vedanta
transforming for good

CAIRN

LEVERAGING TECHNOLOGY TO UNLOCK INDIA'S HYDROCARBON POTENTIAL

Cairn 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 deployed by Cairn 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 the 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
- First 4D seismic in India
- India's largest 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:

- The Mega Merge seismic PSTM and PSDM processing, integrated all individual 3D surveys from various field areas, into a single seamless seismic volume. It facilitated the identification and de-risking of new exploration prospects in the Rajasthan block.
- The 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.
- An innovative workflow was implemented to merge two existing seismic vintages with different orientations, generating high-quality seismic images in the Mangala field.
- State-of-the-art local angle domain seismic imaging technology provides better definition of main bounding and intra-field faults, reducing drilling risk in the attic oil development of the Bhagyam field.

HYDRAULIC FRACTURING

Cairn has extensively utilised hydraulic fracturing as a key technology to appraise and develop tight oil and gas fields.

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 wells located in the Raageshwari Deep Gas (RDG) field in the Barmer basin of Rajasthan, significantly improving operational efficiency by reducing frac time from 4.5 days to 2.2 days per stage.
- The 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** in Rajasthan, Cairn successfully drilled the longest onshore 6" lateral section (1380m) in India using the Periscope HD tool. Additionally, more than 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:** The largest oil field in Barmer, Rajasthan and largest polymer flood in India, has seen significant benefits from polymer flooding. This technology has delivered impressive incremental production, boosting the field's ultimate 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.

ARTIFICIAL LIFT SYSTEMS

At Cairn, more than 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.

Cairn has scaled up ASP implementation in Mangala well pads 1 and 19. This is expected to yield approximately 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.

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 the 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.

SKIN EFFECT HEAT MANAGEMENT SYSTEM (SEHMS)

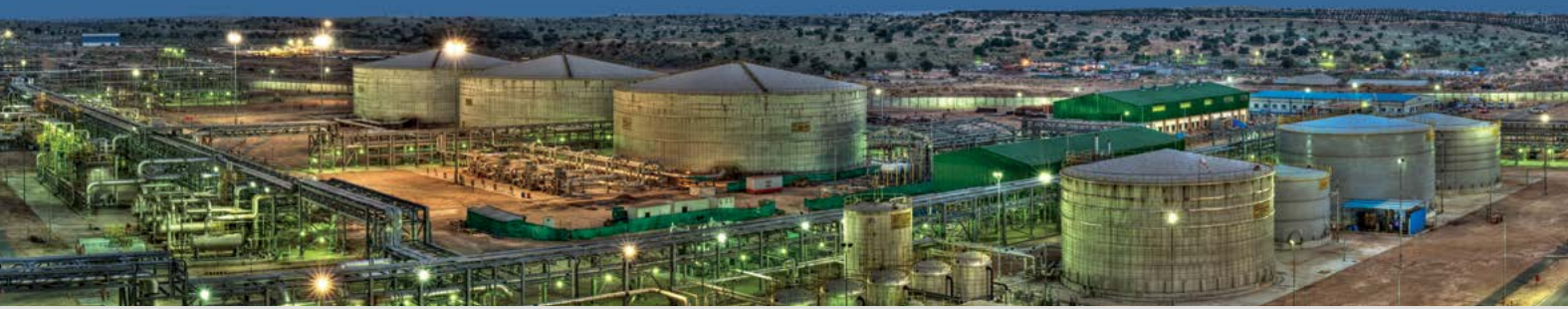
SEHMS technology is a proven electrical heating solution used for long-distance piping and pipelines.

SEHMS 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.

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

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. A dedicated Skin Effect Heat Management System (SEHMS) and power generation infrastructure maintain the required temperature for uninterrupted crude flow. The pipeline has been operational since June 2010.

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
Industrial Internet of Things (IOT)	IOT-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

30 YEARS OF ENERGISING INDIA

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