An Update on U.S. EPA Household Energy Research

Champion, W.M., Williams, C.R., Virtaranta, L., Barnes, M., and Jetter, J.J.

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ETHOS
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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

ORISE

U.S. EPA Household Energy Research

- Supports development and implementation of international standards through ISO (International Organization for Standardization) Technical Committee 285, Clean Cooking Solutions
- Assists in building capacity of international testing centers
- Provides an independent source of information and data on air pollutant emissions and fuel efficiency

Three Laboratory Studies Conducted in 2019

- Comparison of Cookstove Emissions and Performance Results Using the Water Boiling Test v4 and the new ISO 19867-1 Testing Protocols
- Mutagenicity- and Pollutant-Emission Factors of Pellet-Fueled Gasifier Cookstoves: Comparison with Other Combustion Sources
- Pilot Study on the Chemical and Biological Characterization of Fresh vs Aged Cookstove Emissions

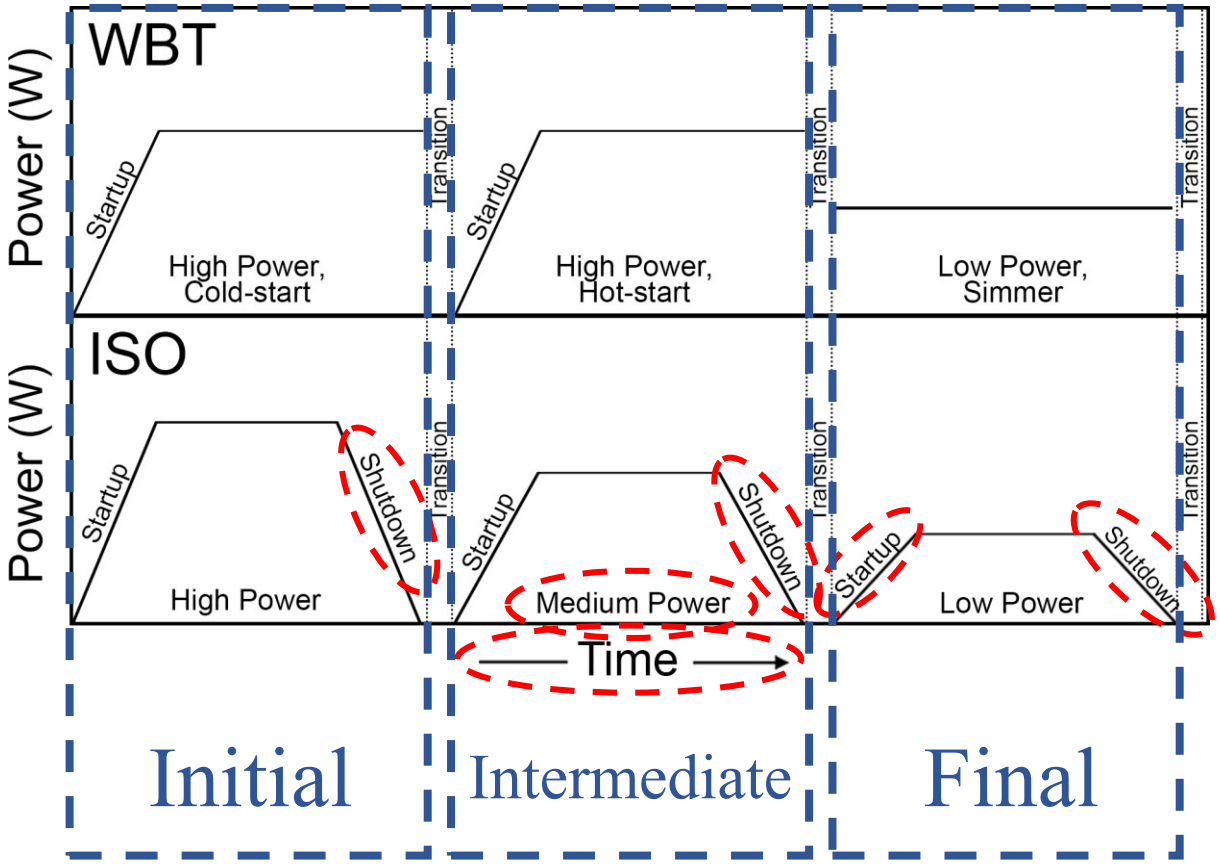
Comparison of Cookstove Emissions and Performance Results Using the Water Boiling Test v4 and the new ISO 19867-1 Testing Protocols

- Water Boiling Test
  - Employed in 1985 as VITA-WBT protocol
  - "Simplified simulation of cooking"
  - Clean Cooking Catalog reports > 450 distinct WBT emissions results
  - Metrics include:
    - Thermal efficiency
    - CO emissions
    - $PM_{2.5}$ emissions
  - Typical discrepancies between lab and field emissions data of 3-5 fold[1,2]
- ISO 19867-1
  - Voluntary performance targets specify separate tier ratings for:
    - Thermal efficiency
    - CO emissions
    - $PM_{2.5}$ emissions
    - **Safety**
    - **Durability**

1. Roden et al. 2009; 2. Wathore et al. 2017

Key differences of ISO protocol include:

1. Shutdown periods in each phase
2. Startup period in low-power phase
3. Additional (medium) power level
4. Duration of high-power phases defined by time and not water temperature



Benefits of new ISO Protocol

- Harmonization of testing protocols and improved comparability of results
- Applicability to wider range of stove and fuels
- Adaptability to meet stakeholder needs
- Continuous improvement over time through ISO process
- Upgrades in procedures, quality assurance, and equipment

Implications of new ISO Protocol

- Governments are adopting or adapting the protocol, using all or parts of it
- Standards bodies are participating in further development
- Test labs are building capacity for testing according to the standard
- Industry has incentives for differentiating higher quality products
- Consumers benefit from better products

Six stove/fuel combinations tested ranging from clean-burning gas stove to traditional

A) Mikachi stove burning LPG fuel
B) Mimi Moto forced-draft semi-gasifier stove burning hardwood pellets
C) Philips HD4012 forced-draft semi-gasifier stove burning cut red oak
D) Envirofit G3300 rocket stove burning cut red oak
E) Kenya Ceramic Jiko stove burning lump hardwood charcoal
F) a “minimally tended” three stone fire (TSF) burning cut red oak

Mutagenicity- and Pollutant-Emission Factors of Pellet-Fueled Gasifier Cookstoves: Comparison with Other Combustion Sources

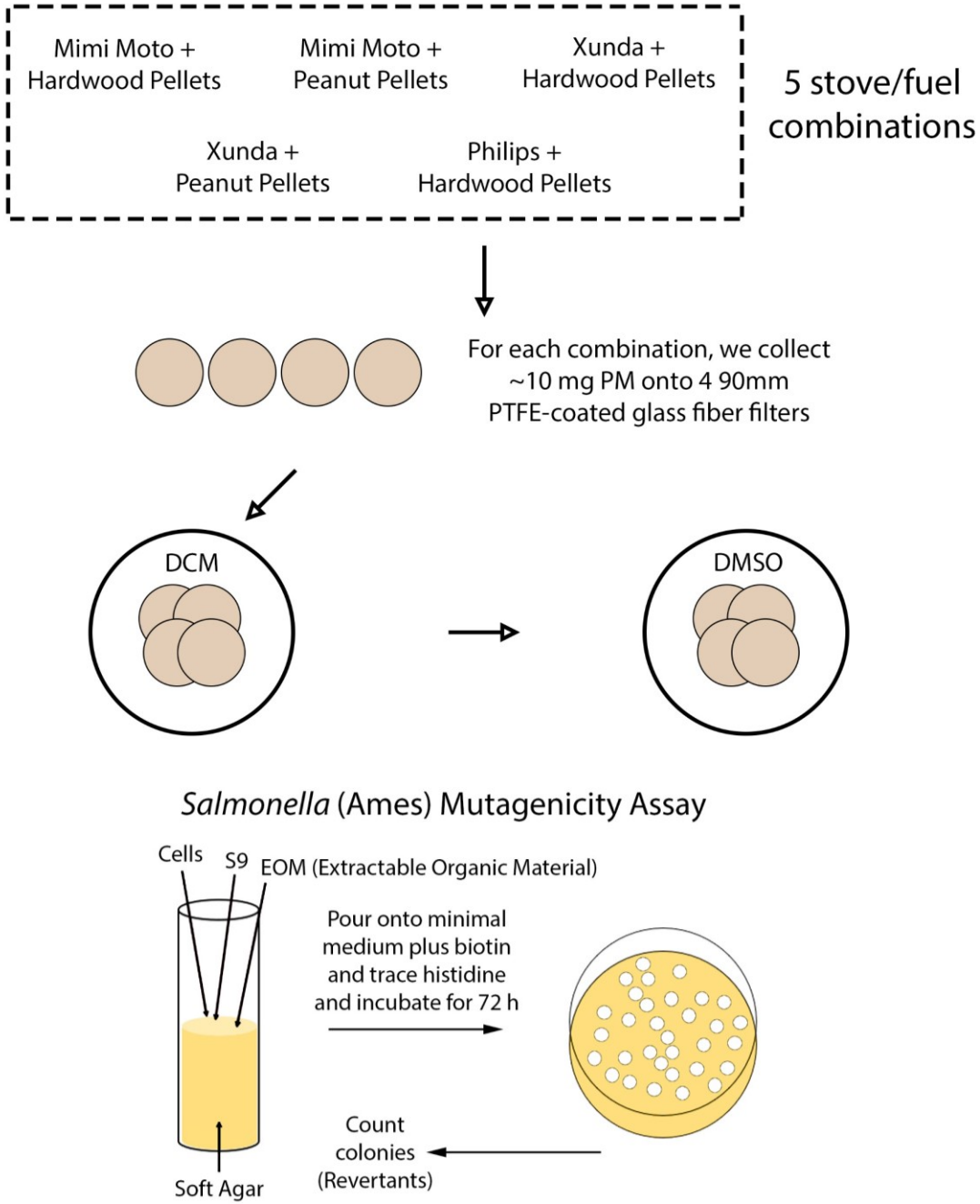
Pellet stoves offer tremendous potential…

The World Health Organization (WHO) recognizes that rural *vs*. urban and peri-urban populations naturally require longer periods (on the order of decades *vs*. years) to transition completely to clean energy carriers. Because 45% of the world's population remains rural, there exists a need for more readily available, yet clean burning, solid-fuel energy options.

4. Champion and Grieshop 2019

Three semi-gasifier stoves and two fuels

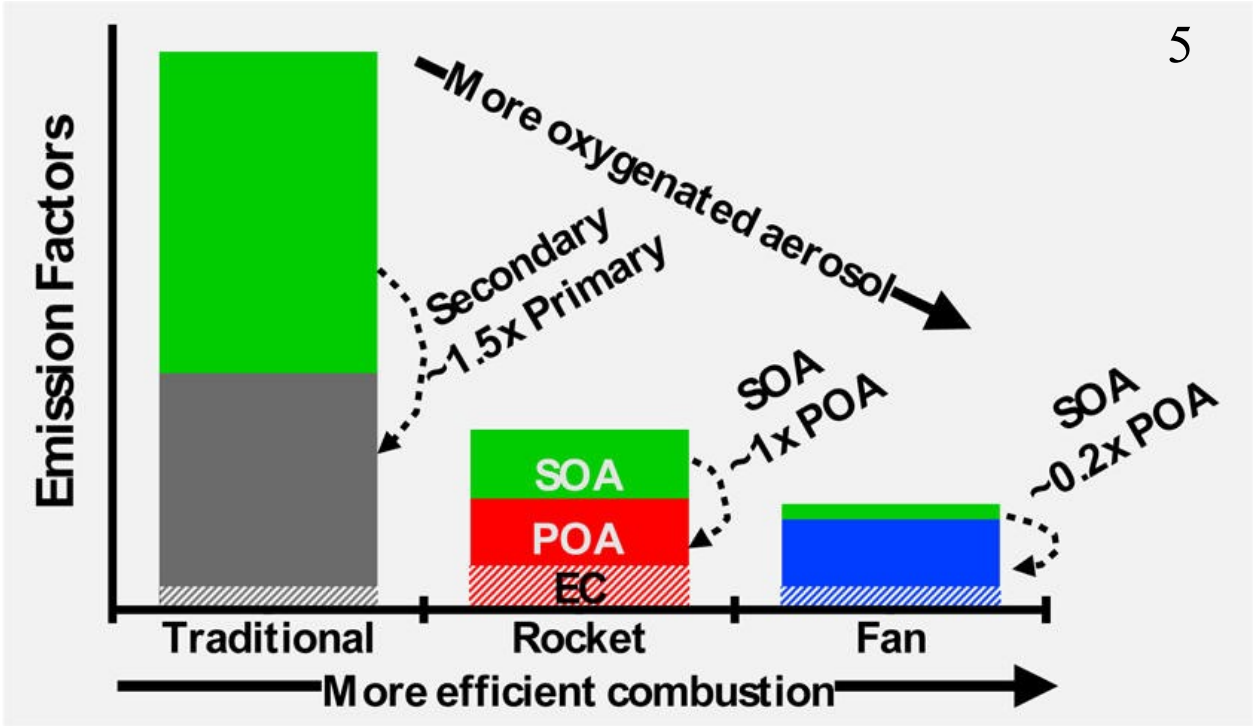
- Mimi Moto, Philips, and Xunda
- Hardwood and peanut hull pellets



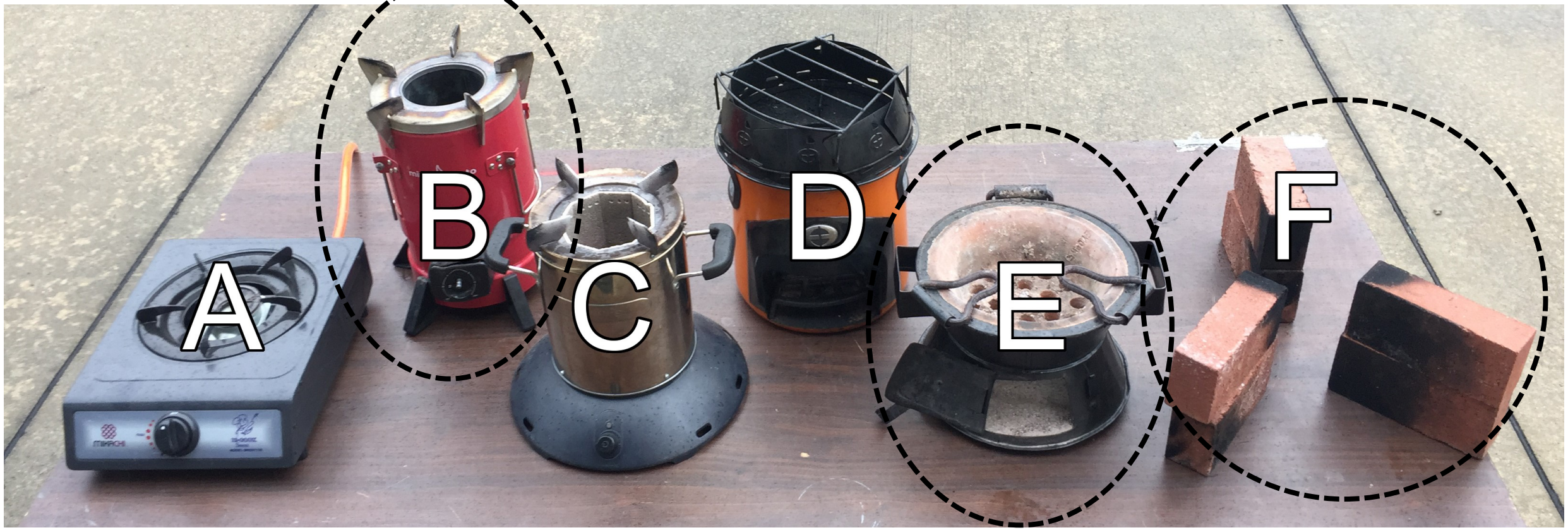
Pilot Study on the Chemical and Biological Characterization of Fresh And Aged Cookstove Emissions

Traditional stoves emit high levels of precursors which react to form SOA

- Gaseous precursors, particularly semi- and intermediate-volatile organic compounds (S/IVOCs), contribute significantly to the formation of secondary organic aerosols
- Characterization of the relationships between chemistry and biology of aged vs. fresh cookstove emissions is limited



5. Reece et al. 2017



Mimi Moto burning hardwood pellets

Kenya Ceramic Jiko burning lump charcoal

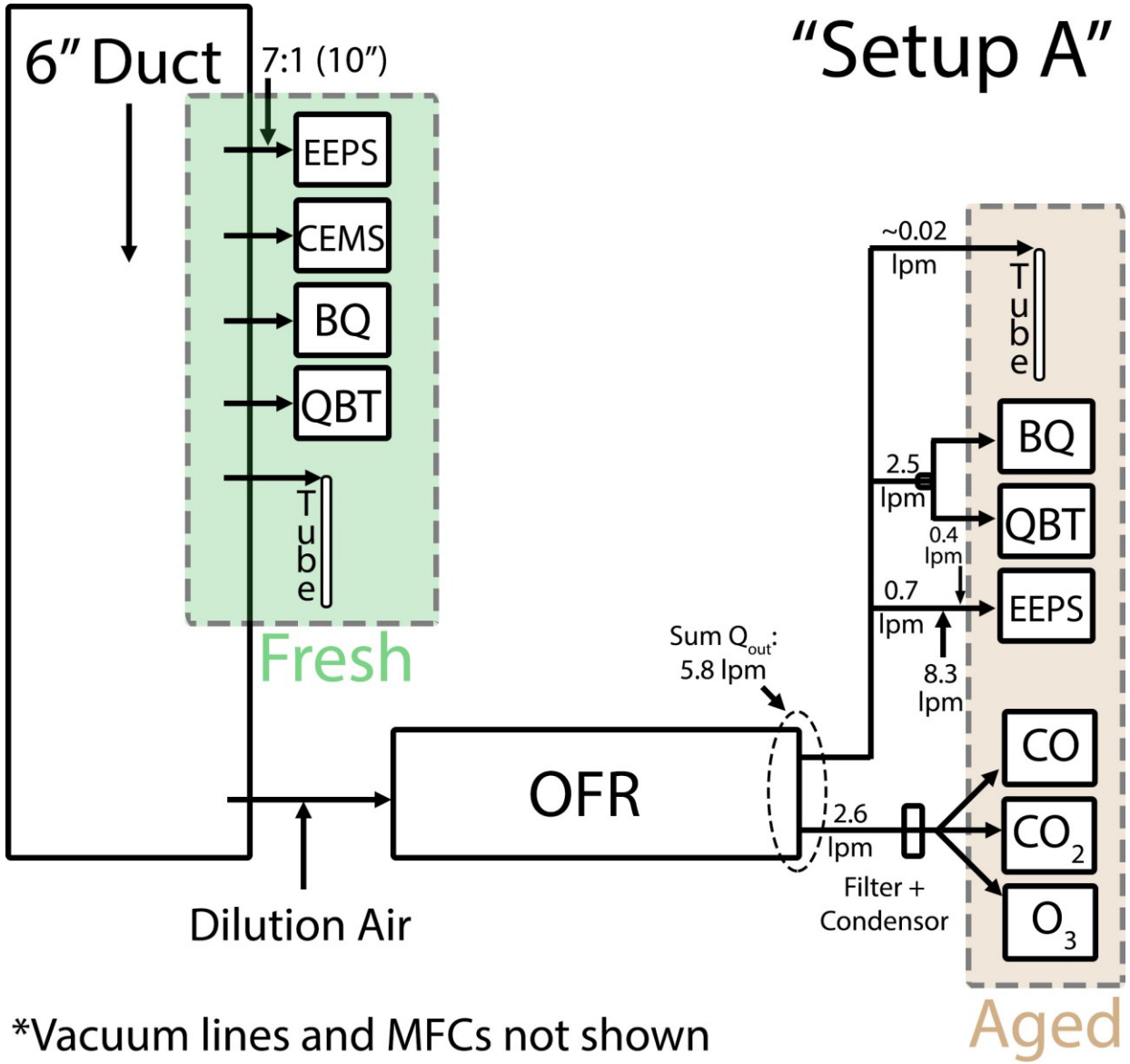
Three stone fire burning cut hardwood

What happens to cookstove emissions when they age in the atmosphere?

How does the chemistry evolve?

Do fresh or aged emissions elicit higher biological responses?

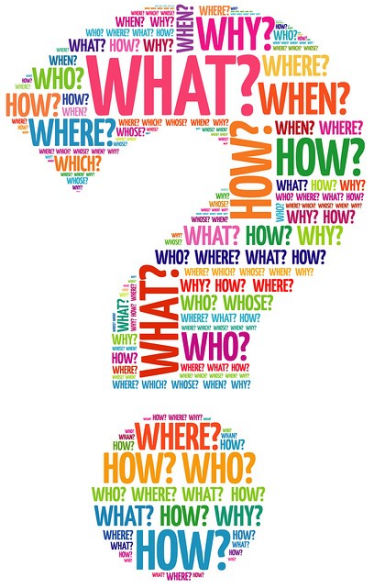
- Three Endpoints:
  - Two chemical:
    - Total phase (gas and particle) semi- and intermediate-volatility organic compounds
    - Annular denuders for gas-phase oxygenated organics
  - One biological:
    - High PM mass loading for toxicological assays



In summary, the US EPA is currently…

- Assessing the influence of protocol choice (new vs. old, ISO vs. WBT) on emissions metrics for a range of cookstove types
  - Forced-draft (and charcoal) stoves heavily influenced, but IWA tiers likely do not shift
- Quantifying the biological effects (mutagenicity) of particulate matter emitted from pellet stove/fuel combinations
  - Pellet stoves are an improvements vs. heterogenous fuels, but not all pellet stove/fuel combinations are created equal!!
- Exploring how cookstove emissions evolve in terms of their chemistry and biology
  - More to come!

Thank you!



Questions?

Champion.Wyatt@epa.gov

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