Unconventional Gas E&P : Essar Approach

26 -27th November, 2015

Essar Exploration & Production
Peninsula Techno-park, Tower II, LBS Marg,
Mumbai 400070, India.

www.essar.com

About Essar

Essar is a multinational corporation with annual revenues of US Dollar 35 billion, investments in Steel, Energy, Infrastructure and Services, presence in more than 29 countries and more than 60,000 people.

ENERGY

Oil & Gas

- 2nd largest single location refineries in India and UK
- c.701k bpd / 34 MTPA operating refining capacity
- c.1500 retail fuel outlets
- **1.36 bn boe reserve and resources**

Power

- 3,910 MW operational capacity increasing to 4,900 MW
- Large scale assets in west, central and east India
- Operating and in development coal mines
- Secured long term PPAs

METALS & MINING

Resources

- 2 bn tonnes of iron ore resources
- 27 MTPA pellet capacity[1]
  - 7 MTPA: Minnesota, USA
  - 20 MTPA: Eastern India

Steelmaking & Marketing

- 14 MTPA steelmaking capacity
  - 10 MTPA India
  - 4 MTPA Canada
- 4thlargest single site globally
- 4 MTPA distribution capacity
- 300+ retail outlets across India

INFRASTRUCTURE

Projects

- $3bn+ order book
- 40 year track record and global operations
- #2 largest equipment bank in India

Ports

- One of India's largest ports businesses
- 5 major strategic locations on the east and west coasts of India
- Ownership of key infrastructure for EGF assets
- 104 MTPA operational capacity
- 194 MTPA planned capacity

SERVICES

Shipping

- 26 ships includes VLCCs, capsize, supramax, bulk carriers & tugs
- Aggregate shipping capacity of 1.6mn (dwt)
- Oilfield Services: 15 land rigs, 1 semi submersible offshore rig

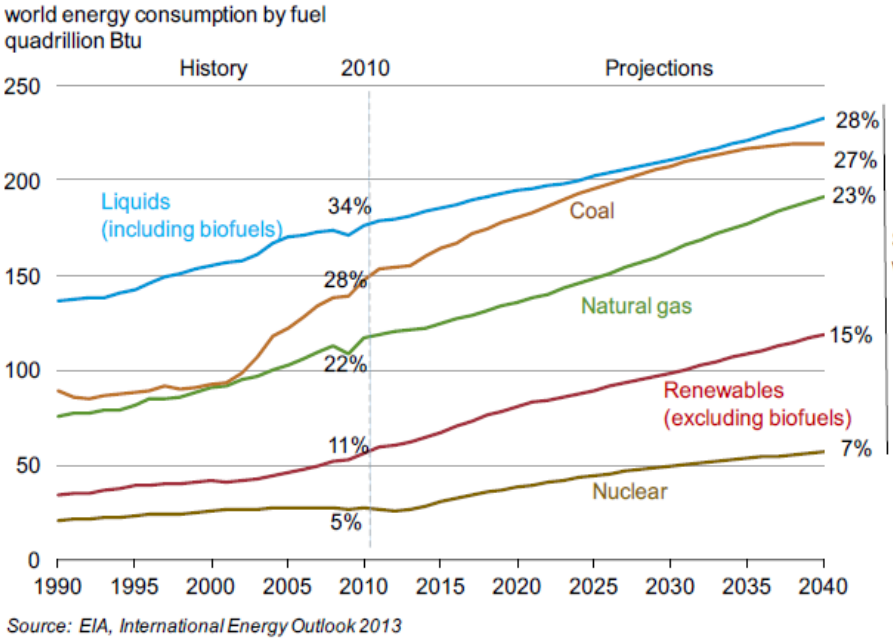
BPO

- 37,000+ employees
- 300+ global clients
- 37 locations in 9 countries

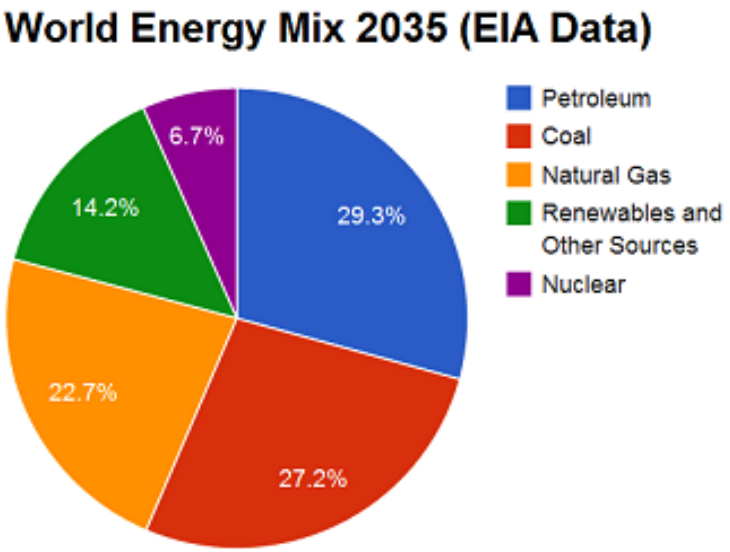
Real Estate

- Portfolio of 16mn sq.ft. in residential, commercial and mixed use projects

Why Unconventionals



Source: EIA, International Energy Outlook 2013

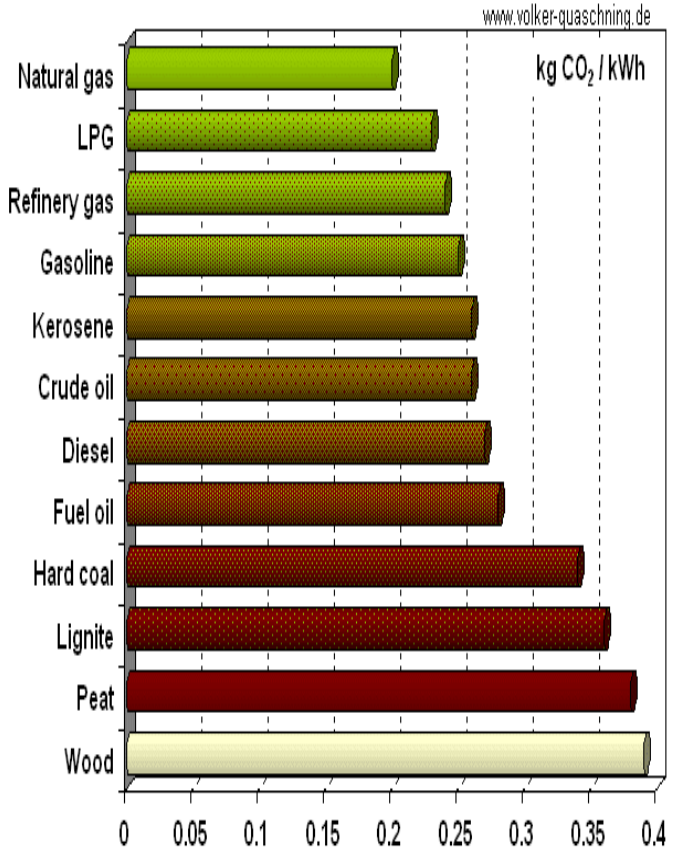


World energy consumption will remain heavily reliant on hydrocarbon sources

- ***Oil & Gas (conventional and unconventional) would continue to have more than 50% of world energy mix***
- ***The conventional resources are decreasing fast and discoveries are far and few, so the trend for unconventional hydrocarbons is going strong globally.***

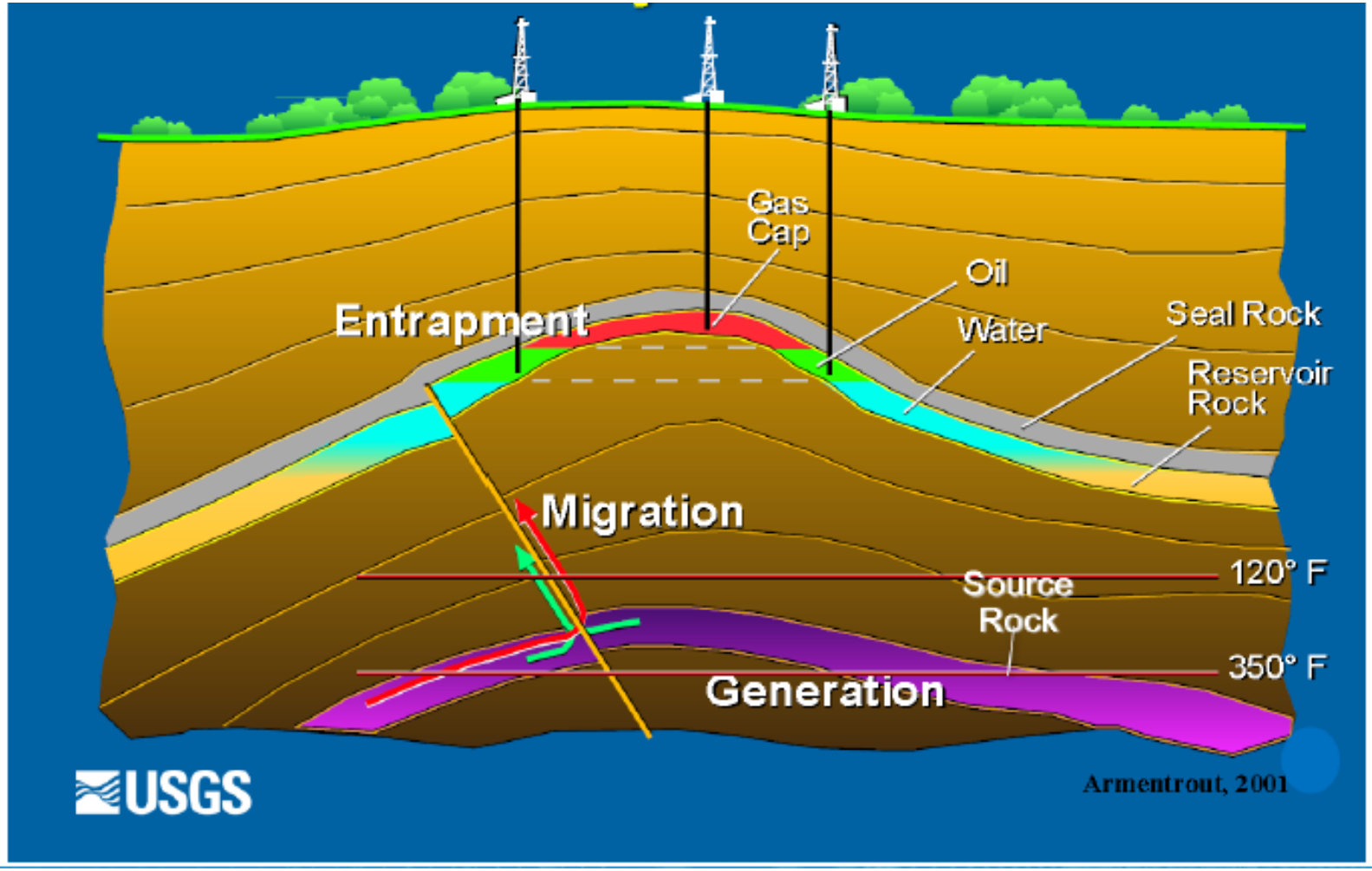
CBM – End use options

CBM

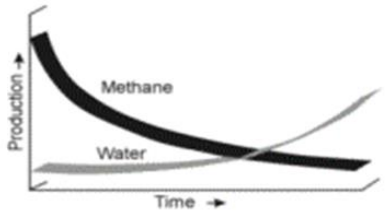


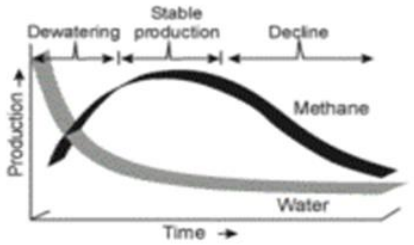
Specific carbon dioxide emissions of various fuels

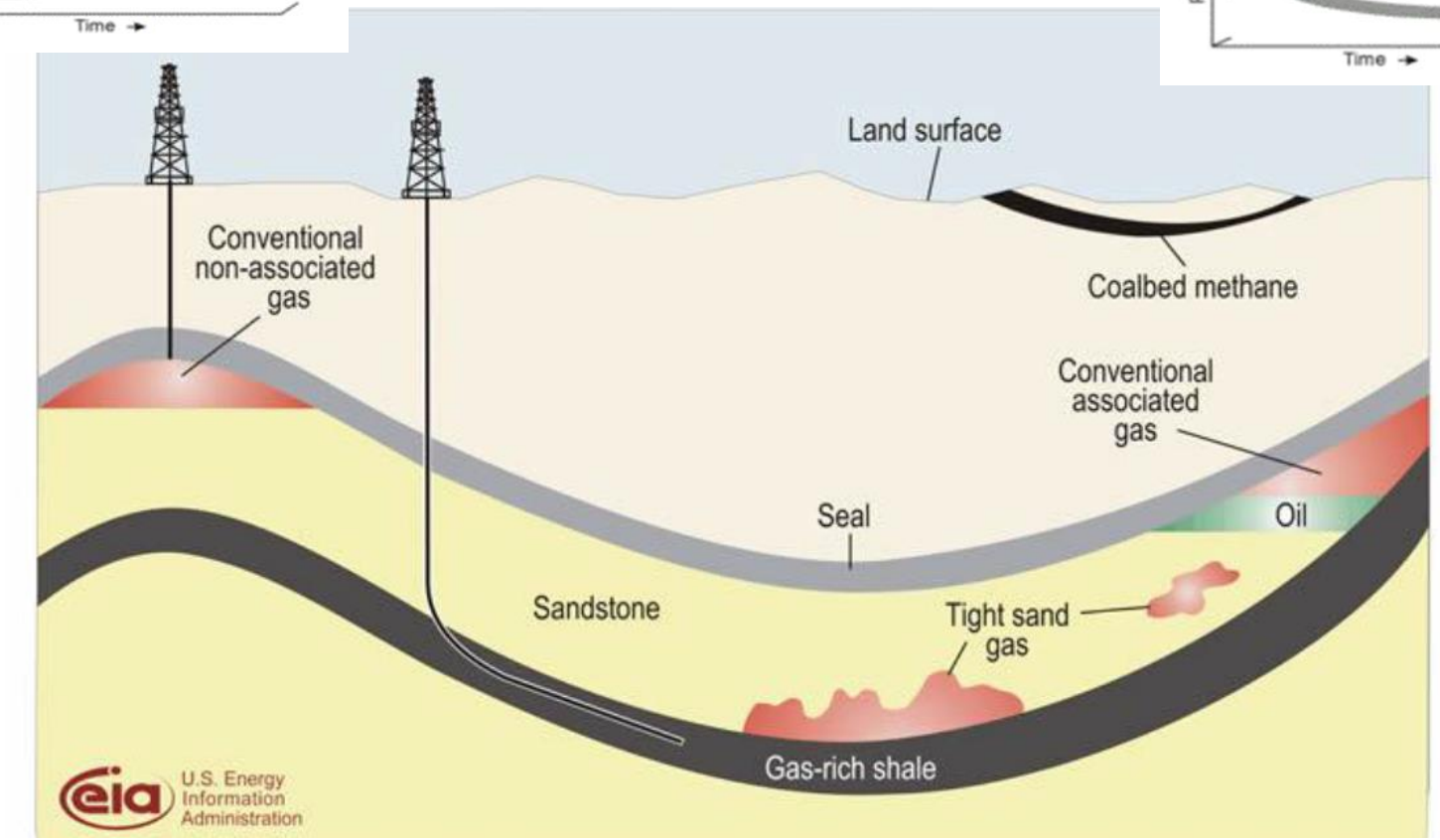
Total Petroleum System



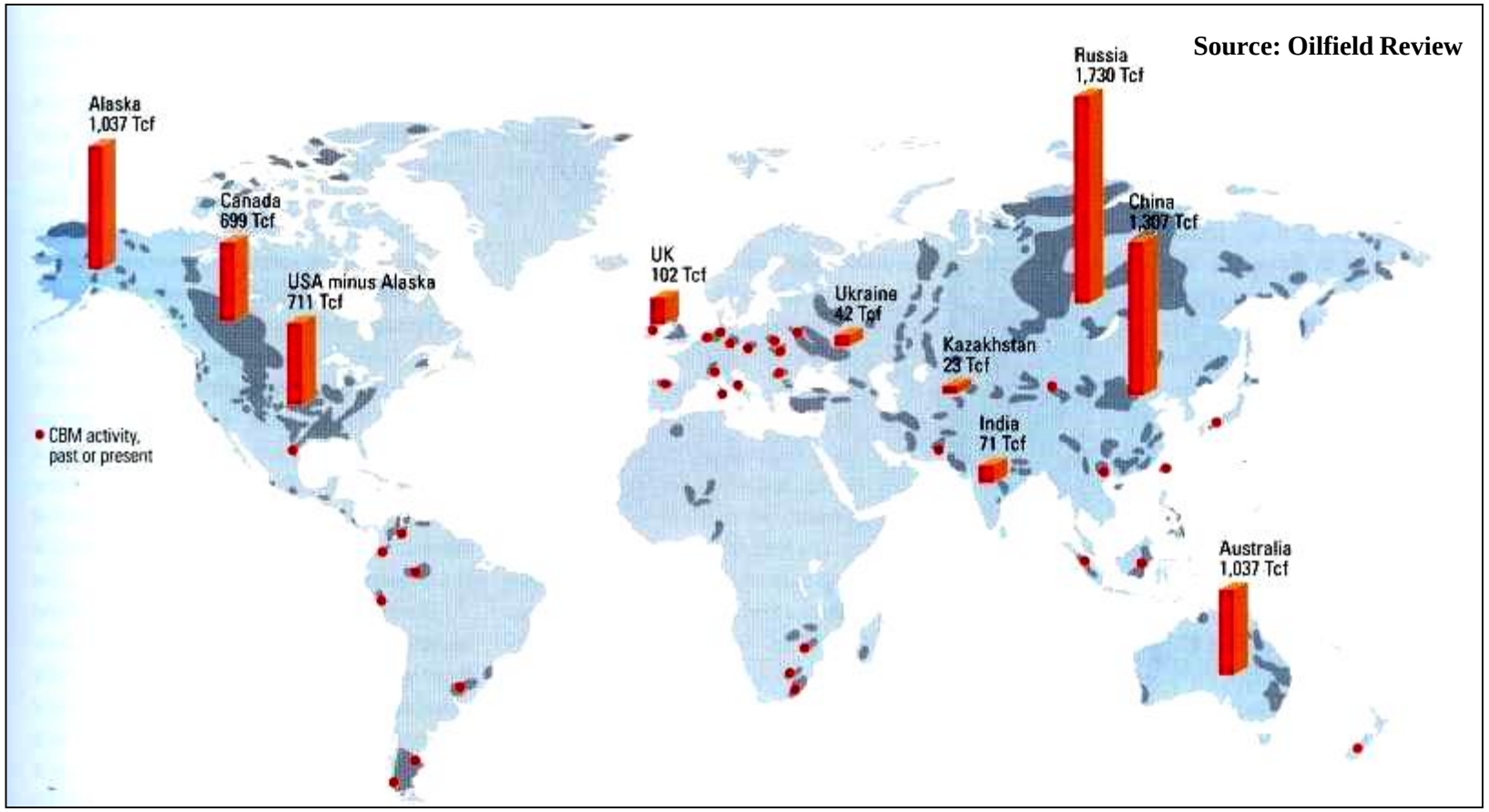
Hydrocarbon Plays







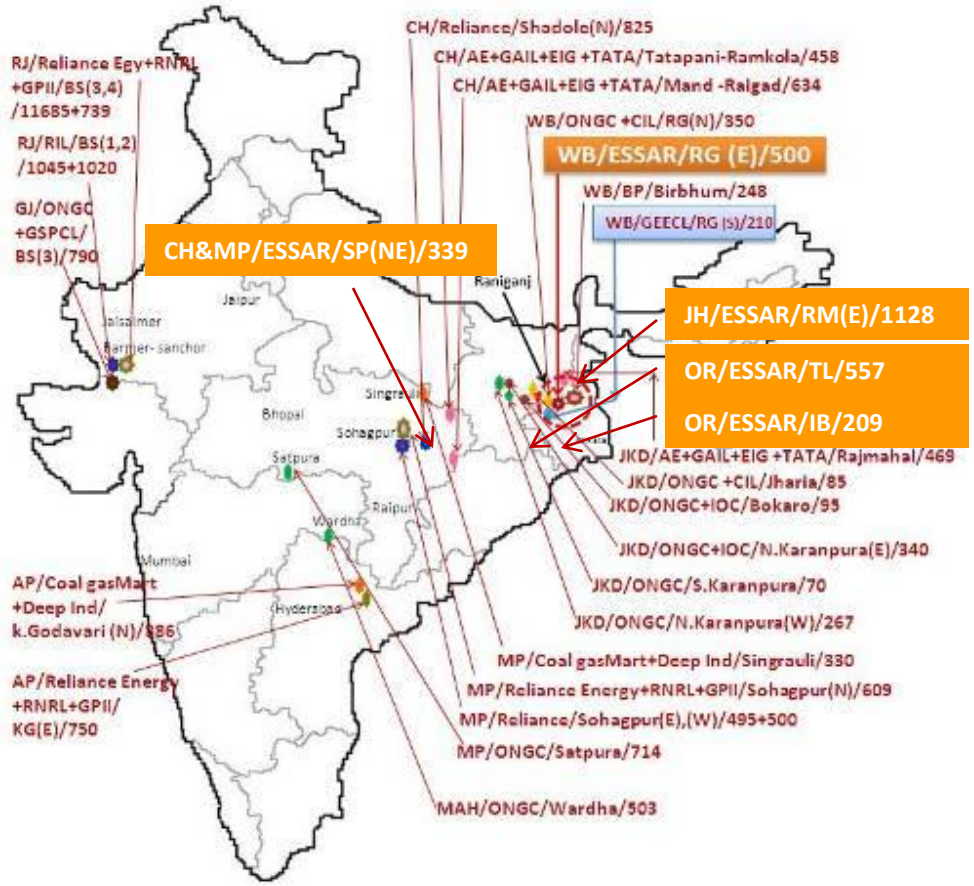
Global CBM footprints



69 Coal Bearing Basin : activity in 35 countries

Global CBM Resource : 270 TCM (9500 TCF)

India CBM Progress



- *33 Blocks CBM Resource potential 62 TCF ; 9.9 TCF established*
- *Main operators are Essar, GEECL , RIL & ONGC, GEECL*

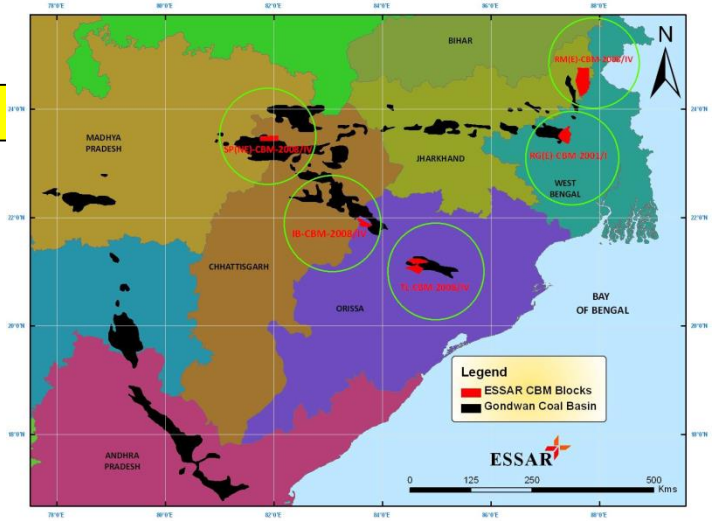
- *Gas production from Raniganj, Bokaro, Jharia & Sohagpur*
- *No conventional O&G in the eastern part of India which has the best Gondwana coals in the country.*

State	No. of Blocks	Area (Sq.Km)
West Bengal	4	1308
Jharkhand	7	2454
Madhya Pradesh	7	3701
Rajasthan	4	3972
Chattisgarh	3	1917
Andhra Pradesh	2	1136
Maharashtra	1	503
Gujarat	1	790
Orissa	2	766
Tamil Nadu	1	766
Assam	1	113
Total	33	17,246

CBM Blocks awarded till date

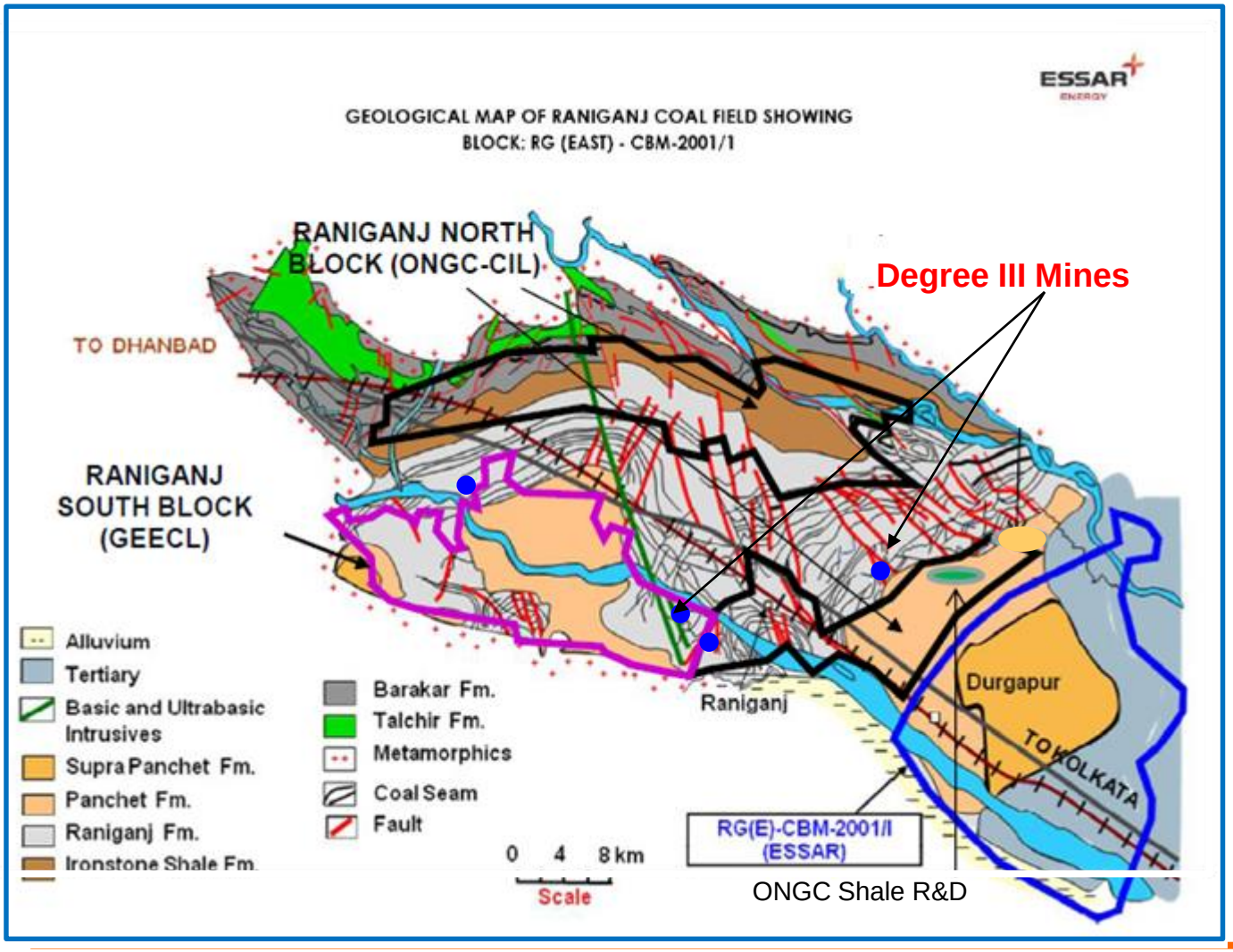
Essar – CBM Portfolio

- **Pioneer in Indian CBM E&P**
- Presence in key CBM Basins
- **Largest CBM acreage and Resources**
- Raniganj Block in Developmental stage while others are in exploration stage
- Technology Leader in India

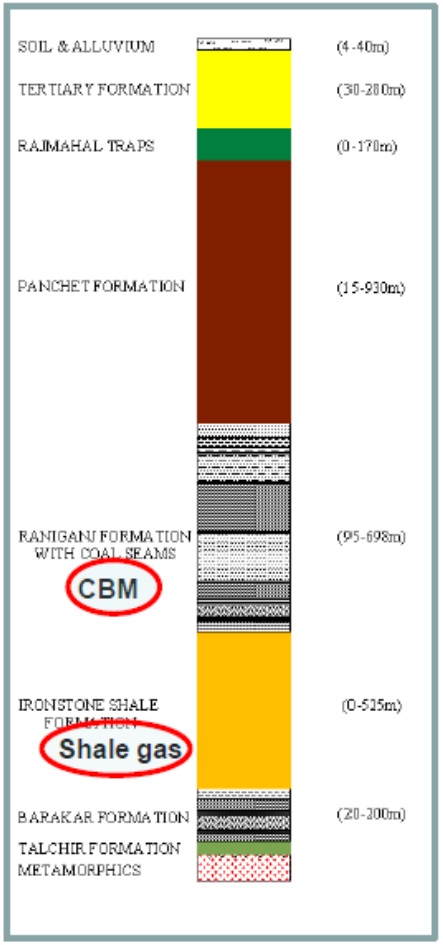


ESSAR CBM blocks in Gondwana basin

Raniganj Coalfield-Storehouse of Unconventional



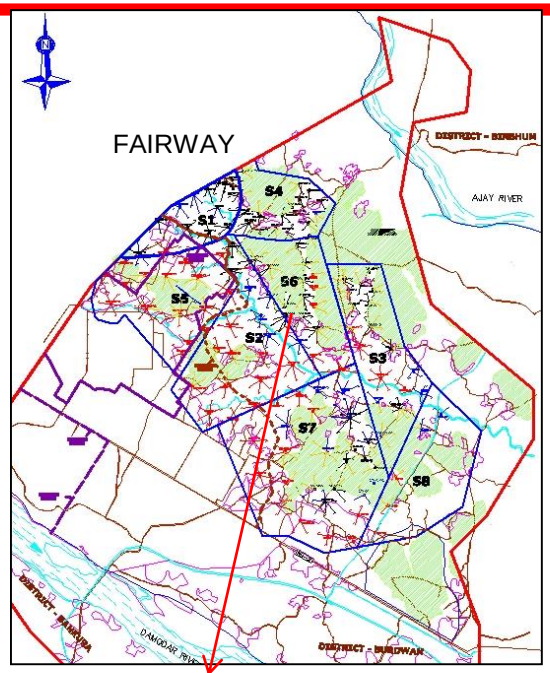
ONGC Shale R&D

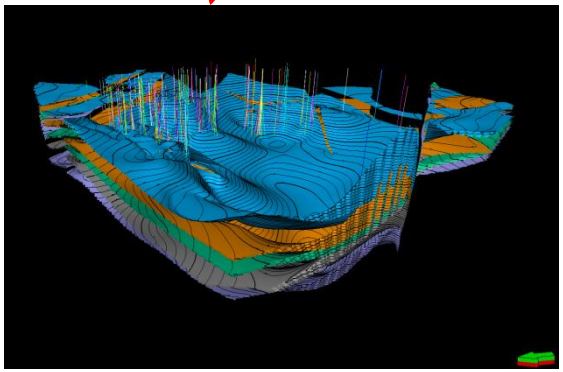


Generalized Stratigraphy

Development Phase Block: RG(E)-CBM-2001/I

- EOL 100% PI
- Area: 500 sq.km
- Exploration Phase I (2009) successfully completed and identified CBM fairway.
- Pilot Assessment Phase II (2012) completed successfully and incidental CBM gas flow established.
- Currently in Development Phase (Phase III)
- Largest number of development wells (~275) in the country
- Third party reserves certification carried out in 2009 & 2011 (0.85 Tcf Recoverable). Next phase of certification in progress.
- Highest CBM producer (c. 24 mmscfd) in the country today. Sizeable is under sale to local industries.
- GGS and Pipeline infrastructure operational.

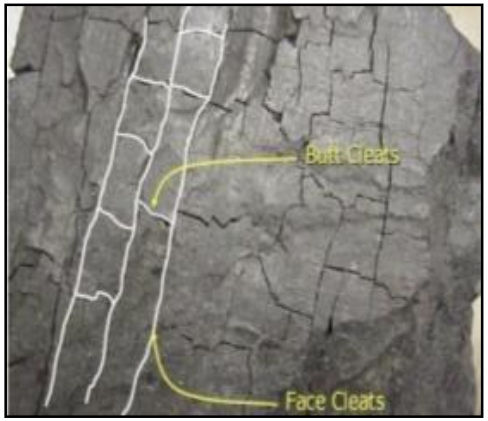




Static Model of the fairway

Key Strategy for field development

- Systematic Reservoir Acquisition
- Fairway Identification
- Pad Drilling –minimum surface footprint
- Cased hole multi seam completion
- Massive Frac Job
- Production Enhancement
  - Well Spacing - 40 & 60 Acres
  - Production Performance monitoring
- Development Plan – 500 Wells
- Prioritization based on Production Data

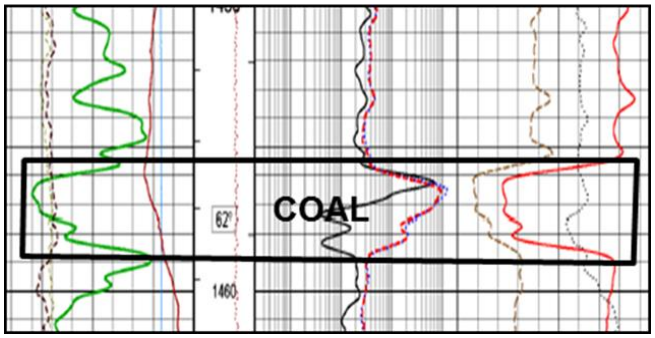


- Cleats are the pathways for gas migration
- Raniganj Coal Seams have well developed cleat system

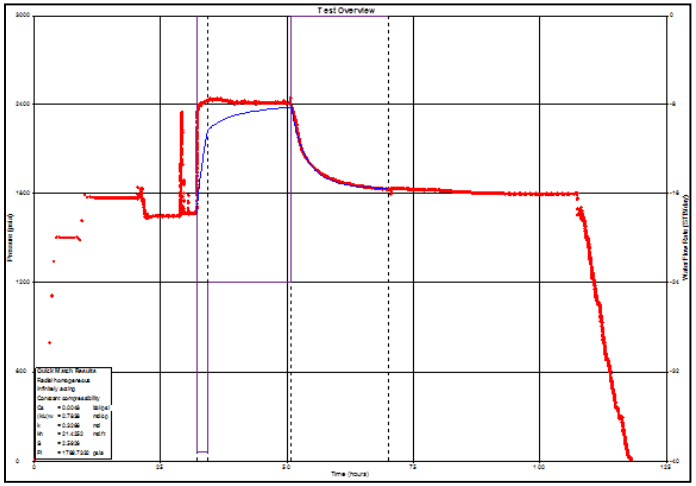
Key Reservoir properties

- Suitable Density cut-off thickness of coal - Log based
- Gas content (Desorption) and Gas saturation (Adsorption)
- Coal Permeability by in-situ coal Injection Fall-off (IFOT) tests

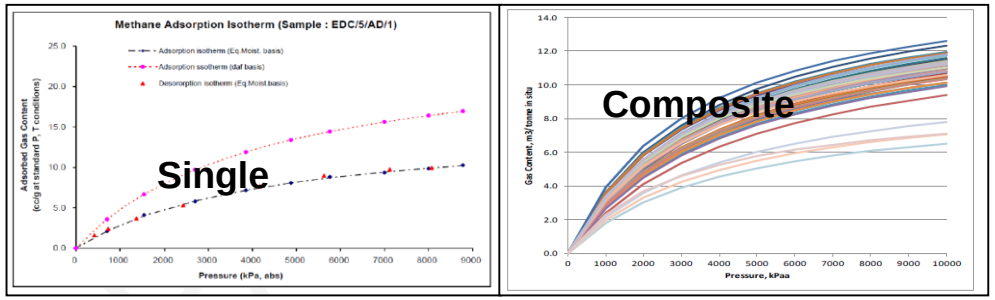
Geophysical Log - Extract



Interpreted coal



IFOT field curve

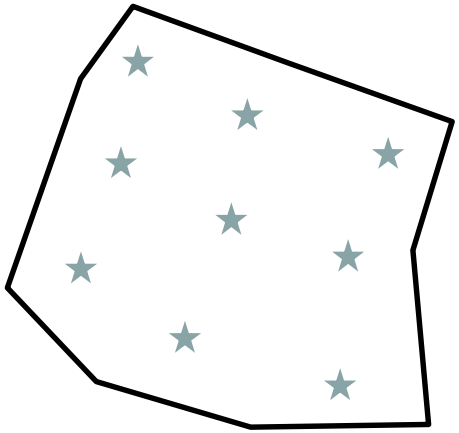


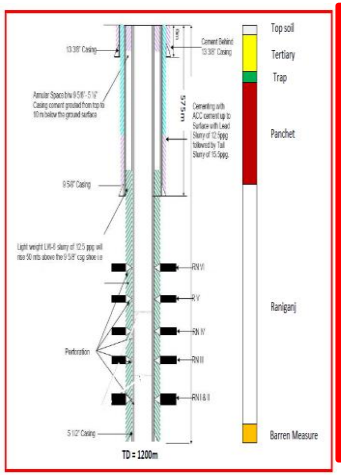
Adsorption Curve

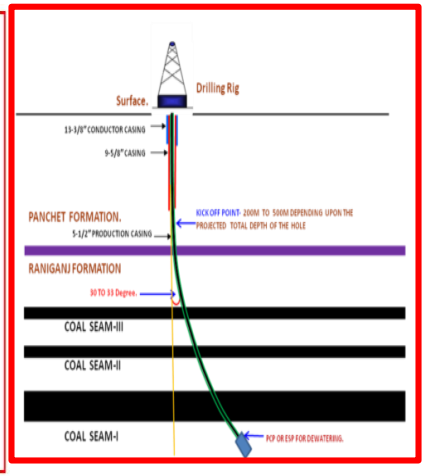
Pad Drilling

- Pad drilling for reducing the surface foot print.
- Time reduction to drill a well by deploying single schramm Rig
- Around 30% reduction in drilling cost

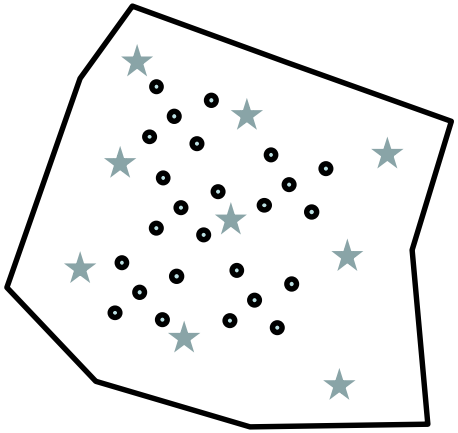
Essar Coring Rig





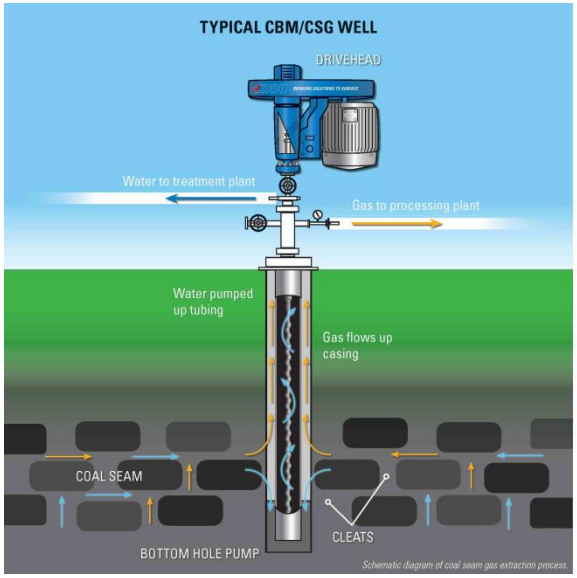


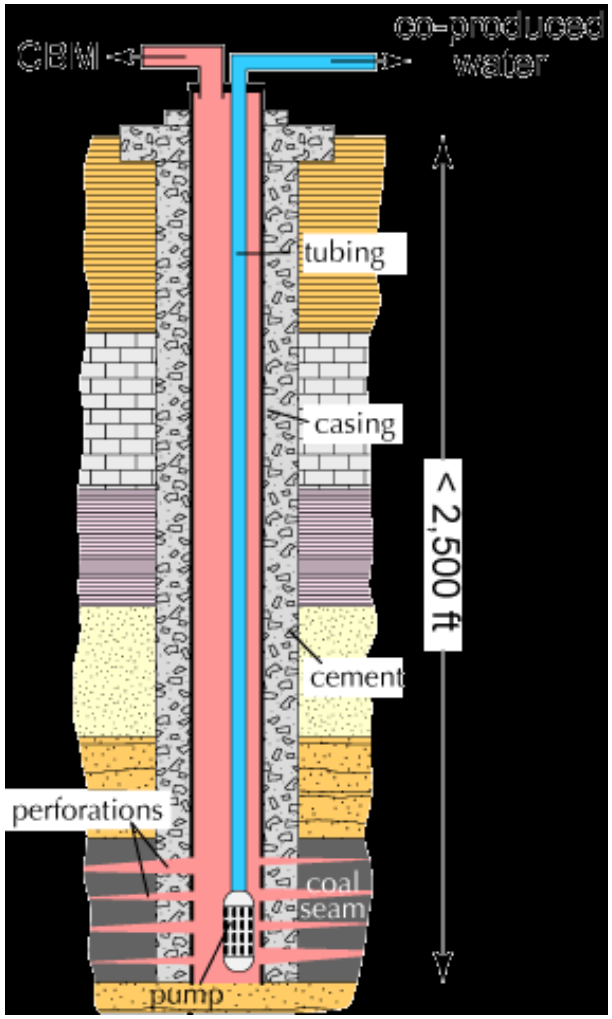
Schramm Rig

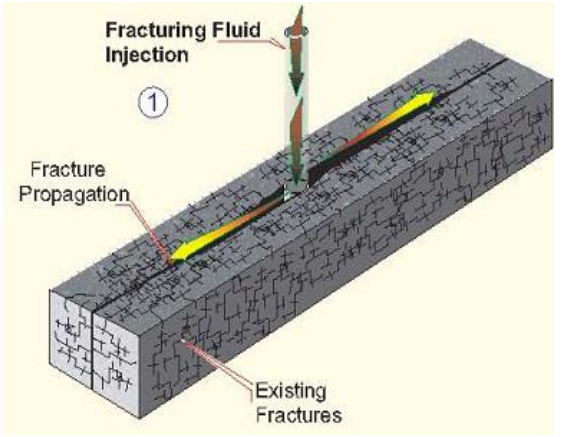


Well Completion

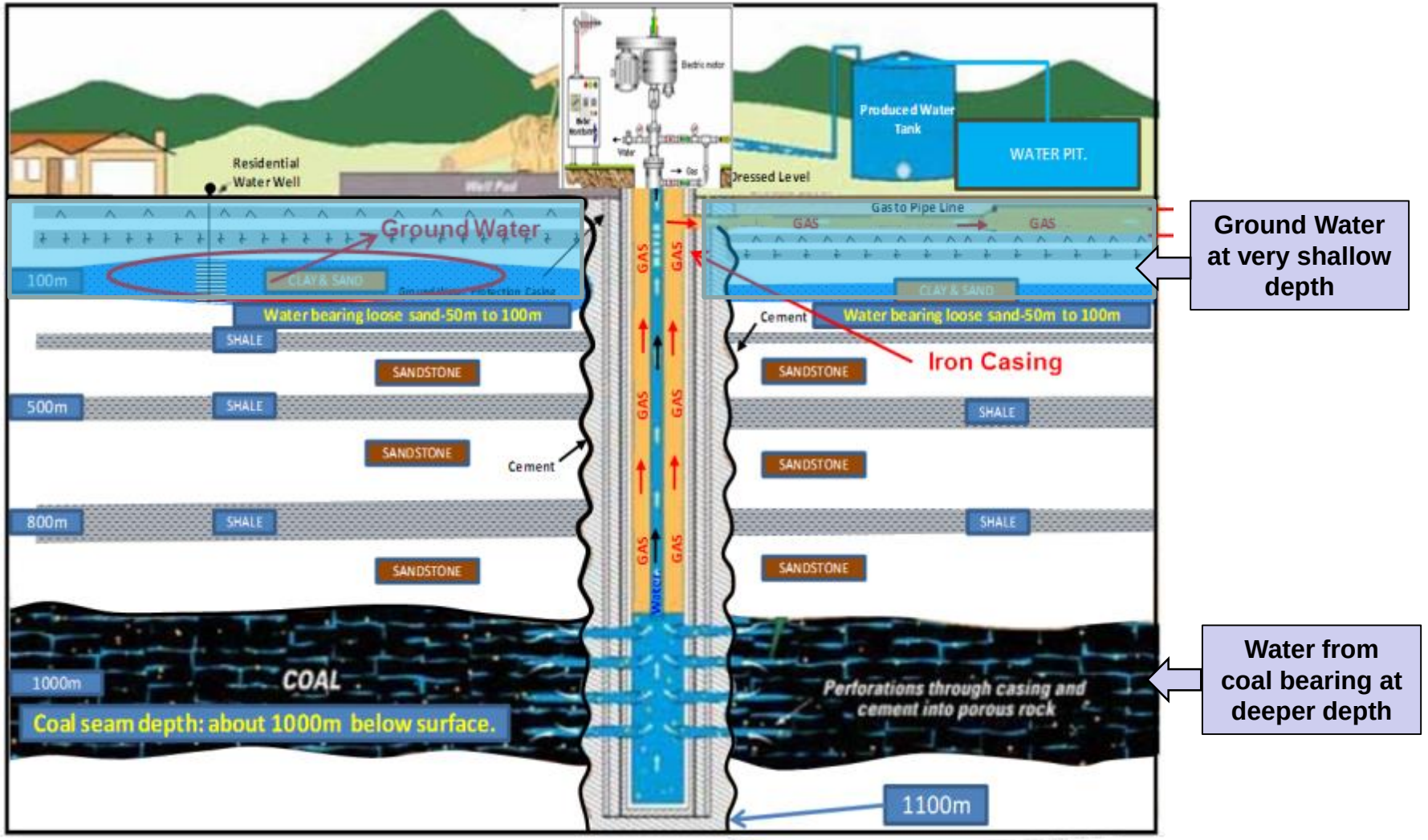
- Casing and Cementing
- Perforation
- Hydraulic Fracturing
- Work-over Operations
- Completion







No threat to Ground water

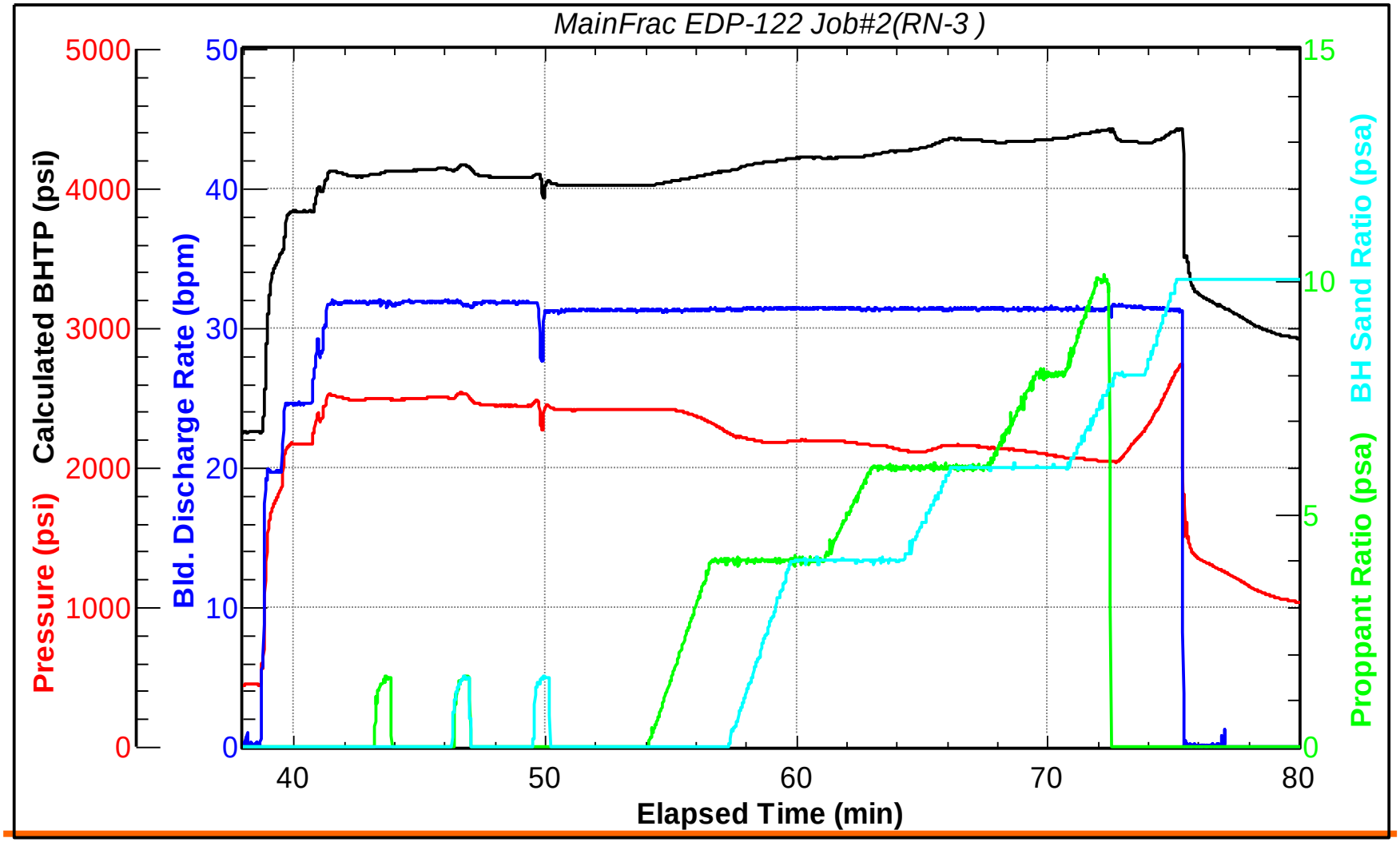


Withdrawn water has no interference with ground water due to Iron casing

Hydro-Fracturing

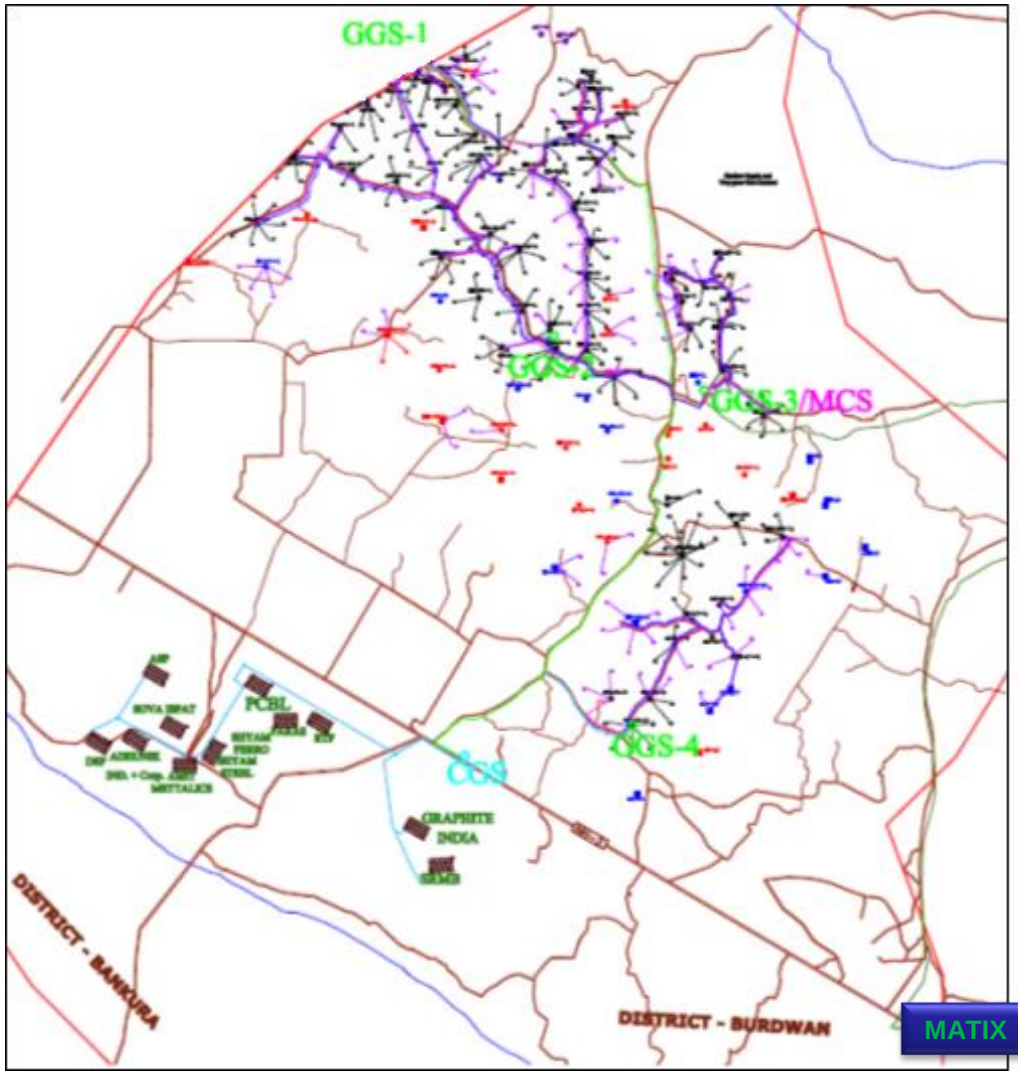
- Per Job cost saving is ~11%
  - ✓ Pumped more number of HF jobs per month - saved pumping charges
  - ✓ Optimised fluid design – 25# guar loading instead of 30# (upto 6 ppa sand)
  - ✓ Improvised job designs – use of water in flush stage & acid displacement
  - ✓ Reduced use of Acid – saving by eliminating Acetic acid consumption

Main Fracture Job Plot



Surface Facility at Site

Pipeline Network & Water Handling

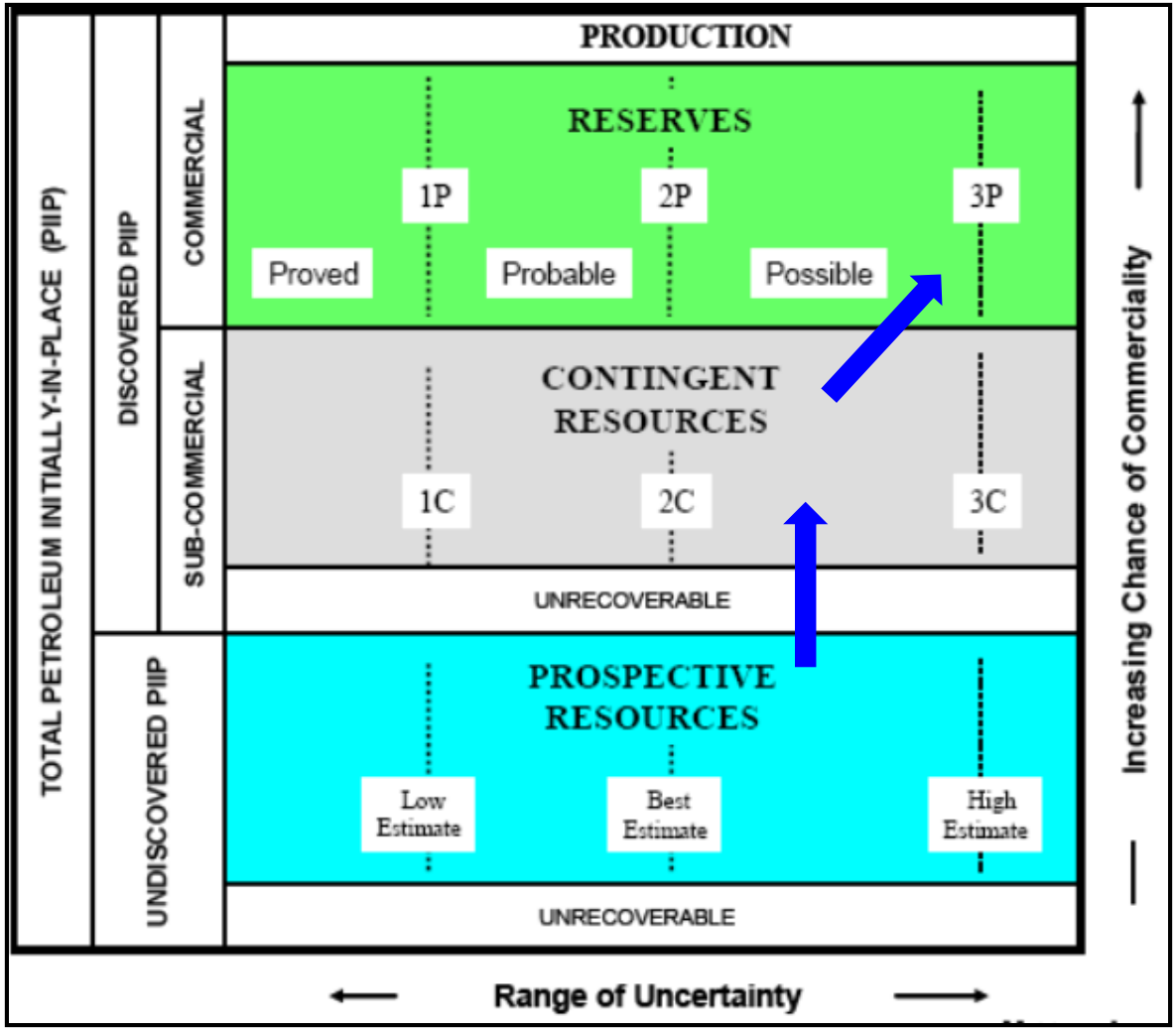


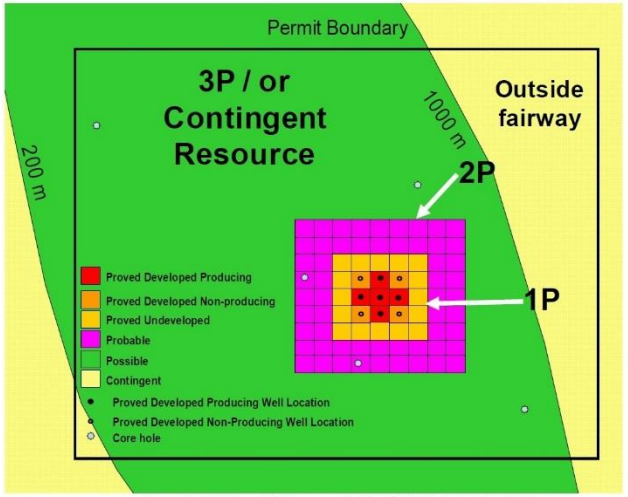
Water Tank & Interim RO

MATIX

CBM ….Well head to Market

Resource Migration

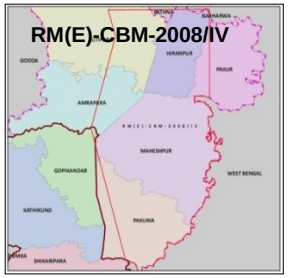


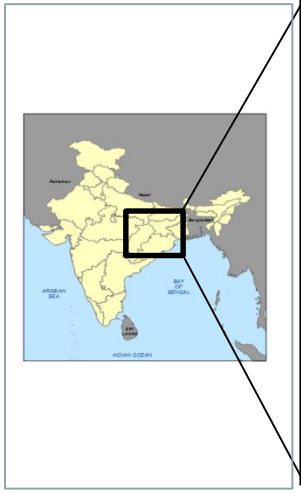


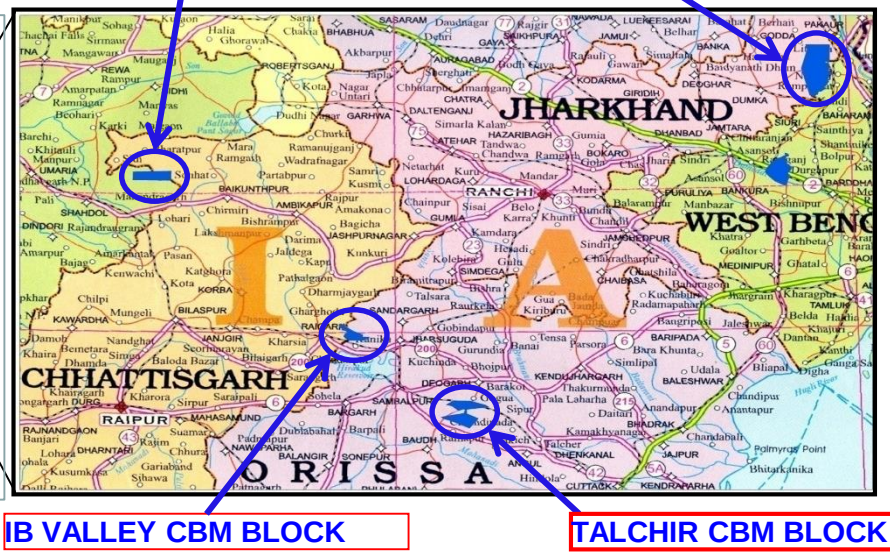
Conceptual 1P 2P and 3P Areas used in the CBM Industry (Barker 2008).

Exploration Blocks

Status : 4 Exploration Blocks





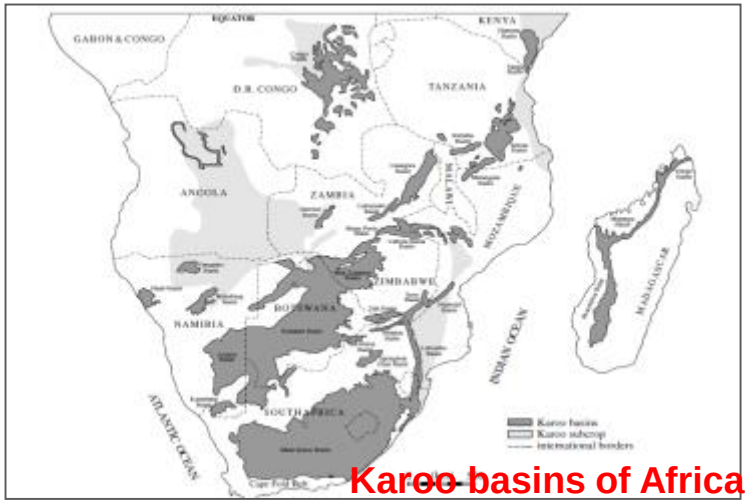


BLOCK NAME		SP(NE)-CBM-2008/IV		RM(E)-CBM-2008/IV	TL-CBM-2008/IV	IB-CBM-2008/IV
STATE		M .P	Chhattisgarh	Jharkhand	Odisha	Odisha
AREA (sq km)		339		1128	557	209
DISTRICTS (sq km)		Shahdol-231 Koriya-108		Pakur -1117 Sahibganj- 09 Dumka -02	Sambalpur-342 Angul-185 Deograh-30	Sundargarh-202 Jharsuguda-07
Resources (TCF)		0.6 (DGH); Recoverable: 0.37		3.2 (DGH); 4.7 (ARI); Recoverable: 1.2	2.6 (DGH); Recoverable: 0.49	1.2 (DGH); Recoverable: 0.4
Minimum Work Programme (as per bid)	Phase I- 02 Yrs	25 Coreholes & 03 test wells		30 Coreholes & 03 test wells	30 Coreholes & 03 test wells	25 Coreholes & 03 test wells
	Phase II- 3 Yrs	25 pilot wells		20 pilot wells	25 Pilot wells	20 Pilot wells

CBM - Multi-Geography Exposure

World-wide

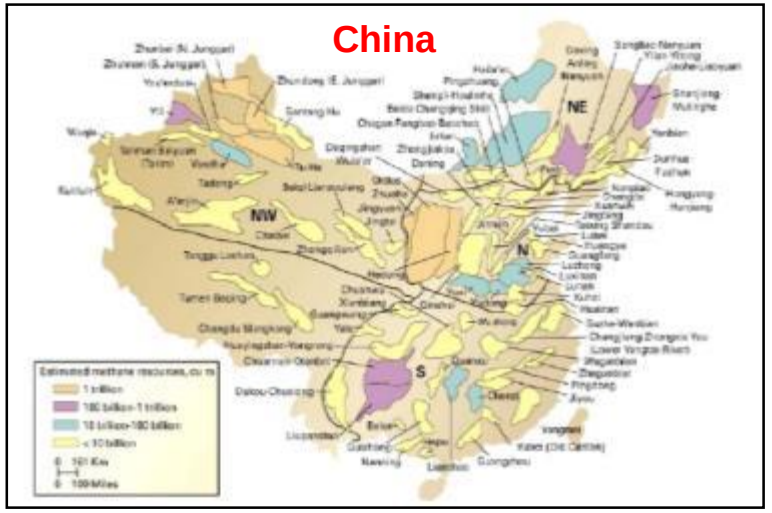
- Sub-Saharan Africa
- China
- Turkey
- USA
- UK
- Indonesia
- Poland
- Australia



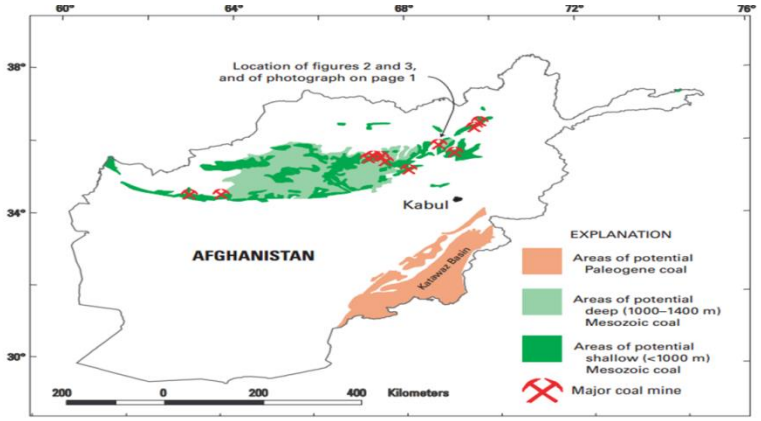
Karoo basins of Africa

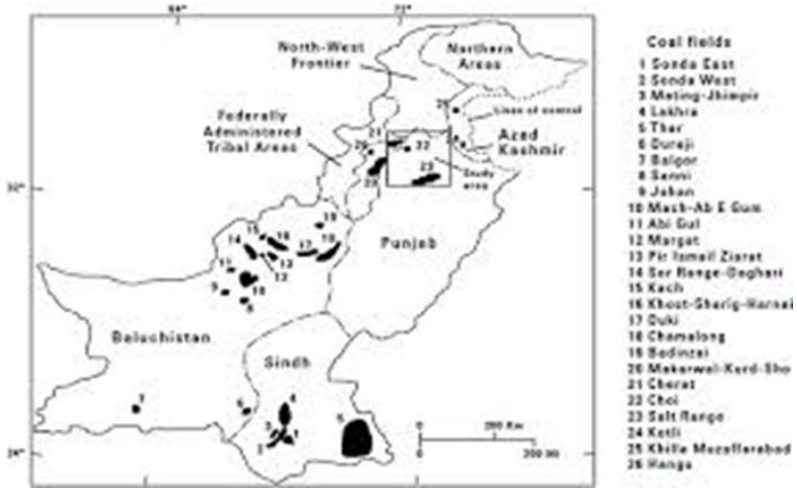
SAARC

- Being part of the master Indian sub-continent regional geology and coal occurrences are very similar across all these SAARC countries.
- Essar internal Unconventional Hydrocarbon Team is already having a good understanding of regional SAARC country geology and keen to work there.
- Ideally positioned to venture into fellow SAARC countries for suitable business ventures under suitable terms.



Few Example - India & Afghanistan/Pakistan





Essar – Other Clean Coal Technology ventures

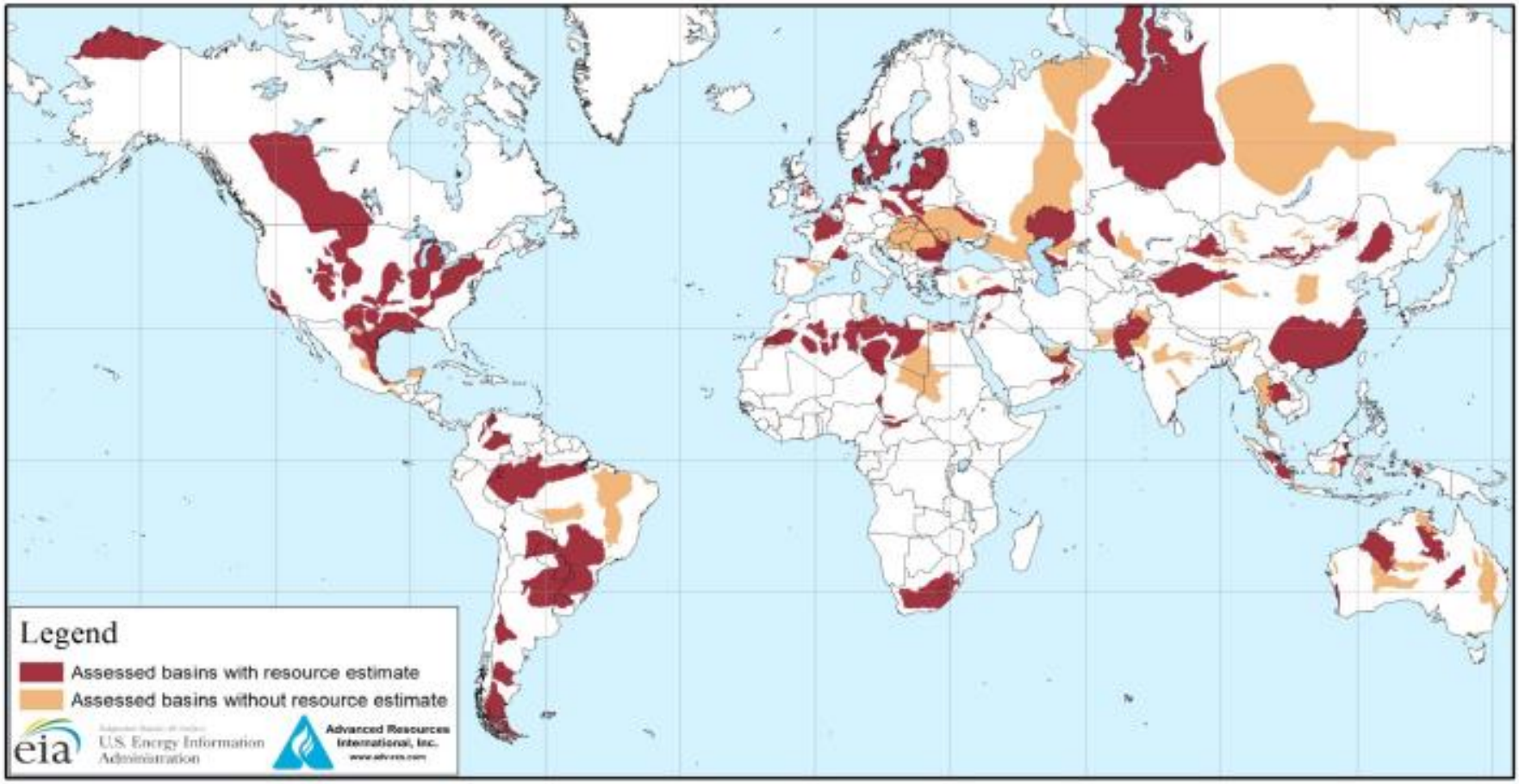
Underground Coal Gasification (UCG)

- Strong understanding of Technology and Alliances with few global expert agencies like Clean Global Energy (CGE), Australia.
- Essar had actively bid/participated in various tender/offers for UCG development so far in India like - Singareni Collieries Company Limited (SCCL) Coal India Limited (CIL) and Rajasthan State Petroleum Limited (RSPCl.
- A Draft Policy Note for UCG/Production of syngas obtained through gasification has been notified by the Govt. of India but yet to be formally announced.

Coal Mine Methane (CMM)/Abandoned Mine Methane (AMM)

- Huge CBM resesource locked in Indian coal mining leasehold areas (possibly in excess of 200 TCF).
- The Team has a good understanding of the process and already worked on CMM/AMM projects in UK and its scope in Raniganj/Jharia Coalfields.
- CIL had in 2011 offered blocks for CMM development in its leaseholds which was bid and qualified by Essar. Final Award on announcement of Development Policy by GoI.
- The Govt. of India is expected is shortly expected to announce the policy for CMM development in CIL and/or private mining leaseholds. Essar with its CBM expertise, experience and service contracts is keen to work with these coal mining companies..

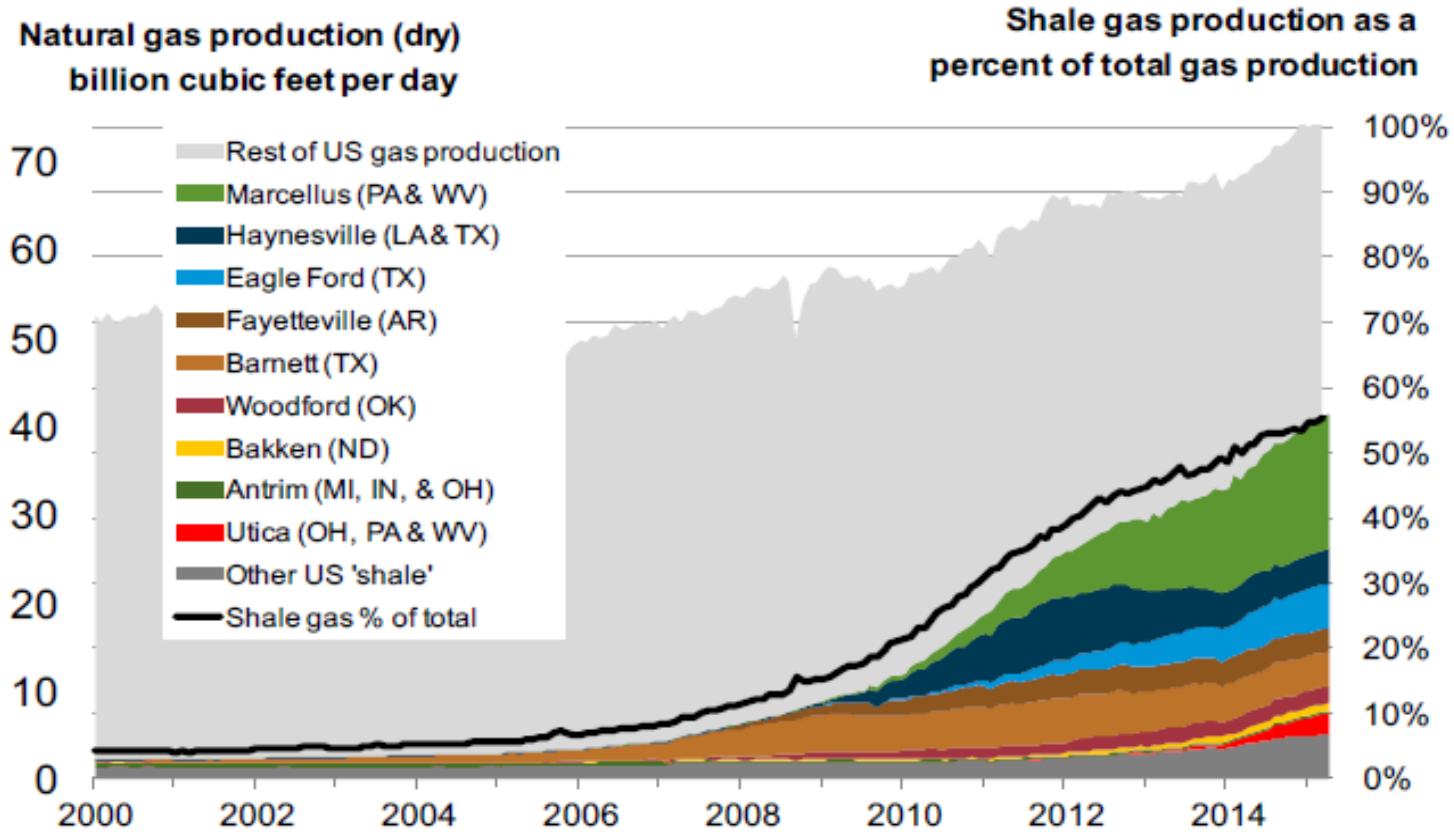
Shale Oil/Gas Prospects - worldwide



Map of 106 basins in 46 countries
Global Shale Gas – 35,782 tcf, Shale Oil – 6753 bboe

The Trend

Estimated U.S. shale gas production was 41.4 Bcf/d in May 2015 about 55% of total U.S. dry production (74.6 Bcf/d)

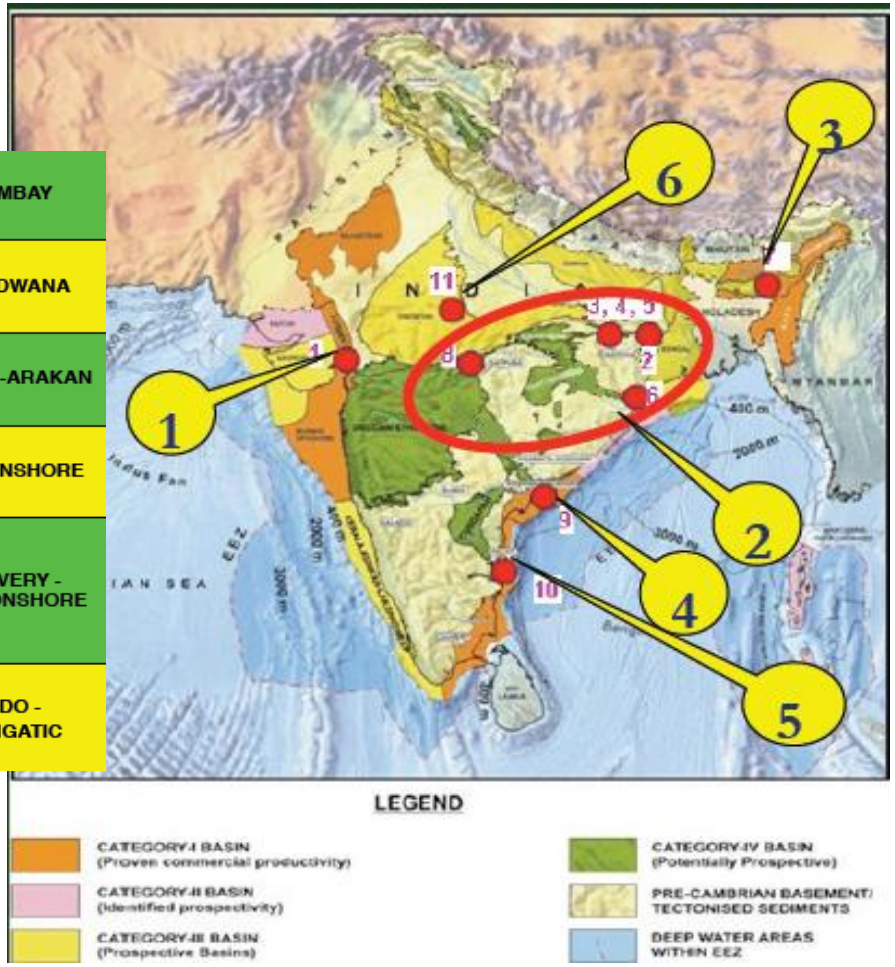


Sources: EIA Natural Gas Monthly data through December, STEO through April 2015 and Drilling Info.

Shale Gas – Indian scenario

The major Gondwana basin CBM plays are strategically central part of the Shale Gas map

1	CAMBAY
2	GONDWANA
3	ASSAM-ARAKAN
4	KG - ONSHORE
5	CAUVERY - ONSHORE
6	INDO - GANGATIC

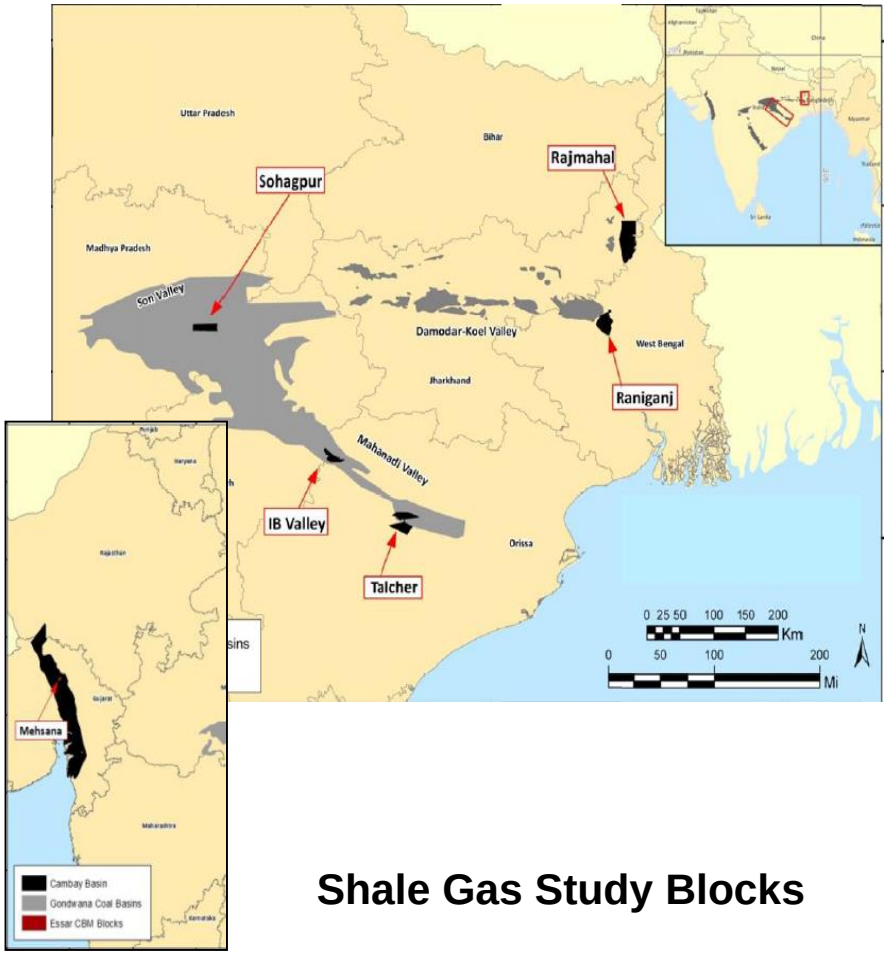


- 6 prospective basins identified by DGH for shale gas exploration
- Final version of Shale Gas Policy 2012 yet to come in force
- **584 TCF** of shale gas resource and **87 billion Barrels** of shale oil resource in 4 basins :Cambay Onland, Damodar, Krishna Godavari Onland & Cauvery onland (EIA 2013)
- ONGC pioneered drilling of Shale wells in Damodar Valley and successfully tested in Raniganj(N) block, close to Essar's Raniganj(E) block.
- Presently ONGC is drilling R&D wells in Gujrat.

Source:DGH & EIA

Shale Gas Feasibility

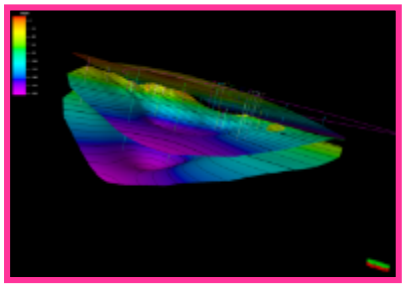
- *Essar Shale gas Feasibility study for its CBM blocks and Mehsana O&G block with support from USTDA*
- *Objective was to a) establish the potential, prospect and risk with Shale Gas development & b) Design an execution from pilot to field Development*
- *Combined in place resources of Mehsana & RG (E) is of the order of 10 TCF.*
- *Shale Gas can be developed in synergy with current CBM development in RG (E) with common infrastructure*



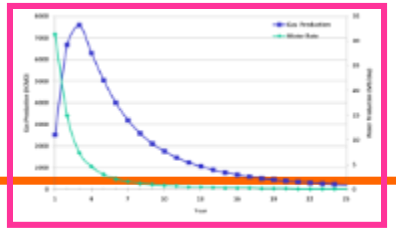
Shale Gas Study Blocks

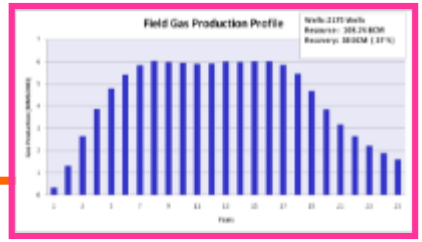
Essar – Expertise

- Multiple geographic and geological province working experience
- Established leadership position in Unconventional CBM gas in India
- A highly enriched technical team consisting of Geoscientists, Engineers, and other technical staff along with a highly motivated management team, consisting of specialists in finance, business development, logistics, human resources, project consultancy and advisors.
- Use of industry benchmark hardware (high-end workstations) and softwares (Prizm-Geographix, Petrel, Eclipse, Comet, Kingdom suites, Frac-Pro, etc.) at offices.



Modeling





Simulations

Unconventional – SAARC co-operations

- Significant geographical and geological similarities in the region.
- All these countries have heavy import burden in terms of primary energy resource
- Coal resources are known and huge Shale Gas/Oil resources has been reported by expert
- Energy transfer through Cross-country pipelines appear imminent
- There is a strong need for mutual co-operation in sharing of technology & expertise among SAARC nations for Energy Security
- Efforts required to unlock ~1000 TCF in-place locked up in SAARC countries in CBM & Shale Gas

THANK YOU