SUSTAINABLE CEMENT ROUTE

Executive & Investment Brief

Bioenergy, Biochar and Industrial Integration for Low-Carbon Cement in Colombia

1. Executive Summary

The **Sustainable Cement Route** is a **territorial industrial architecture** designed to decarbonize the cement industry while regenerating rural economies through the structured integration of **agricultural biomass, bioenergy and biochar**.

Rather than operating assets, **Tierras de Montaña acts as the system architect**, enabling the secure entry of international technology partners, public authorities and industrial stakeholders into a **bankable, scalable and territorially anchored model**.

The Route is structured around a **progressive three-phase trajectory** that de-risks industrial deployment while aligning:

- Rural development
- Energy transition
- Cement decarbonization
- Long-term carbon sequestration

Colombia provides a unique convergence of:

- Strong agricultural biomass availability
- Strategic cement infrastructure
- National priorities on rural transition and decarbonization
- Institutional readiness for pilot-to-industrial scaling

2. Strategic Rationale: Why Cement?

Cement is not the final objective — it is the **strategic entry point**.

The cement sector concentrates:

- Structural, incompressible CO_2 emissions
- High thermal energy demand
- Strong territorial anchoring
- Immediate regulatory and financial pressure

By integrating bioenergy and biochar into cement processes, the Sustainable Cement Route creates a **pull effect** that:

- Structures rural biomass supply chains
- Enables large-scale biochar production
- Anchors investment in long-life industrial assets
- Generates measurable and auditable climate impact

This makes cement the **ideal backbone** for a regional low-carbon industrial ecosystem.

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3. Role of Tierras de Montaña

Tierras de Montaña is **not an EPC, operator or equipment vendor**.

Its role is to:

- Design the **territorial and industrial architecture**
- Secure alignment between **State, industry and technology**
- Structure **logistics, standards, MRV and governance**
- De-risk market entry for international partners

This positioning allows:

- Faster deployment
- Lower political and industrial risk
- Clear allocation of roles and returns

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4. The Three-Phase Industrial Trajectory

This trajectory is designed to progressively reduce the risks of industrial deployment, while aligning rural development, energy transition and the decarbonization of the cement industry.

Validate rural chains, technical performance and measurable impacts.

▨ PHASE 1 — Territorial Bioenergy Pilot Unit (order of magnitude ~12 MWe)

Objective: To validate under real-world conditions the conversion of agricultural biomass into thermal energy, electricity and biochar of certifiable quality.

Main components

- Pretreatment, drying and classification of biomass.
- Continuous controlled roasting/pyrolysis.
- Thermal and electrical production (~12 MWe).
- Production of biochar for agricultural use, composting and pollution control.

Expected results

- Reference situation in terms of energy and environment.
- System performance, stability and efficiency curves.
- Biochar quality protocols according to ASTM/IBI standards.
- MRV (Monitoring, Reporting and Verification) platform for carbon traceability.

☞ **This phase allows the State and its technology partner to validate the parameters before the transition to the State.**

Reduce industrial risk and prepare for integration into cement manufacturing processes.

PHASE 2 — Integration of biochar and biomass into the cement industry

Objective: Partial replacement of fossil fuels and improvement of the thermal and environmental performance of the cement industry.

Technical components

- Roasting or pretreatment line dedicated to local biomass.
- Injection of torrefied biomass or synthesis gas into the calciner / precalciner.
- Integration with a residual heat recovery (RCR) system for improved energy efficiency.
- Optimizing processes through digital operating and maintenance platforms.

Key technical indicators

- **Tonnes/hour** of pre-treated biomass.
- **Tonnes/day** of biochar incorporated into soils and mixtures.
- **% thermal replacement** of traditional fuels.
- **CO_2 reduction (tCO_2/year)** .
- **Impact on rural infrastructure:** stabilized mixtures, roads, embankments, structural fill.

👉 This phase allows Colombia to modernize the cement industry while generating rural supply chains.

Create a reproducible, territorially rooted and bankable industrial asset.

▨ PHASE 3 — Regional biochar and biomass complex (industrial production)

Objective: To create a regional industrial hub capable of producing biochar, ensuring the pretreatment of biomass and providing carbon solutions for agriculture, infrastructure and voluntary/regulated markets.

Components

- Biomass collection and drying centers.
- Continuous biochar production plants.
- Transformation for agricultural purposes, composting, soil remediation and civil engineering.
- Regional laboratory for ASTM/IBI certification.
- MRV platform for carbon credits.

Estimated capacities

- **3 to 12 T/H** of scalable modular production.
- **Applicable certifications:** ASTM E-871, E-1755, IBI Biochar standards.
- **Target markets:** agriculture, reforestation, coffee, cocoa, rural infrastructure, compensation.

☞ This phase ensures industrial stability and a continuous supply to cement plants, governments and producers.

5. Technology Logic

The Route prioritizes **thermochemical pathways** due to:

- High energy stability
- Continuous industrial operation
- Superior biochar quality
- Compatibility with cement kilns

Core technologies:

- Drying & torrefaction
- Controlled pyrolysis
- Gasification
- WHR and digital O&M

Biochemical pathways remain complementary but are not central to the cement route.

6. Applications & Value Creation

Cement & Infrastructure

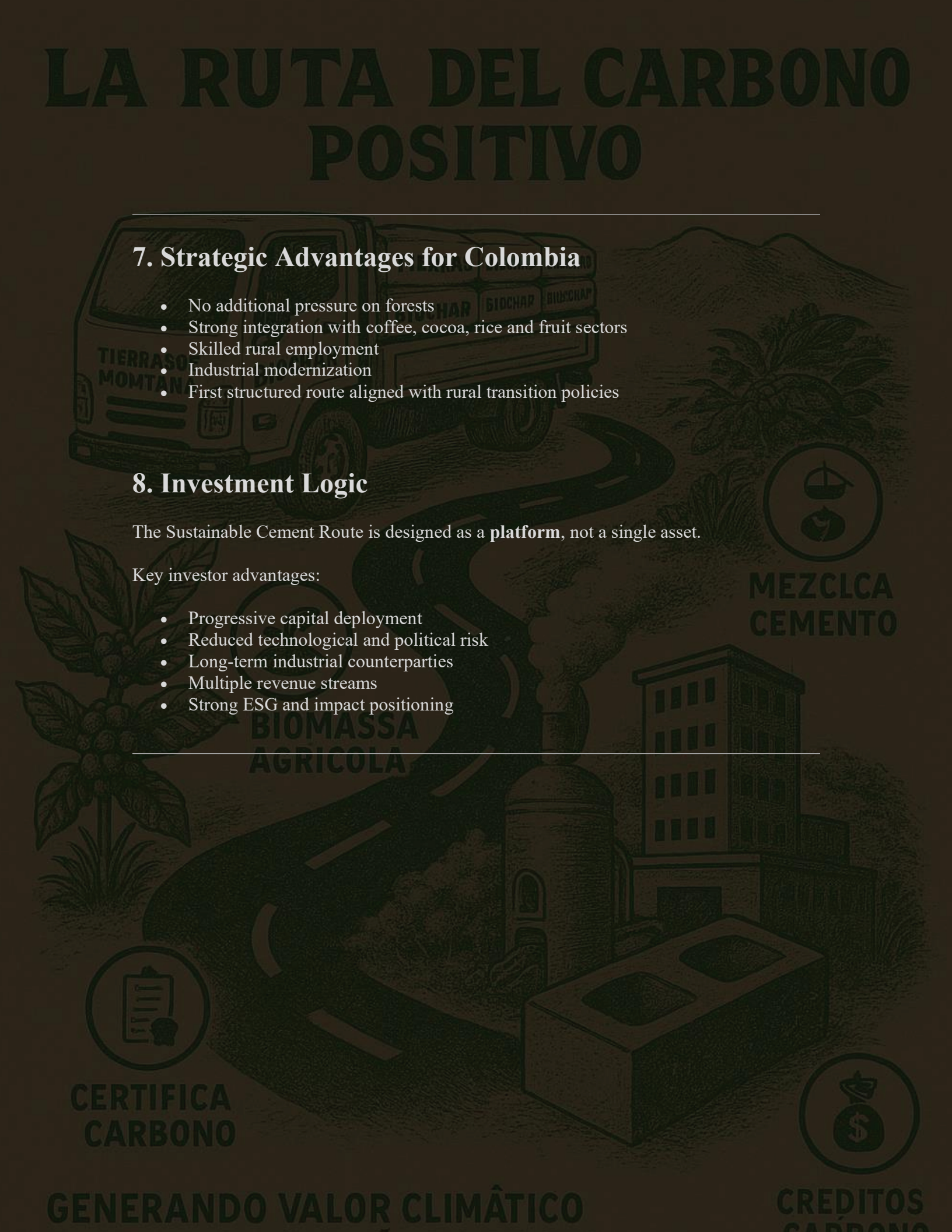
- Partial fuel substitution
- Lower clinker CO_2 intensity
- Stabilized rural roads
- Improved constructability

Agriculture & Territory

- Soil regeneration
- Reduced fertilizer dependency
- Long-term carbon fixation

Carbon & ESG

- Verifiable MRV
- Long-duration carbon storage
- Alignment with voluntary and regulated markets



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7. Strategic Advantages for Colombia

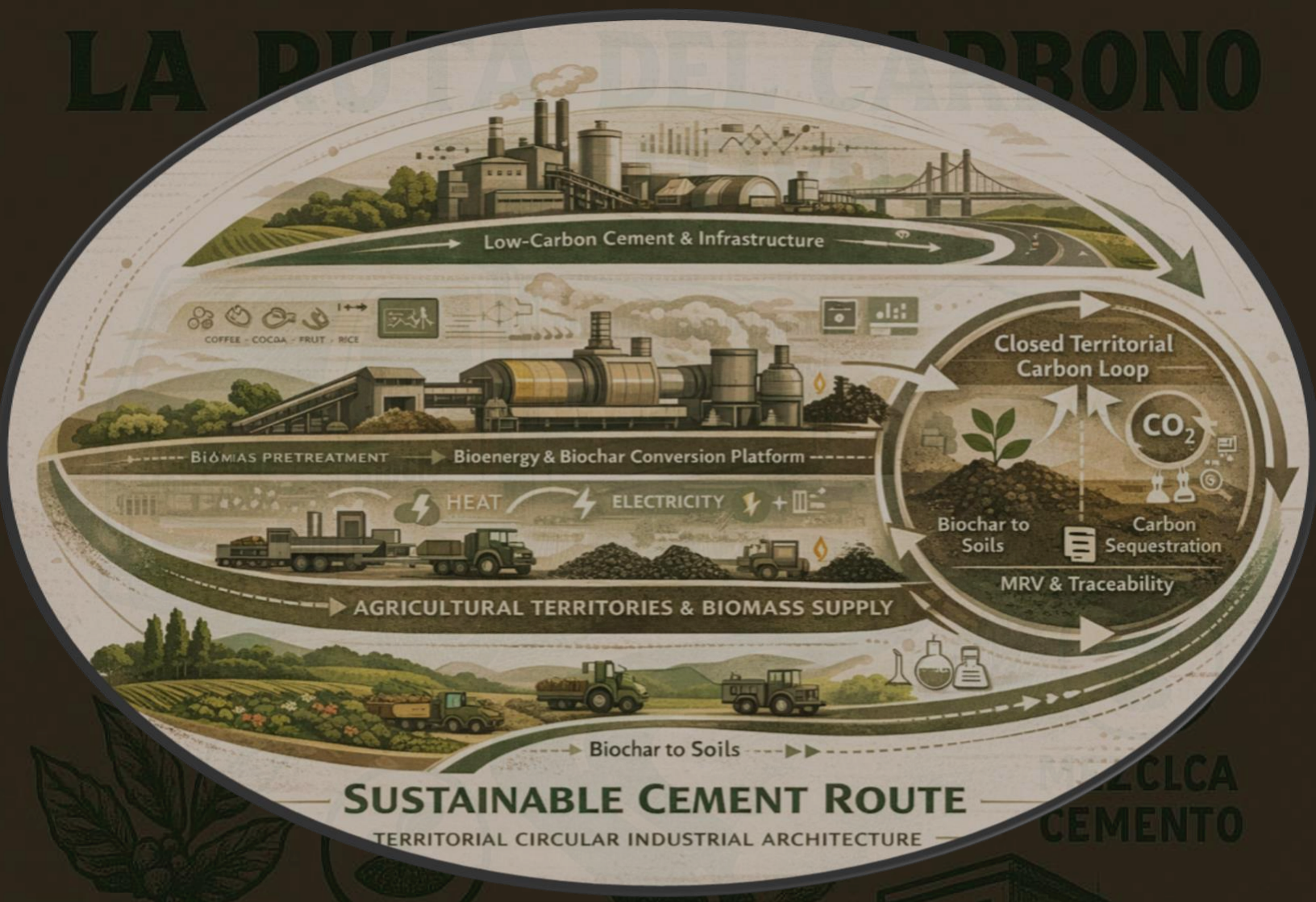
- No additional pressure on forests
- Strong integration with coffee, cocoa, rice and fruit sectors
- Skilled rural employment
- Industrial modernization
- First structured route aligned with rural transition policies

8. Investment Logic

The Sustainable Cement Route is designed as a **platform**, not a single asset.

Key investor advantages:

- Progressive capital deployment
- Reduced technological and political risk
- Long-term industrial counterparties
- Multiple revenue streams
- Strong ESG and impact positioning



The Sustainable Cement Route is not a project — it is a **replicable industrial framework**.

It enables Colombia to:

- Decarbonize heavy industry
- Regenerate rural territories
- Attract international technology and capital
- Build long-term, resilient industrial assets

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