BIO & AGRO RESOURCES

INTEGRATED BIORESOURCE RECOVERY, CIRCULAR AGRICULTURE & BIO-PRODUCTS

Bio & Agro Resources is a strategic production platform within ADS ECO Eco-Industrial Complex. It integrates sustainable agriculture, organic waste valorization, bioenergy production, nutrient recovery, biotechnology and circular bioeconomy principles. The cluster receives diverse biological feedstocks, routes them to the most appropriate conversion process, recovers energy and nutrients, and manufactures quality-controlled products for agriculture, food and feed value chains, renewable energy markets and industrial users.

01 | VISION, OBJECTIVES & DESIGN PRINCIPLES

Strategic Pillar	Technical Meaning	Value Created
Organic resource recovery	Segregated intake, contamination control and route optimization	Higher diversion from landfill and stable process performance
Bioenergy	Anaerobic digestion, biogas upgrading, CHP and biomass utilization	Renewable electricity, heat and biomethane
Circular agriculture	Digestate treatment, composting, nutrient recovery and precision farming	Improved soil health and reduced synthetic input demand
High-value bio-products	BSF, fermentation, extracts, biochar and specialty formulations	Diversified revenue and market resilience
Digital operations	Industrial IoT, SCADA, AI optimization and Digital Twin	Traceability, predictive control and transparent ESG reporting

Vision: Transform biological resources into sustainable economic value, support food security, renewable energy, soil regeneration and environmental sustainability, create a scalable circular bioeconomy platform for regional agriculture and industry. Objectives: Maximize organic resource recovery, develop high-value bio-products, support circular agriculture, reduce organic waste disposal, strengthen food and energy security, generate measurable ESG value. Design Principles: Prioritize prevention, segregation and contaminant control before biological processing; Select technology by feedstock composition, seasonality, moisture, nutrient content and market demand; Integrate energy, water, heat and nutrient loops across ADS ECO; Use modular process trains expandable as supply and markets mature; Apply food/feed safety, environmental controls and digital traceability from intake to product release.

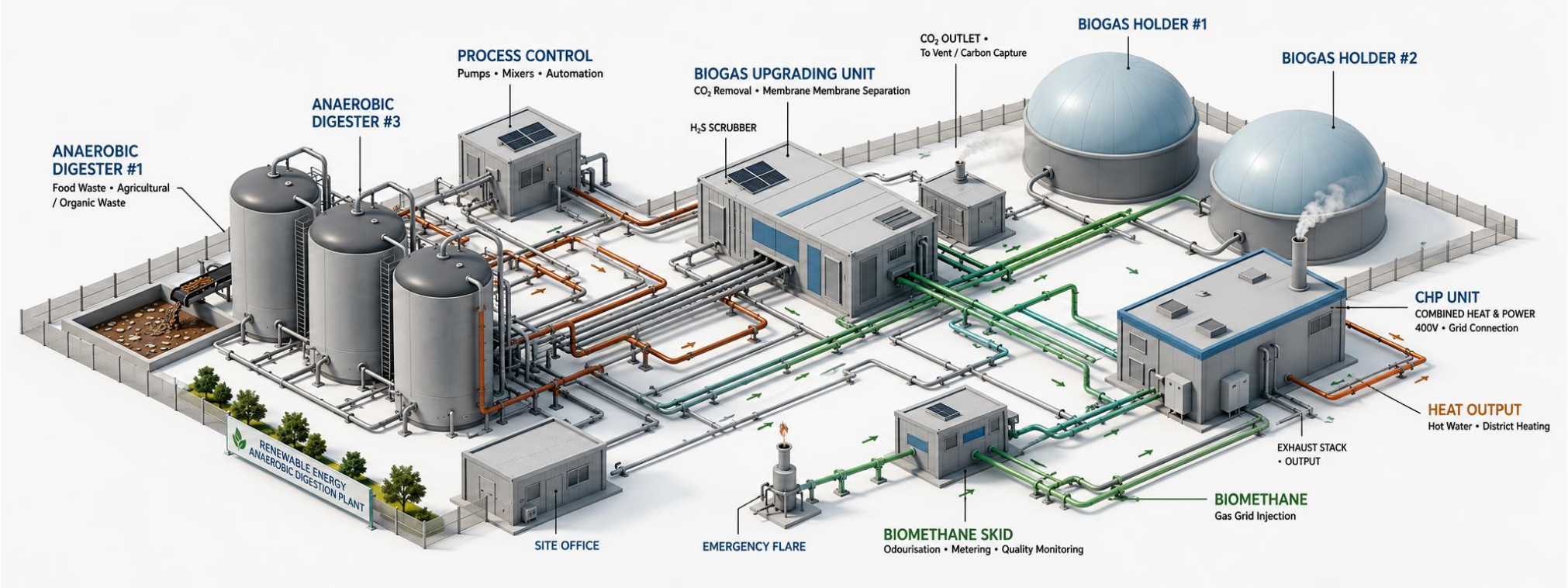
02 | FEEDSTOCK PORTFOLIO & ACCEPTANCE STRATEGY

Every incoming load should be digitally registered and sampled against a feedstock acceptance specification. Key parameters: source, mass, moisture, total solids, volatile solids, C:N ratio, pH, salinity, nutrient content, packaging contamination, pathogens, heavy metals, persistent chemicals, stones, grit and other physical contaminants. Seasonal variation must be reflected in storage capacity, blending recipes and operating plans.

Control Point	Purpose	Typical Method	Decision
Origin and chain of custody	Confirm legal and commercial eligibility	Supplier record, RFID/QR, delivery doc	Accept, hold or reject
Visual and physical inspection	Identify packaging and non-organic contamination	Camera, operator inspection, screen sample	Route to depackaging / cleaning
Rapid chemistry	Protect biological process stability	pH, conductivity, dry matter, ammonia, fats/oils	Blend, dilute or isolate
Laboratory profile	Validate long-term process recipe	COD, VS, nutrients, metals, pathogens	Approve supplier specification
Mass and volume verification	Maintain inventory and contract accuracy	Weighbridge and tank level	Update WMS / mass balance

Process Step	Main Equipment	Critical Variables	Control / Protection
Receiving and weighing	Weighbridge, RFID, sampling station, tipping hall	Source, mass, contamination, delivery time	Access control, washdown, drainage, CCTV
Depackaging	Bag opener, pulper, press, screen, separator	Packaging removal, organics yield, reject rate	Interlocks, metal removal, safe cleaning
Size reduction	Shredder, macerator, hammer mill	Particle size, power draw, wear	Overload protection, spark / metal detection
Slurry and blending	Mix tank, pumps, recirculation, dosing	TS, VS, pH, C:N, viscosity	Level control, anti-foam, recipe management
Sanitation / conditioning	Pasteurizer or thermal conditioning	Time-temperature profile	Validated records, heat recovery, CIP
Buffer storage	Enclosed bunkers, silos, tanks	Residence time, temp, odor	Agitation, ventilation, gas detection

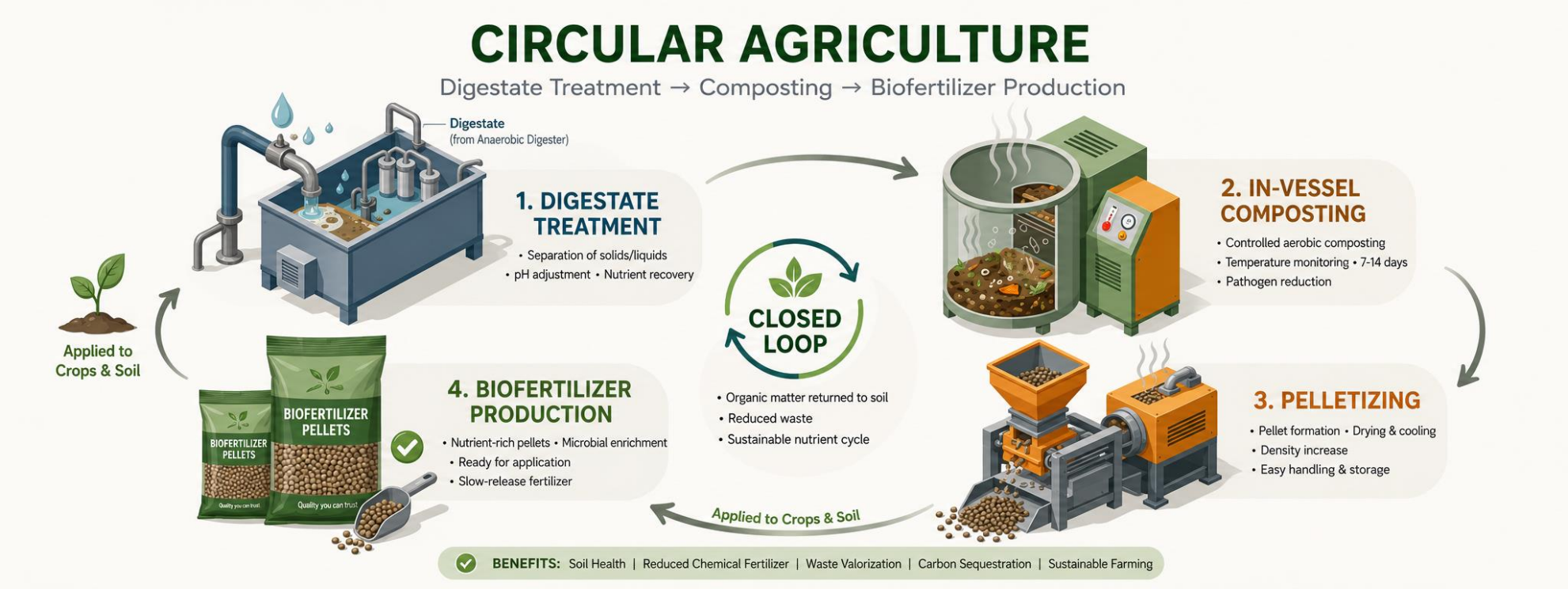
03 | ANAEROBIC DIGESTION & BIOGAS SYSTEMS



Anaerobic digestion converts biodegradable organic matter into biogas and stabilized digestate. Technology selection may include wet CSTR, dry plug-flow or dedicated high-rate reactors for liquid industrial streams. Final configuration based on BMP testing, rheology, inhibitor risk, seasonal feed variability and heat integration. Indicative engineering ranges: Temperature mesophilic 35-40°C or thermophilic 50-55°C, pH 6.8-7.6, organic loading rate technology and feedstock specific, hydraulic retention time commonly weeks, mixing uniform without excessive shear, biogas quality CH4 55-65%.

System	Main Function	Typical Equipment	Key Quality / Safety Controls
Primary gas handling	Collect and buffer variable gas production	Gas holder, blower, condensate traps	Pressure control, flame arrestors, CH4 detection
H2S removal	Protect engines and upgrading	Biological scrubber, activated carbon, iron media	Outlet H2S monitoring, media breakthrough alarm
Drying and siloxane control	Prevent corrosion and deposits	Chiller, coalescing filter, adsorption	Dew point and differential pressure
CHP	Generate electricity and useful heat	Gas engine, generator, heat exchangers	Gas quality, cooling, emissions, synchronization
Biomethane upgrading	Remove CO2 and impurities	Membranes, PSA, water or amine scrubbing	CH4 recovery, product composition, off-gas management
Grid / fuel interface	Meter, odorize and deliver product	Compression, metering, quality analyzer	Custody transfer and emergency shutdown

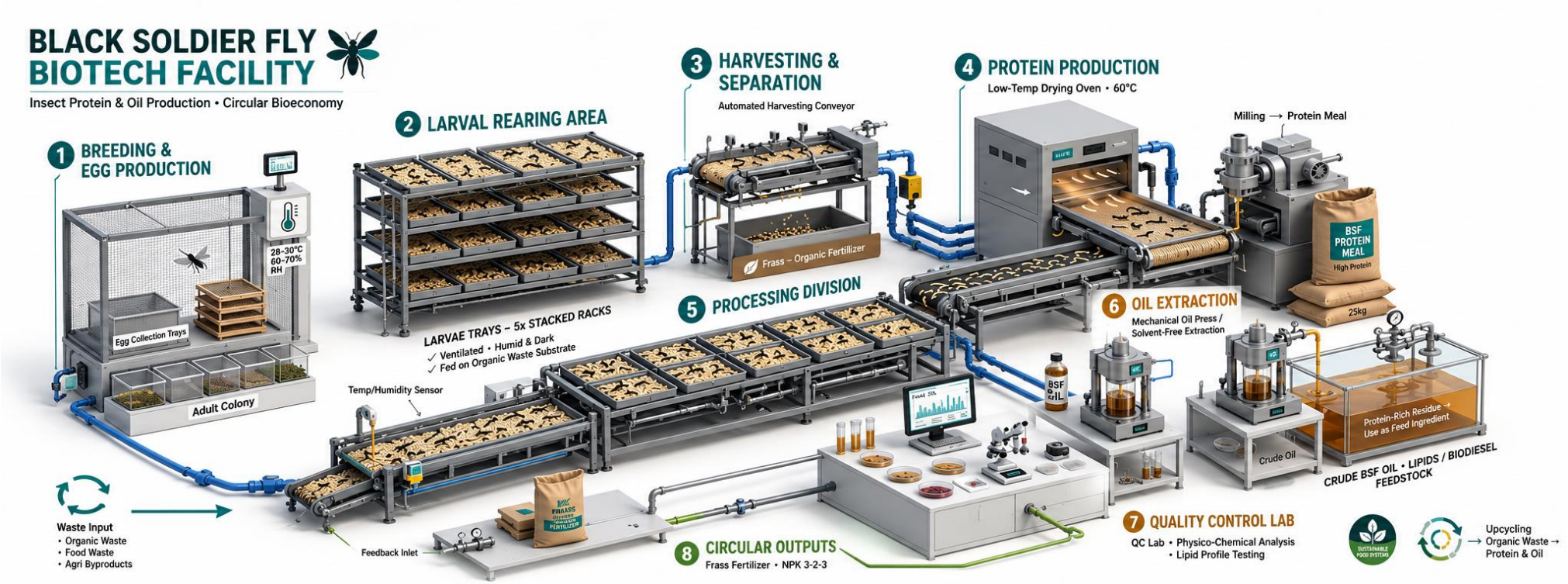
04 | DIGESTATE, COMPOSTING & BIOFERTILIZER



Stage	Technology Options	Primary Output	Critical Quality Parameters
Separation	Screw press, decanter centrifuge, belt press	Fiber fraction + liquid fraction	Dry matter, capture efficiency, polymer use
Liquid nutrient recovery	Struvite precipitation, ammonia stripping, membranes	Concentrated N/P products and reusable water	N,P,K, salinity, metals, pathogens
In-vessel composting	Forced aeration, turning, moisture control	Sanitized soil amendment	Temperature profile, oxygen, moisture, maturity
Curing and screening	Curing bays, trommel, air classification	Stable compost grade	Respiration, odor, particle size, contaminants
Formulation	Blending, granulation, pelletizing, bagging	Market-specific biofertilizer	NPK declaration, bulk density, storage stability
Release	Sampling and lab verification	Certificate of Analysis	Pathogens, metals, impurities, agronomic value

Odor and Emission Control: Enclose high-odor operations and maintain negative pressure; Use acid/alkaline scrubbers and biofilters according to gas composition; Capture leachate and wash water in closed drainage; Monitor ammonia, H2S and odor complaints as operating KPIs.

05 | BLACK SOLDIER FLY BIOTECHNOLOGY & ANIMAL FEED INGREDIENTS



BSF systems convert suitable pre-processed organic substrates into insect protein, oil and frass. Process requires strict substrate eligibility, biosecurity, climate control, hygiene zoning and product traceability. Feed and food regulatory requirements differ by market; therefore accepted feedstocks and product claims must be defined before commercial design.

Process Area	Main Operations	Key Controls	Outputs
Substrate preparation	Grinding, blending, pasteurization as required	Moisture, particle size, contamination, recipe	Consistent larval feed
Breeding and hatchery	Adult colony, egg collection, neonatal larvae	Temperature, humidity, lighting, genetics	Healthy starter larvae
Grow-out	Tray / rack feeding, climate control, automated handling	Feed rate, density, temperature, humidity	Harvest-size larvae and residual frass
Harvest and separation	Sieving, washing, dewatering	Separation efficiency and hygiene	Larvae + frass
Processing	Drying, pressing, milling, optional fractionation	Time-temperature, oxidation, microbiology	Protein meal, oil, specialty fractions
Quality release	Sampling, testing, packaging	Protein, fat, moisture, pathogens, contaminants	Certified feed ingredient

06 | PRECISION FERMENTATION, BIOREFINERY & NATURAL EXTRACTS

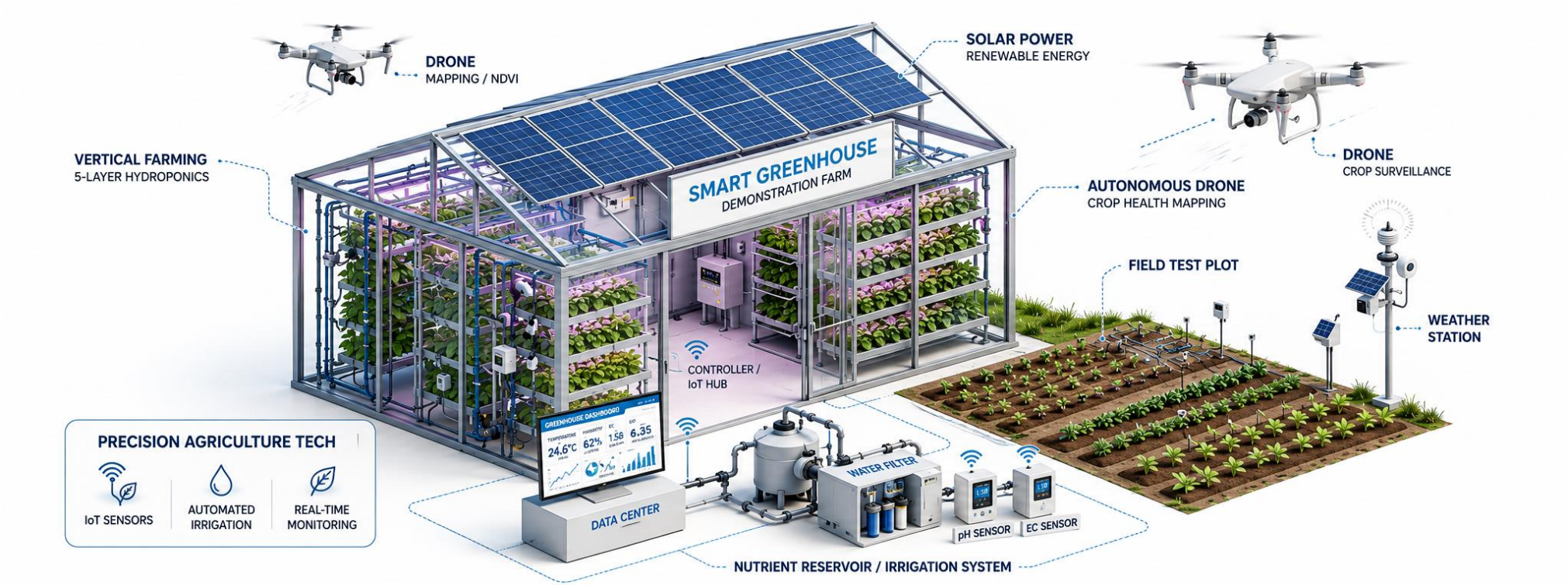
Unit Operation	Typical Equipment	Critical Process Parameters	Design Notes
Feedstock hydrolysis / preparation	Milling, enzymatic reactor, filtration	Solids, sugar profile, inhibitors	Separate low-purity and high-purity routes
Media preparation	Dissolution tank, sterilizer, dosing skids	Composition, sterility, pH	Recipe and batch genealogy
Fermentation	Stainless bioreactor, agitation, aeration	Temp, pH, DO, agitation, gas flow	CIP/SIP, foam control, sterile sampling
Cell / solids separation	Centrifuge, membrane, filter press	Flux, solids capture, product loss	Hygienic design and containment
Purification	Extraction, adsorption, chromatography, evaporation	Purity, solvent use, thermal exposure	Product-specific and often modular
Finishing	Spray drying, freeze drying, blending, filling	Moisture, activity, stability	Controlled environment and packaging

07 | BIOCHAR, BIOMASS ENERGY & CARBON-STABLE PRODUCTS

Dry lignocellulosic residues unsuitable for digestion may be converted through controlled pyrolysis into biochar, process gas and recoverable heat. Biochar can support soil improvement, filtration, animal bedding, compost enhancement or industrial applications, subject to feedstock eligibility and product testing. Thermal system integrated with dryers, greenhouses or process heat users to maximize efficiency. Carbon Management Principle: Any carbon-removal or climate claim should be based on verified feedstock origin, energy balance, product stability, end use and a documented lifecycle methodology. Biochar production should not be presented as carbon negative until project-specific accounting boundary and evidence are established.

Design Element	Technical Requirement	Control / Monitoring
Feedstock preparation	Moisture reduction, size control, metal removal	Moisture sensor, screen analysis, magnetic separation
Pyrolysis reactor	Controlled oxygen-limited thermal conversion	Temperature profile, pressure, residence time
Gas and vapor handling	Combust or recover process gas safely	LEL monitoring, flare / oxidizer, heat recovery
Char cooling	Prevent ignition and re-oxidation	Inert / sealed cooling, temperature interlock
Product conditioning	Screen, activate, blend or pelletize	Particle size, dust control, bulk density
Quality assurance	Verify carbon stability and contaminant limits	Carbon, ash, pH, PAHs, metals, moisture

08 | PRECISION AGRICULTURE, SMART GREENHOUSES & DEMONSTRATION FARMS



Agricultural demonstration platform validates recovered nutrients and bio-products under controlled conditions. Greenhouses, open-field plots, orchards and specialty crops use sensor-driven irrigation, fertigation, climate control, crop imaging and decision-support models. System links agronomic performance with product batch data to demonstrate efficacy and support market development.

Smart Farming Layer	Technologies	Primary Decisions
Soil / substrate sensing	Moisture, EC, pH, temperature, nutrient probes	Irrigation and nutrient dose
Weather and climate	Weather station, greenhouse climate sensors	Ventilation, heating, shading, frost response
Crop monitoring	RGB, multispectral and thermal imaging	Growth, stress, disease and harvest timing
Fertigation	Automated dosing, flow meters, recirculation	Water and nutrient recipes
Farm management	GIS, work orders, traceability and inventory	Plot planning, labor and input optimization
AI decision support	Yield models, anomaly detection, forecasts	Early intervention and resource efficiency

09 | WATER, NUTRIENT & UTILITY INTEGRATION

Utility / Stream	Integration Opportunity	Required Safeguards
Recovered process water	Washdown, slurry preparation, irrigation or cooling make-up	Treatment level matched to reuse; backflow prevention
Low-grade heat	Digesters, dryers, greenhouses, fermentation preheating	Heat exchanger isolation and temperature control
High-grade heat / steam	Sanitation, drying, extraction and biorefinery steps	Pressure safety, condensate recovery, water chemistry
Nutrient-rich liquid	Fertigation or concentrated fertilizer production	Salinity, pathogen and nutrient dosing controls
Separated fiber	Compost bulking, soil product, drying or controlled thermal route	Contaminant and maturity testing
CO2-rich streams	Greenhouse enrichment or industrial use where feasible	Purity assessment, compression safety, exposure control

10 | QUALITY ASSURANCE, TRACEABILITY & EHS CONTROLS

Product Family	Key Tests	Release Documentation	Typical Users
Compost / biofertilizer	Moisture, maturity, nutrients, pathogens, metals, impurities	CoA and batch traceability	Farms, greenhouses, landscaping
Biomethane / biogas	Methane, CO2, H2S, moisture, oxygen, siloxanes	Gas-quality record and custody metering	CHP, grid, transport or industry
BSF meal / oil	Protein, fat, moisture, microbiology, contaminants	Feed specification and lot record	Feed mills and aquaculture
Biochar	Carbon, ash, pH, PAHs, metals, particle size	Product data sheet and use restrictions	Agriculture, filtration, materials
Fermentation products	Identity, activity, purity, microbiology, stability	CoA, batch record and shelf-life	Food/feed, industrial and specialty markets
Natural extracts	Marker compounds, solvents, contaminants, stability	Specification and analytical profile	Nutraceutical, cosmetic or agricultural users

Risk Area	Main Hazards	Engineering Controls	Management Controls
Biogas and biomethane	Flammable gas, pressure, H2S exposure	Gas detection, ventilation, classified equipment, relief and flare	Permit to work, confined space, emergency drills
Organic reception	Odor, bioaerosol, pathogens, moving vehicles	Enclosure, extraction, drainage, traffic segregation	Hygiene zoning, PPE, cleaning schedules
Dust and dry biomass	Combustible dust, fire, respiratory exposure	Dust extraction, spark detection, explosion relief	Housekeeping, hot-work control, dust monitoring
Fermentation / chemicals	Cleaning chemicals, pressure, steam, biological agents	Containment, interlocks, eyewash, controlled ventilation	SDS, training, batch authorization, spill response
Feed / product safety	Cross-contamination, pathogens, foreign matter	Zoning, hygienic design, metal detection, validated heat steps	HACCP-style controls, sampling and recall readiness
Water and environment	Nutrient release, odor, wastewater excursions	Bunds, equalization, treatment, online monitoring	Discharge plan, incident reporting, environmental inspections

Traceability Minimum: Supplier and source identification, incoming inspection and analytical results, process recipe, critical parameters and alarms, laboratory release and packaging record, warehouse location, dispatch record and customer destination. Emergency Preparedness: Integrated fire and gas alarm with clear shutdown philosophy, emergency flare or safe gas disposal for abnormal biogas conditions, backup power for critical mixing, ventilation, controls and monitoring, spill, pathogen, odor and product-recall response procedures, coordination with local emergency services and periodic exercises.

11 | PERFORMANCE MANAGEMENT & IMPLEMENTATION ROADMAP

KPI Family	Example Measurement	Management Use
Resource recovery	Accepted organics, recovered products, rejects and disposal	Mass-balance control and landfill-diversion reporting
Energy	Biogas volume, methane yield, electricity, heat, biomethane	Process efficiency and energy self-sufficiency
Agronomic value	N/P/K recovery, compost maturity, crop response	Product quality and farm-market development
Water	Freshwater use, recovered water, discharge quality	Water efficiency and compliance
Reliability	Availability, OEE, downtime, maintenance backlog	Production planning and lifecycle cost
ESG	CO2e, jobs, training, local procurement, complaints	Investor reporting and stakeholder accountability

Workstream	Minimum Data Required Before FEED
Feedstock supply	Supplier map, annual and seasonal volumes, composition, contamination, logistics and contract terms
Product markets	Target products, specifications, prices, customer tests, certification and offtake structure
Technology selection	Pilot results, BMP, compostability, BSF eligibility, fermentation trials, vendor references
Site and utilities	Plot plan, geotechnical, water balance, heat integration, electrical connection and transport access
Environmental / safety	Emission inventory, odor model, wastewater strategy, fire and explosion studies, biosafety and permitting path
Financial model	CAPEX, OPEX, ramp-up, yield guarantees, energy values, product revenues and sensitivity cases
Digital systems	Tag list, control philosophy, cybersecurity, data ownership, reporting and integration requirements

ADS ECO Bio & Agro Vision: From Nature. Through Innovation. Back to Nature. Creating sustainable value for future generations. All capacities, operating parameters and product claims require validation through project-specific engineering, permitting, laboratory testing and supplier guarantees.

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