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Infrastructure & Sustainability Series

The 2 Billion Ton Problem

Why Waste-to-Energy Is the Missing Piece in Caribbean Infrastructure

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A comprehensive analysis of the Caribbean waste management crisis,
waste-to-energy technology landscape, and the investment case
for integrated waste processing in Small Island Developing States.

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1 Introduction: The Island Waste Paradox

The world generates approximately 2.01 billion tonnes of municipal solid waste annually. By 2050, this figure is projected to reach 3.4 billion tonnes. While the crisis is global, its most acute manifestation is found on islands — where every kilogram of waste that cannot be processed must either be buried in land that does not exist, shipped across ocean at prohibitive cost, or left to accumulate in the environment.

The Caribbean basin exemplifies this paradox with painful clarity.

DINNER TABLE VERSION

Imagine your house has no garbage truck coming. No municipal dump. No recycling center. You generate trash every day — packaging, food waste, broken appliances, construction debris — but there is nowhere to put it. Your backyard is small and already full. Your neighbors will not take it. Shipping it away costs more than the trash is worth.

Now imagine 44 million people living in this situation, spread across dozens of small islands, each generating thousands of tonnes of waste daily, with nowhere for any of it to go.

That is the Caribbean waste crisis. And the kicker is that these same islands are importing expensive diesel fuel to generate electricity at some of the highest rates in the Western Hemisphere. The waste that is choking their landfills contains energy. The diesel they import to make electricity costs a fortune. The connection between these two facts is the foundation of waste-to-energy — and the Caribbean is the most compelling deployment case in the world.

In December 2025, the executive director of the U.S. Virgin Islands Waste Management Authority testified before the territorial legislature that the waste system is "in crisis" — operating far beyond capacity, burdened by aging infrastructure, and constrained by decades of deferred investment. Both major landfills are at or beyond capacity. The authority is seeking $100 million in federal grants for emergency remediation. A wastewater crisis occurs, by the director's estimate, approximately every twelve hours.

This paper examines the structural forces that created the Caribbean waste crisis, evaluates the technology landscape for waste-to-energy solutions, analyzes the project economics specific to island deployment, and presents the investment thesis for integrated waste processing in Small Island Developing States (SIDS).

2 The Scale of the Crisis

2.1 Regional Overview

The Caribbean waste crisis is quantifiable and severe:

Table 1: Caribbean Waste Generation: Key Statistics

Metric	Value
LAC daily waste generation	541,000+ tonnes/day
Caribbean daily waste generation	10,000+ tonnes/day
Waste ending in landfills/dumps	∼90%
Uncollected plastic waste (annual)	322,000+ tonnes
Caribbean e-waste per capita	13 kg/cap/year (2× global avg)
USVI daily vegetative waste	80–85 tonnes/day
Puerto Rico annual solid waste	∼2 million tonnes/year

The waste composition in Caribbean SIDS differs meaningfully from mainland profiles. Organic waste (food and vegetation) typically comprises 40–60% of the municipal waste stream, driven by tropical climate, agricultural activity, and hurricane-generated debris cycles. Plastics account for 10–15%, with the remainder split among paper, metals, glass, construction and demolition waste, and hazardous materials including e-waste.

2.2 The USVI Case Study

The U.S. Virgin Islands represents the crisis in concentrated form. With a population of approximately 87,000 across three main islands (St. Thomas, St. Croix, and St. John), the territory operates two major landfills:

USVI LANDFILL STATUS (AS OF DECEMBER 2025)

Anguilla Landfill (St. Croix): At capacity. A $46 million federal grant has been secured to close most of the site and expand the remaining quarter, providing an estimated five additional years of capacity. Public meetings on new site locations are underway.

Bovoni Landfill (St. Thomas): At capacity. Expansion and compliance work is advancing, but the authority has stated that surrounding property must be acquired to ensure safe continued operations. The site has experienced fires, the most significant source of unintentional persistent organic pollutants (UPOPs) in the territory.

Both landfills operate under EPA federal consent decrees and are behind schedule on required compliance milestones. The territory's Waste Management Authority is requesting $100 million in CDBG-DR grants to address the combined crisis.

The USVI waste challenge is compounded by hurricane vulnerability. Hurricanes Irma and Maria (2017) generated massive debris volumes that overwhelmed existing facilities. Hurricane-related waste management creates a feedback loop: storms damage infrastructure, generate debris that exceeds landfill capacity, and the resulting environmental contamination increases vulnerability to future storm impacts.

2.3 Puerto Rico: Scale and Complexity

Puerto Rico faces the same structural challenges at larger scale. The island generates approximately 2 million tonnes of solid waste annually, with a recycling rate that has historically lagged mainland averages. Key factors include:

- Aging landfill infrastructure, with multiple sites approaching or exceeding design capacity.
- Post-hurricane debris management from Maria (2017) and Fiona (2022) that pushed several facilities past operational limits.
- Electricity rates that have nearly doubled since 2020, with residents paying approximately 8% of household income on electricity versus the U.S. average of 2.4%.
- A fragile grid operated by LUMA Energy that remains vulnerable to both weather events and the economic consequences of fossil fuel dependence.
- Legislative efforts to extend coal-fired generation, reflecting the tension between environmental goals and energy security.

2.4 The Wider Caribbean

Across the wider Caribbean, the pattern repeats with local variations:

Table 2: Selected Caribbean Waste Management Profiles

Territory	Electricity Cost	Primary Waste Method	Key Challenge
USVI	$0.30–0.40/kWh	Landfill (at capacity)	Both landfills under consent decree
Puerto Rico	$0.24–0.30/kWh	Landfill	Post-hurricane debris; grid fragility
Curaçao	$0.42/kWh	Landfill	Malpais dump nearing island's highest point
Jamaica	$0.28–0.35/kWh	Landfill/open dump	Riverton City fires; Kingston Harbour pollution
St. Maarten	$0.35–0.40/kWh	Landfill (overflow)	Post-Irma debris mountain
Trinidad & Tobago	$0.05/kWh	Landfill	Lower energy cost reduces WtE economics

The data reveals an important pattern: the islands with the most severe waste crises are also the islands with the highest electricity costs. This correlation is not coincidental — both problems derive from the same root cause: geographic isolation, small scale, and dependence on imported fossil fuels.

3 Why Conventional Solutions Fail on Islands

3.1 The Landfill Dead End

Landfilling is the dominant waste disposal method in the Caribbean because it is the most scale-efficient option at low volumes. But for SIDS, landfilling is a dead-end strategy for structural reasons:

1. **Land scarcity:** Islands have finite, non-expandable land area. Every hectare consumed by a landfill is a hectare unavailable for housing, agriculture, tourism, or conservation. SIDS are already among the most land-constrained territories on earth.
2. **Coastal siting:** To minimize waste haulage costs and take advantage of flatter terrain, Caribbean nations are forced to site landfills in coastal zones. This creates secondary environmental disasters: leachate contamination of beaches, reefs, wetlands, and groundwater — the same ecosystems that support tourism and fisheries.
3. **Fire risk:** Landfill fires are the most significant source of unintentional persistent organic pollutants (UPOPs) in the Caribbean waste sector. These fires are triggered by operational failures rooted in chronic underfunding. In Curaçao, the Malpais dump generates toxic leaching and gas releases that pollute surrounding communities. In St. Maarten, post-hurricane overflow created a waste mountain visible from the cruise ship terminal.
4. **No exit strategy:** Unlike mainland landfills that can be closed, capped, and converted to parks or commercial space with relative ease, island landfills often sit on the only available land, adjacent to communities and coastline, with no clear post-closure reuse pathway.

3.2 The Recycling Scale Problem

Recycling is economically viable only at scale. A single Caribbean island typically cannot generate sufficient volumes of any individual recyclable material to justify the capital investment in processing equipment. The economics are punishing:

THE RECYCLING MATH ON A SMALL ISLAND

Consider a Caribbean island of 100,000 residents generating 150 tonnes of MSW per day. Assume 12% of the waste stream is recyclable plastic:

- Daily recyclable plastic: 18 tonnes
- Annual recyclable plastic: ∼6,500 tonnes
- Minimum efficient scale for a plastics recycling facility: 15,000–25,000 tonnes/year
- **Result:** The island generates less than half the minimum viable feedstock for a single-material recycling operation.

Regional cooperation could theoretically aggregate volumes across islands, but inter-island shipping costs frequently exceed the commodity value of the recovered materials. The same isolation that creates the waste problem defeats the recycling solution.

The practical consequence is visible across the Caribbean: recyclers collect materials they cannot process, stockpile them for months or years, and during rainy seasons the stockpiles wash into waterways and become the marine litter that the recycling programs were designed to prevent. Over 100,000 families and 200,000–300,000 children in the LAC region survive by scavenging dumped materials in hazardous conditions.

3.3 The Waste Export Collapse

For decades, island nations could export waste problems to mainland processors. This option has largely collapsed:

- **China's National Sword Policy (2018):** Eliminated the world's largest import market for recyclable waste, stranding island nations that had relied on Chinese buyers.
- **Post-COVID shipping costs:** Container shipping rates that spiked during the pandemic have not fully normalized, making waste export economically unviable for low-value materials.
- **Regulatory tightening:** Receiving countries across Southeast Asia and Africa have implemented their own import restrictions, further shrinking the market.

The net effect: Caribbean islands that previously exported their waste problem now have no external outlet. The waste stays on the island. The landfills are full. And the crisis compounds daily.

4 The Waste-to-Energy Technology Landscape

Conceptual rendering: an integrated waste upcycling facility on a Caribbean island, combining gasification, material recovery, solar generation, and community infrastructure.

Waste-to-energy (WtE) technology converts municipal solid waste into useful energy forms — typically electricity and/or heat — while dramatically reducing waste volume. The technology landscape has matured significantly over the past two decades, offering multiple pathways suited to different scales and waste compositions.

4.1 Technology Overview

Table 3: Waste-to-Energy Technology Comparison

Technology	Scale (TPD)	Volume Reduction	Efficiency	Caribbean Suitability
Mass-burn incineration	500–3,000	90%	20–28%	Poor: too large for most islands
Gasification	50–500	90–95%	25–35%	Excellent: modular, scalable
Pyrolysis	20–200	85–90%	20–30%	Good: suits smaller islands
Plasma arc	10–200	95–99%	15–25%	Promising: handles mixed waste well
Anaerobic digestion	20–500	50–70%	15–20%	Good for organic fraction only

4.2 Gasification: The Leading Candidate for Caribbean Deployment

Gasification converts solid waste into synthesis gas (syngas) — a mixture of hydrogen, carbon monoxide, and methane — through thermal decomposition at high temperatures (700–1,200°C) in an oxygen-limited environment. The syngas can then be combusted in gas engines or turbines to generate electricity, or further processed into liquid fuels or chemical feedstocks.

Key advantages for island deployment:

1. **Modularity:** Modern shaft-type gasifiers operate efficiently at 50–200 tonnes per day, matching the waste generation profiles of individual Caribbean islands or island groups.
2. **Fuel flexibility:** Gasification systems can process mixed municipal solid waste including plastics, organics, wood, textiles, and construction debris without the extensive pre-sorting required by some other technologies.
3. **Environmental performance:** Advanced gasifiers with proper emissions controls achieve dioxin and furan levels far below regulatory limits. Modern systems employing high-temperature freeboard zones (800–900°C) and multi-stage gas cleaning can achieve emission levels measured in fractions of nanograms per cubic meter.
4. **Residue management:** Gasification produces vitrified slag rather than raw ash. This slag is chemically inert, passes leachate testing, and can be used as construction aggregate — converting a waste byproduct into a construction material on islands where aggregate is itself an imported commodity.
5. **Proven track record:** Multiple shaft-type gasification facilities have operated commercially since the early 2000s, with demonstrated operational histories exceeding 20 years. The technology is not experimental — it is mature but underdeployed in the Caribbean.

4.3 Pyrolysis: Complementary Technology

Pyrolysis operates at lower temperatures (300–700°C) in the complete absence of oxygen, decomposing organic materials into pyrolysis oil, syngas, and char. For Caribbean applications, pyrolysis is particularly relevant for specific waste streams:

- **Tire recycling:** Caribbean islands accumulate waste tires that are difficult to landfill and constitute a fire hazard. Pyrolysis converts tires into carbon black, steel, oil, and gas — all recoverable commodities.
- **Plastic-to-fuel:** High-density plastic waste streams can be converted to diesel-equivalent fuel through pyrolysis, directly displacing imported diesel.
- **Biochar production:** Organic waste pyrolysis produces biochar, a stable carbon material useful as soil amendment in Caribbean agriculture and as a component in construction materials.

DINNER TABLE VERSION

Think of gasification and pyrolysis as two different ways to cook waste. Gasification is like a very hot oven with controlled air — it breaks everything down into a combustible gas that generates electricity. Pyrolysis is like slow-cooking in a sealed pot with no air — it breaks materials into useful liquids, gases, and solid carbon.

Neither technology is "incineration" in the traditional sense. Old-style incinerators simply burned waste in open air, creating massive pollution. Modern gasification and pyrolysis are controlled chemical engineering processes that extract energy and materials while achieving emissions levels orders of magnitude cleaner than the uncontrolled landfill fires that Caribbean islands currently experience.

4.4 Integrated Approaches

Conceptual rendering: street-level view of an integrated waste upcycling plant (IWUP), designed to integrate with the surrounding community rather than isolate from it.

The most promising Caribbean deployment model is not a single technology but an integrated waste processing facility that combines multiple treatment methods:

1. **Front-end sorting:** Material recovery facility (MRF) extracts recyclable metals, glass, and high-value plastics before thermal treatment.
2. **Organic diversion:** Anaerobic digestion or composting handles the 40–60% organic fraction, producing biogas and soil amendment.
3. **Thermal treatment:** Gasification or pyrolysis processes the residual fraction, generating electricity and recovering construction-grade slag.
4. **Back-end recovery:** Metals recovered from slag, biochar from pyrolysis, and aggregate from vitrified residue create additional revenue streams.

This integrated model maximizes resource recovery, minimizes residual waste requiring landfill disposal (typically reducing the landfill-bound fraction to 5–10% of the original waste volume), and creates a circular economy framework appropriate to island constraints.

5 Project Economics: The Caribbean Advantage

5.1 The Dual-Revenue Model

The economic case for WtE in the Caribbean is fundamentally different from — and stronger than — the economic case on the mainland. The difference is driven by a single variable: **the price of**

the alternative.

On the U.S. mainland, WtE competes against cheap natural gas electricity ($0.04–0.08/kWh) and low-cost landfill tipping fees ($30–60/tonne). The economics are marginal without subsidies.

In the Caribbean, WtE competes against imported diesel electricity ($0.24–0.42/kWh) and landfills that are either at capacity or subject to steeply rising tipping fees. The economics are fundamentally favorable.

Table 4: WtE Economic Comparison: Mainland vs. Caribbean

Parameter	U.S. Mainland	Caribbean SIDS
Electricity price (displaced)	$0.04–0.08/kWh	$0.24–0.42/kWh
Landfill tipping fee	$30–60/tonne	$40–108/tonne (rising)
Land cost for new landfill	Moderate	Extreme/unavailable
Diesel import cost	Low (pipeline)	High (tanker delivery)
Hurricane debris surges	Rare/manageable	Frequent/overwhelming
Federal/EU grant availability	Limited	Substantial
Environmental compliance pressure	Moderate	Severe (consent decrees)

5.2 Revenue Streams for a Caribbean WtE Facility

Conceptual rendering: on-site CNG refueling and EV charging station powered by waste-derived energy — converting community waste into community transportation fuel.

A properly designed integrated waste processing facility on a Caribbean island generates revenue from multiple sources:

1. **Tipping fees:** Payment received for accepting waste. As landfills close or raise fees to comply with consent decrees, WtE tipping fees become competitive. Current Caribbean tipping fees range from $40 to over $100 per tonne.
2. **Electricity sales:** Power generated from waste displaces diesel at $0.24–0.42/kWh. Even at conservative conversion efficiencies, electricity revenue is the largest single revenue stream for Caribbean WtE projects.
3. **Recovered materials:** Metals, glass, and other recyclables extracted during pre-processing generate commodity revenues. Construction-grade slag displaces imported aggregate.
4. **Carbon credits:** Methane avoidance from landfill diversion generates verifiable carbon credits under recognized methodologies. As Caribbean nations increasingly participate in carbon markets, this revenue stream will grow.
5. **Resilience value:** WtE provides distributed, fuel-independent electricity generation that operates during and after hurricanes when diesel supply chains are disrupted. This resilience value, while difficult to monetize directly, has significant strategic worth for island grids.

5.3 Illustrative Project Economics

ILLUSTRATIVE MODEL: 150 TPD INTEGRATED WtE FACILITY

Assumptions:

- Capacity: 150 tonnes per day (54,750 tonnes/year)
- Technology: Gasification with power generation
- Net electrical output: 3–5 MW (after parasitic load)
- Availability: 85% (allowing for maintenance downtime)
- Capital cost: $80–120 million (including MRF, gasifier, power island, emissions controls)

Annual Revenue Estimates:

- Tipping fees (54,750 tonnes × $60/tonne): $3.3M
- Electricity sales (4 MW × 7,446 hrs × $0.25/kWh): $7.4M
- Materials recovery: $0.5–1.0M
- Carbon credits: $0.3–0.5M
- **Total annual revenue: $11.5–12.2M**

Annual Operating Costs: $4–6M (labor, maintenance, consumables, ash disposal)

Net Operating Income: $5.5–8.2M

Simple Payback: 10–18 years before grants; 6–10 years with 40–50% federal/EU grant funding

Note: These are illustrative figures for public analysis. Actual project economics depend on site-specific waste composition, electricity tariff structures, grant availability, and local regulatory conditions.

The critical insight is that Caribbean WtE projects do not require exotic financial engineering to achieve viability. The combination of high electricity prices, rising tipping fees, available grant funding, and the absence of alternative solutions creates a favorable economic environment that mainland projects cannot replicate.

6 The Policy and Funding Landscape

6.1 Regional Frameworks

The Caribbean policy environment for waste-to-energy has evolved rapidly:

- **Zero Waste in the Caribbean Initiative:** EU-funded program operating through UNEP across 16 CARIFORUM member states. Provides policy frameworks, baseline assessments, technical assistance, and financing mechanisms. Active through 2026 with demonstrated progress in Grenada and Dominica.
- **OECS Solid Waste Management:** The Organisation of Eastern Caribbean States has implemented tipping fee structures and waste diversion mandates, creating the regulatory conditions that support WtE investment.
- **CARICOM Circular Economy Strategy:** Regional commitment to circular economy principles, showcased at WCEF 2025, including waste bans, recycling targets, and technology deployment goals.
- **Basel Convention Regional Center for the Caribbean (BCRC):** Provides technical guidance on hazardous waste management, landfill operations, and pollution prevention specific to Caribbean SIDS.

6.2 Federal Funding Pathways (U.S. Territories)

For U.S. territories (USVI, Puerto Rico, Guam, CNMI, American Samoa), federal funding pathways are particularly relevant:

1. **CDBG-DR Grants:** Community Development Block Grant — Disaster Recovery funds. The USVI is actively pursuing $100 million for waste management infrastructure.
2. **EPA Solid Waste Programs:** Technical assistance, compliance support, and infrastructure grants through the EPA's SIDS programs.
3. **USDA Rural Energy Programs:** Funding for renewable energy projects in rural and island communities, applicable to WtE with power generation components.
4. **DOE Bioenergy Technologies Office:** Research and deployment funding for waste-to-energy technologies, particularly those incorporating advanced thermal conversion.

5. **Infrastructure Investment and Jobs Act (IIJA):** Provisions for solid waste infrastructure, grid resilience, and clean energy deployment applicable to island territories.

6.3 EU and International Funding (Non-U.S. Caribbean)

For independent Caribbean nations and non-U.S. territories:

- **EU Green Deal / Global Gateway:** EU infrastructure funding targeting circular economy and clean energy in partner nations, with Caribbean-specific allocations through the Zero Waste initiative.
- **Green Climate Fund (GCF):** Climate finance for SIDS, applicable to WtE as both mitigation (methane reduction) and adaptation (grid resilience).
- **Inter-American Development Bank (IDB):** Infrastructure lending for LAC region waste management modernization.
- **Caribbean Development Bank (CDB):** Regional lending institution with mandate for infrastructure development in member states.

7 Environmental and Social Considerations

7.1 Emissions and Environmental Performance

Modern WtE facilities, properly designed and operated, represent a significant environmental improvement over the status quo of open landfilling and uncontrolled fires. The comparison is not between WtE and some pristine alternative — it is between WtE and the current reality of leaching landfills, toxic fires, marine pollution, and diesel-fired power generation.

Table 5: Environmental Impact: Status Quo vs. Modern WtE

Impact	Current (Landfill)	Modern WtE
Greenhouse gases	Uncontrolled methane (28× CO_2 potency)	Controlled combustion; net GHG reduction vs. landfill
Dioxins/furans	Uncontrolled from fires (highest UPOPs source)	Nanogram levels with modern controls
Leachate	Continuous contamination of groundwater and marine systems	Eliminated for processed waste
Land consumption	1–2 hectares per 50,000 tonnes/year	Facility footprint only; no ongoing land consumption
Marine pollution	Direct contribution from coastal siting	Eliminates waste source of marine litter
Diesel displacement	None	3–5 MW per 150 TPD displaces thousands of tonnes of diesel/year

7.2 Social and Community Considerations

WtE deployment in Caribbean communities must address legitimate concerns:

- **Environmental justice:** Waste facilities have historically been sited in disadvantaged communities. Caribbean WtE projects must prioritize equitable siting, community engagement, and benefit-sharing.
- **Job creation:** A 150 TPD facility typically employs 50–80 permanent staff, with additional jobs in construction, maintenance, and waste collection. These are skilled technical positions that provide career pathways.
- **Informal sector transition:** Over 100,000 families in the LAC region depend on waste scavenging. WtE deployment must include transition programs that provide formal employment pathways for informal waste workers.
- **Community benefit agreements:** Best practice includes discounted electricity rates for surrounding communities, priority hiring for local residents, and transparent environmental monitoring with public reporting.

8 The Investment Thesis

For infrastructure investors, developers, and government procurement agencies, the Caribbean WtE opportunity can be summarized as follows:

THE INVESTMENT CASE

Demand: Unambiguous and growing. Every Caribbean island needs waste processing capacity. Landfills are at or beyond capacity. Federal consent decrees mandate action. The problem worsens with every passing year.

Economics: Favorable and improving. High electricity prices ($0.24–0.42/kWh), rising tipping fees, and available grant funding create project economics that are structurally superior to mainland deployments.

Policy: Supportive and strengthening. Regional frameworks (Zero Waste, CARICOM Circular Economy), federal programs (CDBG-DR, EPA, IIJA), and international finance (EU, GCF, IDB) are actively creating the conditions for WtE deployment.

Competition: Limited. The installed base of modern WtE in the Caribbean is nearly zero. First movers with proven technology and local relationships will establish dominant positions.

Replicability: High. The island waste-energy paradox is not unique to the Caribbean. Pacific SIDS, Indian Ocean islands, and Mediterranean islands face identical challenges. A proven Caribbean deployment model can be replicated globally across 50+ island nations.

Resilience value: Strategic. Distributed, fuel-independent power generation provides grid resilience during hurricanes — a capability that island governments increasingly value as climate impacts intensify.

The fundamental question is not *whether* waste-to-energy will be deployed in the Caribbean. The waste crisis is too severe, the energy costs too high, and the policy momentum too strong for the status quo to persist. The question is *who* will deploy it, *when*, and *at what scale*.

9 Conclusion: The Bridge That Connects Two Crises

The Caribbean waste crisis and the Caribbean energy crisis are not separate problems requiring separate solutions. They are two manifestations of the same structural challenge: island geography that makes conventional approaches uneconomic and unsustainable.

Waste-to-energy technology is the bridge that connects these two crises. It converts a liability (waste that has nowhere to go) into an asset (electricity that displaces expensive imported diesel). It reduces landfill dependence while improving grid resilience. It creates local employment while reducing environmental contamination. And it does so using technology that is mature, proven, and deployable at scales appropriate to Caribbean islands.

The USVI's December 2025 declaration that its waste system is "in crisis" is not an isolated incident. It is the canary in the coal mine for the entire region. Every Caribbean island faces the same trajectory: filling landfills, rising costs, tightening regulations, and no viable conventional alternative.

The waste-to-energy bridge is ready to be built. The question is whether it will be built proactively — as a planned infrastructure investment that captures the full economic and environmental value of waste conversion — or reactively, as an emergency response to a system that has finally and completely collapsed.

The Caribbean deserves the proactive version. The technology exists. The economics work. The funding is available. The only missing piece is execution.

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