Characterization of Plancha Stove Performance in Rural Guatemala

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ETHOS

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Project Overview

Goals:

- **Develop a new lab testing procedure that better reflects stove usage in the field.**
- **Develop an understanding of Plancha stove-design, emissions, efficiency, and usage.**
- Improve upon existing Aler-stove with a Plancha-design that , reduces emissions, increases efficiency, decreases manufacturing costs, and meets the usage needs of our target community.

Contributors:

Research/Testing/Design – UWCCL and BDL

Manufacturing/Field-Research – HFPF

Target Community

Location:

Barillas, Guatemala + surrounding villages

Current-Market Need:

10,000 stoves

Expanded-Market Need:

500,000 stoves

Total-Market Need in Guatemala:

2.4 million stoves

Aler-Stove

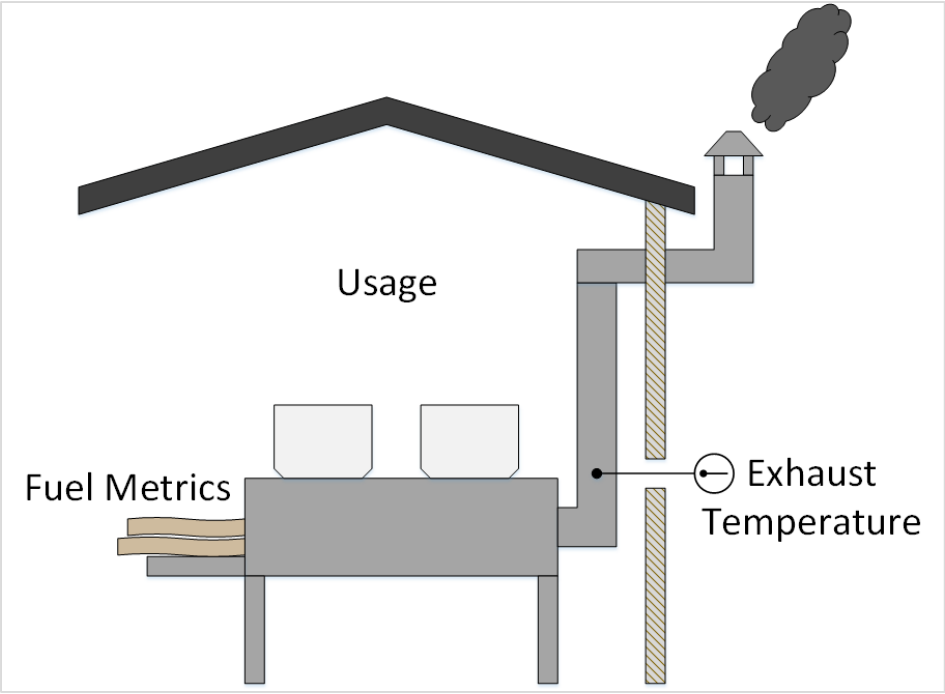
Field Survey

Surveyed households in villages surrounding Barillas that are currently using the Aler-Stove.

# of Stoves in use: ≈ 3000

Survey included:

- Household/stove-usage questionnaire
- Observation of cooking event



Note: Exhaust Temperature was measured using a type-K thermocouple with a 1 min resolution in the center of the stack, 10cm above the lower stack-elbow.

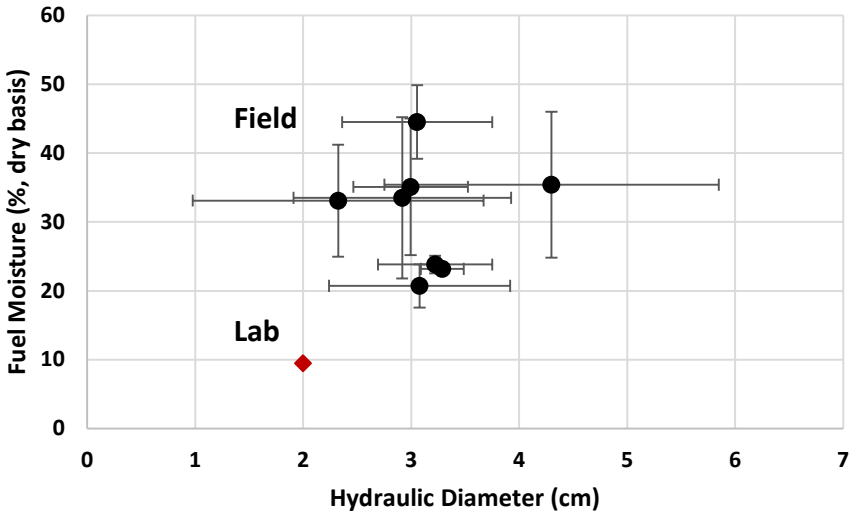
Household Stove-Usage

# of Households Surveyed → 8	
Family Size → 5-7 persons	**Stove Used for Heating** → 75% use stove as a household heat source (seasonal)
Stove Use Per Day → 5-7 hrs	**Stove Used in Between Meals** → 100% don't add wood to the stove between meals
Cooking Technique → 100% used a mixture of pots, pans, and direct stove-top cooking	**Cooking Task** → Tortillas, Tamales, Boiling Beans/Corn/Potatoes, Coffee, Boiling Water

Fuel Characteristics

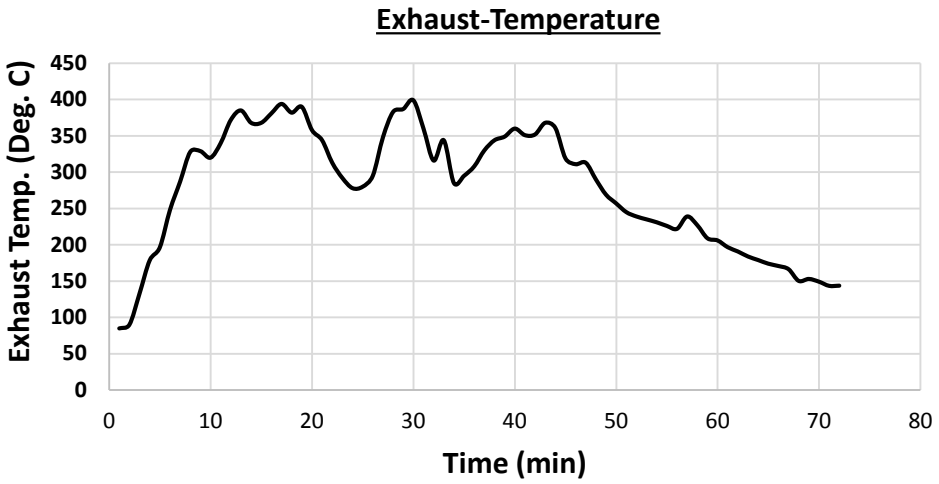
Source of Wood → 100% gather wood (do not purchase)
Wood Storage Technique → 100% use covered wood storage
Stove Used to Dry Wood → 88% use latent heat to dry wood
Fire-Starter Used → 100% use mixture of corn-husks and ocote-kindling

Average Fuel Size (Hyd. Dia.) → 3 ± 0.5 cm
Average Fuel Moisture Content → 31 ± 8 %, Dry Basis

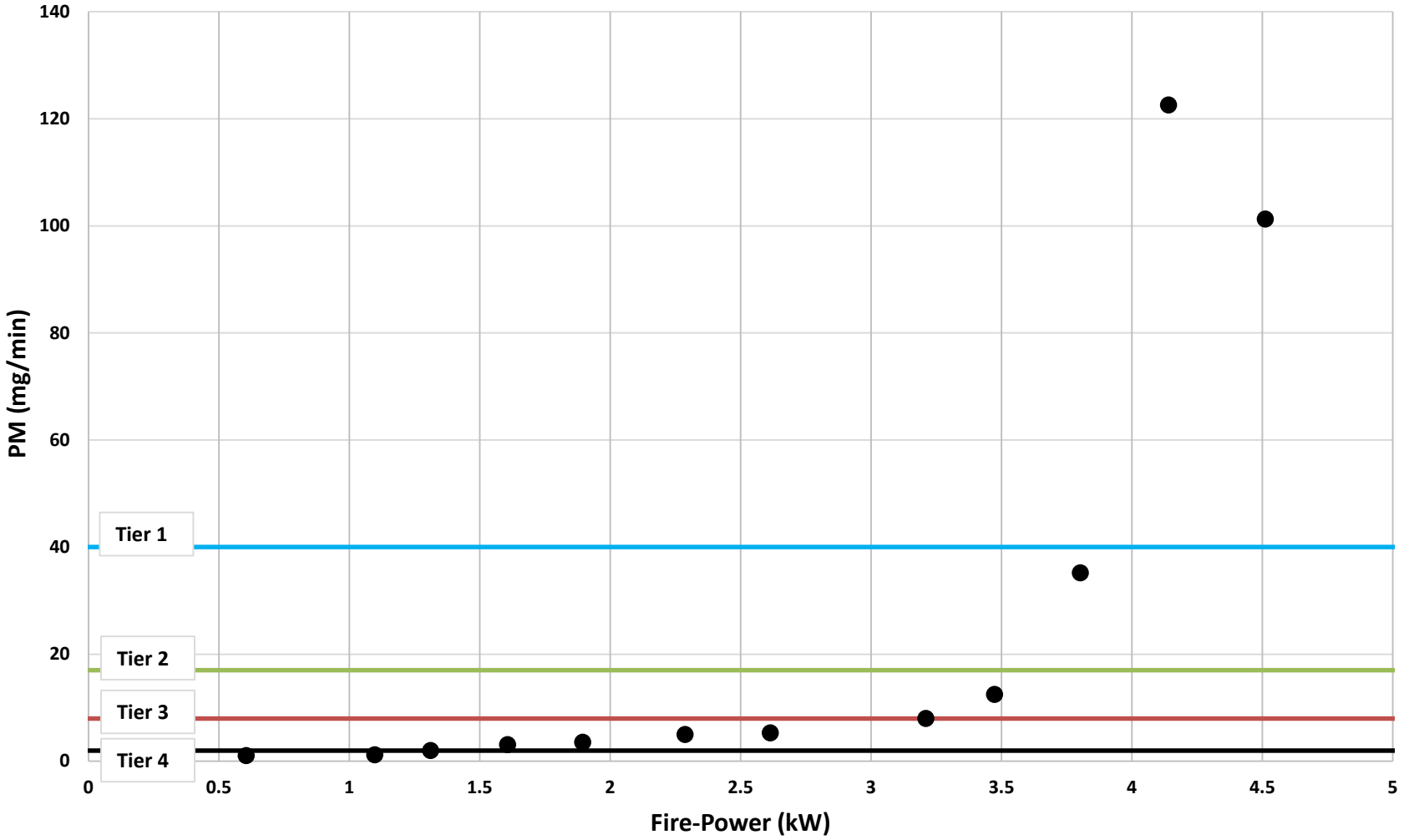


Cooking Event Observation

Meal Cooked → Boiled 15lbs of corn and a pot of coffee
# of People Cooking for → 7
Duration / Time of Day → 71 min / 10:00 AM
# of Sticks / Size / Moisture Content → 5 / 3 cm (hydraulic-diameter) / 21% (dry-basis)
Tending Time → 12 min



Impact of Firepower on Emissions



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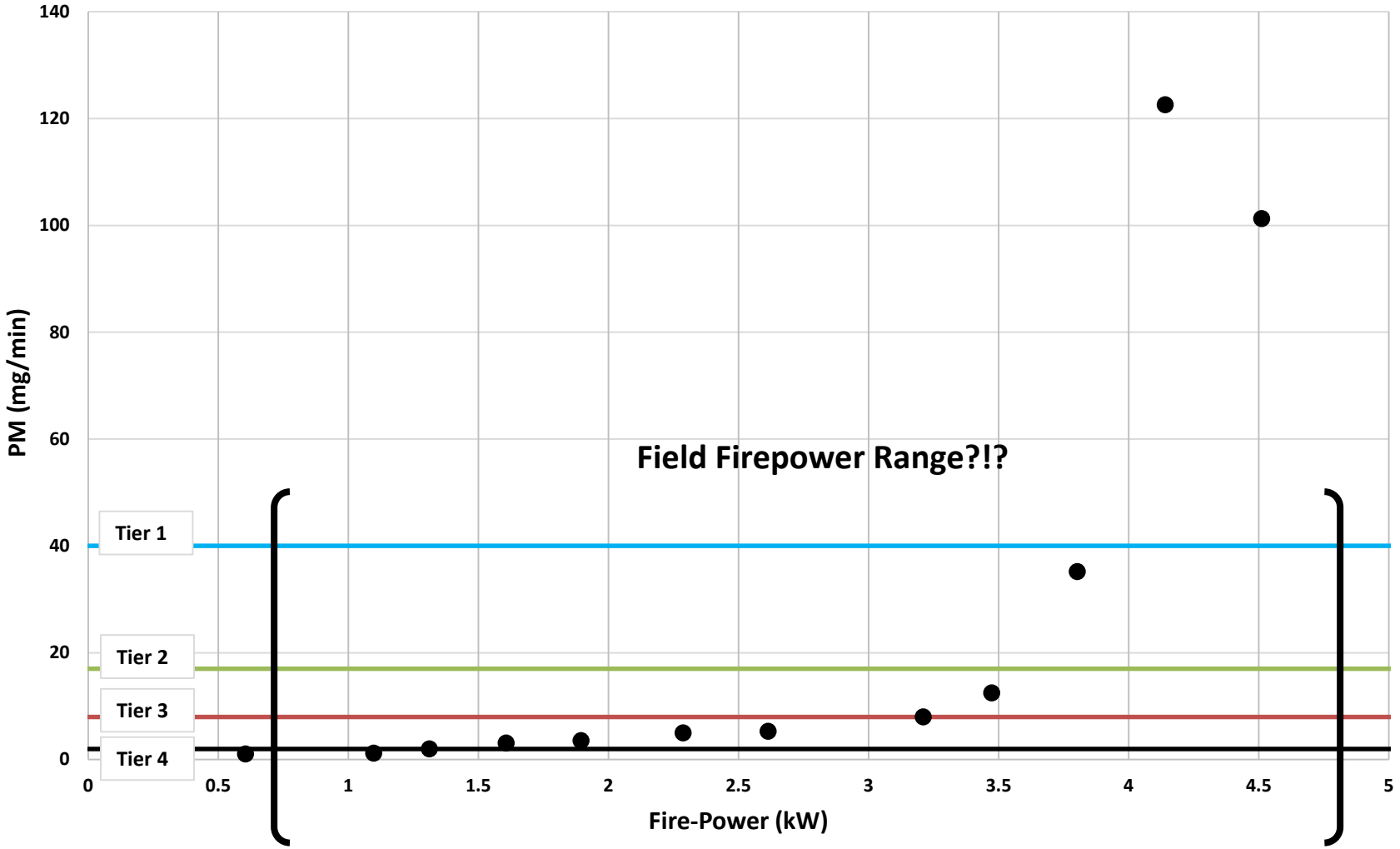

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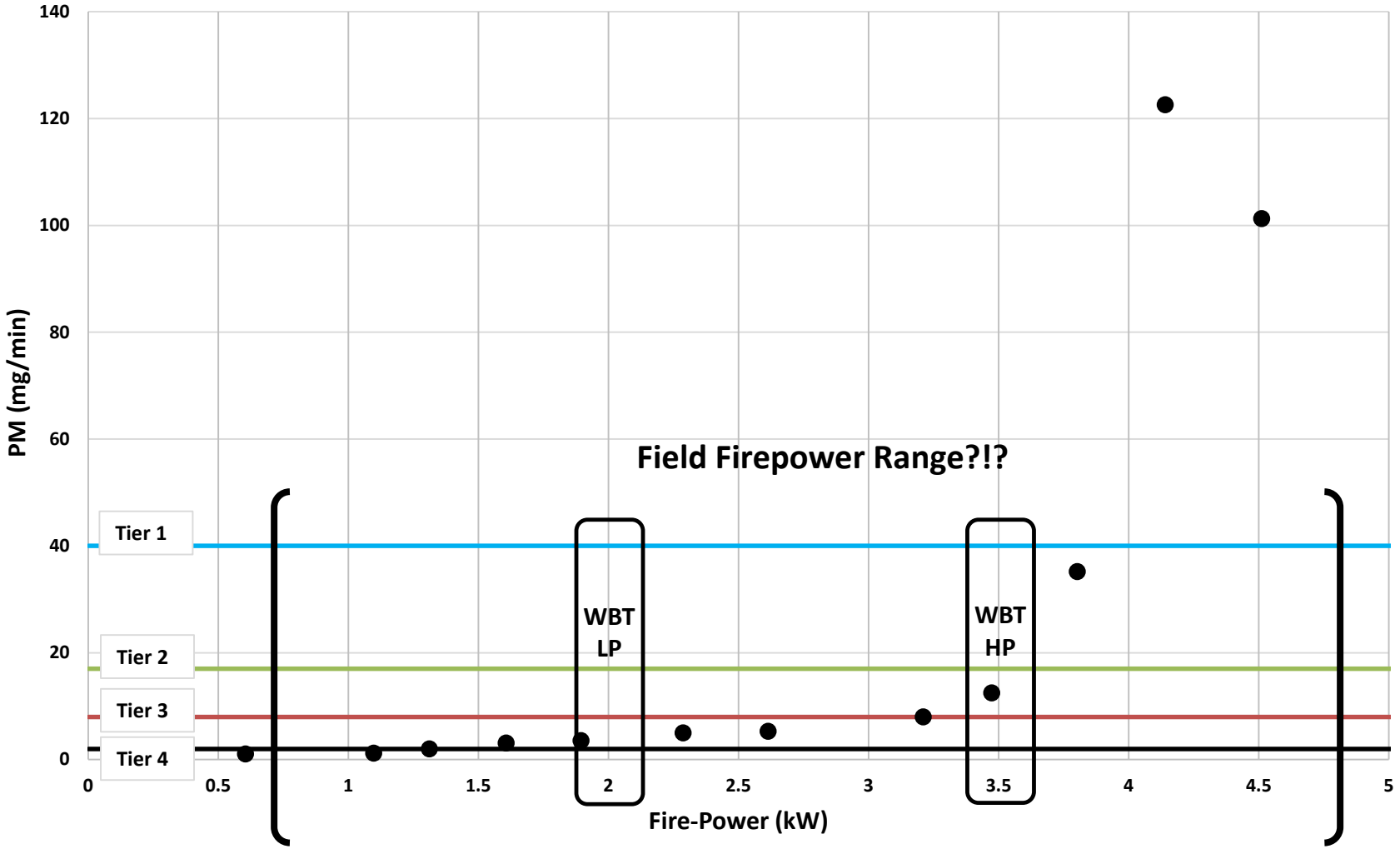

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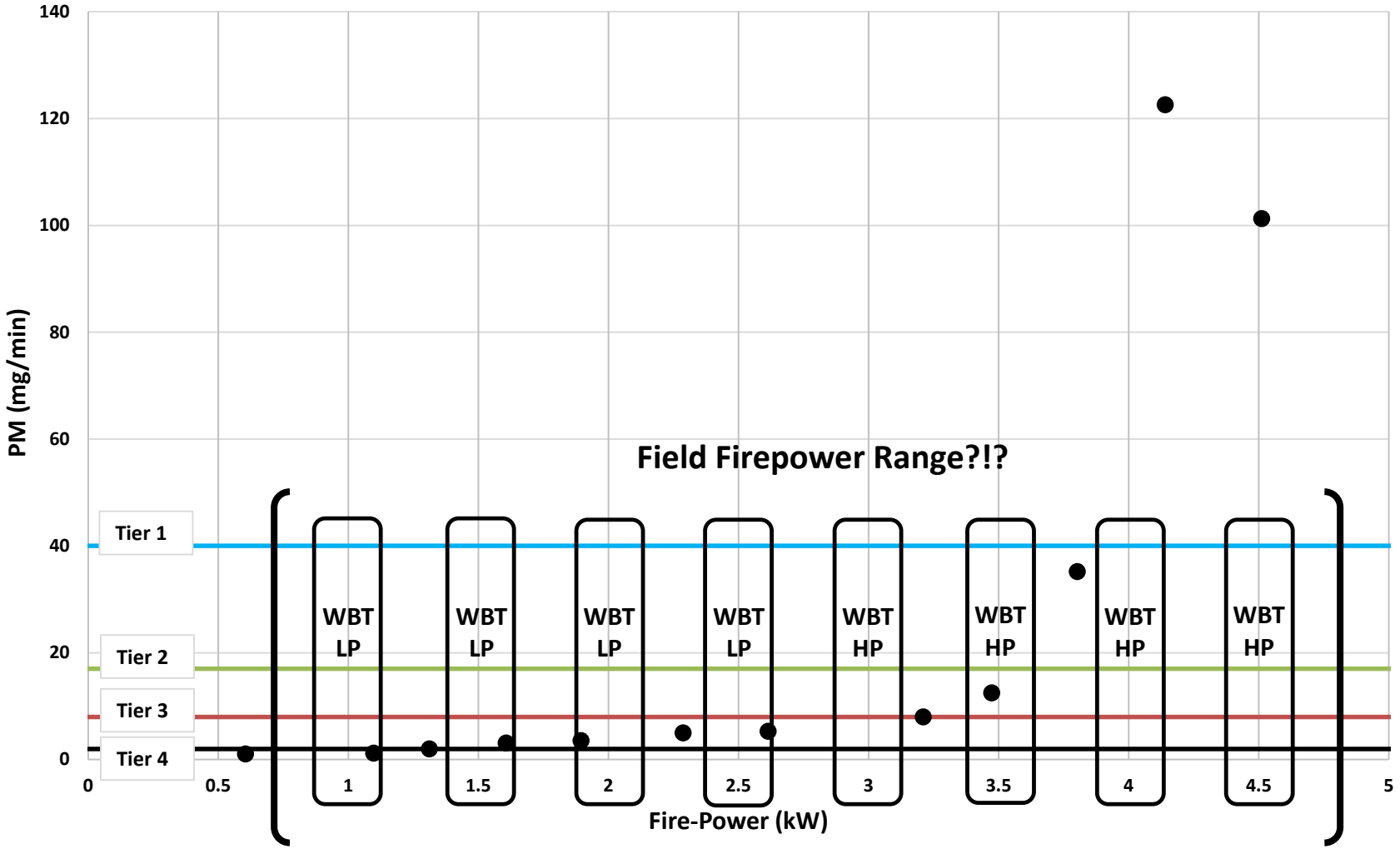

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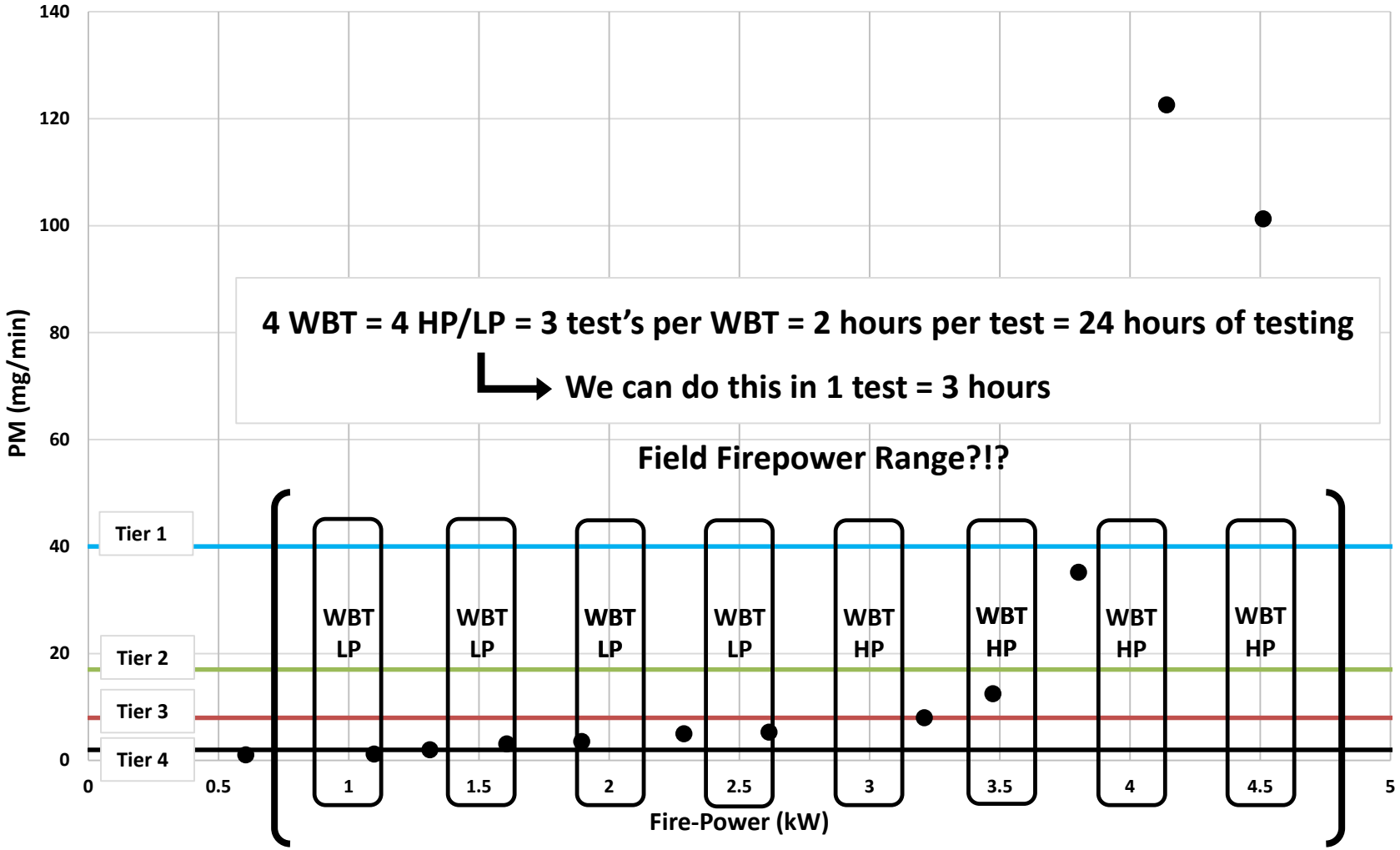


What we know:

- Stove operation can vary significantly in the field.
- Stove operation impacts performance.

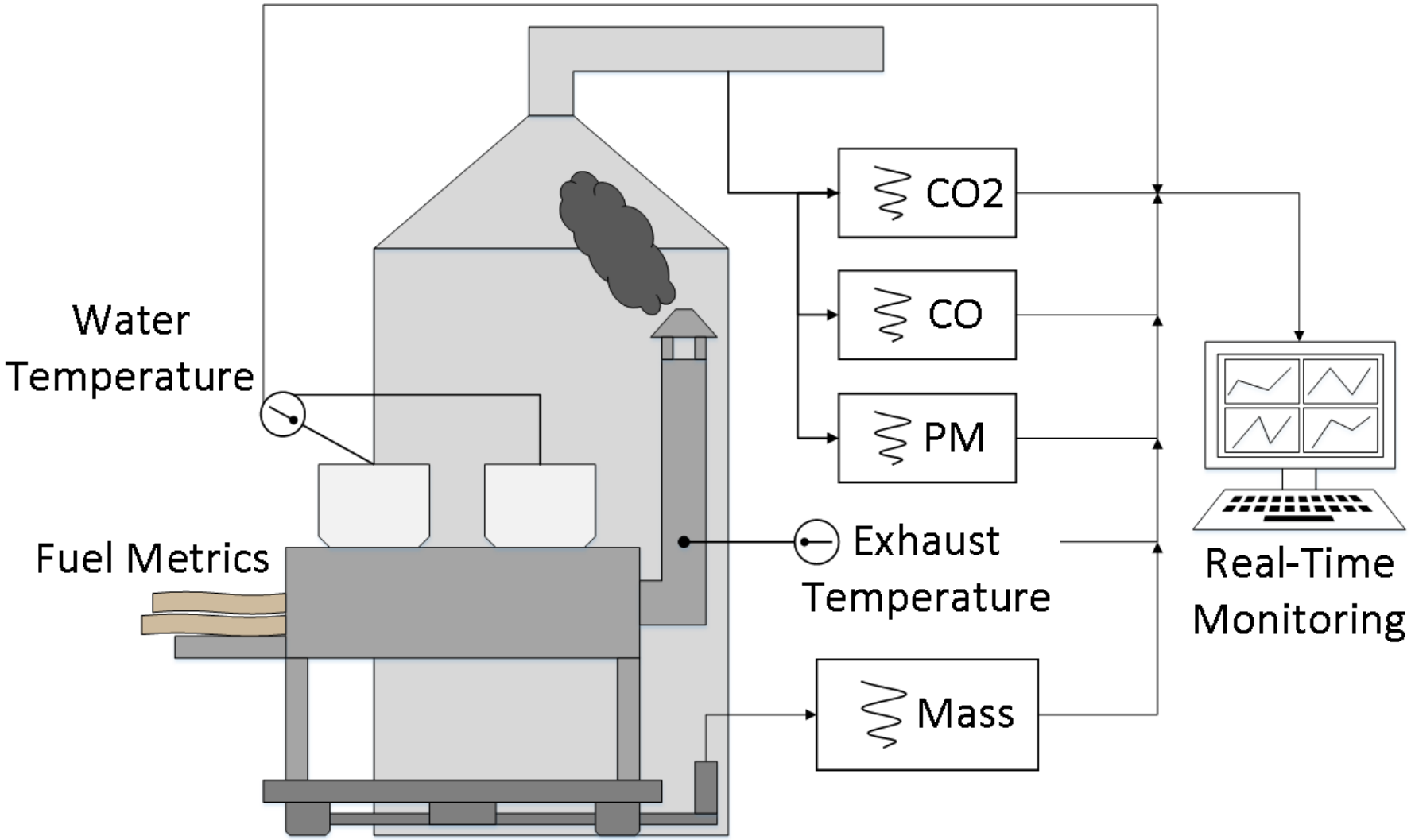
What we need to know:

- How the stove is operated/used in the field.
- Emissions and efficiency in the field.
  - ↳ Difficult to determine without extensive field research…

Potential Solution:

- Use exhaust-temperature to determine the distribution and range of firepower's expected during a typical day in the field.
- Replicate stove usage in the lab based off of field-firepower distribution.
  - ↳ Improved prediction of performance in the field.
  - ↳ Stove design that meets performance goals in the field (NOT just the lab).

Lab Measurements

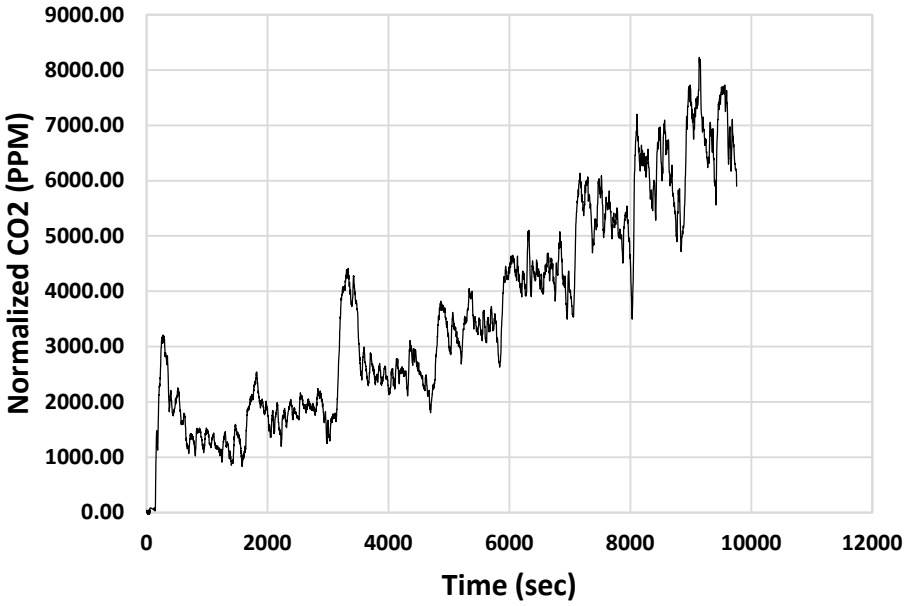


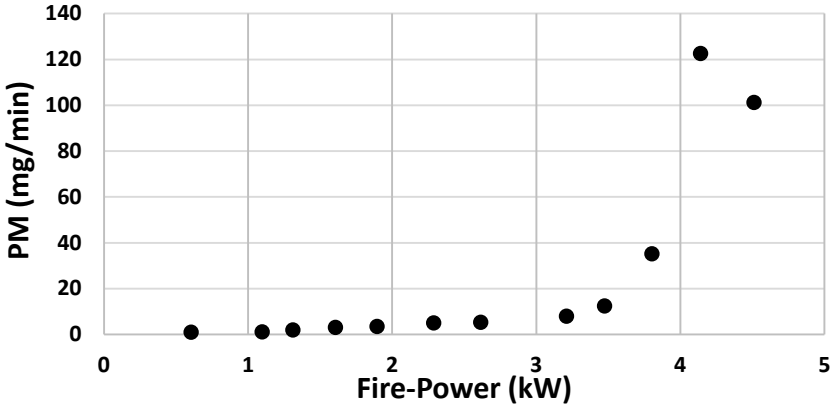
Lab Testing

Test Procedure:

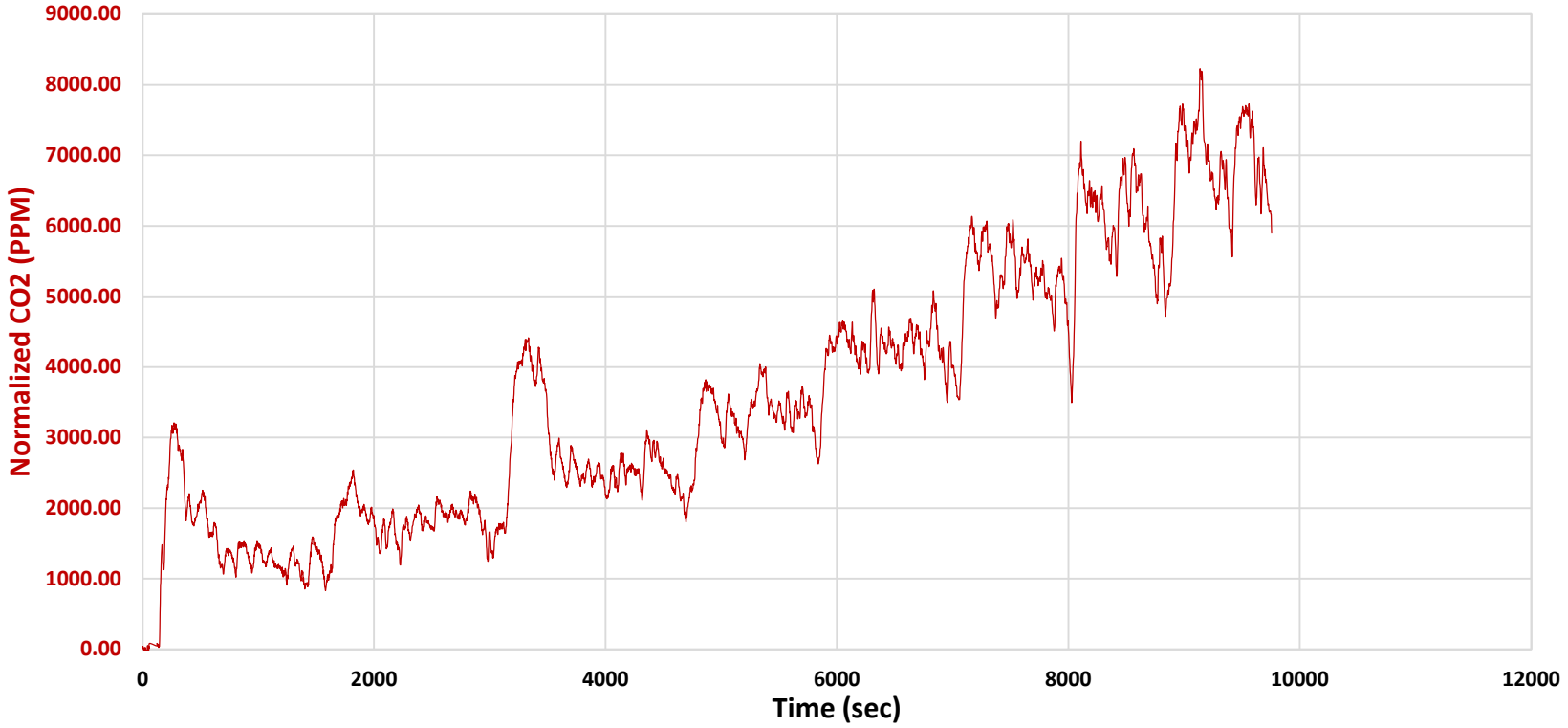
Firepower-sweep – Operate stove continuously throughout a wide-range of firepower's.

- ✓ Use CO2 as indicator of firepower.
- ✓ Correlate exhaust temperature to firepower.
- ✓ Collect behavior-data of emissions, thermal-efficiency, combustion-efficiency, component temperatures, etc.

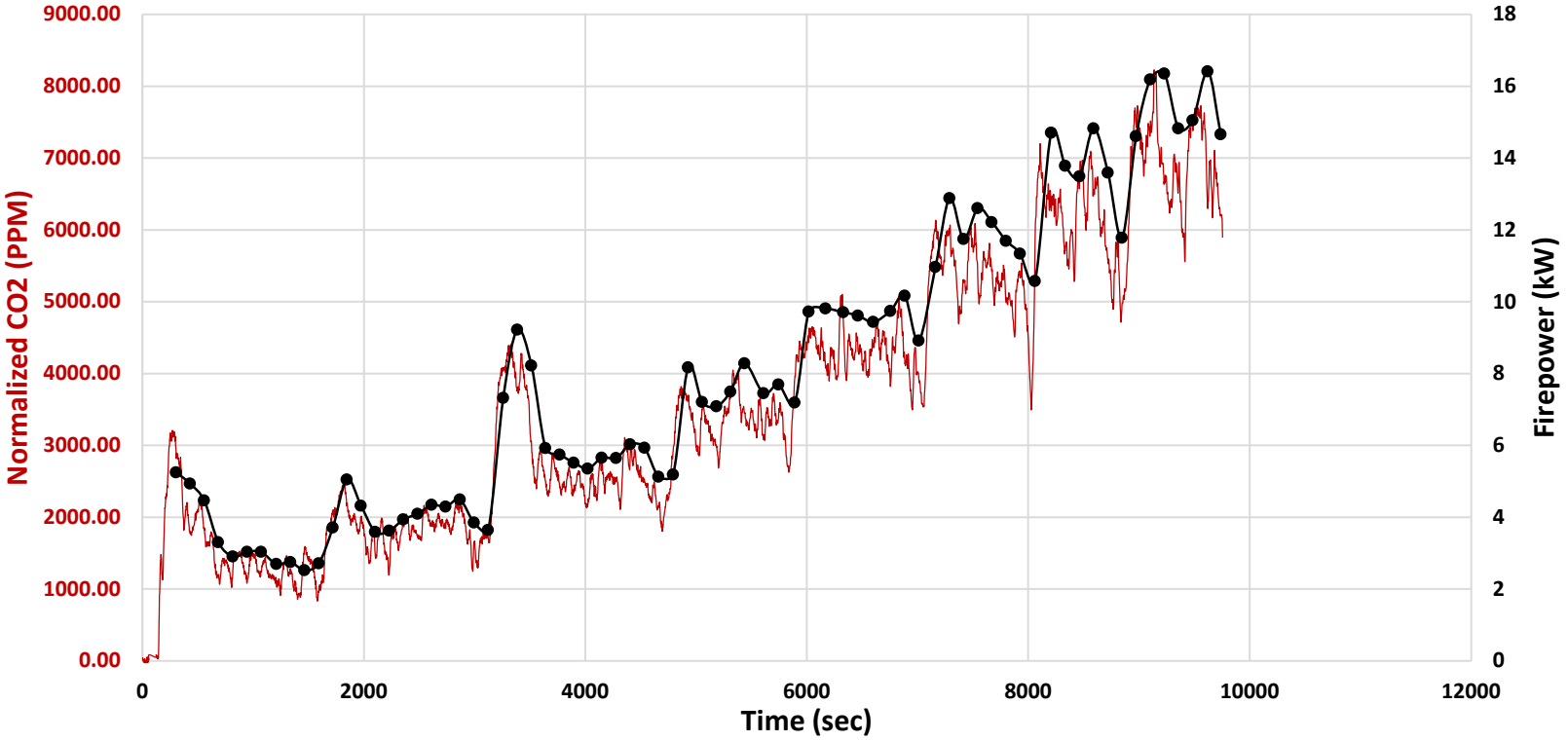




Lab CO2-Concentration



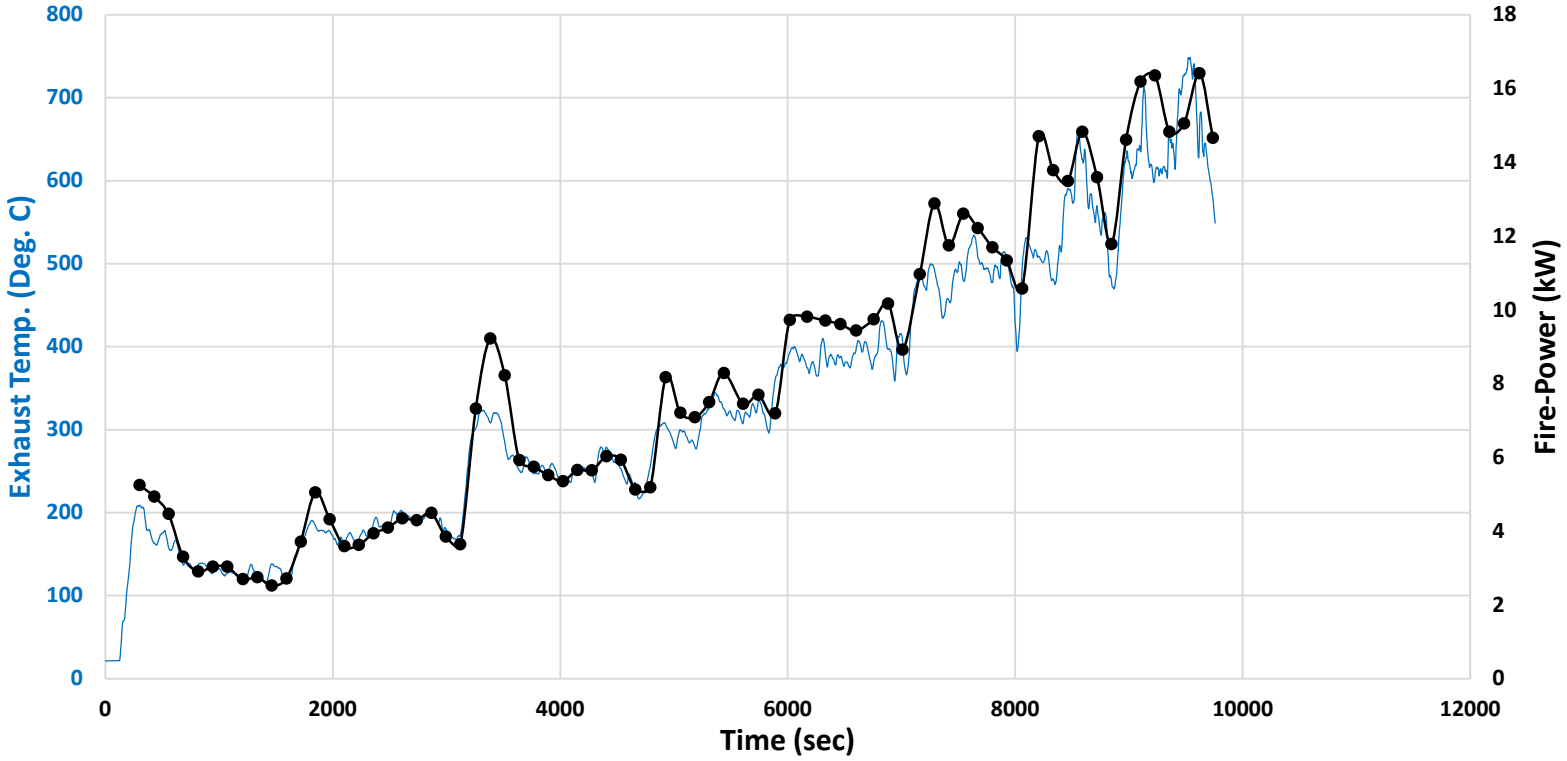
Firepower from CO2



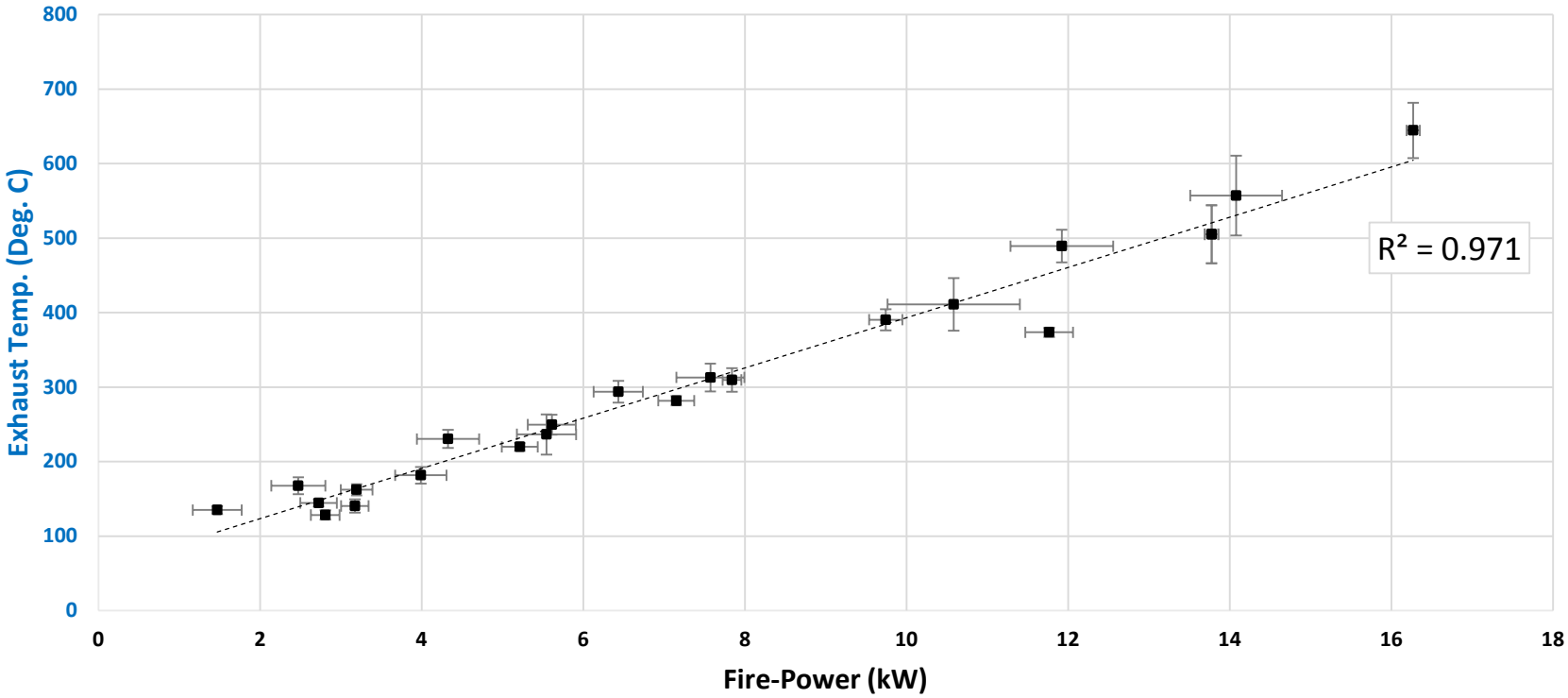
Burn-Rate = f(CO2, C-ratio,Sample-Dilution, Time)

Firepower = f(Burn-Rate, Heating-Value, Time)

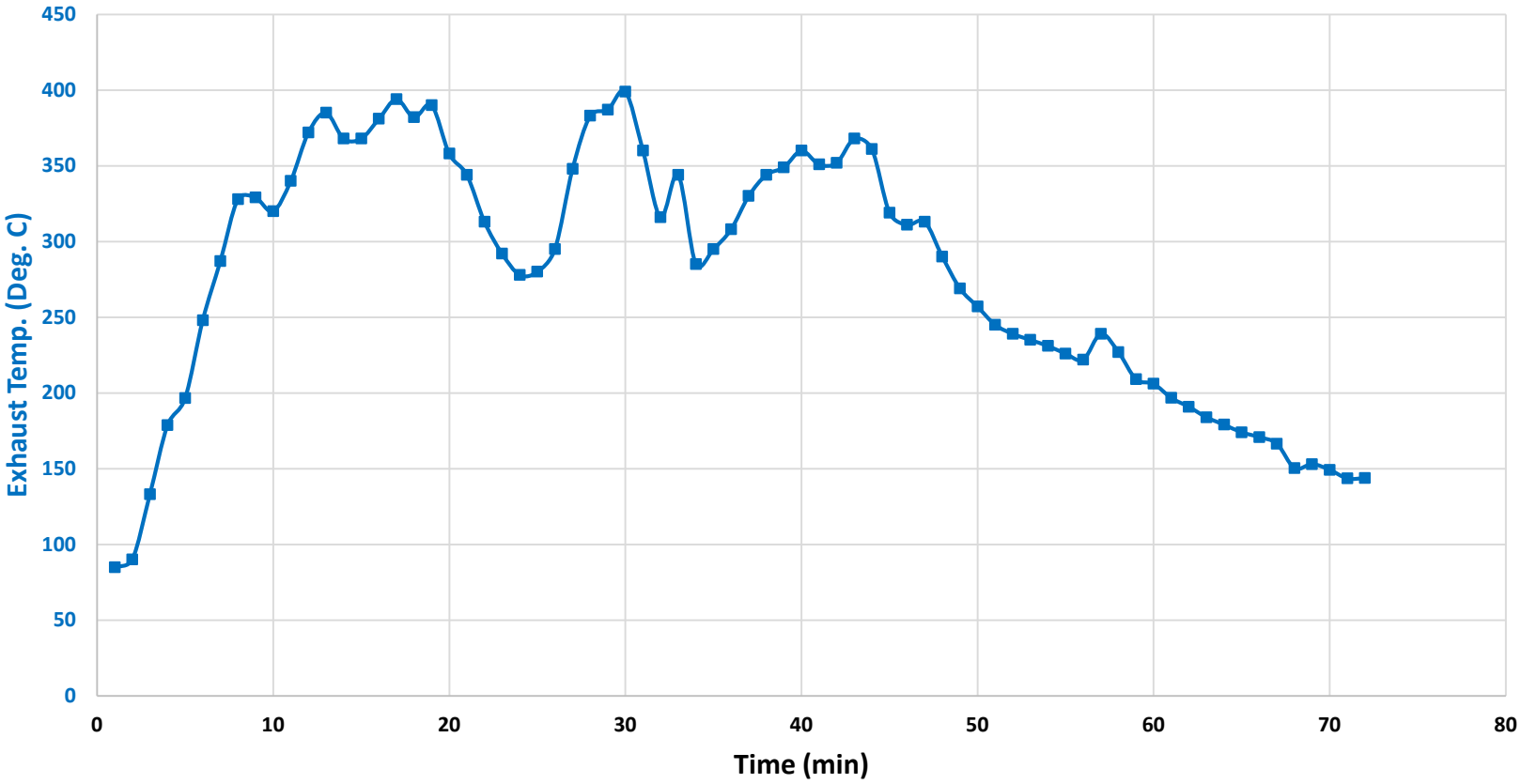
Firepower and Exhaust-Temperature



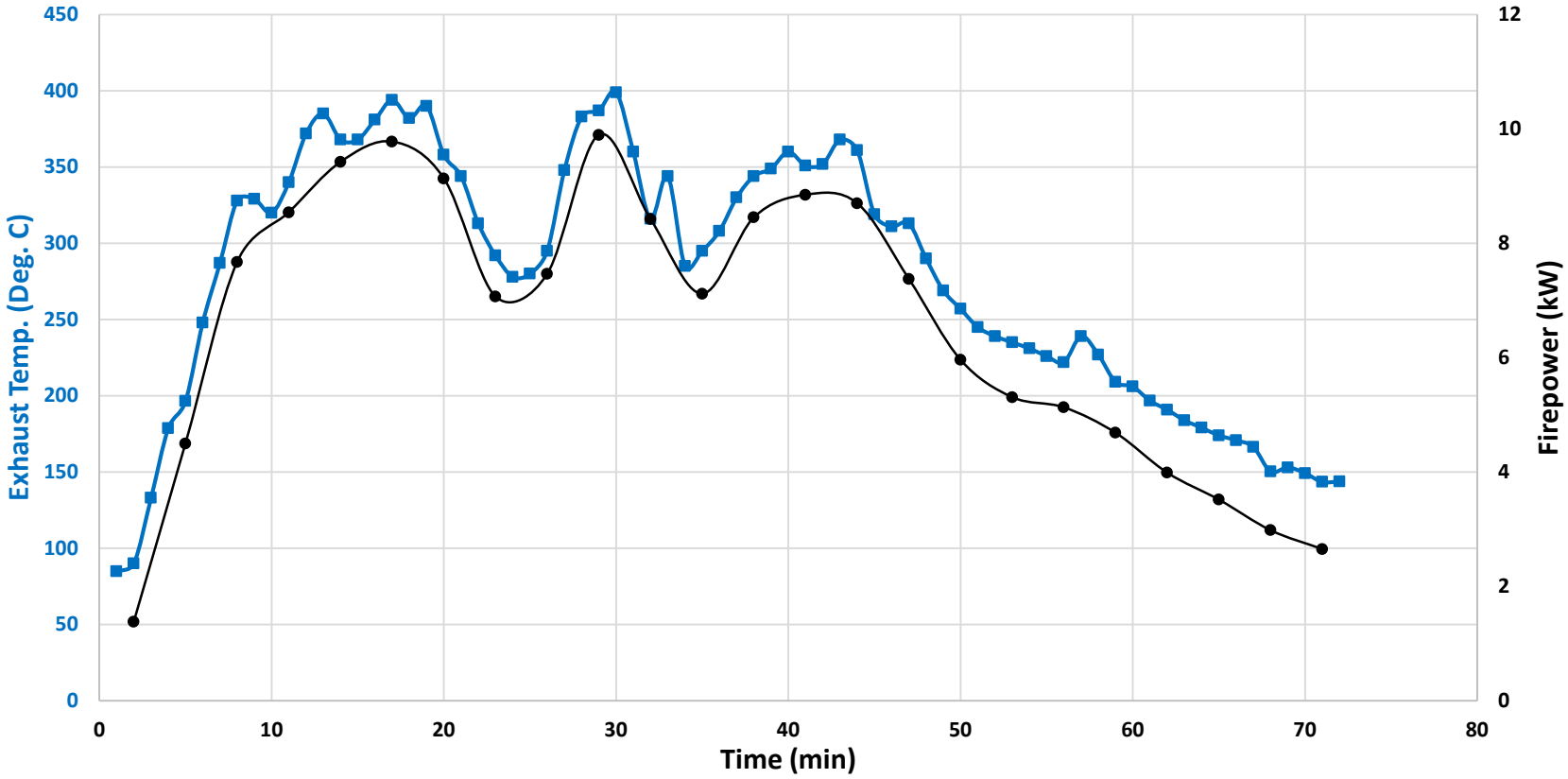
Correlation Between Firepower and Exhaust-Temperature



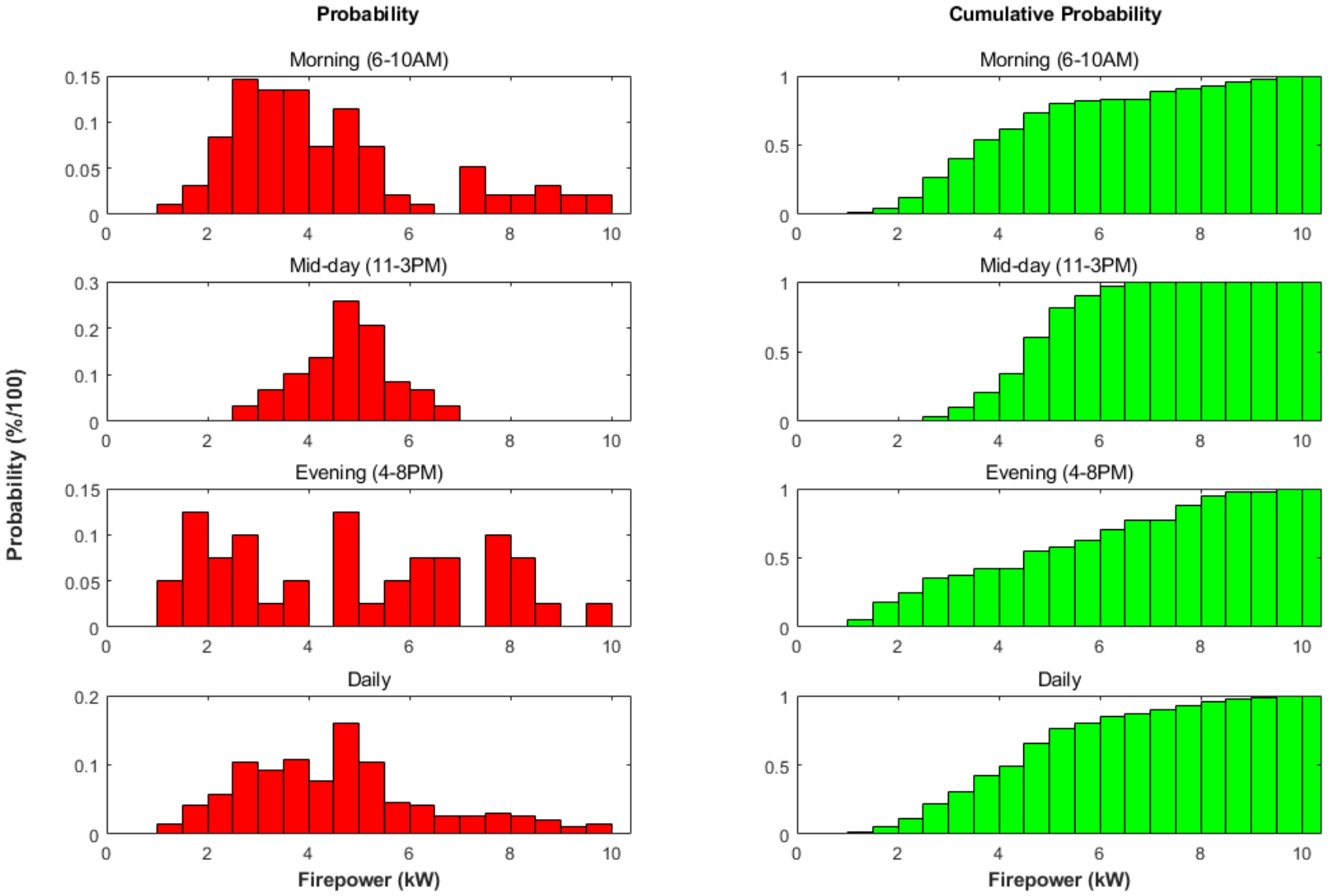
Field Exhaust-Temperature



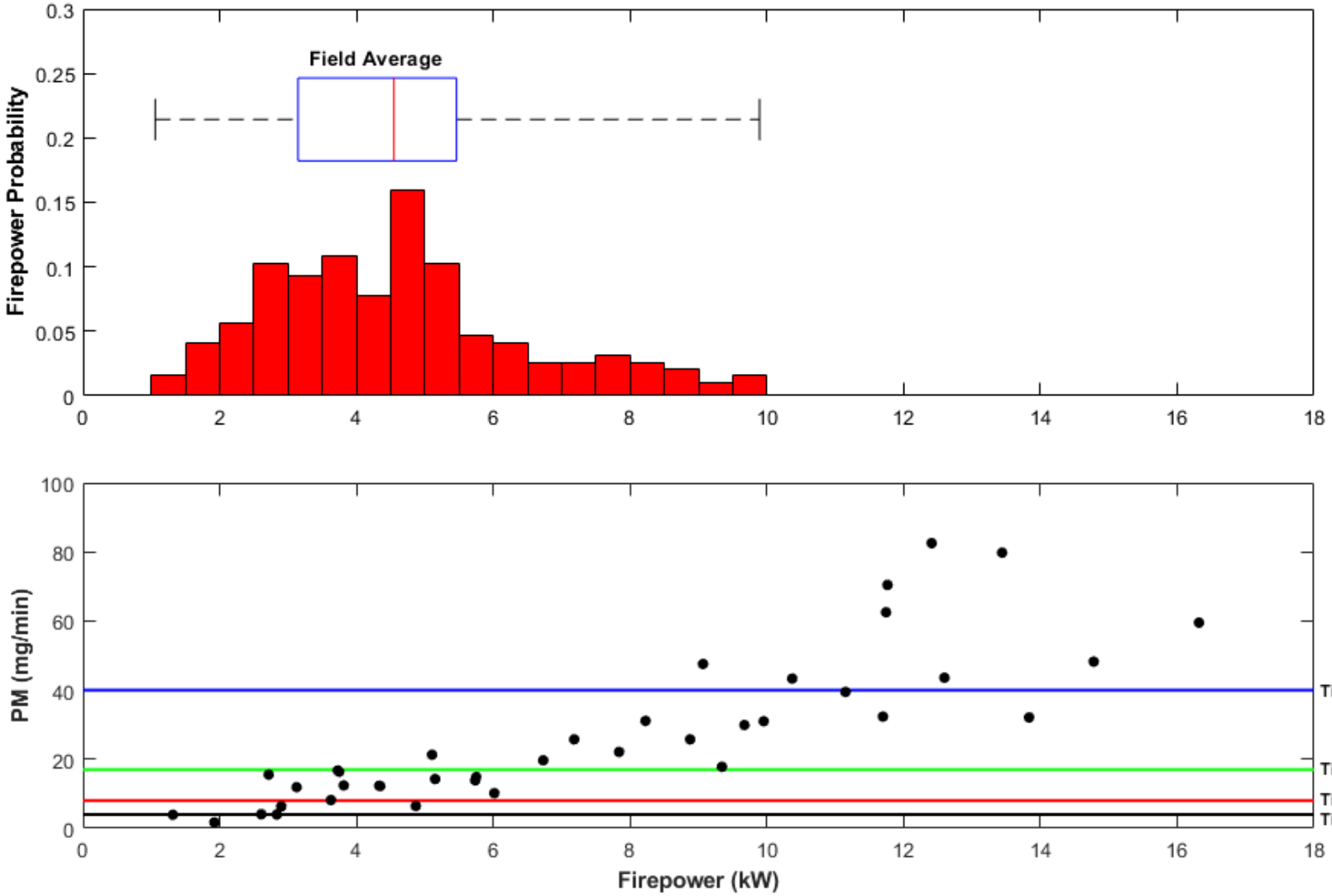
Field-Firepower from Field Exhaust-Temperature



Field-Firepower Distribution



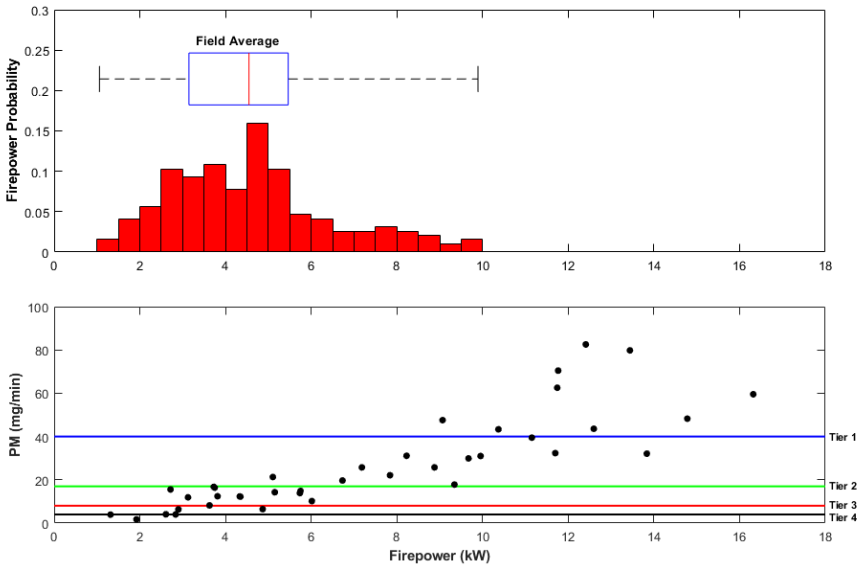
Field PM Analysis



Full Performance Behavior

Each stove design and unique cooking tasks:

- Particulate-Emissions
- CO2 and CO
- Thermal-Efficiency
- Combustion-Efficiency
- Component-Temperatures



1. Predict daily performance using firepower distribution and performance behavior.
2. Informed design decisions.
3. Understand impact of design alterations.

Current Investigations

Exhaust-Temperature/Stove-Performance Model Development:

What are the impacts of –

- Wood size and fuel moisture.
- Ambient temperature and humidity.
- Stove deterioration.
- Cooking technique (pot, stove-top, open stove-top, etc.).
- Cyclic behavior (HP → LP, LP → HP, etc.).

Plancha Efficiency:

- Burner AND stove-top efficiency.

Field Survey Improvements:

- Daily temperature data for each household.
- More specifics about cooking habits/techniques/wants/needs
- Increase sample size!!!

Questions?