Sentinel

From Waste to Worth

Bioenergy Technologies Using Agricultural and Industrial Waste

Sentinel Innovation Co., Ltd

Who We Are

Turning Waste into Clean Energy

Sentinel is a climate-tech startup turning agricultural and industrial waste into low-carbon energy solutions - Including bio-oil, biochar, and carbon black.

Our work spans from coffee husks to used tires, helping communities reduce emissions while creating local energy access

Why Waste-to Energy?

The Rising Challenge and Missed Opportunities

USD 252B

💰 Direct cost of global waste management

USD 361B

🌍 Hidden costs from pollution, health damage, and climate impact

= Total societal cost: Over USD 600B annually

The Problem

Why Waste-to Energy?

Global Shift : Waste as a Resource

The Problem 🗑️

Underutilized organic & industrial waste

Environmental & social costs

Poor recycling & energy access

Sentinel

The Response ✅

Global Waste-to-Energy Initiative

Advanced bio-energy tech

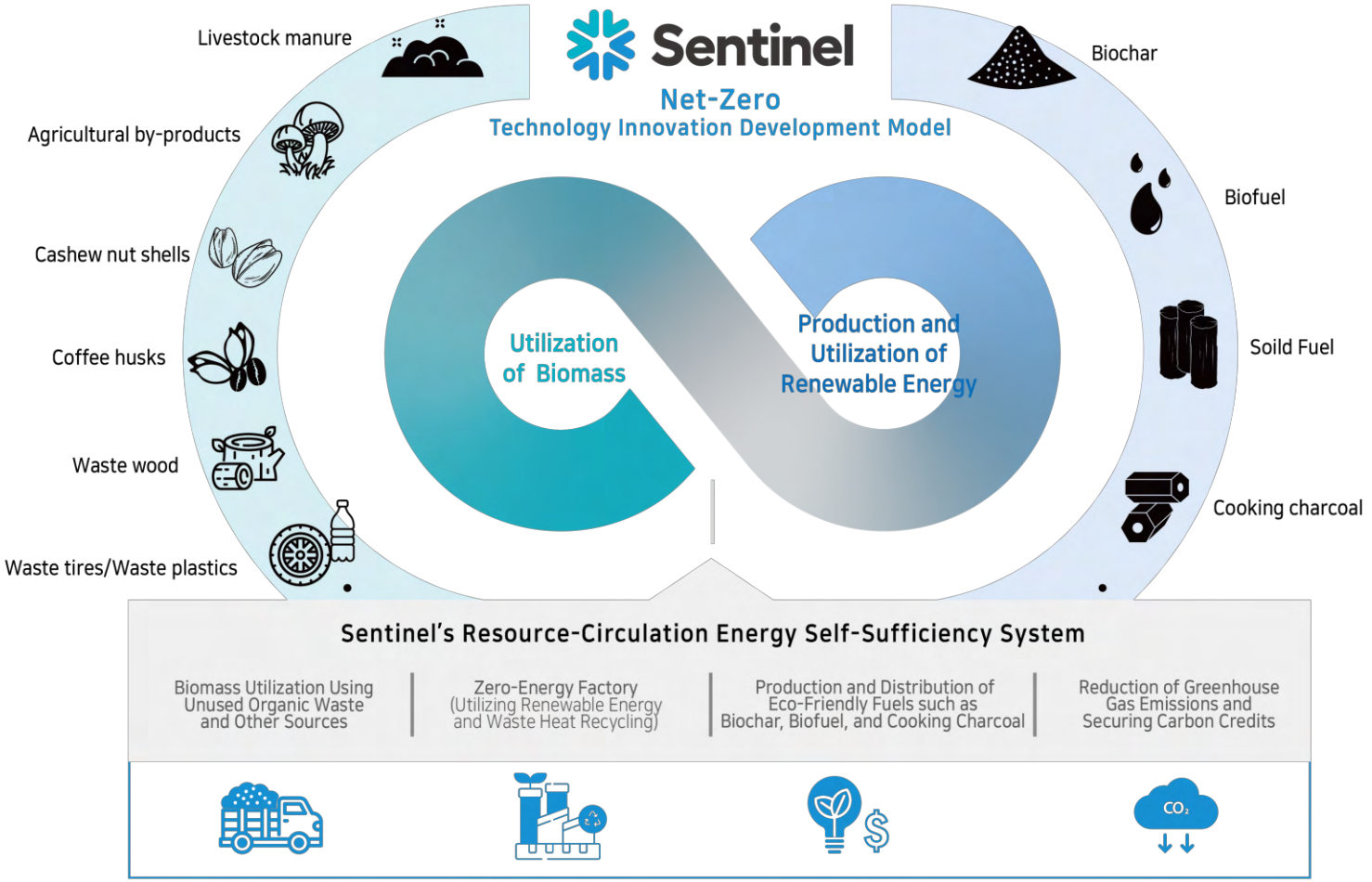
Our Solution

Turning Waste into Clean Energy

- Localized energy production
- Lower carbon emissions
- Circular economy models in under-resourced regions

Our Solution

Turning Waste into Clean Energy



Our Solution

What is Bioenergy?

Bioenergy, derived from biomass, offers low-carbon alternatives to fossil fuels through solid and liquid energy products such as biochar and bio-oil
(recognized by IEA and IPCC)

Solid Biofuel
(Biochar, Briquettes, etc)

Solid carbon-based fuel produced by pyrolyzing agricultural and forestry waste under high-temperature, oxygen-free conditions.

- Low-emission alternative to firewood and charcoal
- Improves indoor air quality and reduces deforestation
- Can be used in institutional settings (schools, refugee camps, etc.)
- Supports energy access in off-grid communities

Liquid Biofuel
(Bio-oil)

Liquid fuel obtained by condensing volatile organic compounds released during the pyrolysis of biomass.

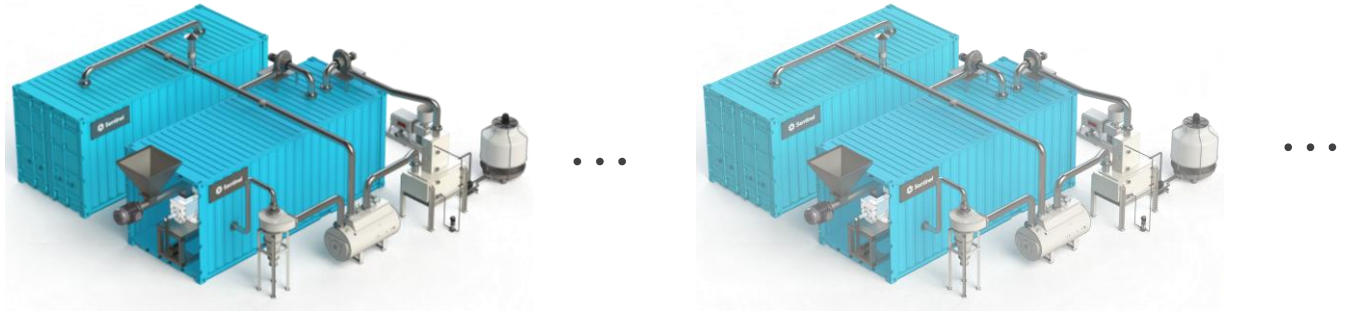
- Viable alternative to diesel and heavy fuel oil
- Exportable to meet global renewable fuel standards (RED II, RFS, ISCC)
- Usable for industrial boilers, blended fuels, and even aviation fuel development
- Generates carbon credits through certified low-carbon performance

Our Business Model

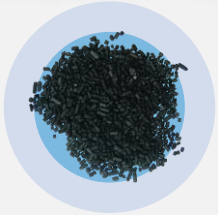
Modular Bioenergy Platform for Scalable, Multi-Stream Revenue

» Platform-based recurring revenue with scalable BOO(Build-Own-Operate) model

Sentinel
Bio-Energy Unit
(Modular Pyrolysis System)

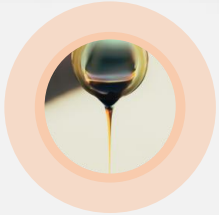


Stream 1



Biochar Sales
(including Bio-briquettes)

Stream 2



Bio-oil Exports

Stream 3

Carbon Credit Trading

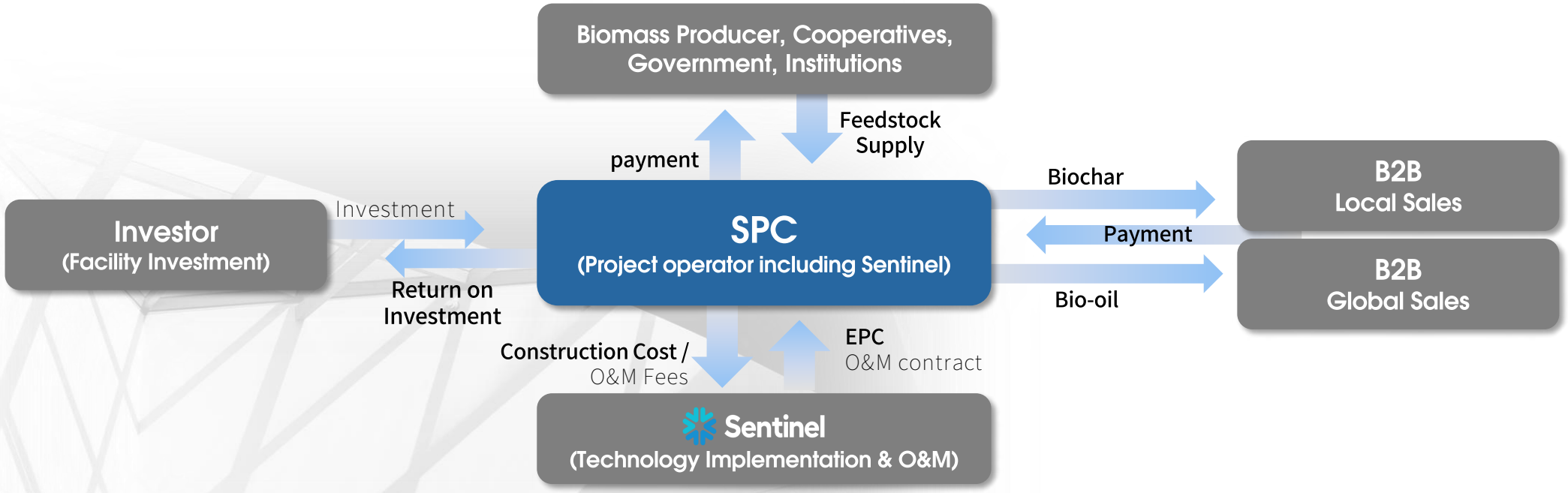
+

Stream 4

Tech Licensing & Advisory Services

Our Business Model

Business Structure & Multi-stream Revenue Model



Multi-Stream Revenue Model

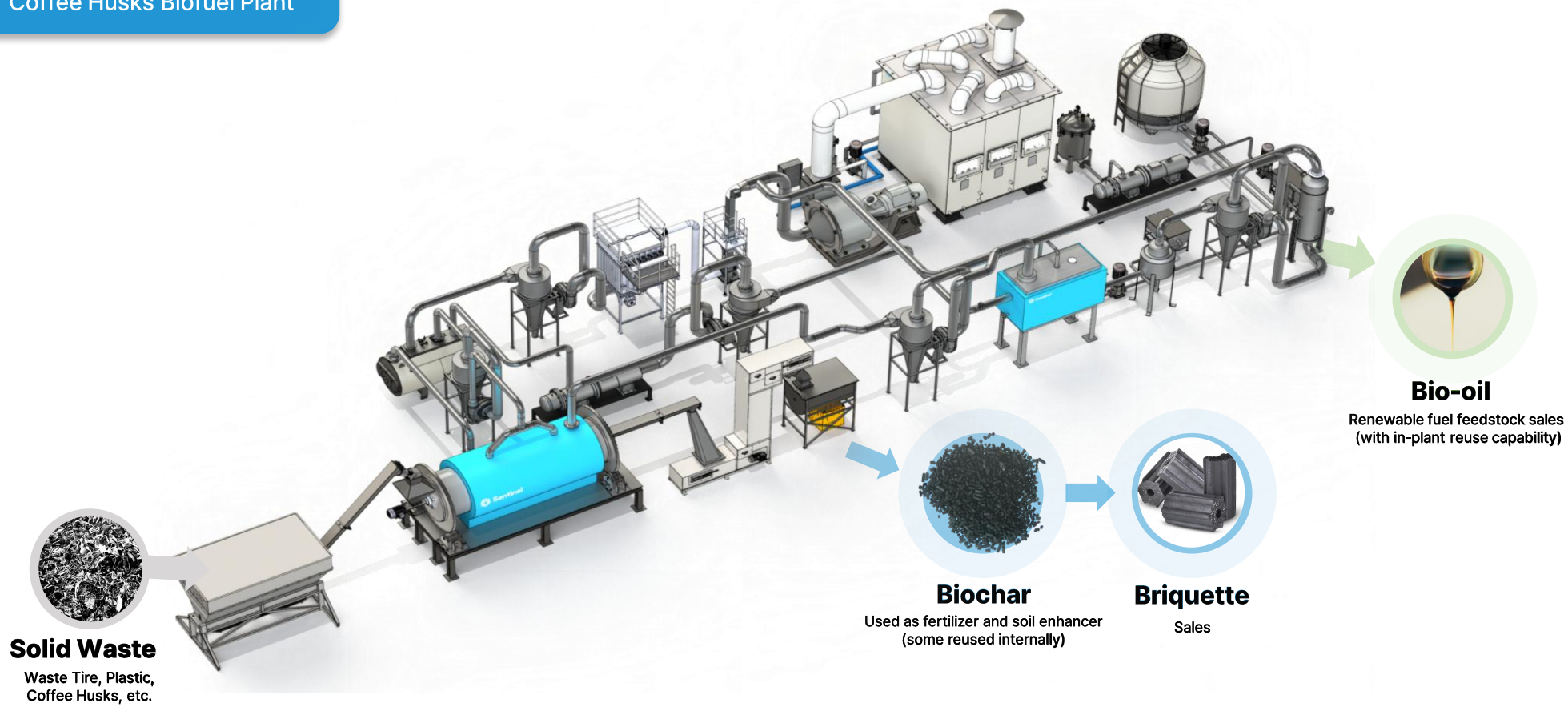
Revenue Stream	Target Region	Target Customers
Biochar(Bio-Briquettes)	East Africa	B2B & B2G : Commercial facilities and international organizations
Bio-Oil	EU & North America	B2B : Bio-oil refiners and blending companies
Carbon Credits	EU & Global	Carbon market brokers, government agencies
Tech Licensing & Consulting	Global	Technology partners, development agencies, international organizations, NGOs

Our Technology

Pyrolysis-based Bioenergy Platform

» Operating a decentralized, modular biofuel plant that internally reuses Biochar, Bio-oil, and syngas—minimizing emissions and energy use.

Coffee Husks Biofuel Plant



* Detailed processes may vary depending on the processing capacity, processing environment and conditions.

Segment

Waste Tire-to-Energy

Our platform enables waste tire-to-energy conversion through pyrolysis, producing oil, gas, and carbon black.

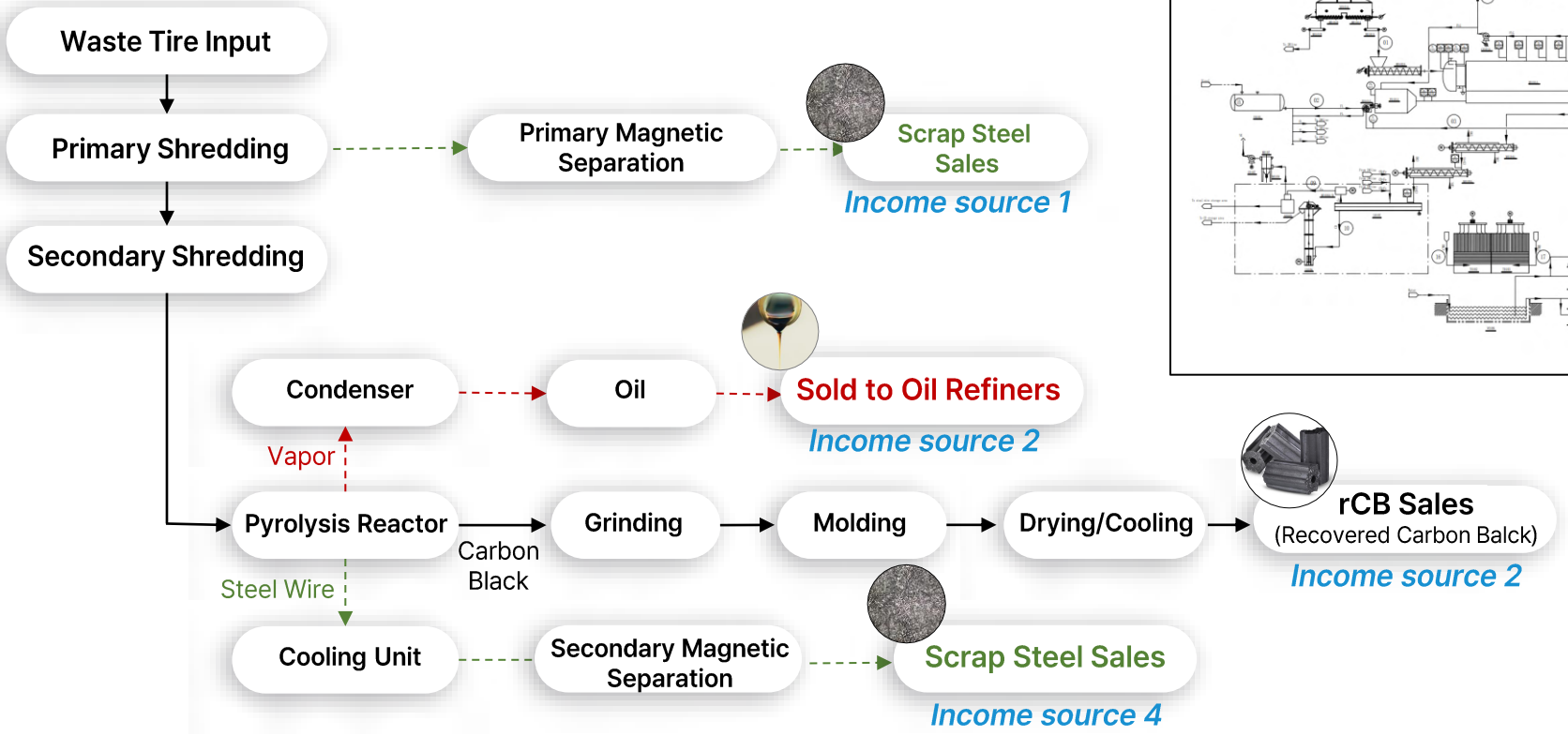
The project aims at energy recovery from waste tires using modular pyrolysis units.

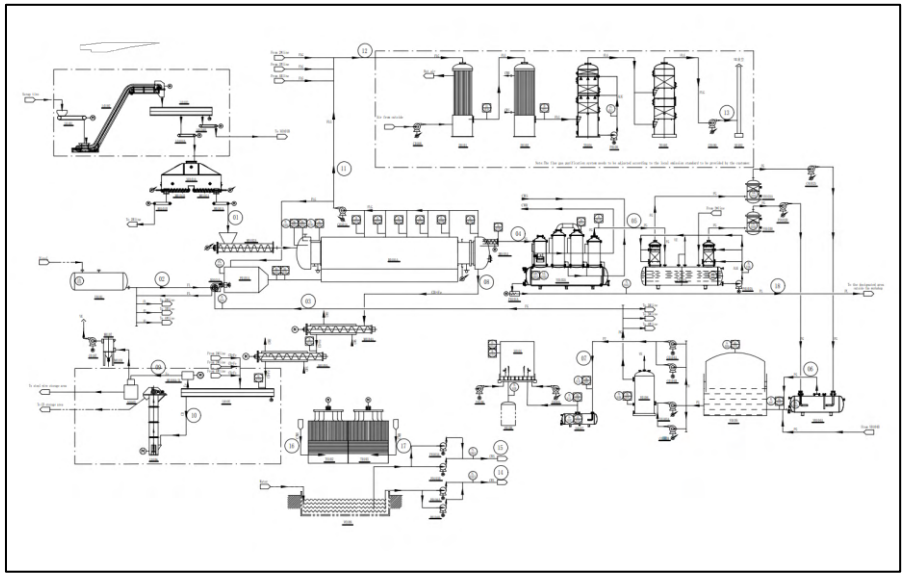
Our Technology

Waste Tire Pyrolysis Unit

» A Pyrolysis-based system designed to extract both Carbon Black and Oil from industrial waste, such as waste tires and plastics.

PFD (Process Flow Diagram)





Reference

Global Project Experience (1) Türkiye

Ahlat Energy, Türkiye

- Waste tire pyrolysis system
- 80,000 tons/year capacity
- 40% oil / 40% carbon black

▲ Waste Tire

▲ Pyrolysis Reactor (Kiln Type)

▲ Carbon Black

Global Project Experience (2) Spain

Greenval Technologies, Spain

- Waste tire chip pyrolysis system
- 10,000 tons/year capacity
- Facility Site Area: 12,000 m² in total

▲ Waste Tire Chips

▲ Pyrolysis Reactor (Screw Type)

Investment & Revenue Projection for Tire Pyrolysis Plant

CAPEX

Plant Capacity		CAPEX (USD)
10~30ton/day (tire input)	Fully automatic	$2.25 million
	Semi-automatic	$1.05 million
	Manual	$0.45 million

* This amount covers machinery costs only, excluding construction, installation and other related expenses. Operational expenditures (OPEX) are not included and may vary by region, labor cost, and plant operation scheme.

* The revenue structure right side is based on a fully automatic facility. Unit prices for each revenue stream are estimated using market reports, industry analysis, and international trading data from recent years.

Revenue Scenarios

* 300 operational days per year (average processing of 30 tons/day per site)

Revenue Sources (yield %)	Base Scenario (USD/year)	Optimized Scenario (USD/year)
Oil (40%)	$1.15M	$2.02M
Carbon Black (30%)	$0.54M	$1.08M
Scrap Steel (10%)	$0.11M	$0.14M
Total	$ 1.80M	$ 3.24M

Revenue Assumptions (Base/Optimized Scenarios)

Oil
- Typical market price : USD 400–700 per ton
- High-quality or suitable for further refining: Above USD 800 per ton

Carbon Black
- Unrefined carbon black: USD 200–400 per ton
- High-quality, refined rCB : USD 500–700 per ton

Scrap Steel
- Average market price: USD 150–250 per ton, depending on the region

Segment

Coffee Husk-to-Energy

Our platform transform agricultural residues, particularly coffee husks, into clean and renewable energy.

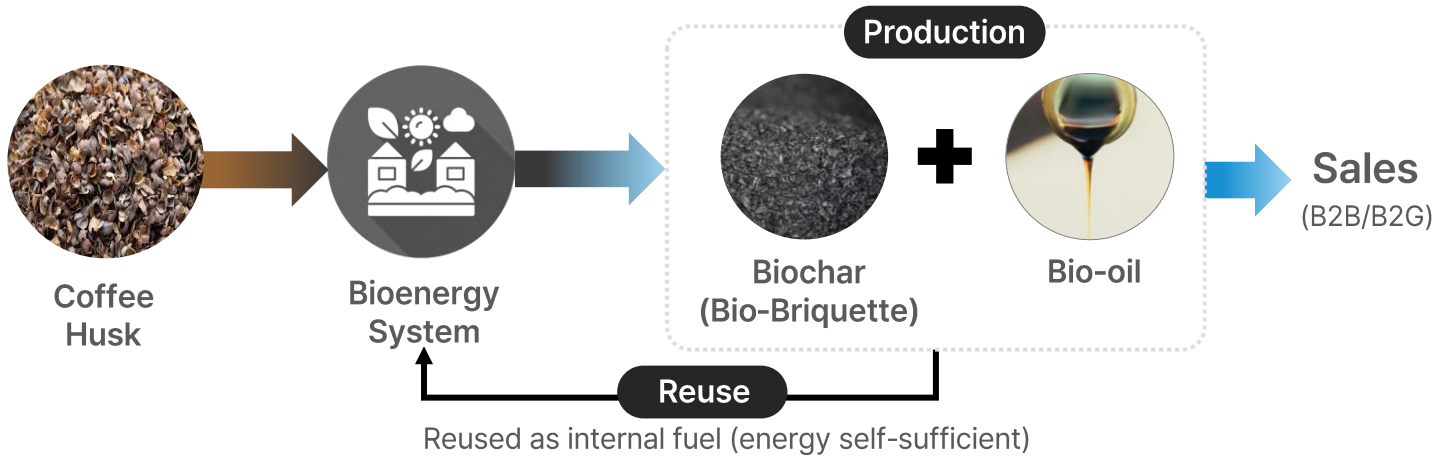
The process produces solid biofuels (bio-briquettes), helping replace wood and charcoal while reducing indoor air pollution and deforestation.

It also generates bio-oil, which is reused as an energy source to operate the systems itself, enabling a self-sufficient, circular energy model.

Our Solution

Circular Bioenergy System: Production – Reuse – Impact

» Abundant feedstock → Fuel Production → Revenue & Impact



Impact

Prevent Deforestation
Replacing firewood & charcoal with Bio-briquettes

Reduce GHG
~4,704 tCO_2e/year through biochar sequestration & cleaner fuel use

Health Improvement
Reduce indoor air pollution from incomplete combustion

Stable Feedstock

- **Among the world's largest coffee producers**: ~600,000 tons of coffee husks generated annually (Uganda alone)
- **Local supply security**: raw material widely available with minimal risk
- **Strategic location**: within East Africa's coffee belt

Scalable Market Opportunities

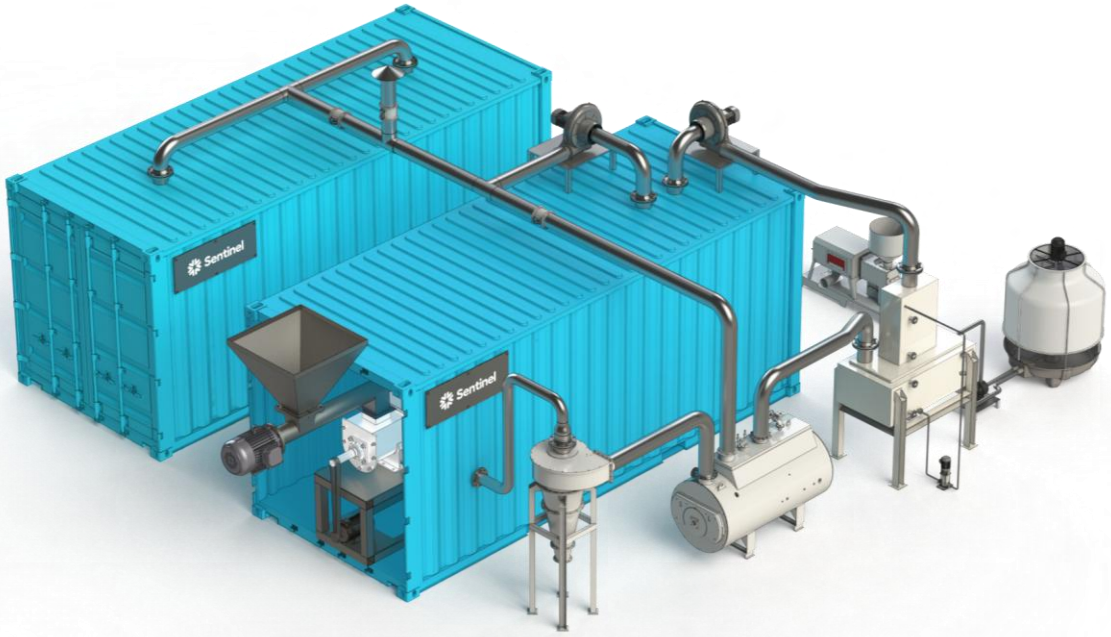
- **Biochar (1,680 t/year)**: replaces ~10% of local charcoal market → ~USD 800M/year potential (East Africa charcoal market ≈ USD 8B)
- **Bio-oil (2,220 t/year)**: part of a global market worth USD 6.82B
- **Diversified revenue streams:** Biochar/Bio-briquettes, Bio-oil, potential carbon credits

*** All figures are based on a single plant processing 6,000tons of coffee husk per year.**

Our Technology

Uganda Coffee Husk-to-Bioenergy Pilot Plant

» Decentralized, modular biofuel plant that internally reuses Biochar, Bio-oil, and syngas—minimizing emissions and energy use.



Specifications

Feedstock Capacity	20 tons/day (coffee husks)
Biochar yield	~30% (1,680t/year)
Bio-oil yield	~40% (2,220t/year)
Technology	Modular pyrolysis unit with internal fuel reuse system
Carbon savings	Up to 4,704 tCO_2/year per unit
CAPEX	Approx. USD 2.5M (equipment only)
Energy self-sufficiency	>70%

- Modular & Scalable
- Low-skill operable
- Self-powered operation
- Adaptable to local waste types

Financial Overview & Market Entry Strategy

ROI Scenarios * 300 operational days per year (average processing of 20 tons/day per site)

Cost Items	Amount (USD)
Total Investment Cost	$5,000,000
Annual Revenue	$2,008,200
Annual Operating Cost	$570,000
Depreciation	$350,000
Annual Net Profit	$1,088,200
ROI (Annual Basis)	21.8%
Payback Period	5 years

Investment recovery within 5 years

- Annual ROI of over 21% → Highly attractive among infrastructure-type projects
- Potential for shortened payback period through carbon credit sales, government incentives for electricity sales, and export markets
- Sequential deployment of additional units after first-year operation to diversify risk
- Market penetration through Bio-briquettes + Bio-oil as diversified fuel product portfolio

East Africa Market Entry Strategy

Technology Expansion

- Localized technology strategy
- GBIL Uganda Jinja PoC Plant (800kg/day) → Expansion to Bioenergy Belt
- Development of an integrated modular solution
- PCT international patent application in progress

Business Expansion

- Establishment of local entity and plant
- Entry based on Official Development Assistance(ODA) projects
- KOICA CTS & IBS : Expansion into East Africa with support from international agencies
- Partnership building (B2B, B2G)
- AfDB SEFA Project (Pilot Demonstration), UNDP Climate Innovation Accelerator (UNICA) project

Funding Acquisition

- Overseas investor engagement : G-Next, Global Accelerator
- International Climate Finance : EDCF (Economic Development Cooperation Fund), Green Climate Fund(GCF), Global Environment Facility (GEF)

Expansion Potential & Market Fit

East Africa Bioenergy Belt

» Developing a coffee husk-based bioenergy belt in East Africa

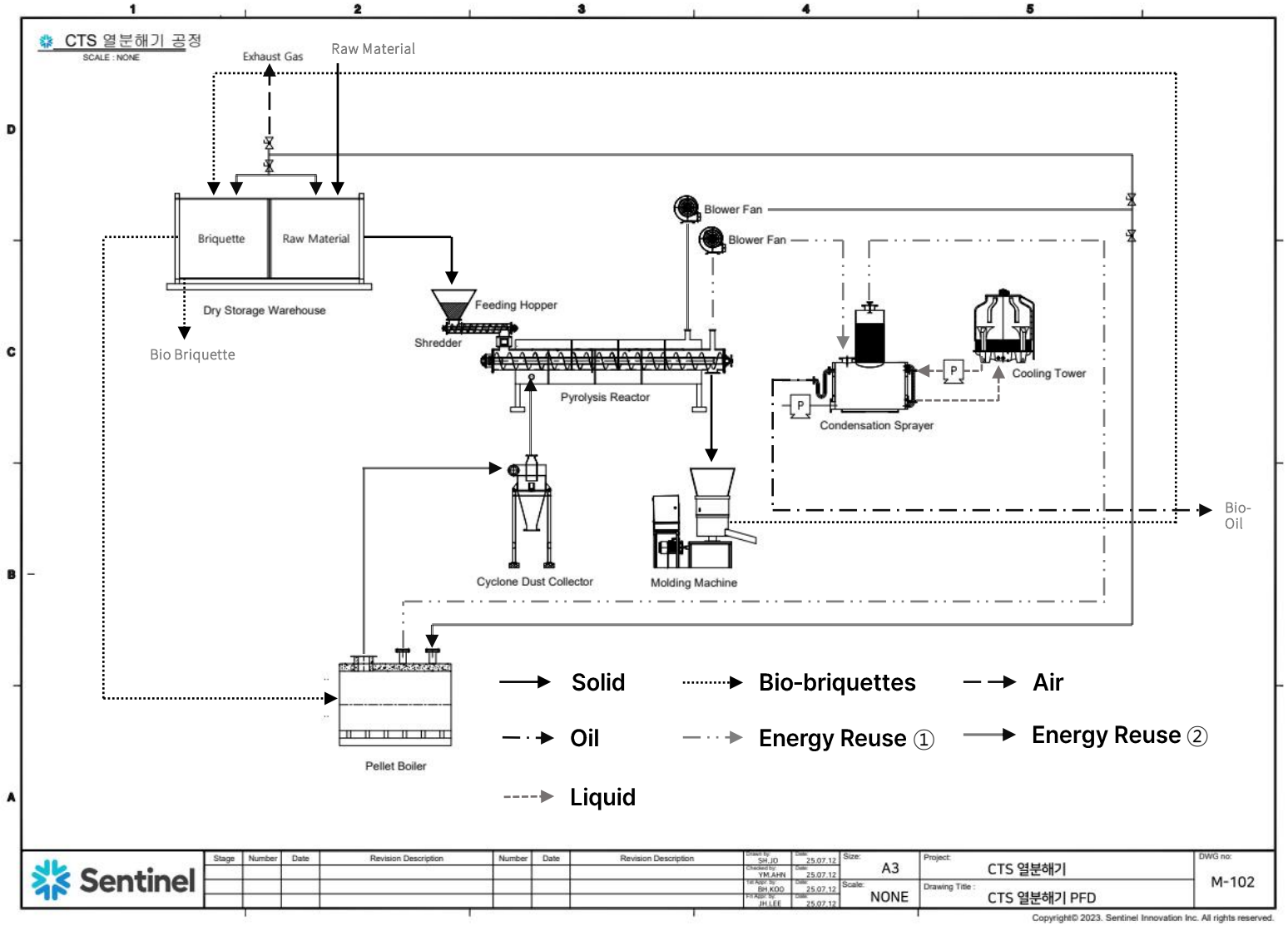
»» Planned phased expansion : 2025-2031

- **Phase 1 (2025-2026) : Launch & Scale in Uganda**
  - Deploy initial modular unit in Uganda
  - Expand to 8 local sites across major coffee-producing regions
  - Establish biomass supply chains and operational partnerships
  - Processing Capacity : 20 tons/day (dry biomass)
- **Phase 2 (2026-2031): Regional Expansion in East Africa**
  - Extend the model to Kenya, Tanzania, and Ethiopia
  - Adapt system to local biomass types
  - Scale production to 80 tons/day (dry biomass)
  - Target carbon market integration and cross-border fuel distribution

»» Why the Belt Model Works

- Easily replicable in high-biomass, low-infrastructure areas
- Supports national clean cooking goals and decentralized fuel access
- Scalable across East Africa's coffee belt and adaptable to diverse biomass types
- Crates a regional platform for cross-border fuel access and carbon credit integration

PFD (Basic type of biochar and bio-oil production)



Sentinel

PFD (Advanced type of biochar and bio-oil production)