

From Waste to Energy to Currency: A Model for Closed-Loop Sustainability in Institutional Communities

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Executive Summary

Conventional institutions—particularly prisons, military bases, and remote settlements—operate as miniature economies that consume large volumes of food, water, and energy while generating equally large volumes of waste. These closed or semi-closed systems face the same challenges confronting nations: how to manage waste sustainably, reduce dependence on external fuel and currency, and create economic incentives for efficient resource use.

This paper proposes a practical policy model that links *waste-to-energy conversion* directly with an *energy-denominated monetary system*. Every Kilowatt-Hour (kWh) of usable energy generated from internal resources—solar, biomass, or Municipal Solid Waste (MSW)—becomes a unit of account and medium of exchange within the institution. Residents, staff, and service departments transact in **energy credits**, a digital currency backed 1:1 by measured electrical or thermal output.

The approach establishes a closed-loop economy in which **waste becomes both resource and currency**. Instead of transferring taxpayer funds to purchase external energy, institutions monetize their own renewable generation and reinvest it into operations, rehabilitation, and education. By making energy tangible and self-issued, this model aligns economic value with thermodynamic reality—every transaction corresponds to physically verified work potential.

Implementation requires no fundamental change to national monetary law; the kWh currency functions as an **internal legal-tender substitute**, similar to commissary credits or carbon allowances, but indexed to measurable energy rather than fiat money. The government's role is to authorize pilot programs, set accounting standards, and guarantee environmental compliance.

The Expected Benefits are Profound:

- **Fiscal:** lower utility and waste-disposal costs through internal energy production.
- **Environmental:** measurable carbon and landfill reductions.
- **Social:** vocational training and reintegration of residents into green-energy sectors.
- **Strategic:** resilience during grid disruptions or supply crises.

In short, the system transforms waste liabilities into monetary assets and establishes a replicable blueprint for energy-backed

micro-economies across the public sector.

Background: Waste and Value in Institutional Economies The Dual Problem

Closed Communities Such as Correctional Farms, Remote Research Stations, and Military Outposts share Two Systemic Inefficiencies:

- **Waste Accumulation:** Food residues, human biosolids, plastics, and packaging often end up in landfills or costly haul-off contracts.
- **External Monetary Dependence:** Energy, food, and consumables are purchased using national currency, even when the community could supply many needs internally.

This disconnect between *physical production and financial accounting* produces chronic budget drains and environmental impact. Despite decades of recycling policy, the majority of institutional waste remains under-utilized as an energy resource.

Energy as the Universal Denominator

Energy—not money—is the ultimate measure of economic potential. A kilowatt-hour can illuminate a room, pump water, or power a tractor; its utility is universal and quantifiable. By contrast, fiat money represents a claim on value but is divorced from physical limits. Indexing exchange directly to energy closes that gap.

The notion of **energy-denominated currency** has precedents: the *energon* proposals of the 1930s Technocracy movement, Odum's *energy accounting*, and recent blockchain "energy tokens." Yet no government has implemented a fully closed-loop, operational version within an institutional micro-economy. Such a controlled environment offers the ideal proving ground.

Why Prison Farms are Ideal Pilot Sites

Correctional agricultural facilities already produce food and maintain renewable installations such as solar fields and biodigesters. They combine labor availability, measurable outputs, and strict auditing-conditions that make a self-contained currency system both practical and monitorable.

A prison farm typically manages:

- 1–5 tons day⁻¹ of organic waste (food scraps, manure).
- 0.5–2 tons day⁻¹ of recyclable or combustible solid waste.
- Installed photovoltaic capacity between 100 kW and 1 MW.

At 25–35 % conversion efficiency, these flows can yield **300–600 kWh day⁻¹** of recoverable energy-enough to power lighting, refrigeration, and small machinery. Valued as $1 E_1 = 1 \text{ kWh}$, the facility could circulate **300–600 E₁** daily within its internal market.

Current Policy Context

Governments worldwide are advancing “zero-waste” and “net-zero carbon” directives:

- The EU’s Circular Economy Action Plan (2020) mandates energy recovery from residual waste [1].
- India’s National Bio-Energy Mission promotes farm-scale biogas and gasification [2].
- The U.S. Federal Bureau of Prisons and Department of Defense have both issued sustainability strategies emphasizing onsite renewables [3].

However, these initiatives remain **budget-funded**, not **self-monetized**. They reduce utility bills but do not create internal currencies or incentive structures that continuously reward conservation and innovation.

The proposed model fills that policy gap by integrating waste management, energy generation, and economic exchange under a single accounting framework.

System Design: Linking Waste-to-Energy and Monetary Circulation

Core Mechanism

The foundation of the model is straightforward:

Energy in → Currency out → Exchange → Energy back.

Each verified kilowatt-hour (kWh) of useful energy produced inside the institution-whether electrical or thermal-is tokenized as one **energy credit (E₁)**.

The institutional treasury (a small administrative board or digital ledger) issues E₁ into circulation at the moment energy enters the community’s usable grid or thermal network. When that energy is later consumed-lighting, cooking, heating-equivalent E₁ are retired.

Thus, the *money supply automatically adjusts* to available energy. Inflation and deflation become physical phenomena: more generation expands liquidity; cloudy days or reduced waste inflow contract it. Every unit of value is backed by a measurable joule.

Infrastructure Overview

Waste Collection and Sorting

Organic matter, plastics, and human biosolids are separated at source. Recyclables are sold externally; combustibles and organics feed digesters or gasifiers.

• Conversion Technologies

- *Anaerobic Digesters*: produce biogas from food waste and sewage.
- *Biomass Gasifiers*: convert dry crop residues and clean plastics into syngas.
- *Solar Photovoltaics*: supply baseline power and charge batteries.

• Generation Metering

Smart meters aggregate kWh output from each source into the energy ledger.

• Digital Ledger & Currency Wallets

Each resident or staff member holds an account or NFC card. All transactions-wages, canteen purchases, tool rentals-occur in E₁.

• Treasury Governance

A five-member board oversees issuance, audits meters, and enforces environmental compliance. Their monthly report balances total energy created against total E₁ in circulation.

Technical Feasibility and Precedents

Anaerobic Digestion

Real-World Examples Demonstrate Reliability at Small to Medium Scale:

- **Home Biogas** household systems (Israel) generate cooking gas from kitchen waste for rural households [4].
- **Punjab Energy Development Agency (India)** operates farm digesters producing both power and fertilizer [5].
- **Her Majesty’s Prison, Northumberland (UK)** piloted a sewage-to-biogas unit reducing energy imports by 30 % [6].

Digesters are ideal for wet waste, simple to maintain, and double as sanitation systems. Methane yield averages 0.2–0.3 m³ kg⁻¹ dry solids-about 2 kWh kg⁻¹.

Biomass and Plastic Gasification

For dry waste, modular gasifiers like the **All Power Labs PP30** (USA) or **Ankur Scientific downdraft units** (India) convert 25–50 kg h⁻¹ of feedstock into 20–40 kW electrical output [7]. Pilot “co-gasification” studies blending 10 % cleaned plastic with wood chips show stable operation and reduced tar formation [8].

Kenya’s **Kibera Waste-to-Energy Project** demonstrates safe municipal waste gasification with emissions below EU limits [9].

Microgrid Integration

The **Samoa Renewable Microgrid** and **Alcatraz Island Solar-Battery System** illustrate islanded grids that balance intermittent solar and generator inputs [10]. Similar control logic can regulate prison-farm energy flows and currency issuance.

Institutional Implementation Model

Economic Roles and Incentives

Every participant becomes both energy producer and consumer.

- **Residents** earn E₁ for labor in agriculture, recycling, and maintenance.
- **Canteens and workshops** charge E₁ for goods, priced by embodied-energy cost.
- **Administration** purchases external supplies (if needed) using surplus E₁ converted at the prevailing grid-energy price.

Wages in E₁ encourage conservation: saving electricity literally saves money. Labor that improves efficiency-cleaning panels, optimizing digesters-yields direct reward.

Digital Architecture

A closed-loop card or mobile system suffices; no internet is required.

Transactions clear through a local server using blockchain-style hashing for audit integrity. Energy meters feed automatic issuance; consumption meters trigger token retirement.

If connectivity exists, surplus E₁ can interface with external **energy credit exchanges**, similar to carbon markets. The conversion rate is pegged to the local cost of 1 kWh in national currency.

Governance and Oversight

Key principles:

1. **Transparency**: daily generation and E₁ totals displayed publicly.

- 2. Environmental Compliance:** emissions, sludge handling, and digestate testing per national standards.
- 3. Education:** residents trained in renewable-energy operations-valuable post-release skills.
- 4. Equity:** price tables reviewed monthly to keep essentials affordable.

The **Energy Treasury Board** (warden, engineer, auditor, resident representative, environmental officer) publishes quarterly audits accessible to state oversight bodies.

Integration with External Policy

Legally, E_1 credits are internal scrip authorized under institutional-budget provisions-similar to commissary tokens or carbon allowances-but with explicit statutory recognition as a *temporary legal tender substitute* within designated facilities.

National legislation would empower departments of Energy, Environment, and Justice jointly to license such currencies under a “Renewable Institutional Economy Act.”

This Framework Mirrors Existing Models:

- **Japan’s Local Currency Ordinances** allowing municipally issued credits for energy savings [11].
- **Sweden’s landfill-tax incentives** that monetize avoided waste volume [12].
- **U.S. Department of Defense microgrid pilots** granting internal energy accounting autonomy [13].

Policy Recommendations

Establish Pilot Programs

Step 1: Site Selection

Begin with one *agricultural correctional facility* and one *military logistics* base to test both civil and defense contexts. Ideal pilots have existing solar arrays and manageable waste streams (1–5 tons day⁻¹ organics).

Step 2: Enabling Mandate

Authorize a joint directive between the **Departments of Energy, Environment, and Justice** to permit internal energy-credit circulation as a *legal-tender substitute* for institutional transactions. This requires only administrative rule-making, not new monetary law.

Step 3: Technical Implementation.

Fund Installation of:

- modular anaerobic digester (100–200 m³) for food and biosolids,
- 50 kW biomass/plastic co-gasifier,
- 250 kW photovoltaic field and 500 kWh battery,
- smart-meter/ledger system to issue and retire E_1 credits automatically.

Step 4: Governance Charter

Constitute an Energy Treasury Board with statutory reporting duties. Mandate quarterly public energy-balance sheets certified by the national audit office.

Integrate with Broader Sustainability Policy

- Embed pilots under the national **Circular Economy Roadmap** so results count toward waste-diversion and carbon-reduction targets.
- Align with **renewable-portfolio standards**; each internally generated kWh qualifies for tradable renewable-energy certificates.
- Create vocational accreditation for inmates and staff trained

as digester/gasifier operators-feed this into workforce-reentry programs.

Fiscal Instruments

• Energy-Credit Tax Equivalence

Recognize 1 E_1 as equivalent to 1 kWh of taxable value. Internal trades remain tax-exempt; external E_1 sales are treated as renewable-energy income.

• Green Bonds for Infrastructure

Finance digesters and gasifiers through green-bond issuance repaid in future E_1 revenues.

• Carbon-Debit Offsets.

Allocate carbon-credit revenue from avoided methane and landfill emissions to the facility’s energy reserve fund.

Regulatory Safeguards

- **Environmental standards:** require flue-gas analysis, digestate testing, and pathogen control consistent with EPA 503 or equivalent.
- **Health & safety:** implement gas-detection, ventilation, and fire-suppression systems; operators certified in confined-space entry.
- **Data integrity:** adopt government-approved digital-ledger software with cryptographic audit trails to prevent currency tampering.

Expected Impacts

Economic

- Typical 500-inmate farm generates 400 kWh day⁻¹ from waste and 800 kWh day⁻¹ from solar, offsetting \approx US \$90 000 yr⁻¹ in electricity purchases.
- Circulating E_1 reduces cash handling, commissary accounting, and security costs.
- Internal credit recirculation yields a *local multiplier effect*: every kWh generated may transact 5–10 times before retirement, effectively multiplying utility value.

Environmental

- Diverts > 90 % of organic waste from landfill.
- Cuts CO₂-equivalent emissions by \sim 600 t yr⁻¹ for a mid-size facility.
- Produces nutrient-rich digestate reducing synthetic-fertilizer imports by 40 %.
- Enables net-zero-energy and potentially carbon-negative operation.

Social and Educational

- Provides continuous technical training: biogas management, electrical systems, materials recovery.
- Reinforces behavioral accountability-energy misuse has immediate personal cost in E_1 .
- Demonstrates restorative environmental stewardship, reframing incarceration as participation in a productive ecological economy.

Broader Governmental Value

If pilots succeed, the framework scales easily to:

- **Military installations** (self-sufficiency during grid outages).
- **Remote research stations and islands** (energy independence).
- **Municipal waste districts** (citizen energy-credit incentives).

A national rollout could underpin a “**Green Treasury Network**”-interlinked micro-economies where verified renewable generation issues standardized E_1 credits redeemable across participating institutions. This aligns fiscal flow with physical sustainability, making the national currency partially energy-indexed without

formal monetary reform.

Conclusion

Energy is the one currency that nature always honors. By treating each kilowatt-hour of recovered waste energy as a token of value, governments can unify environmental policy, fiscal prudence, and social rehabilitation under a single measurable standard.

The proposed closed-loop prison-farm economy demonstrates feasibility at human scale: waste becomes fuel; fuel becomes money; money sustains the community that produced it. Once proven, the same logic can extend to any institution or municipality seeking resilience in an era of energy transition.

Adopting this model would position government not merely as regulator but as *architect of thermodynamic justice*-an economy where every act of conservation literally pays.

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