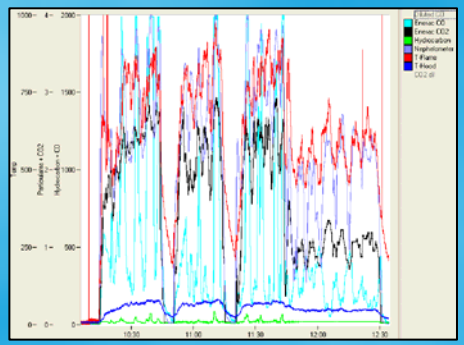
Aprovecho Research Center

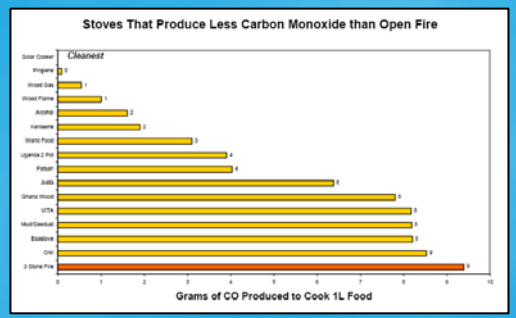
Advanced Studies in Appropriate Technology Laboratory

Testing Stoves

Laboratory Testing

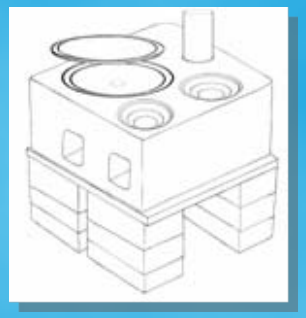
In-Field Testing

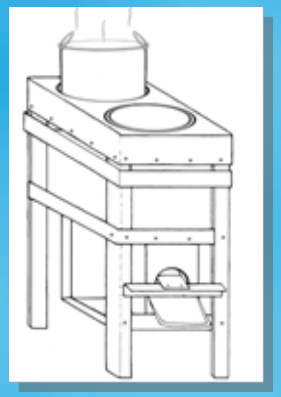


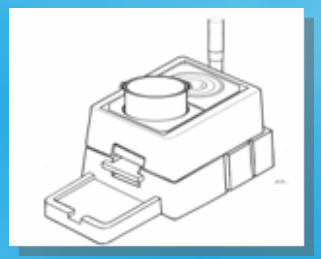


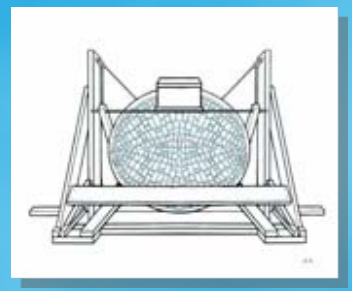
Assisted in developing revised international testing standards with Dr. Kirk Smith, Rob Bailis

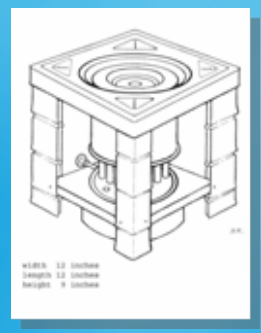
Comparing Cook Stoves

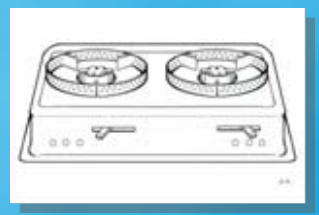


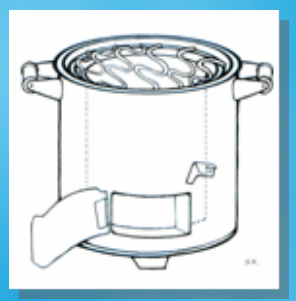


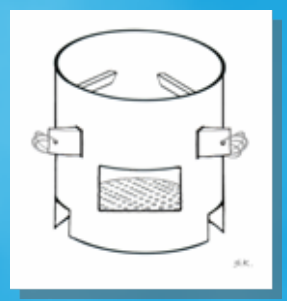


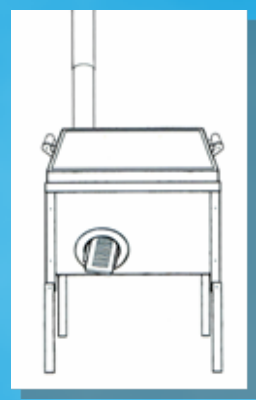












How Stoves Work

Heat Transfer Efficiency + Combustion Efficiency = System Efficiency

- Improving HTE dramatically decreases wood use.
- Improving CE decreases emissions.

Improving HTE

1. Force hot flue gases to scrape against the pot in an appropriate-sized channel.
2. Increase the velocity of hot flue gases.
3. Increase surface area of pot exposed to hot flue gases.
4. Increase temperature of hot flue gases.

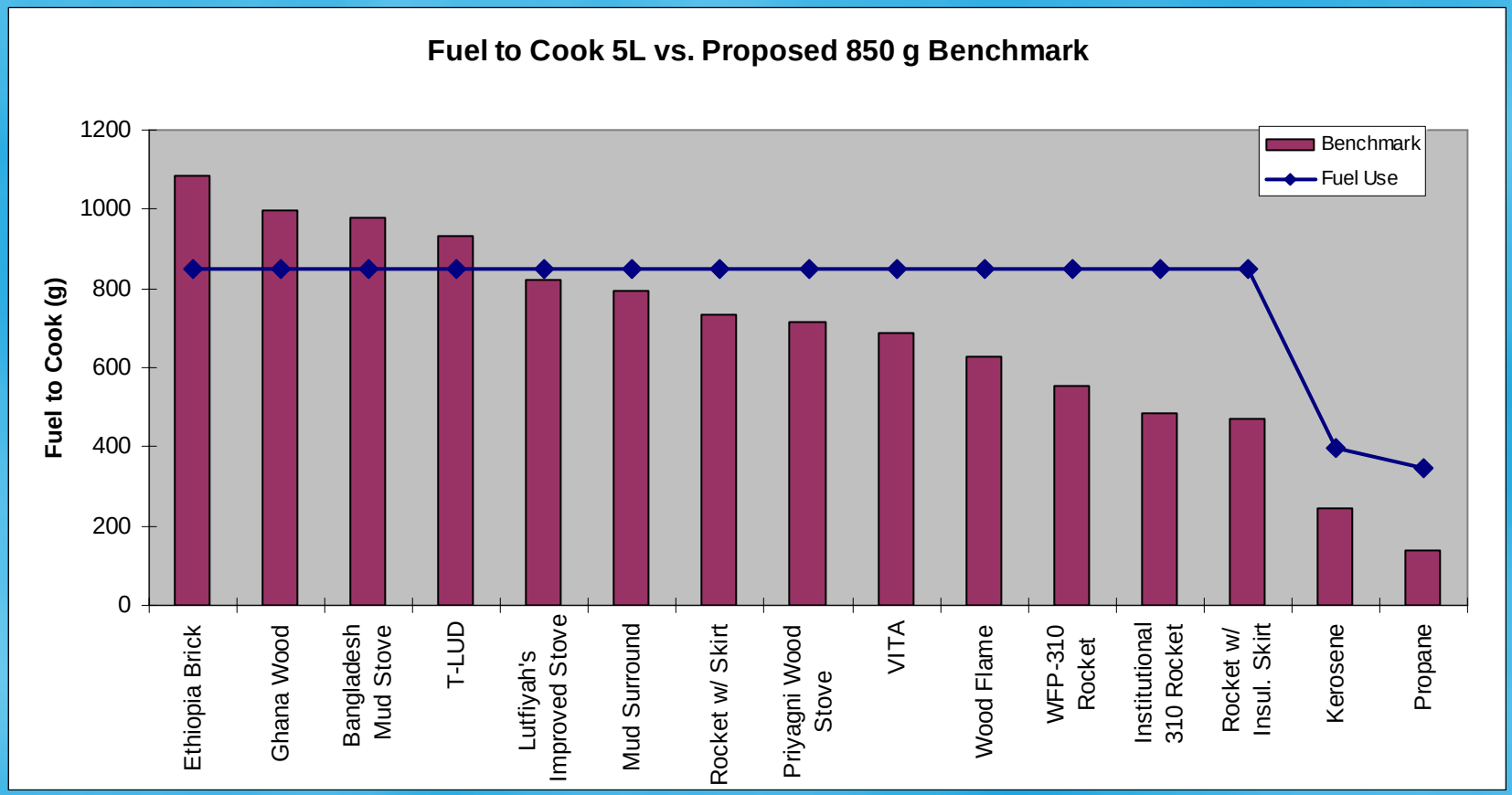
Improving CE

1. Have all wood gas enter the flame.
2. Mix wood gas, air and flame.
3. Higher velocity primary air assists this process.

Proposed Benchmark

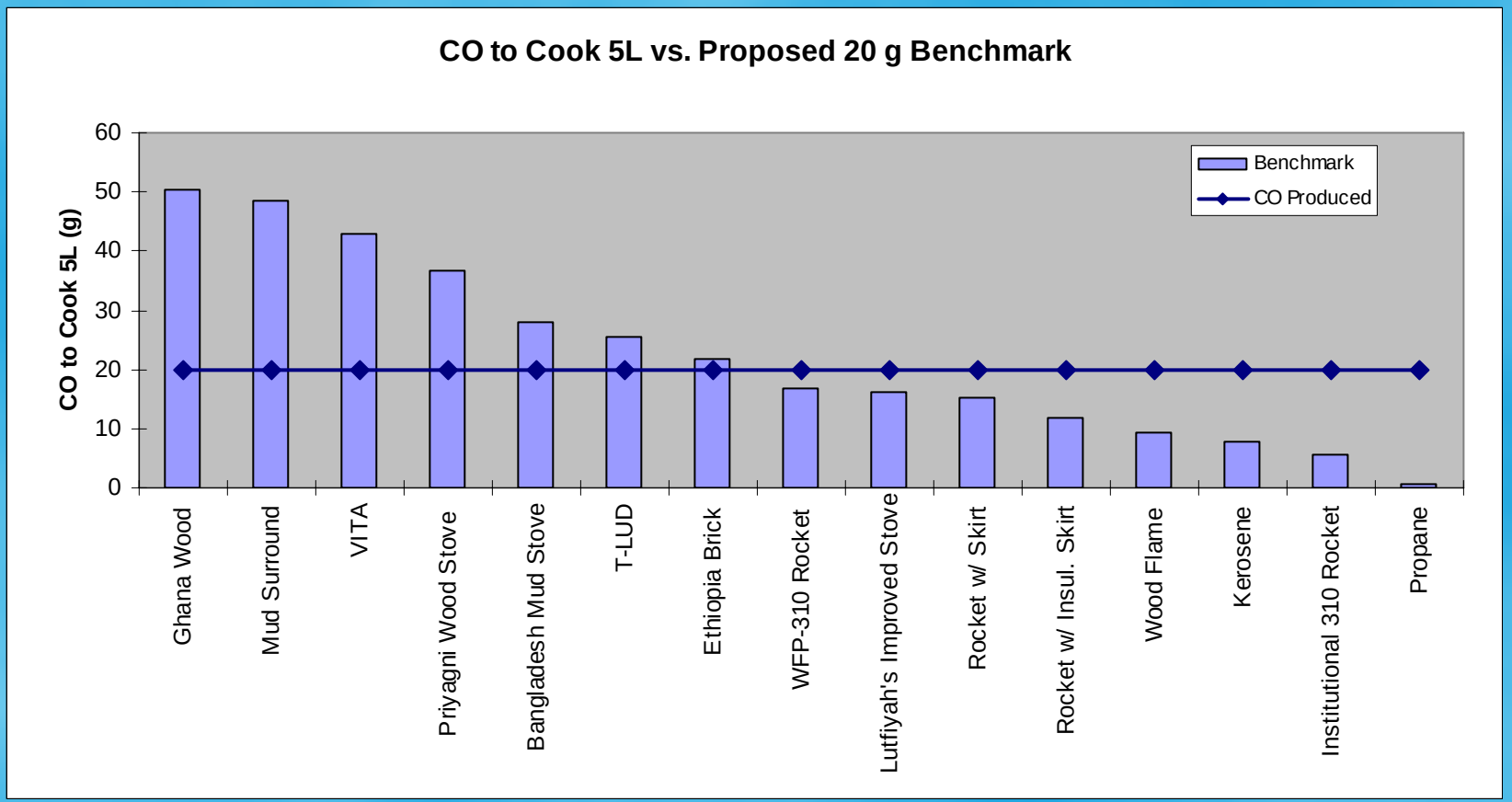
Fuel Use

A wood burning stove without a chimney should use less than 850 grams of wood to bring to boil 5 liters of 25 degree C. water and then simmer it for 45 minutes during the UCB revised Water Boiling Test



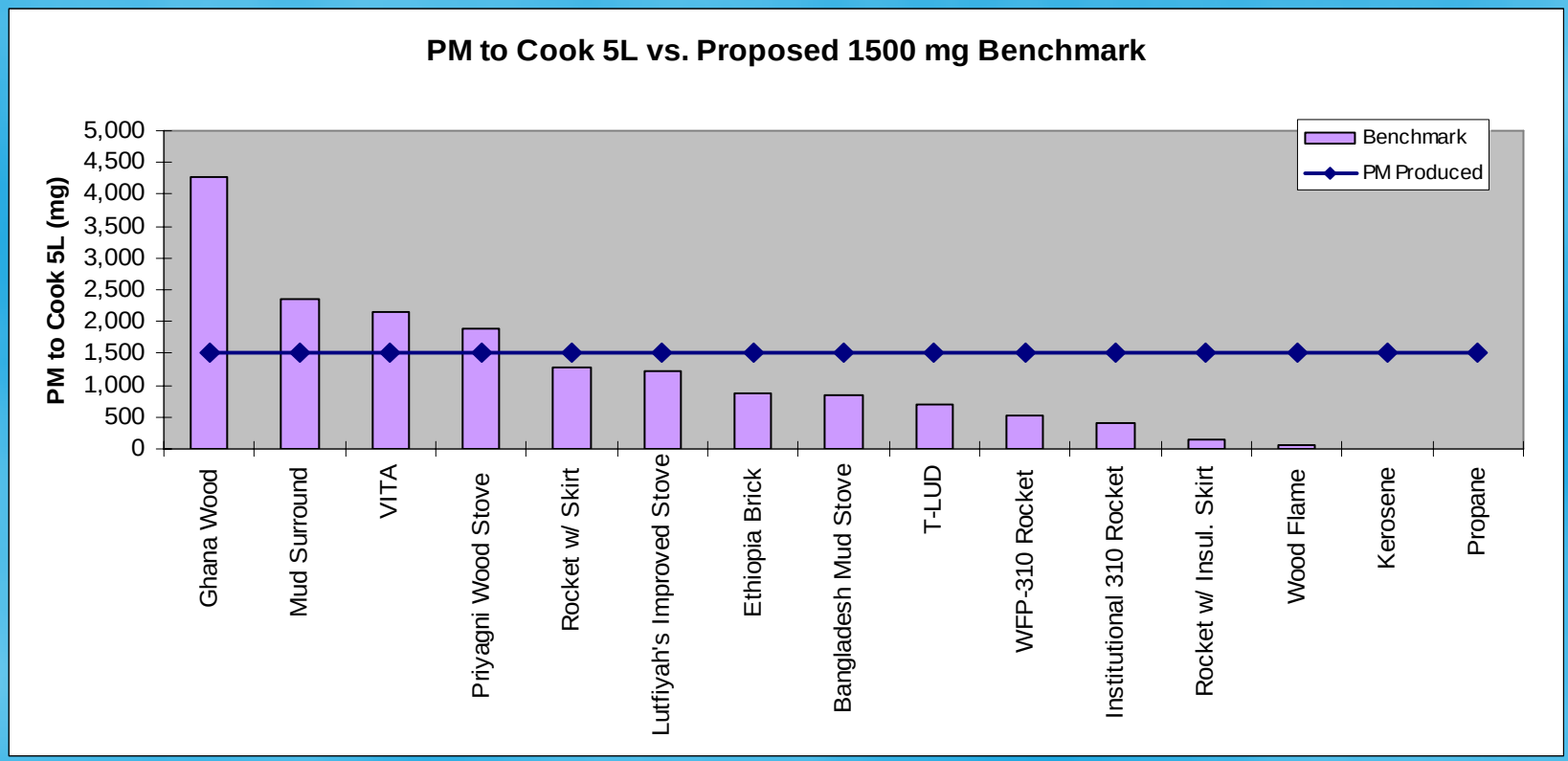
Proposed Benchmark CO Emissions

A wood burning stove without a chimney should produce less than 20 grams of Carbon Monoxide to boil 5 liters of 25 degree C. water and then simmer it for 45 minutes during the UCB revised Water Boiling Test.



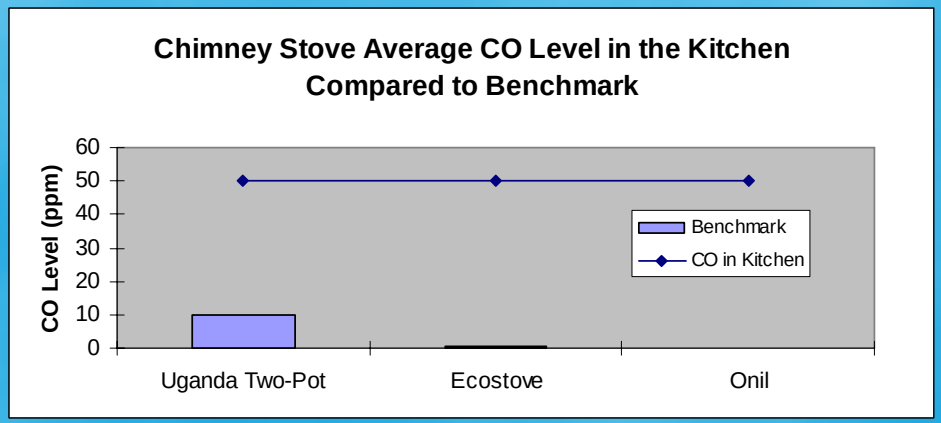
Proposed Benchmark PM Emissions

A wood burning stove without a chimney should produce less than 1500 milligrams of Particulate Matter (2.5 microns or smaller) to boil 5 liters of 25 degree C. water and then simmer it for 45 minutes during the UCB revised Water Boiling Test.

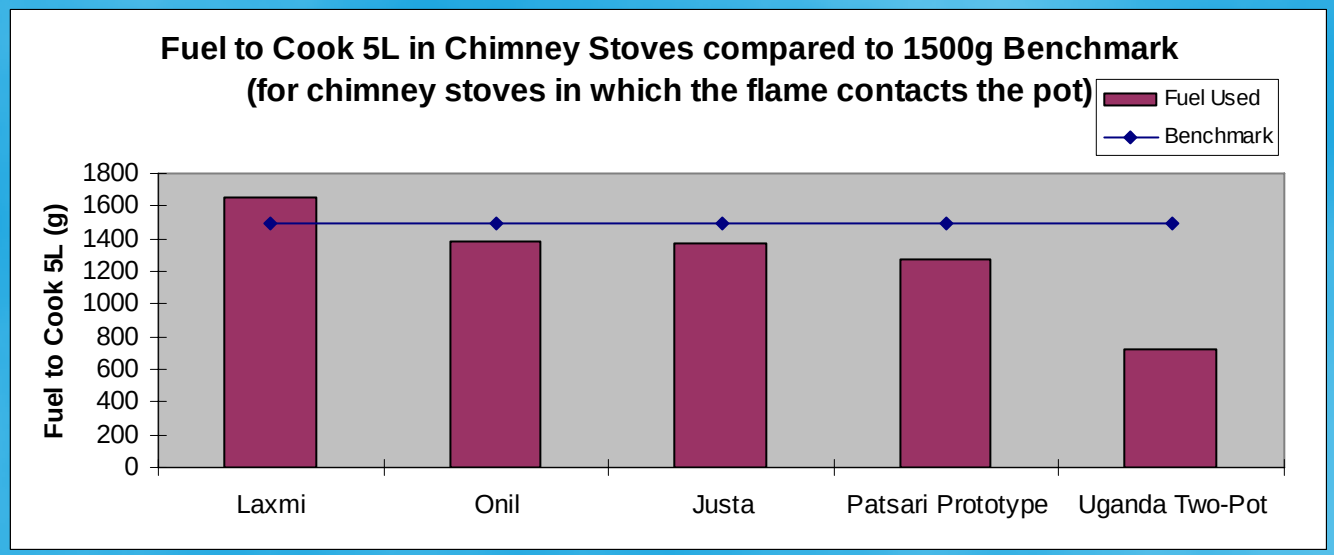


Proposed Benchmark — Chimney Stoves

Chimney Stoves: Wood burning stoves with chimneys are exempt from the above standards if the stove does not allow more than 50 parts per million of Carbon Monoxide to pollute the air anywhere within 30cm of the stove.



Chimney Stoves: Wood burning stoves with chimneys shall use less than 1500g of wood to boil 5L of water and simmer for 45 minutes.



The Need for Emission Testing

No visible smoke does not mean there is no health hazard

•Carbon Monoxide is colorless and odorless
•Fine particulate matter may be difficult to see

The **Portable Emissions Monitoring System (PEMS)** is being developed by Aprovecho so that:

•Stove developers have a useful tool to measure in-field emissions
•Immediate feedback is available for changes in stove prototypes
•Stove emissions can be observed and improved.

The Need for Emissions Testing

Laboratory Testing
- Useful for engineering and design
- Water Boiling Test (WBT) is used

Field Testing
- Shows reality of stove use in the field
- Controlled Cooking Test (CCT) is used, including
  - Local fuel
  - Local food
  - Local cook
  - Local cooking practice

Adding emissions measurements in the field gives a realistic idea of the expected reductions in pollutants.

"What is important to users and the environment is wood used and pollutants produced per meal cooked."

Two Types of Emissions Monitoring

Indirect Measurement

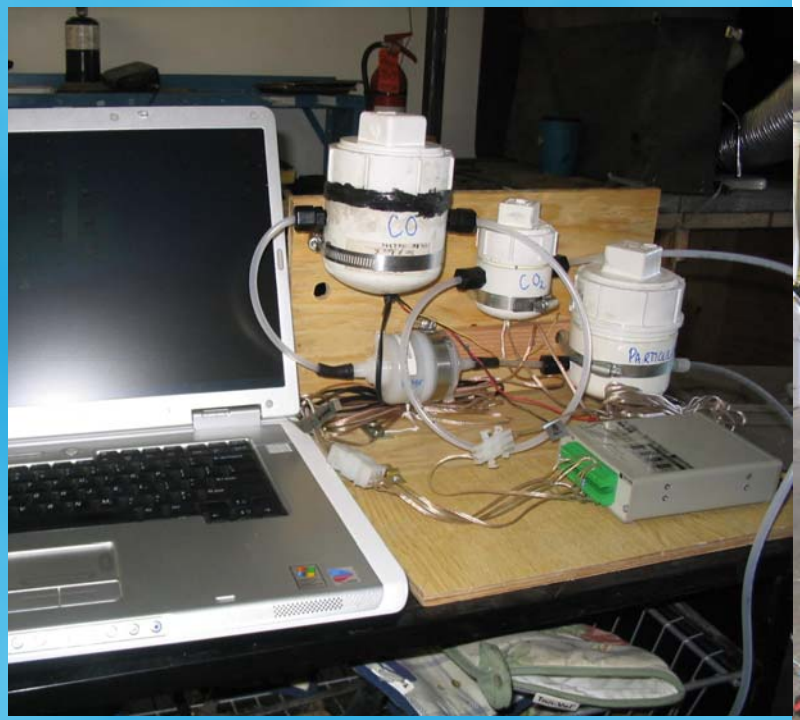
- Monitoring of pollution levels within a home or of the cook herself
- Shows pollution present in a true field situation
- Affected by variables such as home layout, ventilation, season, fuel, wind, temperature, cooking times, day of week, etc.
- May not give information about the stove itself without a large sample
- Can be conducted in conjunction with the Kitchen Performance Test (KPT)

Direct Measurement

- Test in which total emissions are collected and analyzed, typically under an emissions collection hood
- Useful for evaluating the stove itself by minimizing variables
- WBT or CCT is used

Portable Emissions Monitoring System (PEMS)

Emissions collection hood and sensors for real-time *direct emissions monitoring*

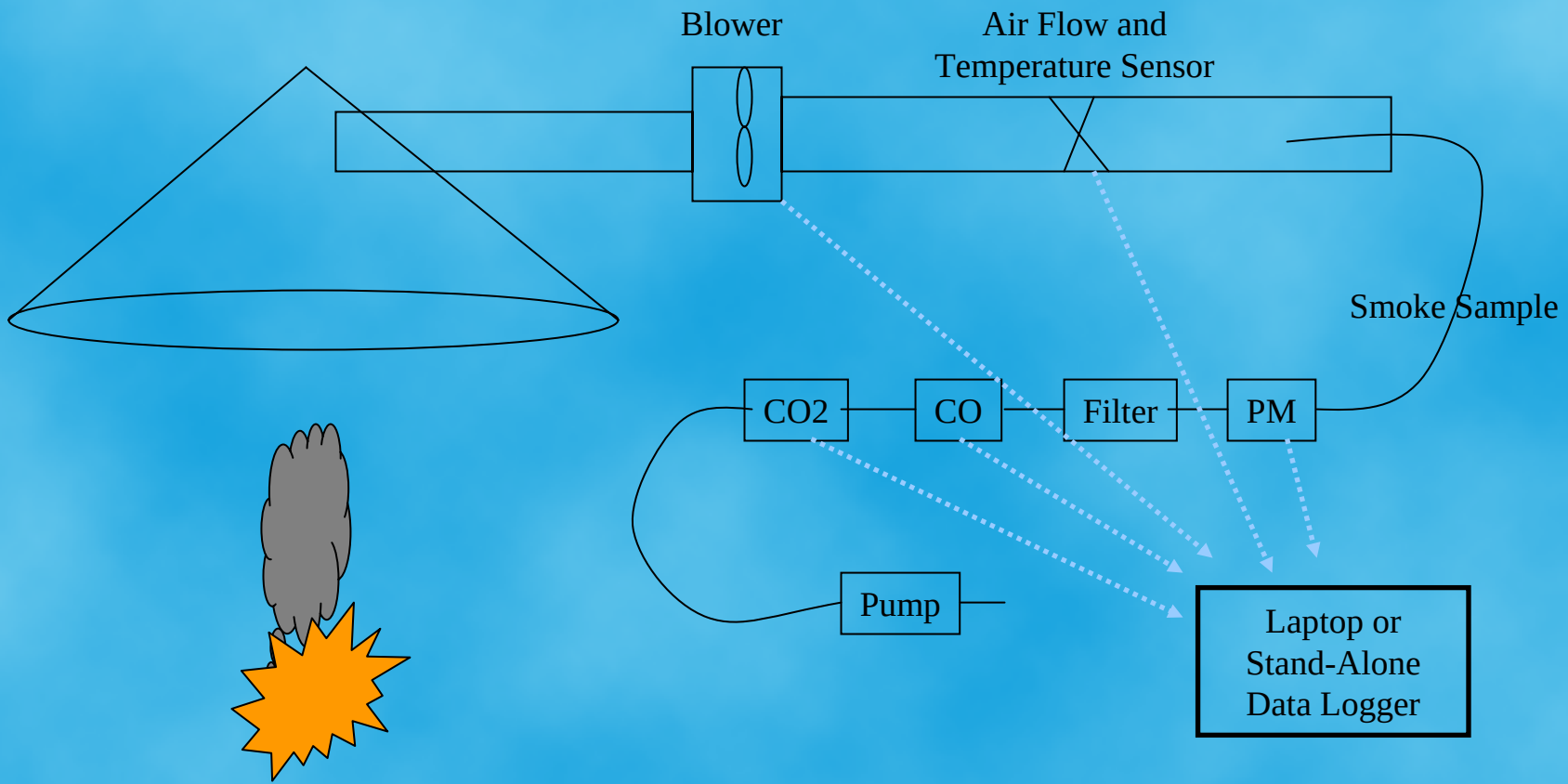


Intended to be accurate, inexpensive, and easy to use in the lab or field.

PEMS -- Schematic

Collects Smoke in Hood and Measures each second:

- Carbon Monoxide
- Carbon Dioxide
- Particulates
- Temperature
- Air Flow



PEMS – Operation

Data is processed in an automated spreadsheet in conjunction with a WBT or CCT to determine:

- Mass of CO, CO_2 and PM produced per cooking task
- Emission Factors per kg of fuel burned
- CO/CO2 and PM/CO2 Ratio

Useful for:

- Evaluating stove design changes
- Field testing and comparing emissions between improved and traditional stoves
- Meeting Performance Benchmarks
- Can be run off grid electricity or 12VDC battery to pair emissions measurement with fuel performance in the lab or in the field.

Also available as a separate CO/PM unit with datalogger for indirect measurements in kitchen studies.

Thanks to Tami Bond and Chris Roden of UIUC and to Shell Foundation!

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