Hydrocarbon Prospectivity

Indian Sedimentary Basins
Sedimentary basins in India

Category I:
- Basins which are commercially producing
- Have ‘reserves’ to produce
- Also have contingent and prospective resources

Category II:
- Basins which have discoveries, yet to produce commercially
- Have ‘contingent resources’
- Also have prospective resources

Category III:
- Basins which are yet to have a discovery
- Have only ‘prospective resources’

PRMS of reporting resources and reserves is the basis for such categorization showing the basin maturity
Sedimentary basins and category

Category I
(7)
- Krishna-Godavari (KG), Mumbai Offshore, Assam Shelf, Rajasthan, Cauvery, Assam-Arakan Fold Belt and Cambay

Category II
(5)
- Saurashtra, Kutch, Vindhyan, Mahanadi and Andaman

Category III
(14)
- Kerala-Konkan, Bengal-Purnea, Ganga-Punjab, Pranhita-Godavari (PG), Satpura-South Rewa-Damodar, Himalyan Foreland, Chattisgarh, Narmada, Spiti-Zanskar, Deccan Syncline, Cuddapah, Karewa, Bhima-Kaladgi, and Bastar

Basins are shown in decreasing order of undiscovered inplace
Saurashtra, Kutch and Bengal-Purnea are under upgrade
Sedimentary basins: new boundaries

• Basins were remapped using latest GIS tools
• Boundaries were redefined, deepwater areas added to respective basins, new areas identified and included
• Shallow water was mapped till 400m water depth and deepwater up to basin boundary/Exclusive Economic Zone (“EEZ”), whichever closer
• Total area: 3.36 million sq km
  – Onland: 1.63 million sq km
  – Shallow water: 0.41 million sq km
  – Deepwater: 1.32 million sq km
Tectonic framework of sedimentary basins

Rifting
- Rajasthan (Barmer), Cambay, Kutch, Saurashtra, Mumbai Offshore, Kerala-Konkan
- Cauvery, Krishna-Godavari(KG), Mahanadi, Bengal-Purnea,
- Pranhita-Godavari(PG), Satpura-South Rewa-Damodar, Narmada

Sag
- Vindhyan, Deccan Synclise, Bhima-Kaladgi, Chattisgarh, Cuddapah, and Bastar

Collision
- Assam-Arakan Fold Belt, Andaman,
- Karewa, Spiti-Zanskar, Himalayan Foreland,
- Ganga-Punjab, Rajasthan(Bikaner-Nagaur), Rajasthan (Jaisalmer)
- Assam Shelf
Assessment of conventional hydrocarbons

- Last assessment was carried out during 1995-96
  - 15 major basins were assessed
  - Aerial Yield method was used
  - Deepwater areas were assessed separately

- During last two decades
  - A vast amount of data has been collated
  - New basins and plays have opened up
  - A few plays/basins entered into mature stages
  - Assessment methodologies have substantially improved

- Reassessment of conventional resources was completed in 2017
  - All 26 sedimentary basins including deepwater areas were reassessed
  - 177 plays were assessed, risk-weighted and concluded with previous findings compared
Results of the study

• Last assessment done for 15 sedimentary basins:
  • Total Inplace assessed: 28,085 MMtoe
  • Deepwater separately assessed with 7,000 MMtoe inplace
• Current assessment done for all 26 basins with deepwater areas included
  • Inplace reassessed: 41,872 MMtoe
    – 15 old basins: 41,004 MMtoe and 11 new basins: 868 MMtoe
    – Discovered: 12,076 MMtoe and Undiscovered: 29,796 MMtoe (71% of the total inplace)
• Increase of total hydrocarbon estimate: 49.1%
• Reassessment at hydrocarbon play level for the first time
• Generated a complete geoscientific database with subsurface models, maps and reports
Assessment results compared

1995-96 study

- Carried out for 15 basins
- Areal Yield method used for all basins
- Assessment at basin level
- Deepwater areas excluded and assessed separately
- Limited tools and less data sets

2015-17 study

- All 26 basins re-assessed
- 13 basins/basin areas with good datasets were assessed using improved tools. Rest with Aerial Yield method
- Assessment at play level
- Deepwater areas included and assessed with basins
- New tools and expanded datasets
Hydrocarbon inplace compared

- New studies indicate significant volume increase for KG, Rajasthan, Assam Shelf, Cauvery and Saurashtra basins
- Ganga-Punjab, Himalayan Foreland and Assam-Arakan have reduced numbers for being risk-weighted
- New study:
  - 15 basins have cumulative inplace of 41,004 MMtoe
  - Remaining basins contribute to 898 MMtoe only, out of which Vidhyan alone has 632 MMtoe.
Category-wise sedimentary basin area

- Majority of the area are under Category III without a discovery and subject to intense exploration
Territorial distribution across category

- Nearly half of the area falls in onland, which further occupies 58% of Category III area.
Conventional hydrocarbons across category

- Category I basins have 85% of total hydrocarbons assessed and 98% of total discovered inplace.
Conventional hydrocarbons across geological era

- Total estimated conventional hydrocarbons: 41,868 MMtoe
- 177 plays mapped
- 87 in Tertiary, 53 in Mesozoic and 37 Pre-Mesozoic

**Total hydrocarbon in place**

- **Tertiary**: 31655
- **Mesozoic**: 8594
- **Proterozoic**: 1265
- **Paleozoic**: 221
- **Archean**: 131
- **Quaternary**: 2
Potential in Tertiary-Quaternary plays

- Total estimated conventional hydrocarbons: 31,655 (Tertiary) + 2 (Quaternary) = 31,469 MMtoe. Quaternary potential includes Biogenic plays.
Total estimated conventional hydrocarbons: 8,594 MMtoe.

### Total hydrocarbon inplace

<table>
<thead>
<tr>
<th>Region</th>
<th>Inplace (MMtoe)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Krishna-Godavari (KG)</td>
<td>2935</td>
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</tr>
<tr>
<td>Cauvery</td>
<td>1929</td>
<td></td>
</tr>
<tr>
<td>Rajasthan</td>
<td>1023</td>
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<tr>
<td>Kerala-Konkan (KK)</td>
<td>970</td>
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<td>Saurashtra</td>
<td>798</td>
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<tr>
<td>Kutch</td>
<td>763</td>
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<tr>
<td>Mahanadi</td>
<td>80</td>
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<td>Pranhita-Godavari (PG)</td>
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<td>Bengal-Purnea</td>
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<tr>
<td>Andaman</td>
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<td>Satpura-South Rewa-Damodar</td>
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<td>Spiti-Zanskar</td>
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<td>Karewa</td>
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<tr>
<td>Cambay</td>
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</table>
Potential in Proterozoic plays

Total estimated conventional hydrocarbons: 1,265 Mmtoe, nearly half of it lies in Vindhyan basin
Potential in Palaeozoic plays

- Total estimated conventional hydrocarbons: 221 MMtoe. Includes Gondwana sediments which also have potential for coal-bed methane and shale oil and gas.
Potential in Achaean plays

Total estimated conventional hydrocarbons: 131 MMtoe.
Includes potential of Basement fractures.
## Category I basin potential

<table>
<thead>
<tr>
<th>Basin</th>
<th>Archean</th>
<th>Proterozoic</th>
<th>Paleozoic</th>
<th>Mesozoic</th>
<th>Tertiary</th>
<th>Quaternary</th>
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<tbody>
<tr>
<td>Mumbai Offshore</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>9,644</td>
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<tr>
<td>Krishna-Godavari (KG)</td>
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<td>6,608</td>
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<td>Assam Shelf</td>
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<td>Rajasthan8</td>
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<td>2,637</td>
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<td>Cambay</td>
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<td>2,585</td>
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<tr>
<td>Cauvery</td>
<td>21</td>
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<td>1,929</td>
<td>13</td>
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<td>Assam-Arakan Fold Belt (AAFB)</td>
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<td></td>
<td>1,633</td>
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Total estimated conventional hydrocarbons: 35,509 MMtoe (85% of total inplace over 30% of total basin area)
Total estimated conventional hydrocarbons: 3,876 MMtoe (9% of total inplace over 23% of total area)
## Category III basin potential

<table>
<thead>
<tr>
<th>Basin Name</th>
<th>Proterozoic</th>
<th>Paleozoic</th>
<th>Mesozoic</th>
<th>Tertiary</th>
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<tbody>
<tr>
<td>Kerala-Konkan (KK)</td>
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<td>970</td>
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<tr>
<td>Bengal-Purnea</td>
<td>70</td>
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<tr>
<td>Ganga-Punjab</td>
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<tr>
<td>Pranhita-Godavari (PG)</td>
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<td>Satpura-South Rewa-Damodar</td>
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<td>54</td>
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<tr>
<td>Himalayan Foreland</td>
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<tr>
<td>Chhattisgarh</td>
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<tr>
<td>Narmada</td>
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<tr>
<td>Spiti-Zanskar</td>
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<td>5</td>
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<td>Deccan Syncline</td>
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<td>Cuddapah</td>
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<tr>
<td>Kareda</td>
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<td>Bhima-Kaladgi</td>
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<tr>
<td>Baster</td>
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</tbody>
</table>

Total estimated conventional hydrocarbons: 2,483 MMtoe (6% of total inplace over 47% of total area)
Hydrocarbon resource conversion

- Inplace: 41.9 Btoe
- Discovered: 12.1 Btoe
- Developed: 10.9 Btoe
- Recoverable: 4.2 Btoe
- Produced*: 2.4 Btoe
- Reserve: 1.9 Btoe

* Includes production from coal bed methane
*Btoe> Billion ton oil-equivalent, 1 ton = 6.29/oil density (0.89) = 7.07 barrel
Unconventional resources

Coal Bed Methane (CBM)

- India’s inplace: 2,600 BCM
- 11 active CBM blocks out of 33 awarded in 4 rounds of CBM bidding
- Blocks spread over 11 States
- Reserves: 295 BCM
- Cumulative production (31.01.20): 3.63 BCM
- Production: 1.8 MMSCMD from 4 blocks
- Operational area: 4,503.5 sq. km.

Shale oil and gas

- Exploration efforts carried out so far by NOCs under Shale Gas & Oil Policy, 2013
- A total of 28 wells drilled by ONGC in Cambay , KG, Cauvery Assam Shelf and Assam- Arakan Fold Belt.
- A total of 4 wells drilled by OIL in Assam Shelf and Jaisalmer Basin.
- No established shale Gas/Oil reserves yet
- Resource estimates by 3 agencies in different basins
- ONGC (Aug.’13) estimated Shale Gas inplace of 5,309 BCM for 5 basins- Cambay, KG, Cauvery, Ganga, Assam
- CMPDI (July’13) estimated Shale Gas resources of 1,297 BCM for Gondwana basins
- USGS (Jan.’11) estimated resources of Shale Gas of 173 BCM for 3 basins: Cambay, KG & Cauvery
Unconventional resources: Gas hydrate

- Natural Gas Hydrate Program Expedition (NGHP) was formed to explore and develop the gas hydrate resources of Indian subcontinent in three stages.
  - The first stage was to identify the presence of gas hydrate deposits in Indian Offshore Basins
  - The second stage was to identify gas hydrate in sand rich geological setting within gas hydrate stability zone and suitable locations for production testing
  - During the second stage, 42 gas hydrate wells at 25 sites were completed in deep water areas of Krishna Godavari and Mahanadi offshore in Eastern Coast of India
  - The third stage is to carry out production testing

- In 2016, ONGC reported prognosticated gas hydrate inplace of nearly 9 TCF in KG basin
Data access and enrichment

National Data Repository (NDR)
• Set up in 2017 in DGH premises, NDR hosts the country’s complete E&P database.
• All bidding of acreages under HELP and DSF Policy are now through NDR
• Companies can view, analyze and buy data at a nominal cost
• Data uploaded on NDR till December 2019:
  – 2.319 million LKM of 2D seismic data
  – 0.787 million SKM of 3D seismic data
  – 17,707 wells and well logs
  – 35,823 well reports

National Seismic Programme (NSP)
• NSP is a 2D seismic data acquisition program in Indian sedimentary basins where scanty or little data were available
• Campaign started in October 2016
• Data generation ongoing, to be completed within 5 years by NOCs
• Data generated are processed and continuously uploaded in NDR
• Target: 48,243 Line Kilometer (LKM)
  Acquired: 43,112 LKM (89%) as of December 2019
• Preliminary findings. Study under finalization
Opportunities to bidders

– Contract areas are all pre-assessed by prospective bidders or pre-defined by Government
  – Information on block-level prospectivity outlined by originator through due diligence report under Open Acreage Licensing Programme (OALP)
  – Information Dockets are available for fields on offer under Discovered Small Field bid rounds
  – Basin-specific technical booklets and the presentation are available online

– NDR ready with the Data Rooms
  – Industry-standard G&G interpretation software with full functionality are available for on-the-spot assessment

– Continued access to NDR for more strength/missed-out data
  – NDR is continuously updated with new data including recently acquired seismic 2D data from NSP (“National Seismic Programme”)
  – Basin-specific information on hydrocarbon resources are available

– NCR (“National Core Repository”) has been conceptualized
  – Until then Cores/ Drill-cuttings/ Fluid samples can be accessible from NOC’s Core Labs, declared as National Assets
Welcome to opportunities of exploring the ‘undiscovered’ potential of both conventional and un-conventional hydrocarbons as well as developing the discovered hydrocarbon resources, under leveraged fiscal terms and simplified contracts...