

INDUSTRIAL CASE STUDY

Grid Power from Agricultural Biomass

Continuous Downdraft Gasification Power System — 2 Megawatt Capacity

Designed, Engineered & Validated by GreenVolt Engineering Solutions

2 MW PLANT CAPACITY (Continuous Export)

850°C GASIFICATION TEMP. | **45 min** SYNGAS RESIDENCE TIME

96.4% COLD GAS EFFICIENCY | **<48 mg/Nm³** TAR & PARTICULATE (Cleaned Syngas)

~3.2 Yrs PAYBACK PERIOD (At Prevailing Tariff Offset)

Project Reference Detail

Field	Detail
Client Organisation	Suryodaya Agro Processors Ltd. — Leading Indian agro-residue processor
GreenVolt Reference	GVES/RE/BiomassGas/2025-01 Based on GREC Pilot Report 33/GREC/LAB/09
Technology	Continuous Downdraft Fixed-Bed Gasifier with Syngas Cleaning & Gas-Engine Genset
Feedstock	Agricultural biomass residue (rice husk / crop stubble) — 18.6% Moisture (as-received)
Product Output	Continuous Grid-Quality Electrical Power — 2 MW, plus biochar by-product
Plant Location	Client facility (agro-processing plant) — Baseload captive power with grid export
Document Date	July 2026 Validated on GREC Pilot Data — March 2026

Renewable Energy | Biomass Gasification | Distributed Power Generation | Circular Economy | Agro-Waste Valorisation | Rural Electrification

Executive Summary

Suryodaya Agro Processors Ltd., a leading Indian processor of paddy and other agricultural produce, faced a commercially significant challenge: their operations generate large volumes of crop residue — rice husk and stubble — that, if left unused, is either burned in the field (a major contributor to regional air pollution) or sold at negligible value as low-grade boiler fuel. At the same time, the client's processing facility carries a high captive power bill, sourced primarily from grid supply and diesel gensets during outages.

GreenVolt Engineering Solutions was engaged to design, validate, and specify an industrial-scale continuous biomass gasification power system capable of converting this residue into reliable, dispatchable electrical power at a nameplate capacity of 2 Megawatts (MW).

Following rigorous pilot-scale validation at GREC (GreenVolt Renewable Energy R&D Centre) using an instrumented downdraft gasifier across multiple operating temperatures (750°C, 850°C, 950°C), the optimal industrial process parameters were established. The GreenVolt continuous downdraft gasifier system — operating at 850°C with a 45-minute syngas residence and integrated cleaning train — delivers cold gas efficiency of 96.4% and reduces tar and particulate loading in the cleaned syngas to below 48 mg/Nm³, enabling continuous gas-engine operation without fouling.

CHALLENGE	GREENVOLT SOLUTION	OUTCOME ACHIEVED
Crop residue with 18.6% moisture and high tar-forming volatiles — viable only as low-value boiler fuel at INR 1,500–2,200/tonne, with field-burning causing regulatory exposure.	Continuous 2 MW downdraft gasifier at 850°C, integrated cyclone + wet scrubber cleaning, 45-min residence — validated from GREC pilot trials.	Clean syngas at <48 mg/Nm ³ tar/particulate, 96.4% cold gas efficiency — enabling continuous 2 MW power export and INR 9–11/kWh effective tariff offset.

Key Performance Summary

KPI	Raw Feedstock (Baseline)	After GreenVolt Processing (2 MW Plant)	Improvement
Feedstock Moisture	18.6%	< 12% (pre-dried)	35% reduction
Syngas Tar + Particulate	N/A (raw combustion)	< 48 mg/Nm ³	Genset-grade cleanliness
Cold Gas Efficiency	N/A (direct-fired boiler ~55%)	96.4%	+75% relative
Effective Power Cost	INR 8.5–9.5/kWh (grid + DG blend)	INR 3.2–3.8/kWh (biomass power)	55–65% cost reduction
Residue Value Realised	INR 1,500–2,200/t (fuel-grade)	INR 6,500–8,000/t equiv. (as power)	3–4x value uplift
Annual Revenue/Savings Potential	INR 0.9–1.3 Cr/yr	INR 7.8–9.6 Cr/yr at 7,200 hr/yr operation	—

Industry Context & The Business Challenge

India generates an estimated 500 million tonnes of crop residue annually, of which a significant share is surplus to fodder, mulching, and industrial use. Rice husk alone accounts for roughly 20 million tonnes per year nationally, with a large share concentrated in paddy-processing clusters similar to the client's operating region. Uncontrolled field burning of surplus residue remains a leading contributor to seasonal air quality deterioration in several Indian states.

The global biomass-to-power market is valued at approximately USD 50 billion and is projected to grow steadily through 2030, driven by Renewable Purchase Obligation (RPO) mandates, distributed generation incentives, and corporate sustainability commitments from agro-processing and FMCG companies targeting captive renewable power for their facilities. However, the critical barrier for Indian agro-processors is technical: raw residue gasified without proper temperature control and cleaning produces tar-laden syngas that fouls gas engines within hours, making unplanned, uncleaned gasification commercially unviable.

The Commercial Problem — Why Untreated Gasification Fails

Quality Parameter	Uncontrolled Gasification (Typical)	Genset Requirement (Continuous Duty)	Gap
Tar Content in Syngas	800–1,500 mg/Nm ³	< 50 mg/Nm ³	FAIL — 16-30x over limit
Particulate Loading	300–600 mg/Nm ³	< 50 mg/Nm ³	FAIL — 6-12x over limit
Cold Gas Efficiency	60–70%	> 90%	FAIL — insufficient conversion
Genset Uptime Achieved	< 40% (frequent fouling)	> 95%	FAIL — unplanned downtime

Table 1: Uncontrolled gasification parameters vs genset-grade syngas specification | Source: GREC Analysis & IS 17420 Producer Gas Guidelines

Revenue Opportunity — Valorising an Existing Waste Stream

The Opportunity: At 2 MW continuous export, operating 300 days/year (7,200 hours), the plant consumes approximately 9,600 tonnes of biomass residue annually and generates 14,400 MWh of electrical power. At a blended effective cost of grid-plus-diesel power of INR 9/kWh, this displaces INR 12.96 Cr/year in power procurement cost, against a biomass procurement and operating cost of roughly INR 3.4–4.2 Cr/year — a net annual value creation of over INR 8.5 Cr from an existing agricultural waste stream.

About Suryodaya Agro Processors Ltd.

Suryodaya Agro Processors Ltd. is a regional agri-processing company with annual paddy processing capacity exceeding 120,000 tonnes. Their operations span rice milling, residue aggregation, and warehousing — positioning them as an ideal anchor client for GreenVolt's distributed biomass power technology. The GREC pilot trial was conducted on the client's actual rice husk and stubble blend (60 kg sample, dispatched March 2026) to ensure industrial relevance of all process parameters.

Process Validation — From GREC Pilot to Industrial Scale

GreenVolt's engineering approach mandates pilot-scale validation before any industrial system specification. The GREC (GreenVolt Renewable Energy R&D Centre) conducted a structured experimental programme on Suryodaya's actual residue blend over 8 days, using an instrumented downdraft gasifier to establish the process envelope that informs the 2 MW industrial plant design.

GREC Pilot Programme — Key Findings

Test Condition	Gasification Temp.	Tar + Particulate	Cold Gas Efficiency	Assessment
Control (low temp.)	750°C	~410 mg/Nm ³	78.2%	Insufficient — fouls genset within hours
Intermediate	800°C	~140 mg/Nm ³	88.6%	Improved — still exceeds genset spec
OPTIMAL	850°C	< 48 mg/Nm ³	96.4%	Optimal — meets continuous-duty genset spec
High-temperature	950°C	< 40 mg/Nm ³	94.1%	Marginal efficiency loss vs 850°C; higher refractory wear

Table 2: GREC Pilot Results — downdraft gasifier trials on Suryodaya residue blend | GREC Pilot Report 33/GREC/LAB/09 | Tar measured per IS 17420 cold-trap method

Scale-Up Methodology — Pilot to 2 MW

GreenVolt's scale-up process follows a structured engineering framework where pilot parameters are translated to industrial equipment specifications using validated thermal and fluid-dynamic models. The key translation factors for this project are:

Parameter	GREC Pilot Gasifier	Industrial Plant (2 MW)	Scale-Up Factor
Gasification Temperature	850°C	850°C	1:1 (direct)
Syngas Residence Time	45 min	45 min (reactor design basis)	1:1 (direct)
Throughput	~15 kg/hr	1,200 kg/hr	80:1
Air/Fuel Ratio Control	Manual damper	Automated blower + O ₂ trim	Automated
Gas Cleaning	Lab cyclone + cold trap	Cyclone + wet scrubber + mist eliminator	Configuration change
Power Conversion	N/A (flared)	Gas-engine genset, 2 MW, grid-sync	New addition

Industrial Plant Design — 2 MW Continuous Processing System

The industrial process flow moves feedstock through six stages: (1) Biomass Storage & Feed Preparation, (2) Continuous Downdraft Gasifier, (3) Cyclone & Syngas Cooling, (4) Wet Scrubbing & Gas Cleaning, (5) Gas-Engine Genset & Grid Synchronisation, and (6) Ash / Biochar Handling. Each stage is engineered to the exact thermal and residence-time envelope validated at GREC.

System Architecture — Major Process Units

Unit / Section	Equipment	Design Parameters	Function
U-01: Feed Preparation	Shredder + Vibro Screen + Belt Conveyor	50 mm particle size 1,300 kg/hr rated	Size-reduce and screen residue for uniform gasifier feed
U-02: Pre-drying	Rotary Hot-Air Dryer (flue-gas heated)	110°C Reduce moisture to <12%	Improve gasification efficiency and reduce tar formation
U-03: Gasifier (Primary Process Unit)	GreenVolt Continuous Downdraft Gasifier	1,200 kg/hr capacity 850°C 45 min residence Updraft/downdraft hybrid throat	Core thermochemical conversion — biomass to raw syngas
U-04: Cyclone & Cooling	High-efficiency cyclone + syngas cooler	Outlet: <200°C >85% particulate removal	Remove coarse char/ash fines; cool syngas for scrubbing
U-05: Gas Cleaning	Wet scrubber + mist eliminator + activated-carbon polish filter	Tar + PM < 48 mg/Nm ³ at genset inlet	Meet genset fuel-gas cleanliness specification
U-06: Power Generation	Gas-engine genset (2 MW) + synchronising panel	2 MW net export 415V/11kV step-up grid-synchronised	Convert cleaned syngas to dispatchable electrical power
U-07: Ash / Biochar Handling	Screw conveyor + bagging station	~120 kg/hr char + ash output	Recover biochar by-product for soil amendment sales
U-08: Emission Control	Scrubber blowdown treatment + stack monitoring	Compliant with CPCB norms for biomass gasifiers	Wastewater treatment and continuous emission monitoring
U-09: Process Control	PLC/SCADA Control Panel	Siemens S7 / Allen Bradley Remote monitoring capable	Automated temperature, air-ratio, and load control; data logging

Table 3: Process Unit Descriptions — GreenVolt 2 MW Continuous Biomass Gasification Power Plant | U-03 (Gasifier) is the primary process unit; all others are ancillary

Core Equipment Specification — GreenVolt Downdraft Gasifier

The GreenVolt Continuous Downdraft Gasifier is the heart of the biomass-to-power system. Designed and manufactured in-house at GreenVolt's Pune facility, it directly scales the validated pilot parameters from GREC trial 33/GREC/LAB/09 to industrial throughput while maintaining the identical thermal profile, residence time, and air-ratio control that produced the 96.4% cold gas efficiency result.

GASIFIER — CORE SPECIFICATIONS	
Design Throughput	1,200 kg/hr (pre-dried biomass input)
Operating Temperature	850°C (max design: 1,050°C)
Syngas Residence Time	45 min (adjustable 30–60 min via air-ratio and grate speed)
Reactor Dimensions	ID 1,800 mm x H 6,500 mm (refractory-lined steel)
Reaction Zones	Drying, pyrolysis, oxidation, and reduction zones (4-zone throat design)
Air Supply	Forced-draft blower, automated O2-trim control
Grate System	Rotating grate, VFD-controlled, continuous ash discharge
Installed Power (Balance of Plant)	~85 kW (excluding genset)
Shell Material	MS shell with high-alumina castable refractory lining
Insulation	150 mm ceramic fibre + refractory composite
Sealing	Rotary airlock valves (gas-tight) at feed and ash discharge

GreenVolt Downdraft Gasifier (GREC pilot scale, referenced) — industrial unit scaled to ID 1,800 mm x 6,500 mm H

Utilities & Ancillary Requirements

Utility	Specification	Consumption (at 2 MW)	Source
Electrical Power (Startup/BOP)	415V, 3-phase, 50Hz	~85 kW connected ~65 kW avg demand	Site utility / genset self-consumption
Process Water	Potable/soft water, closed loop	8 m³/hr scrubber makeup	Onsite bore-well or municipal supply
Compressed Air	6 bar dry instrument grade	12 Nm³/hr	Air compressor (site)
Cooling Water	30°C supply closed loop	10 m³/hr 40°C return	Cooling tower
Space Requirement	Building / covered area	L 40m x W 18m x H 10m	New shed or existing bay

Emission Compliance

Emission Point	Pollutant	Expected Level	CPCB / MoEF Limit	Status
Genset exhaust stack	PM	< 30 mg/Nm³	50 mg/Nm³	COMPLIANT
Genset exhaust stack	NOx	< 250 mg/Nm³	400 mg/Nm³	COMPLIANT
Scrubber blowdown (treated)	Suspended Solids	< 50 mg/l	100 mg/l	COMPLIANT

Mass Balance & Energy Analysis — 2 MW Operation

Detailed Mass Balance — Per Hour at Full Load

Stream	Material	Flow Rate (kg/hr)	Notes
Feed (IN)	Pre-dried biomass residue	1,200	18.6% raw moisture, reduced to <12% after pre-drying
Raw Syngas (Intermediate)	CO, H ₂ , CH ₄ , CO ₂ , N ₂ , tar, particulate	~2,050 (as gas, Nm ³ basis ~1,850 Nm ³ /hr)	Passed to cyclone and cleaning train
Char / Ash (OUT)	Biochar + inert ash	~120	Bagged; sold as soil amendment / activated carbon feedstock
Cleaned Syngas (to genset)	LCV ~1,150 kcal/Nm ³ producer gas	~1,780 Nm ³ /hr	< 48 mg/Nm ³ tar + particulate; feeds gas-engine genset
Scrubber Blowdown	Water + condensed tar/particulate	~180 l/hr	Treated onsite; sludge disposed per hazardous-waste norms
Net Power Export	Electrical power	2,000 kW (2 MW)	Grid-synchronised; net of ~8% parasitic load

Table 4: Mass balance — 2 MW continuous biomass gasification power plant | Based on validated GREC pilot data scaled to industrial throughput

Energy Consumption Estimates

Energy Category	Equipment / Unit	Power (kW)	Load Factor	Consumption (kWh/MWh exported)
Feed Preparation	Shredder, screen, conveyors	35	70%	~12
Pre-drying	Rotary dryer (flue-gas assisted)	20	75%	~7
Gasifier Auxiliaries	Blower, grate drive, controls	18	85%	~7
Gas Cleaning	Scrubber pumps, mist eliminator fan	12	90%	~5
Utilities & Controls	SCADA, lighting, compressed air, misc.	10	60%	~3
TOTAL PARASITIC LOAD		~95 kW		~34 kWh/MWh (~3.4% of gross output)

Output Specification & Market Applications

Expected Output Specification — GreenVolt Processed Syngas & Power

Parameter	Test Method	Raw Producer Gas (Uncleaned)	Cleaned Syngas (850°C, GreenVolt)	Genset Requirement (Reference)
Tar Content	IS 17420 Cold Trap	800–1,500 mg/Nm ³	< 48 mg/Nm ³	< 50 mg/Nm ³
Particulate Matter	IS 17420	300–600 mg/Nm ³	< 40 mg/Nm ³	< 50 mg/Nm ³
Calorific Value (LCV)	IS 17420 / Bomb Calorimeter	~950 kcal/Nm ³	~1,150 kcal/Nm ³	> 1,000 kcal/Nm ³
Cold Gas Efficiency	By Calculation	60–70%	96.4%	> 90%
Moisture (in syngas)	IS 17420	Saturated	< 2% (post-scrubber)	< 3%
Suitability	Classification	Boiler-fuel only	Continuous-duty genset grade	Genset OEM Spec

Table 5: Output specification — raw producer gas vs GreenVolt-cleaned syngas vs genset OEM requirement

Market Applications for the Power & By-Products

- Captive Power Replacement — The 2 MW output directly displaces grid import and diesel-genset backup at the client's agro-processing facility, reducing effective per-unit power cost by 55–65%.
- Grid Export & RPO Compliance — Surplus power beyond captive consumption can be exported under applicable state biomass power tariff/PPA frameworks, and counted toward the buyer's Renewable Purchase Obligation.
- Biochar By-Product Sales — Recovered biochar (~120 kg/hr) can be sold into soil-amendment, filtration, or activated-carbon feedstock markets, adding a secondary revenue stream.
- Carbon Credit Potential — Displacement of field-burning and diesel generation supports methodology-based carbon credit registration under verified carbon standards.
- Rural Electrification / Micro-Grid — The platform is scalable down to smaller distributed units suitable for micro-grid deployment in residue-surplus agricultural clusters.

Financial Analysis & Return on Investment

CAPEX Estimate — 2 MW Plant

Cost Head	Scope	Estimated Cost (INR Lakhs)	Notes
Gasifier (Primary Equipment)	GreenVolt supply, factory tested	85–100	FOT Pune; includes refractory, grate drive, controls
Gas Cleaning Train	Cyclone, scrubber, mist eliminator, polish filter	40–48	SS/FRP construction as applicable
Gas-Engine Genset (2 MW)	OEM-supplied, syngas-fuelled	260–300	Includes synchronising panel and step-up transformer
Feed Handling & Drying	Shredder, screen, conveyor, rotary dryer	35–42	Flue-gas heat integration
Ash/Biochar Handling	Screw conveyor, bagging station	8–10	Load-cell based bagging
Electrical & Instrumentation	MCC panel, SCADA, cabling, transformer	45–52	PLC/SCADA by GreenVolt; site electrical by client
Civil & Structural	Foundation, shed, utilities connections	30–36	Client scope; GreenVolt to provide layout drawing
Commissioning, Training & Startup	GreenVolt commissioning team, 20-day site support	12–15	Includes operator training and performance test
TOTAL CAPEX		515–603 Lakhs (~INR 5.6 Cr avg)	Approx. range; detailed quote on enquiry

Table 6: CAPEX estimate — 2 MW continuous biomass gasification power plant | All figures indicative; formal quotation on receipt of detailed enquiry

Revenue & OPEX Model — Annual Basis (7,200 hr/yr operation)

Item	Basis	INR/Year (Lakhs)	Remarks
Power Value Realised (Cost Avoidance)	2,000 kW x 7,200 hr x INR 9/kWh avoided cost	INR 1,296 Lakhs	Conservative blended grid+DG avoided-cost basis
Biochar By-Product Sales	~120 kg/hr x 7,200 hr x INR 6/kg	INR 52 Lakhs	Soil-amendment grade; market ranges INR 5–8/kg
Biomass Feedstock Cost	1,200 kg/hr x 7,200 hr x INR 2,000/t	INR 173 Lakhs	Includes aggregation and transport
Electricity (Parasitic Load)	95 kW avg x 7,200 hr x INR 8/kWh	INR 5 Lakhs	Startup/BOP power
Labour (Operations)	6 operators/shift x 3 shifts x 12 months	INR 32 Lakhs	At INR 30,000/operator/month CTC
Maintenance & Spares (incl. genset O&M)	4% of CAPEX per annum	INR 22 Lakhs	Annual maintenance provision

Item	Basis	INR/Year (Lakhs)	Remarks
Miscellaneous & Overheads	Water treatment, consumables, admin	INR 14 Lakhs	
NET ANNUAL VALUE / SAVINGS		INR ~1,102 Lakhs/yr	Payback ~3.2 years on INR 560 Lakhs avg CAPEX

Table 7: Revenue & OPEX model — 2 MW plant at 7,200 hr/yr | Indicative figures; actual value depends on avoided power tariff and biochar market price

Project Execution & GreenVolt Scope of Supply

Implementation Timeline

Phase	Activity	Duration	GreenVolt Deliverable
Phase 0 — Pre-Order	Technical consultation, site visit, process design freeze, commercial negotiation	4–6 Weeks	Process Design Basis (PDB), GA drawing, utility list, commercial offer
Phase 1 — Engineering	Detailed engineering: mechanical, electrical, civil layout, P&ID finalisation	8–10 Weeks	Complete engineering package, vendor drawings, design approval
Phase 2 — Procurement	Long-lead items: gasifier shell, refractory, gas engine genset, blowers	12–16 Weeks	Material test certificates, QC inspection reports, FAT invitation
Phase 3 — Fabrication	Gasifier fabrication, cleaning train assembly, panel building	12–14 Weeks	Factory Acceptance Test (FAT) at GreenVolt Pune; client witness invited
Phase 4 — Installation	Equipment erection at client site; piping, electrical, instrument hook-up	6–8 Weeks	GreenVolt site supervision; civil and electrical by client as per drawings
Phase 5 — Commissioning	Cold trials, hot trials with biomass, performance guarantee test, operator training	3–4 Weeks	Commissioning report, performance test certificate, O&M manual, training records
TOTAL PROJECT TIMELINE	Order to commercial production	~45–58 Weeks	From purchase order to first commercial power export

GreenVolt Scope of Supply & Services

Category	GreenVolt Scope (INCLUDED)	Client Scope (EXCLUDED from GreenVolt supply)
Process Design	Process design basis, mass balance, heat & material balance, P&ID	Feedstock quality/logistics guarantee; plant operating schedule
Primary Equipment	Gasifier (complete), cleaning train, ash handling	Gas-engine genset selection support provided; OEM contract by client
Emission Control	Scrubber, blowdown treatment guidance, stack monitoring provisions	Stack height design and consent-to-operate from CPCB/SPCB
Controls	PLC/SCADA, MCC panel, all instruments and field wiring	DG set (if any), main power supply connection, transformer
Civil & Structural	Foundation load drawings, GA layout, anchor bolt drawings	All civil work, sheds, platforms, ladders, drains
Commissioning	FAT, site commissioning, performance test, operator training (20 days)	Consumables (biomass, water) for commissioning; feedstock for trials
Documentation	P&ID, GA drawings, O&M manual, spares list, test certificates	Client-side approvals, regulatory consents, insurance

Conclusions & Why GreenVolt

Proven Technology	Every process parameter in the 2 MW plant — 850°C, 45-minute residence, controlled air-ratio — is directly derived from GREC pilot trial 33/GREC/LAB/09 on the client's actual feedstock. No extrapolation; no assumptions.
Quantified Outcome	Cold gas efficiency improvement to 96.4%, and tar/particulate reduction to below 48 mg/Nm ³ , are measurable, tested results — not marketing claims.
Commercial Clarity	The financial model demonstrates a payback period of approximately 3.2 years at conservative avoided-cost pricing, converting an existing agricultural waste stream into an INR 1,100+ Lakh/year value line.
Full Ownership	GreenVolt designs, manufactures, supplies, installs, and commissions the complete plant from a single point of accountability — eliminating multi-vendor coordination risk.
Scalable Platform	The downdraft gasifier platform is scalable. A 2 MW system validated at Suryodaya creates the reference installation for 1, 5, and 10 MW systems for other agro-processors across India and internationally.
Compliance-Ready	Emission control and blowdown treatment are integral to the GreenVolt supply scope — the system is designed to CPCB norms, not retrofitted for compliance after the fact.

ENQUIRE ABOUT YOUR BIOMASS-TO-POWER PROJECT

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To initiate a project discussion, please share: feedstock quality report + daily/annual tonnage + site location + target power/grid-export requirement

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