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# Field Measurements of the C-Quest Capital Cookstove, Jet-Flame, and Solar Home Kit Program

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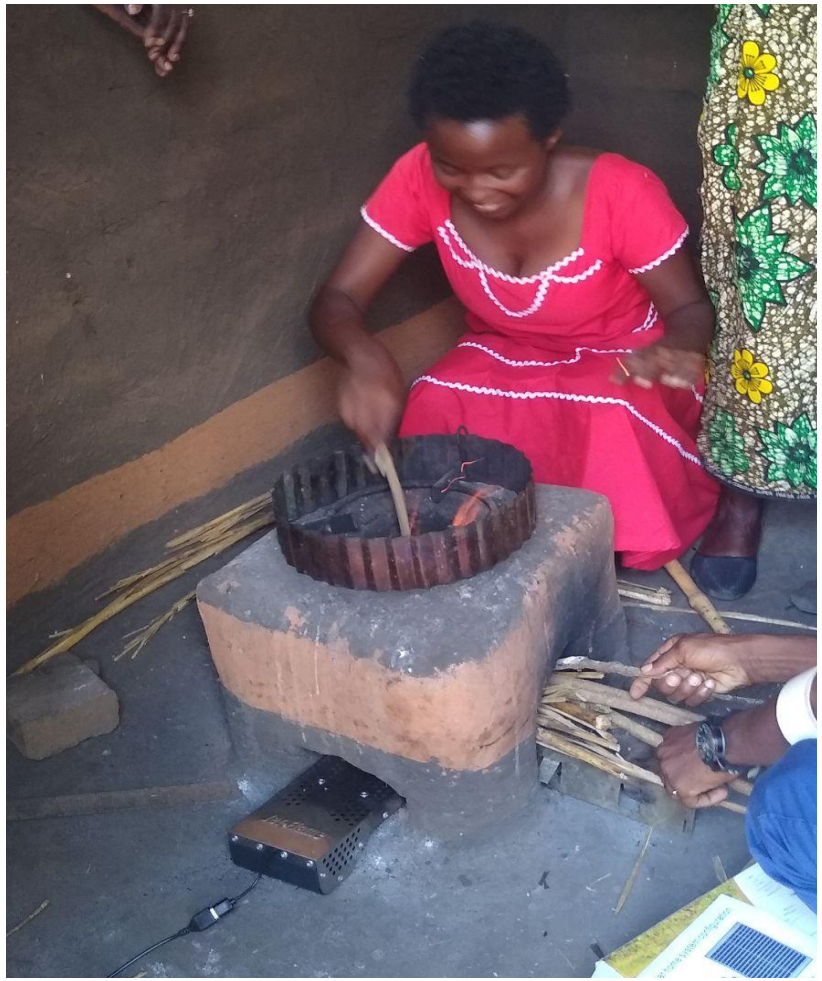
# The Jet-Flame

- Low-cost accessory to inject jets of turbulent air into the fire using a small electric fan

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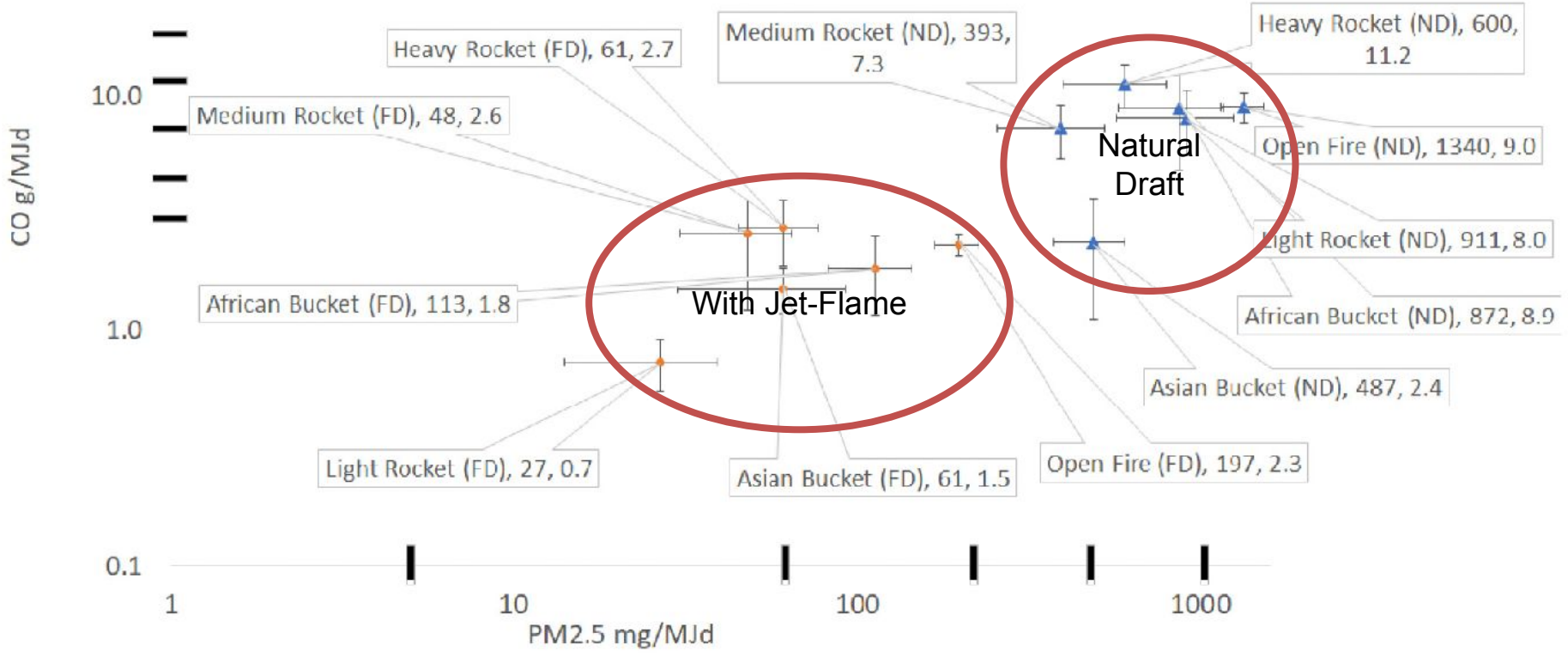
# Jet-Flame Laboratory Performance




Bentson et al, 2022 “Retrofitting stoves with forced jets of primary air improves speed, emissions, and efficiency: Evidence from six types of biomass cookstoves”. *Energy for Sustainable Development*

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# Jet-Flame Laboratory Performance

- Six different stove types tested with careful tending
- Global average $PM_{2.5}$ reduction with the Jet-Flame was 89% relative to the natural draft cases
  - larger relative improvements seen in the most rudimentary stoves.
- CO was reduced by a global average of 74%
- Thermal efficiency was also improved by 21-34%

Bentson et al, 2022 “Retrofitting stoves with forced jets of primary air improves speed, emissions, and efficiency: Evidence from six types of biomass cookstoves”. *Energy for Sustainable Development*

# Field Performance?

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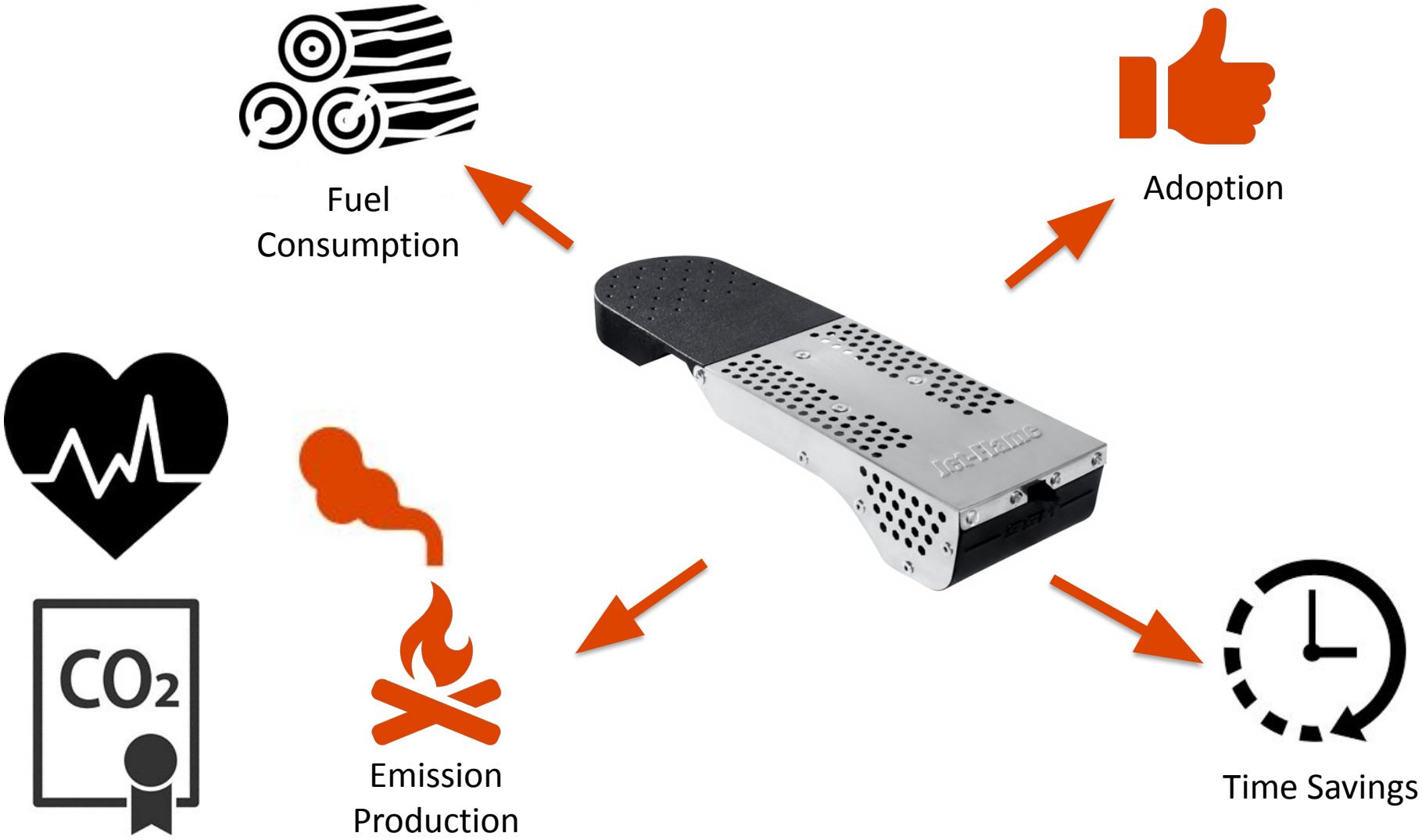

# Methodology

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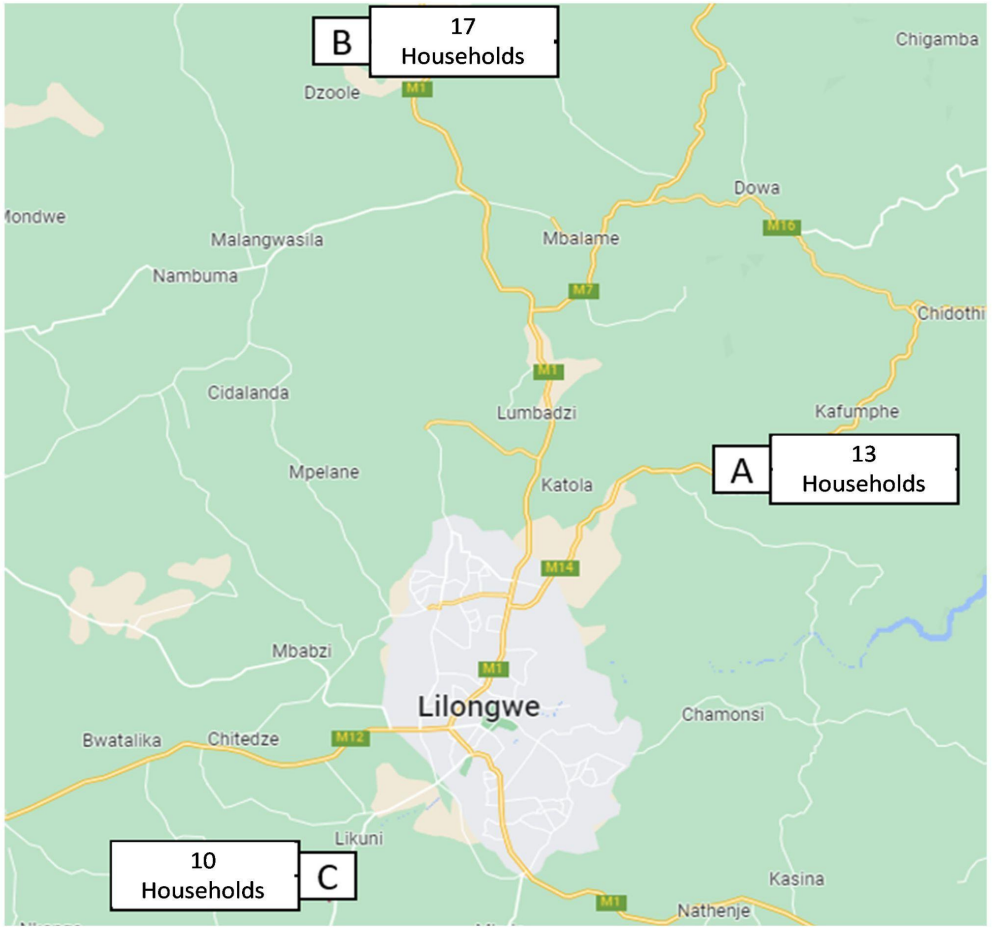
# Study Locations



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# Baseline Stoves

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# Intervention Study Arms

A) Single CQC Rocket

B) CQC Rocket with Jet Flame

C) Double CQC Rocket with Jet Flame

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# Integrated Sensor Suite

EXACT
Sensor

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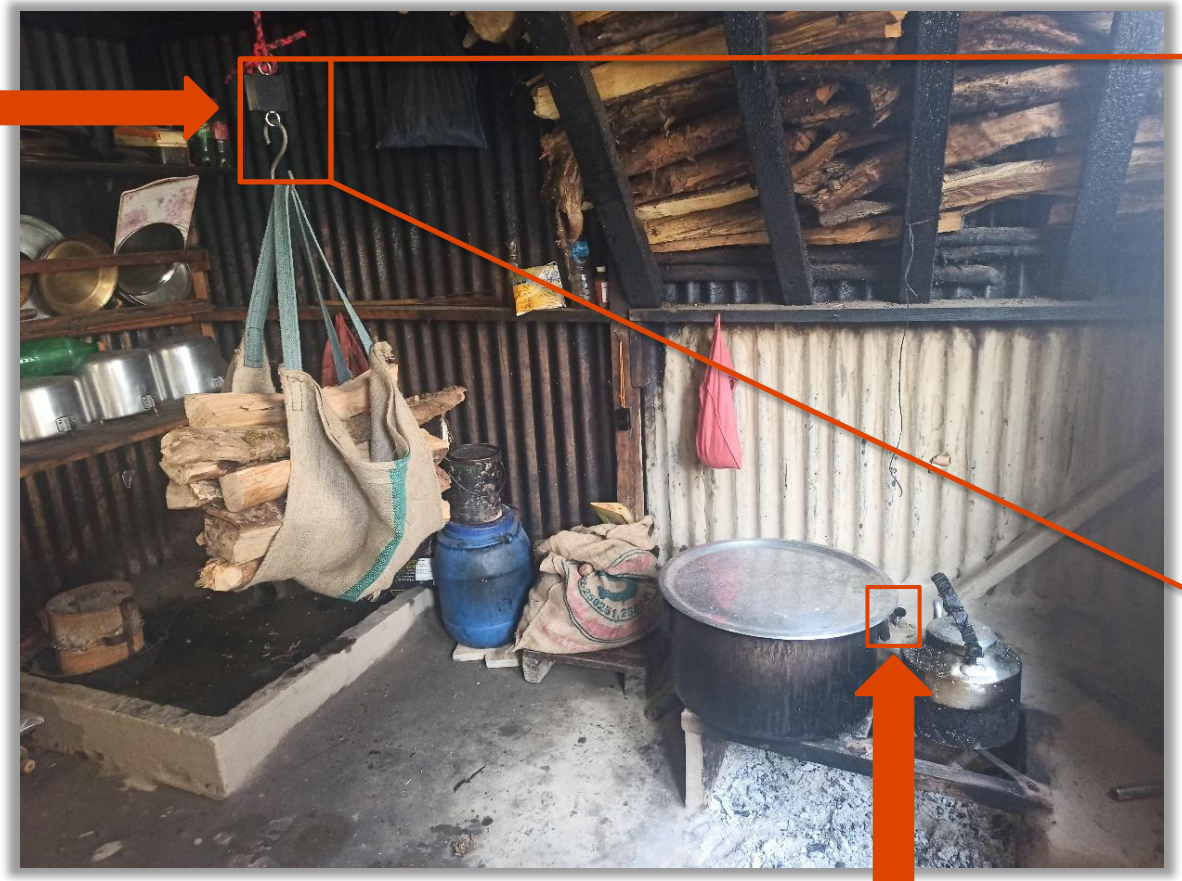
# Integrated Sensor Suite

FUEL
Sensor




EXACT
Sensor

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# Integrated Sensor Suite

FUEL Sensor

HAPEx Sensor

EXACT Sensor

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# Integrated Sensor Suite

FUEL Sensor

HAPEx Sensor

EXACT Sensor

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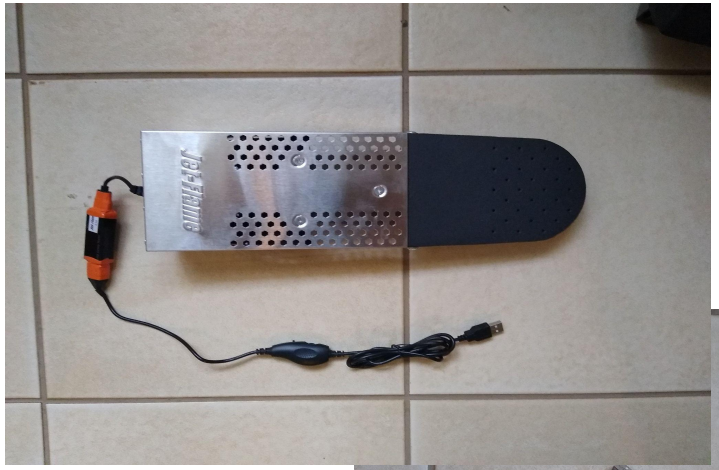
# Solar Home System & USB Power meter



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# KOBO Collect Surveys

- Household metrics
  - Number of People fed, kitchen sizes, fuel type, pictures
- Readings
  - Moisture readings, observations, sensor feedback
- Feedback about technologies

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# Results

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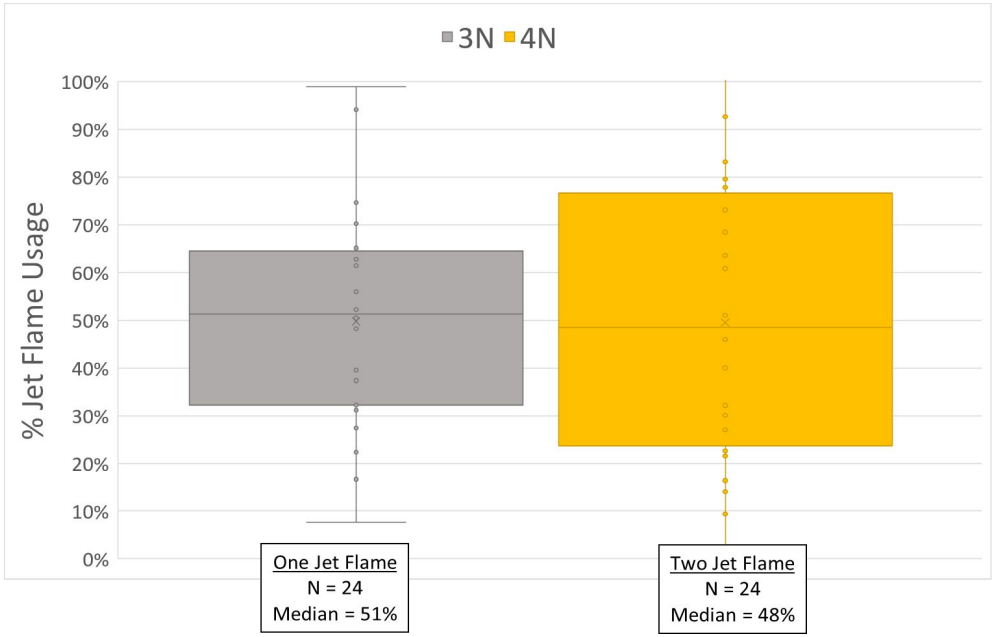
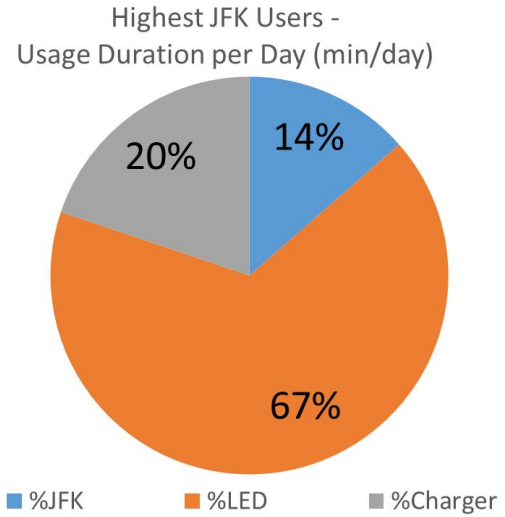
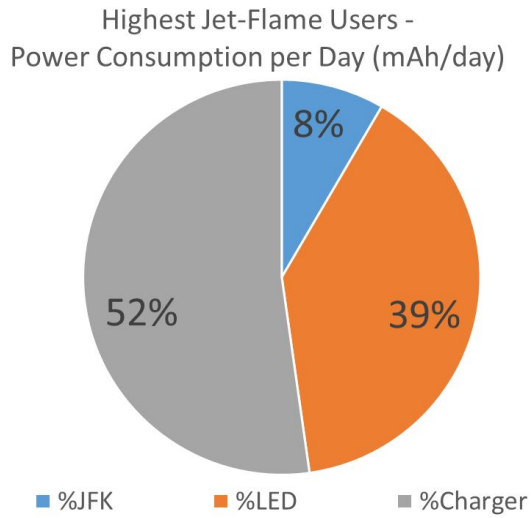
# Jet Flame Usage and Power Consumption




The solar panel charging system failed in ~50% of the households during the jet-flame study arm due to being mislabeled at the manufacturer, therefore power was not available for portions of the study in some households

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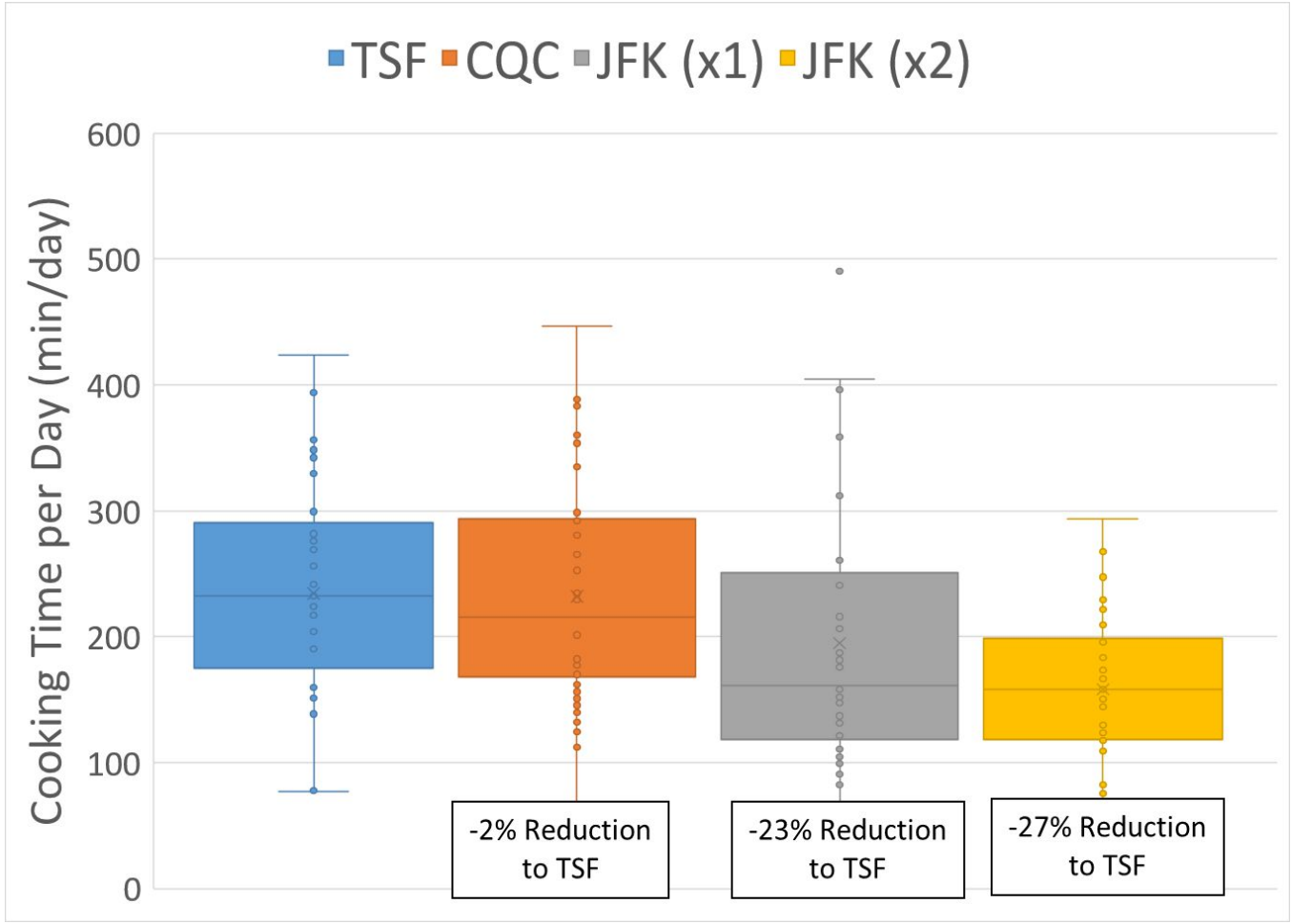
# Time Savings



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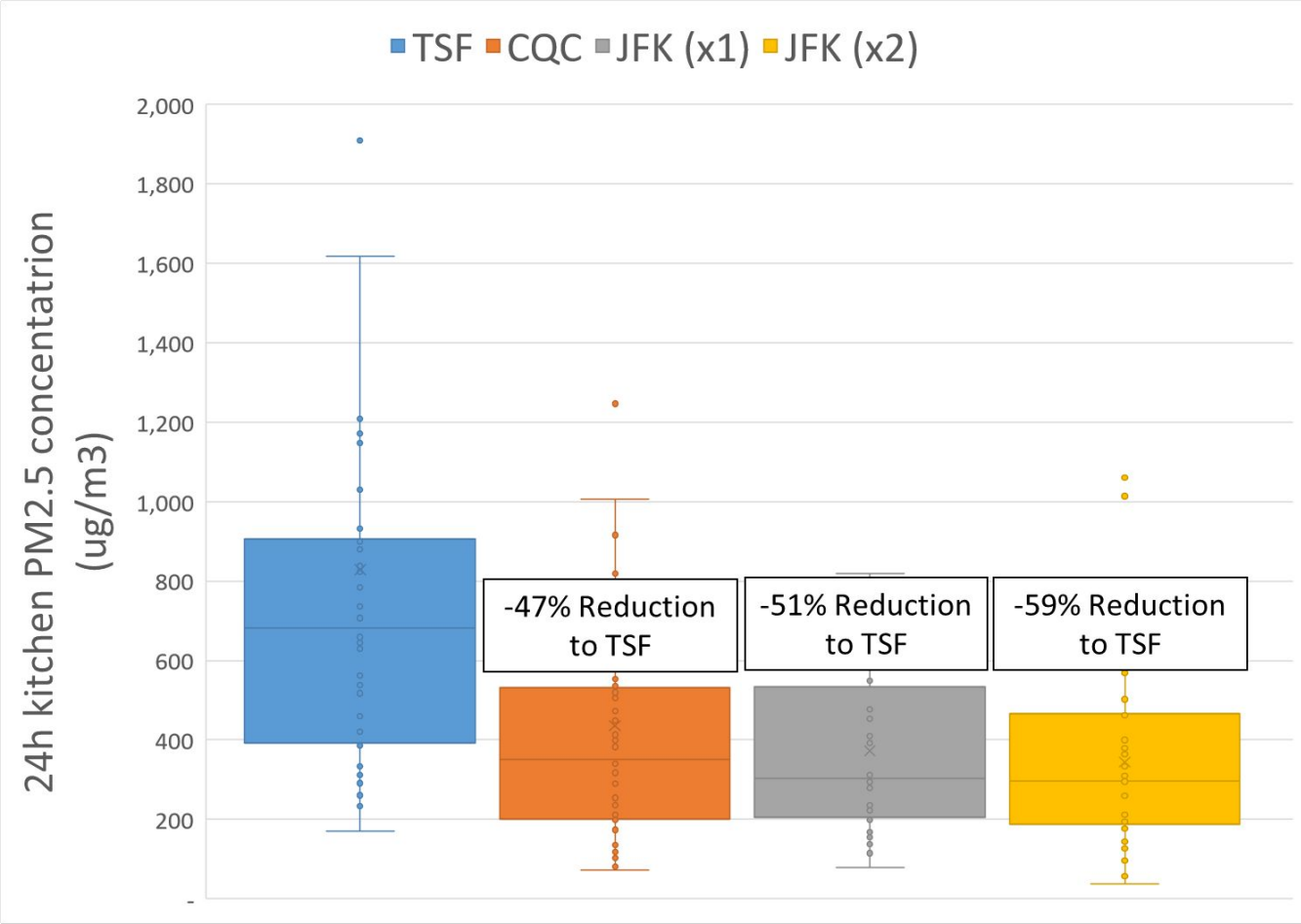
# Emission Reductions



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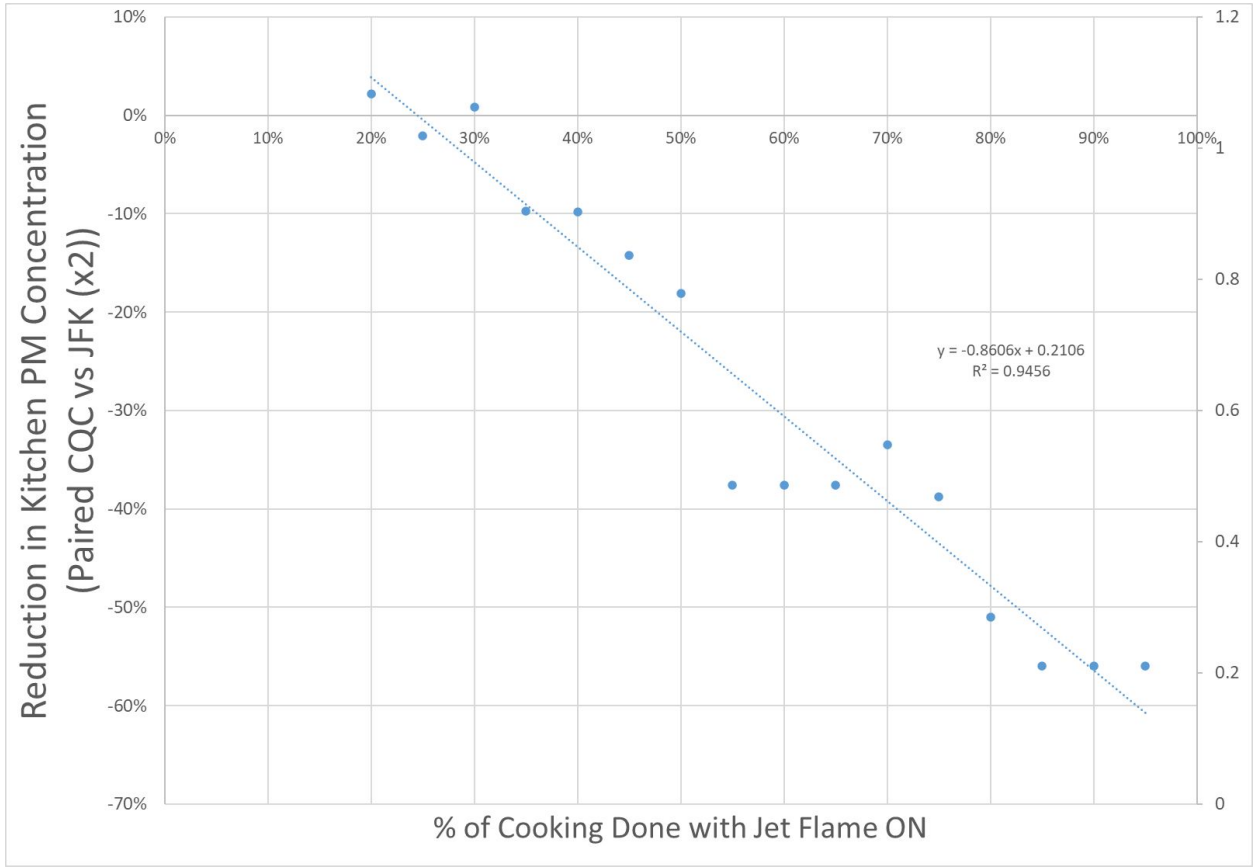
# High-Usage Households




| Jet-Flame usage threshold | Reduction in kitchen PM relative to CQC stove alone | significant at 95% based on Wilcoxon p-value? |
|---|---|---|
| 55% | -43% | YES |
| 80% | -52% | YES |

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# Carbon Calculations

| Table 1. Carbon calculation parameters (Bentson et al., 2022) | | | | |
|---|---|---|---|---|
| | | Baseline | CQC Rocket | CQC Rocket w/ Jet-Flame |
| Efficiency (without char) | % | 10* | 30.9 | 35.1 |
| $EFCO_2$ (Carbon balance corrected, based on effective heating value, no char) | g/MJ | 79 | 86 | 98 |
| EFCO | g/MJ | 1.2 | 2.9 | 0.8 |
| EFPM | mg/MJ | 168 | 207 | 16.1 |
| Black Carbon Fraction | % | 38** | 42 | 19 |
| EF Non-$CO_2$ (including $N_2O$ and $CH_4$)*** | tCO2e/TJ | 26.23 | 26.23 | 26.23 |

*(CDM,2020)
**(MacCarty et al., 2008)
***(IPCC, 2006)

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# Carbon Savings

| | | Baseline | CQC Rocket | CQC Rocket w/ Jet-Flame |
|---|---|---|---|---|
| Fuel Consumption per year | t/year | 4.11 | 1.33 | 1.17 |
| EF non-CO2 (including default N2O, CH4, and measured CO) | tCO2e/TJ | 33.3 | 43.3 | 31.0 |
| Emissions per year per stove without BC and OC | tCO2e/y | 6.22 | 2.32 | 2.04 |
| Emissions reduction per year per stove without BC and OC | tCO2e/y | | 3.90 | 4.19 |
| Percent Reduction from Baseline without BC and OC | % | | 63% | 67% |
| *Analysis including N2O, CH4, CO, and OC and BC* | | | | |
| EF non-CO2 (including default N2O, CH4, and measured CO, OC, and Black Carbon) | tCO2e/TJ | 77.0 | 103.7 | 32.7 |
| Emissions per year per stove with BC and OC | tCO2e/y | 8.65 | 3.40 | 2.06 |
| **Emissions reduction per year per stove with BC and OC** | **tCO2e/y** | | **5.24** | **6.58** |
| Percent Reduction from Baseline with BC and OC | % | | 61% | 76% |
| Fuel Consumption per year | t/year | 4.11 | 1.33 | 1.17 |

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# Invitation to Collaborate on Future Work

- Development and deployment of sensors
- Studies of jet-flame performance and user satisfaction
- Optimization of Jet-Flame technology design for flexibility and durability

# Thank You


- Study Participants
- Cquest Capital Staff in Malawi
- National Science Foundation grant #1662485
- Richard & Gretchen Evans Family Fellowship


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- S. Bentson, David Evitt, Dean Still, Daniel Lieberman, Nordica MacCarty. Retrofitting Stoves with Forced Jets of Primary Air Improves Speed, Emissions, and Efficiency: Evidence from Six Types of Biomass Cookstoves. *Energy for Sustainable Development*. 71: 104-117.  2022.

- MacCarty, N., Ross, G., Lefebvre, O., Morris, A. "Gender and Climate Impacts of the C-Quest Capital Cookstove, Jet-Flame, and Solar Home Kit Program" International Energy Agency/United Nations Development Program/World Bank Conference on "Understanding the Gender and Climate Change Nexus", Online, November 15-17, 2022