



vedanta oil & gas

CAIRN

LEVERAGING TECHNOLOGY TO UNLOCK INDIA'S HYDROCARBON POTENTIAL



Vedanta Oil & Gas is at the forefront of adopting advanced technological solutions to accelerate its vision to contribute 50% of India's domestic crude production and develop new hydrocarbon resources.

The cutting-edge technologies assist in identifying new oil and gas reserves and enhance resource recovery from existing fields, maximising output from operational fields.

Leveraging Operational Excellence through Advanced Technologies

- Executed world's largest jet-pump operation
- World's largest Enhanced Oil Recovery (EOR) polymer flood project
- World's longest continuously heated and insulated pipeline
- World's largest jet-pumping network
- Longest horizontal well in India
- India's first Sub-Sea Template installation in Ambe block, West Coast
- India's first one-of-a-kind 3D Controlled Source Electro-Magnetic (CSEM) survey for exploration in the Deepwater KG block
- First 4D seismic in India
- India's largest commercial Alkaline Surfactant Polymer (ASP) flooding project
- First-of-its-kind petro-technical cloud project, adopting and implementing its own cloud platform for upstream interpretation
- The first company in India to apply Micro Seismic Hydrofrac Monitoring Technology

3D SEISMIC

Cairn has implemented the state-of-the-art seismic imaging and inversion technologies in the structurally complex Barmer Basin in Rajasthan.

- **Mega Merge seismic PSTM and PSDM processing**, integrated all individual 3D surveys from various fields, into a single seamless seismic volume. Facilitated the identification and de-risking of new exploration prospects in the Rajasthan block.
- Application of advanced orthorhombic seismic processing has significantly improved subsurface imaging, enhancing structural understanding and reservoir architecture in the Raageshwari area, crucially reducing development drilling risks.
- Innovative workflow merged two existing seismic vintages with different orientations, **generating high-quality seismic images** in the Mangala field.
- Cutting-edge local angle domain seismic imaging technology provided better definition of main bounding and intra-field faults, **reducing drilling risk** in the attic oil development in Bhagyam.



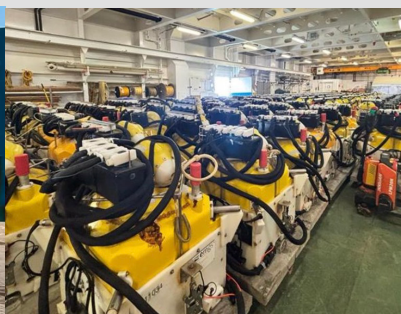
3D CONTROLLED SOURCE ELECTROMAGNETIC SURVEY

Vedanta Oil & Gas has executed **India's one-of-the-first 3D Controlled Source Electromagnetic (CSEM) surveys** in the Krishna-Godavari (KG) Basin on the East Coast of India, setting a new benchmark in deepwater exploration.

Using **advanced "Deep Blue" technology**, this cutting-edge electromagnetic method maps subsurface resistivity to reveal hydrocarbon-bearing formations beyond seismic limits.

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When fused with reprocessed 3D seismic data, the result is unmatched reservoir characterisation, sharper fluid prediction, and smarter prospect prioritisation — **minimising risk and optimising well placement.**

This powerful integration transforms complex subsurface signals into actionable intelligence, **unlocking untapped hydrocarbons in the deep waters.**



SUB-SEA TEMPLATE (SST) INSTALLATION

Cairn installed **India's first Sub-Sea Template (SST) in its Ambe block in the West Coast**. SST is a pre-engineered steel foundation installed on the seabed, forming a key component of a **Conductor Supported Platform (CSP)** for offshore drilling and production. It enables accurate positioning of multiple wells, provides structural support for equipment, and protects wellheads.

SST supports efficient shallow-water field development. The deployment was executed using a **jack-up rig**, demonstrating a flexible and optimised installation approach suited to Indian offshore conditions.

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The SST enables **cluster drilling**, allowing multiple wells from a single location, reducing installation time, development costs, and offshore complexity.

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The **modular design** supports phased development and future expansion. Aligned with the principle of '**Design One, Build Many**', the SST solution enables scalable, cost-efficient development of marginal offshore resources.



HYDRAULIC FRACTURING

Cairn has extensively utilised hydraulic fracturing as a key technology to appraise and develop Tight Oil and Gas fields in Rajasthan.

Cairn has also been at the forefront of successfully applying fracking in volcanic gas reservoir systems, executing **one of the largest commercial developments of tight volcanic reservoirs globally**. This included advanced fracture diagnostics and the application of limited entry fracturing, **increasing reservoir pay coverage from 60% to 85%**.

- Successfully completed **India's largest frac job** (430,000 lbs per stage of proppants) in one of the wells located in the Raageshwari Deep Gas (RDG) field in the Barmer basin, by reducing frac time from 4.5 days to 2.2 days per stage.
- Use of limited entry techniques in the RDG field has **increased reservoir coverage from 60% to 85%**. Additionally, addressable switch technology was implemented to perforate multiple zones in a single E-line run. Evaluation and implementation of fibre-assisted frac technology enhanced fracture conductivity and **reduced frac costs by approximately 50%**.
- Employed advanced diagnostics, such as downhole camera technology, non-radioactive tracer proppants, fluid tracers, and downhole temperature surveys, to optimise fracturing design.

In the **Aishwariya Barmer Hill**, Cairn successfully drilled the longest onshore 6" lateral section (1380m) in India using the Periscope HD tool. Over 150 stages were successfully fractured using the **Broadband Precision Integrated Completion Service** method.



ENHANCED OIL RECOVERY (POLYMER FLOODING)

Enhanced Oil Recovery (EOR) through Polymer Flooding increases the amount of crude oil that can be extracted from a field, going beyond conventional primary depletion or basic water flooding, which typically recovers only 20 to 40% of the **Stock Tank Oil Initially in Place (STOIIP)**.

Remarkable success in polymer flooding across key fields:

- **Mangala Field:** Executing the largest commercial polymer flooding in India's largest onshore oil field has seen significant benefits. This technology has delivered impressive incremental production, boosting oil recovery by ~100 million stock tank barrels beyond water flooding.
- **Bhagyam and Aishwariya Fields:** Polymer flooding was extended to Bhagyam and Aishwariya fields, which possess similar rock and fluid characteristics. The expected net ultimate incremental oil recovery is between 20-25 mmstb each over water flooding.
- **Central Polymer Facility:** Cairn operates the World's largest centralised polymer mixing facility, with a capacity of 80,000 barrels per day of 15,000 ppm polymer mother solution at its production site in Barmer, Rajasthan.





ENHANCED OIL RECOVERY (ASP FLOODING)

Alkaline-Surfactant-Polymer (ASP) flooding is an advanced Enhanced Oil Recovery (EOR) technique, where alkali, surfactant, and polymer are injected into the reservoir to displace crude oil.

Polymers increase viscosity of the injected water, enhancing the macroscopic sweep efficiency by stabilising the displacing front and mitigating the effects of reservoir heterogeneity. **Surfactants reduce the interfacial tension between the injected water and crude oil**, which improves microscopic displacement efficiency by mobilising trapped oil. **Alkaline chemicals react with the crude oil to generate soap**, which further reduces surfactant adsorption to grain surfaces.

Cairn has scaled up commercial ASP implementation in Mangala Well Pads. Together, ASP injection capacity of ~120K bpd has been installed in the field. This is expected to yield approximately 15-20% additional oil recovery in the targeted area. The commercial deployment of ASP flooding is a significant milestone, paving the way for the expansion of ASP across other areas of Mangala and additional fields within the Rajasthan block.



ARTIFICIAL LIFT SYSTEMS

At Cairn, **95% of hydrocarbons are produced using customised artificial lift technologies** such as:

- Electric Submersible Pump (ESP) with Permanent Magnetic Motors (PMM)
- Jet Pump
- Progressive Cavity Pump (PCP)
- Sucker Rod Pump (SRP)
- Gas Lift

Cairn also operates the **world's largest Jet Pump network**, processing approximately 1 million barrels of liquid, including Jet Pump power fluid, further demonstrating its leadership in artificial lift technology.



SKIN EFFECT HEAT MANAGEMENT SYSTEM (SEHMS)



SEHMS technology is a proven electrical heating solution used for long-distance piping and pipelines.

It generates heat on the inner surface of a carbon steel heat tube welded to the carrier pipe. An electrically insulated, temperature-resistant conductor is installed within the tube and connected at the circuit end. The tube and conductor are powered by an AC voltage source in a series connection. This heating method is called **Skin-Effect Heating**, as the circuit current is pulled to the inner surface (~ 1 mm) of the heat tube due to the skin effect and proximity effect between the heat tube and conductor.

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Cairn constructed **Mangala Development Pipeline (MDP)**, the world's longest continuously heated and insulated pipeline (~705 km) and has been operational since June 2010.

The MDP's design was driven by the viscous and waxy nature of crude oil, requiring the crude to remain above the **Wax Appearance Temperature (WAT)** of 65°C for the entire length of the pipeline. To address this challenge, Cairn implemented a continuously heated and insulated pipeline to ensure continuous mobility and flow. The SEHMS and power generation infrastructure maintain the required temperature for uninterrupted crude flow.



ENHANCING PRODUCTION THROUGH DIGITALISATION



Technology	Digital Initiatives
Artificial Intelligence Machine Learning (AI/ML) and Generative Artificial Intelligence	GenAI program for building a custom platform catering to functional use cases
	AI based safety monitoring and surveillance
	AI/ML factory initiative with use cases such as seal failure prediction; improving oil recovery
	Predictive analytics for critical equipments
Process Digital Twin	Process Digital Twin for enhanced operations in onshore Oil and Gas facilities
Advance Process Control	Maximisation of production and reduction in production losses through APC on Artificial lifts
	Steam Header Pressure Stabilisation and STG Power Maximisation, ESP and PCP's using Advance Process Control
	Maintaining GHV of Sales Gas through automated controls using APC
Drones	Use of Drones for overhead transmission lines and Tank Inspection
	Land surveys through LIDAR to understand terrain and elevation of the area

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g to lure on nk d	Industrial Internet of Things (IIoT)	IIoT-enabled steam trap monitoring, vibration monitoring of rotating equipment and solar deployments monitoring
		RFID based inventory management for physical verification and real time reconciliation
		Energy optimisation of HVAC systems
		Use of Edge devices and ML for Artificial Lift Digitalisation in satellite fields
	Augmented Reality / Virtual Reality	Safety trainings to employees and contract workforce through AR/VR
	Data Management & Analytics	Mitigating reservoir decline and production management through an integrated data ops platform
		Asset Performance management platform to improve the health, maintenance, reliability and integrity of equipment
		Business insights through centralised analytical platform
	Automation	RPA based finance process automation
		Automation of permit to work along with asset maintenance processes
		Automation of swing wells open/close process based on real time parameters

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