# Public evaluation statement by Puro.earth

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## Purpose of evaluation and assessment criteria

The purpose of this evaluation is to verify the environmental and climate performance of the equipment, in terms of emissions of air pollutants, management of solid and liquid wastes, and emissions of greenhouse gases. In addition, the aim is to evaluate the capability of the equipment to produce high quality biochar. This evaluation follows the requirements set out in the Puro Standard for Biochar (Edition 2022, Version 2).

Puro's evaluation of pyrolysis equipment is built around the following 7 assessment criteria:

Criteria 1: Methods to ensure complete combustion

Criteria 2: Methods to ensure low emissions of air pollutants

Criteria 3: Methods to ensure safe disposal of any waste stream

Criteria 4: Emission testing of air pollutants

Criteria 5: Emission testing of greenhouse gases

Criteria 6: Testing of biochar quality

Criteria 7: Material choices and expected equipment lifetime

## Endorsed technology partner, equipment models and configurations

| Technology Partner Information | |
|---|---|
| **Name of the manufacturer** | Earth Systems Pty Ltd (Australian Business Number ABN: 29 006 227 532) |
| **Country where manufacturer is registered** | Australia |
| **Website** | www.earthsystems.com.au AND www.thecharmaker.com |
| **Name and contact details of representative, date of submission** | Company representative: Adrian Morphett<br>E: adrian.morphett@earthsystems.com.au<br>M: +61 (0)413 327 120<br>Submission date: 24th October 2024 |

**Equipment model and configurations applicable**

Earth Systems Pty Ltd (ES) **CharMaker**, including 4 Continuous Pyrolysis Plant (CPP) models:

- CharMaker CPP200
- CharMaker CPP500
- CharMaker CPP1000 (2x CPP500 with shared resources)
- CharMaker CPP2000 (4x CPP500 with shared resources)

Key components of a **CharMaker** are:

- Pyrolysis kiln containing a bank of augers to process biomass.
  - 2x augers for CPP200, 6x augers for/per CPP500
- Thermal oxidiser (TO)
  - CPP200 TO cross-section is 1/3 of the TO on CPP500 but is the same length.
  - CPP1000 and CPP2000 TO is twice the size of the TO of the CPP500 and has internal walls (brick) resulting in a TO of the same capacity as the CPP500.
  - TO startup fuel is biodiesel, diesel, light-oil

Possible **configurations** of the ES CharMaker CPP include adding a **Pre-dryer unit** or an **External heat exchanger unit**:

- **Pre-dryer unit**
  - Integrated at the hot exit flange on the TO, utilising waste heat to pre-dry wet feedstock. This component enables CharMaker models to process feedstocks up to 50% moisture. Requires that a cooling plenum is installed to cool combustion gases sufficiently.
- **External heat exchanger unit**
  - For feedstocks with moisture content below 30% and high energy content an external heat exchanger can be installed instead of the pre-dryer. High grade heat is collected by the heat exchanger and can be used for other purposes.
  - Provided by a third party, but ES will facilitate supply, installation and integration to the hot exit flange on the TO.
- If neither of the optional components are used, combustion gases from the TO exit via a chimney.

Other required and optional components include:

- Dosing feed hopper (controls biomass input rate)
- Magnetic separator (optional, depending on feedstock, to remove ferrous metals)
- Ribbed conveyor, dryer inlet hopper, biomass outlet (required if pre-dryer configuration installed)
- Ground mounted ribbed feed conveyor with small hopper at start of conveyor
- Double lock hopper (restricts air ingress to system and moves biomass evenly into system)
- Pyrolysis furnace (pyrolysis reactor producing biochar and pyrolysis gas, temperatures 500-600°C)
- Biochar outlet (biochar exits kiln while preventing pyrolysis gases from exiting the kiln)
- Inclined water auger with quench system (biochar quenching mechanism that can be disabled)
- Wood vinegar condensation tower and filtration drum (optional, using air and water to condense condensable gases and collect wood vinegar product)
- Complete System Automation via Control Panel and auxiliary component
- Emergency water solenoid valve system (that connects to mains water at site)
- Remote connectivity to each plant, via online connectivity via 4G modem and Wi-Fi.

## Assessed criteria and summary of observations

Note – the summary of observations in this public version have been redacted to not disclose any confidential information, and the redaction has been approved by the Technology Partner. Interested buyers may request additional information directly from the Technology Partner.

| Criteria 1: Methods to ensure complete combustion of pyrolysis gases and oils |
|---|
| ☒ Criteria is met, in full.<br>☐ Criteria is met partially.<br>☐ Criteria is not met. |
| **Observations:**<br>*Criteria 1 is met, thanks to the design measures of the thermal oxidiser, evidenced with photos, technical drawings, and written declarations. The design measures ensure that appropriate temperatures and residence times are achieved, gaseous flows are turbulent, and excess air is present. In addition, the thermal oxidiser is continuously monitored, and the combustion process can be adjusted manually or automatically. Considering that the CharMaker models can be equipped with optional components (wood vinegar condensation system, pre-dryer, heat exchanger), it is important that the manufacturer describes clearly the requirements of each component and the differences in product/byproduct generation. Descriptions provided to potential clients are expected to at least include information relating to tar management and collection from the wood vinegar condensation system, as well as tars collected during monthly maintenance, and standard operating procedures for tar (re-)injection.* |

| Criteria 2: Methods to ensure low emissions of air pollutants |
|---|
| ☒ Criteria is met, in full.<br>☐ Criteria is met partially.<br>☐ Criteria is not met. |
| **Observations:**<br>*Criteria 2 is met, thanks to the design measures and conditions of the thermal oxidiser. For most clean biomass feedstocks (e.g. forest residues, agricultural residues, but not e.g. sewage sludge), the flue gas treatment system design seems sufficient. In addition, features to reduce combustion temperature at critical levels are installed, to minimize thermal $NO_x$ formation. It will then be verified on a project basis that equipment installed meets the regulation applicable locally.* |

| Criteria 3: Methods to ensure safe disposal of any waste stream |
|---|
| ☒ Criteria is met, in full.<br>☐ Criteria is met partially.<br>☐ Criteria is not met. |
| **Observations:**<br>*Criteria 3 is met, as the information provided identifies all waste streams and quantifies the amounts generated during normal operations, for the different configurations. The models (with a Bioliquids Recovery System or Wood Vinegar system) assessed are burning most of the pyrolysis oil and thereby minimize generation of pyrolysis oil/tar (residual tar generation rates for the CharMaker CPP500 model are about 50 kg per month according to the manufacturer, collected primarily from the wood vinegar condensation tower and monthly cleaning and maintenance). In the absence of a BRS/WV system, no/zero pyrolysis oil/tar is generated. The manufacturer has stated that the collected tars can be slowly disposed of in the pyrolysis kiln with the biomass feedstock and should provide standard operating procedures for tar (re-)injection rates to ensure that the equipment operates as per specification. If the wood vinegar condensation tower is included in the configuration, adequate management and storage of the liquid byproduct must be in place prior to being used in environmentally friendly applications. Other waste streams collected during maintenance are also quantified (ash) and must be adequately managed and safely disposed. It will then be verified on a* |

*project basis, during regular facility and output third-party audits, that equipment installed meets the regulation applicable locally and that waste streams are disposed accordingly.*

## Criteria 4: Emission testing of air pollutants

☒ Criteria is met, in full.
☐ Criteria is met partially.
☐ Criteria is not met.

**Observations:**
*Criteria 4 is met, based on the emission data provided for two CharMaker CPP500s and a CharMaker CPP2000. Environmental permits have been obtained for machinery operating in Australia (CharMaker CPP500) as well as in Hong Kong (CharMaker CPP500 and CharMaker CPP2000) which produce biochar from mixed species woodchip feedstock. It will then be verified on a project basis, during regular facility and output third-party audits, that equipment installed meets the regulation applicable locally.*

## Criteria 5: Emissions testing of greenhouse gases

☒ Criteria is met, in full.
☐ Criteria is met partially.
☐ Criteria is not met.

**Observations:**
*Criteria 5 is met in full meaning that GHG emissions have been quantified and can be used for determining the carbon footprint of biochar produced with this equipment. Puro notes that $CH_4$ and $N_2O$ emissions are likely to represent up to 6% and 2% of carbon stored in biochar, respectively. It must be noted that the GHG emissions results for both $CH_4$ and $N_2O$ were not detected based on the detection limits of the equipment used during GHG emission testing, limited by the testing company. Therefore, the results are considered conservative in the absence of a more sensitive GHG measurement device. Based on these results, residual $CH_4$ and $N_2O$ emissions are non-negligible and must be included in the calculation of project emissions, with the data provided by the manufacturer, unless additional GHG emissions testing is performed by the user of the equipment.*

## Criteria 6: Testing of biochar quality

☒ Criteria is met, in full.
☐ Criteria is met partially.
☐ Criteria is not met.

**Observations:**
*Criteria 6 is met, meaning that the manufacturer has demonstrated that the equipment can be operated with certain biomass feedstocks (mixed woodchips – primarily Eucalyptus) in a way that leads to biochar of sufficient persistence and sufficient environmental quality for most applications, e.g. soil applications. It will then be verified on a project basis, during regular facility and output third-party audits, that biochar produced is of sufficient persistence and sufficient environmental quality.*

## Criteria 7: Material choices and expected equipment lifetime

☒ Criteria is met, in full.
☐ Criteria is met partially.
☐ Criteria is not met.

**Observations:**
*Criteria 7 is met in full, meaning that material and energy usage for reactor manufacturing have been compiled, enabling calculation of embodied emissions from reactor manufacturing and disposal, as well as an expected lifetime of the reactor (10 years, out of which 12 months is under warranty). As for any other endorsed technology provider, Puro will make adequate disclaimers, ensuring that biochar projects do perform their own due diligence with respect to equipment material quality, expected lifetime, availability of spare parts, support from manufacturer, and warranty.*

## Other comments

None.

## Decision

☒ The applicable equipment by the Technology Provider have successfully passed the Puro.earth evaluation against the requirements set out in the Technology Provider Evaluation Criteria.
☐ The submission requires revisions before the evaluation of the applicable equipment by the Technology Provider can be finished.
☐ The applicable equipment by the Technology Provider have not passed the Puro.earth evaluation against the requirements set out in the Technology Provider Evaluation Criteria.

Documents submitted on 24-10-2024.
First review concluded on 06-12-2024.
Additional documents submitted on 21-01-2025.
Second review concluded on 19-02-2025.