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# Comparative Study on the Performance of A.1 Improved Cookstove and Some Different Design of Wood-fuel Cookstoves from Each Locality in Myanmar






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## Abstract

This study aimed to compare the performance of Forest Research Institute A.1 improved cookstove and some different design of wood-fuel cookstoves from each locality in Myanmar. Thus, stoves sample were collected from Nay Pyi Taw, Yangon, Mandalay, Magwe and Sagaing Region. The tests were carried out in accordance with Adapted Water Boiling Test-AWBT. As a test results, potential cooking time of FRI A.1 can save around 32% compared to E.Free stove. And also, it can be saved 9% for Sanpya A.1, 27% for DE DE stove, 39% for Cement (Pyinmana) stove, 83% for Thar-si stove, 32% for Mercy Corps and 36% for China stove. Also FRI A.1 has a better performance in terms of useful energy which is around 4,900 kJ that is 19% more than E.Free stove and also 6% more than Sanpya A.1, 15% more than De De, 25% more than Cement(Pyinmana), 31% more than Thar-si, 21% more than Mercy Corps and 3% more than China stoves. Moreover, FRI A.1 can-maintained heat longer among the wood-fuel cookstove.

**Keywords:** A.1 improved cookstoves, Wood-fuel Cookstoves, Adapted Water Boiling Test-AWBT

# မြန်မာနိုင်ငံအတွင်း ဒေသအသီးသီးတွင် အသုံးပြုလျက်ရှိသည့် ပုံသဏ္ဍာန်မတူညီသော ထင်းမီးဖိုအချို့၏ စွမ်းဆောင်နိုင်မှုနှင့် အေဝမ်းစွမ်းအားမြင့်မီးဖိုအား နှိုင်းယှဉ်လေ့လာခြင်း

ချောရူပါစိုး၊ သုတေသနလက်ထောက်-၂
**သစ်တောသုတေသနဌာန၊ သစ်တောဦးစီးဌာန**

## စာတမ်းအကျဉ်း

မြန်မာနိုင်ငံအတွင်း၊ ဒေသအသီးသီးတွင်အသုံးပြုလျှက်ရှိသည့် ပုံသဏ္ဍာန် မတူညီသော ထင်းမီးဖိုအချို့၏ စွမ်းဆောင်နိုင်မှုနှင့် သစ်တောသုတေသုနဌာနမှ ထုတ်လုပ် ဖြန့်ဖြူး လျက်ရှိသည့် အေဝမ်းစွမ်းအားမြှင့်မီးဖို၏ စွမ်းဆောင်နိုင်မှုတို့အား နှိုင်းယှဉ် သိရှိနိုင်ရန် အတွက် နေပြည်တော်၊ ရန်ကုန်၊ မကွေး၊ မန္တလေးနှင့် စစ်ကိုင်းတိုင်း ဒေသကြီးအတွင်းမှ ထင်းမီးဖိုအချို့အား ရယူစမ်းသပ်လေ့လာခဲ့ပါသည်။ စမ်းသပ်မှု လုပ်ငန်းစဉ် အားလုံးအား Group for the Environment, Renewable Energy and Solidarity-GERES အဖွဲ့အစည်း၏ သတ်မှတ်ချက်များနှင့်အညီ ဆောင်ရွက်ခဲ့ပါသည်။ ချက်ပြုတ်ချိန် ချွေတာနိုင်မှုတွင် အေဝမ်း စွမ်းအားမြှင့်မီးဖိုက E.Free မီးဖိုထက် ၃၂%၊ စံပြအေဝမ်းမီးဖိုထက် ၉%၊ ဒီးဒီးမီးဖိုထက်၂၇%၊ ကျောက်မီးဖိုထက် ၃၉%၊ သာစည်မီးဖိုထက် ၈၃%၊ မာစီကော့မီးဖိုနှင့် တရုတ်မီးဖိုများထက် ၃၂%နှင့်၃၆% အသီးသီး ပိုမိုချွေတာ နိုင်ကြောင်းတွေ့ရှိရပြီး အသုံးဝင်စွမ်းအင်နှင့် လောင်စာ ချွေတာနိုင်မှုအလားအလာ တို့၌ E.Free မီးဖိုထက် ၁၉%၊ စံပြအေဝမ်းမီးဖိုထက် ၆%၊ ဒီးဒီး မီးဖိုထက် ၁၅%၊ ကျောက်မီးဖိုထက် ၂၅%၊ သာစည်မီးဖိုထက် ၃၁%၊ မာစီကော့ မီးဖိုနှင့် တရုတ်မီးဖိုများထက် ၂၁%နှင့်၃% ပိုမိုကောင်းမွန်ကြောင်းတွေ့ရှိရကာအပူ ထိန်းသိမ်း ထားနိုင်မှုတွင်လည်း လေ့လာစမ်းသပ်ခဲ့သည့် မီးဖိုများအားလုံးထဲတွင် သစ်တော သုတေသန ဌာန အေဝမ်းမီးဖိုက အပူကြာရှည်စွာ ပိုမိုထိန်းသိမ်းထားနိုင်ကြောင်း တွေ့ရှိရပါသည်။

**Comparative Study on the Performance of A.1 Improved Cookstove and Some Different Design of Wood-fuel Cookstoves from Each Locality in Myanmar**

## 1. Introduction

The 2.5 billion people globally who rely on solid biomass for cooking mostly use inefficient and polluting devices. Burning biomass on inefficient cookstoves leads to a negative impact on the environment and health. A technological solution to help mitigates the negative impacts associated with biomass cooking is the use of improved cookstove, a cleaner and more efficient cooking device (GERES 2014).

According to the Myanmar Population and Housing Census of 2014, wood-fuel and charcoal have been the main type of energy for cooking and heating in Myanmar, accounting for about 90% of the total energy consumption. The other types of energy like electricity (16.4%), LPG/ Biogas (0.6%), Kerosene (0.2%) and others (1.7) were included. Also, 70% of the total country's population live in rural area and most of the rural households use traditional cookstove like open-fire cookstove and inefficient cookstove.

In Myanmar, 93% of the populations rely on solid fuel for their household cooking needs, contributing to environmental deforestation and desertification. Inefficient cookstoves also contribute to climate change through emissions of greenhouse gases such as carbon dioxide, methane, and aerosols such as black carbon.

Clean cooking is instrumental in improving energy access in Myanmar. The use of clean, save, and efficient cookstoves and fuel can dramatically reduce fuel consumption and exposure to harmful cookstove smoke, provide myriad economic opportunities, and help address deforestation. More efficient stoves also reduce the time for people, usually for woman, girls and children, spending on wood-fuel collecting, saving time for income-generating activities or schoolwork. Moreover, by using the more efficient stoves, a considerable area of wood-fuel the plantation can be saved annually and valuable commercial and industrial plantation could take their place in those areas.

In this research, the objective is to examine the performance of a range of wood-fuel cooking stoves in Myanmar to determine which can save more wood-fuel and also have longer control of the heat. The more households use wood-fuel stoves with higher efficiency in Myanmar, the less wood-fuel consumption would be, thereby lessening the depletion of national forests. Moreover, the results will contribute to how institutional factors should be developed and improved, and which types of efficient cookstove should be applied to support successful outcomes for a rural area in Myanmar.

In addition, more efficient stoves and cleaner fuels that meet WHO indoor air quality guidelines have the potential to avert millions of deaths each year caused by household air pollution, while also reducing emissions that impact climate change.

Thus, the objectives of this study are:

i. To investigate the performance of different designed wood-fuel cookstoves from each locality.
ii. To compare the investigated wood-fuel cookstoves with A.1 Improved Cookstove of Forest Research Institute.

iii. To improve the living standard of rural households, by using the more efficient wood-fuel cookstoves.

## 2. Literature Review

Globally, almost 3 billion people do not have access to clean cooking facilities and still depend on traditional cookstoves or open fires to meet their cooking and heating needs. The majority of these people are based in rural areas (Putti et al., 2015). The dependence on traditional cookstoves (TCS) leads to a number of negative economic, social and environmental impacts. In many developing countries, energy for cooking needs accounts for the largest share of total energy consumption within the household (Bhattacharya, 2002). Biomass-based fuels are the primary source of energy for almost 90% of households across many developing countries (IEA, 2006). The sector is also an important source of employment for the rural population (Attigah, 2008).

The low efficiency means that substantial quantities of fuel must be collected from the surrounding areas and forests which can contribute to localized deforestation. Over exploitation can potentially lead to lower agricultural productivity and is one of the affecting factors to forest degradation (Brudele et al., 2013). Unsustainable use of forest resources for household combustion also contributes to $CO_2$ increasing in the atmosphere.

And the leading killer of children worldwide is acute respiratory infections (ARI) – accounting for 22% of all communicable child deaths in 2004 (WHO 2005). Strikingly, this exceeds the combined toll of diarrheal diseases, tuberculosis, and malaria. Epidemiological studies identify indoor air pollution (IAP) as a principal culprit, reporting powerful associations between IAP exposure and ARI symptoms (Smith *et al.* 2000, Ezzati and Kammen 2001, Ezzati *et al.* 2004, Pokhrel *et al.* 2005). Biomass combustion within the household is thought to be the main contributor to IAP (Ezzati *et al.* 2004), so women who cook and the infants and children they care for are particularly affected. World Health Report identifies IAP as the single largest environmental risk factor for female mortality, attributing 5% of all female deaths in the developing world to indoor smoke (WHO 2002).

Furthermore, in many households, women spend a considerable time foraging for firewood. In rural Ethiopia, households, mainly women between the ages of 18 to 59 on average spent 11 to 12 hours per week collecting biomass (fuelwood and dung) (Gwavuya et al., 2012). In India, based on the household energy survey of 1996, estimates suggest that women spend 40 minutes every day on collecting fuel and almost 3 hours for cooking every day (ESMAP, 2004). In Kenya, research highlights that deforestation has meant that women need to go further from their homes to gather firewood and spend between 2-3 hours per day foraging for wood. In Darfur, women walk up-to seven hours a day, three to five times a week, to collect firewood for cooking (Kirchstetter et al., 2010).

## 3. Material and Method

### 3.1 Material

For each stove, Bawsa-kaing *Leucaena leucocephala* woods were used as a main fuel. The woods had been sundried and stored in a bag. The moisture content was measured before use and had an average of 16% during the testing period. One kilogram of woods was used for the test and 25 grams of starters were also used for an initiative of the burning. For each test, different types and designs of wood-fuel cookstoves were collected from Nay Pyi Taw Union Territory, Yangon, Mandalay, Magwe and Sagaing Regions. All types and designs of wood-fuel cookstoves are shown below.

**Types and Design of some wood-fuel cookstoves from different regions.**

| | |
|---|---|
|  | The name of this stove is FRI A.1 and Saving of wood-fuel consumption is 40%. The type of stove is clay and it was produced by Forest Research Institute, Yezin, Nay Pyi Taw Union Territory. Fuel type is mainly wood-fuel and can be used with other fuel types such as agricultural residues and wood-based products. |
|  | The name of this stove is E.Free and the type of stove is clay. It was collected from Dry Zone Greening Department of Magwe Region. Fuel type is mainly wood-fuel and it can be used with other fuel types such as agricultural residues. |
|  | The name of this stove is Sanpya A.1 and the type of stove is clay. It was collected from Chaung-U township of Sagaing Region. Its design was based on FRI A.1 Stove. Fuel type is mainly wood-fuel and it can be used with other fuel types such as agricultural residues and wood-based products. |
|  | The name of this stove is Kyauk and the type of stove is cement. It was collected from Pyinmana township of Nay Pyi Taw Union Territory. Fuel type is mainly wood-fuel and it can be used with other fuel types such as agricultural residues. |

| | |
|---|---|
|  | The name of this stove is De De and the type of stove is clay. It was collected from Yangon Region. Fuel type is mainly wood-fuel and also can be used with other fuel types such as agricultural residues. |
|  | The name of this stove is Thar-Si and the type of stove is clay with bucket. It was collected from Mandalay Region. Fuel type is mainly wood-fuel and also can be used with other fuel types such as agricultural residues. |
|  | The name of this stove is Biomass Clean Cookstove and the type of stove is Metal. It was received from International Non-Governmental Organization of China. Fuel type is mainly wood-fuel and also can be used with other fuel types such as agricultural residues. |
|  | The name of this stove is Mercy Corps Improved Cookstove and the type of stove is Metal. It was received from International Non-Governmental Organization of Myanmar. Fuel type is mainly wood-fuel and also can be used with other fuel types such as agricultural residues. |

**3.2 Methods**

Stove performances were tested as follows by Adapted Water Boiling Test- AWBT (Version 2.0 - GERES 2011).

The Adapted Water Boiling Test (AWBT) has been designed by GERES to be **more representative of local** in-use operation and to **ease the implementation** of the test in developing countries. The Water Boiling Test (WBT) is regularly revised and modified, making implementation difficult and complex for local technicians. The AWBT is easier, more precise (**fewer error sources**) and accessible to local development agencies and organizations working on the evaluation and dissemination of cookstoves. However, the AWBT developed by GERES is favoring stoves able to operate in **high power**, the common way of cooking in the region. This protocol is used for laboratory testing, not to define an energetic yield but to provide a comparison of fuel usage between two cookstoves: this test will not calculate stove efficiency but a relative difference in useful energies between two stoves with same fuel. Then, a potential fuel saving can be calculated based on useful energies. The AWBT has been validated in different countries and has provided a good approximation of field testing. Unlike the WBT, in the AWBT protocol, the quantity of fuel is fixed at the beginning of the test and will be the same for all tests and stoves that will be compared. The AWBT consists of two phases that immediately follow each other:

a) The **cold-start high-power** phase: at ambient temperature, the stove is loaded/ fed with a fixed quantity of fuel to bring to boil 3 liters of water in a standard pot.

b) The **evaporating high-power** phase consists of evaporating the remaining water until the water temperature drops to 3°C below the boiling point. The quantity of water evaporated during each phase of the AWBT is measured. The useful energy (UE) is then calculated. It represents the energy absorbed by the mass of water (Mw) to raise its initial temperature Ti to the boiling temperature Tb (sensible heat: Q sensible) and the energy absorbed by the mass of water evaporated (Mwe) to change its phase from liquid to vapor (latent heat: Q latent).

UE [kJ] = Q sensible [kJ] + Q latent [kJ]

Q sensible [kJ] = Mw [kg]*C*(Tb-Ti) [˚C]

Q latent [kJ] = Mwe [kg]*Lv

Where: C is the specific heat capacity = 4.18 kJ/kg.˚C

Lv is the specific latent heat of vaporization = 2257 kJ/kg.˚C

For the **AWBT**, a flat bottom pot (24cm diameter and 12cm height) filled with **3 liters** of water was used for all tests. No lid was used, as recommended in the AWBT protocol.

### 3.2.1 Testing Procedures

Firstly, prepare the fixed quantities of fuel and water (**1 Kilogram and 3 liters).** And then put the pot on the stove, start the fire, measure the initial water temperatures, start the timer and record water temperatures every three minutes until it reaches the boiling point **(local boiling point is 98.7ºC**). And then when the boiling is reached, record the time (TTB). At the same time kept the water evaporating by using the remaining fuel until the water temperature drops to 3ºC below the boiling point. When temperature drops to 3ºC below the boiling point, record the time for total time to test (TTT). Finally, record the final masses of water and fuel remaining.

## 4. Data analysis

In this research, mean and coefficient of variation of stove performance (Time to boil-TTB, Total Time to test-TTT, Heating speed and Useful Energy) were calculated by using Group Energie Renouvelable, Environment Et Solidarities (GERES-2011).

## 5. Results and Discussion

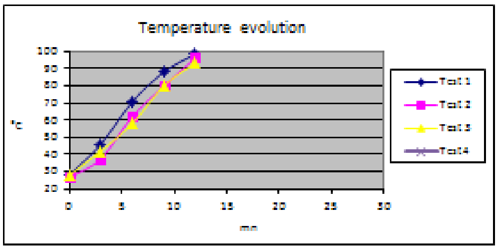
### 5.1 Comparison of stove performance of FRI A.1 and E.Free

The comparison of the stove performance of FRI A.1 and E.Free wood-fuel cookstoves are shown in table 1. The tests have run for 3 times for each stove (1 set of tests) to ensure the acceptable rage of variation. In every test, the fuel starter and water quantity are the same.

**Table 1**

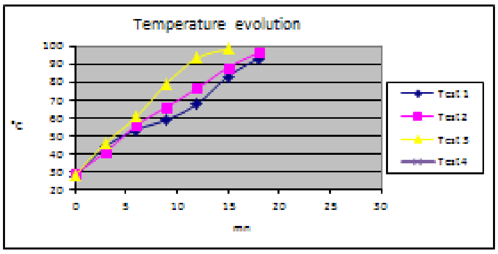
ANALYSIS OF AWBT WOOD : RESULT

| STOVE 1 | FRI A.1 |
|---|---|




| Mean Burning rate | 16.04 gr/mn |
|---|---|
| Mean Evaporating rate | 36.38 gr/mn |
| TTT | 62.33 mn |
| TTB | 13.03 mn |
| Fin Vat. | 1.21 Kg |
| Useful Power high | 1.172 Kw |
| Useful Power Low | 1.369 Kw |
| Useful Energy | 4960 KJ |
| Estimated efficiency | 33.07% |

| STOVE 2 | E.Free |
|---|---|




| Mean Burning rate | 18.89 gr/mn |
|---|---|
| Mean Evaporating rate | 40.56 gr/mn |
| TTT | 52.93 mn |
| TTB | 18.70 mn |
| Fin Vat. | 1.61 Kg |
| Useful Power high | 0.824 Kw |
| Useful Power Low | 1.544 Kw |
| Useful Energy | 4040 KJ |
| Estimated efficiency | 26.94% |

| Fuelwood Potential Saving | 18.54% | Stove 1/2 |
|---|---|---|

According to the table 1, compared to E.Free stove, FRI A.1's potential cooking time saving is around 32% and FRI A.1 can maintain heat for around 15% longer than E Free. The potential fuel saving of FRI A.1 is around 19 % compared to E.Free stove.

The potential fuel saving is the ratio of the useful energy provided by the cookstoves. This ratio shows the potential fuel differences between two cookstoves. **It starts to be significant above 10%.** The potential fuel saving is calculated with the following formula:

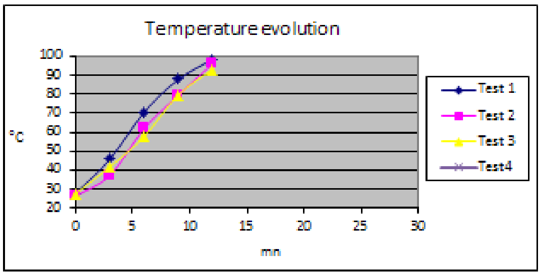
PFS [%] = 100 *(UE improved – UE traditional) / UE improved

## 5.2 Comparison of the stove performance of FRI A.1 and Sanpya A.1 wood-fuel cookstove

**Table 2**

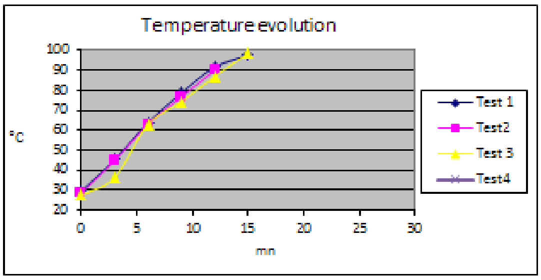
ANALYSIS OF AWBT WOOD : RESULT

| STOVE 1 | FRI A.1 |
|---|---|




| | |
|---|---|
| Mean Burning rate | 16.04 gr/mn |
| Mean Evaporating rate | 36.38 gr/mn |
| TTT | 62.33 mn |
| TTB | 13.03 mn |
| Fin Wat. | 1.21 Kg |
| Useful Power high | 1.172 Kw |
| Useful Power Low | 1.370 Kw |
| Useful Energy | 4961 KJ |
| Estimated efficiency | 33.07% |

| STOVE 2 | Sanpya A.1 |
|---|---|




| | |
|---|---|
| Mean Burning rate | 17.02 gr/mn |
| Mean Evaporating rate | 38.55 gr/mn |
| TTT | 58.77 mn |
| TTB | 15.40 mn |
| Fin Wat. | 1.33 Kg |
| Useful Power high | 0.974 Kw |
| Useful Power Low | 1.453 Kw |
| Useful Energy | 4671 KJ |
| Estimated efficiency | 31.14% |

| | | |
|---|---|---|
| Fuelwood Potential Saving | 5.84% | Stove 1/2 |

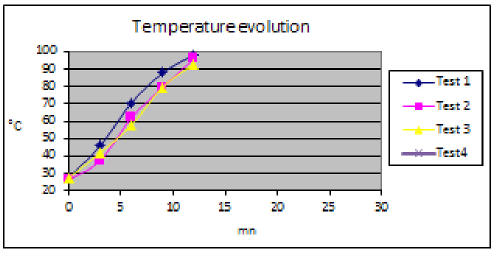
As a result, potential cooking time saving is around 9% and FRI A.1 can maintain heat for about 5% longer than Sanpya A.1. Potential fuel saving of FRI A.1 is around 6% compared to Sanpya A.1. So, there is no significant difference between FRI A.1 and Sanpya A.1.

### 5.3 Comparison of the stove performance of FRI A.1 and DE DE wood-fuel cookstove

**Table 3**

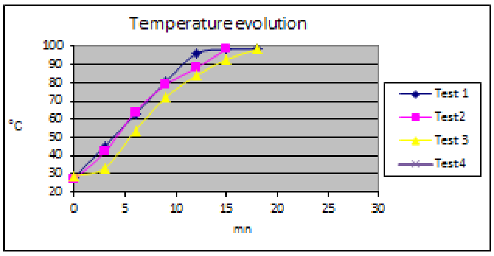
ANALYSIS OF AWBT WOOD : RESULT

| STOVE 1 | FRI A.1 |
|---|---|




| | |
|---|---|
| Mean Burning rate | 16.04 gr/mn |
| Mean Evaporating rate | 36.38 gr/mn |
| TTT | 62.33 mn |
| TTB | 13.03 mn |
| Fin Wat. | 1.21 Kg |
| Useful Power high | 1.172 Kw |
| Useful Power Low | 1.369 Kw |
| Useful Energy | 4960 KJ |
| Estimated efficiency | 33.07% |

| STOVE 2 | DE DE |
|---|---|




| | |
|---|---|
| Mean Burning rate | 18.45 gr/mn |
| Mean Evaporating rate | 40.27 gr/mn |
| TTT | 54.20 mn |
| TTB | 17.97 mn |
| Fin Wat. | 1.54 Kg |
| Useful Power high | 0.849 Kw |
| Useful Power Low | 1.522 Kw |
| Useful Energy | 4198 KJ |
| Estimated efficiency | 27.98% |

| | | |
|---|---|---|
| Fuelwood Potential Saving | 15.37% | Stove 1/2 |

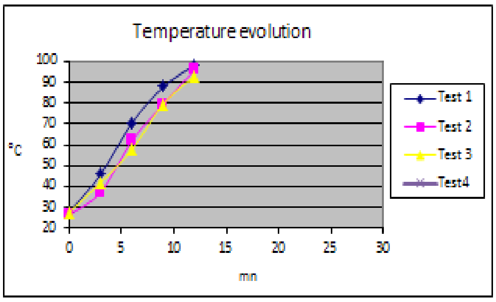
According to table 3, potential cooking time saving is around 27% and FRI A.1 can maintain heat for around 13% longer than DE DE. Potential fuel saving of FRI A.1 is around 15% compared to DE DE. Therefore, stove performance of FRI A.1 is moderately higher than DE DE wood-fuel cookstove.

## 5.4 Comparison of stove performance of FRI A.1 and Cement (Pyinmana) wood-fuel Cookstove

**Table 4**

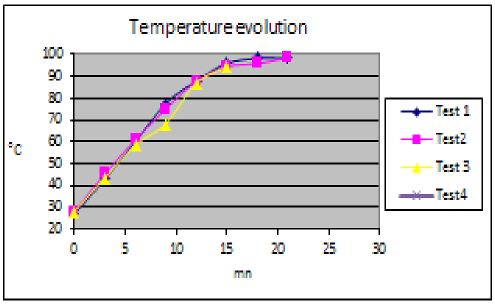
ANALYSIS OF AWBT WOOD : RESULT

| STOVE 1 | FRI A.1 |
|---|---|




| Mean Burning rate | 16.04 gr/mn |
|---|---|
| Mean Evaporating rate | 36.38 gr/mn |
| TTT | 62.33 mn |
| TTB | 13.03 mn |
| Fin Wat. | 1.21 Kg |
| Useful Power high | 1.172 Kw |
| Useful Power Low | 1.370 Kw |
| Useful Energy | 4961 KJ |
| Estimated efficiency | 33.07% |

| STOVE 2 | Cement(Pyinmana) |
|---|---|




| Mean Burning rate | 21.47 gr/mn |
|---|---|
| Mean Evaporating rate | 46.17 gr/mn |
| TTT | 46.57 mn |
| TTB | 19.70 mn |
| Fin Wat. | 1.76 Kg |
| Useful Power high | 0.775 Kw |
| Useful Power Low | 1.740 Kw |
| Useful Energy | 3711 KJ |
| Estimated efficiency | 24.74% |

| Fuelwood Potential Saving | 25.20% | Stove 1/2 |
|---|---|---|

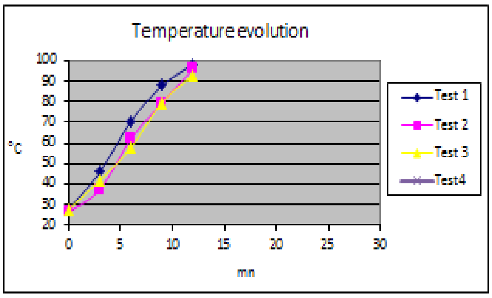
According to the table 4, potential cooking time saving is around 39% and FRI A.1 can maintain heat for around 25% longer than Cement (Pyinmana) Potential fuel saving of FRI A.1 is around 25% compared to Cement (Pyinmana). Therefore, stove performance of FRI A.1 is significantly higher than Cement (Pyinmana) wood-fuel cookstove.

### 5.5 Comparison of stove performance of FRI A.1 and Thar-si wood-fuel cookstove

**Table 5**

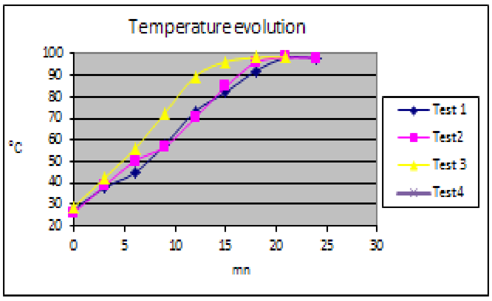
ANALYSIS OF AWBT WOOD : RESULT

| STOVE 1 | FRI A.1 |
|---|---|




| | |
|---|---|
| Mean Burning rate | 16.04 gr/mn |
| Mean Evaporating rate | 36.38 gr/mn |
| TTT | 62.33 mn |
| TTB | 13.03 mn |
| Fin Wat. | 1.21 Kg |
| Useful Power high | 1.172 Kw |
| Useful Power Low | 1.370 Kw |
| Useful Energy | 4961 KJ |
| Estimated efficiency | 33.07% |

| STOVE 2 | Thar-Si |
|---|---|




| | |
|---|---|
| Mean Burning rate | 22.19 gr/mn |
| Mean Evaporating rate | 58.07 gr/mn |
| TTT | 45.07 mn |
| TTB | 26.03 mn |
| Fin Wat. | 1.89 Kg |
| Useful Power high | 0.592 Kw |
| Useful Power Low | 2.230 Kw |
| Useful Energy | 3405 KJ |
| Estimated efficiency | 22.70% |

| | | |
|---|---|---|
| Fuelwood Potential Saving | 31.37% | Stove 1/2 |

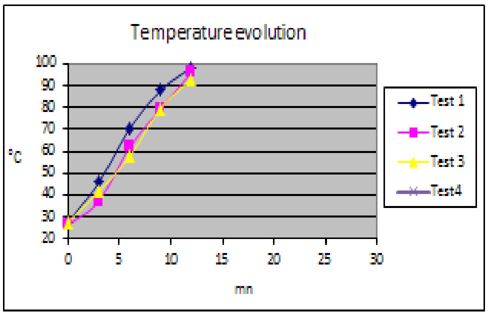
According to table 5, potential cooking time saving is around 83% and FRI A.1 can maintain heat for about 27% longer than Thar-si stove. Potential fuel saving of FRI A.1 is around 31% compared to Thar-si stove. Therefore, stove performance of FRI A.1 is significantly higher than Thar-si wood-fuel cookstove.

### 5.6 Comparison of stove performance of FRI A.1 and Mercy Corps wood-fuel cookstove

**Table 6**

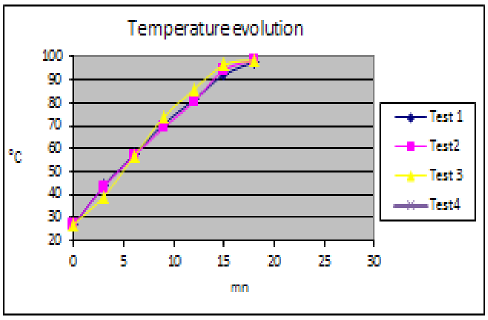
## ANALYSIS OF AWBT WOOD : RESULT

| STOVE 1 | FRI A.1 |
|---|---|




| | |
|---|---|
| Mean Burning rate | 16.04 gr/mn |
| Mean Evaporating rate | 36.38 gr/mn |
| TTT | 62.33 mn |
| TTB | 13.03 mn |
| Fin Wat. | 1.21 Kg |
| Useful Power high | 1.172 Kw |
| Useful Power Low | 1.370 Kw |
| Useful Energy | 4961 KJ |
| Estimated efficiency | 33.07% |

| STOVE 2 | Mercy Corps |
|---|---|




| | |
|---|---|
| Mean Burning rate | 17.78 gr/mn |
| Mean Evaporating rate | 35.53 gr/mn |
| TTT | 56.23 mn |
| TTB | 18.73 mn |
| Fin Wat. | 1.67 Kg |
| Useful Power high | 0.818 Kw |
| Useful Power Low | 1.337 Kw |
| Useful Energy | 3925 KJ |
| Estimated efficiency | 26.16% |

| Fuelwood Potential Saving | 20.89% | Stove 1/2 |
|---|---|---|

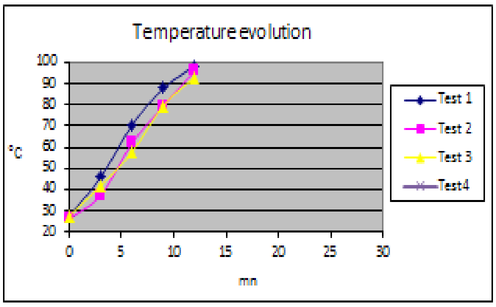
According to table 6, potential cooking time saving is around 32% and FRI A.1 can maintain heat for around 10% longer than Mercy Corps stove. Potential fuel saving of FRI A.1 is around 21% compared to Mercy-Corps stove. Therefore, stove performance of FRI A.1 is moderately higher than Mercy Corps wood-fuel cookstove.

### 5.7 Comparison of stove performance of FRI A.1 and China wood-fuel cookstove

**Table 7**

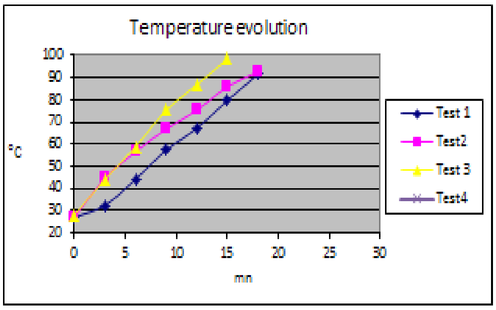
ANALYSIS OF AWBT WOOD : RESULT

| STOVE 1 | FRI A.1 |
|---|---|




| Mean Burning rate | 16.04 gr/mn |
|---|---|
| Mean Evaporating rate | 36.38 gr/mn |
| TTT | 62.33 mn |
| TTB | 13.03 mn |
| Fin Wat. | 1.21 Kg |
| Useful Power high | 1.172 Kw |
| Useful Power Low | 1.369 Kw |
| Useful Energy | 4960 KJ |
| Estimated efficiency | 33.07% |

| STOVE 2 | China |
|---|---|




| Mean Burning rate | 17.43 gr/mn |
|---|---|
| Mean Evaporating rate | 44.46 gr/mn |
| TTT | 57.37 mn |
| TTB | 18.60 mn |
| Fin Wat. | 1.28 Kg |
| Useful Power high | 0.831 Kw |
| Useful Power Low | 1.710 Kw |
| Useful Energy | 4803 KJ |
| Estimated efficiency | 32.02% |

| Fuelwood Potential Saving | 3.16% | Stove 1/2 |
|---|---|---|

According to table 7, potential cooking time saving is around 36% and FRI A.1 can maintain heat for around 9% longer than China stove. Potential fuel saving of FRI A.1 is around 3% compared to China stove. So, there is no significant difference between FRI A.1 and China wood-fuel cookstoves.

## 6. Conclusion

Every test of AWBT for each stove takes around 1 hour to complete; depending on each stove's performance.

As a result, FRI A1 has a better performance in terms of useful energy that is around 4,900 kJ and is 19% more than E.Free stove, 6% more than Sanpya A.1, 15% more than De De, 25% more than Cement (Pyinmana), 31% more than Thar-si, 21% more than Mercy Corps and 3% more than China stoves.

Also potential cooking time of FRI A.1 can be saved by around 32% compared to E.Free stove. And it can be saved by 9% compared to Sanpya A.1, 27% DE DE stove, 39% Cement (Pyinmana) stove, 83% Thar-si stove, 32% Mercy Corps and 36% China stove.

Moreover, FRI A.1 can maintain heat longer among the wood-fuel cookstove.

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