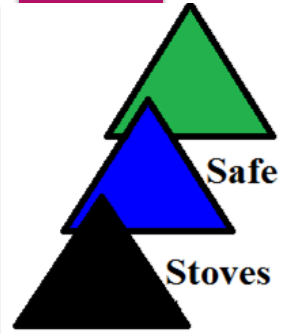




NORTHERN
ARIZONA
UNIVERSITY



Research Plan to Evaluate Efficiency and Emissions in Cookstoves for Lesoit, Tanzania

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EGR 476C Students, Spring 2016

Instructor: Professor Dianne McDonnell

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THE WOMEN IN LESOIT



Woman in Lesoit cooks with wood [1]

ISSUES FACING WOMEN IN LESOIT

Health Problems



Health problems caused by indoor air pollution[4]

Lack of Education



Spending time collecting wood[3]

Economics



Time spent collecting fire wood[2]

NO GAS

NO ELECTRICITY



cooking emissions [6]



possible solutions to
cooking smoke [7]

TESTING COOKING TECHNOLOGY OPTIONS



Solar Stoves [8]



Improved stoves[9]

RESEARCH PLAN



SURVEY

**Room
Dimensions**

**Cooking
Locations**

**Smoke
Protection**

Ventilation

**Cooking
Duration**

**Health
Issues**



CRITERIA

Reduce Emissions
Cooking (Thermal Efficiency)
Save Time

Wood Burning
Collecting Wood



Women in Tanzania [5]

METHODOLOGY

- ▶ Thermal efficiency and cooking time
 - ▶ Predicting energy output (heat transfer and thermodynamics)
 - ▶ Solar cookers (radiation energy)
 - ▶ Fuel Stove (chemical energy)
 - ▶ Measure time to boil
- ▶ Emissions (by fuel type)
 - ▶ Predict emissions (stoichiometry and Gibbs Free energy -> calculate the Energy from combustion)
 - ▶ Test = (In-situ) Drager tubes – syringe (controlled combustion) – different fuels
- ▶ Emissions (by fuel with stove)
- ▶ Socio-economic analysis

SOLAR COOKERS



Solar cooking

Why Solar Cooker?

- Eco-Friendly
- Location
- Quality of Food

Types of Solar Cookers

- Parabolic Dish
- Parabolic Trough
- Box
- Panel

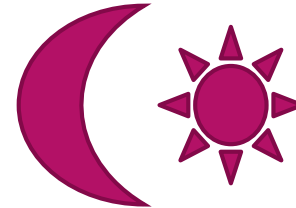
DIRECT SOLAR COOKER

- Absorber
- Reflector
- Insulation



INDIRECT SOLAR COOKER

- Absorber
- Reflector
- Insulation
- Storage System
- Battery or Heat Exchanger



SOLAR COOKERS OPTIONS

SOLAR COOKER TESTING AND COMPARING

Testing



No Emissions =
No Air Quality
Test



Water
Boiling

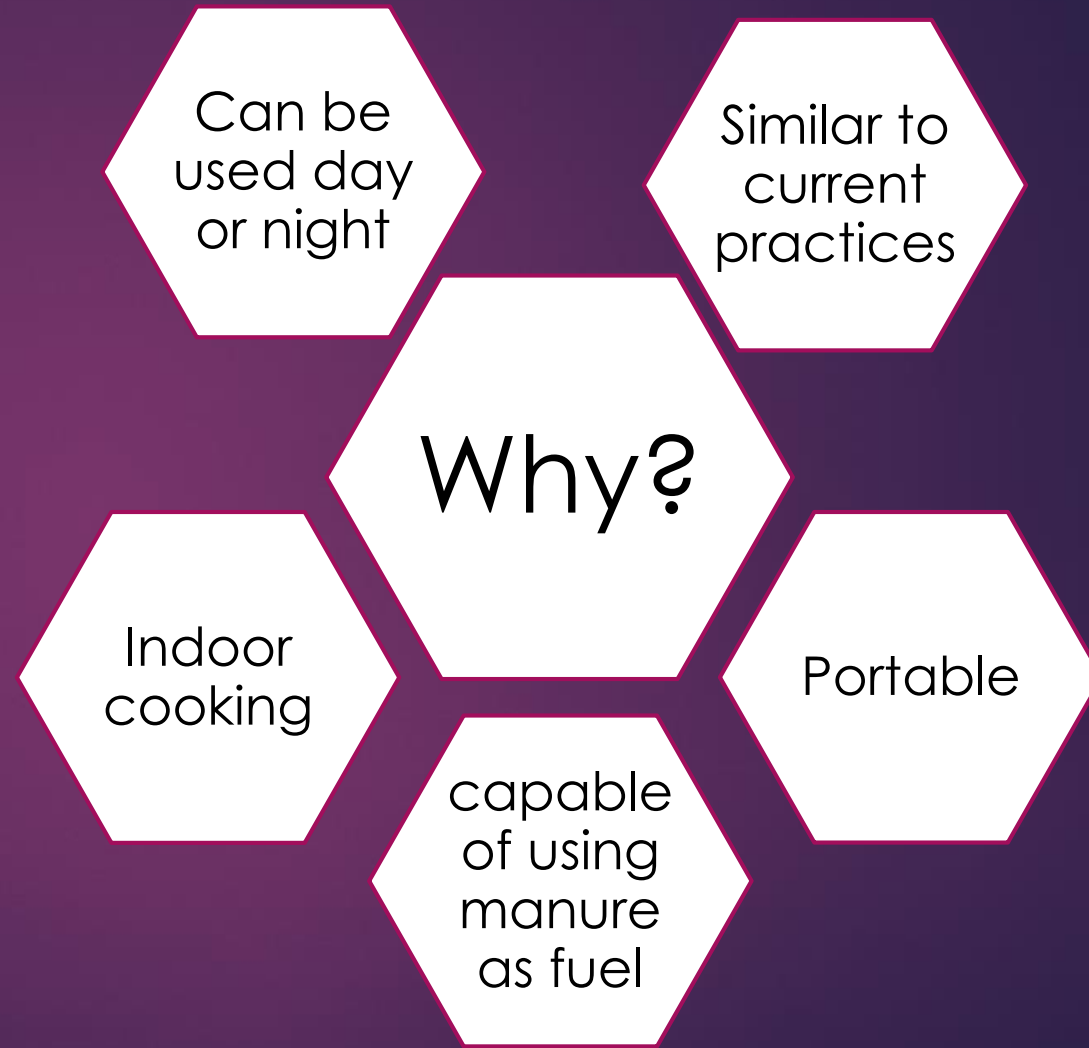


Efficiency

$$P_i = \frac{(T_f - T_i) * M * C_v}{t}$$

(t = 600 sec)

WHY IMPROVED COOKSTOVES?



TYPES OF IMPROVED COOKSTOVES



Jikko
Stove



Gasifier
Stove



Rocket
Stove

GASIFIER STOVE



Gasification process produces cleaner burning combustible gasses [14]



Up to 27% efficiency compared to three-stove stove efficiency of 6.5%



Improved Stove[15]

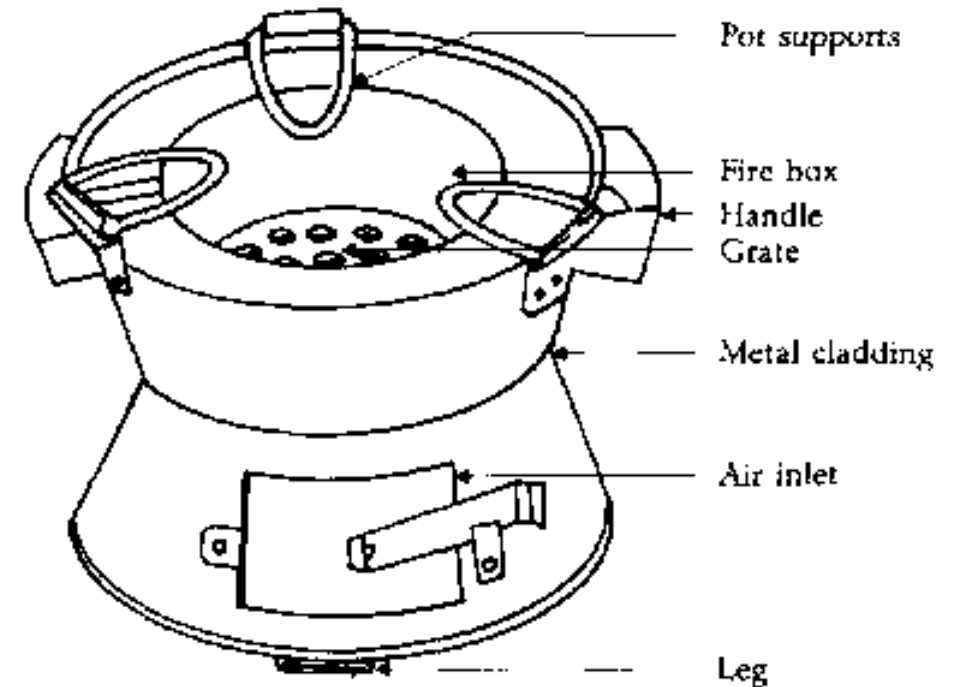
JIKKO STOVE

Shape Focuses Heat
on Pot

Can be Made From
Local Materials

Popular in Kenya

Up to 50% Fuel
Reduction



Jikko Stove [16]

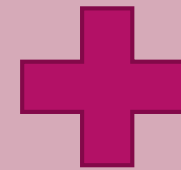
ROCKET STOVE



Rocket Stove [17]

Vertical
Combustion
Chamber →
Increased Oxygen

Insulation increases
efficiency



Reduces fuel
consumption up to
47%

Reduces CO
emissions up to 60%

IMPROVED STOVES TESTING



Women cooking [18]

Emissions Test

Particulate
matter (PM)

Carbon
Monoxide
(CO)

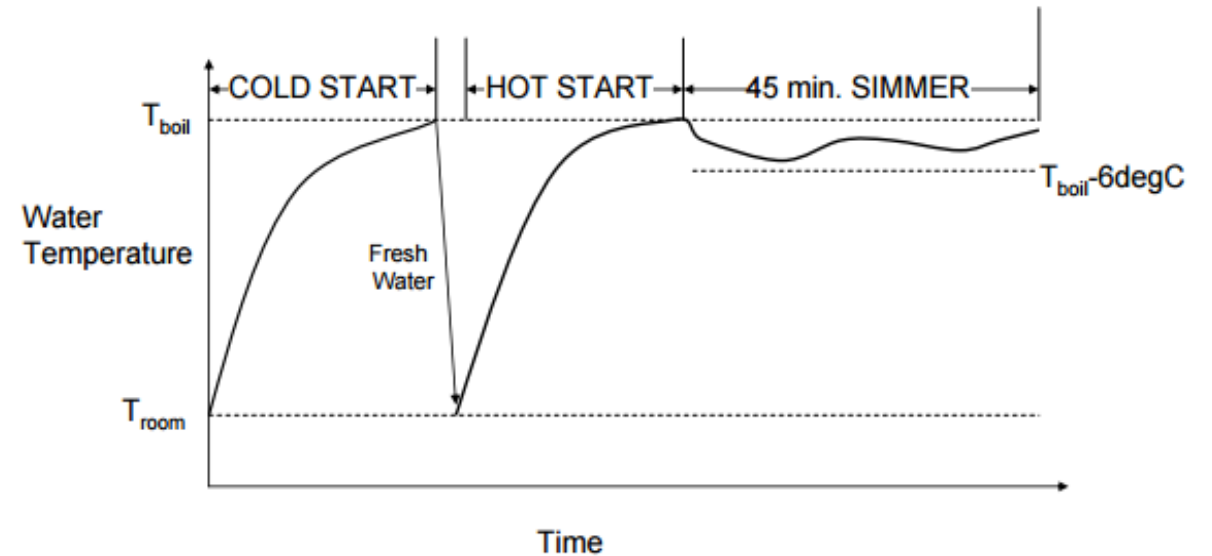
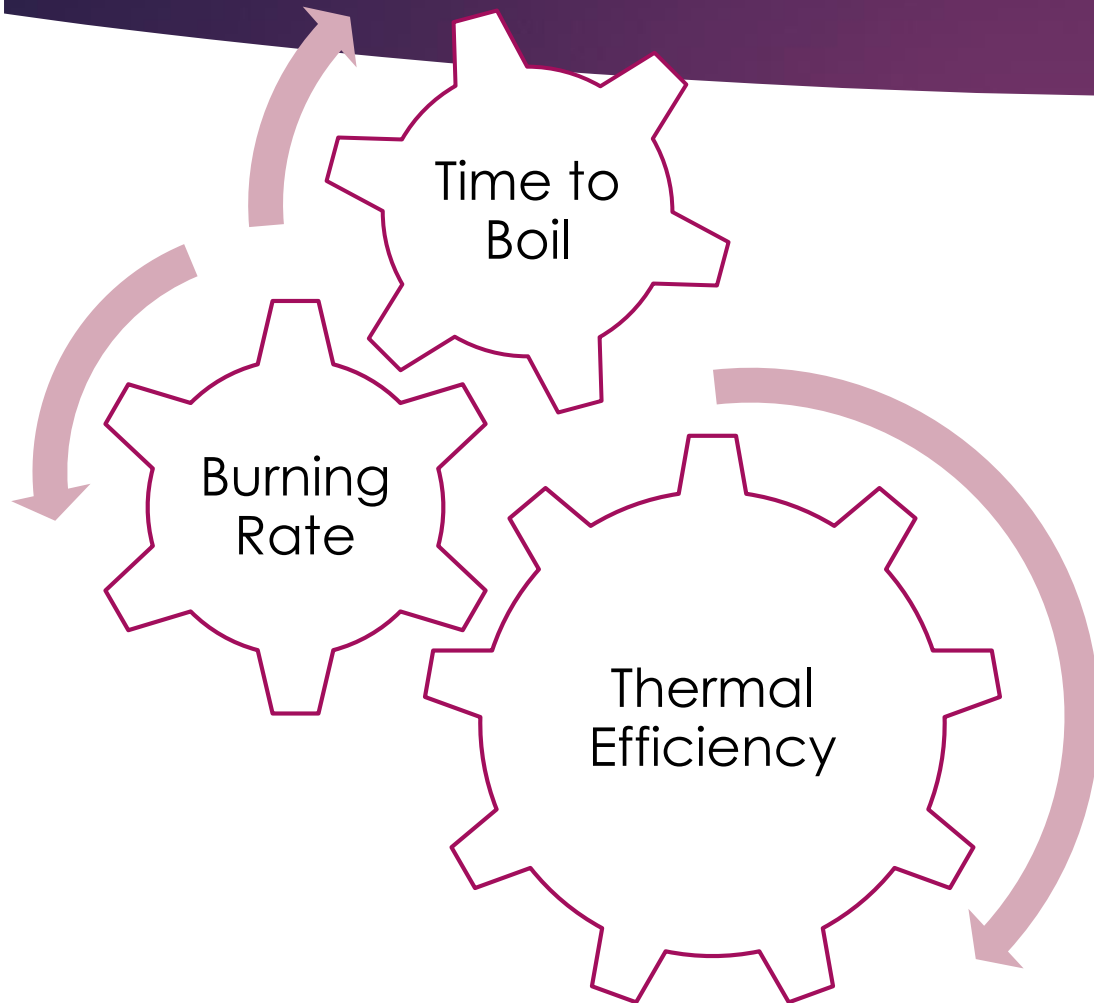
Efficiency

More efficient
stoves mean
less fuel is
needed.

Less time
cooking.

EFFICIENCY TESTING

Water Boiling Test 4.2.3



Temperature vs Time, water boiling test [19]

EMISSIONS TESTING



Drager glass tubes [20]

Particle Counter

- Concentrations of Particulate Matter (PM)
- Ranges of PM tested 2.5 μm to 10 μm

Drager Glass tubes

- Concentrations of **CO**
- Ranges of concentrations



Particle Counter
Met One Model 212 [21]

Efficiency and Emissions Metrics

- ▶ Time to boil
- ▶ Thermal efficiency \rightarrow Energy Delivered/Energy Released
- ▶ Fuel consumption rate \rightarrow Mass Fuel Used/Time
- ▶ Emissions rate \rightarrow Emissions/Time
- ▶ Emissions/Kilojoules Delivered

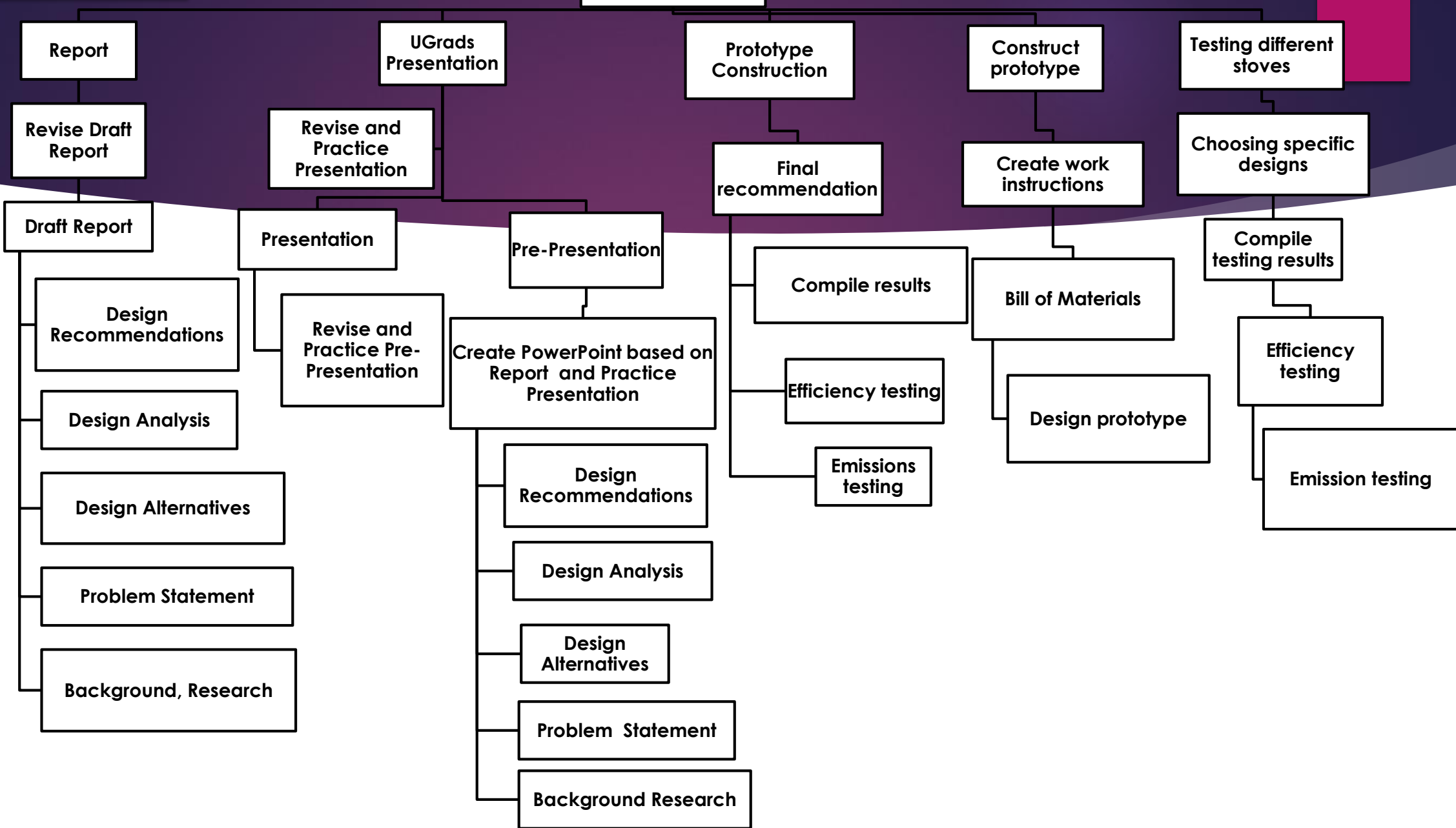
MATERIALS AND MANUFACTURABILITY

Materials are going to be available locally, so the women of Lesoit can build them themselves.

Alternatives and Testing material	Parts	Quantity	Price
Air quality testing	Glass tubes (Drager glass tubes) CO	7 testing glass tubes for each compound emissions.	140\$
Three stones stove	Wood	5 lb	(Tanzania)
	Base material	Three average to big size stones	N/A
Jikko stove	Jikko (The stove itself)	1	(Tanzania)
	Wood and manure	5 lb each	(Tanzania)
Gasification stove	Aluminum or steel or stainless steel	# ft ² area and # ft thickness	(Tanzania)
	Wood and Manure	5 lb each	(Tanzania)
Solar stove	Reflector	1 Mylar Roll	30\$
	Absorber	One Copper pipe Black Matte Paint	15\$
	Design with Insulation	Wood	30\$
	Tracking system	2 of 5 watts solar panels	40\$

WBS

Sustainable Cookstove



GANTT CHART

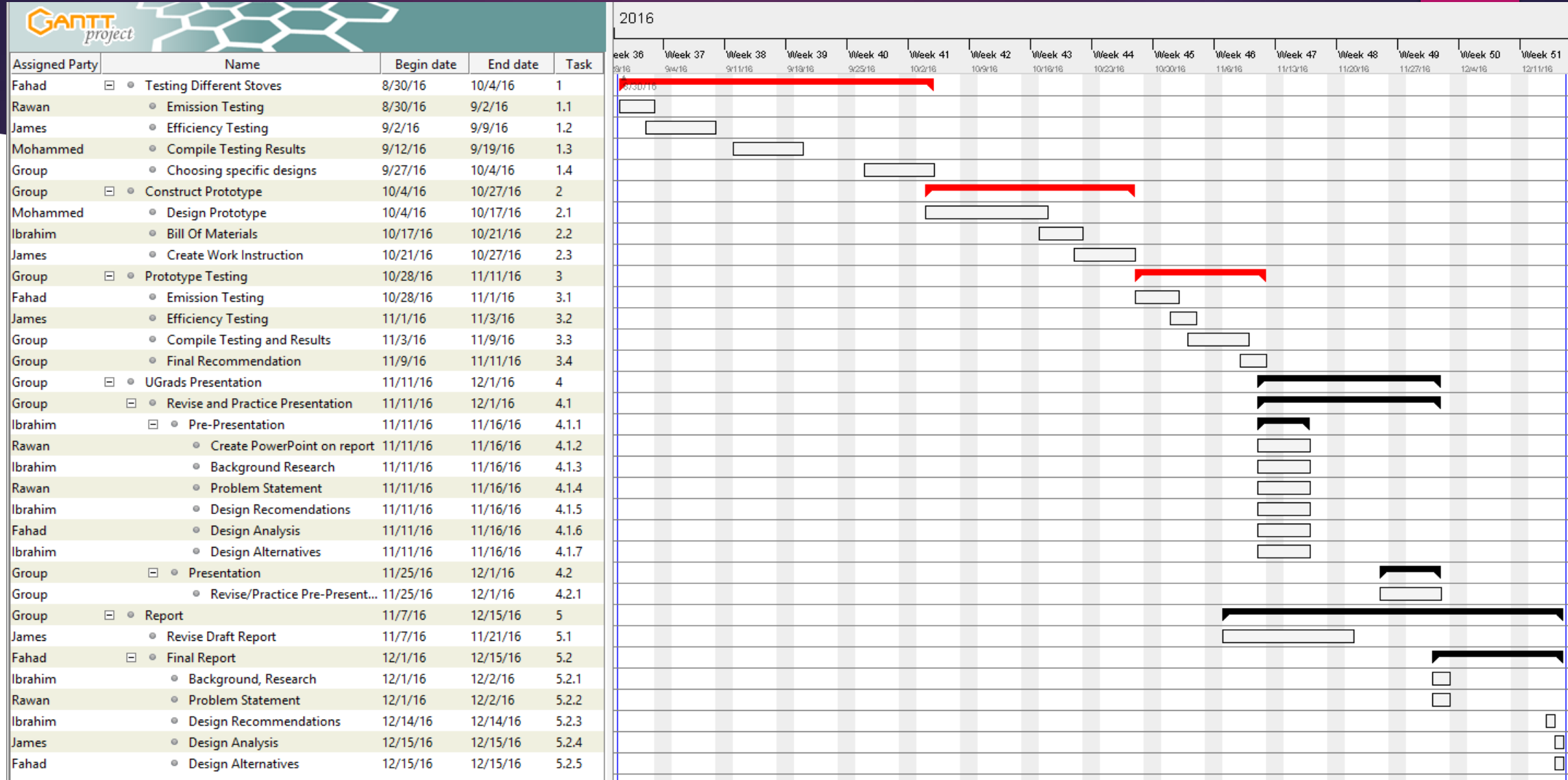


Figure 24: The Safe Stove team Gantt Chart



Wood
Emissions

Improved
Cook
Stoves &
Solar Stove

More Time
Less
Emissions



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ASK US!

