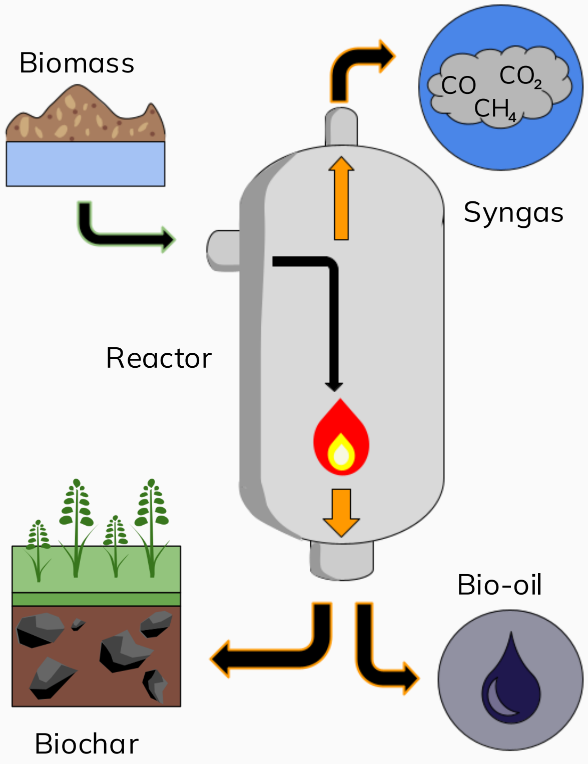
NYC waste utilization via pyrolysis updates

By Sivan Spiel

Jan 15th, 2026

How its made - pyrolysis



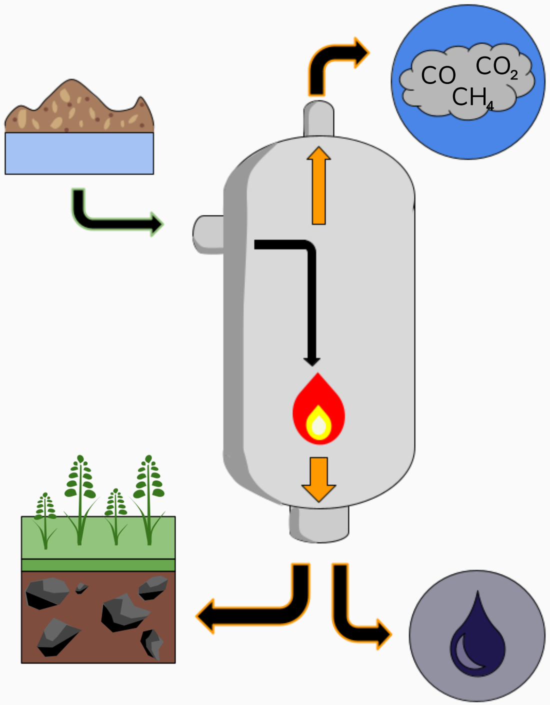
- The feedstock is any biomass (plant material) such as park, food, or agricultural waste
- The biomass is heated (250-800˚C) in the **absence of oxygen** (pyrolysis) stabilizes the carbon for 100-1000s of years
- Three products: biochar (solid), bio-oil (liquid), syngas (gas)

Common variables:
temperature, feedstock,
reactor design

Goals for this project

Understand the differences between DSNY feedstock and our model feedstock (pine)

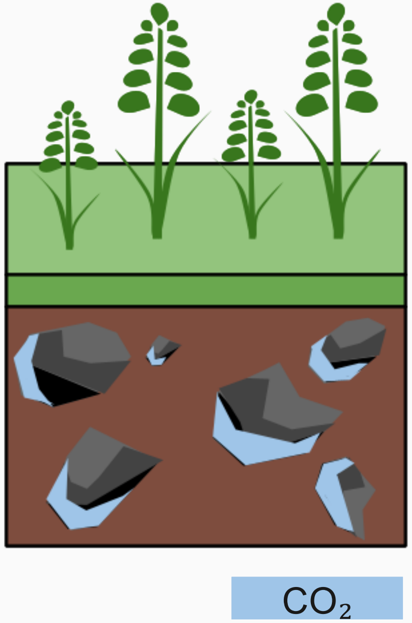
- How much CO_2 can be sequestered per unit mass of the feedstock?
- How much energy to dry the feedstock?
- How much energy to pyrolyze the feedstock into biochar?
- What is the product distribution biochar vs bio-oil vs syngas?



Goals for this project

Understand the differences between DSNY feedstock and our model feedstock (pine)

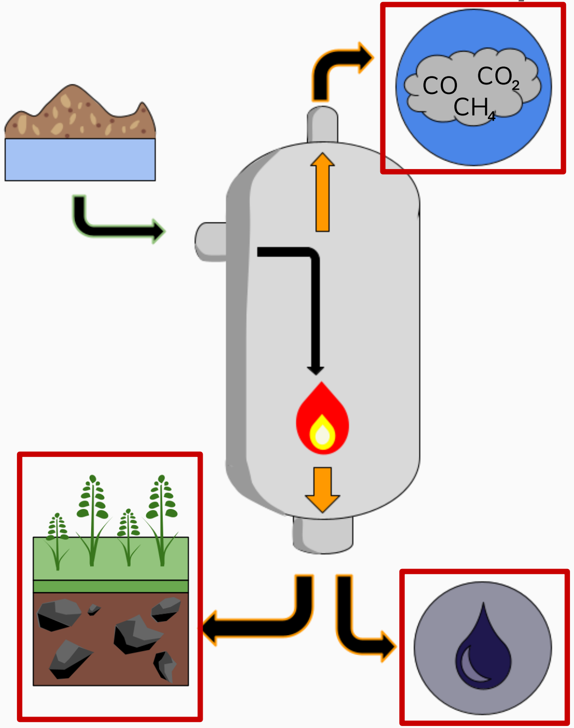
- How much CO_2 can be sequestered per unit mass of the feedstock?
- How much energy to dry the feedstock?
- How much energy to pyrolyze the feedstock into biochar?
- What is the product distribution biochar vs bio-oil vs syngas?



Goals for this project

Understand the differences between DSNY feedstock and our model feedstock (pine)

- How much CO_2 can be sequestered per unit mass of the feedstock?
- How much energy to dry the feedstock?
- How much energy to pyrolyze the feedstock into biochar?
- What is the product distribution biochar vs bio-oil vs syngas?



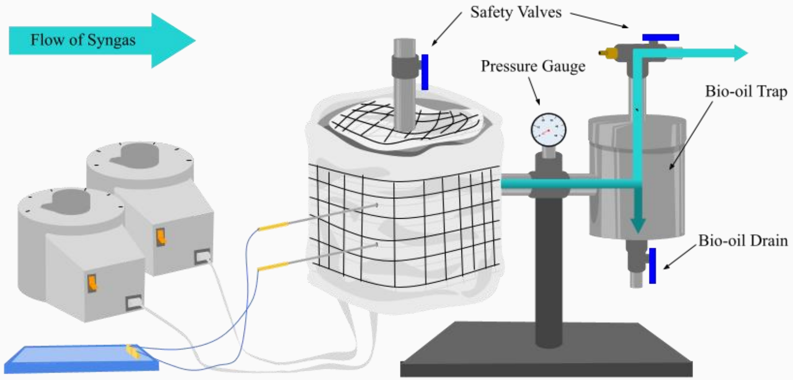
Methods for this project

The feedstock is loaded in the reactor

The electric heating elements allow us to easily measure and change the energy added

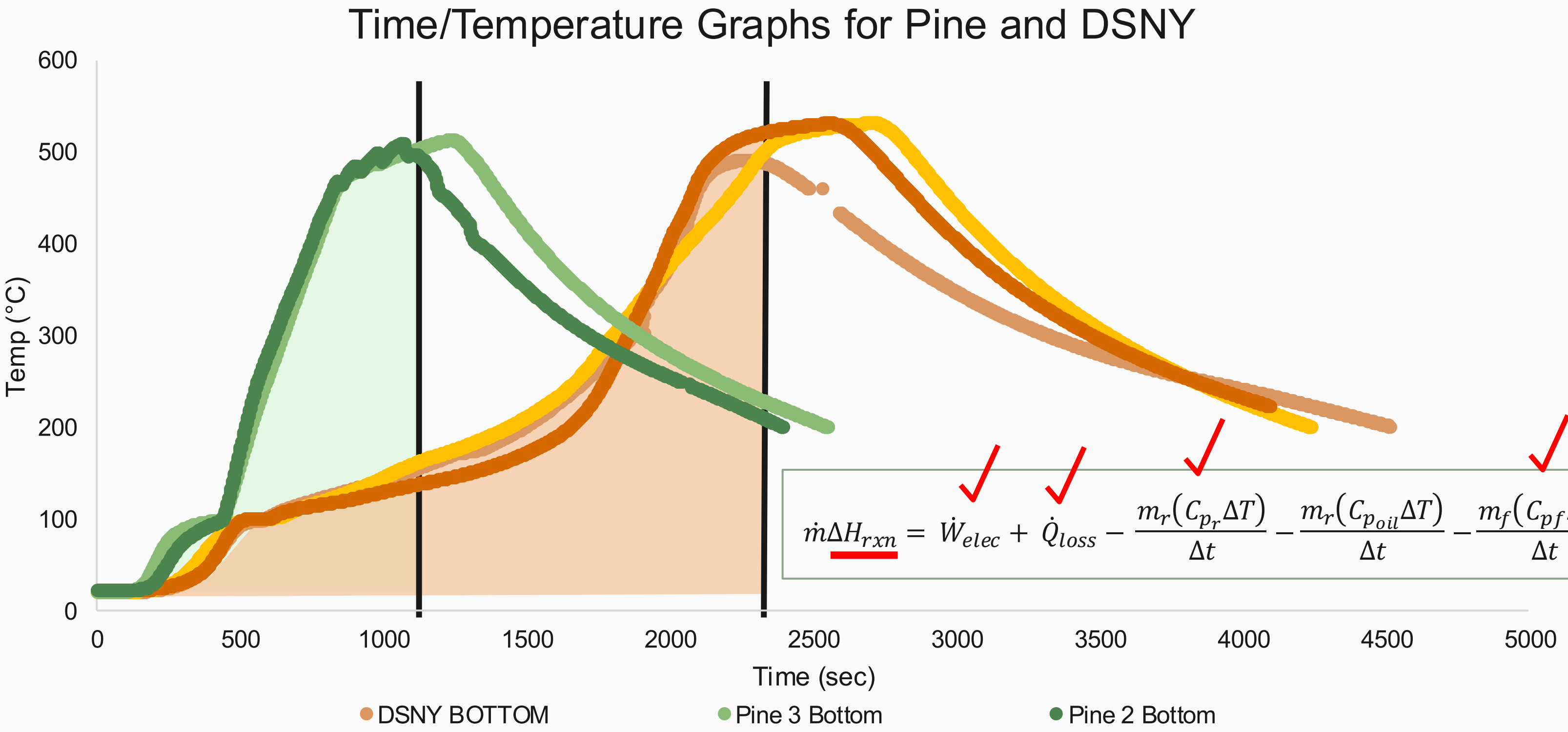
Two temperature probes are used to track the syngas and feedstock temperature as the reaction takes place

Using the collected data, we can calculate the **CO_2 sequestered, energy required, and product distribution** of the reaction while changing the **temperature, reaction time and feedstock used**



Experimental Set up

Raw Data Collection



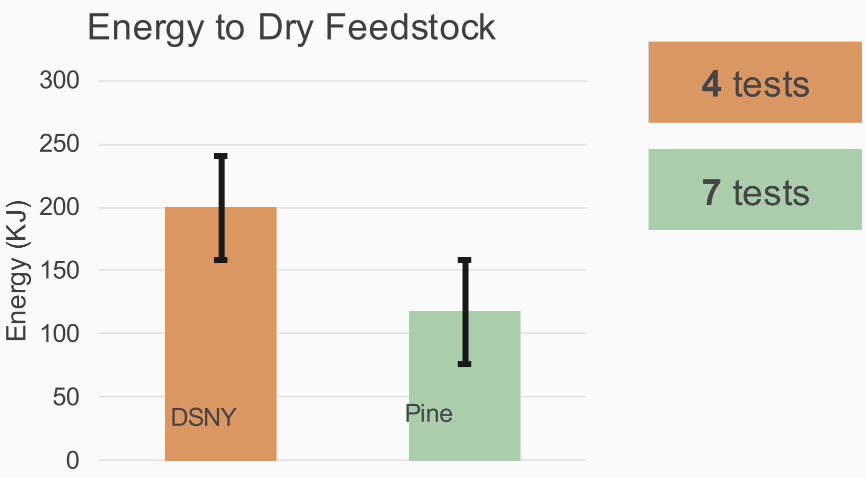
$$\dot{m}\Delta H_{rxn} = \dot{W}_{elec} + \dot{Q}_{loss} - \frac{m_r\left(C_{p_r}\Delta T\right)}{\Delta t} - \frac{m_r\left(C_{p_{oil}}\Delta T\right)}{\Delta t} - \frac{m_f\left(C_{pf}\Delta T\right)}{\Delta t} - (\dot{m}H)_{gas}$$

Feedstock Differences

Energy required to dry feedstock

DSNY contains around ***3.3 x the amount of moisture*** than pine, this increases the energy required to dry the feedstock in the reactor

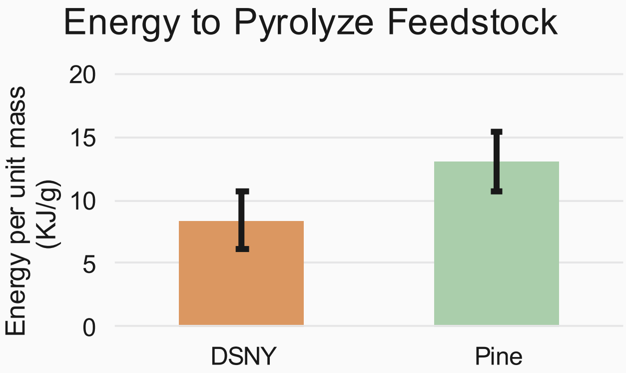
DSNY requires 41% more energy to dry



Energy required to pyrolyze

DSNY requires around ***34% less energy/mass*** to pyrolyze than our model feedstock

This is due to the density of DSNY, more biomass can be used in each batch compared to pine

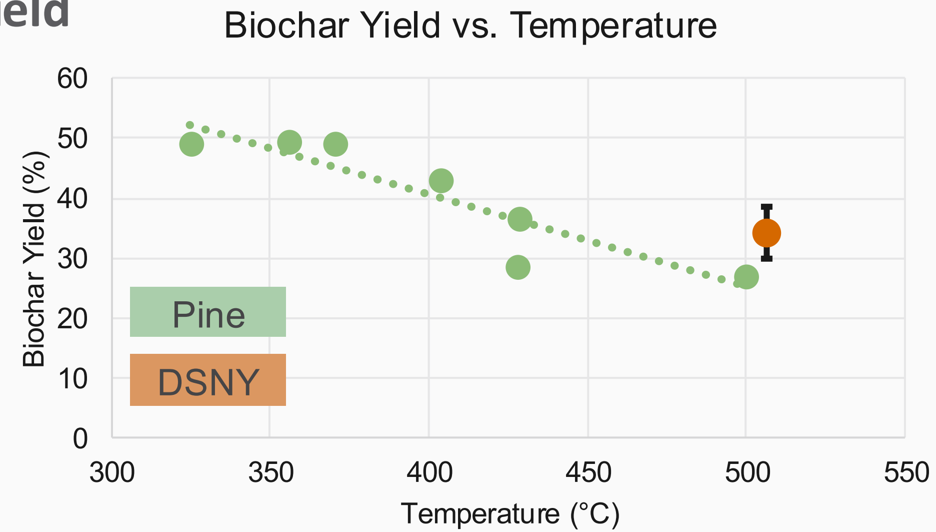


Feedstock Differences

CO_2 sequestration power/ Biochar yield

DSNY sequesters around ***30% more CO_2 (g/g_feedstock)*** than our model feedstock

This is due to the higher biochar yields at the same temperature caused by the differing amounts of lignin and cellulose in the DSNY vs. pine feedstock

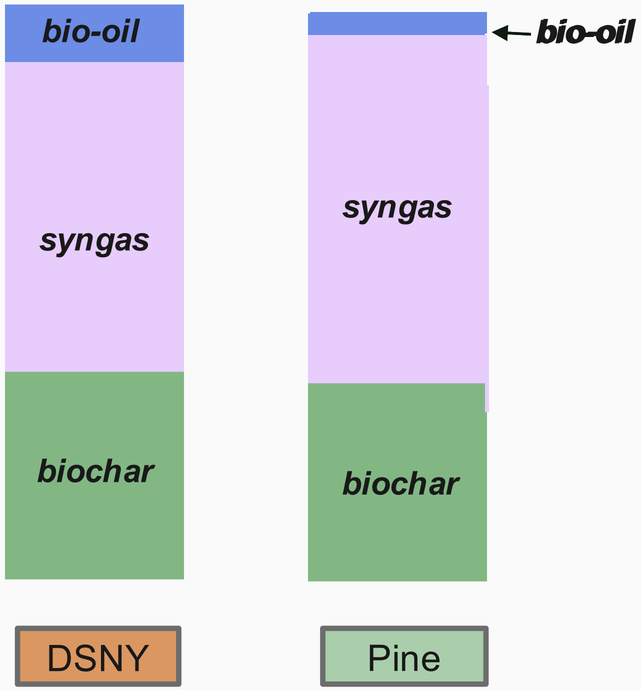


Feedstock Differences

Product Distribution

DSNY had a distribution of: ***7% bio-oil, 28% biochar, 24% steam, and 41% syngas (500-550°C)***

Pine produced more syngas and less bio-oil, with the distribution being: ***4% bio-oil, 30% biochar, 9% steam, and 58% syngas (350-500°C)***



Biochar Characteristics Test

Standards/Tests

The International Biochar Initiative (IBI) has a set of standards that must be met to determine if the biochar is suitable for soil amendment

There are three tests:

Basic utility properties

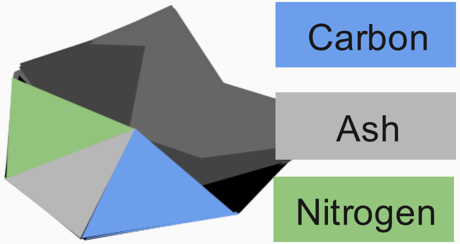
Toxicant assessment

Advanced analysis and soil amendment properties (optional)

Biochar Characteristics Test

Basic utility properties

- Moisture content (biochar not feedstock)
- pH
- Organic carbon, ash and nitrogen content
- Electrical conductivity
- Particle size distribution



Biochar Characteristics Test

Standards/Tests

The International Biochar Initiative (IBI) has a set of standards that must be met to determine if the biochar is suitable for soil amendment

There are three tests:

- **Basic utility properties**
- **Toxicant assessment**
- **Advanced analysis and soil amendment properties (optional)**

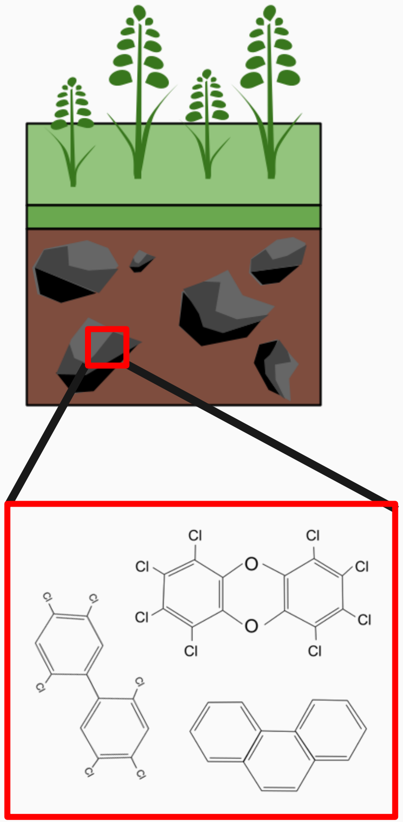
Biochar Characteristics Test

Toxicant assessment

- Germination tests (can plants grow with this biochar?)

- Harmful chemicals possibly present and their concentration (arsenic, cadmium, chromium, lead, etc.)

- PAHs, PCDDs, PCB content (harmful chemical compounds)



Biochar Characteristics Test

Standards/Tests

The International Biochar Initiative (IBI) has a set of standards that must be met to determine if the biochar is suitable for soil amendment

There are three tests:

Basic utility properties

Toxicant assessment

Advanced analysis and soil amendment properties (optional)

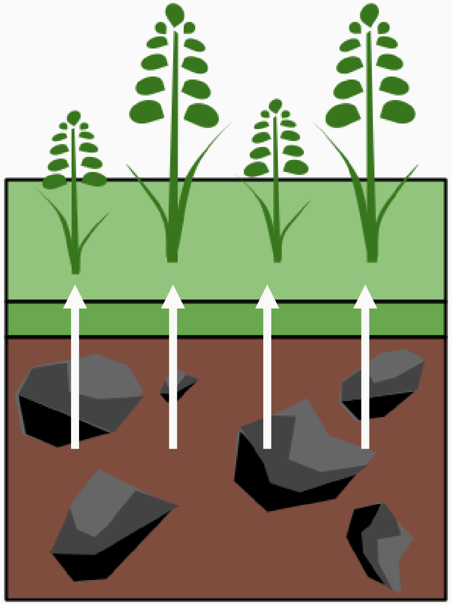
Biochar Characteristics Test

Advanced analysis and soil amendment properties (optional)

This test is performed to quantitatively determine how much the biochar will improve the soil

It quantifies the different mineral availabilities present after the addition of biochar

Phosphorus, calcium, magnesium and sulfur are a few of the tested minerals, and the presence of these chemicals can drastically improve soil/plant health



Biochar Characteristics Test

Standards/Tests

The International Biochar Initiative (IBI) has a set of standards that must be met to determine if the biochar is suitable for soil amendment

There are three tests:

- **Basic utility properties**
- **Toxicant assessment**
- **Advanced analysis and soil amendment properties (optional)**

There are companies such as carbon standards international that can perform and grade biochar and the pyrolysis process

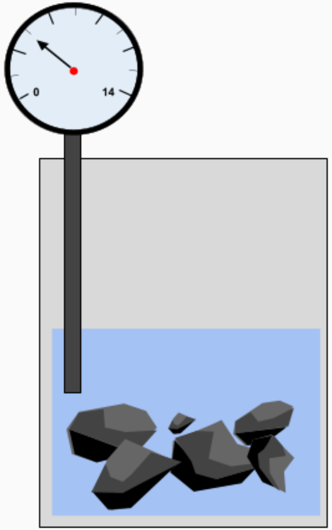
Future Work

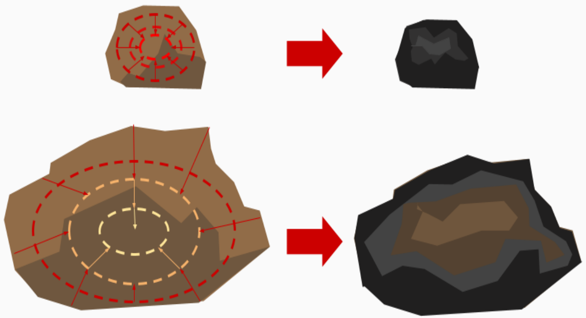
The preliminary characterization tests being completed:

pH tests of pine and DSNY (Renee Ma, ChE 2025)

Moisture, carbon, ash content of the ***biochar***

Particle size distribution and electrical conductivity of ***biochar***





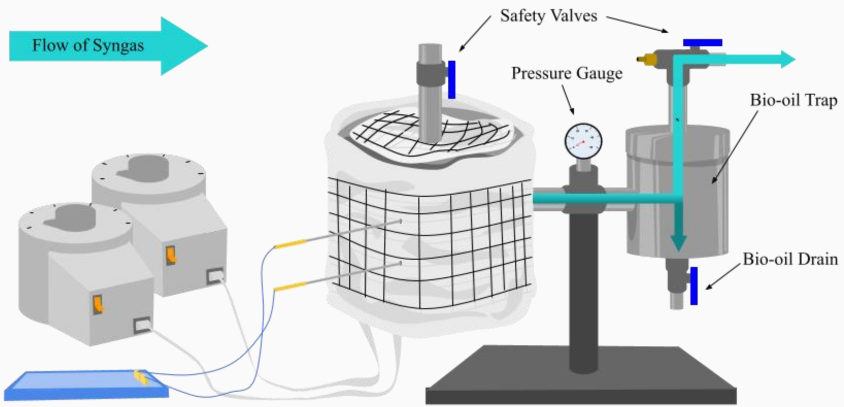
Future Work

Other future work will include

Energy balances: drying, power supply, residence time

Product distribution optimization: temperature ranges for minimizing bio-oil while maintaining quality biochar

Enthalpy calculations: self-sustaining pyrolysis, endothermic/exothermic zones



Experimental Set up

Thank you!