

# DOE Bioenergy Technologies Office (BETO) 2021 Project Peer Review

## Advancing wood heater evaluation methodology for accelerating innovation



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Systems Development and Integration (SDI)

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**BROOKHAVEN**  
NATIONAL LABORATORY



BROOKHAVEN SCIENCE ASSOCIATES

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# Project Overview

## Objective Statement

Develop low-cost measurement tools and analysis to enable manufacturers to estimate performance in **expensive** standard certification tests.

This will remove complex testing as a barrier to innovation.

Developed methods will **NOT** be a certification test



## Short term goals

1. Identify major hurdles preventing innovation of wood heaters
2. Obtain feedback from experts on technical approach for simplified testing methodology
3. Establish a working group to guide our research and maximize impact




# 1 – Management



**Energy Conversion Group**  
 Thomas Butcher  
 Rebecca Trojanowski



**Energy Technologies Area**  
 Vi Rapp  
 Julien Caubel

Task	Description 	Lab
1	Report evaluating protocols and propose equipment to review with manufacturers. and validate proposed instrumentation costs	Shared
2	Wood heater workshop	Shared, BNL lead
3	Validate facilities and develop framework for simplified test method	Shared
4a	Evaluate, validate and optimize simplified test protocols for hydronic heaters and warm air furnaces.	BNL
4b	Evaluate, validate and optimize simplified test protocols for wood space heaters	LBNL
5	Preliminary evaluation of simplified protocol use in the field	Shared
6	Publish simplified test protocol and results	Shared



**Working group established to guide project**  
 Includes industry, academia, and policy makers


# 1 – Management



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Risk 	Probability / Severity	Response	Description
Expensive Equipment	Low / Moderate	Developing correlations between high-accuracy equipment & lower-cost sensors that could lead to different options for manufacturers in terms of the accuracy/cost tradeoff.	Protocol requires equipment that is too expensive
Dilution Sampling	Low / Moderate	Explore low-volume sampling from the stack with dilution before analysis.	Dilution sampling setup for field testing

# 2 – Approach



## Technical Approach

1. Based on prior work in the emissions and ambient air quality field, published literature, and commercial practice, the team will down select the measurement method and operating protocol.
2. The team will engage with industry to ensure our technical approach will meet their needs.
3. The approach will require extractive dilution sampling.
4. The team will validate the method against established certification tests with a target of 10-25% accuracy.
5. Lab tests will be extended into the field to evaluate potential use for evaluating actual performance and local air quality impacts.

## Challenges

1. Wide dynamic range range in flue gas pollutant concentrations;
2. Cost of measurement methods;
3. Needs to be useful in climate of rapidly evolving certification test methods;
4. Acceptance by community.



# 2 – Approach



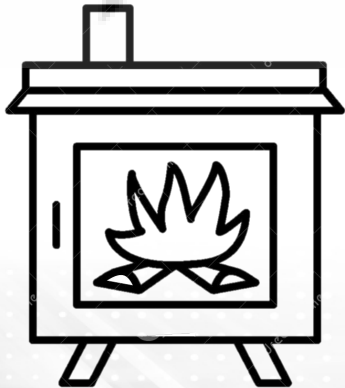
Go/No-Go Decisions	
Description	Date
Complete framework for simplified protocol for evaluating performance of wood heaters and solicit feedback from relevant stakeholders.	6/30/2021



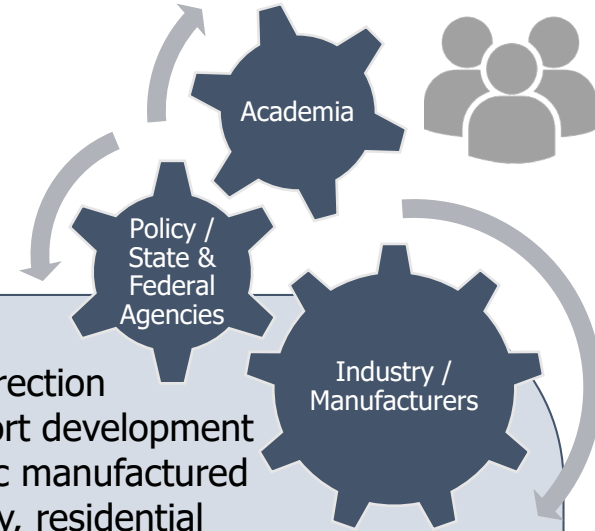
Progress Metrics	
Description	Date
Demonstrate simplified test method is capable of accurately predicting desired performance metrics to 10% to 15% for pellet stoves and 25% to 30% for cord wood stoves compared to ASTM E2779, Disseminate test method and results to community and relevant stakeholders.	6/30/2021
Demonstrate simplified test method's potential for field evaluation of efficiency and emissions performance. Publish field testing emission results.	12/31/2022

# 3 – Impact

Direct combustion of biomass in homes is the most common use of woody feedstocks but is the **dominant factor in ambient air quality** in many parts of the U.S.



- Addresses Congressional direction (S. Rept. 115-422) to support development and testing of new domestic manufactured low-emission, high efficiency, residential wood heaters.
- Established compliance for new residential wood heaters, hydronic heaters, and forced-air furnaces by developing a simple testing protocol to accelerate technology innovations and commercialization of clean and efficient wood heaters.
- Enabling this technology innovation will allow millions of families, schools, institutions, and corporations access to affordable, efficient, and clean wood stoves that supports the growing bioeconomy.
- Also supports a parallel BETO initiative to develop advanced biomass combustion products with increased efficiency and reduced air pollutant emissions (DE-FOA-0002029). Performers under this FOA can leverage test methods developed under this project.







# 4 – Progress and Outcomes



First workshop with working group – July 2020



## Key Findings

- All interested and willing to act as project advisors;
- Industry expressed strong need for lower cost development methods;
- Helpful for manufacturers to have data from the field on their units;
- Manufacturers want to stay ahead of their competitors;
- Manufacturers want to move towards real-time instrumentation.

Company	Area	Expertise
<b>Industry</b>		
Hearth Lab Solutions	NE	Stove testing
Blaze King	NW	Stove Manufacturer
Woodstock Soapstone (retired)	NE	Stove Manufacturer
Myren Consulting	NW	Stove testing
Tarm Biomass USA	NE	Boiler Manufacturer
Windhager USA	NE	Boiler Manufacturer
WoodMaster	MW	Boiler Manufacturer
<b>Academia/Research</b>		
University of Rochester	NE	Particulate measurements
USDA Forest Service	MW	Testing/Evaluation of gasifying units
Cornell University	NE	Particulate measurements
NYS Department of Health	NE	Particulate measurements
<b>Policy</b>		
NESCAUM	NE	
NYSERDA	NE	



# 4 – Progress and Outcomes



## Task 1: Completed Review of Certification Test Methods World-wide.

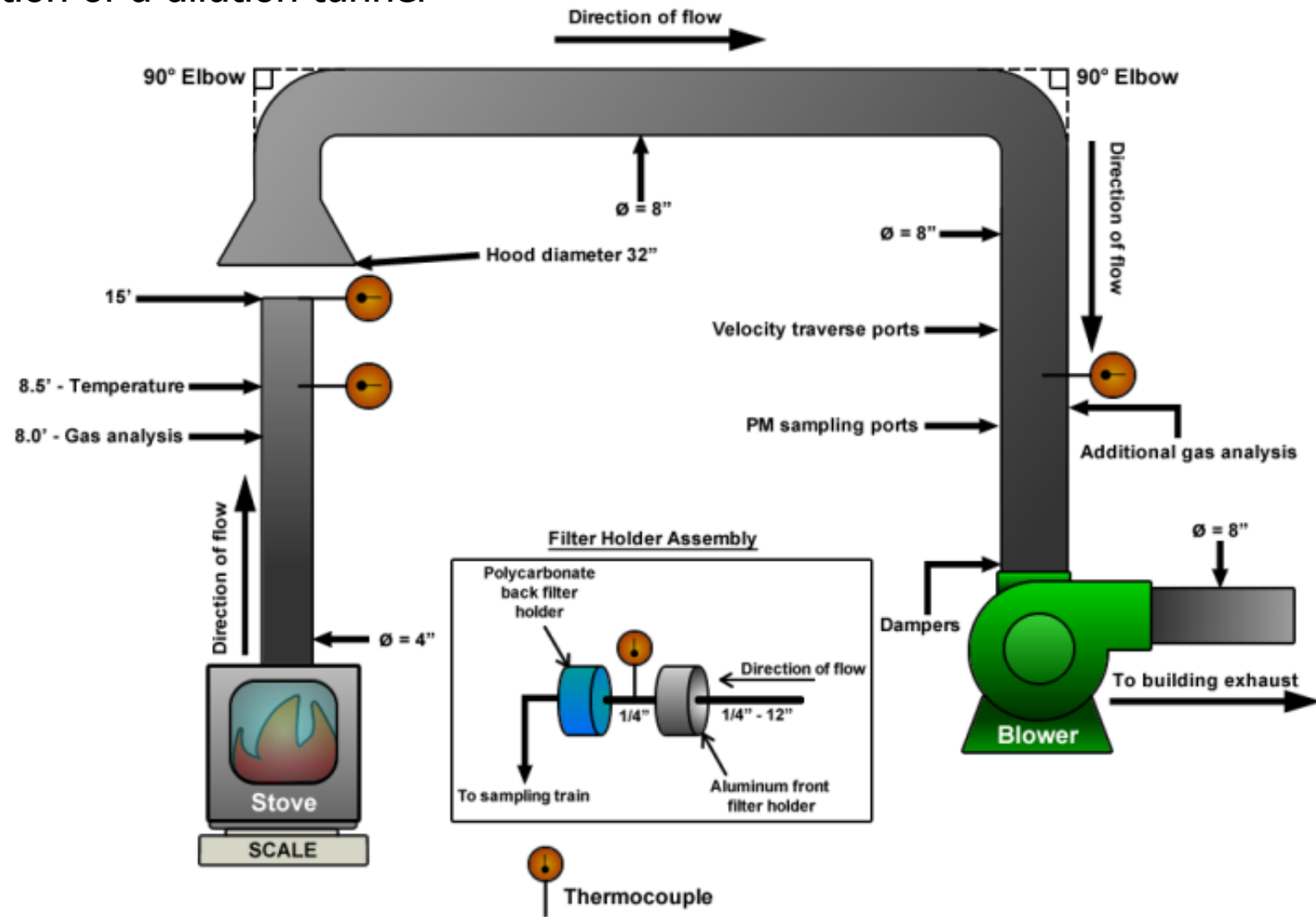
### Highlights:

- U.S. methods established by EPA and ASTM
  - Based on dilution tunnel and testing in fixed load categories
  - PM based on integrated filters from dilution tunnel
- European test standard EU-wide but PM measurements vary
  - Most countries use hot in-stack filter and estimate condensables by gas-phase hydrocarbon measurement
- New test methods emerging!
  - A new “Be-Real” method has been developed in Europe which involves realistic duty cycles and integrated hot filter measurements. **Not yet adopted**
  - In the U.S. duty cycle vs fixed load tests being proposed with potential use of **real-time PM measurements**

Note: Under typical combustion conditions, roughly half of the PM are condensables and the particulates are carbon rich. Under very clean conditions the particulates are largely inorganic and condensables are low. **Any method we develop must be able to handle all conditions.**

# 4 – Progress and Outcomes

Illustration of a dilution tunnel



# 4 – Progress and Outcomes



## Task 1: Completed Review of Particulate Measurement Methods.

### Highlights:

- Dilution is necessary to accurately capture condensables
  - A full dilution tunnel is too expensive for the goals of this project and not easily used in field studies
  - Small sampling diluters are envisioned—many designs exist, and we have considerable experience with different designs
- Integrated filters do not provide the time resolution needed
  - TEOM (Tapered Element Oscillating Microbalances) could be a good option but expensive (?)
- In Europe, lower cost integrated portable test devices which use TEOM-type devices are available and used for routine field testing
  - We have considerable experience with these, but accuracy and cost may not meet our goals—needs to be discussed with our working group
  - Optical methods are low cost but do not capture the smallest particles and correlation with filter-based methods depends on size distribution
    - This is under consideration but will require considerable testing to develop accurate correlations.

### Recommendations from Task 1 Report:

- More efficient and cost-effective methods;
- Key aspects of burn phase needed for simplified protocol;
- Potential solution to lab and field testing.

# 4 – Progress and Outcomes



First Lab Studies – Tests of a Single Stove at Both BNL and LBNL:



Existing biomass combustion facility with dilution tunnel at BNL

Dilution tunnel facility built at LBNL

# Summary

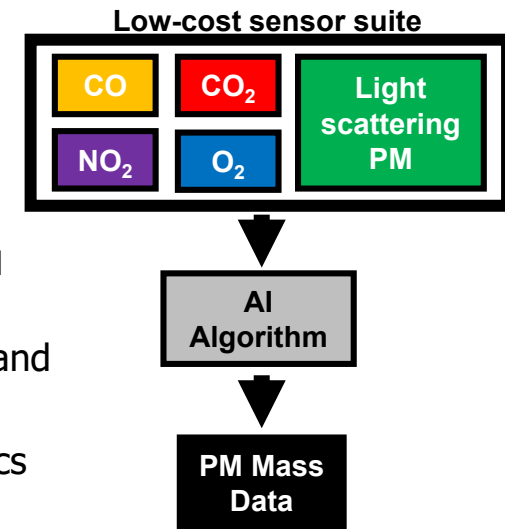


## Project Objectives

- Develop simplified test method to reduce industry costs and support innovation of new wood heaters
- Identify gaps and improvements with current test methods and opportunities to correlate with in-home performance
- Evaluate potential to extend to field measurements

## Recommendations for protocol and measurement methods

- **Real-time measurements** of emissions to enable manufacturers to target specific operating phases in developing cleaner products
  - Harmonized evaluation: use simplified instrument suite for both lab and field testing
- Must be **easily conducted** in-house by manufacturers to guide R&D and prepare for certification tests
- Include startup, reload, shutdown, and steady-state performance metrics consistent with other methods
- Can **quickly and affordably provide performance metrics** to guide and inform design decisions prior to investing in costly certification testing



## Future plans:

- HPBA conference presentation
- Planning online workshop



# Quad Chart Overview (AOP Project)

## Timeline

**Start:** January 1, 2020

**End:** December 30, 2022

	FY20	Active Project
DOE Funding	(10/01/2019 – 9/30/2020) \$360,000 BNL \$300,000 LBNL	(negotiated total federal share over active project) \$1,095,692 BNL \$900,000 LBNL

## Project Partners

- Lawrence Berkeley National Laboratory

## Barriers addressed

(List 1-2 technical barriers from the [Multi-Year Program Plan](#) addressed by your project. This can be found in your Quarterly Report file.)

**No Barrier Relevant**

## Project Goal

Develop simplified wood heater performance test methods that will reduce extensive **cost** and **time** associated with repeated certification testing, and provide approach for evaluating wood heaters in the field

## End of Project Milestone

Demonstrate test method's ability to predict performance in certification tests and potential for field evaluation of efficiency and emissions performance. Publish field testing emission results.

## Funding Mechanism

Negotiated AOP