Life Cycle Assessment

Cairn Oil & Gas

Contents

General Aspects & Goal Definition

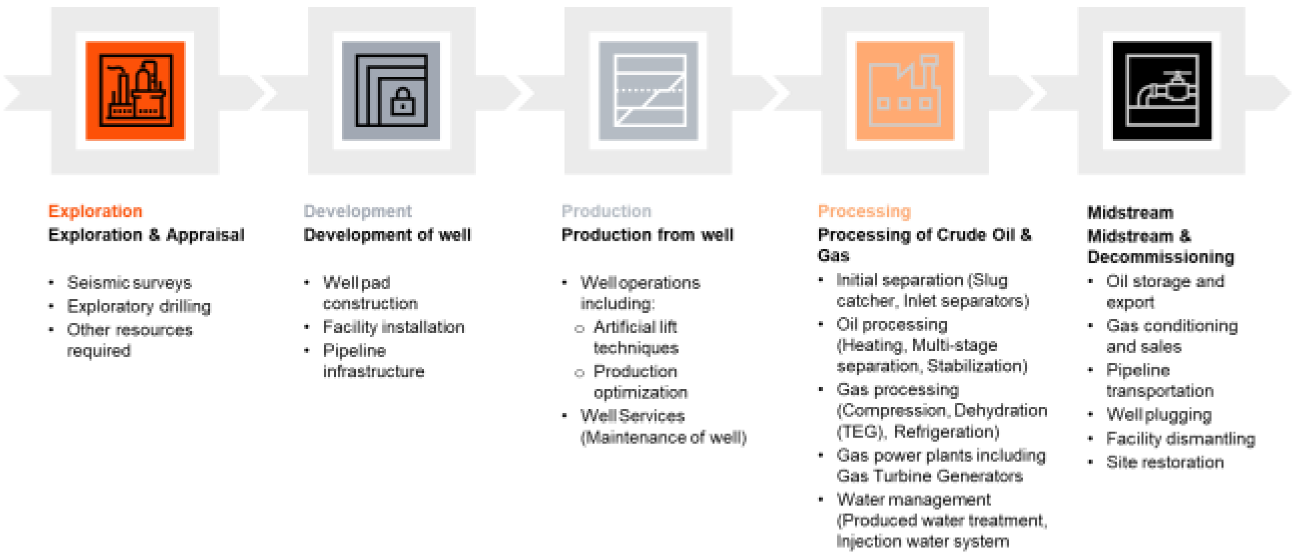
LCA Principles and Standards

This Life Cycle Assessment has been conducted in accordance with **ISO 14040** and **ISO 14044** standards. We used the ReCiPe 2016 methodology with SimaPro software to evaluate environmental impacts across 18 categories including climate change, resource depletion, and ecotoxicity.

Study Objectives and Scope Definition

The study evaluates the environmental footprint of Cairn's crude oil and natural gas operations from cradle-to-gate. We assessed both onshore and offshore facilities, covering five operational stages: Exploration, Development, Production, Processing, and Midstream operations. The assessment is based on one tonne of product as the functional unit.

- **Goal & Scope**: The study assessed cradle-to-gate environmental impacts of Cairn's crude oil and natural gas operations across onshore and offshore facilities for FY 2024-25, covering five life cycle stages:



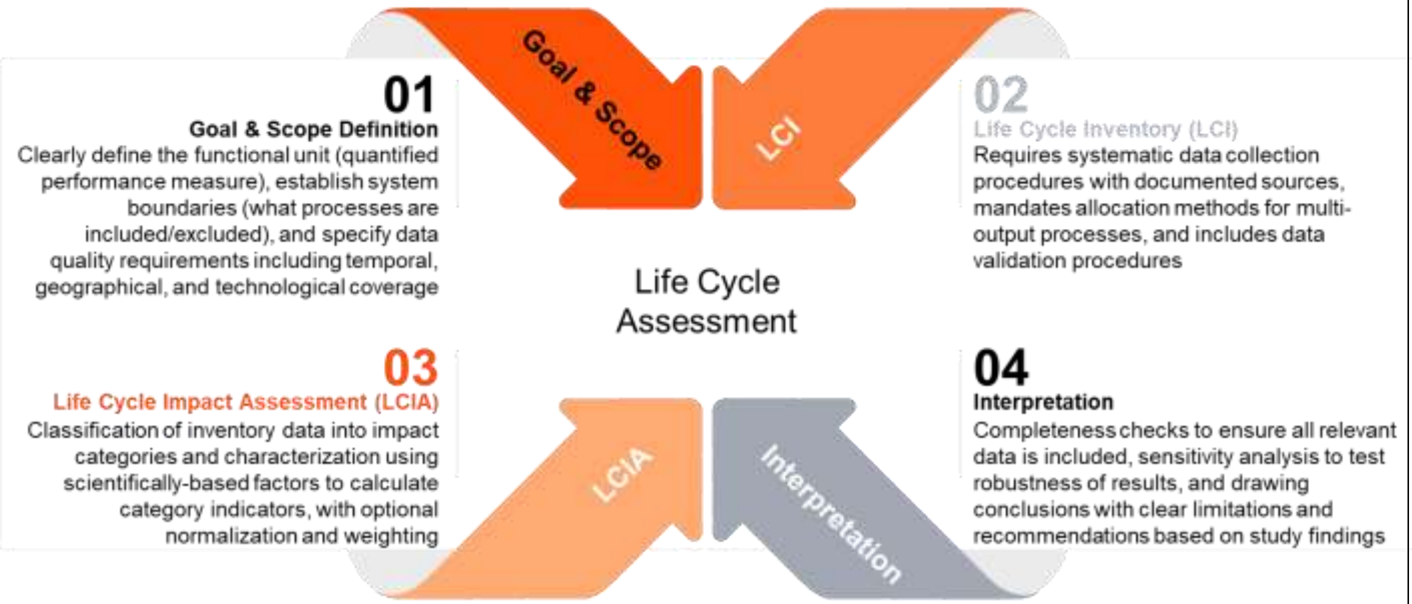
- **Key Assumptions**: Offshore impacts allocated between products based on calorific value share, water impacts considered negligible due to re-injection programs, waste impacts assumed zero through recycling initiatives, development phase impacts for offshore assumed equivalent to onshore, and 25-year lifecycle for onshore wells.

- **Critical Findings**: Processing stage dominates emissions (67-86% of total), offshore operations show 75-90% lower carbon intensity than onshore equivalents

- **Recommendations**: Prioritize offshore development for 10x emission reduction potential, target processing optimization as the highest impact opportunity focusing on electricity and gas flaring

Methodology Framework

ISO 14040 establishes the framework and principles, while ISO 14044 provides the detailed methodology and requirements for LCA studies Includes critical review procedures for ensuring study quality and credibility



Life Cycle Inventory Analysis

Operational data was collected from Cairn's facilities including site visits to get real-time understanding and empirical field data. Data collection covered energy consumption, material inputs, chemical usage, waste generation, and emissions. Where primary data was unavailable, established LCA databases like ecoinvent were utilized.

Life Cycle Impact Assessment Methodology

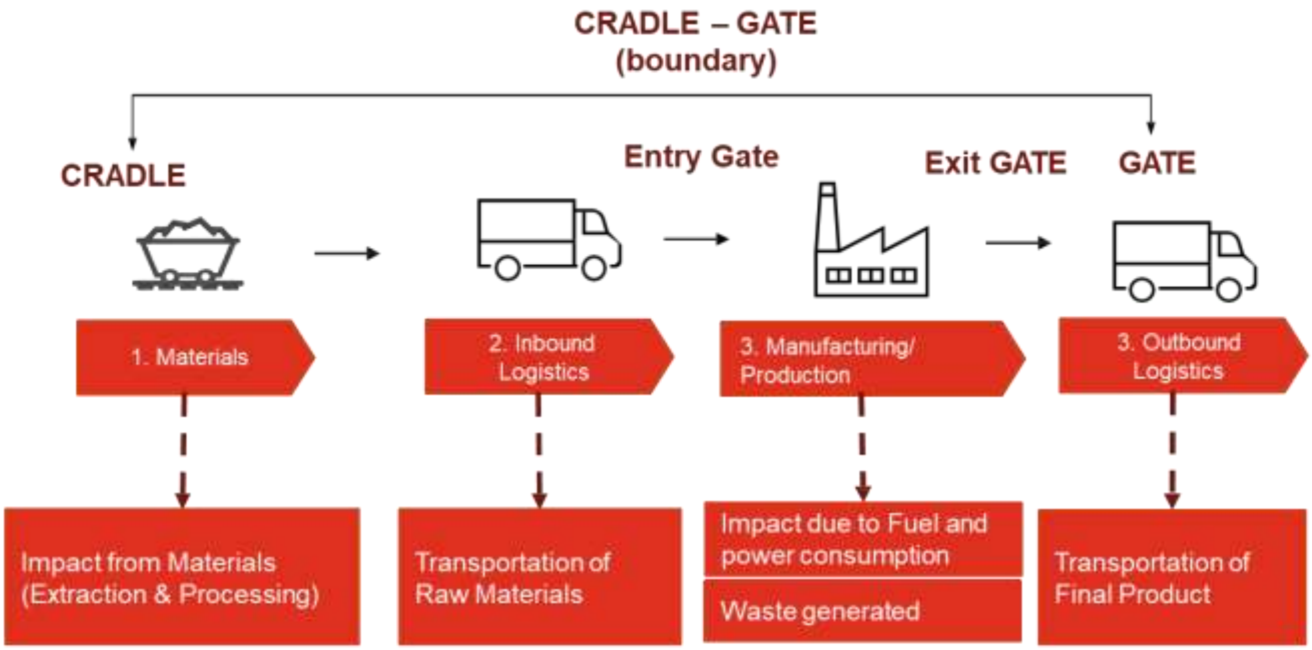
The ReCiPe 2016 methodology converts operational data into environmental impact indicators. The methodology covers the following indicators:

Impact Category	UoM	Description
Global warming	kg CO2 eq	Evaluates emissions contributing to climate change as CO2 equivalents.
Stratospheric ozone depletion	kg CFC11 eq	Potential impact of substances on the ozone layer, using CFC-11 as a reference.
Ionizing radiation	kBq Co-60 eq	Exposure risk from radioactive emissions, using Cobalt-60 as a standard.

Ozone formation, Human health	kg NOx eq	Contribution of emissions to smog that affects human respiratory health, measured in NOx equivalents.
Fine particulate matter formation	kg PM2.5 eq	Quantifies tiny airborne particles from emissions that pose health risks, measured in PM2.5 equivalents.
Ozone formation, Terrestrial ecosystems	kg NOx eq	Emissions' effects on terrestrial life due to ground-level ozone, measured in NOx equivalents
Terrestrial acidification	kg SO2 eq	Increase in soil acidity due to emissions, comparing effects to SO2 emissions.
Freshwater eutrophication	kg P eq	Assesses the impact of nutrient run-off on freshwater ecosystems, measured in phosphorus equivalents.
Marine eutrophication	kg N eq	Evaluates nutrient pollution leading to algae blooms in marine environments, measured as nitrogen equivalents.
Terrestrial ecotoxicity	kg 1,4-DCB	Measures the toxic effects of substances on land ecosystems, using 1,4-dichlorobenzen as a reference.
Freshwater ecotoxicity	kg 1,4-DCB	Harmful chemical effects on freshwater organisms
Marine ecotoxicity	kg 1,4-DCB	Toxicity of chemicals to marine life
Human carcinogenic toxicity	kg 1,4-DCB	Cancer risk potential from toxic chemical exposure
Human non-carcinogenic toxicity	kg 1,4-DCB	Other health risks from chemicals
Land use	m2a crop eq	Environmental impact of converting land for agricultural or urban purposes, in square meter-year crop equivalents.
Mineral resource scarcity	kg Cu eq	Impact of mining on mineral availability, measured in copper equivalents.
Fossil resource scarcity	kg oil eq	Evaluates the depletion of fossil fuels, in oil equivalent
Water consumption	m3	Evaluates the usage of freshwater resources

System Boundaries and Key Facilities

The assessment covers operations from raw material extraction through product delivery, excluding the use phase and end-of-life disposal. Analysis includes processing terminals, well infrastructure, and pipeline networks across onshore fields and offshore operations.



***Cradle** to **Gate** System Boundary for Cairn*

Key Environmental Impact Results

Carbon Footprint Analysis and Lifecycle Stage Contributions

	Onshore		**Offshore**	
(kgCO2e/T)	**Crude Oil**	**Natural Gas**	**Crude Oil**	**Natural Gas**
Exploration	4.84	0.38	0.35	0.40
Development	0.01	0.81	0.00	0.01
Production	42.26	5.73	0.80	0.90
Processing	375.36	81.50	33.29	37.78
Midstream	12.36	33.26	7.10	8.06
Total	**434.84**	**121.68**	**41.55**	**47.14**

Emission Hotspots

Processing accounts for the majority of environmental impacts across all operations - 86% for onshore crude oil, 67% for onshore natural gas, and 80% for offshore operations. The main contributors are associate gas combustion (191 kg CO_2e/T), gas flaring (92 kg CO_2e/T), and electricity consumption (92 kg CO_2e/T).

Life Cycle Interpretation

Key Findings and Strategic Insights

Processing operations represent the biggest opportunity for emission reductions. Offshore development could deliver significant environmental benefits - up to 10 times better than onshore equivalents. Water management and recycling programs deliver substantial environmental benefits through re-injection and circular economy practices.

Study Assumptions and Limitations

- Environmental impacts for offshore operations are allocated between crude oil and natural gas based on calorific value share, reflecting the energy content contribution of each product to total production output.
- Proprietary chemicals with undisclosed compositions are modeled using closest available chemicals with similar physical and chemical properties from established LCA databases.
- Chemical transport is assumed to occur via truck transportation across all operational locations.
- Environmental impacts during the development phase for offshore operations are assumed equivalent to onshore operations, based on consultation with Cairn technical teams.
- Water-related environmental impacts are considered negligible as water is predominantly re-injected into wells, supplemented by Cairn's comprehensive water reuse and recycling initiatives.
- Fluid and drilling waste environmental impacts are considered zero due to comprehensive recycling programs, including sale of waste materials as raw materials for cement production and other industrial applications.
- The assessment represents operational data for FY 2024-25.Lifecycle of onshore wells is assumed to be 25 years.
- Primary data from Cairn operations takes precedence over secondary database values; where unavailable, industry-standard proxy data from established LCA databases (ecoinvent, etc.) is utilized with regional characterization factors applied where available, otherwise global average factors are used.

Recommendations

Resource Management	• Reduce electricity consumption in processing facilities and minimize associate gas combustion
Prioritize Offshore	• Prioritize offshore development given 10x lower emissions (42 vs 435 kg CO2e/T for crude oil)
Chemical & Transport	• Optimize polymer usage and reduce transport distances where operationally feasible to minimize

Optimize processing operations: Since processing accounts for 67-86% of impacts, improvements here will deliver the biggest benefits. Focus areas include reducing electricity consumption, improving gas utilization, and deploying more efficient separation technologies.

Enhance resource management: Optimize chemical logistics and reduce transportation distances

Processing optimization should be the primary focus. Cairn should continue leveraging water management expertise for stakeholder engagement, and position recycling initiatives as examples of circular economy leadership.