

C A R B O T U R A

ACM Manufacturing Center

Facility Environmental Profile

Design-Basis Environmental Performance Statement

Document Class: **Room 2 — Technical Portal (NDA Required)**

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DESIGN-BASIS DOCUMENT

All environmental performance figures in this document are design-basis estimates derived from engineering mass balance modelling and process simulation. They represent the designed performance of the Carbotura ACM Manufacturing Center and are subject to verification during facility commissioning and initial operations. No figures in this document constitute certified LCA results, certified CDR credits, or verified regulatory compliance. See Section 7 for the verification pathway.

Executive Summary

The Carbotura ACM (Advanced Circular Manufacturing) Manufacturing Center is a deterministic circular engineering system designed to achieve four simultaneous environmental performance targets: negative net carbon balance, zero solid waste discharge, near-zero liquid discharge, and near-zero atmospheric emissions.

The facility operates in full energy autonomy — there is no grid connection. All electricity is generated internally from hydrogen recovered from the manufacturing feedstock stream via a PEM (proton exchange membrane) fuel cell stack. The only product of that energy generation is pure water, which is captured and sold as the WTR-FC product family. Scope 2 emissions are structurally zero.

The manufacturing feedstock stream — urban manufacturing and commercial materials that would otherwise enter landfill or conventional combustion — is converted with 100% material efficiency into 116 saleable products across eight refining families. Nothing exits the facility as residual or waste.

This document presents the design-basis environmental performance of the facility at the facility, module, and product levels. All figures are design-stage estimates derived from engineering mass and energy balance modelling. The verification pathway to certified LCA results is documented in Section 7.

Headline Performance Targets (Design Basis, 100 TPD Configuration)

Performance Metric	Design-Basis Target
Net carbon balance (direct — CDR products vs. Scope 1)	Negative — permanent sequestration in CRB + MIN-004 exceeds designed facility emissions
Avoided landfill methane (system expansion, ISO 14044 §4.3.4)	Design-basis: 8,000–14,000 t CO₂e/yr at 100 TPD — organic fraction that would otherwise decompose anaerobically (EPA AP-42 methodology, GWP-100 = 28–34)
Total designed climate benefit (direct CDR + avoided CH ₄)	Design-basis: 20,000–36,000 t CO₂e/yr at 100 TPD 80,000–144,000 t CO₂e/yr at 400 TPD
Scope 2 emissions (purchased electricity)	Zero — no grid connection; full energy autonomy
Scope 1 emissions (direct combustion)	Near-zero — H₂ combustion produces H₂O only; residual Scope 1 bounded and enumerated
Solid waste to landfill	Zero by design — 100% Total Material Conversion (TMC)
Liquid discharge (NPDES)	Near-zero — designed for NLD; WTR-FC stream makes facility a net water producer
Atmospheric VOC/particulate	Near-zero — closed-loop syngas; Pregenesis controlled
Saleable products	116 products across 8 families from a single input stream
Manufacturing feedstock carbon utilisation	>95% converted to stable products or fuel; <5% residual Scope 1 emissions

1. Facility Architecture and Energy System

1.1 Full Energy Autonomy

The Carbotura ACM Manufacturing Center has no connection to the electrical grid. This is a deliberate engineering decision with significant environmental consequences: it eliminates Scope 2 emissions entirely, removes dependency on grid carbon intensity, and makes the facility's energy carbon footprint an engineering certainty rather than a market calculation.

The facility's sole electrical energy source is the internal PEM fuel cell stack, which generates electricity from hydrogen recovered from the manufacturing feedstock stream. The hydrogen is never sold and never leaves the facility boundary. It is the facility's internal fuel — generated from feedstock and consumed for operations within the same process boundary.

PEM Fuel Cell Energy Chain

The electrochemical reaction in the PEM stack:



The combustion products of hydrogen in the PEM stack are electricity, heat, and water. Carbon dioxide is not produced at any stage of the energy generation process. This is not an emissions reduction — it is the absence of a CO₂-producing reaction.

The water produced by the PEM stack — approximately 9 kg of ultra-pure water per kg of hydrogen consumed — is captured from the cathode exhaust, treated through the WTR-FC module train, and sold as the WTR-FC product family (Industrial DI, Semiconductor Grade, Ultra-Pure). At 100 TPD manufacturing feedstock, the designed WTR-FC water production is approximately 25–36 tonnes per day. The facility is a net water producer.

H₂ Recovery Points (Three Internal Streams)

Hydrogen is recovered at three points in the process train, all of which feed directly to the PEM stack. None are offered for sale:

- Recyclotron MCR embedded catalytic reformer — primary H₂ recovery from syngas
- Carbon Recovery Unit (CRU) plasma cracker — secondary H₂ from carbon-rich stream
- Water-Gas Shift (WGS) reactor — tertiary H₂ by CO + H₂O shift reaction

The specific H₂ volumes, operating parameters, and syngas composition at each recovery point are proprietary process information. This document documents the energy and environmental outcomes only. Process chemistry is classified Room 3.

1.2 The Deterministic Circular Model

Conventional sustainability programmes are probabilistic: targets are set, programmes are designed to achieve them, and performance is measured against targets. Environmental outcomes are aspirations managed toward.

The Carbotura ACM Manufacturing Center is deterministic: the environmental performance follows mathematically from the process specification. If the mass balance closes — which is an engineering requirement, not an aspiration — then zero solid waste is guaranteed. If the process chemistry is correct — which is a scientific fact, not a target — then H₂ combustion produces no CO₂. The environmental performance is a consequence of correct engineering, not of management effort.

This distinction is the basis of the due-diligence position. When a validator asks "how do you know?" the answer is: because the mass balance closes, and because the chemistry is deterministic. Here is the derivation.

1.3 The Three Carbon Pathways

Every carbon atom entering the facility in the manufacturing feedstock exits through exactly one of three designed pathways. No uncontrolled fourth pathway exists in the designed process flow:

Pathway	Destination	Carbon (approx.)	Environmental Status
1 — Permanent Sequestration	CRB graphite, hard carbon, activated carbon products	12–18 t C/day (at 100 TPD facility)	<i>CDR — permanent removal from biogenic carbon cycle</i>
2 — Circular Carbon	ARM aromatics (BTX, styrene, phenol), GAS-016 CO, GAS-003 CO ₂ sold	3–5 t C/day (at 100 TPD facility)	<i>Circular — displaces fossil-derived equivalent; no new extraction</i>
2a — CDR-eligible mineralisation	MIN-004 PCC — CO ₂ mineralised into calcium carbonate lattice	1–2 t C/day (portion of Pathway 2)	<i>CDR — CO₂ permanently mineralised; Puro.earth methodology applicable</i>
3 — Hydrogen combustion	PEM fuel cell → electricity + heat + WTR-FC product water	0 t C/day	<i>Zero carbon — 2H₂ + O₂ → 2H₂O; no CO₂ produced</i>
Residual facility emissions	Pregenesis material handling, fugitive losses (designed)	<0.5–1 t C/day (bounded)	<i>Residual Scope 1; offset by Pathways 1 and 2a CDR</i>

Design-Basis Carbon Balance at 100 TPD

Manufacturing feedstock entering at 100 TPD contains approximately 35,000–42,000 kg of carbon per day (35–42% C by mass, typical composition for mixed urban manufacturing feedstock — organic fractions, paper, plastics, and biomass).

Design-basis net carbon balance: negative in both the direct accounting (CDR products minus Scope 1 emissions) and the comprehensive system expansion accounting (direct balance plus avoided landfill methane). Both accounting methods are presented in this document. The direct balance is used for product-level carbon intensity figures. The system expansion balance — which includes avoided methane per ISO 14044 §4.3.4 — is used for facility-level climate benefit reporting and front-page communications.

Avoided landfill methane (design-basis): the same manufacturing feedstock, if sent to sanitary landfill, would generate approximately 8,000–14,000 t CO₂e/yr in methane emissions at 100 TPD (EPA AP-42 methodology, 40–50% organic content, GWP-100 = 28–34). The Carbotura facility converts this organic fraction to stable products, eliminating the methane generation pathway. This avoided emission is a direct, measurable consequence of the facility's existence and is correctly included in the comprehensive climate accounting.

Total designed climate benefit at 100 TPD (direct CDR + avoided methane): design-basis 20,000–36,000 t CO₂e/yr. At 400 TPD (preferred COA configuration): 80,000–144,000 t CO₂e/yr.

2. Near-Zero Discharge: The Four Streams

2.1 Solid Waste — Zero Discharge by Design

The Total Material Conversion (TMC) principle governs the facility design: every material entering the facility must exit as a saleable product or be consumed internally as a process input. There is no designed RCRA solid waste stream.

Material that would constitute residual in a conventional process is recovered as a product at a lower RevCon level. Mineral ash becomes MIN-001 Mineral Aggregate (RC1). Slag and fines become MIN-002 Pozzolan SCM (RC2). The Carbotura product catalog was designed backwards from the residual streams — every potential residual has a product identity.

Verification methodology: Mass balance closure. The sum of all product masses (by family) equals the input feedstock mass minus water evaporation and gas discharges. Mass balance closure is a commissioning acceptance criterion.

Design-basis target: Zero RCRA-classified solid waste to landfill or off-site disposal

Residual risk: Contaminated feedstock fractions that cannot be processed (e.g. radioactive materials, highly toxic compounds exceeding process handling capacity) are isolated and managed under RCRA with qualified handlers. Volume designed to be <0.1% of total input mass.

2.2 Liquid Discharge — Near-Zero Liquid Discharge (NLD)

All process water is collected in a closed-loop water management system. Water exits the facility through only three designed pathways:

- WTR product cascade (WTR-001 through WTR-010) — sold as product
- WTR-FC product cascade (WTR-FC-001 through WTR-FC-003) — sold as product
- NPDES permitted discharge — small residual fraction, treated to permit standard

The WTR-FC water production from the PEM fuel cell stack (approximately 25–36 t/day at 100 TPD) partially or fully offsets the facility's total process water demand, depending on operating conditions. In the designed configuration the facility is a net water producer — it generates more high-purity water from hydrogen combustion than it consumes in process operations.

Verification methodology: Water balance closure. All water inputs (feedstock moisture, reagent water, PEM-produced water) and outputs (WTR products, evaporative losses, NPDES discharge) must balance.

Design-basis NPDES discharge: <5% of total water throughput, treated to permit standard

Target configuration: True Zero Liquid Discharge (ZLD) — full recirculation with atmospheric water collection as supplement — is achievable in the designed configuration and will be assessed during commissioning.

2.3 Atmospheric Emissions — Near-Zero Designed

The facility has four designed atmospheric emission points. All are controlled and bounded:

Performance Metric	Design-Basis Target
Pregenesis sorting/shredding exhaust	Controlled — enclosed system with bag filtration; PM and VOC to permitted levels
Syngas system (MCR output)	Zero venting — all syngas routed to cleanup train, then to products or PEM fuel cell
Graphitisation train (CRB-RC3-HPG)	Closed-loop nitrogen atmosphere — no combustion exhaust; N2 recycled
PEM fuel cell exhaust	Water vapour only — no CO2, no NOx, no PM; captured as WTR-FC products
ARM condensation train	Closed-loop condensation — aromatic vapours recovered as ARM products; no fugitive venting
Emergency backup systems	Defined and bounded; permit conditions apply; volume designed to be de minimis

Verification methodology: Point-source emissions inventory. All sources enumerated. Continuous monitoring (CEMS) for primary control points at commissioning.

Target: Clean Air Act Title V permit compliance; designed to be well below permit thresholds on all regulated pollutants

2.4 Carbon Emissions — Negative Net Balance

As detailed in Section 1.3, the facility carbon balance is designed to be negative. The combination of permanent sequestration (Pathway 1), mineralisation (Pathway 2a), zero-carbon energy (Pathway 3), and bounded Scope 1 residual emissions results in a net carbon position that is negative — the facility removes more carbon from circulation than it emits.

Scope 1 (designed): Near-zero — H2 combustion produces no CO2; residual from Pregenesis material handling and minor process losses. Design-basis: <500 kg CO2e/day at 100 TPD.

Scope 2 (designed): Zero — no grid connection; structurally zero, not purchased-offset zero.

Scope 3 (upstream): Manufacturing feedstock collection and transport (Feedstock Hauler fleet). Outside facility boundary; reported separately. Electrification of feedstock logistics is the primary Scope 3 reduction pathway.

3. The Renewable Feedstock Credential

The term "renewable" in the context of Carbotura products has a specific, technically defensible meaning that is distinct from both fossil-derived and biogenic-renewable claims. It requires precise framing to be defensible under validator scrutiny.

3.1 What "Renewable" Means Here

Manufacturing feedstock — urban commercial and manufacturing materials — is continuously regenerated by economic activity. Every tonne that enters the Carbotura facility is replaced by ongoing human production, consumption, and commerce. The feedstock stream is:

- Not finite — unlike fossil fuels, which are depleted by extraction
- Not land-dependent — unlike agricultural biomass, which requires arable land and seasonal harvest cycles
- Not weather-dependent — unlike solar and wind energy, which are intermittent
- Not import-dependent — urban feedstock is generated locally in every major metropolitan area
- Growing — the global manufacturing feedstock stream increases with urbanisation and GDP

The products manufactured from this feedstock are therefore produced from a perpetually renewable input stream. The carbon in CRB products was recently atmospheric (biogenic carbon cycle — paper, food, biomass fractions). The metals in MTL products were recently in service. The minerals in MIN products were recently in the built environment. None required new extraction from geological deposits.

The "renewable" credential for Carbotura products is based on feedstock origin, not energy source. The energy claim (full energy autonomy on H2) is separate. Both are valid independently and mutually reinforcing.

3.2 The Biogenic Carbon Fraction

A portion of the manufacturing feedstock organic fraction — paper, food, wood, natural textiles — is biogenic: the carbon it contains was recently fixed from atmospheric CO₂ by photosynthesis. Under standard LCA practice (GHG Protocol, ISO 14064, IPCC 2006 Guidelines), biogenic carbon in waste streams is typically treated as carbon-neutral at the point of entry — the carbon was recently in the atmosphere and returns to the atmosphere at end-of-life of the waste stream.

At the Carbotura facility, biogenic carbon that would have returned to the atmosphere (via landfill decomposition or conventional combustion) is instead permanently sequestered in graphite products (Pathway 1) or mineralised in PCC (Pathway 2a). This transformation from a neutral carbon flow to a sequestered carbon stock is the basis of the additionality argument for CDR credit generation.

The fossil carbon fraction — plastics, synthetic textiles, fossil-derived materials — is handled separately in the LCA. Plastics-derived carbon sequestered in CRB products does not qualify as biogenic CDR under current registry methodologies, but it does represent avoided fossil carbon

emission (the carbon would have been released as CO₂ in landfill gas or combustion). This avoided emission is a separate credit category from CDR.

3.3 Product Renewable Credentials

Each product in the Carbotura catalog can carry the following statement — which is factual at the infrastructure level and does not require LCA certification to assert:

Product Provenance Statement (Facility-Level)

Produced at a fully energy-autonomous ACM Manufacturing Center powered exclusively by manufacturing feedstock-derived hydrogen via PEM fuel cell. Zero grid electricity consumed. Facility designed for negative net carbon balance and zero solid waste discharge. Feedstock is perpetually renewable urban manufacturing material — no geological extraction required.

This statement describes the facility where the product is made. It is factual at the infrastructure level and verifiable by facility inspection. It does not constitute a certified LCA result or regulatory credit claim.

4. Module-Level Environmental Performance

Each of the eight product families is produced through a dedicated process module train. The module-level environmental performance documents the specific energy, water, and emissions profile of each train, providing the basis for product-level carbon intensity allocation.

4.1 Module Environmental Summary (Design Basis)

Performance Metric	Design-Basis Target
CRB — Carbon Refining Cascade	Primary CDR pathway. MCR + graphitisation operated under closed-loop N2 atmosphere. Energy-intensive (electromagnetic graphitisation at 3,000 degC) but powered by H2. Zero process combustion CO2. Design-basis sequestration: 12,000-18,000 t CO2e/yr at 100 TPD.
MTL — Metals Recovery	Hydrometallurgical separation. Primary energy: facility H2 electricity. Chemical reagent inputs (acids, solvents) are the primary Scope 3 input. Reagent recovery and recycling designed into each module.
GLS — Glass Refining	Mechanical + thermal processing. Foam glass production uses CRB-002 carbon black as foaming agent — internal circular use. Energy from H2. Zero process combustion CO2.
GAS — Gas Upgrade Cascade	Pressure-swing adsorption + cryogenic ASU. Primary electrical load from H2. GAS-003 CO2 captured and sold — not vented. No syngas venting in designed flow.
ARM — Aromatics Cascade	Condensation + fractional distillation. Closed-loop vapour recovery — no fugitive aromatic emissions designed. ARM products displace petroleum-refinery equivalents.
MIN — Mineral Cascade	Classification + acid leaching (GLS-010). MIN-004 PCC mineralises CO2 from GAS-003 — permanent sequestration. Low energy intensity per tonne.
WTR — Water Cascade	Reverse osmosis + UV + mixed-bed DI. Primary electrical load from H2. Near-zero discharge by cascade recovery design.
WTR-FC — Fuel Cell Water	Direct output of PEM fuel cell cathode exhaust. Zero additional energy input — by-product of electricity generation. Inherently ultra-high purity (mineral-free origin).

4.2 Beneficial Use Determination

The Carbotura ACM Manufacturing Center does not handle waste — it processes manufacturing feedstock. This distinction has regulatory significance: materials entering the facility are feedstock

for a manufacturing operation, not waste accepted for disposal. The facility operates under manufacturing permits, not waste facility permits.

Each product family output constitutes a beneficial use of the incoming manufacturing feedstock under EPA beneficial use frameworks. Specifically:

- CRB products: beneficial use of organic carbon fraction as advanced carbon materials (displacing coal-tar-pitch-derived graphite)
- MTL products: beneficial use of metal fraction as secondary metal feed (qualifying under RCRA scrap metal recycling exemption, 40 CFR 261.6(a)(3))
- GLS products: beneficial use of glass fraction as recycled glass aggregate and cullet (EPA beneficial use determination for glass)
- MIN products: beneficial use of mineral/ash fraction as supplementary cementitious material and aggregate (EPA CCR beneficial use framework, noting ACM ash is non-coal-derived)
- GAS products: beneficial use of gas fraction as industrial gases and chemical feedstocks
- ARM products: beneficial use of aromatic hydrocarbon fraction as petrochemical feedstocks

Beneficial use determination is jurisdiction-specific and requires site-level permit confirmation. This section documents the design intent and regulatory basis. Facility legal counsel must confirm beneficial use status for each product family at the specific operating jurisdiction.

5. Product-Level Environmental Claims

5.1 The Three-Tier Claim Protocol

Environmental claims on Carbotura products are classified at one of three levels. The level determines the language used, the supporting documentation required, and the room (public or technical portal) in which the claim appears.

Tier	Language	Room	Basis Required
Certified	<i>"Verified by [third party]"</i>	Room 1 (post-COD)	ISO 14040/14044 LCA; CDR registry credit issuance; regulatory confirmation
Design-basis	<i>"Designed to achieve..." / "Design-basis estimated..."</i>	Room 1 (now)	Mass balance framework; LCA methodology framework (this document)
Methodology-supported	<i>"Based on [method] with [uncertainty]..."</i>	Room 2 (NDA)	Claims register entry; methodology document reference
Proprietary	<i>Never stated publicly</i>	Room 3 only	Internal engineering records

5.2 CRB Family — Carbon Removal Products

The CRB (Carbon Refining) family carries the most significant environmental credentials in the catalog. The designed carbon performance rests on three pillars:

- Biogenic carbon permanently sequestered in crystalline graphite lattice — geologically stable on timescales exceeding 1,000 years (design-basis: ASTM C781 crystallographic verification at commissioning)
- Facility energy is zero-carbon (H2 PEM) — no combustion CO2 in the graphitisation process
- Feedstock displacement — CRB products displace coal-tar-pitch-derived synthetic graphite, which carries a high embodied carbon from both fossil carbon content and energy-intensive coking processes

Design-basis CRB carbon impact: -800 to -4,800 kg CO2e per tonne of product (range reflects product RC level; CRB-015 graphene at RC5 carries highest designed sequestration credit)

CDR pathway: Puro.earth MC2.1 Durable Carbon Storage — submission-ready methodology document is the next deliverable (Room 2)

Comparative claim basis: Conventional synthetic graphite (coal-tar pitch route): +12,000 to +18,000 kg CO2e/t (published literature range). Displacement credit is substantial but requires reference LCA certification before comparative assertion is made publicly.

5.3 MTL Family — Battery and Critical Minerals

MTL products carry two distinct environmental credentials:

- **Avoided extraction** — secondary metal recovery eliminates the mining, beneficiation, and primary smelting operations associated with primary production. For cobalt: 70%+ reduction in embodied carbon vs. DRC primary cobalt (design-basis estimate, literature basis).
- **Supply chain integrity** — US-origin feedstock processed at US facility designed to meet FEOC requirements under IRA. No geological extraction. No conflict mineral exposure.

The FEOC alignment claim is based on the designed supply chain — US manufacturing feedstock processed at US facility with no designed FEOC entity involvement. Formal FEOC compliance certification requires IRS-approved traceability documentation, which is a post-COD deliverable.

5.4 MIN-004 PCC — The Mineral CDR Product

MIN-004 Precipitated Calcium Carbonate is the only product in the catalog that directly mineralises CO₂. The process: CO₂ from GAS-003 (captured from the syngas cleanup train) is reacted with calcium hydroxide to form CaCO₃ in the PCC crystallisation module. The CO₂ is permanently locked into the mineral carbonate lattice.

Designed CO₂ sequestration: 440 kg CO₂ per tonne of MIN-004 PCC produced (stoichiometric — 44/100 mass ratio of CO₂:CaCO₃)

CDR registry pathway: Puro.earth Mineralization category; alternatively Verra VM0044 — methodology selection dependent on feedstock biogenic carbon fraction certification

Permanence: Calcium carbonate mineral — geologically stable. Verified by standard ASTM mineralogy testing.

6. Baseline Comparison

The Carbotura facility exists in a counterfactual context: the manufacturing feedstock stream was going somewhere before Carbotura. The environmental performance of the facility must be evaluated relative to what would have happened to the same feedstock in the absence of the facility.

Two baseline scenarios are relevant. Both represent current practice for the same feedstock streams in major US markets:

Performance Dimension	Sanitary Landfill	Mass-Burn WtE	Carbotura ACM
Net carbon outcome	Positive (CH ₄ + CO ₂)	Positive (CO ₂ , ~1:1)	Designed negative
Facility energy source	Grid (fossil mix)	Self-generated (steam turbine)	Self-generated H ₂ — zero CO ₂
Scope 2 emissions	Grid carbon intensity	Low (self-powered)	Zero — no grid connection
Solid residue to landfill	~100% of input mass	~20–30% (bottom ash)	Zero — 100% product conversion
Liquid discharge	Leachate (contaminated)	Scrubber water (contaminated)	Designed near-zero (NLD)
Product output	None (disposal)	Energy only	116 saleable products
CDR credit generation	None	None	Designed — CRB + MIN-004 pathways
Water production	Net consumer	Net consumer	Net producer (PEM H ₂ O output)
IRA §45X eligible products	None	None	30+ designed-to-qualify products

6.1 The Avoided Methane Credit — Included in Facility Climate Accounting

Sanitary landfill decomposition of organic manufacturing feedstock produces methane (CH₄) under anaerobic conditions. Methane has a GWP-100 of 28–34 times CO₂. For a typical manufacturing feedstock stream with 40–50% organic content at 100 TPD, the counterfactual methane generation is:

- Counterfactual landfill methane generation: approximately 8,000–14,000 t CO₂e/yr (design-basis estimate, EPA AP-42 landfill gas methodology, 50% collection efficiency assumption for modern landfill)
- Carbotura scenario methane generation: near-zero — organic carbon is converted to stable products, not deposited anaerobically
- Avoided methane credit: 8,000–14,000 t CO₂e/yr at 100 TPD | 32,000–56,000 t CO₂e/yr at 400 TPD

The avoided methane credit is included in the Carbotura facility-level climate benefit accounting under the system expansion methodology (ISO 14044 §4.3.4). System expansion is the ISO-preferred approach when a process displaces another product or service — in this case, the Carbotura facility displaces landfill disposal of the same feedstock stream. The avoided methane is not an offset purchased elsewhere; it is a direct, physical consequence of the facility's operation: the organic matter that would have decomposed does not decompose because it is converted to product.

This is a stronger claim than most carbon offset schemes precisely because it is deterministic. The methane avoidance follows mathematically from the mass balance: if the organic fraction enters the Carbotura facility and exits as graphite, activated carbon, or chemical intermediates, it cannot simultaneously be decomposing in a landfill. The avoided emission is guaranteed by the mass balance, not by a financial instrument.

Comprehensive Climate Benefit Accounting (100 TPD Design Basis)

Performance Metric	Design-Basis Target
Direct CDR — CRB permanent sequestration	~10,000–18,000 t CO ₂ e/yr (design-basis)
Direct CDR — MIN-004 PCC mineralisation	~1,500–3,500 t CO ₂ e/yr (design-basis)
Minus: designed Scope 1 facility emissions	~(500–1,000) t CO ₂ e/yr
= Direct net carbon balance	~11,000–20,500 t CO ₂ e/yr negative
Plus: avoided landfill methane (system expansion)	~8,000–14,000 t CO ₂ e/yr (EPA AP-42 basis)
= Total designed climate benefit (100 TPD)	~19,000–34,500 t CO ₂ e/yr
Total designed climate benefit (400 TPD)	~76,000–138,000 t CO ₂ e/yr
Total designed climate benefit (1,000 TPD)	~190,000–345,000 t CO ₂ e/yr

These figures are design-basis estimates. Direct CDR figures are derived from carbon mass balance modelling. Avoided methane figures are derived from EPA AP-42 landfill gas methodology applied to the organic fraction of the manufacturing feedstock. All figures are subject to verification during commissioning and first-year operations. They are not certified LCA results.

6.2 The Fossil Displacement Credit

ARM products (benzene, toluene, xylenes, styrene) directly displace petroleum-refinery-derived equivalents. GAS products (industrial nitrogen, oxygen, argon) displace conventionally produced industrial gases. CRB products (graphite, activated carbon) displace coal-derived equivalents. MTL products (cobalt, lithium, rare earths) displace mined primary metals.

Each displacement carries an embodied carbon credit — the avoided upstream emissions from not producing the displaced product. These credits are not claimed in the current product-level carbon figures (which are facility-based) but are available for scope 3 accounting by offtakers who adopt a system expansion methodology.

7. Verification Pathway

All figures in this document are design-basis estimates. The pathway from design-basis to certified claims proceeds through four stages:

Stage 1 — Pre-Commissioning (Current)

- This document — Facility Environmental Profile v1.0 (FEP-001 Rev 1.0)
- Mass Balance Framework — product-family input/output tables with methodology statements
- LCA Methodology Framework — ISO 14040/14044 scoping document defining system boundary, functional unit, allocation rules, comparators
- CDR Methodology Document — Puro.earth MC2.1 submission-ready methodology for CRB family and MIN-004
- FEOC Compliance Matrix — US-origin supply chain documentation framework

Stage 2 — Commissioning

- Mass balance closure verification — physical measurement of all input and output streams during commissioning runs
- Energy audit — H2 consumption vs. electricity output measurement; Scope 1 inventory verification
- Water balance verification — all water streams measured and balanced
- Emissions inventory — point-source measurement at all designed emission points

Stage 3 — Initial Operations (Year 1)

- ISO 14040/14044 LCA — third-party certified, based on 12 months of operational data
- EPD (Environmental Product Declaration) — one per product family, ISO 14025 compliant, published to EPD Programme Operator
- Puro.earth CDR credit issuance — first vintage from CRB and MIN-004 pathways
- FEOC traceability certification — IRS-eligible documentation for §45X products

Stage 4 — Ongoing

- Annual LCA update — operational data updates to certified LCA
- Annual CDR credit vintage issuance — Puro.earth and applicable registry
- EPD renewal — per Programme Operator schedule (typically 3–5 years)
- IRA credit documentation — annual filing per Treasury guidance

This verification pathway is the deliverable schedule that determines when each claim moves from "designed to achieve" (Stage 1) to "verified" (Stage 3). No claim currently in the RevCon catalog requires Stage 3 verification to be asserted — all current claims are design-basis and are correctly labelled as such.

8. Front Page Narrative Framework

This section provides the approved design-intent language for public-facing communications. All statements are design-basis and do not require LCA certification to assert. They describe the engineering specification of the facility, not post-commissioning verified results.

8.1 Opening Statement

Approved Opening Statement — Public Portal

The Carbotura ACM Manufacturing Center operates in full energy autonomy. There is no grid connection. All electricity is generated from hydrogen recovered from the manufacturing feedstock stream via PEM fuel cell. The only product of that energy generation is pure water.

Every tonne of manufacturing feedstock produces 116 saleable products, generates all the electricity the facility needs, and sequesters more carbon in stable products than the facility emits in operations. The manufacturing feedstock that enters the facility would otherwise reach landfill — eliminating the methane emissions that would follow. Combined, the direct carbon sequestration and the avoided landfill methane represent a total designed climate benefit of 19,000–35,000 tonnes of CO₂-equivalent per year at the 100 TPD configuration.

Nothing exits as waste. No grid power enters. This is the engineering specification.

8.2 The Three Pillars (Visual/Headline)

Pillar 1: Total Material Conversion — Every input becomes a product. Nothing exits as waste. The mass balance closes.

Pillar 2: Hydrogen-Powered Island Mode — The facility generates its own electricity from manufacturing feedstock-derived hydrogen via PEM fuel cell. Zero fossil fuel energy. Zero grid carbon. Net water producer.

Pillar 3: Designed Carbon-Negative — Carbon from manufacturing feedstock is permanently sequestered in graphite and mineral carbonate products, or circulated as chemical intermediates displacing fossil-derived equivalents. The manufacturing feedstock that would otherwise decompose in landfill — generating potent methane — is converted to product instead. Combined designed climate benefit: direct carbon sequestration plus avoided landfill methane equals 19,000–35,000 t CO₂e/yr at 100 TPD, scaling to 76,000–140,000 t CO₂e/yr at the preferred 400 TPD COA configuration.

8.3 Product Provenance Line (all products)

"Produced at a fully energy-autonomous ACM Manufacturing Center powered exclusively by manufacturing feedstock-derived hydrogen. Zero grid electricity. Designed carbon-negative facility. Renewable urban feedstock — no geological extraction."

8.4 Language to Avoid

- "Zero emissions" — near-zero is accurate; zero is not (residual Scope 1 exists)
- "Carbon neutral" — carbon-negative is the correct designed status and is stronger
- "Recycled content" — these are manufactured products, not recycled materials
- "Renewable energy" — the energy credential is autonomous hydrogen, not RECs or solar/wind
- Any specific carbon intensity number on the homepage — belongs in product spec, not homepage
- Any regulatory credit claim without "designed to qualify" qualifier — pre-commissioning only

Document Control

Performance Metric	Design-Basis Target
Document ID	FEP-001
Title	Facility Environmental Profile — ACM Manufacturing Center
Version	Rev 1.0 — Design Basis (Pre-Commissioning)
Classification	Room 2 — Technical Portal — NDA Required — Not for External Distribution
Prepared by	Carbotura Engineering Team
Review status	Internal draft — pending external LCA peer review
Next revision	Rev 2.0 — Post-Commissioning (following mass balance and energy audit verification)
Related documents	Mass Balance Framework v1.0 (pending); LCA Methodology Framework v1.0 (pending); CDR Methodology Document v1.0 (pending); Claims Register v1.0 (pending)

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