

RainbowTM

Rainbow pyrolysis vetting program Beston - BST-50

Manufacturer Beston

Model BST-50

Year 2026

Summary

Manufacturer	Beston
Model	BST-50
Vetting decision	Approved
Manufacturer representative	Matt Zhang - Marketing director
Rainbow representative	Angel Vargas Montes (climate@rainbowstandard.io)
Methodology name	Biomass carbon removal and storage (BiCRS)
Methodology ID	RBW-BICRS-GEN-V1.1
Module name and version	Infrastructure and machinery Version 1.4
Date of assessment	02-07-2026
Date of decision	07-07-2026

The vetting decision for the model BST-50 of Beston applies exclusively to its use under the Rainbow methodology Biomass Carbon Removal and Storage (BiCRS) V1.1. The technology shall be reassessed following changes in methodology or major changes in machinery specifications. Beston is responsible for communicating any major change likely to affect the performance of the machinery under Rainbow methodology or Rainbow Standard rules.

The approval status gives project developers the certainty that the BST-50 model of Beston is capable of operating and delivering as per Rainbow methodology requirements. However, project developers must independently verify compliance with Rainbow methodology and Rainbow Standard rules, and ensure optimal conditions are met to deliver biochar quality as specified by BiCRS V1.1.

1. About Beston

Beston, founded in 2013, manufactures pyrolysis and carbonization equipment for biomass and waste processing. The company supplies equipment internationally, with installations reported across Southeast Asia, Africa, Europe, and the Americas.

In biochar production, Beston's engineering development has focused on four areas: (1) optimizing the gas combustion system to improve combustion completeness and reduce NO_x and CH₄ emissions; (2) redesigning gas piping to minimize tar accumulation and enable longer continuous production runs; (3) upgrading cooling and dust removal units to reduce particulate and gaseous pollutant discharge; and (4) modifying the biochar discharge system to lower polycyclic aromatic hydrocarbon (PAH) concentrations in the output biochar. The company states that these improvements were developed in collaboration with unnamed universities and industrial partners following an integrated product development (IPD) process.

Current development priorities include waste heat recovery, process automation, and scaling production capacity for larger biomass throughputs.

Beston's target markets for biochar equipment include wood processing, biomass pellet manufacturing, food processing, palm oil production, and iron ore processing — sectors where biochar application or biomass waste valorization is operationally relevant.

2. BST-50 Model

The BST-50 has undergone two technical upgrades. The first focused primarily on extending continuous operation time while ensuring large-scale processing, thereby improving equipment productivity and return on investment. The second was based on operational recommendations from a strategic client in South America and centered on reducing operational and maintenance complexity to optimize the user experience. Going forward, we will focus on developing automation features, power generation and steam generation capabilities, and dMRV functionality.

The BST-50 is a continuous retort pyrolysis unit for biochar production. Its estimated capacity is of around 21,600 tonnes of feedstock per year at 15% moisture content (wet basis) and can produce 5,400 tonnes of biochar per year at 5% moisture content (wet basis). Validated feedstocks include forestry by-products, wood-processing residues and waste wood, agricultural residues, food-processing products, digestate, and sewage sludge.

The unit requires no industrial water, generating no wastewater. Continuous annual operation above 7,200 hours is guaranteed. Temperature uniformity is maintained through a double-cylinder design with a unified chamber and low-speed cylinder rotation combined with a spiral feed structure, including a multi-layered, multi-point sealing structure. Tar build-up is prevented by maintaining the syngas pipeline above 380°C through electric heating, hot smoke circulation, and insulation.

2.1 Documents provided

The following documents were provided by Beston and assessed as proof of compliance with the assessment criteria:

1. Vetting program form
2. Technical Specifications / Datasheet
3. Simplified Bill of Materials (BOM)
4. Biochar Laboratory Analysis (for at least 3 feedstocks) containing H/Corg<0.7 and carbon content
5. Sample operations Data Log (Temperature)
6. Emissions Test Reports (CH₄/Syngas)

2.2 Publicly disclosed specifications

- Differentiation: Continuous annual operation for more than 7,200 hours is guaranteed; No industrial water is required during the production process, and no wastewater is generated; Methods to ensure complete combustion of pyrolysis gases and oils and Methods to ensure low emissions of air pollutants are implemented.
- Type of technology: Continuous retort

- Feedstock Throughput: around 21600 tonnes/year at 15 % MC on wet basis
- Biochar Output: around 5400 tonnes/year with 5% moisture content on wet basis
- Validated type of biomass used: Forestry by-products, Wood-processing residues and waste wood, agricultural residues, food-processing products, digestate or sewage sludge.
- Target temperature range: 550°C - 680 °C
- Temperature variation: $\pm 5\%$ for the target temperature. Proved below 20% for 144 hours of operation in cycles of 8 hours.
- Thermocouples locations: 2 at pyrolysis combustion chamber, 1 at syngas outlet, 1 at excess combustible gas combustion chamber, 2 at dryer inlet and outlet, 2 at inlet and outlet of a baghouse dust collector
- Temperature uniformity secured through: 1. Double-cylinder design with a unified chamber providing improved insulation and heat retention, ensuring uniform heat distribution and eliminating localized high- and low-temperature zones. 2. Low-speed rotation of the cylinders, combined with a spiral feed structure, continuously tumbles, mixes, and moves the material
- Sealing mechanism: multi-layered, multi-point sealing structure, such as sealing cloth, aluminum foil, steel wire rope, outer fish-scale plates, inner fish-scale plates, sealant, graphite blocks, and sealing cloth gaskets
- Includes separated combustion chamber
- Process description for complete combustion: Automatic oxygen adjustment based on the output of pyrolysis gas to ensure complete combustion, excess pyrolysis gas is directed to the separated combustion chamber which maintains a flame temperature at no less than 800°C. The burner employs advanced technologies such as air-fuel ratio adjustment and premixed combustion. The burner design accounts for pollutant reduction requirements (CO, NO_x, C_xH_y, CH₄), of which measurements have been taken and reported. The burner is equipped with safety devices, including flame failure protection, explosion protection, and overheat protection.
- Combustion Components: Sealed combustion chamber, pyrolysis gas burner, flame detector, igniter, solenoid valve, combustion auxiliary air system, combustion control system, carbon monoxide analyzer, air blower.
- Optional Monitoring and control systems: Online flue gas monitoring which works in conjunction with flue gas fan, oxygen supply fan and feedstock feed rate to monitor and control pollutant emissions.
- Tar build-up prevention in addition to complete combustion measurement: Maintaining the temperature of the syngas pipeline above 380 °C
- Can include an optional pollutant emission monitoring and integrated control.
- Methane emission rate reported as: 5.3g/tonne of feedstock
- 3 feedstock types, with H/Corg<0.7:
 - Pecan shell: 0.28,
 - almond shell: 0.38,
 - sawdust: 0.3
- Regions where support can be provided: Capable of dispatch engineers to most countries around the world to provide installation guidance.
- Access to data through: Downloadable files from API/software integration
- System weight: 131,473 kg
- Footprint dimensions: 65m x 15 m
- Electricity consumption: 204 kWh
- Fuel consumption in cold start: 220-260 m³/ start

- Net thermal power output: 400-500 KWth as heat
- Syngas for export: Yield: 1000~1200Nm³/hour

3. Compliance decision basis

The BST-50 model has been assessed against the Rainbow Standard — Machinery & Infrastructure Module for Biomass Carbon Removal and Storage (BiCRS) and has been found to **comply with Rainbow requirements**. The model is hereby **Rainbow Vetted/endorsed**.

The following requirements were verified through the following documents:

- Reactor technology was confirmed through form response and Technical Specifications / Datasheet
- Annual feedstock throughput and biochar output were confirmed through the Technical Specifications / Datasheet
- Validated biomass types (seven categories) were confirmed through the Technical Specifications / Datasheet
- Pyrolysis temperature $\geq 350^{\circ}\text{C}$ and capability to run with temperature variations $< 20\%$ was confirmed through Sample operations Data Log.
- Thermocouple and sensors location was confirmed through Technical Specifications / Datasheet
- Verifiable exportable logs of temperature were confirmed through the Sample operations Data Log
- Equipment sealing measures was confirmed through the Technical Specifications / Datasheet.
- Confirmation of the system capturing, cleaning or burning all pyrolysis gases was corroborated through the Technical Specifications / Datasheet.
- Combustion chamber features were confirmed through Technical Specifications / Datasheet
- Complete combustion and tar prevention design was confirmed through the Technical Specifications / Datasheet
- $\text{H/Corg} < 0.7$ for all tested feedstocks (feedstock) was confirmed through three independent Biochar Laboratory Analysis.
- Integrated methane emission was corroborated through the Technical Specifications / Datasheet.
- Methane emission rate was verified through Emissions Test Reports.
- Maintenance support was confirmed through the Vetting program form.
- Temperature/residence time log exportability was confirmed through Technical Specifications / Datasheet and Sample operations Data Log.
- Data access for audits was confirmed through the Technical Specifications / Datasheet
- Pyrolyzer weight was confirmed through Simplified Bill of Materials (BOM).
- Operational lifetime was stated in the Vetting program form.
- Electricity consumption was confirmed through the Technical Specifications / Datasheet
- Fuel for cold starts was confirmed through the Technical Specifications / Datasheet

- Net thermal power output was confirmed through the Technical Specifications / Datasheet

The Vetting program form is a form used as tool to record and evaluate the compliance of the BST-50 with Rainbow requirements, containing a Declaration of Accuracy and Disclosure Obligation.

4. Limitations

This vetting assessment evaluates the capability of the BST-50 to operate within Rainbow Standard requirements based on manufacturer-provided documentation, data logs, lab analyses, and technical specifications. Many operational parameters, such as actual biochar H/Corg ratios, pyrolysis temperature consistency, residence times, and emission levels, are inherently dependent on the day-to-day operation of the machine, the feedstock characteristics used, and the maintenance practices followed by the operator. Therefore, **what has been assessed is that the BST-50 is capable of operating under conditions that meet Rainbow Standard and methodology requirements, not that it will do so in all circumstances.**

This approval is strictly limited in scope to the technical and operational parameters assessed at the time of review. **It does not constitute a warranty, guarantee, or representation regarding the machinery's performance under any specific project conditions.** Rainbow accepts no liability for non-conformance arising from changes to the machinery, its operation, or applicable methodology requirements occurring after the date of this approval. This approval is issued on an as-assessed basis. Rainbow makes no representation that the machinery will perform in conformance with methodology requirements under all operating conditions or in all project contexts.

Approval of the BST-50 model does not constitute an endorsement of Beston as an entity, its commercial representations, or any claims made outside the scope of this assessment.

Compliance with Rainbow Standard requirements during actual project operations remains the responsibility of the project developer. Project developers shall independently verify that their specific installation, operational parameters, feedstock supply, and maintenance routines meet Rainbow Standard requirements on an ongoing basis. Project developers shall not rely solely on this approval status as evidence of compliance, independent verification of site-specific conditions, operational practices, and output quality remains their sole responsibility. **The vetting status of the BST-50 does not exempt the project developer from demonstrating operational compliance during audits and monitoring periods.**

5. Remarks

Temperature data: Temperature variation is compliant at different zones including the combustion chamber and the pyrolysis reactor. Startup and cooldown phases might show greater variation but are out of scope as no biochar is produced during those phases.

Feedstock validation: The manufacturer declares the machine can operate on all checked feedstock types. However, moisture content and/or particle size should be confirmed. The laboratory analysis presented to prove H/Corg<0.7 are representative of three types of feedstocks that might not include all the declared.

Methane monitoring: Continuous methane monitoring is not integrated into the BST-50 system but reports have been provided. Optional pollutant monitoring and control can be integrated.

Random Reflectance (Ro): Ro data is not available for the BST-50.

Machinery lifetime: The operational lifetime for GHG quantification purposes will be assumed as 15 years. This figure cannot be warranted, as actual machinery lifespan depends on operating conditions, maintenance practices, feedstock characteristics, and environmental factors at each installation site. However, Beston does guarantee 7,200 hours of continuous operations per year.

Clément Georget Co-founder, CPTO, certifies and acknowledges awareness of the content of this document.

Clément Georget

Clément Georget

Co-founder, CPTO

Audit trail

Details

FILE NAME	Beston_BST-50_vetting_decision - 7/7/26, 11:52 AM
STATUS	Signed
STATUS TIMESTAMP	2026/07/09 11:27:37 UTC

Activity

SENT	angel@rainbowstandard.io sent a signature request to: Clément Georget (clement@rainbowstandard.io)	2026/07/07 09:53:24 UTC
SIGNED	Signed by Clément Georget (clement@rainbowstandard.io)	2026/07/09 11:27:37 UTC
COMPLETED	This document has been signed by all signers and is complete	2026/07/09 11:27:37 UTC

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