 30th annual publication of DGH titled "India's Hydrocarbon Outlook 2023" is a must-read for investors, industries, and policymakers. My heartiest congratulation to team DGH for this informative compilation.

Rameswar Teli
24/2/23

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Pankaj Jain
Secretary

पंकज जैन
सचिव

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पेट्रोलियम एवं प्राकृतिक गैस मंत्रालय
शास्त्री भवन, नई दिल्ली-11001

Government of India
Ministry of Petroleum and Natural Gas
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India is one of the fastest growing economies, and its growth contributes to making it third-largest energy consuming country in the world. India is also the fastest growing energy market, and its share has been estimated to be 25 % of the incremental growth in global energy demand over the next few years.

The share of hydrocarbons in India's energy mix has increased to about ~33% of our energy basket. The import dependency of oil stands at 85.7% while for natural gas it was 48.2%.

The goals of energy sufficiency require an impetus to be given to the upstream sector. The acceleration of domestic exploration and production of oil and gas is among the top priorities for the Indian energy sector. Multiple exploration rounds under HELP-OALP, DSF awards have been made in past few years which should bear fruits in near and long term.

The Ministry of Petroleum & Natural Gas (MoPNG) has been spearheading a multi-pronged strategy to substantially step up policy and regulatory reforms to accelerate the exploration and production of oil and gas. MoPNG has been leading wider stakeholder consultations, including with globally reputed MNCs, to review its contractual and fiscal frameworks to lend fresh vigour to India Exploration Campaigns. This has been backed up by the release of vast offshore sedimentary areas for exploration for the first time. To facilitate Ease of Doing Business, major strides have been made through the simplification of procedures and processes for Production Sharing Contracts. Approval processes have been streamlined by digitization and standardization of contractual submissions on the e-platform. Several other proindustry reforms are on the anvil.

With endeavours towards continuous improvement, it is our endeavour to play a proactive and facilitative role. Our focus, besides enhancing production and enabling investments in E&P, is to encourage collaboration with industry, academia, investors, service providers and consultants to bring in new technologically, cost and operational efficiency.

DGH will continue to play its facilitative role to encourage investors to invest in prospective sedimentary basins of India. As noted above, India provides an additional attraction of assured long-term market to absorb higher volumes of domestic oil and gas.

Through the 30th edition of the DGH Annual Publication "India's Hydrocarbon Outlook – 2022-23" we have tried to present a comprehensive review of the Indian upstream sector. I am confident that this report will be a valuable reference to all stakeholders in the industry. MoPNG is open to receiving views for further strengthening of the Indian upstream sector and for improvements/enhancements in this document.

Pankaj Jain





MESSAGE BY DIRECTOR GENERAL, DGH

India, at the forefront of economic growth, is also the third largest consumer of energy in the world. A concomitant of economic growth is development of domestic energy resources for increasing supply of energy, enhancing energy security and reaping the associated multiplier outcomes. The demand for energy is growing fast resulting in greater oil and gas import dependency. Additionally, volatility in global crude oil and gas prices, currency parities have additionally strained the public exchequer. Expert bodies assess that India's demand for oil and gas will continue to increase significantly till 2040. The demand for crude oil may double over the next 10-15 years or so.

To meet the national goal of enhancing energy security, accelerating domestic exploration and production of oil and gas is a top priority for the country. DGH is fully aligned for building domestic oil and gas reserves base and increasing production.

Several far-reaching policy reforms have been recently ushered by the Government of India. To make India a preferred destination for investment in upstream oil and gas sector, initiatives such as opening of offshore areas for exploration with the target of exploration acreage of 0.5 million sq. km. by 2025, upgradation of national

data repository, provision of self-certification by E&P Operators have been taken. While new discoveries of oil and gas are being brought on production progressively, bulk of current production comes from matured and maturing fields. These fields require infusion of new technologies and business models backed by policy led incentives.

Government of India has offered 10 blocks covering around 34,365 sq. km of acreage area under OALP Bid Round-VIII and 26 blocks spanning an area 2.23 lakh sq.km of acreage area under OALP Bid Round-IX for exploration and development through international competitive bidding (ICB). Under Special CBM Bid Round, Government of India announced offering of 16 CBM Blocks totalling 5817 sq. km, under ICB.

Upgrade of the National Data Repository (NDR) to a cloud-based, state-of-the-art facility with virtual data rooms is in progress for investors for 24x7 access to E&P data. Since April 2021, DGH has adopted the Petroleum Resources Management System (PRMS) guidelines for reporting the hydrocarbon resources in the country. Adoption of these global standards and practices will make it easier for global companies to evaluate the hydrocarbon potential of India and make investment decisions.



With endeavours towards continuous improvement, we are today playing a pro-active and facilitative role. Our focus, besides production enhancement and enabling investments in the E&P sector, is to encourage collaboration among the industry, academia, investors, service providers and consultants to bring-in new technology, ensure economy and efficiency of operations and encourage good practices.

The Urja Pragati portal launched by DGH to streamline and expedite grant of various approvals/clearances is one of the pro-active steps undertaken by DGH. Additionally, Upstream India portal has been developed to allow seamless coordination among various E&P operators and other related stakeholders through an online platform. Site Restoration Fund (SRF) Management e-Portal was launched to allow E&P contractors to manage their SRF accounts more efficiently and without any hassle.

The team of highly skilled technical staff at DGH has not only carried out the mandate given by the Government of India, but has contributed

immensely in accelerating the exploration and production activities, bringing state of the art technology and healthy competitive atmosphere in this sector. It is a matter of satisfaction that in 30 years of its journey, DGH has established itself as a well-regarded institution in E&P Sector.

I am confident that DGH will stand by its commitments for a better tomorrow in developing the E&P industry to enable the nation towards achieving greater levels of self-reliance in meeting its huge energy requirements in the form of oil and gas.

Through our Annual Publication 'India's Hydrocarbon Outlook - 2022-2023' we have tried to present a comprehensive review of Indian upstream sector as well as 30 years of our journey in the service of E&P industry in India. I sincerely trust that this 30th anniversary issue will be a useful reference for all stakeholders in the industry.

With best regards,



S. C. L. Das





1

DGH 30 YEARS JOURNEY

Background

India has been involved in oil exploration for over a century, making it one of the few countries with such a rich history in the industry. Initially, Oil & Natural Gas Corporation Ltd. and Oil India Ltd dominated the exploration and exploitation of oil and natural gas resources in India till 1970. Exploration was primarily limited to onshore and shallow offshore areas, until the discovery of the massive Mumbai High fields in 1974, which became the mainstay of India's indigenous production.

In the seventies and eighties, the sector was opened to private companies to augment exploratory efforts, mainly in offshore areas. The process of offering exploration activities to private companies started in 1980, and several rounds of exploration bidding were announced. However, the results of the first three rounds of bidding in 1979, 1982, and 1986 were not encouraging. Subsequently, the government

reviewed and revised the terms of the contract in the fourth, fifth, and sixth rounds of bidding. Between 1980 and 1995, 28 exploration blocks were awarded to private companies, including ONGC and OIL.

The liberalized economic policy adopted by the Government of India in July 1991 deregulated the core sectors, including the petroleum sector, with partial disinvestments of government equity in Public Sector Undertakings. The upstream petroleum sector was largely a monopoly of public sector companies until 1991, and the sector was being increasingly opened to new operating companies in the private and joint sectors. The liberalization policy of 1991 opened the E&P sector further, with both domestic and foreign private companies allowed to explore sedimentary basins. Consequently, several exploration blocks and small & medium sized discovered fields were offered to Private

and Joint Venture Companies through various bidding rounds.

Due to this spurt in activities in the upstream sector, the Ministry of Petroleum and Natural Gas had under consideration the need to have an appropriate agency to regulate and oversee the upstream activities in the petroleum and natural gas sector and also advise the Government in these areas. Subsequently, various committees headed by experts recommended for the creation of an autonomous conservation board and an independent regulatory body for the sound management of hydrocarbon resources in the country.

A committee under the Chairmanship of Late Dr. A.B Dasgupta, former Managing Director of OIL, which had reviewed the management of the Bombay High reservoir in 1990, recommended for the creation of an autonomous conservation board to oversee and review oilfield development programmes to conform to sound reservoir engineering practices in line with national interests. Subsequently, a committee was constituted in 1992 under the chairmanship of late Shri P. K. Kaul, former Cabinet Secretary, to examine the need for restructuring ONGC's organizational structure. This committee recommended for establishment of an independent regulatory body to be called the Directorate General of Hydrocarbons.

DGH-Objective

To promote sound management of the Indian Petroleum and Natural Gas resources having a balanced regard for the environment, safety, technological and economic aspects of the petroleum activity.



1.1 Formation of DGH

In April of 1993, the Government of India established the Directorate General of Hydrocarbons (DGH) under the administrative control of the Ministry of Petroleum & Natural Gas (MoPNG). This organization was tasked with regulating and overseeing upstream activities in the petroleum and natural gas sector, in order to ensure optimal exploration and exploitation of the country's oil and gas resources, and also to advise the government in these matters. The decision to establish the DGH was driven by concerns regarding proper reservoir management of oil fields such as Mumbai High, as well as the entry of private players in the Exploration & Production (E&P) business, which had hitherto been under the control of National Oil Companies (NOCs) like ONGC and OIL.

The prime goal of DGH is to facilitate prudent management of the petroleum and natural gas resources in India, while ensuring an equitable balance between environmental conservation, technological advancement, and economic development in the petroleum industry.





MONITOR

Monitor Exploration & Development operations/ activities of companies holding acreages



PROMOTE

Promote investments in Indian E&P sector



REGULATE

Regulate, preserve, upkeep of geological data of the country



ADVISE

Advise Government on offering of acreages, exploration strategies and production policies

DGH has been entrusted with multifaceted functions and responsibilities which include:

- a) Providing technical expertise and advice to the Ministry of Petroleum and Natural Gas on pertinent issues related to the exploration and optimal exploitation of hydrocarbons in India and abroad by national oil companies.
- b) Scrutinizing and assessing the exploration programs of companies holding Petroleum Exploration Licenses (PELs) under the oilfields (Regulation and Development) Act, 1948 and the Petroleum and Natural Gas Rules, 1959, with a view to advising the government on the adequacy of these programs.
- c) Re-evaluating the estimated and discovered hydrocarbon reserves in coordination with the operating companies.
- d) Advising the government on the allocation of exploration acreages to companies and matters concerning the relinquishment of such acreages.
- e) Reviewing the development plans proposed by operating companies for commercial discoveries of hydrocarbon reserves, assessing the feasibility of these plans and the proposed exploitation rates, and making recommendations to the government.
- f) Concurrently reviewing and monitoring the management of petroleum reservoirs by operating companies and advising on any corrective actions required to ensure optimal exploitation of reserves and conservation of petroleum resources.
- g) Regulating the storage, maintenance, and preservation of data and samples related to petroleum exploration, drilling, and production, and preparing data packages for the allocation of exploration acreages to companies.
- h) Undertaking other incidental functions and any other responsibilities as assigned by the government from time to time.



New responsibilities assigned to DGH by Government through Gazette notification dated 1st September 2006

- 💧 Assess and oversee the exploration program and development plans for commercial discoveries of hydrocarbon reserves proposed by the licensee or lessee with the goal of maximizing hydrocarbon recovery from a reservoir in accordance with widely recognized international petroleum industry practices;
- 💧 Evaluate the management of petroleum reservoirs by the licensee or lessee and provide guidance on any measures that may ensure proper management of the petroleum reservoirs, including their preservation, in accordance with widely recognized international petroleum industry practices;
- 💧 Request and maintain in a readily retrievable form all geo-scientific data, reports, and information from the licensee or lessee and store and preserve data and samples related to petroleum exploration, drilling, production, and related activities;
- 💧 Review the reserves discovered by the licensee or lessee in accordance with widely recognized international petroleum industry practices;
- 💧 Establish guidelines for the declaration or announcement of discoveries by the licensee or lessee;
- 💧 Exercise the authority of the Central Government as given in Rules 24,25,26,27 and 30 of the Petroleum and Natural Gas Rules, 1959;
- 💧 Monitor oil and gas production and royalty or any other charges, fees, or levies, and where appropriate, cost petroleum, etc., due to the Central Government, to ensure that accurate royalty and other statutory charges are received by the due date. In cases where the Central Government has signed a Production Sharing Contract or a contract or an agreement for the exploration and production of hydrocarbons, the powers and functions shall be discharged by the Directorate General of Hydrocarbons in accordance and consistent with the respective Production Sharing Contract or contract or agreement.

Government delegates new responsibilities under Production Sharing Contracts to DGH through new office order dated 25th June 2018

- 💧 Empowering for approval of Excusable Delays under the Policy for Extension in Exploration Phase, dated 18.04.2006
- 💧 Empowering for approval of cost recovery in excess of Appendix H estimates in respect of PSCs signed under NELP-V to NELP-IX, except in case of S-type exploration blocks
- 💧 Empowering for notification of Audit Exceptions in PSC and prescribing timeframe for appointment of auditors and carrying out of audit.



Government strengthens DGH's compliance, regulatory, development and coordination roles through new delegation of Powers & functions (office order dated 10th Oct 2019)

1. All powers and functions of the Central Government under the Production Sharing Contracts, Coal Bed Methane Contracts and Revenue Sharing Contracts in connection with petroleum operations or coal bed methane operations;
2. Provided that the Central Government shall continue to exercise the allowing powers and functions under the Production Sharing Contracts, Coal Bed Methane Contracts and Revenue Sharing Contracts, as the case may be:
 - i execute, amend, extend and terminate the contract;
 - ii grant or recommend grant of Petroleum Exploration License and Petroleum Mining Lease;
 - iii shift and change of delivery point beyond the Contract Area;
 - iv approve cases of excess cost recovery exceeding twenty percent of Appendix-H estimates in respect of Production Sharing Contracts signed under bid round V to IX of New Exploration and Licensing Policy and S-type Exploration blocks;
 - v nominate Government representatives as members of the Management Committee and Steering Committee and designate Chairman and Deputy Chairman;
 - vi decide the quantum of damages in Pre-NELP Production Sharing Contracts and Production Sharing Contracts of bid round I to VII under New Exploration and Licensing Policy or penalties payable to the Government;
 - vii exercise the right to prospect for and mine minerals or substances other than petroleum or grant a license or other rights to any party for such purposes;
 - viii extend or enlarge the Contract Area to include entire area of reservoir situated outside existing Contract Area;
 - ix approve or disapprove Development Plan in case the Management Committee fails to convey its decision regarding approval of the same and where the relevant contract so permits, upon rejection of the Development Plan by the Management Committee;
 - x require joint development or unit development where parties are unable to agree on joint development or a plan for joint development and cause preparation of the plan for such joint development or unit development;
 - (xi) take Government's share of profit petroleum in kind or cash and in case Government's share of profit petroleum is to be taken in kind, agree upon the procedure for delivery of Government's share of profit petroleum and on composition of petroleum to be delivered;
 - xii take in kind and dispose of the Government's share of crude oil;
 - xiii all powers related to valuation and allocation of crude oil, condensate and Natural Gas including determination of the mechanism, formula, basis of calculation and prices of sales;

- xiv regulate the sale, use and disposal of natural gas, Associated Natural Gas, excess Associated Natural Gas, Non Associated Natural Gas and condensates;
 - xv transfer or assignment of Participating Interest; and
 - xvi give consent to change in the management or control of any Party constituting the Contractor or in its relationship with a guarantor, handling and settlement of Audit conducted by Comptroller and Auditor General of India.
3. Any matter having major ramifications on the revenue of the Government or policy implications, which in the opinion of Director General, DGH is a matter of significance requiring Government.

1.2 Governance

Advisory Council

The Directorate General of Hydrocarbons has an Advisory Council that is appointed by the Government and consists of a Chairman and members who are distinguished individuals in the field of hydrocarbon exploration and production. The Directorate provides support to the Advisory Council and is headed by the Director General, who also serves as the Member Secretary to the Council.

Administrative Council

The Government of India established an Administrative Council on February 2nd, 2001, through Office Memorandum No. O-32012/1/95-ONG-III dated 2.2.2001, to provide guidance and oversee all administrative aspects of the DGH's operations. The Administrative Council is responsible for making decisions related to establishment, budgeting, and conducting periodic reviews of the DGH's functioning. It is chaired by the Secretary (P&NG) and comprises the following members:

Table 1.1: Composition of Administrative Council of DGH

Name	Designation
Secretary, MoP&NG	Chairman
Additional Secretary, MoP&NG	Member
AS&FA, MoP&NG	Member
Joint Secretary (Exploration), MoP&NG	Member
Secretary, OIDB	Member
Director General, DGH	Member - Convenor



Figure 1.1: Exploration and Production Regimes in India

The timeline illustrates the progression of oil and gas exploration and production in India, starting from a state monopoly in 1947 and moving through various policy reforms and international agreements up to 2023.

Year	Key Event / Policy Change
1947	State Monopoly Public sector upstream companies
1980	Beginning of de-regulation 28 producing fields and 28 exploratory blocks offered to players including private
1980-1995	Liberalization of E&P Sector (1997-2012)
1997-2012	9 NELP and 4 CBM rounds. 254 exploratory and 30 CBM Blocks through competitive bidding and 3 Nomination CBM Blocks
2014	Discovered Small Field Policy
2016-17	OALP Bid Round - I, 55 blocks awarded
2018	Discovered Small Field Bid Round-II
2019	Policy permitting exploration & exploitation of unconventional hydrocarbons
2020-21	Policy to promote & incentivise enhanced recovery
2021-22	Policy reforms such as exemption from seeking Environment Clearance for exploratory drilling and no restriction on early monetization of Hydrocarbons
2022-23	Natural Gas marketing reforms - to move towards Gas based economy
2023	Launch of OALP Bid round-VIII, Launch of OALP Bid round-IX, Launch of SCBM-2022



DGH's funding is obtained through OIDB (Oil Industry Development Board) grants, and each year DGH presents its estimate for the required funds and seeks approval from the administrative council.

In the past thirty years, ever since its creation under the purview of the Ministry of Petroleum and Natural Gas, the Directorate General of Hydrocarbons (DGH) has transformed into a formidable entity, serving as a dynamic force that catalyzes and facilitates the optimal growth and progress of the petroleum industry's upstream sector.

A Decade-by-Decade Look at the Indian Petroleum Sector's Rapid Evolution...since the formation of DGH.

the 1990s

The petroleum sector in India was initially run by two national oil companies, Oil & Natural Gas Corporation and Oil India. In the 70s and 80s, private sector involvement was encouraged through invitations for foreign oil companies to explore, particularly in offshore areas. The liberalization policy of 1991 opened the sector further, with both domestic and foreign private companies allowed to explore sedimentary basins. This led to the offering of exploration blocks and small-medium discovered fields through bidding rounds to private and joint venture companies. The increased activities prompted the need for a regulatory body and thus, the Government of India established the Directorate General of Hydrocarbons in April 1993 to oversee exploration and development activities. Between 1980 and 1995, 28 exploration blocks were awarded to private companies, including ONGC and OIL. In 1991-1993, the government signed contracts for 29 discovered fields under the Pre-NLEP Discovered Field Rounds. In 1993, blocks for geophysical and other surveys to update the information on hydrocarbon potential of India's unexplored sedimentary basins were offered. Following the completion of these surveys, the blocks were scheduled to be made available for further exploration in subsequent rounds. The government also instigated strategic reforms to disseminate exploration undertakings across the nation. Frontier basins and Deepwater regions, which had remained uncharted or insufficiently surveyed for a considerable time due to geological ambiguities, technological hurdles, complex logistics, and high risks, were targeted for exploration. The exploration bidding rounds that were previously launched continued with the provision of more blocks from non-producing basins. As the response of private firms to these high-risk rating blocks was not encouraging, the government introduced the New Exploration Licensing Policy (NELP) in 1997. The policy provided attractive fiscal terms, not only to promote, expand, and expedite exploration activities across most sedimentary areas, including deep offshore, but also to create a level playing field for both private and national oil companies (NOCs). The government has also recognized the potential of coal bed methane and formulated the CBM Policy in 1997. The NELP Policy was operationalized in 1999. In the year 2000, 24 Production Sharing Contracts were inked under the NELP-I round. The upstream hydrocarbon industry in the country underwent a momentous transformation with the introduction of the New Exploration Licensing Policy in 2000.



the 2000s

DGH played an important role in bringing more areas under hydrocarbon exploration through various geoscientific surveys and other related policies. Production Sharing Contracts (PSCs) for 211 exploration blocks in onland, shallow/deep water areas under NELP-II to NELP-VIII rounds were signed. First CBM bidding round commencing in 2001. Subsequently, there were 3 other bidding rounds in 2003, 2005, and 2008. 29 CBM blocks were awarded through these rounds and an additional 2 blocks were awarded on nomination basis. One block was awarded under the Foreign Investment Promotion Board Route. NGHP carried out the expedition-01 in 2006. Under NGHP-01, 39 holes were drilled to explore the presence of gas hydrate at 21 sites in Krishna-Godavari (KG), Mahanadi, Andaman, and Kerala-Konkan Basin. The presence of significant quantities of Gas Hydrate has been established in the KG, Mahanadi, and Andaman basins. The perception about India being a less favoured destination underwent a paradigm shift. Many companies viewed India as an attractive business destination for oil and gas and brought new technology from across the globe to search hydrocarbons. The investment in the sector also went up substantially. The petroleum sector has seen several key discoveries including the Mangala Oil Field in Rajasthan Basin, MA oil field in KG offshore, and D1 & D3 Gas fields in KG Offshore and Discoveries in KG-DWN-98/2 block by ONGC. DGH has taken several initiatives during the year to further open new areas by acquiring 2D speculative surveys, reprocessing of old seismic data and promoting Indian exploration acreages for systematic exploration. DGH started taking steps to establish the National Data Repository (NDR) that will cater to the needs of the E&P sector and academicians for geo-scientific data requirement which will be made available to help national & international companies looking for opportunities in India.

the 2010s

Major gas discoveries made in East Coast and Oil discoveries in Rajasthan were put on production. The Government initiated the process of establishing a National Data Repository (NDR) which was a pre-requisite for Open Acreage Licensing Policy (OALP) to award of blocks for exploration on a regular basis and impart flexibility to the bidding system. Production Sharing Contracts (PSCs) for 19 exploration blocks in onland, shallow/deep water areas during NELP-IX bidding round signed in 2012. A memorandum of understanding with the Department of State in the US in 2010-11 was signed to aid in resource assessment and policy formation for shale gas exploration and production. To understand the prospectivity and untap the Shale Gas and Oil resource potential in India, Shale gas and Oil exploration policy was launched in 2013.

Policy for geo-scientific data generation for Hydrocarbons in Indian sedimentary basins launched in 2014 that allowed Service Provider to carry out Multi- Client Survey (Non-exclusive Multi-client Model). NGHP carried out the expedition-02 in 2015 and was successfully completed. Under NGHP-02, 42 holes were drilled at 25 sites in KG and Mahanadi Basin. Sand reservoirs with gas hydrate were located at two places in KG Basin and the considered to be prospective for future production testing. The National Data Repository (NDR) was launched in 2017-18 to consolidate and archive all geo-scientific data and provide an e-platform for investors to access and purchase exploration and production data. A re-assessment of hydrocarbon resources was carried out by a Multi Organization Team (ONGC, OIL & DGH) in 2017-18 in all 26 sedimentary basins and the reassessed conventional hydrocarbon volumes estimated were approximately 42 billion tons of oil and oil equivalent gas, signifying a 49.1% increase in resource estimates. The government introduced the Discovered Small Field Policy-2015 to increase domestic production and monetize hydrocarbon resources. In a bid to acquire more data about unexplored and unapprised areas with hydrocarbons prospectivity, a

the 2010s

“National Seismic Program (NSP)” was formulated to conduct 2D seismic surveys in all sedimentary basins of India where no/scanty data is available. The Open Acreage Licensing Program (OALP), as part of the Hydrocarbon Exploration and Licensing Policy (HELP), was introduced by the government on 30th March 2016, and became operational on 1st July 2017, by adopting Revenue Sharing Contract Model. This program gives exploration companies the freedom to select their own exploration blocks without having to wait for formal bid rounds from the government. Blocks/Fields under OALP & DSF bidding rounds were awarded. Several new initiatives were taken by DGH to open new areas for exploration by promoting Indian exploration acreages abroad through board room meetings and by road shows at important venues abroad.

**the 2020s
till March 2023**

DGH implemented various measures to streamline the grant of licenses and clearances. Blocks under OALP & DSF bidding rounds were awarded. GOI launched Special CBM Bid Round (SCBM-21) under the Hydrocarbon Exploration Licensing Policy (HELP) through International Competitive Bidding, in September 2021. An early monetization scheme put in place to facilitate and encourage commercial production from a new discovery while exploration of the block is still underway. In line with the opening of EEZ, Government of India decided to fund the first ever seismic survey of the entire un-appraised portion of EEZ. ‘Urja Pragati’ portal to expedite the grant of clearances and ‘Upstream India’ portal to allow seamless coordination with E&P operators were launched. Empowered Coordination Committee (ECC) established to streamline and accelerate clearance and approvals. A dedicated ‘Hydrocarbon Clearance Cell (HCC)’ to liaises with Central/State Government authorities for expeditious grant of clearances/approvals was setup at DGH. North-East Coordination Committee (NECC) was created and Coordinators placed with various Departments of State Govts of Assam, Arunachal Pradesh, and Tripura for ease of processing Clearance and Approval proposals. Process improvements have been made in the contract management system by introduction of Self-certification processes in contracts for all awarded contracts. The Government has lifted restrictions on areas situated along the West Coast, East Coast, and Andaman regions, allowing for the exploration of these previously designated “No-Go” zones. Exploration and Production (E&P) companies are now permitted to take their data collected during exploration activities outside of India for further analysis. To promote commercial production from newly discovered reserves, an early monetization plan has been implemented. To streamline the contract management system, self-certification processes have been integrated into all awarded contracts. New OALP bidding rounds Launched for award of new exploration blocks. E&P companies are being encouraged to take up large acreages in the newly opened EEZ, supported by quality data and a pro-investor incentive structure. In order to reach out to foreign investors, DGH is pro-actively engaging with them at roadshows and bilateral events.



A sneak Peek at Key Milestones as DGH turns 30

Geoscientific studies and surveys from 1995 onwards

New Exploration Licensing Policy (bidding rounds during 1999 -2012)

Coal Bed Methane Policy and bidding rounds

National Gas Hydrates programme (NGHP)

Discovered Small Field Policy, 2015

Hydrocarbon Exploration Licensing Policy (HELP) in 2016

Setting up of National Data Repository, 2017.

Appraisal of Unappraised areas in Sedimentary Basins, 2017

Re-assessment of Hydrocarbon Resources, 2017

1. Geoscientific studies and surveys (from 1995 onwards)

The Directorate General of Hydrocarbons (DGH) has played a pivotal role in expanding the scope of hydrocarbon exploration by implementing various geoscientific surveys and policies. One of the primary objectives of the DGH is to enhance the geo-scientific knowledge base of

the country's under-explored basinal regions. This objective is accomplished by conducting cutting-edge geo-scientific surveys in these areas, either through speculative means or by utilizing its own funding and resources. This has resulted in the identification of vast swathes of land that are now available for systematic exploration and bidding in various rounds.

Geoscientific Surveys by DGH

S.No.	Area/Block	Survey Type	State/ offshore	Year
I. RECONNAISSANCE SURVEY				
1	Western & Eastern Offshore	Satellite Gravity	Western, Eastern & Andaman Offshore	1995-98
2	Kutch Offshore & Onland	Aero-Magnetic	Gujarat	1995-96
3	Nagpur-Wardha-Belgaum	MT	MP, Maharashtra & Karnataka	1996-98
4	Himalayan Foreland	Aero-Magnetic	Punjab & Haryana	2003-04, 2004-05
5	Punjab and Foot Hills of Himalayas	Aero-Magnetic	HP, Punjab, Part of Haryana & Uttaranchal	2005-06
II. JOINT VENTURE SPECULATIVE SURVEYS OFFSHORE				
OFFSHORE				
6	East Coast	2D seismic & GM	Deep waters	1996-97
7	Andaman-Nicobar	2D seismic & GM	Andaman sea	1996-97
ONLAND				
8	Ganga Valley (GV-ON-90/5)	2D seismic	UP & Bihar	1997-98
9	Vindhyan (VN-ON-90/5)	2D seismic	UP, MP & Bihar	1997-98

S.No.	Area/Block	Survey Type	State/ offshore	Year
III. SPECULATIVE SURVEYS				
10	Western & Eastern Offshore	2D seismic	Shallow & Deep water of west and east coast	2005-07
11	Western Offshore	2D seismic (Re-processing)	West coast of India	2007-08
12	Andaman Offshore	2D seismic	Andaman sea	2007-09
13	Eastern Offshore	CSEM	East coast- KG Basin	2007-08
14	Western Offshore	2D seismic	West coast of India	2009-10
15	Western Offshore	2D seismic	West coast of India	2009-10
16	West and east coast	2D seismic	Shallow & Deep water of west and east coast	2008-10
17	Andaman Islands of India	2D seismic (Re-processing)	Andaman Islands of India	2009-10
18	Kutch	Airborne HRAM	Gujarat	2007-09
		Airborne GM	Gujarat	2009-10
IV. SEISMIC SURVEYS				
OFFSHORE				
19	Andaman Infill	2D Seismic	Andaman Offshore	1999
20	Southern Tip (ST)	2D Seismic	Deep waters	2001-02
21	East Coast (EC)	2D Seismic	Deep waters	2001-02
22	Andaman-Nicobar (AN)	2D Seismic	Deep waters	2001-02
23	West Coast (WC)	2D Seismic	Deep waters	2002-03
ONLAND				
24	Ganga Valley (GV)	2D Seismic	Bihar	2002-03
25	Chambal Valley (CV)	2D Seismic	MP & Rajasthan	2003-04
26	Kutch	2D Seismic (Acquisition)	Gujarat	2006-09
V. INTEGRATED GEOPHYSICAL SURVEYS				
27	Deccan Syncline (DS) Narmada-Tapti Area	Gravity, MT, DRS, 2D seismic	MP, Maharashtra & Gujarat	2003-04
VI. GRAVITY -MAGNETIC SURVEYS & OTHER GEOPHYSICAL SURVEYS				
28	Vindhyan (Amriti)	GM	MP	2003-04
29	Gulf of Kutch	MS & MMT	Gujarat	2006-08
30	Central India	Land MT	MP & Rajasthan	2006-09
31	Narmada-Cambay/ Deccan Syncline	Analysis of Aerial Images/ Remote sensing data	Maharashtra, MP, Gujarat	2006-08

S.No.	Area/Block	Location	Year
VII. GEOCHEMICAL SURVEYS			
1	Chambal valley	Madhya Pradesh & Rajasthan	2002-03
2	Kutch Onland	Gujarat	2002-03
3	Chhattisgarh	Chhattisgarh, Madhya Pradesh, Orissa	2003-04
4	Cuddapah	Andhra Pradesh	2004-05
5	Bhima-Kaladgi	Karnataka	2005-06
6	Mizoram	Mizoram	2005-06
7	Bastar	Chhattisgarh	2005-07
8	Ganga	Uttar Pradesh-Bihar	2007-09
9	Deccan Syneclise	Maharashtra-Madhya Pradesh-Karnataka	2007-08
10	Vindhyan	Madhya Pradesh-Rajasthan	2008-10
11	Rajasthan	Rajasthan	2009-10
12	Bengal Onland	West Bengal	2009-10
13	Cauvery Basin	Tamil Nadu	2010-11
14	Spiti-Zaskar and Karewa	Jammu-Kashmir & Himachal	2012-13



2. New Exploration Licensing Policy (bidding rounds during 1999 -2012)

Since its inception in February 1999, the New Exploration & Licensing Policy (NELP) has revolutionized the exploration sector by instituting a competitive bidding system for exploration blocks. This has leveled the playing field for National Oil Companies (NOCs) by pitting them against Indian and foreign companies, ensuring fair and equal opportunity for all to secure Petroleum Exploration acreages.

NELP has facilitated the awarding of 254 blocks to Indian, private and foreign companies through an International Competitive Bidding

process. Moreover, deepwater exploration, which is considered the final frontier in oil and gas exploration, has witnessed significant discoveries. These discoveries have had a profound impact on the oil and gas sector in India, accelerating the pace of exploration, and bringing in deep-water oil and gas production, infusion of technology, and investment in the E&P sector, among other benefits.

About 1.50 Million Sq. Km was awarded through nine rounds of bidding. Production Sharing Contracts (PSCs) for 254 exploration blocks were signed for blocks awarded in onland, shallow/deep water areas. Details given below.

Parameter	NELP I	NELP II	NELP III	NELP IV	NELP V	NELP VI	NELP VII	NELP VIII	NELP IX	Total
Year of launch	1999	2000	2002	2003	2005	2006	2007	2009	2010	
No. of Blocks Offered	48	25	27	24	20	55	57	70	34	360
No. of Blocks Bid For	28	23	24	21	20	52	45	36	33	282
No. of blocks awarded	25	23	23	21	20	52	44	34	19	261
Blocks Awarded/ Blocks offered	52%	92%	85%	88%	100%	95%	77%	49%	56%	73%
No. of PSCs signed	24	23	23	20	20	52	41	32	19	254
Area Awarded Lakh Sq. KM	2.3	2.6	2.0	1.9	1.1	3.1	1.1	0.5	0.3	15.0

Most of the gas discoveries in India have been made in shallow water offshore and deepwater blocks located mainly in Eastern Offshore areas. These discoveries include several gas discoveries made by ONGC, RIL, and GSPC in Mahanadi-North East Coast, Krishna-Godavari, and Cauvery basins. These discoveries have propelled India onto the deepwater oil and gas map of the world, cementing its position as a global player in the exploration and production of hydrocarbons.

3. Coal Bed Methane Policy and bidding rounds

The government also formulated the CBM Policy in 1997, with the first CBM bidding round

commencing in 2001. Subsequently, there were 3 other bidding rounds in 2003, 2005, and 2008. 29 CBM blocks were awarded through these rounds and an additional 2 blocks were awarded on nomination basis. One block was awarded under the Foreign Investment Promotion Board Route.

Special CBM Bid Round 2021 under OALP (SCBM-2021): The Government of India on 22nd September 2021 launched the Special CBM Bid Round- 2021 under the Open Acreage Licensing Policy (OALP) offering 15 CBM Blocks covering 8458 sq. km. with ~700 BCM prognosticated CBM resource. International Competitive Bidding (ICB) for the 15 CBM blocks was concluded on 31.05.2022.



Under SCBM Bid Round- 2021, four (4) Blocks were awarded to 03 companies (ONGC, Vedanta and Invenire Petrodyne Energy) covering an area of 3862 Sq. Km.

Special CBM Bid Round 2022 under OALP (SCBM-2022): On October 10, 2022, the government initiated the second round of the Special Coal Bed Methane (CBM) Bid Round, in which 16 CBM blocks spanning an approximate area of 5817 square kilometers were made available for bidding through an International Competitive Bidding process, which will conclude on March 17, 2023. It is worth noting that all the offered 16 blocks are situated within Category-III basins.

Refer Chapter - 7 for more details

4. National Gas Hydrates programme (NGHP)

Gas hydrate exploration in India is steered by the Ministry of Petroleum & Natural Gas under National Gas Hydrate Program (NGHP). Two expeditions, the first in 2006 (NGHP-01) and the second in 2015 (NGHP-02) were undertaken. Under NGHP-01, 39 holes were drilled to explore the presence of gas hydrate at 21 sites in Krishna-Godavari (KG), Mahanadi, Andaman, and Kerala-Konkan Basin. Except Kerala-Konkan, the presence of gas hydrate was established in all three basins, but such gas was proved to be non-exploitable with existing technologies. Under NGHP-02, 42 holes were drilled at 25 sites in KG and Mahanadi Basin. Sand reservoirs with gas hydrate were located at two places in KG Basin and the considered to be prospective for future production testing.

International and national experts engaged through MoU under NGHP advised that future production testing should be undertaken in three phases. Phase 1 was proposed to deal with integration and interpretation of data acquired under NGHP-01 & 02 campaigns. Phase-2 would involve acquisition of additional data to better-understand the subsurface integrity required for successful production testing. Phase-3 was proposed to conduct production testing at selected sites.

Currently, Phase-1 activities are underway at various places in India, Japan and USA.



5. Discovered Small Field Policy, 2015

The Marginal Field Policy, later renamed as the Discovered Small Field (DSF) Policy, was approved by the Cabinet Committee on Economic Affairs (CCEA) on September 2, 2015 and notified in a notification on October 14, 2015, in order to bring previously un-monetized discoveries of National Oil Companies (NOCs) into production. The first DSF Round was launched on May 25, 2016.

On February 7, 2018, the CCEA approved an extension of the policy to include un-monetized discoveries and small fields from the Production Sharing Contract regime, in addition to un-monetized discoveries from the Nomination regime. The second DSF Round was launched on August 9, 2018. The government has also decided to extend the DSF Policy for future bidding rounds and has established a committee, consisting of Additional Secretary & Financial Advisor (MoPNG), JS (Exploration), MoPNG and Director General of Hydrocarbons, to identify fields and discoveries that will be put on offer for future bidding rounds, in consultation with the CMDs of ONGC and OIL. The extension of the DSF Policy was notified in a notification on April 5, 2018.

Three DSF rounds have been conducted so far. Salient details are as under:

DSF Bid Round-I 2016

- 💧 Launch date: 25th May 2016
- 💧 Offered Areas: 46 Contract Area (67 fields), 1551 Sq.km of area, 86 MMTOE of Inplace
- 💧 134 bids were received for 34 contract areas
- 💧 Awarded: 30 Contract Areas (43 Fields), 777 Sq.km of Area, 45 MMTOE of Inplace
- 💧 Contact signing date: 27th March 2017

DSF Bid Round-II 2018

- 💧 Launch date: 09th Aug 2018
- 💧 Offered Areas: 25 Contract Area (59 fields), 3,042 Sq.km of area, 190 MMTOE of Inplace
- 💧 145 bids were received in 24 Contract Areas
- 💧 Awarded: 24 Contract Area (58 Fields), ~3000 Sq.km of Area, 188.9 MMTOE of Inplace.
- 💧 Contact signing date: 7th March 2019

DSF Bid Round-III 2022

- 💧 Launch date: 10th June 2021.
- 💧 Offered Areas: 32 Contract Area (75 fields), ~13000 Sq.km of area, 232 MMTOE of Inplace
- 💧 107 bids were received for 32 contract areas (CA) i.e. 3.3 Bids every CA. 27 Companies participated (04 PSU & 2 Foreign Companies).
- 💧 RSC signed for 30 Contract Area (72 Fields), 12,400 Sq.km of Area, 230 MMTOE of Inplace. (One CA- RSC yet to be signed)
- 💧 Contact signing date: 9th Sept. 2022.

Refer Chapter - 6 for more details

6. Hydrocarbon Exploration Licensing Policy (HELP) in 2016

The Hydrocarbon Exploration and Licensing Policy (HELP) was instituted with the aim of augmenting the production of oil and gas in the Indian sedimentary basin. HELP represented a paradigm shift from a cost-recovery to a revenue-sharing mechanism and was a significant step towards enhancing the ease of doing business in the Indian exploration and production (E&P) sector. As part of HELP, the Government of India introduced the Open Acreage Licensing (OAL) mechanism, which enables exploration companies to self-select the exploration blocks, without having to wait for formal bid rounds from the government. Some of the most notable features of HELP that have garnered industry acclaim include:

- 💧 Opportunity to demarcate blocks utilizing the National Data Repository (NDR)
- 💧 A Unified Licence for both conventional and unconventional Hydrocarbons
- 💧 A straightforward and easy-to-administer Revenue Sharing model
- 💧 A minimal regulatory burden
- 💧 Permissive entry and exit barriers
- 💧 Complete transparency and a time-bound process
- 💧 A level playing field for global private companies as well as National Oil Companies
- 💧 Market-driven pricing and unrestricted market access
- 💧 A concessional royalty regime for Ultra-Deep water and Shallow Water areas
- 💧 Exploration rights for the entire contract term

Refer Chapter - 6 for more details



7. Setting up of National Data Repository, 2017.

The Government of India notified the Open Acreage Licensing Programme (OALP) as a part of the Hydrocarbon exploration and Licencing Policy (HELP) on 30th June, 2017. National Data Repository (NDR) is a pre-requisite and key component for making OALP operational to view the surface and sub-surface geological, geophysical and other technical data by the investors. NDR was launched on 28th June, 2017

National Data Repository (NDR) set up at DGH and launched on 28th June, 2017 to make the entire Exploration and Production (E&P) data available for commercial exploration, research and development and academic purposes.

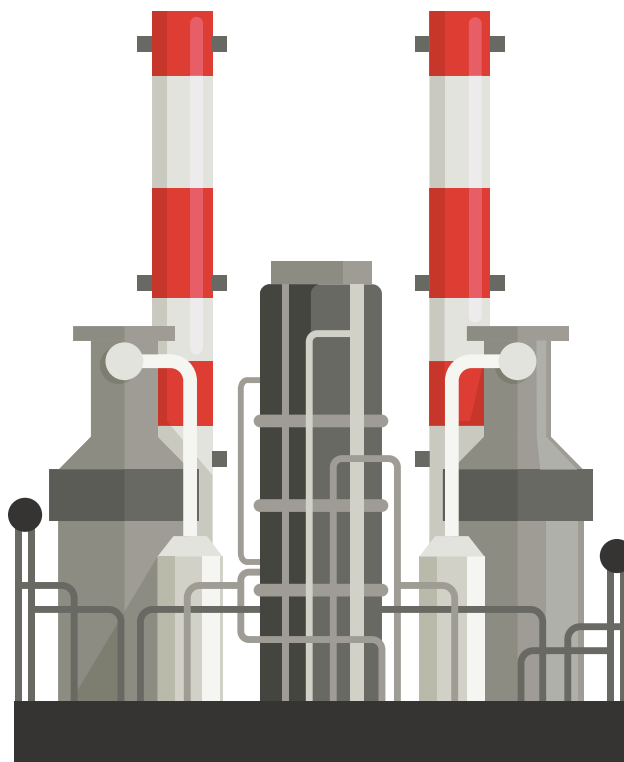
Future ready National Data Repository 2.0 [NDR 2.0]

Next generation National Data Repository 2.0 (NDR 2.0) is planned with the aim to further improve the data accessibility (downloading), data reporting, submission (Uploading) and enhance storage (for all E&P data types including seismic field data) and to create a cloud enabled database platform.

Refer Chapter - 3 for more details

8. Appraisal of Unappraised areas in Sedimentary Basins, 2017

- The Government has taken up programme of undertaking 2D seismic survey of entire unappraised areas. National Seismic programme (NSP) was launched on 12th October 2016. With its aim to undertake appraisal in all sedimentary basins across India, especially where no/scanty data is available, a total of ~ 46,960 LKM acquired out of the target 48,243 LKM – close to 97% of the target has been met.
- There are some areas as per project plan where seismic survey couldn't be carried out due to in-accessible terrain and hostile environment. Appraisal of such difficult areas is being taken up through Airborne Geophysical Survey. Total 40,000 LKM flight LKM Gravity Gradiometry and Gravity-



Magnetic data is to be acquired in these areas within a year. The project is implemented through Oil India Limited and tendering for hiring services for undertaking Airborne Geophysical Survey is under progress.

- The area surrounding the Andaman & Nicobar (A&N) islands have significant potential for oil and gas. Thus, for a comprehensive appraisal of Andaman offshore, DGH formulated a plan to acquire 22,500 LKM 2D Broadband seismic data acquisition, processing, and interpretation thereof covering basinal area of approx. 281,613 Sq. Km. The survey activities has been completed in February 2022.
- **Exclusive Economic Zones (EEZ) survey, (Ongoing):** Approximately 1.13 Million Sq. Km. is unappraised in the Offshore Basinal Areas of Indian sedimentary basins up to EEZ. ONGC was entrusted as nodal agency for EEZ survey. Accordingly, ONGC awarded the contract (70,000 LKM with a provision of 20% extension) to service provider for 2D Broadband Seismic Data Acquisition covering three sectors; Western, Eastern

and Andaman Offshore up to EEZ. Appx. 50,320 LKM seismic data has already been acquired under EEZ survey till 28th February 2023.

Refer Chapter - 3 for more details

9. Re-assessment of Hydrocarbon Resources, 2017 (September 2015- November 2017)

A Multi Organisation Team comprising of representatives of ONGC, OIL and DGH carried out estimation of hydrocarbon resource potential in the country. The prognosticated conventional hydrocarbon resources in 26 sedimentary basins of the country are re-assessed to the order of

41.87 billion tonnes of oil and oil equivalent of gas (O+OEG), which is about 49% increase as compared to earlier estimates of 28.08 billion tonnes of O+OEG

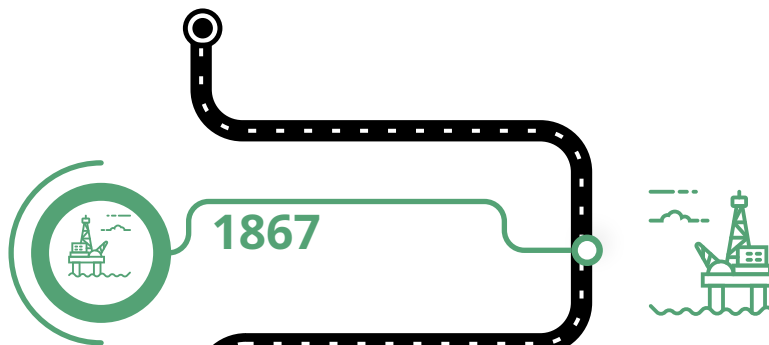
The amount of data increased significantly since then on account of increased E&P activities as well as government sponsored programmes. The seismic data has been re-processed and new discoveries have been made in recent times.

However, considering the pace of data acquisition and the advancement in assessment tools and technologies, it is envisaged to undertake the Hydrocarbon Resource Assessment Study (HRAS). This will act as a guiding tool for re-aligning the exploration strategy for Indian sedimentary basins helping companies align their investment interest.



KEY MILESTONES OF INDIAN E&P SECTOR

- Struck Oil in Jeypore Assam



1882



- Assam Railway Trading Company set up to explore oil

- First Commercial Discovery at Digboi, Assam



1890



1891



- Assam Oil syndicate set up a refinery at Margherita, Assam

- Assam Oil Company to take over petroleum interest from Assam Oil Syndicate



1895



1901



- First Oil Refinery Set up at Digboi, Assam

- Burmah Oil Company bought shares from ARTC, and appointed commercial and technical managers from AOC



1922



- Bombay High discovered
- Discoveries of Bassein Gas Field, Mumbai Offshore, Kharsang oil field, Arunachal Pradesh
- Discovery of Heera oil field, Mumbai Offshore

1981-1986



- Oil India Ltd became wholly owned GoI Enterprise
- Discovery of Gandhar Oil field, Gujarat
- GoI decision for participation of private companies in development of discovered oil and gas fields
- Neelam Oil Field, Mumbai Offshore discovered

1974-1977



1959-1961



- ONGC became statutory body
- Discovery of Ankleshwar oil field, Gujarat
- Oil India Pvt Ltd incorporated as 50% JV between GoI and BOC

1956



- Oil and Natural Gas Commission established
- Discovery of oil in Moran, Assam

1953



- Discovery of Naharkatia Oil Field, Assam

1948



- Industrial Policy Resolution passed
- Oil fields Regulation and Development) Act, 1948 came into existence

1930



- Crude Oil Production rose upto 2,50,000 tonnes per annum and exploration activities continued in Assam-Arakan range



- Ravva Oil Field discovered in KG Offshore
- DGH Established
- ONGC is re-organised as a corporation



1987-1993



1997-1999



- Govt formulated CBM Policy
- Govt approved NELP
- NELP-I launched offering 48 blocks

- NELP-II launched with 25 blocks on offer
- First round of CBM bidding
- NELP-III launched offering 27 blocks



2000-2002



2003



- Second Round of CBM blocks bidding
- NELP-IV launched

- Mangala Oil Field discovered in Rajasthan
- Third Round of CBM bidding
- NELP-V launched offering 20 blocks



2004-2005



2006



- NELP-VI launched offering 55 blocks
- MA Oil Field, KG Offshore Discovered

- NELP-VIII launched with 57 blocks on offer
- CBM extension policy introduced
- Discovery of D1 & D3 Gas Fields, KG offshore



2007

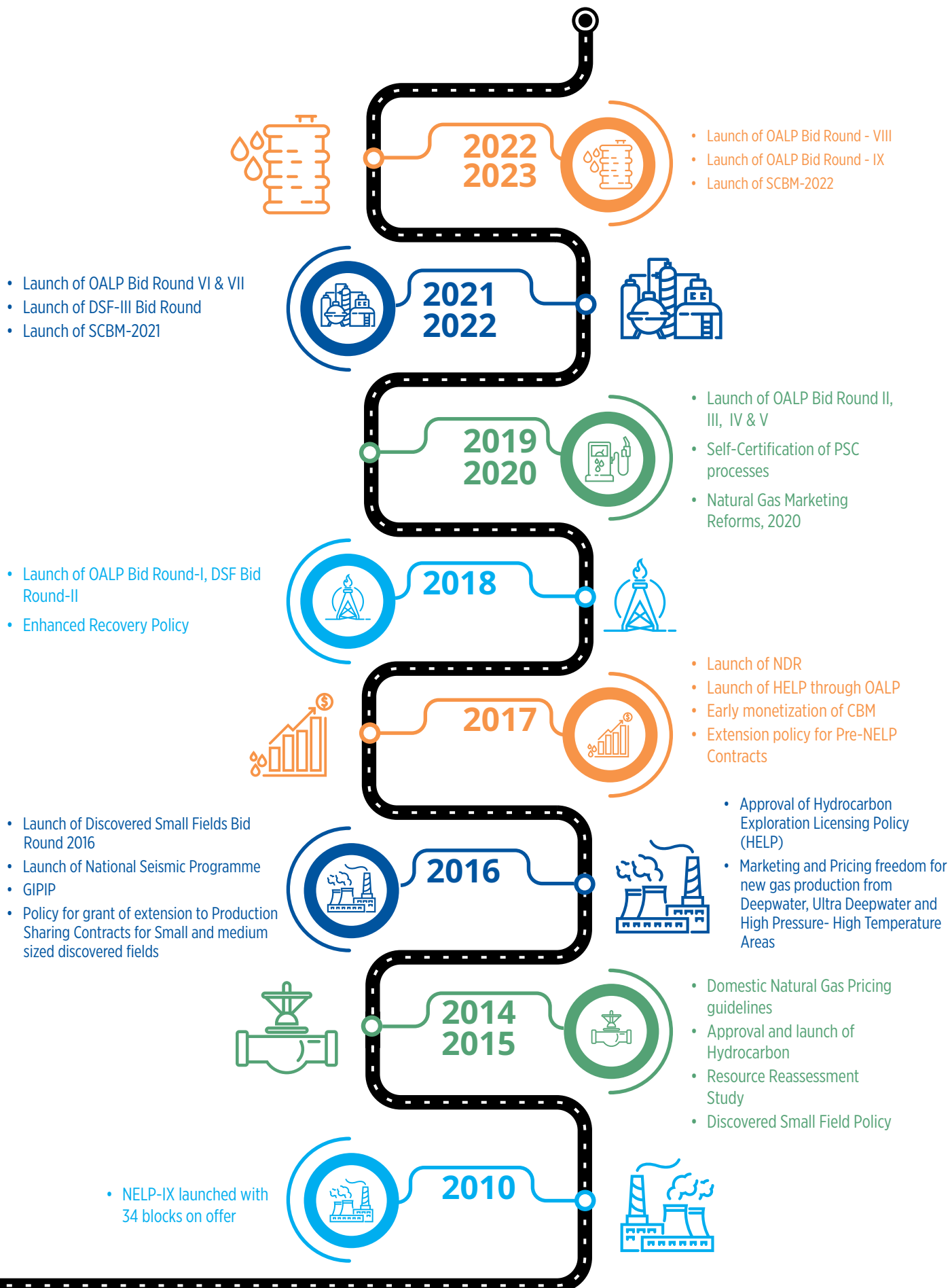


2008- 2009



- Fourth round of CBM bidding
- NELP-VIII launched with 70 blocks on offer







2

UNLOCKING HYDROCARBON POTENTIAL OF INDIA'S SEDIMENTARY BASINS

India has a sedimentary basin cover of 3.4 million sq km and is appraised through geoscientific surveys to the extent of 61% of total area. However, the exploration through drilling has penetrated to less than 10% of the area. The country is favourably located with thick sedimentary rocks, in suitable geological settings of Rift, Fold-belt and Foreland regions. It belongs to Region 8 (South Asia) and is part of 171 Hydrocarbon Provinces mapped by USGS in 2012.

There are 26 sedimentary basins mapped using latest GIS tools and categorized into three, based on conventional hydrocarbon resources,

following the rationale of Petroleum Resources Management System (PRMS), a global standard for accounting of petroleum resources and reserves based on techno-commercial merits. There are 9 offshore basins, which account for 51% of total basin area.

Based on conventional resource potential, 7 basins, which are commercially producing, are grouped under Category-I covering 30% of total basinal area (1.0 million sq km) and a total hydrocarbon of 21,487 MMTOE, which is 86% of country's total that includes discovered as well as risked undiscovered potential. These 7 basins are namely Krishna-Godavari (KG),

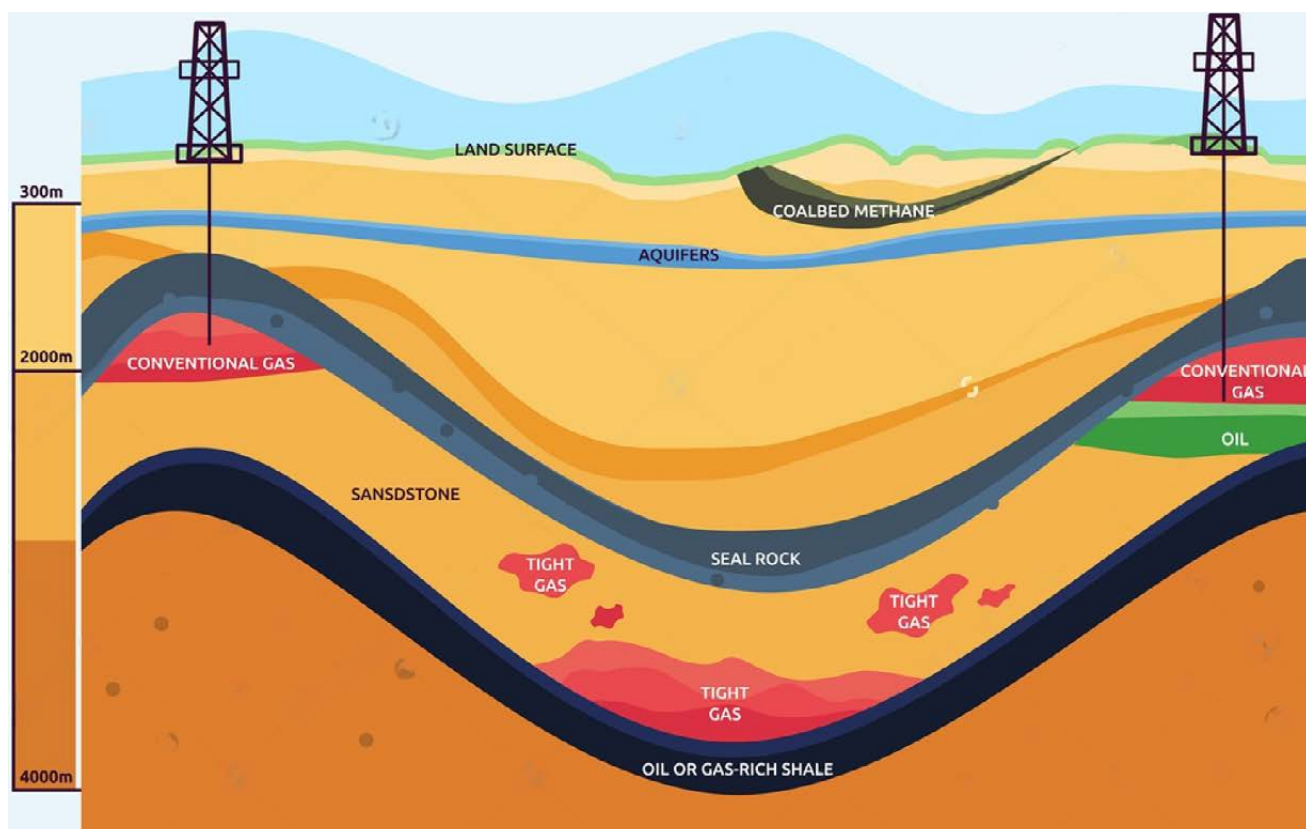
Mumbai Offshore, Assam Shelf, Rajasthan, Cauvery, Assam- Arakan Fold Belt and Cambay. These basins are largely appraised with 57% of country's total active operational area (0.36 million square kilometer).

Similarly, Category-II basins, which are discovered but awaiting development, cover 0.78 million sq km (23% of total basinal area), holding 8% (1,951 MMTOE) of the total hydrocarbon in-place. 5 basins fall in this category and those are namely Saurashtra, Kutch, Vindhyan, Mahanadi and Andaman. These basins are moderately appraised with 32% of country's total active operational area.

Further, Category-III basins, which are prospective, cover 1.58 million sq km (47% of total basinal area), holding 6% (1,543 MMTOE) of the total hydrocarbon in-place. 14 basins fall in this category and those are namely Kerala-Konkan, Bengal-Purnea, Ganga-Punjab, Pranhita-Godavari (PG), Satpura-South Rewa-Damodar, Himalyan Foreland, Chattisgarh, Narmada, Spiti-Zanskar, Deccan Syneclise, Cuddapah, Karewa, Bhima-Kaladgi, and Bastar. These basins are fairly appraised with 11% of country's total active operational area.

The grouping of the basins under the category is dynamic, a Category III basin can be upgraded to II in case there is significant hydrocarbon resource established through discovery (viz. Bengal-Purnea basin is proposed for upgrade to Category II during the next periodical assessment of country-level hydrocarbon resources) or Category II to I, if discoveries are developed for commercial production (Kutch/Saurashtra basin could be the next as few field development plans were approved for implementation). For unconventional resources, the above category will have a different connotation. For example, CBM gas is currently produced from Damodar sub-basin of Satpura-South Rewa-Damodar basin, which is a Category III basin for conventional resources, however by virtue of commercial gas production, the basin will be deemed Category I for unconventional resources.

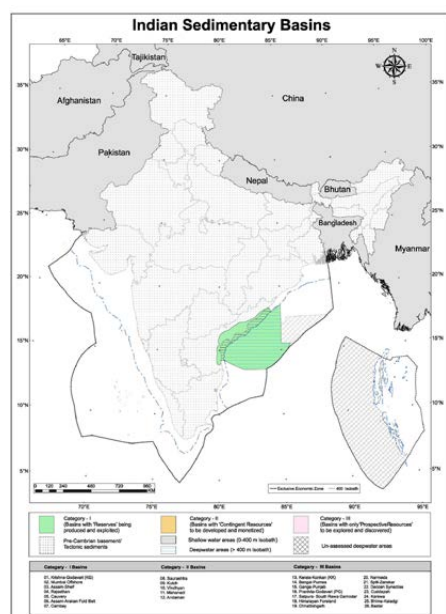
Under redrafted Revenue Sharing Contract for Hydrocarbon Exploration Licensing Policy, Contractors, operating in Category II and Category III basins for respective conventional and unconventional resources are now exempt from revenue sharing with the government during bid submission and until a windfall gain.



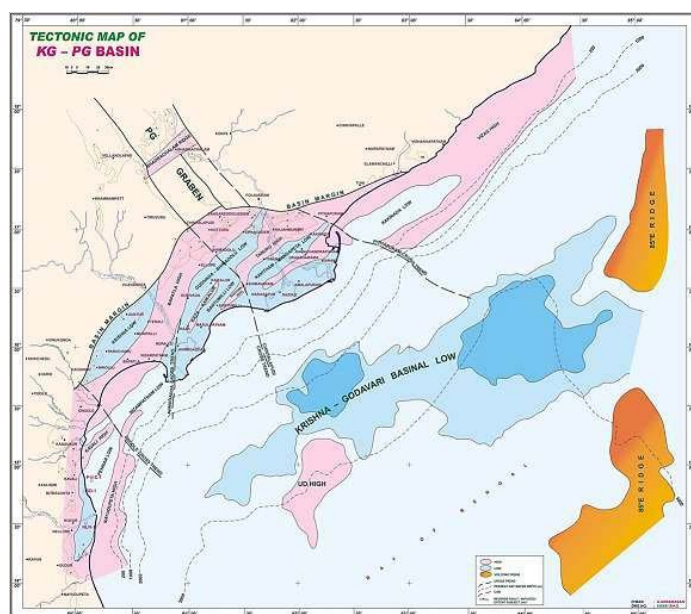
1. KRISHNA-GODAVARI (KG) BASIN

Krishna-Godavari (KG) is a Category I basin, implying that the basin has significant commercial discovered inplace, that is to be produced at an optimum level. The basin has an area of 230,000 sq. km. with 31,456 sq. km. onland area, 25,649

distribution over onland, offshore including ultradeep bathymetry. Several oil and gas fields have been discovered both onland and offshore with structural, stratigraphic and strati- structural entrapment conditions. The



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sq. km. shallow water area (upto 400m water depth) and 172,895 sq. km. deepwater area. In the basin, 12 plays are present within Basement, Permian, Mesozoic, Paleocene, Eocene, Miocene(+Biogenic), Pliocene (+Biogenic).

Krishna-Godavari (KG) is characterized primarily by siliciclastic shelf margin sediments. The basin is located along the east coast of Indian peninsula, lying between Mahanadi basin in the north and Cauvery basin towards south. The basin is most prospective and largely proven with maximum resources (38% of total offshore), and was known for country's largest deepwater biogenic gas field. With 2.0 BTOE resource established, proven plays have significant prospective resources. Both deepwater and shallow water are extensively appraised with large-scale datasets, which is an opportunity for intensive exploration of stratigraphic traps, majorly the channelized deposits.

Commercial hydrocarbon occurrences spread over a wide stratigraphic horizons ranging from Permian to Pliocene with geographical

exploration thrust in the basin has resulted in discovery of large to medium to small-sized oil and gas pools across onland and offshore areas of shallow, deep and ultradeep waters. It is a dual-rift province with the Late Jurassic rift having resulted in NE-SW trending passive margin basin orthogonally superimposed over the NW-SE trending Pranhita-Godavari basin with Gondwana sediments. The KG basin consists of sediments with thickness of more than 7,000m, ranging in age from the Early Permian to Recent. The basin's onland part is mostly covered by the alluviums deposited by the two major river systems, viz., Godavari and Krishna and several stratigraphic sequence including Lower Gondwanas that are outcropped near the basin margin. The reservoirs are primarily sandstones with isolated occurrences of limestone and unconventional reservoirs like fractured basalts. Effective source rocks are identified to be the shales of Permian to Eocene. The hydrocarbon accumulations often indicate charging by more than one source. Biogenic reservoirs and gas hydrate deposits have been established in the basin.

Prospectivity

The Krishna-Godavari (KG) basin has a total hydrocarbon inplace of 4,766 MMTOE, out of which 1,976 MMTOE has been discovered and it includes both commercial and sub-commercial inplace. The remaining, 2,790 MMTOE, nearly 59% of total inplace, is potential to be explored and discovered.

The basin has been assessed earlier during 1995-96 study along with 14 other basins. During 2017 Hydrocarbon Resource Assessment Study, 3D PSM (Petroleum System Modelling) approach has been used due to availability of adequate datasets.

The 2017 resource reassessment study has incorporated 85,300 LKM of 2D seismic data, 68,000 SKM of 3D seismic data, 770 drilled well information. Data quality is good. Gravity,

geochemical, 2D/3D seismic, well data and reports are excellent while magnetic data are of good quality. Reliability of results is excellent. 3D PSM and Trap Density method have been used to assess hydrocarbon resources due to good data control for making robust 3D static model. Mapping of facies propagation in deepwater areas is challenging. Synrift and Eocene plays can be targets for exploration. Intensive exploration is recommended for inherent prospectivity of the basin.

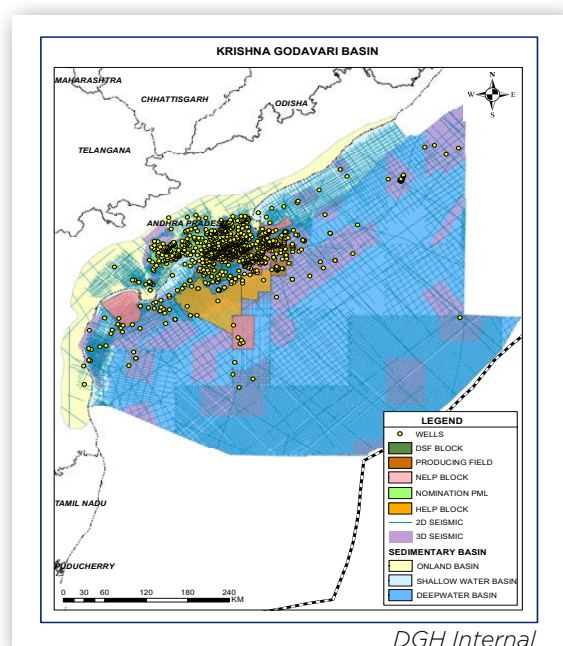
The area towards the eastern part outside the current basin boundary have data. This area was however excluded during the 2017 resource study for lack of congruence check with basin. The area is proposed to be taken up along with Mahanadi basin in the next periodical assessment.

The play-level undiscovered (risked) hydrocarbon inplace for Krishna-Godavari (KG) basin is given below:

Cenozoic Pliocene (Biogenic):	606 MMTOE	Mesozoic Cretaceous (Late):	36 MMTOE
Cenozoic Pliocene (Thermogenic):	732 MMTOE	Mesozoic Cretaceous (Early):	106 MMTOE
Cenozoic Miocene (Biogenic):	236 MMTOE	Mesozoic Jurassic (Late):	505 MMTOE
Cenozoic Miocene (Thermogenic):	163 MMTOE	Mesozoic Triassic:	187 MMTOE
Cenozoic Eocene:	131 MMTOE	Paleozoic Permian:	30 MMTOE
Cenozoic Paleocene:	5 MMTOE	Archean Basement	59 MMTOE

The onland part of the basin is spread into the state of Andhra Pradesh.

Status, available datasets and opportunities



In terms of awarded acreage that are now active in Krishna-Godavari (KG) basin, 4,882 sq km are under Nomination, 1,580 sq km are in producing fields under Pre-NELP/NELP, 4,921 sq km lie under NELP, 6,308 sq km are under HELP & 2,387 sq km lie under DSF.

Under National Seismic Programme, conducted during 2016-22 in unappraised onland areas, 981 LKM broadband 2D seismic data were acquired in the basin.

As of March 1, 2023, NDR, for Krishna- Godavari (KG) basin has archived 230,304 LKM of 2D seismic data, 255,343 SKM of 3D seismic data, 1,329 drilled well information. Under OALP Bid Round VIII, one ultra-deepwater block of 1,200 sq km area has been offered.

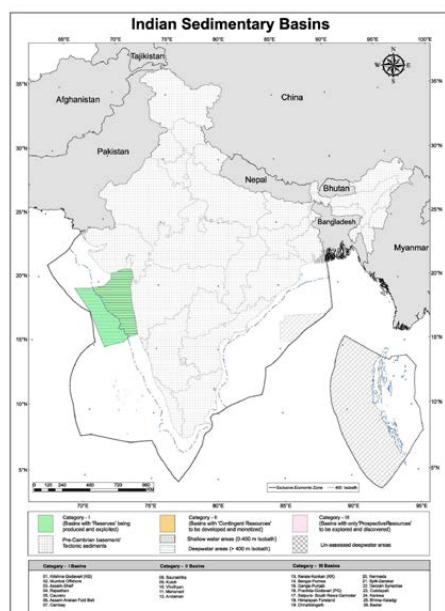
In the upcoming Offshore Mega OALP Round IX, there is an opportunity of 24,745 sq km prospective areas that are carved into three blocks, one located in shallow-water and two others in ultra-deepwater.



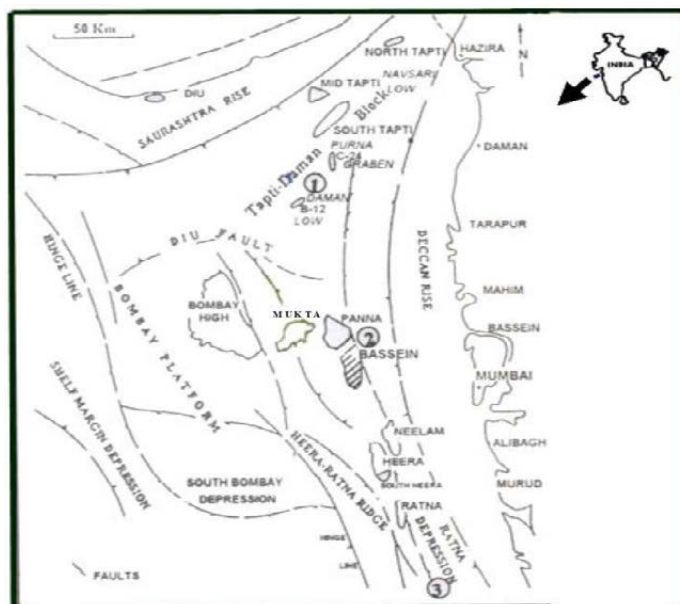
2. MUMBAI OFFSHORE BASIN

Mumbai Offshore is a Category I basin, implying that the basin has significant commercial discovered inplace. The basin has an area of 212,000 sq. km. with 118,389 sq. km. shallow water

spread over the Tertiary stratigraphic interval ranging from the oldest sediments of Paleogene to the youngest sediments of Plio-Pleistocene. Though the basin is a major thermogenic



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area and 93,611 sq. km. deepwater area. In the basin, 10 plays are identified within Basement, Tertiary (Mid-Late Miocene, biogenic), Pliocene-Pleistocene (Biogenic).

The basin is exclusively offshore and the most prolific petroliferous province of India, contributing nearly half of oil and gas production of the country annually. Mumbai basin is characterized primarily by carbonate-siliciclastic shelf margin facies and located along the West Coast of Indian peninsula.

Though, the basin has discovered resources of 4.8 BTOE, the deepwater areas are not enough explored and opportunity lies in deepwaters to chase the basinward extension of prospective plays (Paleocene and Eocene). Similarly, Mesozoic plays are still elusive in the basin, hence sub-basalt exploration for Mesozoic play remains an opportunity for deeper exploration (3,000m+).

The Mumbai basin is still under active exploration stage. Commercial hydrocarbon occurrences

hydrocarbon province but recently biogenic gas has been discovered within shallow plays of strati-structural entrapment. The basin is a peri-cratonic, passive margin rift basin, with individual rift graben set-ups forming many sub-basins. This basin hosts thick pile of sediments, mainly ranging from Paleocene to Recent. The basin extends into areas of both shallow water and deepwater of Arabian sea. Deepest sequence of Basal Clastics of Late Cretaceous to Early Paleocene of Deccan Traps to Pliocene biogenic plays form the petroleum system of the basin. Though northerly located Saurashtra basin and Southerly Kerala-Konkan basin has Mesozoic sequences identified and discovered, the basin has not yet been deeply explored for Mesozoic.

Prospectivity

The Mumbai Offshore basin has a total hydrocarbon inplace of 7,171 MMTOE, out of which 4,794 MMTOE has been discovered and it includes both commercial and sub-commercial

inplace. The remaining, 2,377 MMTOE, nearly 33% of total in-place is potential to be explored and discovered.

The basin has been assessed earlier during 1995-96 study along with 14 other basins. During 2017 Hydrocarbon Resource Assessment Study, 3D PSM approach has been used due to availability of adequate datasets.

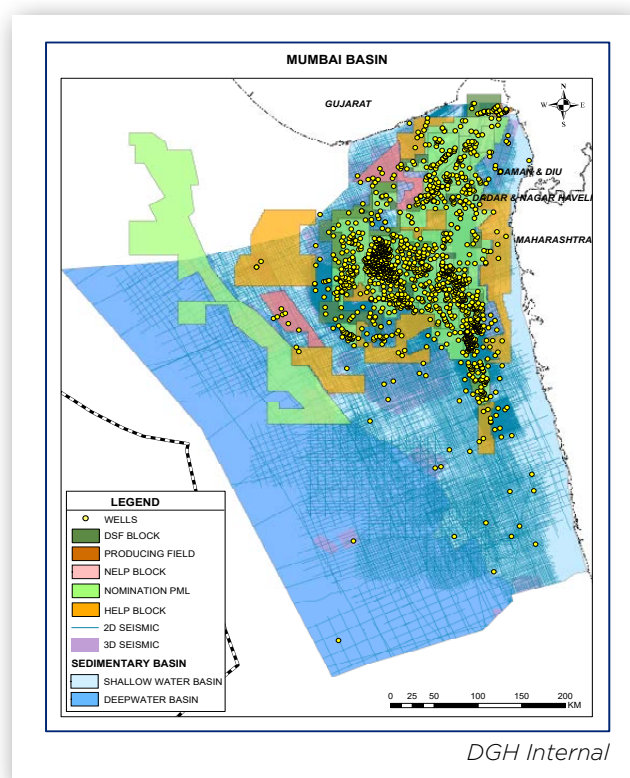
The 2017 resource reassessment study has incorporated 48,000 LKM of 2D seismic data, 30,000 SKM of 3D seismic data, 900 drilled well information. Data availability is good.

Geochemical, 2D/3D seismic, well data and reports are excellent while gravity data are good and magnetic data are fair. Reliability of results is good. 3D PSM and Trap Density method have been used to assess hydrocarbon resources since a robust static 3D model can be constructed for adequate input data. Deepwater areas have sparse seismic data and a very few wells were drilled. Paleocene and Eocene plays can be future exploration targets. Deeper sequences and plays are recommended to be future target of exploration, particularly in Tapti-Daman area.

The play-level undiscovered (risked) hydrocarbon inplace for Mumbai Offshore basin is given below:

Cenozoic Pleistocene-Recent (Biogenic):	<1 MMTOE	Cenozoic Oligocene (Late):	685 MMTOE
Cenozoic Pliocene (Biogenic):	6 MMTOE	Cenozoic Oligocene (Early):	148 MMTOE
Cenozoic Miocene (Biogenic):	<1 MMTOE	Cenozoic Eocene	262 MMTOE
Cenozoic Miocene (Middle):	26 MMTOE	Cenozoic Paleocene-Eocene (Early):	965 MMTOE
Cenozoic Miocene (Early):	120 MMTOE	Mesozoic (Late Cretaceous and Basal Clastics)	164 MMTOE

Status, available datasets and opportunities



In terms of awarded acreage that are now active in Mumbai Offshore basin, 33,402 sq km are under Nomination, 3,645 sq km lie under NELP, 19,123 sq km are under HELP and 6,959 sq km lie under DSF.

As of March 1, 2023, NDR, for Mumbai Offshore basin has archived 772,604 LKM of 2D seismic data, 152,630 SKM of 3D seismic data, 3,948 drilled well information.

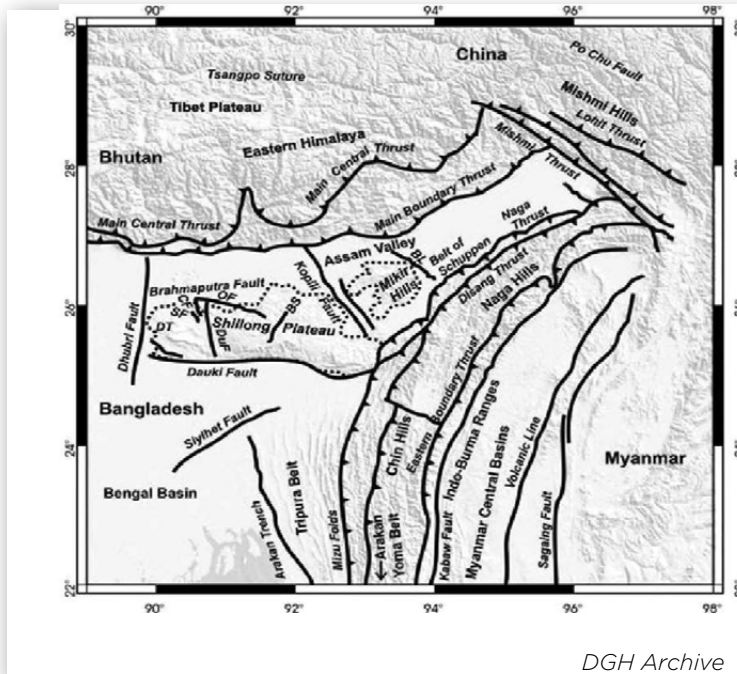
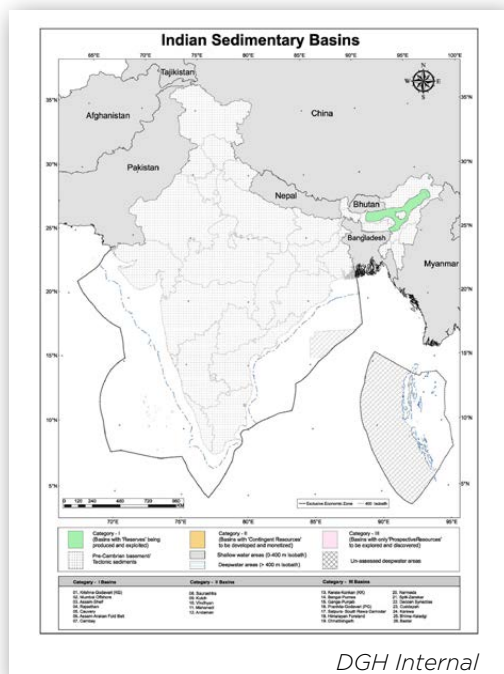
Under OALP Bid Round VIII, one shallow water block of 4,108 sq km area has been offered.

In the upcoming Offshore Mega OALP Round IX, there is an opportunity of 27,573 sq km prospective areas that are carved into two blocks, both located in shallow-water. One block is targeted for deeper exploration into Mesozoic plays.



3. ASSAM SHELF BASIN

Assam Shelf is a Category I basin, implying that the basin has significant commercial discovered inplace.



The basin has an area of 56,000 sq. km. which is entirely onland. In the basin, 8 plays are present within Basement and Tertiary.

The Assam Shelf basin is a petroliferous province, characterized primarily by siliciclastic deposits of shelf margin, situated to the north-east region of Indian peninsula, falling mostly within the state of Assam.

The Assam Shelf basin is still under active exploration stage. Commercial hydrocarbon occurrences, besides Basement is spread over different stratigraphic intervals ranging from the oldest sediments of Paleocene (Tura) to the youngest sediments of Pliocene (Girujan). Several oil and gas fields have been discovered within structural, stratigraphic and strati-structural entrapment conditions. Assam Shelf basin is a peri-cratonic, passive margin basin, with the signature of compressional tectonics as a result of Himalayan orogeny. The basin hosts thick pile of Tertiary sediments, ranging from Paleocene to Recent which overlies Basement consisting of Granitic and Metamorphic complex. Gondwana sediments are exposed in the western extremity

of Garo Hills, consisting of gritty sandstones, carbonaceous shale and lenticles of coals. The basin unconformably extends up to the northern

bank of Brahmaputra river. The hydrocarbon accumulations often indicate charging from multiple source sequences.

Prospectivity

The Assam Shelf basin has a total hydrocarbon inplace of 2,705 MMTOE, out of which 1,827 MMTOE has been discovered and it includes both commercial and sub-commercial inplace. The remaining, 878 MMTOE, nearly 32% of total inplace is potential to be explored and discovered.

The basin has been assessed earlier during 1995-96 study along with 14 other basins. During 2017 Hydrocarbon Resource Assessment Study, 3D PSM approach has been used due to availability of adequate datasets.

The 2017 resource reassessment study has incorporated 2,723 LKM of 2D seismic data, 10,995 SKM of 3D seismic data, 275 drilled well information. The basin is highly explored with good seismic coverage.

Geochemical, 2D/3D seismic, well data and reports are excellent while gravity data is good

and magnetic data are fair. Reliability of results is excellent. 3D PSM and Trap Density method have been used to assess hydrocarbon resources due to good quality data existing throughout the basin. Biggest challenge is that mature source

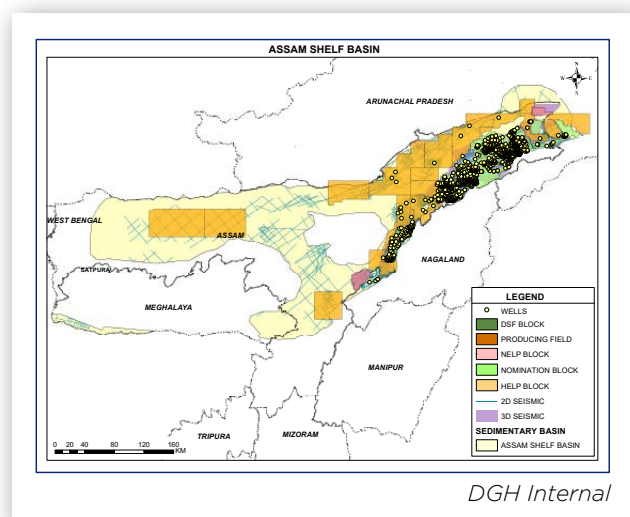
rocks lie below the thrust belt. Naga thrust belt can be future focus for exploration. Shallow play near Naga-Schuppen belt is recommended target for exploration.

The play-level undiscovered (risked) hydrocarbon inplace for Assam Shelf basin is given below:

Cenozoic Pliocene (Girujan):	1 MMTOE	Cenozoic Eocene (Kopili):	46 MMTOE
Cenozoic Miocene (Tipam):	215 MMTOE	Cenozoic Eocene (Sylhet):	67 MMTOE
Cenozoic Oligocene (Barail Coal Shale):	192 MMTOE	Cenozoic Early Paleocene (Tura):	102 MMTOE
Cenozoic Oligocene (Barail Main Sands)	242 MMTOE	Archean Basement:	9 MMTOE

The basin is spread into the state(s) of Arunachal Pradesh, Assam, Meghalaya, Nagaland.

Status, available datasets and opportunities



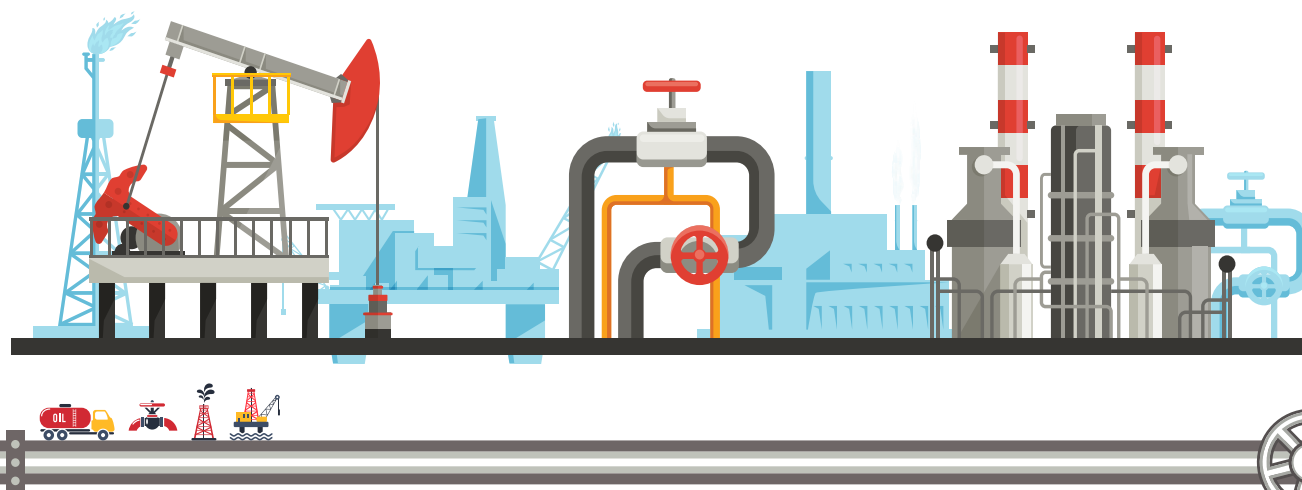
NELP, 18,825 sq km are under HELP, 206 sq km lie under DSF.

Under National Seismic Programme, conducted during 2016-22 in unappraised onland areas, 2,416 LKM broad-band 2D seismic data were acquired in the basin. Actual quantum of 2D seismic survey may be slightly different as acquisition was conducted in sectors that have transgressed beyond the basin boundary and thus accounted within Assam-Arakan Fold-belt basin.

As of March 1, 2023, NDR, for Assam Shelf basin has archived 27,644 LKM of 2D seismic data, 36,522 SKM of 3D seismic data, 3,205 drilled well information.

In terms of awarded acreage that are now active in Assam Shelf basin, 5,652 sq km are under Nomination, 56 sq km are in producing fields under Pre-NELP/NELP, 567 sq km lie under

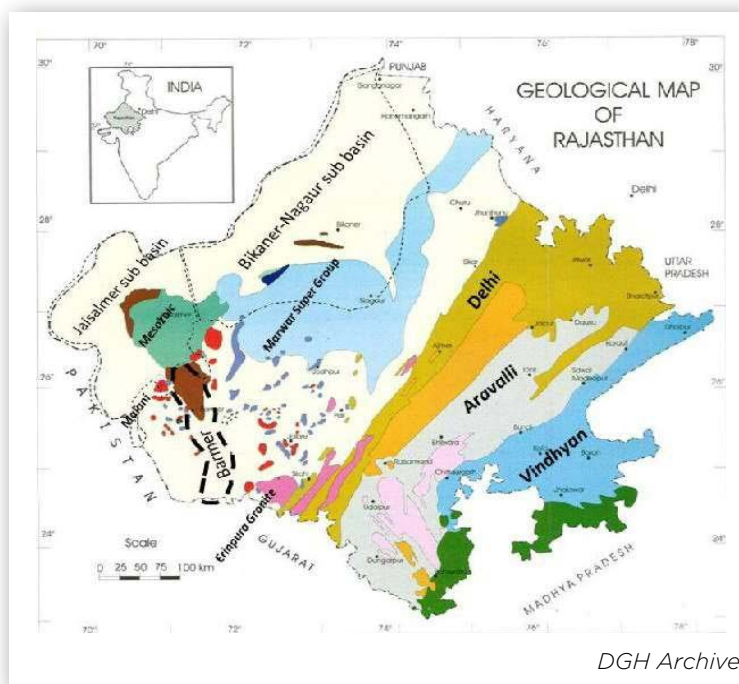
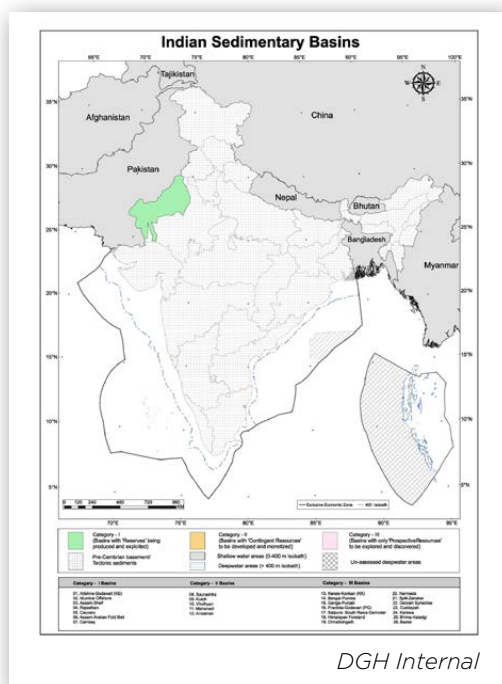
Under OALP Bid Round VIII, one block of 2,058 sq km area has been offered. Under OALP IX Mega Round, 2 blocks of cumulative area of 2,952 sq km has been put on offer.



4. RAJASTHAN BASIN

Rajasthan is a Category I basin, implying that the basin has significant commercial discovered inplace. The basin has an area of 126,000 sq. km. which is entirely onland. In the basin, 7 plays are identified within Basement, Cretaceous,

are encountered in Tertiary sediments. The sub-basin is peri-cratonic rift set-up as an extension of southerly located producing Cambay basin. Sediments include rift-fill siliciclastic deposits and hosts thick pile of Mesozoic-to-Tertiary



Volcanics, Paleocene-Eocene in Barmer sub-basin; 9 plays within Jurassic- Cretaceous, Paleocene-Eocene in Jaisalmer sub-basin and 3 plays within Pre-Cambrian in Bikaner-Nagaur sub-basin.

The Barmer sub-basin is situated in the western region of Indian peninsula and the most prominent among the three sub-basins of Rajasthan basin. It falls entirely within the state of Rajasthan. The sub-basin accounts for one-fourth of oil production of the country. The Barmer sub-basin is currently under active exploration stage. Commercial hydrocarbon occurrences, besides Deccan Trap and Basement, are found in different stratigraphic intervals ranging from the oldest sediments of Cretaceous (Ghaggar- Hakra) to the youngest sediments of Paleocene and Eocene (Barmer Hill, Fatehgarh, Thumbli). Several oil and gas fields have been discovered within structural, stratigraphic and strati-structural entrapment conditions, of which majority of the discoveries

sediments, ranging from Cretaceous (Ghaggar Hakra) to Eocene (Thumbli). Multiple source rocks are evident with instances of same play acting as source and reservoirs. Fatehgarh and Barmer Hill of Paleocene are major producing sequences of the subbasin.

The Jaisalmer sub-basin is mainly a Mesozoic rift basin set up during Permo-Triassic period. The sub-basin is under active exploration stage. Commercial accumulation of gas deposits is reported from clastic sequences of Late Jurassic (Baishakhi-Badeshar) to Early Cretaceous (Pariwar). The sub-basin is tectonically affected by Himalayan orogeny, having caused strike-slip fault system as a part of major structural framework. With the sequences thickening westward, such faulting has contributed to local hydrocarbon entrapment. Late Jurassic to Eocene are part of proven play system while Permo-to-Middle Jurassic plays are identified and known, but not yet proven. Though gas accumulation has been established in the sub-

basin, there is a possibility of liquid hydrocarbon accumulation due to the presence of Type-II organic facies mixed with predominantly Type-III facies in the sub-basin.

The Bikaner-Nagaur is a shallow Proterozoic sub-basin with a Pre-Cambrian basement comprised of the Malani Igneous Suite and Delhi Metamorphites. The sub-basin is a part of Punjab platform of Indus basin having a general dip towards west and sedimentary units thickening towards northwest. The sub-basin is under active exploration stage with sporadic discovery of high viscous oil from Jodhpur formation of Infra Cambrian age. Bikaner Nagaur sub-basin is a distinct thick Infra-Cambrian stratigraphic section. Despite the widely spaced 2D and patchy 3D seismic data, a fault pattern could be discerned. All major faults and relevant individual faults may reveal a structural style and orientation. The main structural style is strike slip deformation associated with ENE-WSW trending fault system which is dominant

in Bagheewala and surrounding areas. High angle reverse faulting system is seen across the Bagheewala strike-slip fault. The Bikaner-Nagaur Sub-basin, equivalent to Salt-range Group of Punjab platform was mainly under a marginal-to-shallow marine set-up during the Infra-Cambrian period and sometimes under arid climatic conditions. The bottommost Jodhpur Group was deposited as a shoreface facies under marginal marine set up. The overlying Bilara group represents inter-tidal carbonate depositional setting, and overlain by HEG (Hanseran Evaporite Group) formation, which is comprised of Sabkha deposit representing an arid climate and the topmost Upper Carbonate deposit represents a carbonate platform set up under shallow marine condition. There are three known petroleum accumulations in the basin. Most of the reservoirs are getting charged from more than one source rock or each source rock is charging more than one reservoirs.



Prospectivity

The Rajasthan basin has a total hydrocarbon inplace of 2,176 MMTOE, out of which 938 MMTOE has been discovered and it includes both commercial and sub-commercial inplace. The remaining, 1,238 MMTOE, nearly 57% of total inplace is potential to be explored and discovered.

The basin has been assessed earlier during 1995-96 study along with 14 other basins. During 2017 Hydrocarbon Resource Assessment Study, 3D PSM approach has been used due to availability of adequate datasets.

The 2017 resource reassessment study has incorporated 13,650 LKM of 2D seismic data, 31,041 SKM of 3D seismic data, 390 drilled well information. Data have fair-to-good coverage. Gravity, geochemical data and reports are good while magnetic, 2D/3D seismic, well data are fair. Reliability of results is excellent. 3D PSM and Trap Density method have been used to assess hydrocarbon resources due to adequate data. Velocity modelling is challenging due to well data scarcity in areas of Bikaner-Nagaur sub-basin. Permo-Triassic & Jurassic plays in Jaisalmer and Cretaceous (Ghaggar-Hakra) plays in Barmer can be areas of focus. High quality API of close grid seismic is recommended.

The play-level undiscovered (risked) hydrocarbon inplace for Barmer area is tabulated below:

Cenozoic Eocene (Thumbli):	42 MMTOE	Mesozoic Cretaceous (Late Raageshwari Volcanics):	54 MMTOE
Cenozoic Eocene (Dharvi-Dungar):	56 MMTOE	Mesozoic Cretaceous (Ghaggar Hakra):	67 MMTOE
Cenozoic Paleocene (Barmer Hill):	264 MMTOE	Archean Basement	44 MMTOE
Cenozoic Paleocene (Fatehgarh):	302 MMTOE		

The sub-basin is spread into the state(s) of Rajasthan.

The play-level undiscovered (risked) hydrocarbon inplace for Jaisalmer area is tabulated below:

Cenozoic Eocene (Bandah):	4 MMTOE	Mesozoic Jurassic (Late Baisakhi Badesar):	57 MMTOE
Cenozoic Eocene (Khuiala):	1 MMTOE	Mesozoic Jurassic (Middle Jaisalmer):	29 MMTOE
Cenozoic Paleocene (Sanu):	4 MMTOE	Mesozoic Jurassic (Early Lathi):	12 MMTOE
Mesozoic Cretaceous (Middle Goru):	15 MMTOE	Paleozoic Permo-Triassic (Bhuana):	10 MMTOE
Mesozoic Cretaceous (Early Cretaceous):	81 MMTOE		

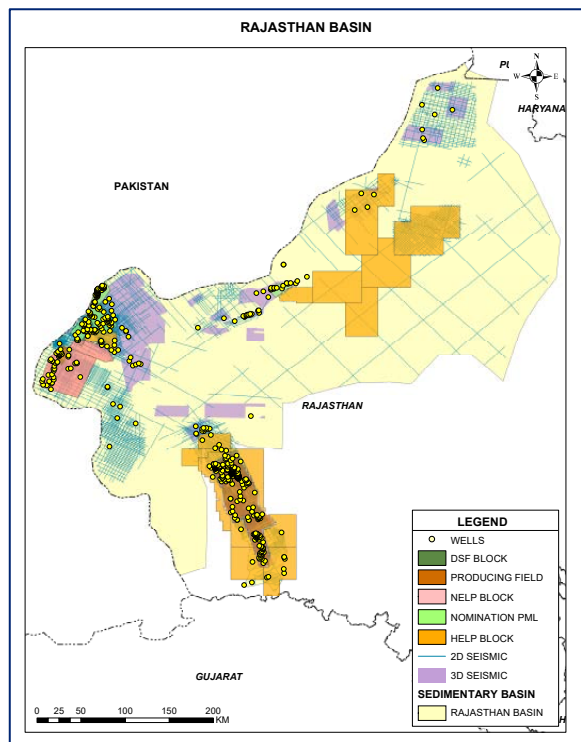
The sub-basin is spread into the state(s) of Rajasthan.

The play-level undiscovered (risked) hydrocarbon inplace for Bikaner-Nagaur area is tabulated below:

Paleozoic Infra-Cambrian (Upper Carbonate)	57 MMTOE	Paleozoic Infra-Cambrian (Bilara)	4 MMTOE
Paleozoic Infra-Cambrian (Jodhpur)	67 MMTOE		

The sub-basin is spread into the state(s) of Punjab, Rajasthan.

Status, available datasets and opportunities



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In terms of awarded acreage that are now active in Rajasthan basin, 1,287 sq km are under Nomination, 3,294 sq km are in producing fields under Pre-NELP/NELP, 2,538 sq km lie under NELP, 19,482 sq km are under HELP and 167sq km lie under DSF.

Under National Seismic Programme, conducted during 2016-22 in unappraised onland areas, 2,752 LKM broad-band 2D seismic data were acquired in the basin.

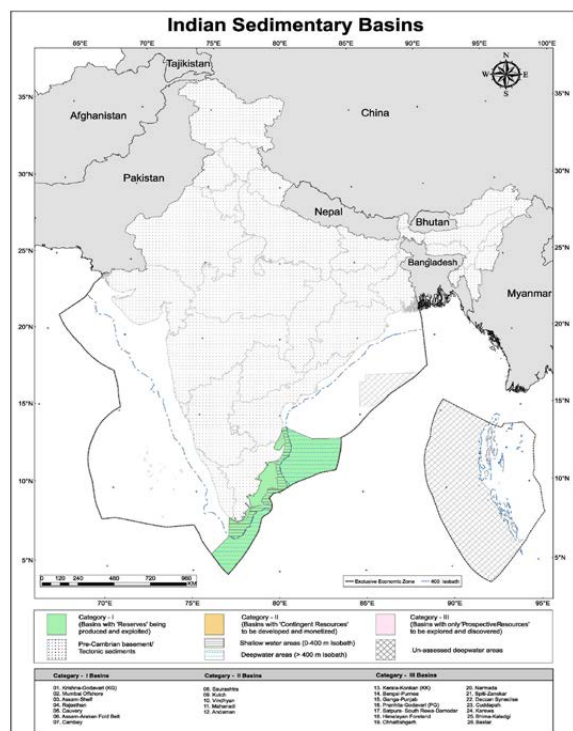
As of March 1, 2023, NDR, for Rajasthan basin, has archived 51,269 LKM of 2D seismic data, 37,166 SKM of 3D seismic data and 1,206 drilled well information.



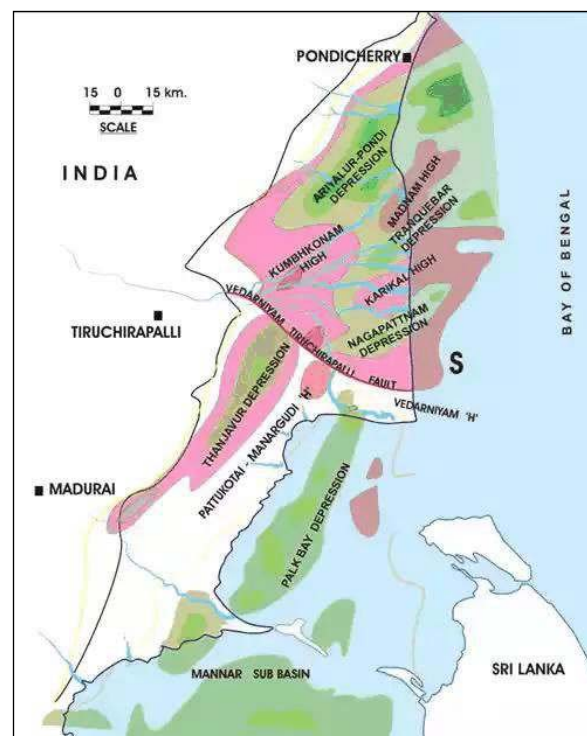
5. CAUVERY BASIN

Cauvery is a Category I basin, implying that the basin has significant commercial discovered inplace. The basin has an area of 240,000 sq. km. with 37,825 sq. km. onland area, 43,723

gas fields have been discovered with structural, stratigraphic and strati-structural entrapment conditions. Cauvery basin, like other east coast basins of India, is a peri-cratonic, extensional



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sq. km. shallow water area and 158,452 sq. km. deepwater area. In the basin, 9 plays are present within Basement, Jurassic, Cretaceous and Paleocene-to-Miocene.

The basin is characterized primarily by siliciclastic shelf margin, sediments, situated southerly along the east coast of Indian peninsula. Basin has significant production from Mesozoic and Basement with deep-to-ultradeep water largely appraised but explored only 2%. Ultradeep exploration opportunity is envisaged in undrilled areas in the northeast and southern part towards Gulf of Mannar.

The Cauvery basin is currently under active exploration stage. Commercial hydrocarbon occurrences, besides basement, are encountered in wide stratigraphic sequences within the oldest sediments of Jurassic. Several oil and

passive margin basin, with a number of individual rift graben structures forming sub-basins. The basin hosts thick pile of sediments of the order of 8,000m, ranging from Late Jurassic to Recent across onland, offshore including deep and ultradeep areas. The basin's onland part is mostly covered by the alluvium deposited by the major river system of Cauvery and several stratigraphic sequences including Lower Gondwanas that cropped out along the basin margin areas. The hydrocarbon accumulations often indicate charging from multiple source sequences.

Prospectivity

The Cauvery basin has a total hydrocarbon inplace of 1,427 MMTOE, out of which 292 MMTOE has been discovered and it includes

both commercial and sub-commercial inplace. The remaining, 1,135 MMTOE, nearly 80% of total inplace is potential to be explored and discovered.

The basin has been assessed earlier during 1995-96 study along with 14 other basins. During 2017 Hydrocarbon Resource Assessment Study, 3D PSM approach has been used due to availability of adequate datasets.

The 2017 resource reassessment study has incorporated 120,000 LKM of 2D seismic data, 7,500 SKM of 3D seismic data, 610 drilled well

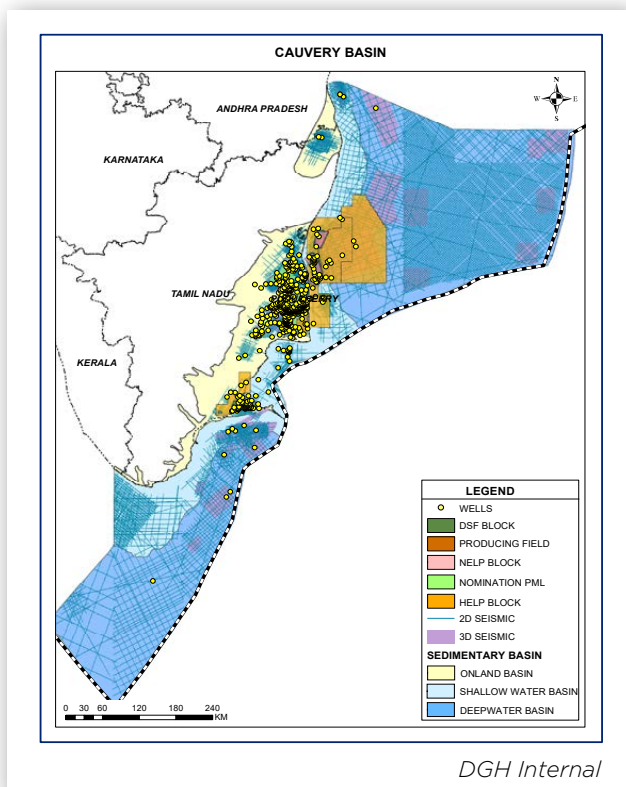
information. Data quality is good. Gravity, 2D/3D seismic, well data and reports are excellent while magnetic and geochemical data are good. Reliability of results is excellent. 3D PSM and Trap Density method have been used to assess hydrocarbon resources due to sufficient well and seismic data. Some challenges are mapping of deeper plays and facies propagation of Pre-Albian sequences. Cretaceous and Basement plays can be area of focus. Seismic acquisition in transitional areas along coastal tract and sub-basalt imaging in Gulf of Mannar are recommended.

The play-level undiscovered (risked) hydrocarbon inplace for Cauvery basin is given below:

Cenozoic Miocene:	<1 MMTOE	Mesozoic Cretaceous (Cenomanian - Turonian):	61 MMTOE
Cenozoic Oligocene:	6 MMTOE	Mesozoic Cretaceous (Early):	202 MMTOE
Cenozoic Paleocene-Eocene:	44 MMTOE	Mesozoic Jurassic:	117 MMTOE
Mesozoic Cretaceous (Late Campanian - Maastrichtian):	178 MMTOE	Archean Basement:	164 MMTOE
Mesozoic Cretaceous (Santonian):	366 MMTOE		

The onland part of the basin is spread into the state(s) of Andhra Pradesh, Kerala, Puducherry, Tamil Nadu

Status, available datasets and opportunities



In terms of awarded acreage that are now active in Cauvery basin, 4,028 sq km are under Nomination, 426 sq km are in producing fields under Pre-NELP/NELP, 858 sq km lie under NELP, 17,955 sq km are under HELP, 484 sq km lie under DSF.

As of March 1, 2023, NDR, for Cauvery basin has archived 235,569 LKM of 2D seismic data, 85,171 SKM of 3D seismic data, 849 drilled well information.

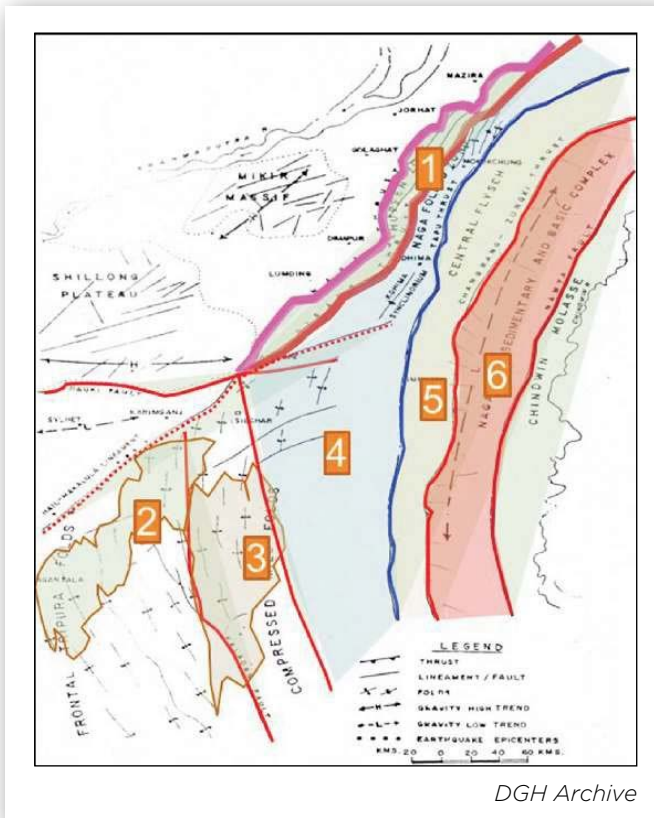
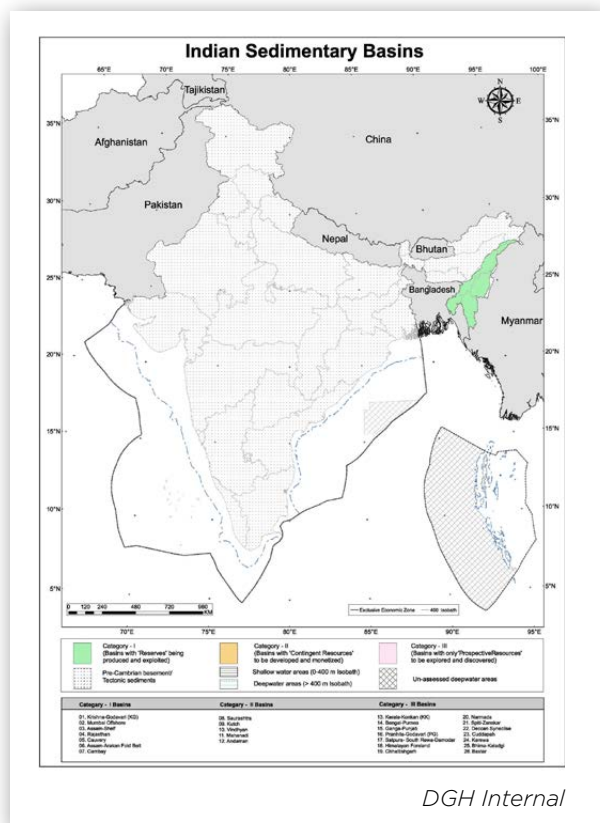
In the upcoming Offshore Mega OALP Round IX, there is an opportunity of 27,155 sq km prospective areas that are carved into three back-to-back blocks, all located in ultra-deepwater.



6. ASSAM-ARAKAN FOLD BELT (AAFB) BASIN

Assam-Arakan Fold Belt (AAFB) is a Category I basin, implying that the basin has significant commercial discovered inplace. The basin has an

the signature of compressional tectonics during Himalayan Orogeny. The basin includes two distinct tectonic setting, viz. Tripura-Cacchar



area of 80,825 sq. km. which is entirely onland. In the basin, 7 plays are present within Eocene to Pliocene.

The basin is characterized primarily by siliciclastic deposits of fluvial to shelf margin setup, situated in the northeast region of Indian peninsula. It cuts through major states of North-East Region (NER) of India (Assam, Arunachal Pradesh, Nagaland, Manipur, Mizoram and Tripura).

The basin is currently under active exploration stage. Commercial hydrocarbon occurrences are mainly encountered within Miocene and Pliocene formation except some small discoveries in Oligocene and Eocene sequences. Several gas pools have been discovered within the structural closure while hydrocarbon accumulations often indicate charging from deeper sequence. Assam Arakan Fold Belt basin is a peri-cratonic, passive margin basin, with

Fold Belt and Naga- Schuppen belt. The basin hosts thick pile of Tertiary sediments, ranging from Paleocene to Recent which overlies the Archean basement consisting of granitic and metamorphic rocks. Mio-Pliocene petroleum system is discovered and producing. Deepest Oligocene play (Renji) is yet to be thoroughly explored. All proven system has significant risked resources.

Prospectivity

The Assam-Arakan Fold Belt (AAFB) basin has a total hydrocarbon inplace of 1,178 MMTOE, out of which 178 MMTOE has been discovered and it includes both commercial and sub-commercial inplace. The remaining, 1,000 MMTOE, nearly 85% of total inplace is potential to be explored and discovered.

The basin has been assessed earlier during 1995-96 study along with 14 other basins. During 2017

Hydrocarbon Resource Assessment Study, 3D PSM and Aerial Yield have been used based on the merit of adequate datasets.

The 2017 resource reassessment study has incorporated 15,000 LKM of 2D seismic data, 1,400 SKM of 3D seismic data, 317 drilled well information. Gravity, well data and reports are good while magnetic, geochemical and 2D/3D data are fair. Data availability is better in Tripura-Cachhar while it is poor in rest of the basin. Reliability of results is good. 3D PSM and Trap

Density method have been used to assess hydrocarbon resources due to fair data in some parts and conceptual information in rest of the basin. There is inadequate coverage of data in major part of the basin. The fact that structural traps primarily formed since Miocene, sequential restoration and migration of thrusts can be focus area.

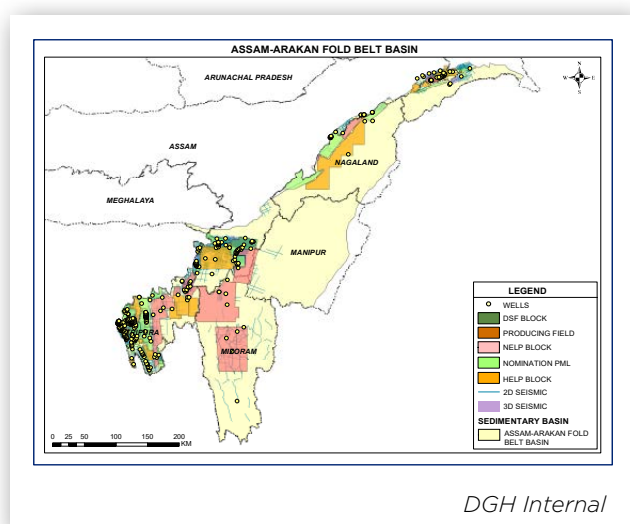
Detailed structural restoration and analysis, close grid seismic API and regional velocity modelling are recommended.

The play-level undiscovered (risked) hydrocarbon inplace for Assam-Arakan Fold Belt (AAFB) basin is given below:

Cenozoic Pliocene (Tipam):	124 MMTOE	Cenozoic Miocene (Lower Bhuban):	117 MMTOE
Cenozoic Miocene (Bokabil):	191 MMTOE	Cenozoic Oligocene (Renji):	78 MMTOE
Cenozoic Miocene (Upper Bhuban):	187 MMTOE	Cenozoic Eocene (Disang):	11 MMTOE
Cenozoic Miocene (Middle Bhuban):	292 MMTOE		

The basin is spread into the state(s) of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura.

Status, available datasets and opportunities



In terms of awarded acreage that are now active in Assam-Arakan Fold Belt (AAFB) basin, 5,864 sq km are under Nomination, 87 sq km are in producing fields under Pre-NELP/NELP, 10,321 sq km lie under NELP, 6,569 sq km are under HELP and 638 sqkm lie under DSF.

Under National Seismic Programme conducted during 2016-22 in unappraised onland areas, 2,829 LKM broad-band 2D seismic data were acquired in the basin. Actual quantum of 2D seismic survey may be slightly different as acquisition was conducted in sectors that have transgressed beyond the basin boundary and thus accounted within Assam Shelf basin.

As of March 1, 2023, NDR, for Assam-Arakan Fold Belt (AAFB) basin has archived 25,826 LKM of 2D seismic data, 16,310 SKM of 3D seismic data, 452 drilled well information.



Cambay is a Category I basin, implying that the basin has significant commercial discovered inplace. The basin has an area of 53,500 sq. km. with 48,882 sq. km. onland area and 4,618 sq. km. shallow water area. In the basin, 7 plays exist within Basement, Paleocene, Eocene and Miocene.

structural, stratigraphic and strati-structural entrapment conditions, out of which two-third of the discoveries has been made in Middle Eocene. Cambay basin is peri-cratonic rift basin with the signature of inversion tectonics during Himalayan Orogeny, falling mostly in



The basin is characterized primarily by siliciclastic rift-fill sediments, situated in the western region of Indian peninsula. The basin is endowed with most matured petroleum provinces of India with major producing fields and 88% of total hydrocarbons already discovered.

The Cambay basin, though enough exploited, still has targets for active exploration. Commercial hydrocarbon occurrences spread over different stratigraphic intervals ranging from the oldest sediment including Deccan Trap volcanics of Cretaceous-Paleocene to the youngest sediments of Miocene. Several oil and gas fields have been discovered with

the state of Gujarat. The basin hosts thick pile of Tertiary sediments, ranging from Paleocene to Recent which is overlying the Deccan Trap. Cambay shale of Paleocene is the major source rock charging Middle Eocene reservoirs of Kalol (north and central) and Hazad (southern) deltaic reservoirs with Tarapur (Oligocene) acting as the regional cap rock. During later exploration, Miocene reservoirs (Babaguru) are proved to be potential reservoirs of oil and gas in southern onland part of the basin and the offshore area that extends into the Gulf of Cambay.

Prospectivity

The Cambay basin has a total hydrocarbon inplace of 2,053 MMTOE, out of which 1,800 MMTOE has been discovered and it includes both commercial and sub-commercial inplace. The remaining, 253 MMTOE, nearly 12% of total inplace is potential to be explored and discovered.

The basin has been assessed earlier during 1995-96 study along with 14 other basins. During 2017 Hydrocarbon Resource Assessment Study, 3D PSM has been built using close-spaced 2D seismic lines. However, the basin has extensive 3D seismic data too.

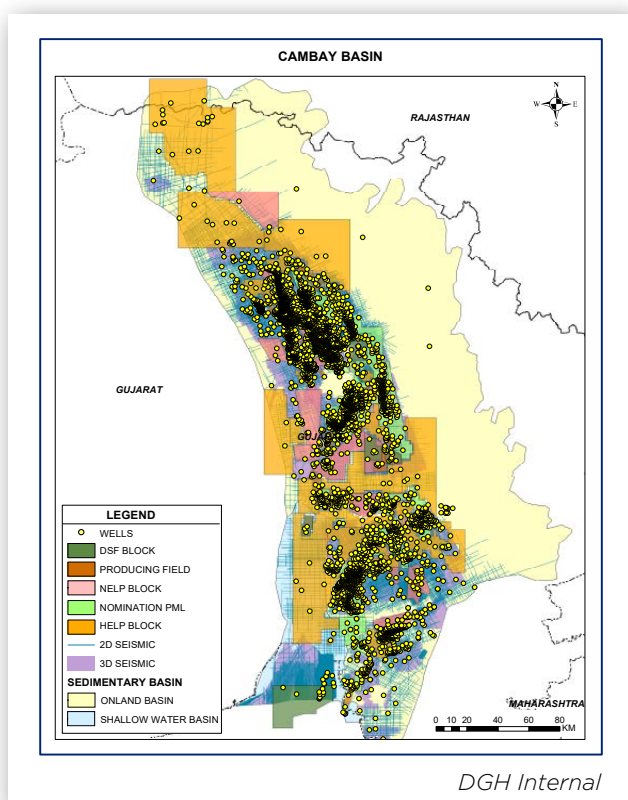
The 2017 resource reassessment study has incorporated 15,000 LKM of 2D seismic data, 670 drilled well information. Data quality is good. Gravity, geochemical, 2D/3D seismic, well data and reports are excellent while magnetic data are of good quality. Reliability of results is excellent due to good quality seismic and well data. 3D PSM and Trap Density method have been used to assess hydrocarbon resources. There is good data control to construct 3D static models. Prospectivity for Mesozoic could not be carried out as quality of seismic data below basalts is poor. Paleogene plays in Akholjuni and Gandhar can be focus area. High resolution studies and detailed facies analysis are recommended for strati-structural prospects.

The play-level undiscovered (risked) hydrocarbon inplace for Cambay basin is given below:

Cenozoic Oligo-Miocene:	5 MMTOE	Cenozoic Paleocene (Late):	28 MMTOE
Cenozoic Eocene (Late):	11 MMTOE	Cenozoic Paleocene (Early):	34 MMTOE
Cenozoic Eocene (Middle):	96 MMTOE	Mesozoic Cretaceous (Deccan Trap):	19 MMTOE
Cenozoic Eocene (Early):	60 MMTOE		

The onland part of the basin is spread into the state(s) of Gujarat, Rajasthan.

Status, available datasets and opportunities



In terms of awarded acreage that are now active in Cambay basin, 5,806 sq km are under Nomination, 1,408 sq km are in producing fields under Pre-NELP/NELP, 2,922 sq km lie under NELP, 12,402 sq km are under HELP and 1,192 sqkm lie under DSF.

Under National Seismic Programme, conducted during 2016-22 in unappraised onland areas, 1,469 LKM broad-band 2D seismic data were acquired in the basin.

As of March 1, 2023, NDR, for Cambay basin has archived 119,750 LKM of 2D seismic data, 44,349 SKM of 3D seismic data, 9,066 drilled well information.

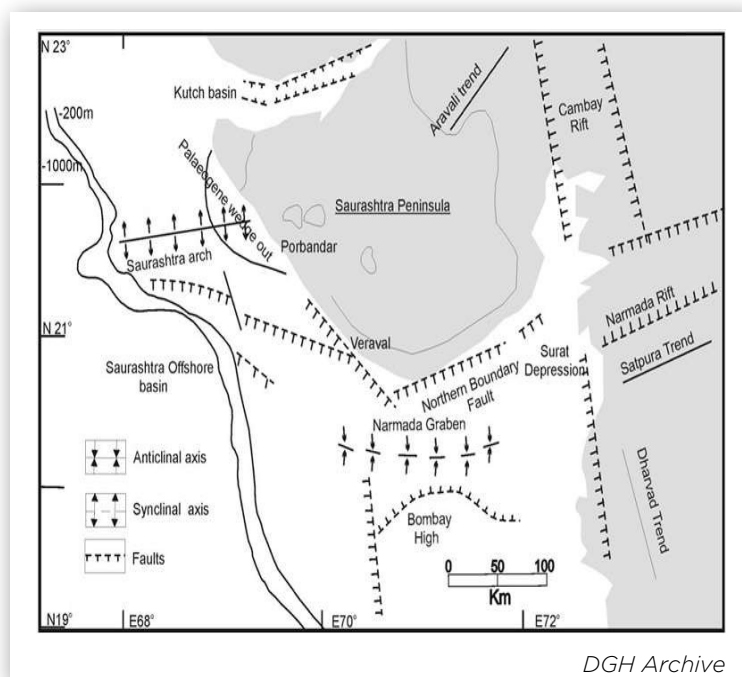
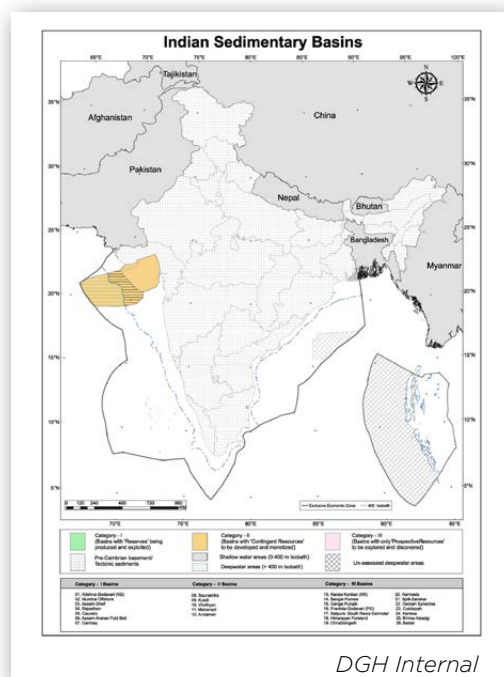
Under OALP Bid Round VIII, one block of 189 sq km area has been offered. Under OALP IX Mega Round too, another block of 714 sq km area has been put on offer.



8. SAURASHTRA BASIN

Saurashtra is a Category II basin, implying that the basin has sub-commercial discovered inplace, which needs to be adequately appraised and developed for commercial production. The basin has an area of 194,114 sq. km. with 75,076 sq. km. onland area, 42,617 sq. km. shallow water area and 76,421 sq. km. deepwater area. In the basin, 16 plays are identified within Mid Jurassic-to-Early Cretaceous in Onland and Mid Jurassic-to-Trap-to-Mid Miocene in Offshore.

present below the Deccan trap basalts in the offshore. Thus, in onland part of Saurashtra basin, Mesozoic strata are only present. In offshore, the basin lies north of commercially proven Mumbai Offshore Basin, while the onland part borders with the commercially proven Cambay Basin on its eastern flanks. The deeper offshore Saurashtra borders with the Indus fan. Two wells have been drilled in the onland part of the basin viz., Lodhika-1 and Dhandhuka-1.



The basin is geologically contiguous with Kutch basin and separated by the Saurashtra Arch in the offshore part, which trends north-northwest-south-southeast direction. The basin has presence of prospective plays of Middle Jurassic to Early Cretaceous with significant potential of sub-basalt Mesozoic plays. There has been a gas discovery in Early Cretaceous reservoirs at 4,500m depth, below 2,500m thick weathered basalts. The northerly located proven Tertiary Plays of Kutch basin is extended into this basin.

Major part of Saurashtra mainland is covered with Deccan Trap basalts with thin veneer of Miocene and younger sediments, exposed along Porbandar coast. The Cenozoic sediments have been encountered in the wells drilled in the offshore Saurashtra basin and expected to be

The granitic basement has been encountered in well Dhandhuka-1 near to the western margin fault. Also, basalt/dolerite dykes and sills are frequently present in the sandstone beds of Wadhwan and Dhrangadhra formations in these two wells. Interplay of three major Pre-Cambrian tectonic trends of western India, Dharwar (NNW-SSE), Aravalli-Delhi (NE-SW) and Satpura (ENE-WSW) controlled the tectonic style of the Saurashtra basin. The Saurashtra horst is the uplifted part of a west-southwest-plunging basement arch which divide the western continental margin into a northern Kutch-Saurashtra shelf and a southern Mumbai-Kerala shelf. The geological history of the basin indicates that the basin was formed by sequential reactivation primordial faults. Regional uplift took place during the Late Cretaceous and was

followed by Deccan Trap volcanism. Phases of tectonic deformation in the Cenozoic are indicated by extensive unconformities. The basin was built with Pre-Cambrian basement overlain by Mesozoic sediments followed by Deccan traps. A thin cover of Neogene and Quaternary sediments occurs at the top. A number of volcanic plugs are present in the west and in the southeast. The Jurassic Lodhika Formation is composed of volcanic rocks and overlying Cretaceous sedimentary rocks are exposed over northeast part of the Saurashtra Peninsula and comprise the Lower Cretaceous Dhrangadhra and Wadhwan Formations. The Cenozoic consists dominantly of shallow-marine clays and limestones. Post-Trap carbonates and fine-grained clastics are considered to be prospective offshore targets. The drainage of Saurashtra shows a radial pattern from the central highland. The synrift sediments of Early Cretaceous constitute the principal source rocks in the basin. Almost all hydrocarbon accumulations in both Tertiaries and Cretaceous are sourced from Early Cretaceous sediments. It is inferred that the source rocks maturity of Cretaceous is poor and remains immature in onland. The effect of igneous intrusions in effect of igneous intrusions in onland wells (Not wells of onland) can be seen on the thermal maturity while the generation capacity of Jurassic source rocks is higher than the Cretaceous source rocks in onland.

Prospectivity

The Saurashtra basin has a total hydrocarbon inplace of 310 MMTOE, out of which 79 MMTOE has been discovered and this is now entirely sub-commercial inplace. The remaining, 231 MMTOE, nearly 75% of total inplace is potential to be explored and discovered.

The basin has been assessed earlier during 1995-96 study along with 14 other basins. During 2017 Hydrocarbon Resource Assessment Study, 3D PSM and Aerial Yield have been used. 2D seismic data are reported combined with Kutch Basin due to contiguity of datasets.

The 2017 resource reassessment study has incorporated 27 drilled well information. Basin has sparse seismic data having less record length and a few number of wells drilled. Gravity, 2D seismic data and reports are good while magnetic, geochemical, 3D seismic, well data are fair. Reliability of results is good. 3D PSM and Trap Density method have been used to assess hydrocarbon resources due to adequate data coverage. Sub-basalt imaging, variable basalt thickness and inadequate onland seismic data are a few challenges. Cretaceous plays can be focus area. Low frequency 2D seismic API for Saurashtra onland, magneto-telluric (MT) and controlled source electromagnetic (CSEM) survey are recommended.



The play-level undiscovered (risked) hydrocarbon inplace for Onshore area is tabulated below:

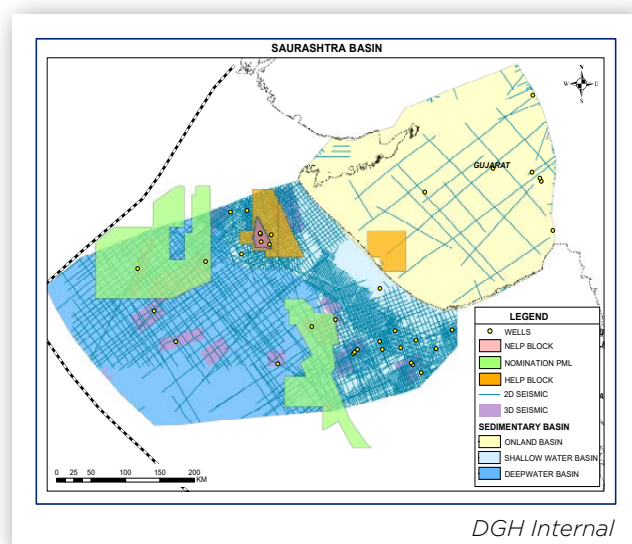
Mesozoic Cretaceous (Early):	10 MMTOE	Mesozoic Jurassic (Upper Middle):	96 MMTOE
Mesozoic Jurassic (Late):	9 MMTOE	Mesozoic Jurassic (Lower Middle):	60 MMTOE

The onland part of the sub-basin is spread into the state(s) of Daman and Diu, Gujarat.

The play-level undiscovered (risked) hydrocarbon inplace for Offshore area is tabulated below:

Cenozoic Miocene (Middle, Clastic):	7 MMTOE	Mesozoic Cretaceous (Late Clastic):	5 MMTOE
Cenozoic Eocene (Early, Clastic):	7 MMTOE	Mesozoic Cretaceous (Late Carbonate):	3 MMTOE
Cenozoic Eocene (Early, Carbonate):	3 MMTOE	Mesozoic Cretaceous (Early):	5 MMTOE
Cenozoic Paleocene (Clastic):	3 MMTOE	Mesozoic Jurassic (Late):	16 MMTOE
Cenozoic Paleocene (Carbonate):	8 MMTOE	Mesozoic Jurassic (Upper):	16 MMTOE
Cenozoic Paleocene (Weathered Basalt):	22 MMTOE	Mesozoic Jurassic (Lower):	67 MMTOE

Status, available datasets and opportunities



In terms of awarded acreage that are now active in Saurashtra basin, 25,808 sq km are under Nomination, 552 sq km lie under NELP, 6,532 sq km are under HELP.

Under National Seismic Programme, conducted during 2016-22 in unappraised onland areas, 2306 LKM broad-band 2D seismic data were acquired in the basin.

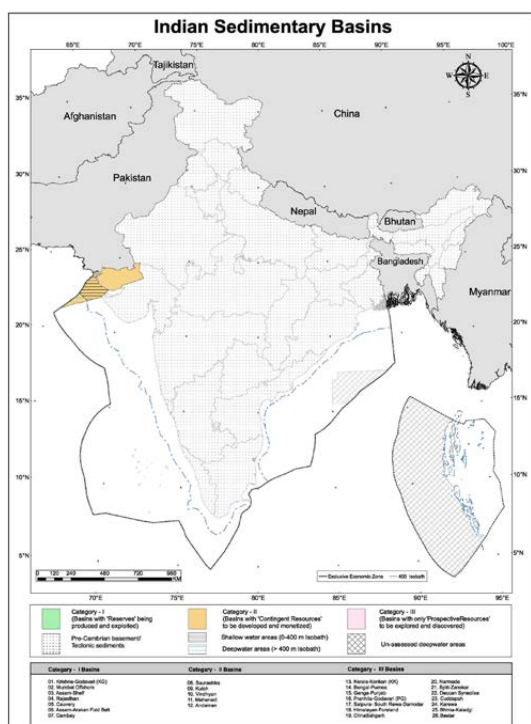
As of March 1, 2023, NDR, for Saurashtra basin has archived 175,047 LKM of 2D seismic data, 20,707 SKM of 3D seismic data, 36 drilled well information.

Under OALP Bid Round VIII, one deepwater block of 2,743 sq km area has been offered. In the upcoming Offshore Mega OALP Round IX, there is an opportunity of 18,270 sq km prospective areas that are carved into five blocks, four located in shallow-water and other in ultra-deepwater. Under a short-term collaborative project on basin research, the geoscientific datasets of the basin are now independently assessed by Pandit Deendayal Energy University (PDEU).

9. KUTCH BASIN

Kutch is a Category II basin, implying that the basin has sub-commercial discovered inplace. The basin has an area of 58,554 sq. km. with 30,754 sq. km. onland area, 20,500 sq. km. shallow water area and 7,300 sq. km. deepwater area. In the basin, 17 plays are present within Mid Jurassic-to-Cretaceous in Onland and Mid Jurassic-to-Trip-to-Mid Miocene in Offshore.

Basin, opportunity also lies for exploring Mesozoic Plays. Exploration in the basin started in the early 1960's with the first offshore seismic survey conducted during 1964-65. Since then the whole area had been covered with various campaigns of 2D, 3D and long-offset seismic data along with gravity and magnetic surveys. A



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The geologically contiguous Kutch and Saurashtra basins are separated by the Saurashtra Arch in the offshore part. The Mesozoic sediments ranging in age from Middle Jurassic to Cretaceous are exposed in the mainland Kutch and encountered in the wells drilled in offshore. The Cenozoic strata are also exposed in the southwestern part of Kutch mainland and encountered in the offshore wells.

The basin has significant opportunity to consolidate discovered resources of Tertiary Plays. Under a recently awarded contract for discovered small fields, 8 gas discoveries with Inplace of 21 BCM are now contemplated for development. Being analogous to Saurashtra

total of 68 exploratory wells (including 10 onland) were drilled in the basin. During the Late Triassic period, the Indian sub-continent broke off from the Gondwana mainland and started drifting northward. Concurrently, rifting started along existing Pre-Cambrian structural trends mostly influenced by the northeast-southwest Aravalli, eastnortheast-west-southwest Son-Narmada-Tapti and northnortheast-south-southwest Dharwar trends. The rifting, which was instrumental in the origin of the Kutch and Son-Narmada Tapti basins, came to an end during Cretaceous with the deposition of thick clastics of the prograding delta in the basin. At this time, the Indian plate had reached the reunion hotspot which caused the outpouring of basalt



to form the Deccan Trap over the Mesozoic sediments. The Cenozoic sedimentation marked the beginning of the post rift development of the western continental margin of India. As the Indian plate drifted away from the spreading centre, the continental margin experienced passive subsidence and got differentiated into shelf, slope and basin floor. Tectonic activity in the Tertiary was mild as could be seen from the presence of numerous unconformities. Till the Early-Middle Miocene similar depositional system tracts could be seen repeated during each sea level change. Post Middle Miocene, monotonous shale/clay were deposited over the entire western margin indicating heavy clastic influx resulting in the basinward shift of the shelf-edge to its present position.

The Kutch onland basin extends between Allah Bund Fault in the North, Kathiawar Fault in the South and Barmer-Radhanpur Arch in the East. It extends into the offshore with wide shelf platform. Malani Rhyolites, which are exposed in Rajasthan, Nagar-Parkar range in Pakistan, and encountered in the onshore drilled wells at Banni Graben (Banni-2) and Saurashtra Peninsula (Dhanduka-1), have formed the Pre-Cambrian basement and it is even correlated with granitic rocks of Seychelles, indicating a continuity before it got separated from Indian Plate during Late Cretaceous. Stratigraphically, the northern limit of Kutch outcrops is continued beyond Indo-Pakistan border. In the offshore of Kutch and further south, the basin is contiguous with Saurashtra Offshore basin. Middle Miocene and Early Eocene are the main plays and additional

hydrocarbons plays are established in Paleocene, Late Cretaceous, and Early Cretaceous in the basin. All the hydrocarbon accumulations are related to mild inversion tectonics involving Mesozoic and Tertiary sections.

Prospectivity

The Kutch basin has a total hydrocarbon inplace of 508 MMTOE, out of which 71 MMTOE has been discovered and this is now entirely sub-commercial inplace. The remaining, 437 MMTOE, nearly 86% of total inplace is potential to be explored and discovered.

The basin has been assessed earlier during 1995-96 study along with 14 other basins. During 2017 Hydrocarbon Resource Assessment Study, 3D PSM and Aerial Yield have been used. 2D seismic data are reported combined with Saurashtra Basin due to contiguity of datasets.

The 2017 resource reassessment study has incorporated 95,576 LKM of 2D seismic data, 68 drilled well information. Data quality is good. Gravity, geochemical, 2D/3D seismic, well data are good, reports are excellent while magnetic data are fair. Reliability of results is good. 3D PSM and Trap Density method have been used to assess hydrocarbon resources due to sufficient data support. Poor sub-basalt imaging is a major deterrent for assessing Mesozoic geology. Mesozoics can be major thrust of exploration. Acquisition of close grid 2D seismic long offset data is recommended, followed by 3D campaigns.

The play-level undiscovered (risked) hydrocarbon inplace for Onshore area is tabulated below:

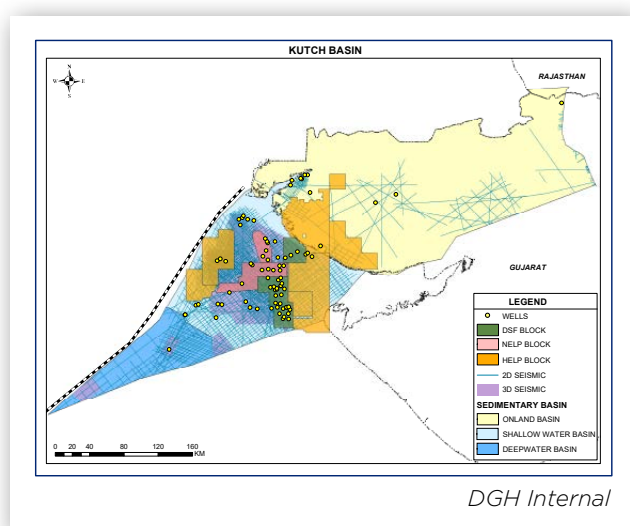
Mesozoic Cretaceous (Early):	7 MMTOE	Mesozoic Jurassic (Upper):	15 MMTOE
Mesozoic Jurassic (Late):	6 MMTOE	Mesozoic Jurassic (Lower):	11 MMTOE

The onland part of the sub-basin is spread into the state(s) of Gujarat, Rajasthan.

The play-level undiscovered (risked) hydrocarbon inplace for Offshore area is tabulated below:

Cenozoic Miocene (Clastic):	35 MMTOE	Mesozoic Cretaceous (Clastic):	18 MMTOE
Cenozoic Oligocene (Clastic):	10 MMTOE	Mesozoic Cretaceous (carbonate):	2 MMTOE
Cenozoic Eocene (Clastic):	36 MMTOE	Mesozoic Cretaceous (Early):	102 MMTOE
Cenozoic Eocene (Carbonate):	14 MMTOE	Mesozoic Jurassic (Late):	18 MMTOE
Cenozoic Palaeocene (Clastic):	18 MMTOE	Mesozoic Jurassic (Upper):	14 MMTOE
Cenozoic Palaeocene (Carbonate):	65 MMTOE	Mesozoic Jurassic (Lower):	42 MMTOE
Cenozoic Paleocene (Weathered Basalt):	23 MMTOE		

Status, available datasets and opportunities

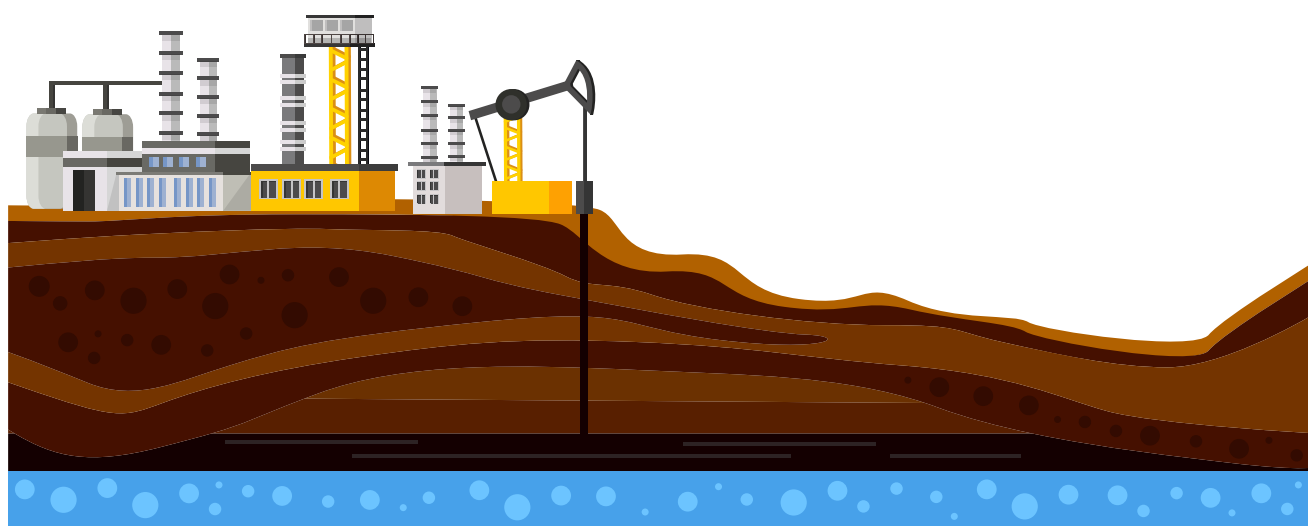


In terms of awarded acreage that are now active in Kutch basin, 1,880 sq km lie under NELP, 10,876 sq km are under HELP, 2,092 sq km lie under DSF.

Under National Seismic Programme, conducted during 2016-22 in unappraised onland areas, 1,809 LKM broad-band 2D seismic data were acquired in the basin.

As of March 1, 2023, NDR, for Kutch basin has archived 56,942 LKM of 2D seismic data, 27,893 SKM of 3D seismic data, 83 drilled well information.

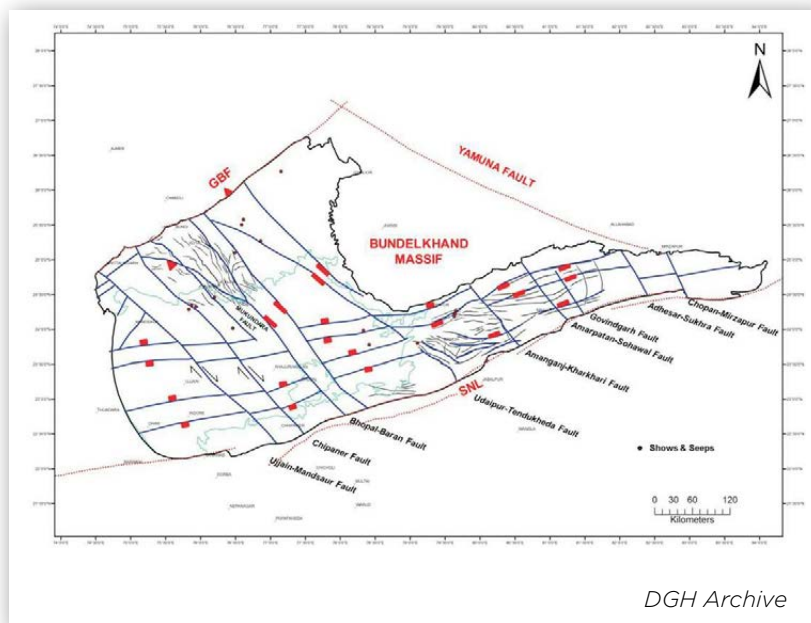
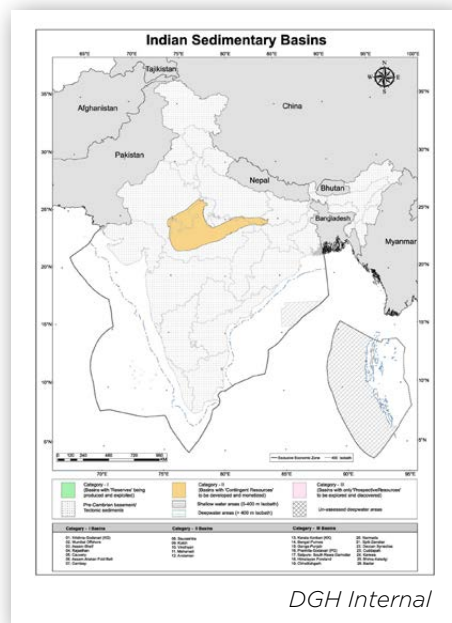
Under a short-term collaborative project on basin research, the geoscientific datasets of the basin are now independently assessed by PDEU.



10. VINDHYAN BASIN

Vindhyan is a Category II basin, implying that the basin has sub-commercial discovered inplace. The basin has an area of 202,888 sq. km. which is entirely onland. In the basin, 3 plays are present within Pre-Cambrian-to-Paleozoic (Jardepahar-Mohana-Rohtas).

on geological rationales majorly the structural fabric. In the basin, three major stratigraphic horizons ("plays") viz. Rohtas, Mohana and Jardepahar were identified and their extent depicted. Geochemical data and source rock assessments made through drilled well and



Vindhyan Basin, comprising of Son and Chambal sub-basins, occupies the numero uno position amongst all the Proterozoic petroliferous basins of India due to its large areal expanse and vast potential of natural resources.

The exploratory efforts for hydrocarbon in the basin commenced in 1970's, it is only after the initial successes met at Jabera-1, Nohta-2 and Damoh-4, its hydrocarbon potential got revealed gradually. The effort to assess the hydrocarbon resources was fraught with challenges primarily due to patchy and meagre data as nearly one third of the basin remains covered by Deccan Trap basalts, over which no significant data set is available. The discovery made in the Son Valley of Vindhyan Basin was considered as an analogue by itself. An integrated structural and tectonic model for Vindhyan Basin has been prepared and prospectivity of different plays has been evaluated. Entire basin has been divided into eighteen assessment units based

outcrop studies provided a lead to identify three discrete petroleum systems.

Prospectivity

The Vindhyan basin has a total hydrocarbon inplace of 685 MMTOE, out of which 1 MMTOE has been discovered and this is now entirely sub-commercial inplace. The remaining, 684 MMTOE, nearly 100% of total inplace is potential to be explored and discovered.

The basin has been assessed for the first time. During 2017 Hydrocarbon Resource Assessment Study, Aerial Yield has been used using intra-basin calibration for each play. The basin has 6 profiles of VSP ("Vertical Seismic Profile") along with Aeromagnetic survey (59,771 stations), GM data (6,001 stations) and 5 profiles of DSS ("Deep Seismic Sounding").

The 2017 resource reassessment study has incorporated 9731 LKM of 2D seismic data, 839 SKM of 3D seismic data, 19 drilled well

information. There were large gaps in seismic data. Gravity, 2D Seismic and reports are of good quality whilst Magnetic, Geochemical and Wells are of fair quality. Reliability of the data is good. Inadequate geoscientific data leads to adopt areal yield method to assess the hydrocarbon

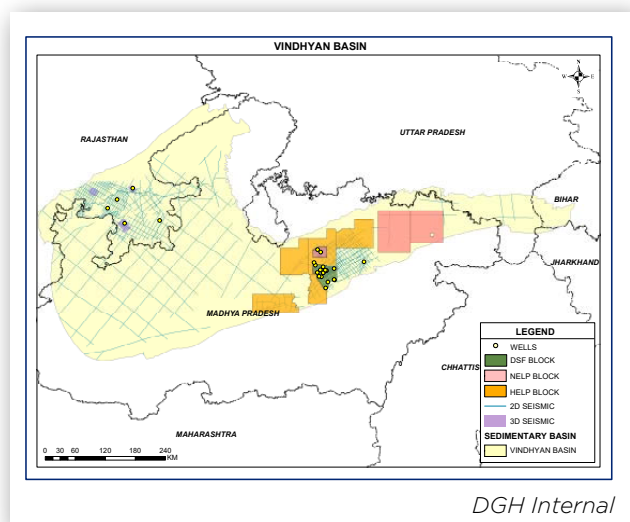
resources. The trap covered area of the basin does not have seismic data. Reservoir layers are tight with low porosity and permeability. Results may be reviewed as and when new sets of data are available.

The play-level undiscovered (risked) hydrocarbon inplace for Vindhyan basin is given below:

Proterozoic Paleo-Proterozoic (Mohana):	146 MMTOE	Proterozoic Paleo-Proterozoic (Rohtas):	384 MMTOE
Proterozoic Paleo-Proterozoic (Jardepahar):	154 MMTOE		

The basin is spread into the state(s) of Bihar, Madhya Pradesh, Rajasthan, Uttar Pradesh.

Status, available datasets and opportunities



In terms of awarded acreage that are now active in Vindhyan basin, 9,155 sq km lie under NELP, 13,260 sq km are under HELP, 1,472 sq km lie under DSF.

In 2018, the basin witnessed a significant gas discovery at well, Hatta-2 in tight Porcellanite

reservoir of Jardepahar play. The discovery has opened up a holistic appraisal/exploration campaign for tight play through an intensive subsurface analysis for improved reservoir characterization. Being analogue to other Proterozoic basins, the discovery has also scaled up a focussed exploration strategy of these basins.

Under National Seismic Programme, conducted during 2016-22 in unappraised onland areas, 5,373 LKM broad-band 2D seismic data were acquired in the basin.

As of March 1, 2023, NDR, for Vindhyan basin has archived 19,073 LKM of 2D seismic data, 1,480 SKM of 3D seismic data, 25 drilled well information.

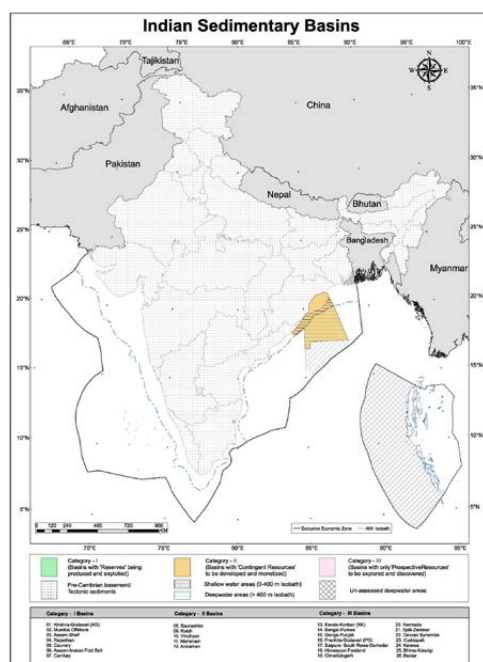
Under a short-term collaborative project on basin research, the geoscientific datasets of the basin are now independently assessed by Rajiv Gandhi Institute of Petroleum Technology (RGPT).



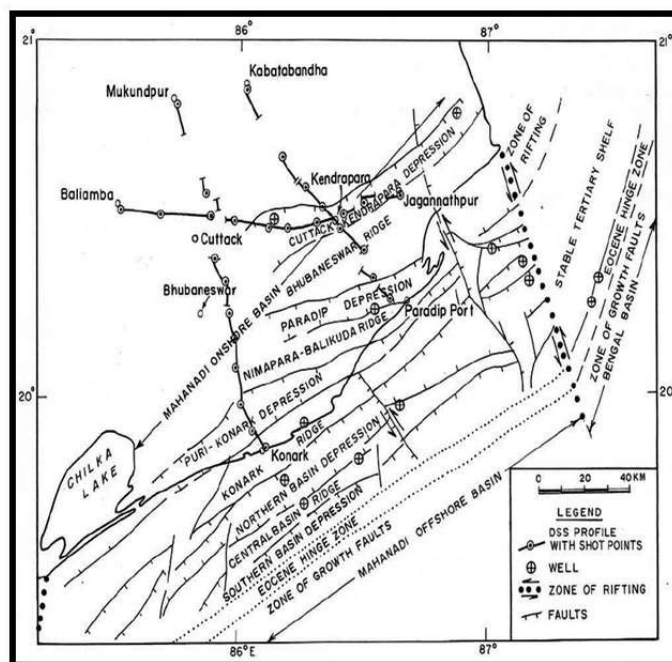
11. MAHANADI BASIN

Mahanadi is a Category II basin, implying that the basin has sub-commercial discovered inplace. The basin has an area of 99,500 sq. km. with 15,500 sq. km. onland area, 14,211 sq. km. shallow water area and 69,789 sq. km. deepwater area. In the basin, 8 plays exist within Cretaceous-Tertiary.

while magnetic, geochemical, 3D seismic and well data are fair. Reliability of results is good. Cretaceous sequence of KG basin. has been used as analogue. 3D PSM and Trap Density method have been used to assess hydrocarbon resources due to fair-to-good control of seismic



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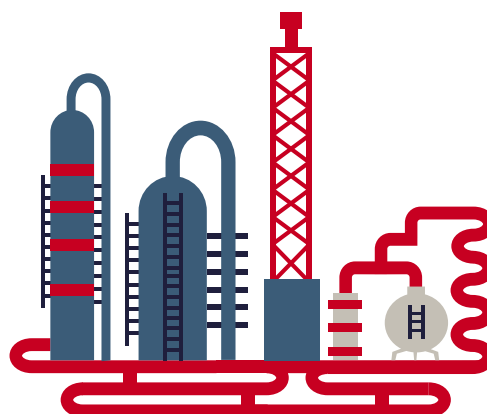
Prospectivity

The Mahanadi basin has a total hydrocarbon inplace of 398 MMTOE, out of which 77 MMTOE has been discovered and this is now entirely sub-commercial inplace. The remaining, 321 MMTOE, nearly 81% of total inplace is potential to be explored and discovered.

The basin has been assessed earlier during 1995-96 study along with 14 other basins. During 2017 Hydrocarbon Resource Assessment Study, 3D PSM approach has been used due to availability of adequate datasets.

The 2017 resource reassessment study has incorporated 27,843 LKM of 2D seismic data, 6,309 SKM of 3D seismic data, 46 drilled well information. Data are clustered near shelfal part of offshore while deeper plays do have less data. Gravity, 2D seismic data and reports are good

data. Very scanty data for deeper plays and deepwater areas are a few challenges. Model results show good potential towards northeast part of offshore adjoining Bengal offshore. High resolution seismic acquisition to delineate deeper plays and future exploration in high pressure area are recommended.



The play-level undiscovered (risked) hydrocarbon inplace for Onshore area is tabulated below:

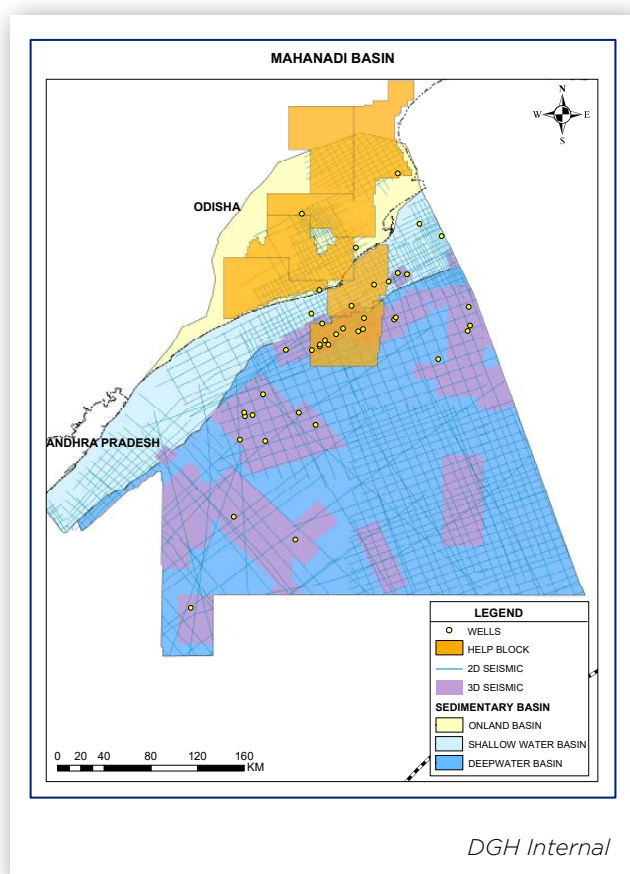
Cenozoic Tertiary:	20 MMTOE	Mesozoic Cretaceous:	2 MMTOE
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The onland part of the sub-basin is spread into the state(s) of Odisha.

The play-level undiscovered (risked) hydrocarbon inplace for Offshore area is tabulated below:

Cenozoic Pliocene:	105 MMTOE	Cenozoic Oligocene:	4 MMTOE
Cenozoic Miocene:	42 MMTOE	Cenozoic Eocene:	16 MMTOE
Cenozoic Miocene (Middle, Biogenic):	36 MMTOE	Cenozoic Paleocene:	42 MMTOE
Cenozoic Miocene (Middle, Thermogenic):	17 MMTOE	Mesozoic Cretaceous:	21 MMTOE

Status, available datasets and opportunities



In terms of awarded acreage that are now active in Mahanadi basin, 18,425 sq km are under HELP.

Under National Seismic Programme, conducted during 2016-22 in unappraised onland areas, 2,481 LKM broad-band 2D seismic data were acquired in the basin.

As of March 1, 2023, NDR, for Mahanadi basin has archived 70,493 LKM of 2D seismic data, 57,737 SKM of 3D seismic data, 41 drilled well information.

Under OALP Bid Round VIII, one ultra-deepwater block of 9,717 sq km area has been offered.

In the upcoming Offshore Mega OALP Round IX, there is an opportunity of 37,503 sq km prospective areas that are carved into four blocks, all located in ultra-deepwater.

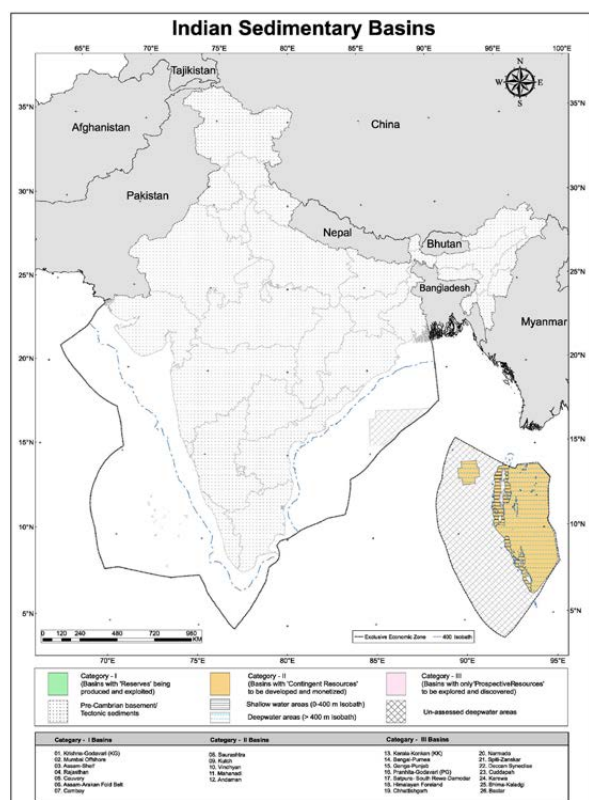
The area towards the southern part outside the current basin boundary have data. This area was however excluded during the 2017 resource study for lack of congruence check with basin. The area is proposed to be taken up along with KG basin in the next periodical assessment.



12. ANDAMAN BASIN

Andaman is a Category II basin, implying that the basin has sub-commercial discovered inplace. The basin has an area of 225,918 sq. km. with 18,074 sq. km. shallow water area and 207,844 sq. km. deepwater area. In the basin, 6 plays are identified within Eocene-to-Mid Miocene in East Andaman and Cretaceous-Tertiary in West Andaman.

detail study. The basin is currently under active exploration stage. Commercial hydrocarbon occurrences are reported in Mid Miocene Play, geographically present in East Andaman part. Potential future gas discoveries are considered mainly within structural entrapment conditions. The hydrocarbon accumulations often indicate charging from deeper source



Prospectivity

The Andaman basin has a total hydrocarbon inplace of 72 MMTOE, out of which 2 MMTOE has been discovered and this is now entirely sub-commercial inplace. The remaining, 70 MMTOE, nearly 97% of total inplace is potential to be explored and discovered.

The basin has been assessed earlier during 1995-96 study along with 14 other basins. During 2017 Hydrocarbon Resource Assessment Study, 3D PSM and Aerial Yield have been used based on the merit of adequate datasets.

The 2017 resource reassessment study has incorporated 55,778 LKM of 2D seismic data,

20,639 SKM of 3D seismic data, 19 drilled well information. GM, geochemical, 3D seismic and well data are fair while 2D seismic data and reports are good. Data quality is good in East Andaman however little data is available in the West Andaman. Reliability of results is good. 3D PSM and Trap Density method have been used to assess hydrocarbon resources due to fair-to-adequate data. Constraint of geochemical data and structural complexity are major challenges. Southeastern area of East Andaman can be considered prospective due to source rock maturity. Detailed interpretation of available high-resolution seismic data would have better insight to complex structural set-up.

The play-level undiscovered (risked) hydrocarbon inplace for West area is tabulated below:

Cenozoic Tertiary:

2 MMTOE

Mesozoic Cretaceous (Upper):

14 MMTOE

The play-level undiscovered (risked) hydrocarbon inplace for East area is tabulated below:

Cenozoic Miocene (Middle):

33 MMTOE

Cenozoic Oligocene:

<1 MMTOE

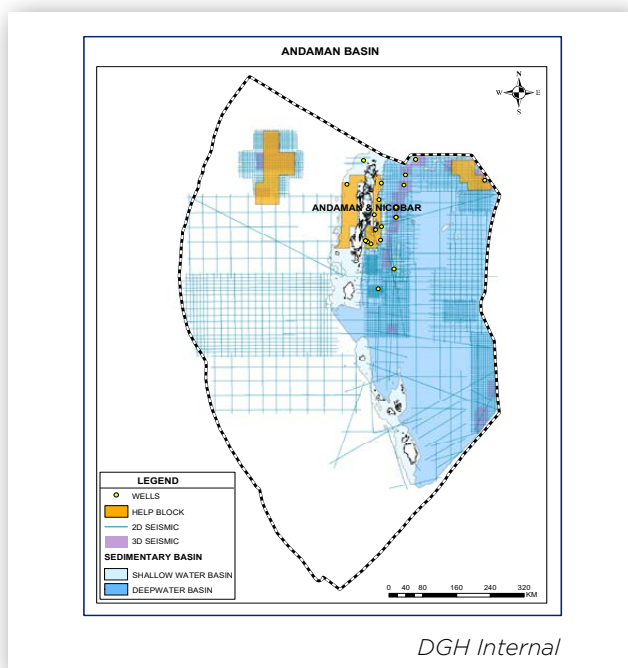
Cenozoic Miocene (Early):

20 MMTOE

Cenozoic Eocene:

<1 MMTOE

Status, available datasets and opportunities



In terms of awarded acreage that are now active in Andaman basin, 23,245 sq km are under HELP.

Under National Seismic Programme, conducted during 2016-22 in unappraised onland areas, 264 LKM broad-band 2D seismic data were acquired in the basin. This, during the next periodical resource study will help explore onland extension of the basin, which is now considered entirely offshore.

As of March 1, 2023, NDR, for Andaman basin has archived 205,882 LKM of 2D seismic data, 34,335 SKM of 3D seismic data, 22 drilled well information.

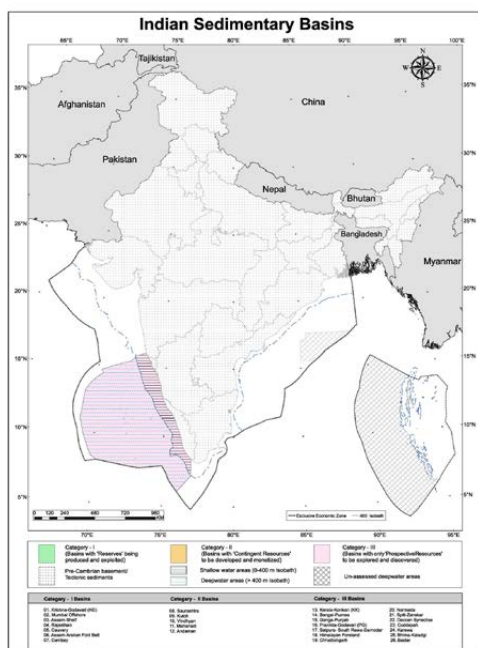
In the upcoming Offshore Mega OALP Round IX, there is an opportunity of 53,099 sq km prospective areas in back-arc regions that are carved into four blocks, all located in ultra-deepwater.



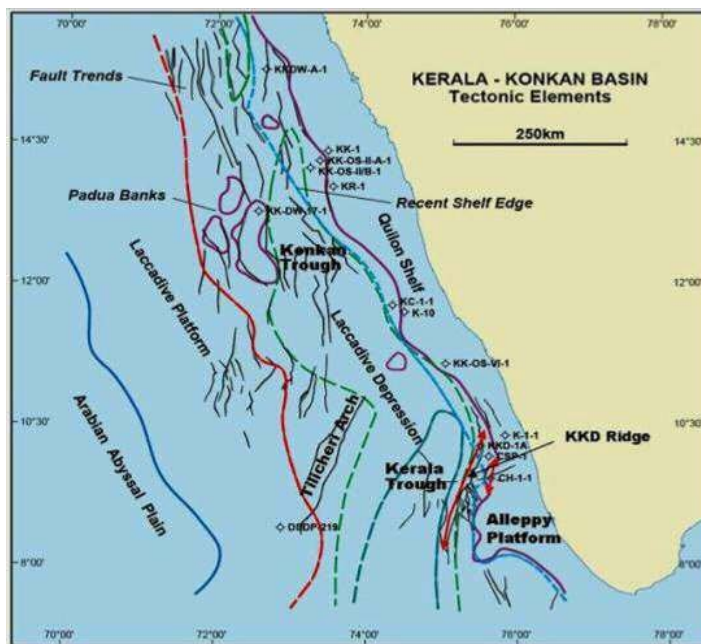
13. KERALA-KONKAN (KK) BASIN

Kerala-Konkan (KK) is a Category III basin, and it has an area of 580,000 sq. km. with 90,380 sq. km. shallow water area and 489,620 sq. km. deepwater area. In the basin, 5 plays are present within Early Cretaceous-to- Miocene.

Resources are entirely undiscovered. Prospective area points to shelf area around Cochin Low. Half of total resources envisaged in Late Cretaceous play are below basalts.



DGH Internal



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Kerala-Konkan Basin is a potential petroliferous province, characterized by carbonate-siliciclastic shallow to deepwater sediments. The basin outline covers mainly the offshore provinces with isolated fringes of Miocene and younger sediments in coastal onland area. Situated on the south-west tip of India, Kerala-Konkan basin is flanked by two prominent North-South oriented oceanic fracture zones.

The basin is a rifted passive margin basin that hosts sediments, ranging from Mesozoic to Recent. Situated on the south-west tip of India, Kerala-Konkan basin is flanked by two prominent North-South oriented oceanic fracture zones. Deepest play is the Early Cretaceous and shallowest are Oligo-Miocene. Petroleum system model could be constructed based on corroborative datasets of broad-grid seismic and wells.

Prospectivity

The Kerala-Konkan (KK) basin has a total hydrocarbon inplace of 605 MMTOE, which is entirely undiscovered and potential for intense exploration.

The basin has been assessed earlier during 1995-96 study along with 14 other basins. During 2017 Hydrocarbon Resource Assessment Study, 3D PSM approach has been used due to availability of adequate datasets.

The 2017 resource reassessment study has incorporated 142,061 LKM of 2D seismic data, 13,529 SKM of 3D seismic data, 20 drilled well information. Seismic coverage is broad grid and well data are sparse.

Gravity, 2D seismic data and reports are good while magnetic, geochemical, 3D seismic and

wells are fair. Reliability of results is good. Gulf of Mannar has been used as analogue for Kerala sub-basin.

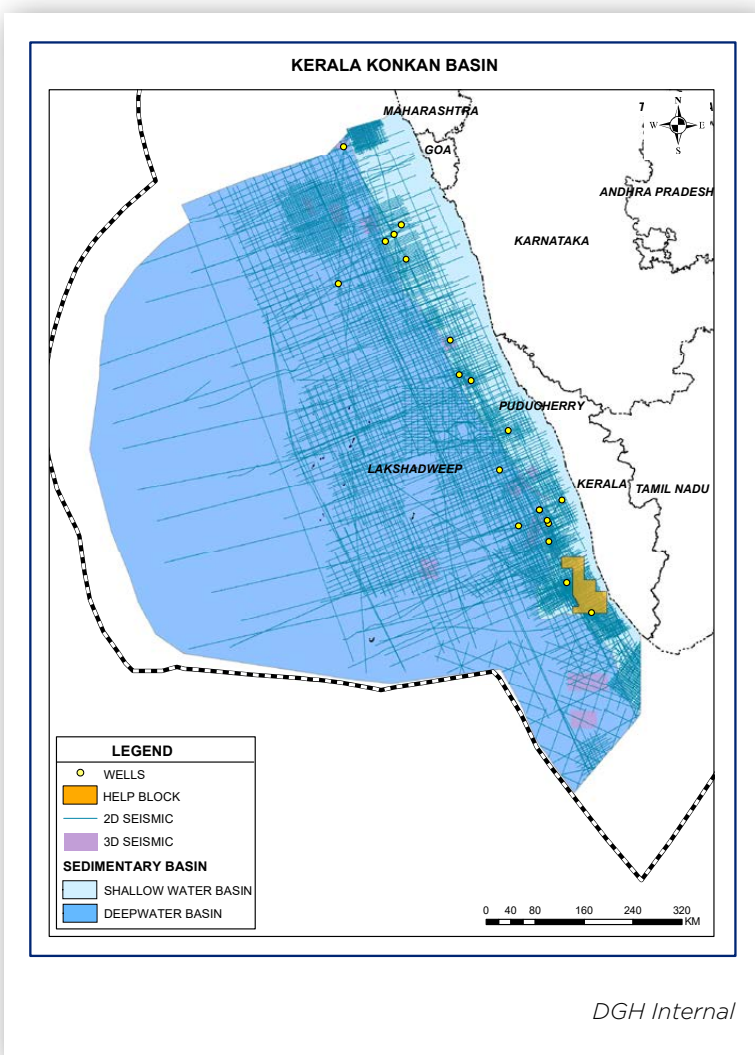
Initiated with aerial yield approach, later 3D PSM and Trap Density method have been used to assess hydrocarbon resources due to spread-out data points. Some challenges are poor sub-

basalt imaging and sparse seismic coverage. Shelfal areas around Cochin Low in Kerala sub-basin can be focused for future exploration. Long-offset sub-basalt imaging, magneto-telluric, controlled source electromagnetic surveys are recommended.

The play-level undiscovered (risked) hydrocarbon inplace for Kerala-Konkan (KK) basin is given below:

Cenozoic Oligo-Miocene:	106 MMTOE	Mesozoic Cretaceous (Late):	303 MMTOE
Cenozoic Eocene (Late):	46 MMTOE	Mesozoic Cretaceous (Early):	85 MMTOE
Cenozoic Eocene (Early):	62 MMTOE		

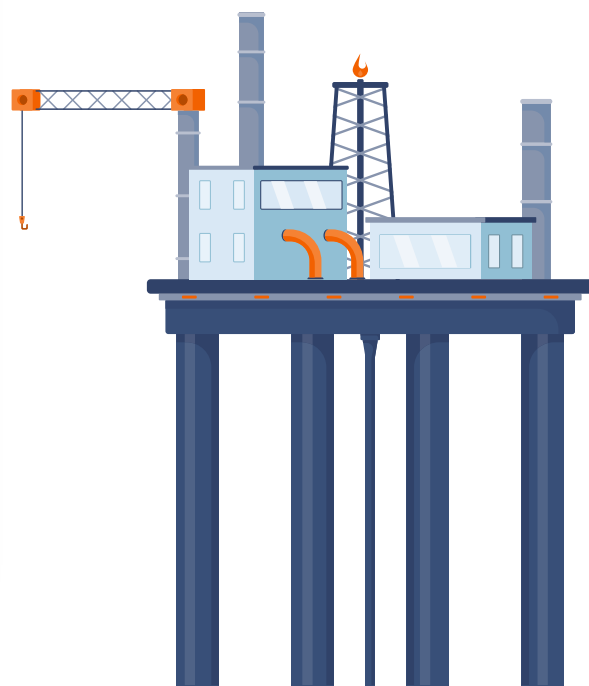
Status, available datasets and opportunities



In terms of awarded acreage that are now active in Kerala-Konkan (KK) basin, 3,520 sq km are under HELP.

As of March 1, 2023, NDR, for Kerala-Konkan (KK) basin has archived 440,987 LKM of 2D seismic data, 14,232 SKM of 3D seismic data, 20 drilled well information.

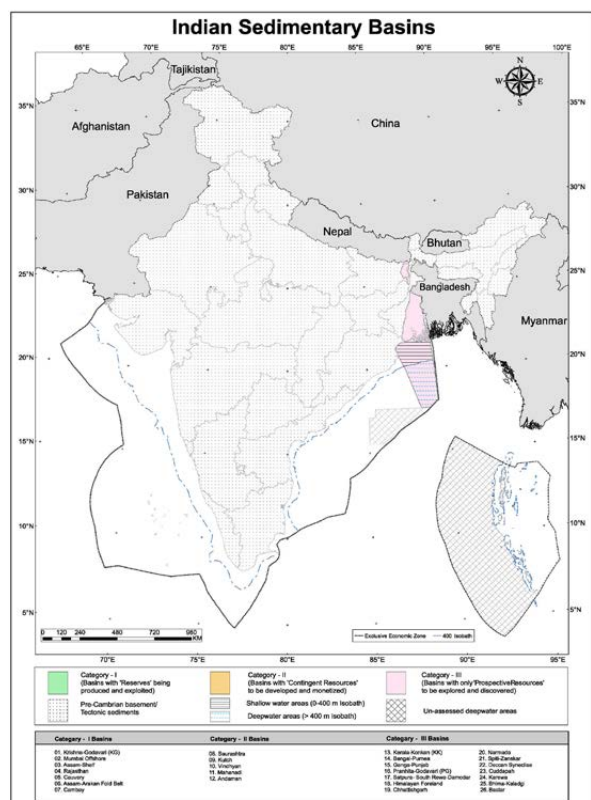
Under OALP Bid Round VIII, one shallow water and another deepwater block with cumulative area of 7,831 sq km has been offered.



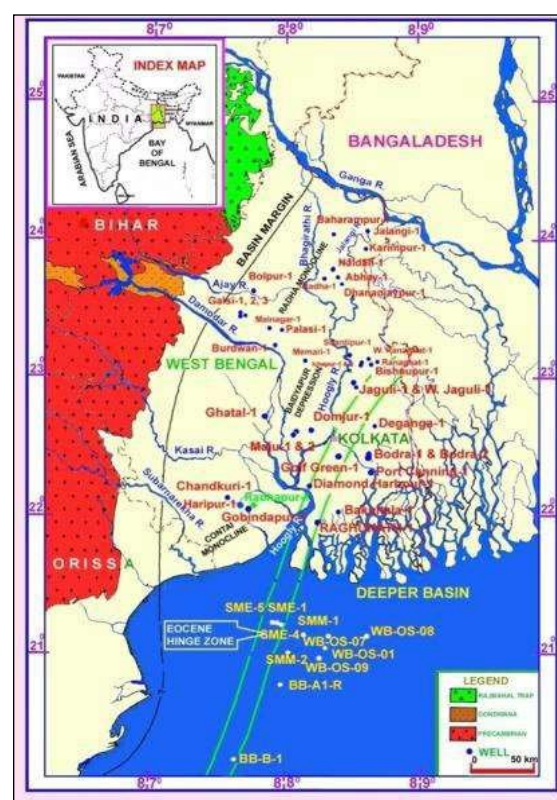
14. BENGAL-PURNEA BASIN

Bengal-Purnea is placed at Category III, to be intensively appraised and explored. In the event of the significant onland discovery (Asokenagar-1) and reallocation of old discoveries from earlier North East Coast (NEC) to newly mapped Bengal offshore part, the basin is proposed for upgrade to Category II during the next periodical assessment of country-level hydrocarbon resources. The basin has an area of 121,914 sq. km. with 42,414 sq. km. onland area, 33,465 sq. km. shallow water area and 46,035 sq. km. deepwater area. In the basin, 5 plays exist within Gondwana-Cretaceous-Tertiary in the Onland part, 8 plays within Eocene-Pliocene in Offshore part and 3 plays within Gondwana (Karharbari-Barakar-Raniganj) of Purnea sub-basin.

The offshore part of basin has 2/3rd potential lying in Middle Miocene play and six gas discoveries are contemplated for development. Occurrence of channelised deposits associated to subtle structures in the east-central area may be significant exploration targets. Bengal basin is currently under active exploration stage. Some biogenic gas shows are reported from the Tertiary stratigraphic interval ranging from the oldest sediments of Paleogene to the youngest sediments of Miocene-Pliocene complex, geographically distributed majorly over offshore areas with strati-structural entrapment conditions. The basin, like other east coast basins of India, is also a peri-cratonic, rift/extensional-passive margin basin, with number of individual Gondwana rift grabens in the onland part and a



DGH Internal



DGH Archive

Bengal-Purnea basin has three sub-basins namely Bengal onland, Bengal offshore and Purnea onland. The basin is a potential hydrocarbon-bearing province, characterized primarily by siliciclastic shelf margin sediments, situated along the East Coast of Indian peninsula.

passive margin set up in the offshore region. This basin hosts thick pile of sediments of 10 km and more, ranging from Permo-Triassic to Recent. The basin's onland part is mostly covered by the Mesozoic sediments, overlain by the thick Tertiary sediments comprising of Paleocene

to Recent sediments, mainly deposited by the Ganga-Brahmaputra river system. The hydrocarbon accumulations often indicate charging from in-situ shallower biogenic source sequences. The establishment of thermogenic plays (Mio-Pliocene) in recent discoveries in Bengal onland point to potential deep-seated source rocks, that can also charge deeper plays.

Prospectivity

The Bengal-Purnea basin has a total conventional hydrocarbon inplace of 541 MMTOE, which is mostly undiscovered and potential for intense exploration.

The basin has been assessed earlier during 1995-96 study along with 14 other basins. During 2017 Hydrocarbon Resource Assessment Study, 3D PSM approach has been used due to availability of adequate datasets.

During both the terms, potential of conventional hydrocarbons was assessed.

The 2017 resource reassessment study has incorporated 70,550 LKM of 2D seismic data, 13,118 SKM of 3D seismic data, 83 drilled well information. Data are scanty to delineate and characterize the deeper plays. Gravity, 2D seismic, well data and reports are good while magnetic, geochemical and 3D data are fair. Reliability of results is good. Gondwana sequence of KG basin has been used as analogue. 3D PSM and Trap Density method have been used to assess hydrocarbon resources due to fair-to-good quality 2D/3D seismic data along with many wells. Seismic quality is very challenging to identify channels in deeper plays. Hinge zone of Bengal basin can be future exploration thrust. More data acquisition from seismic and wells is recommended for characterising channel facies.

The play-level undiscovered (risked) conventional hydrocarbon inplace for Onshore area is tabulated below:

Cenozoic Pliocene:	35 MMTOE	Cenozoic Oligocene:	35 MMTOE
Cenozoic Miocene (Upper):	26 MMTOE	Cenozoic Eocene:	7 MMTOE
Cenozoic Miocene (Middle):	204 MMTOE		

The onland part of the sub-basin is spread into the state(s) of Odisha, West Bengal.

The play-level undiscovered (risked) hydrocarbon inplace for Offshore area is tabulated below:

Cenozoic Pliocene:	51 MMTOE	Cenozoic Paleocene:	41 MMTOE
Cenozoic Miocene:	40 MMTOE	Mesozoic Cretaceous:	14 MMTOE
Cenozoic Oligocene:	46 MMTOE	Mesozoic Triassic (Upper Gondwana):	5 MMTOE
Cenozoic Eocene:	11 MMTOE	Paleozoic Permian (Lower Gondwana):	12 MMTOE

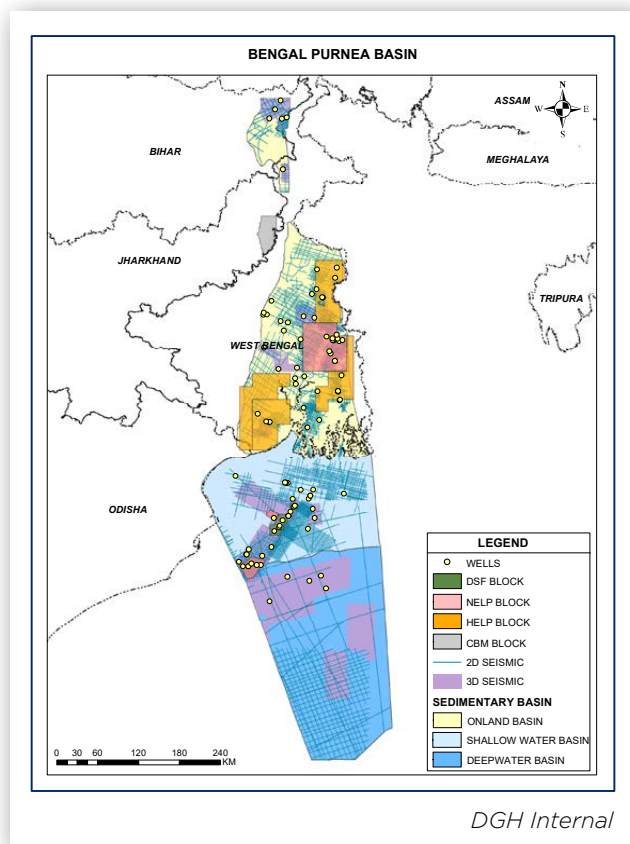
The play-level undiscovered (risked) conventional hydrocarbon inplace for Purnea area is tabulated below:

Paleozoic Permian (Late Raniganj):	3 MMTOE	Paleozoic Permian (Early Karharbari):	6 MMTOE
Paleozoic Permian (Early Barakar):	6 MMTOE		

The onland part of the sub-basin is spread into the state(s) of Bihar, West Bengal.



Status, available datasets and opportunities



As of March 1, 2023, NDR, for Bengal-Purnea basin has archived 67,437 LKM of 2D seismic data, 66,243 SKM of 3D seismic data, 98 drilled well information which includes CBM wells too.

Under OALP Bid Round VIII, one shallow water block of 5,755 sq km area has been offered.

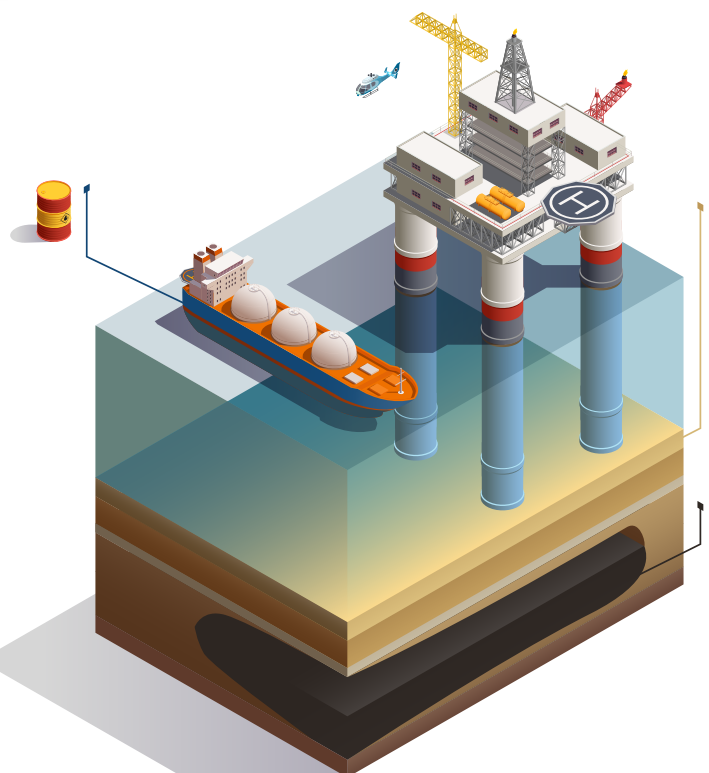
In the upcoming Offshore Mega OALP Round IX, there is an opportunity of 19,979 sq km prospective areas that are carved into two blocks, one located in shallow-water and the other in ultra-deepwater.

In Bengal onland sub-basin, 2 CBM blocks with cumulative acreage of 761 sq km are on offer under Special CBM Bid Round 2022. The blocks are spread one each in Jharkhand and West Bengal.

In terms of awarded acreage that are now active in Bengal-Purnea basin, 4,775 sq km lie under NELP, 11,616 sq km are under HELP, 541 sq km lie under DSF, 991 sq km are under CBM.

The basin had witnessed a significant discovery (NELP Block) in Upper Miocene reservoirs at the well, Asokenagar-1. Gas in upper zone and oil in lower zones were notified to be potential discoveries in 2019. As a part of ease-of-doing-business, the oil discovery was approved for early monetization. The discovery has led to a spate of intense exploration activities in the area, including appraisal drilling for discovered pools and a renewed subsurface understanding of reservoir development and supporting play system elements.

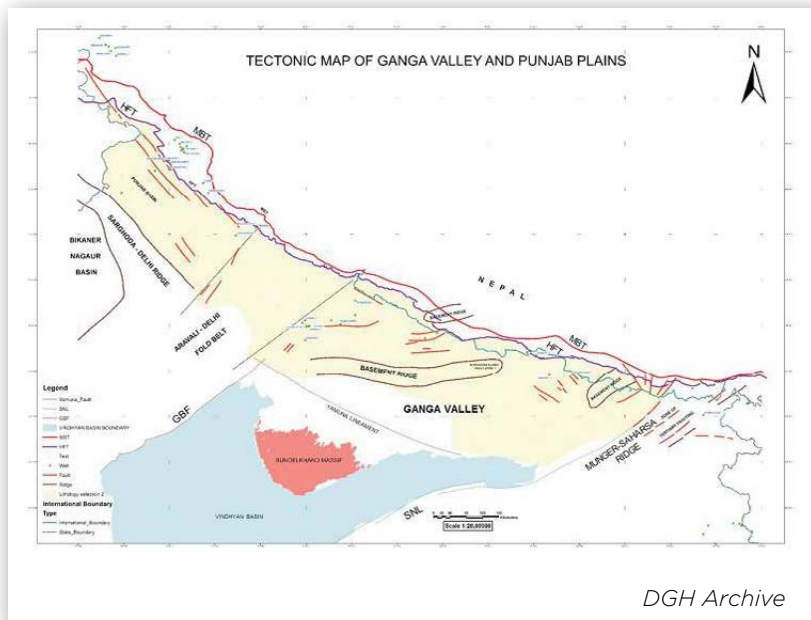
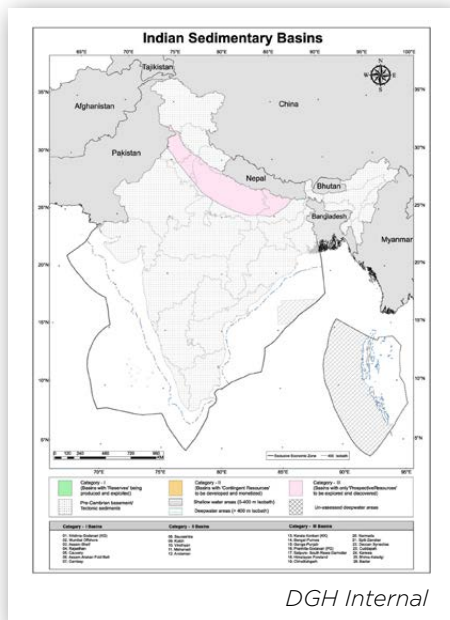
Under National Seismic Programme, conducted during 2016-22 in unappraised onland areas, 911 LKM broad-band 2D seismic data were acquired in the basin.



15. GANGA-PUNJAB BASIN

Ganga-Punjab is a Category III basin, and it has an area of 304,000 sq. km. which is entirely onland. In the basin, 2 plays are present within Pre-Cambrian and Mid Miocene.

refraction data was acquired. M/s ONGC started exploration in the year 1978-79 in the Gandak depression of the Ganga sub basin. Exploration began with field mapping, gravity-magnetic and



The Indo-Gangetic plain, which is the extensive alluvial plain of Ganga, Indus and Brahmaputra rivers and their tributaries separate the Himalayan range from peninsular India. Ganga valley and Punjab plain are the integral part of Indo-Gangetic plain, representing the river Ganga and Indus catchment area respectively.

Ganga-Punjab basin is covered by thick alluvium, which conceals the pre-collisional (Indo-Eurasian plates Proterozoic and post-collisional Tertiary records. The pre-collisional setup of Indian passive margin is of considerable importance for better understanding of the tectono-sedimentary evolution of the Proterozoic sediments of Ganga-Punjab basin. Post-collision flexuring of the Indian lithosphere and thrust fold loading produced the Himalayan peripheral foreland in Early Miocene. The basin expanded during Middle Miocene and attained its present configuration in Late Quaternary.

The exploration in the Ganga-Punjab basin started in late 1950. The aeromagnetic survey was carried out in the year 1956. During 1957-58, regional single-fold seismic reflection and

aeromagnetic surveys followed by acquisition and processing (AP) of 2D seismic data and exploratory drilling. Hydrocarbon discovery in adjoining Vindhyan basin in well Nohta-2 from Paleo-Proterozoic unconventional Rohtas play spurred the exploration efforts.

In 2006, 2,500-station GM data was acquired in Gandak depression of Ganga sub-basin. The aeromagnetic and GM data were also acquired by M/s Cairn in Madhubani depression during 2007. The Ganga Basin was covered by 2D seismic surveys under various campaigns. The first 2D seismic survey was carried out by M/s ONGC in the year 1978 in the Gandak depression of the Ganga Basin. In 1980's most of the 2D data was acquired in the Raxual, Madhubani and Bettiah area. Later, 2D seismic survey was conducted in the Sarda depression and 12/24/48/60-fold data was acquired. In Madhubani depression, M/s Cairn acquired 2D seismic data. M/s OIL acquired 2D seismic data in Kashipur block of Sarda depression. Till date, only two 3D seismic campaigns were carried out by M/s ONGC in Gandak depression.



20 exploratory wells, 16 wells in Ganga sub-basin and 4 wells in Punjab sub-basin were drilled. In Ganga sub-basin, 2 wells were drilled in Madhubani depression, 5 wells in the Gandak depression, 9 wells in Sarda depression. Ganga-Punjab basin is delimited in north and north-east by the Himalayan upland along Himalayan Frontal Thrust (HFT), where the folded and faulted outer Himalayan belt (Siwalik) structurally terminates against the Indo-Gangetic alluvial sediments. Southern limit is delineated by the Yamuna lineament along Bundelkhand massif, Vindhyan basin and Delhi-Sargodha Ridge. Munghyer-Saharsa Ridge mark the eastern boundary and Indo-Pakistan international border of Punjab and J&K is the Western limit. Delhi-Aravalli ridge is considered as the boundary between Ganga sub-basin and Punjab sub-basin.

Ganga-Punjab basin hosts the Proterozoic and Tertiary sediments over the granitic basement. Ganga sub basin is a poly-history basin, marked by rifting during Meso-Proterozoic, platformal deposition during Neo-Proterozoic, passive margin sedimentation during Paleocene to early Eocene and opening up of foreland-basin during early Eocene, followed by deposition of Molasse sediments forming Siwalik Supergroup during Neogene.

Among the most important structural elements that have been identified in this foreland basin, Aravalli Horst trends in northeast-southwest direction. There are transverse ridges and their associated spurs, which divide the Indo-Gangetic plain into prominent basinal lows. Structurally, Ganga sub-basin is subdivided into three depressions viz., (i) Sarda, (ii) Gandak and (iii) Madhubani, each separated by intervening basement ridges.

Sarda Depression is aligned east-west and has a sediment thickness of more than 7,000m. Two prominent sub-depressions, Puranpur low and Bahraich low can be identified within it from GM data. Gandak Depression, located east of the Sarda has a sediment thickness of the order of 7,000-8,000m and Madhubani Depression lying east of the Gandak has a narrow graben with sediment thickness of more than 6,000m. Current views on the age of Ganga-Punjab basin are based on the recent biochronological data sets. Since long, the sediments of Ganga sub-

basin were considered to be of Proterozoic age but studies by M/s ONGC extended the age of the sediments to Paleozoic age. Since Proterozoic sediments are present in the north (Himalayan Foothills) and south (Vindhyan basin), the sediments in the intervening Ganga basin are also expected to be of Proterozoic Eon. In Ganga sub-basin two speculative plays have been identified i.e. Neo-Proterozoic unconventional play and Middle Miocene conventional play. Whereas in Punjab sub-basin only one hypothetical play i.e. Middle Miocene Play is envisaged as only Tertiary sediments, resting directly over metamorphic basements.

Ganga sub-basin Neo-Proterozoic play is unconventional tight gas play like Vindhyan play. Play fairway was delineated combining the thickness of Ujhani, Tilhar and Karnapur formations, which have source as well as reservoir sequences. Intermediate shales and the tight reservoirs can act as seals, while both vertical and short lateral migration are envisaged.

Middle Miocene play (Lower Siwalik) has been considered as a conventional play, where source rock indicates richness of organic matter and hydrocarbon generation potential, however initial geochemical results are inconclusive on maturity of organic matter. In absence of structural traps due to reduced tectonic activity, stratigraphic traps are primary exploration targets.

Prospectivity

The Ganga-Punjab basin has a total hydrocarbon inplace of 123 MMTOE, which is entirely undiscovered and potential for intense exploration.

The basin has been assessed earlier during 1995-96 study along with 14 other basins. During 2017 Hydrocarbon Resource Assessment Study, Aerial Yield has been used on analogy of Vindhyan basin (Pre- Cambrian sequences) and Duarmara gas field of Assam (Tertiary sequences). The study has incorporated 19 wells of Ganga subbasin and 4 wells of Punjab subbasin. Besides, 2,251 LKM 2D seismic data and 706 LKM seismic refraction data from Punjab sub-basin along with 3D seismic data from Ganga sub-basin have been used. Other non-seismic data namely Aeromagnetic survey (130,700SKM), GM data (76,000 stations), MT

data (250 stations) and Geochemical data (15 surveys) have also been used in the study.

The 2017 resource reassessment study has incorporated 41,895 LKM of 2D seismic data, 400 SKM of 3D seismic data, 23 drilled well information. Gravity, 2D seismic data and reports are good, magnetic, geochemical and well data are fair while there is no 3D seismic data. Despite the fact that there is less seismic data, reliability of results is good. Vindhyan basin and Duarmara field of Assam Shelf has

been used as analogue. Areal Yield method has been used due to inadequate geoscientific data. There are large data gaps without adequate linkage. Presence of source rocks and maturity of Tertiary sequences may be explored. Results may be reviewed as and when new sets of data are available.

The play-level undiscovered (risked) hydrocarbon inplace for Ganga-Punjab basin is given below:

Cenozoic Tertiary:

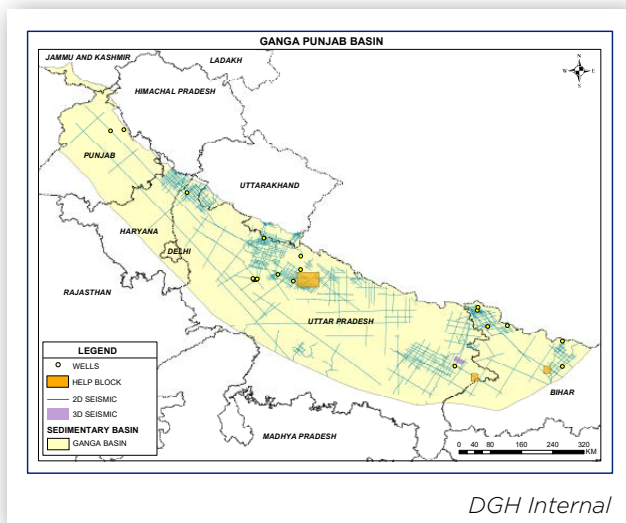
1 MMTOE

Proterozoic Neo-Proterozoic:

125 MMTOE

The basin is spread into the state(s) of Bihar, Chandigarh, Delhi, Haryana, Himachal Pradesh, Jammu and Kashmir, Madhya Pradesh, Punjab, Uttar Pradesh, Uttarakhand.

Status, available datasets and opportunities



In terms of awarded acreage that are now active in Ganga-Punjab basin, 2,428 sq km are under HELP.

Under National Seismic Programme, conducted during 2016-22 in unappraised onland areas, 3,858 LKM broad-band 2D seismic data were acquired in the basin.

As of March 1, 2023, NDR, for Ganga-Punjab basin has archived 28,781 LKM of 2D seismic data, 1,363 SKM of 3D seismic data, 19 drilled well information.

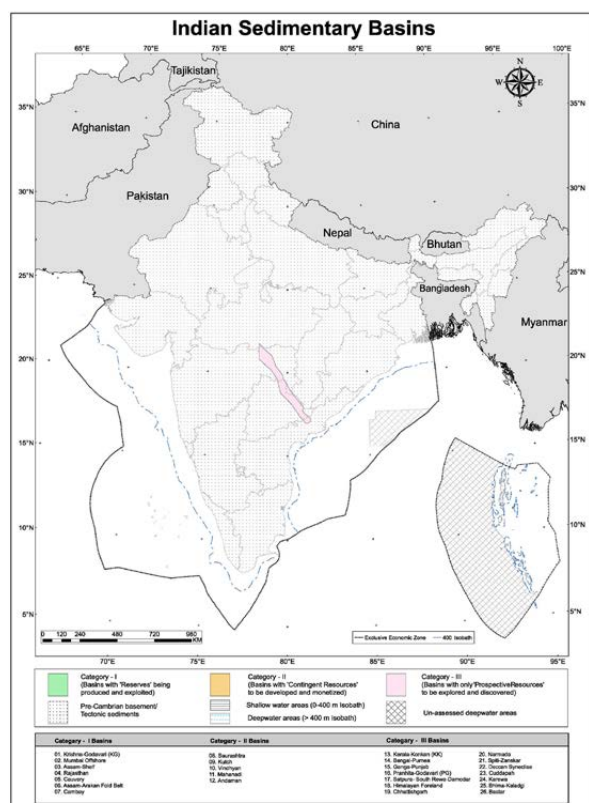
Under a short-term collaborative project on basin research, the geoscientific datasets of the basin are now independently assessed by RGIPT.



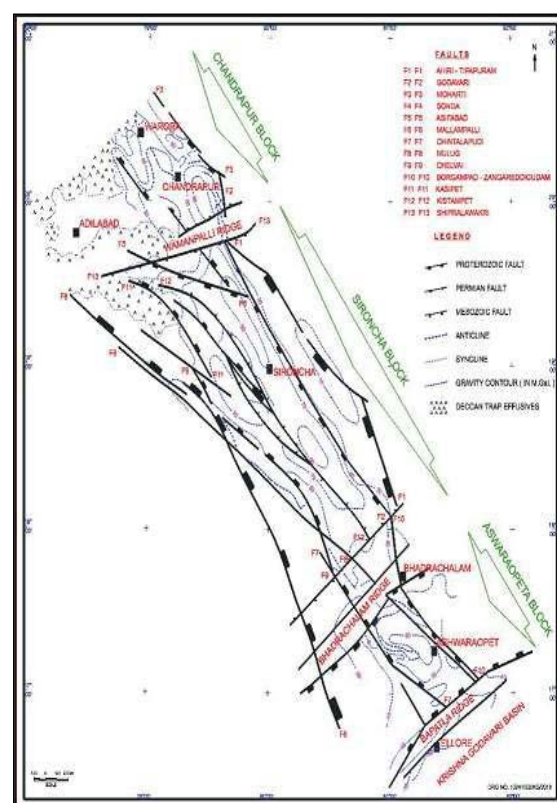
16. PRANHITA-GODAVARI (PG) BASIN

Pranhita-Godavari (PG) is a Category III basin, it has an area of 30,000 sq. km. which is entirely onland. In the basin, 4 plays exist within Lower Permian-to-Lower Triassic.

of Chandrapur block are covered by Deccan Trap. Aswaraopeta and Sironcha blocks have three play units. Chandrapur has low thickness



DGH Internal



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The basin is a NW-SE trending intracratonic rift, located over Peninsular India and bounded by metamorphic rocks of Bastar to its northeast and Dharwar cratons to its southwest.

Geoscientific data available in the basin is inadequate with limited 2D seismic along with two drilled well information. The underlying Proterozoic metasediments with poor source and reservoir characteristics are not been considered to be prospective. Potential plays are envisaged in Talchir, Barakar, Lower, Middle and Upper Kamthi Formations. Geologically the basin is divided into four tectonic blocks namely, Aswaraopeta, Sironcha, Chandrapur and Nagpur blocks. Of these, Nagpur block along with a part

of sediments and Nagpur completely covered by Deccan Trap basalts.

Geological data indicates presence of about 4 to 5 Km of sediments. The oldest sediments known from surface exposures are the Lower Proterozoic overlain by Gondwana sediments. There are two speculative petroleum systems. Based on geological similarity, the Permo-Triassic sediments of Mandapeta area of KG onland basin are the close analogue.

Prospectivity

The Pranhita-Godavari (PG) basin has a total hydrocarbon inplace of 92 MMTOE, which is entirely undiscovered and potential for intense exploration.

The basin has been assessed for the first time. During 2017 Hydrocarbon Resource Assessment Study, Aerial Yield has been used on analogy of KG Basin. The study has incorporated geological map, GM data, and geochemical data (source rock samples).

The 2017 resource reassessment study has incorporated 750 LKM of 2D seismic data, 2 drilled well information. Gravity data and report are of

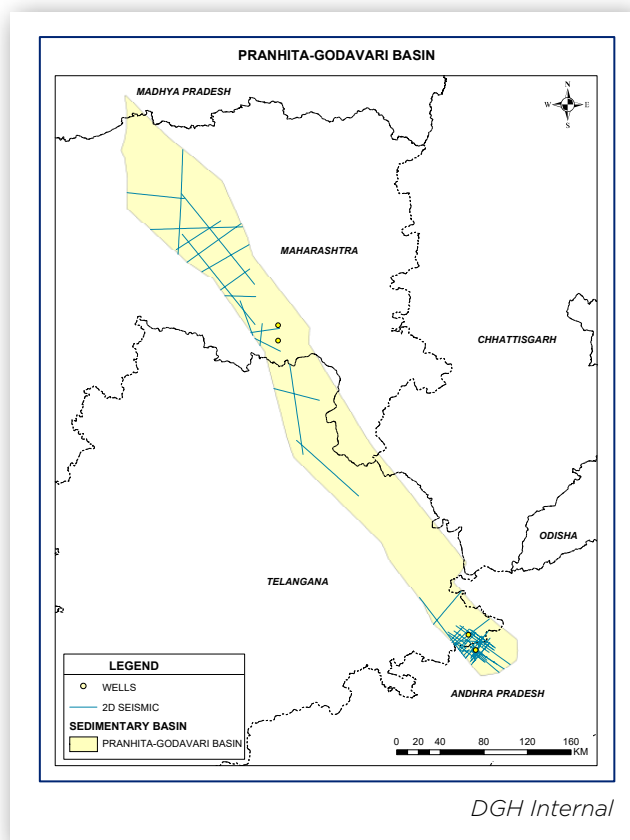
good quality while Magnetic and Geochemical data are fair and 2D Seismic and Wells data are poor with 3D Seismic. The data reliability is good. Mandapeta area of the KG Basin, has been used as analogue. Inadequate geoscientific data leads to adopt areal yield method to assess the hydrocarbon resources. Less seismic data is available. Maturity of sediments is primary focus. Results may be reviewed as and when new sets of data are available.

The play-level undiscovered (risked) hydrocarbon inplace for Pranhita-Godavari (PG) basin is given below:

Paleozoic Permo-Triassic (Upper Kamthi):	4 MMTOE	Paleozoic Permian:	44 MMTOE
Paleozoic Permo-Triassic (Middle Kamthi):	43 MMTOE	Paleozoic Carboniferous (Upper Permian):	3 MMTOE

The basin is spread into the state(s) of Andhra Pradesh, Chhattisgarh, Madhya Pradesh, Maharashtra, Telangana.

Status, available datasets and opportunities



Under National Seismic Programme, conducted during 2016-22 in unappraised onland areas, 735 LKM broad-band 2D seismic data were acquired in the basin.

As of March 1, 2023, NDR, for Pranhita- Godavari (PG) basin has archived 1,903 LKM of 2D seismic data, 4 drilled well information.

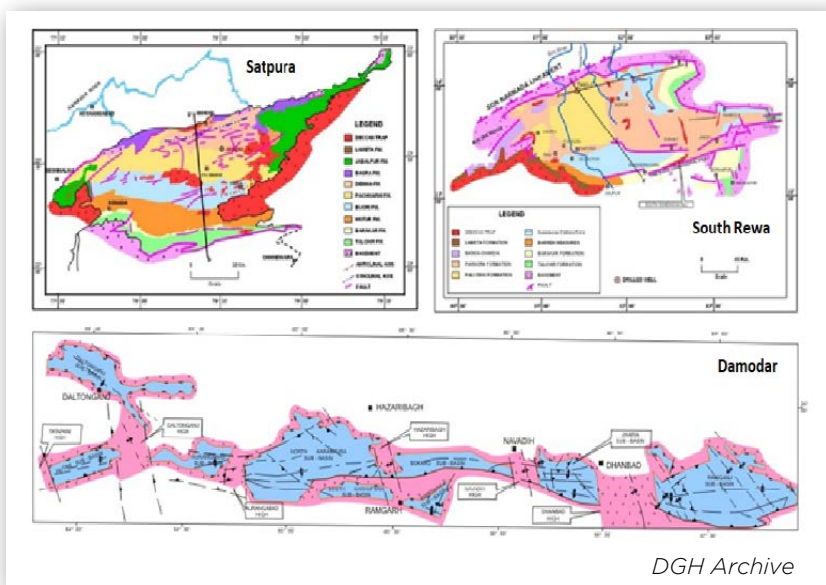
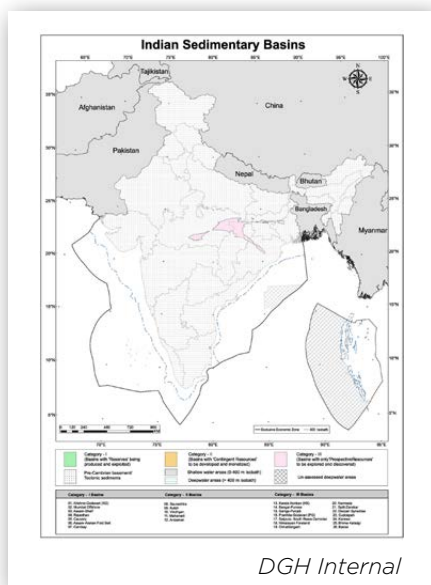
In PG basin, 5 CBM blocks with cumulative acreage of 1,063 sq km are on offer under Special CBM Bid Round 2022. The blocks are spread in Telangana(3) and Maharashtra(2).



17. SATPURA-SOUTH REWA-DAMODAR BASIN

Satpura-South Rewa-Damodar is a Category III basin, implying that the basin has entirely undiscovered conventional inplace, that is to be intensely explored and discovered. The basin has an area of 57,180 sq. km. which is entirely onland. In the basin, Satpura has Early Permian-to-Cretaceous play, South Rewa Early Permian-to-Cretaceous and Damodar Early Permian-to-Triassic.

petroleum system, which, based on geological rationale is considered to be a close analogue with the Cooper Basin of Australia. There are three plays identified. viz. Early Permian, Mid. to Late Permian and Triassic to Cretaceous across all three sub-basins viz. Satpura, South Rewa and Damodar.



The Gondwana rocks of Satpura-South Rewa-Damodar Basin are exposed along a linear belt in Indian peninsular region. The basin has limited geoscientific data, specific to exploration of conventional hydrocarbons. The elements of conventional petroleum system in the basin are hence speculative. Satpura sub-basin, the westernmost among the three sub-basins, is located south of Son-Narmada lineament. Peninsular gneisses of Betul-Chindwara plateau marks its southern limit. The eastern and western parts are covered by Deccan Trap basalts.

The rectangular South Rewa sub-basin is bounded by the Malwa Ridge and the Manendragarh-Pratappur ridge to its north and south respectively. The Gondwana rocks of Damodar Basin occur in several isolated east-west trending depressions over the Chotanagpur Plateau. The basin has instances of Gondwana sediments - both Lower Permian plays and the Upper Mesozoic. The study envisages the hypothetical Gondwana

Prospectivity

The Satpura-South Rewa-Damodar basin has a total conventional hydrocarbon inplace of 61 MMTOE, which is entirely undiscovered and potential for intense exploration.

The basin has been assessed for conventional hydrocarbons the first time. During 2017 Hydrocarbon Resource Assessment Study, In all subbasins of Satpura, South Rewa and Damodar, Aerial Yield method has been used on analogy of Cooper Basin (Australia). The Satpura subbasin has 2D refraction seismic data (73 LKM), geological map (7,276 SKM), GM data (8,451 stations). The South Rewa subbasin has geological map (10,475 SKM), GM data (3,445 stations) and geochemical data of a few surface samples. In Damodar sub-basin, geological map, GM data (Durgapur depression) and geochemical data (source rock) are incorporated. In this sub-basin, 41 wells that are drilled for CBM and 4 wells for shale gas have been used for the study.

The 2017 Resource Reassessment Study has incorporated 4,126 LKM of 2D seismic data, 48 drilled well information. Gravity data and report is of good quality; Magnetic, Geochemical and 2D Seismic data is of fair quality; well data is of poor quality with no availability of 3D seismic data. The data reliability is good. Cooper Basin of

Australia has been used as analogue. Inadequate geoscientific data leads to adopting areal yield method to assess the hydrocarbon resources. Igneous intrusions pose challenge for mapping hydrocarbon resources. There are large gaps in data. Results may be reviewed as and when new sets of data are available.

The play-level undiscovered (risked) conventional hydrocarbon inplace for Satpura area is tabulated below:

Mesozoic Triassic-Cretaceous: 1 MMTOE

Paleozoic Permian (Early): 12 MMTOE

Paleozoic Permian (Middle-Late): 6 MMTOE

The sub-basin is spread into the state(s) of Madhya Pradesh.

The play-level undiscovered (risked) conventional hydrocarbon inplace for South Rewa area is tabulated below:

Mesozoic Triassic-Cretaceous: 7 MMTOE

Paleozoic Permian (Early): 19 MMTOE

Paleozoic Permian (Middle-Late): 13 MMTOE

The sub-basin is spread into the state(s) of Chhattisgarh, Madhya Pradesh, Odisha, Uttar Pradesh.

The play-level undiscovered (risked) hydrocarbon inplace for Damodar area is tabulated below:

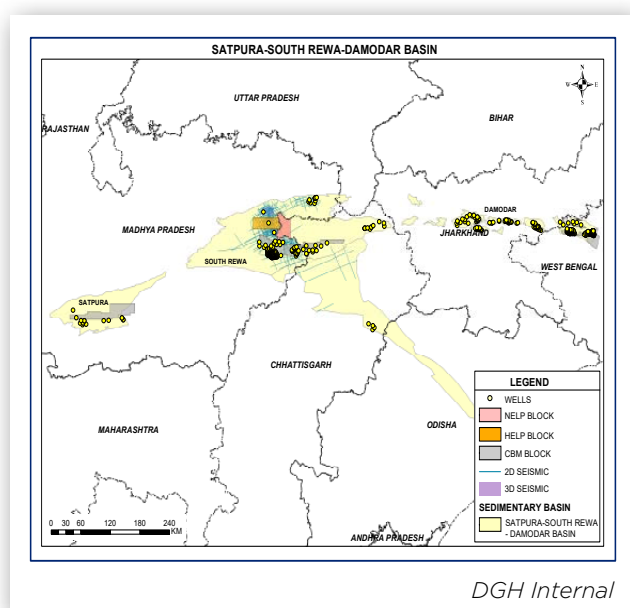
Mesozoic Triassic-Cretaceous: <1 MMTOE

Paleozoic Permian (Early): 2 MMTOE

Paleozoic Permian (Middle-Late): 1 MMTOE

The sub-basin is spread into the state(s) of Jharkhand, West Bengal.

Status, available datasets and opportunities



In terms of awarded acreage that are now active in Satpura-South Rewa-Damodar basin, 790 sq km lie under NELP, 906 sq km are under HELP, 6,457 sq km are under CBM,

Under National Seismic Programme, conducted during 2016-22 in unappraised onland areas, 1124 LKM broad-band 2D seismic data were acquired in the basin. As of March 1, 2023, NDR, for Satpura-South Rewa-Damodar basin has archived 28,753 LKM of 2D seismic data, 550 SKM of 3D seismic data, 892 drilled well information, which includes mostly CBM wells.

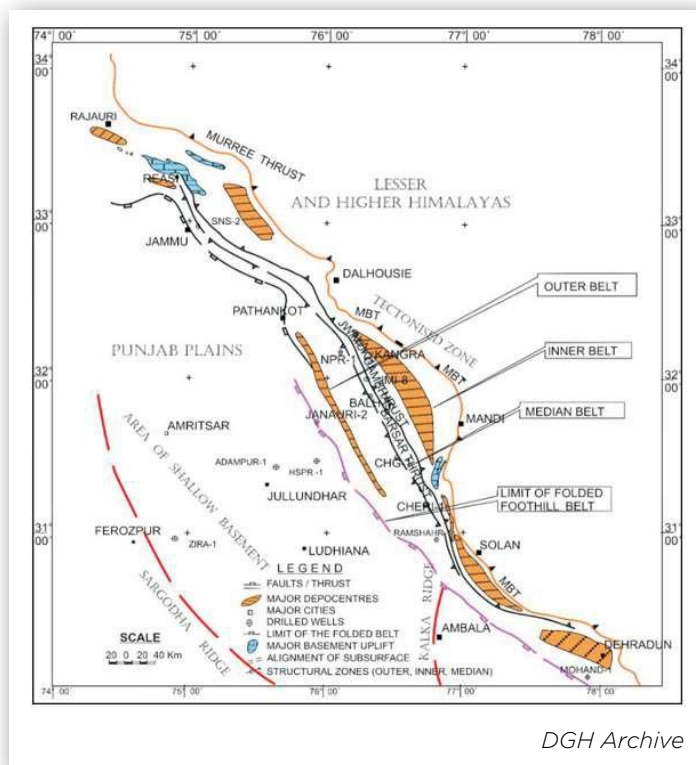
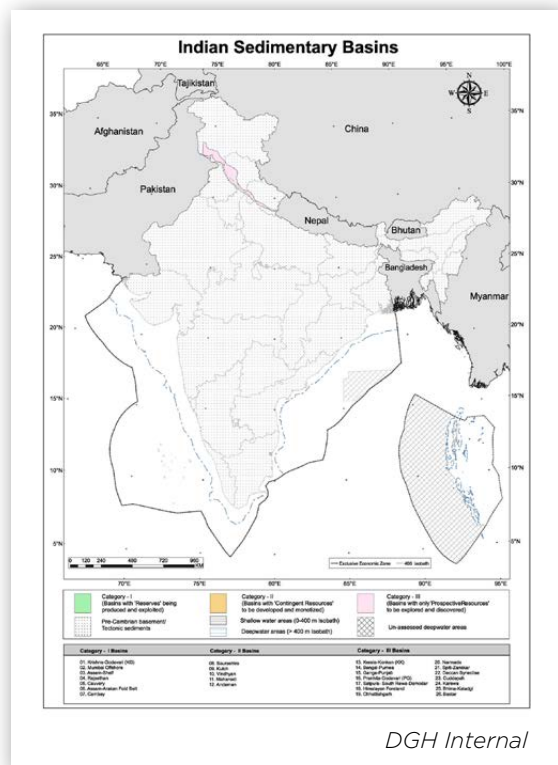
In South Rewa sub-basin, 9 CBM blocks with cumulative acreage of 3,093 sq km are on offer under Special CBM Bid Round 2022. The blocks are spread in Madhya Pradesh (4), Chhattisgarh(3) and Odisha(2).



18. HIMALAYAN FORELAND BASIN

Himalayan Foreland is a Category III basin and it has an area of 30,110 sq. km. which is entirely onland. In the basin, 4 plays are identified within Pre-Cambrian, Tertiary and Pleistocene.

sedimentary features, reconnaissance traversing and investigations of oil and gas shows were carried out. Geochemical survey was conducted in Subathu (Eocene) and Lower Dharamsala



In the adjacent Potwar basin of Pakistan, which is located in the northwestern Himalayas, several oil and gas fields have been discovered. On the basis of such analogy along with available geoscientific knowledge, the areas of Himalayan Foothills of Jammu & Kashmir (J&K), Himachal Pradesh, Uttarakhand and adjoining Indo-Gangetic Plains in Punjab are considered primary targets for hydrocarbon exploration. Himalayan foreland basin is an east-west trending elongate basin that extends from Pakistan in the west to India in the east. The basin came into existence at the close of Mesozoic Era following the first India-Asia impingement ~58 Ma resulting in the deposition of the initial foredeep sediments in front of the rising Himalaya.

Hydrocarbon exploration in Himalayan Foothills of erstwhile-named Punjab Basin was initiated in 1956 by M/s ONGC through geological surveys. Field mapping, special studies on

(Oligocene) for laboratory analysis of samples. Under geophysical campaign, aeromagnetic surveys were conducted in 1957, which was followed by seismic and gravity-magnetic (GM) surveys in 1957-58. Major part of the basin is covered by GM surveys. Such surveys bring out clearly that northwest-southeast Himalayan trend is the dominant lineament in the basement. However, there is a strong perception of northeast-southwest Aravalli trend in the area lying between Kalka and Dehradun. Initially, seismic surveys conducted in the Punjab plains were of refraction, which was followed by reflection surveys during 1970's, covering mostly the foothill areas. The Himalayan tectonic system comprises the Himalayan orogen, the active foreland basin, and the Indus/Bengal fans; all formed as a result of India-Asian collision in Cenozoic era.

The Himalayas are divided into five physiographic zones. The Foothills or the Sub-Himalaya (Paleogene- Neogene-Quaternary) has molasse sediments deposited in the Himalayan Foreland Basin (HFB). The Lesser Himalaya have the metamorphosed Proterozoic rocks in north, overlying the Tertiary rocks along the Main Boundary Thrust (MBT). The Higher Himalaya consists of the crystalline thrust sheets with Main Central Thrust (MCT) occupying the highest tectonic level. The MCT marks the southern boundary of the Greater Himalaya against the low-grade metamorphic rocks of the Lesser Himalaya. Tethyan Himalayan sediments are exposed on the back slope of the Greater Himalayan basement rocks.

Topographically, the Tethyan Himalayan rocks form low-dipping mountains of high altitude and resemble the Tibetan plateau. The southern boundary of the Tethyan Himalayan metasediments is believed to be represented by the South Tibetan Detachment Fault/Thrust (STDT). The Tethyan Himalaya is made up of the Neoproterozoic-Eocene succession and it rests non-conformably over Central Crystallines. The Indus-Tsangpo Suture Zone representing rocks associated with the Suture lie between the Indian and Asian plates. The stratigraphic sequences comprise of a basement of igneous and metamorphic rocks over which the Proterozoic carbonate deposition took place. These formed the floor for the subsequent Cenozoic deposition to the extent of 10Km and also for the deposition of Palaeozoic-Mesozoic succession in the adjacent Potwar Plateau which are the extension of the litho-tectonic elements of the Jammu sub Himalayas. Based on earlier studies from 2D seismic multi-channel reflection data in Poonch-Rajauri area of J&K with Kohat-Potwar Plateau of Pakistan, Siwalik and Murree sequences are envisaged to be underlain by Eocene carbonates and Mesozoic-Paleozoic strata. Reflection events corresponding to these strata were observed to be of similar seismic characters and thickness of different sequences matched at both the places.

Pre-Tertiary sedimentation took place in the Poonch-Rajauri area and also to the north of major normal fault and is likely to have continued in the concealed Jammu-Pathankot-Dasuya graben in Punjab Plains. The stratigraphic sequence of

foreland basin sediments in the Punjab plains comprises of granitoids and metamorphic rocks as their basement, overlain by Middle to Late Proterozoic sediments, dominantly made up of carbonates and unconformably followed by the Cenozoic sediments. Neo-Proterozoic-Infra-Cambrian-Paleozoic play are within the oil generation window and source rocks are shallow marine.

Subathu rocks are within the oil generation window and source rocks are shallow marine to lagoonal. Dharamshala and Siwalik have Vaishnodevi limestone/shale and Subathu shales being potential source rocks/facies, representing mostly fluvial with marine influences in the basal part of Lower Dharamshala. In general, fault closures along thrust plane form the likely entrapment while sandstone and limestone are the reservoir facies/rocks.

Prospectivity

The Himalayan Foreland basin has a total hydrocarbon in place of 45 MMTOE, which is entirely undiscovered and potential for intense exploration.

The basin has been assessed earlier during 1995-96 study along with 14 other basins. During 2017 Hydrocarbon Resource Assessment Study, Aerial Yield method is used on analogy of Kohat Potwar Basin (Pakistan). The basin has 10,000m envisaged sedimentary thickness. Amongst various datasets, semi-detailed geological mapping and reconnaissance traverse (300 LKM), aeromagnetic survey, 2D refraction seismic (3,696 LKM), GM data (14,913 stations), Magneto-Telluric data (5 profiles) and geochemical survey (analysis of adsorbed gas of 6,013 samples) have been incorporated.

The 2017 resource reassessment study has incorporated 4,542 LKM of 2D seismic data, 29 drilled well information. Gravity, 2D seismic, Wells and reports are of good quality while magnetic and geochemical data is of fair quality with no availability of 3D data. Reliability of the data is good. Potwar Basin of Pakistan has been used as analogue. Areal Yield method was adopted to assess the hydrocarbon resources. Main challenge faced was in seismic data mapping in thrust fold belt. Improved seismic is required for understanding of complex structures.

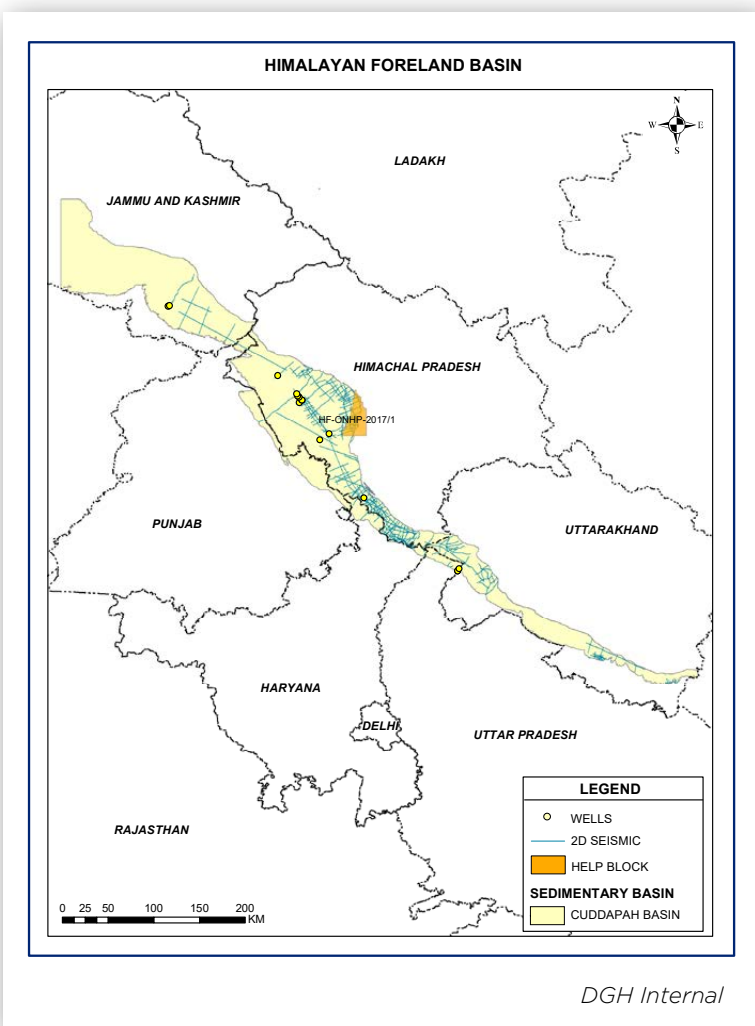


The play-level undiscovered (risked) hydrocarbon inplace for Satpura area is tabulated below:

Cenozoic Miocene (Middle) - Pleistocene:	4 MMTOE	Cenozoic Paleocene (Late) - Eocene	18 MMTOE
Cenozoic Oligocene Miocene (Early):	10 MMTOE	Proterozoic Neo-Proterozoic-Paleozoic (Early):	14 MMTOE

The basin is spread into the state(s) of Chandigarh, Haryana, Himachal Pradesh, Jammu and Kashmir, Punjab, Uttar Pradesh, Uttarakhand.

Status, available datasets and opportunities



In terms of awarded acreage that are now active in Himalayan Foreland basin, 666 sq km are under HELP.

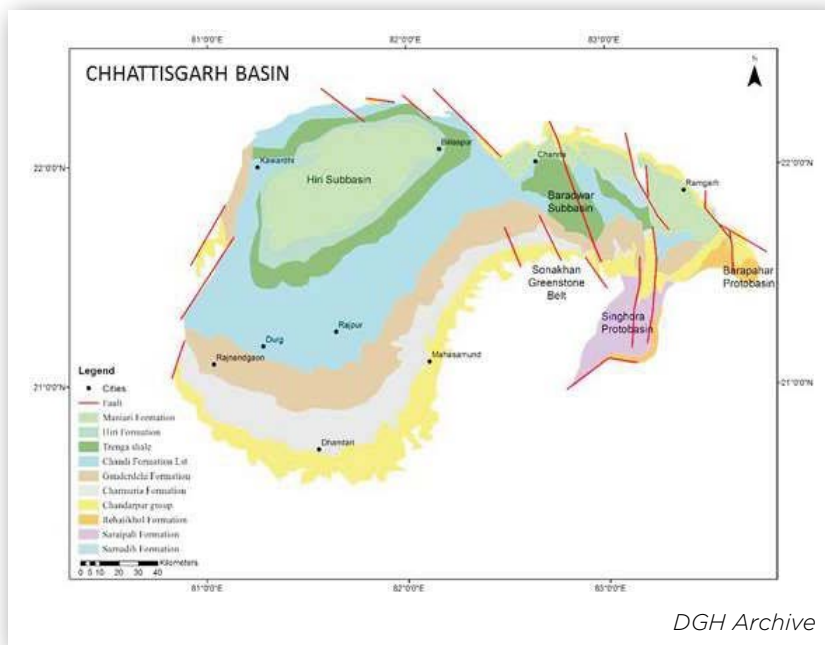
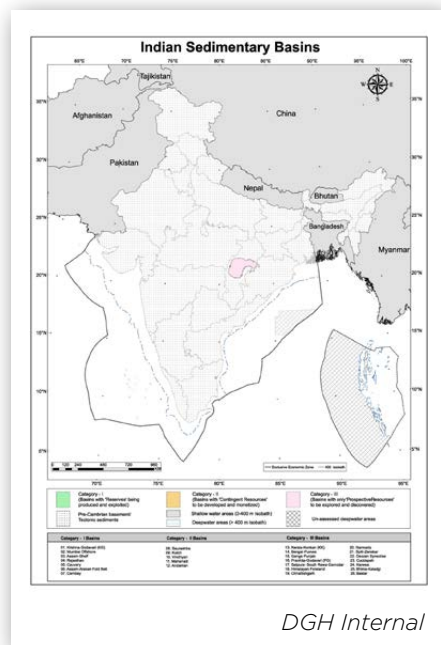
Under National Seismic Programme, conducted during 2016-22 in unappraised onland areas, 1556 LKM broad-band 2D seismic data were acquired in the basin.

As of March 1, 2023, NDR, for Himalayan Foreland basin has archived 6,876 LKM of 2D seismic data, 15 drilled well information.



19. CHHATTISGARH BASIN

Chhattisgarh is a Category III basin and it has an area of 32,000 sq. km. which is entirely onland. In the basin, 1 play is known in Pre- Cambrian.



The basin is located over the Bastar craton of Peninsular India.

The basin has inadequate geoscientific data and the elements of petroleum system in the basin are largely speculative. The basin is bounded by the Kotri-Dongargarh orogen and Satpura mobile belt towards west and north while Gondwana graben of Mahanadi and the Eastern Ghats mobile belt mark the north-eastern and south-eastern limits. Basement gneisses along with the rocks of Sonakhan greenstone belt forms the basin floor for Proterozoic sedimentation. Entire Proterozoic sequence of the basin has been considered as a single Proterozoic Play and sub-divided into four assessment units based on geological rationales. Paleo- to-Meso-Proterozoic Basuhari-Rhotas play of Vindhyan Basin is considered a close analogue.

Prospectivity

The Chhattisgarh basin has a total hydrocarbon inplace of 25 MMTOE, which is entirely undiscovered and potential for intense exploration.

The basin has been assessed for the first time. During 2017 Hydrocarbon Resource Assessment

Study, Aerial Yield approach has been used on analogy of Vindhyan Basin. The basin has 2,500m envisaged sedimentary thickness. Geological map, GM data, geochemical survey (analysis of adsorbed gas on few samples) have been used in the study.

Gravity data are of good quality; Magnetic, reports are of fair quality; Geochemical data are poor with no availability of seismic and well data. The data reliability is good. Vindhyan Basin, has been used as analogue. Inadequate geoscientific data leads to adopting areal yield method to assess the hydrocarbon resources. No subsurface information is available. Focus should be made to the sediment below the basalt. Results may be reviewed as and when new sets of data are available.



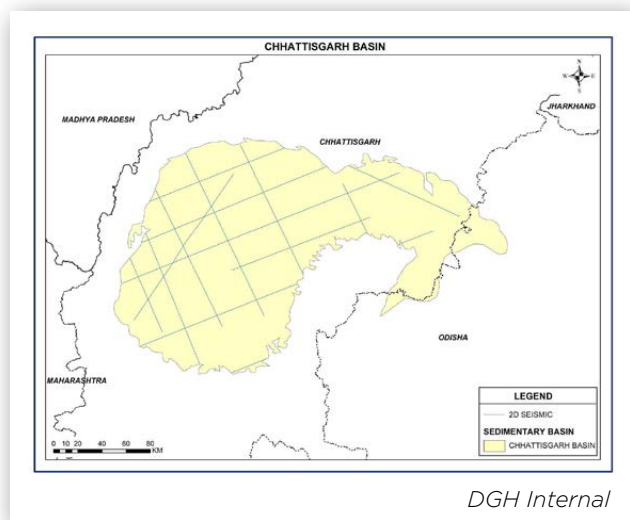
The play-level undiscovered (risked) hydrocarbon inplace for Chhattisgarh basin is given below:

Proterozoic:

25 MMTOE

The basin is spread into the state(s) of Chhattisgarh, Odisha.

Status, available datasets and opportunities



Under National Seismic Programme, conducted during 2016-22 in unappraised onland areas, 1778 LKM broad-band 2D seismic data were acquired in the basin.

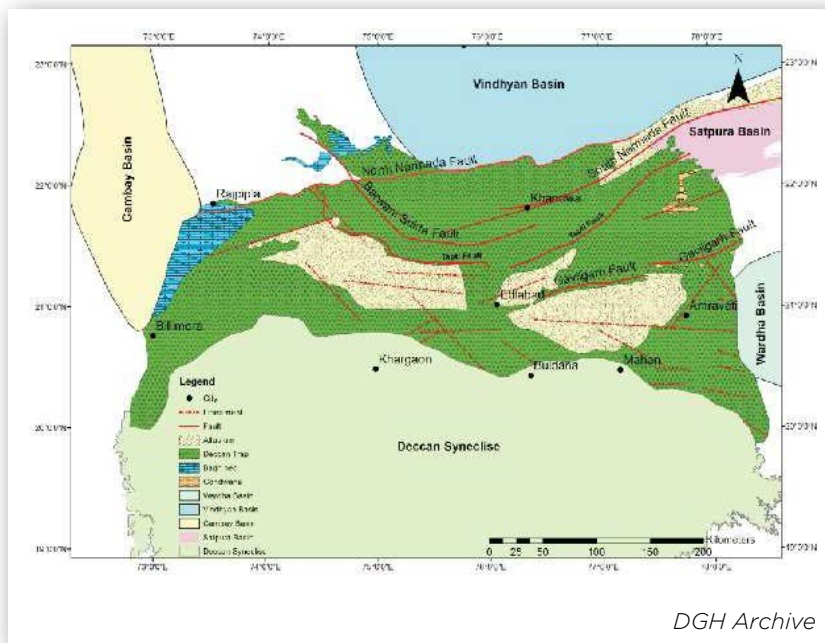
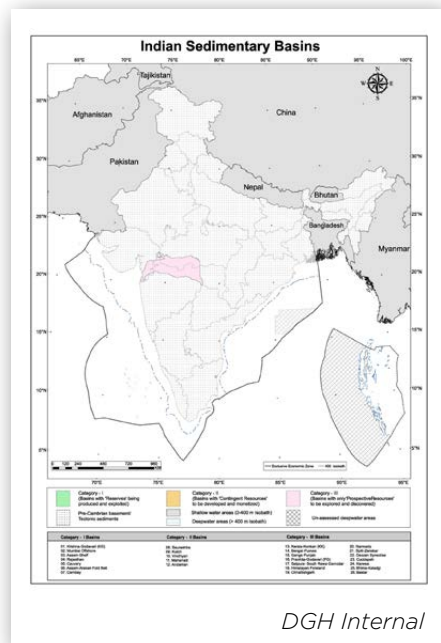
This is new data from NSP, which will be pivotal to the next periodical resource assessment.

As of March 1, 2023, NDR, for Chhattisgarh basin has archived 1665 LKM of 2D seismic data,



20. NARMADA BASIN

Narmada is a Category III basin and it has an area of 95,215 sq. km. which is entirely onland. In the basin, 1 play is identified within Sub-Trappean Gondwana.



The basin is located in the northwestern part of Indian Peninsula and it extends up to the eastern limit of Cambay Basin while eastward it merges with the western boundary of Satpura.

The basin has limited geoscientific data and the elements of petroleum system in the basin are largely speculative. The basin is fully covered by Deccan Trap volcanics. However, Pre-Trappean Gondwana sediments are speculated to be present over the basement rocks in the basin. Based on Gravity and DSS data, sedimentary thickness of the basin is envisaged to be in the range of 300 m to 2.0 kms. The basin has Pre-Trappean Gondwana play, which is divided into four assessment units based on available geological rationales.

Prospectivity

The Narmada basin has a total hydrocarbon inplace of 9 MMTOE, which is entirely undiscovered and potential for intense exploration.

The basin has been assessed for the first time. During 2017 Hydrocarbon Resource Assessment Study, Aerial Yield method is used on analogy of Cooper Basin, Australia. The basin has envisaged 400-1,500m sedimentary thickness. Geological map (semi-detailed), DSS data along 3 profiles, GM data (regional), MT data (3 profiles) and geochemical survey for adsorbed gas are included in the study.

Seismic data in form of Deep Seismic Sounding profiles is available. Gravity data is of good quality while Magnetic data and report are fair and Geochemical data are poor. No subsurface information is available. Basin is covered by Decan trap. Focus should be made to the sediment below the basalt. Results may be reviewed as and when new sets of data are available.



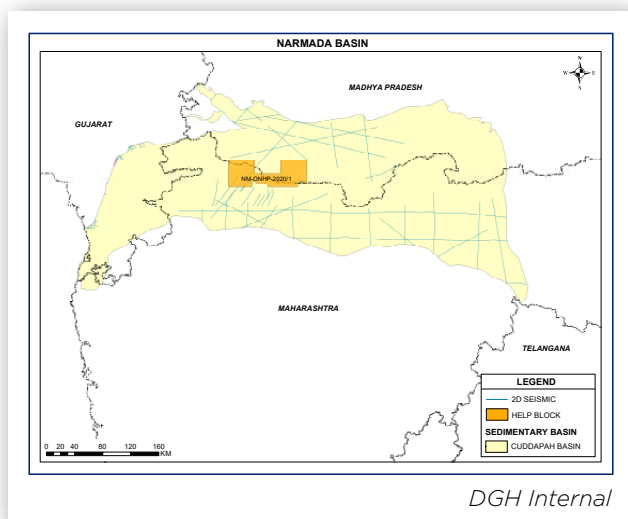
The play-level undiscovered (risked) hydrocarbon inplace for Narmada basin is given below:

Mesozoic Cretaceous (Lower Gondwana):

9 MMTOE

The basin is spread into the union territory and state(s) of Dadra and Nagar Haveli, Daman and Diu, Gujarat, Madhya Pradesh, Maharashtra, Telangana.

Status, available datasets and opportunities



In terms of awarded acreage that are now active in Narmada basin, 2999 sq km are under HELP.

Under National Seismic Programme, conducted during 2016-22 in unappraised onland areas, 1,618 LKM broad-band 2D seismic data were acquired in the basin.

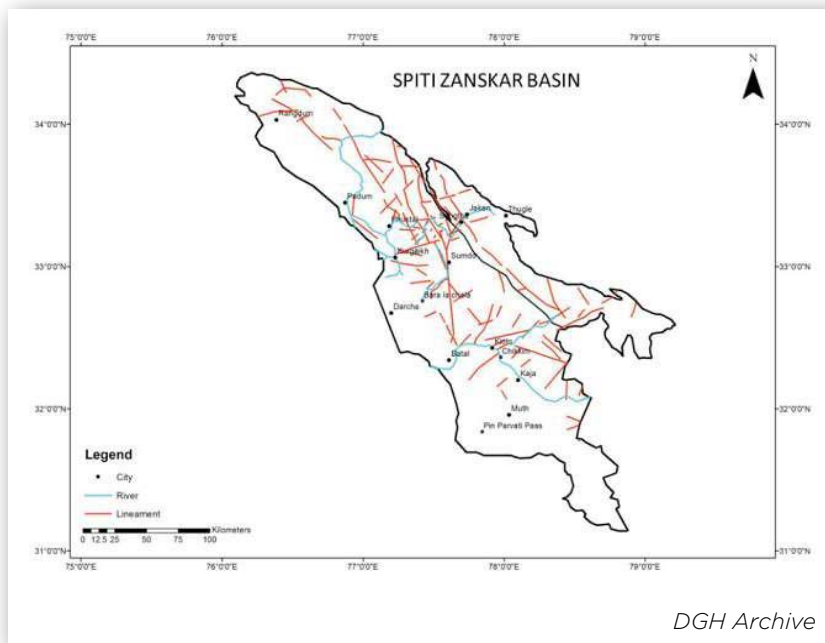
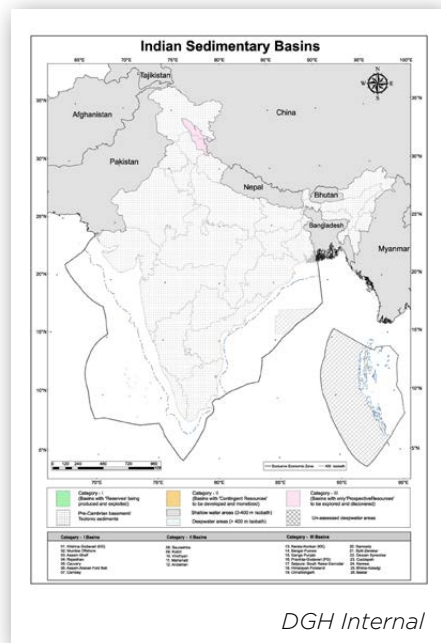
This is new data from NSP, which will be pivotal to the next periodical resource assessment.

As of March 1, 2023, NDR, for Narmada basin has archived 4,802 LKM of 2D seismic data, 37 SKM of 3D seismic data, 1 drilled well information.



21. SPITI-ZANKSKAR BASIN

Spiti-Zankskar is a Category III basin and it has an area of 32,000 sq. km. which is entirely onland. In the basin, 2 plays are present within Paleozoic and Mesozoic.



The basin is situated within north-northwestern Himalayan Mountains along northern margin of India. The Basin exposes about 11,000 metre of Paleozoic, Mesozoic and a part of Lower Tertiary sediments.

The basin is sparsely explored with inadequate geoscientific data and the elements of petroleum system in the basin are speculative. The basin is bounded in the north by Indus Tsangpo Suture Zone (ITSZ). The metamorphic basement of central crystalline complex, exposed to the south of the basin forms the floor for sedimentary sequence. The south-eastern limit of the basin is limited up to India's international boundary with China. The basin comprises of sedimentary sequence of Precambrian to Eocene age. The Paleozoic and Mesozoic Plays of the Potwar Basin of Pakistan are considered close analogues. These plays have four assessment units identified based on geological rationales.

Prospectivity

The Spiti-Zankskar basin has a total hydrocarbon inplace of 11 MMTOE, which is entirely undiscovered and potential for intense exploration.

The basin has been assessed for the first time. During 2017 Hydrocarbon Resource Assessment Study, Aerial Yield method has been used on analogy of Kohat Potwar Basin (Pakistan). The basin has envisaged 11,000m sedimentary thickness. Geological map and GM data (1,077 stations) are used in the study.

Seismic data is not available. Gravity data are of good quality while the Magnetic data and Reports are of fair quality but the Geochemical data is poor. The data reliability is good. Inadequate geoscientific data leads to adopting areal yield method to assess the hydrocarbon resources. No subsurface information is available. The basin is highly deformed. Results may be reviewed as and when new sets of data are available.



The play-level undiscovered (risked) hydrocarbon inplace for Spiti-Zaskar basin is given below:

Mesozoic Paleozoic:

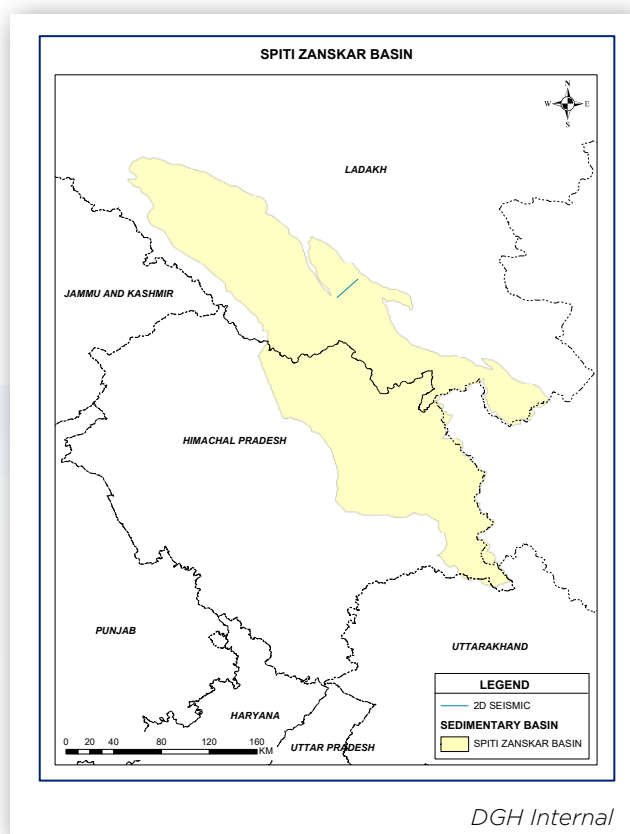
4 MMTOE

Paleozoic:

6 MMTOE

The basin is spread into the state(s) of Himachal Pradesh, Jammu and Kashmir, Uttarakhand.

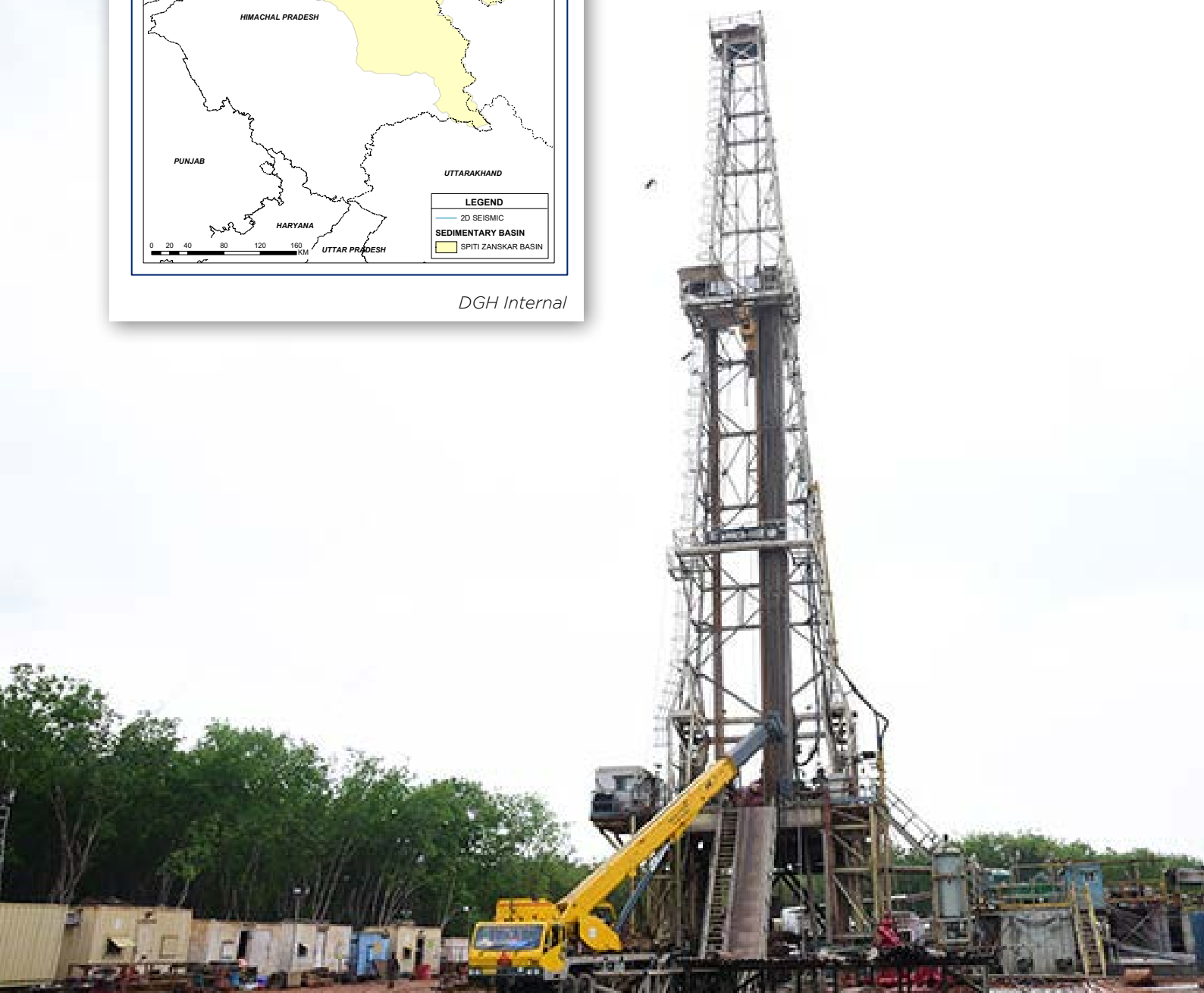
Status, available datasets and opportunities



Under National Seismic Programme, conducted during 2016-22 in unappraised onland areas, 8 LKM broad-band 2D seismic data were acquired in the basin.

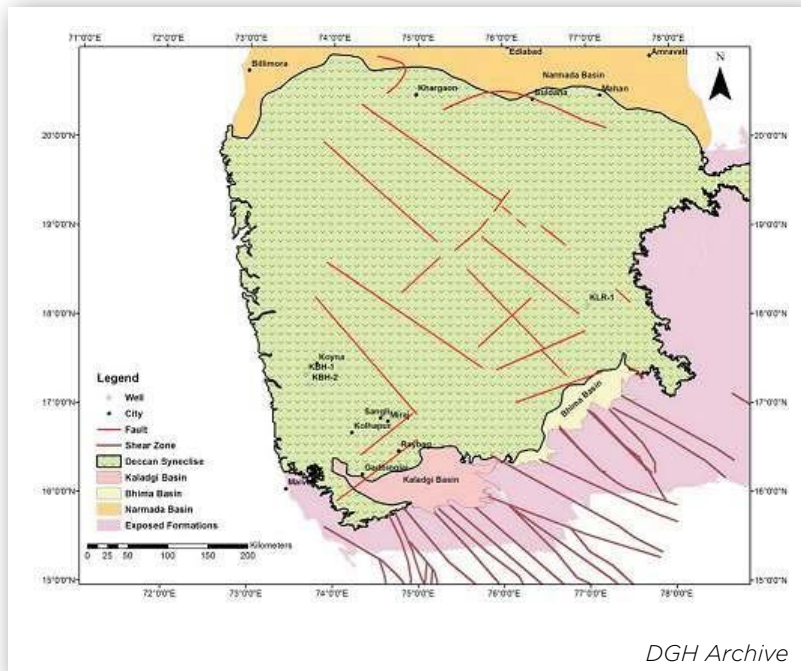
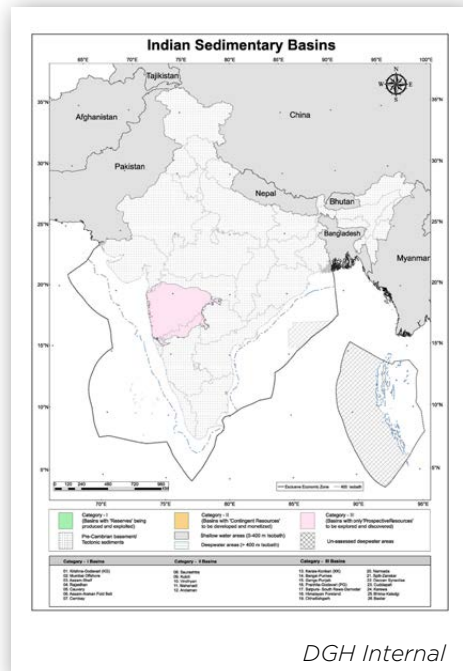
These are new lines from NSP, which will be significant input to the next periodical resource assessment.

As of March 1, 2023, NDR, for Spiti-Zaskar basin has archived 21 LKM of 2D seismic data.



22. DECCAN SYNECLISE BASIN

Deccan Syneclise is a Category III basin and it has an area of 237,500 sq. km. which is entirely onland. In the basin, 2 plays exist within Precambrian and Late Paleozoic (Gondwana).



Deccan Syneclise basin is located in the western and south-central part of India.

The basin is sparsely explored with limited geoscientific data and the elements of petroleum system in the basin are speculative. The basin is bounded to the north by the inferred southern limit of Narmada Basin, to the south by exposures of Precambrian sediments and the east by the outcrops of Archaean metamorphic rocks. Towards west, the coast line is considered as the basin limit. Based on gravity and DSS data about 1.5-2.0 Km thick sediments are speculated to be present underneath Deccan Trap basalt. The inferred geological history of this area favours presence of Pre-Trappean Gondwana and Proterozoic sequences in the area. The Cooper Basin of Australia and India's Vindhyan Basin are suitable analogues for Pre-Trappean Gondwana Play and Proterozoic Play respectively. The basin has been divided into three assessment units on the basis of tectonics. Two units in north-east being proximal to Satpura Basin may represent Pre-Trappean Gondwana sequence whereas the third unit represents the Proterozoic sequence.

Prospectivity

The Deccan Syneclise basin has a total hydrocarbon inplace of 12 MMTOE, which is entirely undiscovered and potential for intense exploration.

The basin has been assessed for the first time. During 2017 Hydrocarbon Resource Assessment Study, Aerial Yield method has been used on analogy of Vindhyan Basin (Pre-Cambrian) and Cooper Basin, Australia (Gondwana). 1,500m sedimentary thickness is envisaged in the basin. Geological map (semi-detailed), DSS along 2 profiles, GM data (6,000 stations), MT data (5 profiles) and geochemical survey (analysis of adsorbed gas on 1,006 samples) are used in the study.

Seismic data in form of Deep Seismic Sounding profiles is available. Gravity data is of good quality while Magnetic data and report are fair and Geochemical data are poor. The data reliability is good. Cooper Basin of Australia and Vindhyan Basin has been used as analogue. Inadequate geoscientific data leads to adopt areal yield



method to assess the hydrocarbon resources. No subsurface information is available. Focus should be made to the sediment below the

basalt. Results may be reviewed as and when new sets of data are available.

The play-level undiscovered (risked) hydrocarbon inplace for Deccan Syneclise basin is given below:

Mesozoic Cretaceous (Lower Gondwana):

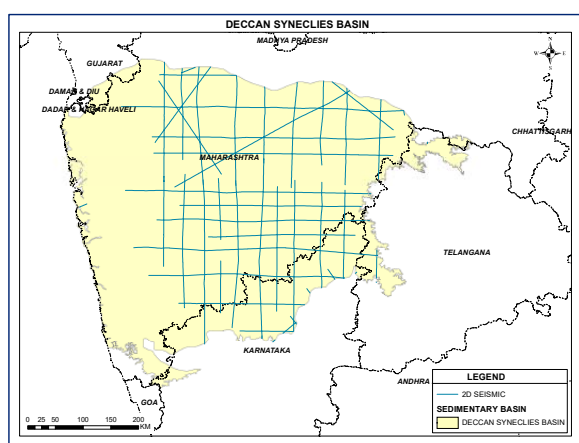
11 MMTOE

Proterozoic:

1 MMTOE

The basin is spread into the union territory and state(s) of Dadra and Nagar Haveli, Goa, Gujarat, Karnataka, Maharashtra, Telangana.

Status, available datasets and opportunities



DGH Internal

Under National Seismic Programme, conducted during 2016-22 in unappraised onland areas, 10,436 LKM broad-band 2D seismic data were acquired in the basin.

This is new data from NSP, which will be pivotal to the next periodical resource assessment.

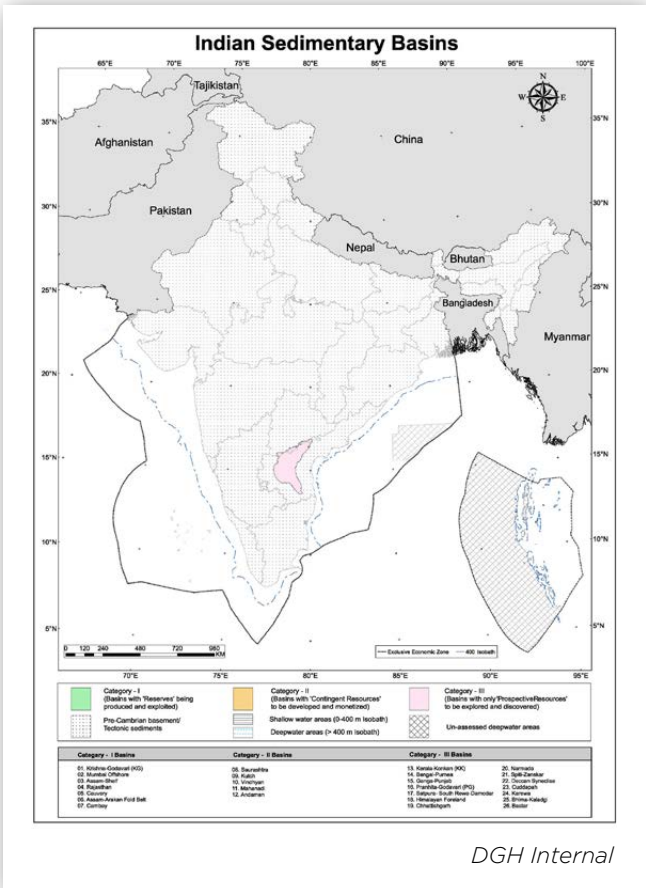
As of March 1, 2023, NDR, for Deccan Syneclise basin has archived 8,788 LKM of 2D seismic data,



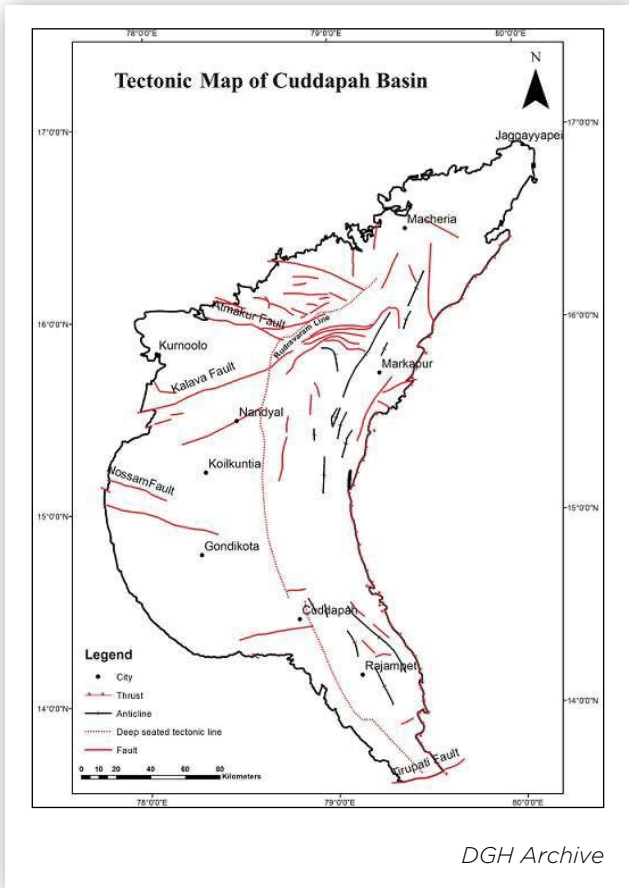
23. CUDDAPAH BASIN

Cuddapah is a Category III basin , implying that the basin has entirely undiscovered inplace, that is to be intensely explored and discovered.

The basin has an area of 40,100 sq. km. which is entirely onland. In the basin, 1 play is known within Pre- Cambrian.



DGH Internal



DGH Archive

The crescent shaped Cuddapah basin is located in the eastern part of Dharwar craton.

Geoscientific data available is limited and the elements of petroleum system in the basin are speculative. The Eastern Ghat mobile belt thrusts over Proterozoic rocks marks the eastern limit of the basin while along the western convex margin, the sediments display unconformable relationships with the gneissic and Late Archaean granites of Dharwar craton. The basin with Paleo- to-Neoproterozoic age has stratigraphic thickness ranging 6 to 12 km. The Paleo-to-Meso-Proterozoic Basuhari-Rhotas play of Vindhyan Basin is the close analogue. Entire Proterozoic sequence of the basin is considered a single Proterozoic Play, subdivided into five assessment units based on geological rationales.

Prospectivity

The Cuddapah basin has a total hydrocarbon in place of 5 MMTOE, which is entirely undiscovered and potential for intense exploration.

The basin has been assessed for the first time. During 2017 Hydrocarbon Resource Assessment Study, Aerial Yield method is used on analogy of Vindhyan Basin. 6,000-10,000m sedimentary thickness is envisaged in the basin. Geological map, DSS along 2 profiles, MT data along part of DSS profile, geochemical survey (analysis of adsorbed gas) on 304 samples are included in the study.

Seismic data in form of Deep Seismic Sounding profiles is available. Gravity data is of good quality while Magnetic data and report are



fair and Geochemical data are poor. The data reliability is good. Vindhyan Basin has been used as analogue. Inadequate geoscientific data leads to adopting areal yield method to assess

the hydrocarbon resources. No subsurface information is available. Results may be reviewed as and when new sets of data are available.

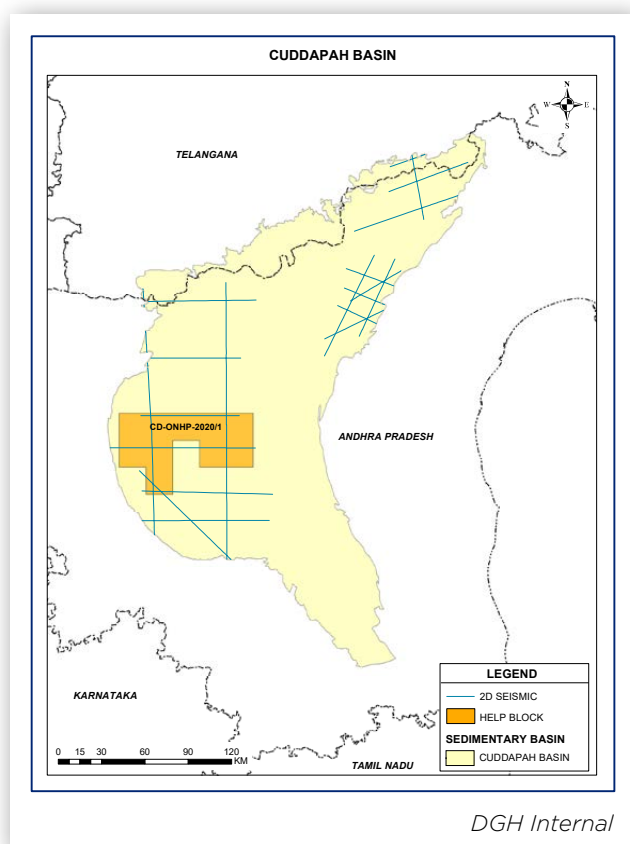
The play-level undiscovered (risked) hydrocarbon inplace for Cuddapah basin is given below:

Proterozoic:

5 MMTOE

The basin is spread into the state(s) of Andhra Pradesh, Telangana.

Status, available datasets and opportunities



In terms of awarded acreage that are now active in Cuddapah basin, 3,306 sq km are under HELP.

Under National Seismic Programme, conducted during 2016-22 in unappraised onland areas, 1,387 LKM broad-band 2D seismic data were acquired in the basin.

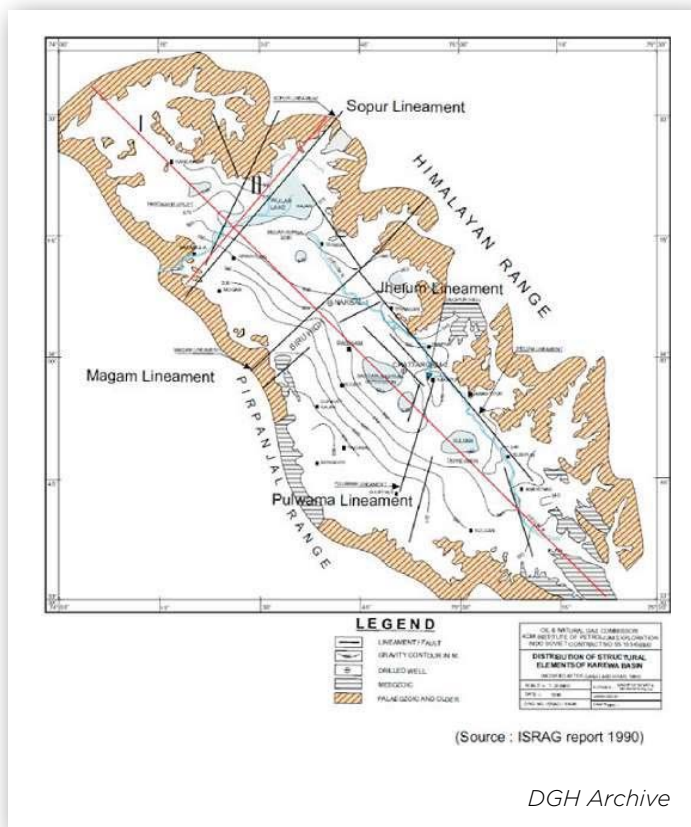
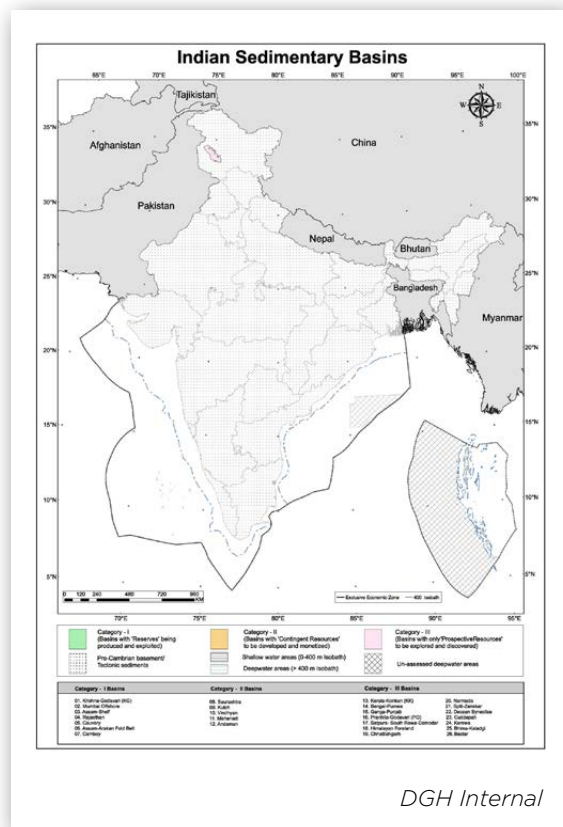
This is new data from NSP, which will be pivotal to the next periodical resource assessment.

As of March 1, 2023, NDR, for Cuddapah basin has archived 1,387 LKM of 2D seismic data,



24. KAREWA BASIN

Karewa is a Category III basin and it has an area of 6,671 sq. km. which is entirely onland. In the basin, 3 plays are present within Paleozoic, Mesozoic and Pliocene-Pleistocene.



The intermontane Karewa Basin is located in Kashmir valley of northwestern Himalayas. It is an oval shaped basin between Pir-Panjal Range in the southwest and Zaskar Range to its northeast.

Geoscientific data available is limited and the elements of petroleum system in the basin are largely speculative. The tectonically deformed Paleozoic-Mesozoic sequences of Kashmir Valley formed the basin floor. The Paleozoic-Mesozoic sequences are overlain by Plio-Pleistocene sediments. The Paleozoic, Mesozoic and Cenozoic Plays of the Potwar Basin of Pakistan are considered close analogues. The identified three plays viz. Paleozoic Play, Triassic Limestone Play and Plio-Pleistocene Play has six assessment units each.

Prospectivity

The Karewa basin has a total hydrocarbon in place of 6 MMTOE, which is entirely undiscovered and potential for intense exploration.

The basin has been assessed for the first time. During 2017 Hydrocarbon Resource Assessment Study, Aerial Yield approach is used on analogy of Kohat Potwar Basin (Pakistan). 14,000m sedimentary thickness has been envisaged in the basin. Data from 9 shallow wells (100-200m) and 2 deep wells (1,30 1,600m) along with geological map, 2D refraction seismic (56 LKM along 16 profiles), GM data (1,009 stations) and geochemical survey (source rock analysis on 48 cutting samples and adsorbed gas analysis on soil samples) are used in the study.



The 2017 resource reassessment study has incorporated 758 LKM of 2D seismic data, 11 drilled well information. Gravity Report is good while Magnetic and Geochemical data are of fair quality with poor data coverage for 2D Seismic (refraction) and wells with no 3D seismic. Though less seismic data is available the reliability of data is good. Potwar Basin of Pakistan. has been used as analogue.

Inadequate geoscientific data leads to adopting areal yield method to assess the hydrocarbon resources.

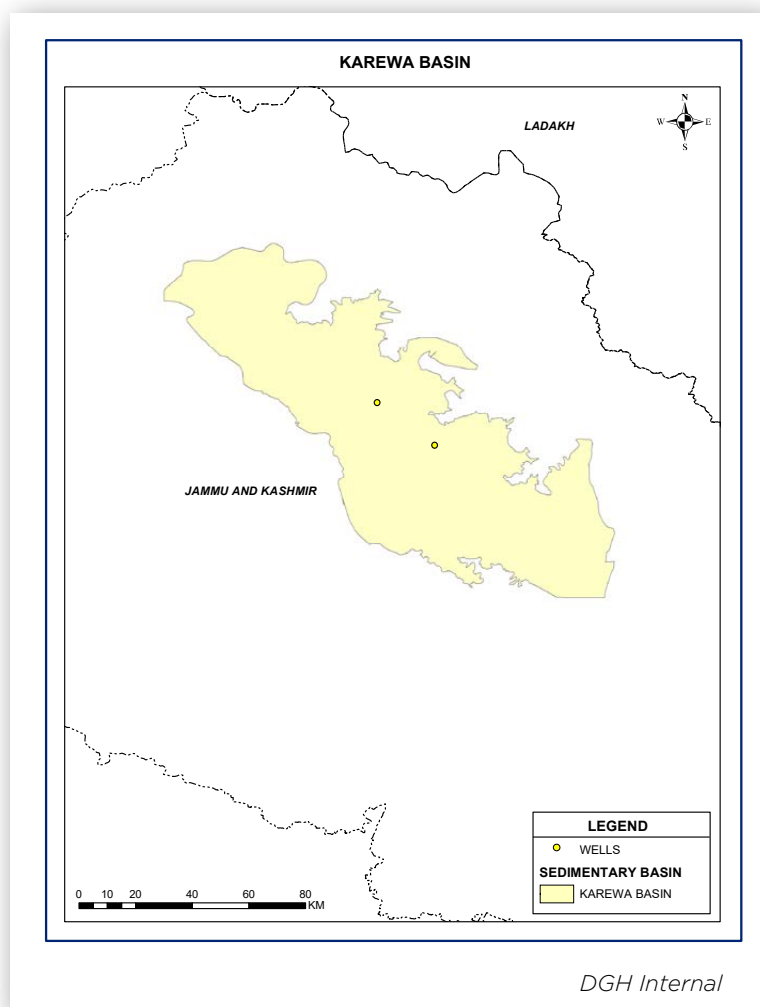
Information on deeper sequence data is absent. Results may be reviewed as and when new sets of data are available.

The play-level undiscovered (risked) hydrocarbon inplace for Karewa basin is given below:



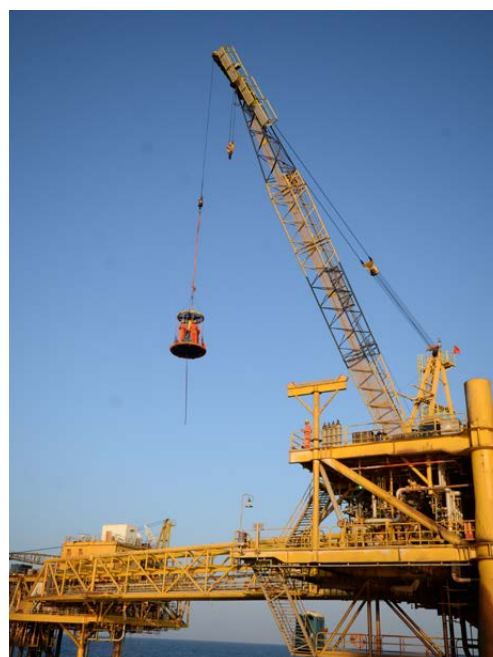
The basin is spread into the state(s) of Jammu and Kashmir.

Status, available datasets and opportunities



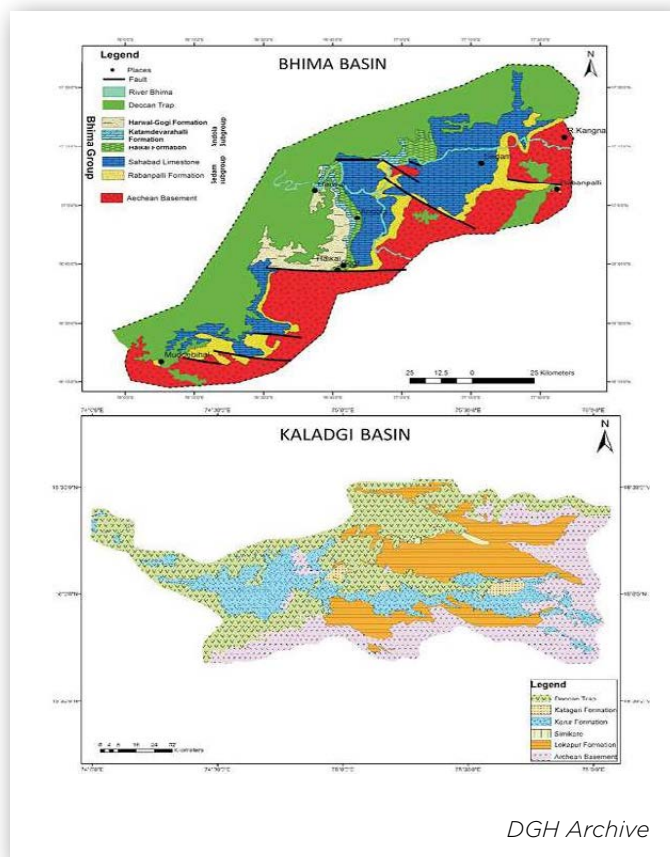
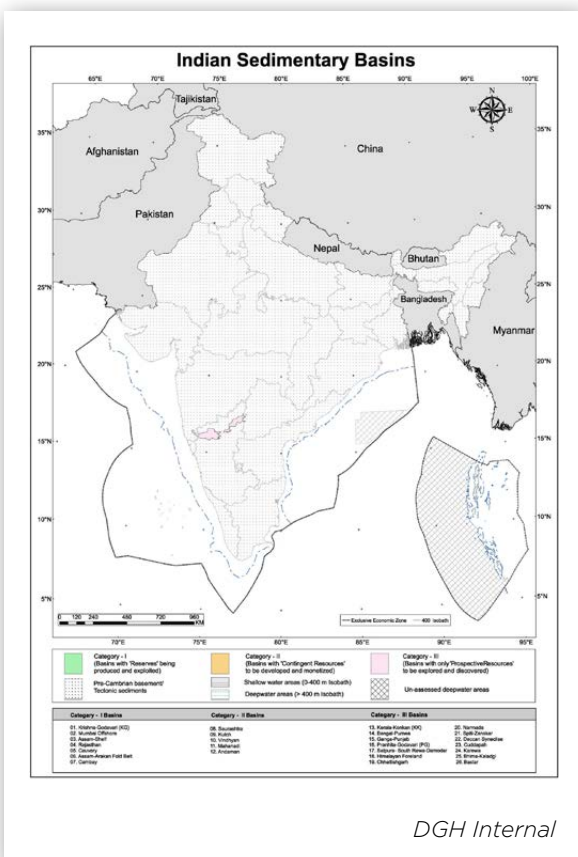
As of March 1, 2023, NDR, for Karewa basin has archived 2 drilled well information.

Under National Seismic Programme, conducted during 2016-22 in unappraised onland areas, 107 LKM 2D seismic data were planned in the basin, but the same could not be acquired due to operational constraints.



25. BHIMA-KALADGI BASIN

Bhima-Kaladgi is a Category III basin and it has an area of 14,100 sq. km. which is entirely onland. In the basin, 1 play is identified within Pre-Cambrian.



Bhima-Kaladgi are two Proterozoic sub-basins situated over Dharwar craton, covering areas of 5,300 and 8,800 square kilometres respectively. Geoscientific data available is limited and the elements of petroleum system in the basin are largely speculative. The northwestern part of Bhima and northern part of Kaladgi sub-basin are underlain by basalts of the Deccan Trap. Bhima sub-basin is characterized by Neo Proterozoic sedimentary sequence of 250 m thickness whereas Kaladgi sub-basin is represented by 450 m thick Paleo-to-Neo-Proterozoic sediments. Entire Proterozoic sequences in Bhima-Kaladgi Basin has been considered as single play, sub-divided into three assessment units each on the basis of their respective tectonic set-up. Paleo-to-Meso-Proterozoic Basuhari-Rhotas play of Vindhyan Basin is considered a close analogue.

Prospectivity

The Bhima-Kaladgi basin has a total hydrocarbon inplace of 6 MMTOE, which is entirely undiscovered and potential for intense exploration.

The basin has been assessed for the first time. During 2017 Hydrocarbon Resource Assessment Study, Aerial Yield method is used on analogy of Vindhyan Basin. Sedimentary thickness of 270m (Bhima) and 3,000-4,500m (Kaladgi) are envisaged. Geological map, gravity data, geochemical survey (analysis of adsorbed gas) on few profiles are included in the study.

No seismic data is available. Gravity data is of good quality while Magnetic data and report are fair and Geochemical data are poor. The data reliability is good. Vindhyan Basin has been used as analogue.



Inadequate geoscientific data leads to adopting areal yield method to assess the hydrocarbon resources. No subsurface information is available.

Focus should be made to the sediment below the basalt. Results may be reviewed as and when new sets of data are available.

The play-level undiscovered (risked) hydrocarbon inplace for Bhima area is given below:

Proterozoic:

<1 MMTOE

The sub-basin is spread into the state(s) of Karnataka, Telangana.

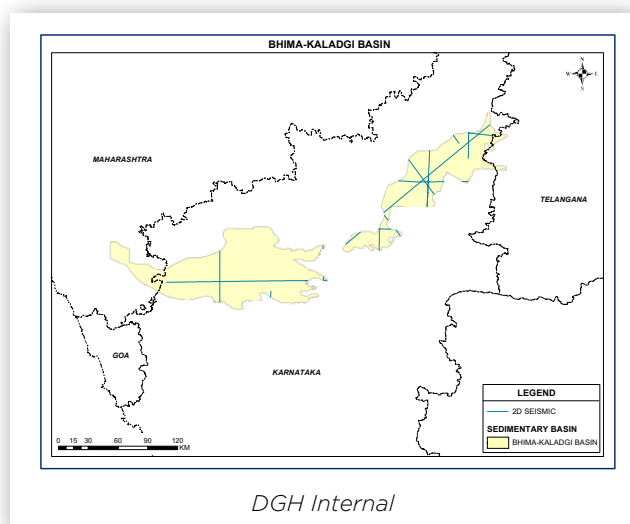
The play-level undiscovered (risked) hydrocarbon inplace for Kaladgi area is tabulated below:

Proterozoic:

6 MMTOE

The sub-basin is spread into the state(s) of Karnataka, Maharashtra.

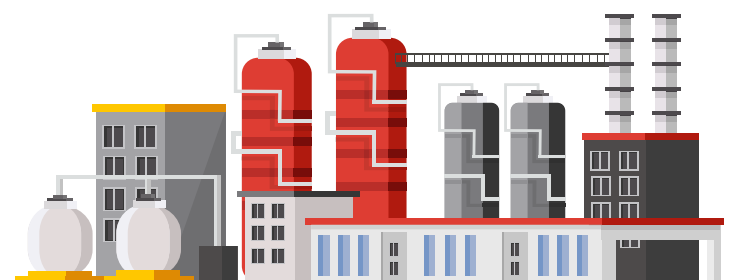
Status, available datasets and opportunities



Under National Seismic Programme, conducted during 2016-22 in unappraised onland areas, 869 LKM broad-band 2D seismic data were acquired in the basin.

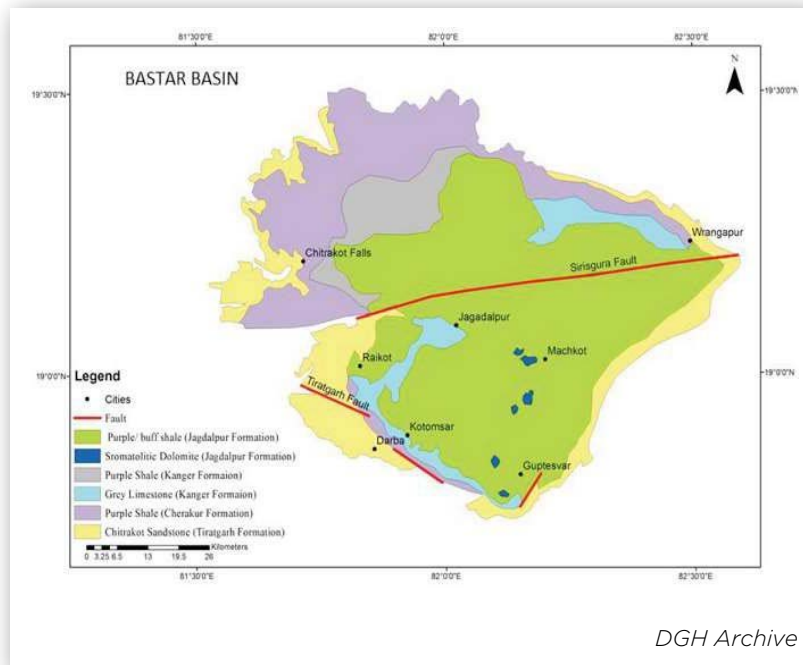
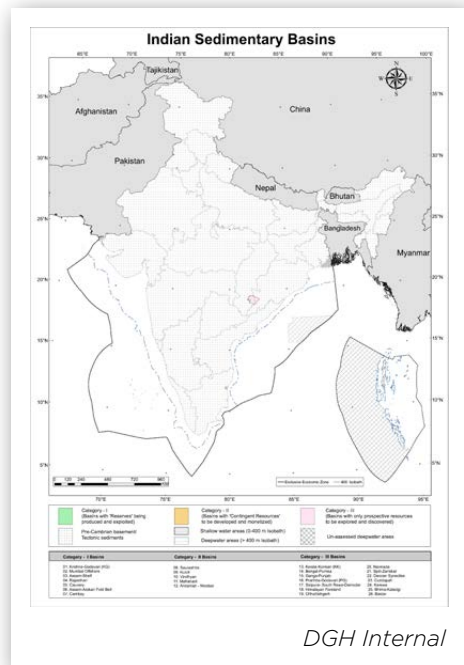
This is new data from NSP, which will be pivotal to the next periodical resource assessment.

As of March 1, 2023, NDR, for Bhima-Kaladgi basin has archived 639 LKM of 2D seismic data,



26. BASTAR BASIN

Bastar is a Category III basin and it has an area of 5,360 sq. km. which is entirely onland. In the basin, 1 play is known within Pre- Cambrian.



Bastar Basin, one amongst the several Proterozoic sedimentary basins is located over Peninsular India.

Geoscientific data available is very limited and the elements of petroleum system in the basin are largely speculative. The basin is characterized by Meso-to-Neo-Proterozoic sediments, named Indravati Group, and it unconformably overlies the Archean basement complex. The maximum sedimentary thickness of the basin in the order of 500-600 m. Entire Proterozoic sequence of the basin has been considered as a single play, sub-divided by a fault into two assessment units. Paleo-to-Meso-Proterozoic Basuhari-Rhotas play of Vindhyan Basin is considered a close analogue.

Prospectivity

The Bastar basin has a total hydrocarbon in place of 1 MMTOE, which is entirely undiscovered and potential for intense exploration.

The basin has been assessed for the first time. During 2017 Hydrocarbon Resource Assessment Study, Aerial Yield method has been used on analogy of Vindhyan Basin. Geological map, gravity map, magnetic profiles (2 lines of 383km and 403km) and geochemical data (adsorbed gas from 204 samples) are used in the study.

Gravity data are of good quality; Magnetic data and their reports are of fair quality; Geochemical data are poor with no availability of seismic and well data. The data reliability is good. Vindhyan Basin has been used as analogue. Inadequate geoscientific data leads to adopting areal yield method to assess the hydrocarbon resources. No subsurface information is available. Focus should be provided for low sediment thickness. Results may be reviewed as and when new sets of data are available.



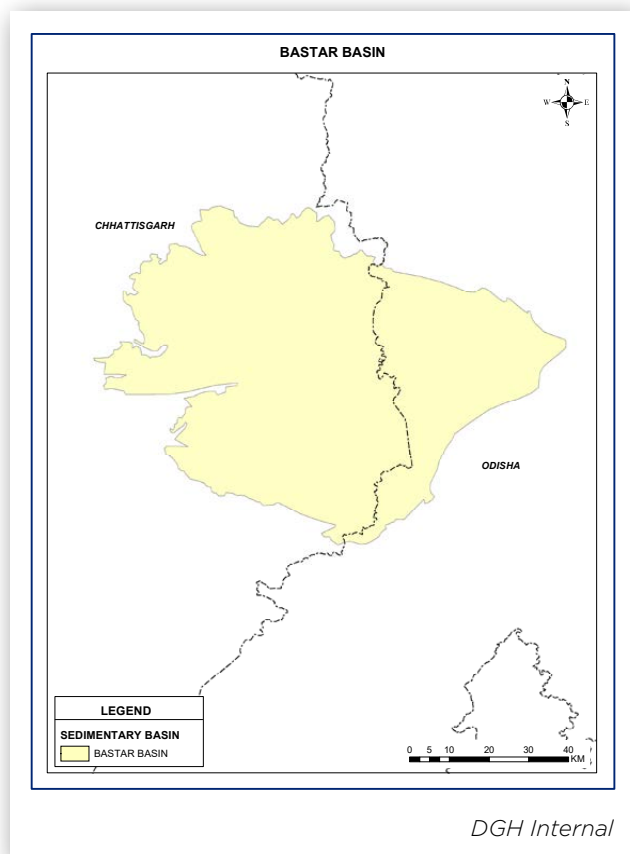
The play-level undiscovered (risked) hydrocarbon inplace for Bhima area is given below:

Proterozoic:

1 MMTOE

The basin is spread into the state(s) of Chhattisgarh, Odisha.

Status, available datasets and opportunities



Under National Seismic Programme, conducted during 2016-22 in unappraised onland areas, 107 LKM 2D seismic data were planned in the basin, but the same could not be acquired due to operational constraints.

Conclusions

Insightful knowledge of hydrocarbon prospectivity of any sedimentary basin is imperative for a meaningful attempt in holistic exploration of hydrocarbons. The above narrative on the profiles of India's sedimentary basins is intended to give a snapshot view with a subsurface perspective, providing a summative reference to brief exploration history, past major studies, status of available datasets, and most importantly, Government of India's persistent efforts of data acquisition and data enrichment

in order to open up upstream opportunities, so that bidders and stakeholders can increasingly participate.

In the given view, potential of conventional resources across 26 sedimentary basins has been discussed and this is primarily based on the available studies on conventional resources. These studies are fairly documented in various reports, that are published, accessible or even unpublished internal workings. On the contrary, the potential of unconventional resources, particularly coal bed methane has been outlined giving a limited facts of the matter. Coal bed methane resources, in India are producing, nevertheless, the potential is still largely tentative and range-bound. For a comprehensive assessment, a country-level integrated study of CBM resources, as a research project has been undertaken by IIT-ISM in 2022.

In terms of available opportunities in the basins, overview of two OALP Rounds (VIII & IX) and one Special CBM Round (2022) is highlighted and these can be referred to the relevant sections of the report, including DGH website for more details.







3

DATA - GROWTH ENGINE OF E&P INDUSTRY

Background

Oil and Gas Industry is one of the most data-rich industries and upstream data, that is, Exploration & Production (E&P) data is a significant part of it. Historical and new data have always been crucial to the success of any E&P venture. Throughout the E&P lifecycle, a significant amount of data is continuously generated during the planning, exploration, field development, and management phases. The industry has recognized the importance of leveraging data for making key business decisions from the early days of exploration.

India has a rich history of E&P activity dating back to the 19th century. Methodical E&P activity began after the first commercially successful well was discovered in Digboi, Assam, in 1889. The discovery of the first oil well in independent India was made by Assam Oil Company Limited (AOC) in Nahorkatiya in 1953, followed by Moran in 1956, both in upper Assam. AOC was later

incorporated into Oil India Private Limited in 1959, which became Oil India Limited as a PSU (in 1981) to increase the pace of exploration in Assam. In 1959, the Government set up Oil and Natural Gas Commission (ONGC), which intensified and spread exploration to various parts of the country. ONGC systematically started geophysical surveys in other sedimentary basins considered prospective, resulting in the discovery of the Ankleshwar oil field in Gujarat in 1960.

Offshore exploration in India was initiated with the experimental seismic survey in the Gulf of Cambay in 1962 and later in the western offshore. Detailed seismic surveys in the western offshore resulted in the discovery of a giant structure in Bombay Offshore in 1972-73, later termed as Bombay High Field. ONGC and OIL generated considerable amounts of E&P data through geoscientific surveys and drilling, making them the earliest dominant players in the Indian E&P

industry. However, private sector E&P companies also contributed to data generation through the global bidding route under Pre-NELP (1980-95) and pre-NELP field rounds (1992-93) offers and discovered field rounds since the 1980s.

The real boost in exploration efforts and appraisal of Indian basins came during the NELP regime (1999-2015), particularly in offshore areas, resulting in a quantum jump in data volume from the preceding era. Both NOC and private operators contributed to this using the latest technology of the time. Recently, new data is being acquired by Operators of various blocks awarded in Open Acreage Licensing Policy (OALP) and Discovered Small Field (DSF) rounds under Hydrocarbon Exploration and Licensing Policy (HELP) (2016-). A significant amount of seismic data has also been acquired under the government-funded National Seismic Programme (NSP) and Multi-client surveys conducted under Non-Exclusive Multi-Client (NEMC) Policy. Service providers are also reprocessing vintage 2D/3D data under the "value-addition" clause of NDR data policy.

3.1 E&P data – A National Resource

E&P data is considered a valuable national resource, and its ownership lies with the government. The Petroleum and Natural Gas (Amendment) rules of 2006 mandate that all E&P operators in India to provide the Central Government or its designated agency with any data obtained as a result of petroleum operations in the country, free of cost. The E&P data policy issued by MoPNG in 2017 outlines the framework for data assimilation, disclosure, sharing, accessibility, and dissemination through the National Data Repository (NDR). The policy designates DGH as the nodal agency for the purpose.

Technological advancements in data processing, interpretation, and visualization provide opportunities to gain new insights into even age-old E&P data. The exponential growth in data volume and diversity of data types enables the processing of diverse data sets to identify relational patterns, which can improve understanding of the subsurface, design exploration campaigns, and optimize oil and gas production. Effective data management is crucial to develop a robust national E&P

database and accelerating exploration and production activities in the country. Therefore, safeguarding E&P data is a matter of national significance.

3.2 National Data Repository:

The National Data Repository (NDR) was established by the Government of India in 2014 under the Directorate General of Hydrocarbons (DGH) to assimilate, preserve, and disseminate a vast amount of data acquired by public and private companies, operators, agencies, and contractors during E&P activities over several decades. The data was previously scattered across different work centres of ONGC, OIL, and DGH, or held by the respective operating companies.

The main objective of the NDR is to organize and regulate the data for future exploration

The NDR is a key enabler of Open Acreage Licensing Policy (OALP) and Discovered Small Fields (DSF) rounds under the Hydrocarbon Exploration and Licensing Policy (HELP) regime. It provides E&P operators with the freedom to carve out blocks of their interest and size, facilitated by the NDR.

and development activities, as well as for research and development by educational institutions and government bodies. The NDR serves as a national-level establishment capable of managing a massive volume of data and providing access to it for public use.

To implement the project, the government awarded a turnkey contract for the "Build, Populate and Operate" model for the NDR to M/s Halliburton Offshore Services in March 2014. After the initial set up and data loading, the NDR was officially launched for public use



on 28th June 2017. The establishment of the NDR has facilitated the efficient management and utilization of E&P data and has helped to promote exploration and development activities in India's hydrocarbon sector.

The NDR is a key enabler of Open Acreage Licensing Policy (OALP) and Discovered Small Fields (DSF) rounds under the Hydrocarbon Exploration and Licensing Policy (HELP) regime. It provides E&P operators with the freedom to carve out blocks of their interest and size, facilitated by the NDR.

The NDR is a valuable resource for the Indian energy industry, offering a centralized repository of E&P data for reliable decision-making and future development.

Since inception, NDR has been contributing significantly towards further streamlining standards, procedures, and workflows pertaining to data submission, cataloguing,

viewing, retrieval, and dissemination for all the stakeholders including inter alia E&P companies and service providers, government agencies, academia.

NDR is equipped with Physical Data Room with graphic intensive workstations to facilitate detailed study / evaluation of the Oil and Gas data by prospective bidders during the OALP and DSF rounds, as well as by DGH's internal team. These graphic workstations have visualization & interpretation capability for the data residing in NDR using specialized software like 'Decision Space Geo-science (DSG)' from M/s Halliburton and 'Petrel' from M/s Schlumberger in addition to other similar software from M/s. AspenTech for seismic data processing and well log data processing/visualisation.

3.2.1 Secondary Data Centre

DGH established its Secondary Data Centre (SDC) in high-tech Software Technology Parks of India (STPI) Building, at Bhubaneswar. SDC is located in a different seismic zone and geography than Primary Data Centre (PDC), NOIDA. STPI is a Tier-III data centre built under the aegis of Ministry of Electronics and Information Technology (MEITY).

Data replication and synchronisation is maintained by 1 GBPS dedicated link between PDC and SDC. SDC would work as Business Continuity/Disaster Recovery Centre of Primary Data Centre (PDC) of National Data Repository of DGH, Noida. The Secondary Data Centre (SDC) is fully operational since 4th August 2018. SDC will be able to resume essential business operations in case of a disaster at PDC.

Apart from being data repository and recovery centre, SDC is also involved in providing quality industrial and educational trainings to the students of various academic institutions and organizations. These training programs are intended to give a domain-specific and industry-oriented approach for knowledge to the trainees. The course content of these training programs has rigorously been worked out by technical experts keeping in mind the syllabus of various institutions and its linkage to E&P industry.

Objectives of NDR

- 💧 To assimilate, validate, archive, preserve, reproduce, and disseminate data relating to prospecting, exploration, development, and production of hydrocarbons.
- 💧 To create and maintain a modern state of the art platform for reporting, managing, mapping and visualization using the latest technologies.
- 💧 To ensure that industry, academia, research bodies and other users have ready access to the E&P data in NDR for promoting E&P research
- 💧 To ensure transparent access to quality E&P data and promote conditions for innovation and investment in exploration and production to discover and drive development of new discoveries

Data available in NDR

Data available in NDR as of 28th February, 2023

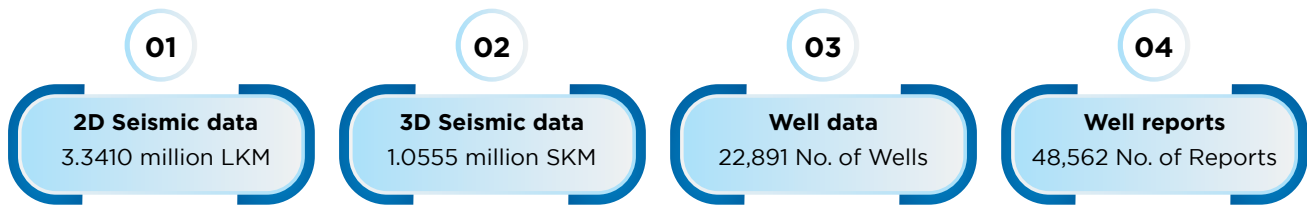
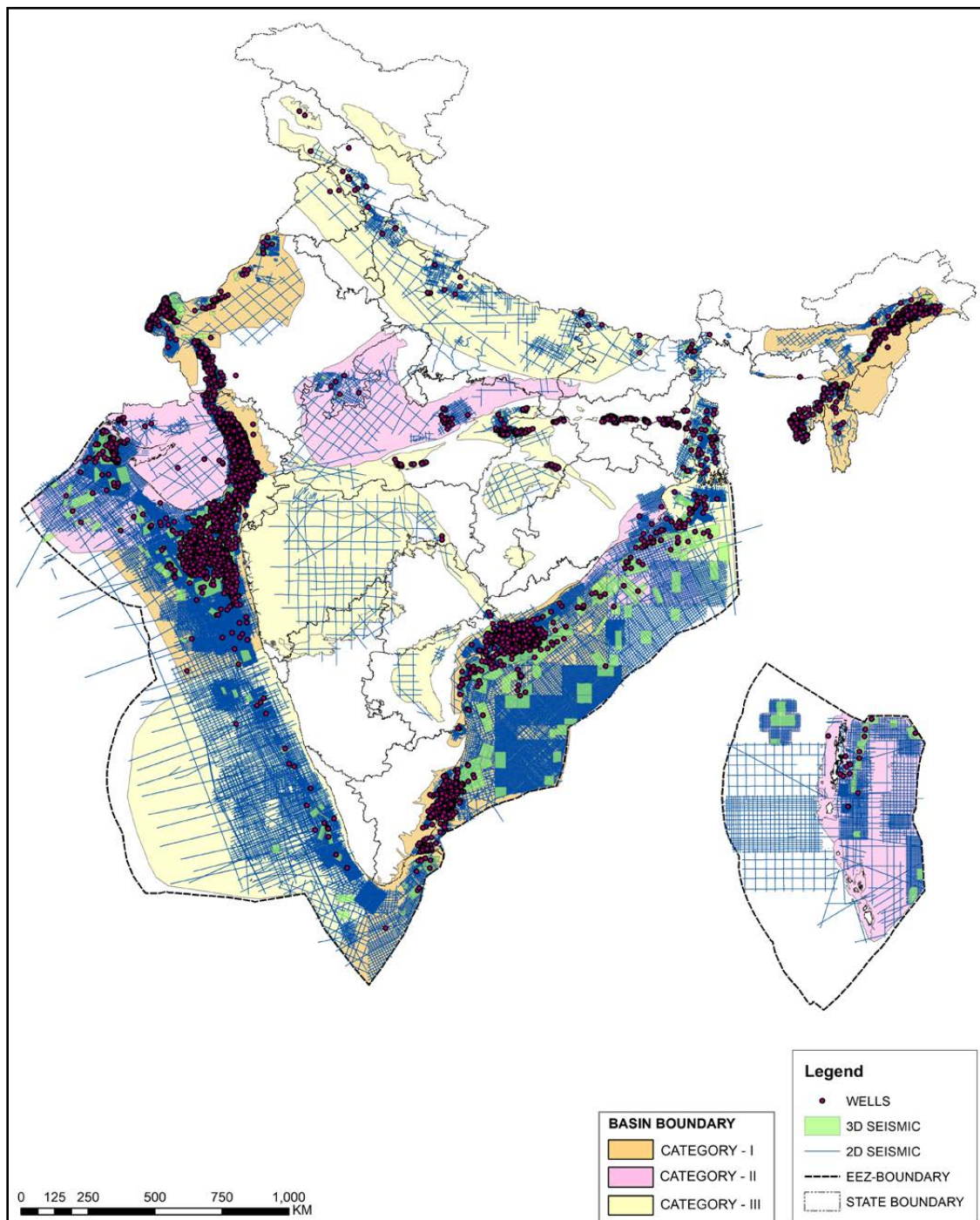


Figure 3.1: Map of India showing coverage of 2D/3D Seismic and well data in NDR



3.2.2 Role of NDR in OALP/DSF bid rounds

NDR is playing a pivotal role in the ongoing OALP / DSF rounds under HELP regime. It provides a gateway for operators/investors to carve out/select blocks/acreages of choice based on existing data, concessions, and no-go areas for putting up expression of interest/bids. NDR constantly updates its portal with the latest data, E&P related information, active license areas, restricted areas and other cultural features. NDR is providing easy access of quality data to the investors thus helping them make robust evaluation of blocks/acreage for investment decision. NDR is not only preparing data packages for blocks offered under every round but also facilitating interested E&P investors with visualization of G&G projects in the physical data room where they can understand and interpret available data within offered blocks. In addition, NDR is also open to its users/academia for online browsing as well as evaluation/viewing of E&P data of any basinal area in its physical data room.

3.3 Key Achievements of Year 2022-23

Promoting exploration interests through Data visualisation room

In-house Seismic data Interpretation projects to be used in data visualization room were created in DSG software application for 10 blocks of OALP-VIII, 16 blocks of CBM and 26 blocks of OALP-IX (Mega Offshore) on offer by DGH. All the 52 block projects including several vintages of 2D, and 3D seismic data along with well data were prepared and made ready for visualization within a stipulated timeline after shorting-out all the quality control issues including data conditioning. Specific G&G projects were made incorporating 2D and 3D seismic data available in East coast sedimentary Basins of India, viz. Bengal, KG and Cauvery basin for showcasing data to International Operating companies like Chevron, TotalEnergies etc. Showcasing of data for OALP/CBM/Mega Offshore projects in data visualisation room was done for 12 companies at 30 instances. Data packages of 10 OALP-VIII and 16 CBM blocks were prepared for bid rounds so that prospective investors could buy data specific to their areas of interest. In total, 30 specific data packages were purchased by companies for doing their due diligence which

excludes other bulk data purchases for general technical purpose.

Mini Data visualisation Centre at India Energy week (IEW) 2023 and GeoIndia Conference 2022

Based on the concept of physical data visualisation room of NDR at Noida, a mini data visualisation centre of was set up at DGH stalls of IEW at Bengaluru and GeoIndia at Jaipur. To facilitate this mini data centre, seven specific interpretation projects, each catering to one basin, were created in Decision Space Geoscience (DSG) software. Each project included the 2D seismic data, well data and selected 3D seismic volumes. This gave good choice to each stakeholder to get an idea of the availability and quality content of data in a particular area of interest. An opportunity to visualize and assess data of blocks on offer with hands-on working in a workstation environment received a lot of attention from companies, investors, delegates, and academia during the conference. This tailor-made block specific projects, providing an insight into the subsurface basin analysis through seismic and well data also motivated stakeholders to visit physical data centre at Noida or to get specific data directly from NDR in later to carry out their detailed analysis and comprehensive due diligence for upcoming bidding rounds of OALP/CBM/DSF. The Mini Data Centre was set up with inhouse available resources using high-end workstation laptop loaded with projects in DSG application, big size good resolution graphics screen and highspeed internet connectivity. The internet connectivity was required for hosting NDR portal for showcasing active concession areas, blocks on-offer, basin and EEZ boundaries and other culture data for the general benefit of visitors and their familiarisation.

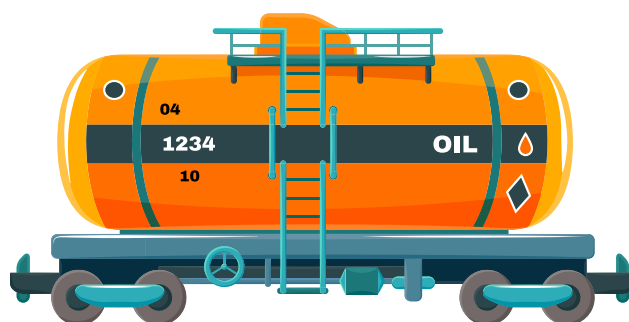


Figure 2: Showing the Mini Data Centres set up during Geo India 2023 (left) and India Energy Week 2023 event (right)



Data Dissemination in Year 2022-23

Huge volume of 2D/3D Seismic and well data and associated reports are being shared with stakeholders since the inception of NDR. In this process, total 5,16,194 LKM 2D seismic, 3,08,915 SKM of 3D seismic and 711 well data have been disseminated to at least 28 E&P companies and 10 research/ academic institutes. More than 11,000 SKM of 3D raw seismic data have also been disseminated to users in FY 2022-23.

Comprehensive revamp of NDR policy:

Making NDR more responsive to user's expectation and promote R&D activity in academia through liberalized access of data have necessitated revamp of NDR data policy. NDR took up scouting and study of practices of other NDRs worldwide, prepared comparative reports, organized a feedback session on existing NDR policy with wider community of operators in India. Based on the outcome of these activities a new draft NDR data policy has been formulated considering national interest and requirements of global investors and wider community of stakeholders. This draft policy is currently under consideration by MoPNG.

Collaboration with University of Houston, Texas, USA:

In the presence of Hon'ble Minister of Petroleum & Natural Gas and Housing & Urban Affairs- Mr. Hardeep Singh Puri, Secretary P&NG- Mr. Pankaj Jain, Ambassador of India to the

U.S. - Mr. Taranjit Singh Sandhu, Directorate General of Hydrocarbons (DGH) entered into a Memorandum of Understanding (MoU) with the University of Houston (UH) on 7th February 2023 during the event of India Energy Week 2023. The agreement was signed by Mr. Akash Goyal, Additional Director General on behalf of DGH and by Prof. Ramanan Krishnamoorti, VP, Energy and Innovation, on behalf of UH. Key Objectives are:

- 1) To establish the UH-DGH Data Centre which will host geoscience data of Indian sedimentary basins/blocks at Houston to reach out to major energy companies for facilitating them to participate in bidding process.
- 2) To collaborate with UH to take up subsurface/ geoscientific study of select Indian offshore basins for developing regional geological framework and identifying most prospective plays for exploration thereby enhance perspective perception and overall value addition from exploration point of view.

The MoU is for a duration of 5 years.

Collaboration with University of Houston to establish a data Center which will host Geoscience data of Indian Sedimentary basins at Houston, to reach out to major energy companies.





“Our expanding energy sector is creating new opportunities for investment and collaborations in India.

**Hon'ble Prime Minister of India
SHRI NARENDRA MODI**

Figure 3.3: Signing of MoU in presence of Hon'ble Minister of Petroleum and Natural Gas; Housing and Urban Affairs and the Ambassador of India to the United States during India Energy Week 2023



Technical collaboration with research organizations and academia:

- 1) MoU between DGH and Geological Survey of India (GSI) has been signed on 02nd November 2022 at DGH Office Noida for subsurface data sharing and technology transfer. MoU has been signed for initial 5 years tenure as an initiative to broaden the usage of subsurface geological data and information earlier acquired for oil and gas exploration.

The broad objectives of the MoU are:

- i) To collaborate and facilitate sharing of geoscientific data available with both the organizations for sustainable development of mineral resources,
- ii) To plan a common program including institutional strengthening and capacity building for 3D modelling and visualization technologies and
- iii) To transfer of know-how with regard to NDR of DGH in connection with proposed

National Geoscience Data Repository (NGDR) of Ministry of Mines.

- 2) On September 7th, 2022, the DGH and the Wadia Institute of Himalayan Geology (WIHG) signed an MoU for subsurface data analysis with the application of AI/ML. The project's objective is to enhance understanding of subsurface structures, including their geometry, architecture, structural evolution, and basin architecture in the Upper Assam region.
- 3) A research collaboration has been established with the School of Earth Sciences at the University of Western Australia to conduct a study on the geomorphology of deep-water deposits located in the Bay of Bengal.
- 4) MoU has been signed between DGH and Pandit Deen Dayal Energy University (PDEU) on 14th December, 2022 for technical collaboration for detailed prospectivity study of Kutch Saurashtra basins of offshore Gujarat.



- 5) MoU has been signed between DGH and Rajiv Gandhi Institute of Petroleum Technology (RGPT) on 23rd January, 2023 to jointly execute research work on geoscientific data analysis of Ganga-Punjab and Vindhyan basins. Professor A S K Sinha, Director, RGPT signed the MoU on behalf of RGPT while Dr C Laxma Reddy, ADG, DGH inked the MoU on behalf of DGH.
- 6) A Research collaboration on structural deformation, fluid migration patterns within deep water fold-and-thrust belts from seismic data of offshore Krishna Godavari Basin being carried out in collaboration with Department of Earth and Climate Science, Indian Institute of Science Education and Research (IISER) Pune.

Promoting Indian Start-up:

Caliche Private Limited, an upstream Indian start-up company is currently working in partnership with DGH on the topic “Machine Learning based Data Processing, Enrichment and Interpretation of Indian E&P Data for value addition”. Under this partnership, AI-enabled seismic data processing software will also be built encompassing validation and expertise from domain experts of DGH.

In-house subsurface studies:

NDR data analysis team has been working on geologically older and relatively less explored II/III basins like Ganga and Chhattisgarh Basins to understand its E&P potential using 2D seismic data acquired under National Seismic program (NSP). Some of the major studies are as follows:

- 1) Application of paleo-structural and seismic sequence stratigraphy analysis to determine the potential plays within the Proterozoic sequence of the Ganga Basin, India

Detailed Paleo-structural, seismic sequence stratigraphy and depositional

environmental studies have been carried out for Proterozoic Ganga basin. Further, plays and prospectivity studies have been carried out and envisaged possible petroleum system element within the basin. Outcome of the study has been published in internationally renowned Journal of Asian Earth Sciences.

- 2) Prospectivity Perception and Speculation of Petroleum System Elements in Chhattisgarh Basin, India, using 2D Seismic Data Acquired Under NSP

A detailed study carried out on Prospectivity Perception and Speculation of Petroleum System Elements in Chhattisgarh Basin, India, using 2D Seismic Data Acquired Under NSP. Cumulative area of ~17000 Sq. km area within Hirri and Baradwar subbasins are identified as potentially prospective with sediment thickness goes up to 1650-2900m respectively. Outcome of the study delivered as technical presentation in India Energy week 2023 which was held in Bengaluru between 6-8 February 2023.

- 3) Paleo-Environment and Tectonic Evolution of the Proterozoic Sequence in Chhattisgarh Basin



Paleo-structural analysis and study of depositional environments have been carried out for older sedimentary units within Chhattisgarh basin to be published at upcoming 84th EAGE Annual Conference & Exhibition, 2023 to be held between 5-8 June 2023 in Vienna, Austria.

- 4) A statistical analysis to estimate the average rig time and easiness of drilling in the Indian Sedimentary Basins

A statistical tool was developed to estimate the average rig time, easiness of drilling, and target depth, in the Indian Sedimentary Basins using data analytics. This statistical tool may help potential investors by providing a ready reference on the time and money required for drilling basin-wise which may assist them in decision making while bidding for any exploratory acreage and thereafter before venturing into any E&P project. The outcome of the paper will be presented at the Global Scientific Congress on Geology and Earth Science to be held on May 08-9, 2023 Dubai, UAE.

Data rejuvenation, reprocessing and reorganization through Value-addition model of NDR:

Under the provision of Article 3.7 of NDR Data Policy 2017, M/s TGS has carried out East Coast India 2D cubed seismic reprocessing project comprised of generating a set of 2D matched and merged migrations 2D cubed volumes. Through this project, M/s TGS has generated 570,000 Sq. km of seismic volume in East Coast India covering Cauvery, Krishna-Godavari (KG), Mahanadi and Bengal offshore basins. Total 250,000 LKM of Pre-Processed 2D seismic data were used to generate 2D cubed volume. For this project, M/s TGS used '2Dcubed' algorithm, represents a new interpolation technique, which provides a 3D seismic volume based on relatively dense 2D seismic grids. This 2D cubed volume is suitable for regional interpretation over the all East Coast sedimentary basins.

Figure 3.4: (a) Time slice at 5500 MS of 2D cubed volume of entire East Coast India (b) Zoomed-in slice of KG-Cauvery region

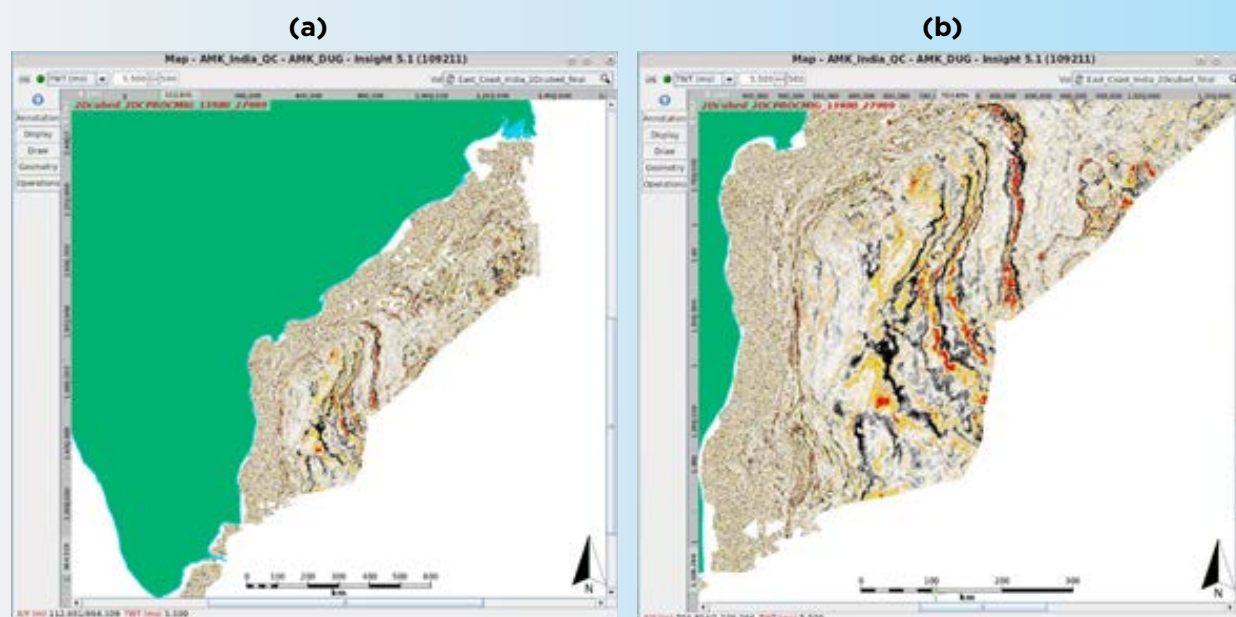
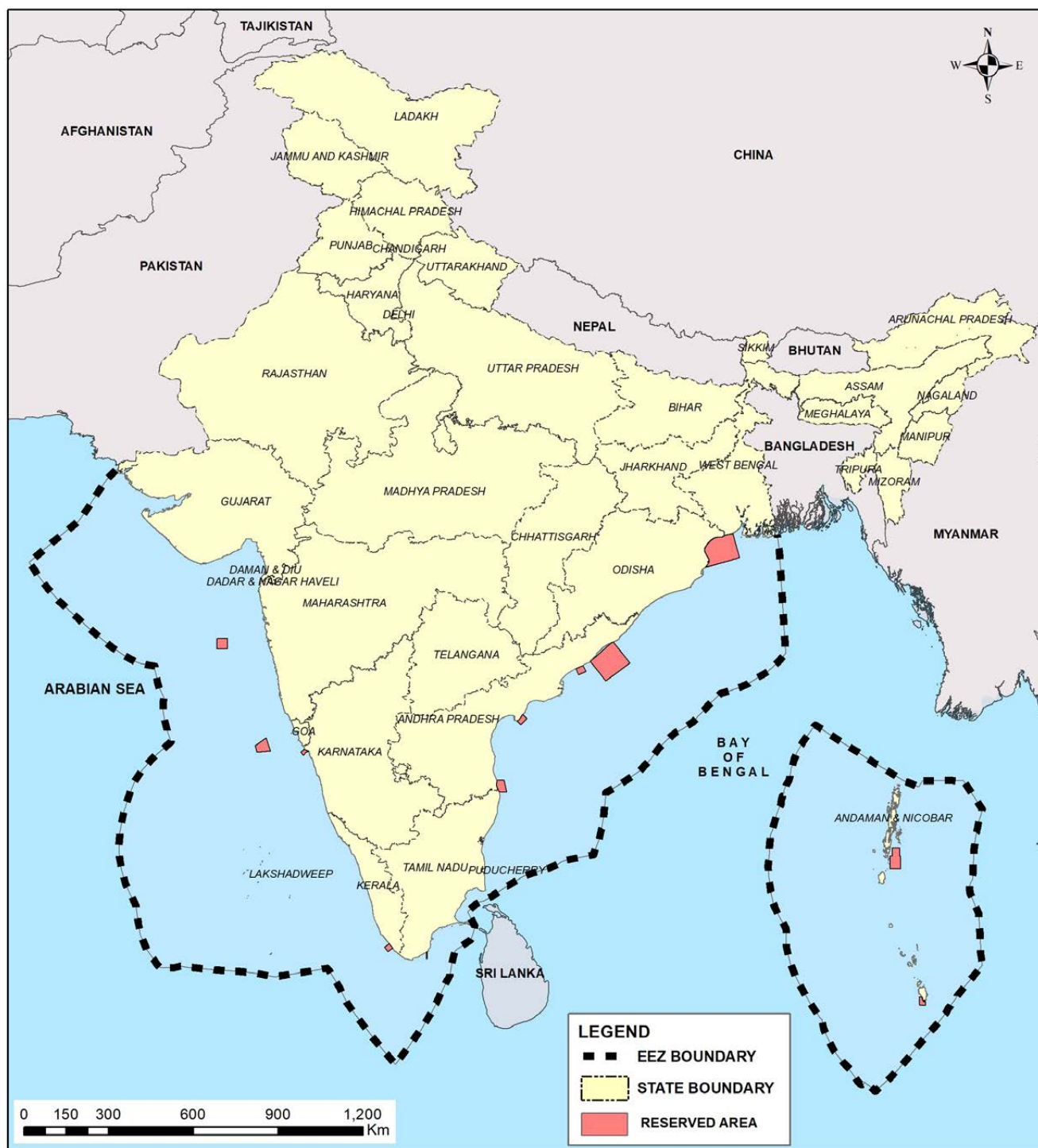


Figure 3.5: Map showing present No-Go areas in Indian Offshore up to EEZ Area



3.4 National Data Repository 2.0

The NDR has been operational for eight years, successfully meeting the demands of all of its stakeholders such as investors, operators, service-providers, R&D institutes, academia, and government bodies. However, with the rapid transformation of digital technology and the emergence of cloud technology, along with

advancements in E&P data management, the current NDR needs to evolve to meet the ever-rising user expectations, the existing NDR needs to be taken to the next generation of its role and utility.

Next generation National Data Repository 2.0 (NDR 2.0) aims to substantially improve the data accessibility (downloading), data reporting,

submission (uploading) and enhance storage (for all E&P data types including seismic field data) and create a cloud-enabled database platform.

With the objectives of NDR 2.0 outlined above and coupled with the fact that existing IT hardware has reached obsolescence, while user demands have increased multi-fold, DGH is planning to upgrade the existing NDR to cloud enabled NDR 2.0 which will have following salient features:

a) Cloud-based Solution:

- i. New look GIS-based portal with dashboard having extended search capabilities and enhanced user experience on data preview, data visualization and quick-look analysis with custom settings.
- ii. Self-service data loading with automated data QC/ validation and downloading for entitled users. This feature will significantly reduce time for data submission and delivery through contactless process.
- iii. Online data ordering, payment through web based online portal and online delivery of stack seismic data, well data and reports up to certain volume.
- iv. Facility of web based virtual data view rooms for anytime anywhere accessing of E&P data of the country equipped with graphic intensive virtual workstations to facilitate detailed study / evaluation of the Oil and Gas data by prospective bidders.
- v. 24x7 Virtual Data Room - Online/ anywhere/anytime data visualization and interpretation facility.
- vi. Enhanced industry academia collaboration.
- vii. Safeguarding E&P data as a strategic national asset.
- viii. Enhanced application security.

b) Data Management:

- i. To create a database platform to be able to apply Data Science methods such as AI and Machine Learning.
- ii. To leverage existing E&P data of NDR to gain understanding of potential occurrence of or delineation and development of oil and gas in the subsurface of a basin.
- iii. Automation of NDR system and processes will enhance end user experience and automate most of the repetitive work processes.
- iv. Improving upon key areas of NDR processes reduced data order processing time, while eliminating manual intervention at each step, efficient QC of data, faster user query resolution using cognitive technologies etc.

c) Upgradation of Storage, Compute and Network:

- i. Enhanced disk storage based sub-system to facilitate efficient raw and raw/Pre-Stack data management and delivery.
- ii. 100% redundancy from disaster recovery point of view.
- iii. Improved efficiency in access of such data with low latency.
- iv. High speed direct link between NDR-DGH and Data Centre of Cloud Service Provider.
- v. Replacement of existing hardware with MEITY-empaneled Public cloud-based IT infrastructure i.e. Virtual Private Cloud (VPC) for Primary Data Centre (PDC) and Disaster Recovery Solution for business continuity.



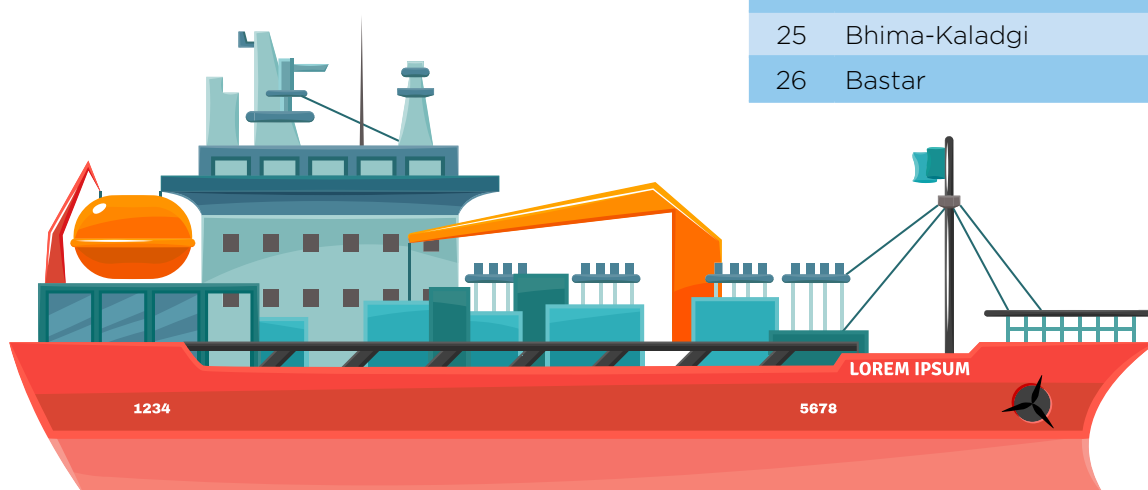
3.5 National Seismic Programme (NSP)

1.0: Journey so far and way forward

India is endowed with twenty-six sedimentary basins having wide geological spread from Proterozoic to Tertiary. Present domestic oil and gas production comes mainly from the Tertiary basins with some contribution from the Mesozoics as well. However, National Oil Companies were chasing the older basins consistently and of late, the Proterozoic basins, gave encouraging results though commercial production is yet to commence. Out of 26 sedimentary basins (list given in the table below), 16 basins are located onland and 10 basins are offshore or extend into offshore. The total sedimentary basinal area is 3.36 Million sq.km. spread over onland, shallow water and deep-water areas. Out of total basinal area of 3.36 Million sq.km., 1.63 million sq km is onland, 0.41 million sq km in shallow water (up to depth of 400m) and 1.32 million sq km in deep water, extending into the Exclusive Economic Zone (EEZ). In 2019, Government categorized 26 sedimentary basins in 3 categories as per prospectivity and resource potential, based on data generated by exploration and production (E&P) companies over the decades. Out of this about 1.502 Million sq.km. i.e., 48% of the total sedimentary cover remained poorly explored with minimal geo-scientific data, especially for the older basins and for the play extensions for the producing basins. To launch future Exploration and Production (E&P) activities, holistic appraisal of these unappraised areas is considered to be an important task to validate and tap the prognosticated resource.

Table 3.1: Indian Sedimentary Basins

Category - I: Basins are commercially producing hydrocarbons	
1	Krishna-Godavari (KG)
2	Mumbai Offshore
3	Assam Shelf
4	Rajasthan
5	Cauvery
6	Assam-Arakan Fold Belt (AARB)
7	Cambay
Category - II: Basins have discoveries, not yet commercially developed	
8	Saurashtra
9	Kutch
10	Vindhyan
11	Mahanadi
12	Andaman
Category - III: Basins have no discoveries yet, less explored	
13	Kerala-Konkan (KK)
14	Bengal-Purnea
15	Ganga-Punjab
16	Pranhita-Godavari (PG)
17	Satpura-South Rewa-Damodar
18	Himalayan Foreland
19	Chhattisgarh
20	Narmada
21	Spiti-Zaskar
22	Deccan Syneclise
23	Cuddapah
24	Karewa
25	Bhima-Kaladgi
26	Bastar





As per India Hydrocarbon Vision 2025, 100% Indian sedimentary area is to be appraised. To thrust the domestic hydrocarbon exploration and production and recognizing the pivotal role of exploration data in boosting E&P activities, Government of India launched the National Seismic Program (NSP) on 12th October, 2016 for appraisal of all unappraised onland areas of sedimentary basins by acquiring ~ 48243 Line Kilo Metres (LKM) 2D seismic data. NSP began with the exploration activities in the on-land part of the sedimentary basins. Under the programme, Government has approved the proposal for conducting 2D seismic survey for data Acquisition, Processing and Interpretation (API) of 48,243 LKM). Accordingly, 46,960 LKM of 2D data was acquired, thus covering 97% of assigned target.

To cover the inaccessible and hostile geographical areas under NSP project, a volume of 40,000 flight LKM Airborne Geophysical Survey has also been planned. On behalf of Ministry, Oil India Ltd. has been selected as Nodal agency for carrying out Airborne Gravity and Gradiometry (AGG) survey.

As per India Hydrocarbon Vision 2025, 100% Indian sedimentary area is to be appraised. To thrust the domestic hydrocarbon exploration and production and recognizing the pivotal role of exploration data in boosting E&P activities, Government of India launched the National Seismic Program (NSP) on 12th October, 2016 for appraisal of all unappraised onland areas of sedimentary basins

Data acquisition is important in order to have an initial insight into the basins which would in turn help in planning the future E&P activities, decide further focus areas of exploration activities and help E&P companies to prioritize areas for submission of Expression of Interests (EOI) followed by bidding in OALP rounds and ultimately attract investments in E&P sectors. The 2D seismic data of 46960 LKM was acquired in three field seasons targeting mainly the lower category basins and also relatively unexplored

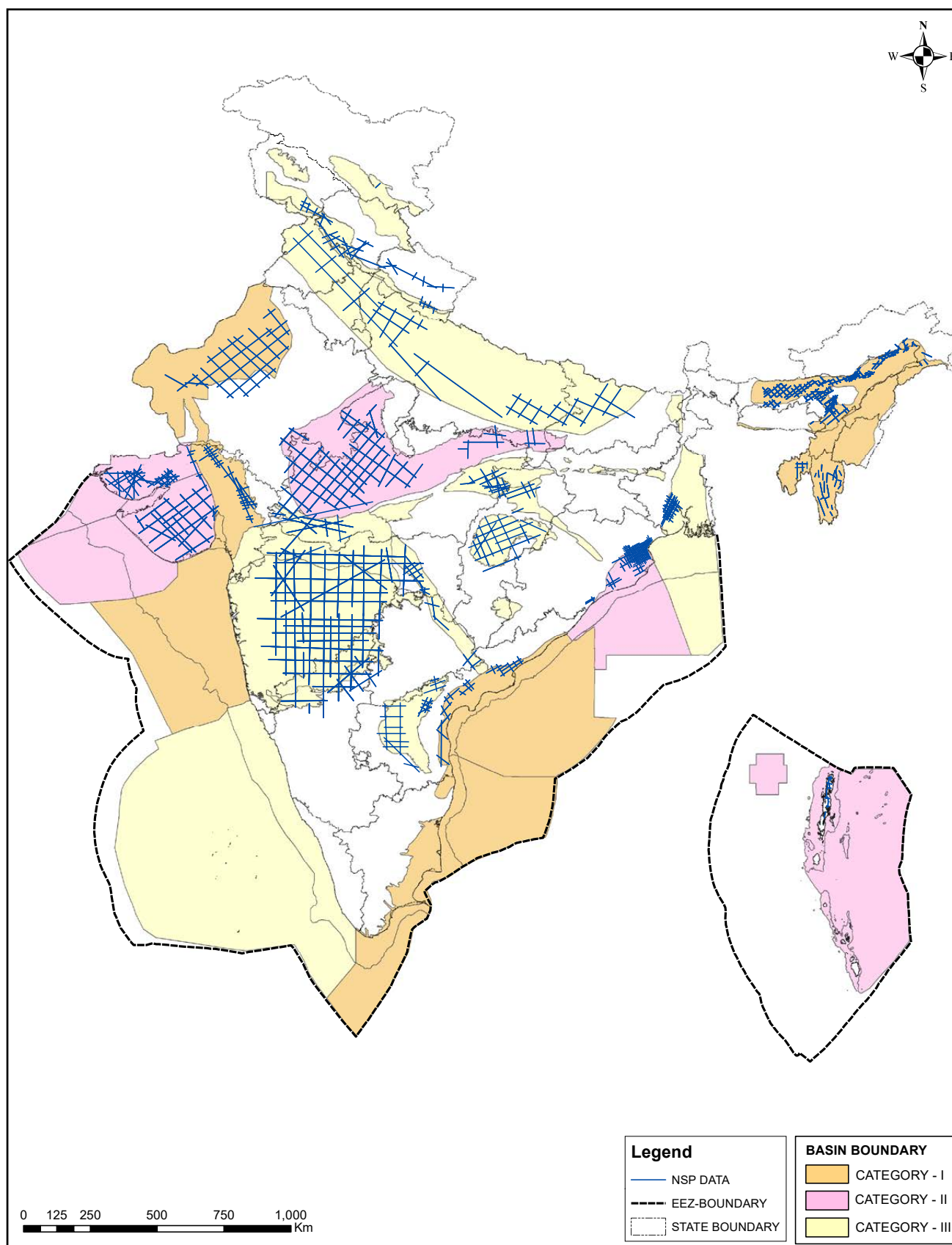


parts of higher category basins. Processing and interpretation of the data has been completed and all the data is available at NDR. Coverage along with the map is given in the table below:

Table 3.2: Coverage of NSP data in different sectors

Details of Data Generated under NSP		
Sector	Area	Data Acquired (LKM)
1	Cambay	1468.8
	Saurashtra	2305.95
2	Kutch	1808.95
	Rajasthan	2752.44
3	Krishna Godavari	980.8
	Pranhita Godavari	735.18
	Cuddapah	1386.9
4	Andaman	263.92
5	Bengal	911.4
	Mahanadi	2480.62
6	Ganga	2671.5
6A	Ganga-Punjab	1186.14
7	Deccan Synclise North	5471.09
8	DSS	4964.5
	Bhima	611.64
	Kaladgi	257.22
9	Vindhyan-A	4904.41
	Narmada	1617.96
10	Vindhyan-B	468.18
	South Rewa Damodar	1124.42
	Chhattisgarh	1778.16
11	Himalayan Foreland	1186.33
	Spiti Zaskar	7.74
11A	Himalyan Foreland11A	370.08
Area-1 Sector - I	Assam & Arunachal	2416.32
Area-2 Sector - 4	Arunachal-Assam	743.82
Area-2 Sector - II	Manipur	4.7
Area-2 Sector - 3	(North Cachar-Hills)	937.68
Area-1 Sector - II	Mizoram	1143.06
Total		46960

Figure: 3.6 Map showing coverage of NSP Lines



Following objectives were set forth for the project:

- i. To have a fair understanding of the tectonic setup and petroleum system of these unappraised onland basins through the acquired 2D seismic data.
- ii. To redefine the basin boundaries in these basins
- iii. To increase the area under exploration after understanding the Sub-surface geology of these basins.
- iv. To identify the focused areas for taking up further exploration activities out of these so called unappraised basin areas.
- v. To enrich NDR with state of the art 2D data which would help E&P bidders to identify the blocks of interest for bidding in these areas under OALP rounds.
- vi. Ultimately to add the new hydrocarbon acreages in the country to enhance the oil & gas production and to reduce the Oil & Natural Gas import dependency.

Pathway for future Exploration in India

Seismic data of NSP campaign have been acquired across India covering all sedimentary basins with varied geographic terrains viz. hilly areas to alluvial plains, desert to riverine areas, thick forested and vegetated lands to barren areas, trap covered areas etc. using different technologies (vibrators and explosives as the energy source, cable and cable less telemetry, nodes, 10 Hz and low frequency sensors using very long offsets ranging from 6 to 9 kms symmetric split spreads).

Following were realised out of NSP data:

- It helped in re-assessment of hydrocarbon reserve/resources in the country.
- It paved a way forward by identifying the need for further data generation by way of acquiring more close grid 2D data or focused 3D data or drilling few parametric wells to bring out the prospectivity perception with

an objective to enhance the confidence of interested bidders in these blocks for taking the investment decisions for E&P activities.

- The G&G data generated under NSP is using the longest possible spread (12 to 18 Km) and state-of-the-art technology (broad band 2-D seismic data).
- NSP data has provided vital sub-surface geological information in many unappraised areas which would facilitate immensely in developing good understanding of the geological set-up of these basins.
- The data has provided significant leads towards the extension of existing producing basins as the information about the tectonics framework has been improved.
- This data has increased the sedimentary area for exploration by enhancing the perception of prospectivity especially in Category II and III basins.
- E&P operators/investors have shown interest in NSP data to evaluate blocks or acreages of interest for submission of Expression of Interest (EoI) under various OALP rounds.
- Resource Assessment Studies (2021) is planned to be carried out incorporating available seismic data acquired under NSP to improve prospectivity perception of Category-II&III basins of India.

Way forward:

In most of the areas the interpreters have carried out seismic to well ties, determine depth-velocity relations, identified the primary stratigraphic horizons in seismic sections, prepared time/structure maps of different horizons and time-thickness/isopach maps, geological models and identified prospects/interesting features/areas as per the scope of work.

It has been observed that barring a few areas under the Proterozoic basins e.g., Bhima, Kaladgi, Deccan Syncline (North and South) having insignificant sedimentary cover are thought to be of low hydrocarbon potential with

the present level of understanding while most of the other areas have moderate hydrocarbon potential and there exists a scope to add to the resource base of the country in case of achieving drilling success. The present work carried out under NSP program will help in reassessment of hydrocarbon reserve/resources in the country. Some parametric wells are also to be drilled to corroborate and correlate with the seismic data acquired under NSP. The way forward in respective areas in the form of future close grid 2D/3D studies, geochemical surveys, drilling parametric wells have been realized which would serve as a future exploration guide.

3.6 National Seismic Programme (NSP) 2.0 Journey so far and way forward

Aligned with the E&P Vision 2025 and with an aim to build a reliable and robust geoscientific

database covering all sedimentary basins, a comprehensive appraisal of the basins with at least one parametric well in each basin for calibration of the depth of investigation is crucial. In view of the availability of resources and the need to embark on a survey of priority areas forthwith, Mission Anveshan has been planned to be carried out as an upgrade of NSP project which will be implemented in phased manner where the activities are prioritized in phases sequentially, based on identified priority areas and activities.

An exhaustive understanding of the country's subsurface geology is crucial for effective planning and execution of exploration and production (E&P) activities. Adequate subsurface geological information about the basins is a precursor to any meaningful attempt towards the exploration of oil and gas. Such



information is derived from the geoscientific data which is acquired through geophysical surveys and drilling of parametric wells.

Among the geophysical surveys, seismic surveys are the most advanced and preferred methods to get subsurface images of sedimentary sequences and wells drilled give accurate information of rocks and the much-needed calibration of the depth of investigation. The 'geological information' is thus rooted in 'geoscientific data', which eventually forms the basis of hydrocarbon resource mapping and prospectivity assessment. For acquiring authentic information about a country's subsurface geology, a sound geoscientific database of the country is very much a key necessity. The initial insight into the basins helps in planning the future exploration activities enabling increase in basin areas for hydrocarbon exploration, identification of the prospective areas, carving out the blocks, and generating the interest of bidders in Open Acreages Licensing Policy (OALP) etc. which will add more acreages.

To build a reliable and robust geoscientific database covering all sedimentary basins of India, a comprehensive appraisal of the basins by acquiring close-grid 2D seismic, in un-appraised and partially appraised areas and drilling of at least one parametric well in each of the basin for accurate information of lithology and the much-needed calibration of the depth of investigation was required. Resource Assessment Studies

(RAS) required to be undertaken for upgradation of prospectivity perception of the basins by integrating acquired data. So, with the aim to undertake a comprehensive appraisal of the Indian sedimentary basins with at least one parametric well in each basin and to build a reliable and robust geoscientific database covering all sedimentary basins of India, Mission Anveshan project has been planned duly aligned with the E&P Vision 2025.



Way forward

- The prospects/leads identified out of such projects need to be further evaluated by acquiring 3D data in the areas.
- Appraisal of un-appraised offshore areas also need to be taken up. Already 22500 LKM of 2D seismic data has been acquired through OIL in Andaman offshore and its data processing -Interpretation is in progress. Further, unappraised offshore areas up to EEZ are undergoing.
- Further, merging of data of different vintages including NSP data to be done by state-of-the art processing technology.



Andaman Seismic Programme:

Andaman Basin is a potential petroleum prolific basin located in the south-eastern part of the Bay of Bengal in the proximity of the most prolific petroleum provinces of Southeast Asia. Andaman Basin including the total EEZ boundary area measures 6,64,080 sq. km. and comprises a major chunk of the unappraised area of the offshore sedimentary basins of India. The basin has been appraised to the extent of 36% with 71,290 LKM of 2D seismic and 13,710 Sq. Km of 3D seismic data and 22 exploratory wells, in the eastern part of the basin.

The 2D/3D seismic or well data acquired in the basin was scanty and the data coverage was moderate to sparse. The area surrounding the Andaman & Nicobar (A&N) islands has significant potential for oil and gas, but the exploratory activities could not be taken up there because most of the area was designated as a "No-Go" Zone (0.37 million sq. km. of the "No-Go" zone area falls in the Andaman Basin).

Pursuant to the directives of the Island Development of Authority (IDA) and the

decisions taken by the Empowered Coordination Committee (ECC) of the Cabinet Secretariat, DGH formulated a plan to carry out seismic survey for the purpose of gathering geo-scientific data for evaluation of the hydrocarbon resource potential of the areas in close coordination with the Department of Space and associated safety directives related to the areas concerned. Accordingly, DoS and DGH laid down an appropriate framework to ensure that there is no impact on the Space Mission of Government of India, while side by side, scientific assessment is carried out of the prolific hydrocarbon resource potential of the Andaman Basin.

For comprehensive appraisal of Andaman offshore, DGH formulated a plan to acquire 22,500 LKM 2D Broadband seismic data acquisition, processing, and interpretation thereof covering basinal area of approx. 281,613 Sq.Km. The project has been implemented through M/s Oil India Limited. A total of 22,500 LKM seismic data was acquired in deep Andaman offshore and the whole data is uploaded on NDR portal.

Figure 3.7: Map showing 2D seismic lines of Andaman seismic programme



Exclusive Economic Zones (EEZ) survey, (Ongoing):

Approximately 1.13 Million Sq. Km. is unappraised in the Offshore Basinal Areas of Indian sedimentary basins up to EEZ. ONGC was entrusted as nodal agency for EEZ survey. Accordingly, ONGC awarded the contract (70,000 LKM with a provision of 20% extension)

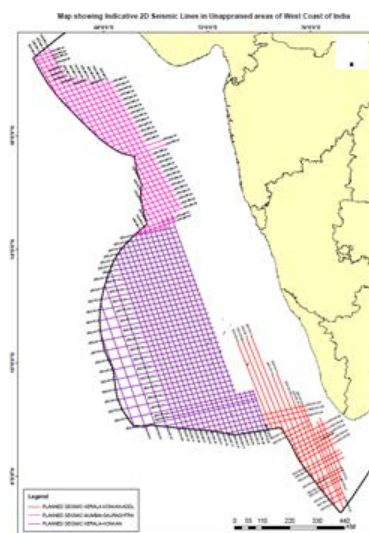
to service provider for 2D Broadband Seismic Data Acquisition covering three sectors; Western, Eastern and Andaman Offshore up to EEZ. The project is ongoing and Appx. 60,000 LKM seismic data has already been acquired under EEZ survey as on 20.03.2023.

Eagle Explorer Vessel

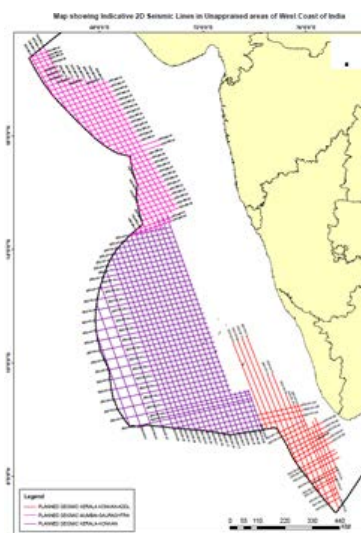


Figure 3.8: Map showing 2D seismic lines of EEZ survey

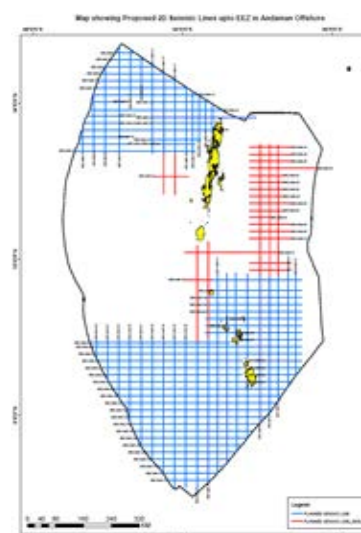
Sector-1 (Western Offshore)



Sector-2 (Eastern Offshore)



Sector-3 (Andaman Offshore)





4

EXPEDITING RESOURCES TO RESERVES CONVERSION BY IMPLEMENTING PRMS

Earlier, in our country more generalised methodologies were in use for Reserves & Resources, its Estimation and Reporting. They were not consistent and uniform company to company, nomination regimes to contract regimes, conventional to unconventional hydrocarbons.

Petroleum resources management system (PRMS) summarizes a consistent approach in estimating oil & gas quantities within a comprehensive classification, categorization & project-definition framework.

Directorate General of Hydrocarbon (DGH), Ministry of Petroleum & Natural Gas, in collaboration with DeGolyer and MacNaughton (D&M), USA, organized the three-day workshop (10-12 January 2023) on Petroleum Resource Management System (PRMS). Various E&P companies, academic universities along with

financial institution participated to make this workshop a success.

The technical sessions over the course of three days were conducted by Mr. Charles F. Boyette, President & COO, D&M and Ms. Donna G. Freyder, SVP & Division Manager of Reservoir Studies Division, D&M.

The sessions covered the following aspects:

1. SPE-PRMS guidelines and definitions for classification and categorization of petroleum resources into reserves, contingent resources, and prospective resources
2. Reserve-estimation methods and their workflows; data requirements needed to evaluate a company's net reserve position

3. Discussion on Economic evaluation of petroleum resources and its importance to Financial lending institutions, Investment Banks and Stock-Exchanges.

Key Takeaways:

- 💧 A standard by which value and performance of assets may be compared to other companies around the world
- 💧 Allow access to international financial institutions
- ① Stock exchanges
- ① Investment banks

Determination of Discovery Status:

A discovered petroleum accumulation is determined to exist when one or more exploratory wells have established through testing, sampling, and/or logging the existence of a significant quantity of potentially recoverable hydrocarbons and thus have established a known accumulation. "Significant" implies that there is evidence of a sufficient quantity of petroleum to justify estimating the in-place quantity demonstrated by the well(s) and for evaluating the potential for commercial recovery.

Estimation of In-Place:

Uncertainty in Assessment Method over Project Life

- 💧 Even when using good data sets and reasonable methods, estimates are inherently uncertain
- 💧 Develop range of estimates
 - ① Low
 - ① Best
 - ① High
- 💧 Build a case to support the estimates
 - ① Document the data and interpretation used to build the case
- 💧 Range of uncertainty should decrease over time with additional data
 - ① More wells

- ① Additional seismic
- ① Pressure/Production data
- 💧 Volumetric estimates can be made using probabilistic or deterministic methods
 - ① Probabilistic
- 💧 Statistical Analysis Using Established Monte Carlo Methodology
- 💧 Attractive Due to Rigor; Difficult to Explicitly Defend
- 💧 Spreadsheet based
- 💧 Crystal Ball, @Risk, GEOX, etc
- 💧 3D Model based
- 💧 Petrel, RMS, etc

Why and How are Reserves estimates used?

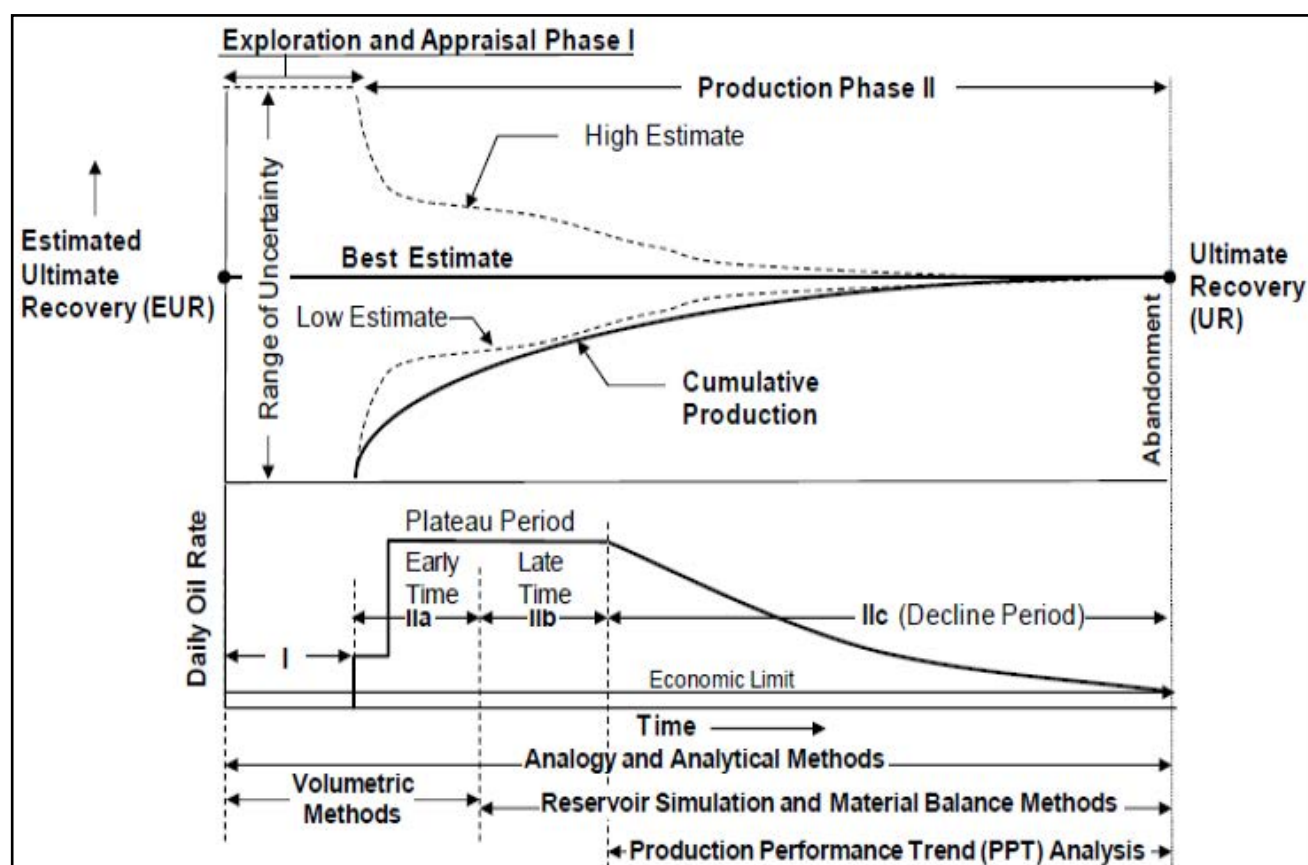
- 💧 A standard by which value and performance of the company is measured
 - ① Gives a "snapshot" of the company's performance at a given data
- 💧 Allows the company and its investors to compare its performance to similar companies
 - ① To attract and protect investors
- 💧 Long and short term planning
 - ① To compare investment opportunities within company
 - ① To evaluate the effectiveness of investment programs
- 💧 Government reporting and shareholders
 - ① Annual Report to Shareholders - Listed and non-listed companies

"Significant" implies that there is evidence of a sufficient quantity of petroleum to justify estimating the in-place quantity demonstrated by the well(s) and for evaluating the potential for commercial recovery.



- ① Energy Ministries/State Oil Company
- ① Financing
- ① Project Finance – value of collateral
- ① Borrowing Base
- ① To justify capital projects
 - Processing facilities
 - Transportation infrastructure
 - LNG projects

Estimation of Recoverable Resources:



Recoverable estimates

- ① Material balance
- ① Decline curve analysis
- ① Reservoir simulation
- ① Analogy
- ① Recovery factors
- ① Forecasting reserves

Material Balance: In-Place and Recoverable Quantities Can be...

- ① Used to estimate gas and/oil in-place estimates

- ① Compared to volumetric estimate of in-place to confirm and increase confidence

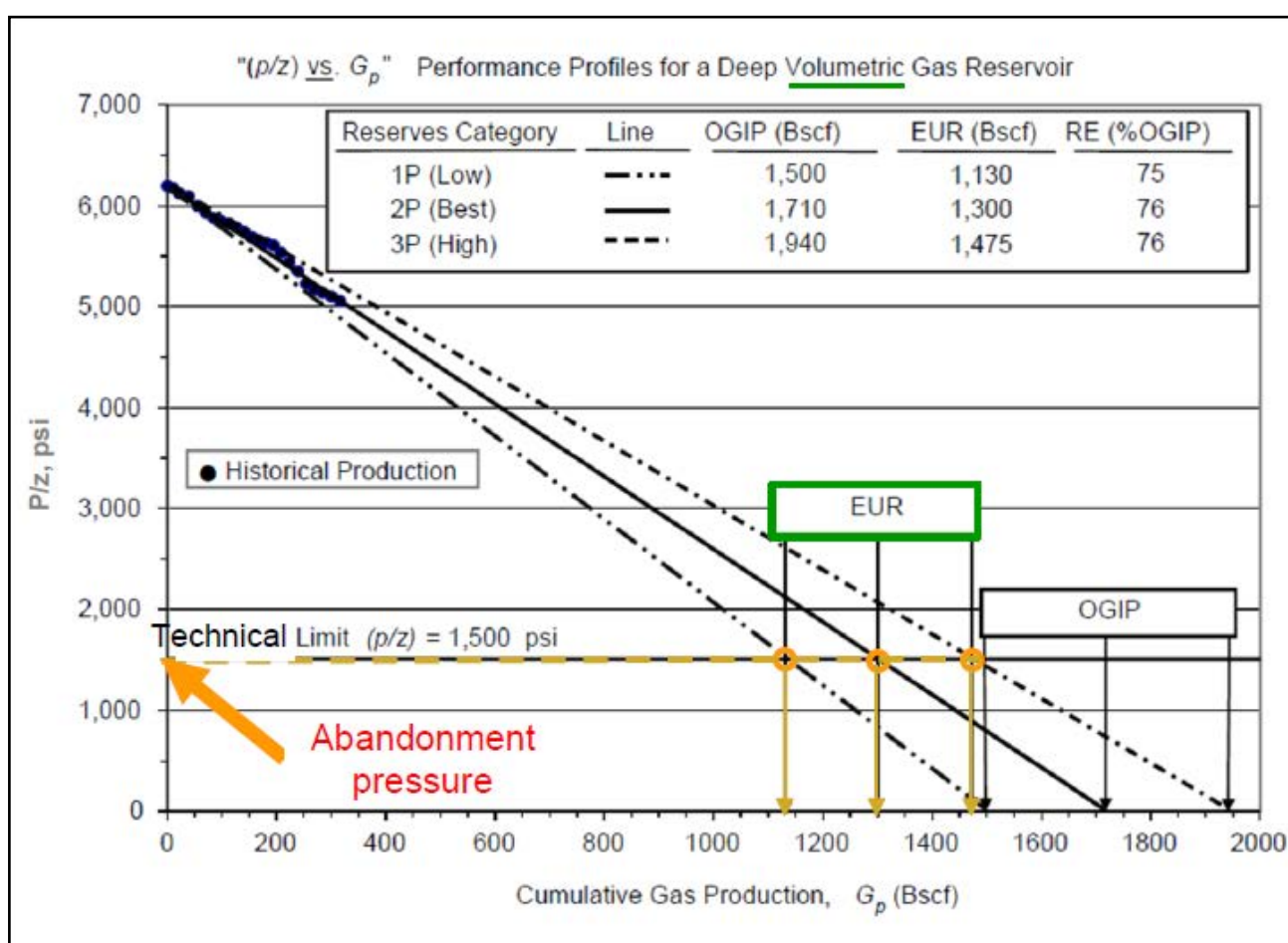
Technical Recoverable Quantities vs. Reserves:

- ① Technical Recoverable Quantities –have met all technical guidelines for reserves but commercial or economic viability has not been established
- ① Reserves –portion of technical recoverable quantities that are commercially producible
- ① Approved development plan

- ① Legal and regulatory requirements met
- ① Sales market and sales contracts
- ① Economically viable (positive future net revenue)
- ① Timing (development planned within ~ 5 years)
- ① “Reserves” must be economic...technical recoverable quantities may not be
- ① Level of maturity
- ① Potential drive mechanisms
- ① Amount and quality of available data
- ① Reconcile with volumetric estimates for initial in-place
- ① Consider appropriate abandonment pressure
- ① Assign appropriate level of certainty

Gas Material Balance: Summary

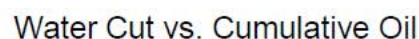
Be aware of potential sources of uncertainty



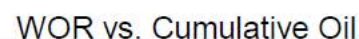
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Rate vs. Time



Oil-per-well Rate vs. Time



- 💧 To use for reserves the model must be thoroughly vetted
- 💧 Established history match at the field, area, and well levels for all phases of production, injection, pressure etc.
- 💧 Geologic model must be current using all available data
- 💧 No anomalies such as flow barriers, high perm streaks, unusual adjustments of engineering parameters to gain the history match, tuning of wells on and off (should match actual operational procedures) etc.
- 💧 Simulation models can be used in conjunction and cross checked with other methodologies (Material Balance, Decline Curve Analysis and with Analogue field recovery factor)

Courtesy: Presentation by D&M in “DGH PRMS workshop in collaboration with D&M – 10-12 January 2023”

Petroleum Resources Management System (PRMS) in DGH:

Previously, Reserves & Resources were being reported at Directorate General of Hydrocarbons (DGH), using a generalised methodology not following a standard format. In the last one and half year, significant efforts have been made to fully implement Petroleum Resources Management System (PRMS) in DGH.

In this regard, DGH has issued several directives to Exploration and Production(E&P) companies for adoption of PRMS standard.

This enjoins that all hydrocarbon discoveries must be declared and reported in accordance with the guidelines set forth by the PRMS, approved by Society of Petroleum Engineers in June 2018 and as amended from time to time.

As per directives of 2021, E&P Operators in the country need to undertake Estimation, Classification, Categorization, Auditing and Reporting of all hydrocarbons reserves and resources in accordance with PRMS standard and furnish reports & data to DGH as of 01.04.2021 and onwards annually.

It has also been made mandatory for all technical submission such as "Declaration of Commerciality, Field Development Plan

(FDP) and RFDP, project status and chance of commerciality" to conform the PRMS from 1st April 2023 onwards.

DGH has fully introduced the PRMS standard, which is considered the basis of Good International Petroleum Industry Practices (GIPIP). E&P companies in the country are advised to fully adopt and comply the PRMS standard.





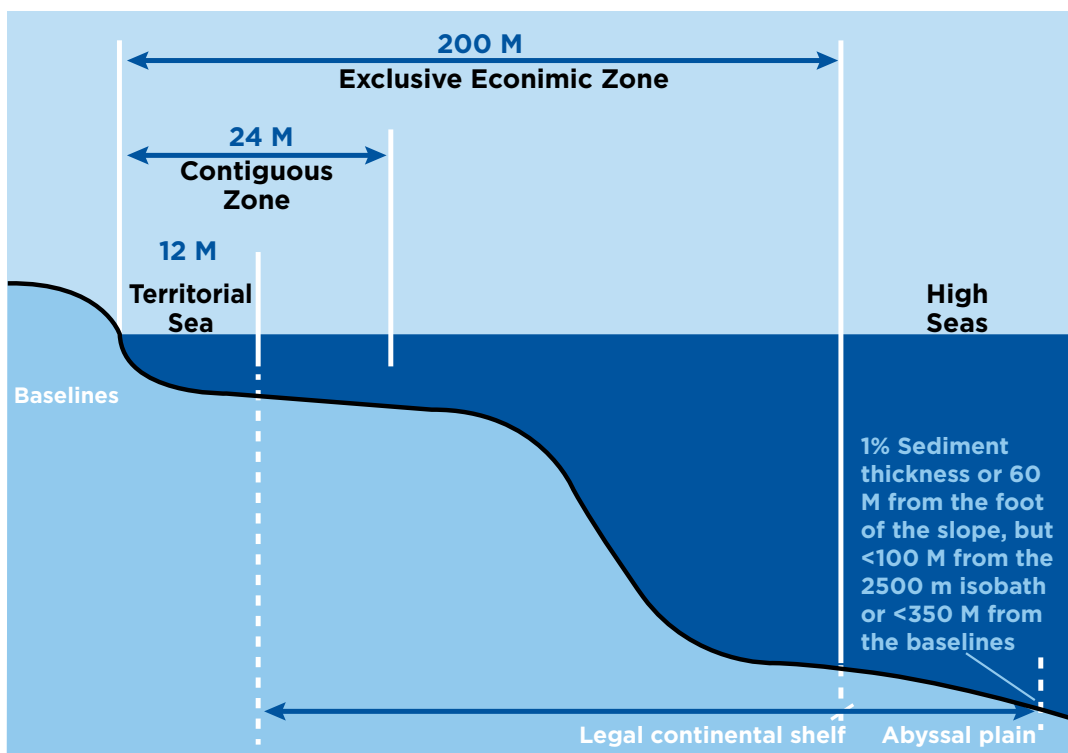
5

BLUE ECONOMY-INDIA'S QUEST FOR OIL AND GAS IN EEZ

Introduction

India, a nation with a coastal stretch extending over 7,500 kilometers, boasts a veritable plethora of aquatic resources, including the Bay of Bengal, the Arabian Sea, and the Indian Ocean. With an Exclusive Economic Zone (EEZ) sprawling over a massive 2.36 million square kilometers, this region teems with both living and non-living resources, ranging from the recoverable to the precious, such as crude oil, natural gas, and gas hydrates.

The jurisdiction of the EEZ extends 200 nautical miles from the coastline, thereby conferring on the coastal state the right to manage, explore, exploit, and conserve all resources within its purview, be they living or non-living. The offshore areas are classified based on depth, with shallow water production comprising depths below 400 meters, deepwater production covering depths of up to 1500 meters, and ultra-deepwater production restricted to depths greater than 1500 meters.



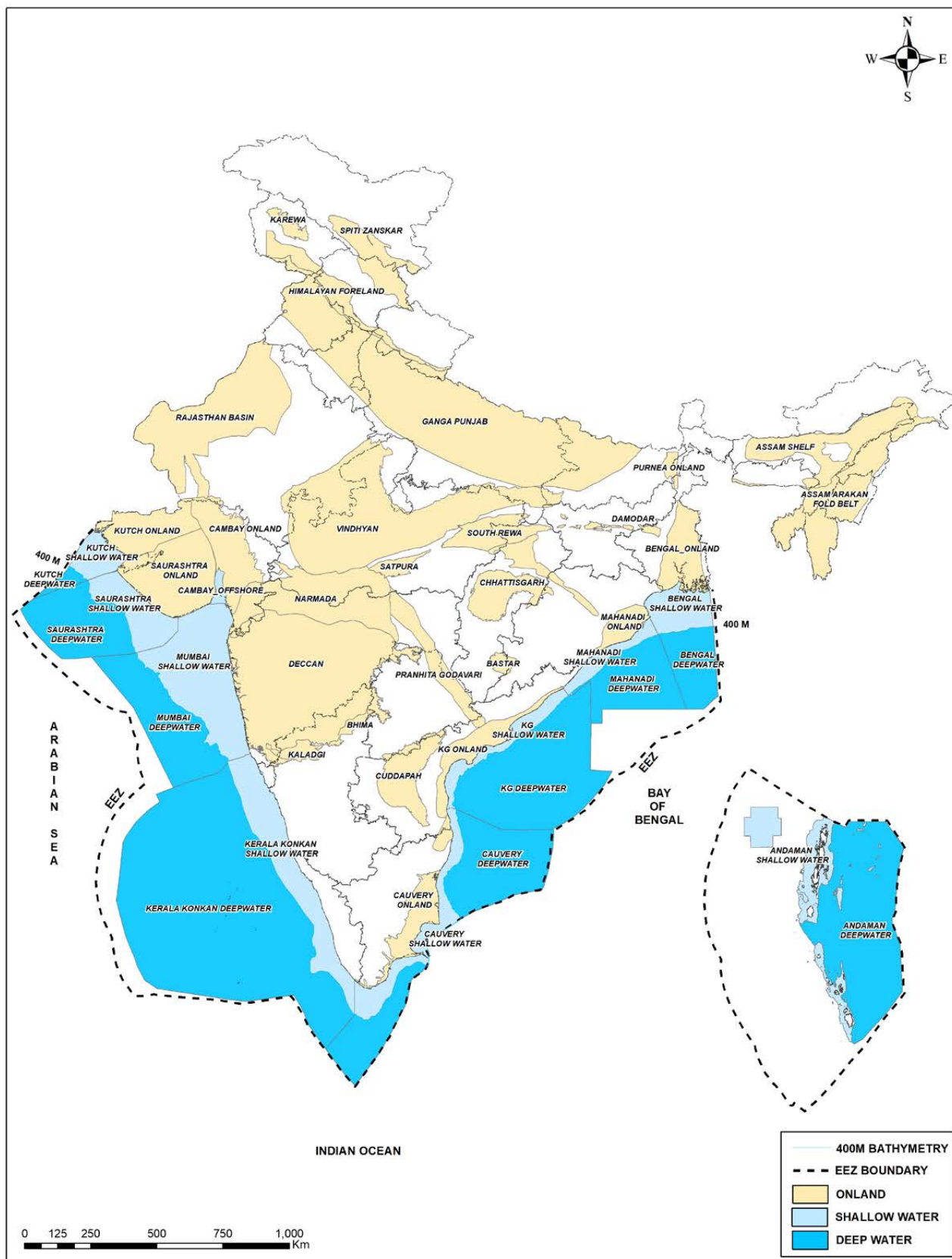
Source: www.reparationlaw.com

The vulnerability of India's east coast to cyclonic storms stands in stark contrast to the Arabian Sea, which exhibits relatively lower vulnerability to such storms. Nevertheless, tropical cyclones

have witnessed a marginal increase over the Arabian Sea in recent times, albeit to a lesser extent than in the Bay of Bengal.



INDIAN SEDIMENTARY BASINS



For oil and gas production, deepwater and ultra-deepwater fields represent the last bastion of hope. As many onshore and shallow water fields approach exhaustion, deepwater and ultra-deepwater production seem to be the only feasible option available in the foreseeable future. The viability of oil and gas production in these water depths depends critically on the prevailing prices of oil and gas, with the extraction costs typically escalating in tandem with water depth.

Advances in drilling and production technology have made it possible to extract oil and gas from ever-deeper depths. High-resolution geophysical exploration technology enables scientists to detect oil and gas deposits in seabed and geological strata, to depths of up to 12 kilometers, leading to the discovery of many major new deposits in recent years.

Despite the high cost of drilling in deep water, the high productivity of oil and gas fields can justify the expense, provided oil and gas prices remain high enough to make them profitable. The world's deepest oil and gas project, Stones, operates in around 2,900 meters of water in an ultra-deep area of the US Gulf of Mexico. The project started production in September 2016 from a Floating Production, Storage, and Offloading (FPSO) facility that connects to subsea infrastructure, producing oil and gas from reservoirs situated nearly 30,000 feet below sea level.

Exploration and production of oil and gas in offshore areas entail extensive use of seismic imaging and geologic analysis, rigorous engineering design and planning, construction of highly specialized equipment, and compliance with federal or state environmental regulations, all of which necessitate substantial time and financial investment. Offshore drilling operations involve complex, high-risk systems, as the interplay of technological and operational complexities, harsh environmental conditions, geological uncertainties, and high-pressure flammable fluids can potentially trigger catastrophic events, such as the Macondo blowout in the US Gulf of Mexico in 2010 (Deep Water) and the tragic incident at Mumbai High offshore field in 2005 (Shallow Water).

Offshore regions already account for a substantial volume of global oil and gas production, with

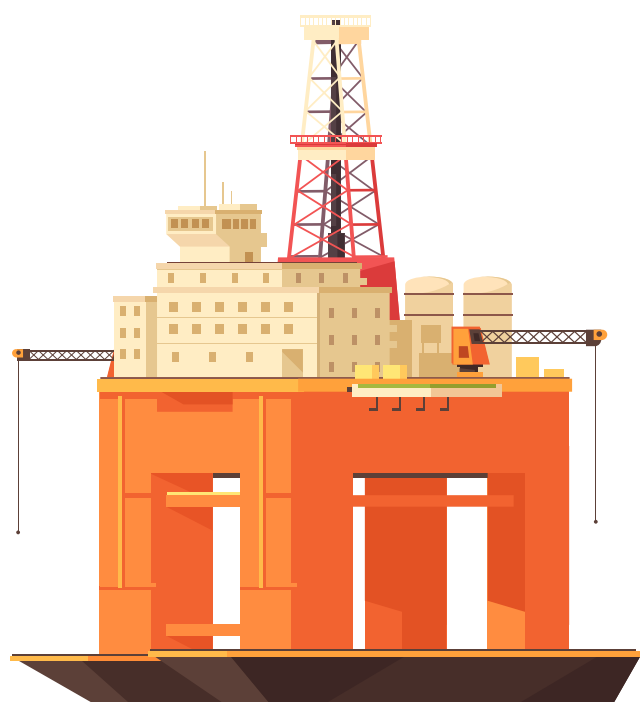
offshore oil production constituting more than 40% of the world's total oil production and more than 30% of global gas production sourced from offshore fields, with this proportion poised to surge in the foreseeable future.

5.1 Hydrocarbon Resources in EEZ

India is home to 26 sedimentary basins, which cover a total area of 3.36 million square kilometers. These basins are distributed over onland, shallow water that extends up to 400 meters of water depth, and deep water that goes beyond the Exclusive Economic Zone (EEZ).

Of the total sedimentary area, 49% is located onland, 12% in shallow water, and 39% in deepwater areas. There are 16 onland basins, seven basins that lie in both onland and offshore, and three basins that are completely located offshore. These basins are classified into three groups based on their tectonic origin, which can be traced back to rifting, plate collision, and crustal sag.

The hydrocarbon resources in these basins are divided into three categories based on their maturity. Category-I basins already have reserves and are currently producing. Category-II basins have contingent resources that are pending commercial production, while Category-III basins have prospective resources that are awaiting discovery.



5.2 Offshore Sedimentary Basins

Amongst the 26 sedimentary basins in India, 10 of them are located either entirely or partially in offshore regions.

The sedimentary basins of Kerala Konkan, Andaman, and Mumbai are exclusively situated in offshore regions. In addition, approximately 84% of the basinal area of the Cauvery basin, roughly 86% of the basinal area of the Krishna Godavari basin, around 84% of the basinal area of the Mahanadi basin, roughly 61% of the basinal area of the Saurashtra basin, approximately 47% of the basinal area of the Kutch basin, and 8.6% of the basinal area of the Cambay basin are located in offshore regions."

Based on the assessment of conventional resource potential, 7 basins have been classified as Category-I, encompassing 30% of the total basinal area and containing 85% of the total unrisks conventional hydrocarbon in-place of 41.8 billion tons of oil and oil-equivalent gas.

Table 5.1: Basins lying in offshore Area

Sr No.	Basin Name	Basin Category	Onland Area SKM	Shallow Water Area SKM	Deep Water Area SKM	Total Area SKM	Total Offshore Area SKM	Offshore area % of Total Sedimentary Basin Area	% of Total Offshore Sedimentary Basinal Area of Country
1	Kerala-Konkan	III	0	90,380	4,89,620	5,80,000	5,80,000	100.0%	33.5%
2	Andaman	II	0	18,074	2,07,844	2,25,918	2,25,918	100.0%	13.0%
3	Mumbai Offshore	I	0	1,18,389	93,611	2,12,000	2,12,000	100.0%	12.2%
4	Cauvery	I	37,825	43,723	1,58,452	2,40,000	2,02,175	84.2%	11.7%
5	Krishna-Godavari	I	31,456	25,649	1,72,895	2,30,000	1,98,544	86.3%	11.5%
6	Saurashtra	II	75,076	42,617	76,421	1,94,114	1,19,038	61.3%	6.9%
7	Mahanadi	II	15,500	14,211	69,789	99,500	84,000	84.4%	4.8%
8	Bengal-Purnea	III	42,414	33,465	46,035	1,21,914	79,500	65.2%	4.6%
9	Kutch	II	30,754	20,500	7,300	58,554	27,800	47.5%	1.6%
10	Cambay	I	48,882	4,618	0	53,500	4,618	8.6%	0.3%
Total			2,81,907	4,11,626	13,21,967	20,15,500	17,33,593	-	100%

5.3 Key operations area:

Out of the total operational area of approximately 168,000 square kilometers in offshore regions, 64% of the operational area (around 108,000

square kilometers) is situated on the west coast, while the remaining 36% (approximately 60,000 square kilometers) is located on the east coast.

Indian Offshore Hydrocarbon Resources

- 💧 Total Sedimentary basin area in the country is 3.36 million sq km.
- 💧 Out of the 26 basins, 10 of them are situated in offshore regions.
- 💧 Offshore basins account for 51% of the basin area and 59% of the total resources.
- 💧 Although deep-water areas comprise a significant portion of the offshore region (76% of the total), they remain less explored.
- 💧 India has discovered 12.1 billion tonnes of oil equivalent (btoe) and possesses a total risked undiscovered potential of 12.9 btoe.
- 💧 Out of the total discovered 12.1 btoe, the recoverable potential is 4.2 btoe. So far, 2.6 btoe have been produced, leaving a balance of 1.6 btoe in recoverable reserves.
- 💧 The area-weighted undiscovered risked potential in onland regions is 5.5 btoe, while offshore areas account for 7.6 btoe. Assuming a 30% recovery rate, the yet-to-find (YTF) potential of offshore areas would be approximately 3.90 btoe.
- 💧 There is an opportunity to explore 7.6 btoe of undiscovered resources and to develop/produce 6.9 btoe of discovered resources.
- 💧 As of April 1, 2022, the cumulative oil and gas production from offshore regions in the country is approximately 1.6 btoe (oil and oil-equivalent gas).
- 💧 Presently, offshore regions contribute approximately 50% of the oil and 67% of the gas production in India.

Table 5.2: Offshore PEL-PML area by Basin

Basin	PEL Area (in Sq.Km)	PML Area (in Sq.Km)	Total Area (in Sq.Km)
East Coast	54796	4982	59778
West Coast	72432	35707	108139
Grand Total	127228	40690	167917



Table 5.3: Offshore PEL-PML area by Basin

BASIN	PEL Area (in Sq.Km)	PML Area (in Sq.Km)	Total Area (in Sq. Km.)
Mumbai	37818	32364	70182
Kutch	23833	2092	25925
Andaman-Nicobar	23013		23013
Cauvery	16219	167	16386
Krishna Godavari	10341	4274	14615
Saurashtra	5274		5274
Mahanadi	5222		5222
Kerala Konkan	3520		3520
Cambay	1988	1251	3238
Bengal-Purnea		541	541
Grand Total	127228	40690	167917



Chemitech DMCC limited

Contribution of offshore in India's total oil and gas production

Table 5.4: Offshore Crude Oil Production in last 5 Years (MMT)

Location	2017-18	2018-19	2019-20	2020-21	2021-22
ONGC Nomination	16.24	14.97	14.54	14.25	13.62
PSC/RSC Regime	1.91	1.9	1.47	1.14	0.95
Offshore Total	18.14	16.87	16.00	15.39	14.57
Total Production in the country	35.66	34.2	32.17	30.49	29.69
% of Offshore Production	50.9%	49.3%	49.7%	50.5%	49.1%

**Offshore has approximately equal share ~49% in crude oil production.
About 47% of country's crude oil production is from Western Offshore Fields.**

Table 5.5: Offshore Gas Production in last 5 Years (BCM)

Location	2017-18	2018-19	2019-20	2020-21	2021-22
ONGC Nomination	17.79	19.04	18.58	17.09	15.94
PSC/RSC Regime	4.22	3.08	2.06	1.34	6.93
Offshore sub Total	22.01	22.12	20.64	18.43	22.87
Total Production in the country	32.64	32.87	31.19	28.67	34.02
% of Offshore Production	67%	67%	66%	64%	67%

Almost two third of Natural Gas Production is from Offshore areas.



Table 5.6: Location-wise Crude Oil Production (MMT)

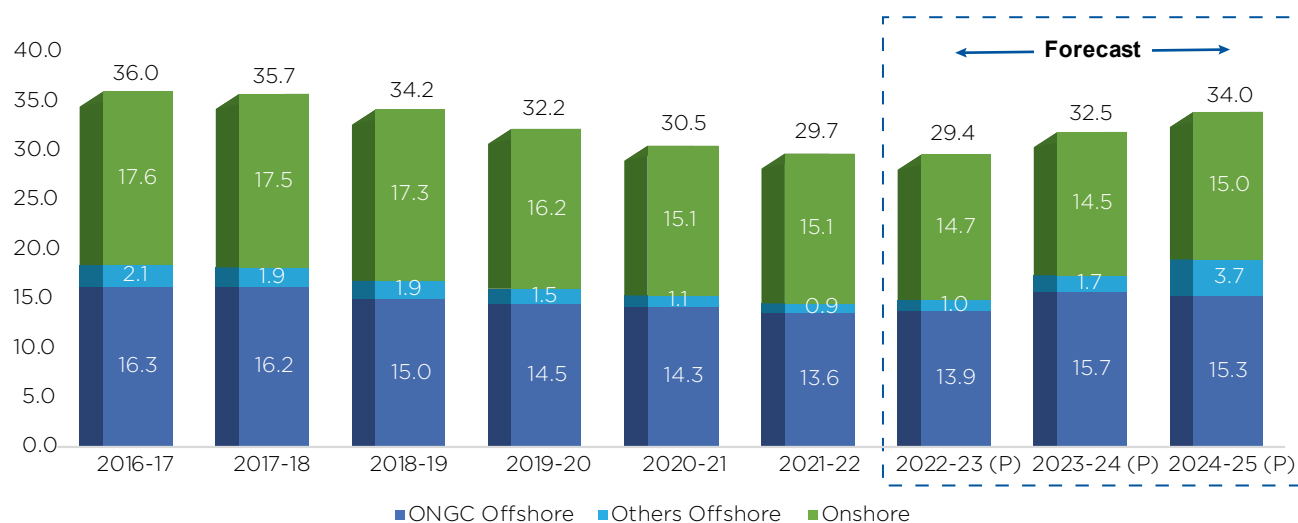
Location	2017-18	2018-19	2019-20	2020-21	2021-22
Western Offshore	17.31	16.20	15.44	14.65	13.94
Eastern Offshore	0.83	0.65	0.56	0.74	0.63
Offshore Total	18.14	16.87	16.00	15.39	14.57

Table 5.7: Location-wise Natural Gas Production (BCM)

Regime	2017-18	2018-19	2019-20	2020-21	2021-22
Western Offshore	19.2	19.66	18.81	16.81	15.84
Eastern Offshore	2.82	2.46	1.82	1.62	7.02
Offshore Total	22.01	22.12	20.64	18.43	22.87

5.4 Focus on increased production from offshore

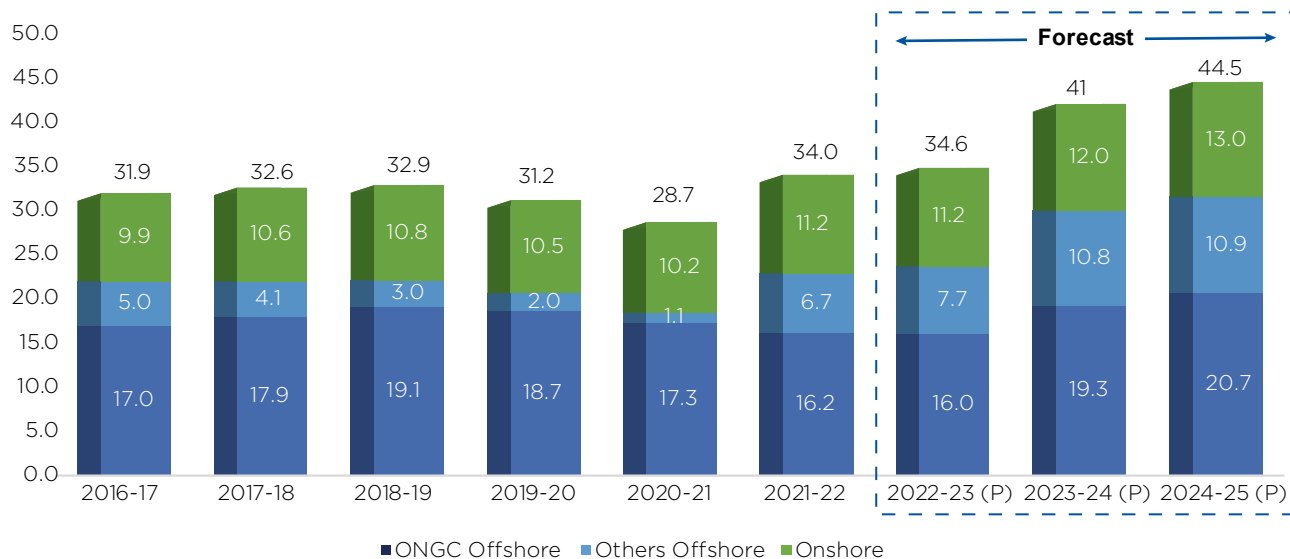
Oil (in MMT)



- Offshore contributes half of oil production
- Offshore fields are expected to account for more than 50% of the total crude oil to be produced in India in 2024-25



Gas (in BCM)



- Offshore contributes 2/3rd of gas production
- Offshore fields are expected to account for more than 70% of the total natural gas to be produced in India in 2024-25
- Eastern offshore is expected to contribute majority of the incremental gas production

Offshore fields are expected to account for 71% of the total natural gas to be produced in India in 2024-25

Contribution in offshore production 2022-23 (P): ONGC: 67.5% | Vedanta: 1% | RIL: 31%

Eastern offshore is expected to contribute majority of the incremental gas production

Sneak Peek at Recent initiatives in E & P Sector in Indian offshore Area

The oil and gas sector plays a critical role in meeting India's growing energy needs and ensuring energy security for the country. India is presently the third-largest oil importer globally. The government is working on several initiatives to enhance domestic production of energy sources to reduce import dependency.

The various measures recently implemented by the Indian government in the offshore territory are steps to bolster exploration endeavors in

the offshore basins. The particulars of these measures are delineated below.

a) Offshore Blocks Awarded in OALP Rounds I to VII

31 offshore blocks awarded in OALP I to VII

- 24 Shallow Water; 2 Deepwater and 5 Ultra Deepwater

Category-I Blocks: 18

Category-II Blocks: 12

Category-III Blocks: 1

- Acreage awarded: 87,300+ Sq. Km

Work Programme Commitment:

- 2D Seismic: 17,880 LKM
- 3D Seismic: 24,863 SKM
- Exploratory Wells: 91
- USD 93 Million committed investment in offshore



Work programme in offshore blocks awarded under OALP

- 31 offshore blocks awarded in OALP I to VII
 - 24 Shallow Water; 2 Deepwater and 5 Ultra Deepwater
 - Acreage awarded: 87,300+ Sq. Km
- Work Programme Commitment:
 - 2D Seismic: 17,880 LKM
 - 3D Seismic: 24,863 SKM
 - Exploratory Wells: 91

**87,300+
Sq. Km**
acreage for
exploration

USD 934 Mn
Investment
Committed in
Offshore

Across 31 Blocks

Cat I: 18

Cat II: 12

Cat III: 1

b) OALP VIII and IX Bid Rounds

The Indian government has recently initiated the eighth round of the Open Acreage Licensing Policy (OALP) bidding process, which was launched on the 7th of July 2022. This round offers ten blocks, out of which eight are located in offshore regions,

encompassing an area of approximately 34,364 square kilometers (offshore area ~32,118 sq. km.). Interested parties have until the 16th of May 2023 to submit their bids for the OALP Bid Round-VIII. The government intends to award the acreage area of around 34,364 sq. km in ten blocks under the OALP Bid Round-VIII by 2023-24.

OALP Bid Round-VIII

7
Basins

8
Blocks

32+
SKM area



c) Offshore Bid Round (OALP Bid Round-IX):

During the Investor outreach program held in Houston on October 10th, 2022, the Government launched the Mega OALP Bid Round IX. This bidding round offers 26

blocks, of which 23 are located offshore, covering a vast area of approximately 2.23 lakh Sq.km for Exploration and Development through International Competitive Bidding. These blocks are expected to be awarded to successful bidders by the year 2023-24.

Offshore Bid Round (OALP Bid Round-IX)

7
Basins

23
Blocks

219K+
SKM area

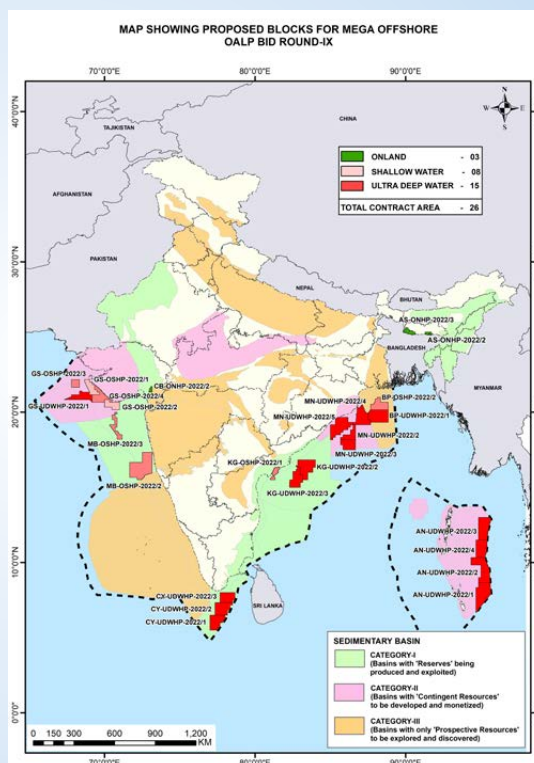


Table 5.8: List of Blocks on offer-OALP Bid Round IX

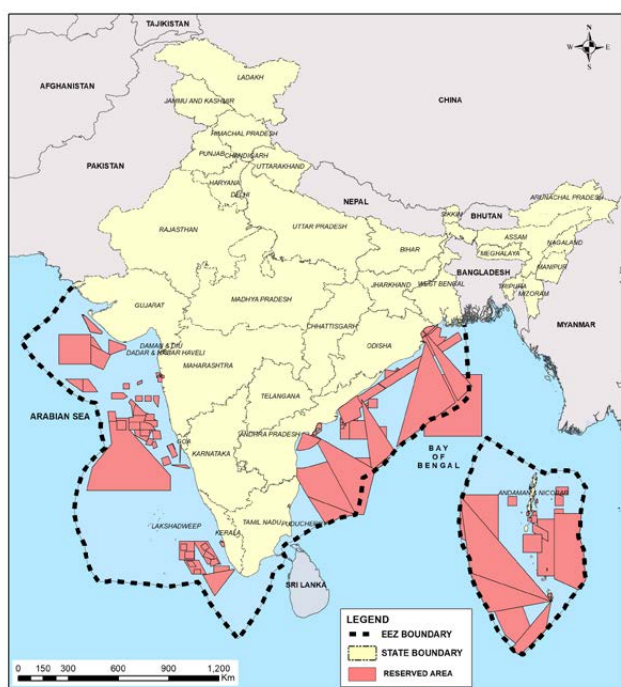
S. No.	Block Name	Area (sq. km)	Basin	Type of Block
Details of DGH Carved Out 18 Blocks				
1	KG-UDWHP-2022/2	12,610.14	Krishna-Godavari	Category-I
2	KG-UDWHP-2022/3	9,337.36	Krishna-Godavari	
3	MN-UDWHP-2022/2	5,520.09	Mahanadi	
4	MN-UDWHP-2022/3	7,169.14	Mahanadi	
5	MN-UDWHP-2022/4	10,657.20	Mahanadi	
6	MN-UDWHP-2022/5	14,157.23	Mahanadi	Category-II
7	GS-UDWHP-2022/1	7,381.27	Saurashtra	
8	AN-UDWHP-2022/1	15,744.97	Andaman-Nicobar	
9	AN-UDWHP-2022/2	14,928.09	Andaman-Nicobar	
10	AN-UDWHP-2022/3	12,531.53	Andaman-Nicobar	
11	AN-UDWHP-2022/4	9,894.62	Andaman-Nicobar	Category-III
12	BP-UDWHP-2022/1	12,353.38	Bengal-Purnea	
13	MB-OSHP-2022/2	22,377.31	Mumbai Offshore	Category-I
14	MB-OSHP-2022/3	5,195.56	Mumbai Offshore	
15	KG-OSHP-2022/1	2,797.19	Krishna-Godavari	
16	GS-OSHP-2022/3	3,050.87	Saurashtra	
17	GS-OSHP-2022/4	7,838.30	Saurashtra	
18	BP-OSHP-2022/2	7,626.47	Bengal-Purnea	Category-III

S. No.	Block Name	Area (sq. km)	Basin	Type of Block	
Details of 8 Blocks EoI Window -XIII					
19	CY-UDWHP-2022/1	9,514.63	Cauvery	Category-I	Ultra-Deep Water
20	CY-UDWHP-2022/2	9,844.72	Cauvery		
21	CY-UDWHP-2022/3	7,795.45	Cauvery		
22	CB-ONHP-2022/2	713.92	Cambay		Onland
23	AS-ONHP-2022/2	784.32	Assam Shelf		
24	AS-ONHP-2022/3	2,168.09	Assam Shelf		
25	GS-OSHP-2022/1	5,585.61	Saurashtra	Category-II	Shallow Water
26	GS-OSHP-2022/2	5,453.96	Saurashtra		
Total Area (sq. km)		223,031.42			

d) Reduction in 'No go' areas:

In a landmark decision, the Government of India has unlocked the Exclusive Economic Zone (EEZ) for exploration and development pursuits. Oil companies are now permitted

to engage in these activities across a staggering 99% of the EEZ, provided they adhere to established protocols and global practices.



Earlier No-Go Area



Present No-Go Area



DEVELOPMENT OF DSF FIELDS IN WESTERN OFFSHORE

**31 Offshore Blocks
(266 MMTOE
In-Place volume)
operational across 3
DSF rounds**

**26 MMTOE cumula-
tive production
expected from
offshore fields award-
ed in DSF I and II**

**Expected production from
offshore blocks in DSF III is
around 21,000 BOPD and
10.3 MMSCMD in next 3-4
years**



MAJOR DEVELOPMENT IN EASTERN OFFSHORE

**KG-DWN 98/2 Block
developed by ONGC**

Peak Production
Expected from
Cluster 2: Oil: 45,000
BOPD | Gas: 12.5
MMSCMD

**KG-DWN 98/3 Block
developed by RIL**

Production target by
FY-2024-25: Gas- 10.18
BCM, Oil- 0.182 MMBbl
Condensate-7.2 MMBbl

**D-55 (MJ Field)
developed by RIL Peak
production:**

Gas-12.2 MMSCMD &
Condensate-20000
BOPD



MAJOR DEVELOPMENT IN WESTERN OFFSHORE

Production from ONGC's Western Offshore
Assets- Oil: ~271000 BOPD; Gas: 43
MMSCMD

Offshore projects (field development, re-development, infrastructure) worth
INR 22K crores under implementation by ONGC







6

NEW INVESTMENT OPPORTUNITIES IN E&P BUSINESS

Introduction

The former policy regime for the exploration and production of oil and gas, known as the New Exploration Licensing Policy (NELP), had been in effect since 1999. The Production Sharing Contracts (PSCs) under NELP were based on the principle of "profit sharing", which required the government to exercise micro-management to control costs and maximize revenue. However, a host of operational issues emerged while administering these contracts under NELP, leading to disputes and arbitrations with the awardee contractors. These issues included the cost recovery limit, procurement issues, the methodology for calculating investment multiples, and the lack of incentives for operators to keep costs low, which had a negative impact on profit petroleum.

Additionally, separate policies and fiscal terms were formulated to administer the exploration and production of different types of

hydrocarbons, such as CBM, shale oil/gas, and conventional hydrocarbons. This fragmented policy framework resulted in inefficiencies in exploiting natural resources. Under NELP, exploration was restricted to blocks offered by the government, which limited access to lucrative opportunities in other untapped areas. To address these structural and functional issues, the government introduced a Revenue Sharing Contract Regime, which included several ground-breaking changes in policy.

6.1 Discovered Small Field Policy, 2015: India's Bold Move to Unlock Small Oil Fields

The Indian Government had introduced a new policy, referred to as the Discovered Small Field (DSF) Policy, 2015, to facilitate the development of small oil fields. This policy offers better fiscal terms, including the exemption of oil cess on crude oil production, moderate royalty

rates similar to those in the NELP regime, the elimination of upfront signature bonuses, pricing and marketing freedom for oil and gas, and no carried interest by National Oil Companies (NOCs). Consequently, this policy has significantly reduced the regulatory burden on operators.

The Marginal Field Policy, which was later renamed the Discovered Small Field (DSF) Policy, was approved by the Cabinet Committee on Economic Affairs (CCEA) on September 2, 2015, and was formally notified in a notification on October 14, 2015. The policy aims to enable previously un-monetized discoveries of National Oil Companies (NOCs) to be brought into production. The first DSF Round was launched on May 25, 2016.

Salient features of DSF Small Field Policy:

- 💧 Revenue Sharing Model
- 💧 Single license for Conventional & unconventional - conventional hydrocarbon
- 💧 No upfront Signature Bonus; Reduced royalty rate in-line with HELP; and no Cess.
- 💧 Full Marketing and Pricing Freedom for Gas produced.
- 💧 Exploration allowed during entire contract Period
- 💧 100% participation from foreign companies/joint ventures

Revolutionary Bid Rounds Under Discovered Small Field Policy, under Revenue Sharing Contract Regime

i. Discovered Small Field Bid Round-I (2016)

The launch of the DSF bid round in May 2016 was part of Hon'ble Prime Minister's overarching vision to reduce India's dependence on imported Oil and Gas.

The bid round offered 46 Contract Areas containing 67 fields across nine sedimentary basins for the exploration and extraction of oil and gas. These fields are estimated to hold an in-place reserve of 86 Million Metric Tonnes of oil and oil equivalent.

The Government of India signed the Revenue Sharing Contracts (RSC) with the successful awardees of the DSF Bid Round 2016 at New Delhi on March 27, 2017. The RSCs were signed for 30 Contract Areas, including 23 onland and 07 shallow offshore, comprising of 43 discoveries with a cumulative area of 776.8 SKM and an in-place reserve of 44.66 MMT (O+OEG).

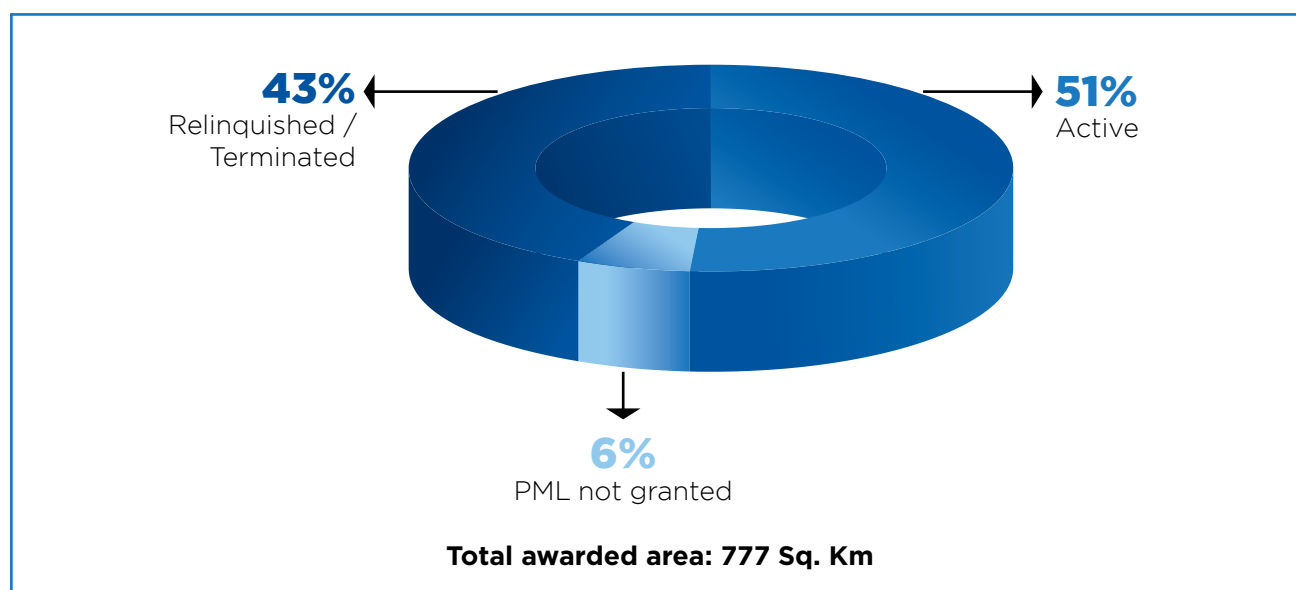
Key Highlights of DSF Bid Round-I:

- 💧 The bid round was concluded in a record time of 10 months, and the contracts were awarded in March 2017.
- 💧 The bidding process was transparent and conducted through an online bidding portal, with strong handholding support provided to bidders and investors.
- 💧 Prior technical experience was not a pre-qualification criterion.
- 💧 A total of 134 bids were received for 34 contract areas.
- 💧 Twenty-two companies, either singly or in consortium, were shortlisted for 31 contract areas. Of these 22 companies, 15 are new entrants to the E&P sector.
- 💧 Thirty contracts (23 onshore and 07 offshore) were successfully awarded.
- 💧 Twenty companies, either singly or in consortium, signed contracts.
- 💧 Thirteen of these companies were new entrants to the Indian E&P industry.



Table 6.1: Status of awarded Contract Areas (CAs) under DSF-I (as of 28th February 2023)

Basin	No. of Contract Areas (CAs)			Total
	Active	PML Awaited	Relinquished/ Terminated	
Assam- Arakan fold belt			2	2
Assam Shelf	5	1	1	7
Cambay	5		0	5
Cauvery		2	0	2
Krishna Godavari	3	1	1	5
Kutch			1	1
Mumbai	2		3	5
Rajasthan			2	2
Vindhyan			1	1
DSF-I Total	15	4	11	30

Figure 6.1: Acreage under DSF-I Bid Round as of 28th Feb 2023


ii. Discovered Small Field Bid Round-II (2018)

Following the successful implementation of DSF Bid Round I-2016, Government proceeded to extend the DSF Policy of 2015 for future DSF Bid Rounds in April 2018. This extension encompasses all the benefits of the original DSF Policy while reducing and aligning applicable royalty rates to the Hydrocarbon Exploration & Licensing Policy (HELP).

On 9th August 2018, DSF Bid Round-II was launched, offering 25 Contract Areas for International Competitive Bidding. This round covered 59 discovered oil and gas fields, occupying area of 3,042 Sq.kms, and boasting prospective resource base of 190 MMT (O+OEG).

Out of the total 145 e-bids received, 103 e-bids were received for onland contract areas, while 42 e-bids were received for

offshore contract areas. The bid round saw an impressive turnout of 40 companies, individually or as a member of the bidding consortium, including six foreign companies from countries such as the USA, UK, Australia, Singapore, and UAE.

This bid round was particularly remarkable, as it witnessed more participation than expected from new entrants from India and foreign countries. After a detailed evaluation process, 14 Companies (singly or in Consortium) were shortlisted for award in 23

Contract Areas. Out of these 14 Companies, eight are new entrants in the E&P Sector.

The DSF Round II was designed to provide industry professionals with an opportunity to invest in larger areas on offer in already discovered basins, thus offering investment opportunities at minimal risk. The DSF round-II process was conducted entirely digitally, offering a transparent, secure, and easy bidding process through a state-of-the-art e-bidding portal.

Key highlights of DSF Bid Round-II:

- 💧 A total of 145 bids were received for 24 Contract Areas, with no bids received for 01 contract area.
- 💧 A notable turnout of 40 companies, individually or as members of bidding consortiums, participated in the bidding process.
- 💧 Additionally, 6 foreign companies also participated in the bidding round, reflecting a significant international interest in the process.
- 💧 After a rigorous evaluation process, 14 companies, either individually or as consortiums, were shortlisted for award in 23 Contract Areas. Impressively, 8 of these companies were new entrants to the E&P Sector.
- 💧 As a result of the bidding round, a total of 23 Revenue Sharing Contracts, comprising 57 discoveries, were signed on March 7, 2019.
- 💧 Subsequently, an additional Revenue Sharing Contract was signed in January 2021 with the successful awardee company.

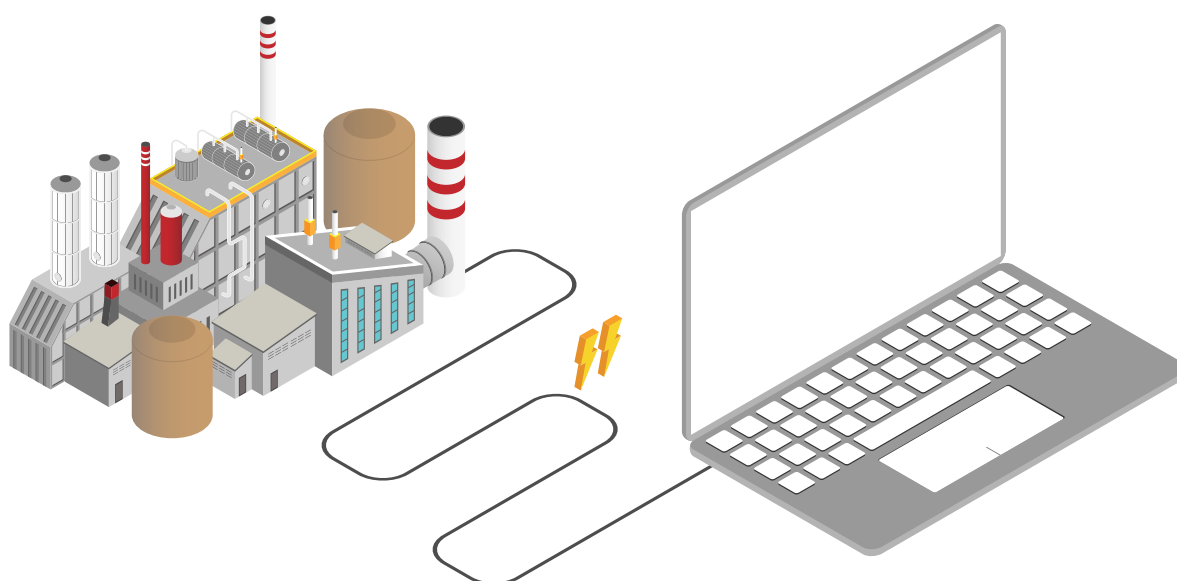
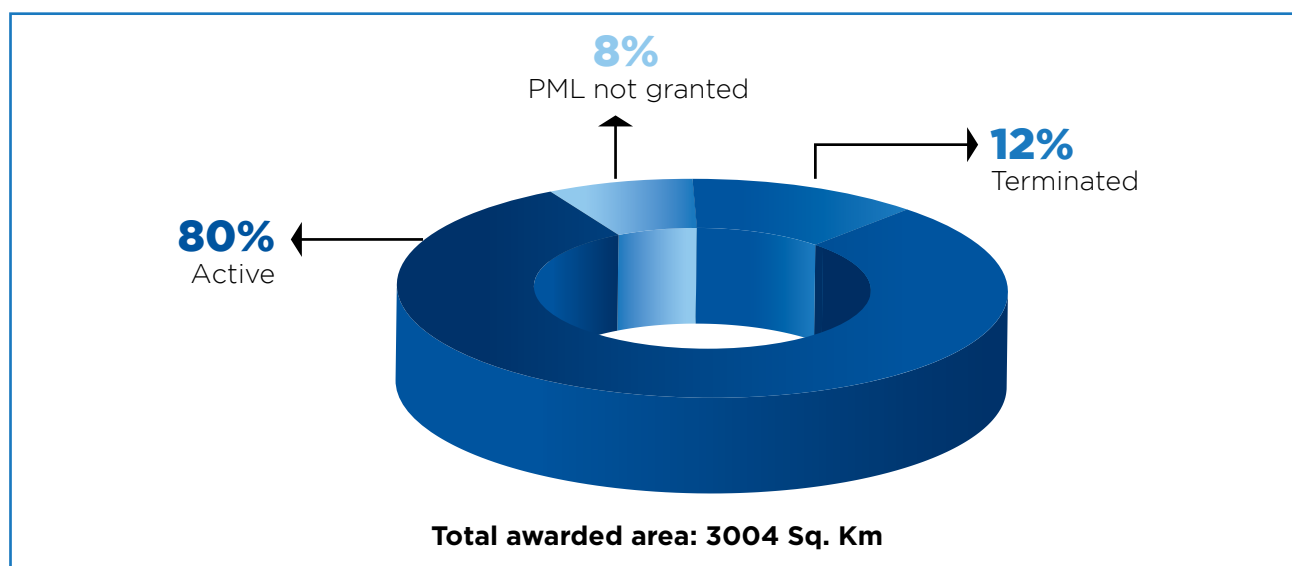


Table 6.2: Status of awarded Contract Areas (CAs) under DSF Round II (as of 28th February 2023)

Basin	No. of Contract Areas (CAs)			
	Active	PML not granted	Terminated	Total
Assam- Arakan fold belt	1			1
Assam Shelf	3		2	5
Bengal-Purnea	1			1
Cambay	1	1	2	4
Krishna Godavari	2	3	1	6
Mumbai	6			6
Rajasthan	1			1
Grand Total	15	4	5	24

Figure 6.2: Current Status of Acreages under DSF-II Bid Round



iii. Discovered Small Field Bid Round-III (2022)

In light of the success of the previous DSF Bid Round-I (2016) & DSF Bid Round-II (2018), coupled with numerous unexplored discoveries, the DSF-III bid round was

initiated on June 10, 2021. This round offers an impressive 32 Contract Areas, covering 75 discoveries, spanning more than 13,000 sq. km of acreage. The prognosticated resource base of this round is estimated at 232 MMTOE (O+OEG).

Feature	Previous Provision	Revised Provision
Biddable Parameter	Weightage: Biddable Work Program: 20% Govt. Revenue Share : 80% No HRP Ceiling	Weightage: Biddable Work Program: 50% Govt. Revenue Share : 50% HRP Upper Ceiling : 50%
Early Production	No Incentive	Incentivizing early commercial production during development period (Oil: Min of 5 US\$/bbl or Quoted LRP) (Gas: Min of 0.2 US\$/MMBtu or Quoted LRP)
Liquidated Damage (LD)	High LD in case of failing to meet Minimum Work Programme	75% reduction in LD amount
Exit Option	No Provision	Option to exit without LD Payment in case of delay in statutory clearances beyond 2 years

DSF Policy liberalised to attract Investors: Key Revisions

Key highlights of DSF Bid Round-III are as follows:

Enhanced Investor Confidence and Increased Participation: The DSF-III bid round saw a remarkable turnout of 107 bids for 32 Contract Areas, with the participation of 27 companies, of which 23 were private players. This increased participation has enhanced investor confidence in the sector.

New Entrants: Five new entrants, including two foreign companies, have entered the Indian E&P sector through this bidding round, demonstrating a growing international interest in the Indian hydrocarbon industry.

Hydrocarbon Potential: The early monetization of the 232 MMTOE hydrocarbon resource offered through this bid round is projected to contribute approximately 2 MMT & 8 BCM of oil and gas annually to domestic production in the next 3 to 5 years.

Move Towards Blue Economy: A noteworthy aspect of this bid round is that approximately 90% of the hydrocarbon resources offered are in the Indian offshore region, signaling a move towards a blue economy.

Attractive Terms: The terms offered in this bid round are particularly appealing, with the issuance of a PML letter alongside the contract signing and incentivization for early monetization, further encouraging investment in the sector.



Figure 6.3: Location-wise segregation of awarded blocks under DSF Round III

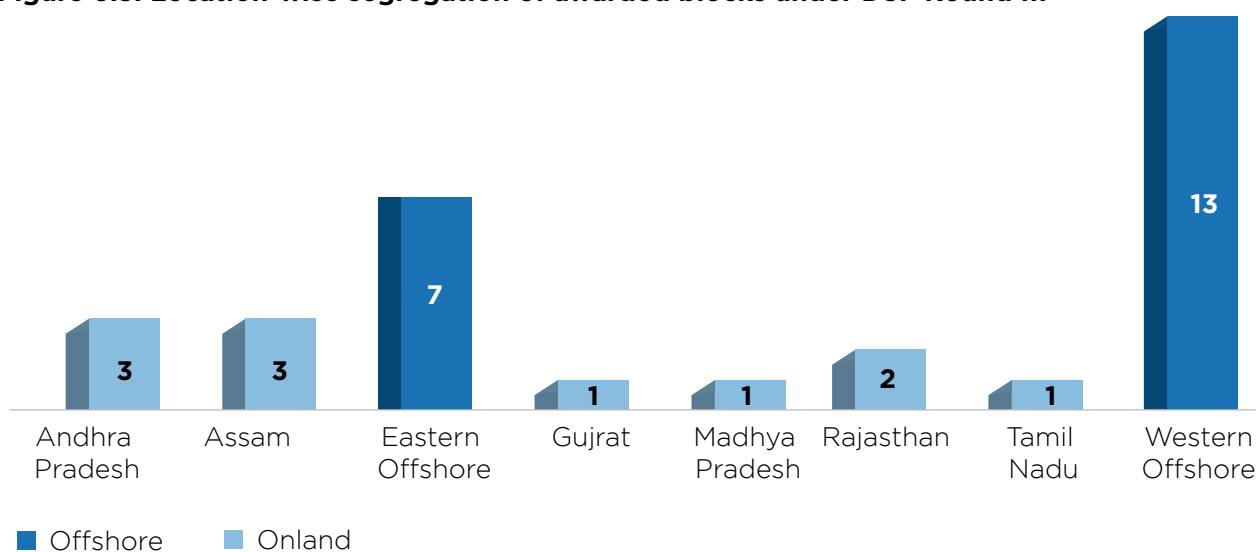


Table 6.3: Status of awarded Contract Areas (CAs) under DSF Round III (as of 28th February 2023)

Basin	No. of Contract Areas (CAs)			
	Active	PML Awaited	RSC not signed	Total
Assam- Arakan fold belt	2			2
Assam Shelf		1		1
Cambay	2	1		3
Cauvery		1		1
Krishna Godavari	5	5		10
Kutch	2	0		2
Mumbai	8	0	1	9
Rajasthan		2		2
Vindhyan		1		1
DSF - III Total	19	11	1	31



Table 6.4: Contract Areas Awarded under DSF-I, II & III by State/Location as of 28th Feb 2023

DSF Bid Round	State / Location	No. of CAs	Awarded Area in SKM					Grand Total
			Active	PML Awaited	Relin- quished	Termi- nated	RSC not signed	
DSF-I	Andhra Pradesh	4	24.7	9.9		9.4		44.0
	Arunachal Pradesh	1		16.5				16.5
	Assam	8	63.7	0.0	10.1	28.8		102.6
	Gujarat	5	41.1	0.0				41.1
	KG Offshore	1	24.2	0.0				24.2
	Kutch Offshore	1		0.0	46.0			46.0
	Madhya Pradesh	1		0.0	15.0			15.0
	Mumbai Offshore	5	239.0	0.0	124.0	80.3		443.3
	Rajasthan	2		0.0	23.7			23.7
	Tamil Nadu	2		20.4				20.4
	DSF-I (subtotal)	30	392.8	46.8	218.8	118.4	0.0	776.8
DSF-II	Andhra Pradesh	4	114.9	219.8				334.7
	Assam	5	104.0	0.0		63.3		167.3
	Gujarat	4	195.0	4.5		218.8		418.3
	KG Offshore	2	93.9	0.0		91.9		185.8
	Mahanadi Offshore	1	541.4	0.0				541.4
	Mumbai Offshore	6	1236.4	0.0				1236.4
	Rajasthan	1	73.0	0.0				73.0
	Tripura	1	47.2	0.0				47.2
	DSF-II (subtotal)	24	2405.9	224.3	0.0	374.0	0.0	3004.2
DSF-III	Andhra Pradesh	3		434.7				434.7
	Assam	3	590.8	21.4				612.2
	Cambay Offshore	2	801.2	0.0				801.2
	Gujarat	1		150.8				150.8
	KG Offshore	6	1241.5	19.7				1261.2
	KG Offshore (Deepwater)	1		203.9				203.9
	Kutch Offshore	2	2092.3	0.0				2092.3
	Madhya Pradesh	1		1471.7				1471.7
	Mumbai Offshore	9	4809.6	0.0			332.4	5142.0
	Rajasthan	2		94.0				94.0
	Tamil Nadu	1		463.3				463.3
	DSF-III (subtotal)	31	9535.4	2859.5	0.0	0.0	332.4	12727.3
Grand Total		85	12334.1	3130.5	218.8	492.4	332.4	16508.2



6.2 Hydrocarbon Exploration and Licencing Policy (HELP)

The Hydrocarbon Exploration Licensing Policy (HELP) replacing the erstwhile NELP policy and all CBM Policies was approved and notified in March 2016. Under the HELP, Open Acreage Licensing Programme (OALP) along with the National Data Repository (NDR) was launched in June 2017 as the key drivers for the acceleration of Exploration and Production activities in India.

The HELP was a paradigm shift from Cost Recovery to Revenue Sharing Mechanism and a giant step towards improving the 'Ease of Doing Business' in the Indian Exploration and Production (E&P) sector. It comes with attractive and liberal terms like reduced royalty rates, no oil cess, marketing and pricing freedom, round the year bidding, freedom to investors for carving out blocks of their interest, a single license to cover both conventional and unconventional hydrocarbon resources, exploration permission during the entire contract period, and an easy, transparent and swift bidding and awarding process.

In continuation to its determination for reduction in import dependency of oil and gas and accelerating E&P activities, Government notified the further policy reforms in upstream sector on 28th February, 2019 to increase exploration activities, attract domestic and foreign investment in unexplored/unallocated areas of sedimentary basins and promote ease of doing business by streamlining and expediting the approval processes. It was a paradigm shift in the core goal of the Government, moving from revenue maximization to production maximization, with focus on exploration.

6.2.1 Government has taken following Policy Initiatives pertaining to HELP in recent past

a. Early Monetization Policy: The Government notified 'Guidelines for Early Monetization of hydrocarbon discoveries under Production Sharing Contracts (PSCs) and Revenue Sharing Contracts (RSCs). These guidelines lay out the procedure for commencing commercial production from a Discovery during the Exploration phase of the Contract

period under the PSCs & RSCs. This would ensure rapid monetisation of Discoveries.

b. Simplification and Standardisation of RSC processes for OALP blocks: To promote Government of India's aim of facilitating Ease of Doing Business and improve efficiency, various RSC processes were extensively reviewed and categorised, so as to enable standardised compliances of different RSC processes. Guidelines in this regard have been issued by the Government for PSC blocks and are under process to be issued for OALP blocks.

c. Rationalisation of No-Go area for carrying out exploration activities: Recently, about 99% of the erstwhile 'No-Go' areas in EEZ have been released for E&P activities. Moreover, a Memorandum of Understanding (MoU) has been signed between DGH and ISRO for carrying out seismic activities in Andaman Nicobar Basin.

d. Amendment in SRF guidelines:

The Government relaxed the requirements of contribution towards Site Restoration Fund. Instead of contribution in the form of cash, operator may furnish Bank Guarantee up to certain limit of the obligations.

e. Simplification of bid documents for future OALP Rounds:

Simplification of model bid documents is under progress for future OALP bid rounds. The purpose is to bring in more ease of doing business in E&P sector and make bid documents globally competitive.

HELP is in line with GOI's policy of Minimum government, Maximum governance and Ease of doing business has received industry accolades for its target to minimize GOI's discretion in decision making, reduce administrative delays and stimulate development and growth in the E&P sector in India.

6.2.2 Status of OALP bidding rounds

a) Increases in Exploration Acreage

With the successful roll out of the HELP/OALP regime, based on the world-class National Data Repository (NDR), the Government has achieved massive enhancement of exploration acreage in India.

b) Summary of Participation

In seven rounds of bid under OALP, 139 blocks were on offer and 134 exploration blocks covering an area of 2,07,691 sq.

Km. were awarded to successful bidders. However, post relinquishment of seven blocks, 127 exploration blocks cover an area of 2,00,631 sq.km. 239 bids were received for remaining 134 blocks that are spread over 16 Sedimentary Basins.

During the last one year starting (from 1st March, 2022 up to 28th February, 2023), a total of twenty nine (29) blocks were awarded for a total area of approx. 51,112 sq.km. under the HELP.

Summary of participation in OALP rounds is as under:

Table 6.5: Summary of Participation in OALP Bid Rounds

OALP Round	Blocks on offer	Number of participant	No. of bids	Total	Area awarded (sq.km.)
OALP-I	55	9	110	59,282	59,282
OALP-II	14	8	33	29,233	29,233
OALP-III	23*	5	42	31,722	29,765
OALP-IV	7	2	8	18,510	18,510
OALP-V	11	3	12	19,789	19,789
OALP-VI	21	3	24	35,346	35,346
OALP-VII	8	4	10	15,766	15,766
Total	139		239	2,09,648	2,07,691

* No bid received for five CBM Blocks.

Overall area of 2,07,691 sq. km is splitted in to three categories of sedimentary basins in following way:

Table 6.6: Acreage Awarded by Basin Category under OALP

Category of Basin	Number of Blocks	Area (sq. km.)	% of area
Category-I	96	109871	52.9%
Category-II	26	72354	34.83%
Category-III	12	25466	12.26%
Grand Total	134	2,07,691	100%

c) Committed Exploration Work Programme and committed Investment

As on 13.03.2023, Investors of the 134 blocks in seven (7) rounds of OALP have committed

30,655 LKM of 2D Seismic Survey and 58,080 sq. km of 3D Seismic survey, 487 number of Exploratory wells, 290 core analysis to establish shale resources. However, post relinquished of seven blocks, Committed



Work Programme up to OALP Bid Round VII is 27,745 LKM of 2D Seismic, 56,443 sq. Km of 3D seismic 470 Exploratory Wells.

This will generate investment of approximately 3.13 USD billion over next 3/4 years.

Summary of Committed Work Programme and Investment is as under-

Table 6.7: Summary of Committed Work Programme & Investment

OALP Bid Round I ,II ,III, IV,V, VI and VII (Combined)					
Name of Company	2D Seismic (API) (in LKM)	3D Seismic (API) (in Sq. KM)	Number of Exploratory Wells	Core Analysis (no of wells for shale resources)	Investment (MMUSD)
Vedanta Limited	10620	22972	192	190	786
Oil India Limited	8455	5884	73	53	728
ONGC Limited	6220	24633	169	35	1444
RIL-BP	5000	1514	2	3	32
SunPetro	350	2063	37	0	94
BPRL	0	174	3	1	15
GAIL	0	292	3	1	10
HOEC	0	79	2	2	3
IOCL	10	469	6	5	24
Grand Total	30655	58079	487	290	3137

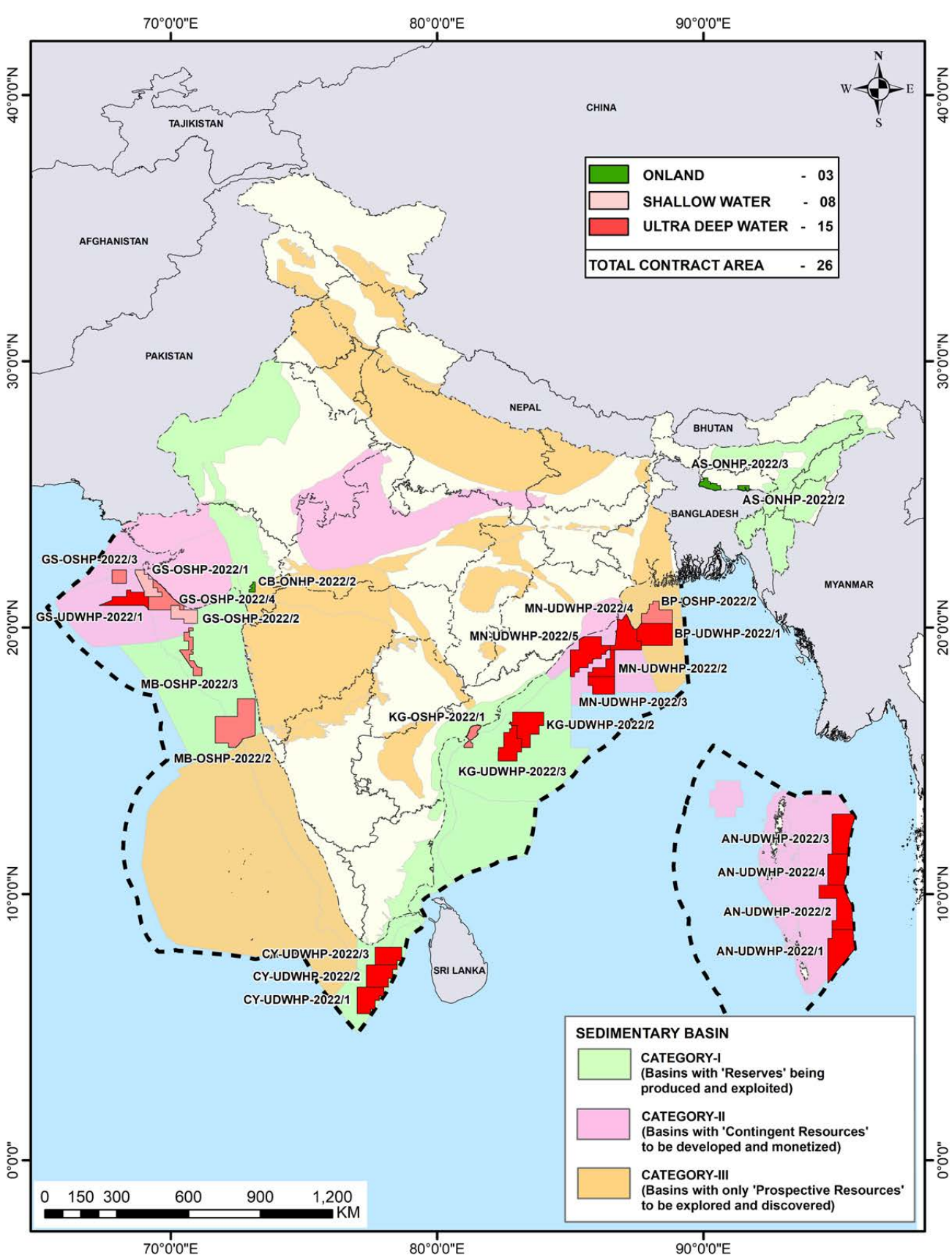
d) Status of current Bid Rounds and Expression of Interest (Eoi) Window

OALP Bid round-VIII and IX are underway. Round-VIII was launched on 07.07.2022 with 10 Blocks (8 offshore and 2 onshore) spread over 9 Sedimentary Basins, covering an area of 34,364 Sq. Km of area (onshore 2246 sq.km and offshore 32118 sq.km) and remains open till 30.03.2023. During the Investor outreach program at Houston on 10.10.2022, Government announced Mega OALP Bid Round-IX with 26 Blocks (23 offshore and 3 onshore) spread over 9 Sedimentary Basins covering an area of 2,23,031 Sq. Km of area (onshore 3,666 sq.km and offshore 219,365 Sq. Km), bid documents subsequent to

need based amendments will be released for OALP bid round-IX in due course. 12 Eols have been received till date during XIV window cycles.

The amendments in the bid documents for bid round VIII and IX is under progress. The objective of such amendments is to address the issues of existing operators which they are facing in existing contractual framework and to make them compatible for the needs of global E&P players so that the bid documents can be made globally competitive. Moreover amendments will bring in more ease of doing business in the upstream sector of India.

Figure 6.4: Map Showing Proposed Blocks for Mega Offshore OALP Bid Round-IX



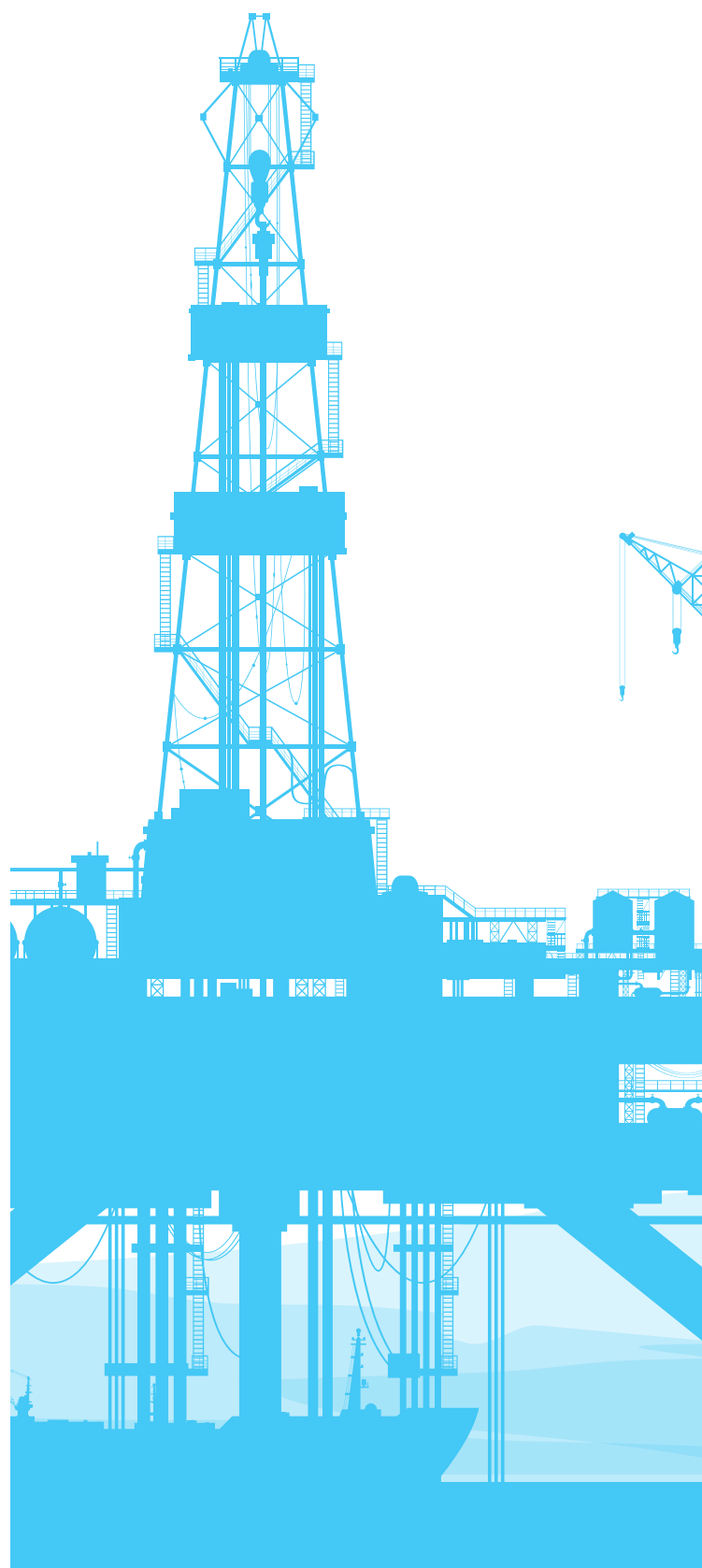
6.2.3 Actual Exploration Work Programme

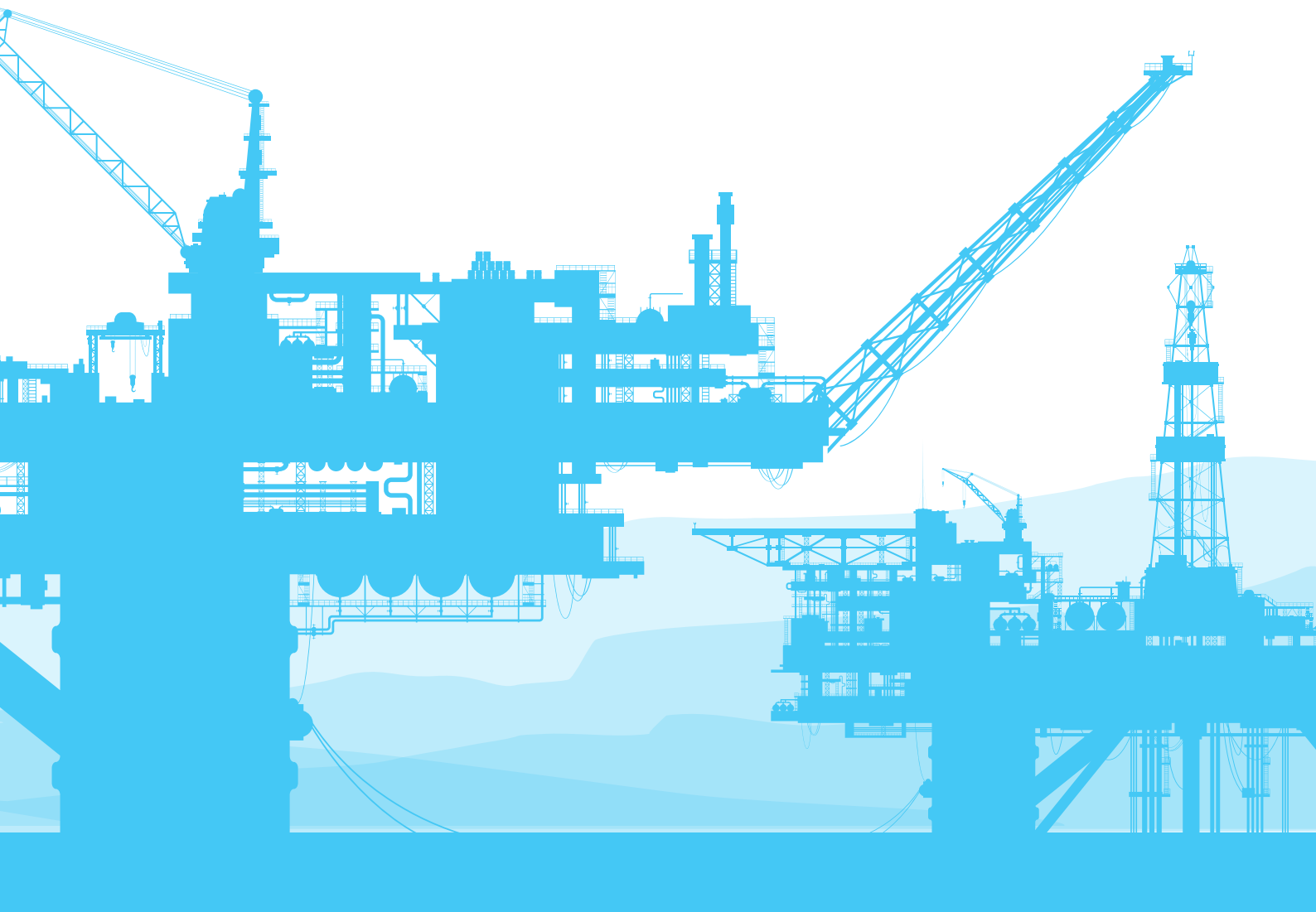
Exploration activities in these awarded blocks are progressing and ~29417 (reconciled Figure) LKM 2D Seismic Survey & ~24191 SKM 3D Seismic Survey completed, and 24 Wells have been drilled till 13.03.2023 since inception.

Table 6.8: Status of Actual Exploration Activities as of 13th Feb 2023

Basin	Acquired 2D Seismic (LKM)	Acquired 3D Seismic (SKM)
Andaman-Nicobar Basin	8501	2131
Assam Shelf Basin	2571	386
Assam-Arakan Fold Belt Basin	558	102
Bengal-Purnea Basin	100	701
Cambay Basin	1519	893
Cauvery Basin	0	1500
Kerala-Konkan Basin	0	1028
Krishna-Godavari Basin	431	1514
Kutch Basin	398	1358
Mahanadi Basin	2305	3586
Mumbai Offshore Basin	940	7711
Narmada Basin	0	0
Rajasthan Basin	10651	655
Saurashtra Basin	202	1288
Vindhyan Basin	1241	1339
Total	29417	24191

As of date, 5 discoveries (3 oil + 2 gas) have been made by M/s Vedanta (2 in Rajasthan and 2 in Cambay Basins) and ONGC (1 in Mumbai Offshore Basin). Oil Discoveries: KW2 Updip-1, Durga-1 & FB-1; Gas/Condensate Discovery: Jaya-1&MBS171HAA-A.







7

REALIZING UNTAPPED POTENTIAL OF UNCONVENTIONAL PETROLEUM RESOURCES

Unconventional resources exist in petroleum accumulations that are pervasive throughout a large area and are not significantly affected by hydrodynamic influences (also called “continuous-type deposit”). Usually, there is not an obvious structural or stratigraphic trap.

These include deposits like the coal bed methane (CBM), Shale gas/oil, Gas Hydrates etc. that lack the porosity and permeability of conventional reservoirs required to flow without stimulation at economic rates. Such accumulations require specialized extraction technology (e.g., dewatering of CBM, hydraulic fracturing, horizontal drilling etc.). The target volumes are larger.

The Government of India had mooted an array of policies since 1997 for the effective extraction and utilization of these resources. Background of the activities carried out in CBM, Shale Gas/Oil and Gas Hydrates in India shall be discussed in the subsequent sections.

7.1 Coal Bed Methane

Coal is a combustible, heterogeneous organic rock made up of organic and inorganic substances and is formed when dead plant matter decays into peat and is converted into coal by the heat and pressure of deep burial over millions of years, the process called Coalification. During the process of coalification or thermal maturation of coal beds, valuable quantities of hydrocarbon gas methane get accumulated, primarily in the adsorbed state.

There are four types of terms used to describe the methane emanating from coal beds:

- Coalbed Methane (CBM) or Coal Seam Gas (CSG)** - A generic term for the methane-rich gas naturally in coal seams typically comprising 80% to 90% methane with lower proportions of ethane, propane, nitrogen, and carbon dioxide. In international use,

this term refers to the methane recovered from unmined coal seams using surface boreholes.

- b. **Coal Mine Methane (CMM)** - Methane gas captured at working mine by underground methane drainage techniques. Any gas captured underground, whether drained in advance or after mining, and any gas drained from the surface of well is including in this definition.
- c. **Ventilation air methane (VAM)** - Methane emitted from coal seams that enters the ventilation air and are exhausted from the ventilation shaft at a low concentration, typically in the range of 0.1% to 1.0% by volume.
- d. **Abandoned Mine Methane (AMM)** - The methane gas recovered from abandoned coal mines

Coal, unlike conventional gas reservoirs, is both the reservoir rock and the source rock for methane. Due to the nature of occurrence, Coal Bed Methane (CBM) or Coal Seam Gas (CSG) is classified as unconventional source of natural gas.

India, having the fifth largest proven coal reserves in the world, presents a significant opportunity for considering CBM as an alternative source for augmenting India's energy resource, in line with the vision of reducing hydrocarbon import and moving towards gas-based economy.

7.1.1 CBM Policy Reforms

In order to harness CBM potential in the country,

India, having the fifth largest proven coal reserves in the world, presents a significant opportunity for considering CBM as an alternative source for augmenting India's energy resource, in line with the vision of reducing hydrocarbon import and moving towards gas-based economy.

the Government of India formulated CBM Policy in 1997, wherein CBM being Natural Gas is explored and exploited under the provisions of Oil Fields (Regulation and Development) Act 1948 (ORD Act 1948) and Petroleum & Natural Gas Rules 1959 (P&NG Rules 1959) administered by Ministry of Petroleum & Natural Gas (MoPNG).

• In 2007, CBM Phases & Extensions Policy was framed to provide a transparent and consistent framework for granting extension in exploration phases, under CBM Contracts.

• In 2015 (re-notified in 2018), the Government of India, granted permission to Coal India Limited (CIL) and its subsidiaries to explore and produce CBM from its areas under Coal Mining Lease allotted to them, thereby, dispensing the requirement of having additional License from Ministry of Petroleum and Natural Gas. This was formulated to increase the area under CBM exploration and to enhance and accelerate the CBM production in the country from Coal mining areas.

• In 2016, Unified Licensing Policy under Hydrocarbon Exploration and Licensing Policy (HELP) was introduced wherein all types of hydrocarbon resources, both conventional and unconventional were allowed to be explored and exploited. The Open Acreage Licensing Policy (OALP) to carry out exploration and production from areas which are either, free or relinquished and Discovered Small Field (DSF) Policy to exploit resources from already discovered fields are two such policies within the HELP regime.

• In 2017, a policy framework for Early Monetization of CBM was introduced to develop alternate sources of natural gas including CBM and promote gas economy. This policy was formulated to provide marketing and pricing freedom for Coal Bed Methane (CBM) and streamline the operational issues in the existing blocks.



- In 2018, the Government of India notified a Policy framework for Exploration and Exploitation of Unconventional hydrocarbons in existing acreages under existing Production Sharing Contracts (PSC), Coal Bed Methane (CBM) Contracts and Nomination fields.

7.1.2 Summary of CBM Bid Rounds

The Government of India formulated a CBM policy in 1997 and a Memorandum of Understanding (MoU) was signed between the Ministry of Coal and the Ministry of Petroleum and Natural Gas, to act in a co-operative manner for the development of CBM. As per the policy, Ministry of Petroleum & Natural Gas (MoPNG) became the administrative Ministry and Directorate General of Hydrocarbons (DGH) was made the nodal agency for development of CBM in the country.

MoC (Ministry of Coal MoC)/CMPDI (Central Mine Planning and Design Institute) carried out the study for the identification of prospective CBM areas out of coal-bearing areas in the country. Four (4) CBM Rounds were carried out from 2001 to 2008 wherein 30 CBM Blocks were awarded. In addition, 2 blocks were awarded on nomination basis and 1 under Foreign Investment Promotion Board Route in 2001. During this period (2001-2008), 16598 Sq Km area was offered for CBM exploration and production. These CBM blocks were in the states of Andhra Pradesh, Assam, Chhattisgarh, Gujarat, Jharkhand, Madhya Pradesh, Maharashtra, Odisha, Rajasthan, Tamil Nadu, and West Bengal.

The total prognosticated CBM resource for the awarded 33 CBM blocks, is about 62 TCF (1767 BCM), of which, 10.5 TCF (296.9 BCM) has been established as Gas-in-Place (GIP).

Further, in pursuit of the goal of energy security and to increase the gas share in the country's energy mix from the present 6% to 15% by 2030 GOI launched Special CBM bid round (SCBM-2021) in September 2021 with attractive fiscal and administrative terms and offered 15 CBM blocks with roughly 8,500 Sq. Km across 6 states under the Hydrocarbon Exploration Licensing Policy

through International Competitive Bidding. The prognosticated resource of these blocks is estimated at around 700 BCM. The SCBM-21 round concluded with the award of Four (4) Blocks of 3862 Sq Km in three (3) states.

Salient features of Special CBM Bid Round-2021:

- No Prior experience in the Oil/Gas sector was mandatory.
- 100% participation is allowed from foreign companies/joint ventures.
- All Blocks are in category-III Sedimentary basin i.e. no revenue sharing until windfall gain.
- Each Block was carved out in a single state for regulatory ease.
- Exploration allowed during the entire contract period.
- Single License for Conventional & Un-conventional Hydrocarbon
- No Overlap between existing/proposed Coal Blocks/mines.
- The Blocks were distributed across 6 states namely, Chhattisgarh, Jharkhand, Odisha, Madhya Pradesh, Maharashtra, and West Bengal.
- Expert Team to be appointed within 180 days after commencement of contract.
- Full marketing and pricing freedom for Gas produced.
- Net Worth includes Compulsory Convertible Debentures (CCD) in the Net worth Definition.
- Gas Pipeline infrastructure through GAIL Pradhan Mantri Urja Ganga Pipeline and availability of City Gas distribution network.

7.1.3 Status of the awarded CBM blocks

The first commercial production from the CBM blocks commenced in the year 2007 from the **Raniganj South** block operated by M/s. Great Eastern Energy Corp. Ltd. (GEECL). Thereafter three (3) more CBM Blocks, **Raniganj (East)** Operated by M/s. Essar Oil & Gas Exploration & Production Ltd (EOGEPL), **Sohagpur (West)** operated by M/s. Reliance Industries Ltd. (RIL) and **Bokaro** operated by M/s. Oil and Natural Gas Ltd. (ONGC) started its commercial production in 2016, 2017 & 2019 respectively. In addition to this incidental CBM gas is being produced during the testing of CBM wells in **Jharia** block operated by ONGC.

At present, the active acreage for CBM exploration & production is around 6200 Sq km, having peak production potential of 18 MMSCMD.

Twelve (12) CBM Blocks are under operation currently of which 4 are in exploration, 3 in development and 5 are in production stage. The cumulative CBM production as of 31st Dec 2022 is 5.6 BCM with average rate of 1.9 MMSCMD.

7.1.4 CBM Resources and Block Performances

The Gondwana sediments of eastern India host the bulk of India's coal reserves and all the current CBM-producing blocks. The majority of the best prospective areas for CBM development are found to be in eastern India, situated in the belt of Damodar-Koel valley and Son valley.

CBM's initial reserve & ultimate reserve has increased drastically since last 10 years. Taking 2008 as base year the initial reserve has increased approximately by 108% and ultimate reserve has increased approximately by 90%.

Table 7.1: Snapshot of CBM resources in India

Total CBM rounds completed	5
No. of CBM Blocks awarded in 5 rounds	37
Area covered under 37 blocks	20,460 Sq. Km
Estimated CBM Resource in Country	2600 BCM (91.8 TCF)
CBM Resources (from 33 Blocks)	1767.06 BCM (62.4 TCF)
Established CBM Reserves (GIP)	295 BCM (10.42 TCF)
Present Area for CBM Operations (12 Blocks)	6292 Sq. Km
Commercial Production commenced	Jul-07
Total No. of Wells drilled	1054
Avg. Gas Production (FY 2021-22)	1.9 MMSCMD
No. of CBM Blocks in Development/Production Phase	8
No. of CBM Blocks in Exploration	4
No. of CBM Blocks Under Relinquishment	13
No. of CBM Blocks Relinquished	11
No. of blocks under Arbitration	1
Annual CBM Production in FY 2022-23	512 MMSCM
Cumulative Production till FY 2022-23	5580 MMSCM

Data up to Dec-22



Table 7.2: State-wise distribution of CBM Resources in India

No.	STATE	Estimated CBM resources	Estimated CBM resources (IN TCF)	GIIP (in TCF)
1	Jharkhand	722.08	25.5	1.99
2	Rajasthan	359.62	12.7	0
3	Gujarat	351.13	12.4	0
4	Odisha	243.52	8.6	0
5	Chhattisgarh	240.69	8.5	0
6	Madhya Pradesh	218.04	7.7	3.64
7	West Bengal	218.04	7.7	4.85
8	Tamil Nadu	104.77	3.7	0
9	Telangana & Andhra Pradesh	99.11	3.5	0
10	Maharashtra	33.98	1.2	0
11	Northeast	8.50	0.3	0
Total CBM Resource		2599.48	91.8	10.48

*Conversion factor: 1 cubic metre = 35.3147 cubic feet

Table 7.3: Status of CBM Blocks

No.	Block	State	Present Area (SKM)	Contractor (PI%)	Contract signed on	Present Status
CBM BLOCKS OFFERED ON NOMINATION/FIPB ROUTE						
1	Raniganj (South)	West Bengal	210	GEECL (100)	31.05.2001	Production
2	Raniganj (North)	West Bengal	311.8	ONGC (74)-CIL (26)	06.02.2003	Development
3	Jharia	Jharkhand	67.1	ONGC (74)-CIL (26)	06.02.2003	Development/ Incidental production
CBM ROUND-I						
4	RG(East)-CBM-2001/I	West Bengal	500	EOGEPL (100)	26.07.2002	Production
5	SP(East)-CBM-2001/I	Madhya Pradesh	495	RIL (100)	26.07.2002	Development
6	SP(West)-CBM-2001/I	Madhya Pradesh	500	RIL (100)	26.07.2002	Production
7	BK-CBM-2001/I	Jharkhand	75	ONGC (80)-IOC (20)	26.07.2002	Production
8	NK-CBM-2001/I	Jharkhand	271.5	ONGC (55)-IOC (20)-PEPL (25)	26.07.2002	Development

No.	Block	State	Present Area (SKM)	Contractor (PI%)	Contract signed on	Present Status
CBM ROUND-II						
9	SH(N)-CBM-2003/II	Chhattisgarh	825	RIL (100)	06.02.2004	Relinquished
	Relinquished					
10	BS (1)-CBM-2003/II	Rajasthan	1045	RIL (100)	06.02.2004	Under relinquishment
11	BS (2)-CBM-2003/II	Rajasthan	1020	RIL (100)	06.02.2004	Under relinquishment
12	SK-CBM-2003/II	Jharkhand	70	ONGC (100)	06.02.2004	Under Relinquishment
13	NK(W)-CBM-2003/II	Jharkhand	267	ONGC (100)	06.02.2004	Relinquished
14	ST-CBM-2003/II	Madhya Pradesh	714	ONGC (100)	06.02.2004	Relinquished
15	WD-CBM-2003/II	Maharashtra	503	ONGC (100)	06.02.2004	Relinquished
16	BS (3)-CBM-2003/II	Gujrat	790	ONGC (70)- GSPC (30)	06.02.2004	Relinquished
CBM ROUND-III						
17	SP(N)-CBM-2005/III	Madhya Pradesh	609	R-Infra (55)- RNRL (45)	07.11.2006	Under Relinquishment
18	SR-CBM-2005/III	Madhya Pradesh	330	DIL (90)-Coal Gas (10)	07.11.2006	Under Relinquishment
19	RM-CBM-2005/III	Jharkhand	469	Dart Energy (35)-GAIL (35)- EIG (15)-TATA Power (15)	07.11.2006	Under Relinquishment
20	GV(N)-CBM-2005/III	Telangana	386	Coal Gas (10)-DIL (40)-Adinath (50)	07.11.2006	Relinquished
21	BB-CBM-2005/III	West Bengal	248	British Petroleum (100)	16.11.2006	Relinquished
22	MR-CBM-2005/III	Chhattisgarh	634	Dart Energy (35)-GAIL (35)- EIG (15)-TATA Power (15)	07.11.2006	Under relinquishment
23	TR-CBM-2005/III	Chhattisgarh	458	Dart Energy (35)-GAIL (35)- EIG (15)-TATA Power (15)	07.11.2006	Under relinquishment
24	BS (4)-CBM-2005/III	Rajasthan	1168	REL (45)-RNRL (45)-Geopetrol (10)	07.11.2006	Under Relinquishment

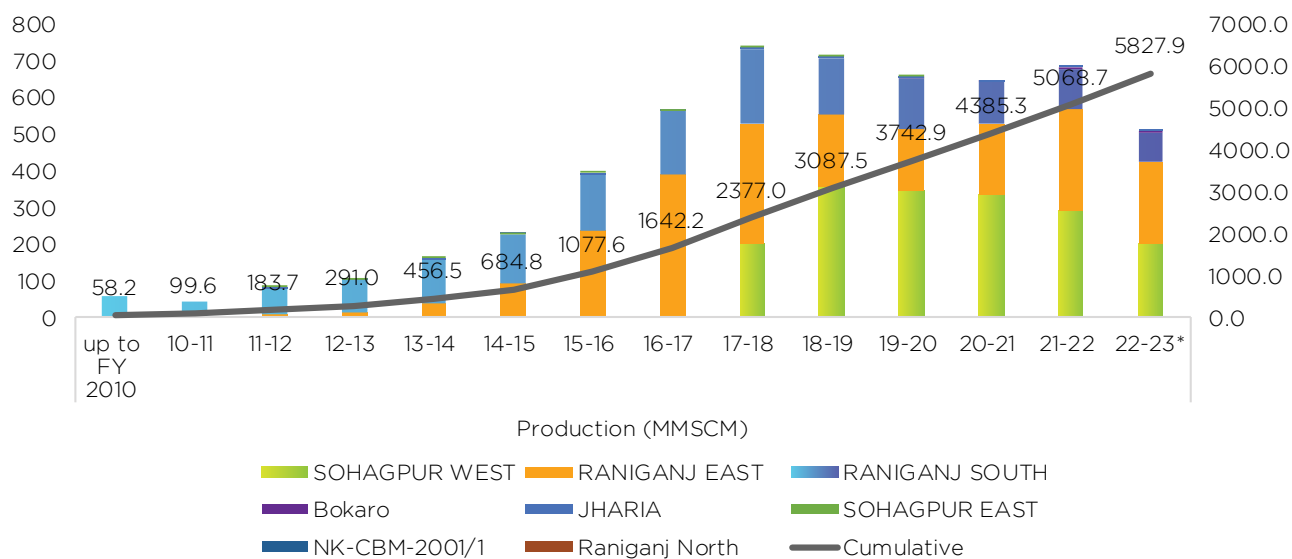


No.	Block	State	Present Area (SKM)	Contractor (PI%)	Contract signed on	Present Status
25	BS (5)-CBM-2005/III	Rajasthan	739	REL (45)-RNRL (45)-Geopetrol (10)	07.11.2006	Under Relinquishment
26	KG (E)-CBM-2005/III	Andhra Pradesh	735	REL (45) - RNRL (45) - Geopetrol (10)	07.11.2006	Relinquished
CBM ROUND-IV						
27	AS-CBM-2008/IV	Assam	113	Dart Energy (10)-OIL (90)	29.07.2010	Under Relinquishment
28	MG-CBM-2008/IV	Tamil Nadu	667	GEECL (100)	29.07.2010	Under Arbitration
29	RM(E)-CBM-2008/IV	Jharkhand	1128	EOGEPL (100)	29.07.2010	Under Relinquishment
30	TL-CBM-2008/IV	Odisha	557	EOGEPL (100)	29.07.2010	Relinquished
31	IB-CBM-2008/IV	Odisha	209	EOGEPL (100)	29.07.2010	Relinquished
32	SP(NE)-CBM-2008/IV	Madhya Pradesh & Chhattisgarh	339	EOGEPL (100)	29.07.2010	Under Relinquishment
33	ST-CBM-2008/IV	Madhya Pradesh	714	Dart Energy (80)-TATA Power (20)	29.07.2010	Relinquished
SPECIAL CBM BID ROUND-2021						
34	BP-ONHP (CBM)-2021/2	Jharkhand	991	ONGC	09.09.2022	PEL Awaited
35	SP-ONHP (CBM)-2021/1	Madhya Pradesh	1771.5	Invenire Petrodyne	09.09.2022	PEL Granted
36	SR-ONHP (CBM)-2021/5	Madhya Pradesh	515	ONGC	09.09.2022	PEL Granted
37	SR-ONHP (CBM)-2021/6	Chhattisgarh	584	Vedanta	09.09.2022	PEL Awaited

*PEL- Petroleum Exploration License, granted by respective State Governments



Figure 7.1: CBM Production trend (in MMSCM)



*Production data upto December 2022

7.1.5 Special CBM Bid Round 2022

In line with the vision of reducing hydrocarbon imports and inching towards Gas based economy, Government of India has launched another CBM

Round, Special CBM Bid Round-2022 (SCBM-22) under the same terms & Conditions as in Special CBM Bid Round-2021 to enhance the CBM acreage vis-à-vis the CBM production.



Salient Features



No revenue sharing until windfall gain.



Prior experience in Oil and Gas Sector NOT mandatory.



Full Marketing and Pricing Freedom for Gas produced.



Exploration allowed during entire contract period.



One Block in one State for administrative ease.



100% participation from foreign companies/Joint ventures.



Availability of Gas Pipeline infrastructure.



Single License for Conventional & Un-conventional Hydrocarbon



No overlap with existing/proposed Coal Blocks/Mines



Only work programme based bidding
Based on number of Core hole and Test well



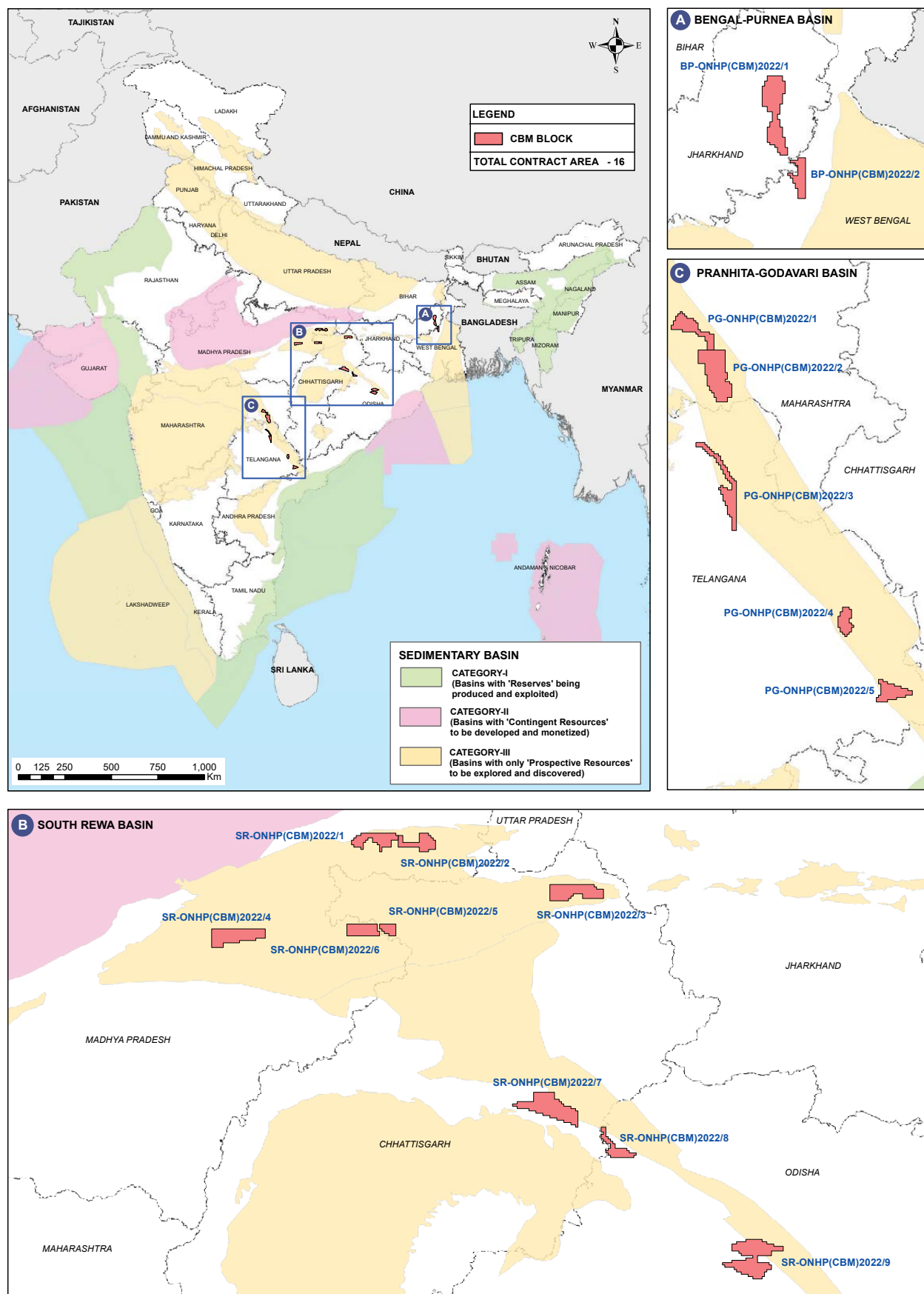
**Table 7.4: SCBM - 2022 Areas on Offer**

SL. NO.	BASIN	BLOCK	STATE	AREA (SQ.KM.)
1	BENGAL-	BP-ONHP(CBM)-2022/1	JHARKHAND	564
2	PURNEA	BP-ONHP(CBM)-2022/2	WEST BENGAL	197
3	PRANHITA- GODAVARI	PG-ONHP(CBM)-2022/1	MAHARASHTRA	331
4		PG-ONHP(CBM)-2022/2	MAHARASHTRA	709
5		PG-ONHP(CBM)-2022/3	TELANGANA	444
6		PG-ONHP(CBM)-2022/4	TELANGANA	195
7		PG-ONHP(CBM)-2022/5	TELANGANA	284
8	SOUTH REWA	SR-ONHP(CBM)-2022/1	MADHYA PRADESH	272
9		SR-ONHP(CBM)-2022/2	MADHYA PRADESH	222
10		SR-ONHP(CBM)-2022/3	CHHATTISGARH	408
11		SR-ONHP(CBM)-2022/4	MADHYA PRADESH	418
12		SR-ONHP(CBM)-2022/5	MADHYA PRADESH	211
13		SR-ONHP(CBM)-2022/6	CHHATTISGARH	88
14		SR-ONHP(CBM)-2022/7	CHHATTISGARH	590
15		SR-ONHP(CBM)-2022/8	ODISHA	191
16		SR-ONHP(CBM)-2022/9	ODISHA	693
Total			5817	

16 Coal Bed Methane (CBM) Blocks in 7 States



Figure 7.2: Blocks under Special CBM Bid Round-2022

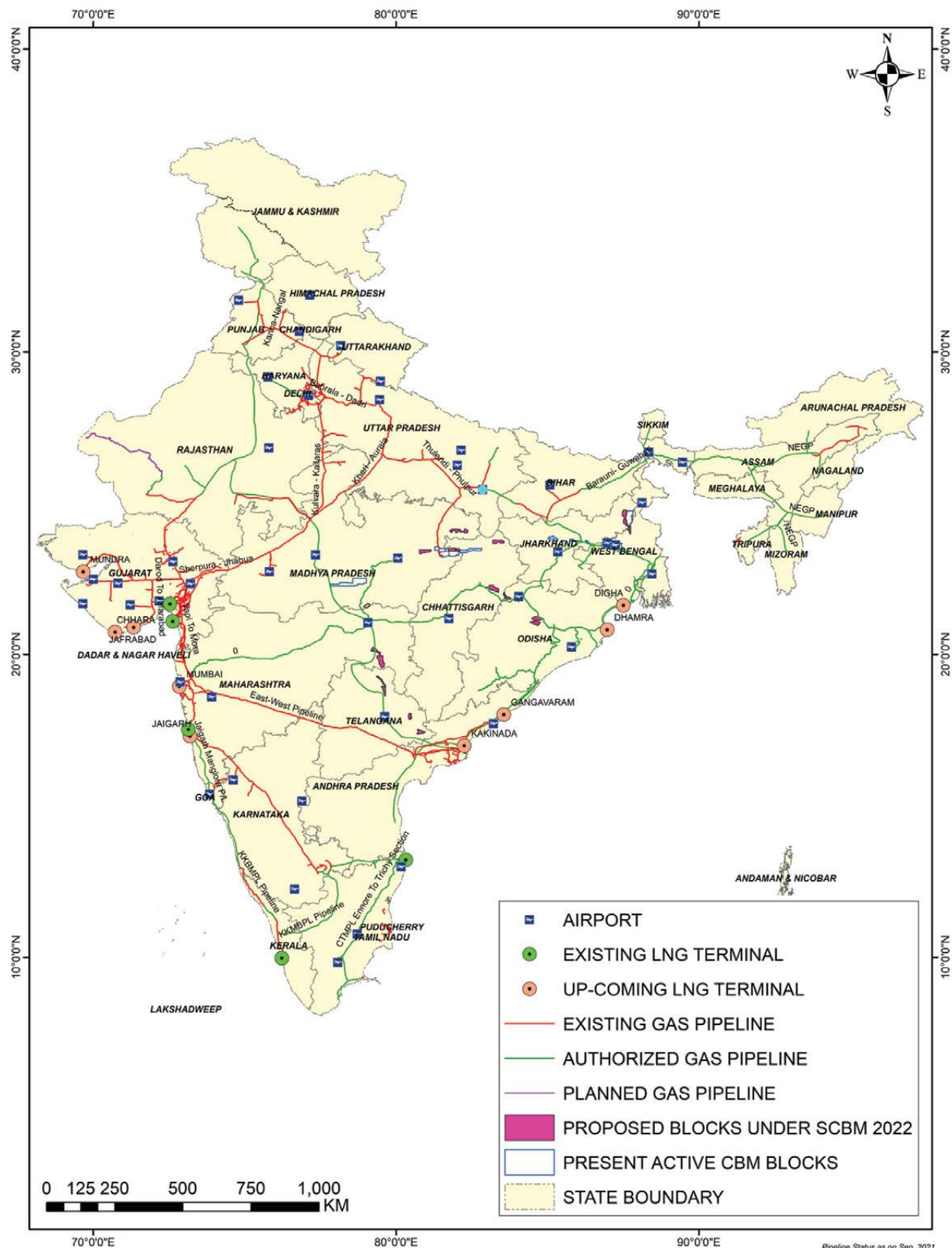


Prognosticated Resources ~500 BCM

Infrastructure availability for CBM Blocks

- Blocks well connected with Roads and Airports
- Gas evacuation infrastructure exists/planned near to the Blocks

Figure 7.3: Infrastructure availability for CBM Blocks



7.2 Shale Gas/Oil

Shale gas/oil is a form of natural gas/oil that remain unexpelled, unmigrated, and entrapped within the pore space and fractures of a source rock (commonly, shale). They are categorized as an unconventional resource due to their nature of occurrence and method of extraction. In general, shales have insufficient permeability (usually in Nano Darcy i.e. 10^{-9} D) for fluid flow to a well bore.

The shale gas/oil is produced commercially when sufficient fracture conductivity is induced by hydraulic fracturing.

In contrast to conventional play exploration where the risk profile is governed by the presence and effectiveness of source, reservoir, trap, timing, and migration of hydrocarbon, shale gas/oil exploration has a much different and usually more predictable risk profile. The gas shale itself contains all of the elements of petroleum risk as mentioned.

The producibility of shale gas is not just limited to a single prospect but to a larger geographic region. Thus, in a proven shale play, the challenge is to develop the proper drilling and completion techniques to optimize the gas production rate versus capital employed and operating costs.

In India, a preliminary resource assessment of Shale gas/oil was carried out by three different organizations.

In 2011, the United States Geological Survey (USGS) estimated the technically recoverable Shale gas/oil as 6.1 TCF for 3 basins: Cambay, Krishna-Godavari (KG), and Cauvery. Again in 2014, it estimated a technically recoverable volume of 62 million barrels of shale oil in Cambay Basin alone.

In 2013, the National Oil Company, ONGC estimated Shale Gas resources of 187.5 TCF from 5 sedimentary basins: Cambay, KG, Cauvery, Ganga, and Assam.

CMPDI in July 2013 had estimated around 45.8 TCF in the Gondwana basin.

In order to understand the prospectivity and untap the Shale Gas and Oil resource potential in India, GoI announced a Shale gas and Oil exploration policy on 14th October 2013 for the National Oil Companies (NOCs), ONGC, and OIL. The companies were required to carry out exploration in their PML and ML areas in three phases.

7.2.1 Shale Gas/Oil Policy Reforms

In addition to the policies notified in 2016 (HELP) and 2018 (Unconventional), in Oct 2018, a policy framework to promote and incentivize Enhanced Recovery Methods for Oil and Gas was notified by the Ministry of Petroleum and Natural Gas, Government of India.

Under this policy, fiscal incentives are provided from the first day of the entire production from future discoveries of unconventional hydrocarbons (Shale Gas/Oil and Gas Hydrate). Many CBM operators have shown interest for exploiting the Shale Gas Resources in their region.

7.2.2 Summary of Shale Gas/Oil Activities in India

Under the Shale Gas Policy - 2013, 50 blocks in 4 basins; Assam, Krishna Godavari, Cauvery & Cambay were identified by ONGC, and 6 blocks in 2 basins; Jaisalmer and Assam were identified by OIL in the Phase-I of exploration which ended in April-2017.

Table 7.5: Basin-wise work carried out by ONGC in its nomination areas:

Basin	Phase-I Blocks	Blocks Taken up for Drilling	Actual Wells Drilled
Cambay	28	16	17
KG	10	6	8
Cauvery	9	1	3
Assam	3	2	2
Total	50	25	30

Table 7.6: Basin-wise work carried out by OIL in its nomination areas

Basin	Phase-I Blocks	Blocks Taken up for Drilling	Actual Wells Drilled
Jaisalmer	1	1	1
Assam	5	0	3
Total	6	1	4

SCBM 2022: Promotional Events

Industry interaction cum promotional events on Special Coal Bed Methane Bid Round – 2022 were held at Bhopal, Nagpur, Raipur, and Hyderabad. The participation was from State Government departments like industries, Mineral Resources Department, Power generation companies like NTPC, Jindal Steel & Power Limited and Shri Bajrang Power, E&P Operators ONGC, Essar, RIL, OIL, Vedanta, and GEECL, mining groups like Megha Engineering, Vajra Granites, SCCL among others.

It was informed during the meet by DGH that the offering under SCBM-22 is designed in a way to boost the Investor's confidence. The terms and conditions are highly investor friendly like no prior experience in Oil & Gas is mandatory, Operator is not to share any revenue with GOI till windfall gain, each Block falls within a single state for administrative ease, and single License for Conventional & unconventional, full Marketing and Pricing Freedom for Gas produced, etc. It was also

conveyed that Geoscientific Data for Blocks on offer is being showcased through National Data Repository's (NDR) data rooms with interpretation facilities which would assist the potential bidders in making informed decisions.

Representatives of the Industries and State department conveyed the messages that State Governments in pursuant to 'Investor Friendly Environment' are focused to create and improve ease of doing business in the State. This is being facilitated by providing accelerated and time-bound grants of various licenses, permissions & approvals, promoting industrial development and facilitating new investments as well as by simplifying the regulatory framework by reducing procedural requirements and rationalizing documents. It was also emphasized that CBM is the need of the hour as a clean energy source to fuel the economy and support the vision of Atmanirbhar Bharat.





8

EASE OF DOING BUSINESS -EXPEDITING CLEARANCES FOR E&P OPERATIONS

Background

“Sustainability refers to the ability of a society, ecosystem, or any such ongoing system to continue functioning into the indefinite future without being forced into decline through exhaustion of key resources.”

Sustainable development broadly refers to a mode of human development in which resource use aims to meet human needs while ensuring the sustainability of natural systems and the environment so that these needs can be met not only in the present, but also for generations to come.

The term “sustainable development” was used by the Brundtland Commission, which coined what has become the most often-quoted definition of sustainable development: “development that meets the needs of the present without

compromising the ability of future generations to meet their own needs”.

The protection and preservation of the environment is integral to the culture and religion of most human communities. Misuse of our natural resources, a key environmental issue, has direct impact on fundamental human rights such as the right to food, right to water, right to air, and right to life itself.

It is important to draw linkages between environment and human rights to further build bridges between legislations relating to the two.

The relationship we share with our environment is undergoing profound changes in the wake of modern scientific and technological developments.

With the above backdrop in place, the oil and gas industry has been playing a vital role in the

development of the Indian economy as well as being a crucial sector among the eight core industries of India.

Before beginning exploration and production activities, contractors or operators of oil and gas blocks must get statutory permits and approvals from various State and central government bodies. Petroleum Exploration License (PEL), Petroleum Mining Lease (PML), environmental clearances such as -- environment clearance, forest clearance, wildlife clearance and so on, clearances from the Ministry of Defence, clearance from the Department of Space, Consent to Establish (CTE), Consent to Operate (CTO), and many others are among the clearances and approvals.

Delays in acquiring such clearances and approvals have an impact on the overall timelines and progress of exploration and production projects.

Environmental clearances are an important part of the upstream exploration and production (E&P) oil and gas sector, as they are required to ensure that oil and gas activities do not cause undue harm to the environment.

The following premises reinforce the necessity of grant of environment-related clearances in upstream exploration and production oil and gas industry:

1. **Compliance with environmental laws and regulations:** Governments have established various environmental laws and regulations to protect the environment and prevent environmental degradation. Obtaining environmental clearances ensures that the E&P activities of the O&G industry are in compliance with these laws and regulations.
2. **Identification of potential environmental impacts:** Environmental clearances require a thorough EIA (environmental impact assessment) of the proposed exploration and production activities. The EIA identifies potential environmental impacts and outlines measures to mitigate them.

3. **Protection of sensitive habitats and species:** E&P activities can have significant impacts on sensitive habitats and species. Environmental clearances ensure that these habitats and species are protected by requiring measures to minimize impacts.
4. **Public participation and transparency:** Environmental clearances often involve a public participation process, where the public can provide feedback and raise concerns about the proposed activities. This process ensures transparency and allows for incorporation of public concerns into the project design.
5. **Risk Management:** E&P activities in the O&G industry involve significant risks, including the risk of spills, leaks, and other accidents. Environmental clearances require risk assessments and mitigation measures to minimize these risks.

Regulatory Compliance of environmental legislations for Oil and Gas E&P Operators:

For oil and gas companies, regulatory compliance is a multi-faceted process and project proponents need to comply with regulations notified from central and state appraising and approving authorities.

The DGH has endeavoured to expedite the timely issuance of licence and clearances by implementing the following measures:

1. Comprehending the shortcomings in the processes for streamlining the procedures.
2. Adopting frequent communication channels with the competent authorities at all levels responsible for granting clearances.
3. Working out way forward, while ensuring the compliances to the existing rules for early clearances by rigorous follow-ups and pursuance by the officials, especially members of NECC.

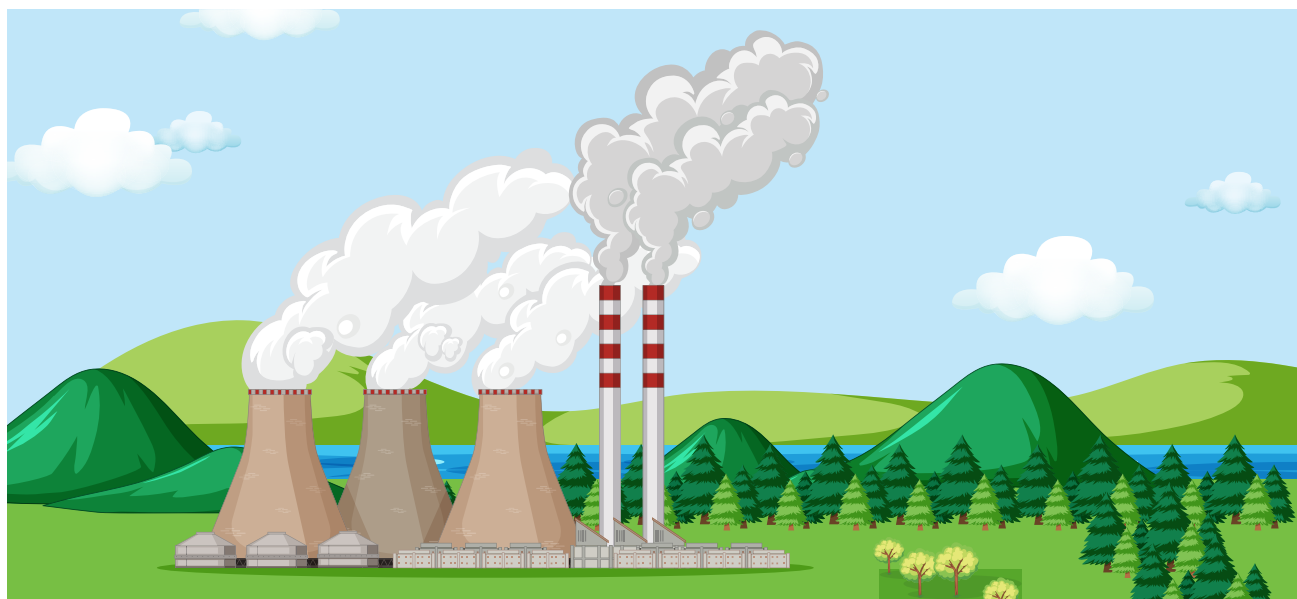


The Directorate General of Hydrocarbons (DGH), has implemented a variety of measures to facilitate and expedite the issuance of clearances related to the environment. These measures include the issuance of Environmental Clearances, Forest Clearances and Coastal Zone Clearances to E&P operators.

A slew of initiatives has been taken up by DGH, since 2019, in collaboration with the Ministry

of Environment, Forest and Climate Change in a bid to streamline and fast track the grant of environment-related clearances.

The efforts made by DGH and the probable outcomes of the same in terms of policy/guideline-making are detailed below in a chronological fashion for ease of comprehension. Further, the policy changes are being categorised according to the types of clearances obtained:



8.1 Environment Clearance:

8.1.1 Year 2019:

May 2019: Streamlining Grant of Approvals for Oil Exploration:

A Committee headed by Vice-chairman, NITI Aayog and comprising of Cabinet Secretary, Chief Executive Officer, NITI Aayog, Secretary, Ministry of Petroleum and Natural Gas, Secretary, Department of Economic Affairs and Chairman & Managing Director of Oil and Natural Gas Corporation was constituted in October, 2018 for suggesting reforms in Exploration & Production (E&P) Sector to enhance domestic Oil & Gas Exploration and Production. The Committee, in

A slew of initiatives has been taken up by DGH in collaboration with the Ministry of Environment, Forest and Climate Change in a bid to streamline and fast track the grant of environment-related clearances.

its report inter-alia recommended constitution of an Empowered Coordination Committee (ECC) under the chairmanship of Cabinet Secretary for streamlining and expediting grant of approval/clearances.

Empowered Coordination Committee (ECC) was constituted in May, 2019 under the Chairmanship of Cabinet Secretary, for considering matters relating to delay in granting various clearances, approvals etc.

Pursuant to the ECC meetings, following steps have been taken:

- I. Petroleum Exploration Licenses (PELs) have been granted in all Blocks awarded under Open Acreage Licensing Policy Round-I in the states of Assam, Madhya Pradesh, Gujarat & some blocks of Arunachal Pradesh,
- II. Petroleum Mining Leases have been granted for many Discovered Small Fields and Nomination blocks in Assam, Tripura, Gujarat and Andhra Pradesh,

- III. Ministry of Defence and Department of Space have agreed to grant additional area for exploration,
- IV. Notification of Eco Sensitive Zone (ESZ) has already been issued around 16 protected areas.

8.1.2 Year 2020

January 2020: Exemption of exploratory drilling from purview of EIA Notification, 2006:

MoEF&CC vide notification dated 16th January, 2020 categorized onshore and offshore oil and gas exploration activities as B2 category for seeking priority Environment Clearance (EC), i.e., Exploration Surveys (not involving drilling operations).

Gol categorizes onshore and offshore oil and gas exploration activities as category B2 for green clearance.

As exploration activities in hydrocarbon sector have been moved from Category A to Category B2, will now require environmental clearance only from the States concerned and will not require preparation of an EIA report or conduct of Public Hearing. However, Development or Production, both on offshore /onshore fields as hydrocarbon blocks, will continue to merit assessment as "category A".

This has been an achievement from upstream O&G industry perspective as B2 projects are exempted for conducting EIA studies and also from holding Public Hearings. Further, Scoping stage (ToR) is not required for B2 projects.

B2 projects are typically those that are expected to have moderate adverse impacts on the

environment and local communities, but these impacts can be mitigated through appropriate measures. B2 projects do not require a detailed EIA report.

The prior EC process for Category 'B2' projects/activities will comprise:

Stage-1: Appraisal

Stage-2: Grant or Rejection of Prior EC

March 2020: Permission for Use of Secondary Data

EIA notification is applicable up to 12 NM and MoEF&CC has taken a view that projects located in offshore areas beyond 12 NM are not covered under EC. This has enabled the upstream E&P oil and gas companies to use secondary data as the baseline data beyond 12 NM.

8.1.3 Year 2021

March 2021: Streamlining EDS

MoEF&CC vide OM dated 15th march 2021, attempted to streamline the process of granting Environment Clearances with regard to Essential Details Sought (EDS) by placing a ceiling of 30 days after which the MoEF&CC shall exclude the proposal from the pendency list.

This issue had been pursued by DGH since long and has given a respite in terms of breaking the deadlock between the E&P Operators and the Ministry in terms of movement of the proposal.

May 2021: Guidelines for Environmental Impact Assessment Studies on Petroleum Exploration and Developmental Projects in Offshore Areas beyond 12 Nautical Miles.

In a bid to increase India's hydrocarbon exploration and production (E&P) footprint to address the rising energy demand, areas are being considered for auctioning/bidding purposes. The MoEF&CC has issued guidelines for operating within 12 NM in offshore areas. DGH endeavoured to formulate guidelines and the best practices to operate in the areas beyond 12 NM in offshore areas, by utilizing the services of CSIR-NIO. NIO has prepared a ready reckoner/handbook on the same to facilitate the E&P operators in the entire hydrocarbon block cycle of exploration, drilling, development, production and site restoration.



December 2021: Streamlining EC Transfer, Application for B2 Projects

MoEF&CC vide OM dated 10th December 2021 clarified the procedure for handling EC transfer cases as per the provisions of S.O. 2817 (E) dtd 13th July 2021.

Wrt the above, a provision has been made that the prior EC vested with the previous lessee shall be deemed to have been transferred during its validity period in terms of the MMDR Act, 1957 to the successful bidder of the mining leases, from the date of commencement of new lease for the remaining validity period. The provision is also subject to the new lessee registering online on PARIVESH portal along with an undertaking to comply with all the conditions of the transferred EC.

This has eased out the process of EC transfer from one project proponent to another.

15th December 2021:

EC application form for B2 projects was released by MoEF&CC to enable them to fill in the application.

Upstream industry is supposed to fill Form-2 on PARIVESH in case the proponents are going for an exploration surveys.

8.1.4 Year 2022

April 2022: Streamlining Composite Clearance

Composite Clearance (Category A) for Exploration, Development and Production under Schedule to EIA Notification 2020: MoEF&CC vide OM dated 26.04.2022 notified that any project that requires EC under Category 'A' require to

For the projects which involve forest land and require Stage-I and Stage-II FC under the provisions of the FCA, 1980, the validity period of the prior EC granted [after Stage-I FC], shall be reckoned from the date of grant of Stage-II FC, or a maximum period of two (02) years, whichever is less.

proceed through the following channels:

Application at CZMA by PP Recommendation of CZMA Application for EC+CRZ at concerned sector of the IA division of Ministry Comments of CRZ sector in the Ministry Recommendation of Sectoral EAC for EC+CRZ Combined Clearance by Ministry (EC+CRZ)

However, if any project is located in CRZ area that requires EC under Category 'B', then the approving authority shall be SEIAA and the clearance shall be routed as illustrated below:

Application at Coastal Zone Management Authority (CZM) by the PP Recommendation of CZMA Application in the concerned SEIAA Recommendation of SEAC for EC & CRZ Clearance by SEIAA (EC & CRZ).

May 2022: Rationalization of Validity of EC

The Hon'ble Supreme Court judgment in W.P. (C) No. 202 of 1995 in the Lafarge case pronounced inter-alia that the EC in respect of projects involving forest land will be granted after the project proponent obtains Stage-I Forest Clearance (FC) in respect of the forest land involved in the project, so that fait accompli situation does not arise. Inline with the directions of the Hon'ble Supreme Court, the Ministry grants EC only after the grant of Stage-I FC, even while the projects/activities get appraised in anticipation of grant of FC.

As per the provisions of FCA, 1980, the FC for the forest land is granted in two stages, i.e.,

In-principle or Stage-I approval

Stage-II approval (on compliance of the conditions of Stage-I approval).

The project proponent can start the work at site only after getting the Stage-II FC in addition to the other statutory permissions/approvals under the various Acts/Rules.

It was analysed that FC approval used to incur inordinate delays. The MoEF&CC rationalised the impact of the time taken in obtaining Stage-II FC, on the validity of EC. In this context, it was decided that the time taken for obtaining Stage-II FC, after the grant of EC, may not be considered as a part of the EC validity upto a maximum of two (02) years, so as not to compromise with the environmental safeguards.

Therefore, the MoEF&CC clarified that for the projects which involve forest land and require Stage-I and Stage-II FC under the provisions of the FCA, 1980, the validity period of the prior EC granted [after Stage-I FC], shall be reckoned from the date of grant of Stage-II FC, or a maximum period of two (02) years, whichever is less.

May 2022: Extension of Validity of EC, Simplifying Public Hearings

EC Validity:

The GoI has extended the tenure of Environmental Clearances (EC) granted for existing or new projects. Hydrocarbon Projects would now have a valid EC for a period of ten (10) years.

A provision for one (01) year extension has also been incorporated.

Easing out of Public Hearing process:

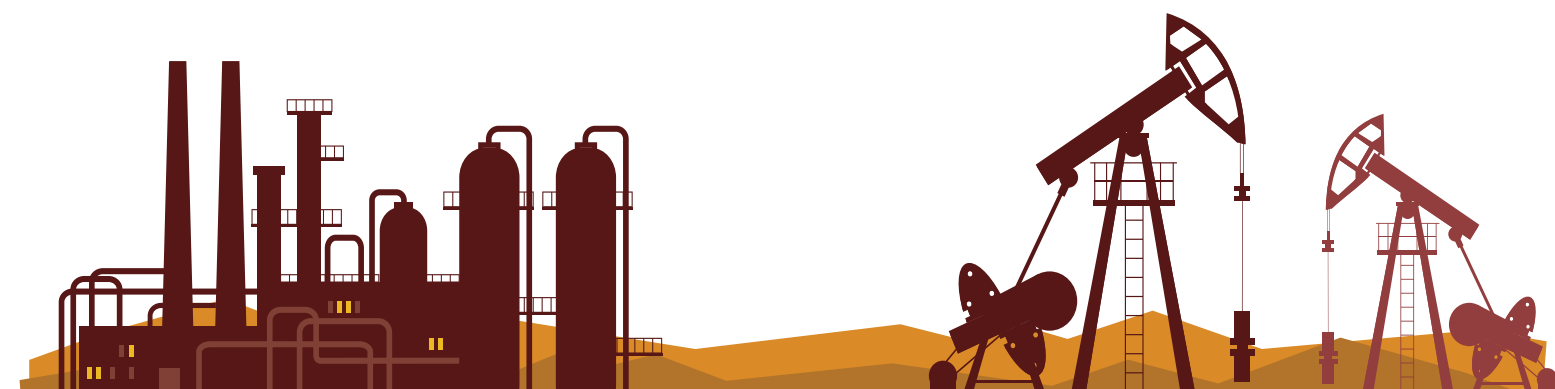
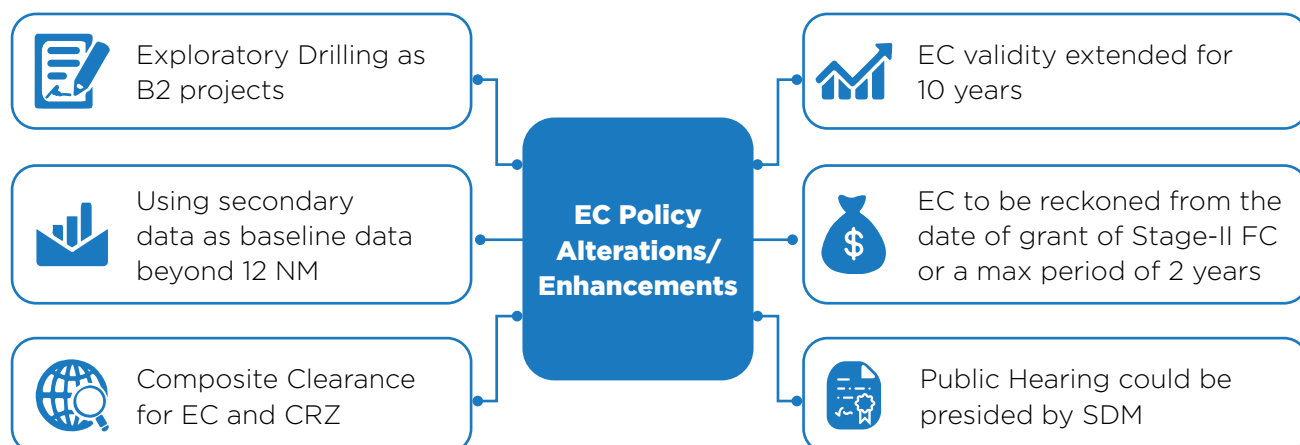
GoI in its amendment dated 09.05.2022 in EIA

notification regarding reduced the notice period to 15 days for rescheduling of public hearing and approved that the Sub-Divisional Magistrate may supervise and preside over the public hearing if the project is confined to the territorial jurisdiction of one sub-division, otherwise any District level officer can preside as authorized by District Magistrate.

June 2022: Standardizing the validity of Baseline data

The MoEF&CC in its OM dated 08.06.2022 standardized the validity of baseline data and public consultation reports for submission of proposal within the validity period of terms of Reference (ToR) under the provisions of the EIA Notification, 2006.

The OM clarifies that the baseline data and the Public Hearing shall not be more than three (03) years at the time of submission of application for consideration of EC.





8.2 Forest Clearance:

Forest Clearance is a crucial process in India as it requires permission from the Govt of India to clear or divert forestland for non-forest purposes, such as mining, industrial projects, highways, and other infrastructure development projects.

This approval is governed by the Forest (Conservation) Act, 1980 which regulates the diversion of forestland for non-forest purposes. The approval is granted only after a detailed examination of the proposal and its impact on the forest and its biodiversity, as well as the rights of local communities.

A multitude of policy changes/additions have taken place in the last 5 years which have facilitated the E&P O&G industry to a great extent.

The narrative placed below explain the said reforms in detail:

8.2.1 Year 2019

September 2021: Guidelines specific to hydrocarbon sector for undertaking seismic surveys and exploratory drilling in forest areas

The MoEF&CC in its OM dated 30.09.2019 clarified that for the purpose of seismic survey, the maximum permissible number of shot holes may be fixed as 80 per sq km of maximum size of 6.5 inch each so that reliable data can be collected. The permission for such activity can be granted at State level. Further, Ministry also clarified that State Govt shall not insist on approval under section 2(iii) of FCA, 1980 at the time of PEL. However, the user agencies shall take all statutory permission before executing of lease/breaking of land.

8.2.2 Year 2021

August 2021: FCA, 1980 Non-applicability to Extended Reach Drilling (ERD) locations

ERD is a directional drilling technique of very long horizontal wells. In order to maximise a well's production and drainage capacity, ERD attempts to: a) reach a bigger region from a single surface drilling location; and b) keep a well in a reservoir for a longer distance.

DGH and E&P industry pursued the case with the MoEF&CC that since ERD technology is a safe technology and has been adopted world-wide, it may not attract the provisions of FCA, 1980 as the actual forestland remains non-diverted. A report has been submitted to the MoEF&CC and is hoped to see the light of the day soon.

8.2.3 Year 2022

June 2022

FC Rules 2022:

The MoEF&CC notified the FC Rules 2022 on 28th June, 2022. It is conferred by Section 4 of the FCA, 1980 and in supersession of the FC Rules, 2003.

If the E&P operations involve diversion of forest land, the FC under FCA, 1980 is required.

FC Rules have been renotified on 28.06.2022 to give special considerations to the E&P industry.

The provisions of FC Rules, 2022 comprise:

Constitution of Committees:

The Rules have advocated the constitution of advisory committee, a regional empowered committee at each of the integrated regional offices and a screening committee at State/ Union Territory (UT) government-level.

Formation of a Project Screening Committee (PSC) in each state /UT for an initial review of proposals involving diversion of forestland. The committee is supposed to meet atleast twice every month and will advise the state governments on projects in a time bound manner. All mining projects between 5-40 Ha are planned to be reviewed within 75 days.

The PSC brings a lot of time saving into the mundane processes of incomplete documents and to and fro query processing. This shall certainly reduce the delays.

Regional Empowered Committees:

All linear projects involving forest land upto 40 Ha and those that have projected a use of forestland having a canopy density up to 0.7-irrespective of their extent for the purpose of survey-shall be examined in the Integrated Regional Office.

Delinking of PEL/PML from FC:

No approval is required for assignment of Petroleum Exploration Licence (PEL) or Petroleum Mining Lease (PML) where neither physical possession nor breaking of forest land is involved, however, for all activities such as the establishment of exploration or developmental wells and connected activities on the forest land, approval under clause (ii) of section 2 of the Act shall be obtained for the actual impact area as per the procedure specified under these rules, subject to provisions of guidelines issued by the Central Government.

Compensatory Afforestation:

It is a mandatory process for mitigating the impacts of human activities on the environment and for promoting sustainable development. The MoEF&CC has taken cognizance of this fact and has facilitated the creation of land banks, a step towards ease of doing business.

The applicants for diverting forest land in a hilly or mountainous state with green cover covering more than two-thirds of its geographical area, or in a state/UT with forest cover covering more than one-third of its geographical area, will be able to take up compensatory afforestation in other states/UTs where the cover is less than 20%.

Accredited Compensatory Afforestation (ACA):

Compensatory afforestation refers to planting activities done in lieu of diversion of forest for non-forest purposes such as mining, setting up of an industry or an infrastructure project.

Earlier, a project developer had to provide land which is not notified as forest against forest diversion and had to bear the cost of raising compensatory afforestation over the same piece of land.

The new rules, however, make way for private individuals who develop such plantation sites on their own land and sell them to project developers.

Now, anyone can raise a plantation on his land and get benefitted by it. The circle rates of such lands will definitely increase. This is a positive step towards encouraging agroforestry and also a move towards sustainable development.

Further, an afforestation shall be counted towards Accredited Compensatory Afforestation if such land has vegetation composed predominantly of trees, having canopy density of 0.4 or more (tree canopy density of 40% or more) and the trees are at least five (05) years old.

In such cases, compensatory afforestation on 10% less land as compared to forest land to be diverted for non-forest purpose will also be accepted.

Furthermore, the MoEF&CC has made a provision which states that the total amount of land that needs to be compensated can be reduced if the plantations or accredited compensatory afforestation are made available in a wildlife corridor or contiguous to a forest. This will encourage plantations near wildlife habitats or carbon sinks.

The Centre has envisaged online submission, processing and approval of proposals pertaining to ACA on a centralized web portal.



A separate & distinct category as "Mining of Mineral Oil" has been created on MoEFCC's PARIVESH portal (the flagship portal of the Environment Ministry for application and approval of green clearances) to cater to hydrocarbon projects vouching for forest clearance. This separate procedure is just to facilitate separate accounting and analysis of hydrocarbon mining projects. Procedures, as envisaged in the Forest Conservation Act, 1980, Rules and Guidelines framed thereunder, as applicable to conventional mining proposals will continue to remain applicable to the proposals pertaining to Hydrocarbon sector.

Non-requirement of FRA Certificate:

The Rules do not require the collector to obtain consent of Gram Sabhas before the In-principle approval. These indicate that the state government may pass an order, after the final approval from the Central Government – after ensuring settlement of rights under FRA and fulfilment of compliances under other laws.

Authorisation to Regional Officers for approving mining projects upto 5Ha

In a bid to simplify the forest clearance process and to fast track the withheld clearances/approvals, the MoEF&CC has authorised the Integrated regional Offices to approve projects whose area between 0-5Ha directly.

This is a progressive step and shall definitely reduce the exorbitant delays that are encountered while applying for smaller patches.

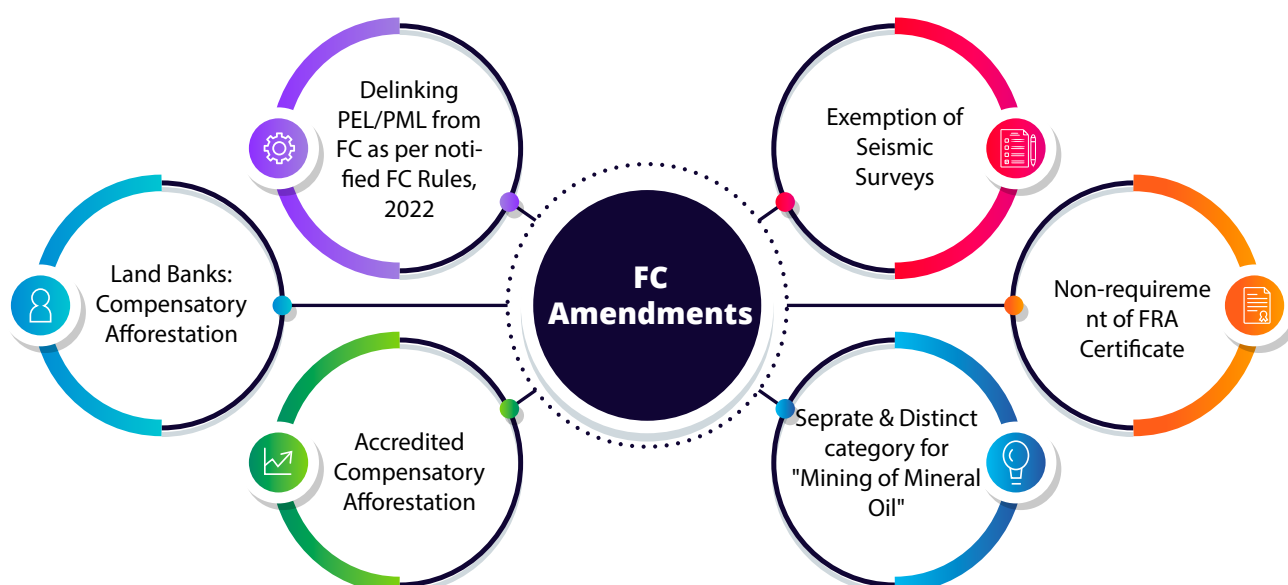
November 2022:

"Mining of Mineral Oil": DGH has been pursuing for a distinct and separate category for the oil and gas sector since the nature of operations of Oil and Gas Exploration and Production and Conventional Mining are completely different.

MoEF&CC has acceded to DGH's request by creating a separate head as "Mining of Mineral Oil" to cater to the hydrocarbon projects on PARIVESH web portal.

This category has been introduced in the Form-A of Forest Clearance process.

This is intended to ease out the operators in applying for forest clearance in areas of fresh diversion considering the content of the form is quite compatible with the terms used in E&P O&G sector.





8.3 Advances vis-à-vis Protected Areas:

Protected Areas or conservation areas are locations which receive protection because of their recognized natural, ecological or cultural values.

The National Wildlife Action Plan (2002-2016) of the MoEF&CC stipulated that state governments should declare land falling within 10 km of the boundaries of the national parks and wildlife sanctuaries as eco-fragile zones or ESZs (Eco Sensitive Zones) under the Environment (Protection) Act, 1986.

While the 10 km rule is implemented as a general principle, the extent of its application can vary. Areas beyond 10 km can also be notified by the Union Govt as ESZs, if they hold larger ecologically important “sensitive corridors”. The basic aim is to regulate these activities around national parks and wildlife sanctuaries so as to minimize the negative impacts of such activities on the fragile ecosystem encompassing the protected areas.

However, lately, Supreme Court in June 2022, directed that every protected forest, national park and wildlife sanctuary across the country should have a mandated eco-sensitive zone

(ESZ) of a minimum one (01) km starting from their demarcated boundaries.

DGH has however been instrumental in pursuing the notification of 36 ESZs across India which have wells in their vicinity. This has given a boost to the E&P industry in producing the deliverables.

8.4 Coordination with State Governments:

DGH has pursued the delayed clearances (environment, forest and wildlife, CRZ) with the various State Governments and has been quite instrumental in facilitation of grant of 147 clearances i.e., a 35% liquidation in pendency in the year 2022. There are 95 cases where DGH is continuing its endeavours in facilitation of the approvals from State and Centre.

The states that have been pursued rigorously are:

- Assam
- Tripura
- Arunachal Pradesh
- Andhra Pradesh
- Gujarat
- Madhya Pradesh

8.5 Launch of Portals:

The overarching priority in DGH is to continue its role as a facilitator to foster deeper and purposeful engagements with all stakeholders for enhancing E&P activities in India.

'Urja Pragati' portal to expedite the grant of clearances and 'Upstream India' portal to allow seamless coordination with E&P operators are currently in the service of the industry.

Contractors and operators have to obtain several clearances from government authorities and non-adherence to stipulated timelines have resulted in delayed licenses and clearances affecting oil and gas exploration and development projects in the country. Efforts have been made to streamline the policies and processes and URJA PRAGATI (**Upstream Response by Joint Action for Proactive Governance and Timely Implementation**) is one step in that direction.

Logo of Portal



This innovative web-based portal conceptualized by E&C group of DGH to track and assess the status of applied permits and approvals by project proponents in the upstream E&P industry is in line with Gol's e-PRAGATI platform.

This platform would facilitate by serving as a single point of contact for filing grievances by the user agencies (E&P operators) electronically in the following manner:

- Single window interface for managing the stakeholders such as Contractors/Operators/DGH personnel/Central Ministries/State Govts./Cabinet Secretariat.
- The entire chain of regulatory authorities has been covered in its ambit and the portal is set to act as a "one stop shop" for monitoring and tackling the bottlenecks in statutory (PEL/PML) and regulatory clearances (EC/FC/WLC) by maintaining the desired transparency, accountability and responsiveness in the ecosystem.
- In the arena of advanced technology, e-governance has distinct place and it



facilitates seamless communication with the stakeholders, thereby increasing the accountability, responsiveness and enhancing transparency in governance unlike in the present system where tracking is comparatively difficult.

For impactful monitoring of progress in grant of licenses and clearances, following three tiers are incorporated in the portal:

- DGH (DG, DGH chairs the review meetings)
- MoPNG (for coordination meetings with State Govt)
- ECC (Empowered Coordination Committee: This committee, which was established in the year 2019, is the highest-ranking body in charge of reviewing licensing and clearance bottlenecks).

The highlights of this portal are:

- An issue tracker (records/manages/prioritizes the issues lodged by the stakeholders),
- A document repository (an organized document management system shared by all the personnel in the division),
- An e-communication module (a unified platform to track, review and archive the conversations between the stakeholders to ensure transparency and accountability),
- An effective visualization instrument in the form of infographics for deriving insights from the data (maintaining the visuals that influence decision-making as in dashboards).



Upstream India' portal was launched which provides handholding to E&P operators along with services like sharing of facilities/ infrastructure available at DGH, creation of a Knowledge Sharing Platform, organization of regular Workshops/Seminars/ Conferences/ Training Sessions/Discussions etc. on latest Government Policies/ Technologies/Usage of Inventories etc.

8.6 Stakeholder Workshops:

DGH has played a pivotal role in organizing workshops with the Central Govt officials and the representatives from the E&P Oil and Gas industry.

Two (02) workshops had been organized. The main motive of the workshops was to hear out

the Central Govt officials on the slew of policy reforms in the fields of Environment and Forest Clearance. A positive development was the interactive session between the Govt and the real stakeholders, i.e., the Project Proponents. The sensitization workshops on EC and FC were held on 10.06.2022 and 30.09.2022 respectively.





9

STRENGTHENING THE E&P ECOSYSTEM THROUGH COLLABORATIONS

The Indian oil and gas industry holds immense significance in terms of contributing to the nation's economic stability and energy security. The synergistic partnership between the industry and academia in this realm is imperative as it fosters the proliferation of innovation and technical progression within the domain of hydrocarbon exploration and production. This collaboration synergizes the practical acumen and expertise of the industry with the theoretical knowledge imparted by academic institutions, thereby resulting in the emergence of novel techniques and technologies that engender the growth and development of the sector.

9.1 Need for Industry-Academia collaboration in Indian E & P

The Indian hydrocarbon industry is a critical component of the country's energy security and economy, and it must adapt to the latest exploration and production techniques to maintain its importance. And this is where the value of collaboration between industry and academia comes into play. By melding the practicality of the industry with the knowledge of academic institutions, the partnership has the potential to spark innovation and drive technological advancements, thereby fueling growth and progression.

The following are a few persuasive reasons why the partnership between industry and academia is vital to the evolution of the Indian oil and gas sector:

- Access to state-of-the-art research and technologies:** The alliance between academia's theoretical insights and the industry's practical expertise promises to spur the creation and implementation of the latest breakthroughs in hydrocarbon exploration and production. Through collaboration, the industry can tap into the newest research and technologies, ensuring that it stays ahead of the curve in the field.
- Bridging theory and practice:** Industry-Academia Collaboration functions as a bridging entity linking academic theories to industrial practices, ensuring that the latest research advances are effectively utilized in Real-World projects.
- Development of new technologies:** The partnership between the industry and academic institutions sparks the development of innovative technologies and methodologies in hydrocarbon exploration and production, broadening and upgrading the sector and promoting its competitiveness in the international arena.
- Enhanced expertise and knowledge:** By collaborating on real-world projects, students and researchers gain hands-on experience, augmenting their expertise and knowledge in the field.

Industry-academia collaboration in India's oil and gas sector is essential for its growth and progress. It provides access to the latest research and technologies, bridges the divide between theory and practice, spurs the development of new technologies and enhances the knowledge and expertise of students and researchers.



9.2 Collaborations leading to growth in the sector

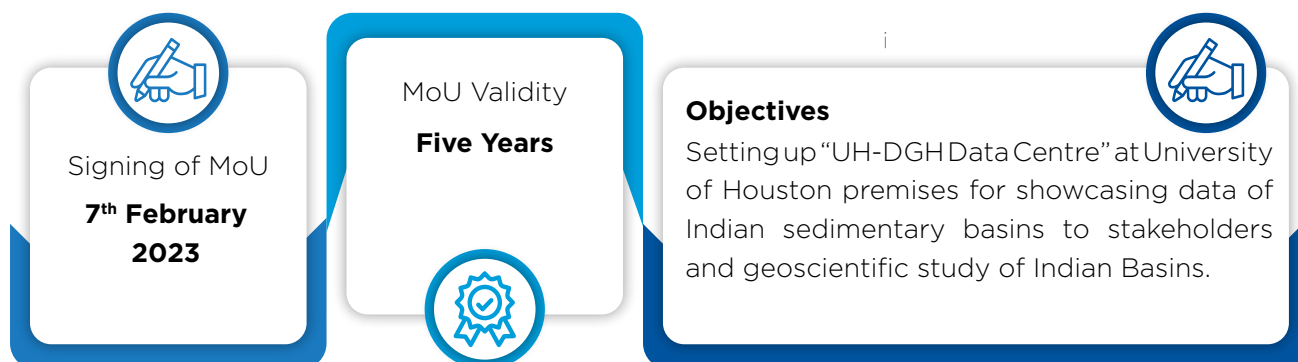
The Indian hydrocarbon sector has been flourishing, powered by a potent partnership between academia and the industry. This synergistic relationship serves as a passage for conveying theoretical understandings from academic realms to practical applications in the industry, nurturing the creation of innovative technologies and methods in hydrocarbon exploration and production. The result of this collaboration has been the growth and competitiveness of the Indian hydrocarbon industry in the global arena.

Furthermore, the collaboration presents students and researchers with the ideal platform to put their theoretical knowledge into practice, thereby gaining hands-on experience and fortifying their skill and expertise in the field. This cyclical connection creates an upward spiral, driving the continuous growth and evolution of the Indian hydrocarbon sector.

The Directorate General of Hydrocarbons (DGH) has signed a number of Memoranda of Understanding (MoUs) with various academic entities as part of this collaboration. Some notable recent examples include:



a) MoU between DGH and the University of Houston, Texas, USA



b) MoU between DGH and Wadia Institute of Himalayan Geology, Dehradun



c) MoU between DGH and Geological Survey of India (GSI)



Signing of MoU
**2nd November
2022**

MoU Validity
Five Years



Objectives

Data sharing for Mineral Exploration and G&G
Technology transfer to GSI.



d) MoU between Pandit Deendayal Energy University, Gandhinagar and DGH



Signing of MoU
**December
2022**

MoU Validity
Six months

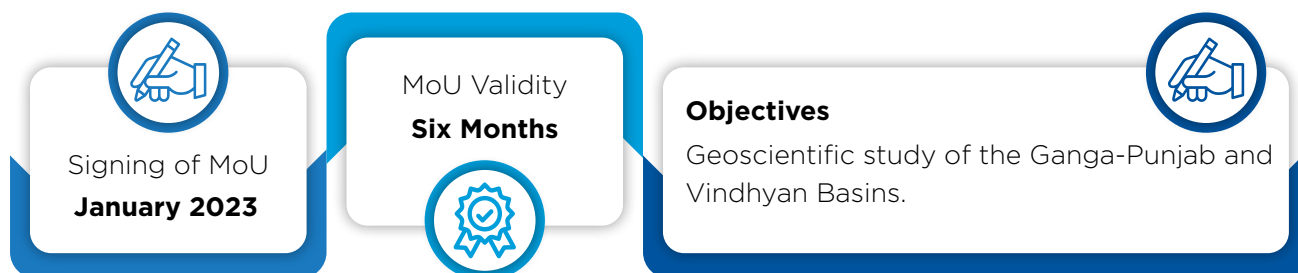


Objectives

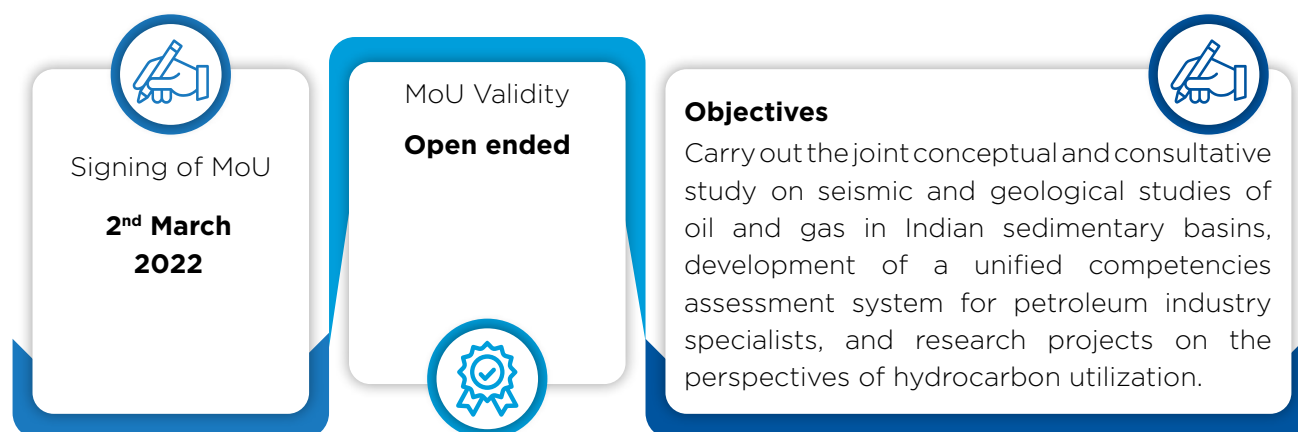
Geo-scientific Data Analysis of the Kutch-Saurashtra Basins



e) MoU between Rajiv Gandhi Institute of Petroleum Technology, Jais, Uttar Pradesh and DGH



f) MoU between Saint Petersburg Mining University, Russia and DGH



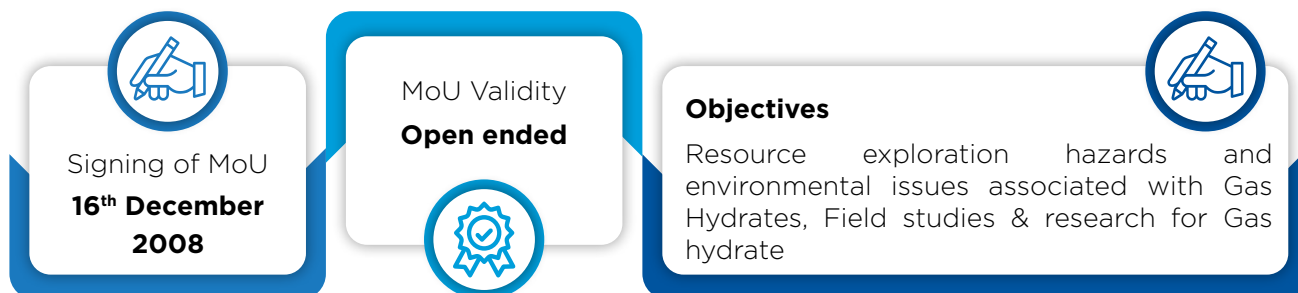
g) MoU between the Indian Institute of Technology (Indian School of Mines) Dhanbad and DGH



h) MoU between the Indian Meteorological Department, Indian National Centre, DGH, Oil Industry Safety Directorate, Directorate General of Shipping, and Indian Coast Guard



- i) MoU between the U.S. Geological Survey (USGS) of the Department of Interior of the United States of America & DGH



Apart from this DGH has entered following collaborations:

1. **School of Earth Sciences, University of Western Australia** (Henry W. Posamentier – Adjunct Professor as Research Investigator) for carrying out Geomorphology of Deep-Water Deposits in Bay-of-Bengal.
2. **Caliche Private Limited** – An upstream Indian start-up company for “Machine Learning based Data Processing, Enrichment and Interpretation of Indian E&P Data for value addition”.

9.3 The Collaboration between Industry and Academia in the Indian Hydrocarbon Sector: A Boon for Students and Researchers

The alliance between industry and academia in the Indian Hydrocarbon sector presents a wealth of advantages to students and researchers. This convergence serves as a conduit, bridging the divide between the theoretical knowledge gained in academic institutions and the real-world applications in industry, fostering

an atmosphere of growth and learning. By collaborating, both industry and academia can augment the skills and knowledge of future professionals, providing them with a valuable platform for practical experience.

One of the most significant benefits of this collaboration is the possibility of working on real-world projects. This offers students and researchers a glimpse into the practical applications of their studies and research, leading to a deeper comprehension of the subject. Moreover, participating in these projects sharpens critical professional skills, such as problem-solving, teamwork, and communication – all of which are critical for success in any industry.

Furthermore, industry-academia collaborations offer students and researchers access to state-of-the-art facilities and equipment, often unavailable in academic institutions. Industry partners possess cutting-edge technology and equipment that students and researchers can use to further their studies and research. This also grants them exposure to the latest advancements in the field, keeping them abreast of industry innovations.



Networking with industry professionals is another valuable aspect of these partnerships. This provides students and researchers with the chance to forge relationships with potential employers, expand their professional network, and learn from experienced professionals in the field. This exposure greatly broadens their knowledge and understanding of the subject, offering them a comprehensive view of the industry.

The hands-on experience provided by industry-academia collaborations is one of their most

critical benefits. This experience is essential in preparing students and researchers for careers in the industry and serves as a fundamental component of their professional development. Working with experienced professionals in the industry offers students and researchers an opportunity to learn about the daily challenges and obstacles faced in the field and the strategies used to overcome them. This valuable experience equips them with the tools necessary for success in the industry, providing them with a solid foundation for their future careers.

The Industry-Academia collaboration in the Indian Hydrocarbon sector presents numerous opportunities to students and researchers. This synergistic partnership enriches the skills and knowledge of future industry professionals, driving its growth and advancement. Such collaborations are critical to preparing students and researchers for careers in the field and ensuring the continued success and innovation of the Indian Hydrocarbon sector.



9.4 From Classroom to Career: How the National Data Repository is Shaping the Next Generation of Oil and Gas Professionals

The National Data Repository (NDR) under the aegis of Directorate General of Hydrocarbons (DGH) has set up a data repository for upstream exploration and production (E&P) in Noida, Uttar Pradesh, India. After publicly been launched on 28th July, 2017, it further got aided with the establishment of secondary data center (SDC) on 04th Aug, 2018 at Bhubaneswar, Odisha. Irrespective of their geographical locations, these data repository centers cater to the need of professionals working in hydrocarbon E & P sector, all throughout the country. Being the custodian of the national data repository, the DGH has immense responsibilities to shoulder upon. So merely not restricting itself to data repository and recovery center, the flagship programs of SDC however have a clear-cut objective of nation building through industrial and educational trainings to the students of various academic institutions and organizations.

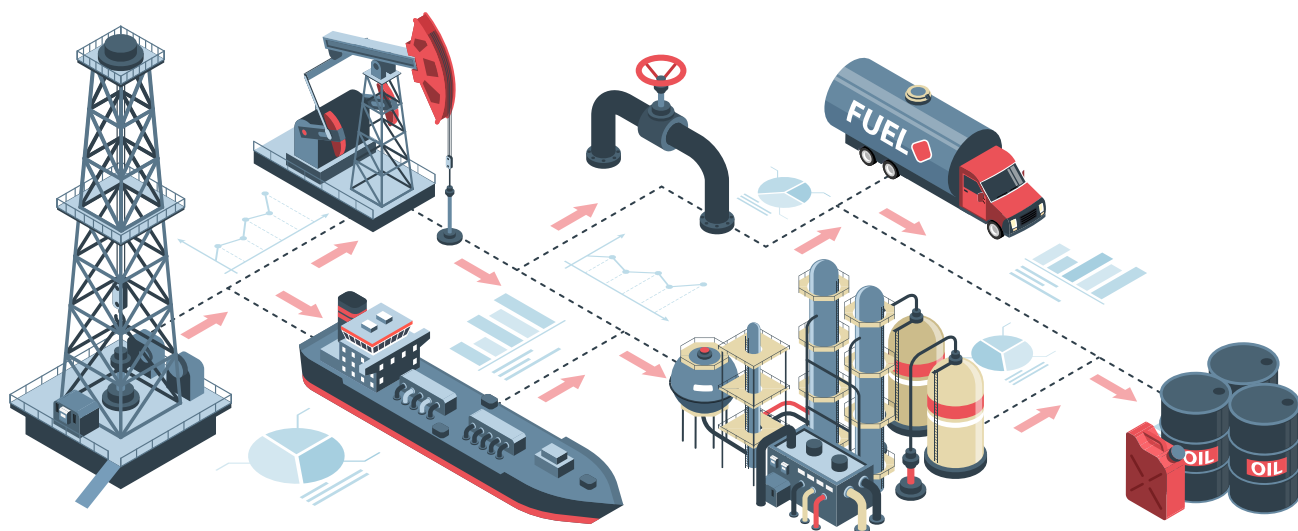
Albeit, the different educational background, syllabus and course curriculum of the students, these training programs are intended towards giving a subjective and simplified approach for the better understanding of each student. The course content of these training programs has rigorously been worked out by technical experts keeping in mind the syllabus of the students and its linkage to E& P sector. Without any doubt

these training programs will be highly beneficial to scores of students across the country. Apart from covering different theoretical aspects of oil and gas exploration and production, idea regarding the seismic data acquisition and interpretation, attribute map preparation, overview of electrical logs and its interpretation, well log correlation, petro-physical parameter calculation and hydrocarbon in-place calculation etc., also were demonstrated to the students. The students also briefly exposed to the industry standard software like Petrel, Geology etc. Further they got a chance to work on all these platforms (industry standard software and hardware) during the hands-on practice sessions. This opportunity not only give them the firsthand idea regarding the utility of these software, rather it would enhance their basic understanding of the processes involved in the E & P of oil and gas industry.

During the FY 2022-23, two (02) such training programs were successfully organized for the students at various universities. The briefs of the internship programs are outlines below:

1. Summer Internship Programme:

The summer internship program was organized by SDC in between 18th to 22nd July 2022, at Bhubaneswar, Odisha. This was first of its kind and aimed towards giving an overview to the students regarding the scope and avenues of hydrocarbon exploration in Mahanadi Basin, Odisha. A total of twenty-two (22) students from two different universities from Odisha



namely Utkal University, Vani Vihar and Indira Gandhi Institute of Technology, Sarang participated in this summer internship program. Throughout the course, these students exhibited a high degree of interactivity. Their proclivity for inquiry prompted them to pose numerous inquiries during the training program, to which the instructors provided comprehensive and satisfactory responses.

2. Winter Internship Programme:

In a similar fashion to that of the summer internship, Winter Internship Programme for six (06) students of MITWPU, Pune and one (01) student of Utkal University, Vani Vihar, Odisha was organized by SDC team at Bhubaneswar office, Odisha. Spanning approximately for one month i.e. from 26th Dec' 2022 to 20th Jan' 2023, the objective of this training program was to give an overview of roles and responsibility of DGH in exploration and production of Oil and Gas business. Further to that, students were also taught thoroughly about the life cycle of Oil & Gas exploration and production covering the topics viz. seismic, types of logs, well correlation, formation evaluation, reservoir

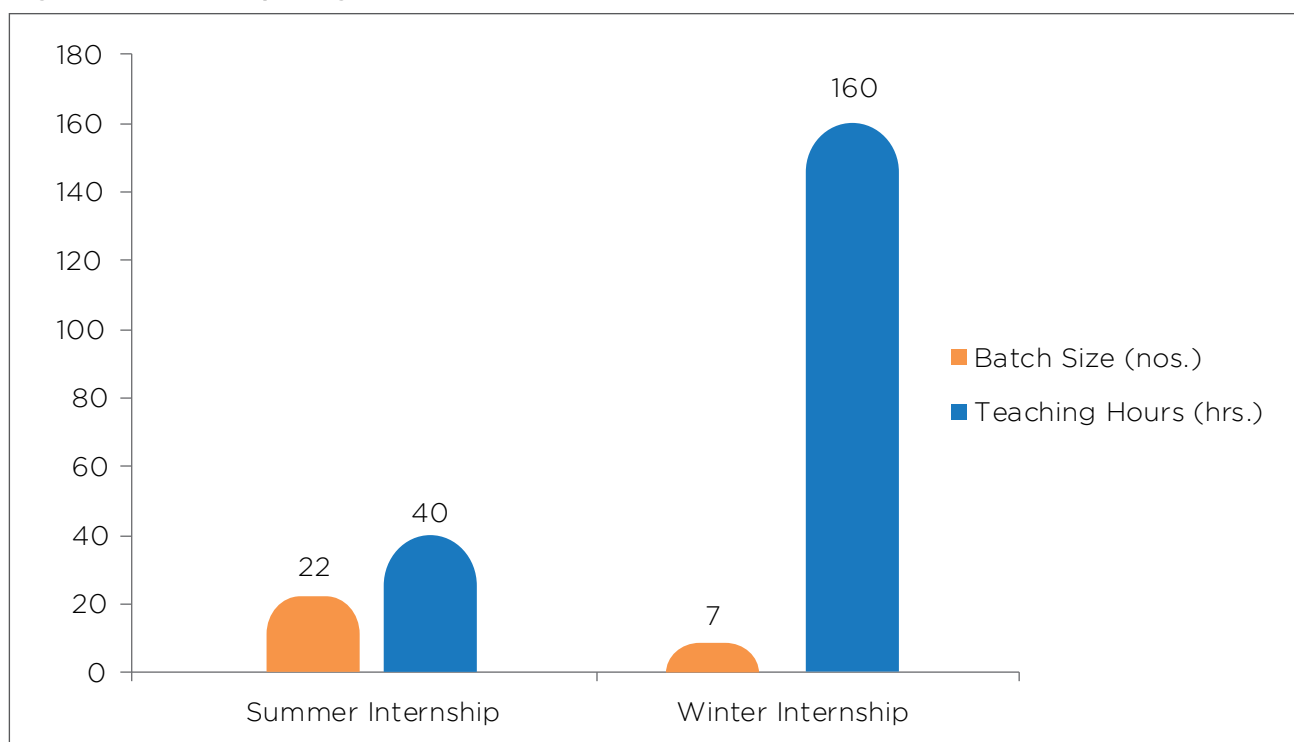
characterization, pressure transient analysis, petroleum economics, PRMS guideline etc.

Despite the smaller cohort size compared to the previous internship program, the students in this training program were able to achieve a highly targeted educational experience, thanks to the longer duration and more intimate class sizes. A comprehensive evaluation of the program was conducted by soliciting feedback from all participants to gauge the degree to which the SDC, Bhubaneswar met the students' expectations. This feedback is invaluable to the SDC and will contribute to the success of future training programs. It was heartening to observe a national-level representation of students, and the overwhelmingly positive response from diverse academic sectors. This feedback undoubtedly boosts morale and encourages the implementation of additional training programs in the future.

During the FY 2022-23, two (02) training programs were successfully organized for the students at various universities.



Figure 9.1 Internship Programme



Program type	Summer Internship	Winter Internship
Batch Size (nos.)	22	7
Teaching Hours (hrs.)	40	160

9.5 Future prospects of Industry-Academia collaboration in Indian E & P

The future prospects of uniting the forces of academia and industry in the Indian petroleum exploration domain are nothing short of tantalizing. With technology's relentless progress, the industry's demands for fresh, cutting-edge innovations and techniques are paramount. Herein lies the significance of the collaboration between industry and academia, as it has the potential to stimulate advancements and secure the Indian petroleum exploration sector's stature as a front-runner in technological evolution.

Data analysis and interpretation are among the most critical areas where this collaboration can bring about impactful change. The oil and gas industry generates an abundance of data, and academia, with their mastery in big data analysis and machine learning, can contribute to the industry's data-driven decision-making process.

The union of industry and academia can also result in the creation of new production methods and technologies. By combining their collective knowledge, they can conceive of imaginative solutions that can streamline production processes, reduce costs, and elevate efficiency.



The collaboration also presents a unique chance for students and researchers in the petroleum sector to gain hands-on experience, work on real-world projects, and enhance their knowledge

and expertise. This type of educational and skill-building opportunity is indispensable in preparing them for a successful career in the industry.

The future prospects of industry-academia collaboration in the Indian oil and gas exploration sector are bright, with the potential for significant advancements in technology, improved efficiency, and cost savings. The collaboration can serve as a catalyst for innovation and help keep the Indian oil and gas sector at the forefront of technological advancements.



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10

SECURING OIL & GAS OFFSHORE INFRASTRUCTURE

Oil and Gas Infrastructure security involves the security of the infrastructure against any threat or challenge that originates from the sea or air. The Oil and Gas Infrastructure security is ensured through coordinated efforts amongst

multiple stakeholders at the Centre and States. All these stakeholders are involved in providing comprehensive security against different kind of threats.

Offshore Oil and Gas Infrastructure Security



India's energy security has a vital role in national development and is highly dependent on the seas. India's E&P industry is heavily dependent upon production from offshore fields. At present offshore oil fields contribute half of oil production and offshore gas fields contribute two-third of Gas Production in the country.

Development of An Integrated Security Management Framework

The Exclusive Economic Zone (EEZ) abuts the entire coast of India. Within the EEZ various E&P companies, both state-owned and private have been awarded blocks for the exploration and exploitation of hydrocarbons.

An Operating Framework was issued on 02 Sept 2022 for concurrent use of EEZ and it consists of a set of protocols and Standard Operating Procedures (SoP) to ensure safety of entities operating by adhering to international practices like NAVAREA*/NOTAM** and swift information exchange about ongoing and upcoming activities in advance. Protocols have also been developed and established for the defence and space agencies operating in the area for ensuring safety of E&P operators.

A GIS based portal was developed by BISAG-N, Gujarat in compliance to the Operating Framework. This portal is essentially a monitoring and decision support system to ensure the adherence with protocols laid down in the Operating Framework. With the help of this portal, all fixed and mobile assets in the EEZ can be monitored in real time. NAVAREA/NOTAM warnings can be directly downloaded from the site, in addition to their being forwarded to operators for compliance and the same can be monitored on this portal.

Preparation of the Operating Framework and development of the GIS based portal are additional tools to ensure the safety of E&P operators. Any tool is as good as the people who handle/utilise it. With the aim of utilizing this tool to the optimum, a group of officers from different departments of DGH were designated as Nodal officers. These nodal officers were designated for implementing the Operating Framework and act as a communication link/bridge between the E&P operator and the Security and Coordination Cell.



A Command and Control (C&C) Center has been established at DGH office to monitor all the fixed and mobile E&P assets in real-time. This C&C Center will also disseminate information regarding the activities of government agencies through nodal officers.

*NAVAREA warnings contain information specific to ocean-going mariners

**NOTAM are notices distributed by means of telecommunication containing information concerning the establishment, condition or change in any aeronautical facility, service, procedure, or hazard



ABBREVIATIONS

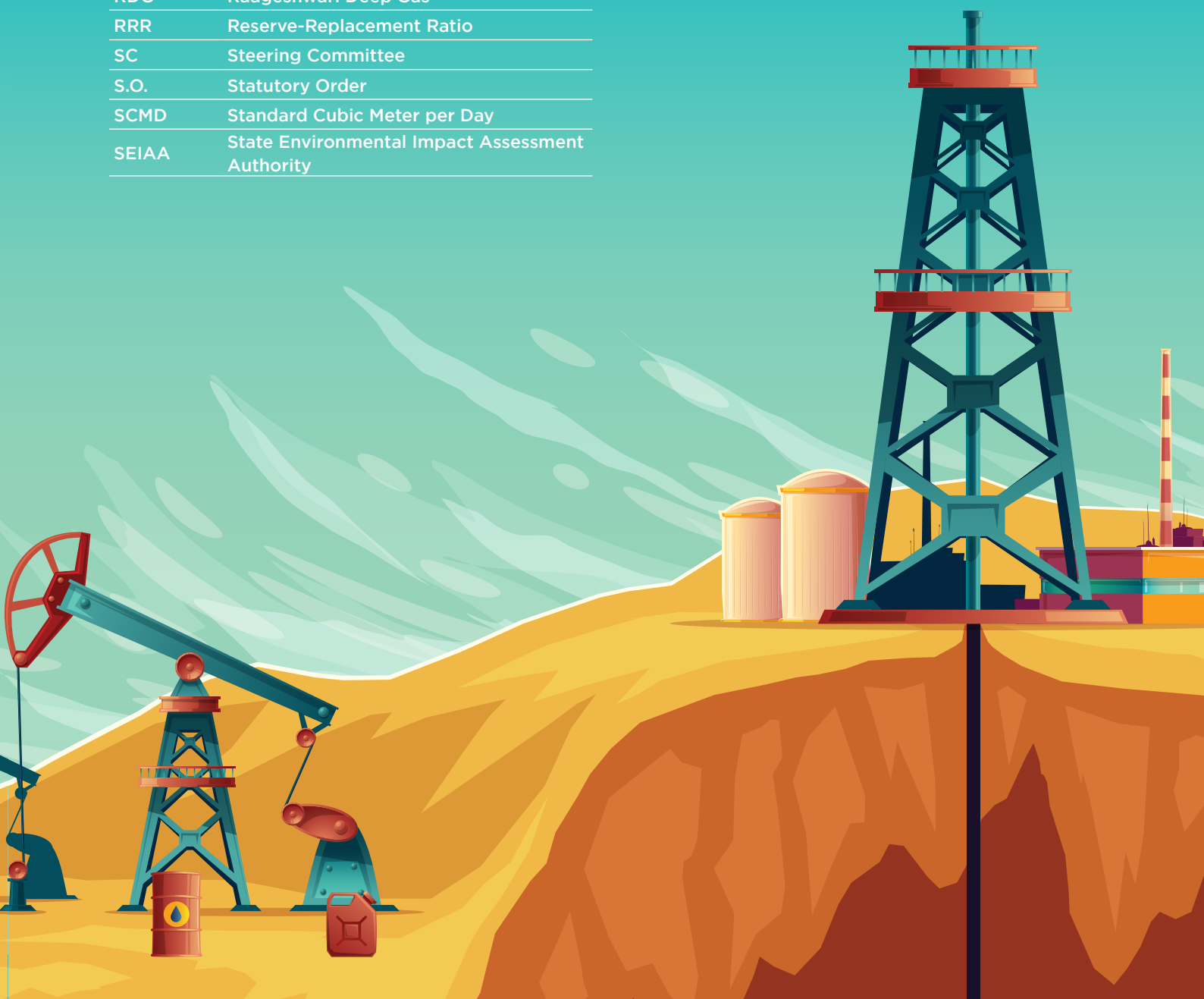
DGH	Directorate General of Hydrocarbons
2D	2 Dimension
3D	3 Dimension
API	American Petroleum Institute
BCM	Billion Cubic Meter
BHT	Bottom Hole Temperature
BOPD	Barrels of Oil Per Day
CBM	Coal Bed Methane
CCEA	Cabinet Committee of Economic Affairs
CCS	Carbon Capture Storage
CCSP	Carbon Capture and Storage Program
CCU	Carbon Capture Utilization
CMPDI	Central Mine Planning and Design Institute
CRZ	Coastal Regulation Zone
CSIR-NIO	Council of Scientific & Industrial Research-National Institute of Oceanography
CZMA	Coastal Zone Management Authority
DoC	Declaration of Commerciality
DRDO	Defence Research and Development Organization
DST	Drill Stem Testing
E&P	Exploration and Production
EAC	Expert Appraisal Committee
ERD	Extended Reach Drilling
EC	Environment Clearance
EIA	Environment Impact Assessment
EPS	Early Production System
FC	Forest Clearance
FCA	Forest Conservation Act
FDP	Field Development Plan
FRA	Forest Rights Act
G&G	Geology and Geophysics
GoI	Govt of India
GIP	Gas In Place

GIPIP	Good International Petroleum Industry Practices
HCPV	Hydrocarbon Pore Volume
HPHT	High Pressure High Temperature
IOR-EOR	Improved Oil Recovery-Enhanced Oil Recovery
KLPD	Kilo Litres Per Day
LCMD	Lakh Cubic Meters per Day
LD	Liquidated Damages
LKM	Line Kilometer
LWD	Logging While Drilling
MC	Management Committee
mD	Milli Darcy
MMbbls	Million Barrels
MMBO	Million Barrels of Oil
MMSCF	Million Standard Cubic Feet
MMSCMD	Million Standard Cubic Meters per Day
MMT	Million Metric Tonne
MMtoe	Million Metric Tonne of Oil Equivalent
MoC	Ministry of Coal
MoD	Ministry of Defence
MoEF&CC	Ministry of Environment, Forest and Climate Change
MoHA	Ministry of Home Affairs
MoP&NG	Ministry of Oil and Natural Gas
MoU	Memorandum of Understanding
MPT	Mangala Processing Terminal
MT	Magneto-Telluric / Metric (Thousand) Tonnes
MWP	Minimum Work Program
NM	Nautical Miles
NDR	National Data Repository
NITI	National Institution for Transforming India
NELP	New Exploration Licensing Policy
NGHP	National Gas Hydrate Program
NSP	National Seismic Programme



NoCs/Pvt/JV	National Oil Company/ Private/ Joint Venture
O+OEG	Oil plus Oil Equivalent Gas
OALP	Open Acreage Licensing Policy
OIDB	Oil Industry Development Board
PARIVESH	ProActive & Responsive Facilitation by Intercative and Virtuous Ennvironmental Single Window Hub
PCI	Potential Commercial Interest
PP	Project Proponent
PEL	Petroleum Exploration License
PML	Petroleum Mining Lease
PSC	Production Sharing Contract
PSI	Pounds per Square Inch
PSUs	Public Sector Undertaking
PVT	Pressure Volume Temperature
RDG	Raageshwari Deep Gas
RRR	Reserve-Replacement Ratio
SC	Steering Committee
S.O.	Statutory Order
SCMD	Standard Cubic Meter per Day
SEIAA	State Environmental Impact Assessment Authority

SKM	Square Kilometer
SRFS	Site Restoration Fund Scheme
STOIP	Stock Tank Original Oil-Place
ToR	Terms of Reference
TCF	Trillion Cubic Feet
TMT	Thousand Metric Tonnes
TPD	Tonnes Per Day
TVDSS	True Vertical Depth Sub Sea
US DOE	United States Department of Energy
USGS	United States Geological Survey
VSP	Vertical Seismic Profiling
WAG	Water Alternating Gas
WLC	Wildlife Clearance
WP&B	Work Program and Budget
W.P.	Writ Petition



LEADING WITH PURPOSE, SHAPING THE FUTURE



Dr. V P Joy, IAS
July 2018-Dec 2019



Shri Ajay Sawhney, IAS
July 2015 – April 2016



Shri R. N. Choubey, IAS
June 2012 – Feb 2014



Shri V.K.Sibal
Nov 2004 – Oct 2009



Shri S C L Das, IAS
January 2020 – till date



Shri. Atanu Chakraborty, IAS
April 2016 – May 2018



Shri B. N. Talukdar
Feb 2014 – June 2015



Shri S. K. Srivastava
Nov 2009 – April 2012



Dr. Avinash Chandra
May 1993 – Sept 2003



POWERED BY TEAMWORK, DRIVEN BY EXCELLENCE THE REMARKABLE ACCOMPLISHMENT OF 'DGH'

Dr. Avinash Chandra (May 1993 – September 2003)

Policy Implementation

- Formulation of Policy for Exploration and Production of CBM
- National Gas Hydrate programme (NGHP)
- New Exploration Licensing Policy (NELP)
- NELP-I, II, III & IV bid rounds

Key Initiative

- First Director General of Directorate of Hydrocarbons (DGH), served the longest period as DG, DGH till date
- Re-assessment of Hydrocarbon Resources in India
- Spearheaded mapping of over 130 Deepwater plays (25,000 LKM of 2D seismic surveys)

Shri V. K. Sibal (November 2004 – October 2009)

Policy Implementation

- Policy for Extension of Exploration Phase Under NELP and Pre- NELP PSC
- Ideation of National Data Repository (NDR)
- Guideline for Announcement of New Discovery
- Guidelines for Uniform System of Classification of Hydrocarbon Resources & Reserves

Key Initiative

- Conducted NELP-V, VI & VII bidding Rounds and CBM-II, III Rounds
- 12000 LKM of 2D seismic data of west coast reprocessed during the 2007-08
- S type blocks offered no requirement of technical capability for PQC
- Initiated oil shale deposits and syn-crude resource estimation project for North Eastern part of India

Shri S. K. Srivastava (November 2009 – April 2012)

Policy Implementation

- Gas Production under PSC increased by 171% as production from KG-DWN-98/3 started in FY 2009-10
- NELP-VIII and NELP-IX bidding Rounds & 1 round of CBM bidding

Key Initiative

- 3607.5 LKM of 2D speculative surveys; 10,000 LKM of reprocessing of old seismic data text and Airborne survey covering 13994.64 LKM in block 3 in Kutch area

Shri R. N. Choubey, IAS (June 2012 – February 2014)

Policy Implementation

- Policy Guidelines of Exploration and Exploitation of Shale Gas and Oil in Nomination ML area of National Oil Companies

Key Initiative

- Re-assessment of Hydrocarbon Resources in India

Shri B. N. Talukdar (February 2014 – June 2015)

Policy Implementation

- Site Restoration guidelines on petroleum operations
- Policy for Extension of Production Sharing Contracts
- Uniform Licensing Policy
- Marginal Field Policy
- Open Acreage Licensing Policy

Key Initiative

- Encouraging E&P Activities in North East
- Multi Client Geo- Scientific Surveys
- National Data Repository (NDR)
- Standing Committee on Petroleum Industry Practices GIPIIP

Shri Ajay Sawhney, IAS (July 2015 – March 2016)

Policy Implementation

- Discovered Small Field (Marginal) Policy
- Hydrocarbon Exploration and Licensing Policy
- Policy for extension of Production Sharing Contracts
- Exploration in Mining Lease Areas
- Policy framework for development of Underground Coal Gasification in coal and lignite bearing areas in India

Key Initiative

- NE Hydrocarbon Vision 2030
- 10% Import Reduction by FY 2021-22
- Site Restoration Guidelines on Petroleum Operations Standing Committee on Petroleum Industry Practices
- Marketing and Pricing freedom for new gas production from Deepwater, Ultra Deep water and High Pressure-High Temperature Areas

Shri Atanu Chakraborty, IAS (April 2016– June 2018)

Policy Implementation

- DSF Bid Round-I (award of 30 fields)
- Policy framework for early monetization of CBM
- Pre-NELP Exploration Blocks
- Site Restoration Guidelines for Petroleum Operations
- Enhanced Recovery Policy
- DSF Bid Round-II and OALP Bid Round-I

Key Initiative

- National Core Repository
- NDR-Secondary Data Centre
- Centre for Advanced Data Research

Dr. V P Joy, IAS (July 2018-December 2019)

Policy Implementation

- DSF Bidding round II, OALP Bidding Round II, III & IV
- Policy framework for exploration and exploitation of unconventional hydrocarbons under existing Contracts
- Policy framework to promote and incentivize Enhanced Recovery methods for oil and gas
- Amendment in the Definition of 'Petroleum' under clause (k) of Rule 3 of the Petroleum & Natural Gas Rules, 1959

Key Initiative

- Dispute Resolution Committee
- Notification of ER Committee for conducting screening of fields
- Constitution of Enhanced Recovery Committee
- Institute for conducting Screening of fields for implementing ER Methods

Shri S C L Das, IAS (January 2020 – till date)

Policy Implementation

- Natural Gas Marketing Reforms, 2020
- DSF Bidding round III, OALP Bidding Round V, VI & VII
- SCBM Bidding round 2021
- Discovery of market price for domestically produced natural gas through e-bidding

Key Initiative

- Andaman Offshore Survey Project, Appraisal of EEZ
- Release of 'No Go' areas for E&P activity
- Streamlining Environment clearance processes & Rationalization of Essentiality Certificate regime
- Adoption of PRMS for Petroleum Reserves and Resource reporting
- Investment Promotion Activities in E&P sector
- Launch of Urja Pragati/ Upstream India portals

IHO 2022-23 EDITORIAL TEAM



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