In-Home Assessment of Greenhouse Gas and Aerosol Emissions from Biomass Cookstoves in Developing Countries

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Introduction

- Nearly half the world's population still relies on solid fuels for their primary energy needs
- Climate forcing emissions from residential cookstoves are not well characterized
- Residential solid fuel use responsible for one-fourth of anthropogenic BC emissions (Bond and Sun, 2005)
- Lack of emissions data from normal daily cooking
- New stoves represent potential for cost-effective CO_2e emission reductions.
- Reducing stove emissions has potential for large co-benefits
  - Health, climate, ecological, economic, social
  - New evidence for reducing incidence of childhood pneumonia (Smith et al. 2011)
- Renewed interest in addressing impacts from use of inefficient cookstoves (Global Alliance for Clean Cookstoves, national programs in India, Peru, Mexico and others)
- We need a better understanding of cookstove emissions and potential impacts of new cooking technologies

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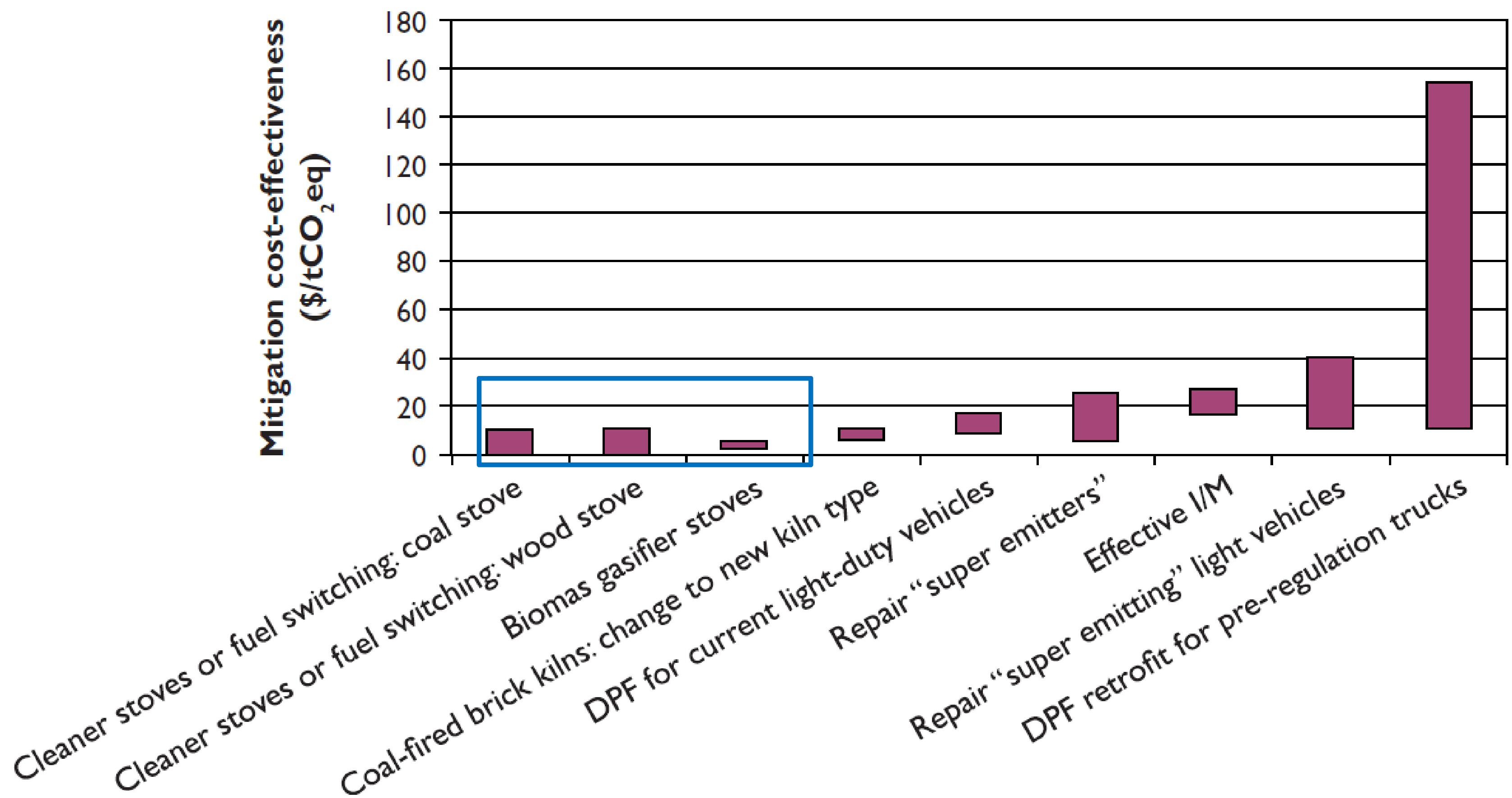
Estimated cost-effectiveness (20-year time frame) of key black carbon abatement measures in Asia.



Graphic from USAID Report: Black Carbon Emissions in Asia: Sources, Impacts, and Abatement Options, 2010, pg. 4

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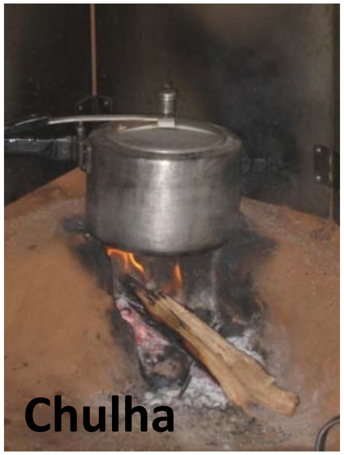
Project description

- Measured emissions of CO_2, CO, CH_4, total non-methane hydrocarbons (TNMHC), and particulate matter (characterized by black and organic fractions), from traditional and project stoves in Uganda, Nepal, and India

Uganda

India

Nepal



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Sampling Methods

- Emission samples were collected in homes during uncontrolled cooking events
- Emissions were collected in the plume above the stove and analyzed for CO_2 and CO with real-time and GC analysis; CH_4 and total TNMHCs with GC analysis; and $PM_{4.0}$ with gravimetric analysis for mass and thermal optical method for EC/OC
- Emission factors were determined using the carbon balance method.
- 100 yr-GWPs for gases applied from IPCC BC and OC from Bond et al. 2011

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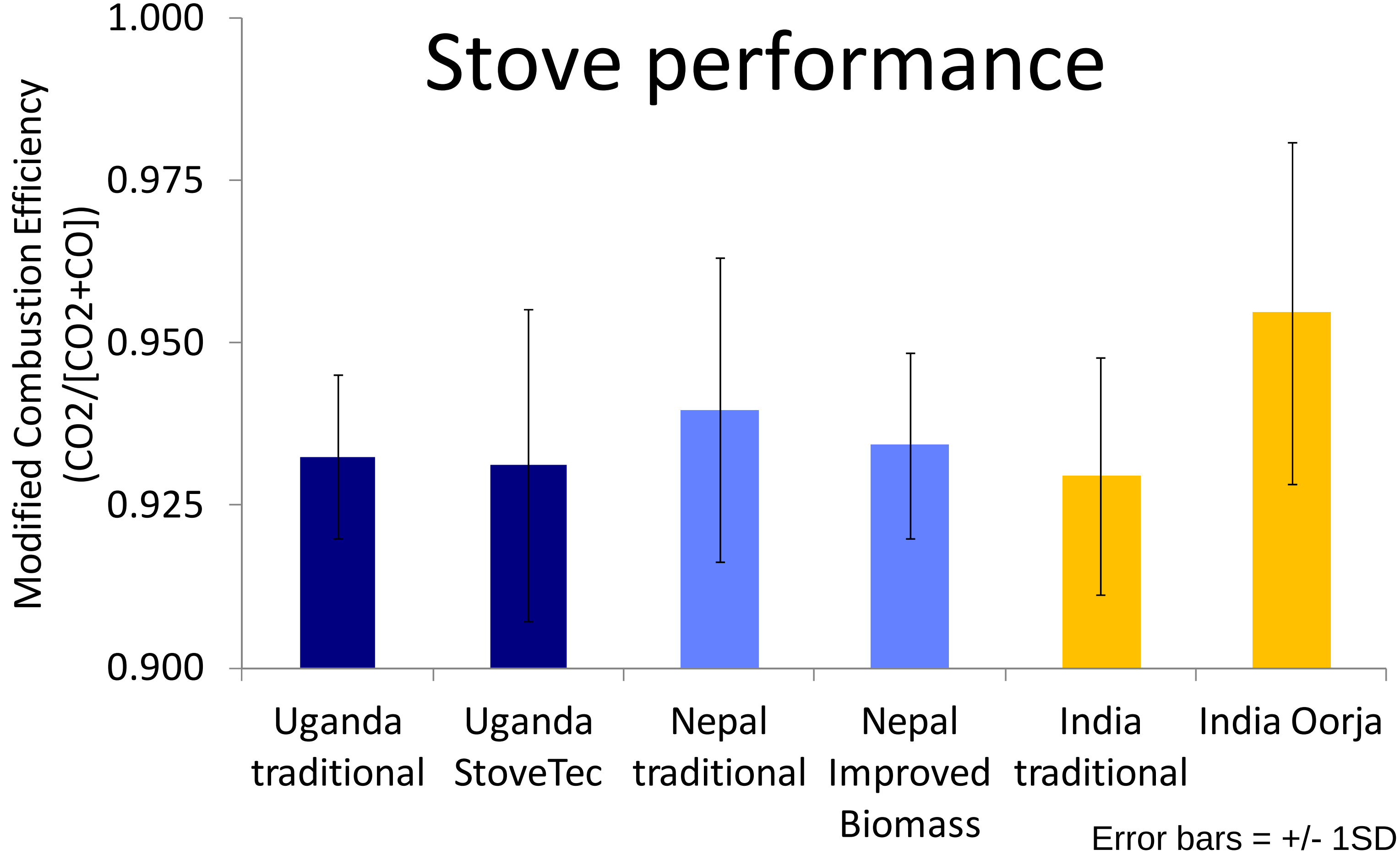
Stove performance



- Similar combustion performance amongst traditional and project stoves (92-94%), with the exception of the Oorja (~96%)
- All project stoves had increased heat transfer efficiency
  - 30-50% less energy per meal

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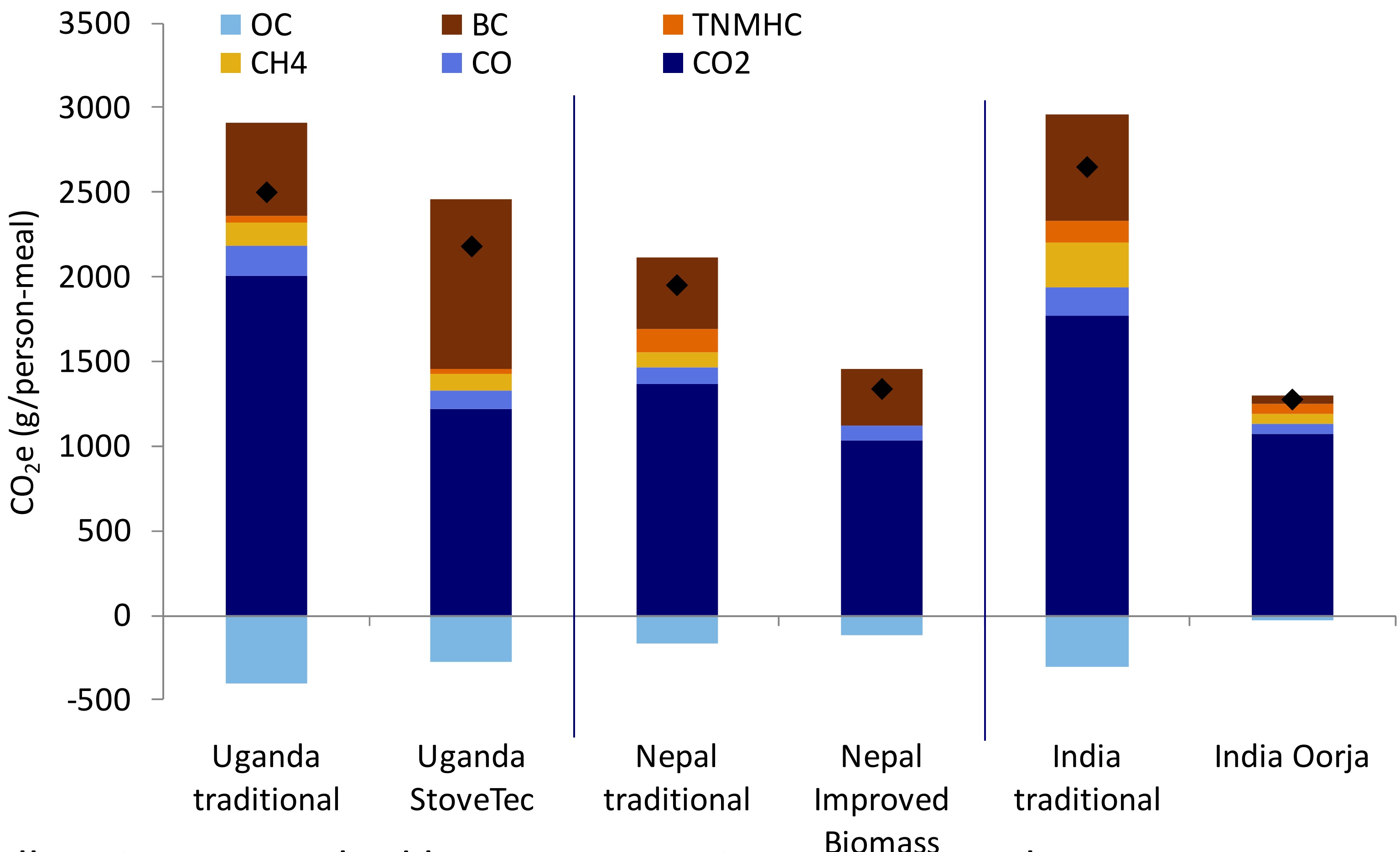
Relative CO_2e emissions



- All project stoves had lower CO_2e emissions per meal
- Oorja combusted fuel more completely
- BC the largest non-CO_2 contributor to CO_2e (4-37%)

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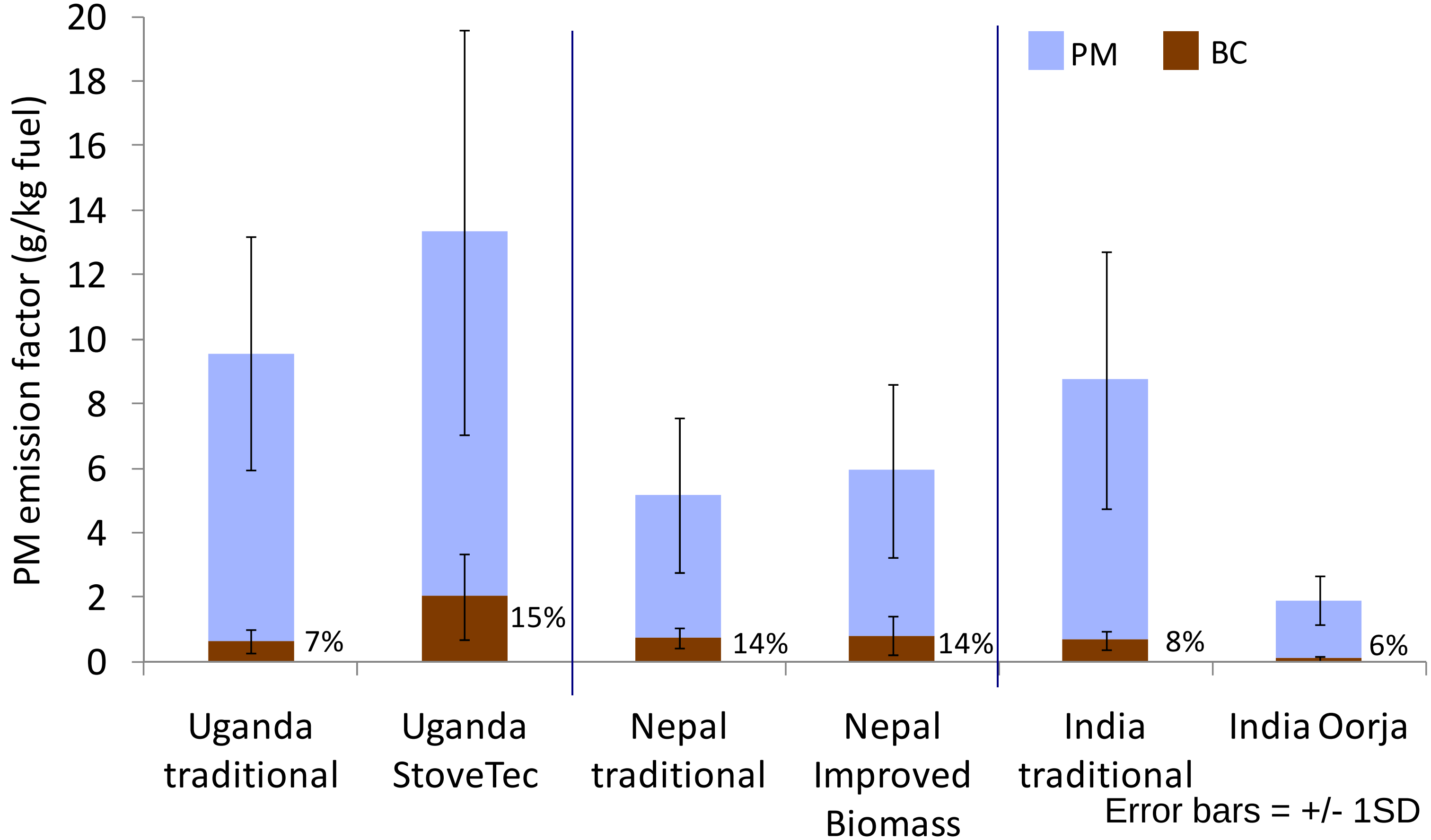
Aerosol Emissions



- Only Oorja emitted less BC and as lower fraction of PM
- StoveTec emitted more BC overall and had higher BC content in PM
- New/intervention stoves need careful evaluation of their climate impacts

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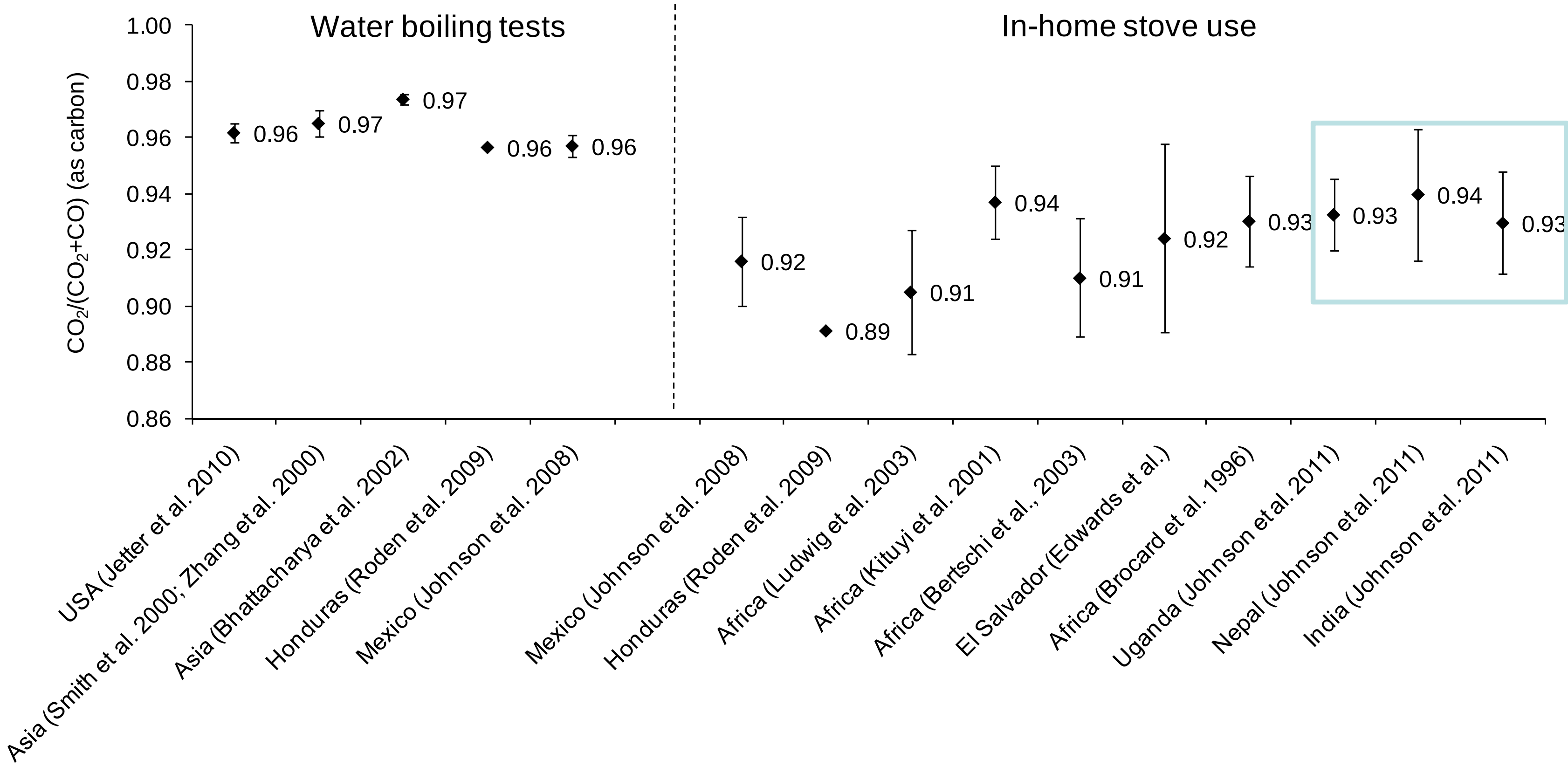
Controlled and uncontrolled testing



- Stoves perform differently during controlled laboratory testing compared to normal usage.
- Many stoves perform better in laboratory due to idealized conditions for boiling water.
- IPCC default and other emission inventories have relied on cookstove emission factors from controlled testing
- We need a comprehensive, field-based emissions inventory of baseline and new cookstoves/fuels

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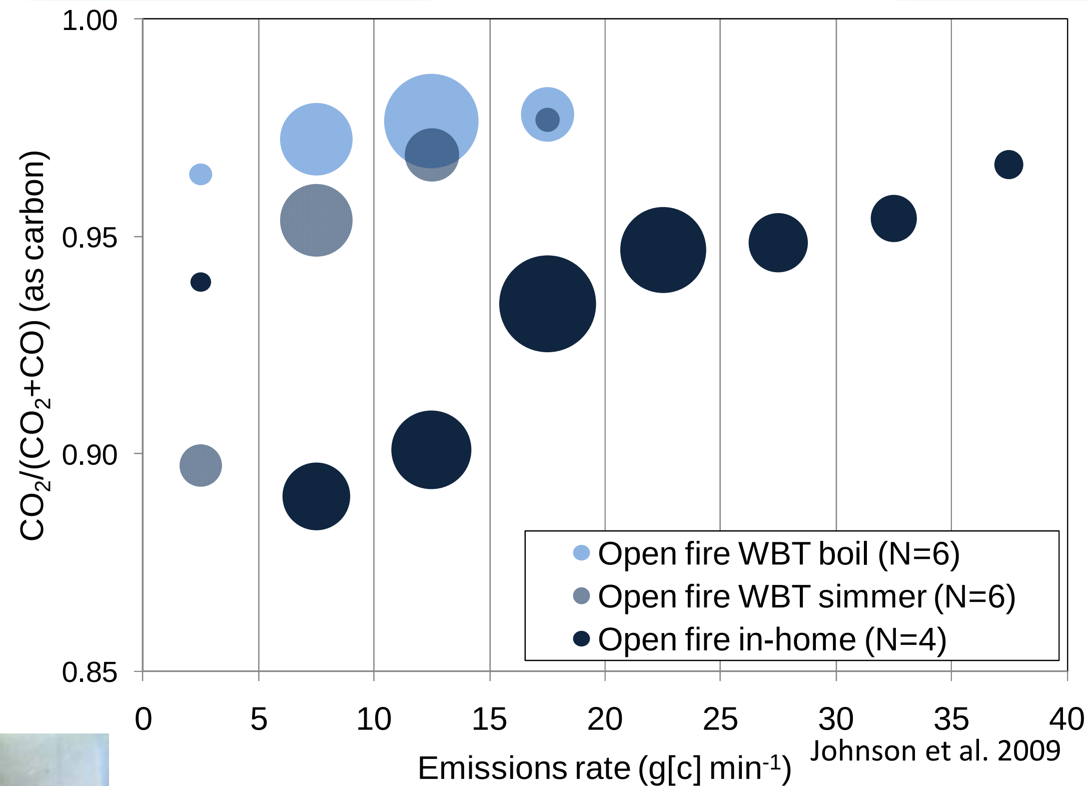
Laboratory testing

- Water Boiling Test (WBT) most common laboratory test
- Designed to replicate cooking cycle of rice or beans
- Idealized fuel conditions and fire tending



Johnson et al. 2009

- Neither the WBT's boiling nor simmering phases representative of normal daily cooking
- Difficult to replicate real-world conditions

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Conclusions

- The relative CO_2e contributions, especially from BC, vary substantially across stove type and test conditions, highlighting the need to carefully evaluate stove emissions in the field to assess potential climate impacts
- Stove adoption, usage, patterns, and lifetime are also critical components which need to be considered when evaluating overall emission's impact
- Assessment of a wider range of cooking solutions, including clean fuels (e.g. LPG, ethanol, biogas, kerosene, and plant oils), advanced stoves (e.g. forced air, gasifier, TLUD, and pyrolytic), rocket stoves, and others would provide a valuable database of stove emissions performance
- Better connection between laboratory and field performance of stoves would aid stove design, protocols for stove standards, and increasing the overall relevance of stove performance testing

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A report on the USAID funded study can be found at:
http://www.usaid.gov/our_work/economic_growth_and_trade/energy/publications/uganda_emissions_report.pdf

A presentation on the field performance assessment of the USEPA funded project can be found at:
http://www.pciaonline.org/files/PCIA_Aug11_Webinar_FieldTestResults_FINAL.pdf.

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