DE-FOA-0002396 Topic Area 4: Residential Wood Heaters

Development of Forced-Air Combustion Systems with Automated Controls to Reduce Emissions from Cordwood Room Heaters in Everyday Use

Oregon State University et al.

Summary/Abstract for Public Release

PI: Dr. Nordica MacCarty, Associate Professor of Mechanical Engineering, Richard & Gretchen Evans Scholar of Humanitarian Engineering

Objectives: This project aims to undertake the development needed to reduce PM emissions throughout the real-world burn cycle of cordwood room heaters by incorporating turbulent jets of forced air into the firebox. To achieve this, we will 1) develop two TRL6 prototypes with closed loop controls. These will be designed as retrofits to fit common existing installed room heaters that exceed the emissions and efficiency requirements of this FOA when installed. They will be tested against UL 1428 for safety certification, undergo 3rd party performance testing by PFS-TECO, and be validated for user acceptance and performance through field testing with partners in underserved and tribal communities. We will also 2) publish open-source design and scaling rules for forced air injection that encompass a large design space and include weighting factors for relevant parameters. These will be publicized through webinars and outreach to industry and academia so that they are applicable within the broader community.

Description: The major research tasks to achieve these outcomes include efforts in fundamental combustion experiments with small and full-scale prototypes to inform lightweight chemical reactor network models which will be used to inform prototyping and user testing in an iterative process. These prototypes will be certified and operationalized with closed-loop sensors and control algorithms. Plans are in place for market transformation with regulatory oversight and open-source knowledge sharing among partner manufacturers and the industry at large.

Impacts: Three substantial positive impacts are expected as a result of accomplishing the proposed work. First, a technology for reducing $PM_{2.5}$ emissions will be developed that can be applied to both ideal and non-ideal (e.g., wet wood, overfeed, etc.) operating conditions. Addressing issues with the latter is particularly important because these conditions contribute the most to $PM_{2.5}$ emissions, yet have often been neglected during research and development. The second major impact of this work is two retrofit kits that will be advanced to TRL6 in conjunction with the industry partner Blaze King. While our technology can be applied to future firebox design, enabling retrofit technology is key to enabling rapid and affordable implementation in underserved and tribal communities who suffer disproportionate health effects from wood smoke exposure. The third positive impact of our work is that key fundamental insights into the cause of reductions in emissions will be gained and broadly shared with the community. This step is critical for helping manufacturers and communities facing non-attainment for PM to implement viable and affordable reductions strategies.

Major participants: The project is led by a group of faculty at Oregon State University (Drs. MacCarty, Blunck, Hagen, Zhang) with expertise in combustion and design for underserved communities, supplemented by Combustion Consulting Services, LLC. Empirical prototype development and field testing will be provided by Aprovecho Research Center and manufacturer Blaze King Industries. User research will be supported by the Nez Perce and Warm Springs Tribes. Our team will also regularly consult our Industry Advisory Group including the Hearth Patio & Barbeque Association, US Stove and other manufacturers, and regulatory and advisory bodies.