Converting Forest Residuals to Biochar
Testing Biochar Production from Various Feedstocks

Schatz Energy Research Center
Humboldt State University
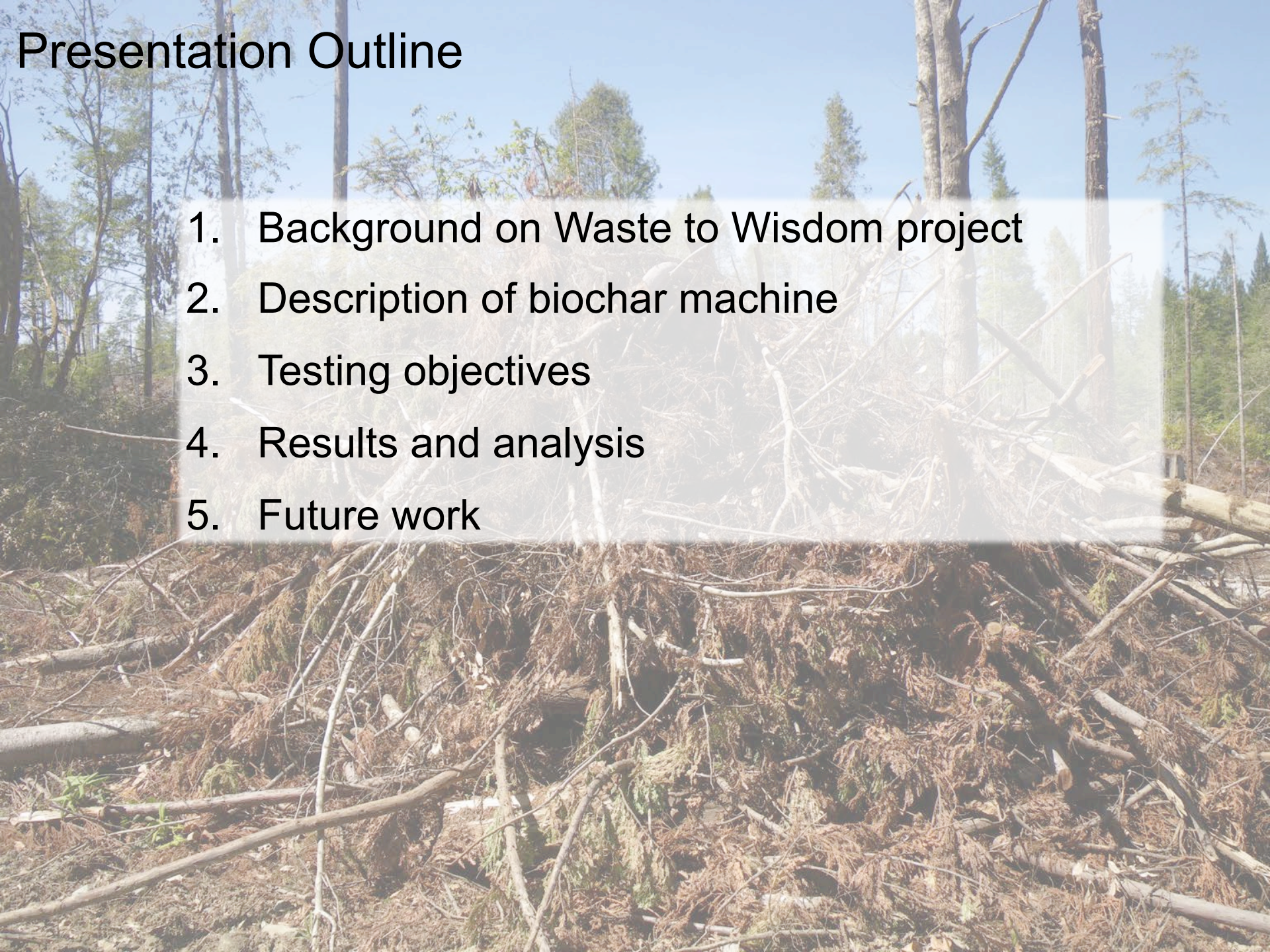
David Carter, P.E.
April 9, 2015

Presentation Outline

1. Background on Waste to Wisdom project

2. Description of biochar machine

3. Testing objectives
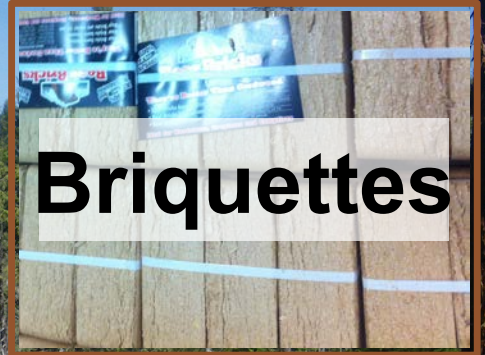
4. Results and analysis

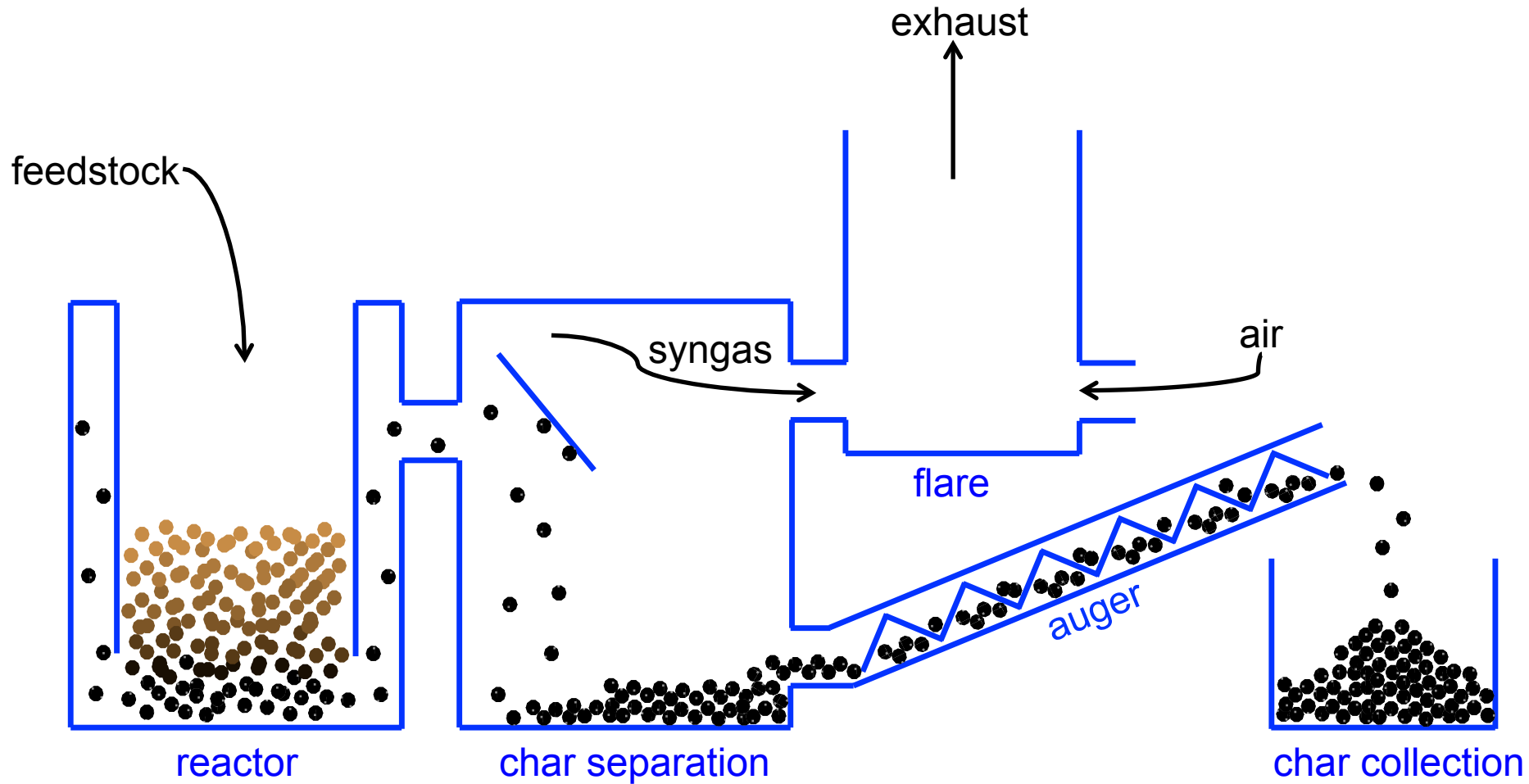5. Future work

"Promoting the use of clean and renewable energy"

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HUMBOLDT STATE UNIVERSITY

Converting forest residuals into valuable energy products.

Briquettes

Torrefied Biomass

Biochar

WASTE TO WISDOM

Biomass is converted into biochar through thermal decomposition in an oxygen limited environment.

exhaust

feedstock

syngas

air

flare

auger

reactor

char separation

char collection

Machine produced by Biochar Solutions, Inc.

Feedstock Hopper

Conveyor

Reactor
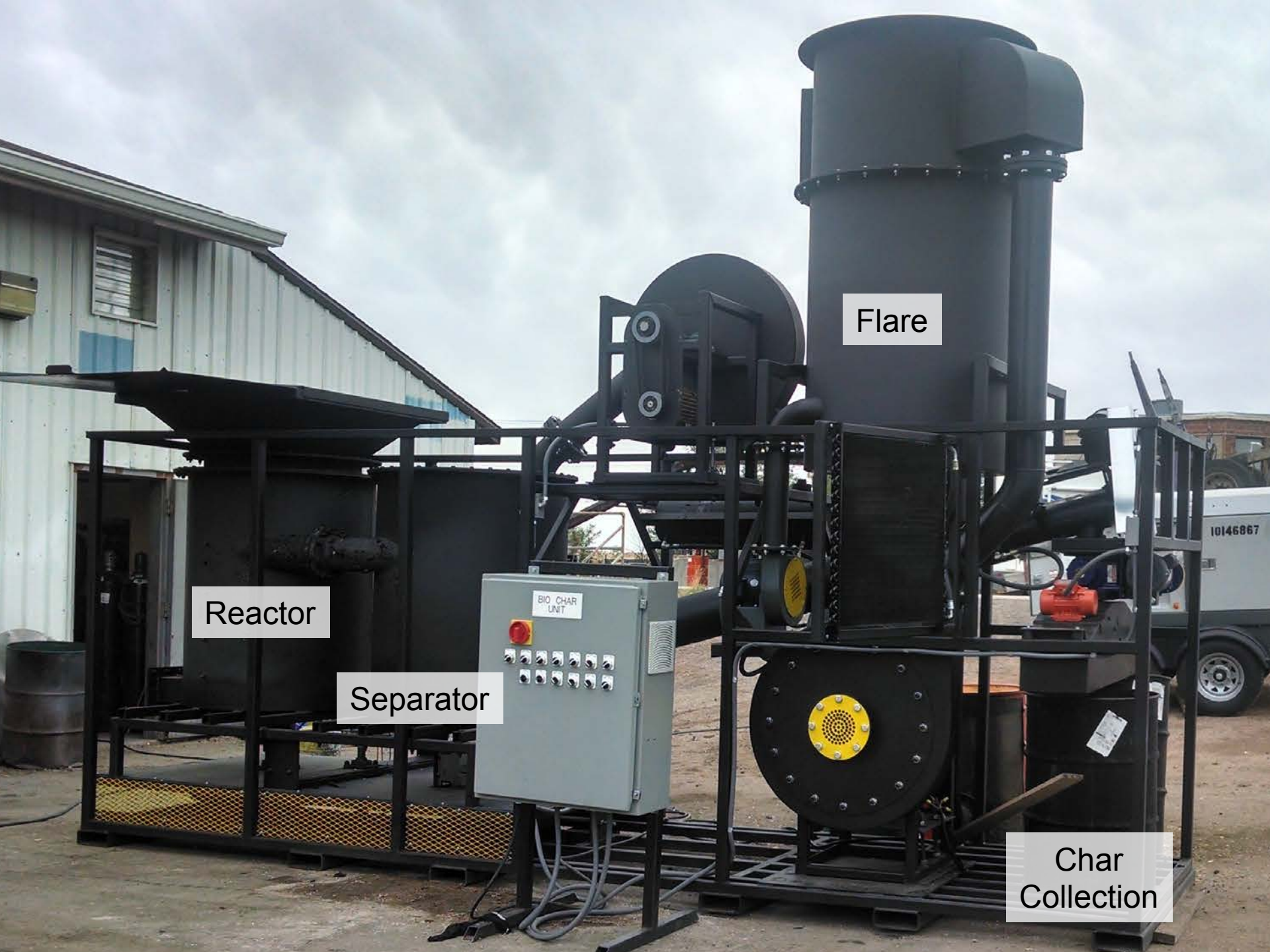
Flare

Reactor

Separator

BIO CHAR
UNIT

Char
Collection

10146867

Testing Goals

- Collect performance data
- Study the effect of feedstock quality on operational parameters
- Measure consumption and production rates
- Assess potential to generate electricity from waste heat
- Determine environmental impact and fire hazard
- Document the operational intensity and labor requirements

Data Collection and Instrumentation

Instruments were installed to collect energy and mass flow data in real time, including

- temperatures
- flow rates
- electric power
- emissions
- humidity
- heat rejection

Feedstock Testing Matrix

Tests performed at fabrication facility in Pueblo, Colorado during August 2014.

| Species	Conifer		Conifer		Conifer		Conifer		Conifer		Hardwood		Juniper	
Comminution Method	Ground		Ground		Ground		Chip		Chip		Ground		Ground	
Contaminant	none		2/3 bole, 1/3 tops		9% soil		none		none		none		as received*	
Moisture Content	15%	19%	17%	15%	14%	16%	37%	25%	22%	20%	15%	16%	10%	10%
Ash Content	2%	2%	7%	2%	14%	14%	0.7%	0.1%	3%	3%	0.3%	1%	26%	21%
Particle Size, % mass (<0.1"/0.1"-1"/>1")	12/80/9		14/77/9		14/77/8		1/99/0		31/69/0		20/79/1		28/64/8	

* Contamination was not added, however the juniper feedstock was highly contaminated as received.

Feedstock Throughput and Biochar Production Rates
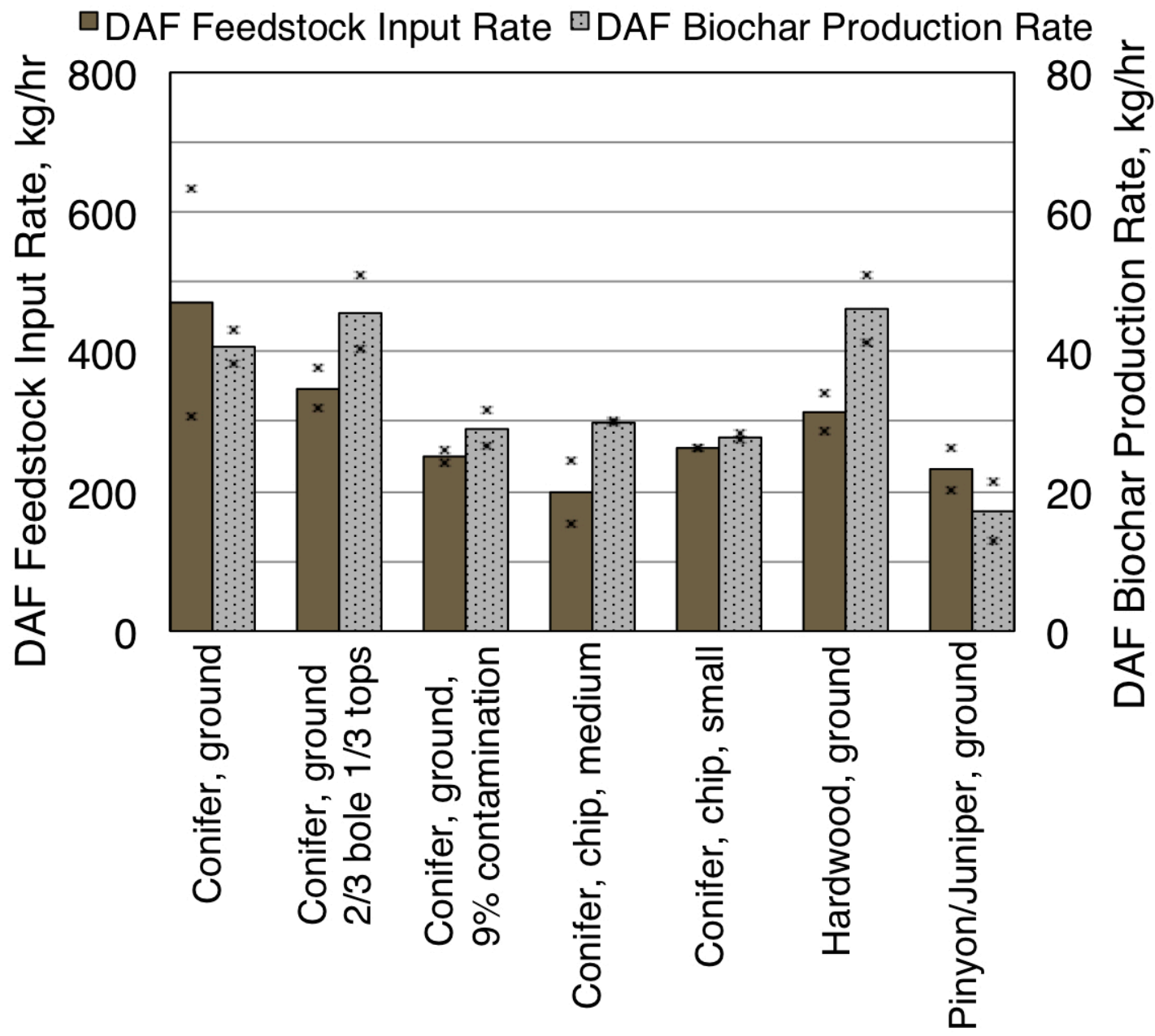
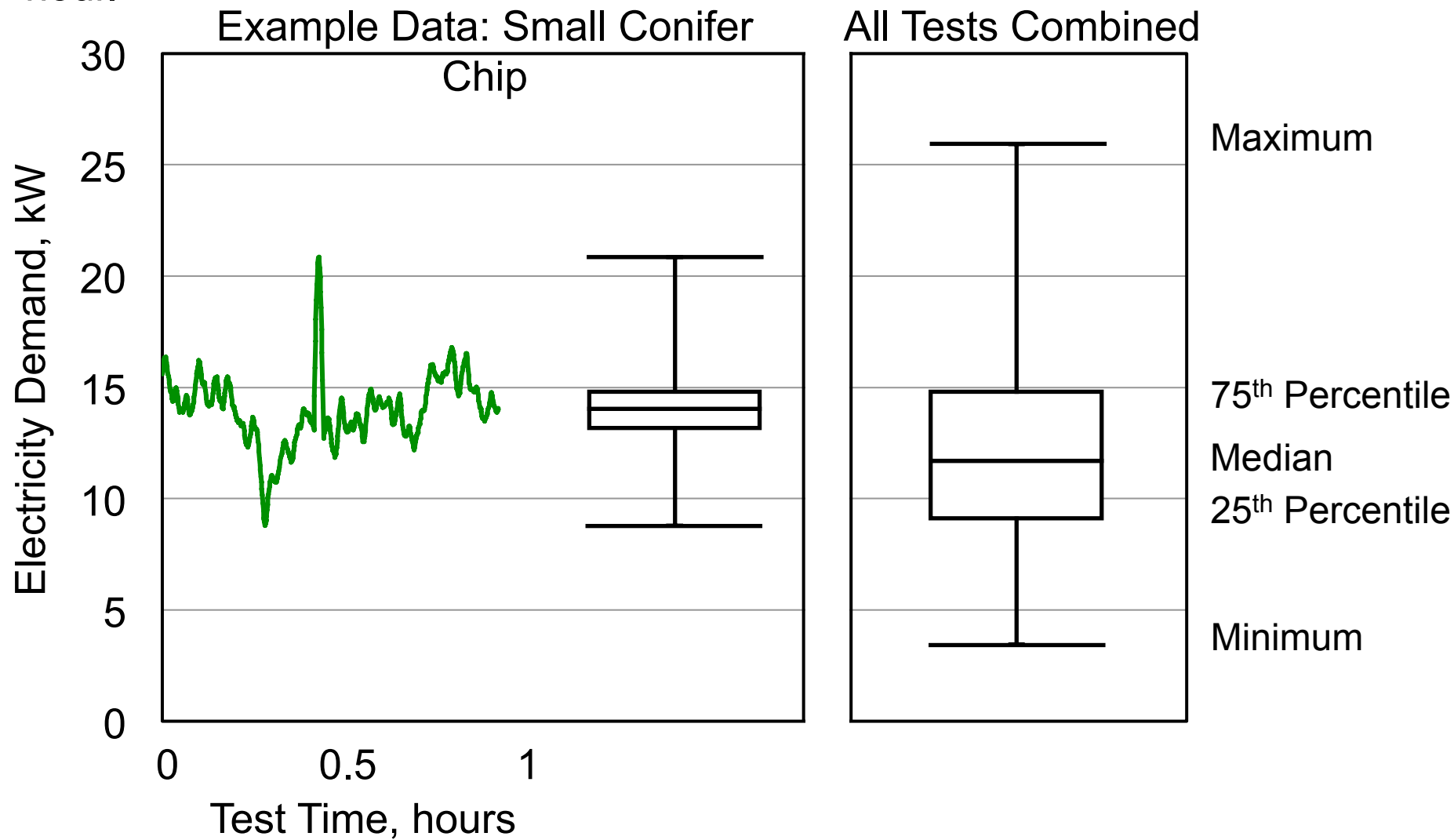# Estimated Labor Hours

Labor requirements increase with moisture and ash content in the feedstock.
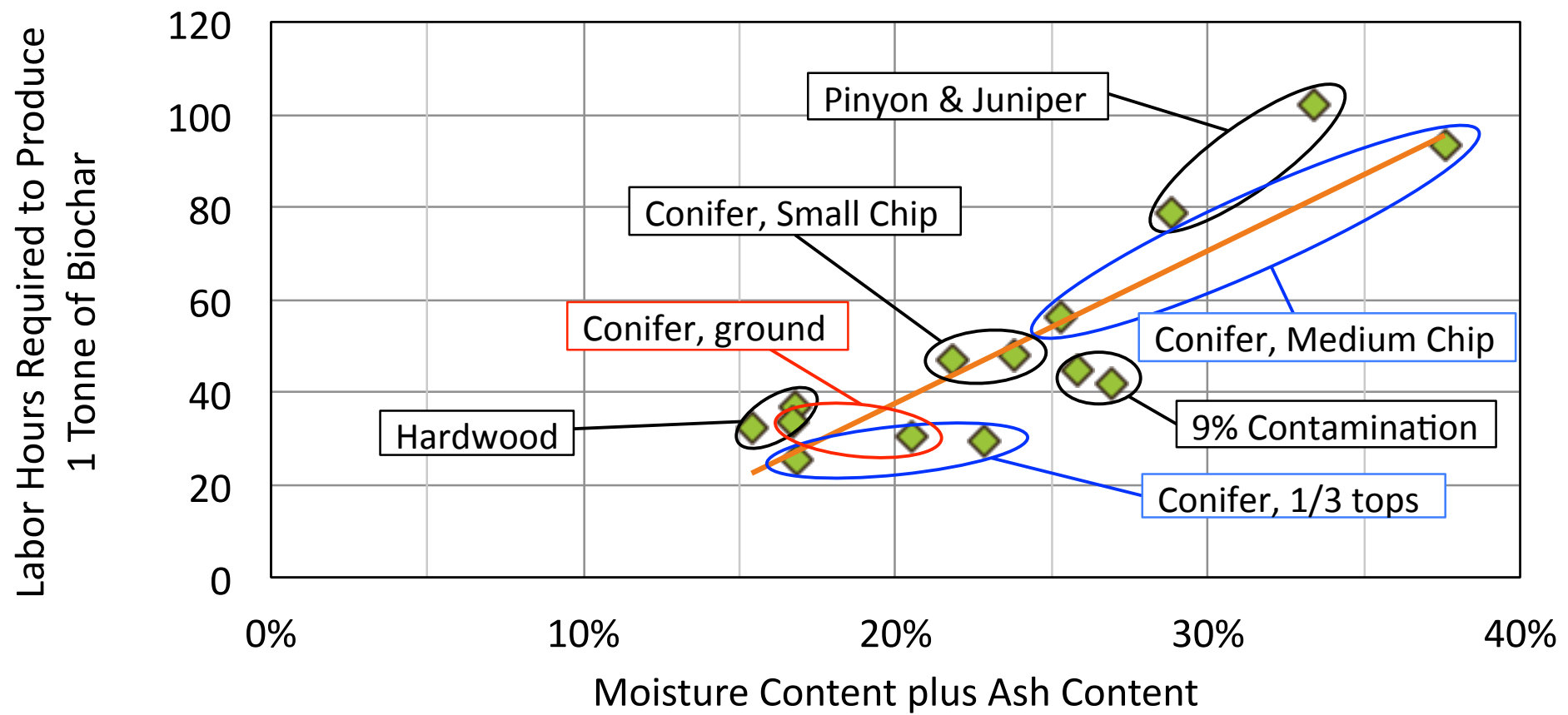
Electricity Demand

Average electricity demand was 12 kW, but can vary by ±10 kW within every hour.

Bioochar Machine Energy Output

Thermal and chemical power exit through the exhaust stack.

Total Energy Output	
Minimum	370 kW
Mean	540 kW
Maximum	730 kW
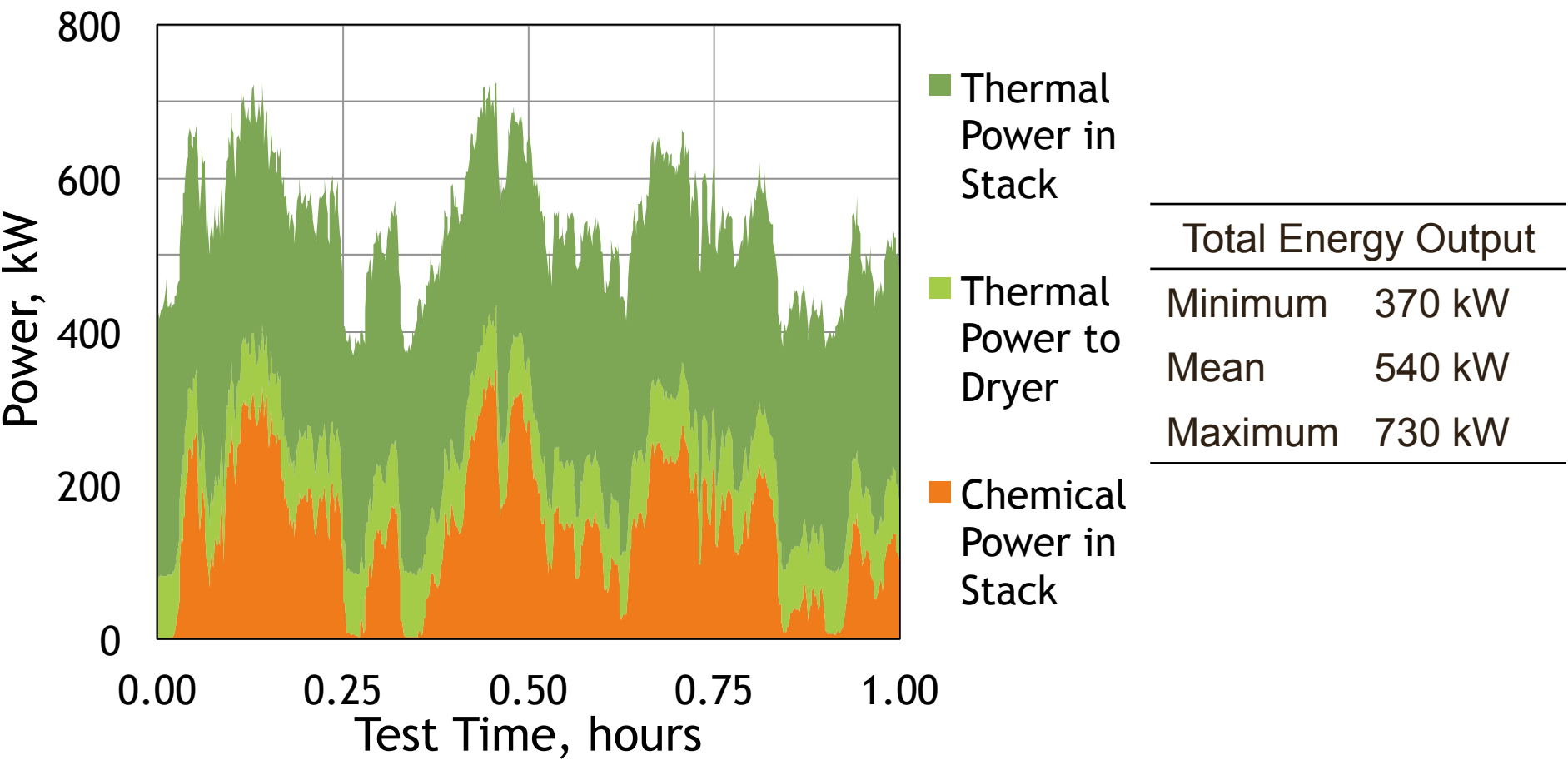
Emissions

Stack emissions are reduced by increasing combustion airflow into the flare.
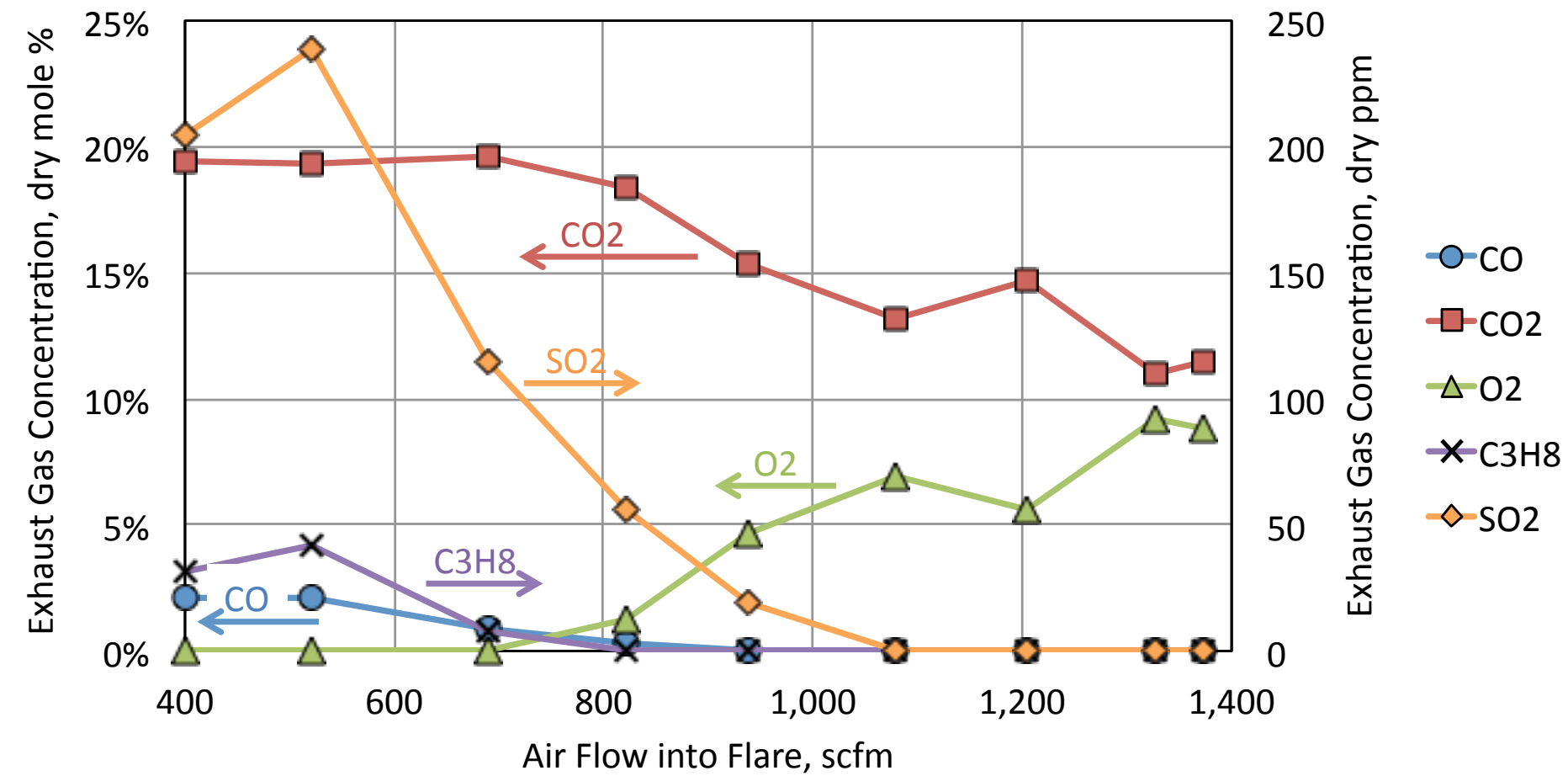
Mechanical Improvements

New flare air blower to promote complete combustion and reduce emissions

Mechanical Improvements

Automatic feed control from an auger dramatically reduces labor requirements.

Motor   Auger   Feedback

Mechanical Improvements

New spark arrestor eliminates embers that pose a fire hazard

Accelerator

Knock-out

Installed

Mechanical Improvements

Redesigned heat exchanger provides 100°C air to dryer

Inlet

Outlet

Future Experiments and Expected Developments

Belt dryer to utilize waste heat for feedstock drying

Norris Thermal Belt-o-matic Series 200 Belt Dryer

Future Experiments and Expected Developments

Biomass gasifier to generate electricity for machine

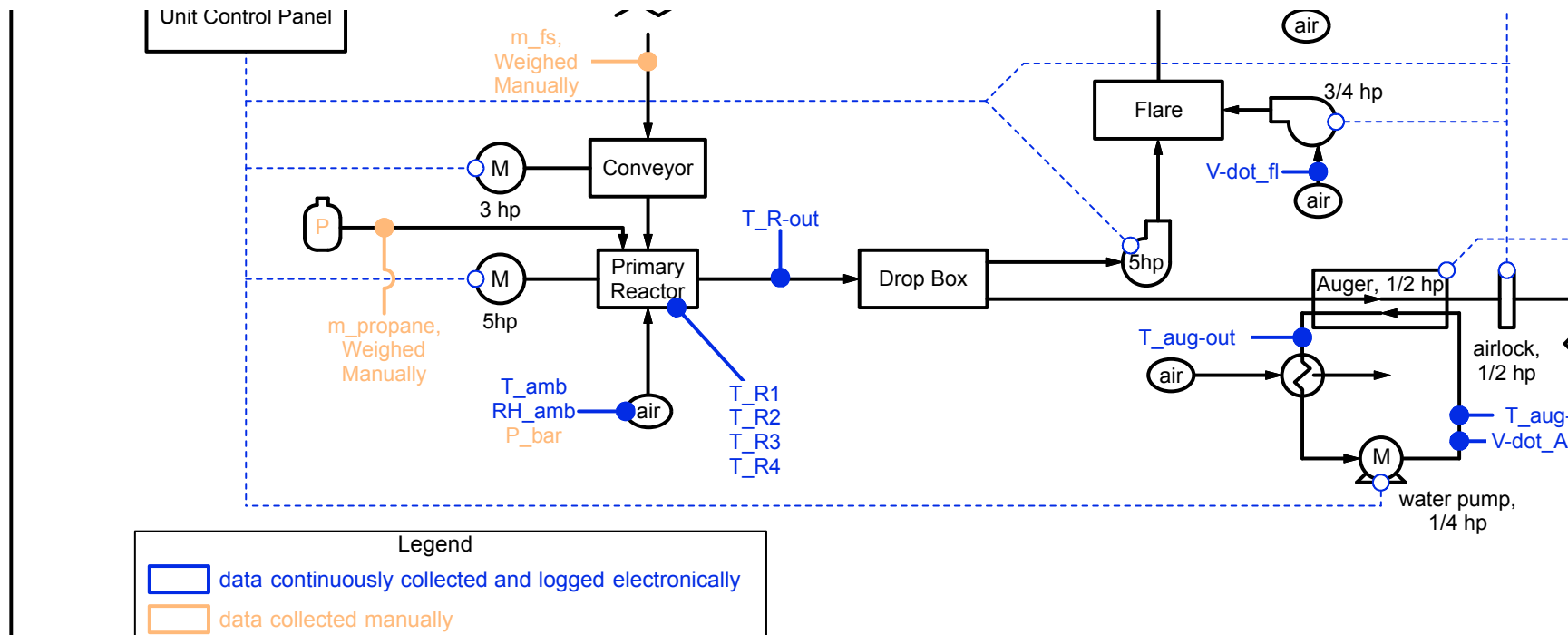

All Power Labs
20 kW Power Pallet

Thank you

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Piping and Instrumentation Diagram

Unit Control Panel

m_fs, Weighed Manually

air

Flare

3/4 hp

Conveyor

3 hp

M

P

m_propane, Weighed Manually

Primary Reactor

5 hp

M

T_amb
RH_amb
P_bar

air

T_R-out

T_R1
T_R2
T_R3
T_R4

Drop Box

5hp

V-dot_fl

air

Auger, 1/2 hp

T_aug-out

air

airlock, 1/2 hp

T_aug-
V-dot_A

M

water pump, 1/4 hp

Legend

data continuously collected and logged electronically	
data collected manually	

Title:	Biochar System Diagram with Instrumentation
Project:	BRDI Waste to Wisdom
Design by:	R. Engel, C. Chamberlin

Date: 06/22/2014   **Revision:** 4

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Comments:

Rev 4 by Mark Severy